Operation Manual

X62-B

Issue 002 2020-01

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1 Introduction

1.1 Operation Manual - change record

Tab 1-1 Change record

New issue 002, 2020-01
- Major adjustments to the contents of the chapter: Operating Media. - 56 general updates to texts, tables, illustrations, links, lists and values across the manual. - Partial removal of misleading example illustrations. - Attachment of Service Bulletins with current injection valve information. - Addition of content for alternative engine control systems WECS and WiCE. - Addition of section views of the engine.
New issue 001, 2018-12
Initial issue of the Operation Manual.

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1.2 Preface

This manual is for use only for the related type of engine (the engine described in this manual).

Make sure that you know the inspection and overhaul intervals before you operate the engine.

Also obey the items that follow:

- **Safety**

  Make sure that you read carefully this manual before you start work on the engine.

  Make sure that you read carefully and obey the data given in chapter safety.

- **Data**

  The specifications and recommendations of the classification societies are included in the design of the engine.

  The data, instructions, graphics and illustrations etc in this manual are related to drawings from WinGD. These data relate to the date of issue of the manual (the year of the issue is shown on the title page and on the footer). All instructions, graphics and illustrations etc can change because of continuous new development and modifications.

- **Equipment and tools**

  Keep all equipment and tools for maintenance and operation serviceable and in good condition.

- **Spare parts**

  Use only original spare parts and components to make sure that the engine will continue to operate satisfactorily.

- **Personnel**

  Only qualified personnel that have the applicable knowledge and training may do work on the engine, its systems and related auxiliary equipment.

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1.3 Technical documentation set

Because of the continuous development of the engine, the technical documentation for the engine changes and is regularly updated. The change record shows all changes.

Important data and changes are given directly to the customer in the service bulletins.

To order technical documents, the data that follows is necessary:

- Engine type, year of manufacture and engine manufacturer
- Name of ship or site of installation
- Cylinder or engine number
- Special equipment
- Document type (printed manuals, CD or Shipdex dataset).

The technical documentation set for this engine includes the publications that follow.

1.3.1 Operation Manual

The Operation Manual (OM) contains data about engine operation, the necessary operating media (oil, water, fuel etc) and descriptions of the components and systems. The manual also gives troubleshooting procedures.

The manual gives data about the standard engine with all cylinder numbers, alternative designs and special equipment.

In this manual the engine connections (refer to the pipe connection plan) are the interface of the description. For a description of the plant supply systems refer to the Marine Installation Manual.

1.3.2 Maintenance Manual

The Maintenance Manual (MM) contains data about disassembly / assembly procedures that are necessary for the engine maintenance. The manual includes the maintenance schedule, data about the masses (weights) of components, a clearance table, tightening values for important screw connections and a tool list.

1.3.3 Spare Parts Catalogue

In the Spare Parts Catalogue (SPC, or code book) all spare parts of the engine are marked with a unique code number. You can order spare parts only with the code number from the Spare Parts Catalogue. Order spare parts from one of the suppliers that follow:

- CSSC Marine Service Co., Ltd.
- Wärtsilä Services Switzerland Ltd.
- Engine supplier.

1.3.4 External supplier documentation

The documentation from external suppliers gives data about the parts of the engine that are not supplied by WinGD, such as turbocharger, automatic filter or damper. Most of this documentation also contains data about spare parts.

1.3.5 Records and drawings

The setting tables, shop trial documents, schematic diagrams and survey certificates of the related engine are given with the first supply of the documentation.

1.3.6 Marine Installation Manual

The Marine Installation Manual (MIM) contains data for design engineers and naval architects, enabling them to optimize plant items and machinery space, and to do installation design work.

1.4 Data module codes (descriptive data)

This manual is divided into several data modules. Each data module is identified with a unique data module code, refer to Table 1-2 - Data module codes (descriptive data). The structure of the data module codes is as follows:

- ??##-####-##???-###?-? (structure)
- AA00-5551-00AAA-043A-A (example).

Tab 1-2 Data module codes (descriptive data)

Code	Description	Length/type	Property	Example
?? [1]	Alternative versions/designs of items. Used when two or more items could be installed in the engine as alternatives for the same function (eg turbochargers from different suppliers)	2 alphabetic characters [A-Z]	sequential, starts with AA	AA
## [2]	Applicability related to cylinder number. 00 = applicable to all engines independent of the number of cylinders; ## = applicable only to engines with that specific number of cylinders.	2 numeric characters [0-9]	arbitrary	00
#### [2]	WinGD design group number	4 numeric characters [0-9]	arbitrary	5551
## [2]	Used for sequential numbering of data modules.	2 numeric characters [0-9]	sequential, starts with 00	00
??? [1]	Used for alternative items differing in design but not enough to change the variant code.	3 alphabetic characters [A-Z]	sequential, starts with AAA	AAA
### [2]	Shipdex information code, eg 043 = description of function attributed to the crew (functional breakdown)	3 numeric characters [0-9]	Shipdex specific	043
? [1]	Shipdex information code variant. Used for sequential numbering	1 alphabetic character [A-Z]	sequential, starts with A	A
? [1]	Shipdex item location code, eg A = information related to items installed on the product	1 alphabetic character [A-D]	Shipdex specific, default is A	A

1 Placeholder symbol for alphabetic characters.

2 Placeholder symbol for numeric characters.

NOTE: For the full list of available Shipdex information codes and more data about the Shipdex specification, refer to www.shipdex.org.

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1.5 Data module codes (procedural data)

This manual is divided into several data modules. Each data module is identified with a unique data module code, refer to Table 1-3 - Data module codes (procedural data). The structure of the data module codes is as follows:

- ??##-####-##???-###?-? (structure)
- AA00-5556-00AAA-520A-A (example).

Tab 1-3 Data module codes (procedural data)

Code	Description	Length/type	Property	Example
?? [1]	Alternative versions/designs of items. Used when two or more items could be installed in the engine as alternatives for the same function (eg turbochargers from different suppliers)	2 alphabetic characters [A-Z]	sequential, starts with AA	AA
## [2]	Applicability related to cylinder number. 00 = applicable to all engines independent of the number of cylinders; ## = applicable only to engines with that specific number of cylinders.	2 numeric characters [0-9]	arbitrary	00
#### [2]	WinGD design group number	4 numeric characters [0-9]	arbitrary	5556
## [2]	Used for sequential numbering for the physical breakdown of components; 00 = complete component, 01 = first breakdown; for illustrated parts (tools) it is used for sequential numbering of data modules.	2 numeric characters [0-9]	sequential, starts with 00	00
??? [1]	Used for alternative items differing in design but not enough to change the variant code (eg AAA = Bearing shell No.1; AAB = Bearing shell No. 2 to #)	3 alphabetic characters [A-Z]	sequential, starts with AAA	AAA
### [2]	Shipdex information code, eg 520 = Remove procedure	3 numeric characters [0-9]	Shipdex specific	520
? [1]	Shipdex information code variant. Used to differentiate different procedures defined by the same information code for the same DMC/Hardware section.	1 alphabetic character [A-Z]	variable	A

Code	Description	Length/type	Property	Example
? [1]	Shipdex item location code. A = information related to items installed on the product; B = information related to items installed on a major assembly removed from the product; C - information related to items on the bench. In this context, it does not matter, for example, whether an item has been removed from the product; D - information related to all three locations A, B, and C. No other combinations are allowed.	1 alphabetic character [A-D]	Shipdex specific	A

1 Placeholder symbol for alphabetic characters.

2 Placeholder symbol for numeric characters.

NOTE: For the full list of available Shipdex information codes and more data about the Shipdex specification, refer to www.shipdex.org.

1.6 About this book

In the sections that follow you find the definitions of WinGD for this book.

1.6.1 Definitions for general text

For general text in this book the definitions that follow are applicable:

- **ASD Simplified Technical English**

  The text in this book obeys the rules for ASD Simplified Technical English.

- **Illustrations**

  The items in an illustration are shown, if possible, in clockwise direction, for example 001, 002, 003.

  NOTE: Illustrations are usually generic or are shown as example. Thus some items can be different on the current engine.

- **Cross references**

  A cross reference to a different section of this book has the number and the title of the section, for example "refer to section 1.2 Preface". In the electronic version, a mouse click on the blue text shows the related section.

  NOTE: The text "[section not applicable for this engine]" shows, that this cross reference and the related section are not applicable for this book.

- **Instructions**

  Instructions in the procedures are given as steps, for example 1, 2, 3. These steps can be divided into sub-steps, for example 1.1, 1.2, 1.3 or also sub-sub-steps, for example 1.1.1, 1.1.2, 1.1.3.

- **Notes**

  Notes give more data to help you do a task, or they give data about the related item. Notes come immediately before or after the related paragraph.

- **Decimal separator**

  In this book a full stop (.) is used as decimal separator, for example 3.21 bar.

1.6.2 Warnings

Warnings in procedures give data about a hazard.

Warnings have the basic structure that follows:

- **Signal word**

  The signal words that follow are applicable:
  - WARNING
  - CAUTION
- **Hazard**

  The hazard data gives the dangerous situation.
- **Procedure**

  The procedure gives data of how to prevent the dangerous situation.

The signal words have the different hazard levels that follow:

- **WARNING**

  The signal word WARNING gives a dangerous situation at which death or large injury are possible. Do the related procedure to prevent this.
- **CAUTION**

  The signal word CAUTION gives a dangerous situation at which moderate or small injury to personnel or damage to equipment are possible. Do the related procedure to prevent this.

1.7 About the engine

In the sections that follow you find the definitions of WinGD for the engine.

1.7.1 Groups of components

Each component of the engine has a four-digit material number. WinGD has divided these components related to the first digit of the number into 9 groups:

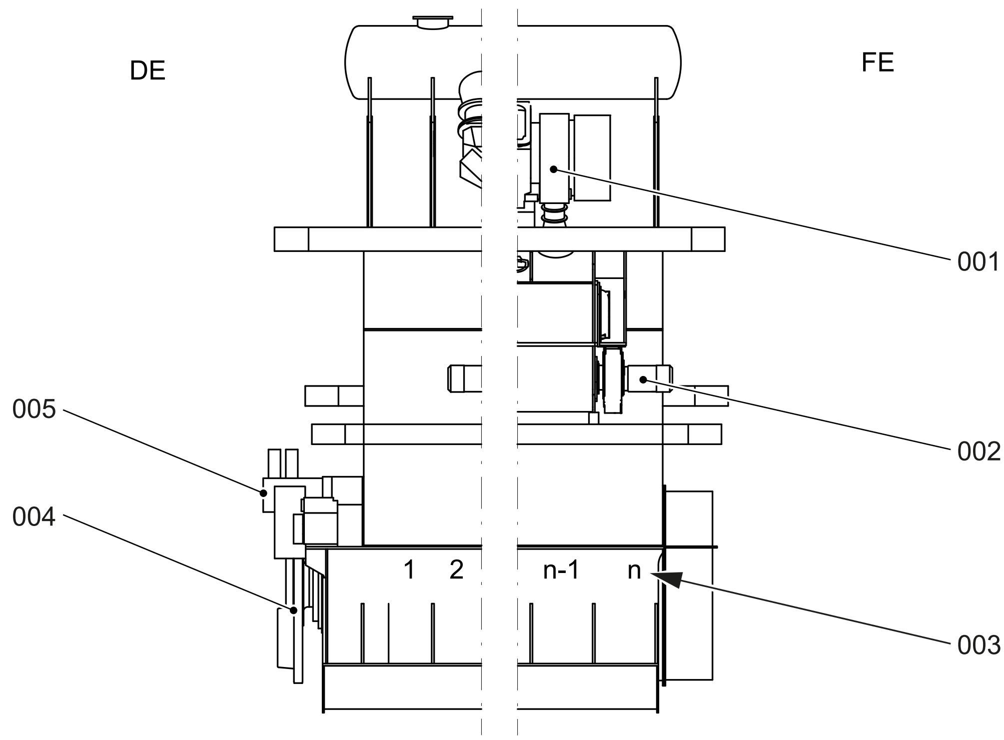
- Group 1 - Engine frame and bearings
- Group 2 - Cylinder
- Group 3 - Crankshaft, connecting rod and piston
- Group 4 - Supply unit drive and control components
- Group 5 - Supply unit, pumps and control valves
- Group 6 - Scavenge air components
- Group 7 - Cylinder lubrication and balancer
- Group 8 - Pipes
- Group 9 - Monitoring instruments.

1.7.2 Engine sides and ends - names

The sides and ends of the engine have the names and abbreviations that follow (refer to Figure 1-1 and Figure 1-2):

- DE - Driving End (end that has a flange to attach the propeller shaft)
- FS - Fuel Side (side that has the equipment for the supply of fuel and other operating media)
- FE - Free End (end that is closed with a cover)
- ES - Exhaust Side (side that has the equipment for the discard of the exhaust gas and for the supply of scavenge air).

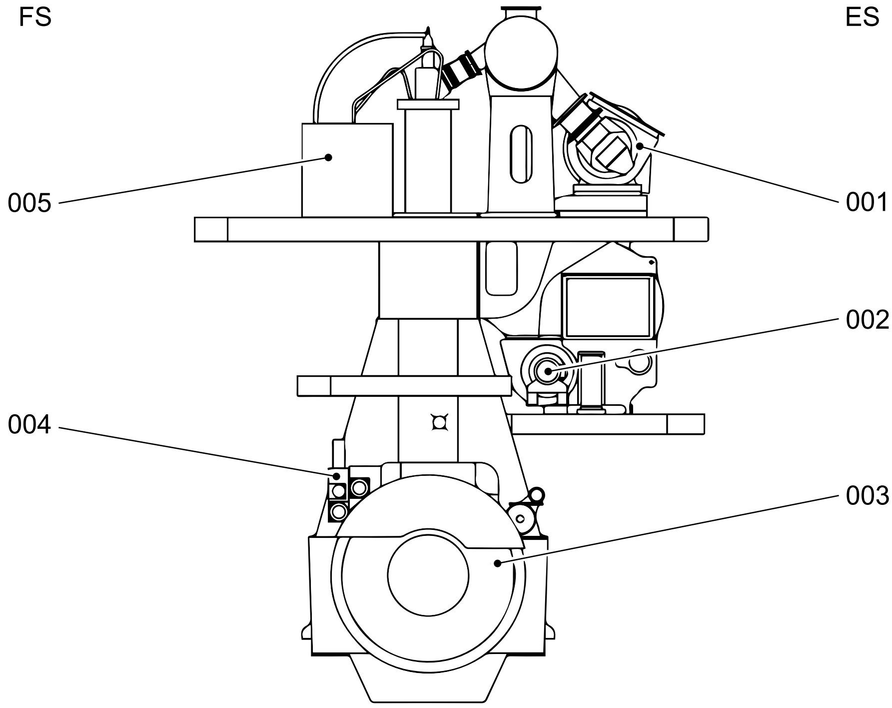
Fig 1-1 Side view (generic)



Legend

FE	Free end	DE	Driving end
001	Turbocharger	004	Flywheel
002	Auxiliary blower	005	Supply unit
003	Main bearing number		

Fig 1-2 End view (generic, seen from the driving end)



Legend

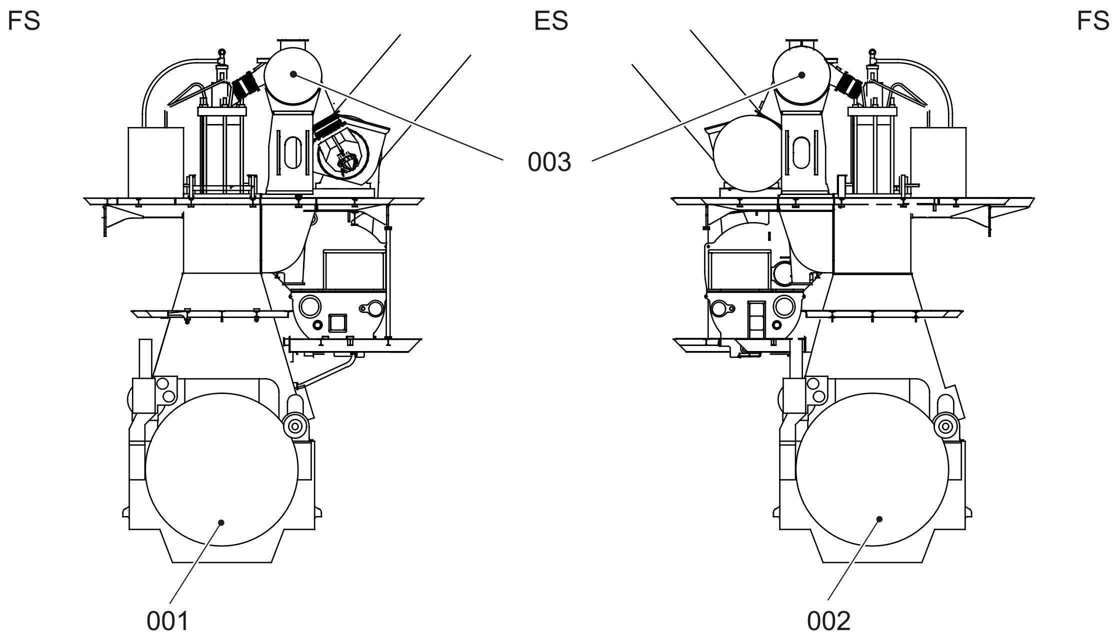
ES	Exhaust side	FS	Fuel side
001	Turbocharger	004	Supply unit
002	Auxiliary blower	005	Rail unit
003	Flywheel		

1.7.3 Standard and LEFT engine

An engine is one of two types (refer to Figure 1-3):

- A standard engine has the exhaust side (ES) on the right side of the engine (seen from the driving end).
- A LEFT engine has the exhaust side (ES) on the left side of the engine (seen from the driving end).

Fig 1-3 Standard and LEFT engine (generic, seen from the driving end)



Legend

001	Standard engine	ES	Exhaust side
002	LEFT engine	FS	Fuel side
003	Exhaust gas manifold		

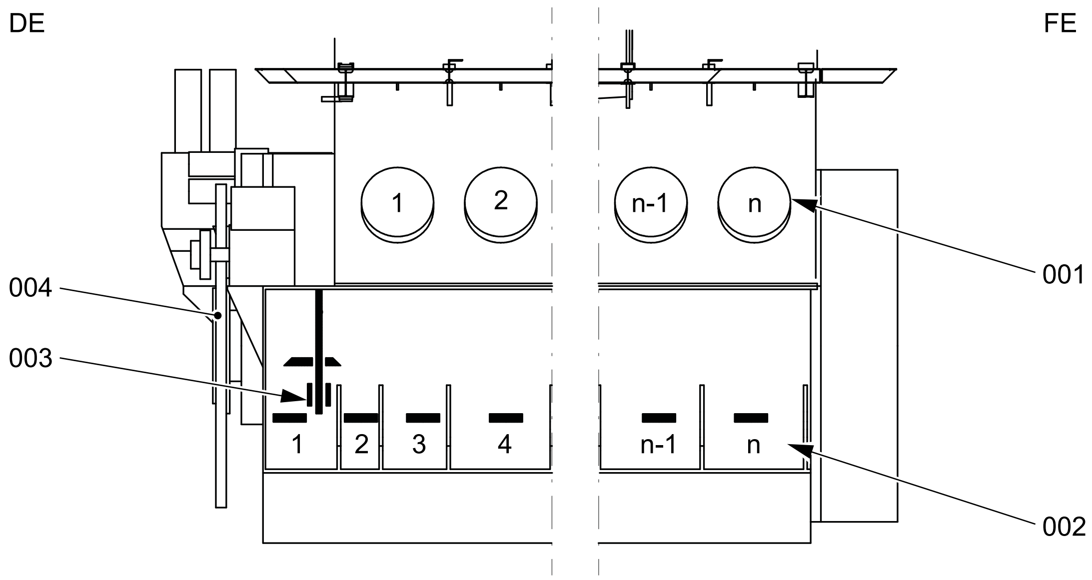
NOTE: In the Spare Parts Catalogue parts that have the mark (LEFT) are only applicable for a LEFT engine. Parts that are applicable for the two engines types (Standard and LEFT) have no mark.

1.7.4 Numbering of items

WinGD uses the definitions for the numbering of items as follows (refer to Figure 1-4):

- In axial direction the numbering starts from the flywheel.
- In radial direction the numbering starts from the center of the flywheel.

Fig 1-4 Engine numbering (generic)



Legend

FE	Free end	DE	Driving end
001	Cylinder number	003	Thrust bearing
002	Main bearing number	004	Flywheel

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1.8 List of abbreviations

Tab 1-4 List of abbreviations and acronyms

Short form	Full form, meaning
ACM	Angle Calculation Module
ADA	crank Angle Determination Algorithm
AHD	ahead
ALM	alarm
AMS	Alarm and Monitoring System
A/R	as required
AST	astern
ASTM	American Society for Testing and Materials
BDC	Bottom Dead Center
BN	Base Number
BSEC	Brake Specific Energy Consumption
BSFC	Brake Specific Fuel Consumption
BSGC	Brake Specific Gas Consumption
BSPC	Brake Specific Pilot fuel Consumption
CAN	Controller Area Network
CCAI	Calculated Carbon Aromaticity Index
CCM	Cylinder Control Module
CCU	Cylinder Control Unit
CCW	counterclockwise
CMCR	Contract Maximum Continuous Rating
COC	Cleveland Open Cup
CPP	Controllable Pitch Propeller
CS	crankshaft
CW	clockwise
Cyl.	cylinder
DBT	Delta Bypass Tuning
DCC	Dynamic Combustion Control
DE	Driving End
DENIS	Diesel Engine coNtrol and optImizing Specification
DF	Dual Fuel

Short form	Full form, meaning
ECA	Emission Control Area
ECR	Engine Control Room
ECS	Engine Control System
eg or e.g.	for example (exempli gratia)
EGR	Exhaust Gas Recirculation
ELBA	ELectrical BAlancer
ES	Exhaust Side
ESS	Engine Safety System
FAME	Fatty Acid Methyl Esters
FAST	Fuel Actuated Sacless Technology
FCM	Flex Control Module
FCV	Forged Crankshaft Version
FE	Free End
FGSS	Fuel Gas Supply System
FLV	Flow Limiting Valve
FPP	Fixed Pitch Propeller
FQS	Fuel Quality Setting
FS	Fuel Side
FZG	Forschungsstelle für Zahnräder und Getriebebau (gear research center)
GAV	Gas Admission Valve
GSS	Gas Safety System
GTD	General Technical Data
GTU	GaTeway Unit
GVU	Gas Valve Unit
HFO	Heavy Fuel Oil
HFR	High Feed Rate
HP	High Pressure
HT	High Temperature
IACS	International Association of Classification Societies
iCAT	integrated Cylinder lubricant Auto Transfer
ICC	Intelligent Combustion Control
ICM	Intelligent Combustion Monitoring

Short form	Full form, meaning
ICU	Injection Control Unit
ie or i.e.	that is (id est)
iELBA	integrated ELectrical BAlancer
iGPR	integrated Gas Pressure Regulation
IMO	International Maritime Organization
Ind.	Indenture
IOM	Input Output Module
ISO	International Standard Organization
JIS	Japanese Industrial Standard
KOH	Potassium hydroxide
LDU	Local Display Unit
LED	Light Emitting Diode
LEL	Lower Explosive Level
LFR	Low Feed Rate
LHV	Lower Heating Value
LLT	Low-Load Tuning
LNG	Liquefied Natural Gas
LP	Low Pressure
LT	Low Temperature
MARPOL	International Convention for the Prevention of Pollution from Ships (MARine POLlution)
MCM	Main Control Module
MCP	Manual Control Panel
MCR	Maximum Continuous Rating
MCU	Main Control Unit
MDO	Marine Diesel Oil
MEG	MonoEthylene Glycol
MEP	Mean Effective Pressure
MGO	Marine Gas Oil
MIM	Marine Installation Manual
MM	Maintenance Manual
Modbus	serial communications protocol published by Modicon
MPG	MonoPropylene Glycol

Short form	Full form, meaning
N/A	not applicable
nil	not illustrated
No.	number
OAT	Organic Acid Technology
OM	Operation Manual
OPI	OPerator Interface (user interface in the engine control room)
PCS	Propulsion Control System
PCV	Pressure Control Valve
PMCC	Pensky Martens Closed Cup method
Pos.	position
PU	Piston Underside
RCS	Remote Control System
REF	Reference
rpm	revolutions per minute
SAC	Scavenge Air Cooler
SAE	Society of Automotive Engineers
SCR	Selective Catalytic Reduction
SCS	Speed Control System
SHD	shutdown
SLD	slowdown
SOI	Start Of Injection
SPC	Spare Parts Catalogue
SPC	Steam Production Control
TC	TurboCharger
TDC	Top Dead Center
UNIC	UNIfied Controls
USB	Universal Serial Bus
VCU	exhaust Valve Control Unit
VEC	Variable Exhaust valve Closing
VEO	Variable Exhaust valve Opening
VIT	Variable Injection Timing
WECS-9520	WinGD Engine Control System 9520

Short form	Full form, meaning
WHR	Waste Heat Recovery
WiCE	WinGD Integrated Control Electronics
WinGD	Winterthur Gas & Diesel Ltd.
WLL	Work Load Limit

2 Safety

2.1 Safety precautions and safety rules

2.1.1 General safety precautions

Use the data given below as a guide to the personnel.

- **Lighting**

  Make sure that there is good permanent lighting in the engine room. Have a sufficient number of hand lamps available at different locations in the engine room.

- **Clean areas**

  Keep the engine as clean as possible. Keep the electronic control boxes on the rail unit clean and dry. Make sure that no dust, sand or chemical vapor can go into the engine room.

  This will help to prevent a fire in the engine room.

- **Fire**

  Make sure that fire-fighting equipment is available in the engine room. Keep covers and casings of the engine closed until the engine is sufficiently cool.

  Make sure that no fire extinguisher gases can be automatically released when personnel are in the engine room.

  Make sure that the emergency exits are clearly marked.

  Make sure that personnel do not smoke in the engine room.

- **Tools**

  Put hand-tools in locations where you can easily get access to them. Put special tools and devices in positions in the engine room near the area where you use them.

  Make sure that all tools have protection from corrosion.

  Make sure that all tools are fixed to prevent from unwanted movement and from damage.

- **Spare parts**

  Keep large spare parts as near as possible to the position where they will be installed and near the engine room crane.

  Make sure that the spare parts have protection from corrosion.

  Make sure that the spare parts are fixed to prevent from unwanted movement and from damage.

  Replace used spare parts as soon as possible.

- **Temperature**

  Parts of the engine become hot during operation. Be careful and use gloves when you have to touch hot parts with your hands.

- **Frost hazard**

  If the ambient air temperature decreases below 0°C and the engine is not in operation, the water in the pipe systems can freeze. To prevent this, drain the pipe systems or increase the temperature in the engine room.

2.1.2 General safety rules

If you do work at or near the engine, obey the rules that follow to prevent risks of harm or damage to personal, to equipment, or to environment.

- **Rules for personnel**

  Wear the correct safety and protective equipment.

  Make sure that you know the fire-fighting procedures.

  Make sure that you know the health and general safety data and the environment protection data.

  Avoid direct contact with operating media or with hot parts.

  Climb only on facilities as intended for this.

  Never stand on pipes, valves or fittings.

  Keep away from the running engine.

  Keep ignition sources away from the engine.

  Carry out all work carefully.

- **Rules for operation**

  Start the engine only if the engine is in good condition.

  Keep the safety signs on the engine clean.

  Keep unauthorized persons away from the engine.

  Clean walk ways and stays regularly.

  Open valves and shut-off devices carefully to prevent injury from released media.

  Do not use water or cleaning fluid to clean the electronic components and control boxes.

- **Rules for service and maintenance**

  Keep the tools serviceable, for example calibrate gauges regularly.

  Use the correct tools in a correct way, for example lifting devices and ropes.

  Protect lifted parts with applicable materials.

  Do work inside the engine with a safety person on the outside.

  Put covers or protection on opened openings or on removed sealing faces.

  Attach removed parts in the engine room to prevent movement of the parts.

  Replace O-rings during an overhaul of components.

  Make sure that after installation all pipes and items are fixed correctly.

  Use lock wires, tab washers, and lock plates one time only.

  Before you assemble screws and studs in very hot areas, apply on the threads a lubricant that is resistant to high temperatures.

- **Rules for electric welding**

  Do electric welding near the engine only if the engine is stopped.

  Set to OFF the electronic system and wait a minimum of one minute.

  Disconnect electronic modules or sensors in a radius of 2 m from the welding place.

  Make sure that there are no explosive fluids or gases in the work area.

  Apply protection to electronic parts to prevent damage from sparks and heat.

  Place the connection to earth as near as possible to the welding object.

  Make sure that the welding cable has no loops and is not parallel to cables of electronic units.

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2.2 Contamination and fire in the scavenge air spaces

2.2.1 Causes of contamination

The primary cause of contamination is when combustion materials are blown between the piston and cylinder into the scavenge air spaces (blow-by). The contamination will be more if the fuel is not fully burned, which causes exhaust smoke.

2.2.1.1 Unsatisfactory combustion

The causes of unsatisfactory combustion are as follows:

- The injection valves do not operate correctly (the nozzle tip has trumpets or is worn).
- The fuel is too cold, specially at low load.
- Operation with a temporarily low air supply during large differences in engine load and the scavenge air pressure fuel-limiter set too high.
- Too much load.
- Low air supply because the ventilation in the engine room is not sufficient.
- The silencer and diffuser on the air side of the turbocharger has contamination.
- The wire mesh and nozzle ring upstream of the turbocharger has contamination.
- The exhaust gas boiler, the air cooler and water separator, the air flaps in the scavenge air receiver and the scavenge ports have contamination.

2.2.1.2 Blow-by

The causes of blow-by are as follows:

- Worn piston rings, broken piston rings or piston rings that cannot move.
- Worn cylinder liner.
- Incorrect operation of a lubricating quill.
- The running surface of the cylinder liners have damage.

If there are one or more of these conditions, the remaining particles will collect at the areas that follow:

- Between the piston ring and piston ring groove.
- On the piston skirt.
- In the scavenge ports.
- On the bottom of the cylinder block (piston underside).
- In the scavenge air receiver.

2.2.2 Causes of fire

The causes of fires are as follows:

- If sealing rings of the piston rod gland are defective, system oil and cylinder oil will collect in the piston underside. If the drain pipes from the piston underside are blocked, this oil can not drain. A high temperature in the piston underside then can cause a fire.
- If piston rings are defective, combustion gases and sparks can go into the piston underside. Contamination in the piston underside then can cause a fire.

You must do regular checks of the bottom of the cylinder block and scavenge air receiver to keep clean the cylinder block and scavenge air receiver, refer to section 8.5 Do checks during operation - general.

2.2.3 Indication of a fire

The indications of a fire are as follows:

- You can hear the related temperature alarms.
- A large increase in the exhaust gas temperature of the related cylinder and an increase in piston underside temperature.

For the fire-fighting procedures, refer to section 2.3 Fire-fighting in the scavenge air space.

2.3 Fire-fighting in the scavenge air space

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- Refer to section 2.2 Contamination and fire in the scavenge air spaces

PROCEDURE

1 If you think there is no fire, do the steps as follows:

- **1.1** Decrease the engine power.
- **1.2** Cut out the injection of the related cylinder.
- **1.3** Increase the feed rate of the lubricating oil in the related cylinder to the maximum, although there is high temperature in the related cylinder.

WARNING

Injury Hazard. Where CO_2 is used to extinguish a fire in the engine, there is a risk of suffocation. Make sure that all related spaces have good airflow to remove all CO_2 gas before you go into the engine.

CAUTION

Damage Hazard. Steam can cause corrosion. If steam is used to extinguish a fire you must do procedures to prevent corrosion.

2 If you think there is a fire, do the steps as follows:

- **2.1** Shut down the engine.
- **2.2** Fight the fire with the installed fire extinguishing system.

3 After approximately 5 minutes to 15 minutes, do the checks as follows:

- **3.1** Do a check of the exhaust gas temperature.
- **3.2** Do a careful check of the temperatures of the doors to the piston underside space.

4 Find the causes of the problems as follows:

- **4.1** Do a check of the cylinder liner running surface, piston and piston rings.
- **4.2** Do a check of the flaps in the scavenge air receiver (replace if necessary).
- **4.3** Do a check for possible leaks.
- **4.4** Do a check of the piston rod gland as much as possible.
- **4.5** Do a check of the injection nozzles.
- **4.6** If necessary, clean or repair the defective items.

5 Start the engine as follows:

- **5.1** If applicable, cut in the injection.
- **5.2** Start the engine.
- **5.3** Start the injection and slowly increase the load.
- **5.4** Set the cylinder oil feed rate to the applicable value.

  NOTE: Do not operate the engine for long periods with a high cylinder oil setting.

CLOSE UP

- None

2.4 Explosions in the crankcase

Examples of explosions in the crankcase of diesel engines have shown that they can only occur in special conditions, and thus do not occur frequently.

The cause of crankcase explosions is oil mist. Oil mist comes from components that have become unusually hot.

The engine has oil mist detectors, refer to section 5.9.3 Oil mist detector.

Correct engine maintenance will help prevent explosions in the crankcase.

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2.5 Prevent explosions in the crankcase

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

WARNING

Danger: If an oil mist alarm is activated, keep away from the engine. There is a risk of explosion.

WARNING

Danger: Do not open the crankcase doors or the covers for a minimum of 20 minutes after engine stop. If air goes into the crankcase, an explosion can occur.

WARNING

Injury hazard: The crankcase doors have relief valves. To prevent accidents no person must be in the areas of gases that can come out of these relief valves. Injury to personnel can occur.

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 If an oil mist detector activates an alarm, do as follows:

- **1.1** Decrease immediately the engine speed (power).
- **1.2** Stop the engine if possible.
- **1.3** Let the engine temperature decrease for a minimum of 20 minutes.
- **1.4** Find the cause and repair the fault.

  NOTE: If no fire-extinguishing system is installed or not in use, a portable fire extinguisher must be kept ready when the crankcase doors are opened.

CLOSE UP

- None

2.6 Access to engine spaces

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- The engine must be stopped and prepared for maintenance, refer to section 8.19 Prepare the engine after stop - general

PROCEDURE

1. Make sure that there is always a safety person on the outer side of the engine.
2. Wear the correct safety equipment.
3. For a DF engine, obey the safety rules for natural gas, refer to section [section not applicable for this engine].
4. Release the pressure in the air spring air pipe to open the exhaust valves.
5. Make sure that the starting air supply pipe has no pressure (ie starting air shut-off valve 30-4325_E0_1 is closed, ball valves 30-8605_E0_6 and 30-8605_E0_7 are open).
6. Engage the turning gear and lock the lever in this position.

   NOTE: Other ships in the water cause currents, which cause the movement of the propeller and the engine. The engine and propeller cannot move when the turning gear is engaged.
7. If applicable, open the indicator valves or the relief valves on the cylinder cover.
8. Make sure that there is sufficient air in the engine spaces, eg use a ventilator.
9. Go into the engine spaces and do the work very carefully.
10. When you go out of the engine spaces, move all the equipment out of the engine.

CLOSE UP

- None

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3 Design and function of the engine

3.1 Short description of the engine

The engine is a single acting two-stroke diesel engine of crosshead design. The engine has a turbocharger and exhaust valves.

General data about the engine are given as follows:

- The engine uses the common-rail system with full electronic control of the fuel injection system, exhaust valve operation, starting valve operation, and cylinder operation.
- Related to the design, the engine turns clockwise or counterclockwise for the ahead direction. For the astern direction the engine can turn in the other direction.
- The engine control system (ECS) electronically controls all important engine functions (eg speed control, overspeed protection and fuel injection). The engine control can have different remote controls, which are related to the WinGD specifications from recommended manufacturers.

3.1.1 Cycle of a two-stroke diesel engine

The sequences of a two-stroke diesel engine are as follows (refer to Figure 3-1):

- **Sequence 1 - 2**

  The piston moves up and thus compresses the scavenge air. This increases the temperature of the air above the self-ignition temperature of the fuel.

- **Sequence 2 - 3**

  At almost TDC fuel at very high pressure is injected into the hot air in the combustion chamber. The fuel ignites and combustion starts.

- **Sequence 3 - 4**

  The gases expand and push the piston down. The pressure in the combustion chamber decreases.

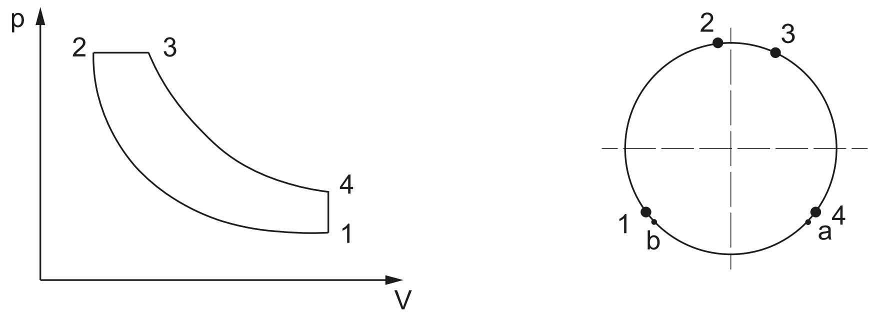
- **Sequence 4 - 1**

  The scavenge air replaces the exhaust gas as follows:

  - At (4) the exhaust valve opens.
  - At (a) the scavenge ports get uncovered. Scavenge air enters the cylinder and pushes the exhaust gas into the exhaust gas manifold.
  - At (b) the scavenge ports get covered.
  - At (1) the exhaust valve closes.

The cycle is completed and starts again.

Fig 3-1 Pressure - volume diagram and schematic of the two-stroke diesel cycle



3.2 Use of the engine

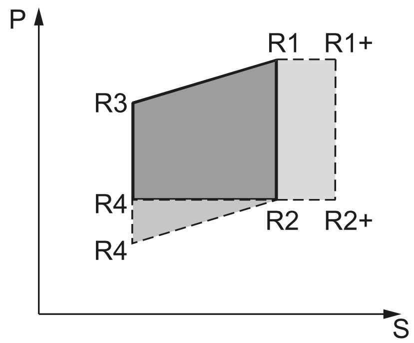
3.2.1 Intended use

The engine is intended to drive a propeller of a vessel. The engine changes the chemical energy of the fuel to mechanical energy.

The engine must only be used in the operating range as given in the data sheets, refer to chapter 11.

Related to the contract the Contract Maximum Continuous Rating (CMCR) is specified in the range of Figure 3-2. The points R1+ and R2+ are only applicable, if the engine has an extended range.

Fig 3-2 Operating range



Legend

R1	Highest power at highest speed	R3	Highest power at lowest speed
R1+	Highest power at highest speed (extended)	R4	Lowest power at lowest speed
R2	Lowest power at highest speed	P	Power
R2+	Lowest power at highest speed (extended)	S	Speed

The intended use of the engine includes the items that follow:

- Obey this Operation Manual.
- Obey the related safety regulations.
- Obey the instructions of the operating company.
- Operate the engine in the specified limits.
- Use the correct operating media.

3.2.2 Incorrect use

Incorrect use of the engine can result in personal injury and in damage to physical properties.

Personal injury or damage to physical properties caused by incorrect use will be the responsibility of the operating company.

The actions that follow must be looked as examples to be an incorrect use:

- Operation of the engine with disabled, changed or defective safety devices
- Operation of the engine with personnel who are not approved.

3.2.3 Tuning

Related to the contract the engine has one of the tuning options that follow (refer to Figure 3-3):

- **Standard tuning**

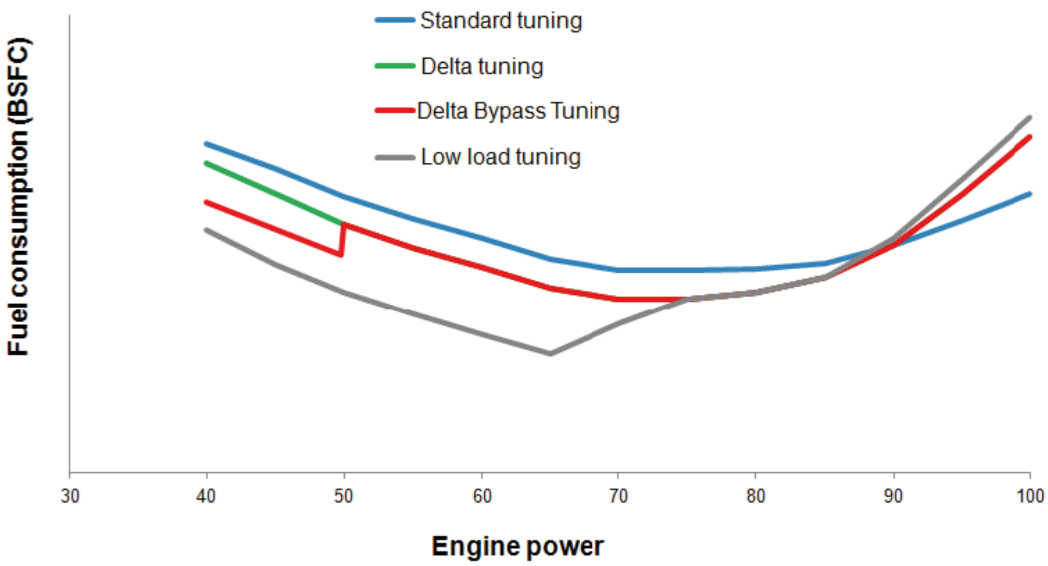
  The standard tuning gives a good fuel consumption over the full engine power range.
- **Delta tuning**

  The delta tuning decreases the fuel consumption below 90% engine power compared to standard tuning. But it increases the fuel consumption between 90% and 100% of engine power.
- **Delta bypass tuning**

  The delta bypass tuning decreases the fuel consumption below 50% engine power compared to delta tuning. For more than 50% of engine power the fuel consumption is the same as delta tuning, but the steam production is increased.
- **Low-load tuning**

  The low-load tuning decreases the fuel consumption below 75% engine power compared to delta tuning or delta bypass tuning. But it increases the fuel consumption between 90% and 100% of engine power compared to delta tuning.

Fig 3-3 Tuning options



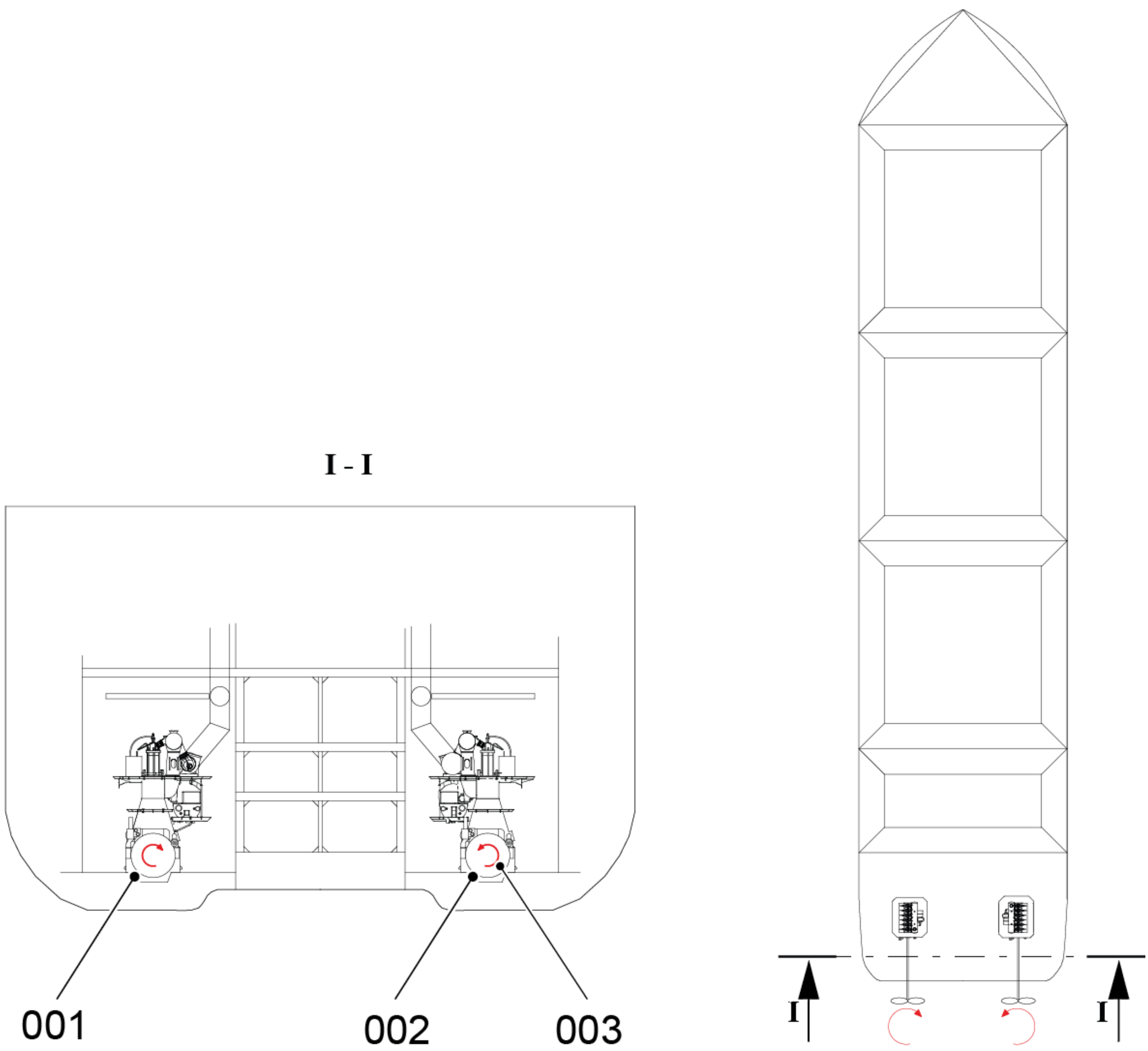
3.2.4 Twin engine propulsion

The engine can be operated in a vessel with twin engine propulsion. Figure 3-4 shows an example of the related installation.

In this configuration the installation must have been done related to the specified rules of the classification societies and of WinGD.

You can operate the two engines in different modes, for example port engine (001) is in diesel mode and, if gas mode is applicable, starboard engine (002) is in gas mode.

Fig 3-4 Twin engine propulsion (generic example)



Legend

001	Port engine	003	Example for direction of rotation
002	Starboard engine		

3.3 The relation between engine and propeller

3.3.1 General

There is a specified relation between the propeller speed and the absorbed power in ships that have fixed pitch propellers. The relation is between the propeller and the speed at which it turns.

The formula that follows (where P = power and n = speed) gives an approximate result, which is sufficient for conventional vessels:

$$\frac{P_1}{P_2} = \left(\frac{n_1}{n_2}\right)^3$$

00095

The graph from this formula is known as the propeller property.

If the engine is in good condition, correctly supplied with air (ie turbochargers in good condition and the resistance of the air and exhaust pipes is in the specifications) and the fuel injection quantity is correctly adjusted (see the shop test protocol), then the mean effective pressure (MEP) developed during service conditions (in accordance with the specified load indication), is related to the approximate MEP for this position on the test bed.

In the diagram (see Figure 3-5), the propeller property line through the CMCR point (100% power at 100% engine speed) is known as the nominal propeller property. Engines that are used for the propulsion of vessels with fixed propellers have a load applied on the test bed in accordance with this propeller property. But, during sea trial of a new ship with a smooth and clean hull, the applicable power is lower and the operation point is below the nominal propeller property.

During operation, a higher torque is necessary for the propeller to keep its speed than at the time of the sea trial (sea margin) because:

- There are changes in wake flow conditions because of marine growth on the hull
- The cargo load has an effect on the depth of the vessel in the water
- The propeller has a rough surface or has mechanical damage
- The vessel operates in bad sea and weather conditions
- The vessel operates in shallow water. The MEP of the engine (and thus the fuel injection quantity) will increase. In such a condition, the operation point will then be at the left of the initial propeller curve which was calculated during sea trials.

A hull that was cleaned and painted will help to decrease the resistance as the vessel moves through the water. It is not possible to get the hull back to its initial condition.

Because the thermal load of the engine is related to the MEP, the position of the operation point is also important. The air supply to the engine and the operation conditions will become unsatisfactory if the operation point is far above the propeller curve.

To get the best conditions, the operation point of the engine for service range must be on or below the nominal propeller property.

3.3.2 Fixed pitch propeller (FPP)

3.3.2.1 Continuous service rating

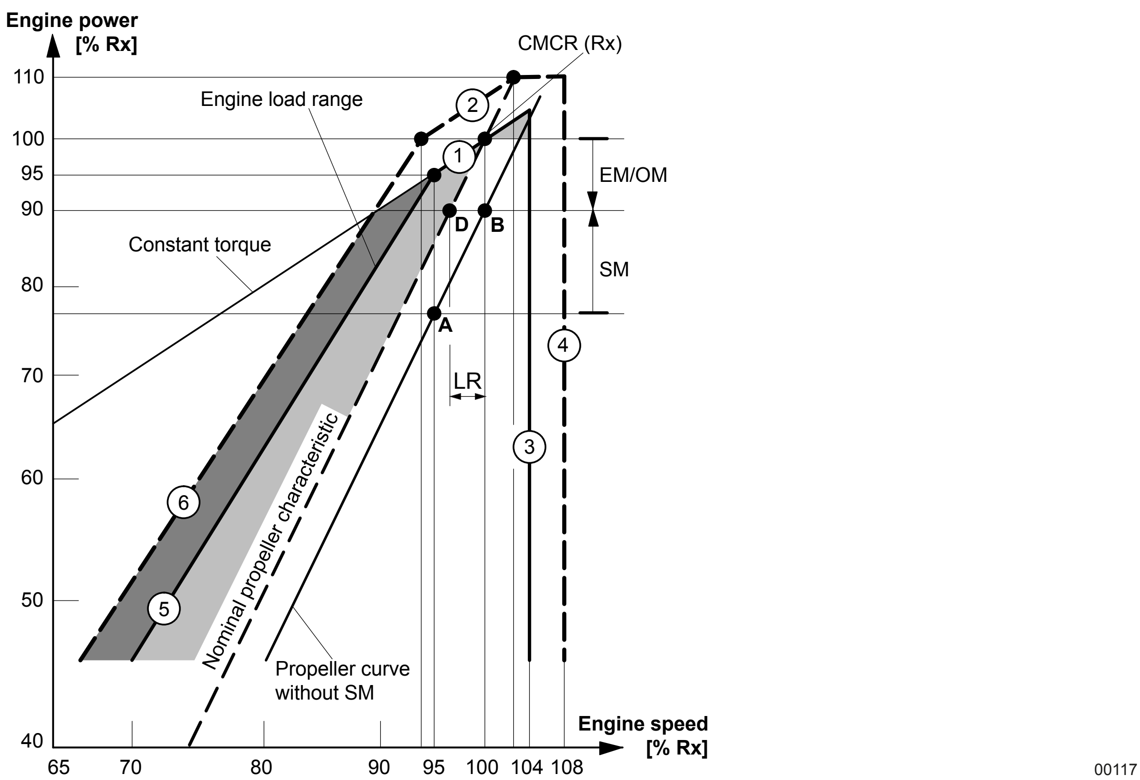
Point A (Figure 3-6) shows the power and speed of a ship that operates at contractual speed in calm seas with a new clean hull and propeller. A power / speed combination at point D is necessary for the same ship at the same speed during service conditions with aged hull and average weather. Point D is then the CSR point.

3.3.2.2 Engine margin / operational margin

Most owners specify the contractual loaded service speed of the ship at 85% to 90% of the contract maximum continuous rating (CMCR). The remaining 10% to 15% of power can be used to catch up with changes in schedules or for the timing of dry-dock intervals. This margin is usually subtracted from the CMCR. Thus, to get the 100% power line, you divide the power at point D by between 0.85 to 0.90.

3.3.2.3 Load range limits

Fig 3-5 Schematic diagram - Relation Speed/Power (FPP)



When the engine has the best values at CMCR (R_X), the limits that follow give the load range of the engine:

- Line 1 is a constant MEP or torque line through CMCR from 100% speed and power down to 95% speed and power.

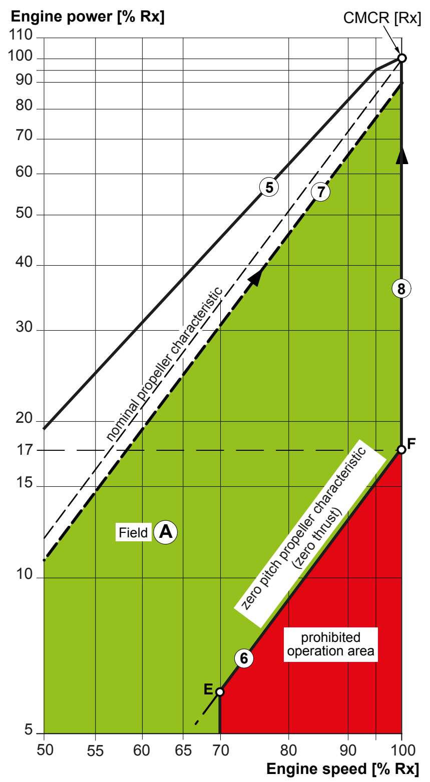
- Line 2 is the overload limit. This is a constant MEP line from 100% power and 93.8% speed to 110% power and 103.2% speed. 103.2% speed is the intersection point between the nominal propeller property and 110% power.
- Line 3 is the 104% speed limit where an engine can operate continuously. For R_X with decreased speed (N_{CMCR} ≤0.98 $_{NMCR}$) this limit can be extended to 106%, but, the torsional vibration must not be more than the specified limits.
- Line 4 is the overspeed limit. The overspeed range between 104% (106%) and 108% speed is only permitted during sea trials if necessary. This is to demonstrate the speed of the ship at CMCR power with a light running propeller in the presence of authorized representatives of the engine builder. The torsional vibration must not be more than the specified limits.
- Line 5 is the permitted torque limit from 95% power and speed to 45% power and 70% speed. This shows a curve defined by the equation: $P_2 \div P_1 = (N_2 \div N_1)^{2.45}$. When the engine speed and power is near the data in Line 5 there will be a decrease in scavenge air, which has an effect on the engine. The area between Lines 1, 3 and 5 show the range in which the engine must be operated. The area in the nominal propeller property, 100% power and Line 3 is recommended for continuous operation. The area between the nominal propeller property and Line 5 must be reserved for acceleration, shallow water and usual flexibility of operation.
- Line 6 gives the equation: $P_2 \div P_1 = (N_2 \div N_1)^{2.45}$ through 100% power and 93.8% speed and the maximum torque limit in transient conditions. The area above Line 1 is the overload range. You must only operate the engine in this range for a maximum of one hour during sea trails in the presence of authorized representatives of the engine builder. The area between Lines 5 and 6 and the constant torque line (shown as a dark area) must only be used for transient conditions, ie during fast acceleration. This range is known as the service range with operational time limit.

3.3.3 Controllable pitch propeller (CPP)

3.3.3.1 Load ranges

After engine start, the engine operates at an idle speed of up to 70% of the rated engine speed with zero pitch. From idle speed, the propeller pitch must be increased with constant engine speed to the minimum at point E, the intersection with Line 9 (see Figure 3-5).

Fig 3-6 Schematic diagram - Relation Speed/ Power (CPP)



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- Line 9 is the bottom load limit between 70% and 100% speed, with a pitch position that at 100% speed, is the minimum power at point F is 37%. The formula shown in paragraph 1 is used for this calculation.
- Along Line 8, the power increase from 37% (point F) to 100% power (CMCR) at 100% speed is the constant speed mode for the shaft generator operation.
- Line 5 is the top load limit and relates to the permitted torque limit.
- The area between 70% and 100% speed and between Line 5 and Line 9 shows the area that an engine with a CPP must be operated.
- Line 7 shows a typical combinator curve for variable speed mode.

Maneuvering at maximum speed with low or zero pitch is not permitted. Thus, installations with main engine-driven generators must have a frequency converter when electrical power is to be supplied (eg to thrusters) at constant frequency during maneuvering. As an alternative, power from auxiliary engines can be used for this purpose.

For test purposes, the engine can be operated at rated speed and low load during a one-time period of 15 minutes on the testbed (eg NO_x measurements) and 30 minutes during dock trials (eg shaft generator adjustment) when there are an authorized representatives of the engine builder on board. More requests must be agreed from WinGD.

3.3.3.2 Control System

The CPP control functions are usually part of the engine control system and include the functions in the paragraphs that follow.

- **Combinator Mode 1**

  Combinator mode for operation without a shaft generator. A combinator curve that includes an applicable light running margin can be set in the permitted operation area, Line 7 (see Figure 3-5).

- **Combinator Mode 2**

  An optional mode used in connection with shaft generators. During maneuvering, the combinator curve follows the Line 9. At sea the engine is operated between point F and 100% power (Line 8) at constant speed.

  For manual and/or emergency operation, different setpoints for speed and pitch are usually supplied.

  An alarm is also usually given in the main engine safety system, or the alarm and monitoring system when the engine operates for more than three minutes in the operation area that is not permitted. If the engine operates for more than five minutes in the operation area that is not permitted, the engine speed must be decreased to idle speed (less than 70%).

4 Design and function of systems

4.1 General for systems

In the chapters that follow you can find a short description of the systems of the engine. The descriptions and figures are generic and simplified.

You can find an overview of the used line codes in Figure 4-1.

Fig 4-1 Line codes for systems

Legend

001	Main supply pipe	006	Double wall pipe
002	Drain / leakage pipe	007	Heating pipe
003	Vent pipe	008	Insulated pipe
004	Waste pipe (dirty drain pipe)	009	Trace heated and insulated pipe
005	Optional pipe		

Page left intentionally blank

4.2 Cooling water system

The cooling water system supplies the items that follow with cooling water:

- Cylinder liner
- Cylinder cover
- Exhaust valve cages
- Scavenge air cooler (SAC).

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The cooling water system has the engine connections as interface to the plant as follows (in Figure 4-2 marked with a circle):

- Connection 01 (cylinder cooling water inlet)
- Connection 02 (cylinder liner cooling water inlet (bypass cooling water system)) (optional)
- Connection 03 (cylinder cooling water outlet)
- Connection 05 (cylinder cooling water drain outlet)
- Connection 07 (SAC LT-cooling water inlet) (not shown)
- Connection 08 (SAC LT-cooling water outlet) (not shown).

If the supply at the engine connection 02 is installed, the cylinder liner is supplied with cooling water at a higher temperature than the cylinder cover.

The cooling water system has the parts that follow:

- **Automatic venting unit**

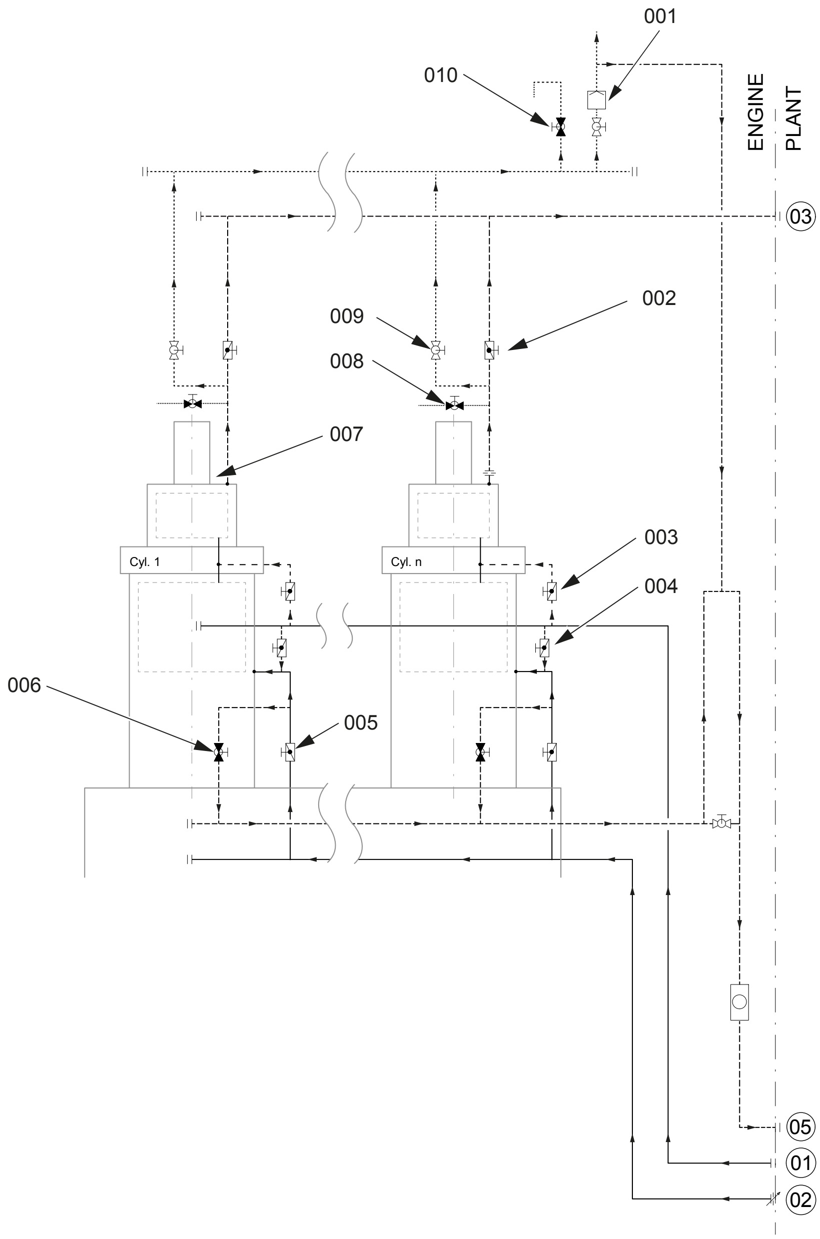
  The automatic venting unit (001) constantly releases unwanted air from the cooling water.
- **Optional vent valve**

  The optional vent valves (008) can be used manually to release unwanted air from the cooling water, if the automatic venting unit (001) does not operate correctly.
- **Vent valve**

  The vent valves (009) constantly release cooling water to the automatic venting unit (001) to release unwanted air from the cooling water.
- **Vent valve**

  The vent valve (010) can be used manually to release unwanted air from the cooling water, if the automatic venting unit (001) does not operate correctly.

Fig 4-2 Cooling water system (generic and simplified)



Legend

001 Automatic venting unit
002 Shut-off valve cooling water outlet
003 Shut-off valve, if supply 02 is installed
004 Shut-off valve, if supply 02 is not installed
005 Shut-off valve
006 Drain valve
007 Orifice
008 Optional vent valve (usually closed)
009 Vent valve (usually open)
010 Vent valve (usually closed)

4.3 Wash-water system

The wash-water system supplies the scavenge air cooler (SAC) with wash-water. This lets you wash the SAC, refer to 9.5 Clean the scavenge air cooler during operation. To regularly wash the SAC increases the service life of the cooler and keeps the performance in the specified range.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The wash-water system has the engine connections as interface to the plant as follows (in Figure 4-3 marked with a circle):

- Connection 06 (SAC drain outlet) (for X35 and X40)
- Connection 11 (water for cleaning plant for TC and SAC inlet)
- Connection 12 (air for cleaning plant for TC and SAC inlet)
- Connection 13 (oily water from receiver outlet)
- Connection 16 (SAC condensate water outlet)
- Connection 17 (SAC wash-water outlet) (optional)
- Connection 18 (SAC venting).

Condensation and wash-water flow through the cyclone separator and back to the plant at the connection 16.

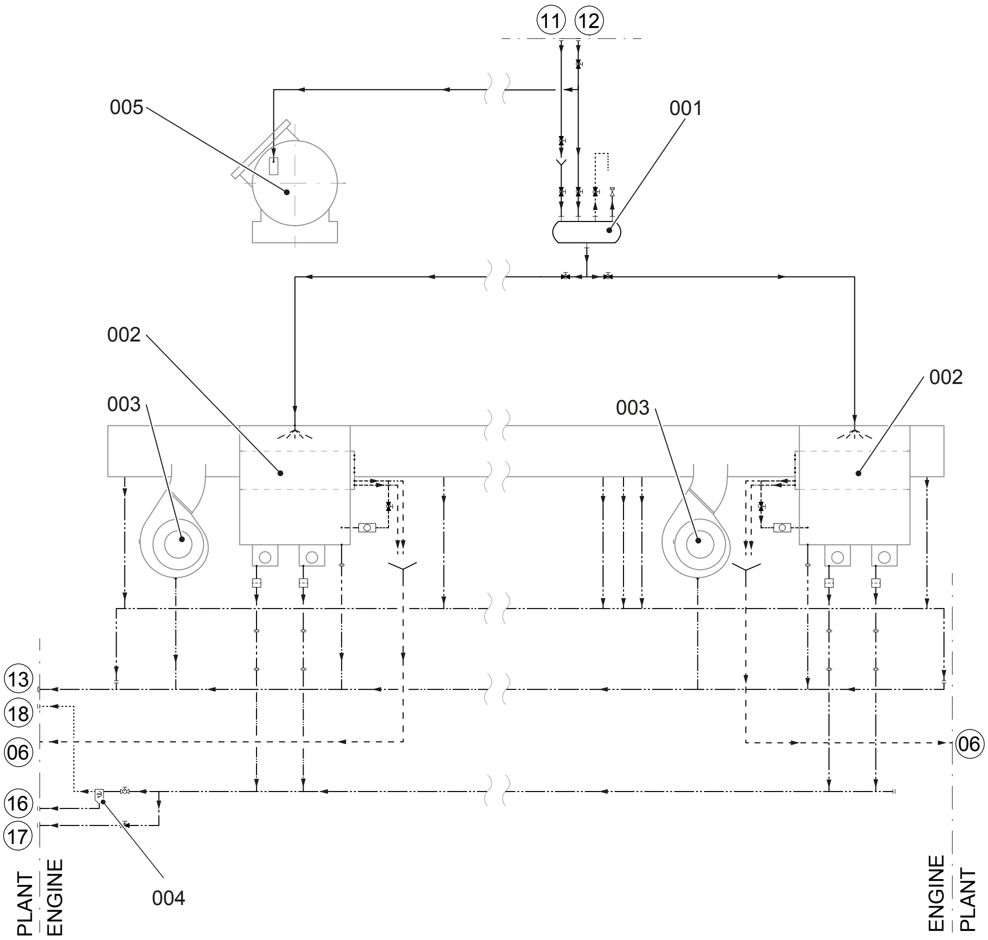
The wash-water system has the parts that follow:

- **Wash-water tank**

  The wash-water tank (001) keeps the wash-water for the wash procedure of the SAC. Compressed air is used to pressurize the wash-water tank before the wash procedure.
- **Cyclone separator**

  The cyclone separator (004) separates the air and the wash-water.

Fig 4-3 Wash-water system (generic and simplified)



Legend

001 Wash-water tank
002 Scavenge air cooler (SAC)
003 Auxiliary blower
004 Cyclone separator
005 Turbocharger

4.4 System oil system

The system oil system supplies the items that follow with system oil:

- Bearings
- Gear wheels
- Vibration dampers
- Pistons
- Crosshead assemblies
- iELBA (optional)
- Other running parts
- Servo oil system.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The system oil system has the engine connections as interface to the plant as follows (in Figure 4-4 marked with a circle):

- Connection 22 (oil drain bedplate horizontal) (if applicable)
- Connection 23 (oil drain bedplate vertical)
- Connection 25 (main oil inlet)
- Connection 26 (lubricating oil turbocharger inlet) (optional)
- Connection 27 (lubricating oil turbocharger outlet)
- Connection 30 (lubricating oil crosshead inlet) (optional)
- Connection 37 (leakage oil gland box outlet).

System oil from the bearings and gear wheels drops into the crankcase.

The system oil system has the parts that follow:

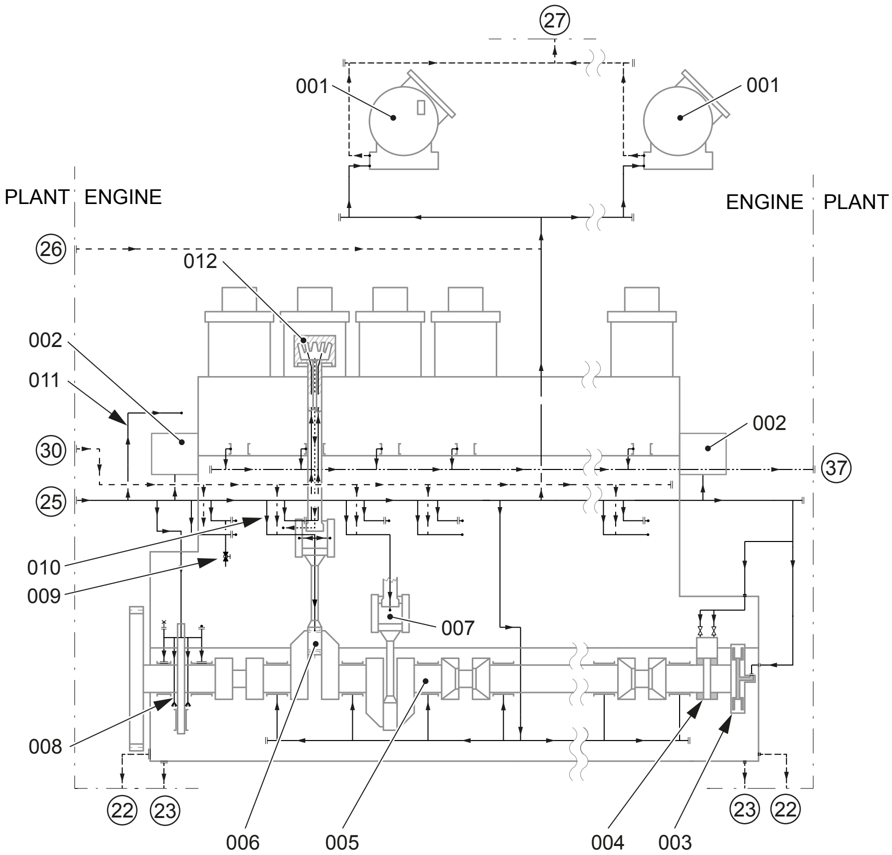
- **Oil pipes**

  The oil pipes connect the items that use oil.
- **Lever**

  The levers (010) in the crankcase supply the oil to the crosshead.
- **Oil sample valve**

  Use the oil sample valve (009) to get a sample of the supplied oil.

Fig 4-4 System oil system (generic and simplified)



Legend

001	Turbocharger	007	Crosshead
002	iELBA (optional)	008	Thrust bearing
003	Torsional vibration damper (optional)	009	Oil sample valve
004	Axial vibration damper	010	Lever
005	Main bearing	011	Supply pipe to servo oil system
006	Crank bearing	012	Piston

4.5 Servo oil system

The servo oil system supplies the items that follow with servo oil:

- Exhaust valve control units (VCU)
- Cylinder lubricating pumps
- Injection control units, if applicable.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The system oil system supplies the servo oil through the supply pipe.

The servo oil system has the engine connections as interface to the plant as follows (in Figure 4-5 marked with a circle):

- Connection 25 (main oil inlet)
- Connection 34 (leakage oil of driving end outlet)
- Connection 35 (leakage oil of free end outlet)
- Connection 38 (oil pipe drain of supply unit outlet).

Servo oil from the pumps and valves collects in the square collector pipe (003). The oil then flows to the connections 34 and 35.

The servo oil system has the parts that follow:

- **Oil pipes**

  The oil pipes connect the items that use oil. All the high pressure oil pipes have double wall. Inspection points in the pipes let find oil leaks.
- **Servo oil service pump**

  The servo oil service pump (005) can supply the servo oil system with oil before the engine start or during maintenance.
- **Servo oil pump (number related to the configuration)**

  The servo oil pumps (004) supply the servo oil system with oil during usual operation.
- **Servo oil rail**

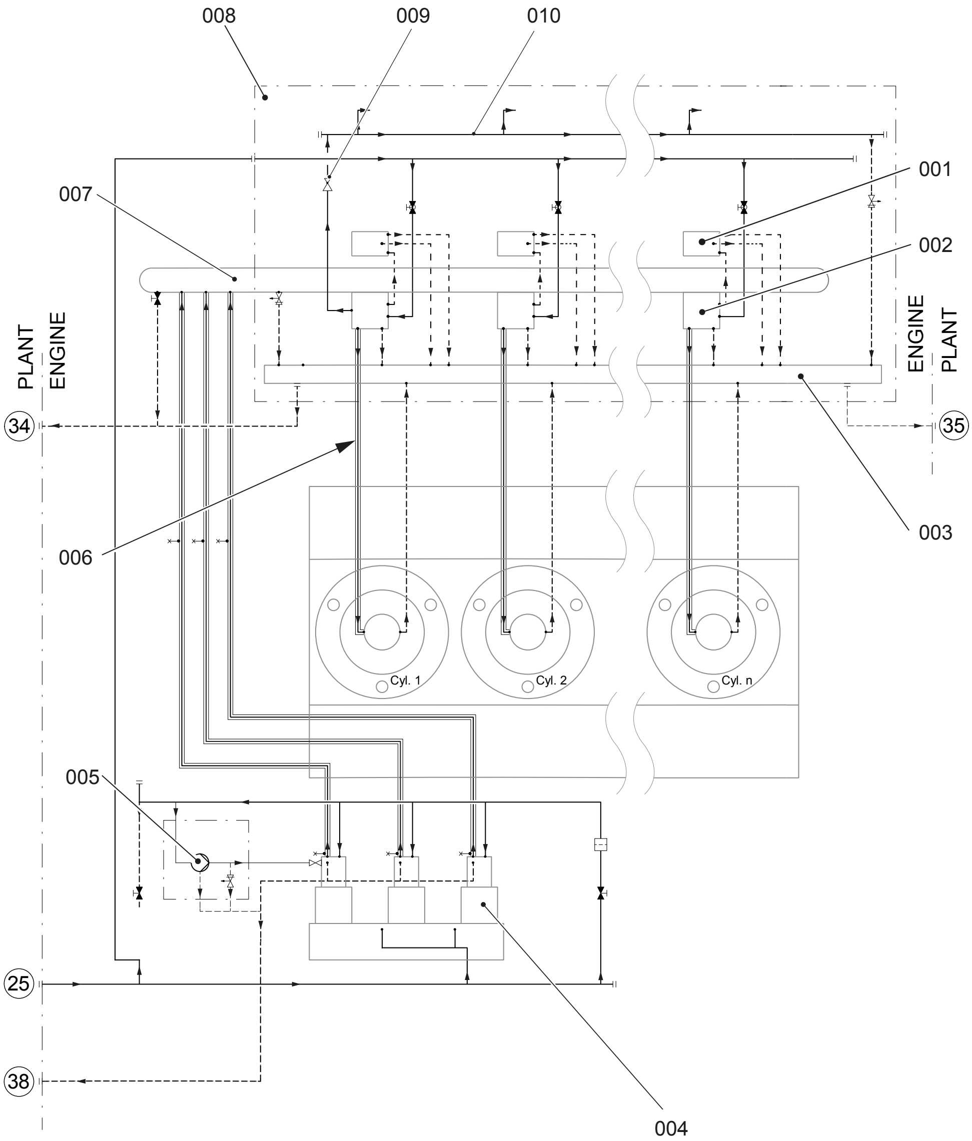
  The servo oil rail (007) supplies the exhaust valve control units with servo oil at approximately 200 to 300 bar.
- **Exhaust valve control unit**

  The exhaust valve control units (VCU) (002) control the servo oil flow to the exhaust valve. From the first exhaust valve control unit some of the oil flows to the pressure reducing valve.
- **Pressure reducing valve**

  The pressure reducing valve (009) decreases the servo oil pressure to the value that is necessary in the distributor pipe (mini-rail).
- **Distributor pipe (mini-rail)**

  The distributor pipe (mini-rail) (010) supplies the cylinder lubricating pumps with servo oil at approximately 60 to 65 bar.

Fig 4-5 Servo oil system (generic and simplified)



Legend

001	Injection control unit (ICU) for X82 and X92	006	Oil pipe to exhaust valve
002	Exhaust valve control unit (VCU)	007	Servo oil rail
003	Square collector pipe	008	Rail unit
004	Servo oil pump	009	Pressure reducing valve
005	Servo oil service pump	010	Distributor pipe (mini-rail)

4.6 Cylinder oil system

The cylinder oil system supplies cylinder oil onto the cylinder liners. The engine control system (ECS) controls the adjustable load-related supply rate of cylinder oil to each lubrication point.

The engine has an automatic pre-lubrication sequence. At each engine start the ECS automatically starts this sequence to make sure, that the cylinders are sufficiently lubricated. The sequence includes a specified number of lubrication pulses. For the specified number refer to chapter 11 Technical data.

NOTE: You also can start the pre-lubrication sequence manually.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The cylinder oil system has the engine connections as interface to the plant as follows (in Figure 4-6 marked with a circle):

- Connection 32 (cylinder oil inlet (high BN)), only applicable on an engine with iCAT
- Connection 33 (cylinder oil inlet (low BN, on an engine with iCAT))
- Connection 36 (dirty oil of piston underside outlet).

The cylinder oil is used only one time.

The cylinder oil system has the parts that follow:

- **Oil pipes**

  The oil pipes connect the items that use oil.

- **Duplex oil filter**

  The duplex oil filter (004) filters the oil before it flows to the cylinder lubricating pumps. The change-over valve makes it possible to shut off one filter chamber.

- **Cylinder lubricating pump**

  Each cylinder has a cylinder lubricating pump (003). Servo oil operates the cylinder lubricating pumps. The ECS controls the cylinder lubricating pumps.

- **Lubricating quill**

  The lubricating quills (002) spray cylinder oil onto the running surface of the cylinder liners. The lubricating quills are installed on the circumference of the cylinder liner.

- **Oil sample valve**

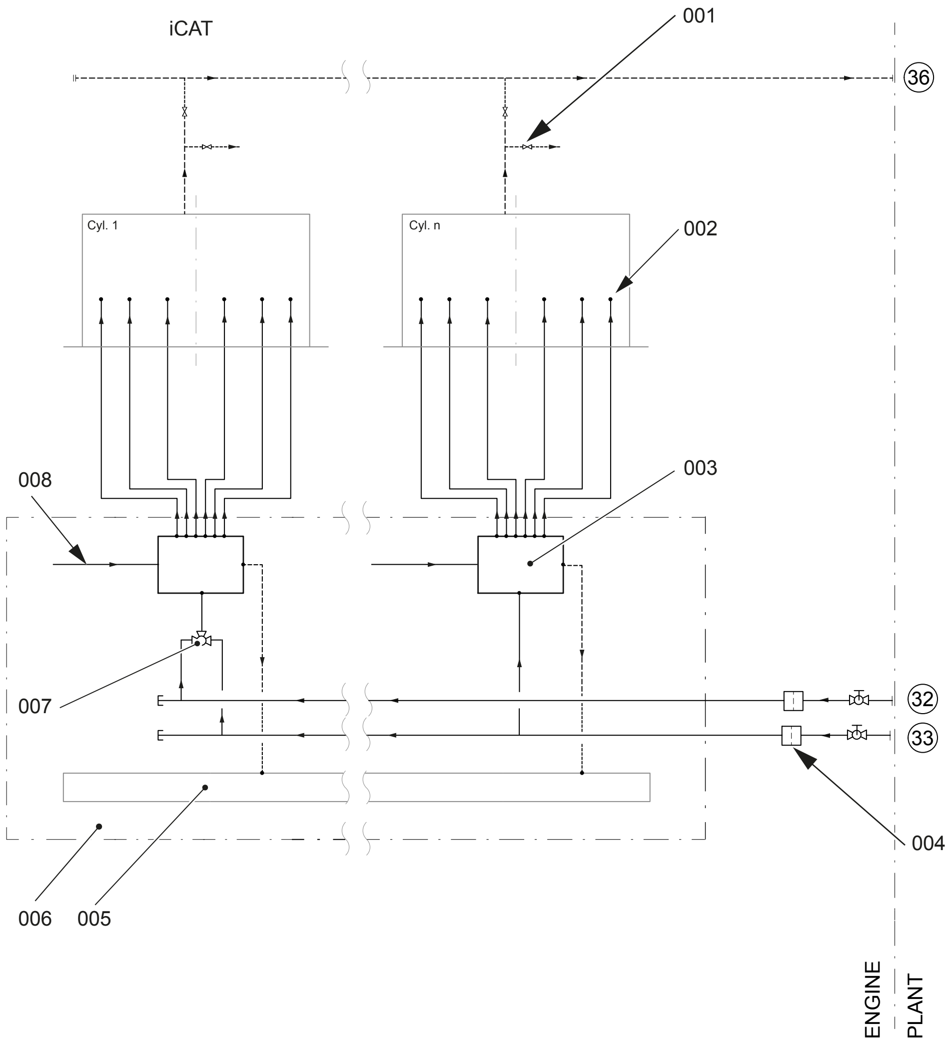
  Use the oil sample valve (001) at the piston underside to get a sample of dirty oil from the piston underside.

- **iCAT (if installed)**

  The iCAT system (integrated Cylinder lubricant Auto Transfer system) automatically selects the cylinder oil with the correct base number (BN) related to the fuel in use. If necessary, the iCAT system automatically changes over the cylinder oil. The change-over valve (007) is near the cylinder lubricating pump (003). Thus the correct cylinder oil is immediately supplied to the cylinder liner. The engine control system (ECS) controls the iCAT system.

  NOTE: You have to enter the correct basic values (eg the sulfur content of the fuels) for the iCAT system in the RCS, refer to the related documentation.

Fig 4-6 Cylinder oil system (generic and simplified, with and without iCAT)



Legend

001	Oil sample valve	005	Square collector pipe
002	Lubricating quill	006	Rail unit
003	Cylinder lubricating pump	007	Change-over valve
004	Duplex oil filter	008	Servo oil supply

4.7 Starting air system

The starting air system turns the crankshaft before the usual combustion cycle of the engine is started.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The starting air system has the engine connections as interface to the plant as follows (in Figure 4-7 marked with a circle):

- Connection point 40 (starting air pipe inlet)
- Connection point 41 (venting crankcase outlet)
- Connection point 45 (control air supply inlet).

The starting air system has the parts that follow:

- **Starting air shut-off valve**

  The starting air shut-off valve (009) supplies the starting air supply pipe with starting air. The starting air shut-off valve has three positions:
  - CLOSED
  - AUTO
  - OPEN.
- **Starting air supply pipe**

  The starting air supply pipe (007) supplies the starting valves of each cylinder with starting air. The starting air supply pipe has a safety valve (003) and two drain valves (004).
- **Starting valve**

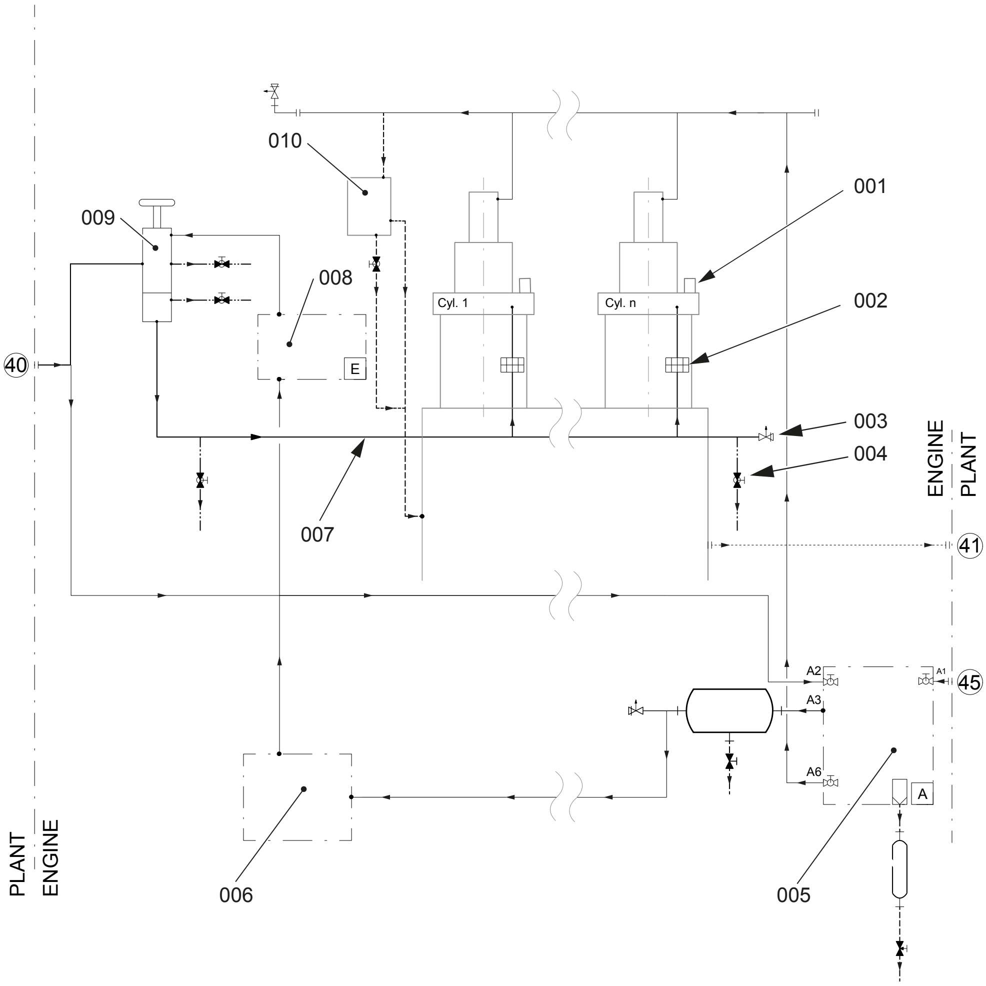
  Each cylinder has a starting valve with a solenoid valve (001). Each starting valve supplies the related cylinder with the specified quantity of starting air at the correct time.
- **Valve unit for start E**

  The valve unit for start E (008) supplies the starting air shut-off valve with control air.
- **Disengaging device turning gear**

  When the turning gear is engaged, the disengaging device turning gear (006) closes the shut-off valve in the supply pipe. This prevents the supply of control air to the valve unit for start E, and thus prevents engine start.
- **Flame arrestor**

  The flame arrestor (002) prevents combustion gas to flow back into the air pipe.

Fig 4-7 Starting air system (generic and simplified)



Legend

001	Solenoid valve	006	Disengaging device turning gear
002	Flame arrestor	007	Starting air supply pipe
003	Safety valve	008	Valve unit for start E
004	Drain valve	009	Starting air shut-off valve
005	Control air supply	010	Collector for leakage oil from the air spring

4.8 Scavenge air system

The scavenge air system replaces the exhaust gas in the cylinder with fresh air.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The scavenge air comes in from the outside through a duct or from the engine room. The scavenge air enters at the silencer of the turbocharger.

The scavenge air system has the parts that follow:

- **Scavenge air receiver**

  The scavenge air receiver (013, Figure 4-8) supplies the cylinders with the applicable quantity of air.

- **Turbocharger**

  The compressor (005) of the turbocharger compresses the air to the applicable pressure. The compressor is attached to the shaft of the turbine (004). The remaining energy of the exhaust gas operates the turbine and thus the compressor.

- **Auxiliary blower**

  The two auxiliary blowers (010) supply the scavenge air at the engine start and during low load operation.

- **Auxiliary blower switch box**

  The auxiliary blower switch box controls the auxiliary blowers.

- **Scavenge air cooler**

  The scavenge air cooler (SAC) (006) decreases the temperature of the hot compressed air from the turbocharger. This increases the mass of air and thus increases the quantity of air that is supplied to the cylinders.

- **Water separator**

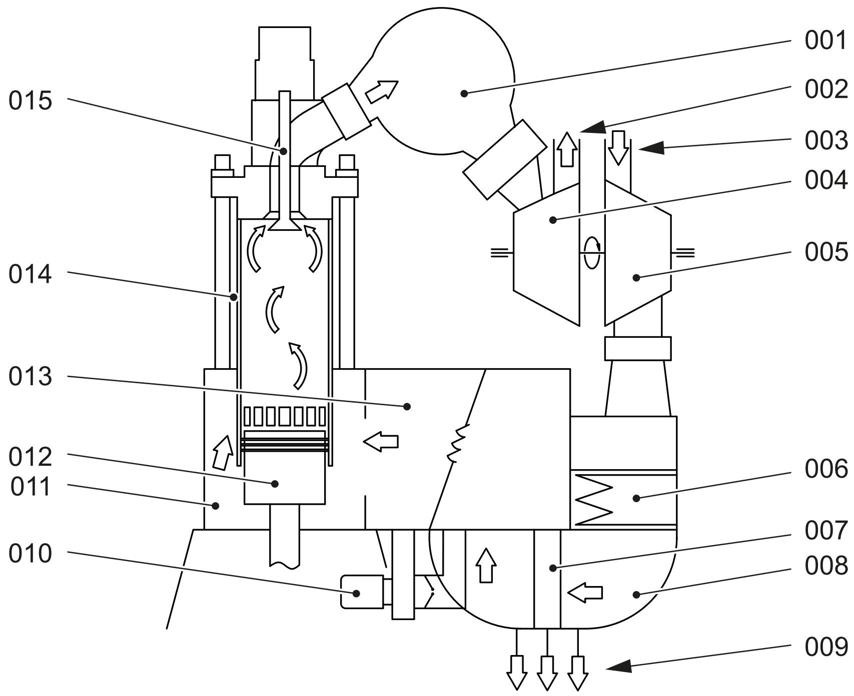
  The water separator (007) removes water from the scavenge air. This prevents damage and gives better combustion in the cylinders. Water occurs when the scavenge air cooler decreases the temperature of wet air. Water also occurs during the wash procedure of the SAC.

- **Drains**

  The scavenge air system has the drains (009) that follow:

  - Condensation drain from the scavenge air cooler
  - Water drain from the water separator
  - Oily water drain.

Fig 4-8 Scavenge air system



Legend

001	Exhaust gas manifold	009	Drains
002	Exhaust gas outlet	010	Auxiliary blower
003	Scavenge air inlet	011	Piston underside
004	Turbine	012	Piston
005	Compressor	013	Scavenge air receiver
006	Scavenge air cooler	014	Cylinder liner
007	Water separator	015	Exhaust valve
008	Charging unit		

4.9 Control air system

The control air system supplies the air spring of the exhaust valves and the starting air system with control air.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The plant supply systems supply compressed air with the specified properties at the two engine connections (in Figure 4-9 marked with a circle) that follow:

- Connection 45 (control air supply inlet) for usual supply
- Connection 40 (starting air pipe inlet) for stand-by supply.

The control air system has the parts that follow:

- **Control air supply**

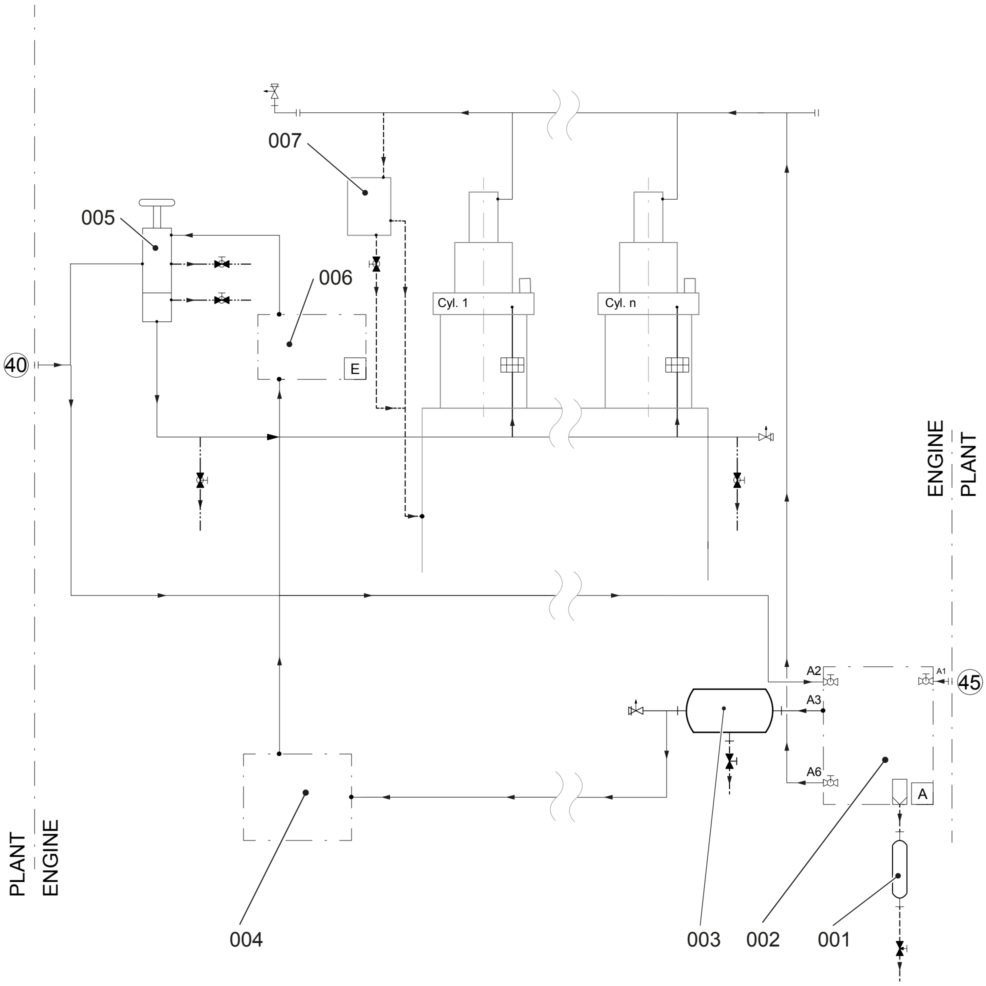
  The control air supply (002) decreases the supply air pressure to the specified pressures.
- **Air tank**

  The air tank (003) is a container for control air. If the two plant air supply systems become defective, the air tank supplies control air to the engine for a short period.
- **Air bottle**

  The air bottle (001) collects condensation from the starting air.
- **Collector for leakage oil from the air spring**

  The collector for leakage oil from the air spring (007) controls the oil leakage from the air spring of the exhaust valves with a float control. When the collector pipe is full, the shut-off valve opens and the oil flows into the crankcase.

Fig 4-9 Control air system (generic and simplified)



Legend

001	Air bottle	005	Starting air shut-off valve
002	Control air supply	006	Valve unit for start
003	Air tank	007	Collector for leakage oil from the air spring
004	Disengaging device		

4.10 Exhaust gas system

The exhaust gas system collects the exhaust gas of the cylinders in a manifold. The remaining energy of the exhaust gas is used to operate the turbine of the turbocharger (002, Figure 4-10) (refer to section 4.8 Scavenge air system).

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The exhaust gas system has as interface to the plant the engine connection 71 (exhaust gas turbocharger outlet, in Figure 4-10 marked with a circle).

The exhaust gas system has the parts that follow:

- **Exhaust valve**

  The exhaust valve (004) of each cylinder releases the exhaust gas of the combustion into the exhaust gas manifold.

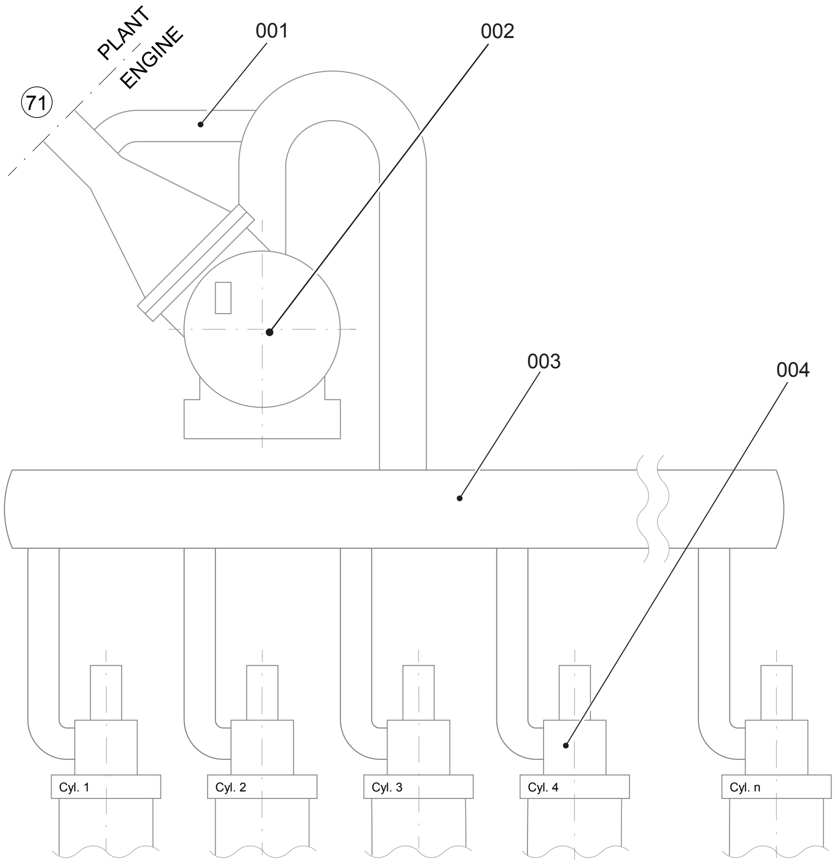
- **Exhaust gas manifold**

  The exhaust gas manifold (003) collects the exhaust gas from the cylinders.

- **Turbocharger bypass pipe**

  Usually the engine has a turbocharger bypass pipe (001) for different operating conditions.

Fig 4-10 Exhaust gas system (generic and simplified)



Legend

001	Turbocharger bypass pipe	003	Exhaust gas manifold
002	Turbocharger	004	Exhaust valve

4.11 Fuel system

The fuel system supplies the injection valves of the cylinders with the applicable quantity of fuel.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

The fuel system has the engine connections as interface to the plant as follows (in Figure 4-11 and Figure 4-12 marked with a circle):

- Connection 49 (fuel inlet)
- Connection 50 (fuel return outlet)
- Connection 51 (fuel leakage rail unit outlet)
- Connection 52 (fuel leakage outlet)
- Connection 57 (leakage outlet)
- Connection 59 (trace heating fuel inlet)
- Connection 60 (trace heating fuel outlet)
- Connection 67 (fire extinguishing plant cylinder block inlet).

The constant flow of fuel through the fuel system keeps the fuel warm.

At low load the ECS automatically cuts out injection valves in each cylinder as follows:

- For an engine with two injection valves - one of the two injection valves
- For an engine with three injection valves - one or two of the three injection valves.

This makes sure that the engine has the best fuel and combustion properties, which decreases smoke and fuel consumption. The ECS cuts out a different injection valve at regular intervals to get an equal thermal load in the combustion chamber. There is no time limit to operate the engine at low load.

The fuel system has the parts that follow:

- **Fuel pipes**

  The fuel pipes connect the items of the fuel system. All the fuel pipes have a trace heating to keep the fuel warm during operation and for short engine stops. The high pressure fuel pipes that are not in the rail unit have a double wall design and leakage inspection points.
- **Pressure retaining valve**

  The adjustable pressure retaining valve (009) in the return pipe keeps the fuel pressure in the supply pipe to the fuel pumps at the correct value.
- **Supply unit**

  The supply unit (007) holds the fuel pumps and the related items.
- **Fuel pump (number related to the configuration)**

  The fuel pumps (008) supply the fuel rail with fuel at up to 1000 bar.
- **Fuel rail**

  The fuel rail (004) supplies the flow limiting valves or the injection control units with fuel.
- **Non-return valve**

  The non-return valves prevent fuel flow back from the fuel rail to the fuel pumps (eg if a fuel pump has no delivery, or a fuel pipe is defective).

- **Pressure control valve**

  The pressure control valve (001) has different functions to control the flow and the pressure in the fuel rail.

- **Relief valve**

  The relief valve (002) is a safety device. If the fuel pressure increases to more than the set value, the relief valve opens.

- **Flow limiting valve**

  The flow limiting valves (003) (FLV, not for X82, X92, RT-flex, and related DF engines) installed on the fuel rail supply fuel to the related injection valves with the adjusted quantity of fuel.

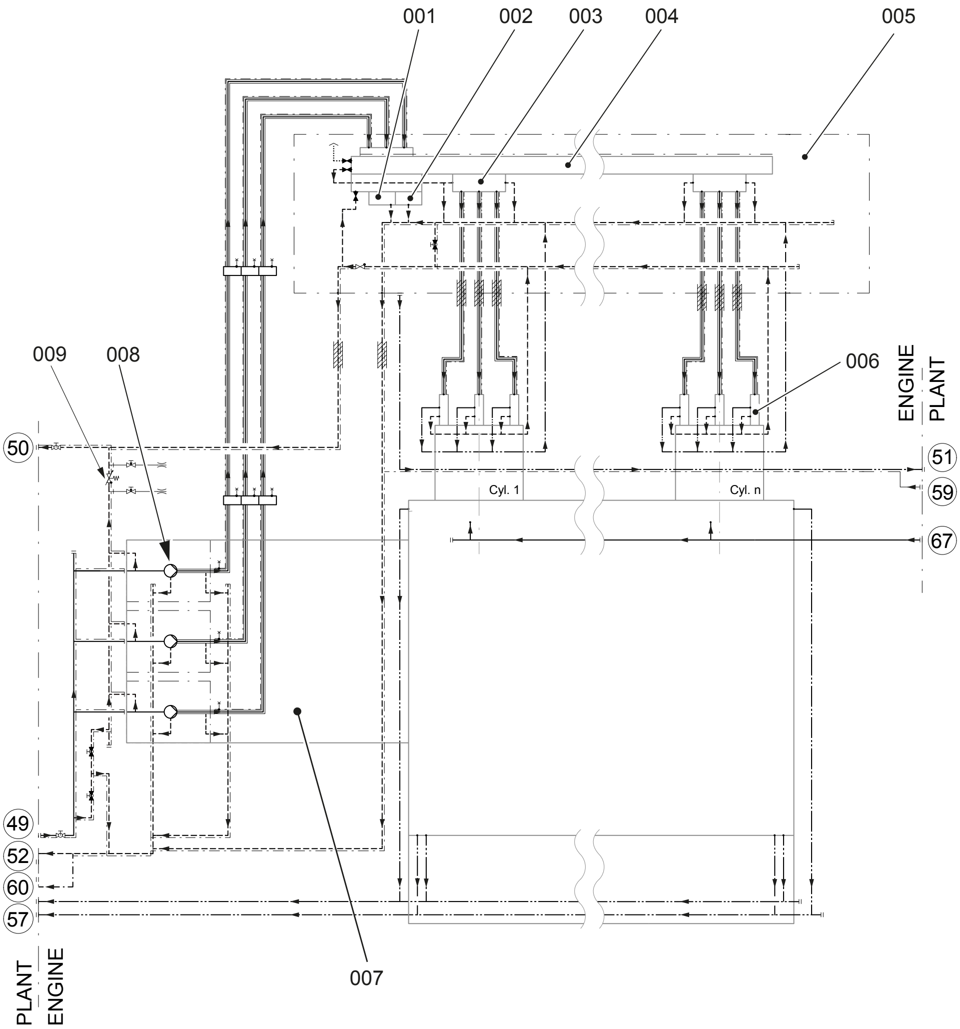
- **Injection control unit**

  The injection control units (003) (ICU, for X82, X92, RT-flex, and related DF engines) installed on the fuel rail supply fuel to the related injection valves with the adjusted quantity of fuel.

- **Injection valve**

  The injection valves (006) supply the fuel into the combustion chamber as a spray.

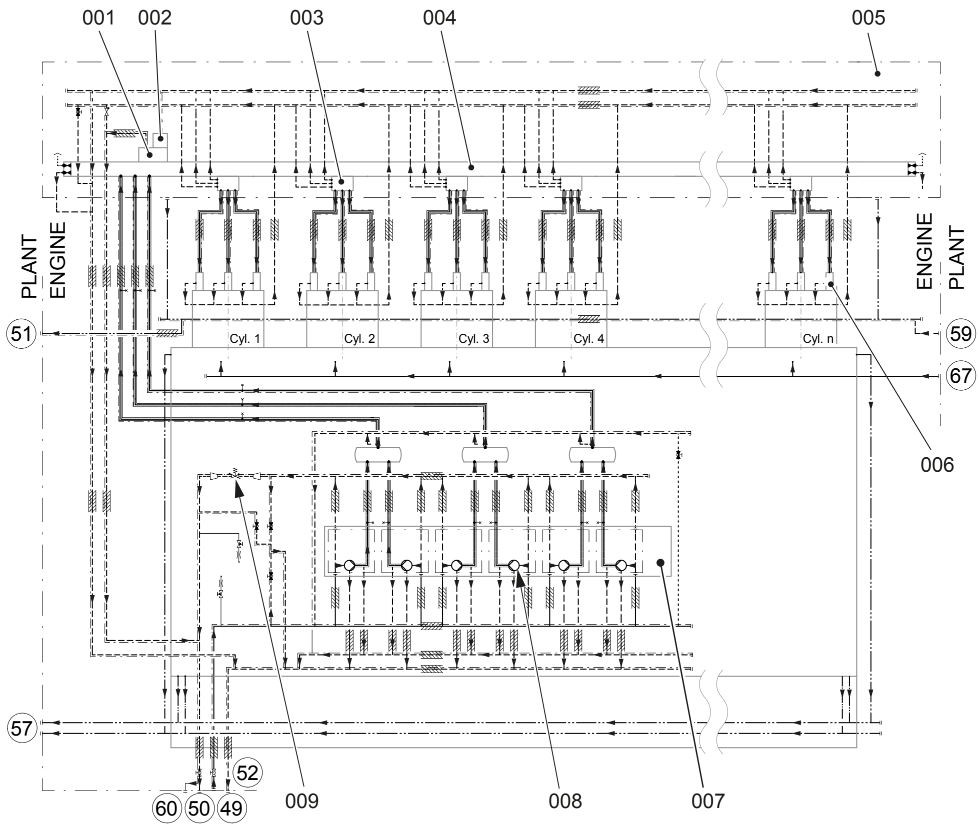
Fig 4-11 Fuel system with FLV (generic and simplified)



Legend

- 001 Pressure control valve
- 002 Relief valve
- 003 Flow limiting valve (FLV)
- 004 Fuel rail
- 005 Rail unit
- 006 Injection valve
- 007 Supply unit
- 008 Fuel pump
- 009 Pressure retaining valve

Fig 4-12 Fuel system with ICU (generic and simplified)



Legend

- 001 Pressure control valve
- 002 Relief valve
- 003 Injection control unit (ICU)
- 004 Fuel rail
- 005 Rail unit
- 006 Injection valve
- 007 Supply unit
- 008 Fuel pump
- 009 Pressure retaining valve

4.12 HP Selective catalytic reduction system

The high pressure selective catalytic reduction (HP SCR) system is an optional system to decrease the level of nitrogen oxides in the exhaust gas. This makes sure that the emissions of nitrogen oxides obey the Tier III regulations of the International Maritime Organization (IMO).

Nitrogen oxides are dangerous and are made in secondary reactions in the engine during fuel combustion.

The HP SCR system is installed between the exhaust gas manifold and the turbocharger. The system design and the supply of components is divided between the HP SCR system supplier, the shipyard and WinGD/engine builder.

The HP SCR system adds an urea water solution as reducing agent to the exhaust gas flow. Chemical reactions change nitrogen oxides to molecular nitrogen and water, which are not dangerous.

NOTE: For a DF engine - the HP SCR system can only be used in diesel mode.

4.12.1 Description of the HP SCR system

NOTE: The HP SCR system can be used for an engine with one or two turbochargers.

The HP SCR system has the parts that follow (refer to Figure 4-13):

- **Urea solution supply unit**

  The urea solution supply unit has the two parts that follow:

  - The urea solution pump unit supplies the urea solution from the tank to the urea solution dosing unit and keeps the applicable pressure in the related pipes.
  - The urea solution dosing unit controls the supply of urea solution to the mixing duct.

- **Mixing duct**

  The mixing duct has an injection lance, which is a double wall pipe. In the inner part, the urea solution is supplied. In the outer part, compressed air is supplied. In the injection nozzle at the end of the lance the two components are mixed and injected through holes into the exhaust gas flow.

  After the injection of the urea solution the heat of the exhaust gas changes the water into steam. The high temperature also changes the urea ($(NH_2)_2CO$) into ammonia (NH_3) and carbon dioxide (CO_2). Installations in the mixing duct make the gases to equally mix. Then the gases flow to the reactor.

- **Reactor**

  The reactor has a steel wall and has an inlet and an outlet cone. A steel structure holds the catalyst layers. At the catalytic surface of the catalyst layers the nitrogen oxides (NO and NO_2) react with the ammonia into molecular nitrogen (N_2) and water (H_2O). These gases are part of the ambient air and are not dangerous.

  Manholes in the reactor walls are used to examine and, if necessary, to clean or replace the catalyst elements.

- **Venting/sealing unit**

  The venting/sealing unit supplies compressed air into the exhaust gas pipes for the functions that follow:
  - Blow out the exhaust gas from the reactor and the pipes after stop of the HP SCR system
  - Seal the reactor during HP SCR bypass operation.
- **Soot blowing unit**

  The soot blowing unit removes soot deposits at regular intervals from the catalyst elements in the reactor.
- **Valves**

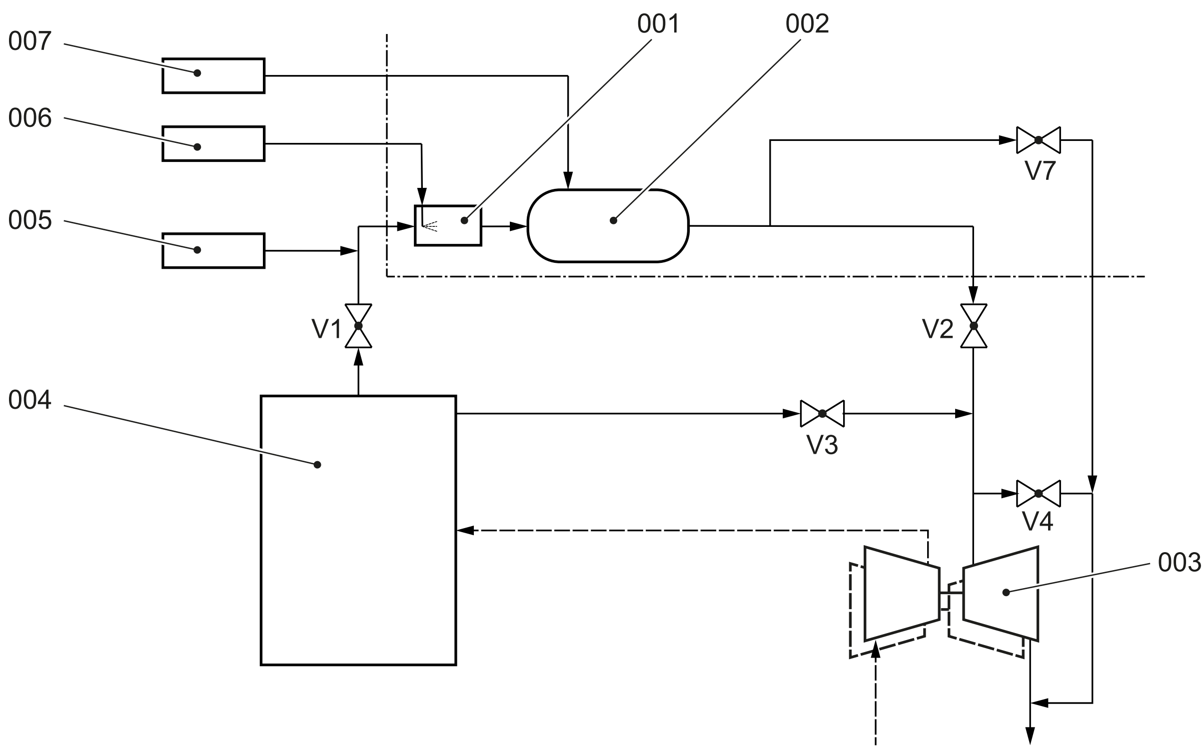
  The valves in the HP SCR system are used for the different operation modes. The HP SCR system has the valves that follow. In parenthesis you find the position of the valves, if there is a complete stop of the current supply (fail position):
  - V1 - Reactor inlet valve (FO - fail open)
  - V2 - Reactor outlet valve (FO - fail open)
  - V3 - Reactor bypass valve (FO - fail open)
  - V4 - Turbine bypass valve (FC - fail closed)
  - V7 - Reactor relief valve (FO - fail open).

  NOTE: In the fail condition, the engine operates in Tier II mode.

  The turbine bypass valve (V4) is also used for other functions of the ECS, E.g. for low-load tuning (LLT) or for steam production control (SPC).

  For more data about the function of the valves, refer to the chapters that follow.

Fig 4-13 HP SCR system - layout



Legend

001 Mixing duct
002 Reactor
003 Turbine of turbocharger
004 Engine
005 Venting/sealing unit
006 Urea solution supply unit
007 Soot blowing unit

The HP SCR system can be operated, if the exhaust gas temperature after the exhaust gas manifold is in the permitted limits shown in Table 4-1 - Operation limits of exhaust gas temperature after exhaust gas manifold. A temperature that is less than the given limit can cause the catalyst elements to clog. A temperature that is more than the given limit can cause the catalyst elements to age faster.

Tab 4-1 Operation limits of exhaust gas temperature after exhaust gas manifold

Operation mode	T_{min}	T_{max}
Preparation (urea injection OFF)	200°C	470°C
Use of low sulphur fuel (≤ 0.5% S) (urea injection ON)	310°C	470°C
Use of high sulphur fuel (> 0.5% S) (urea injection ON) [1]	325 to 340°C [2]	470°C

1 Refer to the HP SCR system documentation if the operation of the HP SCR system with high sulphur fuel is permitted.

2 The engine control system (ECS) calculates this value related to the engine load and to the exhaust gas pressure.

NOTE: WinGD recommends to do a test of the valves regularly during engine stop, refer to Figure 4-27.

4.12.2 Operation modes

The HP SCR system has the operation modes that follow.

4.12.2.1 HP SCR system - emergency bypass

In this operation mode, the HP SCR system is bypassed. The HP SCR control system opens the valve V3 quickly. The engine operates in Tier II mode.

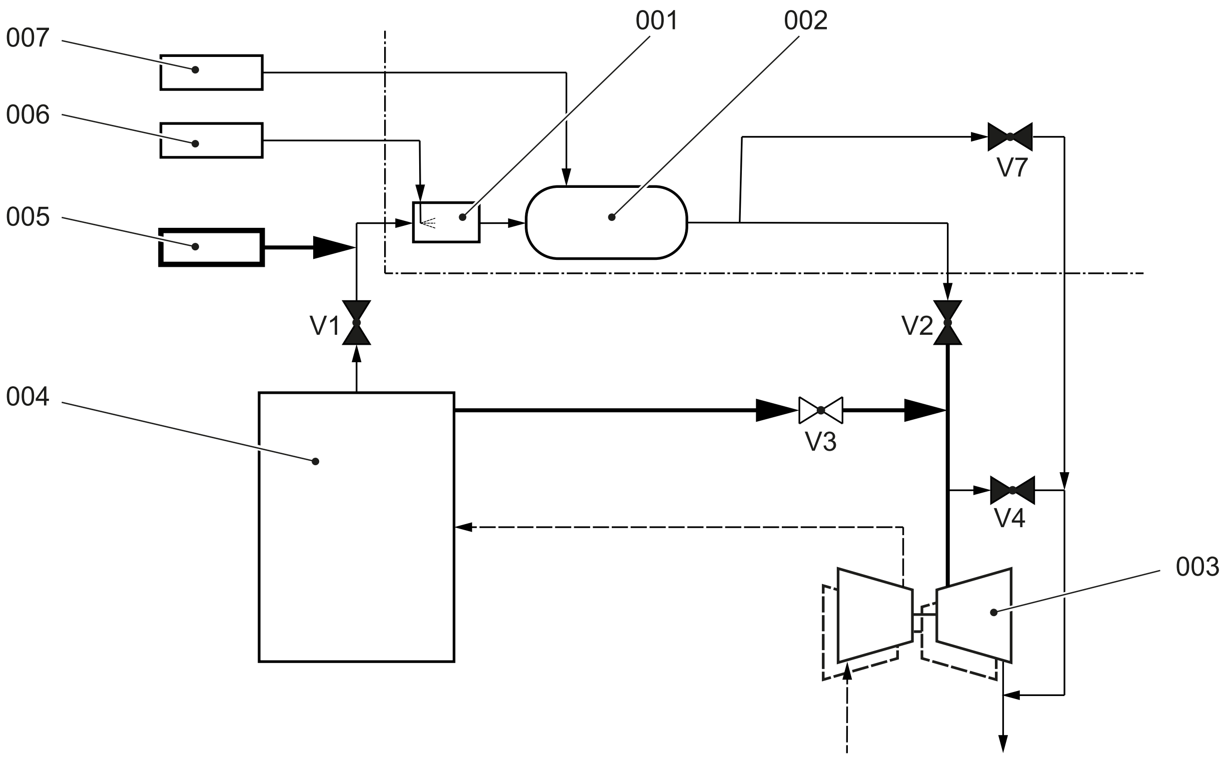
If necessary, you can start this operation mode manually. You use the related switch on one of the control boxes, refer to Para 4.12.3.

The HP SCR control system changes to emergency bypass mode automatically, if a condition for correct operation of the HP SCR system is not given, for example if a bus connection is defective.

The valves have the conditions that follow:

- V1 - Closed
- V2 - Closed
- V3 - Open
- V4 - Controlled by the ECS
- V7 - Closed, can be opened to decrease the pressure in the reactor

Fig 4-14 HP SCR system - emergency bypass



Legend

001 Mixing duct
002 Reactor
003 Turbine of turbocharger
004 Engine
005 Venting/sealing unit
006 Urea solution supply unit
007 Soot blowing unit

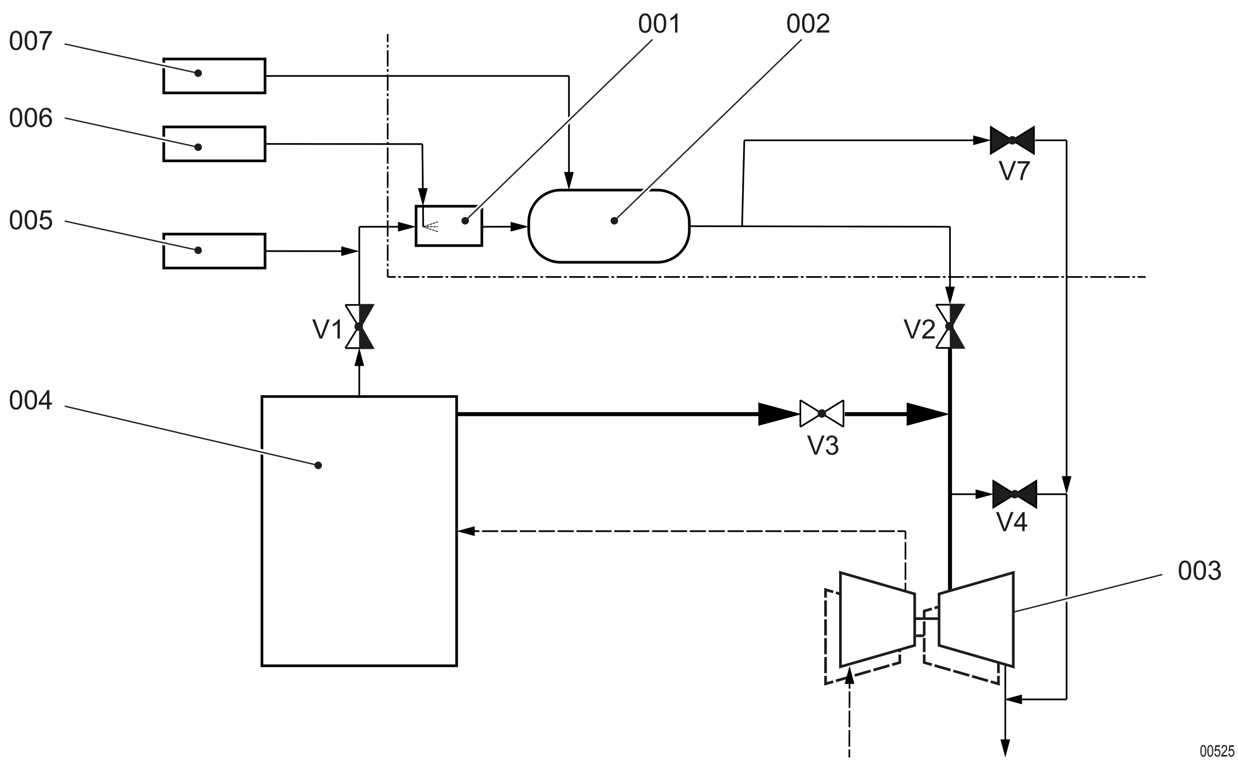
4.12.2.2 HP SCR system - bypass

In this operation mode, the HP SCR system is bypassed. The engine operates in Tier II mode. Urea solution is not injected.

If you change from Tier III mode to bypass mode, the HP SCR control system changes the valve conditions and starts the preservation sequence. If a condition for correct operation for Tier III mode is not given, the HP SCR control system automatically changes to bypass mode.

- First the valves have the conditions that follow (refer to Figure 4-15):
  - V1 - Slowly changes from open to closed
  - V2 - Slowly changes from open to closed
  - V3 - Open
  - V4 - Controlled by the ECS, can be more opened to decrease the scavenge air flow and thus to increase the exhaust gas temperature
  - V7 - Closed, can be opened to decrease the pressure in the reactor
- Then the preservation sequence starts as follows to prevent corrosion of the reactor and of the pipes (refer to Figure 4-16):
  - The purging sequence uses compressed air to remove the remaining urea solution from the injection equipment, from the pipes and from the reactor.
  - The venting/sealing unit starts and the valve V7 opens for some minutes. Thus the compressed air removes the exhaust gas to the exhaust gas system of the plant.
- If the venting/sealing unit is unserviceable, decrease the pressure in the reactor and drain the condensation.

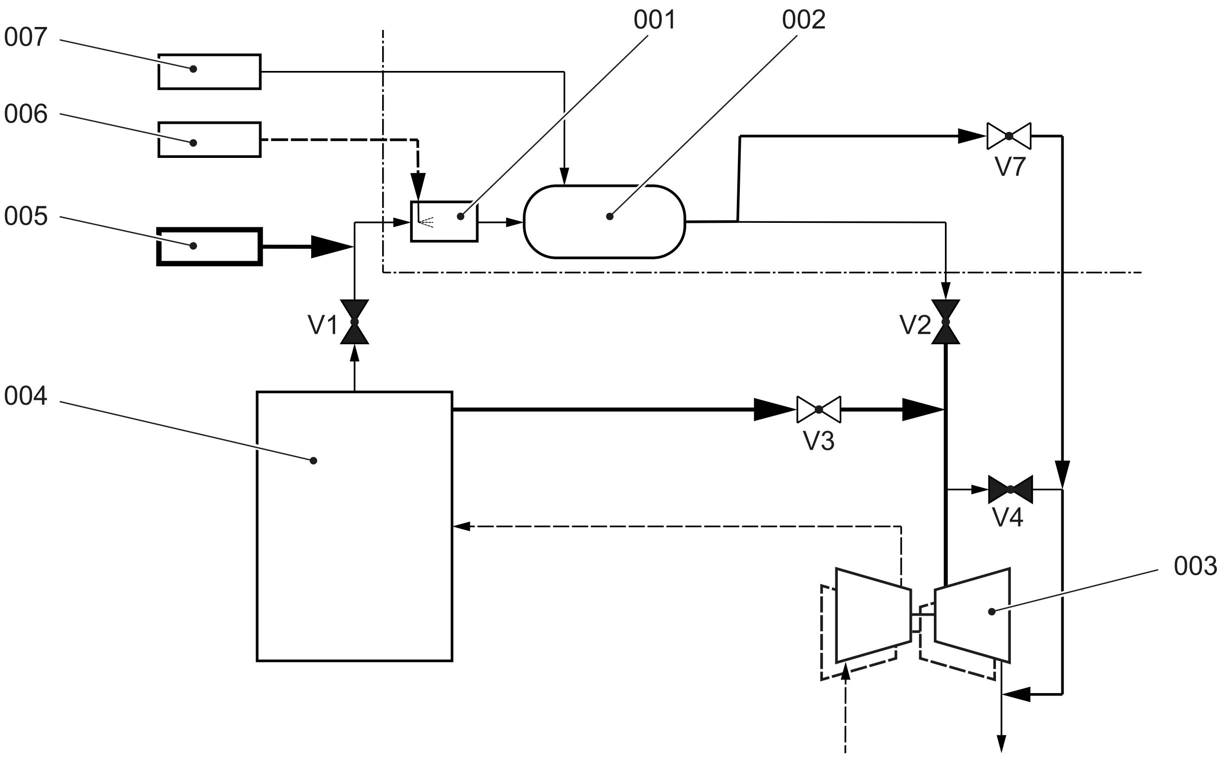
Fig 4-15 HP SCR system - change from Tier III to bypass



Legend

001 Mixing duct
002 Reactor
003 Turbine of turbocharger
004 Engine
005 Venting/sealing unit
006 Urea solution supply unit
007 Soot blowing unit

Fig 4-16 HP SCR system - purging and venting



Legend

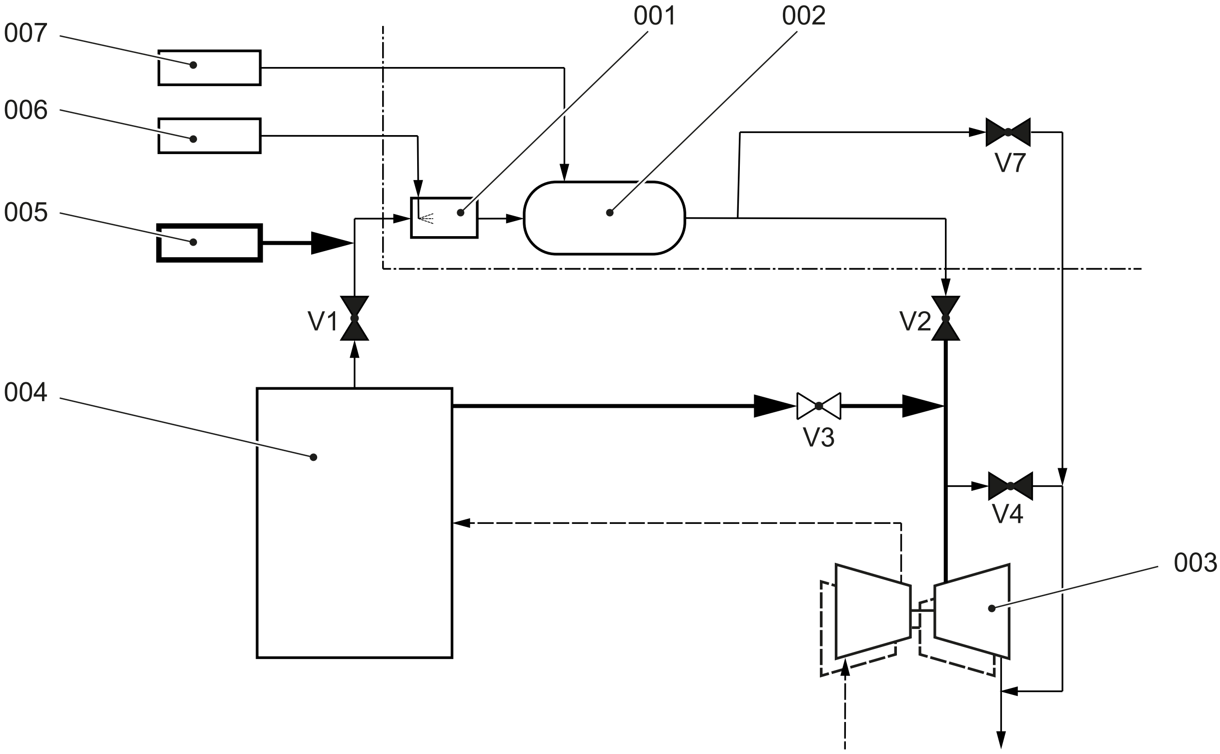
001 Mixing duct
002 Reactor
003 Turbine of turbocharger
004 Engine
005 Venting/sealing unit
006 Urea solution supply unit
007 Soot blowing unit

After that procedure, or directly, the venting/sealing unit supplies compressed air to keep a pressure in the reactor and in the pipes. This makes a seal against the exhaust gas to prevent damage of the reactor. Make sure that the pressure in the reactor is more than the exhaust gas pressure.

The valves have the conditions that follow:

- V1 - Closed
- V2 - Closed
- V3 - Open
- V4 - Controlled by the ECS
- V7 - Closed, can be opened to decrease the pressure in the reactor

Fig 4-17 HP SCR system - emergency bypass



Legend

001 Mixing duct
002 Reactor
003 Turbine of turbocharger
004 Engine
005 Venting/sealing unit
006 Urea solution supply unit
007 Soot blowing unit

4.12.2.3 HP SCR system - preparation

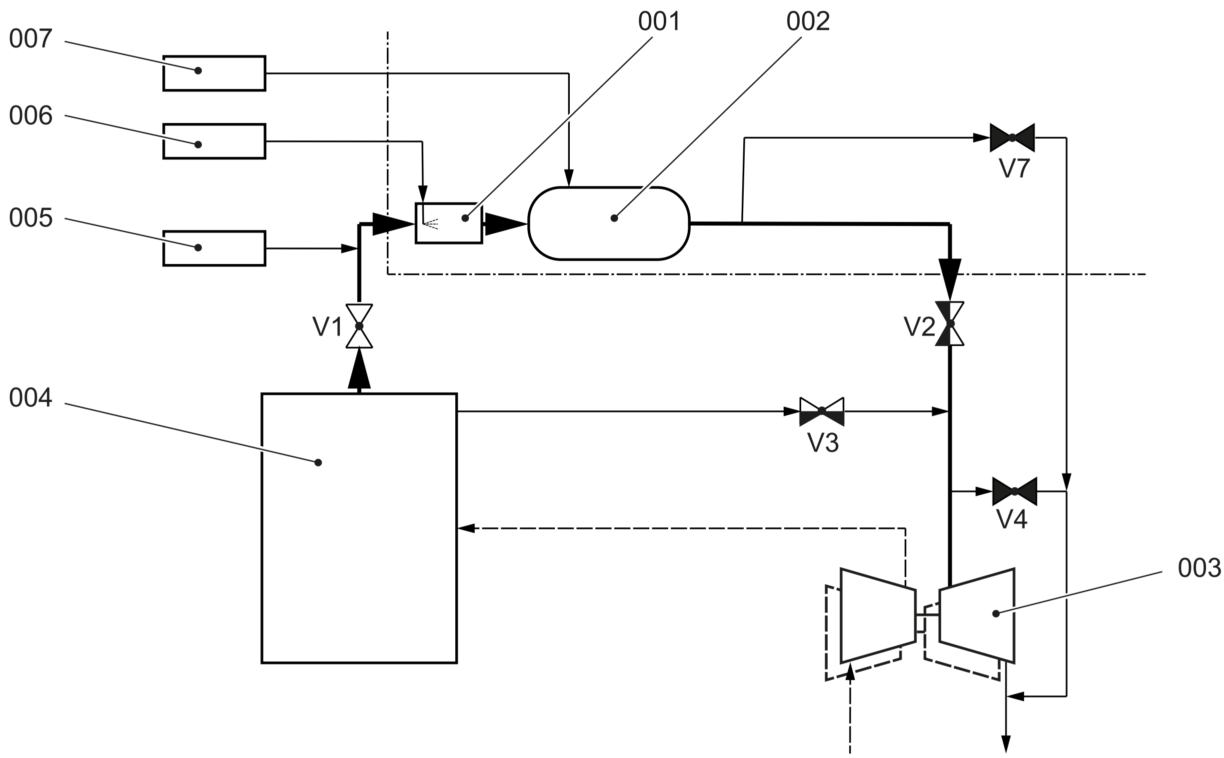
In this operation mode, exhaust gas causes the temperature of the HP SCR reactor to slowly increase. The engine operates in Tier II mode. Urea solution is not injected.

The valves have the conditions that follow:

- V1 - Open
- V2 - Slowly changes from closed to open
- V3 - Slowly changes from open to closed
- V4 - Controlled by the ECS
- V7 - Closed

If necessary, you can operate the engine in this mode for longer periods, for example to be ready for a fast change to Tier III mode.

Fig 4-18 HP SCR system - preparation



Legend

001 Mixing duct
002 Reactor
003 Turbine of turbocharger
004 Engine
005 Venting/sealing unit
006 Urea solution supply unit
007 Soot blowing unit

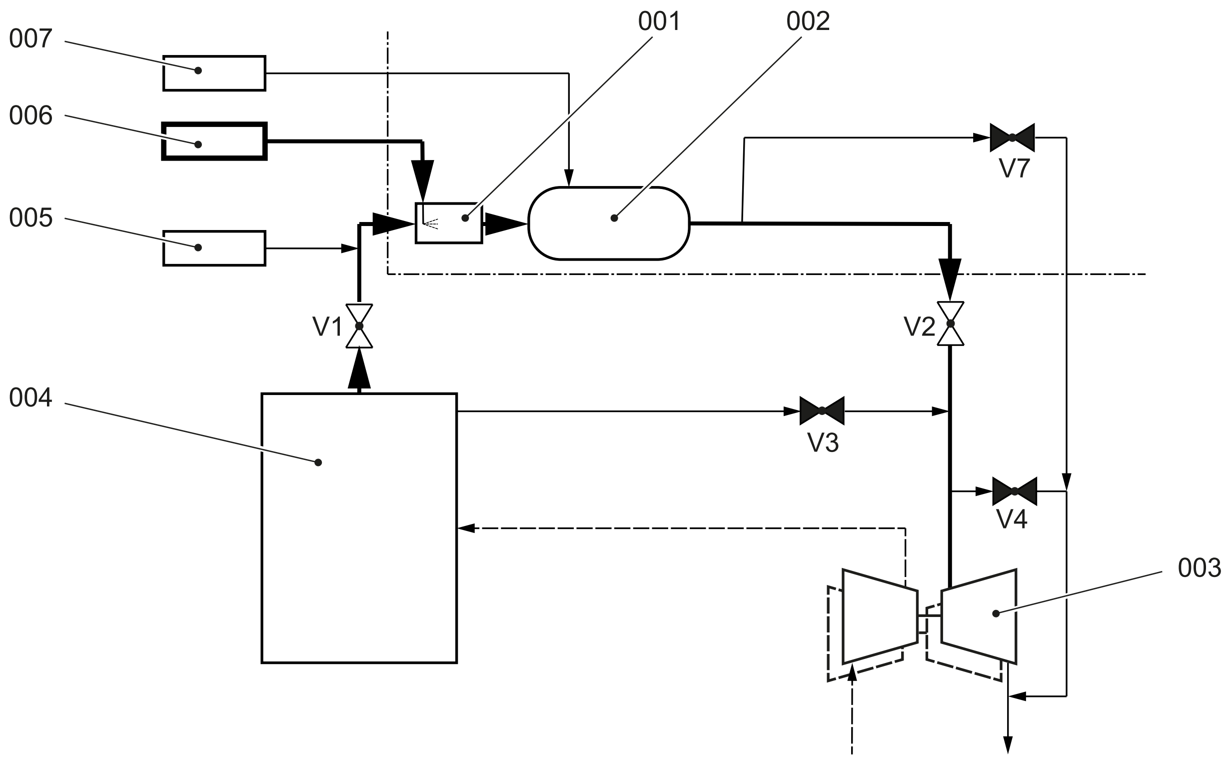
4.12.2.4 HP SCR system - Tier III

In this operation mode, the HP SCR system is set to ON. The engine operates in Tier III mode. Urea solution is injected.

The valves have the conditions that follow:

- V1 - Open
- V2 - Open
- V3 - Closed
- V4 - Controlled by the ECS, can be more opened to decrease the scavenge air flow and thus to increase the exhaust gas temperature
- V7 - Closed, can be opened to decrease the pressure in the reactor

Fig 4-19 HP SCR system - Tier III



Legend

001 Mixing duct
002 Reactor
003 Turbine of turbocharger
004 Engine
005 Venting/sealing unit
006 Urea solution supply unit
007 Soot blowing unit

4.12.2.5 HP SCR system - at engine stop

If you stop the engine in Tier III mode, the HP SCR system changes to bypass mode after some time. Related to the condition the venting/sealing unit starts for some minutes, refer to Para 4.12.2.2.

4.12.2.6 HP SCR system - cut out

If necessary you can cut out the HP SCR system. When the engine is stopped, you can install covers to the valves V1 and V2 to make a safe stop of the exhaust gas through the HP SCR system, refer to section 10.16 Temporary isolate the HP SCR system.

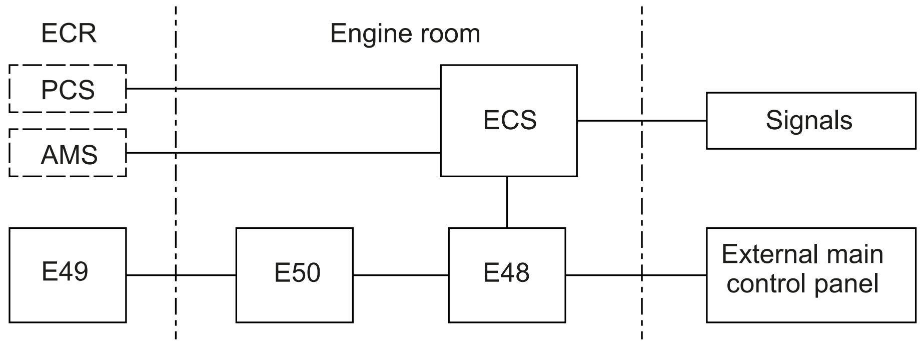
4.12.3 HP SCR control system

The HP SCR control system has the three control boxes that follow:

- Control box E48
- Control box E49
- Control box E50

Each control box is connected through bus connections or hard-wired connections. The control box E48 is connected to the engine control system (ECS) and to the external HP SCR system control through bus connections or hard-wired connections, refer to Figure 4-20.

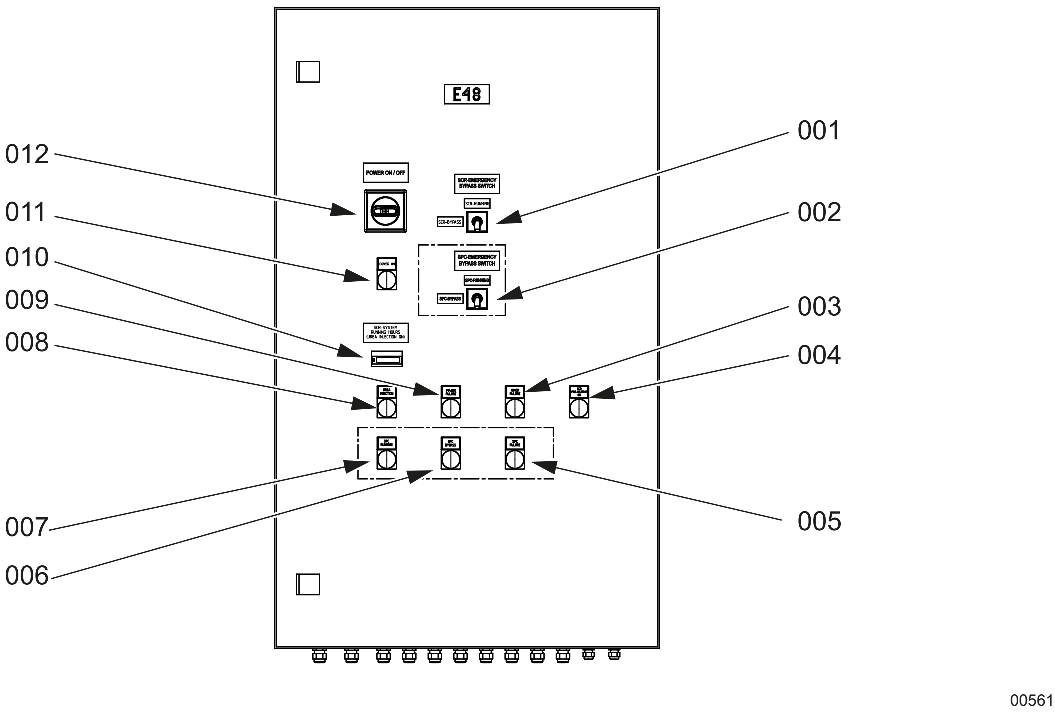
Fig 4-20 HP SCR system - principal control configuration



4.12.3.1 Control box E48

The control box E48 is installed in the engine room and has switches and visual indicators.

Fig 4-21 Control box E48



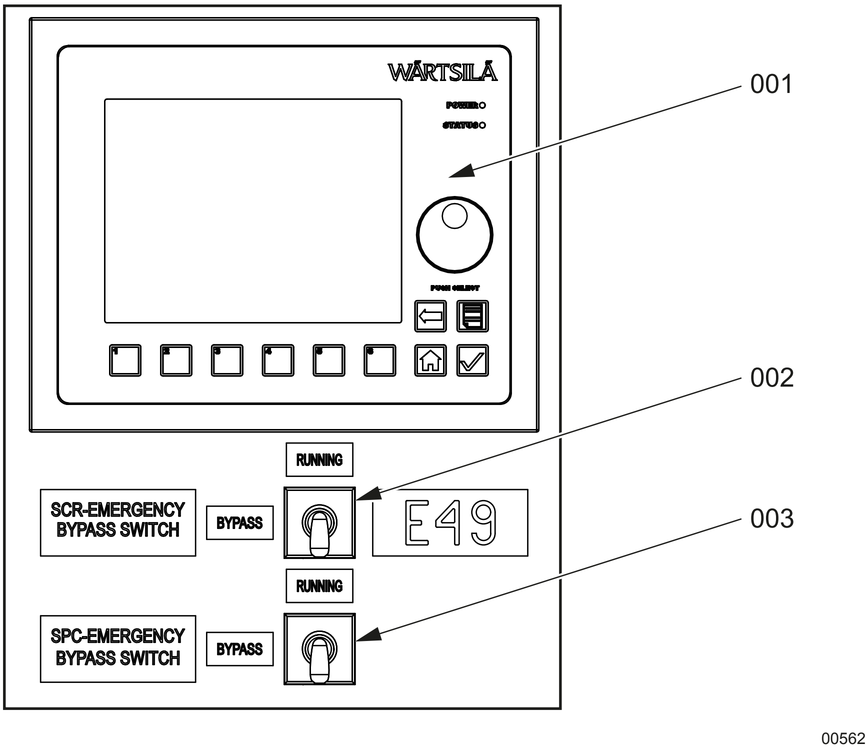
Legend

001	SCR bypass switch	007	Option SPC - Indication - SPC running
002	Option SPC - SPC bypass switch	008	Indication - urea injection
003	Indication - minor failure	009	Indication - major failure
004	Indication - SCR pre-heating on	010	Hour meter
005	Option SPC - Indication - SPC failure	011	Indication - power on
006	Option SPC - Indication - SPC bypass	012	Power switch

4.12.3.2 Control box E49

The control box E49 is installed in the engine control room and has switches below the LDU-20.

Fig 4-22 Control box E49



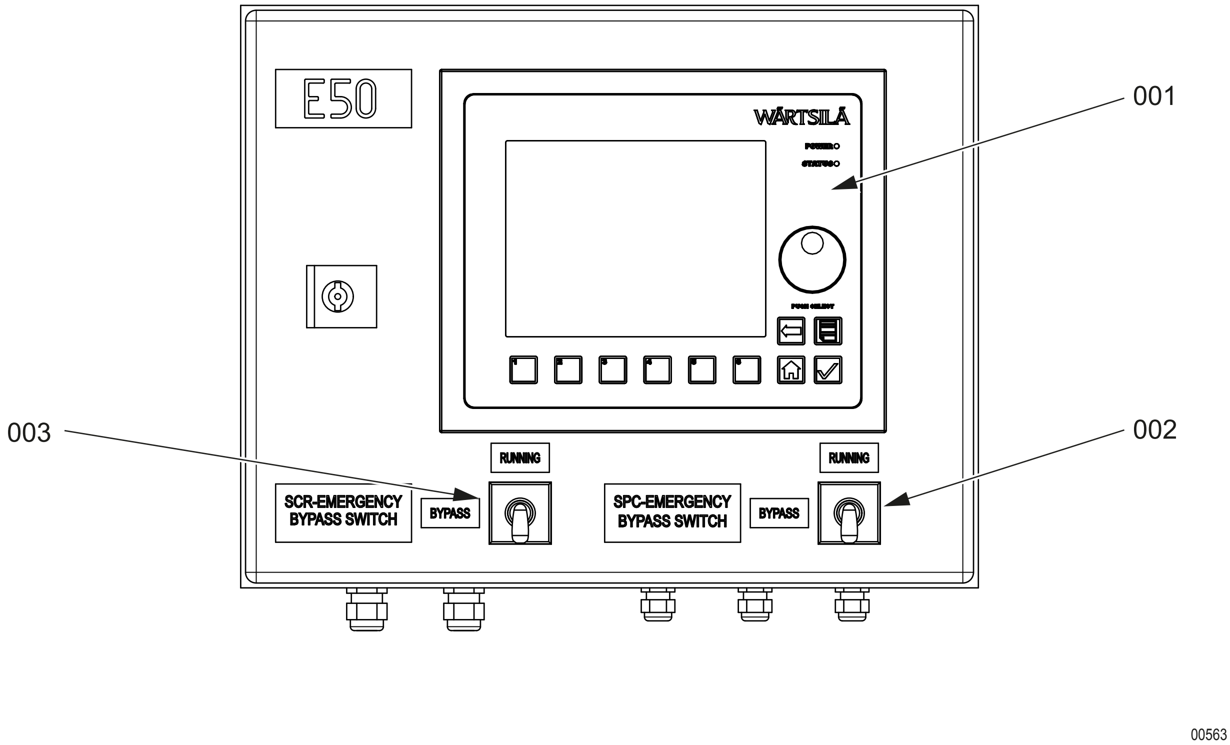
Legend

001 LDU-20
002 SCR bypass switch
003 Option SPC - SPC bypass switch

4.12.3.3 Control box E50

The control box E50 is installed on the engine and has switches below the LDU-20.

Fig 4-23 Control box E50



Legend

001 LDU-20
002 Option SPC - SPC bypass switch
003 SCR bypass switch

4.12.3.4 Messages of the HP SCR control system

The HP SCR control system gives three messages to the alarm and monitoring system (AMS). The messages are as follows:

- **SCR ON**

  This message shows that the HP SCR system is set to ON.
- **SCR minor failure**

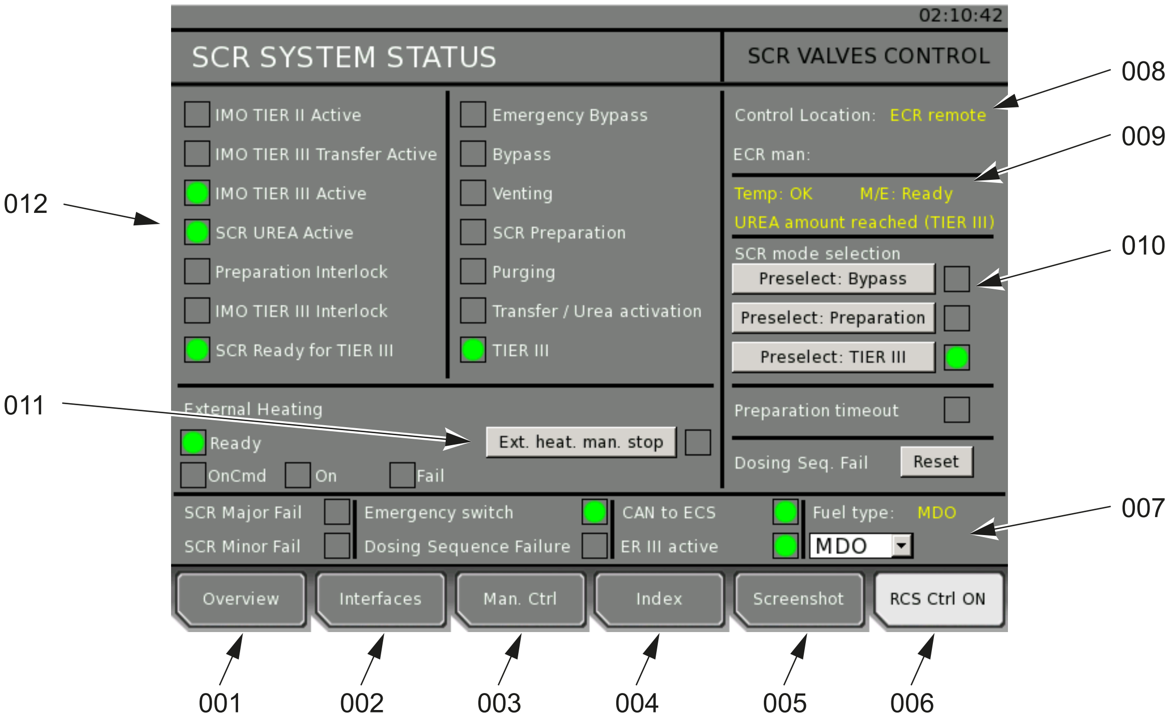
  This message shows a failure that does not have an effect on HP SCR system operation.
- **SCR major failure**

  This message shows a failure that has an effect on HP SCR system operation. The HP SCR control system stops the HP SCR system operation and changes to Tier II mode.

4.12.4 LDU-20 pages

The LDU-20 panel has the pages that follow (examples).

Fig 4-24 LDU-20 page - HP SCR SYSTEM STATUS (MAIN PAGE)

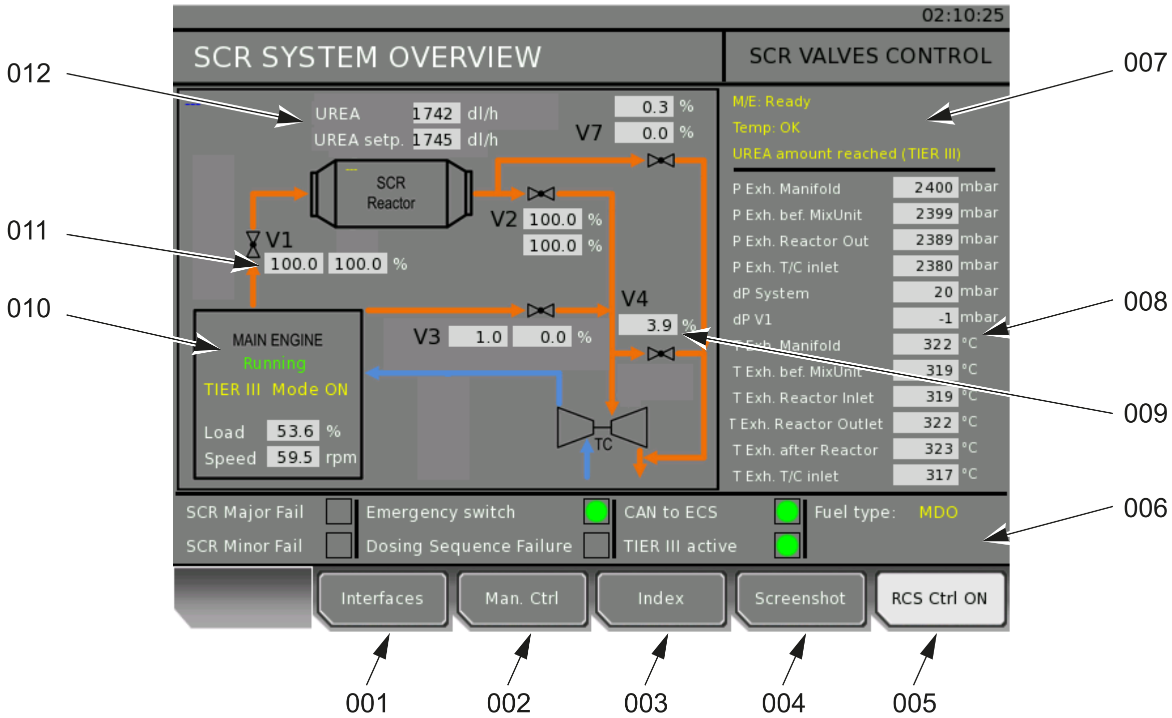


Tab 4-2 HP SCR SYSTEM STATUS (MAIN PAGE)

Item	Function	Effect
001	OVERVIEW button	Opens the SCR system overview page
002	INTERFACES button	Opens the interfaces page
003	MAN CTRL button	Opens the manual control page
004	INDEX button	Opens the index page
005	SCREENSHOT button	Makes a screenshot of the current screen
006	RCS CTRL ON button	Gets control from the remote control system (if button is active)
007	FUEL button	Selects the fuel in use
008	Status indication	Shows the control location
009	Status indication	Shows the SCR status
010	Button and indication	Starts and indicates the related SCR operation mode
011	Button and indication	Stops and indicates the external heating system
012	Status indication	Shows the status of the SCR system

NOTE: After boot-up of the LDU-20, the main page will be displayed. If you change to a different page, press the HOME button of the LDU-20 to go back to the main page.

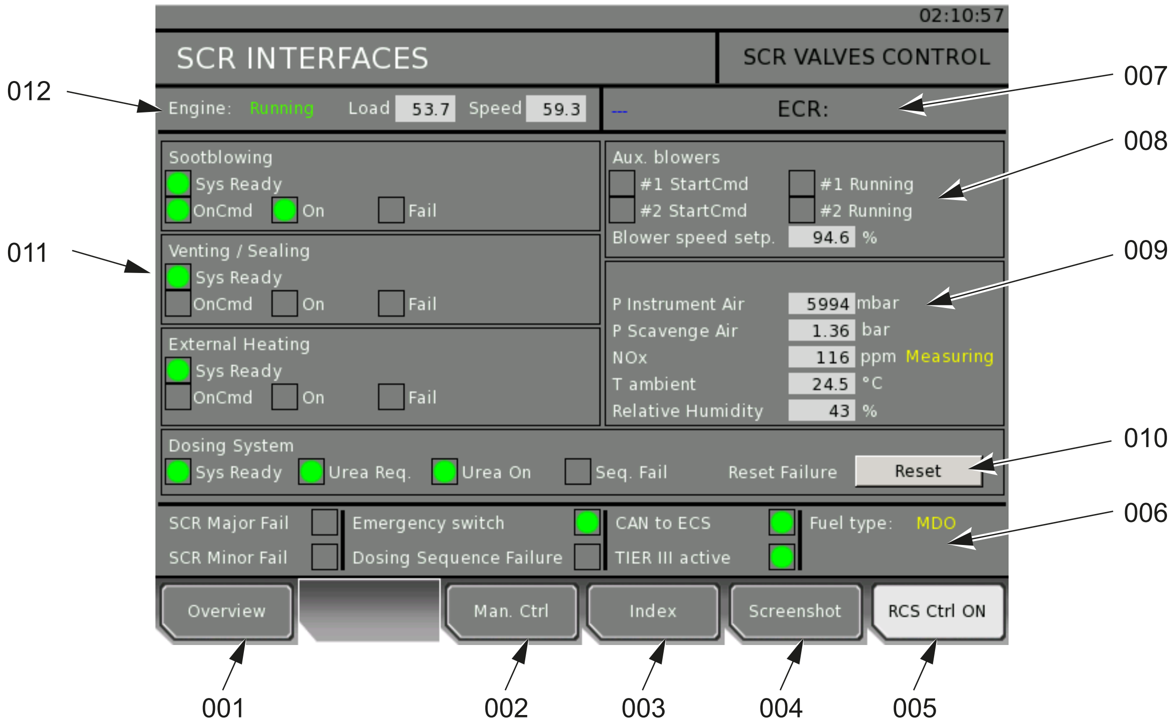
Fig 4-25 LDU-20 page - HP SCR SYSTEM OVERVIEW



Tab 4-3 HP SCR SYSTEM OVERVIEW

Item	Function	Effect
001	INTERFACES button	Opens the interfaces page
002	MAN CTRL button	Opens the manual control page
003	INDEX button	Opens the index page
004	SCREENSHOT button	Makes a screenshot of the current screen
005	RCS CTRL ON button	Gets control from the remote control system (if button is active)
006	Status indication	Shows the SCR status (failure and mode)
007	Status indication	Shows the SCR status
008	Value indication	Shows the values
009	Status indication	Shows the V4 setpoint if E48 has control (in Tier II mode the ECS controls V4)
010	Status indication	Shows the engine status
011	Status indication	Shows the current value and the valve setpoint value in percent (0% to 100%)
012	Status indication	Shows the current value and the setpoint value of the urea solution injection in dl/h

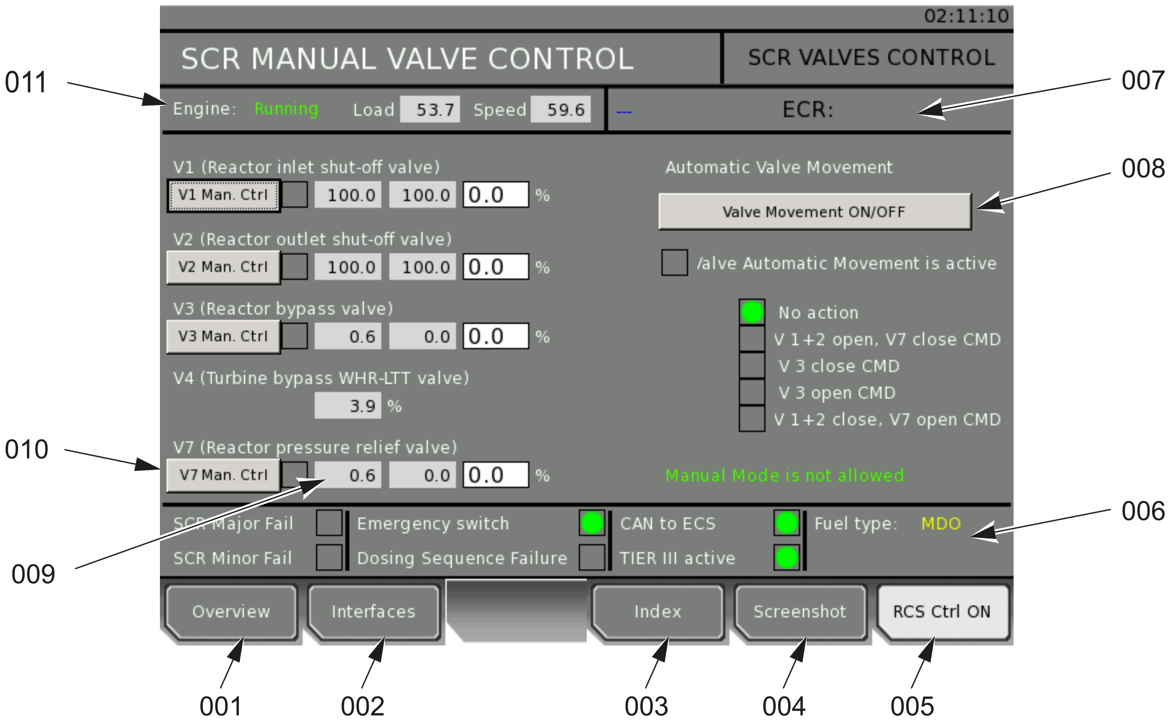
Fig 4-26 LDU-20 page - HP SCR INTERFACES



Tab 4-4 HP SCR INTERFACES

Item	Function	Effect
001	OVERVIEW button	Opens the SCR system overview page
002	MAN CTRL button	Opens the manual control page
003	INDEX button	Opens the index page
004	SCREENSHOT button	Makes a screenshot of the current screen
005	RCS CTRL ON button	Gets control from the remote control system (if button is active)
006	Status indication	Shows the SCR status (failure and mode)
007	Status indication	Shows the control location
008	Status indication	Shows the auxiliary blower status (in preparation mode and Tier III mode E48 controls the auxiliary blowers)
009	Indication	Shows different sensor signals
010	RESET button	Resets a failure message
011	Status indication	Shows the status of external systems
012	Status indication	Shows the engine status

Fig 4-27 LDU-20 page - HP SCR MANUAL VALVE CONTROL

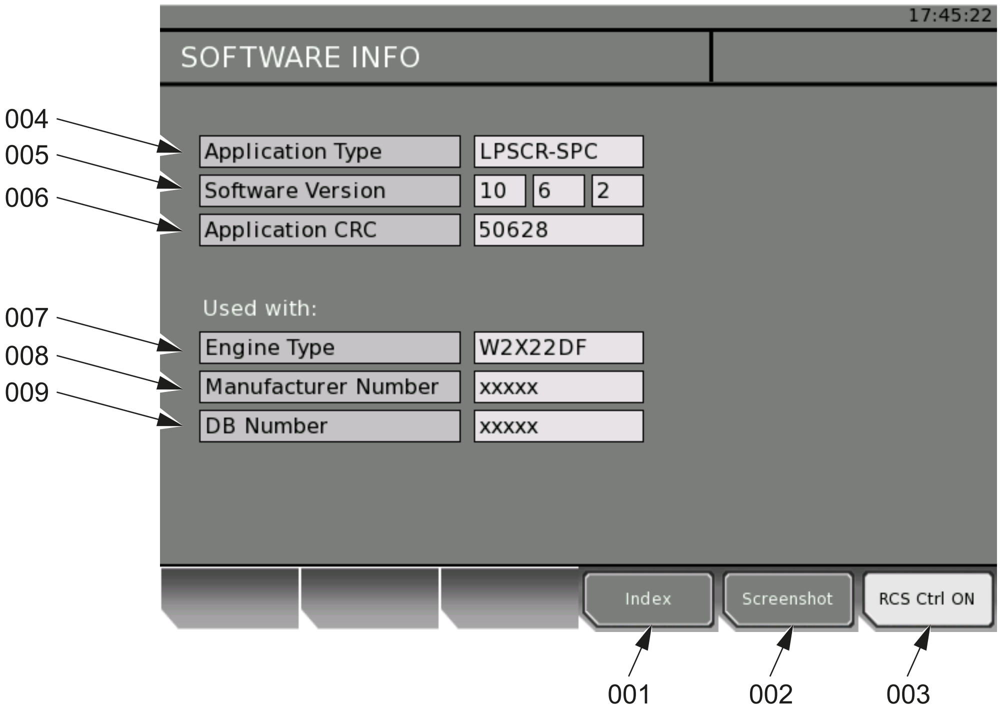


Tab 4-5 HP SCR MANUAL VALVE CONTROL

Item	Function	Effect
001	OVERVIEW button	Opens the SCR system overview page
002	INTERFACES button	Opens the interfaces page
003	INDEX button	Opens the index page
004	SCREENSHOT button	Makes a screenshot of the current screen
005	RCS CTRL ON button	Gets control from the remote control system (if button is active)
006	Status indication	Shows the SCR status (failure and mode)
007	Status indication	Shows the control location
008	Button and indication	Starts and stops the set automatic valve movement as test sequence (serviceable only if the manual mode is permitted) The indication shows the status of the test sequence. **NOTE:** If necessary you can stop the test sequence manually before it stops automatically.
009	Indication and input field	First value shows the valve value in percent (%). Second value shows the valve setpoint value in percent. Third value shows the valve setpoint value in percent from the operator

Item	Function	Effect
010	Button and indication	Gives manual control of the related valve and shows the status (serviceable only if the manual mode is permitted)
011	Status indication	Shows the engine status

Fig 4-28 LDU-20 page - HP SCR SOFTWARE INFO

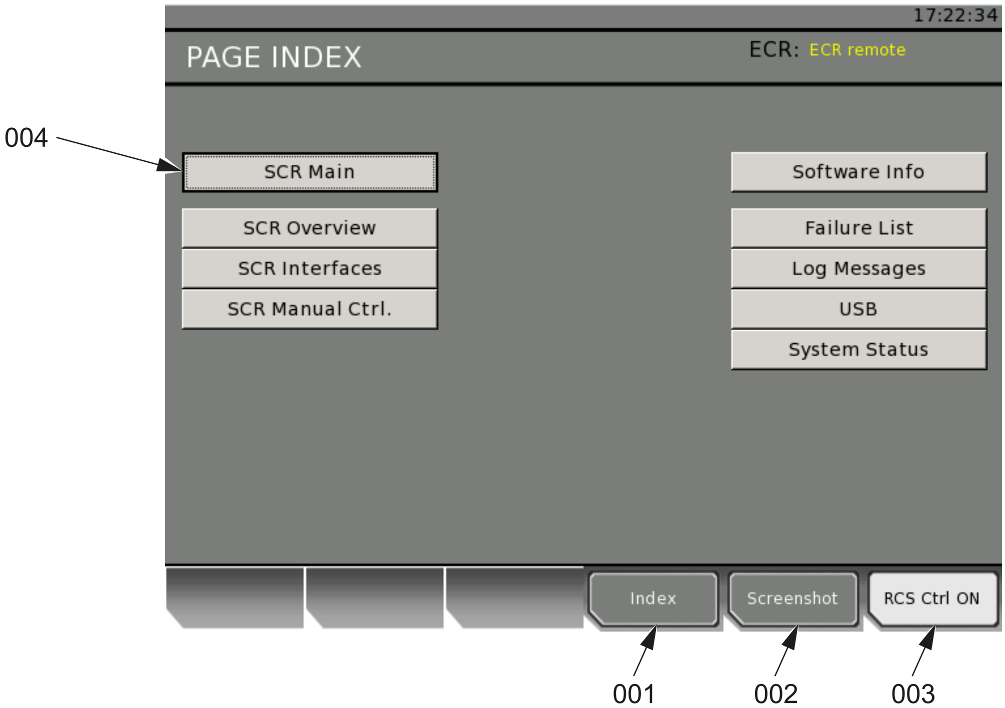


Tab 4-6 HP SCR SOFTWARE INFO

Item	Function	Effect
001	INDEX button	Opens the index page
002	SCREENSHOT button	Makes a screenshot of the current screen
003	RCS CTRL ON button	Gets control from the remote control system (if button is active)
004	Application type	Shows the name of the application
005	Software version	Shows the software version number, (major) (middle) (minor), for example 1.2.0
006	Application CRC (Cyclic Redundancy Check)	Shows the check-sum of the application (binary)
007	Engine type	Shows the applicable engine
008	Manufacturer number	Shows the software manufacturer number

Item	Function	Effect
009	DB number	Shows identification number of the installation

Fig 4-29 LDU-20 page - HP SCR PAGE INDEX



Tab 4-7 HP SCR PAGE INDEX

Item	Function	Effect
001	INDEX button	Opens the index page
002	SCREENSHOT button	Makes a screenshot of the current screen
003	RCS CTRL ON button	Gets control from the remote control system (if button is active)
004	Page button	Opens the selected page

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4.13 LP Selective catalytic reduction system

The Low Pressure Selective Catalytic Reduction (LP SCR) system is an optional system to decrease the level of nitrogen oxides in the exhaust gas. This makes sure that the emissions of nitrogen oxides obey the Tier III regulations of the International Maritime Organization (IMO).

Nitrogen oxides are dangerous and are made in secondary reactions in the engine during fuel combustion.

The LP SCR system is installed after the turbocharger. The system design and the supply of components is divided between the LP SCR system supplier, the shipyard and WinGD/engine builder.

The LP SCR system adds a urea water solution to the exhaust gas flow. Chemical reactions change nitrogen oxides to molecular nitrogen and water, which are not dangerous.

Because of the low exhaust gas temperature after the turbocharger ammonia bisulfates are formed in the LP SCR reactor. You must regularly change to bypass operation and do a regeneration procedure to remove these deposits, refer to the related documentation of the manufacturer. During this procedure the LP SCR system cannot operate.

NOTE: For a DF engine: The LP SCR system can only be used in diesel mode.

4.13.1 Description of the LP SCR system

4.13.1.1 LP SCR system parts

The LP SCR system has the parts shown in the paragraphs that follow (see Figure 4-30 and Figure 4-31):

- **Urea pump unit**

  This unit supplies the urea solution from the tank to the urea solution dosing unit. This keeps the applicable pressure in the related pipes.
- **Urea dosing unit**

  The urea dosing unit controls the supply of urea solution to the decomposition unit.
- **Burner**

  The burner heats up the exhaust gas flow that is used to inject the urea.
- **Decomposition unit**

  In the decomposition unit the exhaust gas and the urea is mixed to form ammonia.
- **LP SCR reactor**

  The LP SCR reactor has a steel wall and has an inlet and an outlet cone. A steel structure holds the catalyst layers. At the catalytic surface of the catalyst layers the nitrogen oxides (NO and NO_2) react with the ammonia into molecular nitrogen (N_2) and water (H_2O). These gases are part of the ambient air and are not dangerous.

  Manholes in the reactor walls are used to examine and, if necessary, to clean or replace the catalyst elements.

- **Valves**

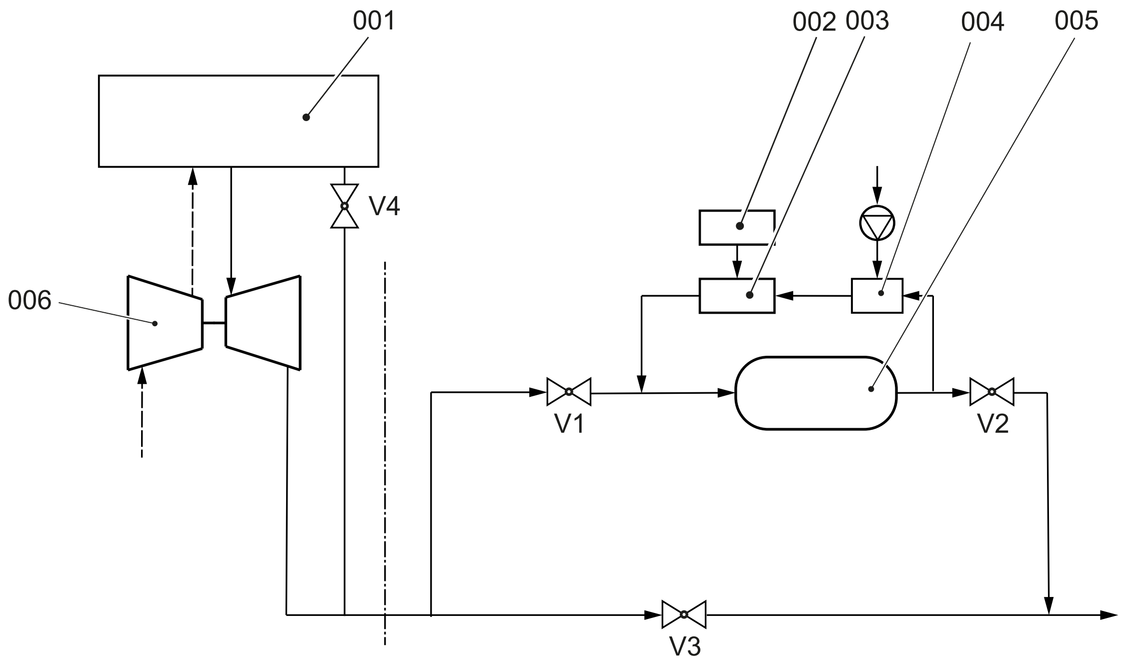
  The valves in the LP SCR system are used for the different operation modes. The LP SCR system has the valves that follow:
  - V1 - reactor inlet valve
  - V2 - reactor outlet valve
  - V3 - reactor bypass valve
  - V4 - turbine bypass valve

  The turbine bypass valve (V4) is also used for other functions of the ECS, for example for low-load tuning (LLT) or for steam production control (SPC).

4.13.1.2 Layout

The LP SCR system can be designed in different layouts related to the project. Two examples are shown in Figure 4-30 and Figure 4-31.

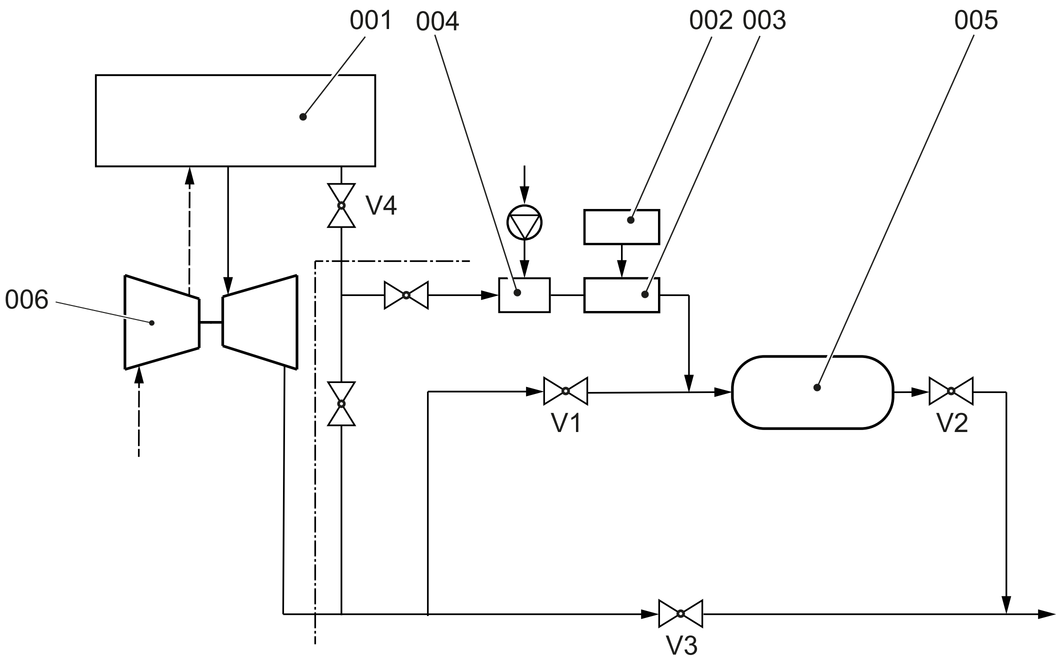
Fig 4-30 LP SCR temperature controlled (example)



Legend

001	Engine	004	Burner
002	Urea dosing unit	005	LP SCR reactor
003	Decomposition unit	006	Turbocharger

Fig 4-31 LP SCR bypass rate controlled (example)



Legend

001	Engine	004	Burner
002	Urea dosing unit	005	LP SCR reactor
003	Decomposition unit	006	Turbocharger

4.13.2 Operation modes

The LP SCR system can be operated if the exhaust gas temperature is in the permitted limits. These limits are adjusted during commissioning. A temperature that is less than the permitted limit can cause the catalyst elements to clog. A temperature that is more than the permitted limit can cause the catalyst elements to become worn quickly.

4.13.2.1 LP SCR system - (emergency) bypass

In this operation mode, the LP SCR system is bypassed. The engine operates in Tier II mode. Urea solution is not injected.

The valves have the conditions that follow:

- V1 - closed
- V2 - closed
- V3 - open
- V4 - the control systems control this valve.

4.13.2.2 LP SCR system - preparation

In this operation mode, exhaust gas causes the temperature of the LP SCR reactor to slowly increase. Urea solution is not injected.

The valves have the conditions that follow:

- V1 - slowly changes from closed to open
- V2 - slowly changes from closed to open
- V3 - slowly changes from open to closed
- V4 - the control systems control this valve.

When the temperature of the LP SCR reactor has the value for operation in Tier III mode, a timer starts. As long as the timer runs, the operator must change to Tier III mode. If the operator does not change to Tier III and the timer stops, the ECS changes back to bypass mode (Tier II).

4.13.2.3 LP SCR system - Tier III

In this operation mode, the LP SCR system is set to ON. The engine operates in Tier III mode. Urea solution is injected.

The valves have the conditions that follow:

- V1 - open
- V2 - open
- V3 - closed
- V4 - the control systems control this valve to keep the temperature of the exhaust gas in the correct range.

4.13.2.4 LP SCR system - at engine stop

If you stop the engine in Tier III mode, the LP SCR system changes to bypass mode immediately and urea solution injection stops.

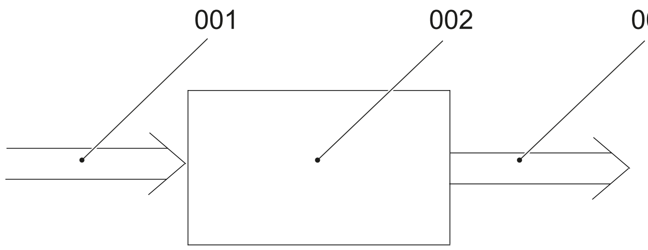
4.13.3 LP SCR control system

The main tasks of the WinGD control system for the LP SCR system are as follows:

- Calculate the setpoint position for the turbine bypass valve (V4) to control the exhaust gas temperature.
- Control the operation of the auxiliary blowers.
- Calculate the setpoint for the urea dosing unit.

Related to the input signals the LP SCR control system gives the related signals to the LP SCR system, refer to Figure 4-32.

Fig 4-32 LP SCR control system layout



Legend

001 Input signals
002 LP SCR control system
003 Output signals

The main input signals are as follows:

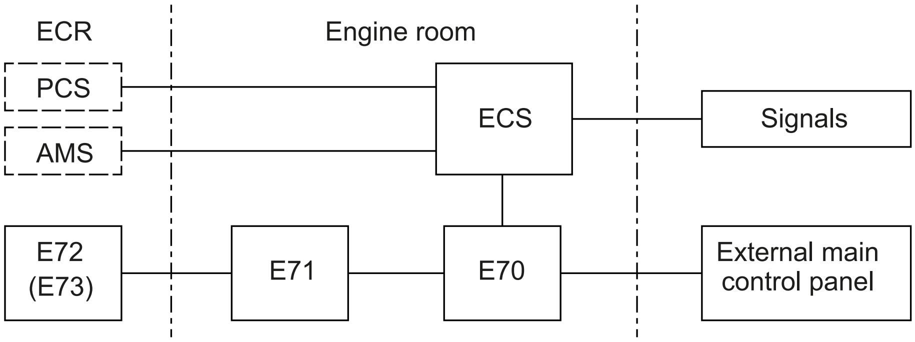
- Engine parameters
- Prepare Tier III command from RCS
- Tier III command from RCS
- Position of turbine bypass valve (V4)
- Different temperatures and pressures

The main output signals are as follows:

- Different temperatures and pressures
- Signals to enable or disable the LP SCR system

The principal control configuration of the LP SCR system is shown in Figure 4-33.

Fig 4-33 LP SCR system - principal control configuration



4.13.3.1 Messages of the LP SCR control system

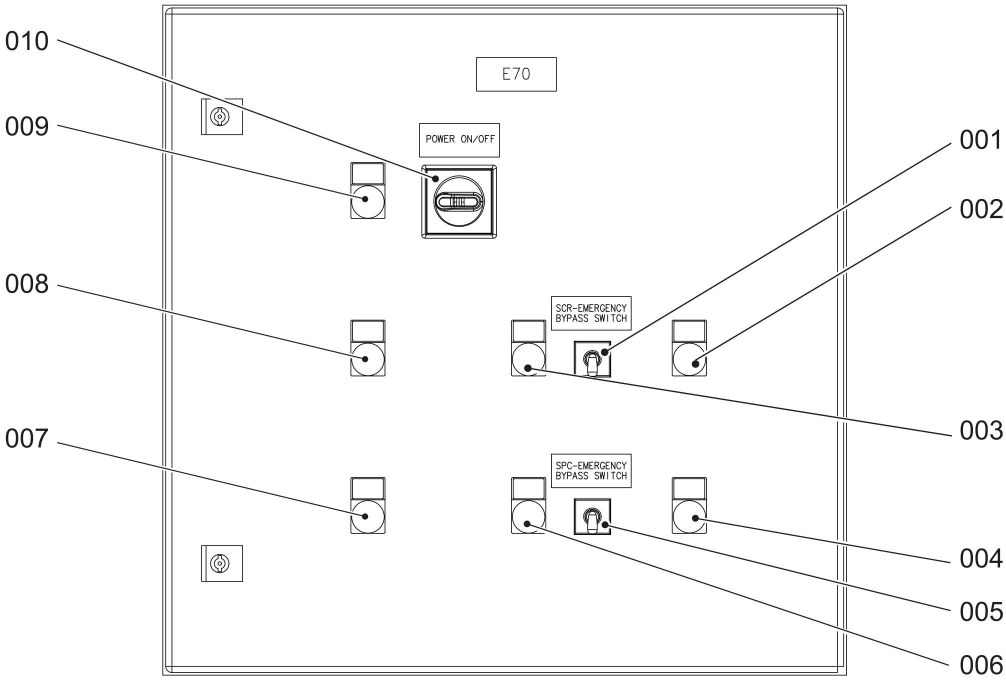
The LP SCR control system gives three messages to the alarm and monitoring system (AMS). The messages are as follows:

- LP SCR ON - This message shows that the LP SCR system is set to ON and thus urea is injected.
- LP SCR minor failure - This message shows a failure that does not have an effect on LP SCR system operation.
- LP SCR major failure - This message shows a failure that has an effect on LP SCR system operation. The LP SCR control system stops the LP SCR system operation and changes to Tier II mode.

4.13.3.2 Control box E70

The control box E70 is installed on the engine and has switches and visual indicators.

Fig 4-34 Control box E70 with option SPC



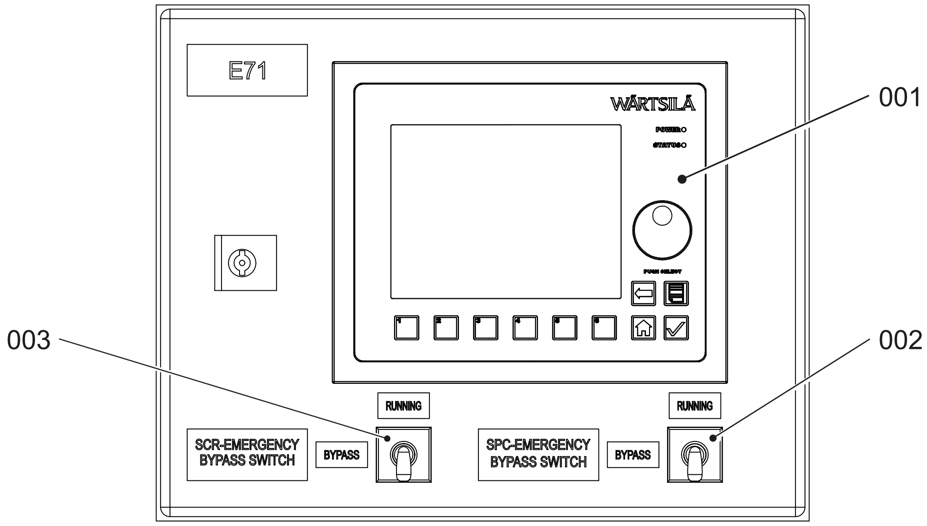
Legend

001	SCR bypass switch	006	Indication (orange) - SPC bypass
002	Indication (red) - SCR failure	007	Indication (green) - SPC running
003	Indication (orange) - SCR bypass	008	Indication (green) - SCR running
004	Indication (red) - SPC failure	009	Indication (green) - Power on
005	SPC bypass switch	010	Power switch

4.13.3.3 Control box E71

The control box E71 is installed on the engine or in the engine room and has switches below the LDU-20.

Fig 4-35 Control box E71 with option SPC



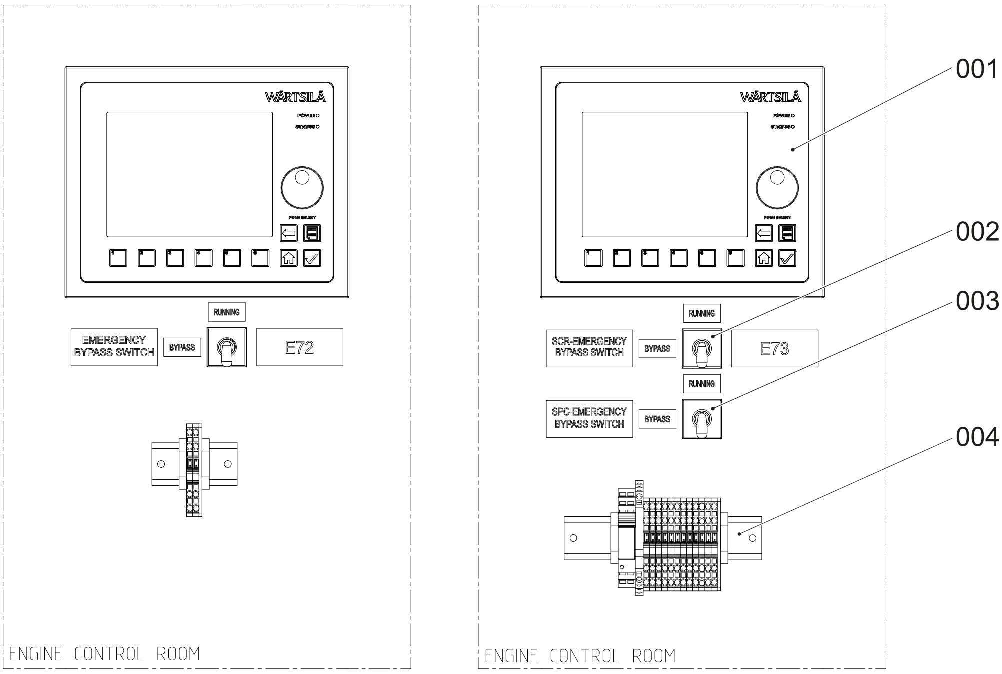
Legend

001 LDU-20
002 SPC bypass switch
003 SCR bypass switch

4.13.3.4 Control box E72 or E73

The control box E72 (without SPC) or E73 (with SPC) is installed in the engine control room and has switches below the LDU-20.

Fig 4-36 Control boxes E72 and E73



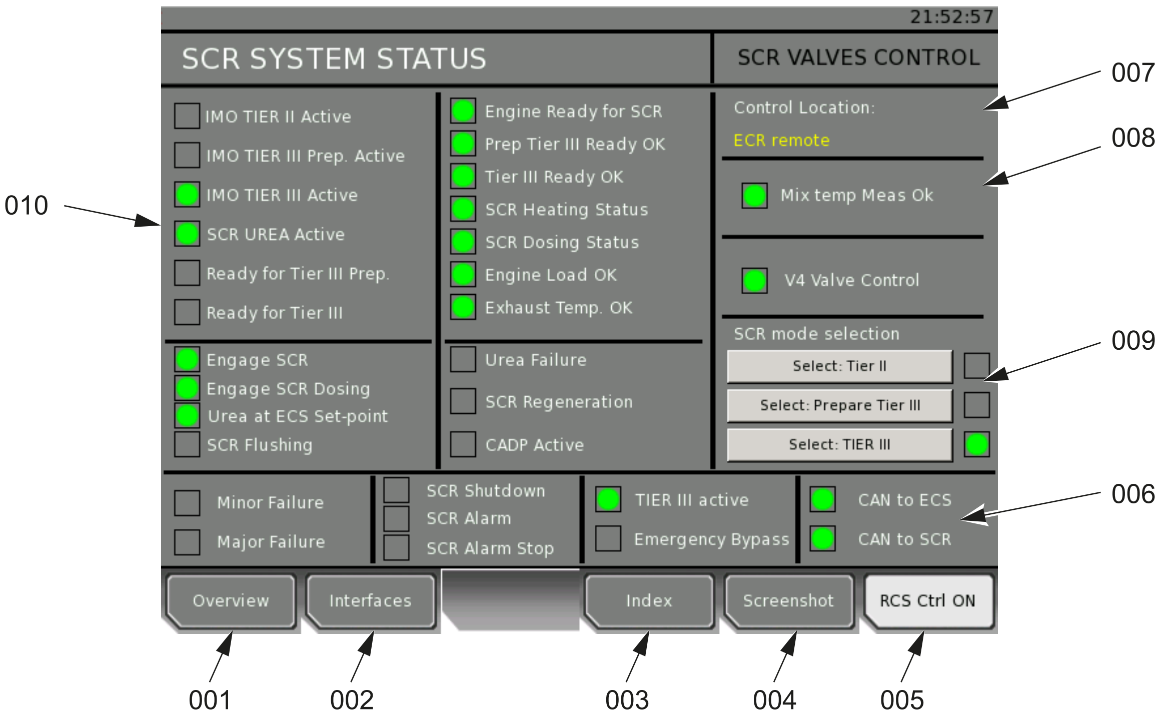
Legend

001 LDU-20
002 SCR bypass switch
003 SPC bypass switch
004 Conductor terminal block

4.13.4 LDU-20 pages

The LDU-20 panel has the pages that follow (examples).

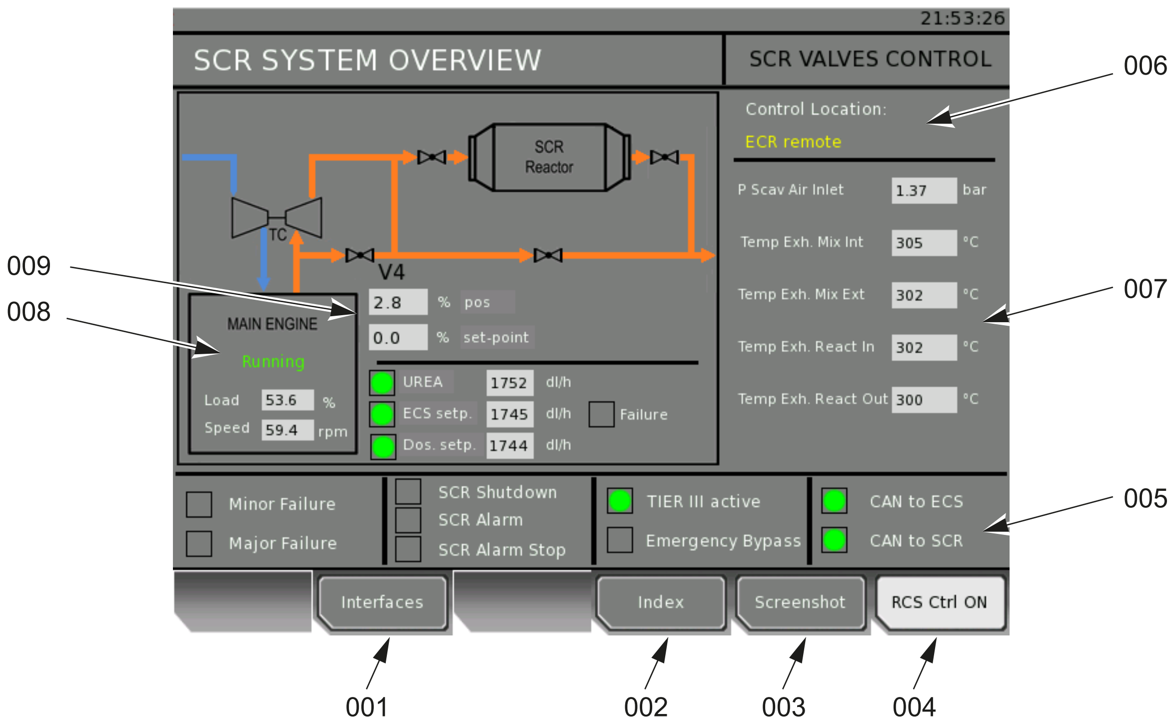
Fig 4-37 LDU-20 page - LP SCR SYSTEM STATUS (MAIN PAGE)



Tab 4-8 LP SCR SYSTEM STATUS (MAIN PAGE)

Item	Function	Effect
001	OVERVIEW button	Opens the SCR system overview page
002	INTERFACES button	Opens the interfaces page
003	INDEX button	Opens the index page
004	SCREENSHOT button	Makes a screenshot of the current screen
005	RCS CTRL OFF button	Gets control from the remote control system (if button is active)
006	Status indication	Shows the SCR status
007	Status indication	Shows the control location
008	Status indication	Shows the related status
009	Button and indication	Starts and indicates the related SCR operation mode
010	Status indication	Shows the status of the SCR system

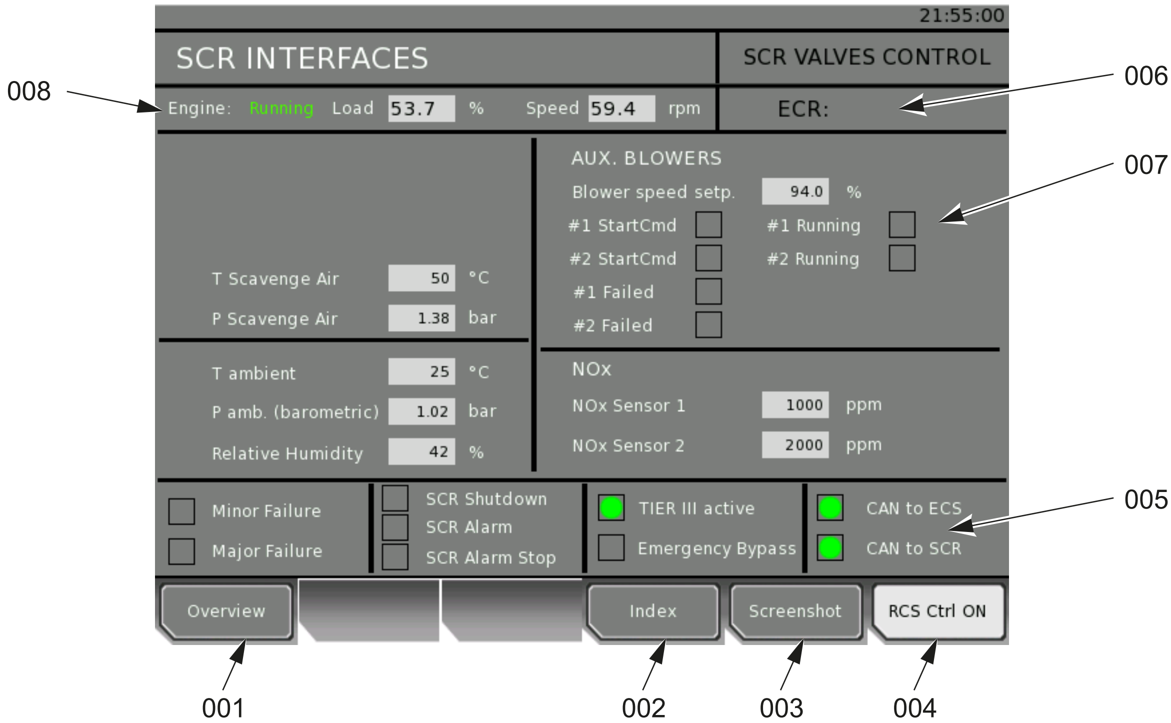
Fig 4-38 LDU-20 page - LP SCR SYSTEM OVERVIEW



Tab 4-9 LP SCR SYSTEM OVERVIEW

Item	Function	Effect
001	INTERFACES button	Opens the interfaces page
002	INDEX button	Opens the index page
003	SCREENSHOT button	Makes a screenshot of the current screen
004	RCS CTRL OFF button	Gets control from the remote control system (if button is active)
005	Status indication	Shows the SCR status
006	Status indication	Shows the control location
007	Status indication	Shows the values
008	Status indication	Shows the engine status
009	Status indication	Shows the current value and the valve setpoint value in percent (0% to 100%)

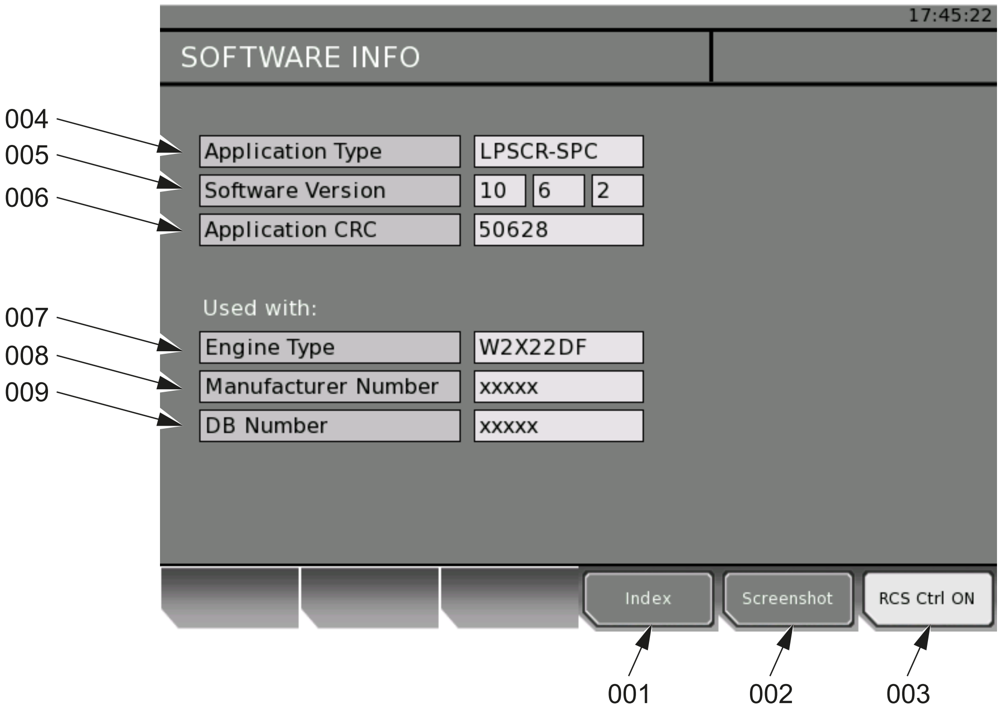
Fig 4-39 LDU-20 page - LP SCR INTERFACES



Tab 4-10 LP SCR INTERFACES

Item	Function	Effect
001	OVERVIEW button	Opens the SCR system overview page
002	INDEX button	Opens the index page
003	SCREENSHOT button	Makes a screenshot of the current screen
004	RCS CTRL OFF button	Gets control from the remote control system (if button is ac-tive)
005	Status indication	Shows the SCR status
006	Status indication	Shows the control location
007	Status indication	Shows the auxiliary blower status
008	Status indication	Shows the status of the SCR system

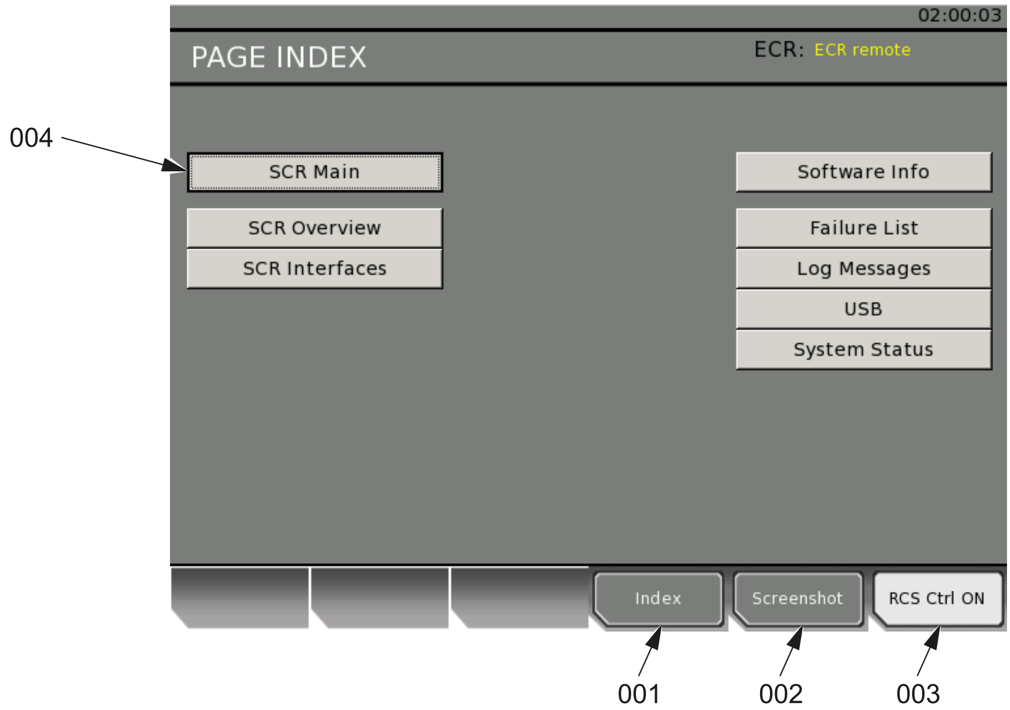
Fig 4-40 LDU-20 page - LP SCR SOFTWARE INFO



Tab 4-11 LP SCR SOFTWARE INFO

Item	Function	Effect
001	INDEX button	Opens the index page
002	SCREENSHOT button	Makes a screenshot of the current screen
003	RCS CTRL ON button	Gets control from the remote control system (if button is active)
004	Application type	Shows the name of the application
005	Software version	Shows the software version number, (major) (middle) (minor), for example 1.2.0
006	Application CRC (Cyclic Redundancy Check)	Shows the check-sum of the application (binary)
007	Engine type	Shows the applicable engine
008	Manufacturer number	Shows the software manufacturer number
009	DB number	Shows identification number of the installation

Fig 4-41 LDU-20 page - LP SCR PAGE INDEX



Tab 4-12 LP SCR PAGE INDEX

Item	Function	Effect
001	INDEX button	Opens the index page
002	SCREENSHOT button	Makes a screenshot of the current screen
003	RCS CTRL ON button	Gets control from the remote control system (if button is active)
004	Page button	Opens the selected page

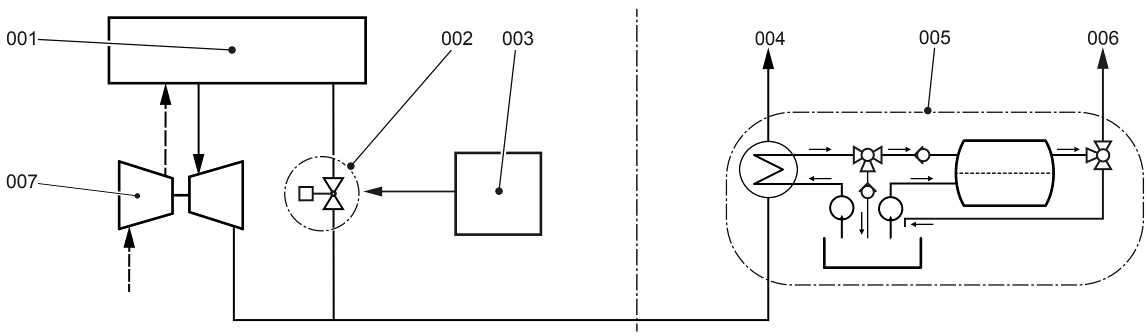
4.14 Steam production control system

The steam production control system (SPC) supplies the steam production of the ship with exhaust gas, which has a higher temperature.

SPC is an optional system.

NOTE: The engine obeys the IMO NOx limits, with and without steam production.

Fig 4-42 Example of SPC



Legend

001	Engine	005	Steam production
002	Exhaust waste gate valve	006	Steam consumer
003	Steam production control system	007	Turbocharger
004	Stack		

4.14.1 Function

The SPC controls the exhaust waste gate valve (002, Figure 4-42). If the exhaust waste gate valve (EWG) opens, a part of the exhaust gas bypasses the turbocharger (007). As a result the temperature of the exhaust gas increases, which is supplied to the steam production (005).

The supply of the turbocharger comes first, before the supply of the steam production.

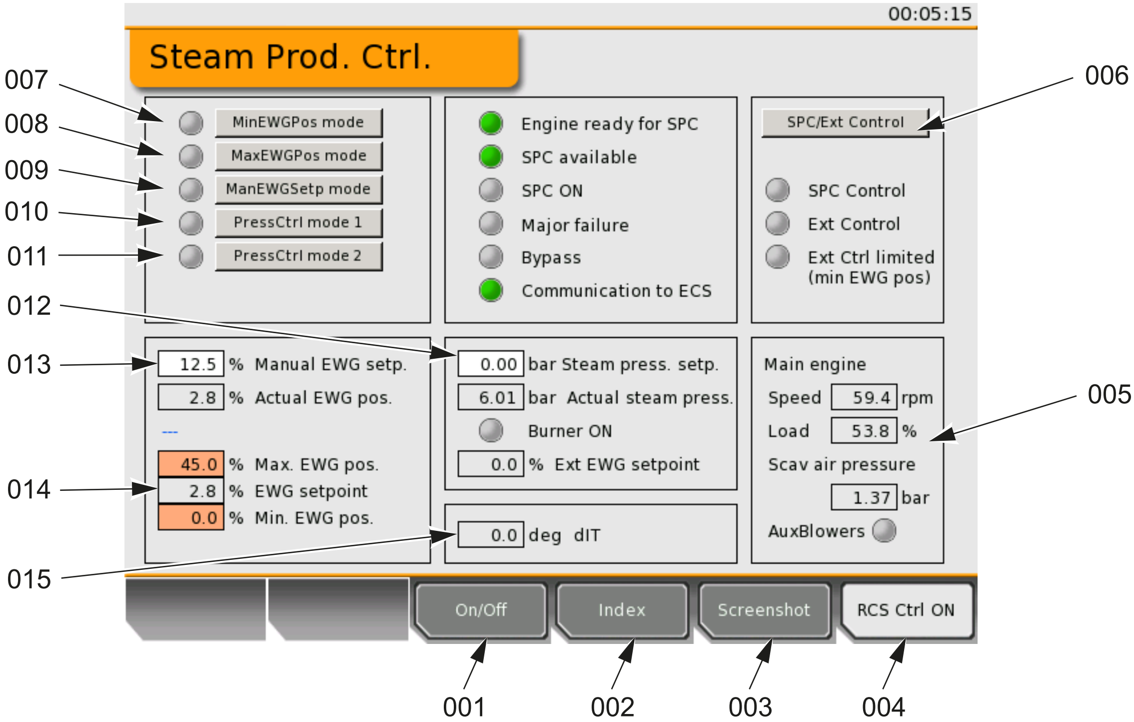
The supply of the steam production is only permitted in the range between the minimum engine load and the maximum bypass rate. These limits are related on the ambient conditions and are project specific.

4.14.2 User interface on the LDU-20

If an SCR system is installed, the control for SPC is part of the SCR system.

If no SCR system is installed, the control for SPC has separate control boxes.

Fig 4-43 LDU-20 page - STEAM PRODUCTION CONTROL



Tab 4-13 STEAM PRODUCTION CONTROL (SPC)

Item	Function	Effect
001	ON/OFF button	Starts or stops the SPC system
002	INDEX button	Opens the index page
003	SCREENSHOT button	Makes a screen shot of the current screen
004	RCS CTRL ON button	Gets control from the remote control system (if button is active)
005	Value indication	Shows the values
006	SPC/EXT. CONTROL button	Changes to the external control of the SPC
007	MinEWGPos mode button	Sets the minimum permitted EWG position Other SPC modes than the initial mode MinEWGPos are only possible, if the signal Engine ready for SPC from ECS is active (green).
008	MaxEWGPos mode button	Sets the maximum permitted EWG position
009	ManEWGSetp mode button	Sets the EWG setpoint, if the specific LDU-20 is in control You can set a value of 0 to 100%, but the SPC uses only a value in the permitted range.

Item	Function	Effect
010	PressCtrl mode 1 button	Starts the PressCtrl mode 1 This mode is applicable only, if the steam pressure signal from the steam plant is correct. SPC compares the setpoint and the actual steam pressure. If there is a difference, it opens or closes the EWG to change the steam pressure. If the status of the steam pressure signal changes to FAIL, SPC will change to MinEWGPos mode.
011	PressCtrl mode 2 button	Starts the PressCtrl mode 2 Same effect as PressCtrl mode 1: But, if the burner is ON, the SPC uses the minimum permitted EWG position only.
012	Steam Pressure Setpoint	Shows the actual setpoint of the steam pressure You can manually set the setpoint, if the PressCtrl mode 1 or 2 is active. It is only possible to set the setpoint if the specific LDU-20 is in control.
013	Manual EWG Setpoint	Shows the actual EWG setpoint If the ManEWGSetp mode is active, you can enter the EWG setpoint.
014	EWG Limitation	Shows the current EWG setpoint together with the actual minimum and maximum limitations Too wide EWG opening decreases the scavenge air pressure. This will start the auxiliary blowers. The limit of the EWG opening prevents the scavenge air pressure to decrease below the switching-On point of the auxiliary blowers.
015	dIT	Shows the delta injection timing (dIT) SPC calculates the dIT. The dIT controls the timing of the fuel injection. This timing is related to the difference between EWG setpoint and the minimum permitted EWG position. The ECS controls, if the dIT from SPC will be used or not. Rule: If ICC is on, then dIT is not used.

5 Design and function of components

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5.1 Group 1 - Engine frame and bearings

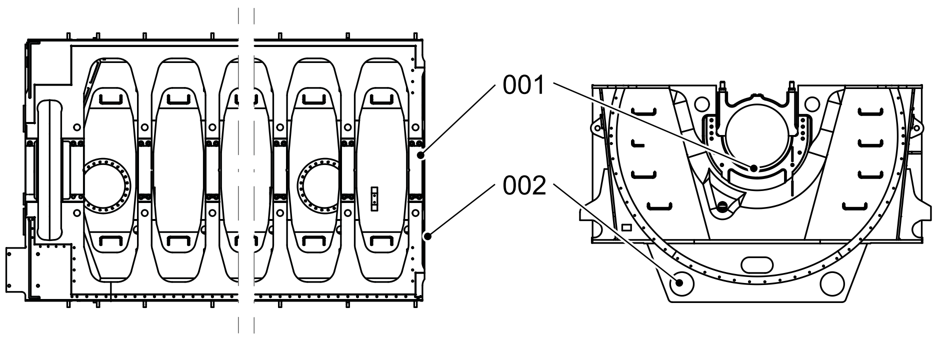
5.1.1 Bedplate

The bedplate is the basic structure of the engine. The bearing girders (001, Figure 5-1) are attached in the bedplate and hold the crankshaft.

The bottom part of the bedplate is the crankcase and collects lubricating oil. This oil flows back to the oil supply system through oil drains (002).

The length of the bedplate is related to the number of cylinders.

Fig 5-1 Bedplate (generic)



Legend

001 Bearing girder

002 Oil drain

Page left intentionally blank

5.1.2 Main bearing

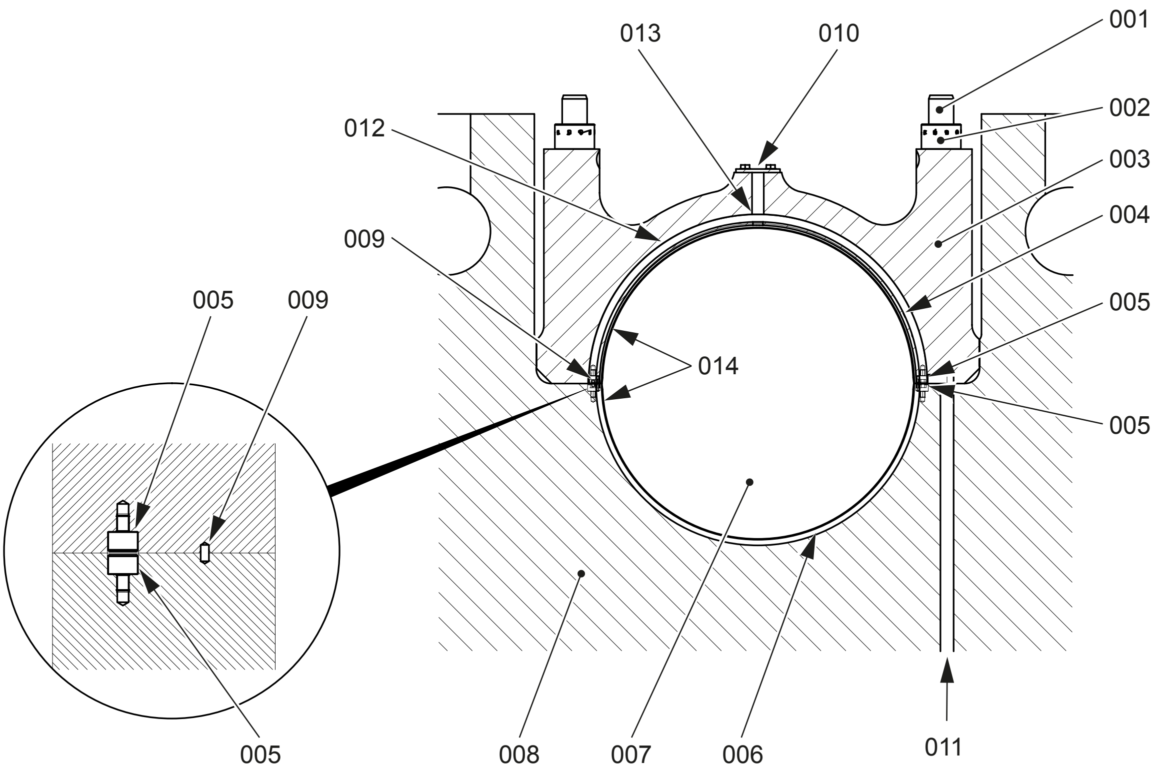
The main bearings hold the crankshaft (007, Figure 5-2) and transmit the forces through the bearing girders (008) into the bedplate.

The bottom bearing shell (006) is installed in the bearing girder (008) of the bedplate and the top bearing shell (004) in the bearing cover (003). The screws (005) engage and hold the top bearing shell and bottom bearing shell in position. The spring dowel pin (009) helps to get the bearing cover (003) in position.

The elastic studs (001) have a non-hardening locking compound applied to the threads. Hydraulic tension is applied to the elastic studs during the install procedure. The round nuts (002) keep the bearing cover (003) against the bearing girder.

Oil flows from the bedplate through the oil inlet (011) to the main bearings. The oil flows through the grooves (012) and bores to the running surface of the main bearing.

Fig 5-2 Main bearing (generic)



Legend

001 Elastic stud
002 Round nut
003 Bearing cover
004 Top bearing shell
005 Screw
006 Bottom bearing shell
007 Crankshaft
008 Bearing girder
009 Spring dowel pin
010 Plug
011 Oil inlet
012 Oil groove
013 Oil bore
014 Coating

Page left intentionally blank

5.1.3 Thrust bearing

The thrust bearing is installed on the crankshaft at the driving end of the engine. The thrust bearing flange (014, Figure 5-3) transmits the axial thrust from the propeller through the thrust pads into the bedplate:

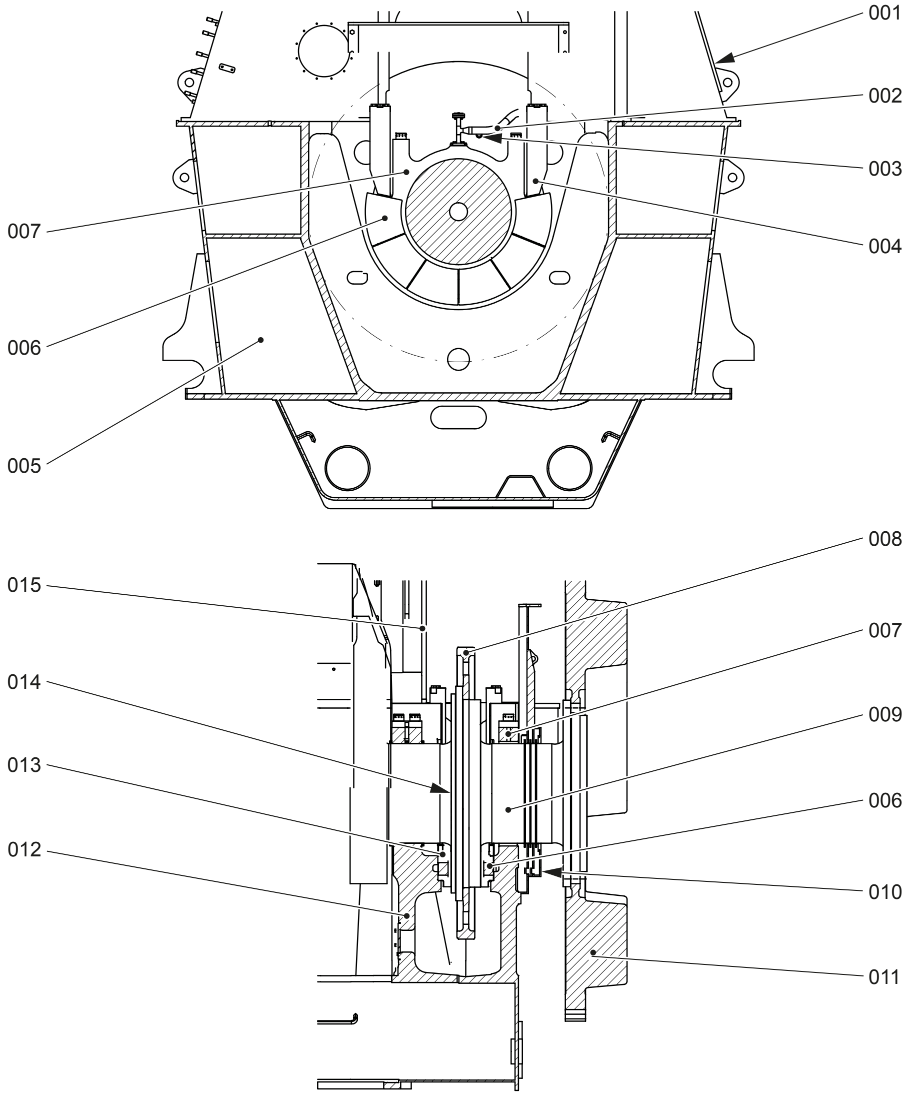
- The thrust pads on the engine side adapt the propeller thrust of the ahead direction.
- The thrust pads on the driving end adapt the propeller thrust of the astern direction.

The thrust pads adapt to the clockwise or counterclockwise rotation of the engine.

The arbor supports (004) prevent circular movement of the thrust pads.

Bearing oil flows through the oil pipe (002) to the two nozzles (003). The oil flows out of the two nozzles as a spray, which becomes an oil layer between the thrust bearing flange (014) and the thrust pads (006, 013).

Fig 5-3 Thrust bearing (generic)



Legend

001 Column
002 Oil pipe
003 Nozzle
004 Arbor support
005 Bedplate
006 Thrust pad (driving end)
007 Bearing cover
008 Crankshaft gear wheel
009 Crankshaft
010 2-part oil baffle
011 Flywheel
012 Bedplate
013 Thrust pad (engine side)
014 Thrust bearing flange
015 Column

5.1.4 Monoblock column

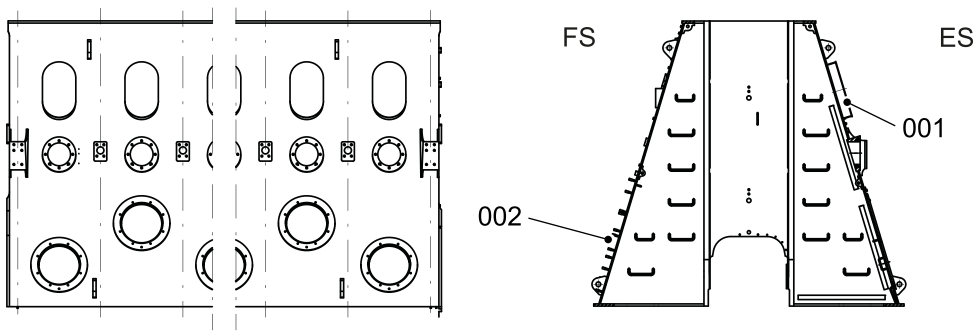
The monoblock column is the middle part of the engine. The monoblock column is installed on the bedplate and holds the cylinders.

On the exhaust side (ES) the monoblock column has one relief valve (001, Figure 5-4) per cylinder. The relief valves open, if the pressure in the monoblock increases too much.

On the fuel side (FS) the monoblock column has one door (002) per cylinder. During normal operation the doors are closed and locked. For maintenance or inspection work the doors can be opened. Obey the safety rules before you open the doors.

The length of the monoblock column is related to the number of cylinders.

Fig 5-4 Monoblock column (generic)



Legend

001	Relief valve	FS	Fuel side
002	Door	ES	Exhaust side

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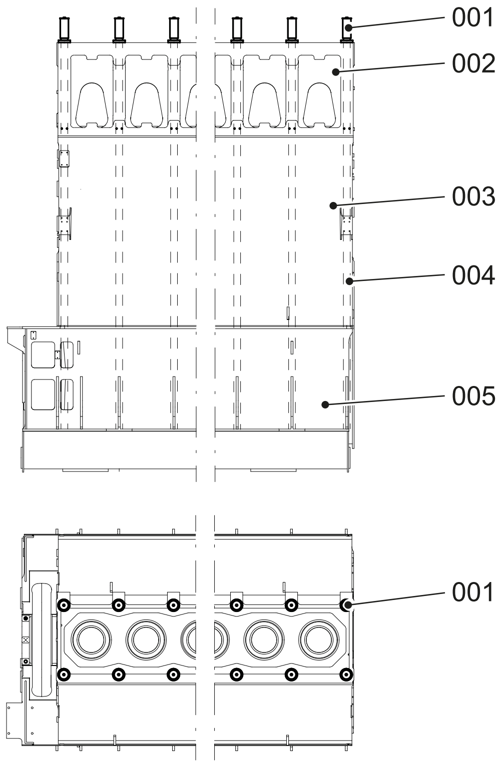
5.1.5 Tie rod

The tie rods (004, Figure 5-5) keep the cylinder block (002), column (003) and bedplate (005) together at four locations around each cylinder.

Fig 5-5 Tie rod (generic)



Legend

001	Protection cover	004	Tie rod
002	Cylinder block	005	Bedplate
003	Column		

If a tie rod breaks in the bottom area, a special device makes sure that the nut of the tie rod does not fall into the crankcase.

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5.2 Group 2 - Cylinder

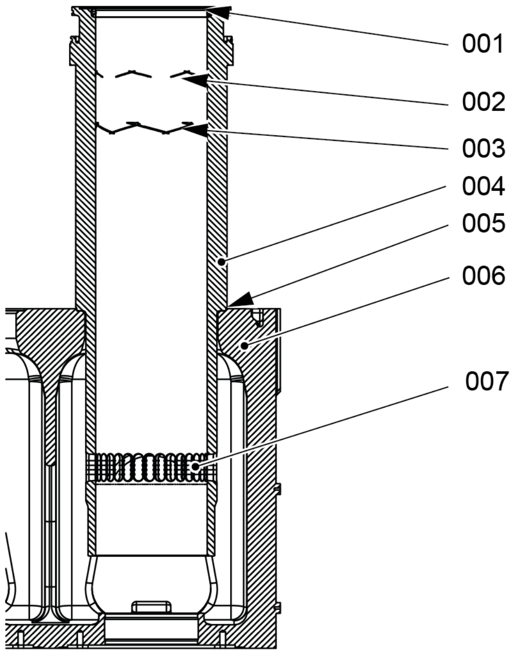
5.2.1 Cylinder liner

The cylinder liner (004, Figure 5-6) is one of the primary parts of the engine. The cylinder liner (004) is on the cylinder jacket (006) and holds the cylinder cover and the water guide jackets. The nuts and the elastic bolts hold these parts together.

The surfaces of the cylinder liner (004) and the cylinder jacket (006) make a metallic seal (005). A non-hardening compound is applied around the surface of the metallic seal to prevent leakage.

The antipolishing ring (001) is installed in the top part of the cylinder liner (004). The antipolishing ring removes coke contamination at the piston crown during operation.

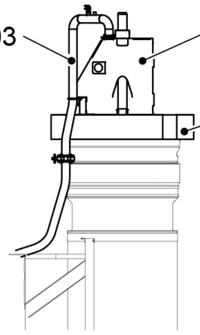
Fig 5-6 Cylinder liner (generic)



Legend

001 Antipolishing ring
002 Oil grooves
003 Lubricating grooves
004 Cylinder liner
005 Metallic seal
006 Cylinder jacket
007 Scavenge ports

Fig 5-7 Cylinder - cooling water outlet (generic)



Legend

001 Exhaust valve cage
002 Cylinder cover
003 Cooling water outlet

Cooling water flows from the bottom water guide jacket to the top water guide jacket. Then the cooling water flows into the cylinder cover (002, Figure 5-7) and the exhaust valve cage (001). The cooling water flows back through the cooling water outlet (003) to the cooling water system of the plant.

To prevent unwanted tension in the top part of the cylinder liner (004, Figure 5-6), the temperature of the cooling water must stay in the permitted range:

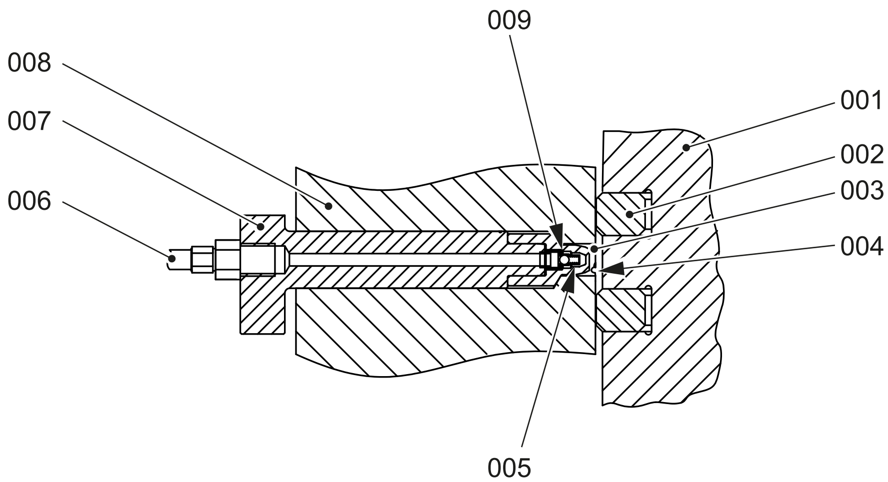
- ±2°C at constant load
- ±4°C during load changes.

5.2.2 Lubricating quill

The lubricating quills spray oil onto the cylinder liner wall. The lubricating quills are installed on the circumference of the cylinder liner.

The cylinder lubricating pump supplies a specified quantity of cylinder oil at high pressure through the cylinder oil inlet (006, Figure 5-8) into the lubricating quills. The non-return valve (009) opens and the cylinder oil flows out of the nozzle tip (003) and the lubricating point (004) as a spray. Some of the cylinder oil flows into the grooves of the cylinder liner wall. The non-return valve (009) prevents the exhaust gas to flow back into the oil pipe.

Fig 5-8 Lubricating quill (generic)



Legend

001	Piston	006	Cylinder oil inlet
002	Piston ring	007	Holder
003	Nozzle tip	008	Cylinder liner
004	Lubricating point in cylinder liner	009	Non-return valve
005	Compression spring		

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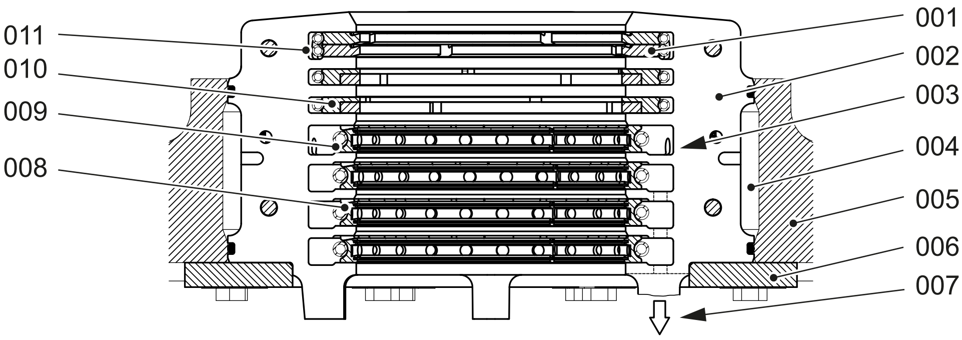
5.2.3 Piston rod gland

The piston rod gland keeps the dirty cylinder oil in the scavenge space and thus prevents contamination of the bearing oil in the crankcase. Also, the piston rod gland seals the scavenge air from the crankcase.

Use the sample valve to get system oil samples regularly. The analysis of this oil gives data about the quality of the cylinder lubrication.

Do regular checks of the leakage oil drain to make sure that oil flows freely. This prevents the risk of fire.

Fig 5-9 Piston rod gland (generic)



Legend

001	Scraper ring (4-part)	007	Oil drain
002	Housing (2-part)	008	Ring support (3-part)
003	Relief opening	009	Scraper ring (3-part)
004	Neutral space	010	Gasket (4-part)
005	Cylinder jacket	011	Tension spring
006	Support		

During operation, the two scraper rings (001, Figure 5-9) remove dirty oil from the piston rod. The dirty oil flows through oil bores and collects in the bottom of the scavenge space. The dirty oil flows out through the leakage oil drain on the fuel side.

The two gaskets (010) prevent the release of scavenge air into the crankcase.

The oil that flows through the relief openings (003) into the neutral space (004) flows into the oil drain.

The ring supports (008) hold the scraper rings (009) in position. The scraper rings (009) remove bearing oil from the piston rod. This bearing oil flows through the oil drain (007) to the crankcase.

The tension springs (011) push the scraper rings (009) and (012) against the piston rod.

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5.2.4 Direct controlled injection valve

The injection valves are installed in the cylinder cover of each cylinder. The injection valves spray the fuel into the combustion chamber. The ECS controls the pilot valve of the injection valves indirectly through the solenoid valve. ECS also controls the timing and the quantity of the injected fuel.

For detailed injection valve instructions, open the chapter: List of service bulletins.

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5.2.5 Starting valve

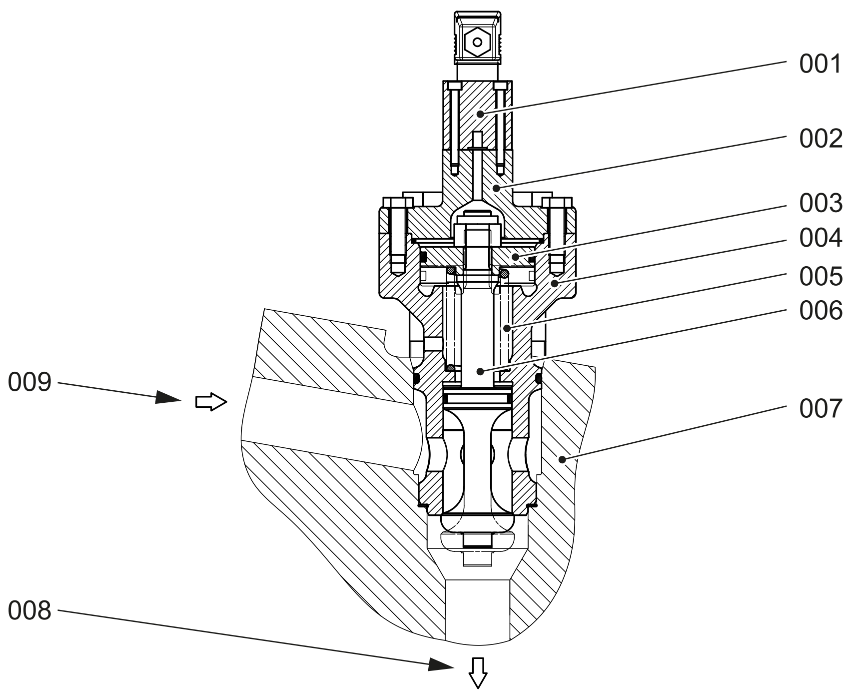
The starting valve in each cylinder cover supplies pressurized air into the combustion chamber in the two situations that follow:

- To start the engine before combustion starts
- To decrease the engine speed when combustion has stopped.

The ECS and the cylinder control modules (CCM-20) control and monitor the starting valves. Each starting valve opens and closes at the correct crank angle of the related cylinder. This makes the piston move down (for engine start) or makes the piston speed decrease (for engine speed decrease).

As soon as combustion starts the starting air supply stops.

Fig 5-10 Starting valve (example)



Legend

001	Solenoid valve	006	Valve spindle
002	Cover	007	Cylinder cover
003	Piston	008	Starting air outlet
004	Housing	009	Starting air inlet
005	Compression spring		

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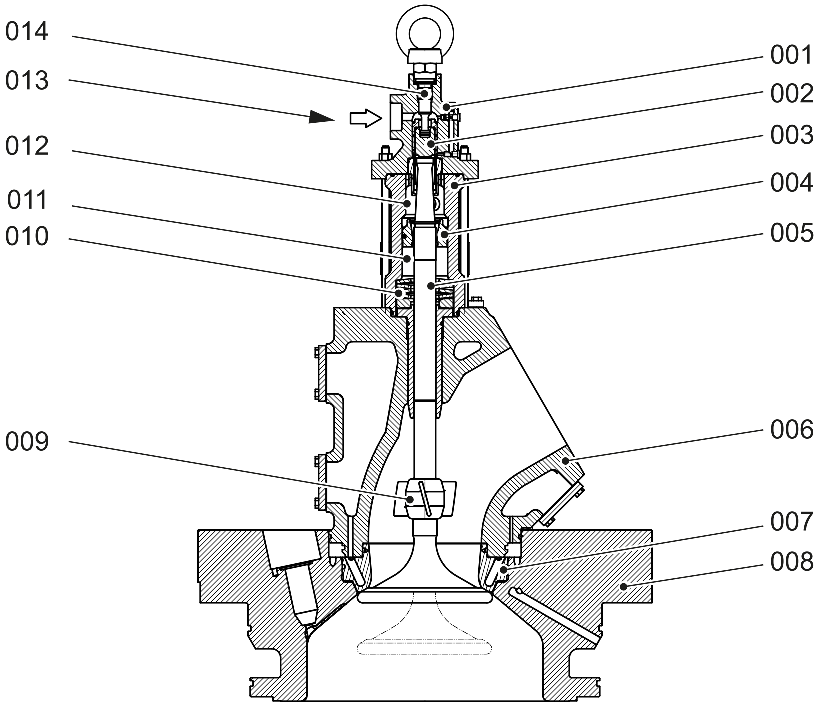
5.2.6 Exhaust valve

The exhaust valve in each cylinder cover releases the exhaust gas of the combustion into the exhaust gas manifold. The hydraulic oil pressure from the exhaust valve control unit (VCU) opens the exhaust valve. The pneumatic pressure of the air spring closes the exhaust valve.

Fig 5-11 Exhaust valve (generic)



Legend

001 Upper housing
002 Inside piston and outside piston
003 Lower housing
004 Air spring piston
005 Valve spindle
006 Valve cage
007 Valve seat
008 Cylinder cover
009 Rotation wing
010 Cup spring
011 Air spring
012 Leakage oil collection space
013 Hydraulic oil inlet
014 Damper

The exhaust valve has the parts that follow:

- **Inside piston and outside piston**

  The inside piston and the outside piston (002, Figure 5-11) move down when the VCU applies pressurized oil through the hydraulic oil inlet (013). The valve spindle (005) moves down and the valve seat (007) is open.

- **Rotation wing**

  The exhaust gas applies a force on the rotation wing (009). This turns the valve spindle (005) to balance the heat and mechanical forces and to prevent particles on the exhaust valve.

- **Air spring**

  When the exhaust valve is closed, compressed air flows through an air inlet connection into the air spring (011). When the exhaust valve opens, this air is compressed to a higher value. When the hydraulic oil pressure releases, the compressed air expands and thus closes the exhaust valve.

- **Thrust piece**

  The thrust piece on the valve spindle (005) prevents damage to the inside piston (002) and to the top of the valve spindle (005) when the exhaust valve operates.

- **Valve stroke sensor**

  The valve stroke sensor monitors and transmits the open and closed positions of the valve spindle (005) to the ECS.

- **Cup spring**

  The cup spring (010) absorbs vibration and shock to prevent damage to the exhaust valve.

Different parts of the exhaust valve are lubricated as follows:

- Leakage oil from the outer piston and inner piston (002) lubricates the air spring piston (004). Oil in the leakage oil collection space (012) drains to the leakage oil drain.
- While the exhaust valve closes, oil flows through the air spring piston (004) and into the air spring (011). The air in the air spring (011) changes oil that collects at the bottom of the air spring into a mist. The mist lubricates the upper part of the valve spindle (005).
- Oil that collects at the bottom of the air spring (011) flows through a groove on the lower side of the distance ring and through holes in the guide bush. Thus the oil lubricates the bottom part of the valve spindle (005).
- When the exhaust valve opens, oil flows out of the air spring (011) through the throttle valve in the air spring pipe to the collector for leakage oil. The oil in the collector automatically drains through the leakage oil pipe into the crankcase.

5.3 Group 3 - Crankshaft, connecting rod and piston

5.3.1 Crankshaft

The crankshaft turns as it gets the power from the pistons. The crankshaft transmits the power to the attached propeller shaft of the ship.

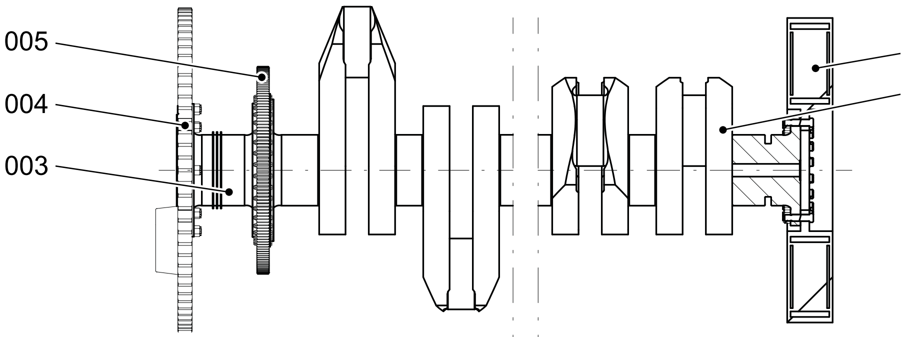
Main bearings on the two sides of each crank (002, Figure 5-12) hold the crankshaft in position.

The crankshaft gear wheel (005) is part of the thrust bearing.

On the driving end of the crankshaft there is a flywheel (004). This flywheel decreases the pulsation from the cylinders.

The length of the crankshaft is related to the number of cylinders.

Fig 5-12 Crankshaft (generic)



Legend

001	Torsional vibration damper (optional)	004	Flywheel
002	Crank	005	Crankshaft gear wheel
003	Crankshaft		

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5.3.2 Torsional vibration damper

The torsional vibration damper decreases the torsional vibrations in the shafting system and in other components of the engine.

If a torsional vibration damper is necessary for the engine, one of the two damper types that follow can be used.

5.3.2.1 Steel spring damper

A steel spring damper (Figure 5-13) is a tuned torsional vibration damper. It consists of two main parts:

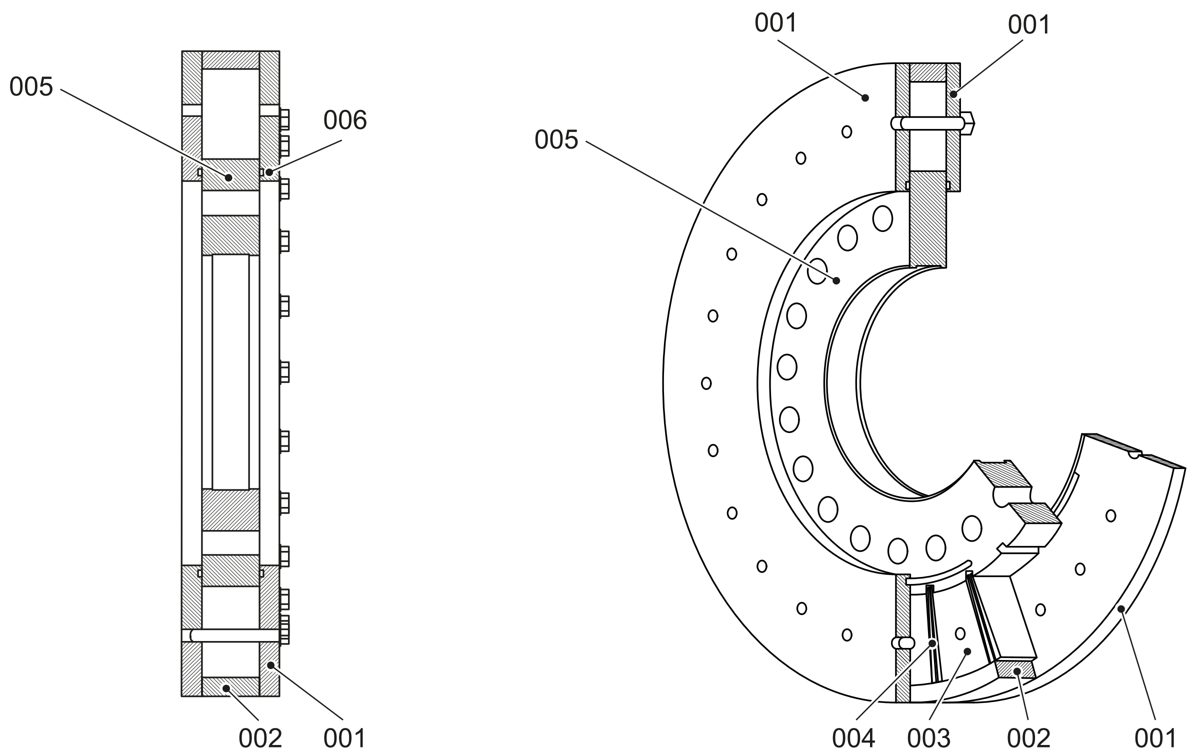
- The inner part (inner star (005) and spring pack (004)) is attached to the crankshaft flange at the free end.
- The outer part (side plates (001), clamping ring (002) and intermediate pieces (003)) is connected with spring packs (004) to the inner part.

The damper is supplied with pressurized system oil that fills the chambers between the inner and outer part. The usual setting value for the oil supply pressure is 2.8 bar. But the setting value can be different, refer to the specification of the damper manufacturer.

If torsional vibrations move the steel springs, oil is pressurized on one side of the oil chambers and pushed through small clearances to the other side of the chambers. This small oil flow creates the damping effect of the damper. The combined effect of spring stiffness and damping decreases the torsional vibrations in the shafting system. The damping work causes heat which is dissipated by the oil flow. The oil drains into the crankcase.

The optional damper monitoring system monitors the dynamic twist in the damper and the oil supply pressure.

Fig 5-13 Steel spring damper (generic)



Legend

001	Side plate	004	Spring pack
002	Clamping ring	005	Inner star
003	Intermediate piece	006	Sealing

5.3.2.2 Viscous damper

A viscous damper (Figure 5-14) is a tuned torsional vibration damper. It consists of two main parts:

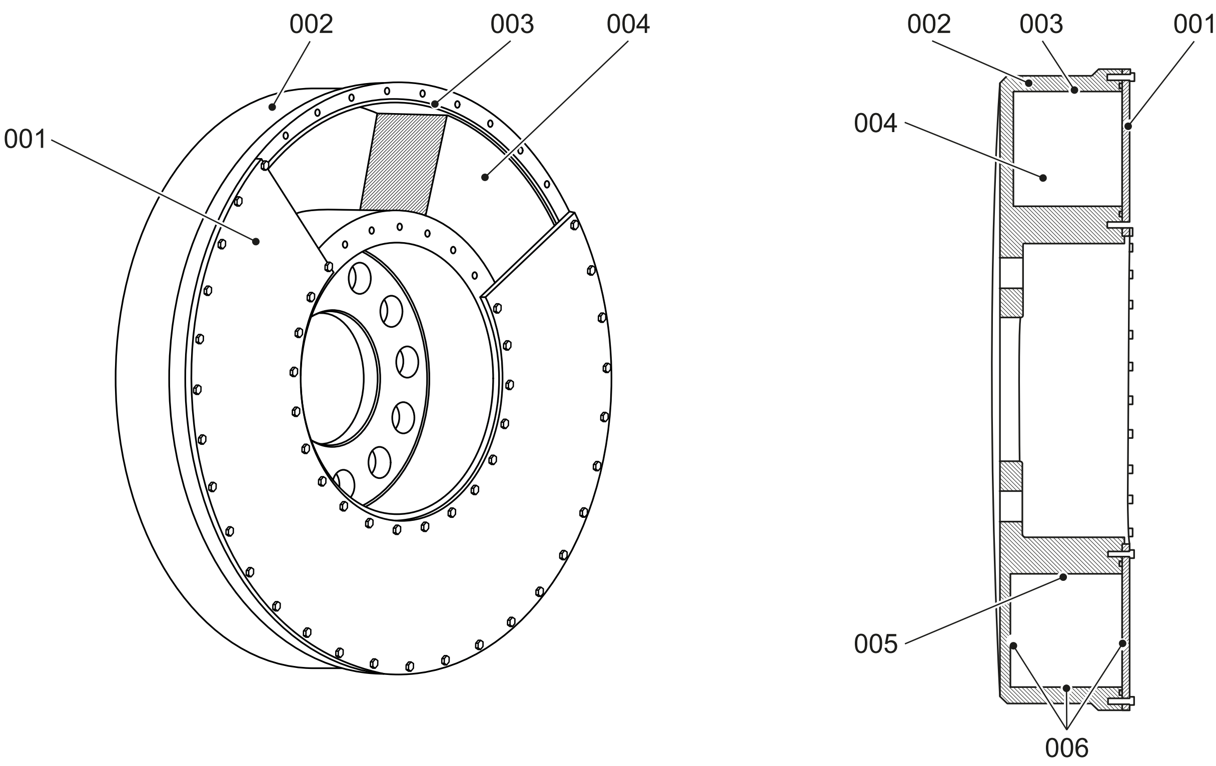
- The housing (002) is fully sealed and is attached to the crankshaft flange at the free end.
- The inertia ring (004) is in the housing. The bearing (005) holds the inertia ring in the housing.

Between the housing and the inertia ring there is a layer of silicone oil (006) of a specified viscosity. If no torsional vibrations occur during engine operation, the housing and the inertia ring turn with the same speed, as the silicone oil transfers the torque. If torsional vibrations occur during engine operation, the housing and the inertia ring dynamically turn at different speeds. This difference shears the silicone oil and thus decreases the vibration.

The damping work causes heat. This heat increases the temperature of the outer side of the damper. The heat dissipates to the ambient air in the crankcase. If installed, system oil is sprayed on the damper to dissipate more heat. The oil drains into the crankcase.

If the viscous damper gets too much dynamic torque and thus causes too much heat, the viscosity of the silicone oil can change. Then the damping effect can change. Thus do regularly a check of the viscosity of the silicone oil, refer to the Maintenance Manual.

Fig 5-14 Viscous damper (generic)



Legend

001	Cover
002	Housing
003	Sealing
004	Inertia ring
005	Bearing
006	Silicone oil

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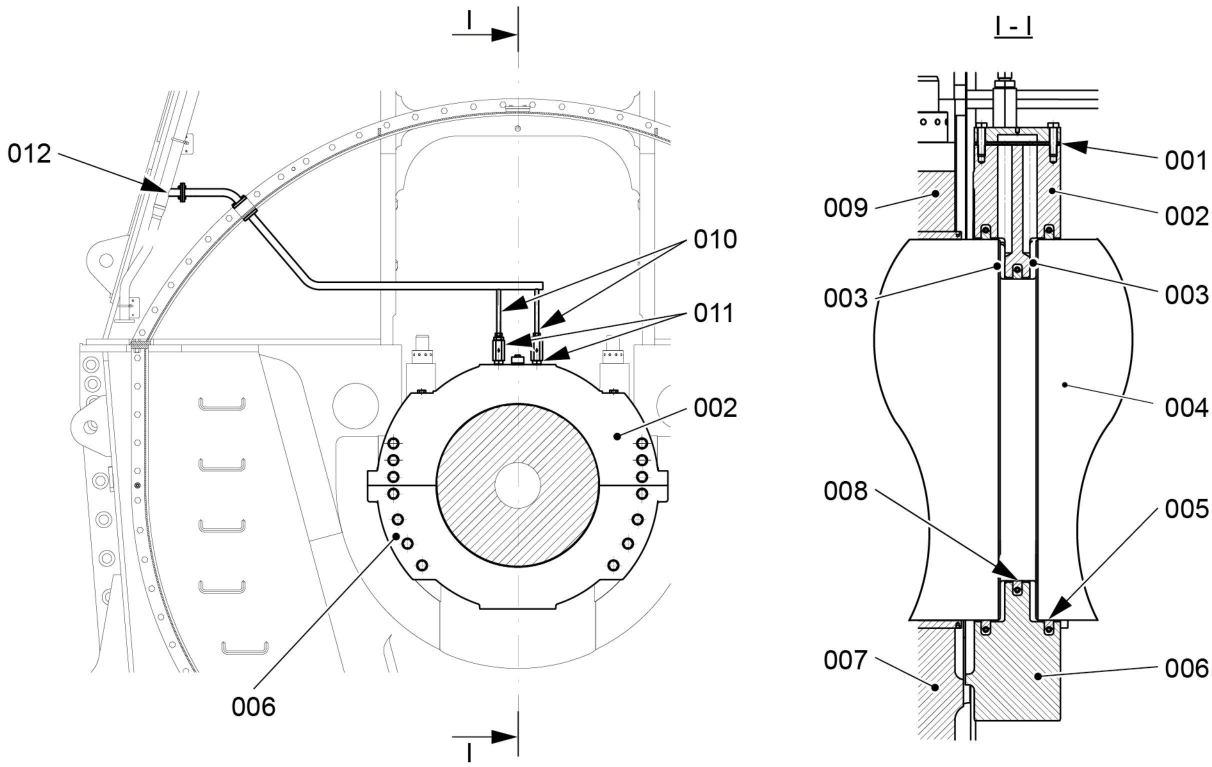
5.3.3 Axial vibration damper

The axial vibration damper decreases the axial vibrations of the crankshaft. The axial vibration damper is attached with bolts to the last bearing girder at the free end of the engine.

The axial vibration damper includes a top cylinder half (002, Figure 5-15) and a bottom cylinder half (006).

Fig 5-15 Axial vibration damper (generic)



Legend

001	Control plate	007	Bearing girder (part of bedplate)
002	Top cylinder half	008	Small sealing ring
003	Annular space	009	Bearing cover
004	Crankshaft	010	Inlet pipe
005	Large sealing ring	011	Non-return valve
006	Bottom cylinder half	012	Oil inlet

5.3.3.1 Function

Oil flows from the oil inlet (012) through the top cylinder half (002) into the two annular spaces (003). When the crankshaft (004) moves in an axial direction, the pressure of the oil in the compressed annular space (003) increases. This makes the oil slowly flow through the small holes in the control plate (001) into the other annular space (003). This slow oil flow decreases the axial vibrations. When the pressure is equal again in the two annular spaces (003), the oil flow stops.

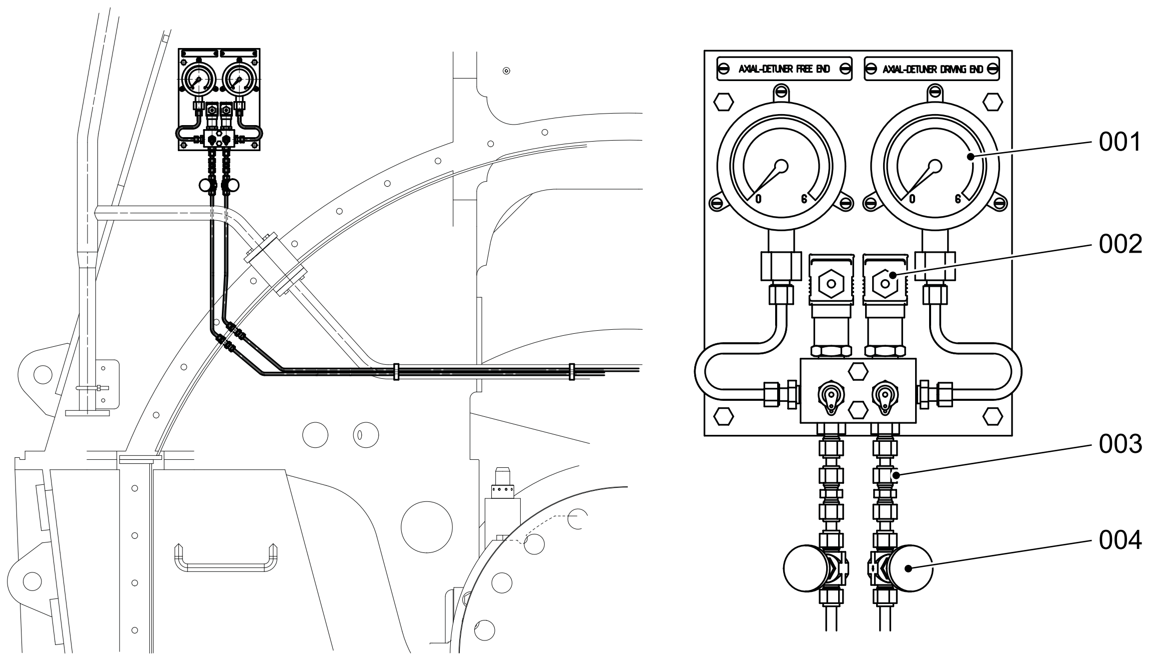
The constant oil flow through the vent bore in the top cylinder half (002) keeps air away from the annular spaces (003).

The small oil leakage through the gap of the large sealing rings (005) drains into the crankcase.

5.3.3.2 Axial vibration damper monitor

The axial vibration damper monitor monitors the oil pressure in the two annular spaces (003, Figure 5-15) of the axial vibration damper. The needle valve (004, Figure 5-16) and the throttle (003) prevent fast movement of the pointer in the pressure gauges (001).

Fig 5-16 Axial vibration damper monitor (generic)



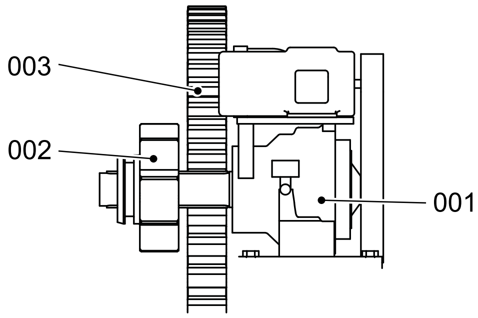
Legend

001	Pressure gauge	003	Throttle
002	Pressure transmitter	004	Needle valve

5.3.4 Turning gear

The turning gear slowly turns the crankshaft and thus moves the pistons, if the pinion (002, Figure 5-17) is engaged on the flywheel (003). The electric motor (001) turns the pinion (002) and is attached on the driving end of the engine. Related to the ratio of the gear wheels there is approximately one full turn of the crankshaft in ten minutes.

Fig 5-17 Turning gear (generic)



Legend

001	Electric motor	003	Flywheel
002	Pinion		

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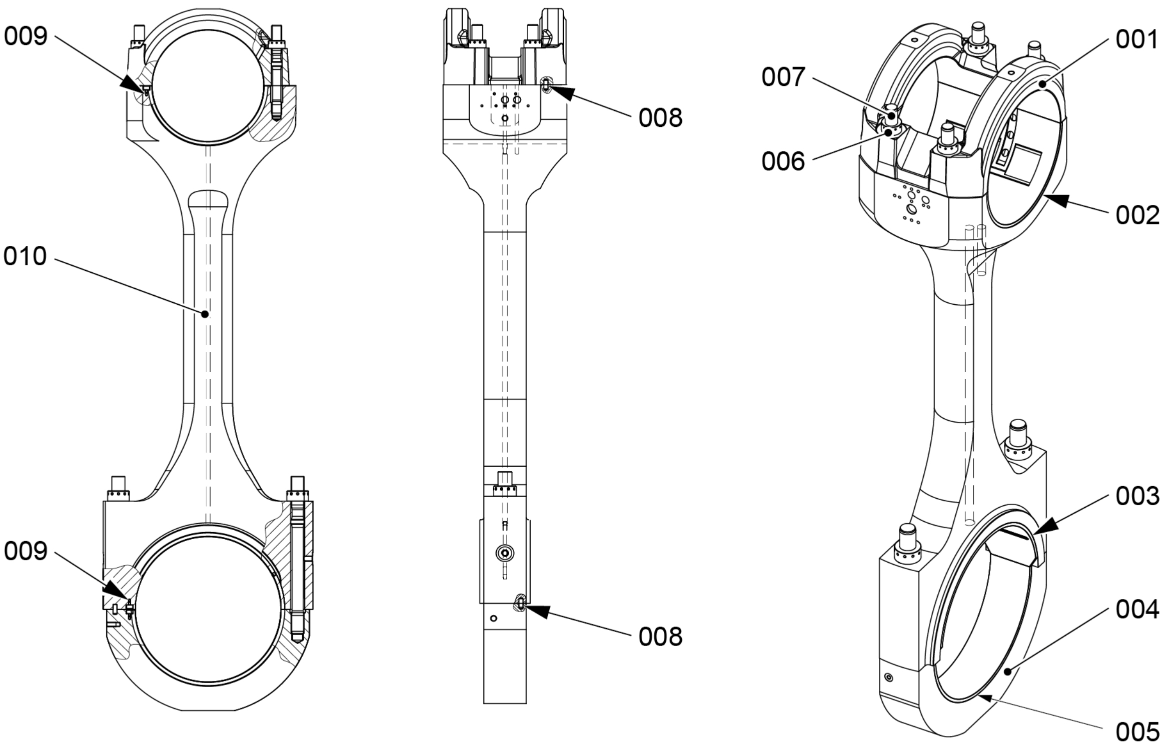
5.3.5 Connecting rod and connecting rod bearing

The connecting rod connects the crosshead with the crankshaft and converts the linear movement of the piston into a circular movement of the crankshaft.

The bearing shells are installed on the connecting rod for the bottom end bearing and the top end bearing. The top bearing cover is lined with white metal.

Crosshead lubricating oil flows through the guide shoe into the crosshead pin. A hole in the crosshead pin lets lubricating oil flow into the bearing shells.

Fig 5-18 Connecting rod and connecting rod bearing (generic)



Legend

001	Top bearing cover	006	Round nut
002	Bearing shell (top end bearing)	007	Elastic bolt
003	Top bearing shell (bottom end bearing)	008	Dowel pin
004	Bottom bearing cover	009	Allen screw
005	Bottom bearing shell (bottom end bearing)	010	Oil bore

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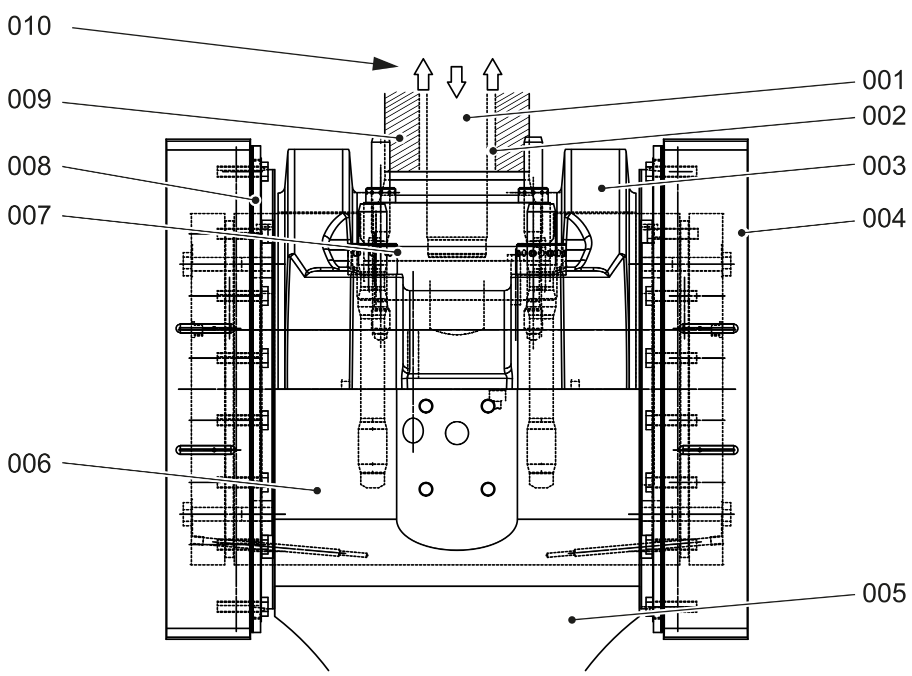
5.3.6 Crosshead and guide shoe

The crosshead guides the piston rod (009, Figure 5-19) and absorbs the lateral forces that come from the connecting rod (005).

The piston rod (009) is attached to the compression shim (007) and the crosshead pin (006) with screws. The bearing oil necessary to keep the piston cool, flows through the space (002) to the piston. The oil from the piston flows back through the oil pipe (001) to the crosshead pin (006). Then the oil flows into the crankcase.

The guide shoes (004) are attached to the crosshead pin (006) and move up and down on the guide ways of the column. The guide rails (008) hold the guide shoes (004) and thus the crosshead in the horizontal position.

Fig 5-19 Crosshead and guide shoe (example)



Legend

001 Oil pipe (from piston)
002 Space
003 Top bearing half (top end bearing)
004 Guide shoe
005 Connecting rod
006 Crosshead pin
007 Compression shim
008 Guide rail
009 Piston rod
010 Oil flow (to piston and from piston)

Page left intentionally blank

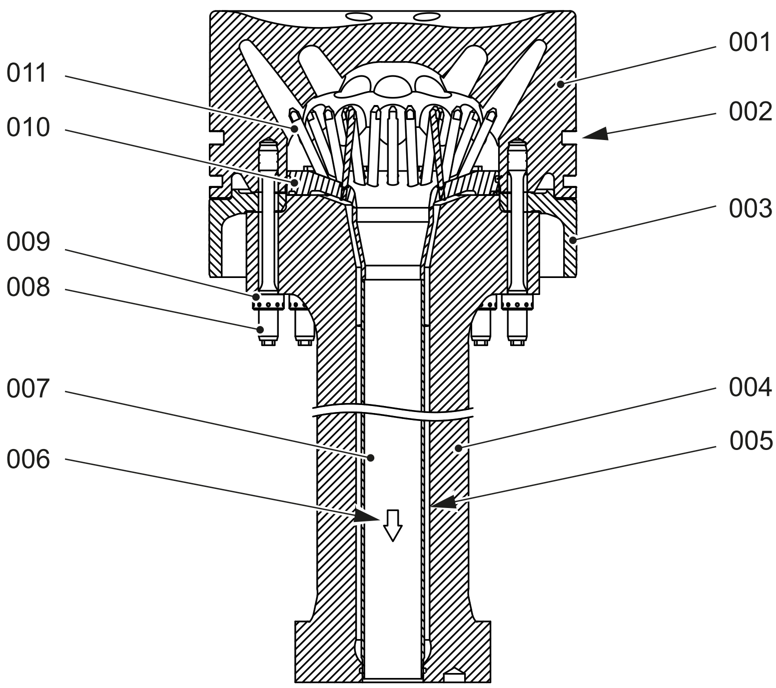
5.3.7 Piston

The piston moves in each cylinder. The piston rings seal the combustion chamber. The piston transmits the force from the gas that expands in the cylinder to the crankshaft through the connecting rod.

Elastic bolts (008, Figure 5-20) and round nuts (009) attach the piston crown (001) to the piston rod (004). The piston skirt (003) is attached to the piston rod with screws. The piston rod (004) is attached to the crosshead pin in a specified position. The compression shims are installed between the piston rod and the crosshead pin. The thickness of the compression shims is related to the specified compression ratio.

System oil is used to keep cool the piston crown (001). This oil flows from the crosshead pin into the space (005) between the oil pipe (007) and the piston rod (004). The oil then flows to the spray plate (010). The oil comes out as a spray from the nozzles (011) into the cooling bores of the piston crown (001). The oil then flows through the oil pipe (007) into the crosshead pin and out through the oil bores to the crankcase.

Fig 5-20 Piston (example)



Legend

001	Piston crown	007	Oil pipe (from piston crown)
002	Piston ring groove	008	Elastic bolt
003	Piston skirt	009	Round nut
004	Piston rod	010	Spray plate
005	Space	011	Nozzle
006	Oil flow		

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5.4 Group 4 - Supply unit drive and control components

5.4.1 Supply unit drive

The supply unit drive is installed at the driving end of the engine on the fuel side.

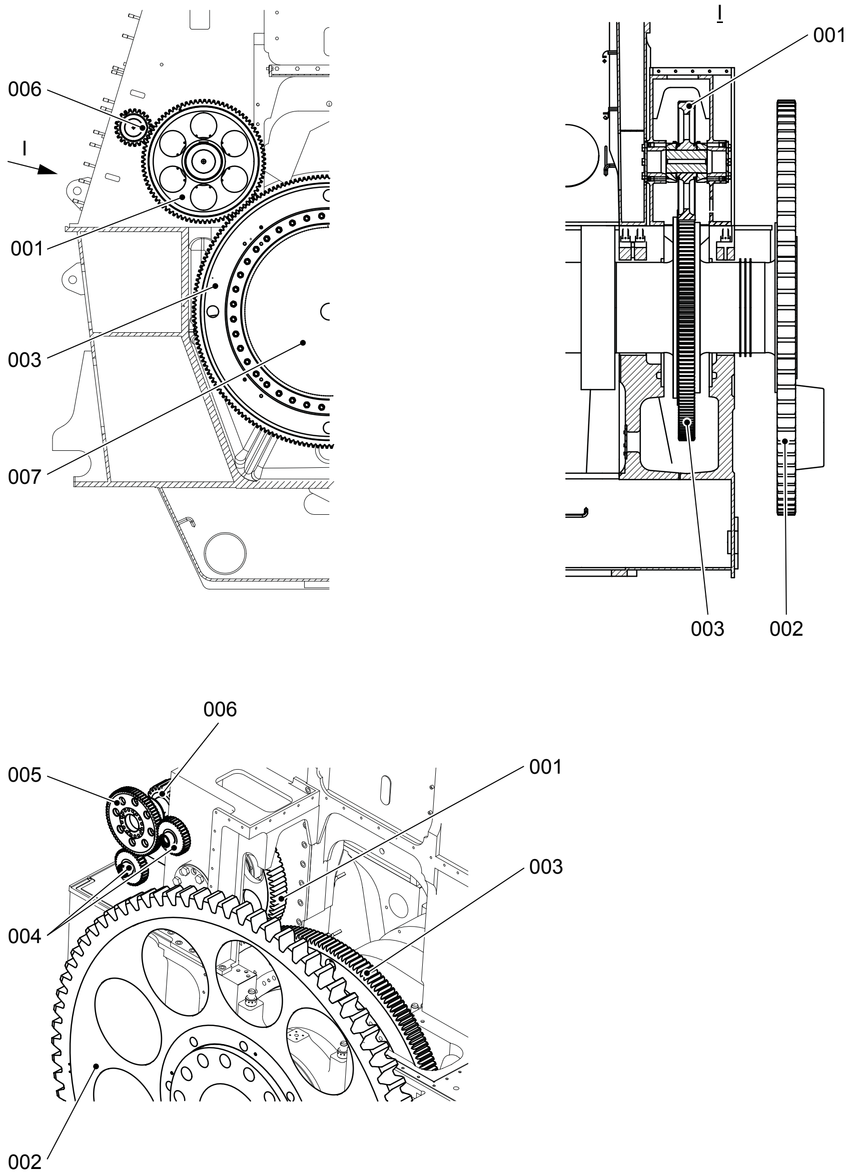
The crankshaft gear wheel (003, Figure 5-21) moves the intermediate wheel (001). The intermediate wheel (001) moves the intermediate wheel (006).

The gear wheel (005) operates the gear wheels (004) for the servo oil pumps. The camshaft of the gear wheel (005) also operates the fuel pumps.

Oil flows through an oil inlet to lubricate the bearings of the gear wheels (004). Oil also flows through the nozzles in the bearing housing to lubricate the teeth of the gear wheels (004) and the gear wheel (005).

If you hear unusual noises from the area of the supply unit drive, you must find the cause and repair the fault immediately.

Fig 5-21 Supply unit drive (generic)



Legend

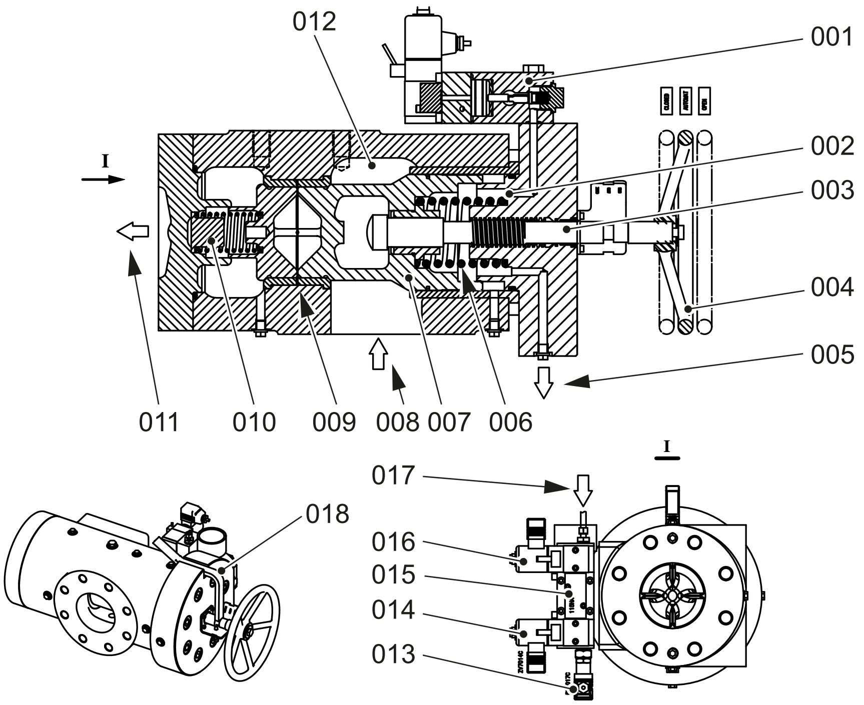
001 Intermediate wheel
002 Flywheel
003 Crankshaft gear wheel
004 Gear wheel (servo oil pump)
005 Gear wheel (servo oil pumps)
006 Intermediate wheel
007 Crankshaft

5.4.2 Starting air shut-off valve

The starting air shut-off valve supplies the starting air pipe with starting air. The starting air shut-off valve has a hand-wheel with three positions:

- CLOSED
- AUTO
- OPEN.

Fig 5-22 Starting air shut-off valve (example)



Legend

001	Control valve	010	Non-return valve
002	Valve space	011	Starting air outlet
003	Spindle	012	Inlet chamber
004	Hand-wheel	013	Pressure switch PS5017C
005	To test valve	014	Solenoid valve CV7014C
006	Spring	015	Double check valve
007	Valve	016	Solenoid valve CV7013C
008	Starting air inlet	017	Control air inlet
009	Balance bore	018	Lever

With the lever (018, Figure 5-22) you can lock the valve in the selected position. During usual operation the starting air shut-off valve is in position AUTO.

Starting air flows through the starting air inlet (008) into the inlet chamber (012), then through the balance bore (009) into the valve space (002). The spring (006) and the pressure in the valve space (002) keep the valve (007) closed.

During the start sequence the MCM-20 / IOM-20 module operates the solenoid valves (014) and (016). The control air from the control air inlet (017) opens the control valve (001) through the solenoid valve CV7014C (014) and releases the pressure in the valve space (002). The valve (007) opens and starting air from the inlet chamber (012) flows through the non-return valve (010) to the starting air outlet (011).

When the control valve (001) closes, starting air flows through the balance bores (009) and fills the inlet chamber (012) again. The valve (007) closes.

The starting air shut-off valve has a test valve. You can use this test valve for a function check of the starting air shut-off valve.

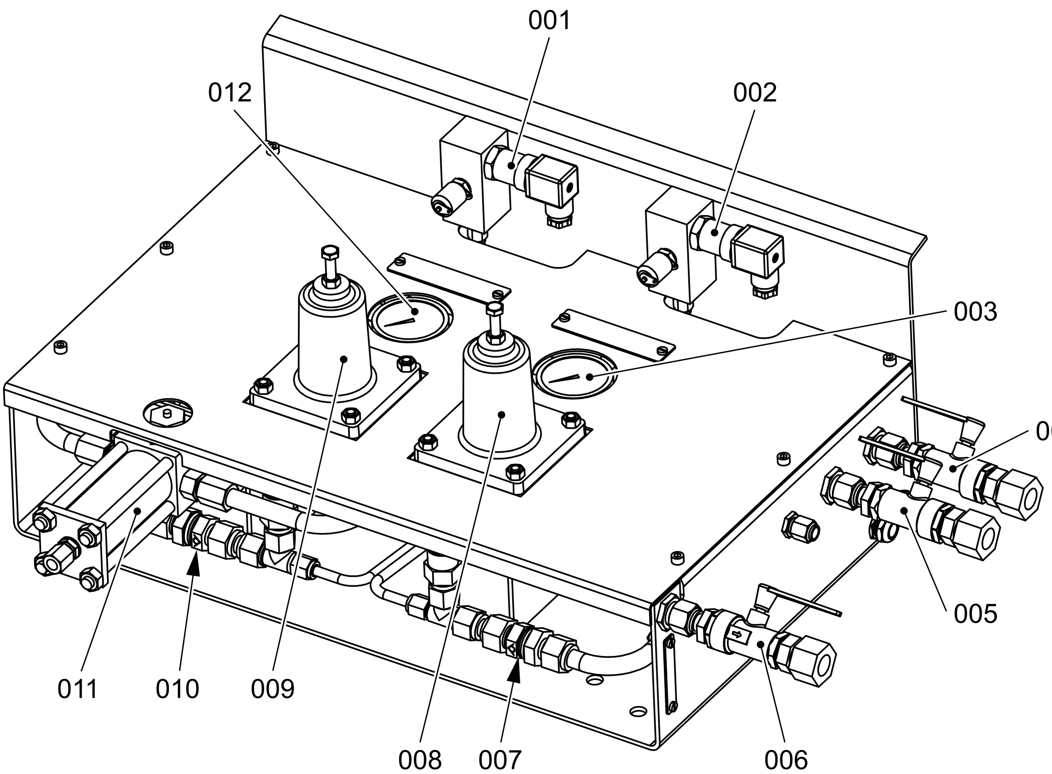
5.4.3 Control air supply

The control air supply supplies control air to the engine. The plant supply systems supply compressed air with the specified properties at the two engine connections that follow:

- Connection 45 (control air supply inlet) for usual supply
- Connection 40 (Starting air pipe inlet) for stand-by supply.

The pressure reducing valves (008, Figure 5-23) and (009) decrease the pressure of the compressed air to the set values. If the plant supply system for control air becomes defective, the supply changes over to stand-by supply. The non-return valves (007) and (010) control the automatic change over of the compressed air supply.

Fig 5-23 Control air supply (generic)



Legend

001	Pressure transmitter PT4411A	007	Non-return valve 35-342HA
002	Pressure transmitter PT4401A	008	Pressure reducing valve 35-23HA
003	Pressure gauge PI4401L	009	Pressure reducing valve 35-19HA
004	3/2-way valve 35-36HB (connection point A1)	010	Non-return valve 35-342HB
005	3/2-way valve 35-36HC (connection point A2)	011	Air filter 35-351HA
006	3/2-way valve 35-36HA (connection point A6)	012	Pressure gauge PI4411L

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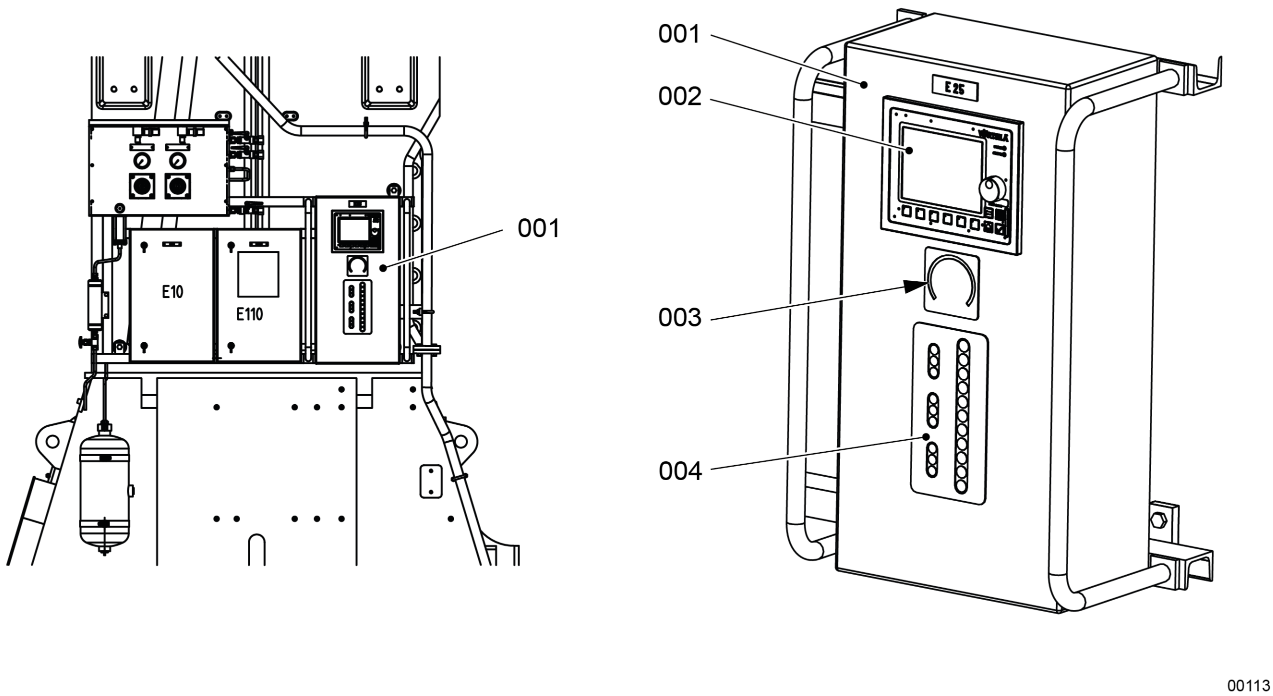
5.4.4 Local maneuvering stand

The local maneuvering stand has the local control panel (001, Figure 5-24) and is attached to the engine at the free end. The local control panel has the components necessary for engine operation. Some components can look different because the remote control manufacturer supplies the local control panel (001).

For data about maneuvering instructions, refer to section 8.9 Maneuver the ship - general.

Fig 5-24 Local maneuvering stand (generic)



Legend

001 Local control panel
002 LDU-20
003 Main engine tachometer
004 Telegraph receiver

5.4.4.1 Local control panel

NOTE: If a fault occurs in the remote control, which prevents engine control from the control room, you can operate the engine from the local control panel.

The local control panel (001) has the electronic components that follow:

- **Local display unit (LDU-20)**

  There are two LDU-20 (002, Figure 5-24). One LDU-20 is installed in the local control panel (001). The other LDU-20 is installed in the engine control room. The two LDU-20 operate independently from the remote control system. For more data about the LDU-20, refer to section 6.6 Local display unit (LDU-20) - general.

- **ME tachometer**

  The ME tachometer (003) shows the engine speed in the ahead or astern directions.

- **Emergency stop button**

  NOTE: Not all local control panels have an emergency stop button installed.

  When you operate the emergency stop button (not shown), the engine stops immediately.

  The fuel pressure control valve (PCV) releases the pressure in the fuel rail. At the same time, the fuel pump supply decreases to 0 (zero).

  - For data about the PCV, refer to section 5.5.4 Pressure control valve.
  - For data about engine stop, refer to section 8.16 Stop the engine.

- **Telegraph receiver**

  The telegraph system is part of the propulsion control system, refer to section 6.1 Engine control system.

5.4.5 Pick-up for speed measurement

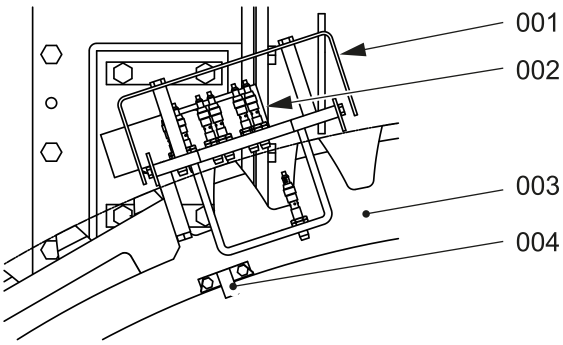
To measure the engine speed (rpm), proximity sensors are installed in a speed pick-up unit, attached to the support near the flywheel.

For safety, there are three electrically isolated proximity sensor groups as follows:

- Speed identification in the remote control system (RCS)
- Overspeed safety system
- Speed control system.

The proximity sensors measure the speed of the flywheel (003, Figure 5-25). When the flywheel turns, the proximity sensors (002) sense the movement of the teeth. The engine control system sends signals to the RCS to monitor the load and speed related functions. Data are also sent to the speed indication instruments.

Fig 5-25 Pick-up for speed measurement (generic)



Legend

001	Cover	003	Flywheel
002	Proximity sensor	004	Crank angle mark

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5.5 Group 5 - Supply unit, pumps and control valves

5.5.1 Servo oil pump

The servo oil pumps (004, Figure 5-26) supply the servo oil system with oil during usual operation. The number of servo oil pumps is related to the engine.

The pressure value is related to the engine load. The electrically controlled system adjusts the system pressure for the full load range, ie high pressure (approximately 300 bar) at high engine load, and decreased pressure at low engine load.

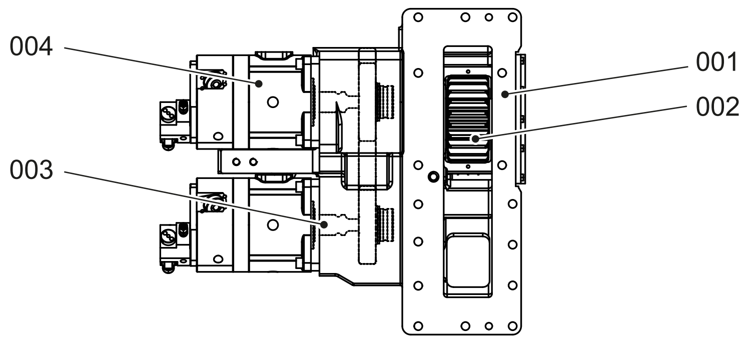
Flow sensors monitor the oil supply in each inlet pipe of the servo oil pumps. A malfunction of a servo oil pump will show in the alarm and monitoring system.

If a servo oil pump cannot turn, for safety the waisted shaft (003) will break. This will prevent too much damage to the supply unit drive.

Also if one servo oil pump becomes defective, the engine can continue to operate at full load.

NOTE: Do not operate the engine with a defective servo oil pump for too long. You must replace a defective servo oil pump as soon as possible.

Fig 5-26 Servo oil pump (example)



Legend

001	Supply unit	003	Shaft
002	Intermediate wheel (supply unit)	004	Servo oil pump

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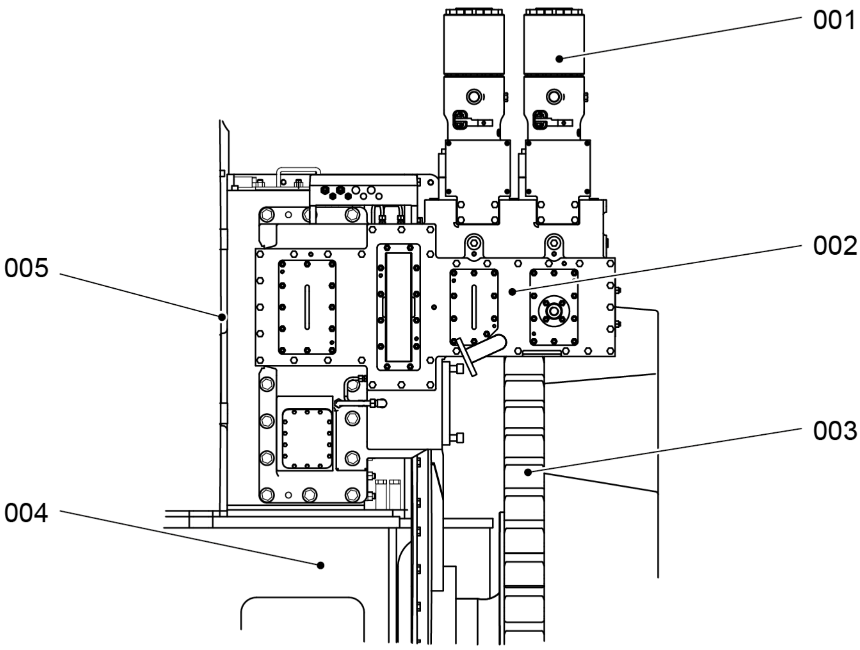
5.5.2 Supply unit

The supply unit includes the servo oil pumps and the fuel pumps. The supply unit is installed on the column at the driving end of the engine. The gear wheels and intermediate wheels in the supply unit operate the fuel pumps and servo oil pumps, refer to section 5.4.1 Supply unit drive.

Fig 5-27 Supply unit (example)



Legend

001 Fuel pump
002 Supply unit with covers
003 Flywheel
004 Bedplate
005 Column

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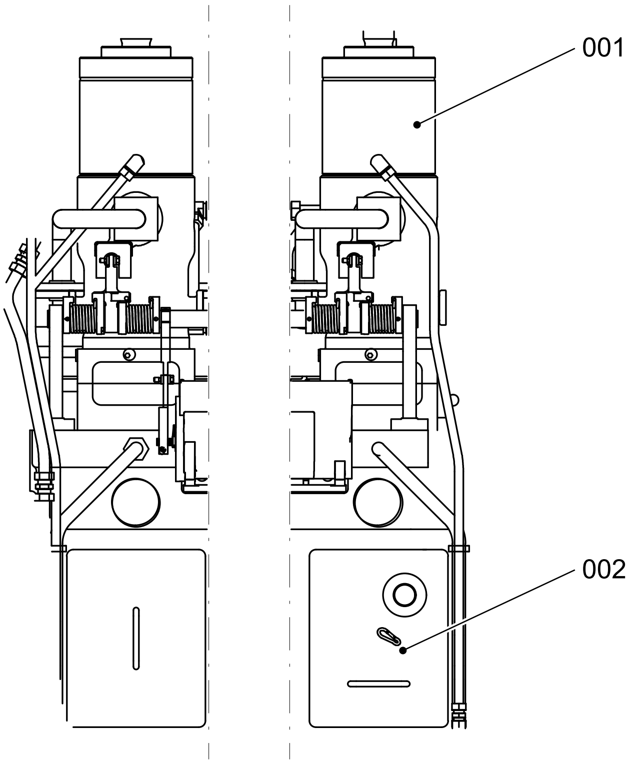
5.5.3 Fuel pump

The fuel pumps (001, Figure 5-28) supply the fuel rail with fuel at high pressure. The number of fuel pumps is related to the engine.

Fig 5-28 Fuel pump (generic)



Legend

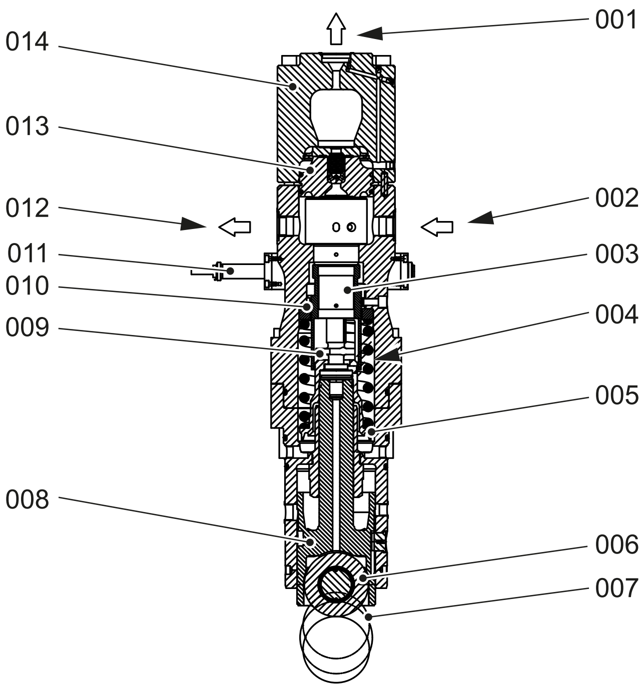
001	Fuel pump	002	Supply unit

5.5.3.1 Function

When the cam (007, Figure 5-29) moves the roller (006) up, the guide piston (008) moves up. Then the bottom spring carrier (005) compresses the compression spring (004). The pump plunger (003) then moves up. The control grooves in the pump plunger (003) control the fuel quantity.

When the toothed rack (011) moves, the teeth engage with the teeth on the regulating sleeve (010) and the regulating sleeve turns. The regulating sleeve (010) turns the driver (009) and thus the pump plunger (003). The quantity of fuel that goes into the plunger chamber is related to the control position (between 0 for zero supply and 10 for maximum supply).

Fig 5-29 Fuel pump - cross section (example)



Legend

001	HP fuel to fuel rail	008	Guide piston
002	Fuel inlet	009	Driver (of pump plunger)
003	Pump plunger	010	Regulating sleeve
004	Compression spring	011	Toothed rack
005	Bottom spring carrier	012	Fuel outlet
006	Roller	013	Non-return valve
007	Cam	014	Pump cover

5.5.3.2 Lubrication

Engine lubricating oil, which flows through the lubricating oil inlet into the bottom housing, lubricates the fuel pump.

Leakage fuel lubricates the pump plunger (003). The leakage fuel and the engine lubricating oil from the regulating sleeve (010) flows through the drain bore. This mixture then flows into an internal bore in the housing of the fuel pump unit.

5.5.3.3 Operation with an unserviceable fuel pump

If a fuel pump is unserviceable (eg the pump plunger cannot move) or the HP fuel pipe is broken (between the fuel pump and the fuel rail) the fault must be repaired immediately. If the fault cannot be repaired, it is possible to cut out the unserviceable fuel pump. Related to the number of installed fuel pumps, there are limits of operation.

5.5.4 Pressure control valve

The pressure control valve (PCV) (002, Figure 5-30) is attached to the fuel rail (007) and has the functions that follow:

- **Usual operation**

  During usual operation the engine software controls the fuel flow and thus the fuel pressure. The PCV is closed because the pressure in the fuel rail is lower than necessary to open the PCV.

- **Operation with a defective item**

  If an item becomes defective or unserviceable (for example missing or incorrect control signals, a flow control valve of a fuel pump is unserviceable), the operator must do the related procedures. Then the engine control sets the fuel pumps to the maximum flow and the PCV controls the pressure in the fuel rail. The PCV opens to gradually drain sufficient fuel to keep the adjusted pressure. Prevent a longer engine operation time in this operation mode to prevent a possible damage to the PCV.

  After this operation mode, do a check of the PCV for a tight seal. The seal can be damaged. You can hear a loud sound like a whistle. Replace the PCV seal if necessary.

- **Engine stand-by**

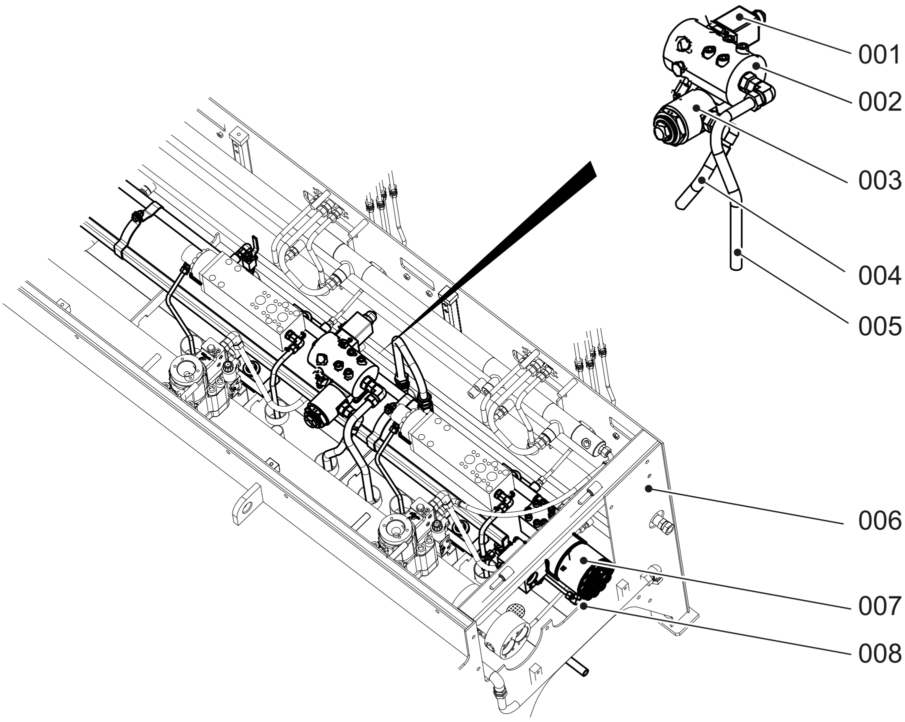
  During engine stand-by, the engine software opens the PCV. This gives a constant flow of fuel through the fuel system.

- **Emergency stop**

  If an emergency stop is activated, the safety system operates the solenoid valve (001) and the fuel pressure in the fuel rail decreases immediately to less than 200 bar (usually to 0 bar). Thus, fuel injection is not possible.

Attached to the PCV are the solenoid valve (001), the relief valve (003) and the fuel return pipes (004, 005). As a safety device the relief valve opens, if the fuel pressure is more than the specified pressure.

Fig 5-30 Pressure control valve - location (example)



Legend

001	Solenoid valve (ZV7061S)	005	Fuel return pipe
002	Pressure control valve (10-5562_E0_5)	006	Rail unit
003	Relief valve	007	Fuel rail
004	Fuel return pipe	008	Drain pipe

5.5.5 Flow limiting valve

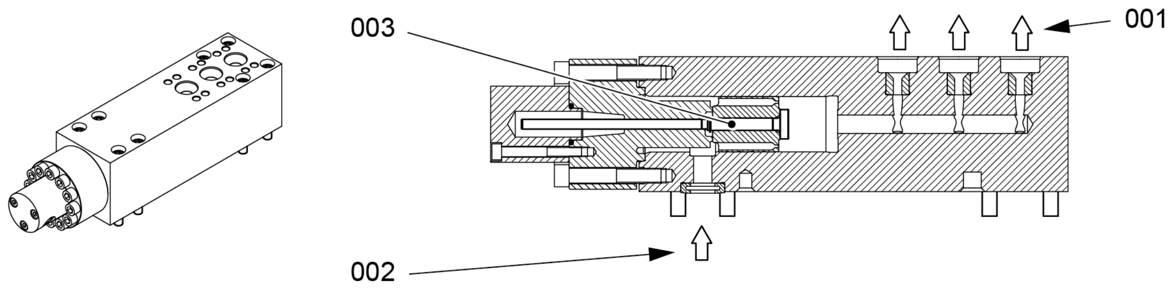
For each cylinder there is one flow limiting valve installed on the fuel rail.

The position of the piston (003, Figure 5-31) gives the quantity of fuel for the injection. When the injection valves open, the piston (003) moves to the right until the injection stops. When the injection valves are closed, the piston (003) moves back to the start position.

If the injection time is too long (for example if an injection valve is stuck open), the piston (003) closes the supply.

If an injection valve is damaged, the flow limiting valve sets the maximum limit of fuel that can be injected into the cylinder.

Fig 5-31 Flow limiting valve (generic)



Legend

001 Fuel outlet (number related to the engine)
002 Fuel inlet
003 Piston

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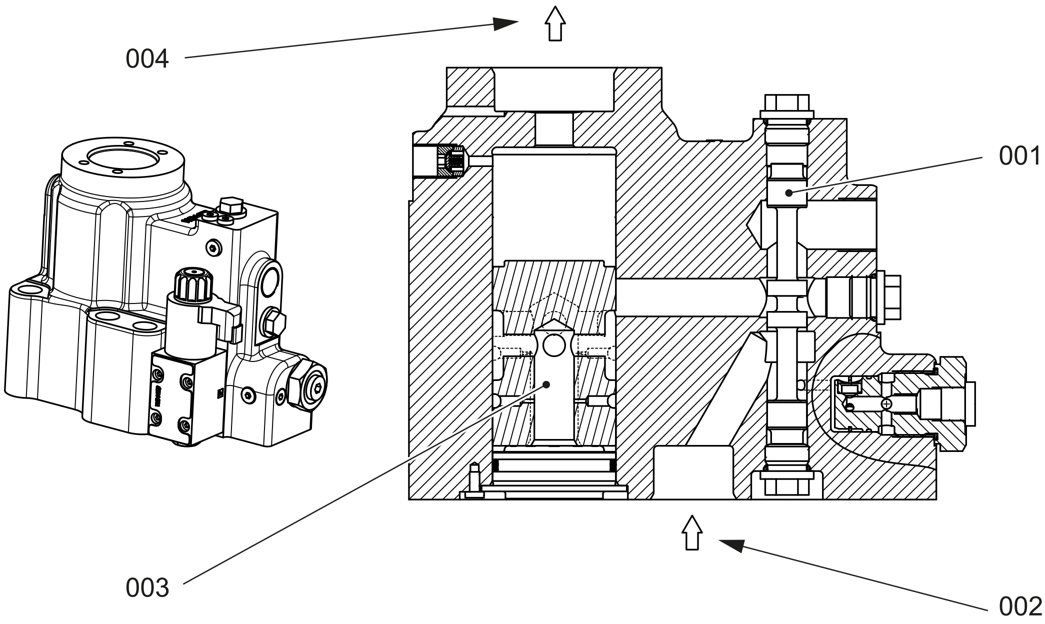
5.5.6 Exhaust valve control unit

The exhaust valve control units (VCU) control the servo oil to the exhaust valve of the related cylinders. The exhaust valve control units are attached to the servo oil rail.

When the solenoid valve operates, servo oil is released to the slide rod (001, Figure 5-32). This releases servo oil to the piston (003). Thus servo oil from the servo oil outlet (004) opens the exhaust valve.

Fig 5-32 Exhaust valve control unit (VCU) (example)



Legend

001 Slide rod
002 Servo oil inlet
003 Piston
004 Servo oil outlet

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5.5.7 Fuel pump actuator

The fuel pump actuator moves the regulating sleeve of the fuel pump and thus controls the fuel quantity, refer to section 5.5.3 Fuel pump. Each fuel pump is connected to its related actuator (for an X92 engine two fuels pumps are connected to there related actuator).

The ECS controls the fuel pump actuators. During operation the fuel pump actuators move at the same time. Each fuel pump actuator has an overload protection. Thus you do not have to disconnect a fuel pump actuator, if the regulating sleeve of a fuel pump cannot move.

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5.6 Group 6 - Scavenge air components

5.6.1 Scavenge air receiver

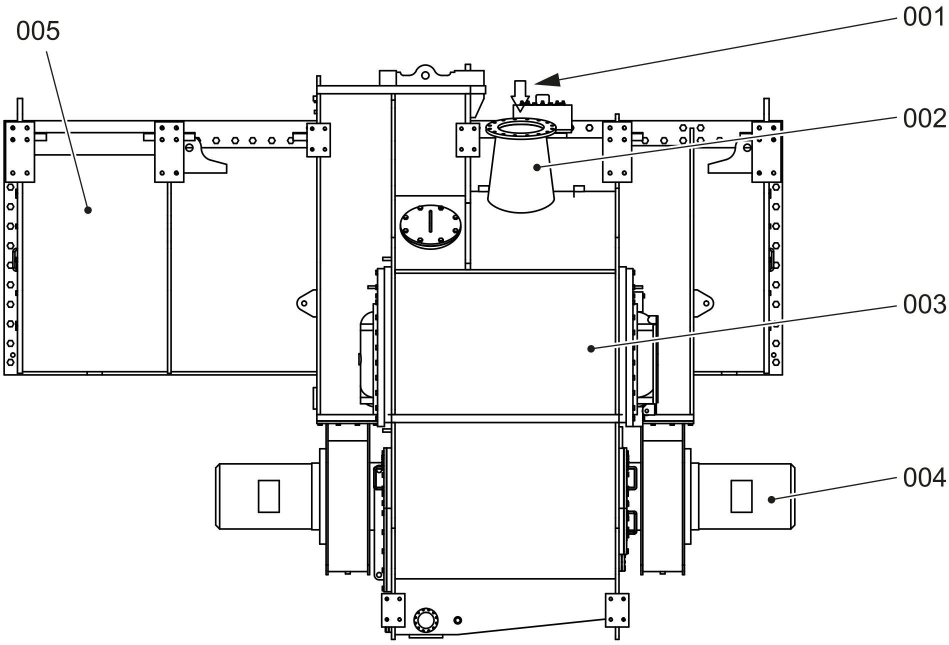
The scavenge air receiver (005, Figure 5-33) supplies the cylinders with the applicable quantity of air.

The scavenge air receiver is a welded assembly attached to the cylinder block on the exhaust side.

The relief valve, installed on the scavenge air receiver, opens when the air pressure increases to more than the permitted value in the air space (001, Figure 5-34).

For more data about the scavenge air system, refer to section 4.8 Scavenge air system.

Fig 5-33 Scavenge air receiver (example)

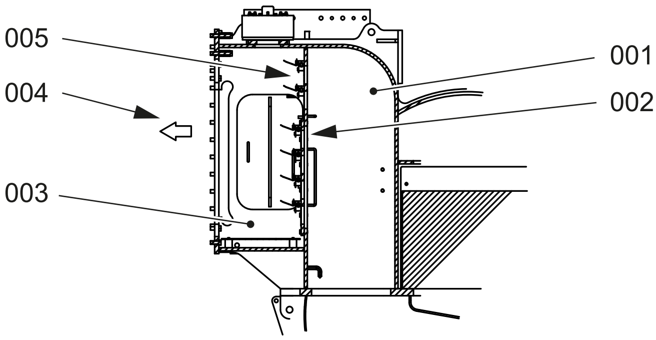


Legend

001	Scavenge air from turbocharger	004	Auxiliary blower
002	Diffuser	005	Scavenge air receiver
003	Scavenge air cooler		

The longitudinal wall (002, Figure 5-34) divides the scavenge air receiver into the receiver space (003) and the air space (001). The flaps (005) are attached to the longitudinal wall (002). The flaps (005) prevent the scavenge air to flow back into the air space (001).

Fig 5-34 Scavenge air receiver - cross section (example)



Legend

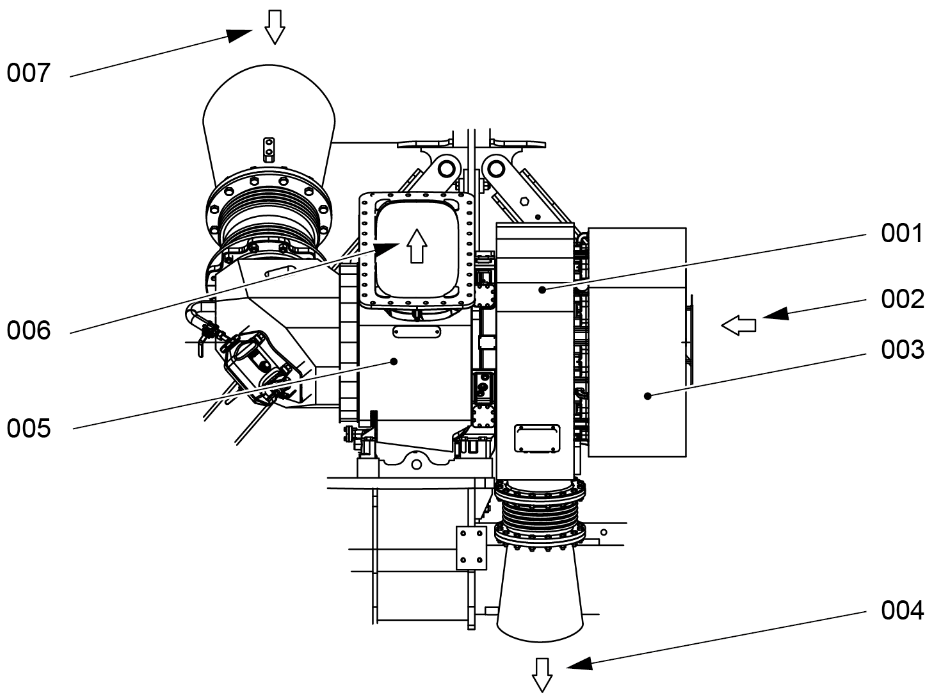
001	Air space	004	Outlet to piston underside
002	Longitudinal wall	005	Flap
003	Receiver space		

5.6.2 Turbocharger

The compressor (001, Figure 5-35) of the turbocharger compresses the scavenge air to the applicable pressure. The compressor is directly attached to the shaft of the turbine (005). The remaining energy of the exhaust gas drives the turbine and thus the compressor.

The number and the size of the turbochargers is accurately tuned to the engine and the number of cylinders.

Fig 5-35 Turbocharger (example)



Legend

001 Compressor
002 Air inlet
003 Silencer
004 Air outlet
005 Turbine
006 Exhaust gas outlet
007 Exhaust gas inlet

If a turbocharger becomes defective, you must stop the engine as quickly as possible to prevent damage.

If repair or replacement of a turbocharger is not immediately possible, you can cut out the defective turbocharger, refer to section 10.13 Temporary isolate a defective turbocharger. Then the engine can operate at decreased load, refer to the limits in section 8.3 Start the engine - general.

WinGD recommends to regularly clean the turbochargers and the silencers, refer to section 9.4 Clean the turbocharger during operation. This prevents or decreases contamination of the turbochargers and thus increases the time between overhauls.

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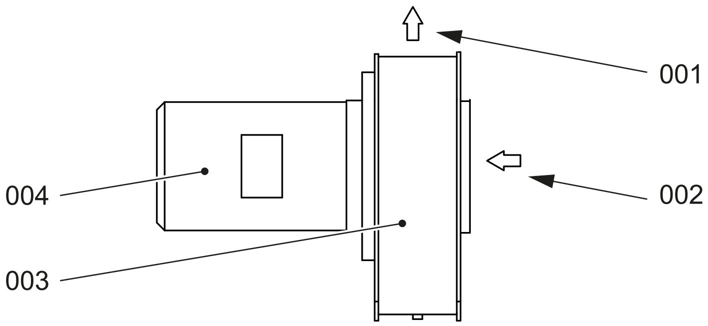
5.6.3 Auxiliary blower

The two auxiliary blowers supply air from the air space into the receiver space during the engine start and during operation at low load. Flaps prevent airflow back from the receiver space to the air space during usual operation of the turbochargers and during engine stop.

The electric motor (004, Figure 5-36) operates the blower (003).

The auxiliary blowers are installed on the scavenge air receiver, refer to section 5.6.1 Scavenge air receiver.

Fig 5-36 Auxiliary blower (generic)



Legend

001	Air outlet	003	Blower
002	Air inlet	004	Electric motor

During the engine start procedure, the first auxiliary blower starts immediately. After approximately two to three seconds, the other auxiliary blower starts.

If one of the auxiliary blowers becomes defective, you also can start and operate the engine. At less than full load, there will be more exhaust smoke.

If the two auxiliary blowers become defective, you cannot start the engine.

When the turbochargers give sufficient pressure in the scavenge air receiver, the auxiliary blowers stop.

If the scavenge air pressure decreases below the minimum pressure necessary, the auxiliary blowers operate as given above.

The auxiliary blower switch box (refer to section 5.6.4 Auxiliary blower switch box) controls and gives data about the condition of the auxiliary blowers.

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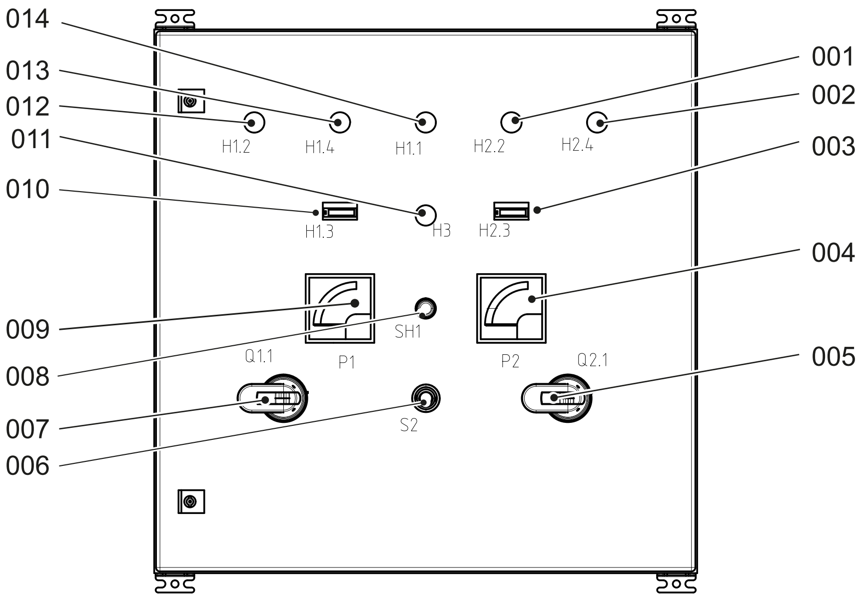
5.6.4 Auxiliary blower switch box

The auxiliary blower switch box controls and gives data about the condition of the auxiliary blowers.

Fig 5-37 Switch box (generic)



Legend

001	Indicator (auxiliary blower No. 2 running)	008	Restart push button
002	Indicator (auxiliary blower No. 2 overload)	009	Ampere meter (auxiliary blower No. 1)
003	Hour counter (auxiliary blower No. 2)	010	Hour counter (auxiliary blower No. 1)
004	Ampere meter (auxiliary blower No. 2)	011	Supply fault indicator
005	Main switch (auxiliary blower No. 2)	012	Indicator (auxiliary blower No. 1 running)
006	Emergency push button	013	Indicator (auxiliary blower No. 1 overload)
007	Main switch (auxiliary blower No. 1)	014	Control voltage indicator

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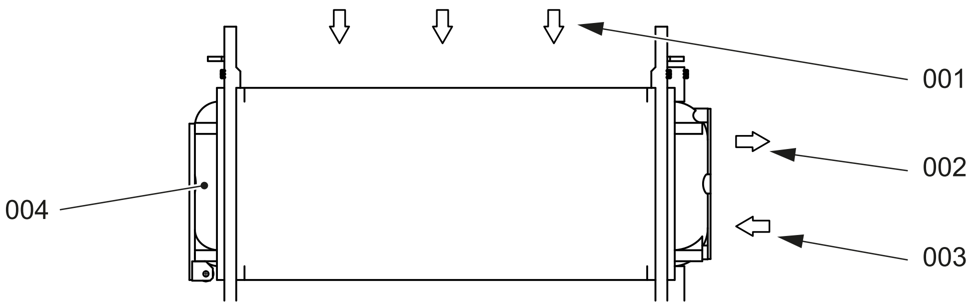
5.6.5 Scavenge air cooler

The scavenge air cooler (SAC) decreases the temperature of the hot compressed air from the turbochargers. This increases the density of the air and thus increases the quantity of air that is supplied to the cylinders.

The cooling water flows constantly through the tubes of the SAC and flows back to the cooling water system of the plant.

The SAC has a cover (004, Figure 5-38). For maintenance you can remove the cover.

Fig 5-38 Scavenge air cooler (generic)



Legend

001	Air flow	003	Cooling water inlet
002	Cooling water outlet	004	Cover

WinGD recommends to regularly clean the scavenge air coolers, refer to section 9.5 Clean the scavenge air cooler during operation. This prevents or decreases contamination of the scavenge air coolers and thus increases the time between overhauls.

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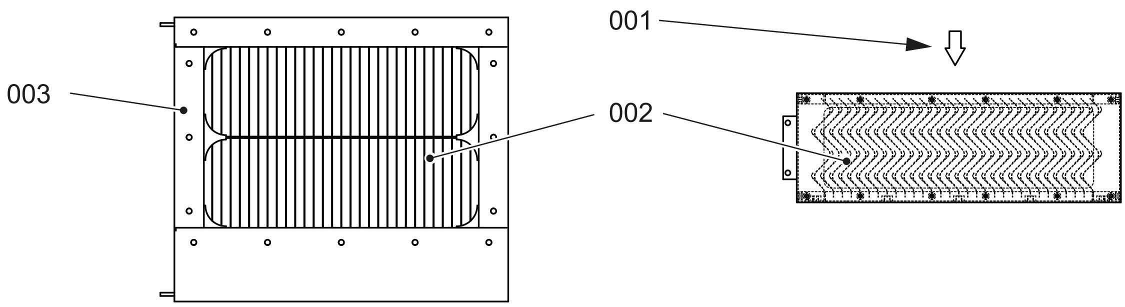
5.6.6 Water separator

The water separator removes water from the scavenge air. This prevents damage and gives better combustion in the cylinders. Water occurs when the scavenge air cooler (SAC) decreases the temperature of wet air. Water also occurs during the wash procedure of the SAC.

The profiles (002, Figure 5-39) hold back the water in the air flow. This water collects at the bottom of the frame (003) and then flows back to the drain system.

Fig 5-39 Water separator (generic)



Legend

001 Air flow
002 Profile
003 Frame

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5.7 Group 7 - Cylinder lubrication and balancer

5.7.1 Cylinder lubrication

For more data about the cylinder oil system, refer to section 4.6 Cylinder oil system.

5.7.1.1 Cylinder lubricating pump

Each cylinder has a cylinder lubricating pump. The cylinder lubricating pumps are connected to the distributor pipe (mini-rail) in the rail unit.

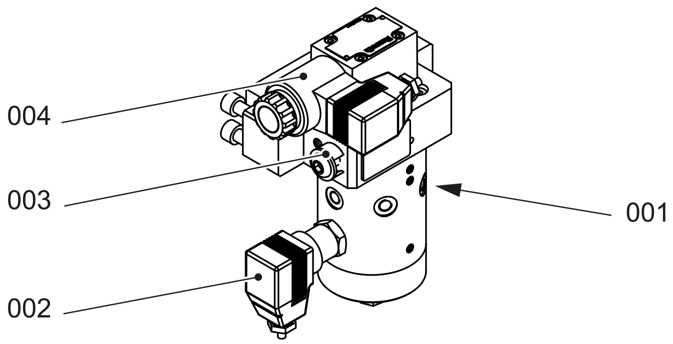
Servo oil from the distributor pipe (mini-rail) operates the cylinder lubricating pumps when the related control signals are released from the ECS.

When the ECS sends a signal to the related solenoid valve (004, Figure 5-40) of the cylinder lubricating pump, the solenoid valve (004) operates. Then a specified quantity of cylinder oil flows through the oil outlets (001) to the related lubricating quills.

Each cylinder lubricating pump has two bushes for different feed rates:

- The low feed rate (LFR) bush is installed on the adjustment screw.
- The high feed rate (HFR) bush is installed in the storage position.

Fig 5-40 Cylinder lubricating pump (generic)



Legend

001	Oil outlet
002	Pressure transmitter
003	Storage position for HFR bush
004	Solenoid valve

5.7.1.2 Supply of cylinder oil

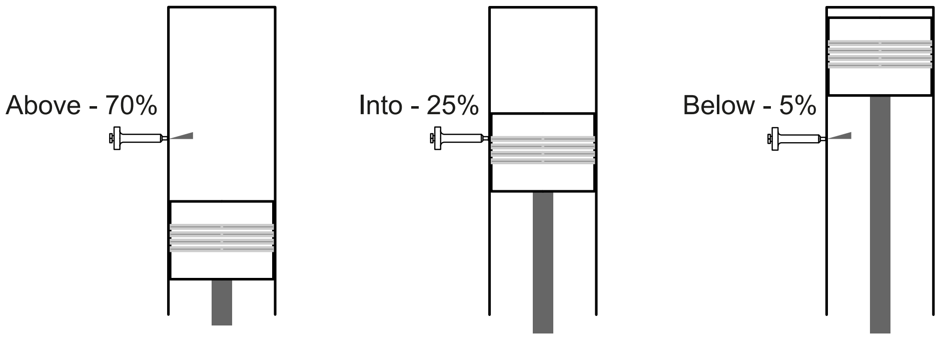
Cylinder oil is injected on to the cylinder liner wall through the lubricating quills installed on the circumference of the support ring.

The nozzle tip in the lubricating quill has holes in specified positions. The cylinder oil flows out of these holes at high pressure. This gives equal lubrication on to the cylinder liner wall.

The ECS parameters adjust the timing, which gives the position and percentage of cylinder oil on the cylinder liner wall and between the piston rings (Figure 5-41).

The ECS parameters also adjust the timing (with its percentage supply of the feed rate) during the first commissioning.

Fig 5-41 Usual vertical oil supply



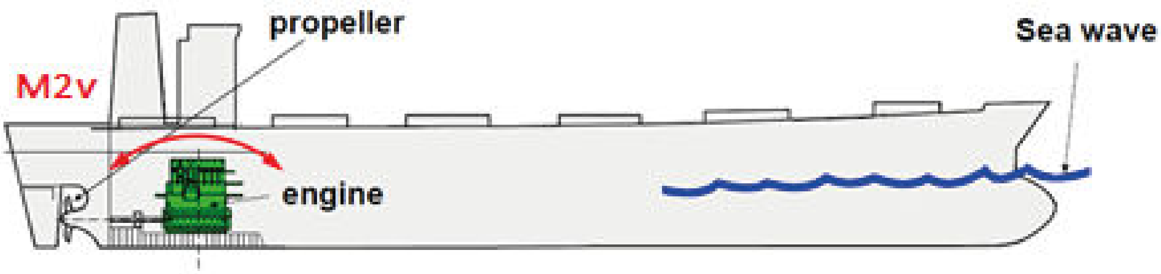
5.7.2 Integrated electrical balancer (iELBA)

The optional integrated ELectrical BAlancer (iELBA) decreases second order vertical mass moments (M2v) of the engine, refer to Figure 5-42.

NOTE: For the engine itself it is not necessary to install a balancer. But a balancer decreases the exitation forces of the engine. A calculation of the mass moment M2v shows if a balancer is necessary for a specified hull design.

Usually there are two iELBAs installed, one at the free end (FE) and one at the driving end (DE) of the engine. For special designs it is possible to install only one balancer at the free end (FE) or at the driving end (DE).

Fig 5-42 Effect of second order moments (M2v) of the engine



5.7.2.1 Function

An electric motor operates the two gear wheels (001, Figure 5-43) and thus the counterweights (002) in opposite directions. The horizontal elements (F_{horiz}) of the forces (F) are always canceled. The vertical elements (F_{vert}) are always added to a resulting vertical force. This resulting force operates up and down with the same frequency as the counterweights (002) turn. The resulting force is transmitted through the bearings (003) to the column (005) and thus to the engine.

The rotating speed (ω) of the counterweights (002) is always two times the engine rotating speed and is in phase to the engine. Thus the second order vibrations in the hull are decreased.

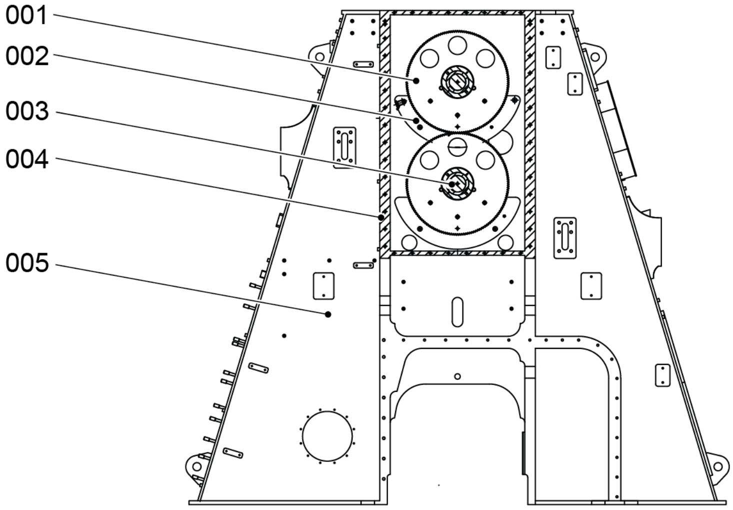
Engine system oil lubricates the iELBA. The oil flows back to the crankcase.

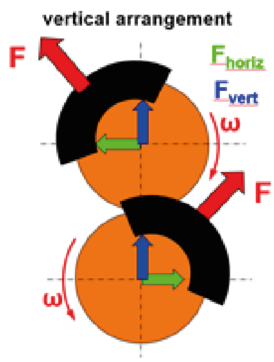
NOTE: Operate the iELBA only if system oil is available at correct pressure and flow rate.

A brake resistor for each balancer changes the rotating energy of the iELBA to heat in the conditions that follow:

- If the engine speed changes quickly.
- If there is an emergency stop of the iELBA.
- If there is an energy sink during the phase synchronisation of the iELBA.

Fig 5-43 iELBA - function





Legend

001	Gear wheel	004	Housing
002	Counterweight	005	Column
003	Bearing		

5.7.2.2 Control system

Each iELBA has two control cabinets (E38 and E39). The control system monitors the speed of the electric motor and the rotating speeds and phases of the counterweights (002) and of the flywheel of the engine. The control system also uses TDC and BDC data of piston #1 of the engine. A frequency converter controls the electric motor.

When the iELBA is started, there are two states that are indicated on the control cabinet:

- **Swing state**

  The electric motor swings the counterweights back and forward some times until the counterweights turn fully.

- **Run state**

  The iELBA has started to turn fully. The control system increases the speed of the iELBA and synchronises it to the engine.

5.7.2.3 Operation

Usually the iELBA operates in the speed range of the engine of 65% to 105% of CMCR in the AHEAD direction.

NOTE: In heavy sea mode the iELBA does not operate.

The engine can also operate if one or the two balancers do not operate (eg in manual mode or if a balancer is defective). Then it is possible that there are more vibrations on the hull.

When the power for the iELBA is set to ON, it takes some seconds to complete the initialisation of the system.

The iELBA operates independently of the engine control system (ECS). The iELBA can be operated in automatic mode or manual mode:

- **Automatic mode**

  In automatic mode the balancers operate as follows:

  - The iELBA starts if the engine speed is higher than the specified threshold value.
  - The iELBA stops if the engine speed is lower than the specified threshold value.

- **Manual mode**

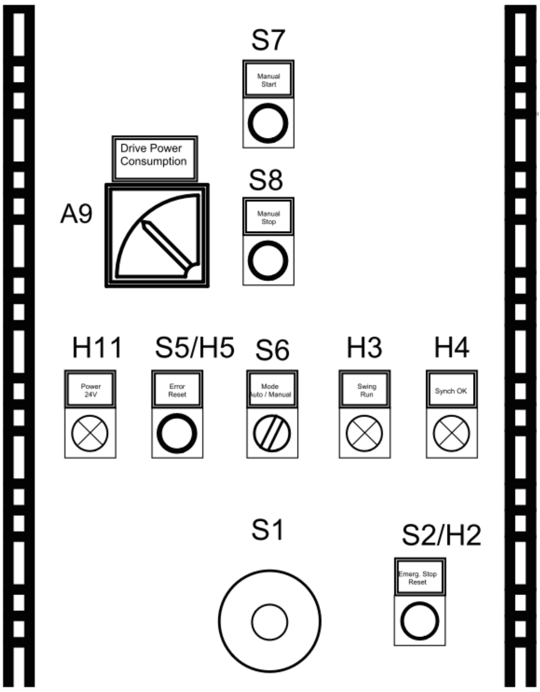
  In manual mode the balancers operate at a specified speed. Use the manual mode for troubleshooting only.

  NOTE: Use the manual mode only if system oil is available at correct pressure and flow rate.

5.7.2.4 Control cabinet

Figure 5-44 shows the buttons and indications on the control cabinet of the iELBA.

Fig 5-44 iELBA - control cabinet



Tab 5-1 iELBA - control cabinet

Item	Function	Effect
A9	Drive Power Consumption indication	Shows the electric motor current (in Ampere)
S7	Manual Start button	Starts the iELBA (in manual mode)
S8	Manual Stop button	Stops the iELBA (in manual mode)
H11	Power 24V indicator light	Shows if electric power is on
S5/H5	Error reset button	Shows and resets iELBA errors, refer to Table 5-2 - iELBA - error indication **NOTE:** If an error occurs, the indicator light shows the related number of flashes. **NOTE:** Only reset an error after you have done the related procedures.
S6	Mode Auto / Manual switch	Changes between automatic and manual mode
H3	Swing / Run indicator light	Shows the state of the running iELBA: • Lamp blinks - iELBA is in swing state • Lamp is steady - iELBA is in run state
H4	Synch OK indicator light	Shows the synchronisation state of the iELBA: • Lamp is steady - iELBA is synchronised to the engine • Lamp blinks slowly - iELBA is +/-15° from engine synchronisation • Lamp blinks quickly - iELBA is +/-30° from engine synchronisation
S1	Emergency stop button	Stops the iELBA immediately
S2/H2	Emerg. Stop Reset button	Resets an emergency stop to enable iELBA restart The integrated indicator light shows as follows: • Lamp is on - an emergency stop is active • Lamp is off - usual operation
A10	Hour indication	Shows the running hours of the electric motor **NOTE:** A10 is installed in the control cabinet.

Table 5-2 - iELBA - error indication shows the possible iELBA error indications related to the number of flashes of the indicator light.

NOTE: The error indications are active in automatic mode and in manual mode.

Tab 5-2 iELBA - error indication

Number of flashes	Status	iELBA state
1	Start OK, “Boost to Control Speed Threshold” not OK	OFF
2	Start OK, “Setpoint Speed” not OK in 60 s	OFF
3	Start OK, speed OK, “Phase Synchronisation” not OK in 60 s	OFF
4	Overspeed error	OFF
5	Electric motor error	OFF
6	The lubricating oil pressure is too low	OFF
7	iELBA pickup sensor error	OFF
8	TDC pickup sensor error	Usual operation
9	BDC pickup sensor error	Usual operation

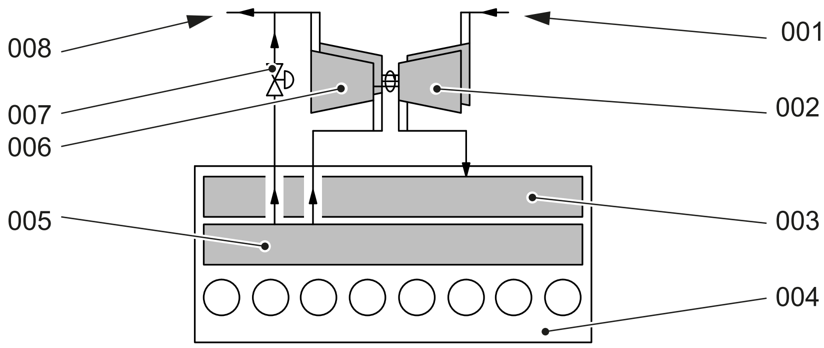
5.8 Group 8 - Pipes

5.8.1 Exhaust waste gate

The optional exhaust waste gate is a by-pass pipe to the turbine (006, Figure 5-45) of the turbochargers. The valve (007) in this pipe controls the flow of exhaust gas through the turbines (006). This controls the compressor (002) of the turbochargers and thus the supply of scavenge air to the scavenge air receiver (003).

During usual operation the valve (007) is closed and thus all the exhaust gas flows through the turbines (006).

Fig 5-45 Exhaust waste gate (generic)



Legend

001	Air inlet	005	Exhaust gas manifold
002	Compressor	006	Turbine
003	Scavenge air receiver	007	Valve
004	Engine	008	Exhaust gas outlet

If the turbochargers deliver too much scavenge air pressure, the ECS opens the valve (007). If the valve (007) is controllable, the ECS opens it as much as necessary. This decreases the performance of the turbochargers and thus the pressure of the scavenge air.

If the valve (007) is blocked in the open position, you have to close the exhaust waste gate, refer to section 10.14 Temporary isolate the exhaust waste gate.

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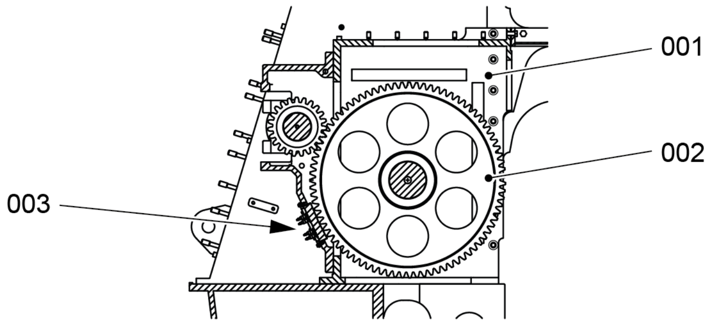
5.9 Group 9 - Monitoring instruments

5.9.1 Crank angle sensor unit

The crank angle sensor unit is installed on the supply unit drive at the driving end.

There are two crank angle systems that monitor the teeth on the intermediate wheel. The two sets of proximity sensors (003, Figure 5-46) operate independently to sense the teeth on the intermediate wheel (002).

Fig 5-46 Crank angle sensor unit on intermediate wheel (example)



Legend

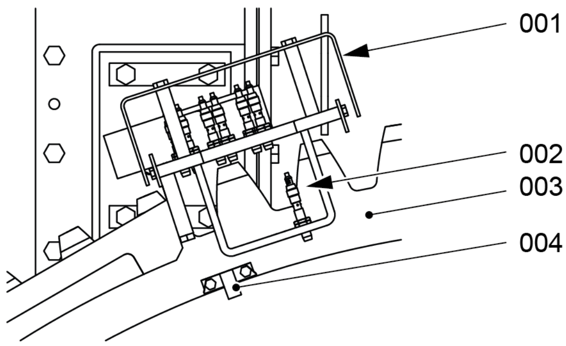
001 Supply unit
002 Intermediate wheel
003 Proximity sensor

Two more proximity sensors (002, Figure 5-47) are used to find the crank angle marks (004) for TDC and BDC on the flywheel (003).

All proximity sensors are connected as follows:

- First sensor pair to MCM-20 and CCM-20#1
- Second sensor pair from CCM-20#2 to CCM-20#n
- TDC and BDC to all CCM-20

Fig 5-47 Crank angle sensor unit on flywheel (example)



Legend

001	Cover	003	Flywheel
002	Proximity sensor	004	Crank angle mark

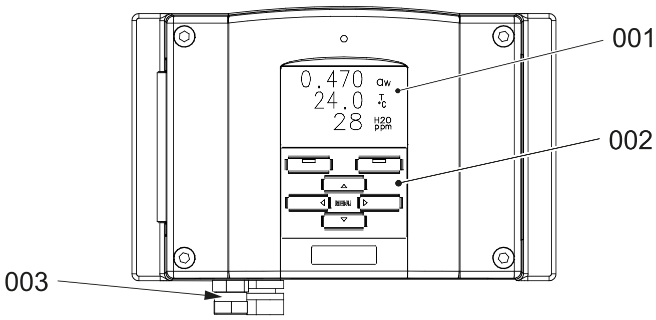
5.9.2 Water in oil monitor

The optional water in oil monitor continuously monitors the concentration of water in the oil supply pipe. The water in oil monitor continuously sends a signal to the alarm and monitoring system (AMS).

On the display (001, Figure 5-48) you can see the data that follow:

- aw - water activity
- T - temperature in °C
- H2O - water content in ppm

Fig 5-48 Water in oil monitor (generic)



Legend

001 Display
002 Keypad
003 Connection points

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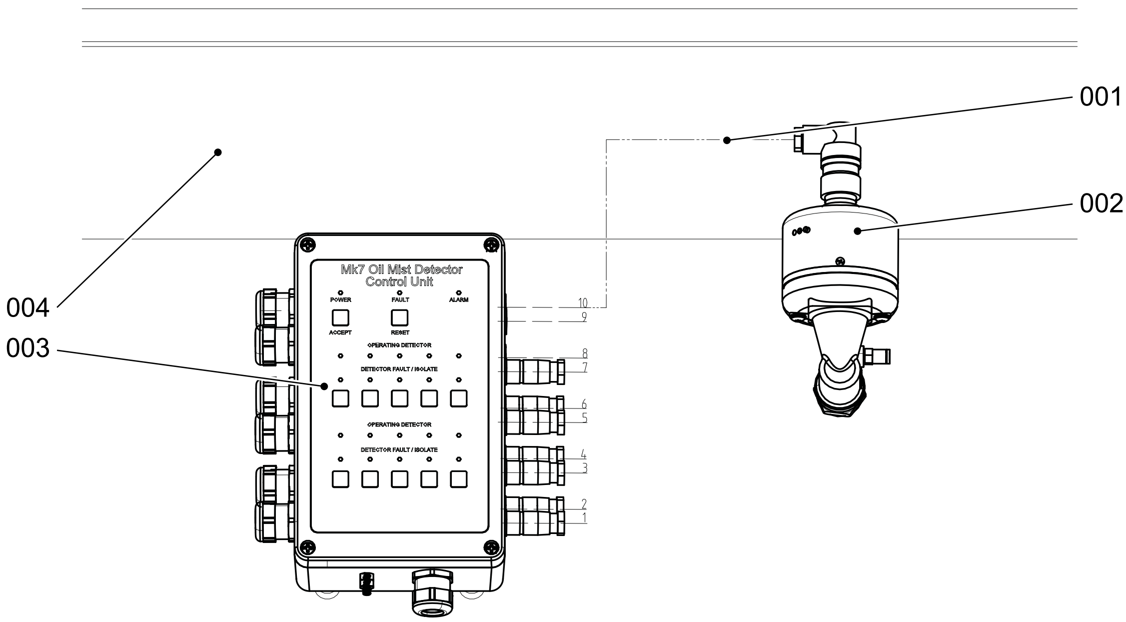
5.9.3 Oil mist detector

The oil mist detection system continuously monitors the concentration of oil mist in the crankcase, in the supply unit drive and in the supply unit. If there is a high oil mist concentration, the oil mist detector activates an alarm. Thus damage to the bearings can be quickly found and explosions in the crankcase can be prevented.

The system includes the sensors (002, Figure 5-49) and the control unit (003) on the engine.

Fig 5-49 Oil mist detector (example)

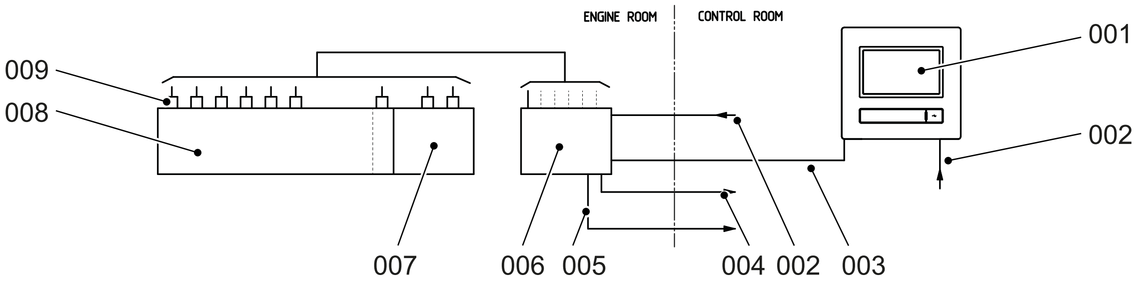


Legend

001	Data cable	003	Control unit E15.1
002	Sensor	004	Column

Each sensor monitors the concentration of oil mist. Each sensor has a self-test function to make sure that there are no internal faults.

Fig 5-50 Oil mist detector - schematic diagram (example)



Legend

001	Control panel	006	Control unit E15.1
002	Power supply	007	Supply unit
003	Data cable	008	Crankcase and gear box
004	To alarm system	009	Sensor
005	To safety system		

Data communication is between the control unit (006, Figure 5-50) and the control panel (001).

The adjustments can be programmed in the display unit (001). The menu-driven software has three user levels:

- User - Read-only of data
- Operator - Password-protected level for access to most adjustments and functions
- Service - Password-protected level for authorized staff of the manufacturer and service personnel.

NOTE: Instructions that relate to adjustments, commissioning, troubleshooting, and maintenance are given in the related documentation of the manufacturer.

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6 Control system

6.1 Engine control system

6.1.1 Engine control system

The engine control system (ECS) is an embedded system that has a modular design. Some parts and functions in the ECS system configuration are optional and are related to the application.

The name of the WinGD engine control system is UNIfied Controls Flex (UNIC-flex). It has the items that follow:

- **Main control module (MCM-11)**

  The main control module (MCM-11) is installed at the local maneuvering stand in the terminal box E25. The MCM-11 has functions for speed control, engine control and common engine functions (eg starting air shut-off valve). External control systems transmit data to the MCM-11.

- **Local display unit (LDU-20)**

  One local display unit (LDU-20) is installed at the local maneuvering stand at the free end. The other LDU-20 is installed in the engine control room (ECR). External control systems transmit data to the LDU-20. The LDU-20 gives the operator a graphical user interface for access to data and system adjustments.

- **Input/output module (IOM-10)**

  The input/output module (IOM-10) is installed at the rail unit in the terminal box E90. The IOM-10 has the engine control functions (eg exhaust waste gate control) and redundant sensor and actuator signals of the MCM-11.

- **Cylinder control module (CCM-20)**

  The cylinder control modules (CCM-20) for each cylinder are installed on the rail unit in the terminal box E95. The CCM-20 have different cylinder-related and engine-related control functions. The CCM-20 also have redundant global functions for the engine control.

Redundant CAN system buses connect all these modules.

Two 230 VAC supplies from the ship installation, supply electrical power to E85.1 to E85.n. The two 230 VAC supplies are isolated from each other.

The power supplies have redundancy. If it is necessary to isolate the ECS, make sure that each of the two 230 VAC power supplies are set to off. This will prevent injury to personnel.

Each control function that is important for engine operation has redundancy in the ECS.

Fig 6-1 ECS modules

Legend

001	Input output module (IOM-10)	003	Cylinder control module (CCM-20)
002	Main control module (MCM-11)	004	Local display unit (LDU-20)

6.1.2 Functions of the engine control system

The main functions of the engine control system are as follows:

- Starting valve control
- Servo oil pressure control
- Exhaust valve control
- Cylinder lubricating control
- Engine speed and crank angle sensor monitoring
- Diesel fuel pressure control
- Diesel fuel injection control
- For a DF engine, also gas injection control

6.1.3 External control systems

The Diesel Engine CoNtrol and OptImizing Specification (DENIS) and the engine control system (ECS) are designed so that different remote controls can be used. All nodes are fully specified. The terminal boxes are installed on the engine, to which the cable ends from the control room or from the bridge can be connected.

The engine control has all the parts necessary to operate and monitor the engine, and for the safety of the engine.

The ECS supplies the data communications to:

- The propulsion control system (PCS)
- The alarm and monitoring system (AMS).

The standard version of ECS includes the external communications that follow:

- Two redundant CANBus lines to the PCS (one CANBus connection to MCM-11 and one connection to the LDU-20 in the terminal box E25)
- Two redundant Modbus lines to the AMS (one Modbus connection to MCM−11 and one connection to the LDU−20 in the terminal box E25).

For the signal flow, refer to Figure 6-2.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

NOTE: The communications between the systems can be different. See the related documentation from the approved propulsion control system manufacturer.

6.1.3.1 Propulsion control system

The propulsion control system (PCS) has the subsystems that follow:

- **Remote control system**

  The remote control system (RCS) has the primary functions that follow:

  - Start, stop and reverse
  - Automatic slow turning

  Data about the ECS status is available in the RCS. This includes measured values of sensors, defects and other indications (refer to the documentation of the remote control manufacturer).

  All commands to operate the engine (eg AHEAD or ASTERN) come from the RCS.

- **Engine safety system**

  The engine safety system (ESS) has the primary functions that follow:

  - Emergency stop
  - Overspeed protection
  - Automatic shutdown
  - Automatic slowdown

- **Telegraph system**

  The telegraph system transmits maneuvering signals from the bridge to the ECR and local control panel.

NOTE: The ESS and telegraph system operate independently and are also fully serviceable if the RCS is defective.

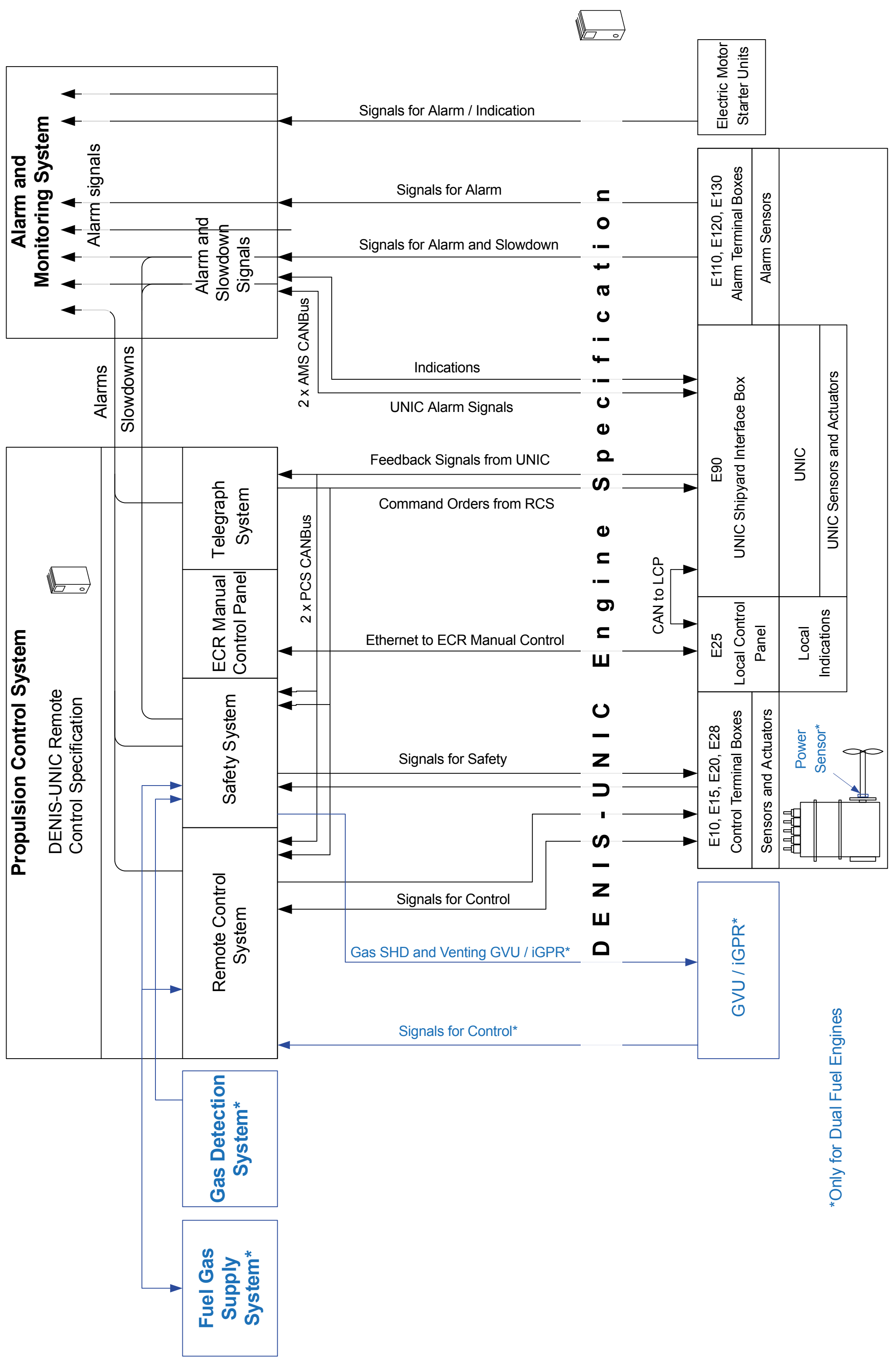
6.1.3.2 Alarm and monitoring system

The alarm and monitoring system (AMS) is an external system and monitors the engine. The AMS gives the operator alarms and status data of the engine to make sure of safe and satisfactory engine operation.

The functions of the AMS are specified in the diesel engine control and optimizing specification (DENIS). The AMS sends signals to the engine safety system to slow down or shut down the engine.

For more data, see the documentation of the AMS manufacturer.

Fig 6-2 Signal flow diagram



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6.2 Intelligent combustion control

The intelligent combustion control (ICC) permanently monitors and automatically controls the combustion process.

The ICC is part of the engine control system (ECS). All ICC modifications of the engine control parameters obey the IMO regulations and are related to the IMO certificate of the vessel.

The ICC system adjusts the injection time to make sure that the maximum firing pressure of the engine is related to the shop test results.

The ICC calculates the best engine control parameters for operation, which balances the compression and firing pressures in the engine (eg injection time offsets and exhaust valve closing time for each cylinder).

- This decreases the excessive wear of engine components.
- This decreases the risk of an engine overload.
- This prevents manual adjustment failures.

In the ECS you can set to OFF or ON each individual function of the ICC system. When all ICC functions are set to OFF, the engine operates in a conventional open-loop control mode.

NOTE: Large differences in the values (eg injection time or exhaust valve operation) for a cylinder is an indication of possible wear or damage of the cylinder. If necessary, replace the defective parts.

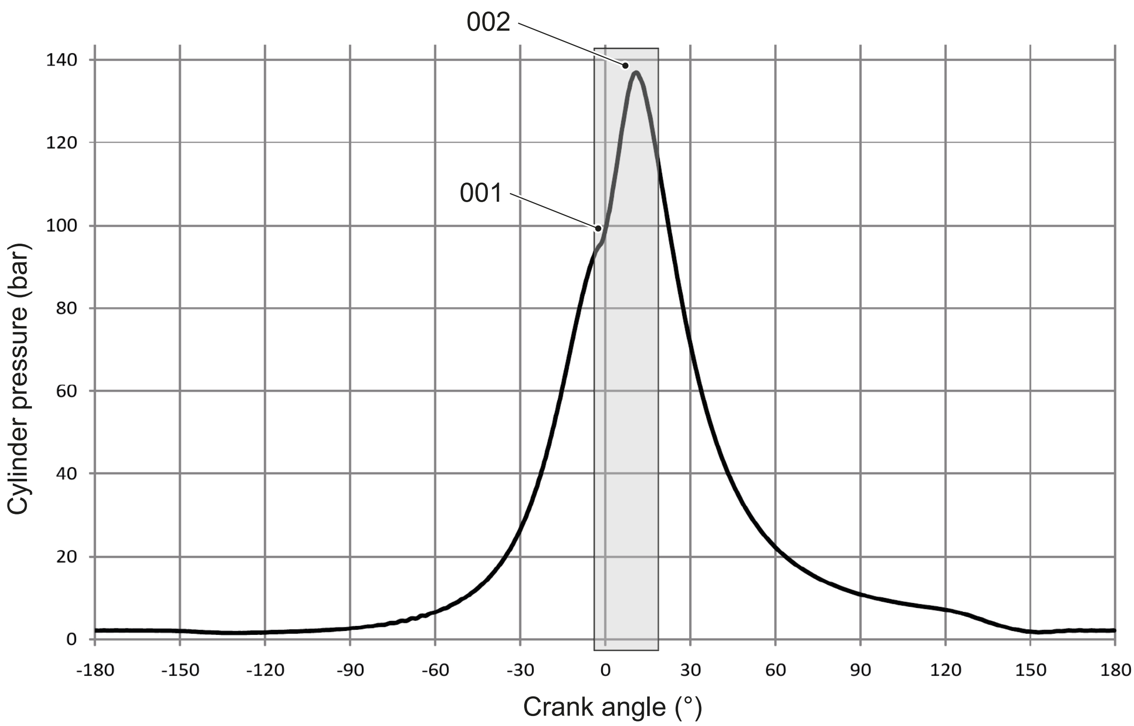
6.2.1 Pressure calculation

In the ICC system, the compression pressure of each cycle is calculated with the polynomial formula and the data of the piston position.

The peak firing pressure (002, Figure 6-3) is the highest measured pressure value in the crank angle range between the start of the injection and approximately 20°CA after TDC.

The pressure increase is the difference between the firing pressure and the compression pressure. The ICC sets the pressure increase limit eg to 40 bar to prevent mechanical overload to the engine.

Fig 6-3 ICC - pressure diagram



Legend

001 Pressure at 0°CA

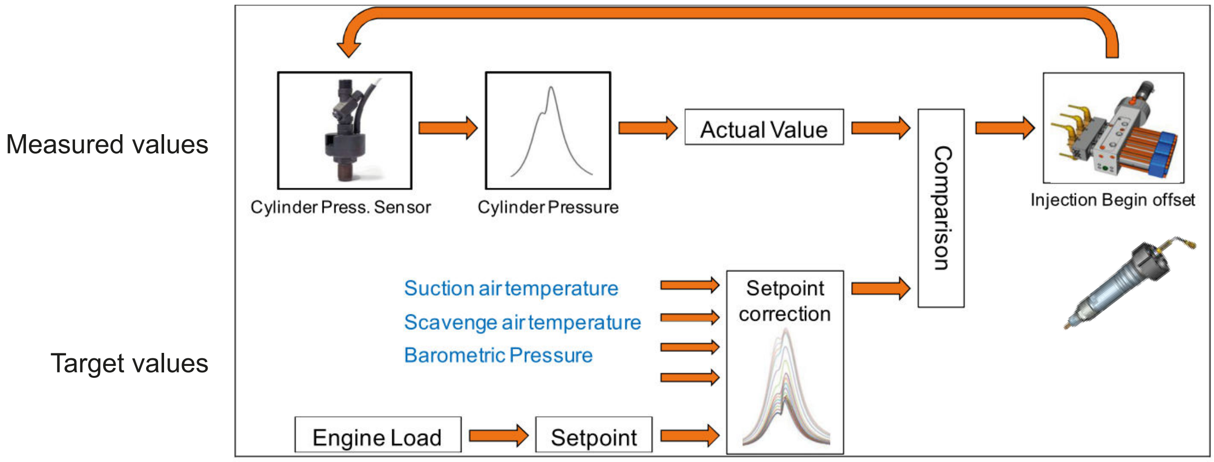
002 Peak firing pressure

6.2.2 ICC control

A pressure transmitter is installed on each cylinder cover. The cylinder pressure data of each cylinder is taken as an analogue input signal from the pressure transmitter into the ECS.

The ECS filters the signals from the sensors and then transmits these signals to a controller. The measured value is adjusted to the correct setpoint value and is related to the engine load. This real-time site correction and comparison is done for each engine cycle (refer to Figure 6-4).

Fig 6-4 ICC - control schematic



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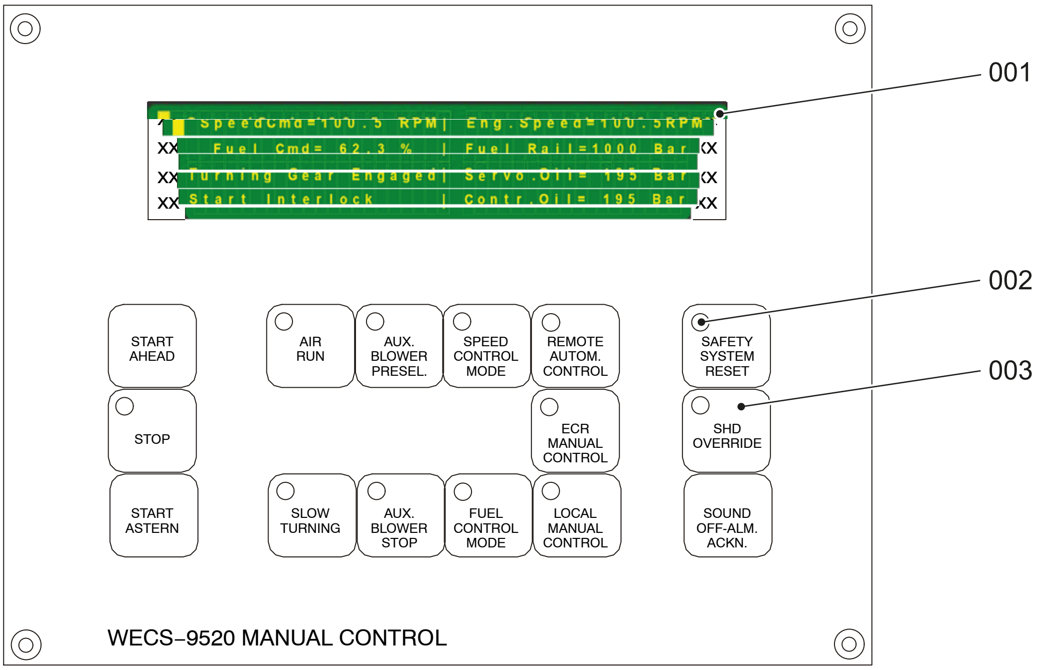
6.3 WECS-9520 manual control panel

The WECS-9520 manual control panel is a multi-purpose module that has an LCD display (001, Figure 6-5) and 15 function buttons (003). Some of the function buttons have a LED indication (002).

Fig 6-5 WECS-9520 manual control panel



Legend

001 LCD display	003 Function button
002 LED indication	

Important conditions are shown on the left side of the LCD display (001) in the third and fourth lines and can include the data that follow:

- Turning Gear Engaged and No Aux. Blower Running
- Emergency stop
- Overspeed
- Shut-down signal active
- Shut-down signal is possible
- Slow-down signal request
- Start interlock (together with an indication in the third line).

Tab 6-1 WECS-9520 manual control panel

Button	LED	Effect
START AHEAD	None	Starts the engine in ahead direction
STOP	Red	Stops the engine, red LED comes on
START ASTERN	None	Starts the engine in astern direction
AIR RUN	Green	Starts the air run mode of the engine, green LED comes on Operates only when the engine is stopped
SLOW TURNING	Green	Starts and stops a slow turning of the engine, green LED flashes Slow turning stops automatically, if the crankshaft has completed one full turn, or when there was a malfunction
AUX. BLOWER PRESEL.	Green	Sets the auxiliary blowers to status preselect, green LED comes on
AUX. BLOWER STOP	Red	Stops the auxiliary blowers manually, red LED comes on
SPEED CONTROL MODE	Green	Sets the speed control mode, green LED comes on, green LED of FUEL CONTROL MODE goes off Use the rotary knob to adjust the value.
FUEL CONTROL MODE	Green	Sets the fuel control mode, green LED comes on, green LED of SPEED CONTROL MODE goes off Use the rotary knob to adjust the value. **NOTE:** The ECS automatically changes to fuel control mode, if the speed control system becomes defective, or if fuel injection quantity adjustment is necessary.
REMOTE AUTOM. CONTROL	Green	Changes from local manual control to remote automatic control, during control transfer the two green LEDs flash, then come on constantly after takeover
ECR MANUAL CONTROL	Green	Changes from local manual control to ECR manual control, during control transfer the two green LEDs flash, then come on constantly after takeover
LOCAL MANUAL CONTROL	Green	Changes from current control to local manual control, during control transfer the related two green LEDs flash, then come on constantly after takeover **NOTE:** The transfer to LOCAL MANUAL CONTROL must be accepted at the control room console.
SAFETY SYSTEM RESET	Green	Resets the shut-down conditions, when the green LED comes on The green LED comes on, if all shut-down conditions are the same as those before, and if all shut-down signals can be reset.
SHD OVERRIDE	Red	Overrides the shut-down signals, when the red LED flashes or comes on constantly

Button	LED	Effect
SOUND OFF-ALM. ACKN.	None	Sets to OFF the acoustic alarms (bell or buzzer) and changes alarm indications that flash to alarm indications that come on constantly Shows data about the version and does a check of the software on the display, when you push the button for approximately five seconds

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6.4 User parameters and maintenance settings for WECS-9520

The operator can get access to the user parameter settings without a password.

The operator can get access to the maintenance settings only with a password or a key.

You use the Operator Interface of the remote control to change or set the parameters in the WECS-9520 as follows:

- User parameters in USER
- Maintenance settings in ADJUST.

For data about how to get these areas to change the related values, see the documentation of the remote control manufacturer.

6.4.1 User parameters

For the available user parameters in USER refer to Table 6-2 - User parameters.

Tab 6-2 User parameters

Item	Parameter	Function
001	**FQS** (Fuel quality setting)	The FQS can be set to adjust the maximum firing pressure to the nominal value. A negative correction angle will advance the injection start and increase maximum pressure. A positive correction angle will retard the injection start and decrease maximum pressure.
002	**VIT** (Variable injection timing) ON/OFF	VIT is usually set to ON (shown as ON). VIT can be set to OFF (shown as OFF) for running-in. OFF means injection starts at the nominal angle and is not related to the engine power.
003	**Inj. cut off** (Injection cut off)	Stops the fuel injection to a cylinder if necessary. The WECS-9520 automatically activates a slowdown signal to prevent engine overload. The exhaust valve continues to operate on the related cylinder. **NOTE:** If the fuel injection is stopped on more than one cylinder, misfiring can cause dangerous engine vibration. Make sure that the engine speed is decreased sufficiently to prevent high torsional vibration. If possible, do not set to OFF cylinders that have a firing order of one after the other.

Item	Parameter	Function
004	**Inj. venting** (Injection bleed)	This function lets you bleed the injector pipes and ICUs. You can select one cylinder, or more than one cylinder. If the fuel rail pressure is more than 250 bar, the function will not operate. The process will continue to operate for 30 seconds. After 30 seconds, the fields automatically go back to the OFF condition until selected again.
005	**Exv. A/M Cmds** (Exhaust valve auto/manual commands)	This function lets you manually open and close an exhaust valve when the engine has stopped. The function can also be used to do tests of the exhaust valve. The service pump must be set to ON to get pressure in the servo oil rail. Air spring pressure must also be available. • AUTO - usual condition. The exhaust valve is closed when the engine is stopped. • MAN.OP - the exhaust valve opens. This function cannot keep the exhaust valve open because oil leaks through the orifice in the valve actuator and the VCU. To keep the exhaust valve open, you must use a special tool. • MAN.CL - the exhaust valve closes. • TURN.GEAR - the exhaust valve opens while the crankshaft turns through the crank angle sector for the selected exhaust valve.
006	**Start Valves Checking** (Common start valves 1/2, enable/disable)	To do checks of the control valves on the shut-off valve for starting air. Set a valve to OFF, then do a check of the other valve.
007	**Heavy Sea Mode**	When set to ON, the Heavy Sea Mode changes some functions in the WECS-9520. These changes make sure of stable and safe engine operation during very bad weather conditions. This function sets the fuel rail pressure to a constant value of 700 bar and is not related to the engine power. Pressure control becomes more stable. Set to OFF when weather conditions become light and before maneuvering. All injectors are used for fuel injection for the full load range. During usual operation at very low engine loads, one injector is cut out to prevent black smoke. Heavy sea mode prevents the failure of a cylinder if one injector becomes unserviceable. VIT is disabled. The VIT angle is set to 0° but the VIT display shows ON.
008	**Lubrication** (Supply rate)	Adjusts the applicable supply rate in steps of 0.05 g/kWh.

6.4.2 Maintenance settings

For the available maintenance settings in ADJUST refer to Table 6-3 - Maintenance settings.

Tab 6-3 Maintenance settings

Item	Parameter	Function
001	**Crank Angle** (Crank angle offset, engine TDC offset)	For crank angle settings and checks after maintenance, or when the crank angle sensor unit is replaced. For the input of crank angle differences (mean values) and to do checks of the measured values.
002	**Exv. closing offset** (Exhaust valve closing offset)	Cylinder pressure fine tuning in service: Lets you adjust the compression pressure.
003	**Inj. begin offset** (Injection begin offset)	Cylinder pressure fine tuning in service: Lets you adjust the compression pressure.
004	**Inj. correction factor** (Injection correction factor)	The injected fuel quantity for each cylinder can be independently decreased to 80%.

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6.5 Engine control system WiCE

6.5.1 General

The engine control system (ECS) is an embedded system that has a modular design. Some parts and functions in the ECS system configuration are optional and are related to the application.

The name of the WinGD engine control system is WinGD integrated Control Electronics (WiCE). It has the items that follow:

- **Cylinder control unit (CCU #1 to #n)**

  The cylinder control units (CCU #1 to #n) for each cylinder are installed on the rail unit in the terminal boxes E95.nn. The CCU have different cylinder-related and engine-related control functions. The CCU also have redundant global functions for the engine control.

- **Main control unit (MCU #1 to #3)**

  The main control units (MCU #1 to #3) are installed in the terminal boxes E27.1 to E27.3. The MCU have functions for speed control, engine control and common engine functions (for example starting air shut-off valve).

- **Gateway unit (GTU #1 and #2)**

  The gateway units (GTU #1 and #2) are installed on the rail unit in the terminal box E90. The GTU transmits data to and from external control systems.

- **Manual control panel (MCP)**

  One manual control panel (MCP) is installed at the local maneuvering stand at the free end. The other MCP is installed in the engine control room (ECR). External control systems transmit data to the MCP. The MCP gives the operator a graphical user interface for access to data and system adjustments.

- **Angle calculation module (ACM #1 and #2)**

  The optional angle calculation modules (ACM #1 and #2) are installed in the terminal boxes E96.1 and E96.2.

Redundant system buses connect all these modules.

Software updates must be done only with the supervision of a WinGD service engineer and in accordance with regulations that WinGD has set.

6.5.2 Functions of the engine control system

The main functions of the engine control system are as follows:

- Starting valve control
- Servo oil pressure control
- Exhaust valve control
- Cylinder lubricating control
- Engine speed and crank angle sensor monitoring
- Diesel fuel pressure control
- Diesel fuel injection control
- For a DF engine, also gas injection control

6.5.3 External control systems

The Diesel Engine CoNtrol and OptImizing Specification (DENIS) and the engine control system (ECS) are designed so that different remote controls can be used. All nodes are fully specified. The terminal boxes are installed on the engine, to which the cable ends from the control room or from the bridge can be connected.

The engine control has all the parts necessary to operate and monitor the engine, and for the safety of the engine.

The ECS supplies the data communications to:

- The propulsion control system (PCS)
- The alarm and monitoring system (AMS).

The standard version of the ECS includes the external communications that follow:

- Two redundant CANBus lines to the PCS
- Three redundant Modbus lines to the AMS.

For the schematic diagrams, refer to section 13.1 Schematic diagrams - general.

NOTE: The communications between the systems can be different. See the related documentation from the approved propulsion control system manufacturer.

6.5.3.1 Propulsion control system

The propulsion control system (PCS) has the subsystems that follow:

- **Remote control system**

  The remote control system (RCS) has the primary functions that follow:

  - Start, stop and reverse
  - Automatic slow turning

  Data about the ECS status is available in the RCS. This includes measured values of sensors, defects and other indications (refer to the documentation of the remote control manufacturer).

  All commands to operate the engine (for example AHEAD or ASTERN) come from the RCS.

- **Engine safety system**

  The engine safety system (ESS) has the primary functions that follow:

  - Emergency stop
  - Overspeed protection
  - Automatic shutdown
  - Automatic slowdown

- **Telegraph system**

  The telegraph system transmits maneuvering signals from the bridge to the ECR and local control panel.

NOTE: The ESS and telegraph system operate independently and are also fully serviceable if the RCS is defective.

6.5.3.2 Alarm and monitoring system

The alarm and monitoring system (AMS) is an external system and monitors the engine. The AMS gives the operator alarms and status data of the engine to make sure of safe and satisfactory engine operation.

The functions of the AMS are specified in the diesel engine control and optimizing specification (DENIS). The AMS sends signals to the engine safety system to slow down or shut down the engine.

For more data, see the documentation of the AMS manufacturer.

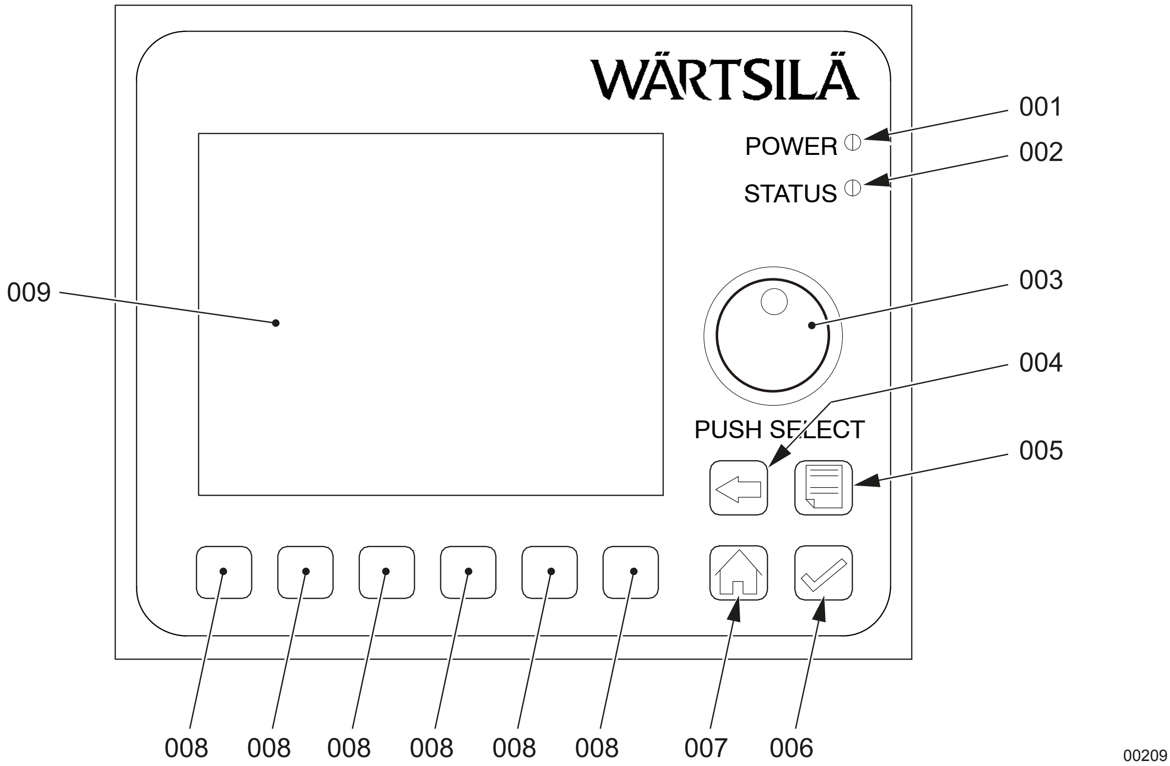
6.6 Local display unit (LDU-20) - general

6.6.1 Local display unit (LDU-20)

The LDU-20 (Figure 6-6) is a multi-purpose module that has an LCD color display (009), ten multi-function buttons (004 to 008) and a rotary button (003).

The number of LDU-20 installed on the engine is related to the engine control system (ECS) and to other optional systems.

Fig 6-6 LDU-20 - overview



Legend

001	Power LED	006	CHECK button (used to accept the action or enter data)
002	Status LED	007	HOME button (push to show the main page)
003	Rotary button (16 steps in one turn, push to select)	008	Multi-function buttons (function is shown on the display)
004	BACK button (used to cancel the action or delete data)	009	Color display
005	Failure LIST button (push to show the failure list)		

6.6.2 Color display

The color display (009) of the LDU-20 shows different pages for each application. After boot-up, or when you push the HOME button, the MAIN page is shown.

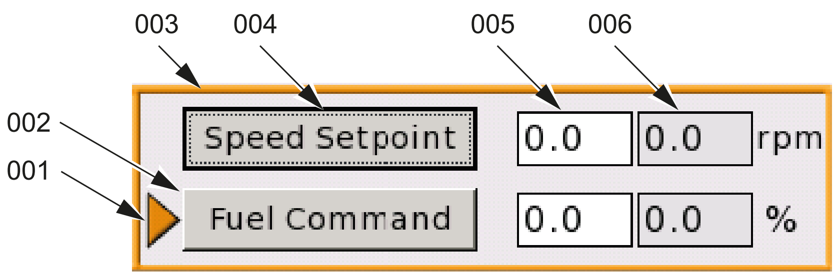
Some elements are shown on all pages as follows:

- In the top right-hand corner, the system time is shown above the title bar.
- Below the system time, Local or ECR is shown. If the LDU-20 is the active control location, the indication In Control is shown.
- The bottom of the color display has some space to show the function of the multi-function buttons.

The color display has the general items that follow, refer to Figure 6-7:

- An orange arrow (001) shows the active item.
- A 3D-rectangle (002) indicates a command button.
- An orange frame (003) indicates the edit mode.
- A black dotted frame (004) around an item shows the position of the cursor.
- A white background (005) shows a parameter, which the operator can adjust.
- A grey background (006) shows a parameter, which the operator cannot adjust.

Fig 6-7 LDU-20 color display - general items



Legend

001	Orange arrow	004	Black dotted frame
002	3D-rectangle	005	White background
003	Orange frame	006	Grey background

For the procedures how to use the LDU-20, eg change a LDU-20 page, refer to section 6.8 Operate the local display unit (LDU-20).

6.7 Local display unit (LDU-20) - pages

6.7.1 LDU-20 pages - general

In the chapters that follow you can find a description of the LDU-20 pages that follow:

- 6.7.2 LDU-20 page - MAIN
- 6.7.3 LDU-20 page - CONTROL LOCATIONS
- 6.7.4 LDU-20 page - CA SENSOR STATUS
- 6.7.5 LDU-20 page - FUEL SYSTEM
- 6.7.6 LDU-20 page - CYLINDER BALANCING DIESEL
- 6.7.7 LDU-20 page - MAIN FUEL INJECTION
- 6.7.8 LDU-20 page - PAGE INDEX
- 6.7.9 LDU-20 page - EXHAUST VALVES
- 6.7.10 LDU-20 page - FAILURE LIST
- 6.7.11 LDU-20 page - CYLINDER LUBRICATION
- 6.7.12 LDU-20 page - USER PARAMETERS
- 6.7.13 LDU-20 page - PERFORMANCE DATA DIESEL
- 6.7.14 LDU-20 page - TEMPERATURES
- 6.7.15 LDU-20 page - SOFTWARE INFO
- 6.7.16 LDU-20 page - LOG MESSAGES
- 6.7.17 LDU-20 page - LOG ENTRY DATA
- 6.7.18 LDU-20 page - SYSTEM STATUS
- 6.7.19 LDU-20 page - SOFTWARE TOOLS
- 6.7.20 LDU-20 page - SYSTEM SETTINGS
- 6.7.21 LDU-20 page - ETHERNET
- 6.7.22 LDU-20 page - DATE
- 6.7.23 LDU-20 page - SCAVENGE AIR - EWG (optional)
- 6.7.24 LDU-20 page - SCREENSHOT
- 6.7.25 LDU-20 page - iELBA Control (optional)

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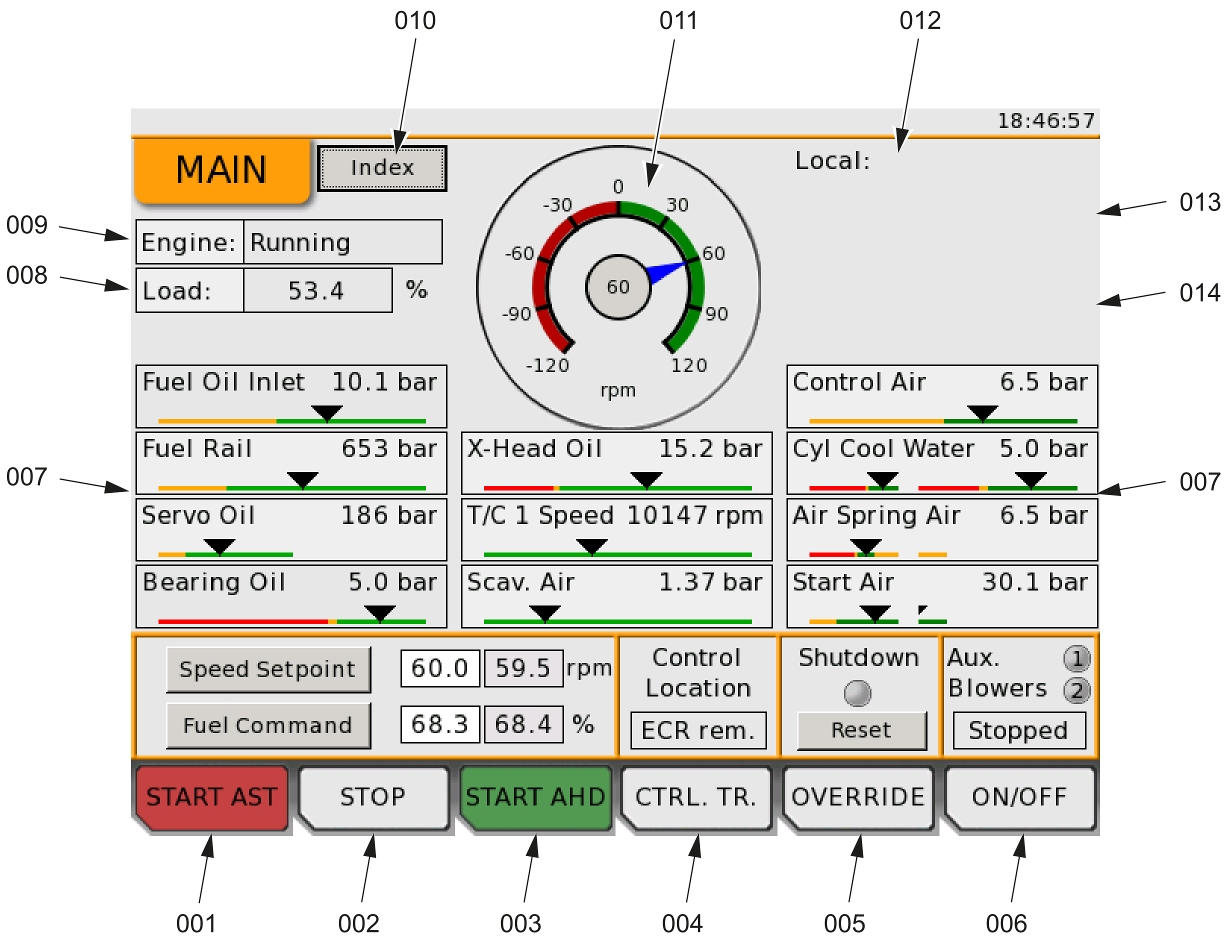
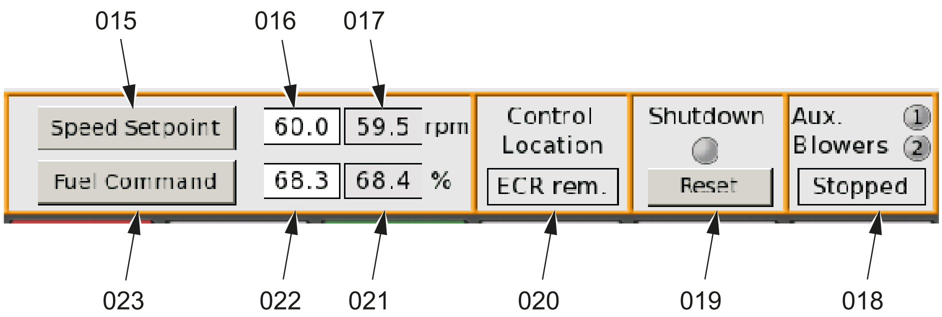
6.7.2 LDU-20 page - MAIN

Fig 6-8 MAIN





Tab 6-4 MAIN

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	OVERRIDE button	Cancels a shutdown from the safety system
006	ON/OFF button	Sets to On and OFF the auxiliary blowers
007	Different sensor indications	Indications that are necessary to operate the engine locally
008	Load	Shows the value of the estimated engine power or the engine load in percent (%)
009	Engine status	Shows the engine status Shows: Start interlock, Stopped, Slow turning, Air Run, Starting, Heavy Start, Running or Shutdown, Angle Detection Slowdown
010	Index button	Opens the INDEX page
011	Engine speed gauge	Shows engine rpm in ahead (AHD) or astern (AST) direction
012	Indication of this LDU-20	Shows if Local has control, or does not have control
013	Control transfer request indication	Text flashes to show a transfer request if one control location requests a control transfer
014	Indication of status	Shows the status of different items, if applicable
015	Speed Setpoint button	Changes to manual speed control mode
016	Manual speed setpoint	Manually adjust the rpm between zero and maximum. The maximum value is related to the installation specifications (rating etc)
017	External speed setpoint	Shows the setpoint sent to the ECS from the remote control system
018	Auxiliary Blower status	Shows by indication bulb if one or the two auxiliary blowers are running Shows: Running or Stopped
019	Indication of shutdown	Shows the shutdown status. When a shutdown is active, the red indicator is on. Press the Reset button to enable a restart of the engine.
020	Control location	Shows the active control location Shows: Local, ECR manual, ECR remote or Bridge
021	External fuel command setpoint	Shows the fuel command setpoint that the ECS calculates related to the speed set point from the remote control system

Item	Function	Effect
022	Manual fuel command setpoint	Manually adjust the fuel command setpoint between 0% and 150%
023	Fuel Command button	Changes to manual fuel command mode

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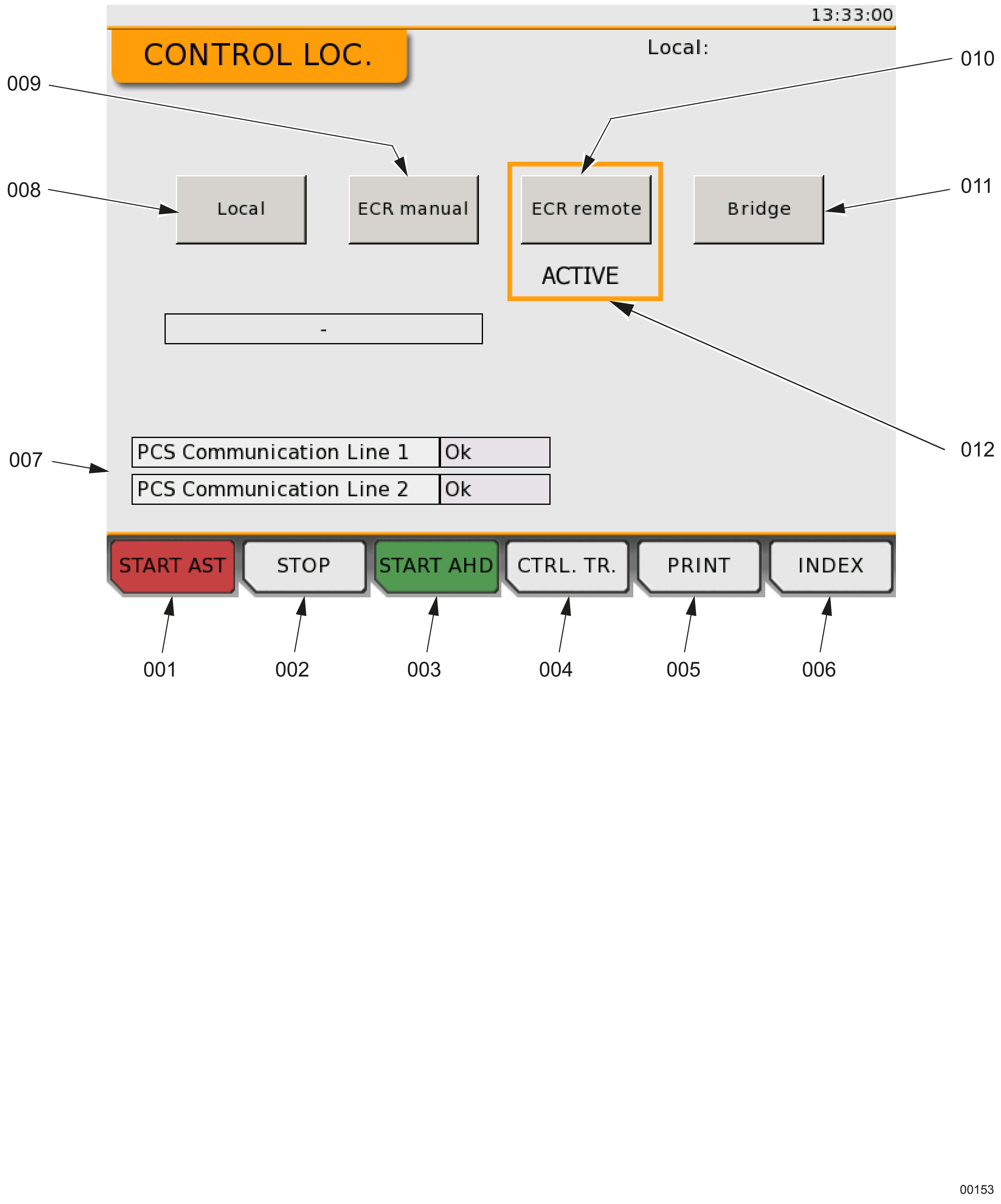
6.7.3 LDU-20 page - CONTROL LOCATIONS

Fig 6-9 CONTROL LOCATIONS

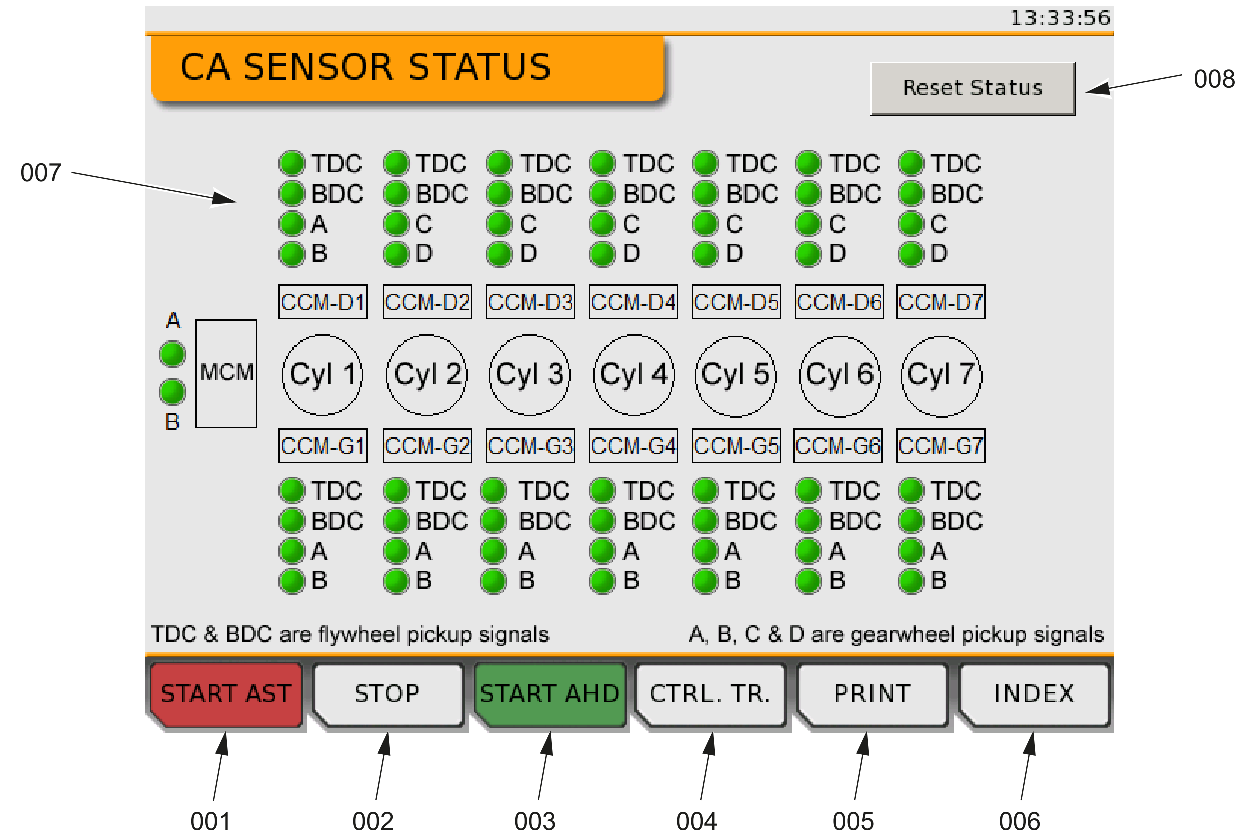


Tab 6-5 CONTROL LOCATIONS

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page
007	PCS Communication Line 1 / 2 status	Shows the status of the two redundant PCS Communication lines between the ECS and the remote control system. Shows OK, or ERROR
008	Local button	Requests or accepts a control transfer to or from the LDU-20 on the engine
009	ECR manual button	Requests or accepts a control transfer to or from the LDU-20 in the ECR
010	ECR remote button	Requests or accepts a control transfer to or from the remote control system in the ECR
011	Bridge button	Requests or accepts a control transfer to or from the remote control system on the bridge
012	ACTIVE frame	Indicates which of the four possible locations is in control of the engine

6.7.4 LDU-20 page - CA SENSOR STATUS

Fig 6-10 CA SENSOR STATUS

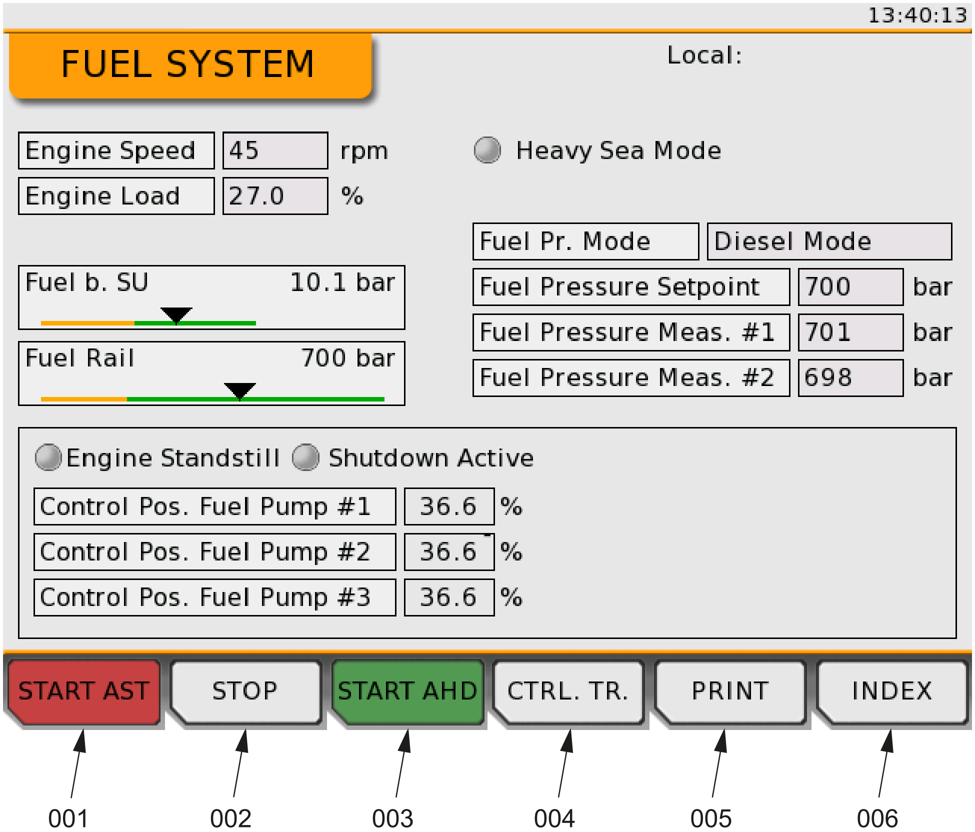


Tab 6-6 CA SENSOR STATUS

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page
007	Status indication	Shows the status of the crank angle sensors: • Green - status OK • Red - status not OK
008	Reset Status button	Resets the status of the crank angle sensors

6.7.5 LDU-20 page - FUEL SYSTEM

Fig 6-11 FUEL SYSTEM



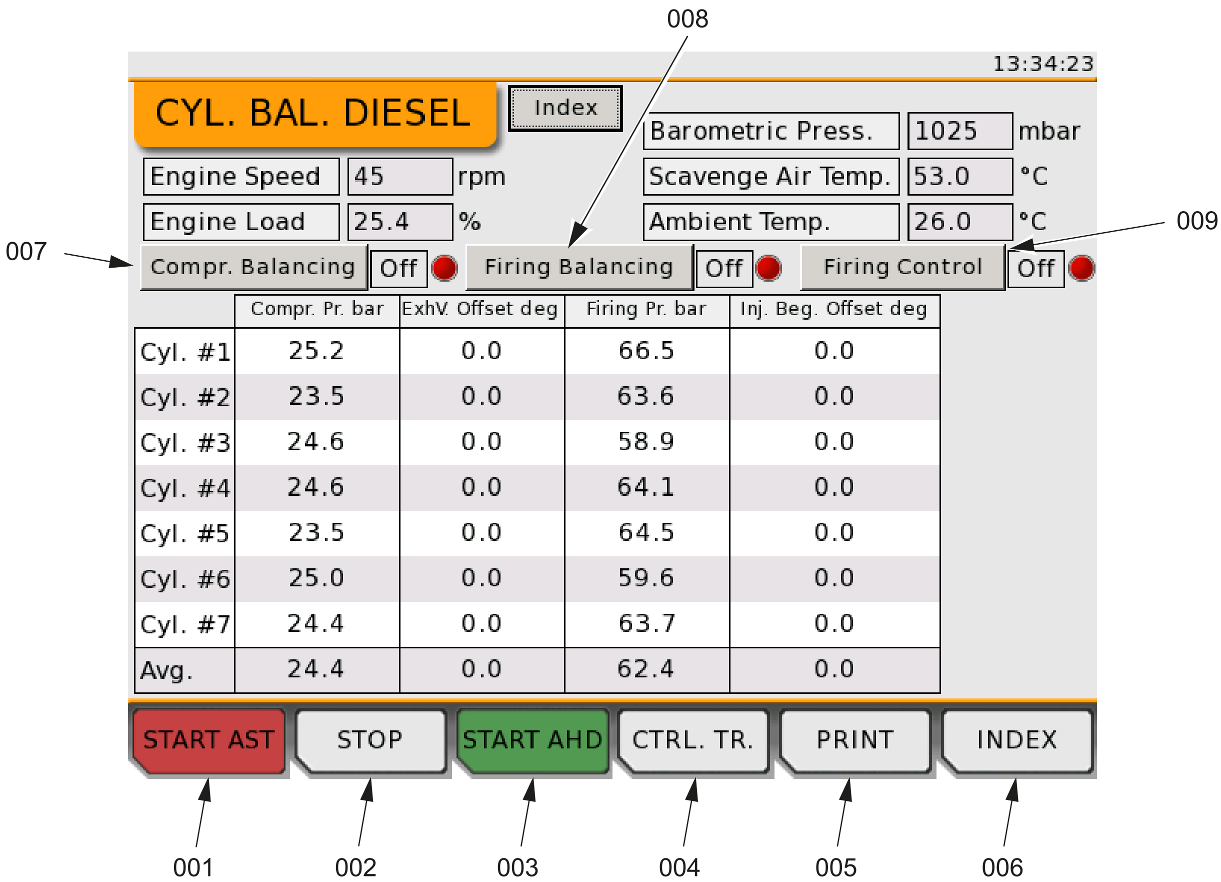
NOTE: Some indications on this LDU-20 page are only applicable for a DF engine.

Tab 6-7 FUEL SYSTEM

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page

6.7.6 LDU-20 page - CYLINDER BALANCING DIESEL

Fig 6-12 CYLINDER BALANCING DIESEL

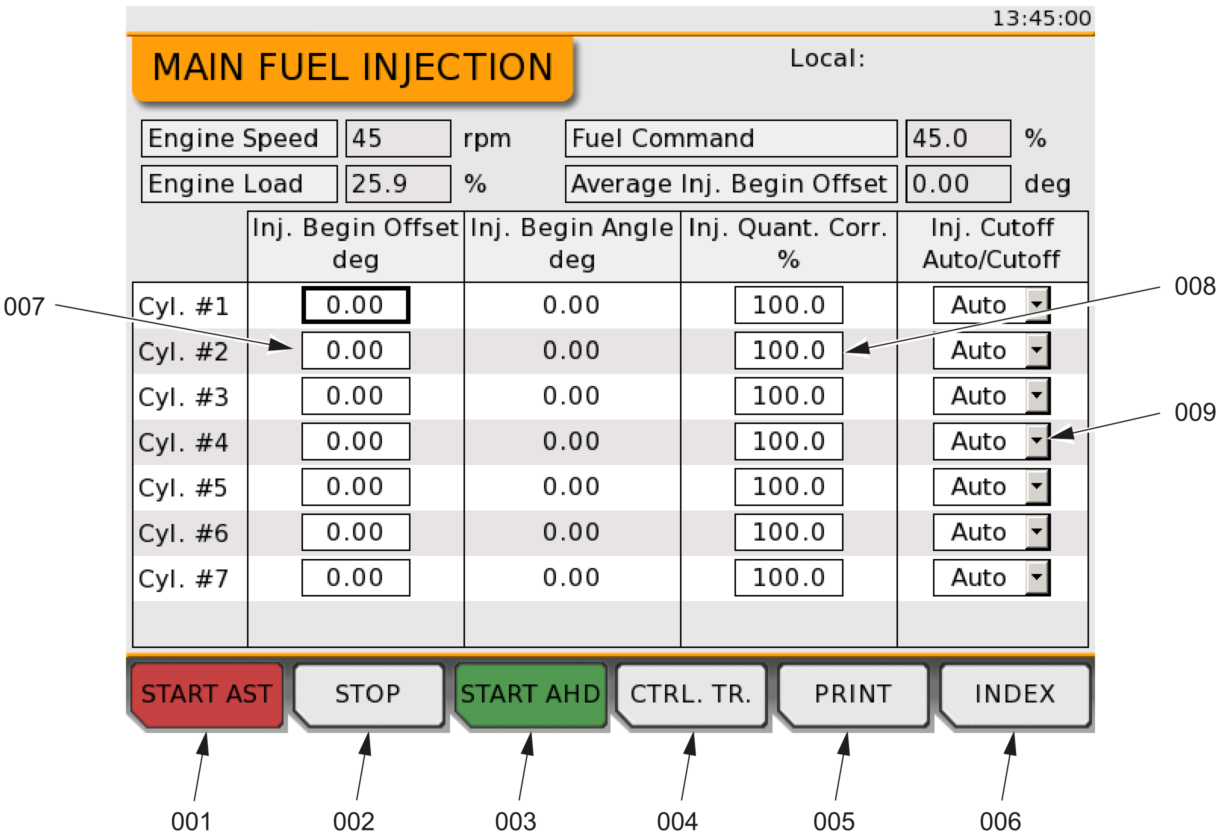


Tab 6-8 CYLINDER BALANCING DIESEL

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page
007	Compr. Balancing button	Changes the compression balancing function • Green - ON • Red - OFF
008	Firing Balancing button	Changes the firing balancing function • Green - ON • Red - OFF
009	Firing Control button	Changes the firing control function • Green - ON • Red - OFF

6.7.7 LDU-20 page - MAIN FUEL INJECTION

Fig 6-13 MAIN FUEL INJECTION

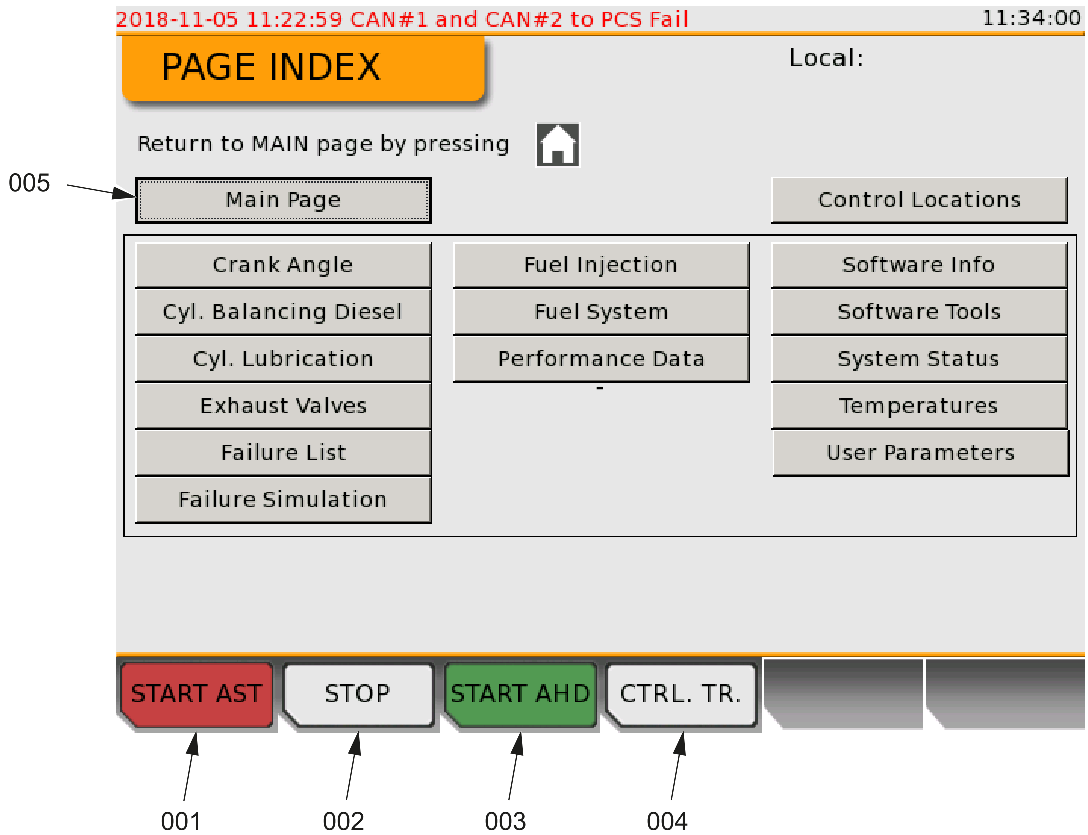


Tab 6-9 MAIN FUEL INJECTION

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page
007	Inj. Begin Offset	Manually adjust the injection begin offset (-1.5 to +1.5 degrees)
008	Inj. Quant. Corr.	Manually adjust the injection quantity (80% to 110%) if there are operation problems in the related cylinder
009	Inj. Cutoff select button	Manually select the operation mode: • Auto - automatic operation • Cutoff - no injection

6.7.8 LDU-20 page - PAGE INDEX

Fig 6-14 PAGE INDEX

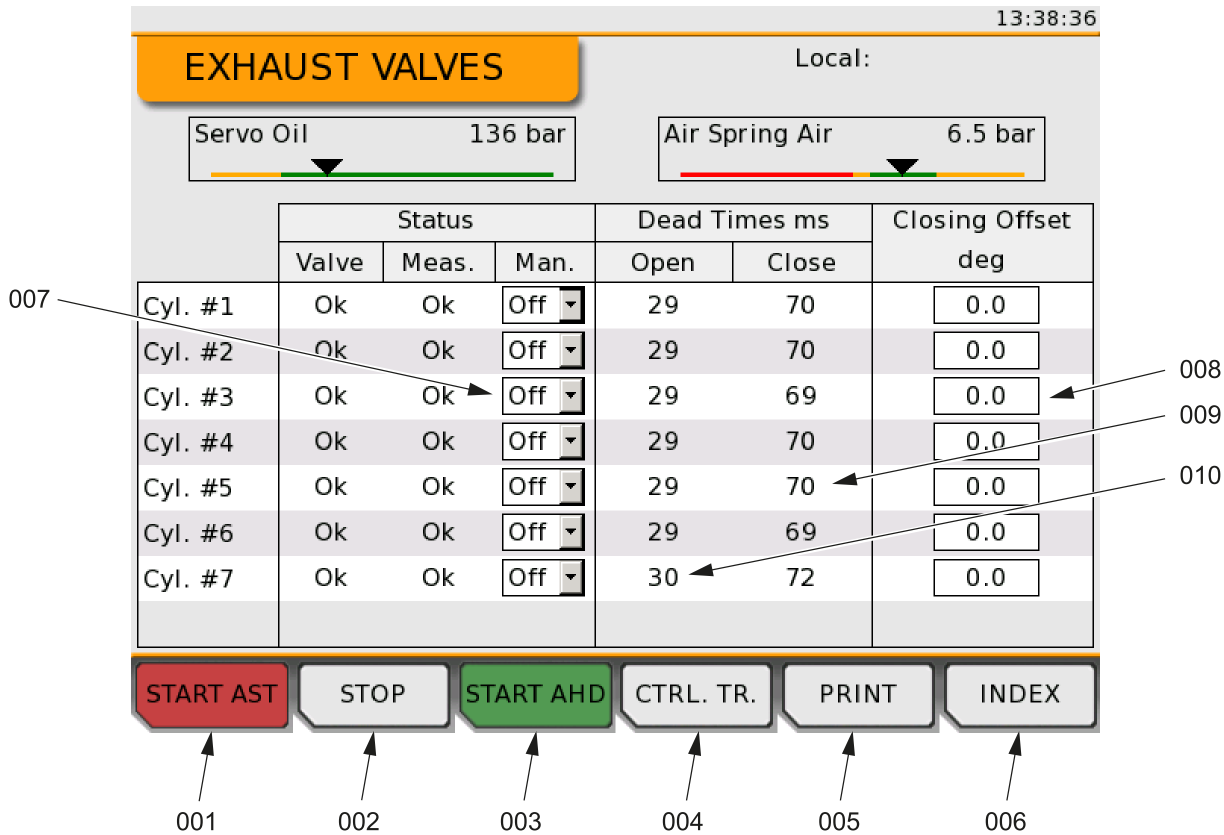


Tab 6-10 PAGE INDEX

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	Page button	Opens the selected page

6.7.9 LDU-20 page - EXHAUST VALVES

Fig 6-15 EXHAUST VALVES

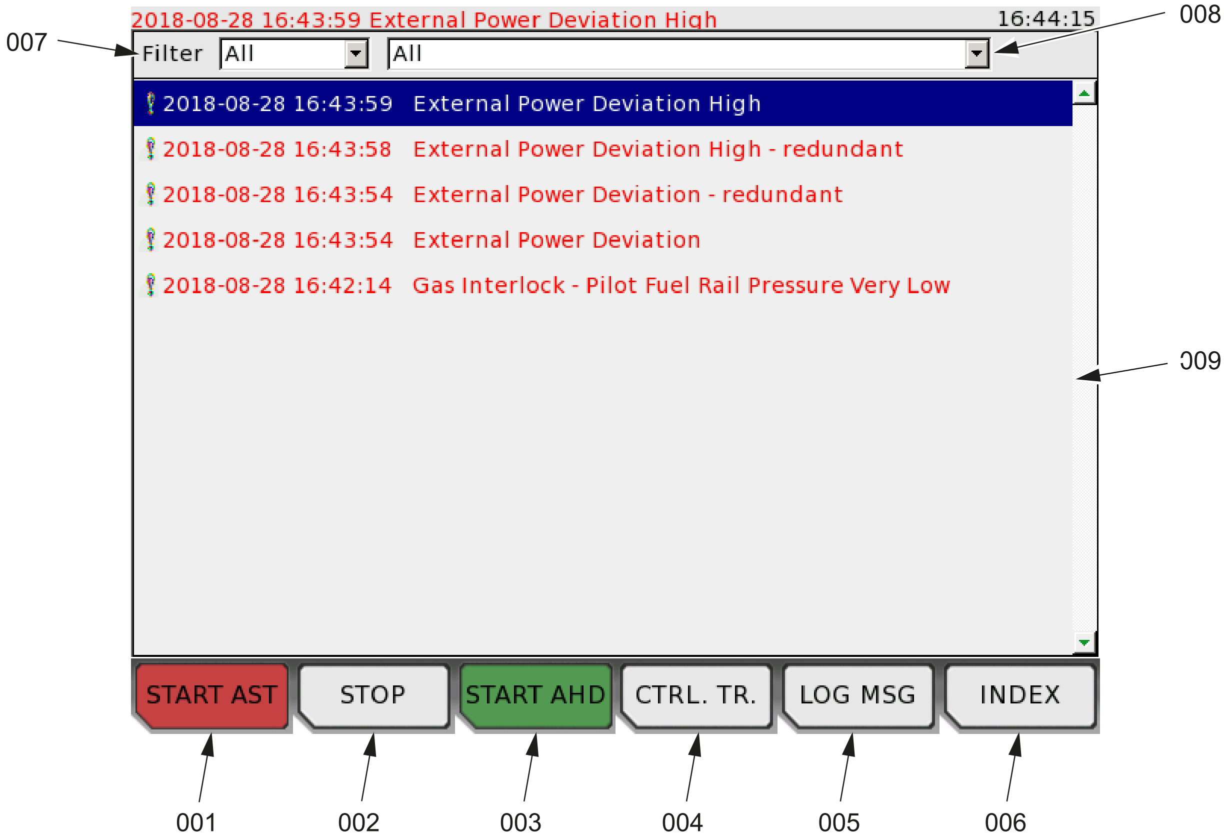


Tab 6-11 EXHAUST VALVES

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page
007	Operation mode selection button	Selects the operation mode of the related exhaust valve • On - manual operation mode (valve opens, if conditions are OK) • Off - automatic operation mode (valve closes)
008	Closing Offset	Manually adjust the closing offset of the exhaust valve
009	Open Dead Times	Shows the time between the open command to the solenoid valve of the VCU and the exhaust valve stroke start
010	Close Dead Times	Shows the time between the close command to the solenoid valve of the VCU and the exhaust valve stroke start

6.7.10 LDU-20 page - FAILURE LIST

Fig 6-16 FAILURE LIST

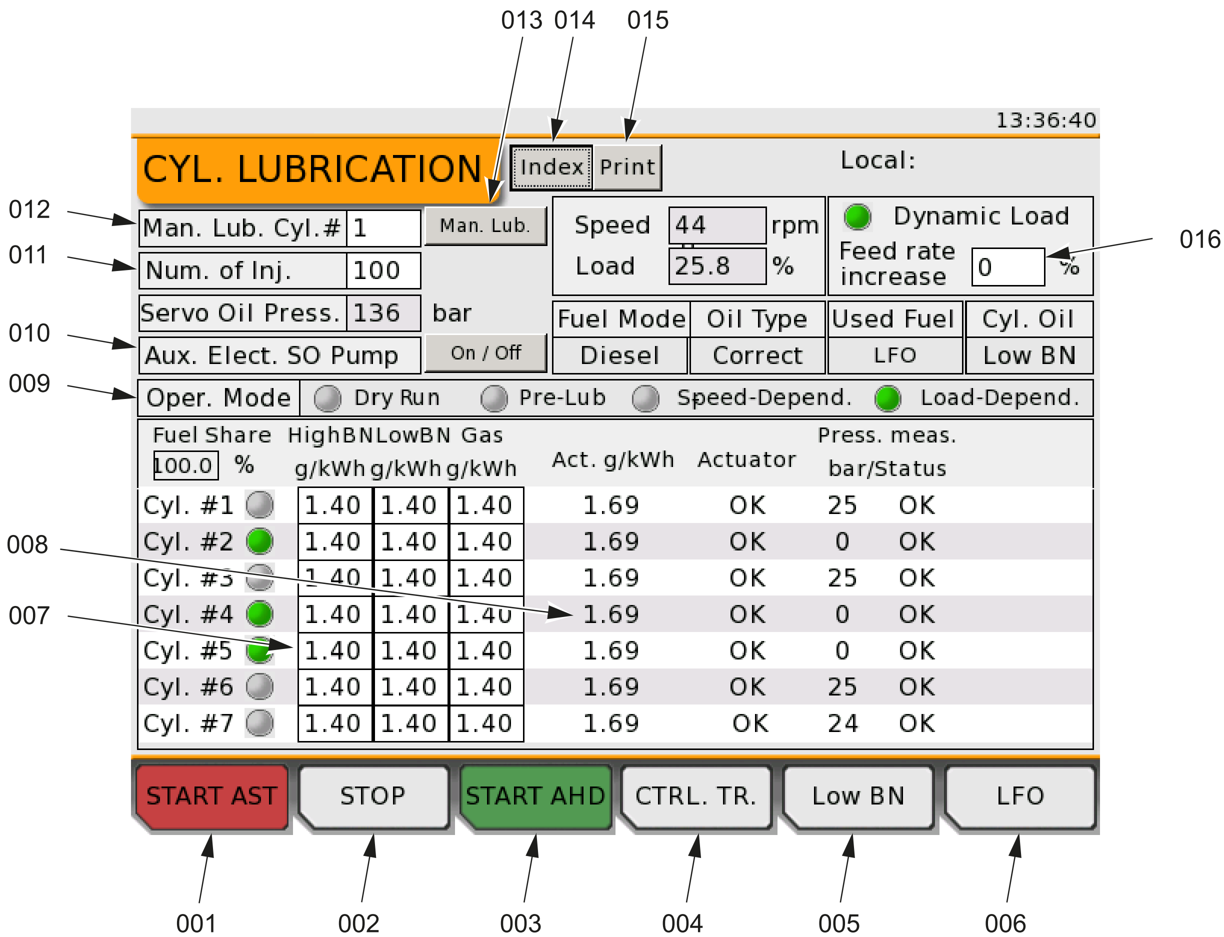


Tab 6-12 FAILURE LIST

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	LOG MSG button	Opens the LOG MESSAGE page
006	INDEX button	Opens the INDEX page
007	Filter button	Manually select the applicable type filter for the related failure
008	Filter button	Manually select the applicable category filter for the related failure
009	Scroll bar	Manually scroll through the failure list

6.7.11 LDU-20 page - CYLINDER LUBRICATION

Fig 6-17 CYLINDER LUBRICATION



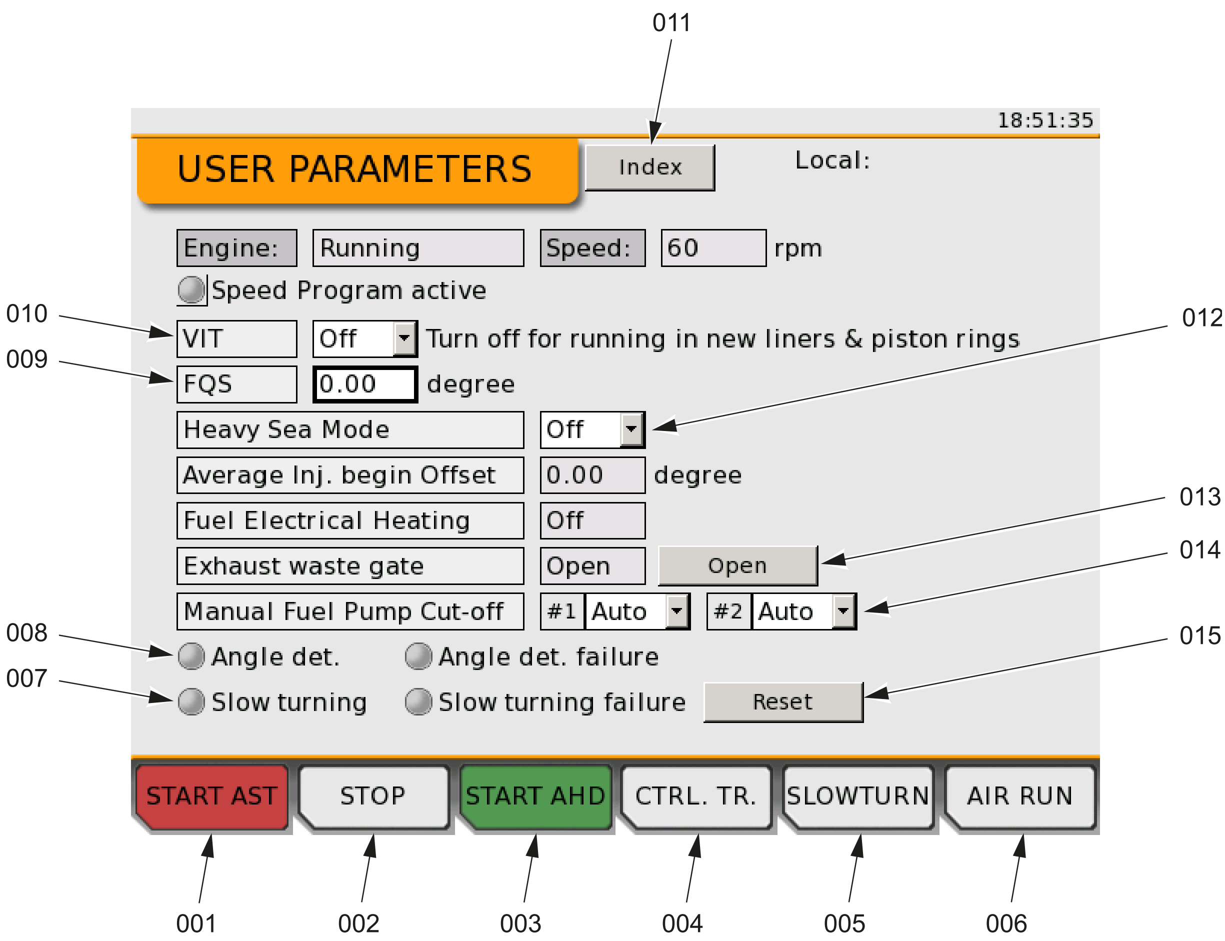
NOTE: Some indications on this LDU-20 page are only applicable for a DF engine.

Tab 6-13 CYLINDER LUBRICATION

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	Low BN button	Changes between low BN and high BN cylinder oil, if button is enabled
006	LFO button	Changes between LFO (Light Fuel Oil) and HFO (Heavy Fuel Oil), if button is enabled
007	Feed rate of cylinder oil	Shows the nominal cylinder oil feed rate at CMCR
008	Feed rate of cylinder oil	Shows the actual cylinder oil feed rate. The value is calculated related to the engine load.
009	Oper. Mode	Shows the active operation mode of the cylinder lubrication with the green indicator
010	On/Off button	Sets to ON and OFF the auxiliary electric servo oil pump (servo oil service pump) **NOTE:** If necessary, start this pump only in engine stop mode.
011	Num. of Inj.	Manually set the number of injections for lubrication at engine stop mode (range 0 to 255)
012	Man. Lub. Cyl.#	Manually select the cylinder for manual lubrication: • Set 100 for all cylinders • Set 1 to n for the related cylinder
013	Man. Lub. button	Starts the manual cylinder lubrication procedure related to the set values
014	Index button	Opens the INDEX page
015	Print button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
016	Feed rate increase	Manually adjust the increase of the cylinder oil feed rate for dynamic load operation

6.7.12 LDU-20 page - USER PARAMETERS

Fig 6-18 USER PARAMETERS

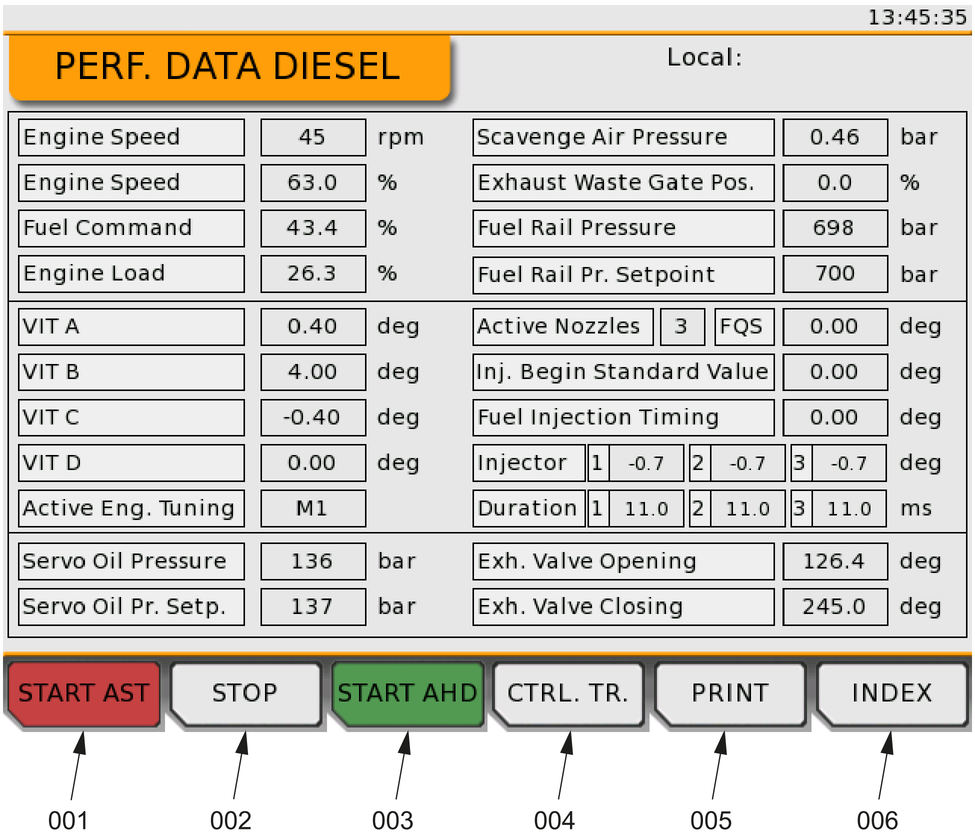


Tab 6-14 USER PARAMETERS

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	SLOWTURN button	Puts the engine in slow turning mode **NOTE:** The engine goes back to stopped mode after it has operated for some turns.
006	AIR RUN button	Starts the air run mode of the engine **NOTE:** The engine is in air run mode as long as you press the AIR RUN button.
007	Slow turning / Slow turning failure indications	Shows the slow turning status. When the slow turning mode is active, the related indicator is on. When there is a slow turning failure, the related indicator is on.
008	Angle determination / Angle determination failure indication	Shows the angle determination status. When the crank angle determination algorithm (ADA) mode is active, the related indicator is on. When there is a crank angle determination failure, the related indicator is on.
009	FQS	Manually adjust the parameter for the fuel quality setting (FQS) from -5° to +5° • A negative correction angle makes an earlier injection start and thus increases the maximum firing pressure. • A positive correction angle makes a later injection start and thus decreases the maximum firing pressure.
010	VIT button	Sets to ON and OFF the variable injection timing (VIT)
011	Index button	Opens the INDEX page
012	Heavy Sea Mode button	Sets to ON and OFF the heavy sea mode **NOTE:** This function sets the fuel rail pressure to a constant value to make the pressure control more stable. All injection valves are in operation.
013	EWG Open button	Opens and closes the exhaust waste gate **NOTE:** This button is only applicable for a binary exhaust waste gate.
014	Manual fuel pump cut off button	Sets the related fuel pump operation mode: • Auto - automatic mode (usual operation) • On - fuel pump is manually set to ON • Off - fuel pump is manually set to OFF
015	Reset button	Resets a failure for angle determination or slow turning

6.7.13 LDU-20 page - PERFORMANCE DATA DIESEL

Fig 6-19 PERFORMANCE DATA DIESEL

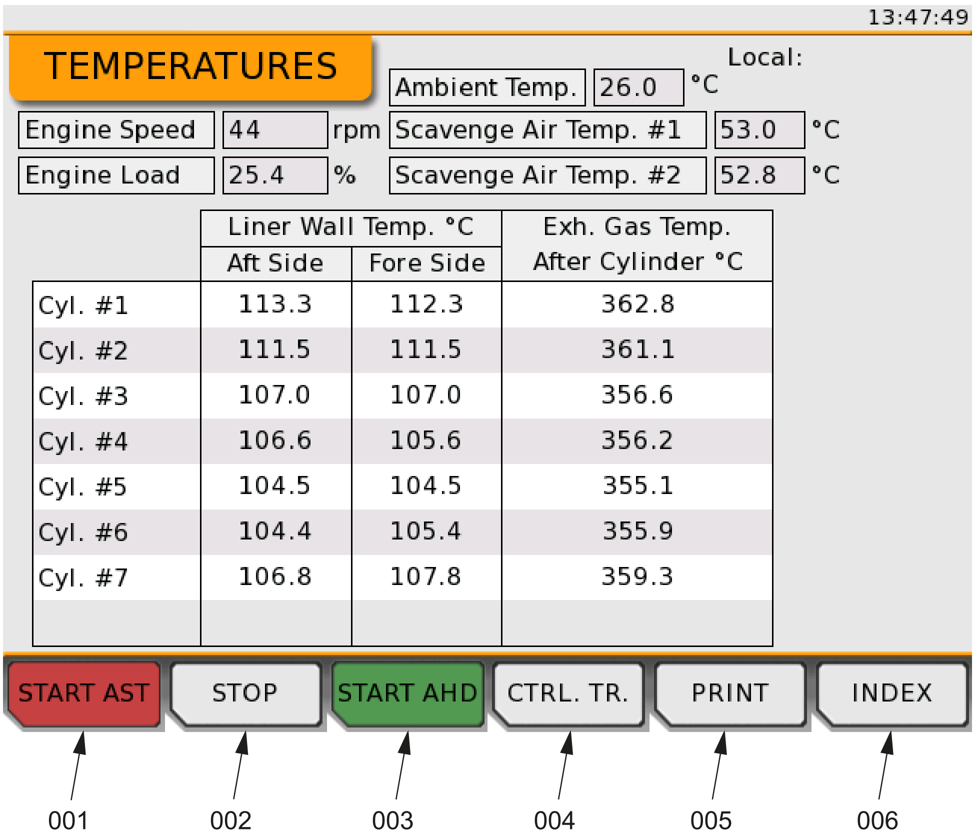


Tab 6-15 PERFORMANCE DATA DIESEL

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page

6.7.14 LDU-20 page - TEMPERATURES

Fig 6-20 TEMPERATURES

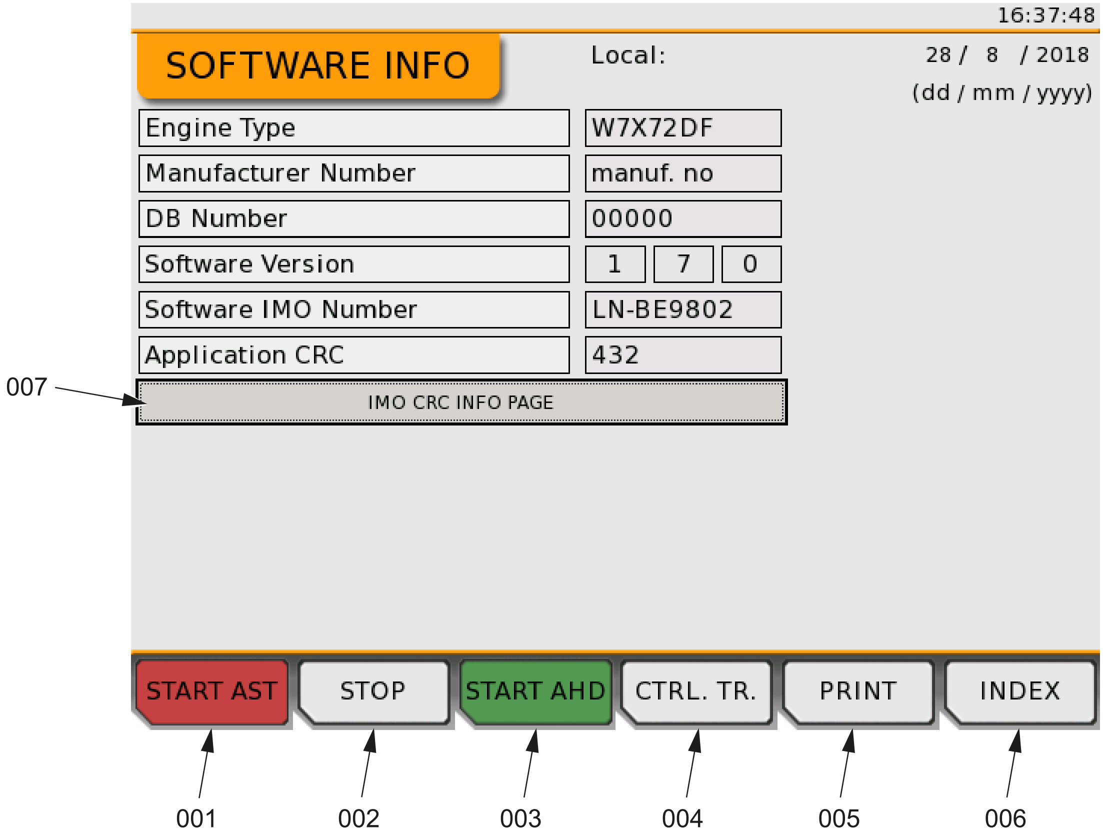


Tab 6-16 TEMPERATURES

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page

6.7.15 LDU-20 page - SOFTWARE INFO

Fig 6-21 SOFTWARE INFO

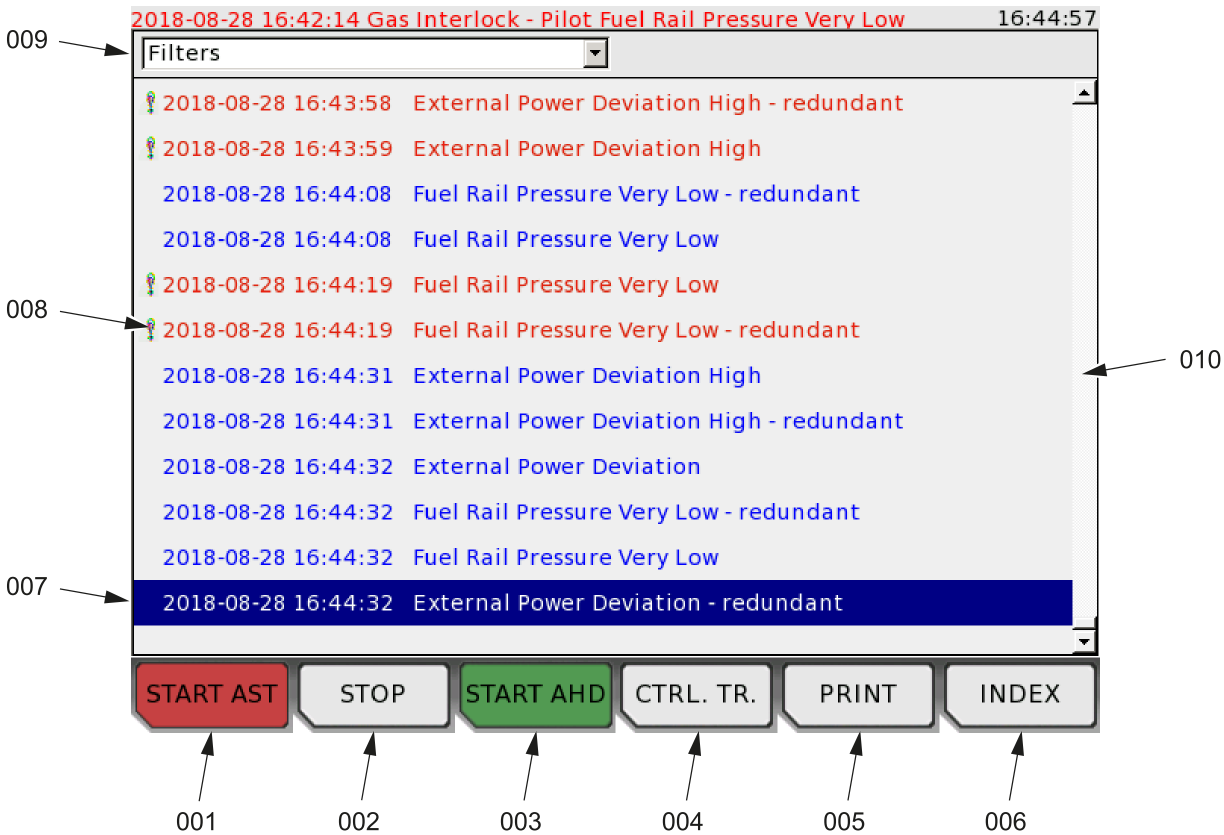


Tab 6-17 SOFTWARE INFO

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page
007	IMO CRC INFO PAGE button	Opens the IMO CRC INFO page

6.7.16 LDU-20 page - LOG MESSAGES

Fig 6-22 LOG MESSAGES

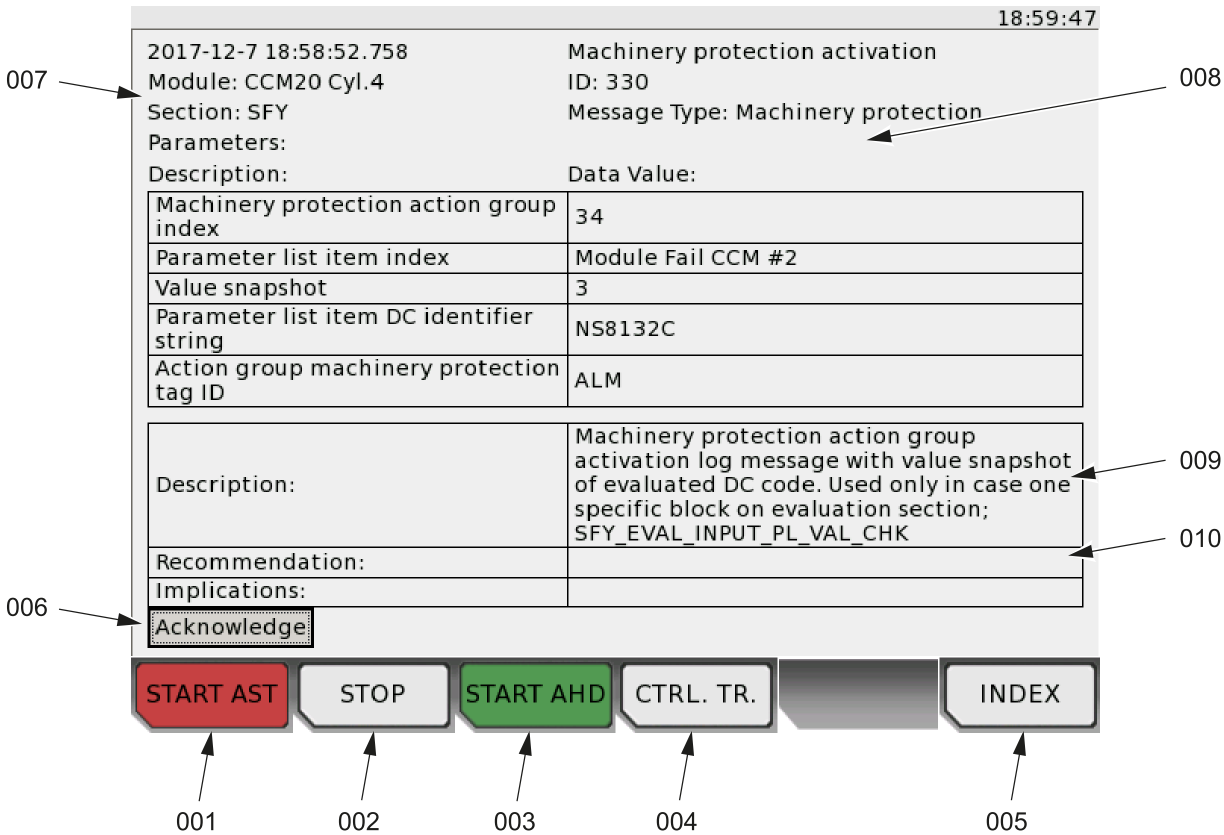


Tab 6-18 LOG MESSAGES

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page
007	Selected log message	Shows the selected log message with a blue background
008	List of log messages	Shows the messages with the latest message at the bottom
009	Filter button	Manually select the applicable filter for the log messages
010	Scroll bar	Manually scroll through the log messages

6.7.17 LDU-20 page - LOG ENTRY DATA

Fig 6-23 LOG ENTRY DATA



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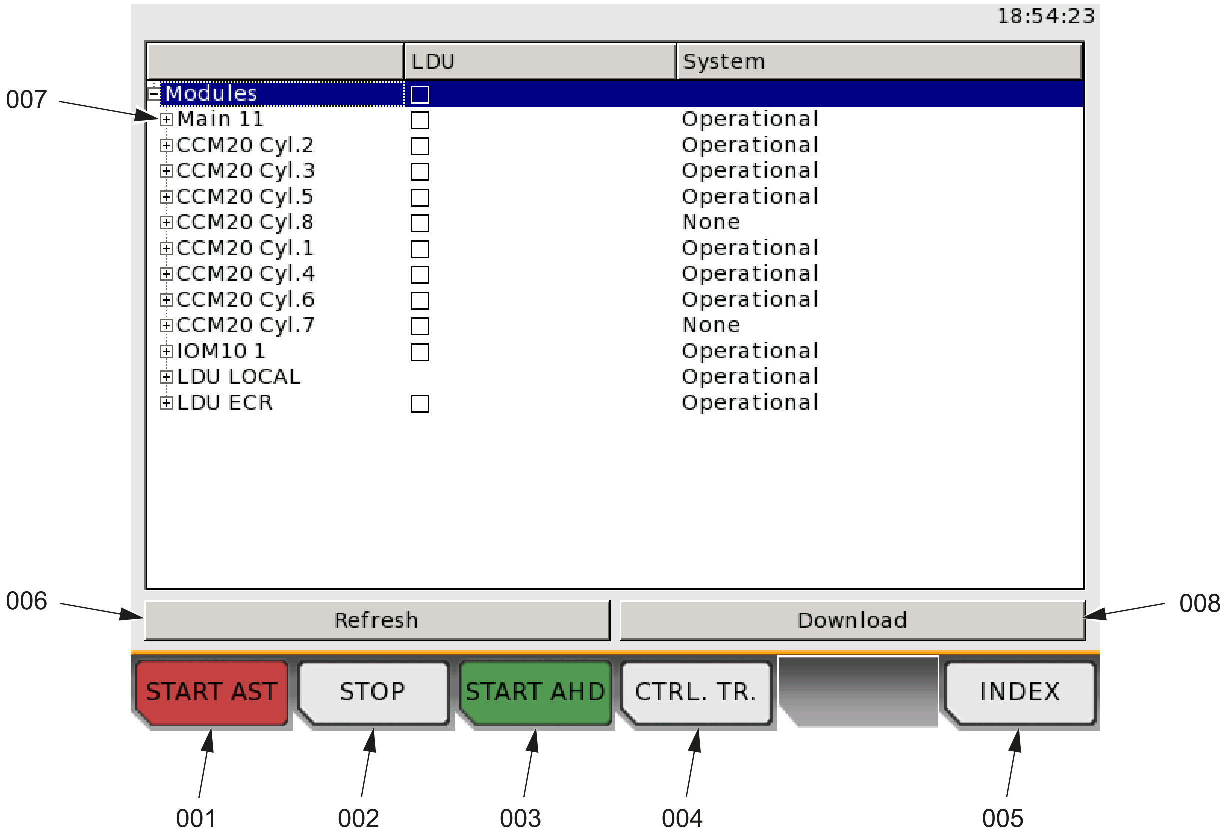
NOTE: Some data on this screen are only applicable to WinGD SW developers, eg the ID and status flag numbers.

Tab 6-19 LOG ENTRY DATA

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	INDEX button	Opens the INDEX page
006	Acknowledge button	Has no function
007	Module identifier	Shows the source module that sent this log entry
008	Message type	Shows the message type. Shows Info, Error, Event, Safety
009	Description	Shows general data about the log entry
010	Recommended action	Shows recommended action that the operator can do to solve the problem

6.7.18 LDU-20 page - SYSTEM STATUS

Fig 6-24 SYSTEM STATUS

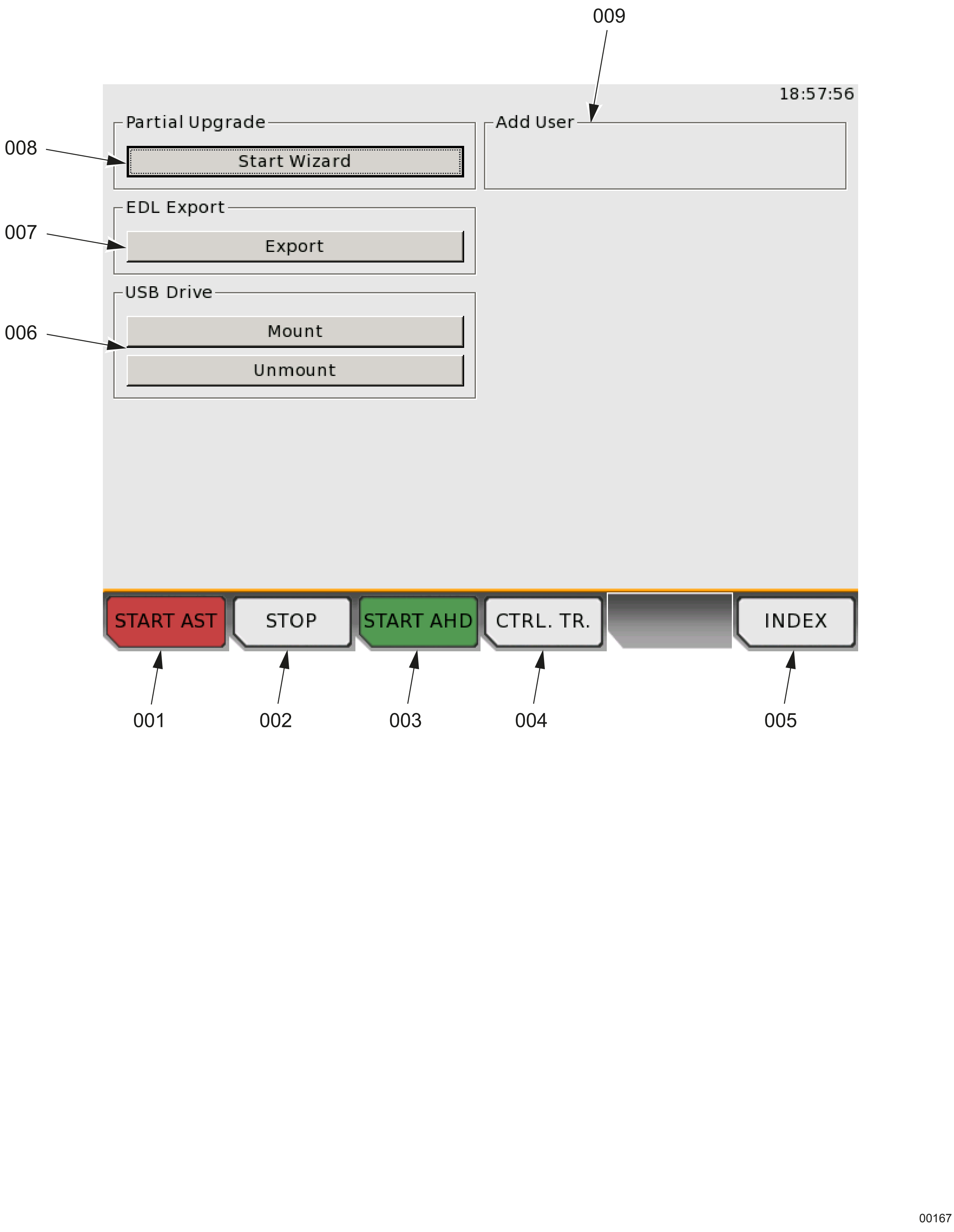


Tab 6-20 SYSTEM STATUS

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	INDEX button	Opens the INDEX page
006	Refresh button	Updates the module status list
007	Status indications for each module	Shows either: • **Initialization:** Hardware module has been reset and bootloader has started the application • **Bootloader, staying in bootloader:** Different version of application/configuration/DSP is found, SW download is necessary to synchronize the module with the rest of the system • **Pre-operational, synchronization:** Module is booting up and waits for synchronization • **Pre-operational, ready:** Module is booting up, everything set-up successfully and is ready to enter Operational state • **Operational:** Module operates correctly, System software and application initialized successfully • **None:** Module is set to OFF or disconnected from the CAN bus • **Stopped:** Module is not configured correctly, system initialization has failed, state is transitioned from pre-operational state The usual working cycle is as follows: • Reset • Initialization • Pre-operational --> Stopped --> Reset • Operational --> Stopped --> Reset
008	Download button	Does a software download on the selected modules

6.7.19 LDU-20 page - SOFTWARE TOOLS

Fig 6-25 SOFTWARE TOOLS

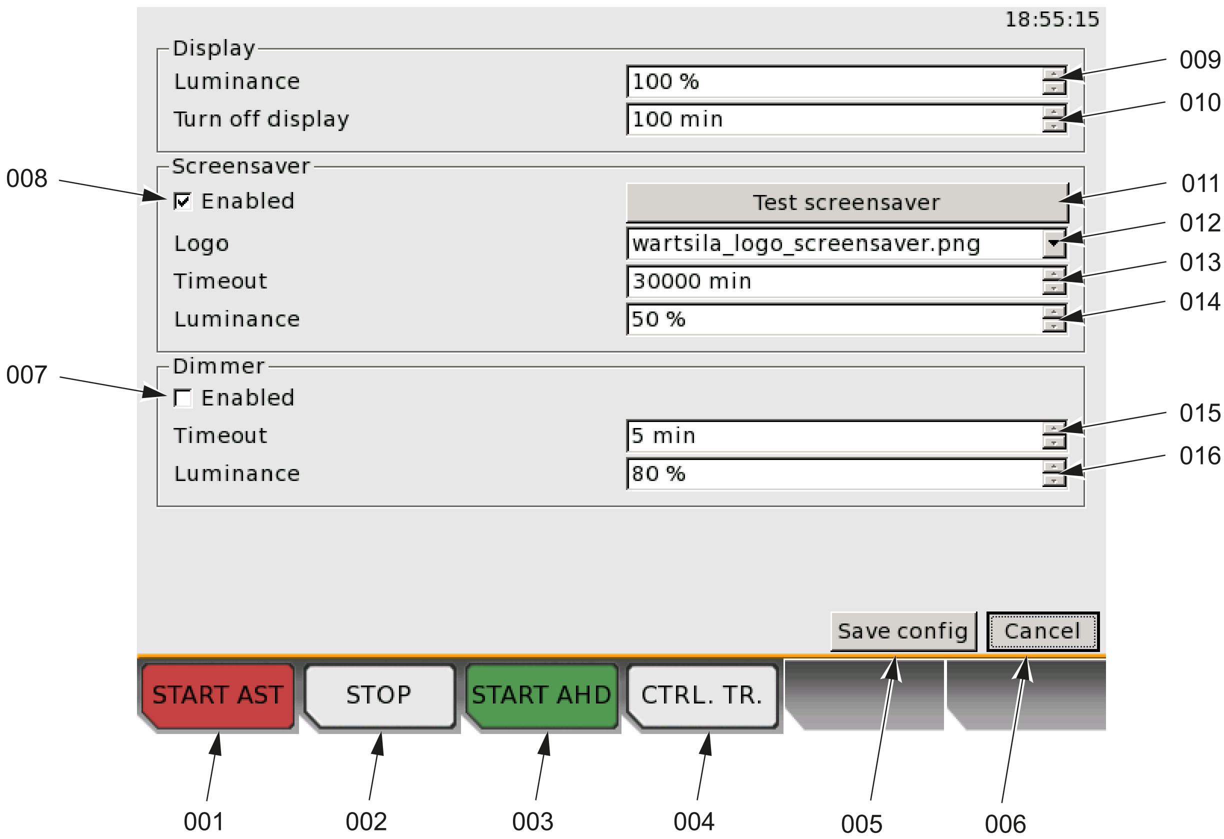


Tab 6-21 SOFTWARE TOOLS

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	INDEX button	Opens the INDEX page
006	Mount / Unmount button	Handles the USB drive
007	Export button	Exports all log messages to a file on a USB drive (if connected)
008	Start Wizard button	Starts the partial upgrade wizard
009	Add User	Not used

6.7.20 LDU-20 page - SYSTEM SETTINGS

Fig 6-26 SYSTEM SETTINGS

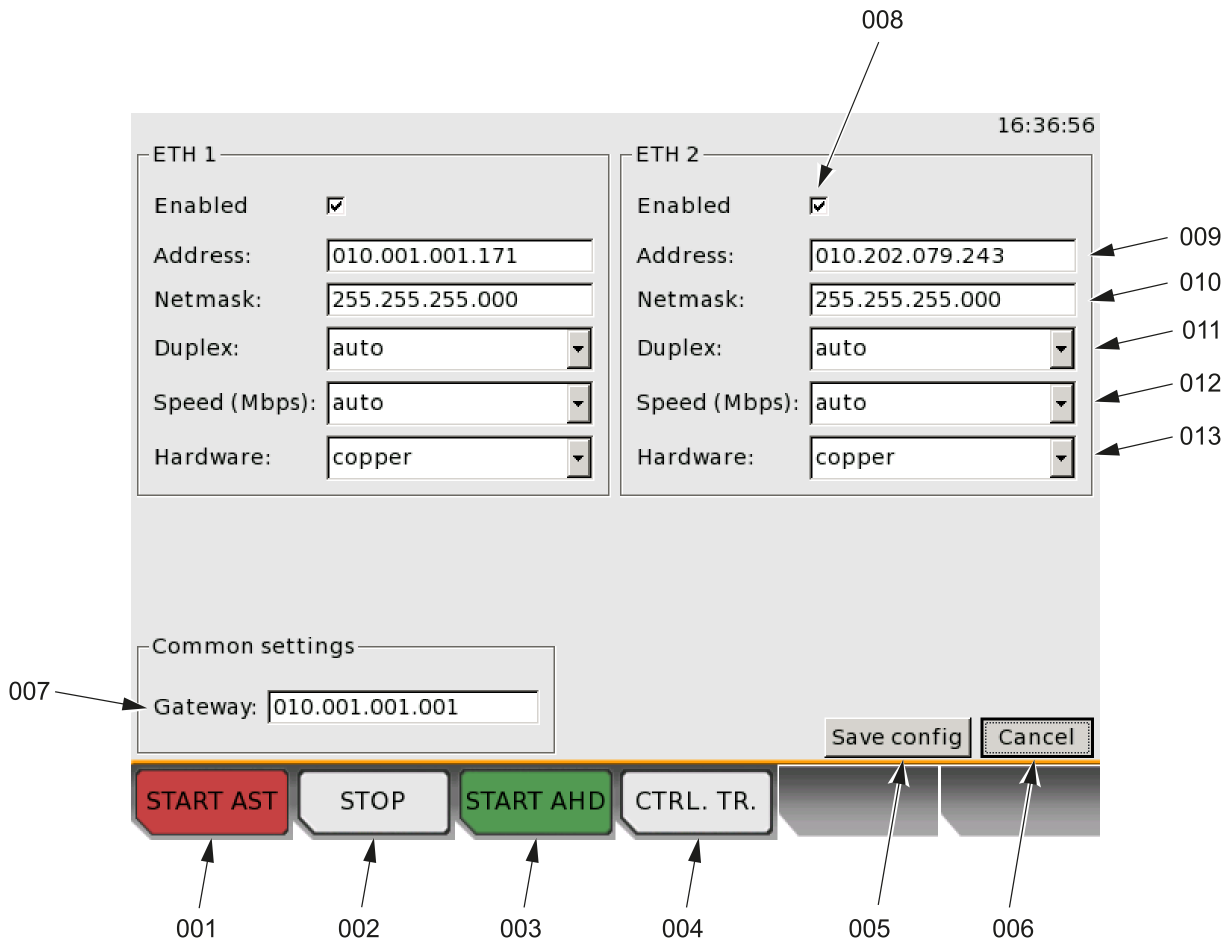


Tab 6-22 SYSTEM SETTINGS

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	Save config button	Saves the configuration settings
006	Cancel button	Cancels the changes and goes back to the last saved settings
007	Enable/Disable dimmer	Enables or disables the dimmer to decrease the display brightness after a specified period of inactivity
008	Enable/Disable screensaver	Enables or disables the screensaver functions
009	Display luminance setting	Adjusts the brightness of the display from 1% to 100%
010	Turn off display	Adjusts the time period to turn off the display after inactivity Set to between 1 min and 100 min Set to 0 to never turn off the display
011	Test screensaver button	Starts and stops the screensaver mode
012	Logo	Selects the picture to use in the screensaver mode
013	Timeout	Adjusts the time period to turn off the display after inactivity. Set to between 1 min and 100 min
014	Screensaver luminance	Adjusts the display brightness for the screensaver mode from 1% to 100%
015	Timeout	Adjusts the time period to dim the display after inactivity. Set to between 1min and 100 min
016	Dimmer luminance	Adjusts the display brightness for the dimmer mode from 1% to 100%
017	Save config button	Saves the configuration settings
018	Cancel button	Cancels the changes and goes back to the last saved settings

6.7.21 LDU-20 page - ETHERNET

Fig 6-27 ETHERNET

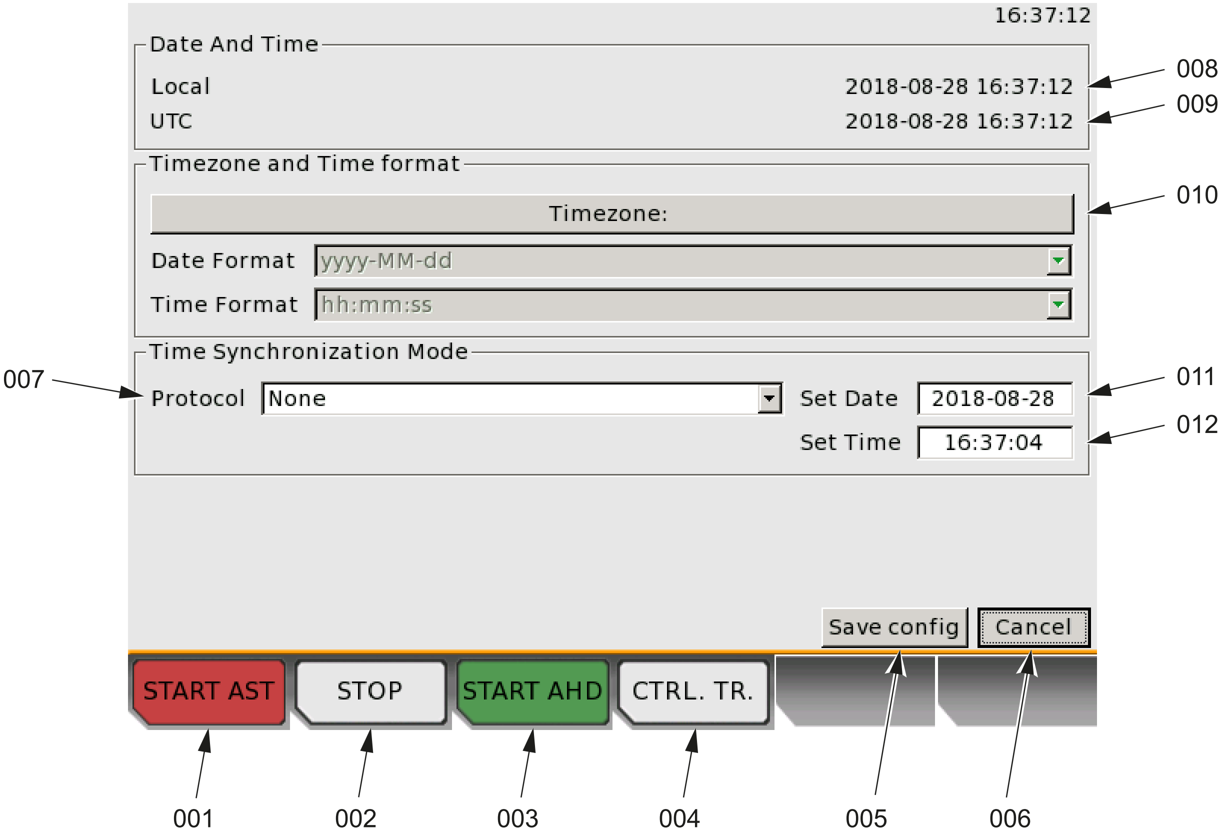


Tab 6-23 ETHERNET

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	Save config button	Saves the configuration settings
006	Cancel button	Cancels the changes and goes back to the last saved settings
007	Gateway field	Manually configure the TCP/IP gateway address Default is 010.001.001.001
008	Enabled button	Manually enable or disable the ethernet ports ETH 1 = plug X31 ETH 2 = plug X32 The two ports must be enabled by default
009	Address field	Manually configure the TCP/IP address for each ethernet port: • LDU-20 Local • LDU-20 ECR
010	Netmask field	Manually configure the TCP/IP netmask
011	Duplex button	Manually configure the ethernet duplex mode • auto (default) • half • full
012	Speed (Mbps) button	Manually configure the ethernet speed • auto (default) • 10 • 100
013	Hardware button	Manually choose the ethernet hardware interface • copper (default) • fiber

6.7.22 LDU-20 page - DATE

Fig 6-28 DATE

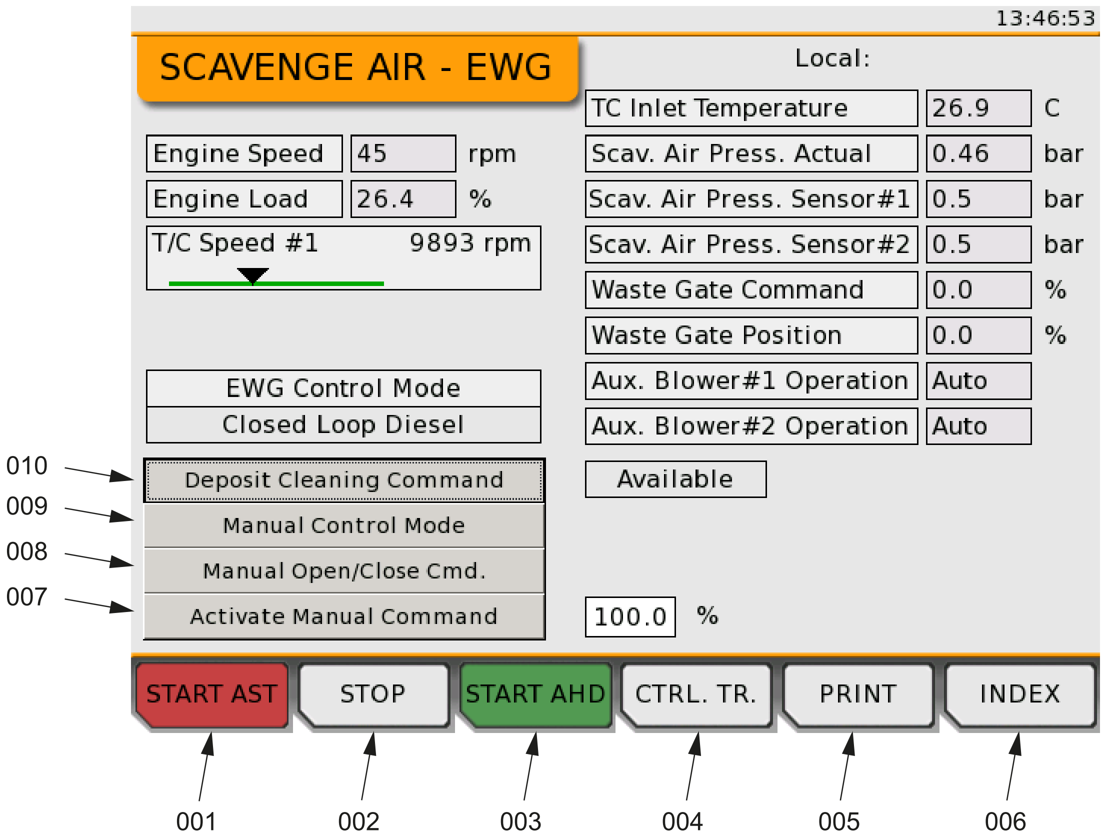


Tab 6-24 DATE

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	Save config button	Saves the configuration settings
006	Cancel button	Cancels the changes and goes back to the last saved settings
007	Time Synchronization Mode button	Selects a Network Time Protocol (NTP). Not used
008	Local time	Shows the time offset from UTC
009	UTC time	Shows the coordinated universal time
010	Timezone button	Opens a list with all available time zones
011	Set Date field	Manually adjust the date setting
012	Set Time field	Manually adjust the time setting

6.7.23 LDU-20 page - SCAVENGE AIR - EWG (optional)

Fig 6-29 SCAVENGE AIR - EWG (optional)



This LDU-20 page is only applicable, if the engine has a controllable exhaust waste gate.

Tab 6-25 SCAVENGE AIR - EWG (optional)

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	PRINT button	Makes a screenshot of the current screen, refer to section 6.7.24 LDU-20 page - SCREENSHOT
006	INDEX button	Opens the INDEX page
007	Activate Manual Command button	Activates the manual exhaust waste gate command. For a controllable exhaust waste gate valve manually adjust the opening of the valve from 0% (closed) to 100% (open).
008	Manual Open/Close Cmd. button	Sends a signal for a manual command to open / close the exhaust waste gate
009	Manual Control Mode button	Sends a signal for a mode change **NOTE:** You only can start the mode change, if the conditions that follow are OK: • Engine at standstill • No shutdown signal active
010	Deposit Cleaning Command button	Starts the deposit cleaning procedure for the EWG, if button shows Available **NOTE:** For the cleaning procedure the exhaust waste gate valve opens 5% during 60 seconds. **NOTE:** You only can start the deposit cleaning, if the conditions that follow are OK: • Engine operates in diesel mode • Engine load is less than 70%

6.7.24 LDU-20 page - SCREENSHOT

This function saves a screenshot of the page to a USB drive (if connected). The saved screenshot is a 640 x 480 pixel image in the xx.png format.

When you save a screenshot, the pop-up text Screenshot saved shows on the bottom right-hand corner of the display. If no USB drive is connected, or if there was an error during the save procedure to the USB drive, the pop-up message shows USB Mounting failed.

NOTE: When the export is done, disconnect the USB drive from the LDU-20. This prevents an unwanted LDU-20 shutdown because of a too high power consumption.

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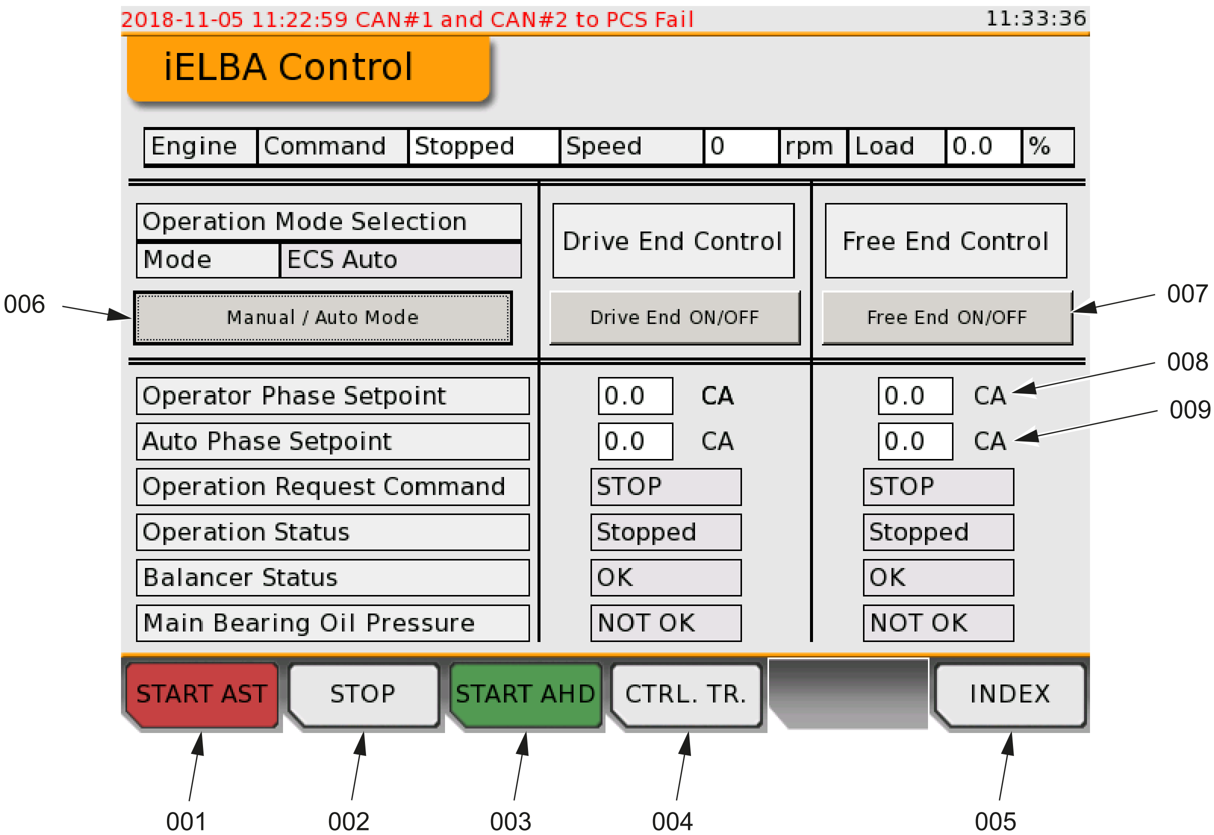
6.7.25 LDU-20 page - iELBA Control (optional)

Fig 6-30 iELBA Control



Tab 6-26 iELBA Control

Item	Function	Effect
001	START AST button	Starts the engine in astern direction (for reversible engine)
002	STOP button	Stops the engine
003	START AHD button	Starts the engine in ahead direction
004	CTRL. TR. button	Sends a signal for a control transfer to this LDU-20
005	INDEX button	Opens the INDEX page
006	Manual / Auto Mode	Changes between automatic and manual control mode of the iELBA
007	Free End ON/OFF	In manual mode - starts and stops the iELBA on the related engine end
008	Operator Phase Setpoint	In manual mode - manually adjust the crank angle setpoint for the related engine end in manual mode
009	Auto Phase Setpoint	In manual mode - manually adjust the crank angle setpoint for the related engine end in auto mode

6.8 Operate the local display unit (LDU-20)

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

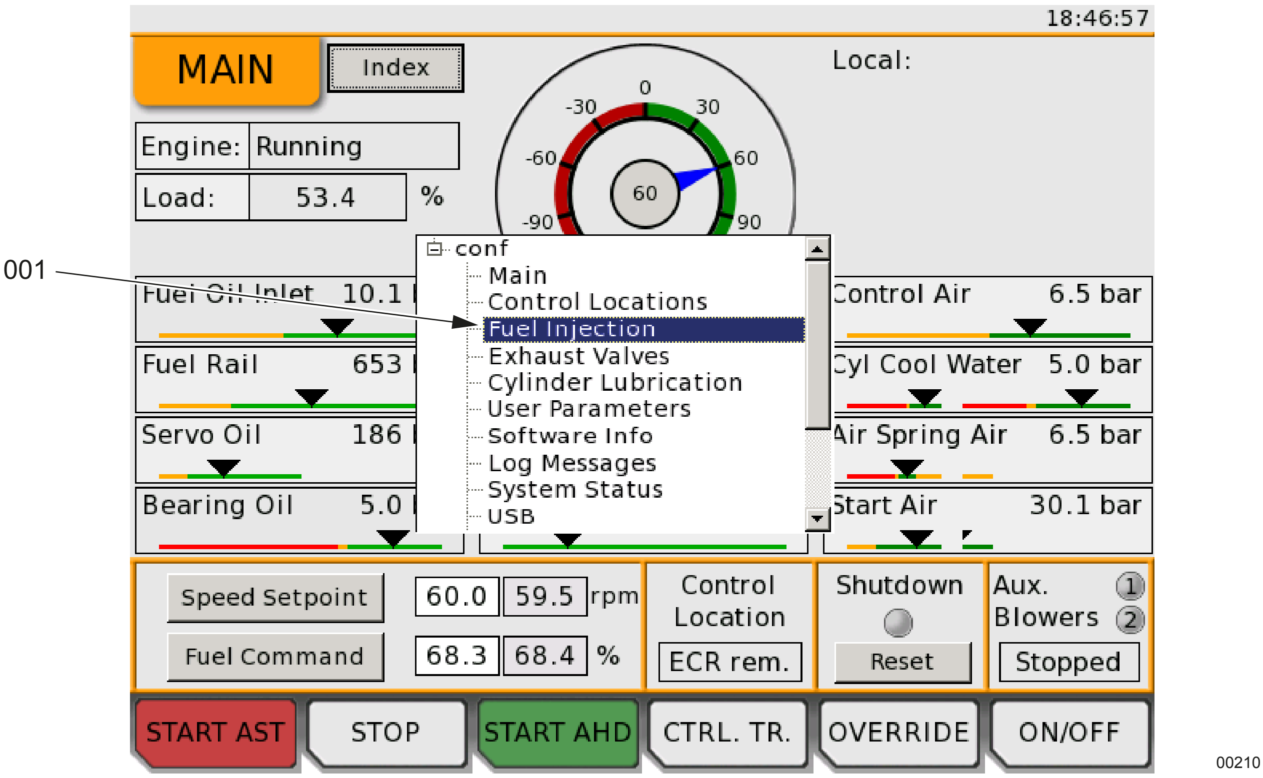
- None

PRELIMINARY OPERATIONS

- The engine control system must be set to on.

PROCEDURE

Fig 6-31 LDU-20 - navigation menu



1 To change between LDU-20 pages, do the steps that follow:

1.1 Push and hold the rotary button for three seconds to show the page navigation menu (001, Figure 6-31).

1.2 Turn the rotary button to select a page:

- To select an item below, turn the rotary button clockwise.
- To select an item before, turn the rotary button counterclockwise.

NOTE: As an alternative you can use the Index button to change between LDU-20 pages.

1.3 Push the rotary button to change to the selected page and to close the navigation menu.

2 To edit a selected item on a LDU-20 page, do the steps that follow:

NOTE: Values and settings that the operator can change are shown with a white background.

2.1 Use the rotary button to select the item.

NOTE: While in edit mode, the text field has an orange frame.

2.2 Push and turn the rotary button.

- To increase the value, turn the rotary button clockwise.
- To decrease the value, turn the rotary button counterclockwise.

2.3 Push the rotary button to apply the change.

3 To operate the engine from the MAIN page, do the steps that follow:

NOTE: The changes have an immediate effect on the engine.

3.1 Make sure that the LDU-20 is the active control location. If necessary, select the CTRL.TR button to transfer control.

3.2 To change modes, move the cursor on the related button then push the rotary button.

NOTE: The indicator (orange triangle) shows the control mode of the LDU-20 (speed mode or fuel command mode).

NOTE: If the MCM-11 becomes defective, a fuel command mode is selected automatically.

NOTE: While in edit mode, the text field has an orange frame. Turn the rotary button to adjust the set point (turn clockwise to increase, counterclockwise to decrease).

3.3 To adjust the speed or fuel command setpoint, move the cursor to the related field then push the rotary button to enter the edit mode.

3.4 To go out of the editing mode, push the rotary button again.

4 To change the LDU-20 control location from the CONTROL LOC. page, do the steps that follow:

4.1 Push the CTRL. TR. button to accept control to the LDU-20 at your location.

4.2 To get / accept control to / from a different location, select the related on-screen button, then push the CHECK button.

5 To adjust the fuel injection parameters from the FUEL INJECTION page, do the steps that follow:

5.1 Turn the rotary button to move the cursor to the related text field.

5.2 Push the rotary button to enter the edit mode.

5.3 Turn the rotary button to adjust the value (turn clockwise to increase, or counterclockwise to decrease).

5.4 Push the rotary button again to go out of the edit mode.

WARNING

After an air run, the crankshaft can turn suddenly when the pressurized air in the cylinder releases. There is a risk of death, serious injury or damage to components. Before you do maintenance on the engine, engage the turning gear, or start the Crank Angle Determination Algorithm (ADA) a second time:

- Make sure that there is no pressurized air in the cylinder and the starting air pipes
- Make sure that you open the relief valves on all cylinder covers to release the pressure

6 To do an ADA Start from the CRANK ANGLE page, do the steps that follow:

NOTE: It is possible to do the ADA procedure with open or closed indicator valves.

6.1 In the LDU-20, get the USER PARAMETERS page.

6.2 Push the AIR RUN button until the engine status changes from ADA to AIR RUN.

NOTE: It is also satisfactory if each cylinder was activated and has moved automatically at the ADA procedure (independently from the direction in which the engine turns).

NOTE: If the ADA procedure has activated each cylinder but the engine stays in its initial position, release the AIR RUN button. Do Step 6.4 to Step 6.7.

6.3 If the ADA procedure is not successful (ie the absolute crank angle position could not be found), do the steps that follow:

6.4 Open the indicator valves on all cylinders to release the compressed air.

6.5 Make sure that the starting air pressure is sufficient.

6.6 If necessary, use the turning gear to turn the engine to another initial position.

6.7 Do Step 6.1 to Step 6.2 again.

7 To open the exhaust valve for inspections from the EXHAUST VALVE page, do the steps that follow:

7.1 Set to ON the servo oil service pump to get some pressure in the servo oil rail.

7.2 Make sure that the air spring air pressure is sufficient.

7.3 Move the cursor to the related text field.

7.4 Push the rotary button to enter the edit mode.

7.5 Turn the rotary button to adjust the value to ON to open the exhaust valve. Adjust the value to OFF to go back to automatic mode. Push the rotary button again to go out of the edit mode.

7.6 Use the manual exhaust valve operation to manually open and close an exhaust valve after the engine has stopped (This can be used for tests and bleed procedures, eg after maintenance).

7.7 Set to OFF the servo oil service pump.

8 To change the filter settings on the LOG MESSAGES page, do the steps that follow:

8.1 Push the BACK button to put the cursor on the Filters field, then push the rotary button to display the list of available filters, eg All/Safety/Event/Info/Error.

8.2 Use the rotary button to move the cursor up or down in the list of available filters.

8.3 Push the rotary button to select or deselect the filters.

8.4 Push the BACK button two times to move the cursor back to the list of log messages.

8.5 Use the rotary button to scroll the list up or down.

8.6 When the cursor (a blue highlight in the list) is on a selected log message, push the rotary button. This shows a different screen, which has more data about this log entry.

9 To export a screenshot from the LOG ENTRY page, do the steps that follow:

9.1 Connect a USB drive to the USB port on the rear of the LDU-20. Make sure that the USB drive has a compatible data format (FAT32).

9.2 Wait until the USB menu window is displayed on the screen.

9.3 Use the rotary button to move the cursor to the SCREENSHOT button.

9.4 Push the rotary button to take a screenshot of the page.

NOTE: The screenshot will be automatically saved to the USB drive.

9.5 If necessary, send the saved xx.png file to WinGD.

10 To download backup files from the SYSTEM STATUS page, do the steps that follow:

NOTE: The dialog box that is shown gives an option to download, or not to download the backup files to the selected modules.

10.1 Use the rotary button (turn and then push) to select the DOWNLOAD button.

10.2 Select Yes to start the download backup files procedure.

NOTE: Select NO if you want to cancel the procedure.

11 To export all log messages from the SOFTWARE TOOLS page, do the steps that follow:

NOTE: Connect a USB drive to the USB port on the rear of the LDU-20 before you select the EXPORT button.

11.1 Use the rotary button to put the cursor on the Export button.

NOTE: The file name EDL Export YYYYMMDD_hhmmss.wxml will be saved to the USB drive. The timestamp display YYYYMMDD_hhmmss is shown as year/month/day_hours/minutes/seconds. This file has the full system log and can be sent to WinGD for troubleshooting.

11.2 Push the rotary button to select Export.

11.3 When the export is done, disconnect the USB drive from the LDU-20. This prevents an unwanted LDU-20 shutdown because of a too high power consumption.

12 To use the partial upgrade wizard from the SOFTWARE TOOLS page, do the steps that follow:

NOTE: You use the partial upgrade wizard to adjust software parameters, which the user does not usually have access. A file from WinGD stored on a USB drive is necessary.

NOTE: Connect the USB drive to the USB port on the back of the LDU-20.

12.1 Use the rotary button to put the cursor on the Start Wizard button.

12.2 Push the rotary button to select Start Wizard.

CLOSE UP

- None

7 Installation

7.1 Installation

The Marine Installation Manual (MIM) gives data about the installation of the engine on the ship. The general installation topics in the MIM are as follows:

- Engine dimensions and masses
- Outline views
- Platform arrangement
- Engine seating
- Engine coupling
- Propulsion shaft earthing
- Engine stays
- Extinguishing system
- Auxiliary systems.

NOTE: The latest version of the Marine Installation Manual and the installation drawings are available on the WinGD website.
https://www.wingd.com/

8 Operation

8.1 Prepare the engine before start - general

If you have done maintenance work on the engine, make sure that you have done the related function tests and the engine is ready for operation.

Do checks on the systems that follow to make sure that the engine is ready for engine start.

NOTE: For the specifications of the operating media refer to section 12.1 General for operating media.

8.1.1 Standard preparation

The systems that follow must be prepared for operation:

- **Cooling water system**

  Make sure that the quality of the cooling water obeys the related specifications.

  Make sure that cooling water is available at the engine connections 01 and/or 02 (cylinder cooling water inlet).

  Make sure that the cooling water system is full.
- **Wash-water system**

  Make sure that the quality of the wash-water obeys the related specifications.

  Make sure that wash-water is available at the engine connection 11 (water for cleaning plant turbocharger and SAC inlet).
- **System oil system**

  Make sure that the quality of the system oil obeys the related specifications.

  Make sure that main lubricating oil is available at the engine connection 25 (main lubricating oil inlet).

  Make sure that crosshead lubricating oil is available at the engine connection 30 (lubricating oil crosshead inlet).

  Make sure that the lubricating oil system is full.
- **Cylinder oil system**

  Make sure that the quality of the cylinder oil obeys the related specifications.

  Make sure that cylinder oil is available at the engine connection 33 (cylinder oil inlet).

  Make sure that the cylinder oil system is full.
- **Starting air system**

  Make sure that the quality of the starting air obeys the related specifications in section 12.2 Compressed air.

  Make sure that starting air is available at the engine connection 40 (starting air pipe inlet).
- **Scavenge air system**

  Make sure that the quality of the scavenge air obeys the related specifications in section 12.3 Scavenge air.

  Make sure that scavenge air is available at the turbocharger inlet.

- **Control air system**

  Make sure that the quality of the control air obeys the related specifications in section 12.2 Compressed air.

  Make sure that control air is available at the engine connection 49 (control air supply inlet).

  Make sure that the control air system is full.

- **Fuel system**

  Make sure that the quality of the fuel obeys the related specifications.

  Make sure that fuel is available at the engine connection 45 (fuel inlet).

  Make sure that the fuel system is full and the fuel can flow.

- **Exhaust gas system**

  Make sure that the exhaust gas system is ready for operation.

- **Power supply system**

  Make sure that the power supply system is ready for operation.

- **Leakage drain system**

  Make sure that the leakage drain tanks of the plant have sufficient capacity.

For a DF engine, also the systems that follow must be prepared for operation:

- **Gas system**

  Make sure that the quality of the gas obeys the related specifications in section [section not applicable for this engine].

  Make sure that gas is available at the engine connection 78 (gas supply inlet).

- **Pilot fuel system**

  Make sure that the quality of the pilot fuel obeys the related specifications.

  Make sure that pilot fuel is available at the engine connection 76 (supply unit fuel pilot valve inlet).

  Make sure that the pilot fuel system is full and the pilot fuel can flow.

NOTE: You can start a DF engine only in diesel mode.

8.1.2 Preparation if components are defective

You also can operate the engine, if components of the engine are defective and you cannot repair the fault immediately. You have to do more preparations related to the defective component, refer to chapter 10 Troubleshooting.

Obey the limits of operation, if components of the engine are not in operation, refer to section 8.3 Start the engine - general.

8.2 Prepare the engine before start

Periodicity

Description	
Engine start	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- Refer to section 8.1 Prepare the engine before start - general

PROCEDURE

1 Make sure that all values for operation are in the correct range, refer to section 11.2 List of usual values and safeguard settings - general.

2 Prepare the control system for operation.

2.1 Set to ON the engine control system (ECS) and the remote control system (RCS).

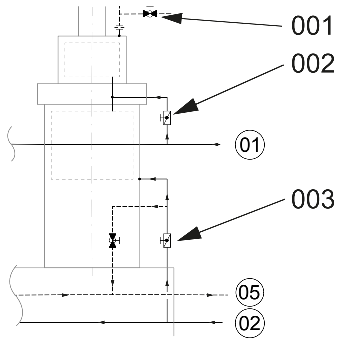
2.2 Set to ON all circuit breakers in the power supply box E85.

2.3 Set to ON the control box for the cylinder oil filter (refer to the documentation of the manufacturer).

3 Prepare the cooling water system for operation.

3.1 For an engine with a bypass cooling water system (refer to Figure 8-1), and when the liner wall temperature is between 60°C and 90°C (for example when the engine is pre-heated or after engine full stop for a sufficient period), release the unwanted air with a high flow rate as follows:

Fig 8-1 Cooling water system with bypass cooling



Legend

001	Optional vent valve	01	Connection 01 (cylinder cooling water inlet)
002	Shut-off valve	02	Connection 02 (cylinder liner CW inlet)
003	Shut-off valve	05	Connection 05 (cylinder CW drain outlet)

3.1.1 Close all shut-off valves (002) in the cylinder cover supply pipes (engine connection 01).

NOTE: This increases the pressure and thus the flow rate at the engine connection 02.

3.1.2 Let the cooling water flow through the cylinder liners for approximately ten minutes.

3.1.3 Close the shut-off valves (003) in the cylinder liner supply pipes of the first half of cylinders (for example cylinder 1 to 3 for a 5 or 6 cylinder engine).

NOTE: This increases again the pressure and thus the flow rate to the other cylinders.

3.1.4 Let the cooling water flow through the other cylinder liners for approximately ten minutes.

3.1.5 Open the shut-off valves (003) in the cylinder liner supply pipes of the first half of cylinders.

3.1.6 Do Step 3.1.3 to Step 3.1.5 again for the second half of cylinders (for example for cylinder 4 and 5 or for cylinder 4 to 6).

3.1.7 Open all shut-off valves (002) in the cylinder cover supply pipes.

3.1.8 If there is unwanted air in the cooling water and the optional vent valve (001) is installed, do as follows:

3.1.8.1 Put an applicable container under the vent valve (001).

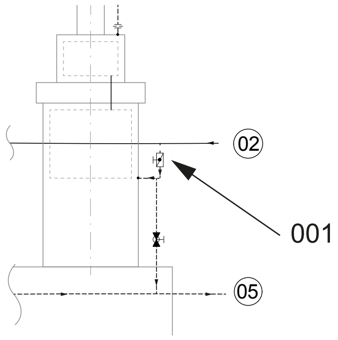
3.1.8.2 Carefully open the vent valve (001) until only cooling water flows out of the vent valve (001).

3.1.8.3 Close the vent valve (001).

3.1.8.4 Discard the hot cooling water correctly.

3.2 For an engine without a bypass cooling water system (refer to Figure 8-2), and when the liner wall temperature is between 60°C and 90°C (for example when the engine is pre-heated or after engine full stop for a sufficient period), release the unwanted air with a high flow rate as follows:

Fig 8-2 Cooling water system without bypass cooling



Legend

001 Shut-off valve

02 Connection 02 (cylinder liner cooling water inlet)

05 Connection 05 (cylinder cooling water drain outlet)

3.2.1 Close the shut-off valves (001) in the cylinder liner supply pipes of the first half of cylinders (for example cylinder 1 to 3 for a 5 or 6 cylinder engine).

NOTE: This increases the pressure and thus the flow rate to the other cylinders.

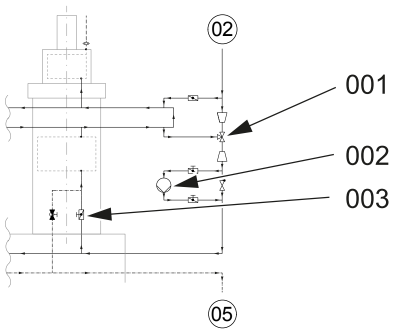
3.2.2 Let the cooling water flow through the other cylinder liners for approximately ten minutes.

3.2.3 Open the shut-off valves (001) in the cylinder liner supply pipes of the first half of cylinders.

3.2.4 Do Step 3.2.1 to Step 3.2.3 again for the second half of cylinders (for example for cylinder 4 and 5 or for cylinder 4 to 6).

3.3 For an engine with an internal circulation cooling water system (with circulation pump and temperature control valve, refer to Figure 8-3), and when the liner wall temperature is between 60°C and 90°C (for example when the engine is pre-heated or after engine full stop for a sufficient period), release the unwanted air with a high flow rate as follows:

Fig 8-3 Cooling water system with circulation



Legend

001	Temperature control valve	02	Connection 02 (cylinder liner cooling water inlet)
002	Circulation pump	05	Connection 05 (cylinder cooling water drain outlet)
003	Shut-off valve		

3.3.1 Close the shut-off valves (003) in the cylinder liner supply pipes of the first half of cylinders (for example cylinder 1 to 6 for a 12 cylinder engine).

NOTE: This increases the pressure and thus the flow rate to the other cylinders.

3.3.2 Let the cooling water flow through the other cylinder liners for approximately ten minutes.

3.3.3 Open the shut-off valves (003) in the cylinder liner supply pipes of the first half of cylinders.

3.3.4 Do Step 3.3.1 to Step 3.3.3 again for the second half of cylinders (for example cylinder 7 to 12 for a 12 cylinder engine).

3.4 Set all valves to their correct positions for operation.

3.5 Release the unwanted air in the cooling water pipes and the scavenge air coolers at the related vent valves.

3.5.1 Carefully open the first vent valve.

3.5.2 After water that has no air flows out, close the vent valve.

3.5.3 Do Step 3.5.1 and Step 3.5.2 again with the other vent valves.

3.6 Make sure that the values that follow are in the permitted range:

- Pressure in the supply pipe of the cylinder cooling water
- Temperature in the supply pipe of the cylinder cooling water
- Pressure in the cooling water supply pipe of the scavenge air cooler (SAC)
- Temperature in the cooling water supply pipe of the SAC.

4 Prepare the air systems for operation.

4.1 Set all valves to their correct positions for operation.

4.2 Drain the air system at the related drain valves.

4.2.1 Open the first drain valve.

4.2.2 After no more water flows out from the valve, close the drain valve.

4.2.3 Do Step 4.2.1 and Step 4.2.2 again with the other drain valves.

4.3 Make sure that the values that follow are in the permitted range:

- Pressure in the supply pipe to the air springs
- Pressure in the supply pipe to the starting air system.

4.4 Set the auxiliary blowers to AUTO.

5 Prepare the lubricating oil systems for operation.

5.1 Set all valves to their correct positions for operation.

5.2 If it is necessary to have servo oil pressure, set to ON the servo oil service pump.

5.3 Make sure that the values that follow are in the permitted range:

- Temperature in the oil supply pipes
- Pressure in the oil supply pipes
- Pressure before the torsional vibration damper (if applicable)
- Pressure in the servo oil rail (only pressure of servo oil service pump)
- Pressure in the distributor pipe (mini-rail)
- Pressure at the turbocharger (if applicable)

5.4 Set to ON the cylinder oil system.

6 Prepare the exhaust gas system for operation.

6.1 If necessary (for example after maintenance), do a check of the exhaust valves for correct function.

6.1.1 Manually open and close the exhaust valve of cylinder No. 1.

6.1.2 Do Step 6.1.1 for a minimum of four times.

6.1.3 Do Step 6.1.1 and Step 6.1.2 again with the other cylinders.

6.1.4 If an exhaust valve does not function correctly, find the cause and repair the fault.

6.2 Make sure that all exhaust valves are closed.

7 Prepare the fuel system for operation.

7.1 Set all valves to their correct positions for operation.

7.2 Make sure that the selected fuel supply is in the permitted range.

8 For a DF engine, prepare the gas system for operation.

8.1 Do a visual check of the gas pipes for damage. If damage is found, replace the defective gas pipes immediately.

8.2 Do the gas related checks. If alarms or failure messages occur, repair the related item.

8.3 Set all valves to their correct positions for operation.

8.4 Make sure that the selected gas supply is in the permitted range.

9 For a DF engine, prepare the pilot fuel system for operation.

9.1 Set all valves to their correct positions for operation.

9.2 Make sure that the selected pilot fuel supply is in the permitted range.

10 Carefully open all indicator valves on the cylinder covers.

NOTE: This makes it possible, that fluids can come out of the cylinder, if the pistons move. Fluids can be in a cylinder, if there are leaks in the water, oil, or fuel system.

WARNING

Injury hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

11 Engage and start the turning gear.

12 If the engine has been stopped for more than approximately five days, start a manual pre-lubrication procedure.

NOTE: This makes sure, that the cylinders get sufficient lubrication before start-up.

13 Turn the engine a minimum of three full turns.

14 If water, oil, or fuel comes out of the indicator valves, do a check of the related components that follow and repair if necessary:

- Cylinder liner
- Cylinder cover
- Piston
- Injection valve.

15 Do a check of all the running gears for correct operation.

16 Stop and disengage the turning gear and lock the lever.

17 If you have started the servo oil service pump, set to OFF the servo oil service pump.

18 On the starting air shut-off valve turn the hand-wheel to the position AUTO.

19 Close the indicator valves on the cylinder covers.

20 Make sure that all doors on the monoblock column are closed and locked.

21 Start the slowturning of the engine on the local control panel.

NOTE: The engine will slowly turn at approximately 5 rpm to 10 rpm.

22 Tell personnel on the bridge that the engine is prepared for operation.

CLOSE UP

- None

Page left intentionally blank

8.3 Start the engine - general

8.3.1 Usual start conditions

The engine must be prepared for operation.

All the auxiliary systems must be in correct operation related to section 8.2 Prepare the engine before start.

You can start the engine from the locations that follow:

- At the bridge or engine control room (ECR) with remote control
- At the backup control panel in the ECR
- At the local control panel of the engine.

Obey the rules for operation related to barred speed ranges:

- Do not continuously operate the engine in a barred speed range.
- If you change the speed, go through the barred speed range as quickly as possible.

NOTE: It is possible that the engine has more than one barred speed range (for example if the axial vibration damper becomes defective, or one or more cylinders are not in operation). You can find data about the barred speed ranges near the telegraph on the bridge, near the local control panel, and in the related documentation of vibration calculations.

8.3.2 Start conditions - limits

With some limits you also can start the engine, if parts of the engine are not prepared for operation, for example:

- One or more turbochargers are defective.
- One or more cylinders are unserviceable.
- The cooling water flow is decreased.

8.3.2.1 One or more turbochargers are defective

To prevent damage to the engine, make sure that you know the limits that follow:

- For an engine with two turbochargers and one turbocharger is defective:
  - Make sure that the exhaust gas temperature at the serviceable turbocharger inlet is less than the maximum permitted temperature.
  - The maximum power output of the engine is approximately 50% related to the power of the serviceable turbocharger.

- For an engine with three turbochargers and one or two turbochargers are defective:
  - Make sure that the exhaust gas temperature at the serviceable turbochargers inlet is less than the maximum permitted temperature.
  - If one turbocharger is defective, the maximum power output of the engine is approximately 66% related to the power of the serviceable turbochargers.
  - If two turbochargers are defective, the maximum power output of the engine is approximately 33% related to the power of the serviceable turbocharger.
  - For a DF engine, the engine can operate in diesel mode, gas mode, or fuel sharing mode.
- If all turbochargers of the engine are defective:
  - The maximum power output of the engine is between 10% (as a minimum) to approximately 15% related to the power of the auxiliary blowers.

8.3.2.2 One or more cylinders are unservicable

Obey the rules for operation, if one or more cylinders are unserviceable:

- Operate the engine only at decreased load.
- It is possible that the turbochargers surge. This makes a loud sound and causes large differences in the scavenge air pressure. In this condition decrease the load of the engine sufficiently.
- It is possible that the engine had stopped in a position from which it cannot start. In this condition start the engine momentarily in the opposite direction to get the crankshaft to a different position.

8.3.2.3 Cooling water flow is decreased

If the cooling water flow is decreased, operate the engine only at decreased load.

8.4 Start the engine

Periodicity

Description	
Engine start	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- Refer to section 8.3 Start the engine - general

PROCEDURE

1 If there is a clutch coupling between engine and propeller, do the steps that follow:

1.1 Engage the clutch coupling.

1.2 Keep the clutch coupling engaged during operation to prevent damage to the engine.

2 Select the applicable control panel.

3 Start the auxiliary blowers.

4 Set the minimum fuel injection quantity on the related control panel.

NOTE: The minimum fuel injection quantity is as follows:

- Approximately 15% for a WECS-9520 engine
- Approximately 30% for each other engine.

5 Push the button START AHD or START AST to start the engine.

NOTE: The ECS starts an automatic pre-lubrication sequence with a specified number of pulses.

NOTE: The ECS increases the engine speed.

6 If new cylinder liners or piston rings were installed, do a running-in, refer to section 9.8 Running-in of new components.

7 If necessary, slowly adjust the fuel injection quantity.

NOTE: The ECS changes the engine speed.

CLOSE UP

- None

8.5 Do checks during operation - general

During operation, do regular checks of the operating values, refer to section 8.6 Do checks during operation. This prevents damage to the engine if malfunctions occur.

Compare the values with those given in the acceptance records. This gives a good indication of the engine performance. If there are unusual differences in the values, find the causes and repair the faults.

Do not open the covers of the rail unit during engine operation.

NOTE: For data about regular maintenance work refer to the Maintenance Manual.

When the engine is at standstill, do also regular checks of the alarm and safety system, refer to section 8.7 Do regular safety checks. This prevents damage to the engine if settings have changed or malfunctions occur.

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8.6 Do checks during operation

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- The engine is running.

PROCEDURE

1 Refer to section 11.2 List of usual values and safeguard settings - general for the usual values for operation.

2 In the control system, do a check of the data that follow:
- Make sure that the values are in the permitted range
- Make sure that there are no alarm signals.

3 If there are unusual values or alarm signals, find the cause and repair the fault.

4 Listen to the engine for unusual noise. If you hear unusual noise, find the cause and repair the fault.

5 If you cannot find the cause of the unusual noise, stop the engine as soon as possible. Find the cause and repair the fault.

6 Do daily the checks and the servicing that follow:

6.1 Do a check of the condensation collectors through the sight glasses of the SAC and the water separator for free flow. If there is a blockage, clean the condensation collector.

6.2 Release the unwanted air from the cooling water system.

7 Do a check of the exhaust gas for dark smoke. If there is dark smoke, find the cause and repair the fault.

8 Do regular checks of the items that follow:
- Levels of fuel, oil and water tanks
- Temperatures of oil, cooling water, bearings and exhaust gas
- Pressures of oil, cooling water and control air
- Pressure difference of the oil filter
- For a DF engine, also pressure of gas.

9 If there are unusual operating values, find the cause and repair the fault.

10 Do regular checks of pipes for leaks. If there are leaks, find the cause and repair them.

11 Do a careful check of the dirty oil drain pipes for differences in temperature.

NOTE: Different temperatures show a blockage in the pipes.

12 If there is an unusual temperature difference, remove the blockage of the pipe as soon as possible.

13 Do weekly the checks and the servicing that follow:

13.1 Do a check of the quality of the cooling water, refer to the instructions of the inhibitor manufacturer.

13.2 Do a careful check of the temperature of the pipe upstream of the starting air valves. If a pipe is too hot, repair the related starting air valve.

13.3 Do a check of the fuel pump cover for oil leaks. If necessary, replace the O-ring.

13.4 Drain the bottle of the filter in the control air supply.

13.5 Do a check of the electrical installations, connectors and modules.

14 For a DF engine, do also the checks that follow:

14.1 Do regular checks (leak checks) of the gas piping system, refer to the related data or documentation.

14.2 Do daily a check of the cylinder compression pressures on the related control panel.

14.3 If there is a drift that is too high or if there is a related alarm message, clean or replace the related pressure transmitter, refer to the Maintenance Manual.

14.4 Do daily a check of the cylinder liner wall temperatures on the related control panel.

14.5 If there is a drift that is too high or if there is a related alarm message, release the unwanted air from the cooling water, for an engine with bypass cooling water system refer to section [section not applicable for this engine].

CLOSE UP

- None

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8.7 Do regular safety checks

Periodicity

Description	
Months	3
Unscheduled	After maintenance work
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	4.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
Pressure calibration hand-pump	94050		1
Smoke test instrument	N/A		1
Ampere meter	N/A		1

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

CAUTION

Equipment Hazard: Leaks can cause faults in the engine control systems and damage to engine components. Leaks that are found during the engine control system checks must be repaired to prevent damage to equipment.

PRELIMINARY OPERATIONS

- The engine must be prepared for operation, refer to section 8.1 Prepare the engine before start - general
- The engine must be stopped.

PROCEDURE

1 Make sure that the remote control system (RCS), the engine safety system (ESS), and the alarm and monitoring system (AMS) are set to ON.

2 Do a check of the EMERGENCY STOP buttons:

2.1 On the control panel in the engine control room (ECR), push the EMERGENCY STOP button.

2.2 Make sure that the pressure control and safety valve 10-5562_E0_5 is electrically operated (ie the coil is energized).

NOTE: This causes an alarm (M/E Emergency Stop) in the AMS.

2.3 Make sure that the EMERGENCY STOP button is deactivated again.

2.4 Do Step 2.1 to Step 2.3 again with the EMERGENCY STOP buttons on the local control panel and on the bridge.

3 Do a check of the pressure switches that follow:

- PS1101S (pressure of cooling water at engine inlet)
- PS2002S (pressure of main oil at engine inlet)
- if applicable PS2012S (pressure of main oil at inlet fuel pump)
- PS2611-nnS (pressure of bearing oil at inlet each turbocharger)
- PS4341S (pressure of air supply to air spring)

3.1 Carefully remove the first pressure switch (for example pressure switch PS1101S).

NOTE: The stop valve in the connection closes automatically.

3.2 Connect the pressure calibration hand-pump to the pressure switch.

3.3 Operate the pressure calibration hand-pump to increase the pressure to more than the SHD pressure of the pressure switch.

NOTE: For the related SHD pressure refer to section 11.2 List of usual values and safeguard settings - general.

3.4 Make sure that the pressure switch opens.

3.5 Decrease the pressure to less than the SHD pressure.

3.6 Make sure that the pressure switch closes at the related pressure.

3.7 If the pressure switch does not close, find the cause and repair the fault.

3.8 Disconnect the pressure calibration hand-pump from the pressure switch.

3.9 Install the pressure switch.

3.10 Do Step 3.1 to Step 3.9 again for the other pressure switches.

3.11 To do a test of the passive failures, temporary disconnect the sockets of the switches that follow:

- PS1101S
- PS2002S
- PS4341S
- FS2521-nnS

4 Do a function check of the oil mist detector:

4.1 Remove a plug from the junction box, or start the Test Menu in the control unit.

4.2 Connect the smoke test instrument to the test connection of a sensor.

4.3 Simulate oil mist to activate an alarm in the safety system.

4.4 If removed, install the plug on the junction box.

5 For a DF engine, do a calibration and a function check of the gas detectors, refer to the related documentation of the manufacturer.

6 Do a check of the auxiliary blowers:

6.1 Make sure that main bearing oil is available.

6.2 If applicable, set to ON the turbocharger oil supply.

6.3 Do a check of the applicable lubricating oil pressure, refer to section 11.2 List of usual values and safeguard settings - general.

6.4 Set to ON the electrical power supply for each auxiliary blower.

6.5 Get control at the local control panel.

6.6 Start the auxiliary blowers.

6.6.1 Make sure that the auxiliary blower 1 starts immediately.

6.6.2 Make sure that the auxiliary blower 2 starts after an interval of between 3 to 6 seconds.

6.7 Make sure that the two auxiliary blowers turn in the correct direction.

6.8 Stop the auxiliary blowers.

6.9 Get control at the control panel in the engine control room (ECR).

6.10 Do Step 6.6 to Step 6.8 again from the control panel in the ECR.

7 Do a check of the auxiliary blowers from the control panel in the engine control room (ECR):

7.1 On the MCM-11, disconnect terminal X33.

7.2 Start the auxiliary blowers.

7.3 Make sure that the command and feedback of auxiliary blowers continue to operate.

NOTE: If the auxiliary blowers do not operate, do a check of the wiring to the starter box.

7.4 Stop the auxiliary blowers.

7.5 On the MCM-11, connect terminal X33.

7.6 On the IOM-10, disconnect terminal X11.

7.7 Start the auxiliary blowers. Command and feedback of auxiliary blowers must continue to operate.

7.8 If the auxiliary blowers do not operate, do a check of the wiring to the starter box.

7.9 Stop the auxiliary blowers.

7.10 On the IOM-10, connect terminal X11.

7.11 Get control at the local control panel.

7.12 Do Step 7.1 to Step 7.10 again from the local control panel.

8 Do a check of the turning gear interlocks:

8.1 Make sure that the turning gear is engaged.

8.2 Make sure that the pressure transmitter PT5017C and the switch ZS5016C do not operate.

NOTE: The pressure transmitter PT5017C operates at 2.0 bar.

8.3 Make sure that the indication Turning Gear Engaged shows on each control panel (in the engine control room and at the local maneuvering stand).

8.4 Make sure that no starting air is in the starting air supply pipe:

8.4.1 Make sure that the starting air shut-off valve 30-4325_E0_1 is in the position AUTO.

8.4.2 Disconnect the plugs on the two solenoid valves CV7013C and CV7014C.

8.4.3 Open the two drain valves in the starting air supply pipe.

8.5 Get control at the local control panel.

8.6 Select the button START AHD.

8.7 Make sure that the indication Turning Gear Engaged is shown on each control panel.

8.8 Make sure that no start command is released.

8.9 Do Step 8.1 to Step 8.8 again from the locations that follow:

- Control panel in the engine control room (ECR)
- Remote control.

8.10 Make sure that the supply of starting air to the starting air supply pipe is possible:

8.10.1 Close the two drain valves in the starting air supply pipe.

8.10.2 Connect the plugs on the two solenoid valves CV7013C and CV7014C.

8.11 Disengage the turning gear.

NOTE: On each control panel, the indication changes to Turning Gear Disengaged. The start command is canceled in the remote control.

9 If there is a malfunction, find the cause and repair the fault, before you start the engine.

CLOSE UP

- None

8.8 Do regular checks for WECS-9520

Periodicity

Description
Unscheduled

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Do each month an engine start in the LOCAL MANUAL CONTROL mode.

2 Do each three months the checks that follow.

2.1 Do a check of the level switches as follows:

2.1.1 Do a check of the electrical cable junctions.

2.1.2 Remove the terminal cover from the sensor.

2.1.3 Change the selector switch from MAX to MIN.

NOTE: An alarm will be activated and the LED display on the sensor shows red.

2.1.4 Set the selector switch back to the original position.

2.1.5 Install the terminal cover to the sensor.

2.2 Do a check of the power supplies for the items that follow:

- FCM-20
- ACM-20
- IOM-10
- Fuel pump actuators.

2.2.1 In the power supply box E85, make sure that all related circuit breakers are set to ON.

2.2.2 At the main switchboard (plant side), set to OFF then set to ON the AC #1 power supply. The WECS−9520 must stay in full operation.

NOTE: Do this step only, if the engine is stopped, eg during the engine start procedure.

2.3 Do a check of the pressure switch PS5017C as follows:

NOTE: If the pressure switch PS5017C on the 3/2-way valve (35-4325_E0_3) is defective, you cannot start the engine in LOCAL MANUAL CONTROL mode.

2.3.1 On the WECS−9520 manual control panel, push the LOCAL MANUAL CONTROL button.

2.3.2 Do the checks that follow of the indications of the turning gear:

- Engaged = switch open
- Disengaged = switch closed.

2.4 Do a check of the starting air control valves as follows:

2.4.1 In the remote control, set to OFF one of the starting air control valves activated by the FCM−20 of cylinder No. 1 or No. 2 (user parameter, function Start Valves Checking).

2.4.2 Do an engine start with starting air (AIR RUN) only, or slow turning.

2.4.3 Do the test procedure again with the other starting air control valve.

NOTE: After each start, the WECS−9520 automatically activates the two starting air control valves.

CLOSE UP

- None

8.9 Maneuver the ship - general

Maneuvering is the operation between leaving a port and approaching to port. Maneuvering also includes all changes during usual operation, for example changing of direction.

The conditions as follows affect the speed of the ship:

- Sailing into strong head winds
- Sailing in heavy seas
- Sailing in shallow water
- Unwanted heavy growth on the hull.

The governor increases the fuel quantity to keep the speed of the ship constant. The increase in the fuel injection quantity shows on the control panel.

8.9.1 Usual maneuvering

The maneuvering range is the speed range between FULL AHEAD and FULL ASTERN. This range is usually divided into four maneuvering steps with related given speeds in each direction.

Load changes must be done slowly to let the piston rings adapt the new conditions. This also prevents increased wear and contamination of the piston rings and the cylinder liners.

The total time to increase the engine load from leaving port to sea speed must not be less than 30 minutes.

The total time to decrease the engine load from sea speed to port approach must not be less then 15 minutes.

Usual time for these two maneuvering operations is between 40 and 45 minutes.

You can do maneuvering operations from the locations that follow:

- At the bridge or engine control room (ECR) with remote control
- At the backup control panel in the ECR
- At the local control panel of the engine.

  NOTE: Maneuvering from the local control panel does not decrease the quality or the safety of the engine operation.

8.9.2 Maneuvering at overload

The engine should only be operated at overload (110% of CMCR power) during sea trials and when there is an authorized representative of the engine builder on board the ship. The limit for operation of the engine at overload is a maximum of one hour each day (refer also to section 3.3 The relation between engine and propeller).

During operation at overload, you must carefully monitor the engine. If there are unusual indications, you must decrease the load (power).

The load indication (fuel injection quantity) and the exhaust gas temperature upstream of the turbocharger show the engine load.

The cooling water temperatures must stay in their usual ranges.

The maximum permitted position of the load indication (fuel injection quantity) is given in the acceptance records. The adjustments are only permitted to show the CMCR power during sea trials with an overspeed of 104% to 108% of CMCR power.

8.10 Maneuver the ship

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Select the applicable control console.

2 To change the speed, do the steps that follow:

- **2.1** Use the rotary button to select the fuel command button.
- **2.2** Turn the rotary button to set the related fuel injection quantity.

  NOTE: Refer to the time limits given in section 8.9 Maneuver the ship - general.

3 To operate the engine in the opposite direction, do the steps that follow:

- **3.1** Use the rotary button to select the fuel command button.
- **3.2** Turn the rotary button to set the fuel injection quantity to approximately 30%.
- **3.3** Push the related button START AHD or START AST.

  NOTE: After some minutes the engine operates in the opposite direction.

CLOSE UP

- None

8.11 Change-over the diesel fuel - general

When you change from heavy fuel oil (HFO) to marine diesel oil (MDO) or back, you must keep the thermal stresses of the related fuel components as low as possible. Thermal stress occurs because of the large temperature changes. Too fast change of the temperature can cause damage to the fuel pump plungers and can cause leakages in the fuel pipes.

During the change-over procedure the temperature of the fuel must not change more than 2°C each minute. This prevents damage to the system, specially when you do the procedure frequently. The small change rate is also because of the large difference of viscosity between HFO and MDO/MGO.

You can do a change-over of the fuel only when the engine is running. While the engine has stopped, there is no fuel flow through the fuel rail. In this situation a change-over is not possible.

8.11.1 Automatic fuel change-over

WinGD recommends the installation and use of an automatic fuel change-over system to prevent problems during the change-over procedure.

- This system decreases the thermal load of the related fuel components (for example fuel pump plungers).
- The safety functions decrease the risk of damage because of thermal loads.
- You can do the change-over procedure at a load of up to 100% CMCR.
- The time period for automatic change-over is less than that of a manual change-over.

8.11.2 Manual fuel change-over

When you do a manual change-over of the fuel, you must make sure that the change-over is safe. Refer to the related procedures.

Make sure that during the procedures HFO never can flow into the MDO tank and pipe system.

NOTE: WinGD recommends to do a manual change-over only, if an automatic change-over system is not installed or if the automatic change-over system is unserviceable.

8.11.3 Recommended viscosity at the inlet of the fuel pumps

For the temperature necessary to make sure that the fuel upstream of the inlet to the fuel pumps is at the correct viscosity, refer to the Viscosity / Temperature Diagram in the related specification, refer to section 12.1 General for operating media. The viscosity for MDO must not be less than 2 cSt.

A viscosimeter measures the viscosity and thus controls the temperature of the fuel.

Make sure that you monitor the viscosity and the temperature of the fuel.

8.11.4 Cylinder oil

When you do a change-over of the fuel, you must make sure that you change to the correct cylinder oil at the same time. This prevents damage of the piston running system because of an incorrect BN. For more data refer to the related procedures.

8.11.4.1 Engine with iCAT

If the engine has an iCAT system (integrated Cylinder lubricant Auto Transfer system), WinGD recommends as follows, when you change-over the fuel:

- If the iCAT system is in auto mode, the iCAT system automatically changes-over the cylinder oil at the correct time.
- If the iCAT system is in manual control (no iCAT functionality mode), you have to manually change-over the cylinder oil at the same time as the diesel fuel change-over.

8.11.4.2 Engine without iCAT

If the engine has no iCAT system (integrated Cylinder lubricant Auto Transfer system), WinGD recommends to monitor the change-over of the cylinder oil. Do a calculation of the cylinder lubricant quantity and make sure that you know the cylinder lubricating feed rate, refer to Figure 8-4.

1. Make sure that you know the cylinder lubricant quantity that is between the change-over valve and the lubricating quills including the measurement tube.
2. Calculate the related lead time that the cylinder oil has to get to the lubricating quills.
3. Use this lead time to have the correct timing for the change-over of the cylinder oil.

NOTE: When you change from MDO to HFO, WinGD recommends to start the change-over of the cylinder oil from low BN to high BN already inside the ECA zone. This prevents operation with high sulphur fuel and low BN cylinder oil.

Fig 8-4 Cylinder lubricant quantity

Cylinder lubricant quantity in piping and measuring tank:

Volume piping: $\sum V = \sum \frac{d^2 * \pi}{4} * l$ $[V] = m^3$ $[d] = m$ $[l] = m$

Mass: $m = \rho * V$ $[m] = kg$ $[\rho] = \frac{kg}{m^3}$ $[V] = m^3$

The density of the cylinder lubricant can be found in the technical data sheet. If not available, an average value of 920 $\frac{kg}{m^3}$ is suitable for this purpose.

Total mass: *Mass of cylinder oil in measuring tank [kg]*
+
Mass of cylinder oil in piping [kg]

Lead time until new lubricant is in use:

$$consumption = \frac{effective\ feed\ rate * current\ power\ output}{1000}$$

$$lead\ time = \frac{total\ mass}{consumption} \qquad [lead\ time] = h \quad [m] = kg$$

$$[consumption] = \frac{kg}{h} \quad [effective\ feed\ rate] = \frac{g}{kWh} \quad [current\ power\ output] = kW$$

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8.12 Change-over the diesel fuel automatically

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- WinGD recommends to always do this automatic change-over procedure when possible. There is no load limit of the engine to do an automatic fuel change-over.

PROCEDURE

1 Start the automatic change-over procedure, refer to the instructions of the manufacturer.

CLOSE UP

- None

8.13 Change-over from HFO to MDO manually

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- WinGD recommends to do a manual change-over only, if an automatic change-over system is not installed or if the automatic change-over system is unserviceable.

PROCEDURE

1 Make a full time schedule for the change-over to obey the ECA rules.

2 If you operate the engine with MDO for a long period, you must change the cylinder oil to the applicable BN at the related time, refer to section 8.11 Change-over the diesel fuel - general.

3 Set to OFF the trace heating of the fuel pipes and fuel rail approximately one hour before the change-over. The correct time is related to the pipe diameter and the waste heat in the system.

4 Set the viscosimeter to 17 cSt to decrease the temperature of the fuel.

5 Set to OFF all heating sources in the system (for example fuel heaters) some minutes before the change-over.

6 Decrease the load of the engine to max. 50% CMCR. The decrease of the engine power is related to the total quantity of fuel that flows in the system (for example the larger the mixing tank, the less decrease in load is necessary).

7 Follow the instructions of the plant to slowly change-over the fuel supply from HFO to MDO. Make sure that you decrease the fuel temperature a maximum of 2°C each minute.

8 If the temperature changes too much, wait until the fuel temperature is stable. Then you can continue the procedure. Try to decrease the temperature as linearly as possible.

9 When the temperature of the fuel is near the applicable value, you can start the cooler slowly to give a linear and smooth temperature change at minimum viscosity.

NOTE: The viscosity of the fuel must not be less than 2 cSt.

10 Do a check of the temperature, viscosity and pressure of the supplied fuel.

11 If the temperature, viscosity, or pressure is not correct, find the cause and repair the fault.

12 If you have to collect the MDO from the leakage and return pipes, do as follows:

12.1 Wait until the system is completely flushed with MDO.

NOTE: This prevents contamination of the MDO with HFO.

12.2 If also a MDO leakage tank is installed, move the 3-way valve in the pipe from the outlet of the fuel leakage fuel pump and injection control to the MDO leakage tank.

12.3 If the fuel return of the pressure control valve goes into the HFO service tank, set the valve positions to have the fuel return go into the MDO service tank.

13 If you have to stop the engine, wait until the change-over procedure is fully completed.

NOTE: This prevents problems during the subsequent engine start because of a mixture of HFO and MDO in the system.

CLOSE UP

- None

8.14 Change-over from MDO to HFO manually

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- WinGD recommends to do a manual change-over only, if an automatic change-over system is not installed or if the automatic change-over system is unserviceable.

PROCEDURE

1 Make a full time schedule for the change-over to obey the ECA rules.

2 Make sure that you have changed the cylinder oil to the applicable BN, refer to section 8.11 Change-over the diesel fuel - general.

3 Set to ON the trace heating of the fuel pipes and fuel rail.

4 If the engine room is cold, after a minimum of one hour make sure to get correct heating.

5 Make sure that HFO cannot flow into the MDO system.

- **5.1** If also a MDO leakage tank is installed, move the 3-way valve in the pipe from the outlet of the fuel leakage fuel pump and injection control to the HFO leakage tank.
- **5.2** If the fuel return of the pressure control valve goes into the MDO service tank, set the valve positions to have the fuel return go into the HFO service tank.

6 Close all covers on the rail unit.

7 Decrease the load of the engine to max. 75% CMCR. The decrease of the engine power is related to the total quantity of fuel that flows in the system (for example the larger the mixing tank, the less decrease in load is necessary).

8 Set the viscosimeter to 13 cSt to increase the temperature of the fuel.

NOTE: The viscosimeter controls the end-heater, which keeps the fuel temperature at the necessary viscosity.

9 Follow the instructions of the plant to slowly change-over the fuel supply from MDO to HFO. Make sure that you increase the fuel temperature a maximum of 2°C each minute.

NOTE: Sudden temperature changes can stop the movement of the fuel pump plungers.

10 If the temperature changes too much, wait until the fuel temperature is stable. Then you can continue the procedure.

11 Do a check of the temperature, viscosity and pressure of the supplied fuel.

12 If the temperature, viscosity, or pressure is not correct, find the cause and repair the fault.

13 If you have to stop the engine, wait until the change-over procedure is fully completed.

NOTE: This prevents problems during the subsequent engine start because of a mixture of HFO and MDO in the system.

CLOSE UP

- None

8.15 Stop the engine - general

You can stop the engine from the locations that follow:

- At the bridge or engine control room (ECR) with remote control
- At the backup control panel in the ECR
- At the local control panel of the engine.

For a diesel engine WinGD recommends to operate the engine with marine diesel oil (MDO) for some time before you stop the engine, refer to section 8.13 Change-over from HFO to MDO manually.

For a DF engine that operates in gas mode are the procedures related to the conditions as follows:

- **The operator pushes the STOP button**

  When the operator pushes the STOP button, the ECS starts the procedures that follow:

  - The ECS changes to stop mode, thus the related control system stops the gas supply and releases the pressure in the gas inlet pipes.
  - The ECS de-energizes the solenoid valve on the gas admission valves (GAV), thus the gas flow to the cylinders stops.
  - The ECS stops the operation of the pilot fuel valves after the crankshaft has turned 360°, thus makes sure that all gas in the combustion chambers burns.

    NOTE: If the crankshaft cannot turn 360°, the ECS sends a signal for an exhaust ventilation request.

- **The ESS or ECS sends a cancelable shutdown signal**

  The engine safety system (ESS) or the ECS sends a cancelable shutdown signal, when a related failure or defect occurs. The procedures are as follows:

  - The ECS changes to diesel mode, thus the related control system stops the gas supply and releases the pressure in the gas inlet pipes.
  - The engine continues to operate in diesel mode until the shutdown signal becomes active.
  - If the operator cancels the shutdown signal within the specified period, the engine continues to operate in diesel mode.

- **The ESS or ECS sends a non-cancelable shutdown signal**

  The ESS or the ECS sends a non-cancelable shutdown signal, when a related failure or defect occurs. The procedures are as follows:

  - The ECS changes to diesel mode, thus the related control system stops the gas supply and releases the pressure in the gas inlet pipes.
  - The ECS de-energizes the solenoid valve on the gas admission valves (GAV), thus the gas flow to the cylinders stops.
  - The ECS stops the engine.
  - The ECS sends a signal for an exhaust ventilation request.

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8.16 Stop the engine

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- Refer to section 8.15 Stop the engine - general

PROCEDURE

1 Select the applicable control panel.

2 Decrease the engine load to the minimum.

3 On the control panel push the STOP button.

NOTE: The ECS shuts down the engine in a controlled manner.

4 For a DF engine, start the exhaust ventilation sequence, if there is a ventilation request.

CLOSE UP

- None

8.17 Emergency stop the engine - general

To stop the engine in an emergency, do the procedure given in section 8.18 Emergency stop the engine.

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8.18 Emergency stop the engine

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.1 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- In some conditions the ECS starts an automatic shutdown.

PROCEDURE

1 In the control room (control console), or on the local control panel, push the EMERGENCY STOP button.

NOTE: The ECS stops the engine immediately.

2 For a DF engine, start the exhaust ventilation sequence, if there is a ventilation request.

3 To make the engine ready for restart after an emergency stop, you must reset the EMERGENCY STOP button.

CAUTION

Damage Hazard. Do this step only as a last alternative selection, if the EMERGENCY STOP button is not working. Damage to the engine can occur.

4 In the power supply boxes E85.1 to E85.#, set to OFF the electrical power to the ECS.

5 Find the cause of the emergency stop and repair the fault.

CLOSE UP

- None

8.19 Prepare the engine after stop - general

After a decrease of the engine speed to less than 8% the ECS automatically starts the post-lubrication of the cylinders.

NOTE: The water and oil pumps must operate for a minimum of 20 minutes after the engine has stopped. This is to make sure that when the engine temperature has decreased, the temperature of engine parts become as stable as possible.

For a short period after an engine stop of one week or less, usually you keep the auxiliary systems in operation, refer to section 8.20 Prepare the engine for a short service break.

For a long period after an engine stop of more than one week or for maintenance of the engine, you do the steps in section 8.21 Prepare the engine for a long shutdown period. If you have to do maintenance, you have to make a decision about which steps of the procedure are necessary for the specified maintenance tasks.

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8.20 Prepare the engine for a short service break

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- The engine must be stopped. Refer to section 8.19 Prepare the engine after stop - general

PROCEDURE

1 Make sure that the auxiliary systems continue to operate.

2 If possible, keep the cooling water warm to prevent too much temperature decrease of the engine.

3 Open the indicator valves in the cylinder covers.

4 Engage the turning gear.

WARNING

Injury hazard. Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

5 Operate the turning gear for a short period at the intervals that follow:

- Daily in damp climate
- Weekly in usual climate.

6 Stop the turning gear so, that the pistons stop in different positions each time.

CLOSE UP

- None

8.21 Prepare the engine for a long shutdown period

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- The engine must be stopped. Refer to section 8.19 Prepare the engine after stop - general

PROCEDURE

1 Open the indicator valves in the cylinder covers.

2 Engage the turning gear.

3 Stop the fuel supply to the engine as follows:

- **3.1** Stop the fuel supply system from the plant.
- **3.2** Close the shut-off valve at engine connection 49 (fuel inlet).
- **3.3** Release the pressure in the fuel system.
- **3.4** Drain the fuel system.
- **3.5** Close the shut-off valve at engine connection 50 (fuel return outlet).

4 Drain the exhaust gas manifold and the exhaust gas pipe.

5 Stop the air supply to the engine as follows:

- **5.1** Stop the air supply systems from the plant.
- **5.2** Close the shut-off valves at engine connection 40 (starting air pipe inlet).
- **5.3** Turn the hand-wheel of the starting air shut-off valve to the position CLOSED.
- **5.4** Drain the air systems of the engine.
- **5.5** Release the pressure in the air pipes.

6 Stop the lubricating oil supply to the engine as follows:

- **6.1** Stop the oil supply systems from the plant.
- **6.2** Close the shut-off valves to the engine at engine connection 33 (cylinder oil inlet).
- **6.3** Set to OFF the control box for the automatic filter.
- **6.4** If installed, close the shut-off valves to the engine upstream of engine connection 25 (main lubricating oil inlet) and of engine connection 30 (lubricating oil crosshead inlet).
- **6.5** Release the pressure in the oil pipes and the oil rail.
- **6.6** Drain the oil systems of the engine.

7 Stop the cooling water supply to the engine as follows:

- **7.1** Stop the cooling water supply system from the plant.
- **7.2** If installed, close the shut-off valves upstream of engine connections 01 and/or 02 (cylinder cooling water inlet).
- **7.3** Release the pressure in the cooling and wash-water pipes.
- **7.4** Drain the water systems of the engine.

8 For a DF engine, stop the gas system.

8.1 If you have to do maintenance downstream of the block valve (CV7285), do as follows:

8.1.1 Make sure that the valve positions are in degassing state.

8.1.2 On the iGPR cabinet switch the button S8 to maintenance to activate the maintenance mode.

8.1.3 On the LDU-20 iGPR page, make sure that all conditions are satisfactory.

8.1.4 On the LDU-20 iGPR page, push the Engine Inerting button to start the engine inerting sequence.

8.1.5 Make sure that the indication in progress shows on the LDU-20.

NOTE: The iGPR control system does the engine inerting sequence.

8.1.6 Wait until the indication passed shows on the LDU-20.

8.1.7 On the iGPR cabinet push the button S7 to degas the system.

8.2 If you have to do maintenance on a component downstream of the master shut-off valve, do as follows:

8.2.1 Make sure that the valve positions are in degassing state.

8.2.2 On the iGPR cabinet switch the button S8 to maintenance to activate the maintenance mode.

8.2.3 On the LDU-20 iGPR page, make sure that all conditions are satisfactory.

8.2.4 On the LDU-20 iGPR page, push the Supply Line Inerting button to start the supply line inerting sequence.

8.2.5 Make sure that the indication in progress shows on the LDU-20.

NOTE: The iGPR control system does the supply line inerting sequence.

8.2.6 Wait until the indication passed shows on the LDU-20.

8.2.7 On the iGPR cabinet push the button S7 to degas the system.

9 For a DF engine, stop the pilot fuel system.

10 Stop the control system from the engine as follows:

- **10.1** Set to OFF all circuit breakers in the power supply box E85.
- **10.2** Set to OFF the engine control system (ECS) and the remote control system (RCS).

11 Do a check of the rail unit as follows:

- **11.1** Open the covers.
- **11.2** Make sure that there is no condensation or corrosion.
- **11.3** If you find condensation or corrosion, do the steps that follow:
  - **11.3.1** Clean the related part.
  - **11.3.2** Find the cause and repair the fault.
- **11.4** If necessary, apply anti-corrosion oil to give protection.
- **11.5** Close the covers.

12 Do a check of the supply unit as follows:

- **12.1** Make sure that there is no condensation or corrosion.
- **12.2** If you find condensation or corrosion, do the steps that follow:
  - **12.2.1** Clean the related part.
  - **12.2.2** Find the cause and repair the fault.
- **12.3** If necessary, apply anti-corrosion oil to give protection.

13 If the engine must have preservation for a long period, speak to or send a message to WinGD for the applicable preservation procedures.

CLOSE UP

- None

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9 Service during operation

9.1 Do an analysis of the system oil

Periodicity

Description	
Working hours	3000
Working hours	6000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
Sample bottles	A/R

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

CAUTION

Injury Hazard: The system oil is hot. Put on gloves and safety goggles to prevent injuries. Do the work carefully.

PRELIMINARY OPERATIONS

- The oil pump is running.
- The system oil has operating temperature.
- The periodicity of 3000 working hours applies for regular oil analysis.
- The periodicity of 6000 working hours applies for FZG and particle count analysis.

PROCEDURE

1 Flush the sample pipe.

NOTE: Use the sample point related to the engine as follows:

- For an engine with servo oil filter, do as follows:
  - Get a sample from the sample point at the engine inlet.
  - If the analysis shows unusual values, get a sample from the sample point after the servo oil filter.
- For an engine without servo oil filter, get the sample from the sample point at the engine inlet.

1.1 Put an applicable container under the sample valve.

1.2 Slowly open the sample valve to flush out oil and possible dirt.

1.3 Close the sample valve.

1.4 Discard the oil correctly.

2 Get an oil sample.

2.1 Put the sample bottle under the sample valve.

2.2 Slowly open the sample valve to fully fill the sample bottle.

NOTE: The necessary quantity of oil is as follows:

- 100 ml for regular oil analysis
- 5 l for FZG and particle count analysis.

2.3 Close the sample valve.

2.4 Close the sample bottle tight.

3 Write the data that follows on the sample bottle:

- Name of the ship
- Type and serial number of the engine
- Date of the sampling
- Location of the sample point
- Operating hours of the oil and of the engine
- Brand and type of the oil.

4 If applicable, do Step 1 to Step 3 again for the other sample point.

5 Send the sample bottles in an applicable package to a laboratory for analysis.

6 Do the procedures related to the results, refer to section [section not applicable for this engine] or to the document “Lubricants” on the WinGD website (https://www.wingd.com/).

CLOSE UP

- None

9.2 Do an analysis of the cylinder oil

Periodicity

Description	
Weeks	1
Unscheduled	After a fuel change
Unscheduled	After a cylinder oil change
Unscheduled	After a feed rate change
Duration for performing preliminary requirements	2.0 man-hours
Duration for performing the procedure	6.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
Sample bottles	A/R

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

CAUTION

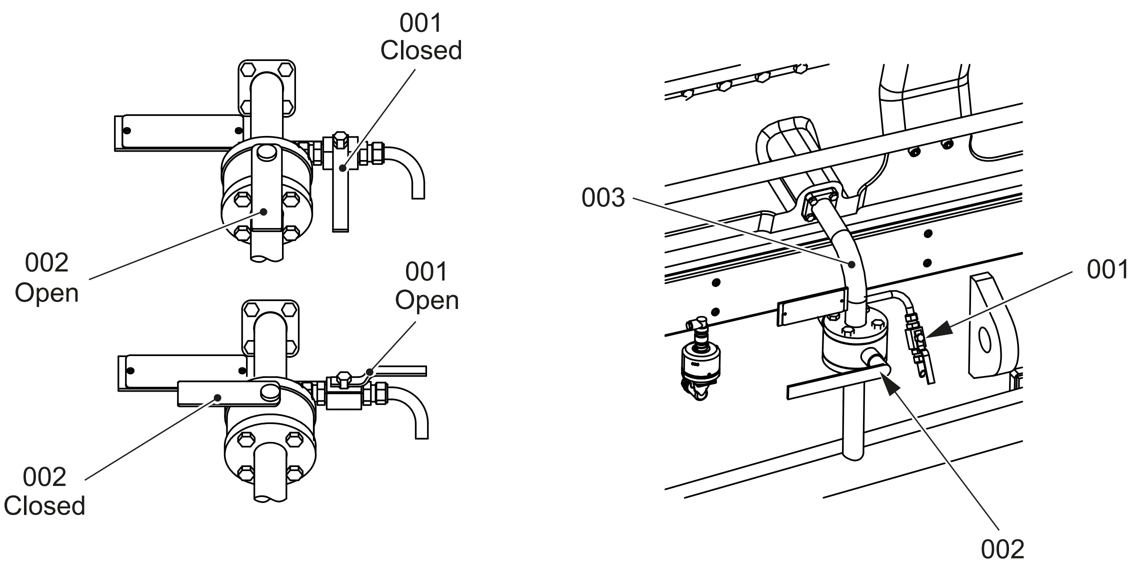
Injury Hazard: The cylinder oil is hot. Put on gloves and safety goggles to prevent injury. Do the work carefully.

PRELIMINARY OPERATIONS

- The engine must be in stable operation for a minimum of 12 hours.
- The duration of the procedure is related to the number of cylinders.

PROCEDURE

Fig 9-1 Location of ball valves - dirty oil samples



1 Do this procedure at a minimum of one time each week, and do it also in the conditions that follow:

- After a fuel change
- After a cylinder oil change
- After a feed rate change.

2 Flush the sample pipe of the related cylinder.

2.1 Close the ball valve (002, Figure 9-1) for approximately 30 minutes to 60 minutes.

NOTE: Some parts can look different.

2.2 Put an applicable container under the oil sample valve (001).

2.3 Slowly open the oil sample valve (001) to flush out oil and possible dirt.

2.4 Close the oil sample valve (001).

2.5 Open the ball valve (002) to drain the remaining oil from the dirty oil pipe (003).

2.6 Close the ball valve (002).

3 Get a sample of the drain oil.

3.1 Make sure that the label on the sample bottle refers to the related cylinder.

3.2 Wait approximately 10 to 60 minutes.

3.3 Put the sample bottle under the oil sample valve (001).

3.4 Slowly open the oil sample valve (001) to fill the sample bottle.

3.5 Close the oil sample valve (001).

3.6 Open the ball valve (002) to drain the oil in the dirty oil pipe (003).

4 Do Step 2 and Step 3 again for each cylinder.

5 Write the applicable data on the oil analysis form (for example operation conditions, fuel parameters, cylinder lubricating feed rate).

6 Do an oil analysis of the samples on-board. The oil analysis must include the data that follows:

- Residual BN
- Iron (Fe) content (if possible).

7 If necessary, do the applicable recommended procedures, refer to section [section not applicable for this engine] or to the document "Lubricants" on the WinGD website (https://www.wingd.com/).

8 Send the oil samples to a laboratory for an oil analysis.

8.1 Make sure that the sample bottles are tightly closed.

8.2 Put the sample bottles in an applicable package.

9 Compare the oil analysis from the laboratory with the oil analysis from on-board.

10 If the oil analyses are different, do the applicable recommended procedures related to the oil analysis from the laboratory, refer to section [section not applicable for this engine] or to the document "Lubricants" on the WinGD website (https://www.wingd.com/).

CLOSE UP

- None

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9.3 Replace the filter element of the duplex filter

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
Filter element		HA1-59-9613-01 -002	pc 1

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Change over to the clean filter chamber.
2 Drain the clogged filter chamber.
3 Remove the cover of the clogged filter chamber.
4 Remove the filter element from the filter chamber.
5 Clean the filter chamber.
6 Clean the filter element or take a new filter element.
7 Install the new filter element into the filter chamber.
8 Install the cover on the filter chamber.
9 Make sure that the cleaned filter chamber has no leaks.

CLOSE UP

- None

9.4 Clean the turbocharger during operation

Periodicity

Description	
Weeks	1
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
Cleaning fluid	A/R

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

CAUTION

Damage Hazard: For an engine with LP SCR system, do not do this procedure, if there is gas flow through the LP SCR reactor. This could cause damage to the components of the SCR system.

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Decrease the engine power to approximately 25 to 85%.

2 Clean the compressor of the turbocharger, refer to the documentation of the manufacturer.

3 Clean the turbine of the turbocharger, refer to the documentation of the manufacturer.

CLOSE UP

- None

9.5 Clean the scavenge air cooler during operation

Periodicity

Description	
Weeks	1
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
Cleaning fluid	A/R

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

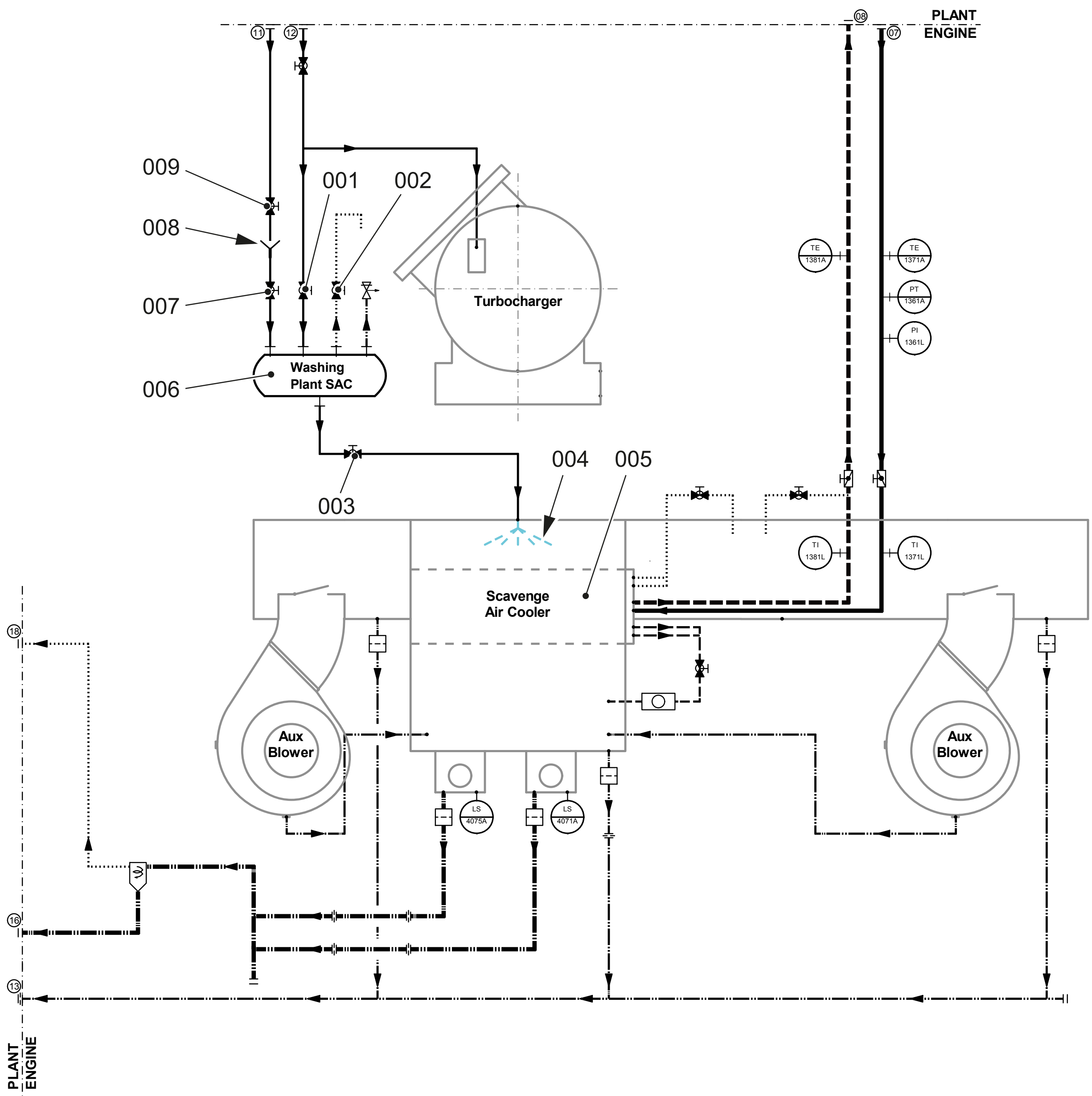
- None

PRELIMINARY OPERATIONS

- None

PROCEDURE

Fig 9-2 SAC - clean during operation (example)



00520

1 Decrease the engine power to approximately 45%.

2 Make sure that compressed air is available at the shut-off valve (001, Figure 9-2) and fresh water is available at the shut-off valve (009).

NOTE: The schematic diagram in Figure 9-2 is an example and is used for reference. Some parts can look different.

3 Fill the tank (006, Figure 9-2) through the funnel (008) with fresh water and the specified quantity of cleaning fluid (max. 30 liters).

3.1 Open the vent valve (002) and the valve (007) of the tank (006).

3.2 Carefully open the shut-off valve (009) in the water supply pipe and fill the tank (006).

NOTE: You can also use a hand-held container filled with cleaning fluid mixed with fresh water to put into the funnel. When you use this method, make sure that the shut-off valve in the supply pipe stays closed.

3.3 Close the shut-off valve (009) in the water supply pipe.

3.4 Close the vent valve (002) and the valve (007) of the tank (006).

4 Open the shut-off valve (001) in the compressed air supply pipe to pressurize the tank (006).

5 Clean the scavenge air cooler (005) as follows:

5.1 Open the shut-off valve (003).

5.2 After no more cleaning water comes out, close the shut-off valve (003).

6 Close the shut-off valve (001) in the compressed air supply pipe.

7 Open the vent valve (002) to release the pressure in the tank (006).

8 After 10 minutes, do Step 2 to Step 7 again with fresh water (no cleaning fluid).

9 Do a check of the water separator for dirt.

10 If the water separator is dirty, clean the water separator (refer to the Maintenance Manual).

CLOSE UP

- None

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9.6 Do a test of the exhaust waste valve

Periodicity

Description	
Weeks	1
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.2 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- This procedure is only applicable, if the engine has operated for a long period at low load with the exhaust waste valve closed.
- The engine load must be less than 70%, or the engine can be stopped.

PROCEDURE

1 On the related control panel manually open the exhaust waste valve.
2 Make sure that the exhaust waste gate is open.
3 Close the exhaust waste valve.
4 If the check is incorrect, find the cause and repair the fault.

CLOSE UP

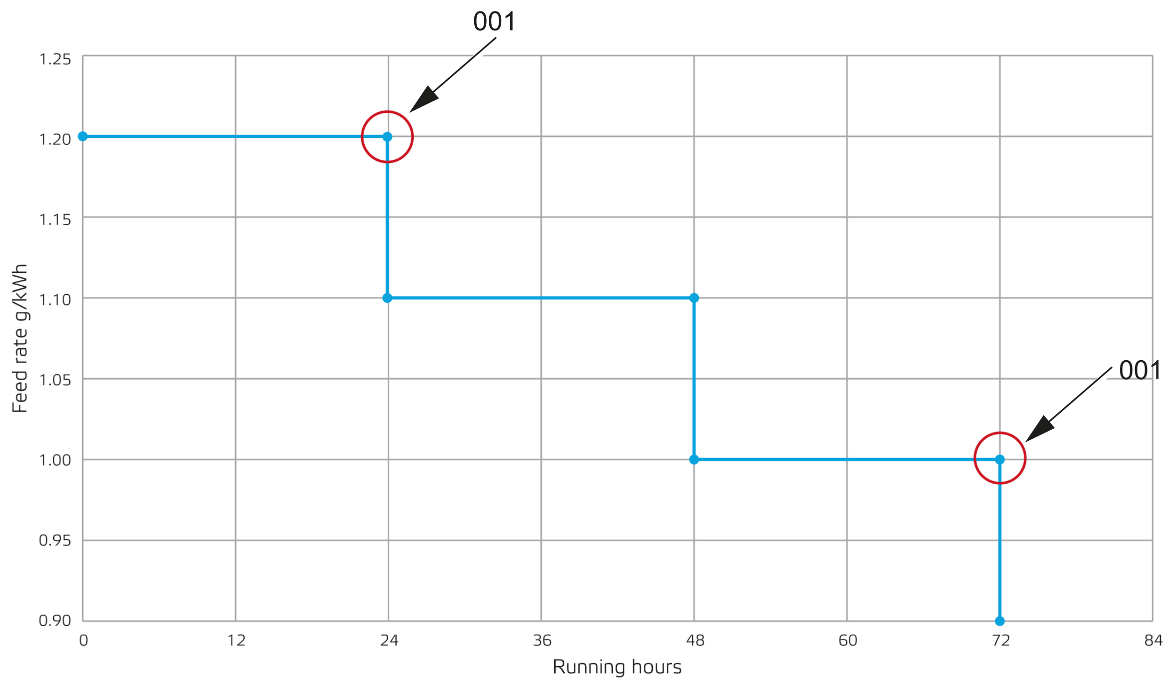
- None

9.7 Running-in of new components - general

After an overhaul or an installation of new components of the piston running system, WinGD recommends a running-in procedure. This makes sure a correct film of cylinder oil on the piston running system is built. The procedure includes a temporary higher feed rate, refer to Figure 9-3.

WinGD recommends an inspection of the cylinder liners and of the piston rings after 24 operation hours and after 72 operation hours (001, Figure 9-3). For this running-in procedure it is not necessary to have a special loading up apart from vessel specific loading up protocols.

Fig 9-3 Feed rate adjustments - running-in



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9.8 Running-in of new components

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	72.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- This procedure is only applicable after an overhaul or an installation of new components of the piston running system.

PROCEDURE

1 Set the cylinder lubricating feed rate for the applicable cylinders in the control system to 1.2 g/kWh.

2 Operate the engine for 24 hours.

3 Inspect the components for damage.

4 If damage occurs, find the cause and repair the fault.

5 If it is necessary to replace parts of the piston running system, do Step 2 and Step 3 again.

6 Set the feed rate to 1.1 g/kWh.

7 Operate the engine for 24 hours.

8 Set the feed rate to 1.0 g/kWh.

9 Operate the engine for 24 hours.

10 Inspect the components for damage.

11 If damage occurs, find the cause and repair the fault.

12 If it is necessary to replace parts of the piston running system, start with Step 1 again.

13 Set the feed rate to 0.9 g/kWh.

CLOSE UP

- After 72 hours set the feed rate to the usual settings. Refer to the document “Lubricants” on the WinGD website (https://www.wingd.com/) or to section [section not applicable for this engine]

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10 Troubleshooting

10.1 Troubleshooting - general data

If the AMS shows trigger value signals, do a check of the data that follow:

- Make sure that all shut-off valves to the instruments are open.
- Make sure that all shut-off valves are in the correct operation position.
- Make sure that the instruments are serviceable.
- Make sure that the cables are connected correctly to the instruments.
- Make sure that there are no leaks.

Before you look for other causes repair defects immediately. For the procedures to replace defective components, refer to the Maintenance Manual.

The tables in section 10.2 Malfunctions of systems and components show how to repair malfunctions on the engine. The tables give the data that follow:

- **Title of the table**

  The title of the table gives the description of the malfunction.
- **Indication**

  This list specifies the number of the signal related to the value. The list can also contain text or be empty.
- **Possible cause**

  This list gives possible causes that have activated the alarm, or have started the malfunction. Refer to the specified sequence to find faults.
- **Procedure**

  This list gives data about the related malfunction. Refer to the specified sequence during troubleshooting. For repair work refer to the related section of the Maintenance Manual. If you cannot repair the malfunction, speak to or send a message to WinGD.

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10.2 Malfunctions of systems and components

10.2.1 Table of malfunctions

Malfunctions of the water systems (XX10NN to XX19NN)

- Table 10-1 - Supply pressure of the cylinder cooling water is too low
- Table 10-2 - Supply temperature of the cylinder cooling water is too low
- Table 10-3 - Cylinder cooling water temperature downstream of a cylinder is too high
- Table 10-4 - Supply pressure of the cooling water to the SAC is too low
- Table 10-5 - Supply temperature of the cooling water to the SAC is too low
- Table 10-6 - Temperature of the cooling water downstream of the SAC is too high

Malfunctions of the oil systems (XX20NN to XX31NN)

- Table 10-7 - Lubricating oil supply pressure at the engine inlet is too low
- Table 10-8 - Lubricating oil supply pressure upstream of the injectors is too low
- Table 10-9 - Lubricating oil supply temperature at the engine inlet is too high
- Table 10-10 - Lubricating oil supply pressure upstream of the crossheads is too low
- Table 10-11 - Servo oil pressure in the distributor pipe (mini rail) is not in the permitted range
- Table 10-12 - Servo oil leakage flow from the servo oil supply unit is too high
- Table 10-13 - Servo oil flow at a servo oil pump inlet is too low
- Table 10-14 - Bearing oil temperature at a bearing outlet is too high
- Table 10-15 - Oil mist concentration is too high
- Table 10-16 - Piston cooling oil temperature downstream of a piston is too high
- Table 10-17 - Piston cooling oil flow to a piston is not in the permitted range
- Table 10-18 - TC bearing oil temperature at a turbocharger outlet is too high
- Table 10-19 - TC bearing oil supply pressure upstream of a turbocharger is too low
- Table 10-20 - TC bearing oil temperature at a turbocharger inlet is too high (external oil supply)
- Table 10-21 - Damper oil supply pressure upstream of the torsional vibration damper is too low
- Table 10-22 - Damper oil supply pressure upstream of the axial vibration damper is too low
- Table 10-23 - Cylinder oil supply pressure is too low
- Table 10-24 - Cylinder oil flow is too low

Malfunctions of the fuel system (XX34NN)

- Table 10-25 - Fuel supply temperature is not in the permitted range
- Table 10-26 - Fuel supply pressure at the engine inlet is too low
- Table 10-27 - Fuel leakage flow from the fuel supply unit is too high

10.2.2 Malfunctions of the water systems (XX10NN to XX19NN)

Tab 10-1 Supply pressure of the cylinder cooling water is too low

Indication	Possible cause	Procedure
PT1101A	The cooling water supply system is defective	• Find the cause and repair the fault.
	There are leaks in the cooling water system (for example cracks in a cylinder liner)	• Find the cause and repair the fault.
	For X92DF, the booster pump is defective	• Repair the booster pump.

Tab 10-2 Supply temperature of the cylinder cooling water is too low

Indication	Possible cause	Procedure
TE1111A	The cooling water supply system is defective	• Find the cause and repair the fault. Adjust the cooling water temperature slowly. This prevents damage caused by sudden temperature change.

Tab 10-3 Cylinder cooling water temperature downstream of a cylinder is too high

Indication	Possible cause	Procedure
TE1121-nnA	This is a result of the malfunction in Table 10-1 - Supply pressure of the cylinder cooling water is too low	• Do the repair shown there.
	The cooling water supply temperature is too high	• Find the cause and repair the fault.
	A cylinder liner, cylinder cover or exhaust valve cage is defective	• Find the cause and repair the fault.
	A piston ring is defective	• As a temporary procedure, cut out the injection of the related cylinder. • As a temporary procedure, increase the feed rate of the cylinder oil of the related cylinder. • Repair or replace the piston rings.

Tab 10-4 Supply pressure of the cooling water to the SAC is too low

Indication	Possible cause	Procedure
PT1361A	The cooling water supply system is defective	• Find the cause and repair the fault.

Tab 10-5 Supply temperature of the cooling water to the SAC is too low

Indication	Possible cause	Procedure
TE1371A	The cooling water supply system is defective	• Find the cause and repair the fault.

Tab 10-6 Temperature of the cooling water downstream of the SAC is too high

Indication	Possible cause	Procedure
TE1381-nnA	This is a result of the malfunction in Table 10-4 - Supply pressure of the cooling water to the SAC is too low	• Do the repair shown there.
	This is a result of the malfunction in Table 10-5 - Supply temperature of the cooling water to the SAC is too low	• Do the repair shown there.

10.2.3 Malfunction of the oil systems (XX20NN to XX31NN)

Tab 10-7 Lubricating oil supply pressure at the engine inlet is too low

Indication	Possible cause	Procedure
PT2001A PT2012A (if applicable)	The oil supply system is defective	• Find the cause and repair the fault.

Tab 10-8 Lubricating oil supply pressure upstream of the injectors is too low

Indication	Possible cause	Procedure
PT2003A	If applicable: the injector oil valve 8423_E0_1 is defective	• Open the shut-off valve 8423_E0_2. • Repair the injector oil valve.
	If injector oil valve 8423_E0_1 is not applicable: shut-off valve 8423_E0_2 is closed	• Open the shut-off valve 8423_E0_2.
	An injection valve is defective or a pipe is clogged	• Find the cause and repair the fault.
The alarm has no effect at engine standstill.		

Tab 10-9 Lubricating oil supply temperature at the engine inlet is too high

Indication	Possible cause	Procedure
TE2011A TE2012A (if applicable)	The oil supply system is defective	• Find the cause and repair the fault.

Tab 10-10 Lubricating oil supply pressure upstream of the crossheads is too low

Indication	Possible cause	Procedure
PT2021A	The crosshead oil supply system is defective	• Decrease the engine load. • Find the cause and repair the fault.

Tab 10-11 Servo oil pressure in the distributor pipe (mini rail) is not in the permitted range

Indication	Possible cause	Procedure
PT2041A	There is an incorrect setting of the pressure reducing valve	• Set the pressure reducing valve to the correct value.
	There is an incorrect setting of the safety valve	• Set the safety valve to the correct value.
	The filter or the opening in the exhaust valve control unit is clogged	• Clean the filter or the exhaust valve control unit.
	A servo oil pump or the servo oil service pump is defective	• Repair the defective pumps.

Tab 10-12 Servo oil leakage flow from the servo oil supply unit is too high

Indication	Possible cause	Procedure
LS2055A	The servo oil unit or a servo oil pipe is defective	• Find the cause and repair the fault, refer to section 10.4 Examine the supply unit for servo oil leakage.

Tab 10-13 Servo oil flow at a servo oil pump inlet is too low

Indication	Possible cause	Procedure
FS2061-nnA	The related servo oil pump is defective	• Replace the defective servo oil pump as soon as possible.
The alarm has an effect only above 30% of engine load.		

Tab 10-14 Bearing oil temperature at a bearing outlet is too high

Indication	Possible cause	Procedure
TE2101-nnA TE2201-nnA TE2301-nnA	This is a result of the malfunction in Table 10-7 - Lubricating oil supply pressure at the engine inlet is too low	• Do the repair shown there.
	A bearing is defective	• Find the cause and repair the fault.
	The oil does not have the specified properties	• Use correct oil.

Tab 10-15 Oil mist concentration is too high

Indication	Possible cause	Procedure
AE2401-nnA (crankcase) AE2415A (gearcase) AE2421-nnA (fuel supply unit)	The oil supply system is defective	• Find the cause and repair the fault.
	Parts that move have become too hot	• As a temporary procedure, decrease the engine load. • Stop the engine. • Wait a minimum of 20 minutes to let the engine temperature decrease. • Find the cause and repair the fault.

Tab 10-16 Piston cooling oil temperature downstream of a piston is too high

Indication	Possible cause	Procedure
TE2501-nnA	This is a result of the malfunction in Table 10-9 - Lubricating oil supply temperature at the engine inlet is too high	• Do the repair shown there.
	A piston ring is defective	• As a temporary procedure, cut out the injection of the related cylinder. • As a temporary procedure, increase the feed rate of the cylinder oil of the related cylinder. • Repair or replace the piston rings.

Tab 10-17 Piston cooling oil flow to a piston is not in the permitted range

Indication	Possible cause	Procedure
FS2521-nnA	This is a result of the malfunction in Table 10-7 - Lubricating oil supply pressure at the engine inlet is too low	• Do the repair shown there.
	A lever is defective	• Repair the defective lever.

Tab 10-18 TC bearing oil temperature at a turbocharger outlet is too high

Indication	Possible cause	Procedure
TE2601-nnA	This is a result of the malfunction in Table 10-9 - Lubricating oil supply temperature at the engine inlet is too high	• Do the repair shown there.
	A turbocharger is defective	• Refer to the turbocharger manual.

Tab 10-19 TC bearing oil supply pressure upstream of a turbocharger is too low

Indication	Possible cause	Procedure
PT2611-nnA	This is a result of the malfunction in Table 10-7 - Lubricating oil supply pressure at the engine inlet is too low	• Do the repair shown there.
	There is an incorrect setting of the adjustable orifice	• Set the adjustable orifice to the correct value.

Tab 10-20 TC bearing oil temperature at a turbocharger inlet is too high (external oil supply)

Indication	Possible cause	Procedure
TE2621A	The external oil supply system is defective	• Find the cause and repair the fault.

Tab 10-21 Damper oil supply pressure upstream of the torsional vibration damper is too low

Indication	Possible cause	Procedure
PT2711A	There is an incorrect setting of the throttle valve	• Set the throttle valve to the correct value.
	An oil supply pipe is defective	• Replace the oil supply pipe.

Tab 10-22 Damper oil supply pressure upstream of the axial vibration damper is too low

Indication	Possible cause	Procedure
PT2721A PT2722A	A sealing ring is defective	• Replace the defective sealing ring.

Tab 10-23 Cylinder oil supply pressure is too low

Indication	Possible cause	Procedure
PT3124A	A filter element is clogged	• Change over to the other filter chamber. • Replace or clean the clogged filter element.
	The cylinder oil tank is empty	• Fill the cylinder oil tank.

Tab 10-24 Cylinder oil flow is too low

Indication	Possible cause	Procedure
	This is a result of the malfunction in Table 10-23 - Cylinder oil supply pressure is too low	• Do the repair shown there.
	This is a result of the malfunction in Table 10-11 - Servo oil pressure in the distributor pipe (mini rail) is not in the permitted range	• Do the repair shown there.
	There is air in the cylinder oil system	• Release the unwanted air from the cylinder oil system.
	Lubricating quills are blocked	• Clean or replace defective parts.

10.2.4 Malfunction of the fuel system (XX34NN)

Tab 10-25 Fuel supply temperature is not in the permitted range

Indication	Possible cause	Procedure
TE3411A	The fuel supply system is defective	• Find the cause and repair the fault.

Tab 10-26 Fuel supply pressure at the engine inlet is too low

Indication	Possible cause	Procedure
PT3421A	The fuel supply system is defective	• Find the cause and repair the fault.
	The fuel does not have the specified properties	• Use correct fuel.

Tab 10-27 Fuel leakage flow from the fuel supply unit is too high

Indication	Possible cause	Procedure
LS3426-27A	An HP fuel pipe or a fuel pump is defective	• Find the cause and repair the defective item, refer to section 10.5 Examine the supply unit for fuel leakage.

Tab 10-28 Temperature difference of the fuel outlet of the two fuel pumps is too high (for X35/-B or X40/-B engine)

Indication	Possible cause	Procedure
TE3431-nnA	Flow control valve of a fuel pump is defective	• Clean or replace the defective flow control valve.
	One of the two fuel pumps is defective	• Replace the defective fuel pump. • As a temporary procedure, close the 3/2-way valve 10-8752_E0_3-4 in the HP fuel pipe of the defective fuel pump.

Tab 10-29 Leakage flow from the rail unit is too high

Indication	Possible cause	Procedure
LS3444-nnA	An item of the rail unit is defective	• Find the cause and repair the defective item, refer to section 10.6 Examine the rail unit for leakage.

Tab 10-30 Fuel leakage flow from fuel rail items is too high (engine with FLV)

Indication	Possible cause	Procedure
LS3446A	A flow limiting valve (FLV), a injector or a pipe is defective	• Find the cause and repair the defective item, refer to section 10.7 Examine the FLV or fuel pipes for fuel leakage.

Tab 10-31 Fuel leakage flow from fuel rail items is too high (engine with ICU)

Indication	Possible cause	Procedure
LS3446-nnA	An injection control unit (ICU) or a pipe or a connecting pipe (if applicable) is defective	• Find the cause and repair the defective item, refer to section [section not applicable for this engine].

Tab 10-32 Fuel pressure in the fuel rail is too high (for X35/-B or X40/-B engine)

Indication	Possible cause	Procedure
PT3461-62C	Control signal is missing or wrong	• Find out the applicable flow control valve. • Related to the necessary engine power close the 3/2-way valve 10-8752_E0_3-4 in the HP fuel pipe of the related fuel pump.
	Flow control valve of a fuel pump is defective	• Clean or replace the defective flow control valve.

Tab 10-33 Fuel pressure in the fuel rail is too low (for X35/-B or X40/-B engine)

Indication	Possible cause	Procedure
PT3461-62C	Control signal is missing or wrong	• Find out the applicable flow control valve. • Disconnect the cable of the applicable flow control valve (The related fuel pump supplies the maximum fuel quantity. The pressure control valve of the fuel rail or the other fuel pump then controls the fuel pressure).
	Flow control valve of a fuel pump is defective	• Clean or replace the defective flow control valve.
	A fuel pump is defective	• Replace the defective fuel pump.

10.2.5 Malfunctions of systems for DF engine (XX33NN to XX39NN)

Tab 10-34 Gas concentration in piston underside is too high

Indication	Possible cause	Procedure
AE3315C	There is a leakage in the gas system	• Find the cause and repair the defective item.

Tab 10-35 Difference pressure of pilot fuel filter is too high

Indication	Possible cause	Procedure
PS3464A	The pilot fuel filter is clogged	• Replace the filter element.

Tab 10-36 Gas supply pressure is too low

Indication	Possible cause	Procedure
PT3901C	The gas supply is defective	• Find the cause and repair the fault.
	The gas filter is clogged	• Clean or replace the gas filter. For the filter of the iGPR refer to [section not applicable for this engine].

10.2.6 Malfunctions of the exhaust gas system (XX37NN)

Tab 10-37 Exhaust gas temperature downstream of a cylinder is too high

Indication	Possible cause	Procedure
TE3701-nnA	The scavenge air flow is too low	• Clean the turbocharger. • Clean the air flaps in the scavenge air receiver. • Clean the scavenge ports.
	This is a result of the malfunction in Table 10-3 - Cylinder cooling water temperature downstream of a cylinder is too high	• Do the repair shown there.
	There is air in the cooling water system	• Open the vent valves of the cooling water system.
	An injection nozzle is defective	• Repair or replace the defective injection nozzle.
	The injection time is too long	• Find the cause and repair the fault.
	There are leaks in the cooling water system (for example cracks in a cylinder liner)	• Find the cause and repair the fault.
	There is a fire in the piston underside	• Do the procedure in section 2.3 Fire-fighting in the scavenge air space.

Tab 10-38 Exhaust gas temperature difference downstream of all cylinders is too high

Indication	Possible cause	Procedure
TE3701-nnA	An injection nozzle is defective	• Repair or replace the defective injection nozzle.
	The fuel supply system is defective	• Find the cause and repair the fault.
	An exhaust valve is defective	• Repair or replace the defective exhaust valve.

Tab 10-39 Exhaust gas temperature upstream of a turbocharger is too high

Indication	Possible cause	Procedure
TE3721-nnA	This is a result of the malfunction in Table 10-37 - Exhaust gas temperature downstream of a cylinder is too high	• Do the repair shown there.

Tab 10-40 **Exhaust gas temperature downstream of a turbocharger is too high**

Indication	Possible cause	Procedure
TE3731-nnA	A turbocharger surges	• As a temporary procedure, decrease the engine load. • If applicable, open the exhaust waste gate valve. • Refer to the turbocharger manual.
	A turbocharger is defective	• Refer to the turbocharger manual.

Tab 10-41 **Exhaust valve does not operate, unwanted noise**

Indication	Possible cause	Procedure
Refer to the display of a control panel	The air spring air pressure is too low	• Find the cause and repair the fault.
	The opening oil pressure is too low	• Find the cause and repair the fault.
	An exhaust valve is defective (piston cannot move, or a piston is defective)	• Repair the exhaust valve.

Tab 10-42 **Smoke is too dark**

Indication	Possible cause	Procedure
	The engine has too much load	• Decrease the fuel injection quantity.
	There is unwanted material in the scavenge air	• Find the cause and remove the unwanted material.
	The fuel does not have the specified properties	• Use fuel with the specified properties.

10.2.7 Malfunction of the air systems (XX40NN to XX44NN)

Tab 10-43 Scavenge air temperature in the receiver is too high

Indication	Possible cause	Procedure
TE4031-nnA	This is a result of the malfunction in Table 10-4 - Supply pressure of the cooling water to the SAC is too low	• Do the repair shown there.
	There is air in the cooling water system	• Release the unwanted air from the cooling water system.
	The SAC is dirty	• Clean the SAC on the air side, refer to section 9.5 Clean the scavenge air cooler during operation.
	The SAC is defective	• Repair or replace the SAC.

Tab 10-44 Scavenge air temperature in the receiver is too low

Indication	Possible cause	Procedure
TE4031-nnA	This is a result of the malfunction in Table 10-5 - Supply temperature of the cooling water to the SAC is too low	• Do the repair shown there.

Tab 10-45 Scavenge air pressure is too high

Indication	Possible cause	Procedure
PT4043-nnC	A turbocharger surges	• As a temporary procedure, decrease the engine load. • If applicable, open the exhaust waste gate valve. • Refer to the turbocharger manual.
	A safety valve is defective	• Repair or replace the defective safety valve.

Tab 10-46 Scavenge air pressure is too low

Indication	Possible cause	Procedure
PT4043-nnC	The silencer, SAC or water separator is clogged	• Remove the blockage and clean the item.
	A turbocharger is defective	• Refer to the turbocharger manual.
	The auxiliary blowers do not operate at low load	• Start or repair the auxiliary blowers.

Tab 10-47 Condensation flow at a water separator is too high

Indication	Possible cause	Procedure
LS4071-nnA	The filter in the return pipe is clogged	• Clean the filter.
	The opening in the return pipe is clogged	• Clean the return pipe.
	There are leaks in the SAC	• Find the cause and repair the fault.

Tab 10-48 Condensation flow upstream of a water separator is too high

Indication	Possible cause	Procedure
LS4075-nnA	The filter in the return pipe is clogged	• Clean the filter.
	The opening in the return pipe is clogged	• Clean the return pipe.
	There are leaks in the SAC	• Find the cause and repair the fault.

Tab 10-49 Scavenge air temperature in the piston underside is too high

Indication	Possible cause	Procedure
TE4081-nnA	There is fire in the piston underside	• Refer to section 2.3 Fire-fighting in the scavenge air space.
	A piston ring is defective	• As a temporary procedure, decrease the load and cut out the injection of the related cylinder. • As a temporary procedure, increase the feed rate of the cylinder oil of the related cylinder. • Repair or replace the piston rings.
	The engine has too much load	• Decrease the fuel injection quantity.

Tab 10-50 Starting air supply pressure is too low

Indication	Possible cause	Procedure
PT4301-nnC	The starting air supply system is defective	• Find the cause and repair the fault.

Tab 10-51 Pressure of the air spring air supply is too high

Indication	Possible cause	Procedure
PT4341A	There is an incorrect setting of the control air supply	• Set the control air supply to the correct value.

Tab 10-52 Pressure of the air spring air supply is too low

Indication	Possible cause	Procedure
PT4341A	There is an incorrect setting of the control air supply	• Set the control air supply to the correct value.
	There is an incorrect setting of the safety valve	• Set the safety valve to the correct value.
	The control air supply is defective	• Repair or replace the defective item of the control air supply.

Tab 10-53 Oil leakage flow in the collector for leakage oil from the air spring is too high

Indication	Possible cause	Procedure
LS4351-52A	The collector for leakage oil from the air spring is clogged	• Clean the collector for leakage oil from the air spring.
	The float control is defective	• Repair the float control.

Tab 10-54 Control air supply pressure is too low (usual supply)

Indication	Possible cause	Procedure
PT4401A	The control air supply system is defective	• Find the cause and repair the fault.
	There is an incorrect setting of the control air supply	• Set the control air supply to the correct value.

Tab 10-55 Control air supply pressure is too low (stand-by supply)

Indication	Possible cause	Procedure
PT4411A	The starting air supply system is defective	• Find the cause and repair the fault.
	There is an incorrect setting of the control air supply	• Set the control air supply to the correct value.

Tab 10-56 Control air supply pressure is too low (safety supply)

Indication	Possible cause	Procedure
PT4421A	This is a result of the malfunction in Table 10-54 - Control air supply pressure is too low (usual supply) and in Table 10-55 - Control air supply pressure is too low (stand-by supply)	• As a temporary procedure, stop the engine. • Do the repair shown there.
	The drain valve of the air tank is open	• Close the drain valve of the air tank.

10.2.8 Miscellaneous malfunctions (XX45NN to XX52NN)

Tab 10-57 Temperature of a thrust bearing pad is too high

Indication	Possible cause	Procedure
TE4521A	This is a result of the malfunction in Table 10-7 - Lubricating oil supply pressure at the engine inlet is too low	• Do the repair shown there.
	The thrust bearing is defective	• Find the cause and repair the fault.
	The oil does not have the specified properties	• Use correct oil.

Tab 10-58 Cylinder liner wall temperature is too high

Indication	Possible cause	Procedure
TE4801-nnC TE4841-nnC	The cylinder oil system is defective	• Find the cause and repair the fault.
	An injection nozzle is defective (for example wrong spray angle, too long spray period)	• Repair or replace the defective injection nozzle.
	This is a result of the malfunction in Table 10-1 - Supply pressure of the cylinder cooling water is too low or in Table 10-3 - Cylinder cooling water temperature downstream of a cylinder is too high	• Do the repair shown there.
	There is air in the cooling water system	• Release the unwanted air from the cooling water system, for an engine with bypass cooling water system refer to section [section not applicable for this engine].
	There are exhaust gas leaks into the cooling water system (for example valve seat area)	• Find the cause and repair the fault.

Tab 10-59 A fuel pump actuator has a failure

Indication	Possible cause	Procedure
XS5046A	The fuel does not have the specified properties	• Use correct fuel.
	A fuel pump actuator is defective	• Repair the fuel pump actuator.

Tab 10-60 Power supply to the power supply box E85 has a failure

Indication	Possible cause	Procedure
XS5056A	The power supply is set to OFF	• Set to ON the power supply.
	The power supply system is defective	• Repair the power supply system.

Tab 10-61 Unwanted engine speed decrease

Indication	Possible cause	Procedure
	The speed setting from the speed control system is decreased or is not in the specified limits	• Do a check of the speed control system.
	The fuel injection quantity from the speed control system is decreased	• A procedure is not necessary because the control system prevents too much load in heavy sea.
	The fuel injection system is defective	• Find the cause and repair the fault.

Tab 10-62 Unwanted engine stop

Indication	Possible cause	Procedure
	The fuel injection system is defective	• Find the cause and repair the fault.
	This is a result of the malfunction in Table 10-61 - Unwanted engine speed decrease	• Do the repair shown there.
	There is heavy sea	• Set to ON the heavy sea mode.

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10.3 Failures and defects of UNIC-flex components

Failures and defects of UNIC-flex components cause failure messages, which are transmitted to the alarm and monitoring system (AMS).

10.3.1 Failure messages

The UNIC-flex engine control system (ECS) constantly does internal integrity checks and monitors the connected sensors. UNIC-flex records each unusual condition and makes an event.

- The system software level does the checks for basic sensor failures.
- The software application level gives the level of the created event.

Related to the severity of the event there are three levels of messages:

- **Minor failures**

  This category contains failures that will not cause to decrease the engine load (slowdown) or to stop the engine (shutdown). But you have to do a check of the message. If necessary correct the fault as soon as possible.

- **Major failures**

  This category contains failures that will cause to decrease the engine load (slowdown) and/or to stop the engine (shutdown). Major failures are divided in the two sub-groups SLD (slowdown) and SHD (shutdown):

  - The SLD sub-group contains failures that cause one cylinder to cut off. The AMS sends a slowdown signal to the ECS.
  - The SHD sub-group contains failures that prevent an engine operation. The engine safety system (ESS) sends a shutdown signal to the ECS. UNIC-flex stops the fuel injection.

  These two sub-groups are not shown in internal or external interfaces. Thus they are only used on the application level.

  If a major failure occurs, the AMS sends a signal to the ECS for a slowdown or shutdown command. Usually the ECS automatically sets the related setpoint for a slowdown or shutdown of the engine, refer also to Para 10.3.2.

- **Info logs**

  This category contains messages which describe engine operation conditions or give more data to other failures. Related to the functional description only the most important messages are sent to the AMS.

The table that follows shows some examples of failure messages.

Tab 10-63 Examples of failure messages

ID	Failure text	Failure type
3	Gear Wheel Sensor A Signal Fail	Minor
46	Crank Angle Measurement Fail CCM #2 to #n	Major / SHD
48	Crank Angle Measurement Fail CCM #1	Major / SLD
250	Remote Start Interlock - Main Start Air Valve Manually Closed	Info

For the complete list of failure messages refer to the document - Modbus to AMS signal list - of the engine.

10.3.2 Special failures

WinGD has specified a few special failures (refer to Table 10-64 - Special failures) that makes it necessary to start other steps.

Tab 10-64 Special failures

ID	Failure text	Failure type
45	Crank Angle Measurement Fail CCM #1 & MCM	Major / SLD
47	Crank Angle Measurement Fail MCM	Minor
96	Module Fail MCM	Minor

If one of these special failures occur, the ECS automatically does the steps that follow:

- The ECS changes the active control location to “ECR manual”.
- The ECS changes to the “Fuel command mode”.

In this condition the ECS cannot set a setpoint for a command. Thus obey the rules that follow:

- If failure 45 occurs the operator must set the fuel command setpoint for slowdown manually.
- If failure 47 or 96 occurs the operator can set the fuel command setpoint if necessary.

10.3.3 Troubleshooting of UNIC-flex failures

If there is an indication of a UNIC-flex failure, use the data that follows to find the failure and to repair it:

- Use the failure ID to find the related system or item.
- If applicable, compare the indicated values with the values on the local instruments.
- Make sure that the related items are mounted correctly and can operate correctly.
- Make sure that the related shut-off valves are in the correct operation positions.
- Do a check of the related cable connections.
- Do a check of the related cable or plugs for damage.
- Do a check of the related item for damage.
- Use a multimeter to do a check of the power supply.
- Use a multimeter to do a check of the sensor signal.
- Use a multimeter to do a check for a short circuit or a ground fault.
- If applicable, do a check of the terminating resistors for correct connection.
- Repair the faults, or temporarily repair defective cables with insulation tape.
- If necessary, replace damaged items.

If you cannot repair a fault, speak to or send a message to WinGD.

10.4 Examine the supply unit for servo oil leakage

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Do a check of the level switch LS2055A for free flow. If necessary, clean the bore of the pipe of the level switch.

2 Carefully do a check of the temperature of the oil leakage pipe of each servo oil pipe to find the leakage pipe that has an oil flow.

NOTE: There is an oil flow in the leakage pipe that has a higher temperature than the other leakage pipes.

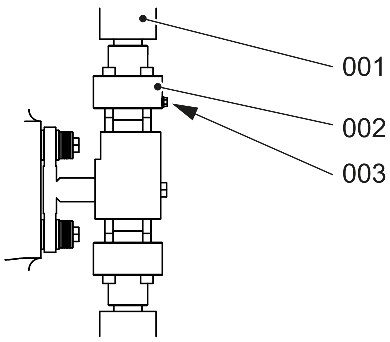
3 Do a check of the related servo oil pipe at the highest inspection point for oil flow.

3.1 Carefully loosen the screw plug (003, Figure 10-1) a maximum of two turns and look for oil flow.

3.2 If there is an oil flow, repair the cause of the leaks as soon as possible. Refer to the Maintenance Manual.

3.3 Tighten the screw plug (003).

Fig 10-1 Example of inspection point



Legend

001 Servo oil pipe
002 Flange
003 Screw plug

4 Do Step 3 again for the other inspection points.

NOTE: Step 5 to Step 8 are only applicable for an X82 engine.

5 Do a check of the level switch LS2076A (if applicable also LS2077A) for free flow. If necessary, clean the bore of the pipe of the level switch.

6 Carefully do a check of the temperature of the oil leakage pipe of each valve control unit (VCU) to find the leakage pipe that has an oil flow.

NOTE: There is an oil flow in the leakage pipe that has a higher temperature than the other leakage pipes.

NOTE: As an alternative you can carefully loosen and tighten the screw plug of the inspection point of each flange a maximum of two turns to find the leakage pipe that has an oil flow.

7 Cut out the injection of the related cylinder and replace the defective oil pipe, refer to the Maintenance Manual.

8 If there is no oil flow from none of the leakage pipes, find (if applicable) the connecting pipe that has a leakage as follows:

8.1 Carefully loosen the screw plug of the inspection point of the first connecting pipe a maximum of two turns.

8.2 Do a check for oil flow.

8.3 If there is an oil flow, shut-off the related connecting pipe an repair it at the next occasion, refer to the Maintenance Manual.

8.4 Tighten the screw plug.

8.5 Do Step 8.1 to Step 8.4 again for the other connecting pipe.

CLOSE UP

- None

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10.5 Examine the supply unit for fuel leakage

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

CAUTION

Injury Hazard: Always put on gloves and safety goggles when you do work on hot or pressurized components. When you open the screw plugs, fuel can come out as a spray and cause injury.

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Do a check of the level switch LS3426A (if applicable also LS3427A) for free flow. If necessary, clean the bore of the pipe of the level switch.

2 Carefully do a check of the temperature of the fuel leakage pipe (002, Figure 10-2) of each fuel pump (001) to find the leakage pipe that has a fuel flow.

NOTE: There is a fuel flow in the leakage pipe that has a higher temperature than the other leakage pipes.

3 Continue with Step 4 to find the location of the leakage at the related fuel pump and its HP fuel pipes.

4 Do a check of the HP fuel pipe (005) at the highest inspection point (004) for leaks.

4.1 Carefully loosen the screw plug a maximum of two turns.

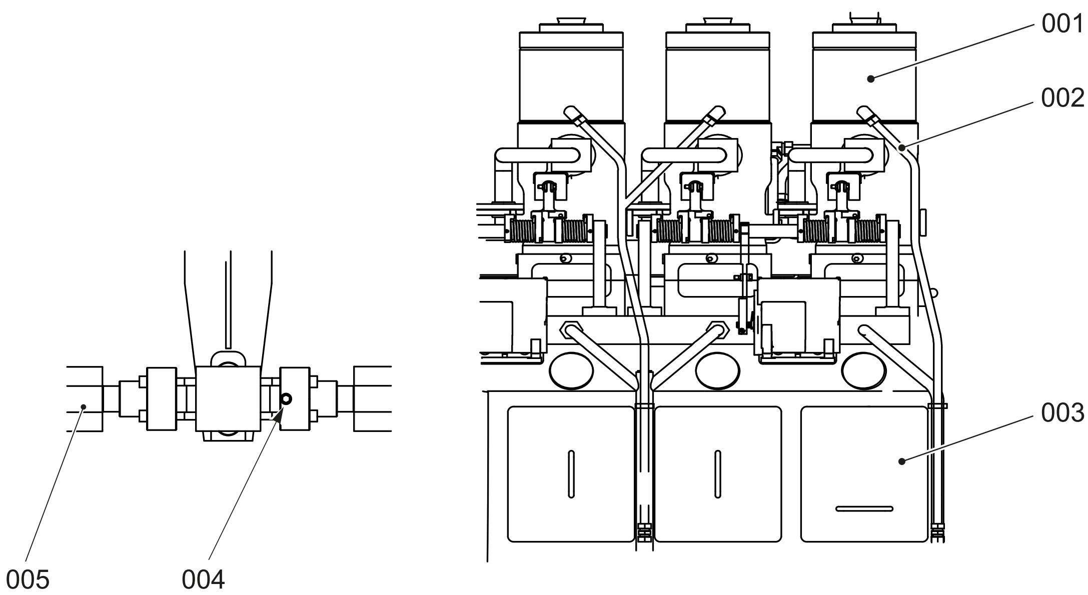
4.2 Do a check for fuel flow.

4.3 If there is fuel flow, repair the cause of the fuel flow as soon as possible, refer to the Maintenance Manual 8752-1.

NOTE: The fuel system has high pressure. Replace a defective HP fuel pipe only when the engine has stopped and the pressure in the system is released.

4.4 Tighten the screw plug.

Fig 10-2 Supply unit (example) and example of inspection point



Legend

001	Fuel pump	004	Inspection point
002	Fuel leakage pipe	005	HP fuel pipe
003	Supply unit		

5 Do Step 4 again for the other inspection points.

6 If the related HP fuel pipes are tight, a fuel pump is defective. Thus do an overhaul of the fuel pump, refer to the Maintenance Manual 5556-1.

NOTE: If the defective HP fuel pipe cannot be replaced immediately (or the engine must continue to operate), the related fuel pump must be cut out.

CLOSE UP

- None

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10.6 Examine the rail unit for leakage

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

CAUTION

Injury Hazard: Always put on gloves and safety goggles when you do work on hot or pressurized components. Fuel can come out as a spray and cause injury.

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Do a check of the level switch LS3444A (if applicable also LS3445A) for free flow. If necessary, clean the bore of the pipe of the level switch.

2 Carefully look into the rail unit to find the cause of the leakage.

NOTE: Possible causes can be a defective pipe to the exhaust valve, a defective flange or an other defective item.

3 Repair the defective item.

CLOSE UP

- None

10.7 Examine the FLV or fuel pipes for fuel leakage

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

CAUTION

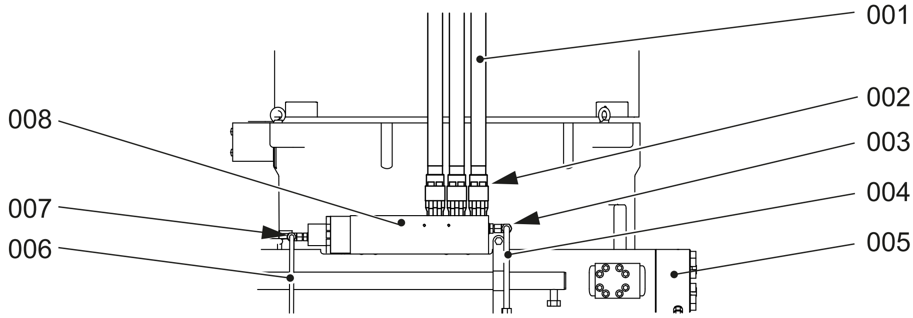
Injury Hazard: Always put on gloves and safety goggles when you do work on hot or pressurized components. When you open the screw plugs, fuel can come out as a spray and cause injury.

PRELIMINARY OPERATIONS

- None

PROCEDURE

Fig 10-3 Leakage on FLV and pipes (example)



Legend

001	HP fuel pipe to injection valve	005	Fuel rail
002	Screw	006	Fuel leakage pipe
003	Screw-in union	007	Screw-in union
004	Fuel leakage pipe	008	Flow limiting valve (FLV)

1 Do a check of the level switch LS3446A for free flow. If necessary, clean the bore of the pipe of the level switch.

2 Carefully do a check of the temperature of the fuel leakage pipe (004, Figure 10-3) of each flow limiting valve (FLV) (008) to find the leakage pipe that has a fuel flow.

NOTE: There is a fuel flow in the leakage pipe that has a higher temperature than the other leakage pipes.

NOTE: As an alternative you can carefully open and close the screw-in union (003) of each FLV a maximum of two turns to find the leakage pipe that has a fuel flow.

3 If there is a leakage pipe (004) that has a fuel flow, do as follows:

3.1 Make sure that the screws (002) are tightened correctly, refer to the Maintenance Manual 8733-1.

3.2 On the fuel leakage pipe (004), carefully loosen the screw-in union (003) a maximum of two turns.

3.3 Do a check for fuel flow.

3.4 If fuel continues to flow from the screw-in union (003), do as follows (an HP fuel pipe (001) is defective):

3.4.1 Stop the engine.

3.4.2 Remove each of the HP fuel pipes (001) until you find the defective HP fuel pipe (refer to the Maintenance Manual 8733-1).

3.4.3 Do a check for damage on the sealing face of the defective HP fuel pipe (001). If you find damage, grind the sealing face (refer to the Maintenance Manual 8733-1).

3.4.4 If the HP fuel pipe is defective, cut out the injection of the related cylinder and replace the defective HP fuel pipe, refer to the Maintenance Manual.

3.4.5 Tighten the screw-in union (003).

3.4.6 Start the engine.

3.5 If no fuel flows from the screw-in union (003), tighten the screw-in union (003).

4 If none of the leakage pipes (004) have a leakage, find the FLV that has a fuel flow more than usual (compared to the amount of leakage from the other FLV) as follows:

- **4.1** Put an oil tray under the screw-in union (007, Figure 10-3) of the fuel leakage pipe (006) to collect the usual fuel flow.
- **4.2** Carefully loosen the screw-in union (007) a maximum of two turns.
- **4.3** Do a check of the fuel flow.
- **4.4** If fuel flows from the screw-in union (007) more than usual (compared to the amount of leakage from the other FLV), the piston rod is defective. Replace the defective piston rod (refer to the Maintenance Manual 5564-1).
- **4.5** Tighten the screw-in union (007).
- **4.6** Do Step 4.1 to Step 4.5 again for the other FLV.

CLOSE UP

- None

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10.8 Temporary cut out a defective injection valve

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Cut out the injection of the related cylinder.

NOTE: If possible, the exhaust valve must always operate.

2 For an engine with direct controlled injection valves, disconnect the electrical connection from the injection valve.

3 For an engine with conventional injection valves, disconnect the electrical connection from the injection control unit (ICU).

4 If it is necessary to operate the engine with the injection cut out for an extended period, do as follows:

- **4.1** Record the settings of the cylinder oil feed rate.
- **4.2** Decrease the cylinder oil feed rate for the related cylinder to the minimum setting.

5 Repair the fault as soon as possible, refer to the Maintenance Manual.

CLOSE UP

- None

10.9 Temporary cut out a defective exhaust valve drive

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- The engine must be stopped and prepared for maintenance, refer to section 8.19 Prepare the engine after stop - general

PROCEDURE

1. Cut out the defective cylinder from the injection, refer to section 10.8 Temporary cut out a defective injection valve.
2. Disconnect the electrical connection to the related exhaust valve control unit (VCU).
3. Repair the fault as soon as possible, refer to the Maintenance Manual.

CLOSE UP

- The engine can be started and operated at decreased load, refer to section 8.3 Start the engine - general

10.10 Temporary isolate a cylinder with cooling water leakage

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
Pressure element	94259		A/R

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- The engine must be stopped and prepared for maintenance, refer to section 8.19 Prepare the engine after stop - general

PROCEDURE

1 Isolate the defective cylinder from the cooling water system.

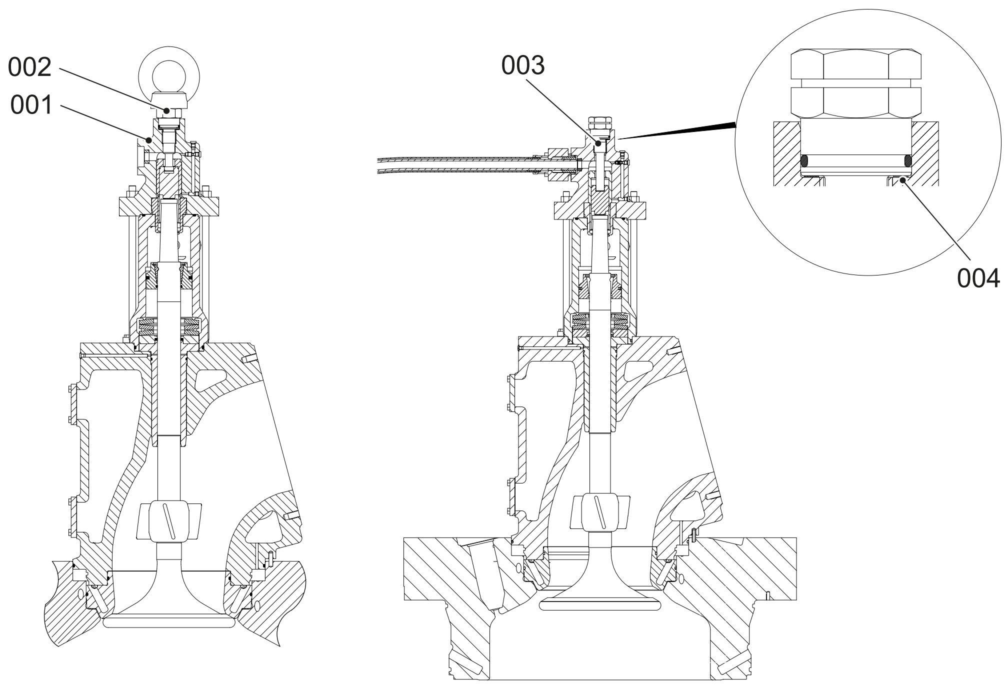
2 Make sure that there is no air spring air pressure.

3 Lock the exhaust valve in the open position as follows:

- **3.1** Remove the damper (002, Figure 10-4) from the top housing (001).
- **3.2** Make sure that you do not lose the shim(s) (004).

  NOTE: The shim(s) must stay in position when the pressure element is installed.
- **3.3** Apply a thin layer of oil to the thread of the pressure element (003).
- **3.4** Install the pressure element (003).

Fig 10-4 Exhaust valve with pressure element



Legend

001	Top housing	003	Pressure element
002	Damper	004	Shim

4 Cut out the defective cylinder from the injection, refer to section 10.8 Temporary cut out a defective injection valve.

5 Disconnect the electrical connection to the related exhaust valve control unit (VCU).

6 Disconnect the control signal connection from the related starting air valve.

7 Repair the fault as soon as possible, refer to the Maintenance Manual.

CLOSE UP

- The engine can be started and operated at decreased load, refer to section 8.3 Start the engine - general

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10.11 Disconnect the fuel pump

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
Flange	94569		pc 1
Flange	94569A		pc 1
Roller lifting tool	94430		pc 1
Claw	94430A		pc 1
Screw	94430B		pc 1

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

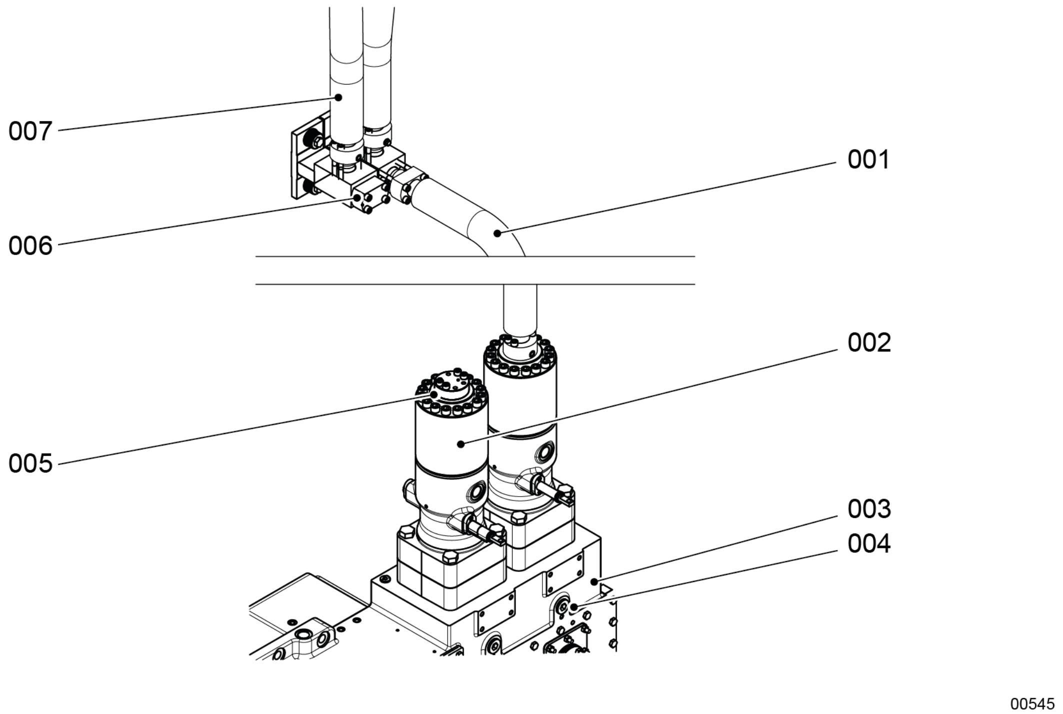
- None

PRELIMINARY OPERATIONS

- The engine must be stopped and prepared for maintenance, refer to section 8.19 Prepare the engine after stop - general

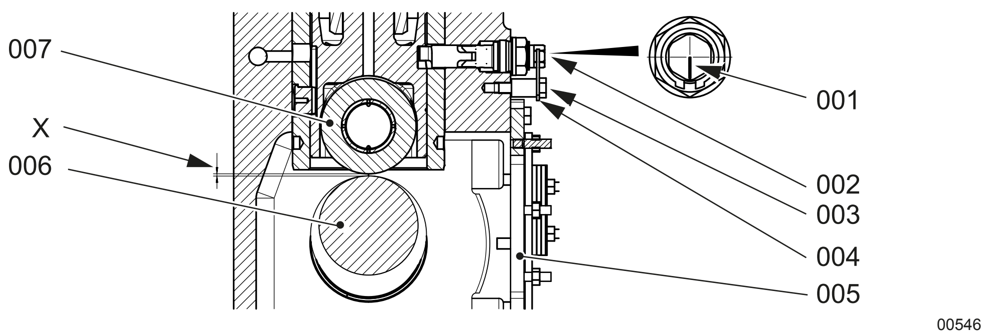
PROCEDURE

Fig 10-5 Fuel pump (example) - isolate



1. Release the pressure and drain the related HP fuel pipe (001, Figure 10-5).
2. Remove the related HP fuel pipe (001) from the fuel pump (002). For the applicable procedure, refer to the Maintenance Manual.
3. Install the flange (005) to the fuel pump (002).
4. Install the flange (006) to the HP fuel pipe (007).
5. Remove the related cover from the supply unit (003).
6. Remove the related plug (004) from the supply unit (003).

Fig 10-6 Fuel pump (example) - cut out



WARNING

Injury Hazard: Make sure that no personnel are near the flywheel or the engine, before you operate the turning gear.

7 Operate the turning gear until the cam (006, Figure 10-6) is at the highest position.

8 Install the roller lifting tool (002) with the mark (001) points down.

9 Turn the roller lifting tool (002) 180° until the mark (001) points up.

NOTE: This gives a clearance X and thus the cam (006) cannot move the roller (007).

10 Install the claw (004) with the screw (003) to lock the roller lifting tool (002).

11 Install the cover to the supply unit (005).

CLOSE UP

- None

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10.12 Connect the fuel pump

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
Flange	94569		pc 1
Flange	94569A		pc 1
Roller lifting tool	94430		pc 1
Claw	94430A		pc 1
Screw	94430B		pc 1

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

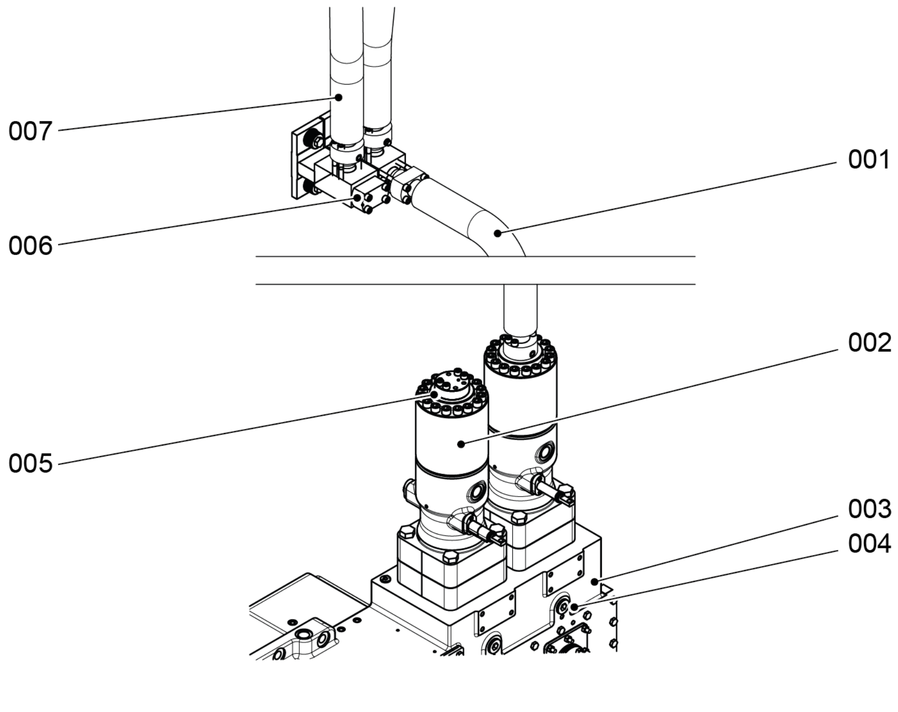
- None

PRELIMINARY OPERATIONS

- The engine must be stopped and prepared for maintenance, refer to section 8.19 Prepare the engine after stop - general

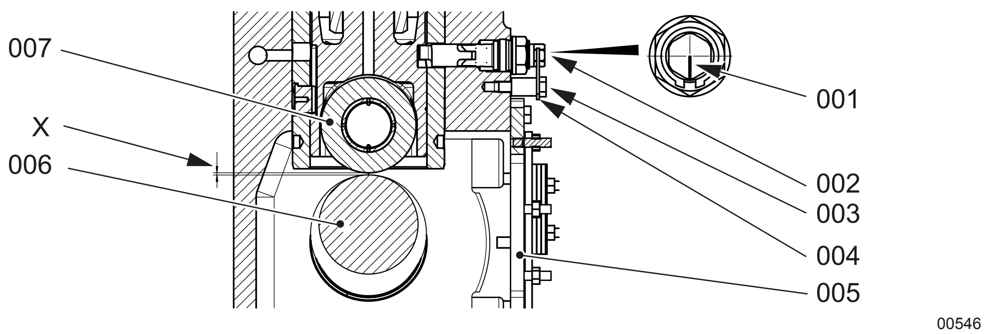
PROCEDURE

Fig 10-7 Fuel pump (example) - connect



1. Release the pressure and drain the related HP fuel pipe (007, Figure 10-7).
2. Remove the flange (005) from the fuel pump (002).
3. Remove the flange (006) from the HP fuel pipe (007).
4. Install the related HP fuel pipe (001) to the fuel pump (002). For the applicable procedure, refer to the Maintenance Manual.
5. Remove the related cover from the supply unit (003).

Fig 10-8 Fuel pump (example) - cut in



WARNING

Injury Hazard: Make sure that no personnel are near the flywheel or the engine, before you operate the turning gear.

6 Operate the turning gear until the cam (006, Figure 10-8) is at the highest position.

7 Remove the claw (004) and the screw (003).

8 Turn the roller lifting tool (002) 180° until the mark (001) points down.

9 Remove the roller lifting tool (002).

10 Install the plug (004, Figure 10-7) to the supply unit (003).

11 Install the cover to the supply unit (003).

12 Make sure that the fuel pump (002) operates correctly.

13 Make sure that the HP fuel pipe (001) has no leaks.

CLOSE UP

- None

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10.13 Temporary isolate a defective turbocharger

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	4.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
Cover	94653A		A/R
Cover	94653B		A/R
Cover	94653C		A/R
Cover	94653D		A/R

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Stop the engine.

2 If not all turbochargers are defective, isolate the defective turbocharger from the exhaust gas system and from the scavenge air system.

NOTE: This step is only applicable for an engine with more than one turbocharger, and if one ore two turbochargers are serviceable.

2.1 Lock the rotor of the defective turbocharger (refer to the turbocharger manual).

2.2 Remove the expansion joint (007, Figure 10-9) between the defective turbocharger and the exhaust gas manifold.

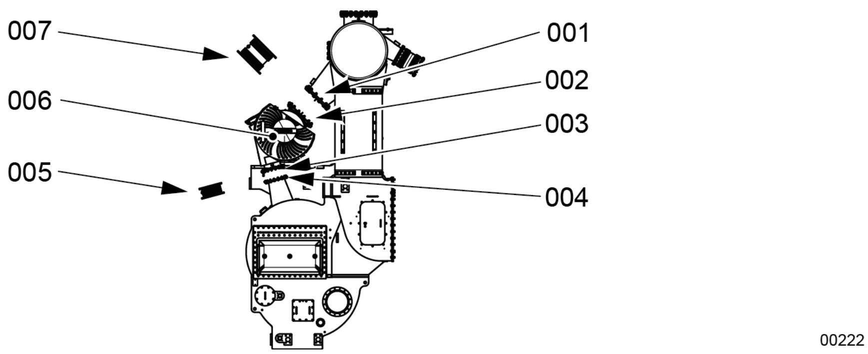
2.3 Install the covers 94653A and 94653B (001 and 002).

2.4 Remove the expansion joint (005) between the defective turbocharger air outlet and the diffusor.

2.5 Install the covers 94653C and 94653D (003 and 004).

NOTE: You only have to install the covers (003), if the turbochargers are connected to a suction duct.

Fig 10-9 Not all turbochargers are defective (example)



Legend

001	Cover 94653A	005	Expansion joint
002	Cover 94653B	006	Turbocharger
003	Cover 94653C	007	Expansion joint
004	Cover 94653D		

3 If all turbochargers are defective, isolate the defective turbochargers from the scavenge air system.

NOTE: This step is applicable for an engine with one, two, or three turbochargers, and none of the turbochargers are serviceable.

3.1 Lock the rotor of the defective turbochargers (refer to the turbocharger manual).

3.2 Remove the expansion joint (005, Figure 10-10) between the defective turbochargers air outlet and the diffusor.

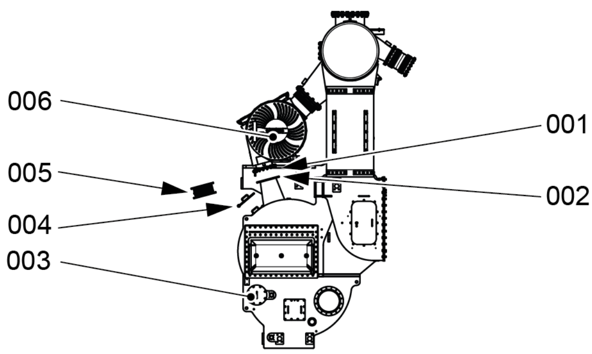
3.3 Install the covers 94653C (001).

NOTE: You only have to install the covers (001), if the turbochargers are connected to a suction duct.

3.4 Open the covers (003 and 004) on the scavenge air receiver.

3.5 Set to ON the auxiliary blowers.

Fig 10-10 All turbochargers are defective (example)



Legend

001	Cover 94653C	004	Cover
002	Cover 94653D	005	Expansion joint
003	Cover	006	Turbocharger

4 Make sure that the air supply to the engine room is satisfactory.

5 Make sure that the oil supply pressure to the serviceable turbochargers is satisfactory.

6 Start the engine with the given limits, refer to section 8.3 Start the engine - general.

CLOSE UP

- None

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10.14 Temporary isolate the exhaust waste gate

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

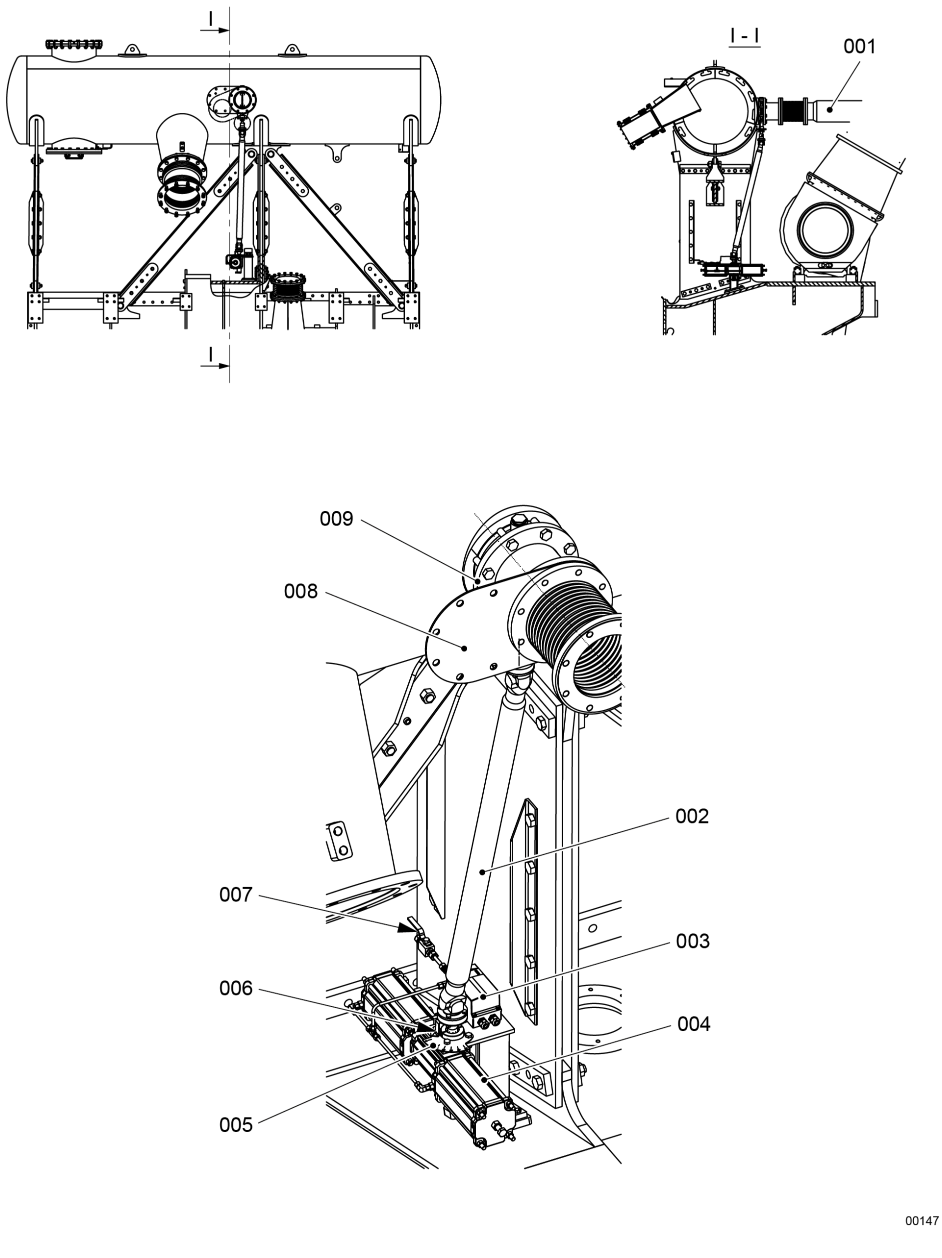
- None

PRELIMINARY OPERATIONS

- None

PROCEDURE

Fig 10-11 Exhaust waste gate (example)



Legend

001 Exhaust gas manifold
002 Cardan rod
003 Positioner and feedback with EMC module
004 Actuator
005 Plate
006 Indicator
007 Ball valve 50-8135_E0_3 (air spring air)
008 Flange
009 Valve

1. Stop the engine.
2. Loosen the screws of the flange (008, Figure 10-11), but do not loosen one of the two middle screws.
3. Turn the flange (008) to close the exhaust waste gate.
4. Tighten the screws to attach the flange (008).
5. Start the engine.

CLOSE UP

- None

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10.15 Isolate a defective engine at twin engine installation

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Basic	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

SAFETY PRECAUTIONS

- None

PRELIMINARY OPERATIONS

- None

PROCEDURE

1 Engage the shaft locking device of the defective engine. Refer to the related documentation of the manufacturer.

NOTE: This prevents the windmilling effect on the propeller of the defective engine (shaft movement), when you operate the other engine.

2 If installed, disengage the shaft clutch of the defective engine. Refer to the related documentation of the manufacturer.

3 If the shaft locking device and the shaft clutch are unserviceable, make sure that you operate the auxiliary systems.

4 If installed, change the pitch of the controllable propeller (CPP) to the lowest resistance.

WARNING
Injury Hazard: Do not go near movable parts of the engine unless you are sure, that in each condition, no part can move.

5 Obey the procedure to get access to the engine spaces, refer to section 2.6 Access to engine spaces.

6 If possible, find the cause and repair the fault.

CLOSE UP

- None

10.16 Temporary isolate the HP SCR system

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	4.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
Cover	94820		2

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

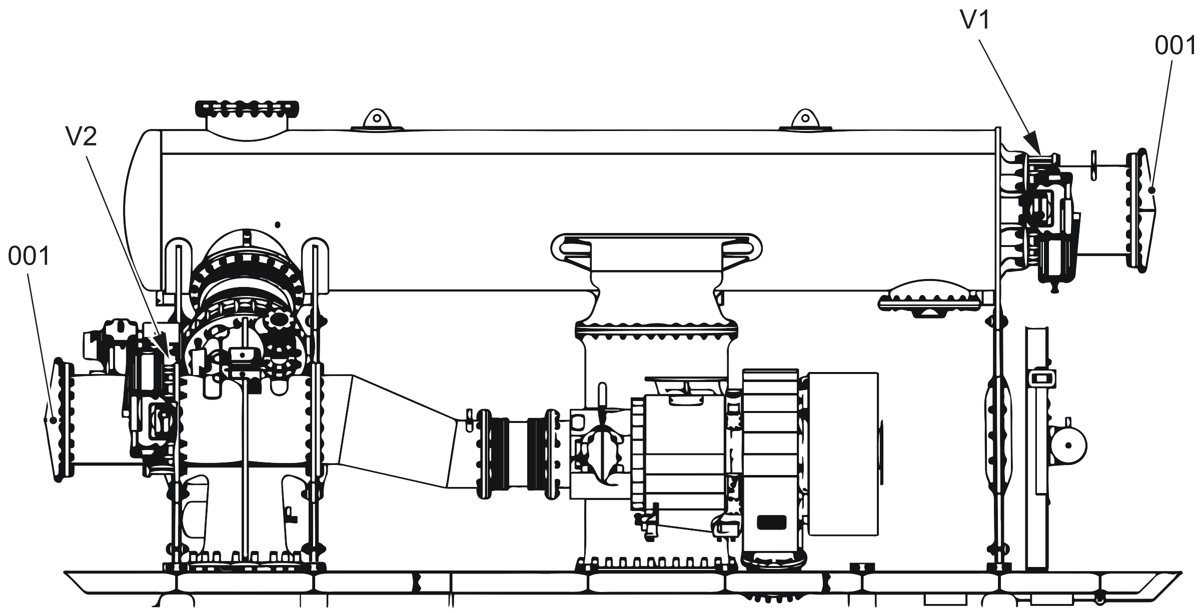
SAFETY PRECAUTIONS

PRELIMINARY OPERATIONS

- The engine must be stopped and prepared for maintenance, refer to section 8.19 Prepare the engine after stop - general

PROCEDURE

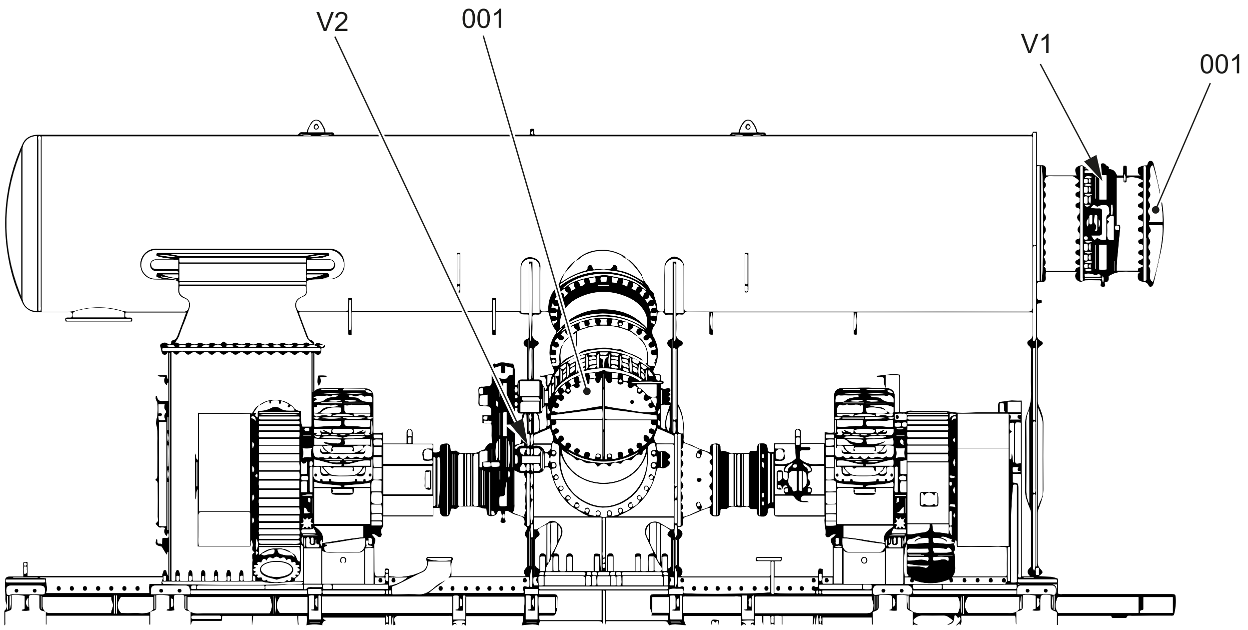
Fig 10-12 SCR system - covers (example for 1 turbocharger)



Legend

001 Cover
V1 SCR inlet valve
V2 SCR outlet valve

Fig 10-13 SCR system - covers (example for 2 turbocharger)



Legend

001	Cover	V2	SCR outlet valve
V1	SCR inlet valve		

1. Remove the pipe to the SCR system from the flange downstream of the valve V1.
2. Install the Cover (001, Figure 10-12 or Figure 10-13) to the flange.
3. Remove the pipe to the SCR system from the flange upstream of the valve V2.
4. Install the cover (001) to the flange.

CLOSE UP

- None

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10.17 Connect the HP SCR system after isolation

Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	4.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

Support equipment

Description	Part No.	CSN	QTY
None			

Supplies

Description	QTY
None	

Spare Parts

Description	Part No.	CSN	QTY
None			

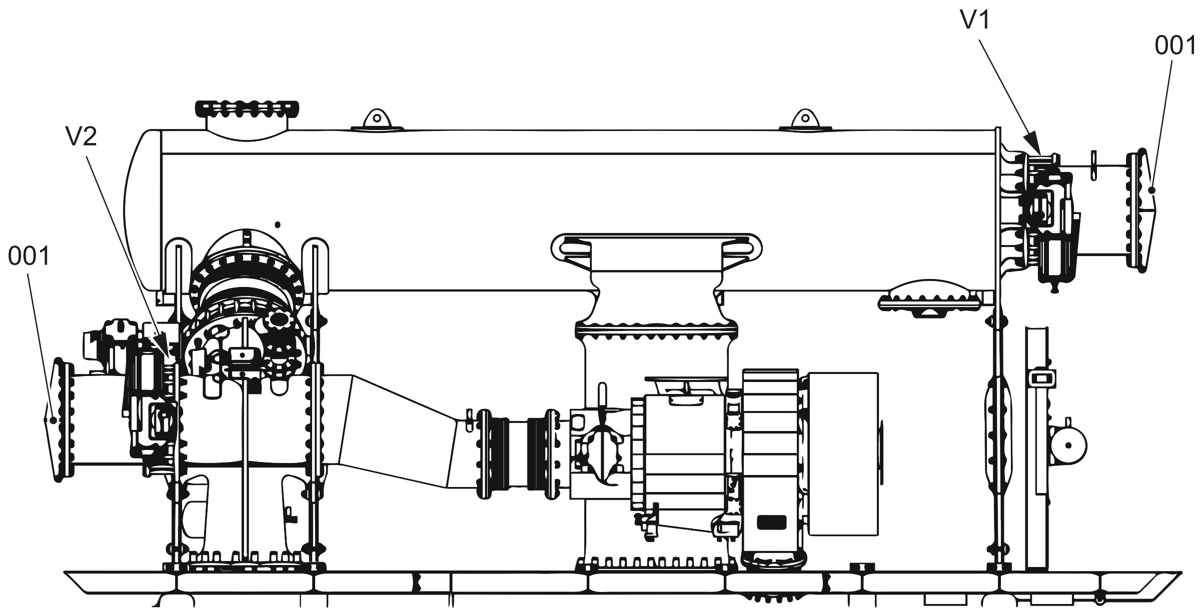
SAFETY PRECAUTIONS

PRELIMINARY OPERATIONS

- The engine must be stopped and prepared for maintenance, refer to section 8.19 Prepare the engine after stop - general

PROCEDURE

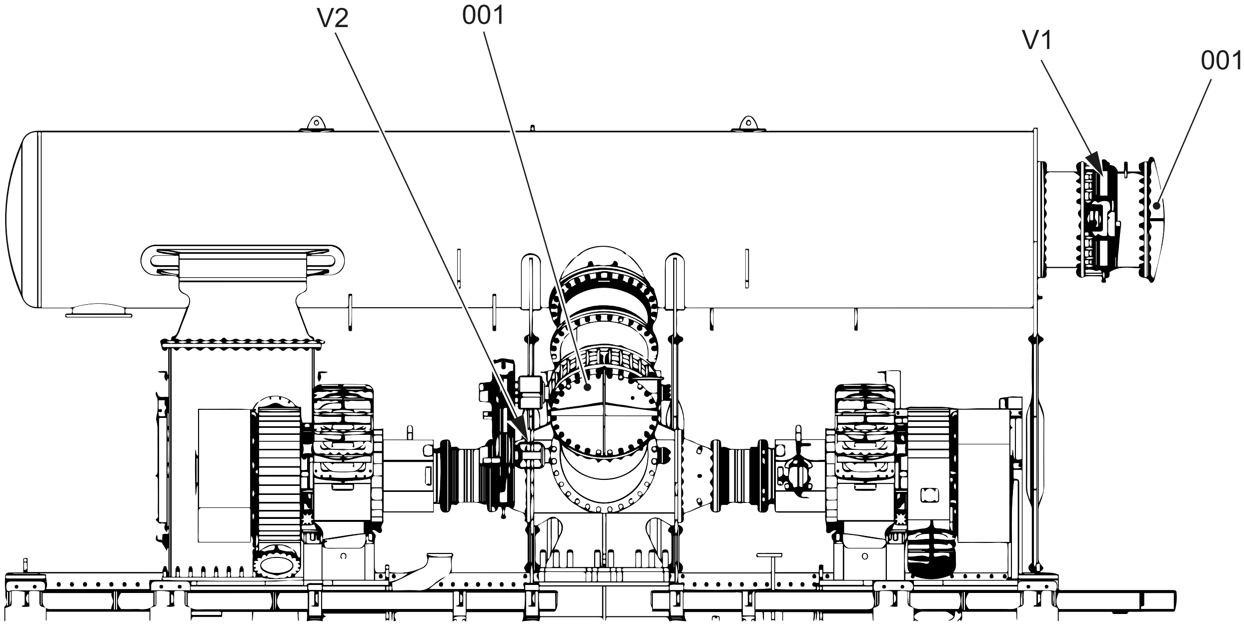
Fig 10-14 SCR system - covers (example for 1 turbocharger)



Legend

001 Cover
V1 SCR inlet valve
V2 SCR outlet valve

Fig 10-15 SCR system - covers (example for 2 turbocharger)



Legend

001	Cover
V1	SCR inlet valve
V2	SCR outlet valve

1. Remove the cover (001, Figure 10-14 or Figure 10-15) from the flange downstream of the valve V1.
2. Install the pipe to the SCR system to the flange.
3. Remove the cover (001) from the flange upstream of the valve V2.
4. Install the pipe to the SCR system to the flange.

CLOSE UP

- None

11 Technical data

11.1 Engine data

The standard data of the X62-B engine is given in Table 11-1 - General data.

Tab 11-1 General data

Item	Value	Unit
Cylinder bore	620	mm
Piston stroke	2658	mm
Speed range	77 to 103	rpm
Stroke / bore ratio	4.29	-
Available number of cylinders	5 to 8	-
Number of pulses for cylinder pre-lubrication	260	-

Table 11-2 - Rated power gives the data that follow:

- **Rating point**

  For the rating points refer to Figure 11-1.
- **Speed**

  This list gives the speed of the crankshaft in rpm.
- **Power**

  The power in kW for each cylinder refers to the ISO standard reference conditions:
  - Total barometric pressure is 1.0 bar
  - Suction air temperature is 25°C
  - Relative humidity is 30%
  - Cooling water temperature at the engine inlet is 25°C.
- **BSFC**

  This list gives the Brake Specific Fuel Consumption (BSFC) for fuel of lower heating value 42.7 MJ/kg (10 200 kcal/kg) and standard tuning.
- **Mean piston speed**

  This list gives the mean piston speed in m/s.
- **MEP**

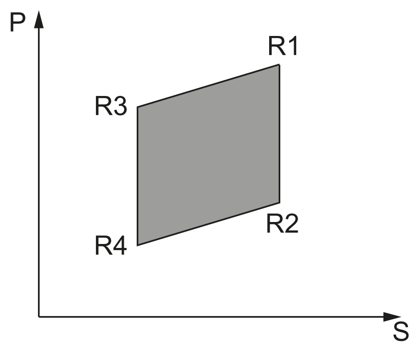
  This list gives the Mean Effective Pressure (MEP) in the combustion chamber in bar.
- **Firing pressure**

  This list gives a guide value for the firing pressure in the combustion chamber in bar. The firing pressure can be lower than the guide values in the table.

Tab 11-2 Rated power

Rating point	Speed	Power	BSFC	Mean piston speed	MEP	Firing pressure
	[rpm]	[kW/cyl.]	[g/kWh]	[m/s]	[bar]	[bar]
R1	103	2900	166.8	9.13	21.0	190
R2	103	2130	159.3	9.13	15.4	190
R3	77	2160	166.8	6.82	21.0	190
R4	77	1590	159.3	6.82	15.4	190

Fig 11-1 Operating range



Legend

R1	Highest power at highest speed
R2	Lowest power at highest speed
R3	Highest power at lowest speed
R4	Lowest power at lowest speed
P	Power
S	Speed

11.2 List of usual values and safeguard settings - general

For each system of the engine the tables in the chapter that follows give the values for usual operation and the trigger values for safeguard settings.

11.2.1 Tables - identification

The tables give the data that follow:

- **Description**

  This list gives the description of the object or of the system.
- **Medium / physical value / location**

  This list gives the data that follow:
  - Medium that is monitored
  - Physical parameter and unit
  - Location of the measurement
- **Usual operation (value or range)**

  This list gives the setpoint or the range for usual operation.
- **Signal number**

  This list gives the signal number as follows (refer also to Para 11.2.2):
  - First two letters (XX) - Function code
  - Four digit number of the signal (for example 10NN)
    - First two numbers - Function group
    - Second two numbers - Running number
  - -nn - If more than one signal of the same type is applicable (for example TE2501-nnA is TE2501A, TE2502A, TE2503A)
  - Last letter - Applied system
- **Function**

  This list gives one of the functions that follow:
  - ALM - Alarm
  - GTrip - Gas Trip (the ECS changes to diesel mode)
  - SLD - Slowdown
  - SHD - Shutdown
- **Level**

  This list gives one of the levels that follow:
  - D - Deviation
  - H - High
  - L - Low

- **Trigger value**

  This list gives the value at which the related safeguard function starts.

  For the analysis elements (AE) of concentration:

  - max - maximum concentration

  For the level switches (LS) and flow switches (FS):

  - min - minimum or no flow
  - max - maximum flow

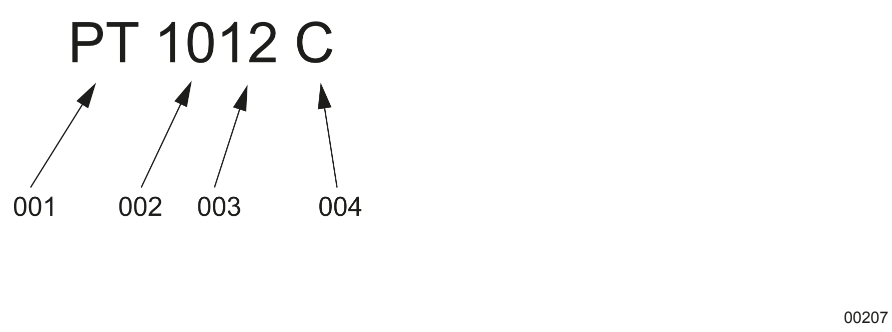
- **Delay**

  This list gives the delay of the action (in seconds) after the trigger value occurs.

11.2.2 Signal codes - identification

An example of a signal code is shown in Figure 11-2.

Fig 11-2 Signal codes



Legend

001 Function code
002 Function group
003 Running number
004 Applied system

Tab 11-3 Function code

Code	First position	Second position
A	Analysis	n/a
C	Control	Control
E	n/a	Element
F	Flow	n/a
G	Gauge	n/a
H	Hand	n/a
I	n/a	Indication
J	Power	n/a
L	Level	n/a
P	Pressure	n/a
S	Speed	Switch
T	Temperature	Transmitter
V	n/a	Valve
X	Unclassified	Unclassified
Y	Vibration	Relay
Z	Position (binary)	n/a

Tab 11-4 Function group

Code	Signal type	System
10 to 19	Signals from the engine	Cooling water
20 to 29	Signals from the engine	System oil, cooling oil
31	Signals from the engine	Cylinder lubrication
33	Signals from the engine	Fuel gas
34	Signals from the engine	Fuel oil
35	Signals from the engine	Fuel gas
37	Signals from the engine	Exhaust gas
40 to 49	Signals from the engine	Air systems
50 to 59	Signals from the engine	Miscellaneous
60 to 69	Signals from the engine	Spare
70 to 79	Signals to the engine	Miscellaneous
80 to 89	Signals to the engine	Miscellaneous

Tab 11-5 Applied system

Code	Description
A	Alarm and monitoring system
C	Control system
L	Local
M	Measured indication, Local control panel
S	Safety system
W	Wrong way alarm
X	Miscellaneous

11.3 List of usual values and safeguard settings

On the pages that follow you find the values for usual operation and the trigger values for safeguard settings as follows:

- Table 11-6 - Cooling water systems (XX10NN to XX19NN)
- Table 11-7 - Oil systems (XX2NNN, part 1)
- Table 11-8 - Oil systems (XX2NNN, part 2)
- Table 11-9 - Oil systems (XX2NNN, part 3 (turbocharger bearing oil))
- Table 11-10 - Oil systems (XX2NNN, part 4)
- Table 11-11 - Fuel system (XX34NN)
- Table 11-12 - Exhaust gas system (XX37NN)
- Table 11-13 - Air systems (XX40NN to XX44NN)
- Table 11-14 - Miscellaneous items (XX45NN to XX52NN)

Tab 11-6 Cooling water systems (XX10NN to XX19NN)

Description	Usual operation (value or range)	Safeguard setting				
Medium / physical value / location		Signal number	Function	Level	Trigger value	Delay
Cylinder liner, cylinder cover						
HT cylinder cooling water / pressure [bar] / engine inlet connection 02	2.2 to 4	PT1101A	ALM	L	≤ 2.0	0
			SLD	L	≤ 1.8	60
	-	PS1101S	SHD	L	≤ 1.5	60
HT cylinder cooling water / temperature [°C] / engine inlet connection 02	72 to 90	TE1111A	ALM	L	≤ 70	0
HT cylinder cooling water / temperature [°C] / outlet each cylinder (engine outlet connection 03)	90 +/-2 [1] 90 +/-4 [2]	TE1121-nnA	ALM	H	≥ 95	0
			SLD	H	≥ 97	60
Scavenge air cooler (SAC)						
SAC LT cooling water / pressure [bar] / engine inlet connection 07	2.5 to 4	PT1361A	ALM	L	≤ 2.0	0
SAC LT cooling water / temperature [°C] / engine inlet connection 07	10 to 36 [3]	TE1371A	ALM	L	≤ 6 [4]	0
SAC LT cooling water / temperature [°C] / outlet each SAC	10 to 75	TE1381-nnA	ALM	H	≥ 80	0

1 This value is applicable for stable operation condition.

2 This value is applicable for transient operation condition.

3 WinGD recommends a setpoint value of 25°C.

4 The trigger value should be 21°C if you use the recommended setpoint value of 25°C.

Tab 11-7 Oil systems (XX2NNN, part 1)

Description Medium / physical value / location	Usual operation (value or range)	Safeguard setting Signal number	Function	Level	Trigger value	Delay
Lubricating oil supply - system side						
Main lubricating oil / pressure [bar] / engine inlet connection 25	4.2 to 5	PT2001A	ALM	L	≤ 4.0	0
			SLD	L	≤ 3.8	60
	-	PS2002S	SHD	L	≤ 3.3	10
Main lubricating oil / temperature [°C] / engine inlet connection 25	45 +/-2 [1] 45 +/-4 [2]	TE2011A	ALM	H	≥ 50	0
			SLD	H	≥ 55	60
External crosshead bearing oil / pressure [bar] / engine inlet connection 30	10.2 to 13	PT2021A	ALM	L	≤ 10.0 [3]	10
			SLD	L	≤ 9.0 [3]	60
Injector lubricating oil						
Injector lubricating oil / pressure [bar] / inlet injectors	4.2 to 5	PT2003A	ALM	L	≤ 2.6 [4]	0
Bearing oil						
Main bearing oil / temperature [°C] / outlet each main bearing (optional)	45 to 60	TE2101-nnA	ALM	H	≥ 65	0
			SLD	H	≥ 70	60
Crank bearing oil / temperature [°C] / outlet each crank bearing (optional)	45 to 60	TE2201-nnA	ALM	H	≥ 65	0
			SLD	H	≥ 70	60
Crosshead bearing oil / temperature [°C] / outlet each crosshead bearing (optional)	45 to 60	TE2301-nnA	ALM	H	≥ 65	0
			SLD	H	≥ 70	60

1 This value is applicable for stable operation condition.

2 This value is applicable for transient operation condition.

3 The trigger value is only applicable above 40% engine load.

4 The trigger value is not applicable when the engine has stopped.

Tab 11-8 Oil systems (XX2NNN, part 2)

Description Medium / physical value / location	Usual operation (value or range)	Safeguard setting Signal number	Function	Level	Trigger value	Delay
Servo oil						
Servo oil / pressure [bar] / distributor pipe (mini rail) [1]	65	PT2041A	ALM	L	≤ 40.0	3
			ALM	H	≥ 75.0	3
Servo oil / flow / inlet each servo oil pump [2]	-	FS2061-nnA	ALM	L	min	0
			ALM	H	max	0
Servo oil leakage / flow / servo oil supply unit	-	LS2055A	ALM	H	max	10
Oil mist						
Oil mist / concentration / crankcase (each cylinder) [3]	-	AE2401-nnA	ALM	H	max	0
		AS2401A	ALM	H	max	0
	-	AS2401S	SLD	H	max	60
Oil mist / concentration / gearcase	-	AE2415A	ALM	H	max	0
Oil mist / concentration / fuel supply unit	-	AE2421A	ALM	H	max	0
Piston cooling oil						
Piston cooling oil / temperature [°C] / outlet each cylinder	45 to 75	TE2501-nnA	ALM	H	≥ 80	0
			SLD	H	≥ 85	60
Piston cooling oil / flow [l/min] / outlet each cylinder	-	FS2521-nnS	SHD	H	max	15
			SHD	L	min	15

1 The trigger values are not applicable when the engine has stopped.

2 The trigger values are only applicable above 30% engine load.

3 The concentration is related to the lower explosive level (LEL).

Tab 11-9 Oil systems (XX2NNN, part 3 (turbocharger bearing oil))

Description Medium / physical value / location	Usual operation (value or range)	Safeguard setting Signal number	Function	Level	Trigger value	Delay
Bearing oil turbocharger ABB A100/200-L with internal oil						
TC bearing oil / pressure [bar] / inlet each turbocharger	1.5 to 5.0	PT2611-nnA	ALM	L	≤ 1.0	5
			SLD	L	≤ 0.8	60
	-	PS2611-nnS	SHD	L	≤ 0.6	5
TC bearing oil / temperature [°C] / outlet each turbocharger	45 to 100	TE2601-nnA	ALM	H	≥ 110	0
			SLD	H	≥ 120	60
Bearing oil turbocharger ABB A100/200-L with external oil						
TC bearing oil / pressure [bar] / inlet each turbocharger	1.5 to 5.0	PT2611-nnA	ALM	L	≤ 1.3	5
			SLD	L	≤ 1.1	60
	-	PS2611-nnS	SHD	L	≤ 0.9	5
TC bearing oil / temperature [°C] / inlet turbocharger	45 to 80	TE2621A	ALM	H	≥ 85	0
			SLD	H	≥ 90	60
TC bearing oil / temperature [°C] / outlet each turbocharger	45 to 120	TE2601-nnA	ALM	H	≥ 130	0
			SLD	H	≥ 140	60
Bearing oil turbocharger MHI MET with internal oil						
TC bearing oil / pressure [bar] / inlet each turbocharger	1.0 to 5.0	PT2611-nnA	ALM	L	≤ 0.7	5
			SLD	L	≤ 0.6	60
	-	PS2611-nnS	SHD	L	≤ 0.4	5
TC bearing oil / temperature [°C] / outlet each turbocharger	45 to 80	TE2601-nnA	ALM	H	≥ 85	0
			SLD	H	≥ 90	60
Bearing oil turbocharger MHI MET with external oil						
TC bearing oil / pressure [bar] / inlet each turbocharger	1.0 to 5.0	PT2611-nnA	ALM	L	≤ 0.7	5
			SLD	L	≤ 0.6	60
	-	PS2611-nnS	SHD	L	≤ 0.4	5
TC bearing oil / temperature [°C] / inlet turbocharger	45 to 50	TE2621A	ALM	H	≥ 60	0
			SLD	H	≥ 65	60
TC bearing oil / temperature [°C] / outlet each turbocharger	45 to 80	TE2601-nnA	ALM	H	≥ 85	0
			SLD	H	≥ 90	60

Tab 11-10 Oil systems (XX2NNN, part 4)

Description	Usual operation (value or range)	Safeguard setting				
Medium / physical value / location		Signal number	Function	Level	Trigger value	Delay
Damper oil						
Damper oil / pressure [bar] / inlet torsional vibration damper [1]	2.8 to 5.0	PT2711A	ALM	L	≤ 2.2	0
Damper oil / pressure [bar] / axial vibration damper space aft side	1.8 to 5.0	PT2721A	ALM	L	≤ 1.7	60
Damper oil / pressure [bar] / axial vibration damper space fore side	1.8 to 5.0	PT2722A	ALM	L	≤ 1.7	60
Cylinder oil						
Cylinder oil / pressure [bar] / cylinder oil rail	≥ 0.3	PT3124A	ALM	L	≤ 0.1	30
Cylinder oil / temperature [°C] / engine inlet	35 to 50	-	-	-	-	-

1 The setpoint and trigger values can be different. For the applicable values, refer to the specification of the damper manufacturer.

Tab 11-11 Fuel system (XX34NN)

Description	Usual operation (value or range)	Safeguard setting				
Medium / physical value / location		Signal number	Function	Level	Trigger value	Delay
Fuel supply - system side						
Fuel (HFO) / viscosity [cSt] / engine inlet connection 49	13 to 17	- [1]	ALM	H	≥ 20	0
			ALM	L	≤ 10	0
Fuel (MDO - MGO) / viscosity [cSt] / engine inlet connection 49	3 to 14	- [1]	ALM	H	≥ 17	0
			ALM	L	≤ 2	0
Fuel supply unit						
Fuel / pressure [bar] / inlet fuel supply unit	7.5 to 10 [2]	PT3421A	ALM	L	≤ 7	0
Fuel / temperature [°C] / inlet fuel supply unit [3]	20 to 150	TE3411A	ALM	H	≥ 50 to 160	0
			ALM	L	≤ 20 to 130	0
Fuel leakage / flow / outlet fuel supply unit	-	LS3426A	ALM	H	max	10
Fuel leakage / flow / outlet fuel rail items	-	LS3446A	ALM	H	max	10
Rail unit						
Leakage / flow / outlet rail unit	-	LS3444A	ALM	H	max	10

1 This measurement is not included in the standard engine supply (the viscometer is a yard supply item).

2 When the engine has stopped, the setpoint is 10 bar. The value decreases when the engine load increases.

3 The values are related to the fuel viscosity.

Tab 11-12 Exhaust gas system (XX37NN)

Description	Usual operation (value or range)	Safeguard setting				
Medium / physical value / location		Signal number	Function	Level	Trigger value	Delay
Exhaust pipe / manifold						
Exhaust gas / temperature [°C] / outlet each cylinder	-	TE3701-nnA	ALM	H	≥ 515	0
			ALM	D	≥ 50	0
			SLD	H	≥ 530	60
			SLD	D	≥ 70	60
Exhaust gas / temperature [°C] / inlet each turbocharger	-	TE3721-nnA	ALM	H	≥ 515	0
			SLD	H	≥ 530	60
Exhaust gas / temperature [°C] / outlet each turbocharger	-	TE3731-nnA	ALM	H	≥ 340	0
			SLD	H	≥ 380	60

Tab 11-13 Air systems (XX40NN to XX44NN)

Description Medium / physical value / location	Usual operation (value or range)	Safeguard setting Signal number	Function	Level	Trigger value	Delay
Scavenge air receiver						
Scavenge air / temperature [°C] / outlet each air cooler	28 to 55	TE4031-nnA	ALM	L	≤ 25	0
			ALM	H	≥ 60	0
			SLD	H	≥ 70	60
Scavenge air / temperature [°C] / piston underside each cylinder	28 to 55	TE4081-nnA	ALM	H	≥ 80	0
			SLD	H	≥ 120	60
Condensation water / flow / at each water separator	-	LS4071-nnA	ALM	H	max	10
			SLD	H	max	60
Condensation water / flow / upstream each water separator	-	LS4075-nnA	ALM	H	max	10
			SLD	H	max	60
Starting air supply						
Starting air supply / pressure [bar] / engine inlet connection 40	20 to 30	-	-	-	-	-
Control air supply unit						
Control air supply / pressure [bar] / engine inlet connection 45	7 to 9	-	-	-	-	-
Control air / pressure [bar] / outlet usual supply	6.5	PT4401A	ALM	L	≤ 6.0	0
Control air / pressure [bar] / outlet stand-by supply	6.0	PT4411A	ALM	L	≤ 5.5	0
Control air / pressure [bar] / air tank for safety supply	6.5 / 6.0	PT4421A	ALM	L	≤ 5.0	15
Air spring						
Air spring air / pressure [bar] / supply to air spring	6.5 / 6.0	PT4341A	ALM	H	≥ 7.5	0
			ALM	L	≤ 5.5	0
			SLD	L	≤ 5.0	60
	-	PS4341S	SHD	L	≤ 4.5	0
Oil leakage / flow / air spring at driving end	-	LS4351A	ALM	H	max	5
Oil leakage / flow / air spring at free end	-	LS4352A	ALM	H	max	5

Tab 11-14 Miscellaneous items (XX45NN to XX52NN)

Description	Usual operation (value or range)	Safeguard setting				
Medium / physical value / location		Signal number	Function	Level	Trigger value	Delay
Thrust bearing						
Pad / temperature [°C] / thrust bearing (AHEAD)	45 to 75	TE4521A	ALM	H	≥ 80	0
			SLD	H	≥ 85	60
	-	TS4521S	SHD	H	≥ 90	60
Cylinder liner						
Wall / temperature [°C] / each cylinder liner aft side	≤ 230	TE4801-nnC	ALM	H	≥ 250	0
			SLD	H	≥ 270	60
Wall / temperature [°C] / each cylinder liner fore side	≤ 230	TE4841-nnC	ALM	H	≥ 250	0
			SLD	H	≥ 270	60
Powertrain						
Crankshaft / speed [% of CMCR] / crankshaft	-	ST5111-12S	SHD	H	≥ 110	0
Tachometer turbocharger						
Impeller shaft / overspeed [rpm] / each ABB turbocharger	-	ST5201-nnA	ALM	H	refer to note [1]	0
Impeller shaft / overspeed [rpm] / each MHI turbocharger	-	ST5201-nnA	ALM	H	refer to note [2]	0

1 For ABB TC the alarm value is 0.97 x nMax on rating plate (nMax usually referred to as nMmax in 1/s).

2 For MHI TC the alarm value is 0.95 x nMax on rating plate (nMax usually referred to as overspeed in rpm).

Some items are continuously monitored for correct function. If an item becomes defective, the AMS sends a message to the ship alarm system, refer to Table 11-15 - Failure messages.

Tab 11-15 Failure messages

Medium / location	Signal number	Delay
Failure of oil mist detector	XS2411A	0
Failure of fuel heating	XS3463A	0
Failure of fuel pump actuator	XS5046A	0

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11.4 Section views

Fig 11-3 Engine cross section

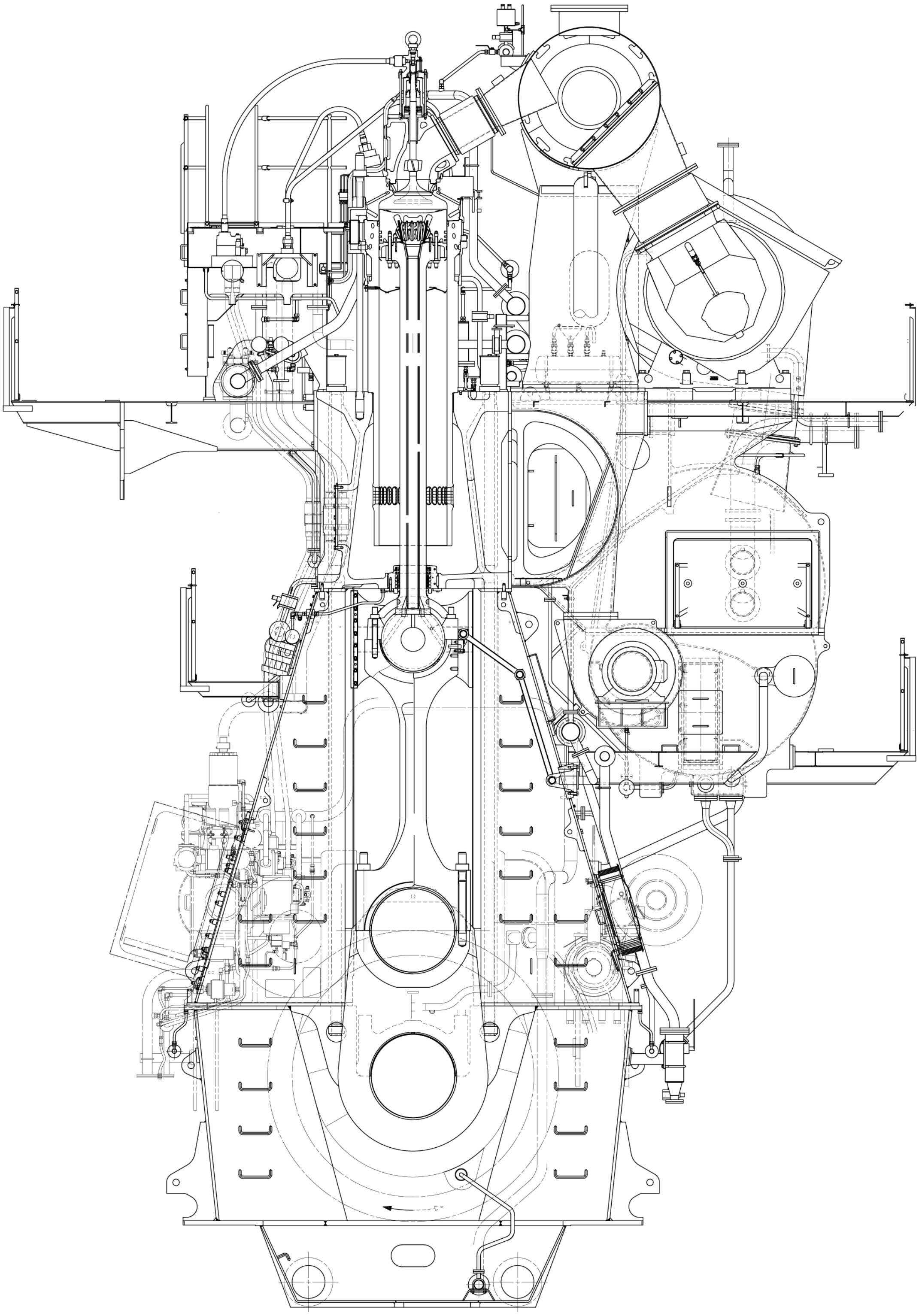
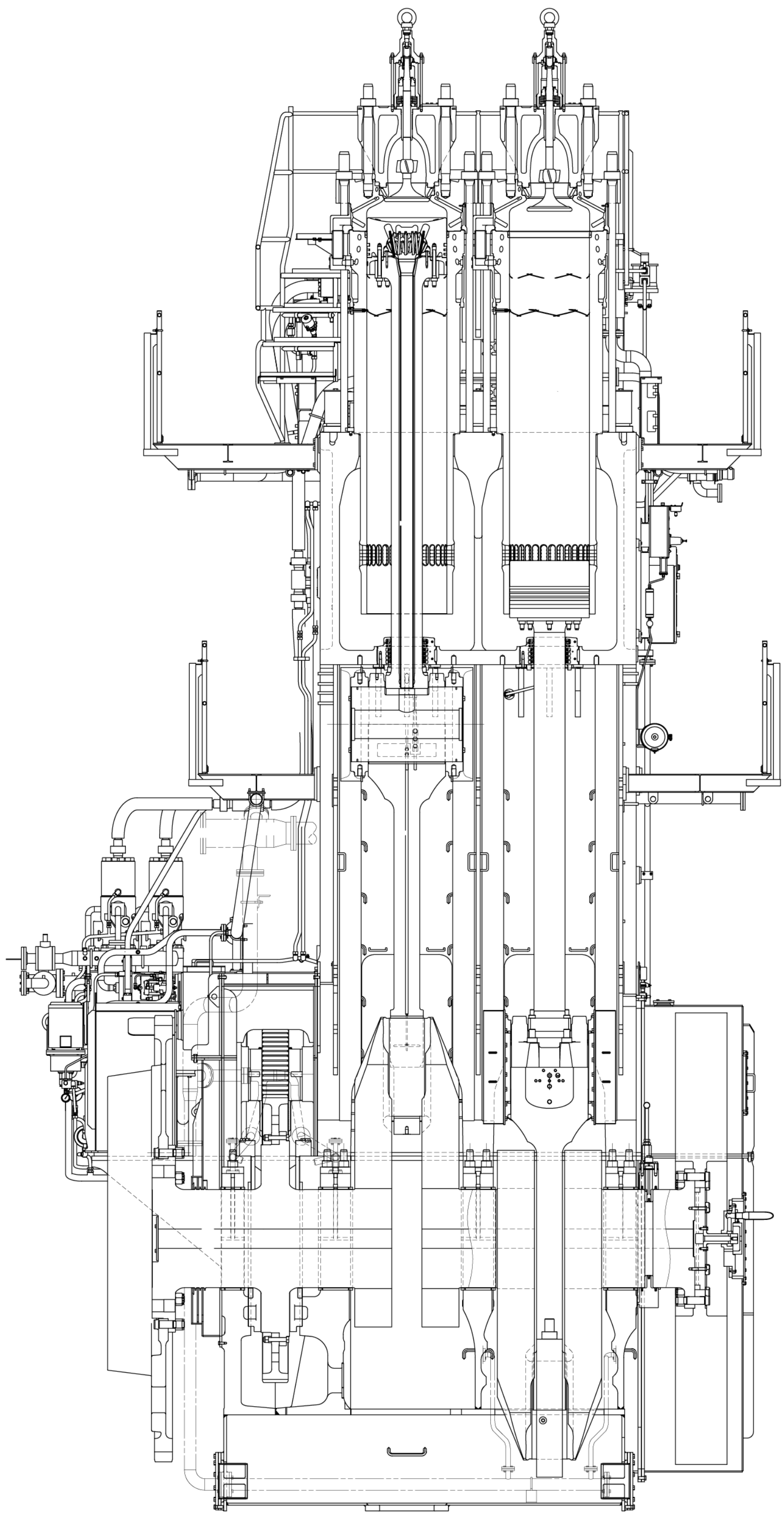


Fig 11-4 Engine longitudinal section



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12 Operating media

12.1 General for operating media

WinGD has specified the requirements of the operating media for the engine.

On the WinGD website (https://www.wingd.com/) the latest versions of the specifications are available for the operating media that follow:

- Fuel
- Lubricants
- Water

NOTE: On the WinGD website go to your engine type, then to “OPERATION & MAINTENANCE”, then to “FUEL LUBRICANTS WATER”.

On the pages that follow the specifications are available for the operating media that follow:

- Compressed air
- Scavenge air
- Gas (if applicable)

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12.2 Compressed air

Compressed air has the functions that follow:

- Compressed air is used as starting air for the starting air system.
- Compressed air is used as control air for the control air system.

12.2.1 Requirements for compressed air

The compressed air must have the basic properties that follow:

- Clean and dry
- Purity class 2-4-2 (ISO 8573-1).

12.2.2 Recommended procedures for compressed air

WinGD recommends to regularly do the procedures that follow to prevent explosions:

- Regularly drain the starting air bottles to remove condensation.
- Regularly clean the starting air pipes to remove oil that can come from the air compressors.
- Regularly do the maintenance work for the air compressors to keep the compressed air as clean as possible.

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12.3 Scavenge air

The turbocharger compresses the air from the engine room or from outside for the scavenge air.

The air must be as clean as possible to keep the wear of cylinder liner, piston rings, turbocharger compressor etc to a minimum. Silencers are installed to the suction part. The silencers have filter mats in them, which help to keep the air clean.

The filter mats must be serviced and/or cleaned regularly. For this data, refer to the turbocharger manual.

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12.4 Diesel engine fuels

12.4.1 General

Almost all hydrocarbon residual, distillate and some renewable fuels can be burned in a diesel engine if applicable procedures are done. The type and quality of the fuel will have an effect on the frequency of overhauls and the work necessary to prepare the fuel. It is the primary economic considerations that according to the type, size and speed of the engine and its application, gives the fuel quality margins.

Gas oils and diesel oils (distillates) can be used in all WinGD engines with some limits. WinGD 2-stroke diesel engines are designed to operate on up to 700 mm^2/s (cSt) at 50°C viscosity heavy fuel oil (ISO 8217:2017 RMK 700 grade) if sufficient fuel heating and treatment is done.

Heavy fuel oil must have treatment in an applicable fuel treatment plant on board. When bunkering, it is possible that the fuel suppliers will report only some of the values given in the Quality Specifications. Frequently, only the density and maximum viscosity is given. This makes the full understanding of the properties of the fuels very difficult, thus it is important to get a full certificate of analysis with each bunker.

The supplier must guarantee the stability of the fuel and thus the resistance to the formation of sludge. Also, the fuel must not have a corrosive effect on the injection equipment and must not contain used lubricating oil, chemical waste or other foreign matter.

Fuels from different bunkers must not be mixed because there is a risk that the fuels have different compositions. This can cause fouling of filters or too much sludge, which will overload the fuel preparation equipment. Fresh bunkers must always be put into empty tanks and not added to old bunkers.

12.4.2 Heavy fuel oil

Fuels used in marine diesel engines are blended using many different products from the petroleum refinery process that can include fuels such as HFO and gas oil. To get the necessary viscosity as specified by the supply specifications, the heavier oil stocks are blended with lighter, less viscous components. Modern refineries also apply a secondary conversion process, such as viscosity breaking (visbreaking) and catalytic cracking to get a higher yield of lighter products. The remaining products are mixed to get HFO.

Viscosity is usually used to identify diesel engine fuels. The viscosity is shown in mm^2/s, referred to as centistokes (cSt) and measured at 50°C. The fuels are classified in accordance with ISO 8217:2017 (Sixth Edition dated from March 2017).

Viscosity is not a quality criterion. To make an analysis of the fuel quality (to make sure that the fuel is applicable for use in a diesel engine), refer to the properties given in Table 12-1 - Specifications for HFO.

Very good supervision, engine maintenance and on board fuel treatment equipment is necessary, especially when the properties of the fuel in use is near the permitted maximum and minimum limits. Poor quality fuels or insufficient or inadequate preparation can give problems in handling and/or combustion. Thus higher maintenance requirements, shorter service intervals and possibly shorter service life of various components of the equipment can be possible.

In Table 12-1 - Specifications for HFO, the values in the column Bunker limit (ISO 8217:2017 RMK700) show the minimum quality of heavy fuel as supplied and bunkered to the ship/installation. Good operation results come from commercially available fuels that are in the ISO 8217:2017 limits. But the use of fuel with lower metal, ash and carbon contents and a lower density can have a positive effect on overhaul periods. This can improve combustion and exhaust gas composition and can decrease the wear.

The fuel as bunkered must be processed before it goes into the engine. It is recommended that you refer to the related specifications of WinGD for the design of the fuel treatment plant. The minimum separator capacity is 1.2 x CMCR x BSFC / 1000 (liters/hour), which is related to 0.21 l/kW. The fuel treatment must remove sludge and decrease catalyst fines and water to the recommended engine inlet limits.

Unwanted substances such as used oil or chemical waste must not be added to the fuel (refer to ISO 8217:2017). These unwanted substances can cause damage to the fuel system components, to the fuel injection equipment, to pistons, piston rings or cylinder liners. Contamination of the turbocharger, the exhaust system or the boiler can also occur because of poor fuel quality. Thus WinGD recommends a sample of the bunkered fuel is tested by a laboratory. If the analysis shows, that the fuel does not obey the specifications, you must do the related procedures.

The specifications of the fuel quality at the engine inlet uses the latest ISO 8217:2017 specification, refer to Table 12-1 - Specifications for HFO. You can get the ISO standards from the ISO Central Secretariat, Geneva, Switzerland (www.iso.ch).

Tab 12-1 Specifications for HFO

Parameter	Bunker limit	At engine inlet	Unit	Test method
Kinematic viscosity at 50°C	Maximum 700	13 to 17 [1] (not related to temperature)	mm^2/s [cSt] [2]	ISO 3104
Density at 15°C	Maximum 1010 [3]	Maximum 1010	kg/m^3	ISO 3675/12185
CCAI	Maximum 870	Maximum 870	-	Calculated
Sulphur [4]	Statutory specifications	Maximum 3.5	mass %	ISO 8754/14596
Flash point	Minimum 60	Minimum 60	°C	ISO 2719
Hydrogen sulphide [5]	Maximum 2.0	Maximum 2.0	mg/kg [ppm]	IP 570
Acid number	Maximum 2.5	Maximum 2.5	mg KOH/g	ASTM D 664
Total sediment, aged	Maximum 0.1	Maximum 0.1	mass %	ISO 10307-2
Carbon residue: micro method	Maximum 20	Maximum 20	mass %	ISO 10370
Pour point (upper) [6]	Maximum 30	Maximum 30	°C	ISO 3016
Water	Maximum 0.5	Maximum 0.2	volume %	ISO 3733
Ash	Maximum 0.15	Maximum 0.15	mass %	ISO 6245
Vanadium	Maximum 450	Maximum 450	mg/kg [ppm]	ISO 14597/IP501/ IP470
Sodium	Maximum 100	Maximum 30	mg/kg [ppm]	IP501/IP470
Aluminum plus Silicon	Maximum 60	Maximum 15	mg/kg [ppm]	ISO 10478/IP501/ IP470
Used lubricating oils (ULO) must not be present: Calcium (Ca) and zinc (Zn)	ULO shows if: Ca>30 and Zn>15 or Ca>30 and P>15	Do no use if: Ca>30 and Zn>15 or Ca>30 and P>15	mg/kg [ppm]	IP501 or IP470 or IP500

1 For Generation X, X-DF and RT-flex engines, the fuel viscosity at the engine inlet must be in the range between 10 mm^2/s and 20 mm^2/s, but WinGD recommends a fuel viscosity at the engine inlet in the range between 13 mm^2/s and 17 mm^2/s. The maximum permitted temperature is 150°C.

2 1 mm^2/s = 1 cSt (Centistoke)

3 The maximum density limit is 991 kg/m^3 if the fuel treatment plant cannot remove water from high-density fuel.

4 In ISO 8217:2017 sulphur limits are not given for HFO. Sulphur limits are related to statutory specifications.

5 The hydrogen sulphide limit is applicable from 1st July 2012.

6 Purchasers must make sure that the equipment on board can always keep the fuel at a temperature above the pour point, specially in cold climates.

It is very important that the fuel is fit for purpose in the related engine application.

NOTE: From 1st January 2015 fuel with less than 0.1% sulphur content must be used in Emission Control Areas (ECA). As an alternative you can burn LNG (Liquefied Natural Gas) or in some areas you can use SO_X scrubbers to decrease the content of sulphur oxides in the exhaust gas.

NOTE: Related to the MARPOL annex VI the maximum permitted sulphur content in fuel is 3.5%.

- LSFO (Low Sulphur Fuel Oil) has a maximum of 1.0% sulphur content
- VLSFO (Very Low Sulphur Fuel Oil) has a maximum of 0.5% sulphur content
- ULSFO (Ultra Low Sulphur Fuel Oil) has a maximum of 0.1% sulphur content.

NOTE: From 1st January 2020 fuel with less than 0.5% sulphur content must be used outside of ECA zones. As an alternative you can burn LNG or in some areas you can use SO_X scrubbers to decrease the content of sulphur oxides in the exhaust gas.

12.4.3 Data about heavy fuel oil specifications

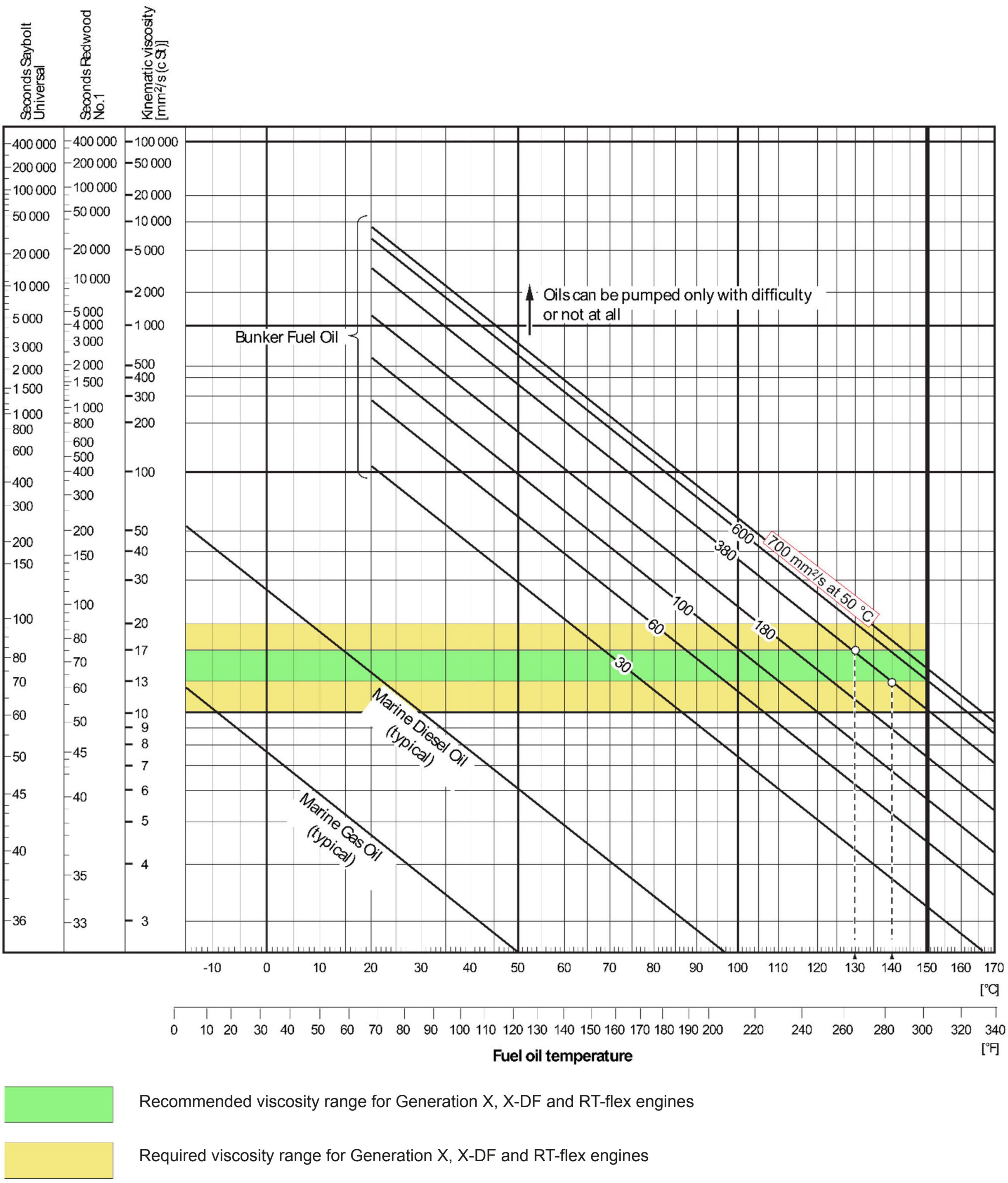
The paragraphs that follow give more data about the specifications for HFO.

12.4.3.1 Viscosity

WinGD recommends a viscosity range at the engine inlet between 13 mm^2/s (cSt) and 17 mm^2/s (cSt). You get the necessary temperature for a given nominal viscosity from the data in Figure 12-1.

The maximum permitted viscosity of the fuel that can be used in an engine installation is related to the heating and fuel preparation facilities available. The flow rate and the temperature of the fuel that flows through the separators must be adjusted in relation to the viscosity to get good separation. The temperature of the fuel must not be increased to more than 150°C to get the recommended viscosity at the engine inlet. This is because the fuel can start to decompose, form particles and the temperature can be above the flash point.

Fig 12-1 Viscosity / Temperature diagram



12.4.3.2 Density

The composition of the fuel gives the density. A high density shows a high aromatic content. It is not always possible to use conventional methods to measure the density at 15°C. Thus, the measurement is made at a higher temperature and then converted and adjusted to the reference temperature. Usually the maximum density of fuel is 1010.0 kg/m^3 related to the ISO 8217:2017 RMK specifications. If you use a fuel with a density higher than 991.0 kg/m^3, you must make sure that an equipment is available on board that can treat such fuels.

12.4.3.3 Calculated Carbon Aromaticity Index (CCAI)

The ignition and combustion properties of the fuel in a diesel engine are related to the specific engine design, load profile and fuel properties.

The CCAI is a calculated value of the ignition properties or ignition delay of the fuel related to the viscosity and density. The CCAI gives no indication of the combustion properties. The CCAI limit is useful to examine fuels with unusual density-viscosity relations.

12.4.3.4 Sulphur

Sulphur limits are not specified in ISO 8217:2017 because statutory specifications put a limit on this value. WinGD 2-stroke engines are designed to operate with high and low sulphur fuels, if:

- You select the alkalinity (base number (BN)) of the cylinder oil in relation to the sulphur content of the fuel in use.
- You use the necessary equipment related to the statutory specifications.

12.4.3.5 Flash point

The flash point is an important safety and fire hazard parameter for diesel fuels. Fuel is always a fire hazard. There can be flammable vapors in the air space above the remaining fuel in the tanks. Take care if you increase the temperature of the remaining fuel above the flash point, as flammable vapor can occur.

12.4.3.6 Hydrogen sulphide (H_2S)

Hydrogen Sulphide (H_2S) is a very toxic gas and exposure to high concentrations is dangerous and can kill you. Be careful when tanks or fuel lines are opened because there can be H_2S vapor. At low concentrations H_2S smells almost the same as rotten eggs. You cannot sense H_2S at moderate concentrations. H_2S causes nausea and dizziness.

12.4.3.7 Acid number

Fuels with high acid numbers can cause damages to fuel injection systems. Most fuels have a low acid number, which is not dangerous, but an acid number above 2.5 mg KOH/g, can cause problems. Some naphthenic fuels can have an acid number of more than 2.5 mg KOH/g, but still be permitted. Only a full laboratory analysis can measure the strong acid number.

12.4.3.8 Sediment, Carbon and Asphaltenes

High quantities of sediment, carbon and asphaltenes decrease the ignition and combustion quality of the fuel. These materials also increase wear and damage to engine components. Asphaltenes also have an effect on the stability of blended fuels and can cause too much sludge in the separators and filters. If the blended fuel is not stable, particles can collect on the bottom of the tank.

To keep risks to a minimum, make sure that bunkers from different suppliers and sources are not mixed in the storage tanks on board. Also be careful when HFO is blended on board to decrease the viscosity. Paraffinic distillate, when added to an HFO of low stability, can cause the asphaltenes to collect, which causes heavy sludge.

HFO can contain up to 14% asphaltenes and will not cause ignition and combustion problems in 2-stroke engines if the fuel preparation equipment is adjusted correctly.

12.4.3.9 Pour Point

The operation temperature of the fuel must be kept between approximately 5°C and 10°C above the pour point to make sure that the fuel can flow easily.

12.4.3.10 Water

The separator and the correct configuration of drains in the settling and service tanks are used to decrease the water quantity in the fuel. A complete removal of water is highly recommended to decrease the quantity of hydrophilic catalytic fines (cat fines) and sodium in the fuel. Sodium is not a natural oil component, but diesel engine fuel often has sea water contamination, which has sodium. A content of 1.0% sea water in the fuel is related to 100 ppm sodium.

To get a good separation effect, the flow rate and temperature of the fuel must be adjusted in relation to the viscosity. For high-viscosity fuels the separation temperature must be increased, and the flow rate must be decreased in relation to the nominal capacity of the separator. For the recommended data to operate the separator, refer to the documentation of the manufacturer.

12.4.3.11 Ash and Trace Metals

Fuels with a low content of ash, vanadium, sodium, aluminum, silicon, calcium, phosphorous and zinc are recommended. High quantities of these materials can increase mechanical wear, high-temperature corrosion and particles in the turbocharger, exhaust system and boilers.

- **Vanadium and Sodium**

  Sodium compounds decrease the melting point of vanadium oxide and sulphate salts, especially when the vanadium to sodium ratio is 3:1 or higher. High sodium quantities (as well as lithium and potassium) at the engine inlet can cause damage to the turbocharger, exhaust system and boilers. Ash modifiers can correct the effect of high-temperature corrosion and particles.

- **Aluminum and Silicon**

  Aluminum (Al) and silicon (Si) in the fuel are an indication of catalytic fines. These are particles of hard oxides (round particles of material almost the same as porcelain) which cause high abrasive wear to pistons, piston rings and cylinder liners. Catalytic fines are used as a catalyst in some processes in petroleum refining and can be found in diesel engine fuels. The most dangerous catalytic fines are between 10 microns and 20 microns.

- **Catalytic fines**

  Catalytic fines cause cylinder liners to become worn. Catalytic fines are attached to water droplets and are very difficult to remove from the fuel. With correct treatment in the fuel separator, the aluminum and silicon content of 60 ppm (mg/kg) can be decreased to 15 ppm (mg/kg), which is thought to be satisfactory. For satisfactory separation, a fuel temperature as close as possible to 98°C is recommended. A decreased fuel flow rate through the separator gives a better separation. This is because the fuel stays in the separator for a longer period. Also obey the instructions of the equipment manufacturer.

  Catalytic fines can collect in the sediment of the fuel tank from other bunkers. During bad weather conditions, the movement of the ship mixes the sediment into the fuel. Thus, it is better to think that all fuels contain catalytic fines, although it is possible that a fuel analysis can show a different result. Thus do also regular procedures to remove sludge and catalytic fines from the fuel that is in the settling tank and the service tanks.

12.4.3.12 Used Lubricating Oil and Chemical Waste

Used lubricating oils and chemical waste must not be mixed into the fuel. If you do so, the fuel would not be stable because the base oil is very paraffinic and can cause too much sludge. Most used lubricating oil is from the crankcase, thus large quantities of calcium, zinc, phosphorous and other additives and wear metals can cause contamination. The limits in ISO 8217:2017 and the WinGD specifications make sure that no used lubricating oil is in the fuel.

Chemical waste (eg polymers, styrene and other chemical substances) must not be added to the fuel. These materials can cause the fuel to become too thick, to become almost solid and thus can cause blocked filters. They can also cause corrosive attacks and damage to the fuel injection system.

12.4.4 Distillate Fuel Specifications

Since 2015 more frequently distillate fuels are used in 2-stroke engines to obey the new ECA rules. Distillate fuels are easier to operate than residual fuel, but caution is necessary for some problems.

In ISO 8217:2017 there are specified the DMX, DMA, DMZ and DMB grades and the new DFA, DFZ and DFB grades with a maximum fatty acid methyl ester (FAME) content of 7.0 volume %. The WinGD specifications use the DMB grade which is the highest viscosity grade, refer to Table 12-2 - Specifications for distillate fuels. The DMX grade is not applicable for use in 2-stroke engines because of its low flash point and viscosity.

Tab 12-2 Specifications for distillate fuels

Parameter	Bunker limit	At engine inlet	Unit	Test method
Kinematic viscosity at 40°C	Maximum 11.0 Minimum 2.0	Minimum 2.0 (not related to temperature)	mm^2/s [cSt] [1]	ISO 3104
Density at 15°C	Maximum 900	Maximum 900	kg/m^3	ISO 3675/12185
Cetane index	Minimum 35	Minimum 35	-	ISO 4264
Sulphur [2]	Maximum 1.5	Maximum 1.5	mass %	ISO 8754/14596
Flash point	Minimum 60	Minimum 60	°C	ISO 2719
Hydrogen sulphide [3]	Maximum 2.0	Maximum 2.0	mg/kg [ppm]	IP 570

Parameter	Bunker limit	At engine inlet	Unit	Test method
Acid number	Maximum 0.5	Maximum 0.5	mg KOH/g	ASTM D 664
Total sediment by hot filtration	Maximum 0.1	Maximum 0.1 [4]	mass %	ISO 10307-1
Oxidation stability	Maximum 25	Maximum 25 [5]	g/m^3	ISO 12205
Fatty acid methyl ester (FAME)	-	-	volume %	ASTM D7963 or IP 579
Carbon residue: micro method on 10% volume distillation residue	Maximum 0.3	-	mass %	ISO 10370
Carbon residue: micro method	Maximum 0.3	Maximum 0.3	mass %	ISO 10370
Pour point (upper) winter [6]	Maximum 0	Maximum 0	°C	ISO 3016
Pour point (upper) summer	Maximum 6	Maximum 6	°C	ISO 3016
Cloud point winter	-	-	°C	ISO 3015
Cloud point summer	-	-	°C	ISO 3015
Cold filter plugging point winter	-	-	°C	IP 309 or IP 612
Cold filter plugging point summer	-	-	°C	IP 309 or IP 612
Water	Maximum 0.3	Maximum 0.2	volume %	ISO 3733
Ash	Maximum 0.01	Maximum 0.01	mass %	ISO 6245
Lubricity, corrected wear scar diameter (WSD) at 60°C [7]	Maximum 520	Maximum 520	µm	-

1 1 mm^2/s = 1 cSt (Centistoke)

2 The purchaser must specify the maximum sulphur content in accordance with the usual statutory specifications.

3 The hydrogen sulphide limit is applicable from 1 July 2012.

4 If the sample is not clear and bright, it is necessary to do the total sediment by hot filtration and the water tests.

5 If the sample is not clear and bright, you cannot do this test. Thus it is not possible to see the compliance with the limit.

6 Purchasers must make sure that the pour point is sufficient for the equipment on board, specially for operation in cold climates.

7 This parameter is applicable to fuels with a sulphur content of less than 0.05 mass %.

12.4.5 Data about distillate fuel specifications

The paragraphs that follow give more data about the specifications for distillate fuels.

12.4.5.1 Viscosity

For distillate fuel a minimum viscosity of 2.0 mm^2/s (cSt) at the engine inlet is necessary. A lower viscosity can cause too much leakage in the fuel system.

Operators must be careful during the change-over procedure from distillate to residual fuel and back to make sure of problem free operation. Refer to the related fuel change-over procedures in the Operation Manual.

In some conditions, it is possible that you cannot get the minimum viscosity of 2.0 mm^2/s (cSt) at the engine inlet. In such conditions, a fuel cooling system is necessary to make sure that the inlet to the engine has the minimum viscosity.

12.4.5.2 Lubricity

ISO 8217:2017 specifies a maximum lubricity wear scar diameter (WSD) of 520 µm to make sure that the fuel has sufficient lubricity. This prevents quick wear of the fuel system components.

12.4.5.3 Density

The distillate density is related to the composition of the fuel. A high density indicates a high aromatic quantity.

12.4.5.4 Cetane index

The ignition and combustion properties of a distillate fuel in a diesel engine is related to the specific engine design, load profile and fuel properties. The Cetane Index is a calculated value of the ignition quality of the fuel related to the distillation and density. The density and the temperature when 10%, 50% and 90% of the fuel is distilled, gives the Cetane Index. This has no effect on the fuel combustion properties.

12.4.5.5 Sulphur

Sulphur limits are specified in ISO 8217:2017 for distillate fuels, but statutory specifications must be obeyed. The alkalinity (BN) of the cylinder oil must be selected in relation to the sulphur content of the fuel in use.

Indications for the selection of the BN of the cylinder oil in relation to the sulphur content of the fuel are found in the related specifications.

12.4.5.6 Acid number

Fuels with high acid numbers can cause damage to fuel injection systems. Most fuels have a low acid number, which is not dangerous, but an acid number above 2.5 mg KOH/g can cause damage.

12.4.5.7 Flash Point

The flash point is an important safety and fire hazard parameter for diesel fuels. Fuel is always a fire hazard because there can be flammable vapors in the air space above the remaining fuel in the tanks.

12.4.5.8 Hydrogen sulphide (H_2S)

Hydrogen Sulphide (H_2S) is a very toxic gas and exposure to high concentrations is dangerous and can kill you. Be careful when tanks or fuel lines are opened because there can be H_2S vapor. At low concentrations H_2S smells almost the same as bad eggs. You cannot sense H_2S at moderate concentrations. H_2S causes nausea and dizziness.

12.4.5.9 Sediment

High quantities of sediment, carbon and asphaltenes decrease the ignition and combustion quality of the fuel and increase wear and damage to engine components. High sediment quantities can cause filters to block, or frequent discharge from filter systems that have automatic cleaning. For more data about mixtures, refer to Para 12.4.3.8.

12.4.5.10 Pour point

The operation temperature of the fuel must be kept between approximately 5°C and 10°C above the pour point to make sure that the fuel flows easily. It is possible that in very cold conditions, there could be problems for distillate fuel.

12.4.5.11 Water

The quantity of water in distillate fuel can be decreased as follows:

- Let the fuel settle in the service tanks.
- Use a separator to remove water from the fuel.

12.4.5.12 Ash and trace metals

Distillate fuels must have low quantities of ash, vanadium, sodium, aluminum, silicon, calcium, phosphorous and zinc related to residual fuels. High quantities of these materials increase mechanical wear, high-temperature corrosion and particles in the turbocharger, exhaust system and the boilers.

12.4.5.13 Used lubricating oil and other contamination

Lubricating oils and chemical waste must not be mixed into the distillate fuel. Lubricating oil can cause water to stay because of the large quantity of detergent. Additive materials such as calcium, magnesium, zinc and phosphorous could increase the ash content to more than that given in the specification.

Chemical waste must not be added to distillate fuel. These materials can have the effects that follow:

- Can cause the fuel to become too thick and thus can cause a blockage of the filters
- Can cause damage to fuel injection systems
- Can cause a blockage of the fuel pump plungers or injectors.

12.4.5.14 Cloud point and cold filter plugging point

Before you bunker fuel, make sure that the pour point, the cloud point and the cold filter plugging point (also known as cold flow characteristics) are correct for your ship’s design and voyage. There could be problems with wax deposits in the storage tanks and in the separators, or with clogged filters.

12.4.6 Bio-derived products and fatty acid methyl esters

Such components can be found in diesel engine fuels and can cause a decrease of greenhouse gases and SO_x emissions. Most bio-fuel components in the diesel fuel are Fatty Acid Methyl Esters (FAME), which come from a special chemical treatment of natural plant oils. These components are mandatory in automotive and agricultural diesel in some countries. FAME is specified in ISO 14214 and ASTM D 6751.

FAME has good ignition properties and very good lubrication and environmental properties, but FAME has also known negative properties as follows:

- Possible oxidation and thus long term storage problems
- A chemical attraction to water and nutrient for microbial growth
- Unsatisfactory low temperature properties
- FAME material particles can appear on exposed surfaces and filter elements.

If you use FAME as a fuel, make sure that the on-board storage, handling, treatment, service and machinery systems can be used with such a product.

12.4.7 Ultra low sulphur fuel oils

Some fuel suppliers are selling ultra low sulphur fuel oils (ULSFO, sometimes also referred to as hybrid fuels) as an alternative to distillate fuels to obey the ECA rules.

Many of these products obey the specifications for residual fuel related to ISO 8217:2017, but they are different to heavy fuel oil (HFO) in properties like sulphur content, compatibility, stability viscosity, density and pour point. Do the same procedures for ULSFO as for HFO related to storage, heating and separation.

The use of ULSFO is under the full responsibility of the operating company. WinGD recommends to speak to the fuel supplier.

12.4.8 Fuel Additives

WinGD does not recommend the use of fuel additives. Additives are not necessary for fuels that obey the ISO 8217:2017 standard or for fuels that WinGD has recommended.

If you think that it is necessary to use additives, WinGD recommends to speak to the fuel supplier and to the additive supplier. They can give you the related results of the use of additives. If you use additives for some causes, you assume full responsibility. Existing No Objection Letters done by Wärtsilä Switzerland Ltd. are no longer applicable and have no more support by WinGD.

NOTE: WinGD does not accept liability or responsibility for the performance or potential damage caused by the use of such additives.

12.4.9 Non-standard fuels

If it is necessary to use non-standard fuels (fuels that are not in the related list from WinGD), speak to or send a message to WinGD before use.

NOTE: WinGD does not accept liability or responsibility for the performance or potential damage caused by the use of non-standard fuels.

13 Attachments

13.1 Schematic diagrams - general

13.1.1 Engine control diagram

The engine control diagram shows data about the control items of the engine and its systems.

In the sub-sections that follow you find general data about the engine control diagram.

13.1.1.1 Area codes in the engine control diagram

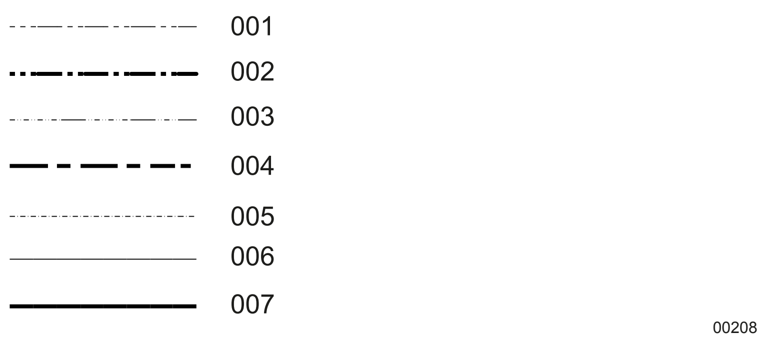
The area codes in the engine control diagram are as follows:

- A - Control air supply unit
- B - Fuel supply
- D - Servo oil supply
- E - Valve unit for start
- K - Local control panel.

13.1.1.2 Line codes in the engine control diagram

The line codes in the engine control diagram are shown in Figure 13-1.

Fig 13-1 Line codes



Legend

001	Low pressure oil circuits	005	Heating
002	High pressure oil circuits	006	Control air circuits
003	Low pressure fuel circuits	007	Starting air circuits
004	High pressure fuel circuits		

13.1.1.3 System codes in the engine control diagram

The system codes in the engine control diagram are as follows:

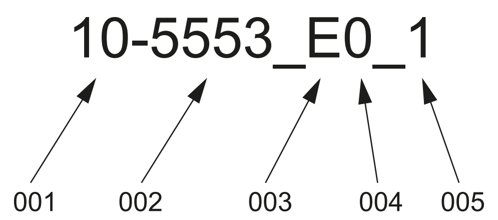
- Code 10 - Fuel system
- Code 20 - Oil system
- Code 25 - Cylinder oil system

- Code 30 - Starting air system
- Code 35 - Control air system
- Code 40 - HT Cooling water system
- Code 48 - Cylinder cooling water system
- Code 50 - Exhaust gas system
- Code 70 - Miscellaneous systems
- Code 80 - Automation system
- Code 99 - Pipe diagram
- Code 900 - Engine room.

13.1.1.4 Component codes in the engine control diagram

The component codes in the engine control diagram are shown as example in Figure 13-2.

Fig 13-2 Process codes



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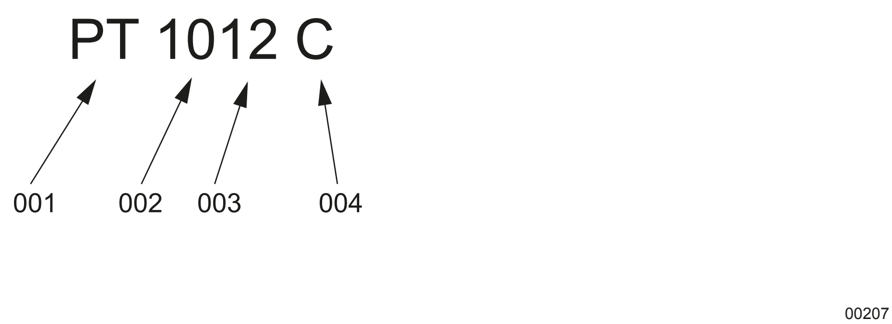
Legend

001	System code	004	CX - Cylinder, eg C5 = for cylinder 5
002	Design group	005	Running number
003	E0 = for engine		

13.1.1.5 Signal codes - identification

The signal codes in the engine control diagram are shown as example in Figure 13-3.

Fig 13-3 Signal codes



Legend

001 Function code
002 Function group
003 Running number
004 Applied system

Tab 13-1 Function code

Code	First position	Second position
A	Analysis	n/a
C	Control	Control
E	n/a	Element
F	Flow	n/a
G	Gauge	n/a
H	Hand	n/a
I	n/a	Indication
J	Power	n/a
L	Level	n/a
P	Pressure	n/a
S	Speed	Switch
T	Temperature	Transmitter
V	n/a	Valve
X	Unclassified	Unclassified
Y	Vibration	Relay
Z	Position (binary)	n/a

Tab 13-2 Function group

Code	Signal type	System
10 to 19	Signals from the engine	Cooling water
20 to 29	Signals from the engine	System oil, cooling oil
31	Signals from the engine	Cylinder lubrication
33	Signals from the engine	Fuel gas
34	Signals from the engine	Fuel oil
35	Signals from the engine	Fuel gas
37	Signals from the engine	Exhaust gas
40 to 49	Signals from the engine	Air systems
50 to 59	Signals from the engine	Miscellaneous
60 to 69	Signals from the engine	Spare
70 to 79	Signals to the engine	Miscellaneous
80 to 89	Signals to the engine	Miscellaneous

Tab 13-3 Applied system

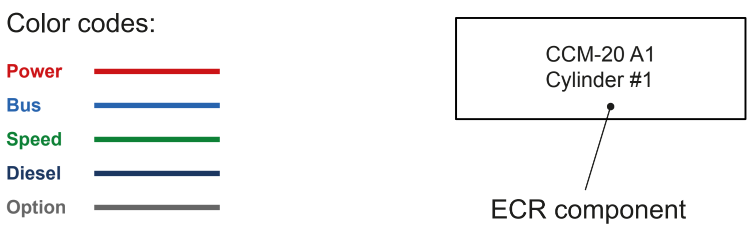
Code	Description
A	Alarm and monitoring system
C	Control system
L	Local
M	Measured indication, Local control panel
S	Safety system
W	Wrong way alarm
X	Miscellaneous

13.1.2 Electric connection diagram

The electric connection diagram shows data about the bus routing connections (without cylinder related signals).

You can find an overview of the used color codes and symbols in Figure 13-4.

Fig 13-4 Color codes and symbols - electric connection diagram



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13.1.3 Piping and instrumentation diagram

The piping and instrumentation diagrams show data about the piping and instrumentation of the auxiliary systems of the engine.

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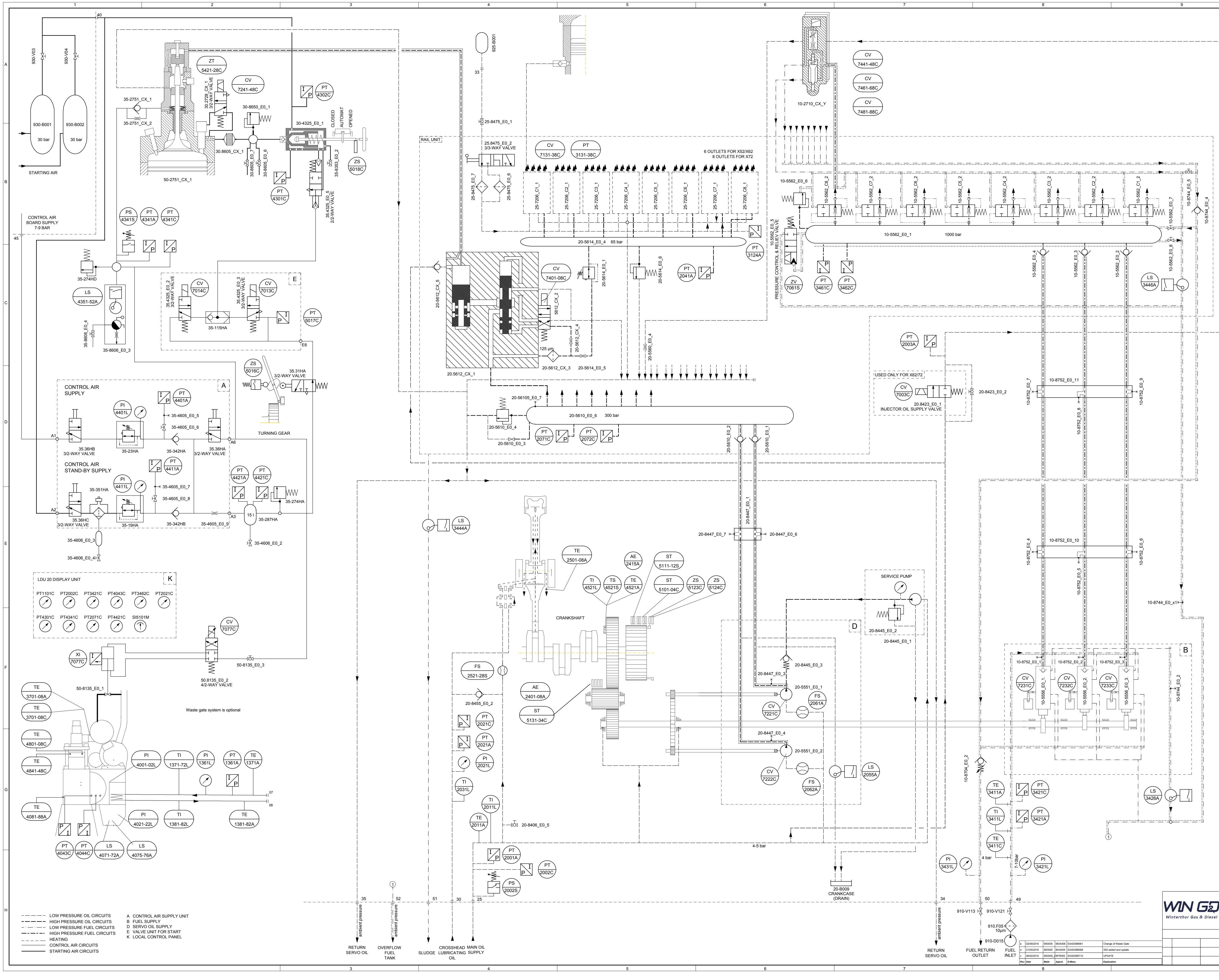
13.2 List of diagrams

Table 13-4 - List of diagrams gives a list of diagrams related to the engine. You find the diagrams on the pages that follow.

Tab 13-4 List of diagrams

Item	Title
1	Engine control diagram
2	Electric connection diagram
3	Piping and instrumentation diagram, 6 cylinder
4	Piping and instrumentation diagram, 7 cylinder



PROCESS CODE	DESCRIPTION	PATH
10-2710_CX_Y	FUEL INJECTION VALVE	(6-A)
10-5556_E0_1.	FUEL PUMP	(8-F)
10-5556_E0_2.	FUEL PUMP	(8-F)
10-5556_E0_3.	FUEL PUMP	(9-F)
10-5562_C1_2	FLOW FUSE CYL. 1	(9-B)
10-5562_E0_1	SINGLE WALL FUEL OIL RAIL	(6-B)
10-5562_E0_2	NON RETURN VALVE	(9-C)
10-5562_E0_3	NON RETURN VALVE	(8-C)
10-5562_E0_4	NON RETURN VALVE	(8-C)
10-5562_E0_5	PRESSURE CONTROL & RELIEV VALVE	(6-B)
10-5562_E0_6	PRESSURE RETAINING VALVE	(6-B)
10-5562_E0_7	FILLING VALVE	(9-B)
10-5562_E0_8	DRAIN VALVE	(9-B)
10-8704_E0_2	ADJUSTABLE PRESSURE RETAINING VALVE	(8-G)
10-8744_E0_5	BALL VALVE	(9-B)
10-8752_E0_10	CONNECTION PIECE	(8-E)
10-8752_E0_11	CONNECTION PIECE	(8-D)
20-5551_E0_1	SERVO OIL PUMP 1	(6-F)
20-5551_E0_2	SERVO OIL PUMP 2	(6-G)
20-5560_E0_4	RESTRICTOR	(5-C)
20-5610_E0_1	NON RETURN VALVE	(6-D)
20-5610_E0_2	NON RETURN VALVE	(6-D)
20-5610_E0_3	2-WAY SHUT-OFF VALVE	(4-D)
20-5610_E0_4	PRESSURE SAFETY VALVE	(4-D)
20-5610_E0_6	SINGLE WALL SERVO OIL RAIL	(4-D)
20-5612_CX_2	SOLENOID VALVE	(4-C)
20-5612_CX_3	FILTER VCU	(4-C)
20-5612_CX_4	RESTRICTOR	(5-C)
20-5614_E0_1	PRESSURE REDUCER VALVE	(5-C)
20-5614_E0_5	RESTRICTOR	(5-C)
20-5614_E0_6	PRESSURE SAFETY VALVE	(5-C)
20-8406_E0_5	BALL VALVE	(4-G)
20-8423_E0_1	INJECTOR OIL SUPPLY VALVE	(7-D)
20-8423_E0_2	BALL VALVE	(7-D)
20-8423_E0_8	FILTER FUEL PUMP 1	(8-F)
20-8423_E0_9	FILTERFUEL PUMP 2	(8-F)
20-8445_E0_1	SERVO OIL SERVICE PUMP	(7-E)
20-8445_E0_2	PRESSURE SAFETY VALVE	(7-F)
20-8445_E0_3	PRESSURE RETAINING VALVE	(6-F)
20-8447_E0_1	CONNECTION PIECE	(6-E)
20-8455_E0_2	NON RETURN VALVE	(4-F)
25-8475_E0_1	BALL VALVE	(4-A)
25-8475_E0_2	3/3-WAY VALVE	(4-B)
25-8475_E0_6	FILTER	(4-B)
25-8475_E0_7	FILTER	(4-B)
30-2728_CX_1	3/2-WAY VALVE	(2-A)
30-4325_E0_1	SHUT-OFF VALVE STARTING AIR	(3-B)
30-8605_E0_6	BALL VALVE	(2-B)
30-8605_E0_7	BALL VALVE	(2-B)
30-8650_E0_1	PRESSURE SAFETY VALVE	(2-A)
30.8605_CX_1	FLAME ARRESTER	(2-B)
35-115HA	DOUBLE CHECK VALVE	(2-C)
35-19HA	PRESSURE REDUCING VALVE	(1-E)
35-23HA	PRESSURE REDUCING VALVE	(1-D)
35-274HA	PRESSURE SAVETY VALVE	(2-E)
35-274HD	PRESSURE SAVETY VALVE	(1-C)
35-2751_CX_1	NON RETURN VAVLE	(1-A)
35-2751_CX_2	RESTRICTOR	(1-A)
35-287HA	CONTROL AIR BOTTLE	(2-E)
35-31HA	3/2-WAY VALVE	(3-D)
35-342HA	NON RETURN VALVE	(2-D)
35-342HB	NON RETURN VALVE	(2-E)
35-351HA	AIR FILTER	(1-E)
35-36HA	3/2-WAY VALVE	(2-D)
35-36HB	3/2-WAY VALVE	(1-D)
35-36HC	3/2-WAY VALVE	(1-E)
35-4325_E0_2	3/2-WAY VALVE	(2-C)
35-4325_E0_3	3/2-WAY VALVE	(2-C)
35-4325_E0_5	2/2-WAY VALVE	(3-B)
35-4605_E0_6	2-WAY SHUT-OFF VALVE	(2-D)
35-4605_E0_8	2-WAY SHUT-OFF VALVE	(2-E)
35-4605_E0_9	RESTRICTOR	(2-E)
35-4606_E0_2	2-WAY SHUT-OFF VALVE	(2-E)
35-4606_E0_3	BOTTLE	(1-E)
35-4606_E0_4	NEEDLE VALVE	(1-E)
35-8353_E0_2	BALL VALVE	(3-B)
35-8606_E0_3	COLLECTOR FOR LEAKAGE OIL FROM AIR SPRING	(1-C)
35-8606_E0_4	BALL VALVE	(1-C)
50-2751_CX_1	EXHAUST VALVE	(2-B)
50-8135_E0_1	BUTTERFLY VALVE	(1-F)
50-8135_E0_2	4/2-WAY VALVE	(2-F)
50-8135_E0_3	BALL VALVE	(2-F)
910-D015	FUEL BOOSTER PUMP	(8-H)
910-V113	2-WAY SHUT-OFF VALVE	(8-H)
910-V121	2-WAY SHUT-OFF VALVE	(8-H)
925-B001	CYLINDER LUBE OIL TANK	(4-A)
995-07	SAC-LT-COOLING WATER INLET	(2-G)
995-08	SAC-LT-COOLING WATER OUTLET	(2-G)
995-25	MAIN LUBRICATING OIL INLET	(4-H)
995-30	LUBRICATING OIL CROSSHEAD INLET	(4-H)
995-33	CYLINDER LUB. OIL INLET	(4-A)
995-34	LEAKAGE OIL DRIVING END OUTLET	(7-H)
995-35	LEAKAGE OIL FREE END OUTLET	(3-H)
995-45	CONTROL AIR SUPPLY INLET	(1-B)
995-49	FUEL INLET	(8-H)
995-50	FUEL RETURN OUTLET	(8-H)
995-51	FUEL LEAKAGE RAIL UNIT OUTLET	(4-H)
995-52	FUEL LEAKAGE OUTLET	(3-H)
995-57	VARIOUS LEAKAGE OUTLET	(3-H)

Winterthur Gas & Diesel

ENGINE CONTROL DIAGRAM

DENIS-UNIC

Units: mm/kg

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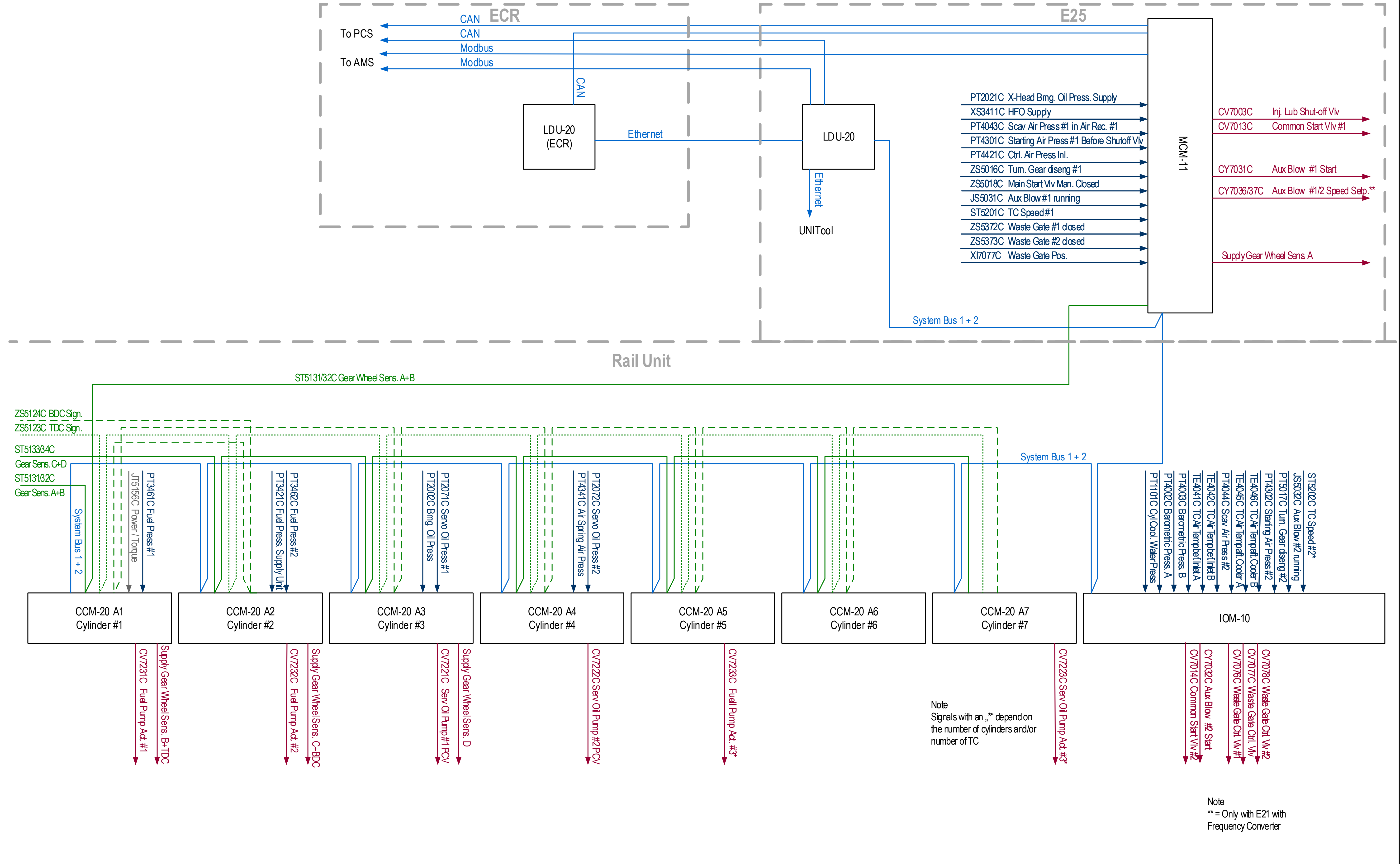
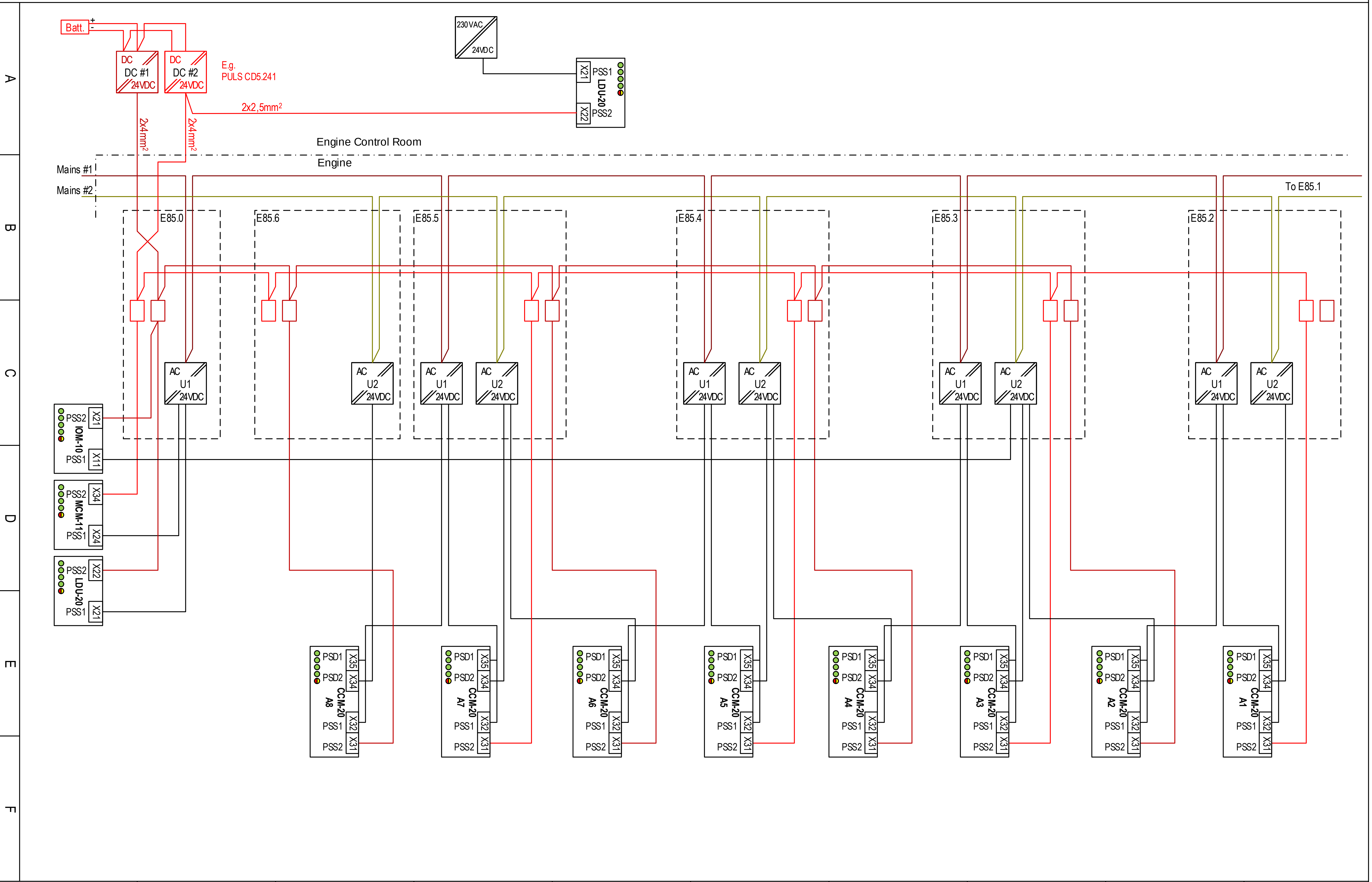


Electric Connection Diagram

System Layout

WIN GD Winterthur Gas & Diesel

1 / 4



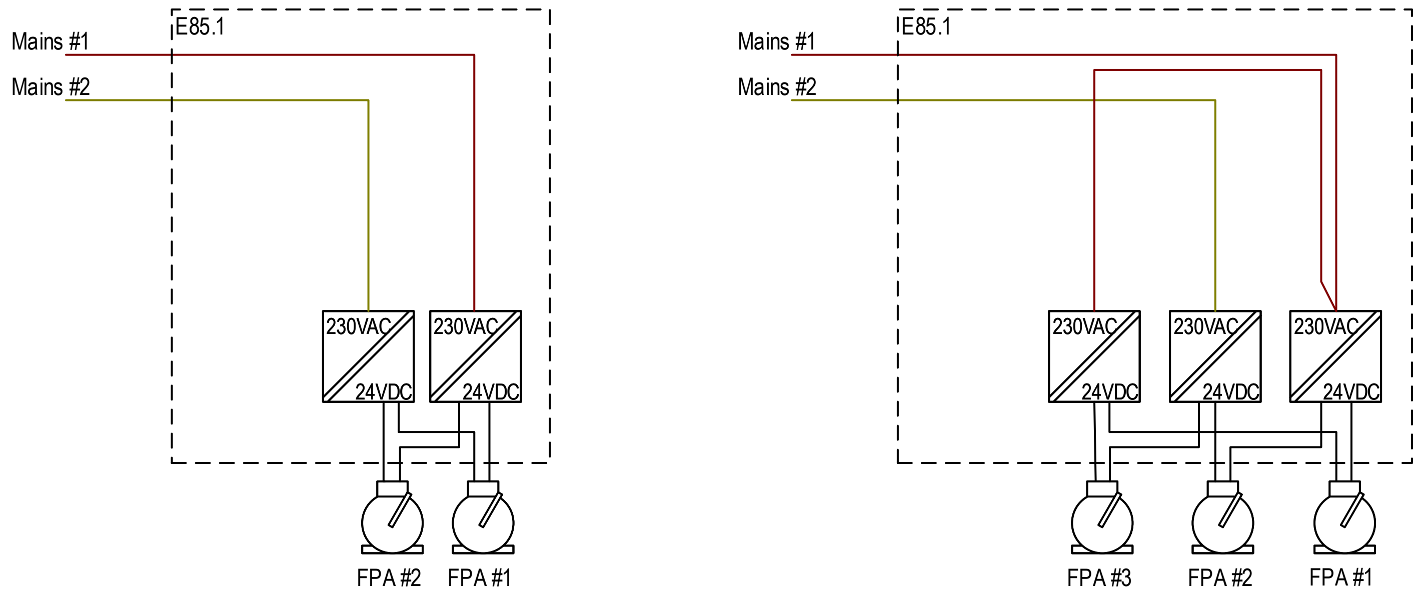
Electric Connection Diagram

System Layout

WIN GD

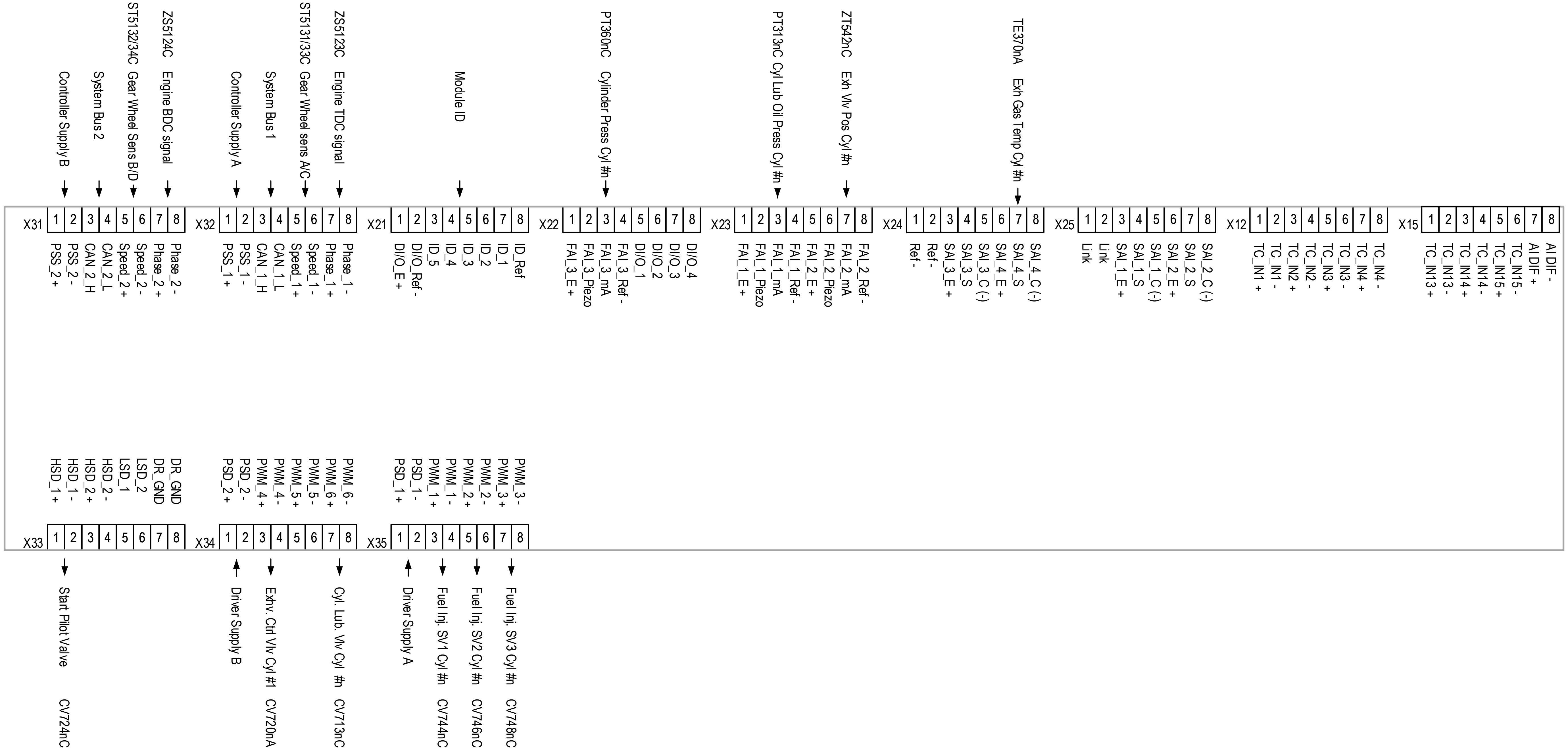
Winterthur Gas & Diesel

FUEL PUMP ACTUATORS



A B C D E F

CCM-20 Common connections Diesel Part



0 1 2 3 4 5 6 7 8 9

Electric Connection Diagram

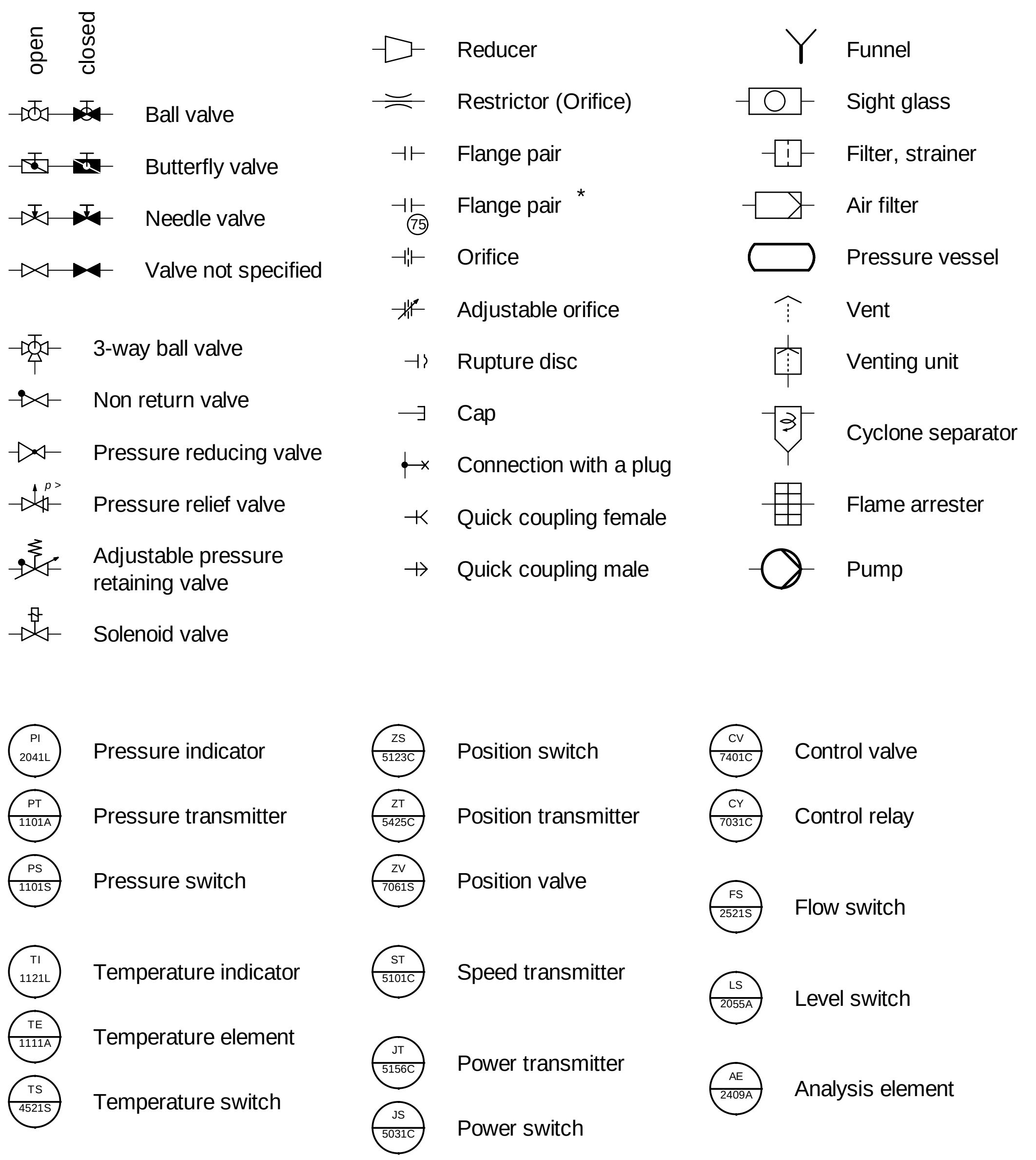
System Layout

Winterthur Gas & Diesel

Piping and Instrumentation Diagram

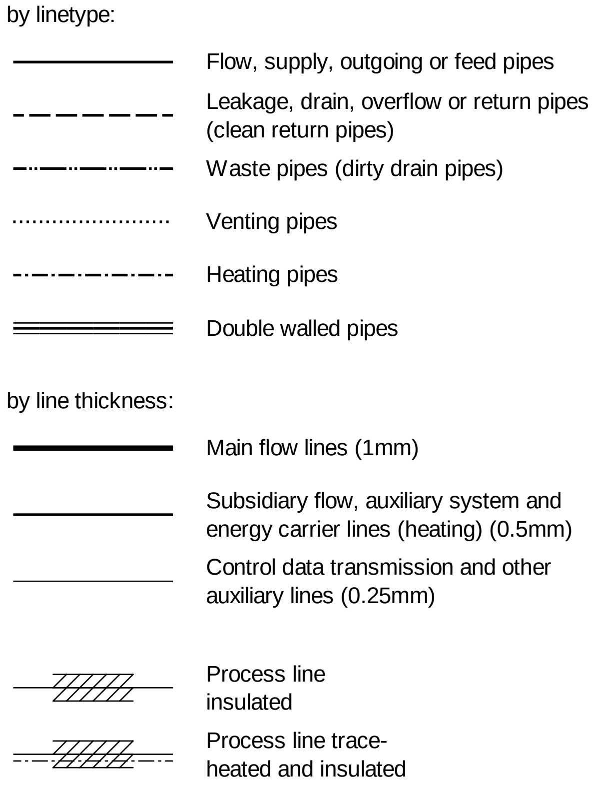
Engine equipped with
one Turbocharger

Symbol definitions:



* Number in information box is corresponding to the pipe connection (Group 8020 / Pipe Connection Plan)

Pipe definitions:



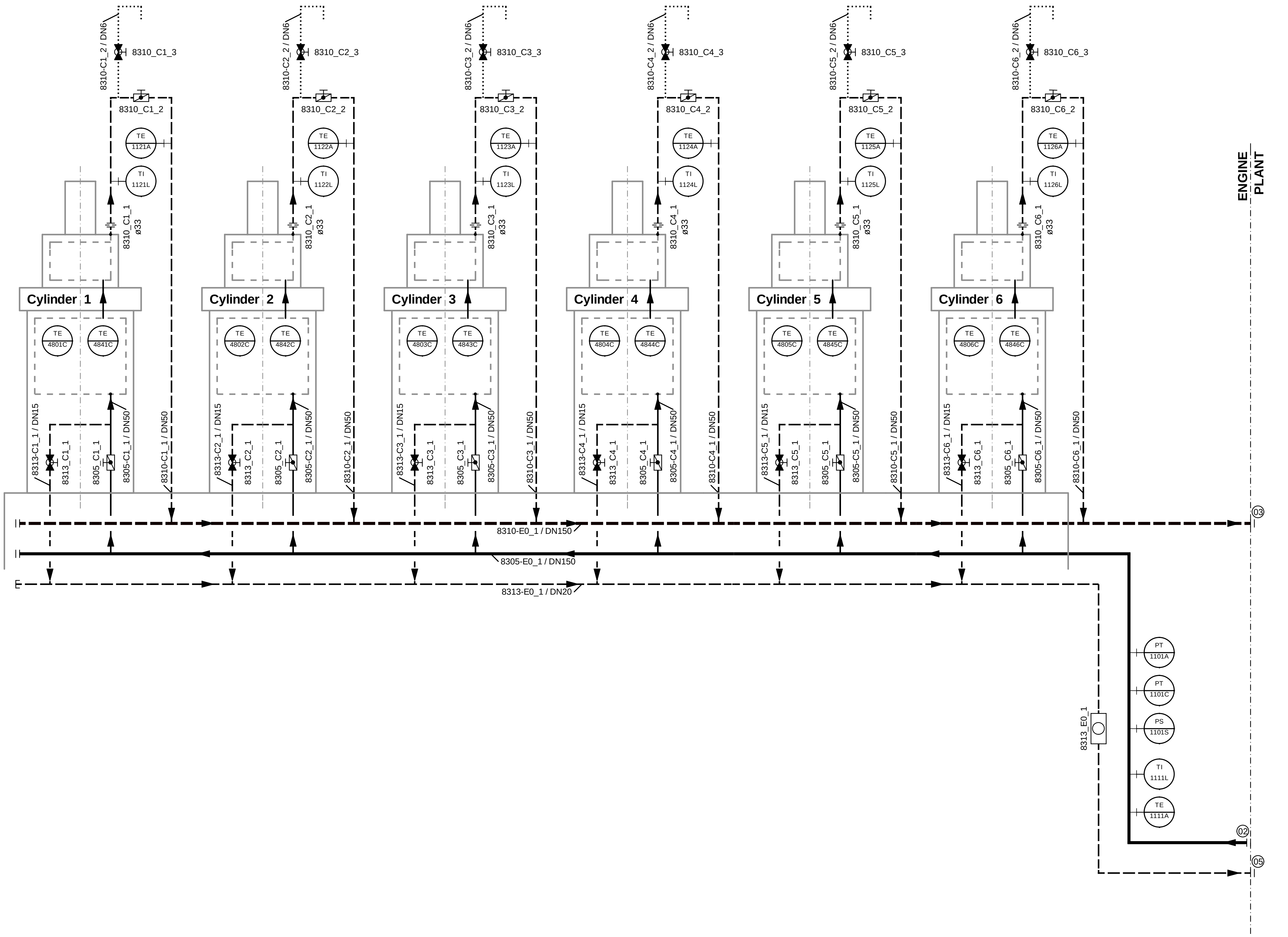
Content:

WIN GD
Winterthur Gas & Diesel

PIPE DIAGRAM

TITLE PAGE

Units: mm/kg
Page No. *1 / 10*



WIN GD Winterthur Gas & Diesel	PIPE DIAGRAM WATER SYSTEMS Cylinder Cooling
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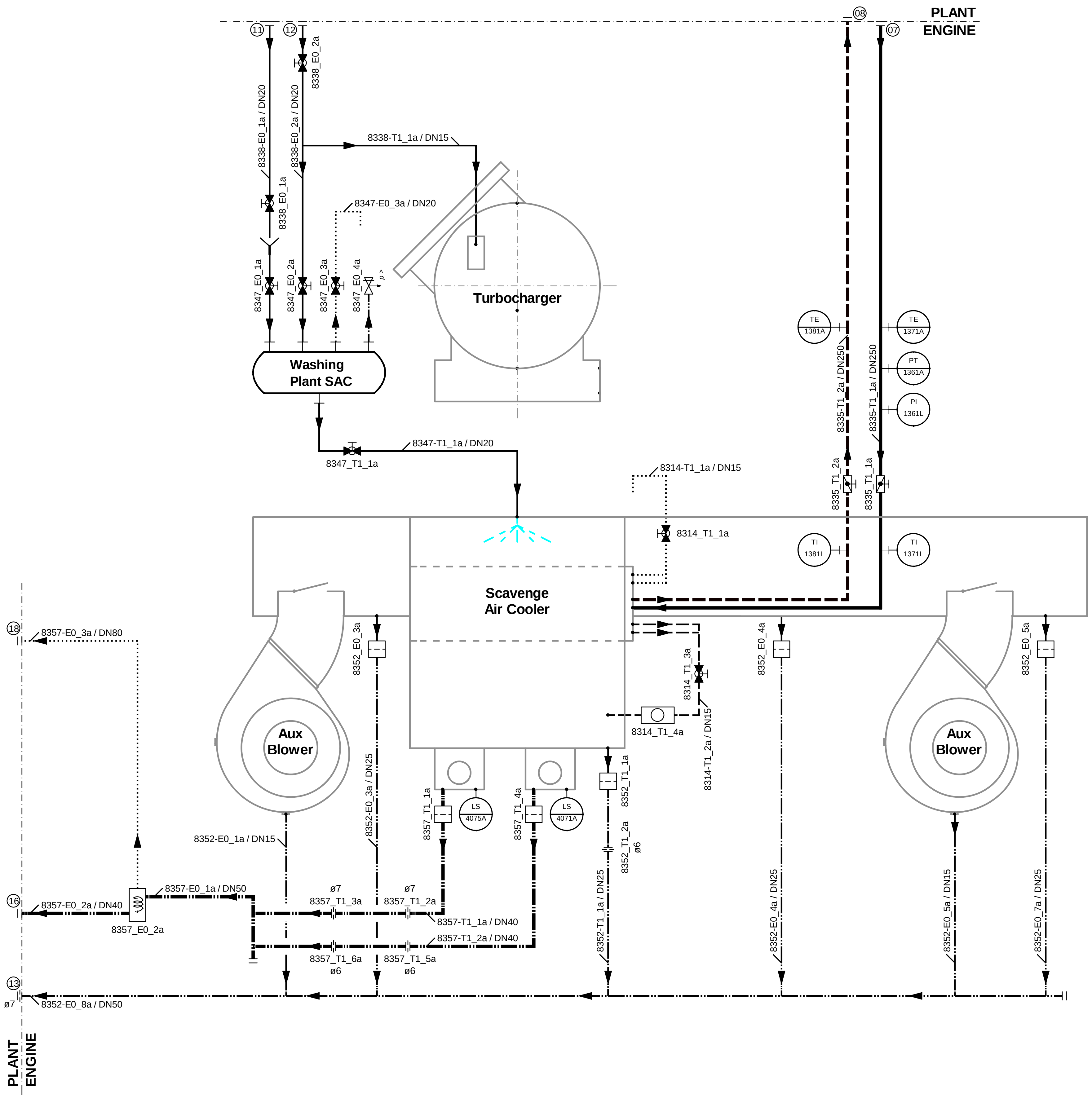
C000146



PIPE DIAGRAM
WATER SYSTEMS
Scavenge Air Receiver & TC

Winterthur Gas & Diesel

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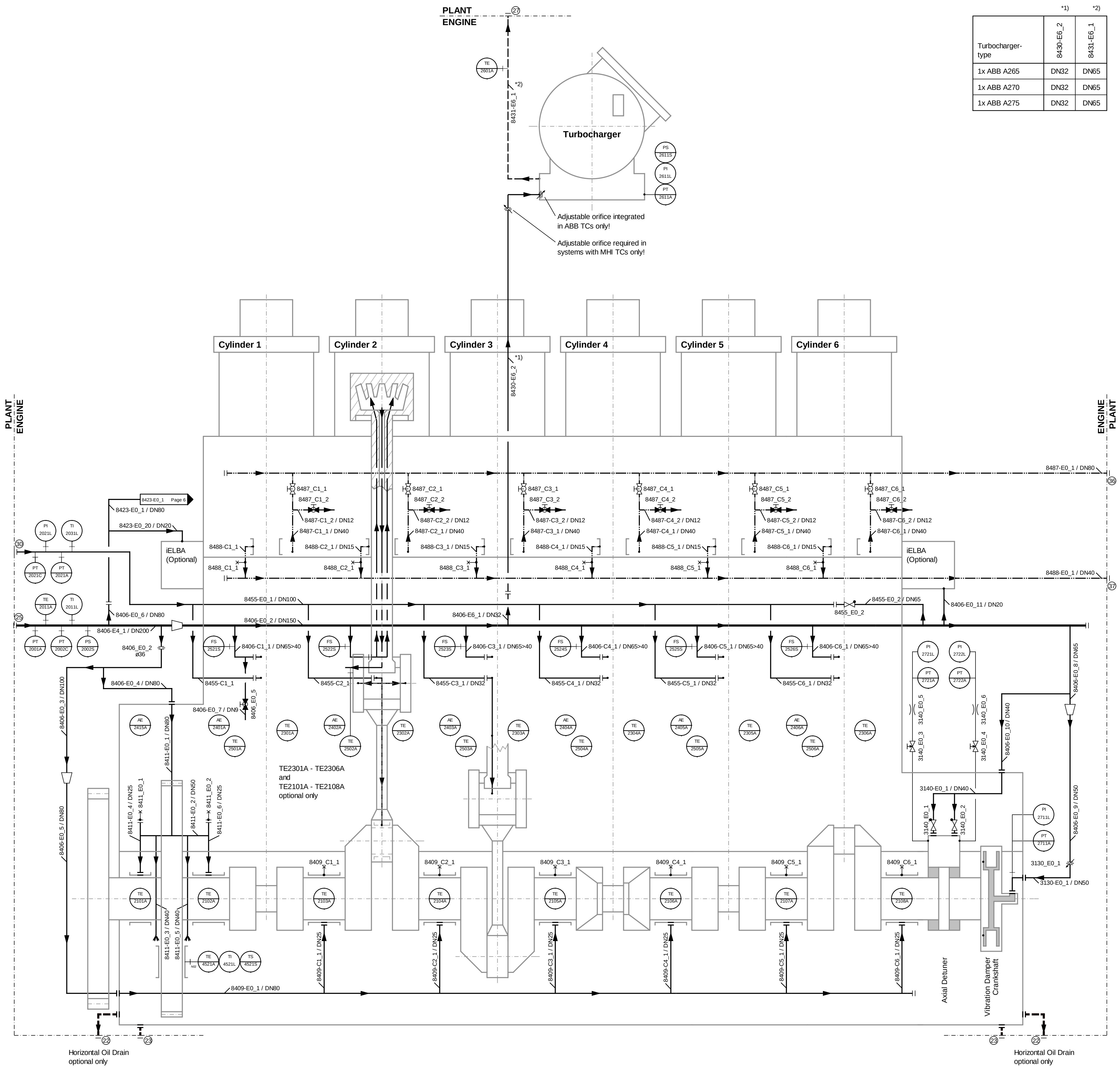
C000146

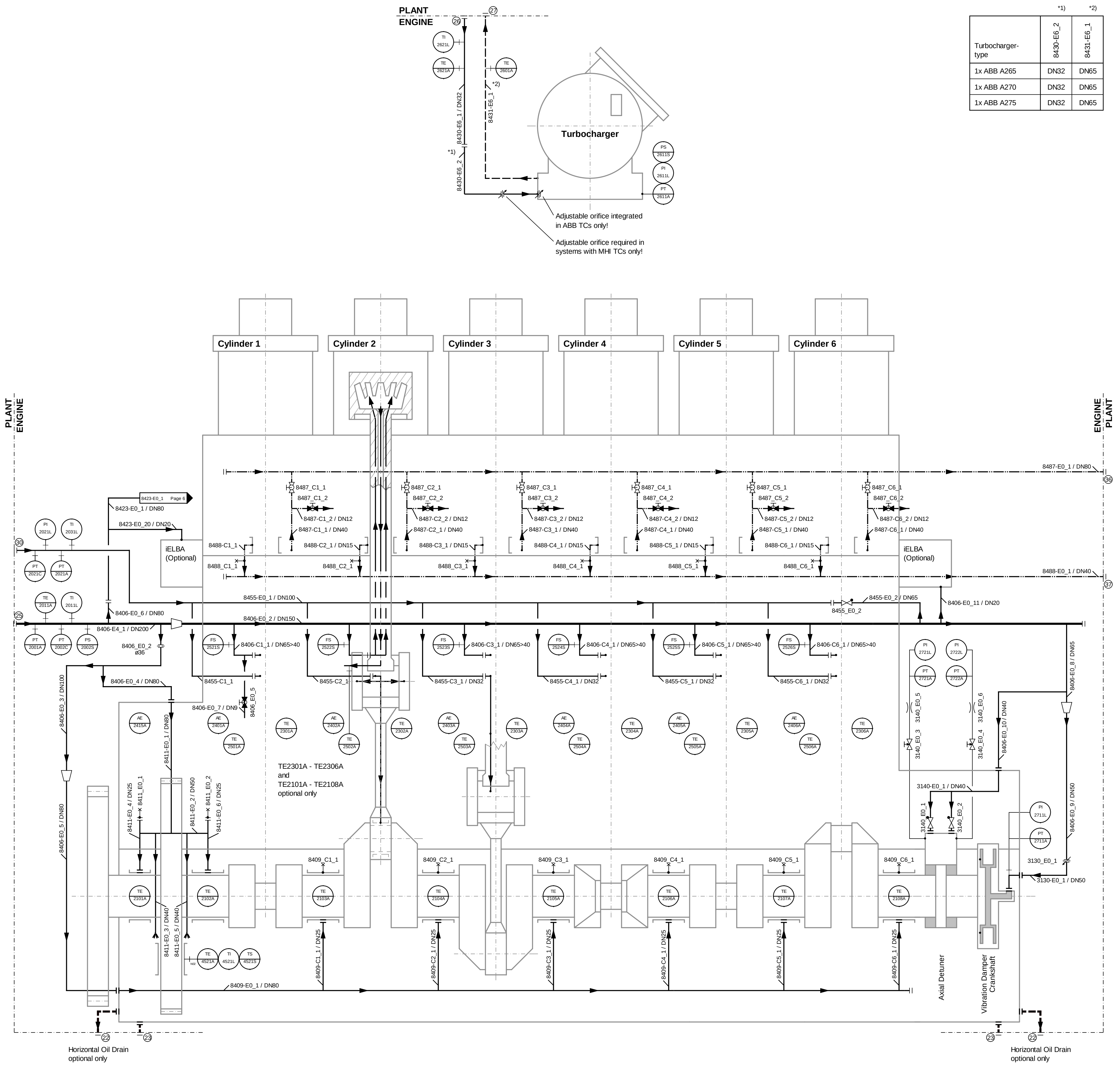
	8430-E6_2 *1)	8431-E6_1 *2)
Turbocharger-type		
1x ABB A265	DN32	DN65
1x ABB A270	DN32	DN65
1x ABB A275	DN32	DN65



PIPE DIAGRAM
OIL SYSTEMS
System Oil & Int. TC Oil Supply

C000146

	*1)	*2)
Turbocharger-type	8430-E6_2	8431-E6_1
1x ABB A265	DN32	DN65
1x ABB A270	DN32	DN65
1x ABB A275	DN32	DN65



WinGD Winterthur Gas & Diesel

PIPE DIAGRAM
OIL SYSTEMS
System Oil & Ext. TC Oil Supply

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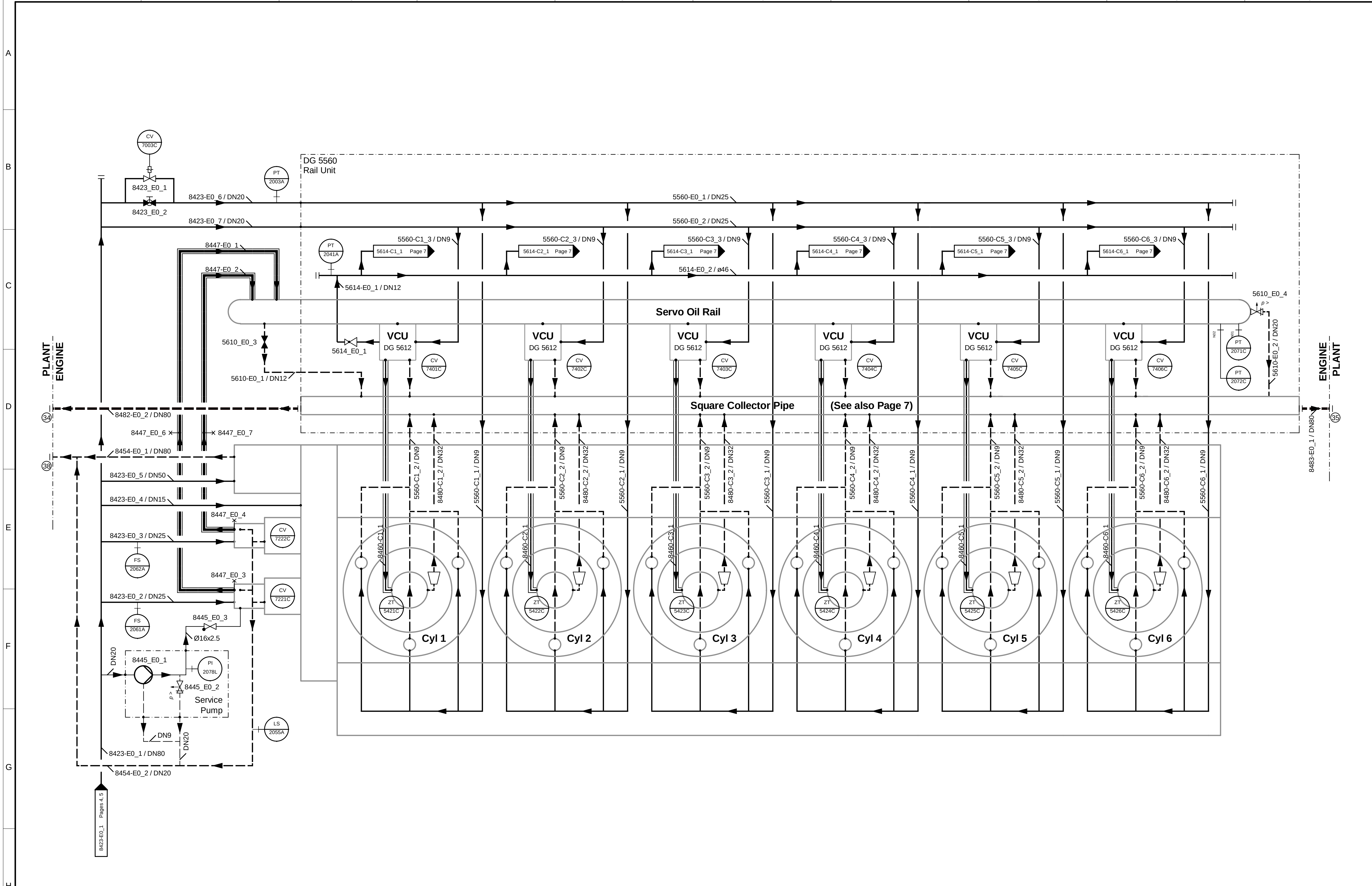
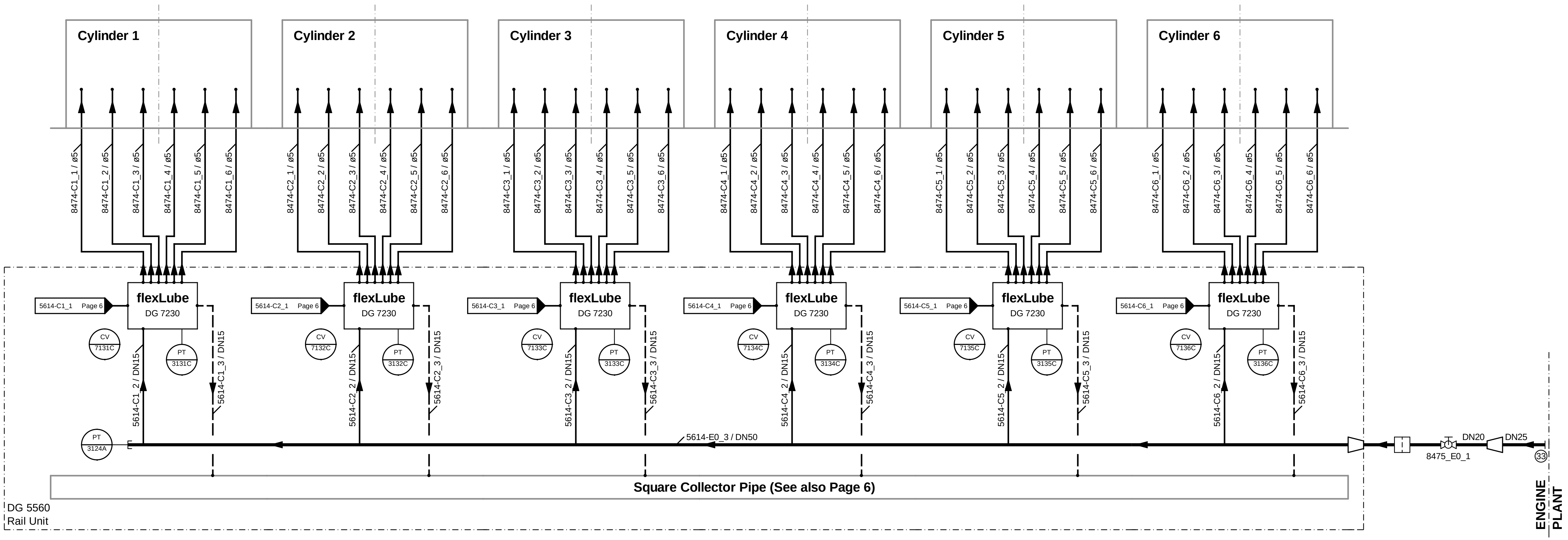


DG 5560
Rail Unit
Servo Oil Rail
Square Collector Pipe
(See also Page 7)
VCU
DG 5612
Cyl 1
Cyl 2
Cyl 3
Cyl 4
Cyl 5
Cyl 6
PLANT
ENGINE
Service
Pump
5560-E0_1 / DN25
5560-E0_2 / DN25
5614-E0_2 / ø46
5614-E0_1 / DN12
5610-E0_1 / DN12
5610-E0_2 / DN20
8423-E0_6 / DN20
8423-E0_7 / DN20
8482-E0_2 / DN80
8454-E0_1 / DN80
8423-E0_5 / DN50
8423-E0_4 / DN15
8423-E0_3 / DN25
8423-E0_2 / DN25
8423-E0_1 / DN80
8454-E0_2 / DN20
8483-E0_1 / DN80

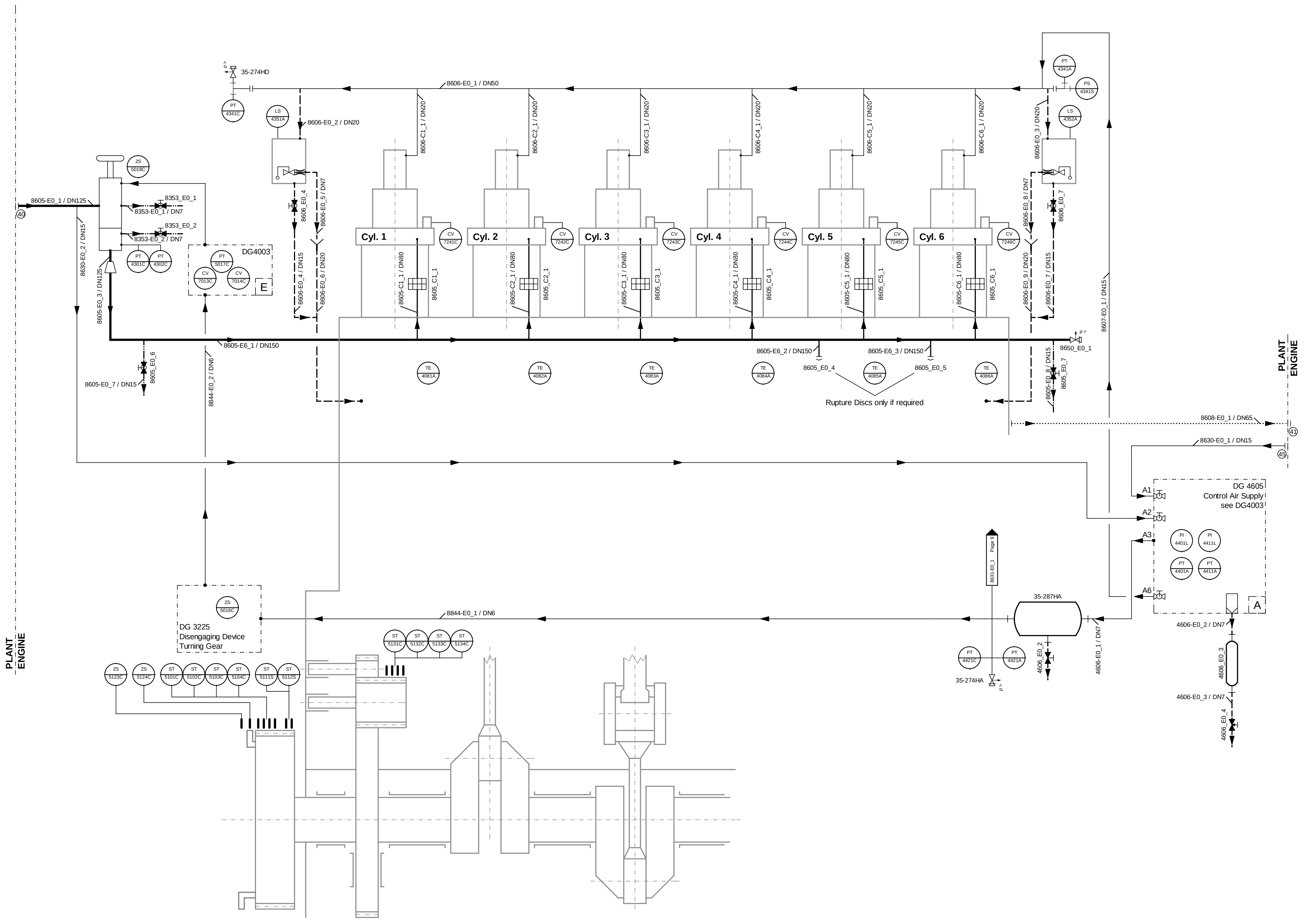
C000146



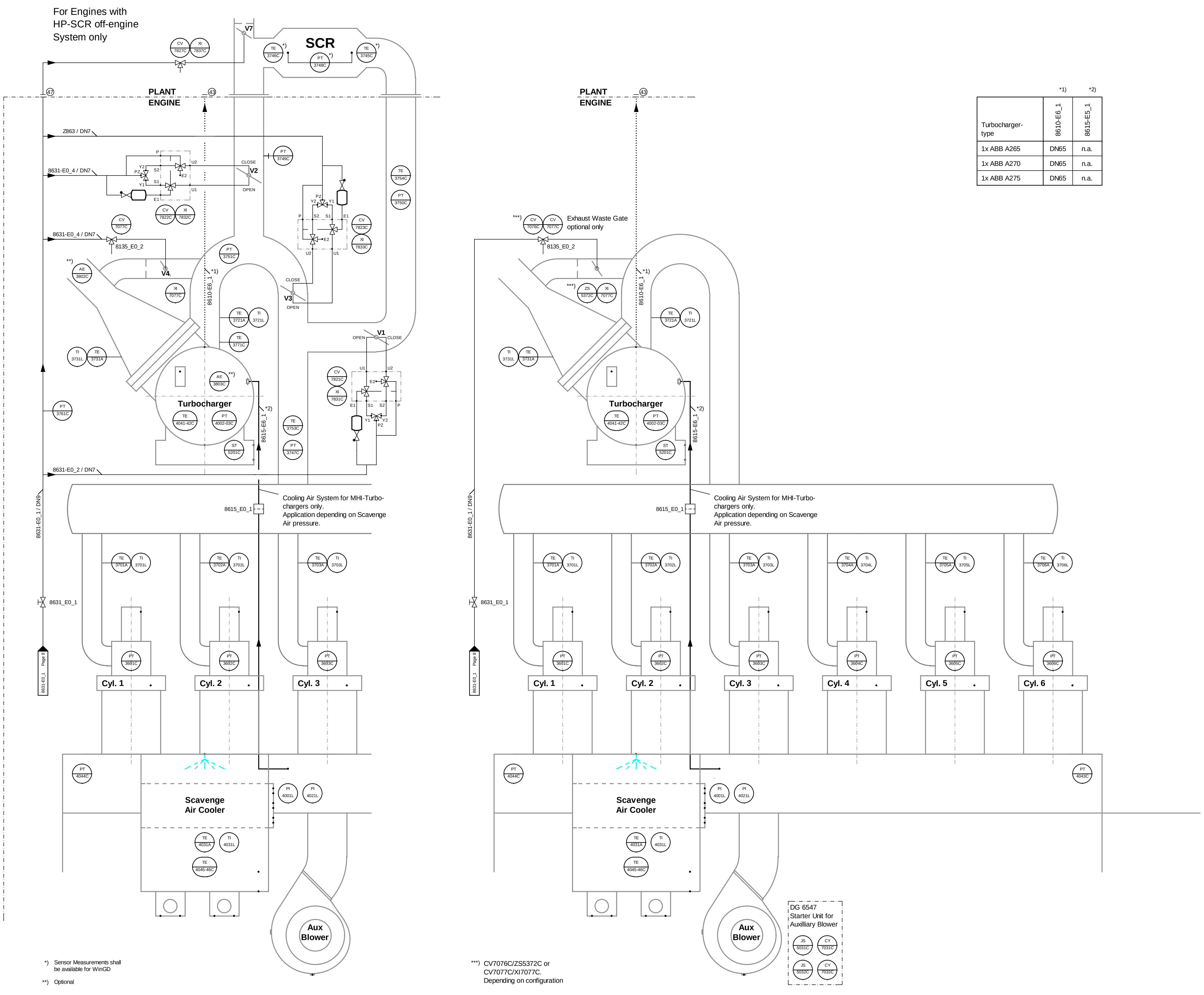
PIPE DIAGRAM
OIL SYSTEMS
Cylinder Lubrication

WIN GD
Winterthur Gas & Diesel

C000146



PIPE DIAGRAM
AIR SYSTEMS
Starting & Control Air



Turbocharger-type	8610-E6_1 *1)	8615-E5_1 *2)
1x ABB A265	DN65	n.a.
1x ABB A270	DN65	n.a.
1x ABB A275	DN65	n.a.

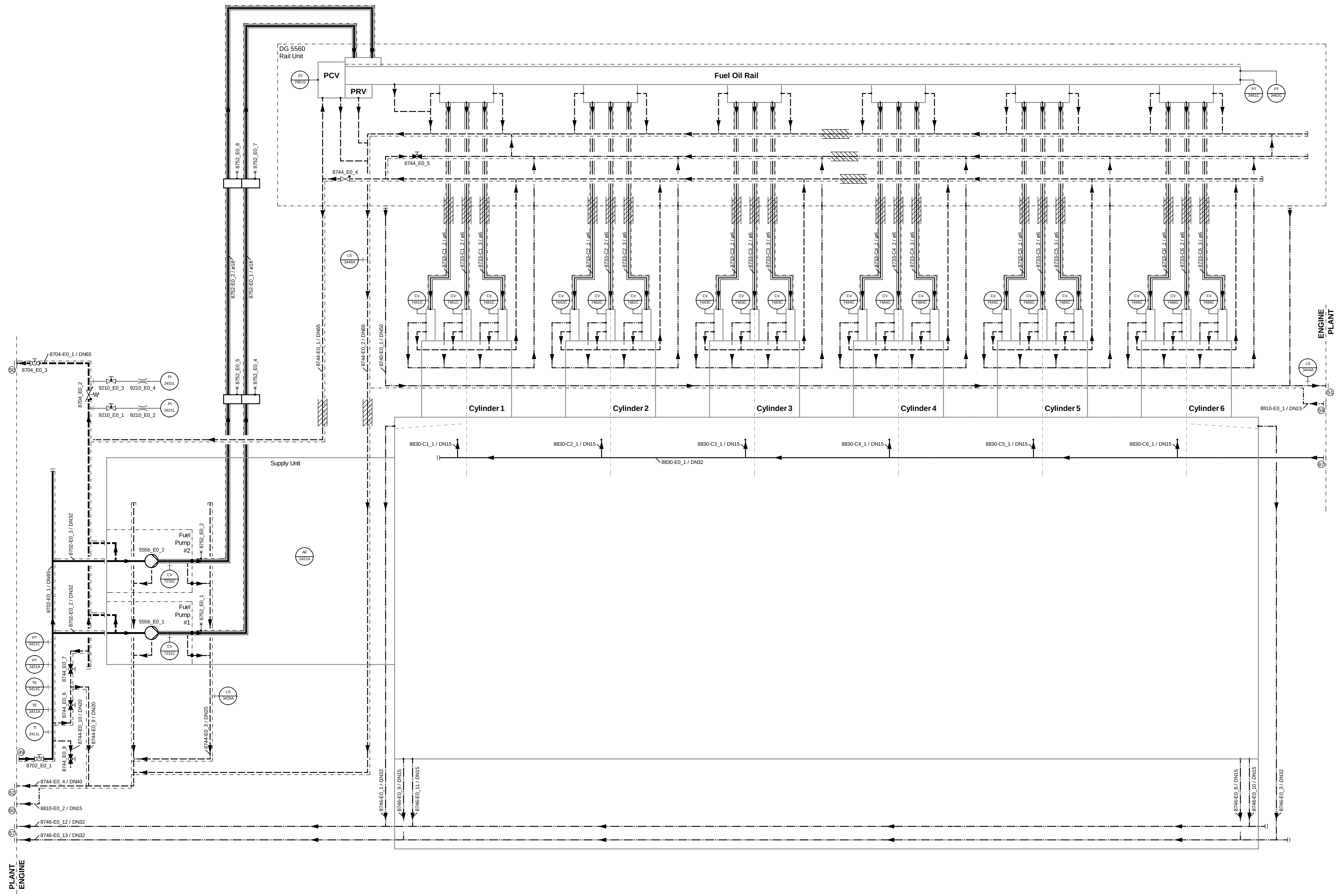
*) Sensor Measurements shall be available for WinGD

**) Optional

***) CV7076C/ZS5372C or CV7077C/XI7077C. Depending on configuration

WIN GD Winterthur Gas & Diesel

PIPE DIAGRAM
AIR SYSTEMS
Exhaust Gas & Scavenge Air



PIPE DIAGRAM

FUEL, DRAIN & EXTING. SYSTEMS

Winterthur Gas & Diesel

Piping and Instrumentation Diagram

Engine equipped with
one Turbocharger

Symbol definitions:

open / closed

- Ball valve
- Butterfly valve
- Needle valve
- Valve not specified
- 3-way ball valve
- Non return valve
- Pressure reducing valve
- Pressure relief valve
- Adjustable pressure retaining valve
- Solenoid valve

- Reducer
- Restrictor (Orifice)
- Flange pair
- Flange pair *
- Orifice
- Adjustable orifice
- Rupture disc
- Cap
- Connection with a plug
- Quick coupling female
- Quick coupling male

- Funnel
- Sight glass
- Filter, strainer
- Air filter
- Pressure vessel
- Vent
- Venting unit
- Cyclone separator
- Flame arrester
- Pump

- PI 2041L Pressure indicator
- PT 1101A Pressure transmitter
- PS 1101S Pressure switch
- TI 1121L Temperature indicator
- TE 1111A Temperature element
- TS 4521S Temperature switch

- ZS 5123C Position switch
- ZT 5425C Position transmitter
- ZV 7061S Position valve
- ST 5101C Speed transmitter
- JT 5156C Power transmitter
- JS 5031C Power switch

- CV 7401C Control valve
- CY 7031C Control relay
- FS 2521S Flow switch
- LS 2055A Level switch
- AE 2409A Analysis element

* Number in information box is corresponding to the pipe connection (Group 8020 / Pipe Connection Plan)

Pipe definitions:

by linetype:

- Flow, supply, outgoing or feed pipes
- Leakage, drain, overflow or return pipes (clean return pipes)
- Waste pipes (dirty drain pipes)
- Venting pipes
- Heating pipes
- Double walled pipes

by line thickness:

- Main flow lines (1mm)
- Subsidiary flow, auxiliary system and energy carrier lines (heating) (0.5mm)
- Control data transmission and other auxiliary lines (0.25mm)
- Process line insulated
- Process line trace-heated and insulated

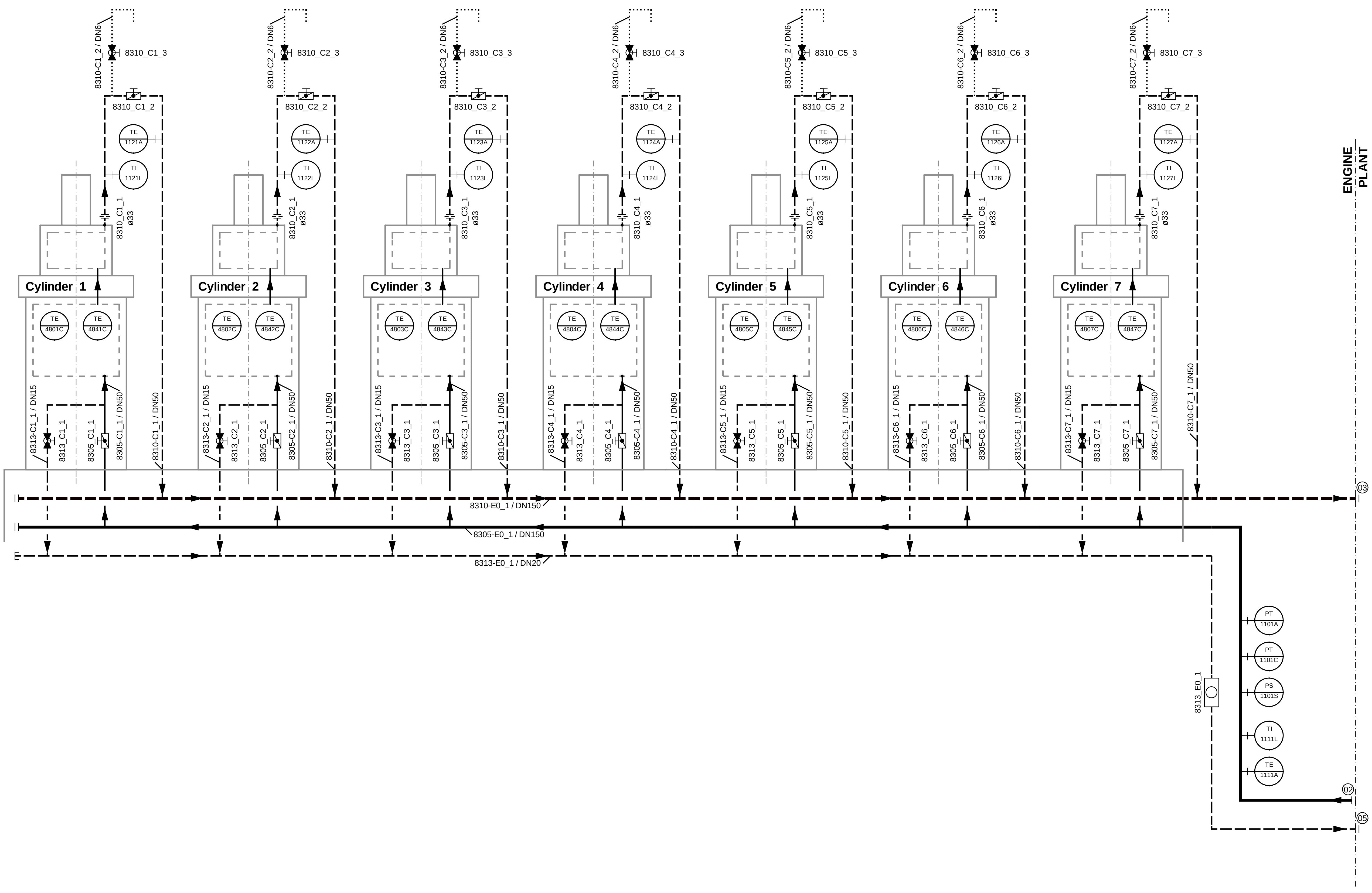
Content:

WIN GD
Winterthur Gas & Diesel

PIPE DIAGRAM

TITLE PAGE

Units: mm/kg



PIPE DIAGRAM
WATER SYSTEMS
Cylinder Cooling

WIN GD Winterthur Gas & Diesel

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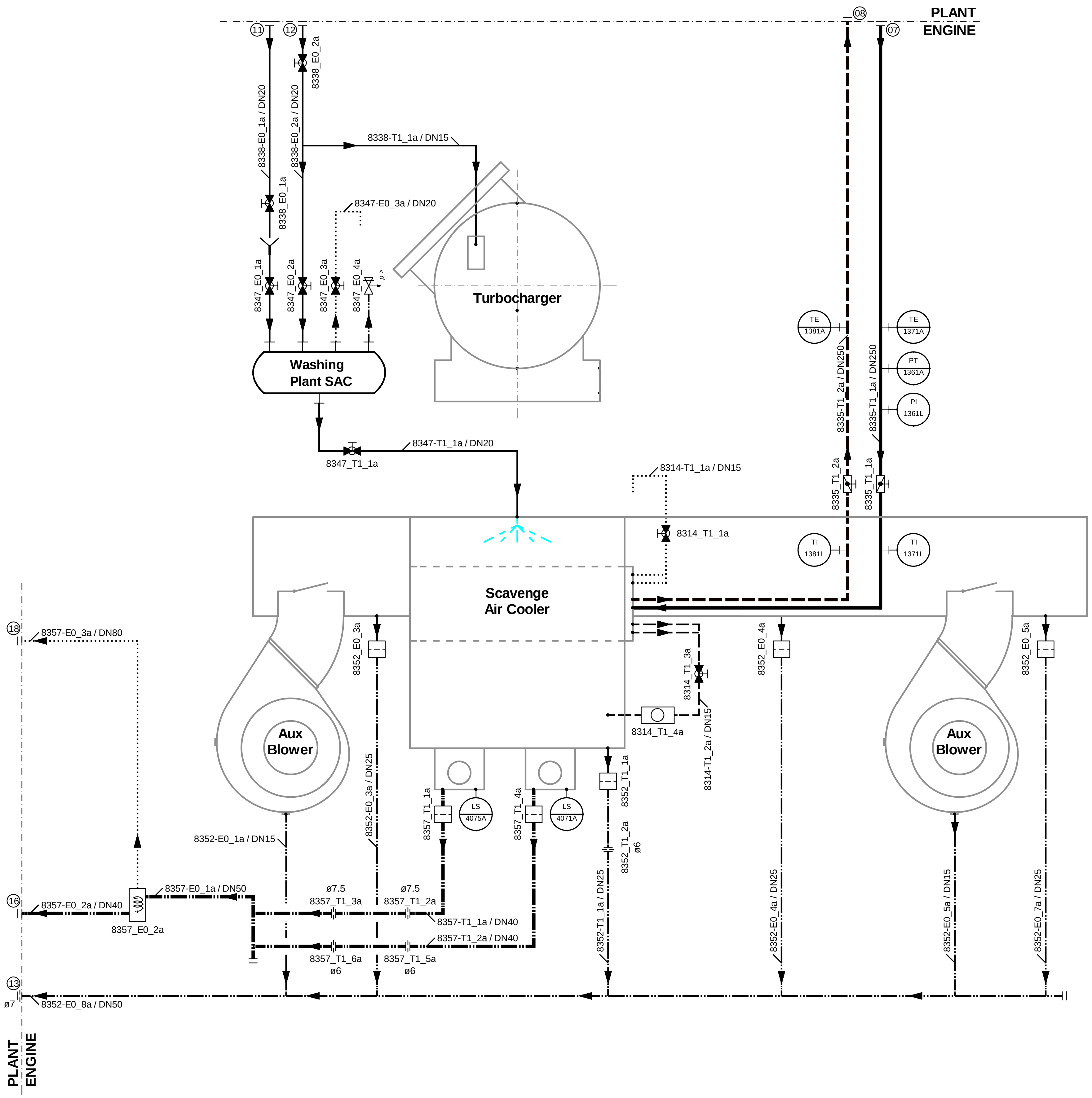
C000146



				WIN GD Winterthur Gas & Diesel	PIPE DIAGRAM WATER SYSTEMS Scavenge Air Receiver & TC	Pages 3 / 10

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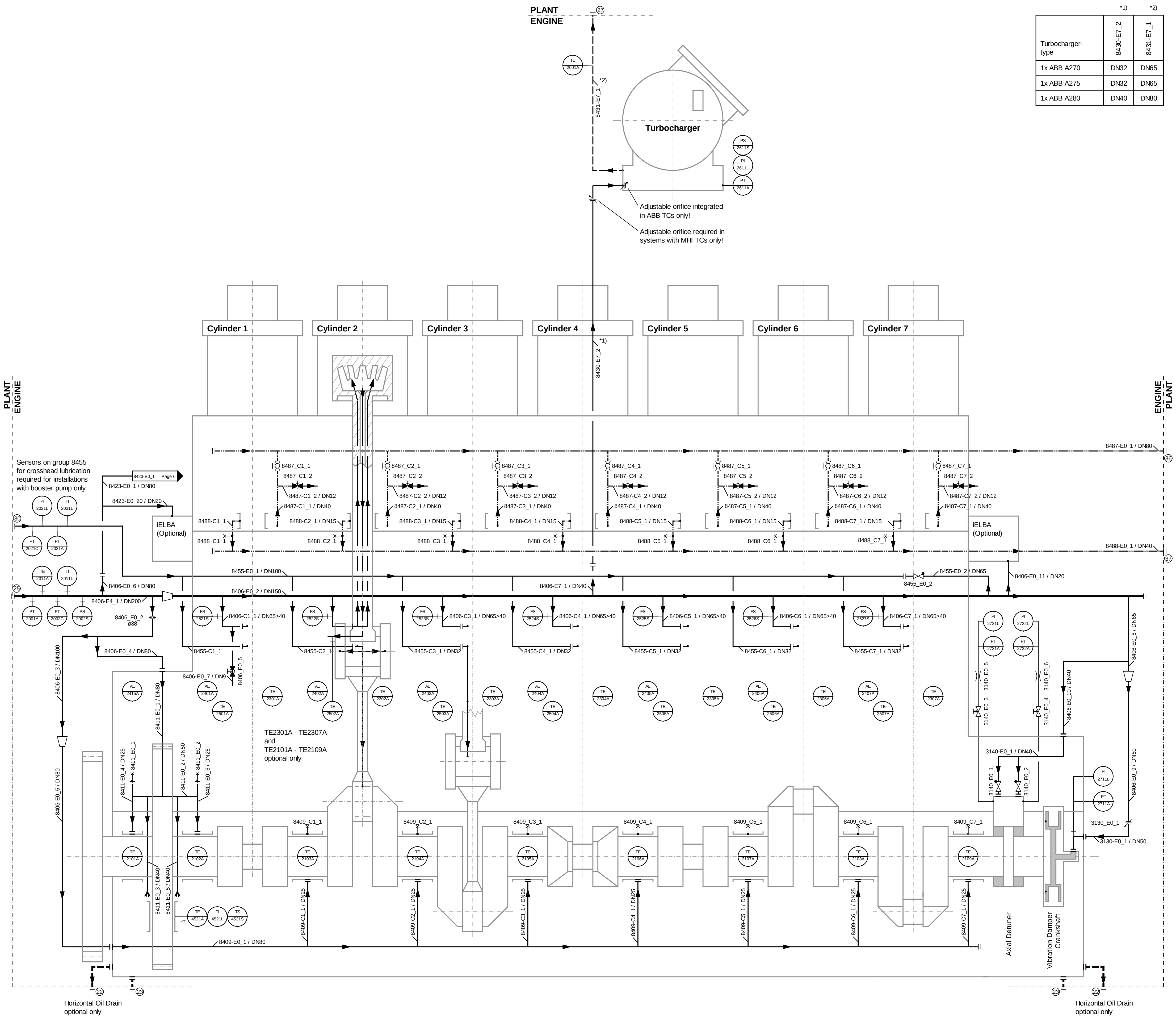
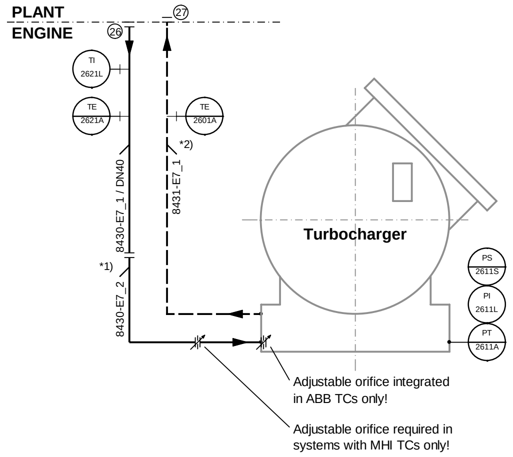
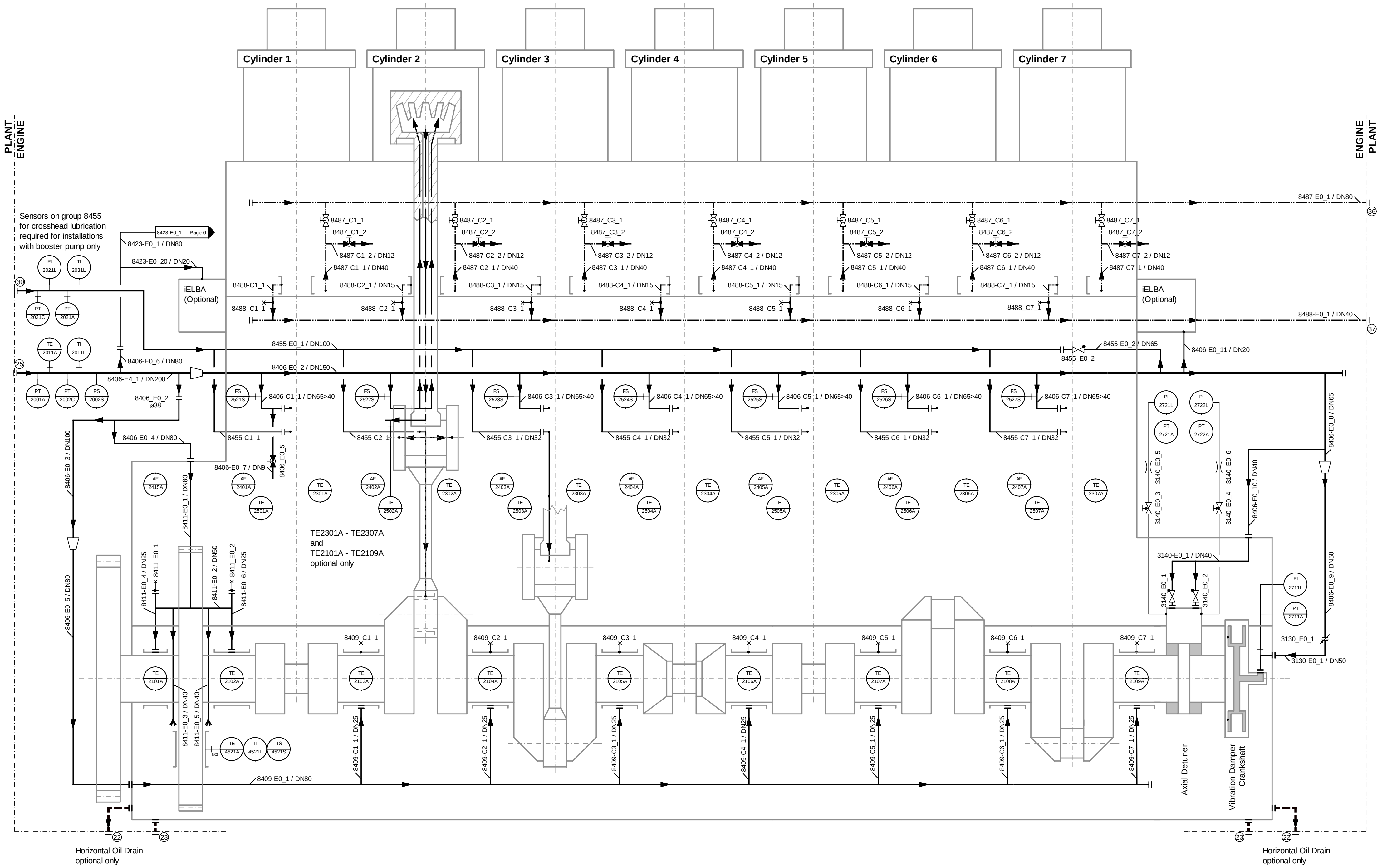


Turbocharger-type	8430-E7_2 *1)	8431-E7_1 *2)
1x ABB A270	DN32	DN65
1x ABB A275	DN32	DN65
1x ABB A280	DN40	DN80

PIPE DIAGRAM
OIL SYSTEMS
System Oil & Int. TC Oil Supply

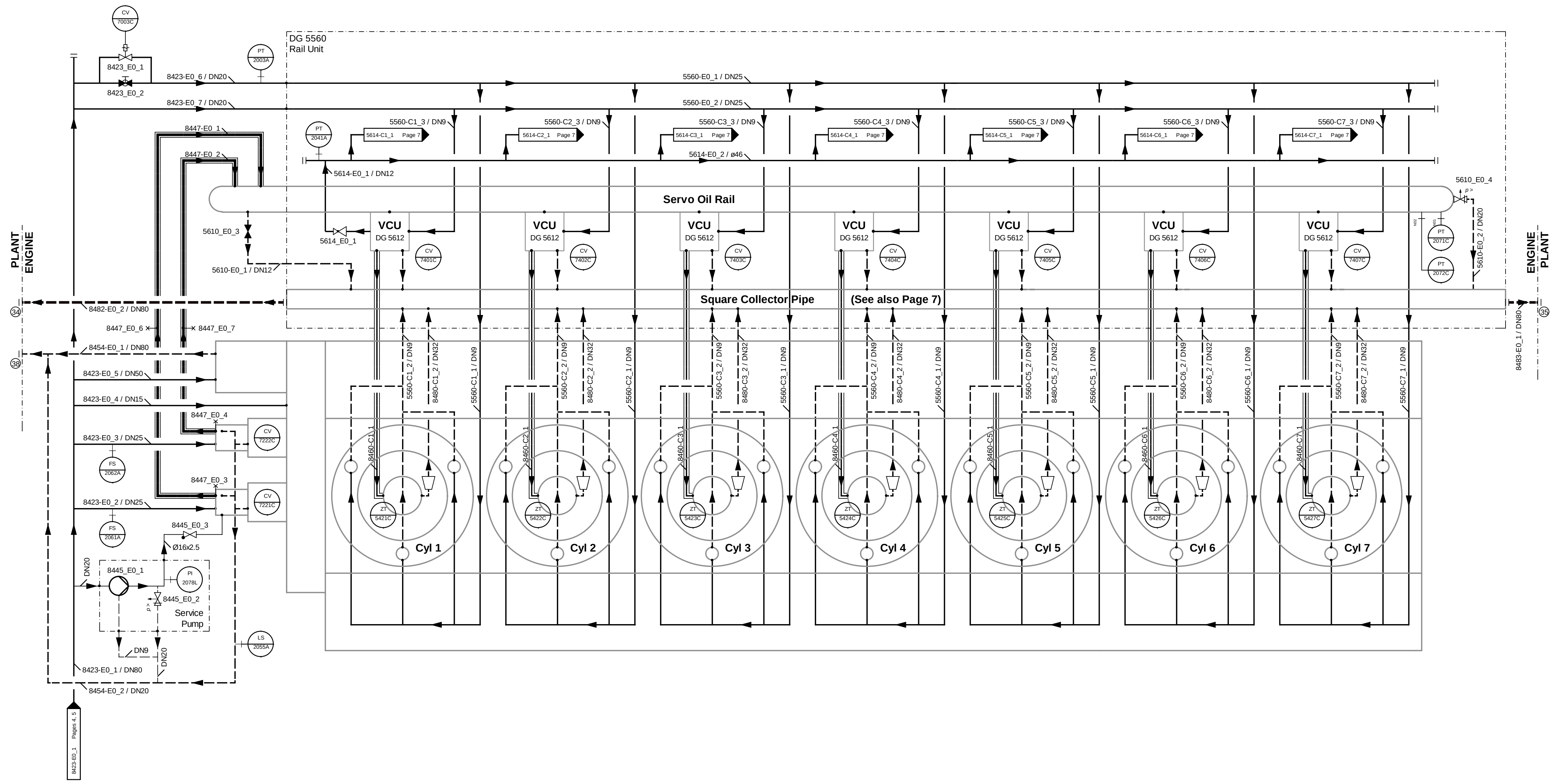


Turbocharger-type	8430-E7_2 *1)	8431-E7_1 *2)
1x ABB A270	DN32	DN65
1x ABB A275	DN32	DN65
1x ABB A280	DN40	DN80

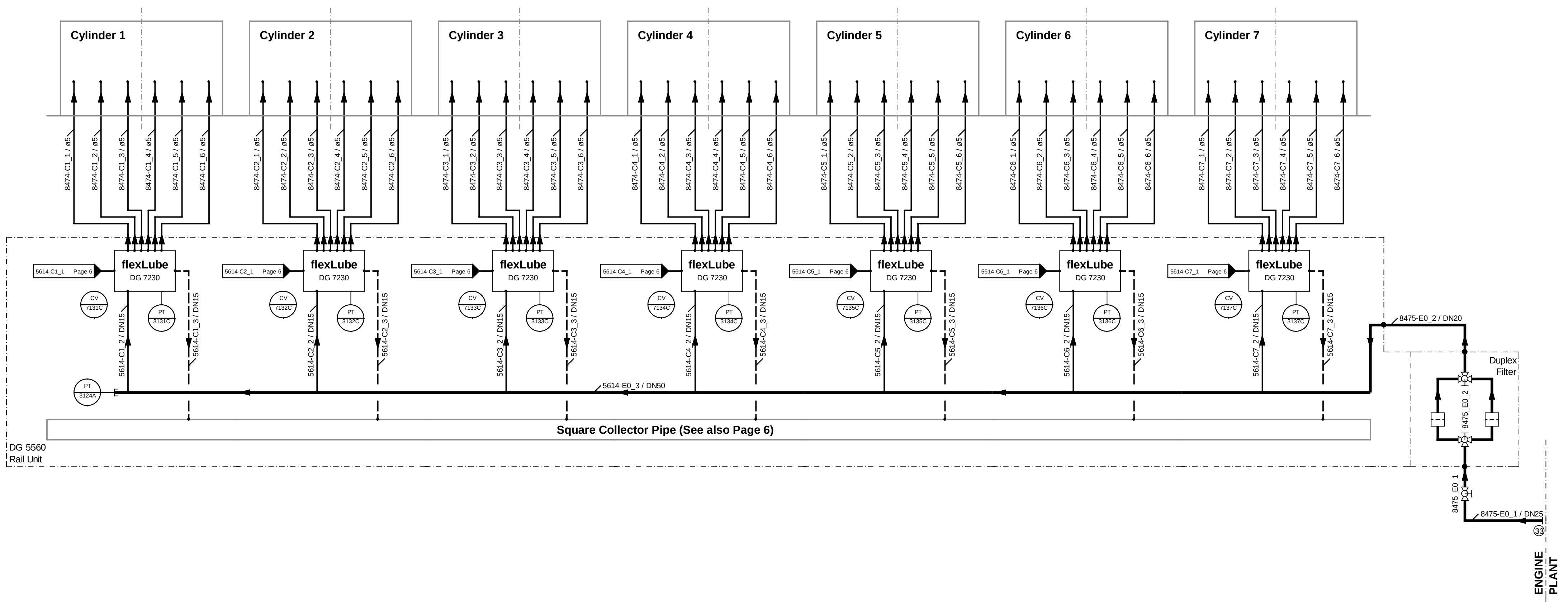


PIPE DIAGRAM	
OIL SYSTEMS	
System Oil & Ext. TC Oil Supply	Pages 5 / 10

WIN GD Winterthur Gas & Diesel



WIN GD Winterthur Gas & Diesel	PIPE DIAGRAM
	OIL SYSTEMS
	Servo Oil & Supply Unit Pipings



Winterthur Gas & Diesel

PIPE DIAGRAM
OIL SYSTEMS
Cylinder Lubrication

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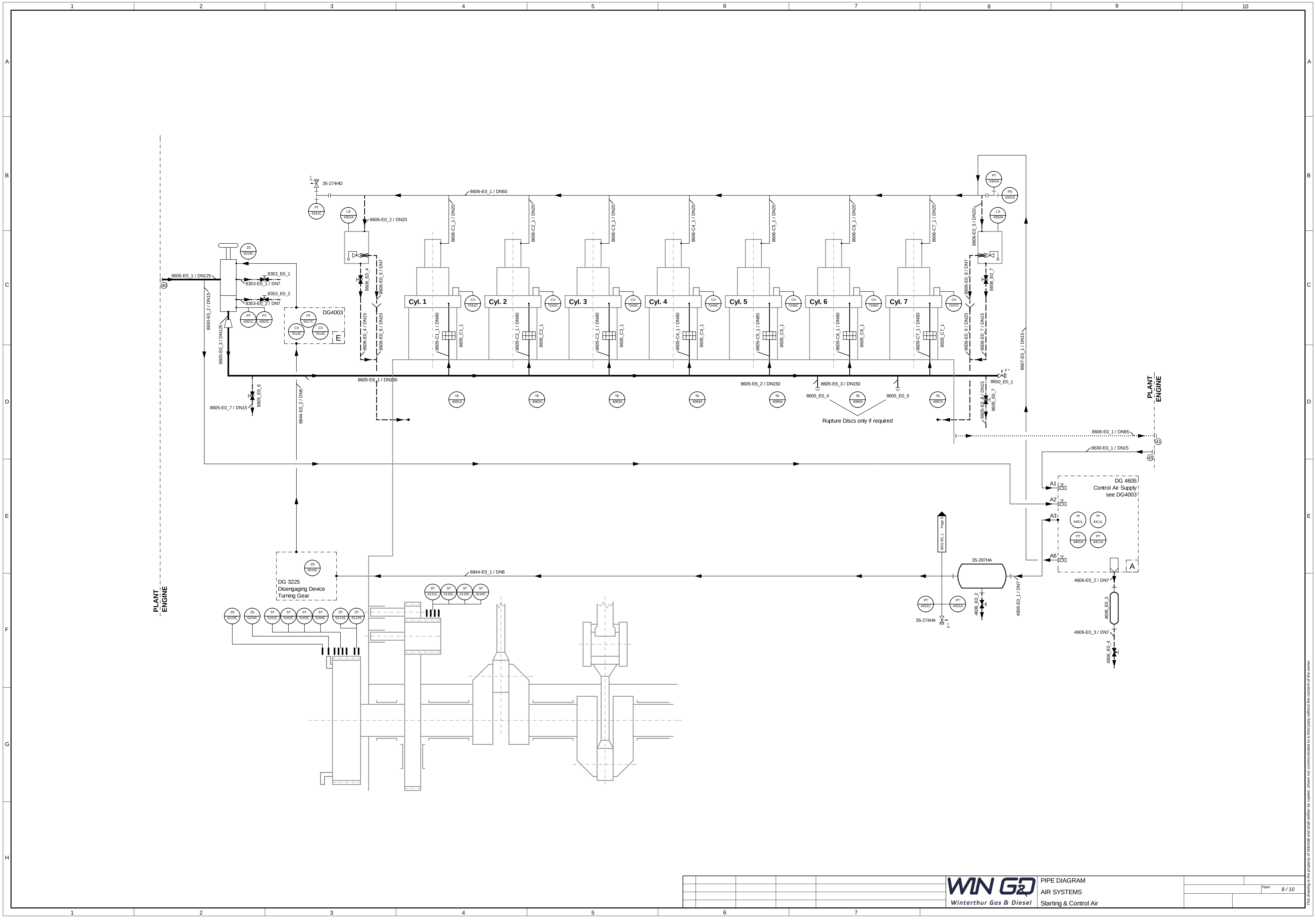

PIPE DIAGRAM
AIR SYSTEMS
Starting & Control Air

Winterthur Gas & Diesel

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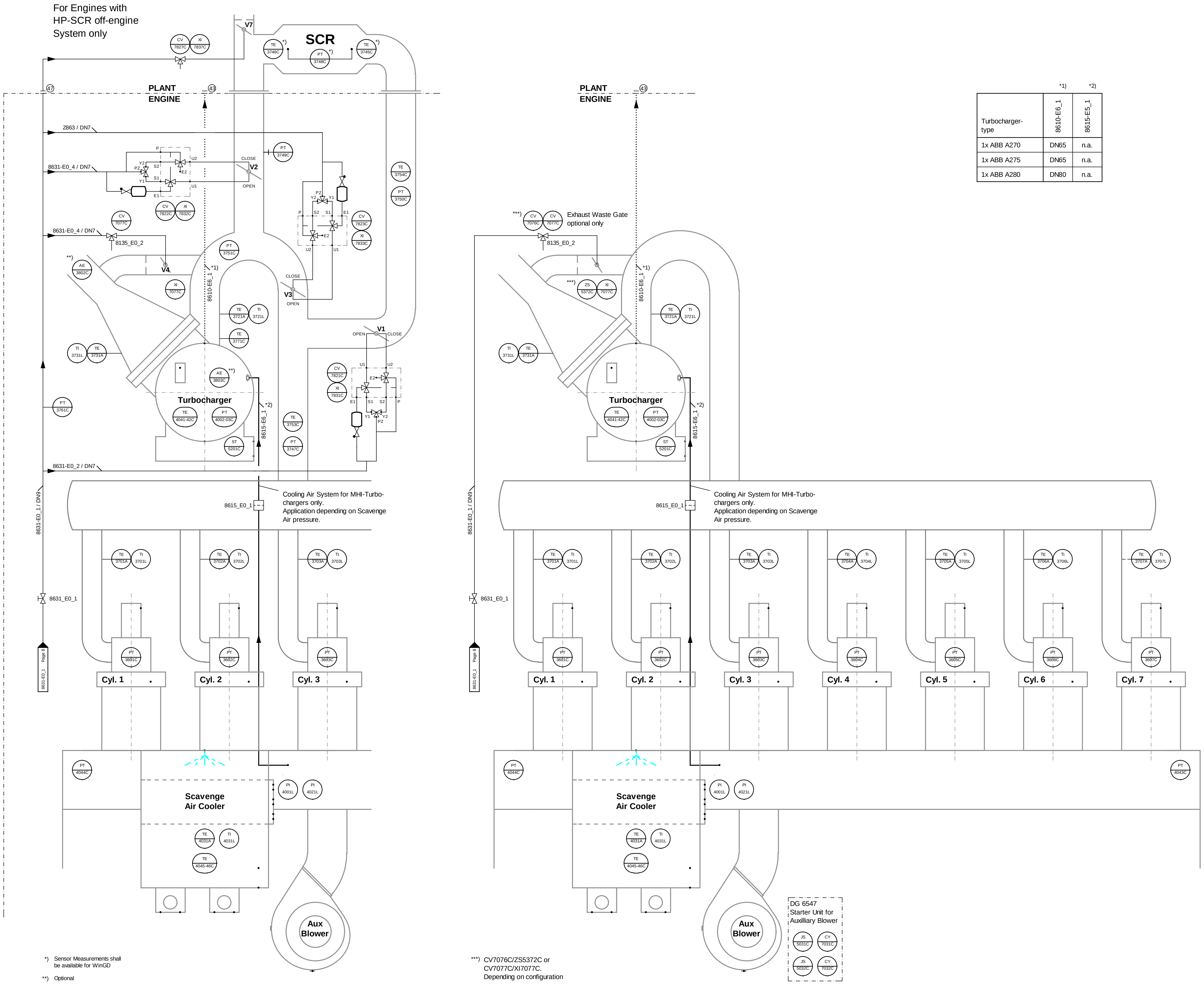


	*1)	*2)
Turbocharger-type	8610-E6_1	8615-E5_1
1x ABB A270	DN65	n.a.
1x ABB A275	DN65	n.a.
1x ABB A280	DN80	n.a.

*) Sensor Measurements shall be available for WinGD

**) Optional

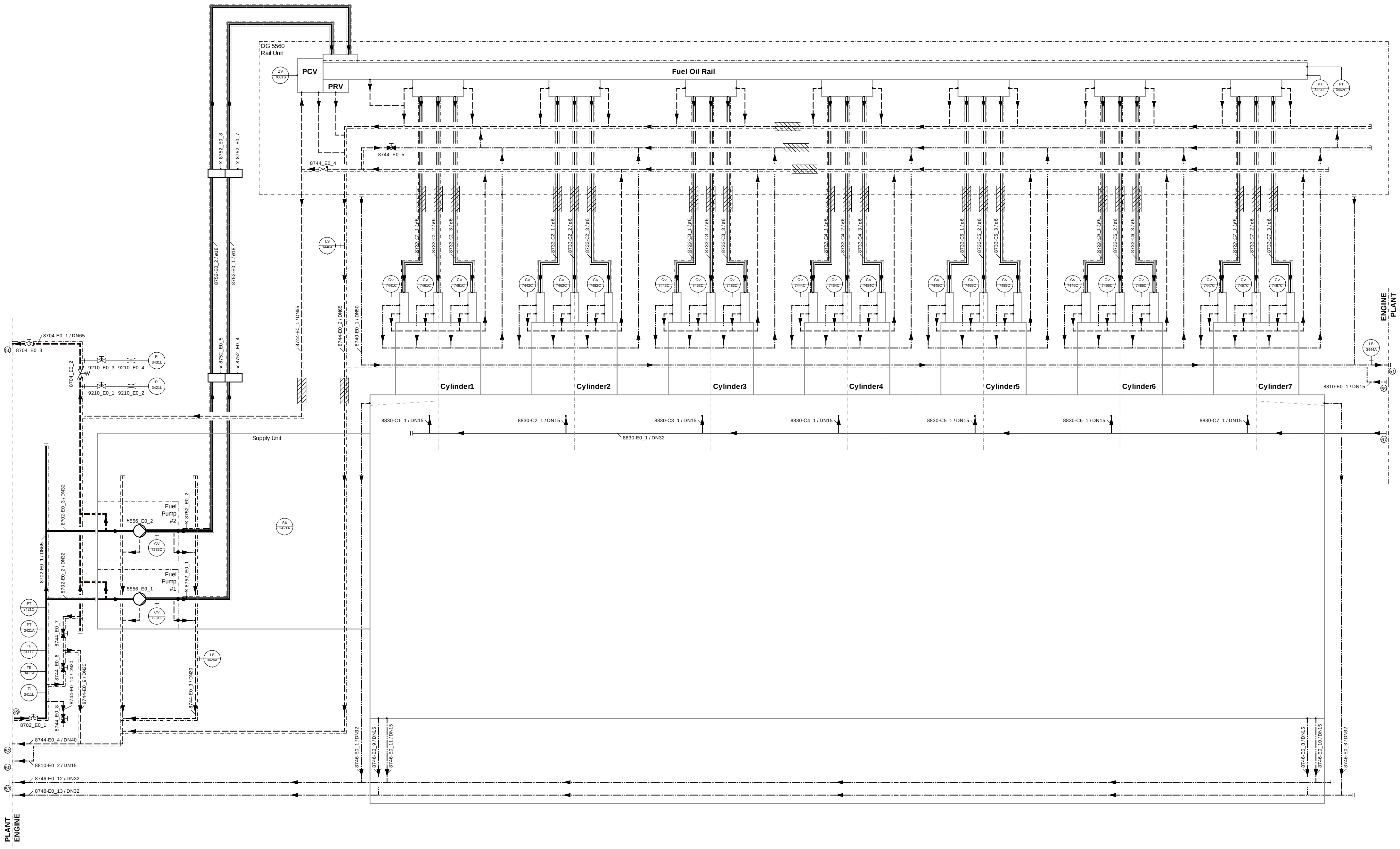
***) CV7076C/ZS5372C or CV7077C/XI7077C. Depending on configuration

Winterthur Gas & Diesel

PIPE DIAGRAM

AIR SYSTEMS

Exhaust Gas & Scavenge Air



WinGD
Winterthur Gas & Diesel

PIPE DIAGRAM
FUEL, DRAIN & EXTING. SYSTEMS

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13.3 List of service bulletins

Table 13-5 - List of service bulletins gives a list of service bulletins related to the engine. You find the service bulletins on the pages that follow.

Tab 13-5 List of service bulletins

Item	Title	Number
1	L'Orange fuel injection valves	-
2	Fuel injection valves maintenance & servicing instructions	-
3	Fuel injection valve checks & testing instructions	-

WÄRTSILÄ

TECHNICAL BULLETIN

2 Stroke Engine Services

RT-198
Issue 1, 19 July 2017

L'Orange fuel injection valves

Information to all Owners and Operators of W-X62 and W-X72 engines

At your convenience

Current situation
Due to operational issues with L'Orange solenoid actuated fuel injectors, several injector and engine modifications were carried out. Based on service experience improved information & instructions to assist in maintenance, troubleshooting & checks were introduced

Concerned components
L'Orange injectors in W-X62 & W-X72 engines.

Purpose / Reason
The document has been created to help better understand, troubleshoot, test and carry out routine maintenance & checks.

Wärtsilä Services Switzerland Ltd
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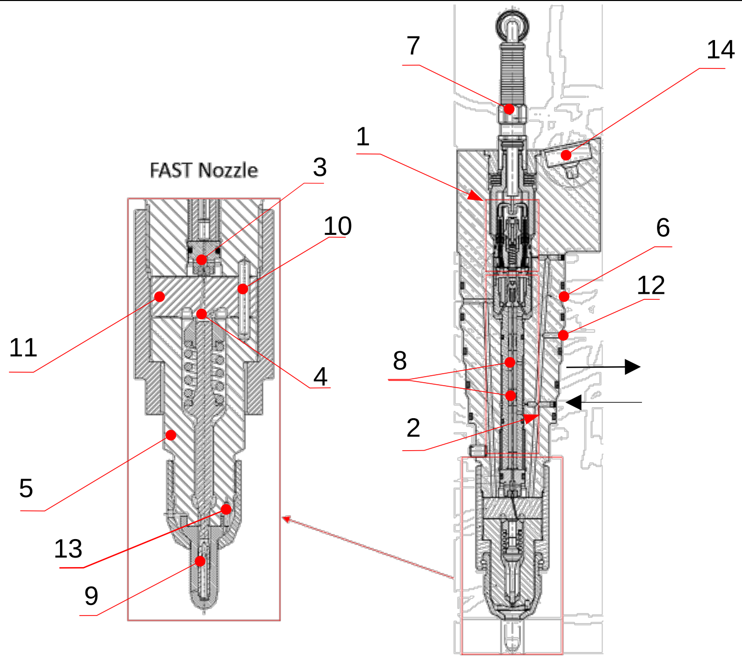
CH-8401 Winterthur

Tel (24h): +41 52 262 80 10
technicalsupport.chts@wartsila.com

Contents

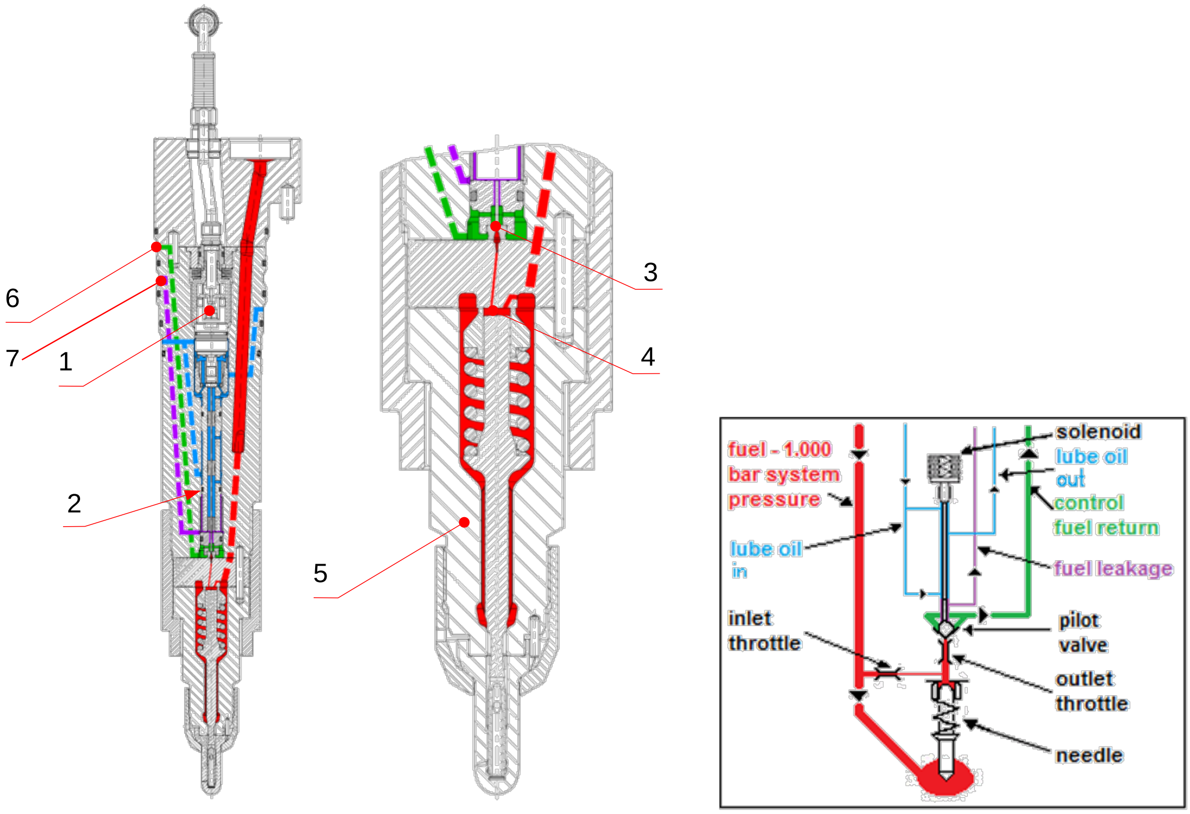
1 Functionality

W-X62 and W-X72 diesel engines are equipped with L'Orange solenoid actuated fuel injection valves, where the pilot valve is actuated electrically, which controls the hydraulic circuit to start and stop fuel injection. The fuel injectors on the W-X62 & W-X72 engines are implemented with FAST (Fuel Actuated Sacless Technology) nozzles.
The electronic control of the injection valve permits high flexibility and improvements in injection-process efficiency.



1. *Solenoid and springs set*
2. *Control element*
3. *Pilot valve with outlet throttle*
4. *Control chamber*
5. *Nozzle (with needle, spring and bush)*
6. Control fuel return
7. Cable connector
8. *Lube oil ports*
9. *Nozzle tip*
10. *Valve plate positioning pin*
11. *Valve plate with inlet throttle*
12. *Fuel leakage port*
13. *Nozzle tip positioning pin*
14. *High pressure pipe connection*

Figure 1: Injector main parts, position of low pressure ports

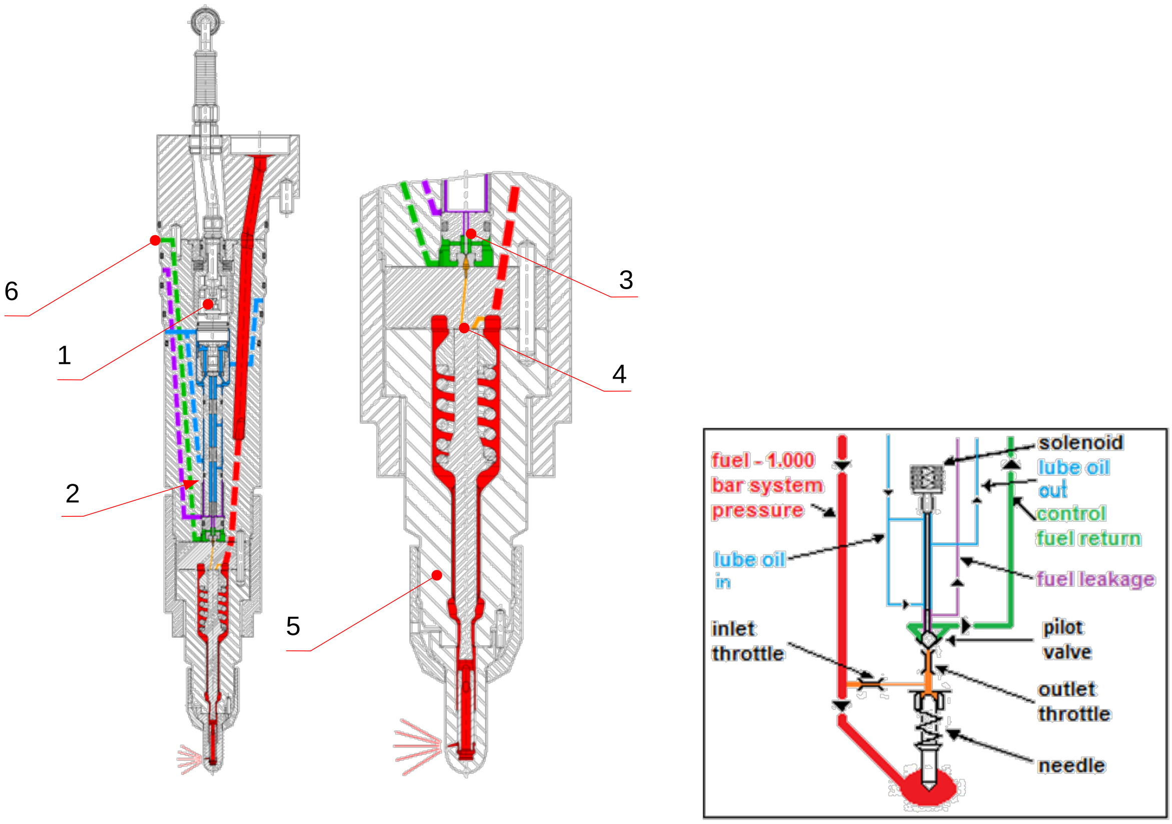


1. *Solenoid and springs set*
2. *Control element*
3. *Pilot valve with outlet throttle*
4. *Control chamber*
5. *Nozzle*
6. *Control fuel return*
7. *Fuel leakage*

Figure 2: Injector closed position, hydraulic diagram

At closed position the electric current energizing the solenoid is off and the outlet throttle, connecting the pilot valve with the control fuel return, is closed, preventing the fuel from the control chamber to flow towards the control fuel return. As the high pressure pipe feeds the nozzle with fuel, the pressure builds up in the control chamber and forces the nozzle spring to move downwards leading then to blocking the fuel flow towards the spray holes (closed position).

At the open position the electric current energizes the solenoid, allowing an upward movement in the control element, which creates a displacement of the pilot valve needle, opening the outlet throttle which leads to a loss of pressure in the control chamber. The difference of pressure between the nozzle and the control chamber creates a flow that results in an imbalance at the nozzle compressing the spring. This movement leads the fuel flow towards the spray holes culminating with injection into the cylinder.



1. *Solenoid and springs set*
2. *Control element*
3. *Pilot valve*
4. *Control chamber*
5. *Nozzle*
6. *Control fuel return*

Figure 3: Injector open position, hydraulic diagram

2 Different Versions

The newest version of L'Orange injectors is equipped with pilot valves having increased clearance. This arrangement provides a solution to sticking needles in the pilot valves. The updated version provides an increased clearance of 30µm which compared with the previous version[1] reduces the problem to a large extent.

Previous-model pilot valves are identified by a yellow mark in the injector housing, while injectors with the new design show a red mark. If you still have old type pilot valves, please upgrade to new type at a suitable opportunity.

[1] The inner diameter of the pilot valve in the previous versions is ca. 1,1mm, with a clearance of ca. 5µm.

W-X62/72 FAST labeling of housing

Figure 4: Injector with current and previous pilot valve version

New pilot valves, as part of the spare part kit, can be identified by their part number as shown in figure 5. However, there are a lot of re-machined pilot valves with increased clearance, where the old part number remains.

VWO-T047V1
New version with
increased clearance

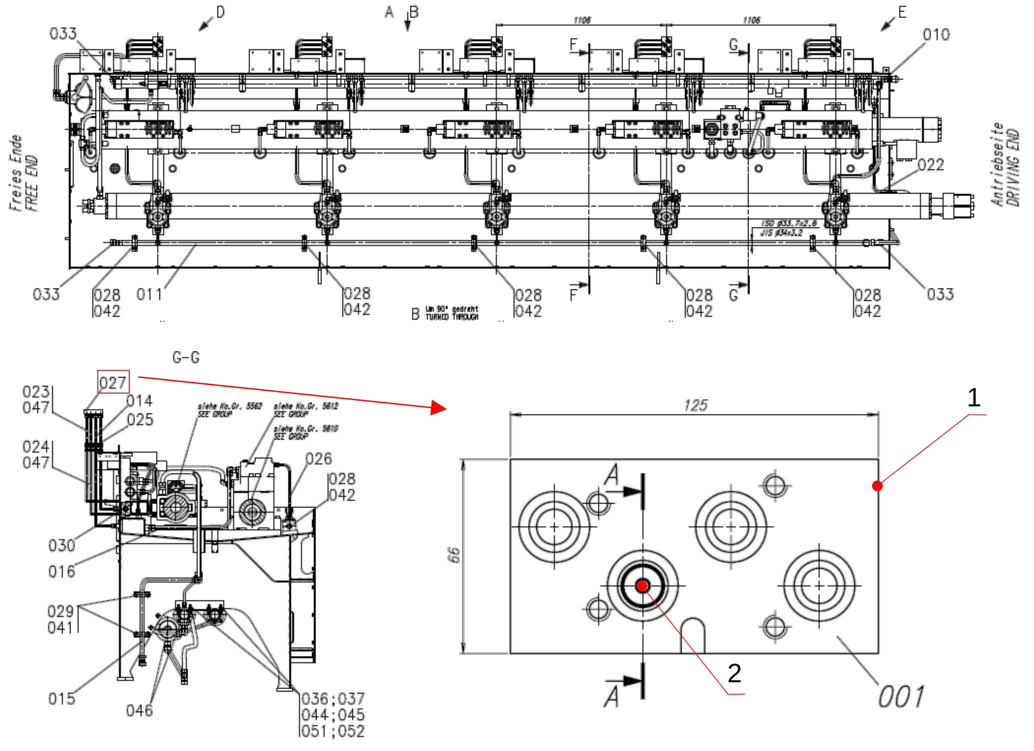
VUO-T1005V2
Previous execution
with small running
clearance

Figure 5: Pilot valve previous and current version

3 Injector Related Engine Modifications

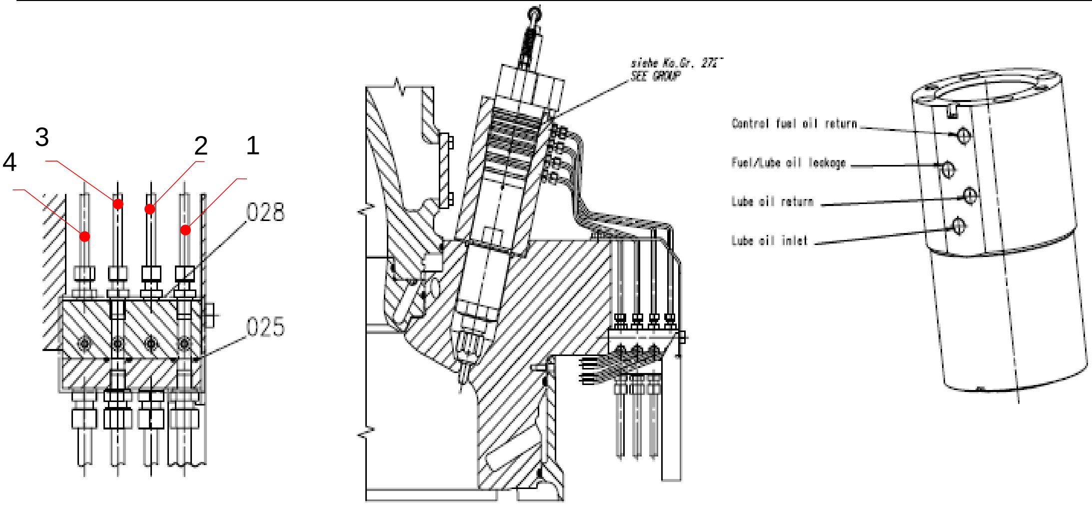
As a preventive measure to avoid fuel sticking in pilot valve/control element, the cooling effect from the lube oil had to be adjusted. This was done by reducing the lube oil flow through the injector to a minimum with an orifice plate in the connection block (figure 6). A temperature of 40-50°C of the Lubricating oil (L.O.) increases the likelihood of having HFO coagulation in control elements.

The L.O. circulation must be stopped when M/E is not running. This prevents cooling of the fuel inside the injector in standstill conditions and avoid sticking problems. Activation/deactivation of the lube oil flow is done automatically by solenoid valve 20-8423 EO 1. In case the solenoid valve is defective, the control of the lube oil circulation can be done manually (see figure 8 and 9).



1. *Connecting block between cylinder cover and rail box*
2. *Orifice for reduction of lube oil flow*

Figure 6: Piping rail unit.



1. *Lube oil inlet pipe*
2. *Lube oil return pipe*
3. *Fuel leakage pipe*
4. *Control fuel return pipe*

Figure 7: Connection-pipe diagram

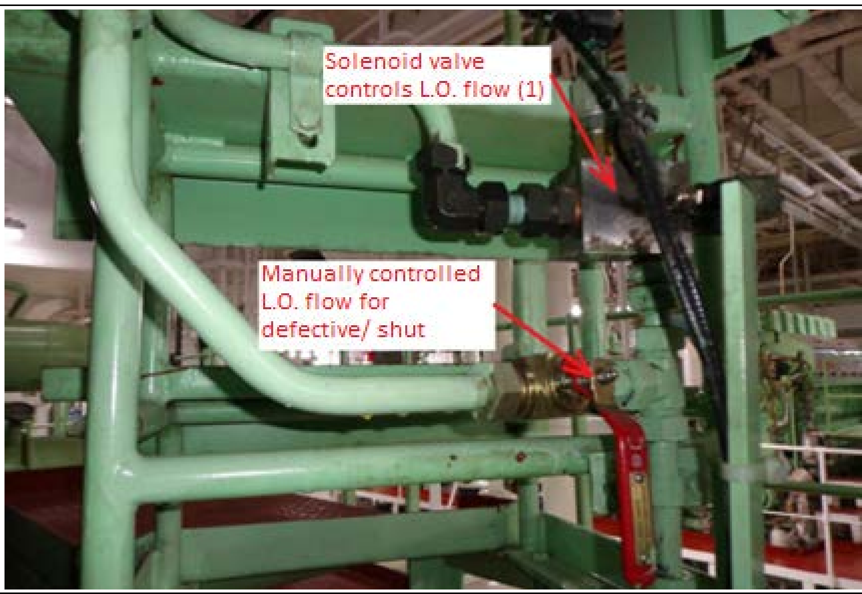
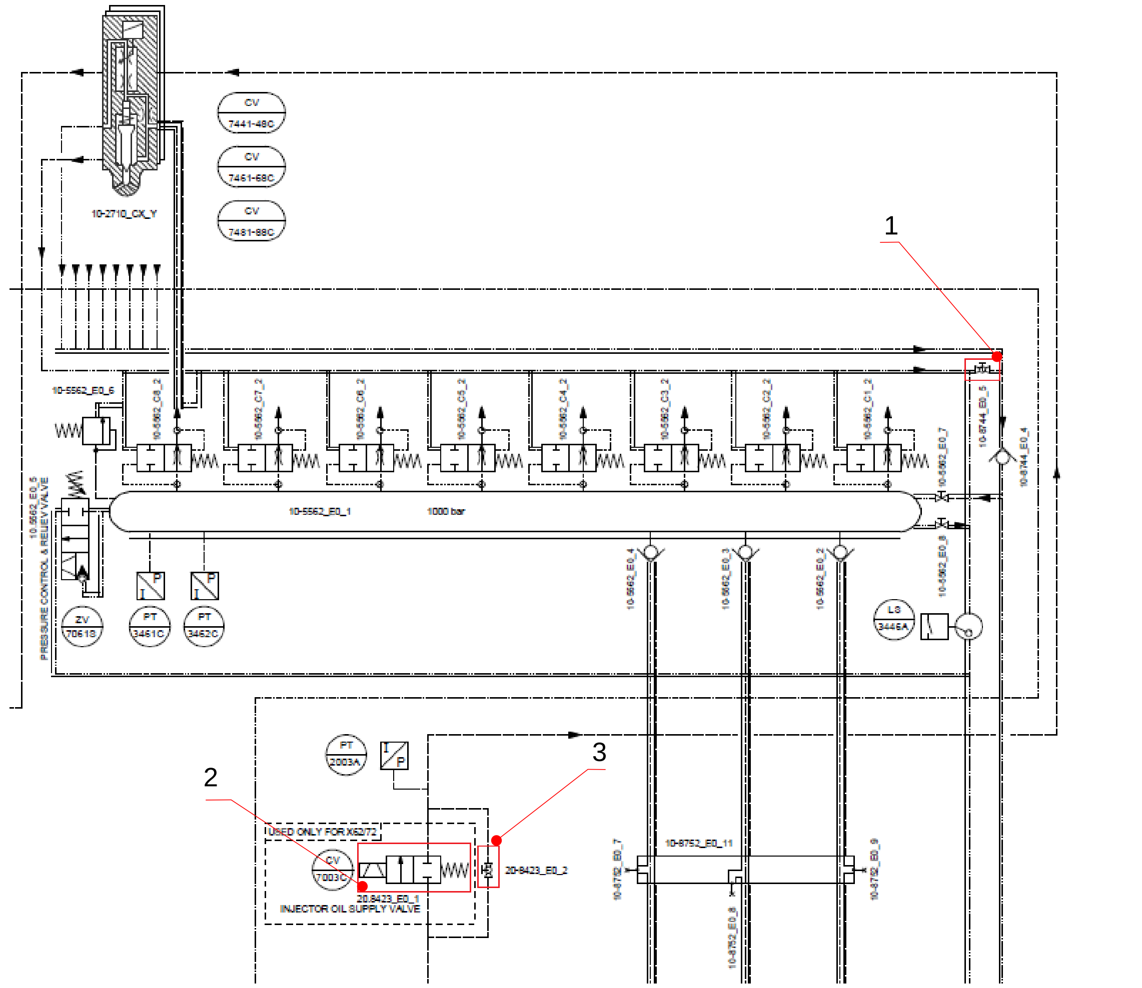


Figure 8: Automatic and manually controlled lube oil flow.



1. *Fuel by-pass valve.*
2. *Lube oil solenoid valve.*
3. *Lube oil by-pass valve.*

Figure 9: Engine control diagram.

NOTE:
The fuel by-pass valve 10-8744 E0 5 must be shut off during normal operation. It should only be open for overhauling/maintenance work. If this valve remains open during operation, excessive fuel leakage will be drained to the fuel leakage tank. The valve is located inside the rail box.

4 Injector Troubleshooting

The following table summarizes the failures that may occur during the operation of the injector. They are sorted according to the probability of occurrence. For each problem, its corresponding solution must be carried out as stated below.

Table 1: Troubleshooting table

	Failure Description	**Possible Cause**	**Solution**
1.1	Low exhaust gas temperature (not firing)	Flow limiting valve closed.	Check and ensure that flow limiting valve is in open position.
1.2	Low exhaust gas temperature	Single Injector out of three not injecting. Sticking injector – HFO coagulation in control elements.	Check Pmax and compare with other units Clean control parts and test (refer to Appendix). For preventive measures refer to section 5.
1.3	Low exhaust gas temperature	Wrong spray direction due to broken nozzle positioning pin and/or nozzle tip positioning pin.	Exchange nozzle positioning pin and/or nozzle tip positioning pin as per instruction in Appendix.
1.4	Low exhaust gas temperature	Broken or defective fuel injector solenoid cable.	Contact Wärtsilä Services Switzerland Ltd.
1.5	Low exhaust gas temperature	Defective solenoid.	Check for respective alarm on LDU for particular cylinder. Test injector – solenoid test.
1.6	Low exhaust gas temperature	Defective CCM.	Check if other CCM cylinder functions are inhibited (like lubrication, and control of FOP, SOP) Replace CCM.
2.0	High exhaust gas temperature	Wrong spray direction due to broken nozzle positioning pin and/or nozzle tip positioning pin.	Exchange nozzle positioning pin and/or nozzle tip positioning pin as per instruction in Appendix 1.
2.1	High exhaust gas temperature and leaking injector	Worn or defective pilot valve/control element.	Replacement by spare kit (refer to instruction in Appendix 1) and check functionality in test bench (refer to instruction in Appendix 2).
2.2	High exhaust gas temperature and leaking injector	Loosened adjustment screw at solenoid[2].	Contact Wärtsilä Services Switzerland Ltd.
2.3	High exhaust gas temperature	Too long injection timing.	Check all injector timings.

[2] Due to the high sensitivity of the task, this process is not serviceable on-board.

2.4	High liner wall temp	Wrong spray direction due to broken nozzle positioning pin and/or nozzle tip positioning pin.	Exchange nozzle positioning pin and/or nozzle tip positioning pin as per instruction in Appendix.
3.1	Fuel contamination into lube oil	O-rings on Injector body damaged.	Exchange the O-Rings.
3.2	Fuel contamination into lube oil	Internal damage or back pressure in fuel leakage outlet.	Contact Wärtsilä Services Switzerland Ltd.
3.3	Fuel contamination into lube oil	Wrong piping assembly.	Check connection diagram and assembly accordingly.
3.4	Fuel contamination into lube oil	Wrong injector assembly.	Injector assembly as per instruction in Appendix.
4.1	Open/short circuit alarm	Incorrect alarm threshold setting in UNIC SW[3].	The issue is under investigation by WSCH.
4.2	Open/short circuit alarm	Cable/connector damaged or corroded.	Check connections to the counter-part in the rail unit and CCM.
5.	Intermittent contact	Water above solenoid valve.	Eliminate source of water Replace affected Injector.
6.	Other malfunctions	Particles of dust/ deposits of fuel in the system.	Check fuel treatment stages. Look for foreign particles that could have appeared during engine new building stage.

1.1. If extremely low exhaust gas temperature is detected, most likely all three injectors in a cylinder fail due to closed flow limiting valve.

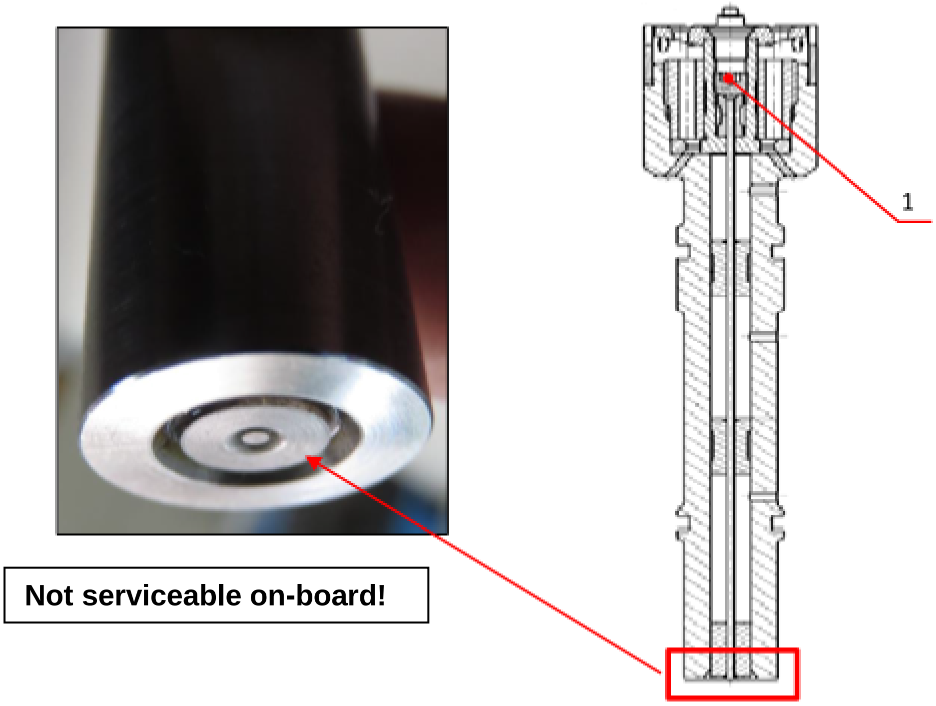
1.2. HFO deposits in the control parts may cause sticking pilot valve and control element, leading to injector failure. Having sticking pilot valve increases the LPOP (Lowest Possible Operating Pressure), which is defined as the minimum pressure at which injection takes place. In order to avoid the undesired effects brought by HFO deposits, cleaning of the control parts can be done according to the instruction in the appendix.

2.1. Worn of defective parts in the injector can lead to undesirable low LPOP. This would increase the amount of fuel injected and therefore, exhaust gas temperatures would be higher. If after replacement by spare parts the operational problems are not corrected, other non-replaceable parts are defective, and in which case the injector must be sent to L'Orange for repair. Worn or defective pilot valve could also lead to continuous fuel leakage coming from the control fuel return pipe.

2.2. Injector leakages appear as a result of incorrect overlap on the control element measured on the rod (figure 10). For W-X engines with FAST injectors, the normal overlap is 0.06 mm. A wrong overlap is most likely due to inadequate tightening of the adjustment screw.

[3] During low load operation & very short injection time, the current is low and system might detect open circuit.

NOTE:
Injectors with defective pilot valve or not properly tightened adjustment screw present **continuous leakage** from the control fuel return pipe. Leakage coming from the control fuel return pipe when injection takes place is normal and is not symptom of wrong operation.



1. *Adjustment screw*

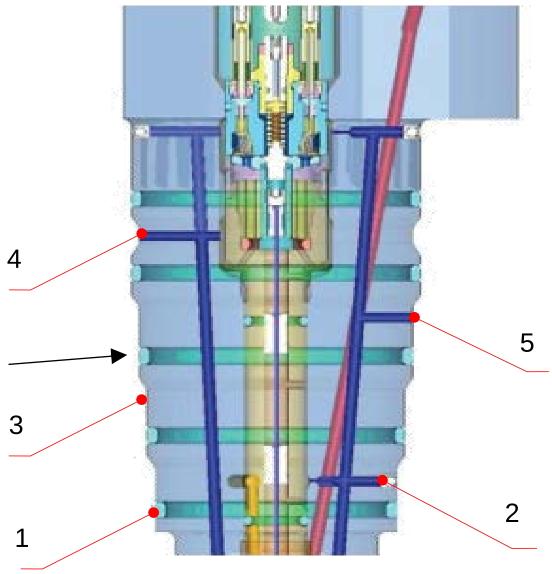
Figure 10: Control element overlap

3.1/3.2. Fuel leakage circuit is a neutral space for leakage of fuel and lube oil. Fuel contamination into lube oil is possible if the black-arrowed O-ring in figure 11 is heavily damaged and leakage fuel pressure is higher than lube oil pressure. Internal damage or residual back pressure in the fuel leakage line might also cause the recirculation of fuel to the L.O system as the fuel leakage line is also prepared for possible lube oil leakages. A defective O-ring at the pilot valve may also contribute to undesired oil losses/oil contamination.

3.3. Frequently it has been found that due to on-board activities involving injector disassembly the connection of the pipes are mixed up, ending with, e.g. control fuel return pipe connected to the leakage port instead. To avoid the problem, pipe connection should be done as per connection diagram (see Figure 7).

4.1. Varying the lower alarm threshold from 800 to 300 mA should help with solving the problem. If alarm still pops up after setting adjustments contact WSCH. Service attendance is required in order to change UNIC settings.

6. A proper fuel treatment in separators as well as a good filtration process is required to avoid undesirable particles in the system and, therefore, to achieve an increased lifetime. Poor or defective treatment of fuel can lead to deposit formation in the system and eventually to malfunction. It is known that during engine building, undesired particles end up collapsing injector's L.O. or fuel pipes. If failure appears short after beginning of operation check for possible clogged pipes.



1. O-ring
2. Lube oil inlet
3. Lube oil outlet
4. Control fuel outlet
5. Fuel leakage outlet

Figure 11: Lube oil, return fuel, leakage circuits and O-rings view

5 Preventive Operational Measures

We propose the following measures to prevent sticking problems in control parts due to cold heavy fuel oil:

- Trace heating of HPP (High Pressure Pipe) should be ON in order to have warm fuel at injector's inlet. This will decrease the viscosity of the fuel and will therefore reduce the likelihood of having sticking pilot valve or control element.

- It is advisable to have jacket cooling water (JCW) temperature at 80°C or above at standstill condition to keep injector control elements warm.

  It is also strongly recommended to frequently check the functionality of the injector (instruction in Appendix 1). In this sense, LPOP (Lowest Possible Opening/Operating Pressure) checks on the test bench every 4000 running hours would help to anticipate injector failures and assist in achieving an extended lifetime of the parts.

  In order to achieve desired injector behaviour it is a prerequisite to have the viscosity of fuel oil within the limits specified in figure 12.

In case of fuel-related problems in injector (e.g. sticking valve phenomena), the fuel can be heated up in order to decrease viscosity and ease the flow of the fuel. However, the fuel should be never heated above 150°C as it may compromise the mechanical properties of the materials. Worth mentioning that this serves only as a measure for HFO. MDO and MGO present adequate viscosities at ambient temperature and hence, it is not required to heat them up.

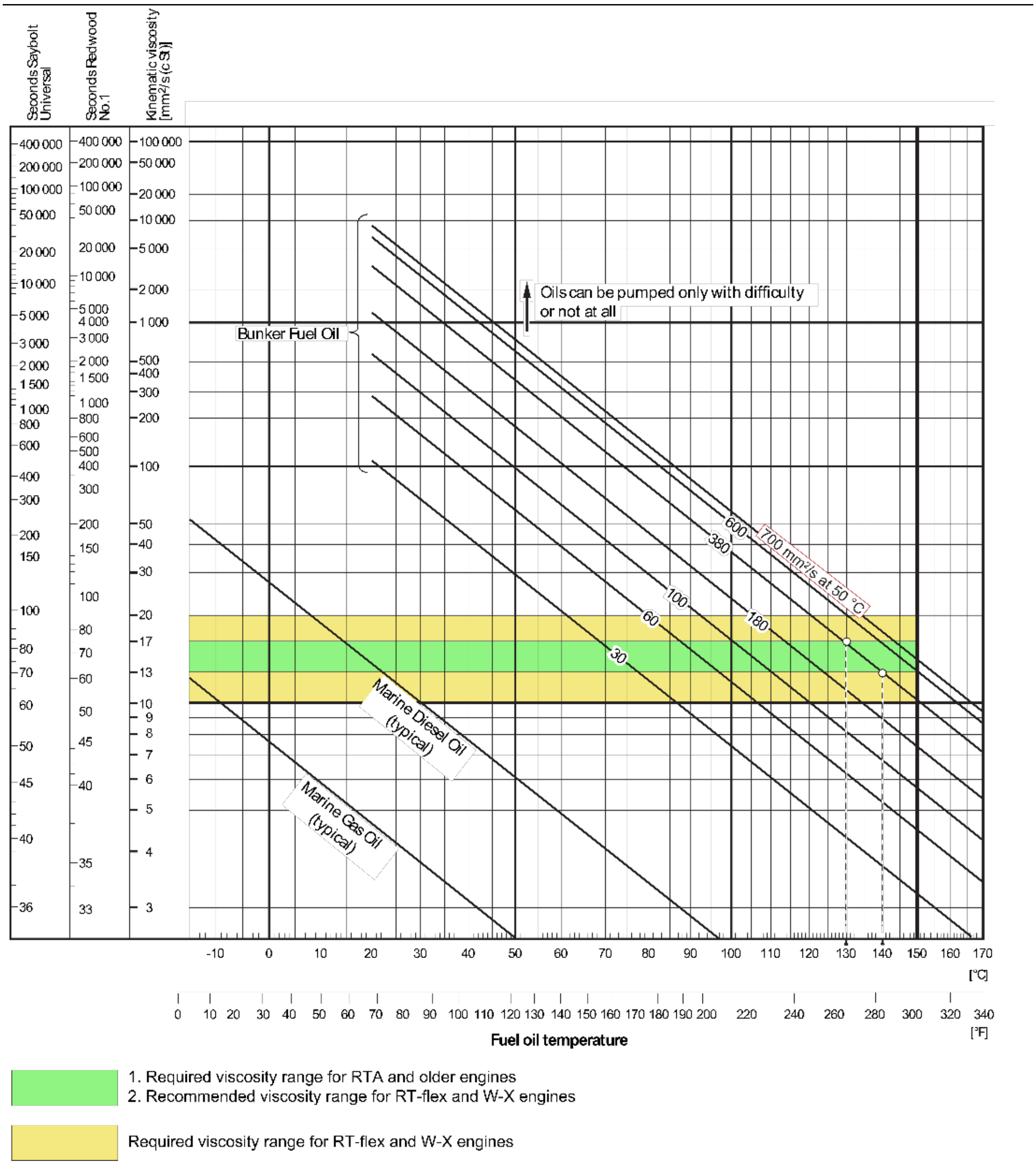


Figure 12: Fuel oil viscosity boundaries at injector's inlet

6 Maintenance Schedule

As per W-X62 and W-X72 Maintenance Manuals, the inspection and overhaul processes are to be done according to table 2.

Table 2: Inspection and Overhaul intervals

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
2722-1	Injection valve (main fuel injector)	-Check externally for tightness.	-before starting the engine after longer standstill.
		-Functional check (nozzle tip inspection, opening pressure) and cleaning.	4000
		-Exchange nozzle tip (FAST type) – BX27244	8000
		-Replace O-rings – BX 96146	8000
		-Replace injection valve complete.	24000
		-Estimated lifetime: Injection valve complete.	24000
		-Estimated lifetime: Nozzle spare parts set (i.e. coupling nut & nozzle body with needle) – BX 96144	8000

The maintenance work every 8000 hours can be done on-board. The procedure for injector checks is to be done according to the test bench instruction (Appendix). For spare parts installation refer to section 7.

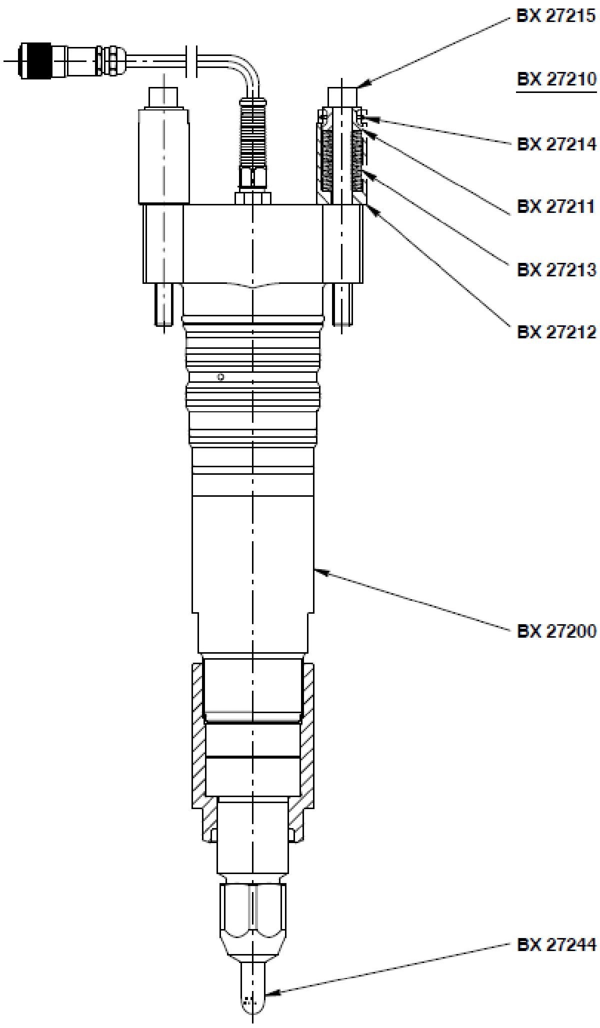
ATTENTION:
Do not use copper paste during assembly as it can be source of electrical problems (especially when close to the solenoid). Instead, the specified grease, Never-Seez® regular grade or molybdenum sulphide ($MoS2$) and Gleitmo 805K are to be applied.

7 Spare Parts

The available spare parts for the injection valve can be found in the spare part catalogue for W-X62 and W-X72 engines[4]. The necessary equipment to carry out the replacement (tools and fixture) can be found in the Appendix.

[4] AX nomenclature for W-X62 spare parts, BX nomenclature for W-X72 spare parts

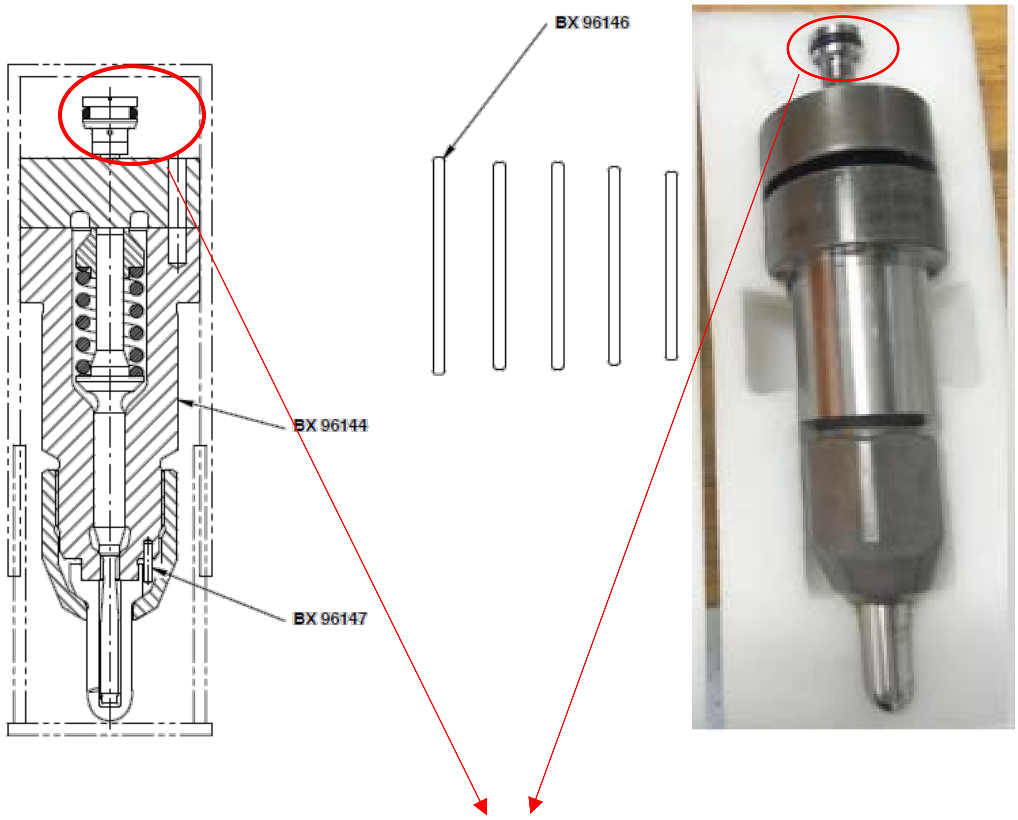
The following are the available spare parts for the injection valve. Although the pictures show spare parts for W-X72 engines, the same can be ordered for W-X62. Similar spare parts available for W-X62,just replace prefix 'BX' with 'AX', in the spare part code eg: 'AX 27212 Bush' for W-X62 instead of 'BX 27212' for W-X72.



BX 27211. Spring guide	*BX 27215. Hexagon socket head cup screw*
BX 27212. Bush	*BX 27200. Injection valve with O-rings (without BX27210 BX27215, BX27244)*
BX 27213. Cup Spring	
BX 27214. Snap Ring	
BX 27210. Tension washer cage, complete (BX 27211 to BX 27214)	*BX 27244. Nozzle tip*

Figure 13: Spare parts injector W-X72

ATTENTION:
Spare injectors and spare kit for the injector come with a protective cap that must be removed prior installation in cylinder cover. The nozzle tip must be ordered separately.



The pilot valve is part of the Overhaul kit and must be replaced after 8000 running hours

BX 96144. Nozzle set *BX 96146. O-Rings set*
BX 96147. Nozzle tip positioning pin

Figure 14: Spare/Overhaul kit nozzle injector W-X72

BX 96144 (nozzle set) includes:

- Nozzle body
- Nozzle tip positioning pin (also available separately; BX 96147)
- Needle
- Guide bushing
- Pilot valve
- Coupling nut
- Protection cap for the needle instead of a nozzle tip

The nozzle tip is not included in BX 96144, it must be ordered separately (BX 27244).

New part numbers for the O-ring of the pilot valve and positioning pins in the valve plate as separate spare parts are being prepared and will be available soon.

8 Appendix 1 (Injector maintenance & servicing instructions)

Appendix 1) L’Orange Fuel Injection valve (Injector maintenance & servicing instructions)

9 Appendix 2 (Injector checks & testing instructions)

Appendix 2) Test Bench Instruction L’Orange Fuel Injection Valve

10 Contacts

10.1 How to contact Wärtsilä

For questions about the content of this Technical Bulletin, or if you need Wärtsilä assistance, services, spare parts and/or tools, please contact your nearest Wärtsilä representative.

10.2 Contact details for emergency issues

10.2.1 Operational support

For questions concerning operational issues, please send your enquiry to:
technicalsupport.chts@wartsila.com
or phone 24hrs support: +41 52 262 80 10.

10.2.2 Field service

If you need Wärtsilä Field Service, please send your enquiry to:
ch.fieldservice@wartsila.com
or phone 24hrs support: +41 79 255 68 80.

10.2.3 Spare parts

If you need Wärtsilä spare parts and/or tools, please contact your nearest Wärtsilä representative or your key account manager.

ch.fieldservice@wartsila.com
or phone 24hrs support: +41 79 255 68 80.

TECHNICAL BULLETIN

2 Stroke Engine Services

Engine section	Engine type	Ref.	Date	Issue	Document no.	Page
	W-X62 and W-X72	2-stroke	19 July 2017	1	**RT-198_A1 Appendix 1**	1(29)

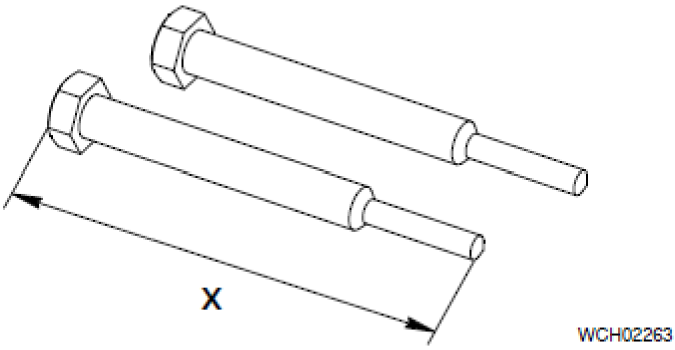
Fuel injection valves maintenance & servicing instructions

Contents

1 Tools

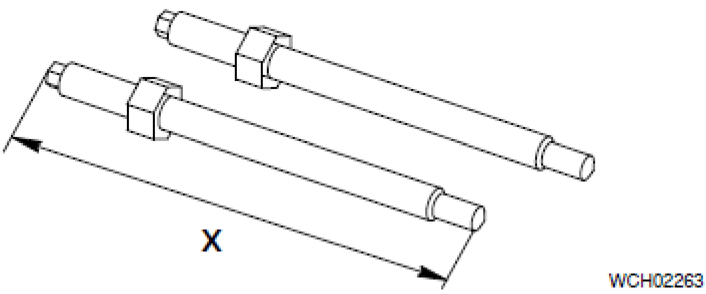
94270C 2 Hexagon head bolt

For injection valve; X = 170 mm



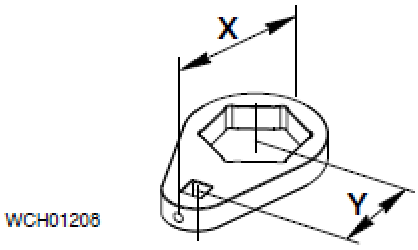
94270D 2 Stud bolt

For injection valve; X = 176 mm



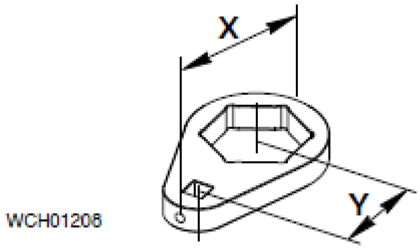
94269C-41 1 Torque wrench extension

For loosening and tightening of
Clamping nut (AF55) to injection valve
with FAST
X = 106 mm
Y = 65 mm

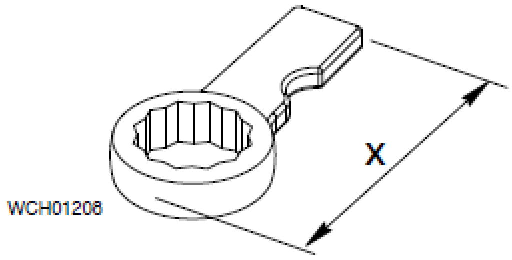


94269C-65 1 Torque wrench extension

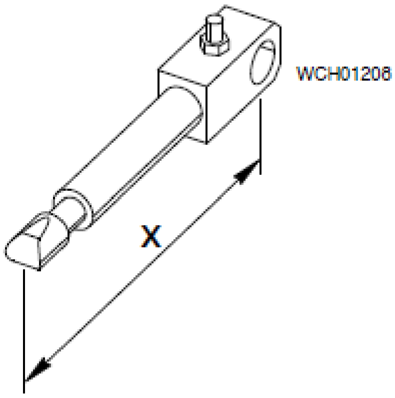
For pre-tightening of coupling nut
(AF70) to injection valve with FAST
X = 144.5 mm
Y = 75 mm



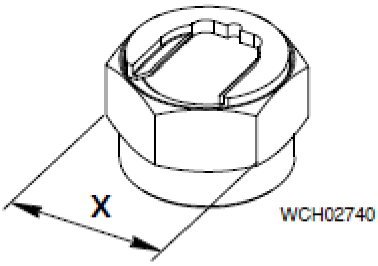
94269A–65 1 Slugging wrench
For loosening and tightening of coupling
Nut (AF70 to injection valve with FAST)
X = 232 mm



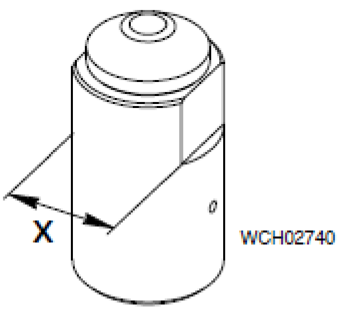
94269B 1 Hydraulic cylinder
For loosening and tightening of coupling
nut to injection valve with FAST
X = 695 mm



94278A 1 Nozzle disassembly tool
For injection nozzle disassembly
X = AF 46 mm

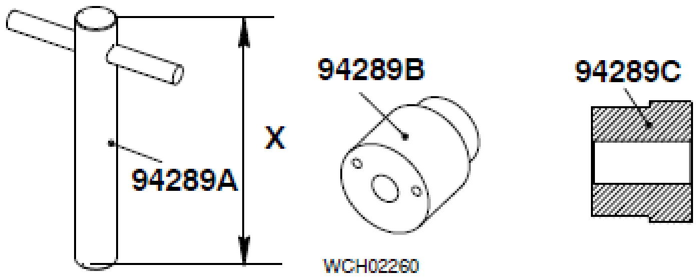


94278B 1 Nozzle assembly tool
For injection nozzle assembly
X = AF 41 mm



94289 1 Assembly tool
Of mounting / dismounting pilot valve
Consisting of:

94289A	1 T-handle
94289B	1 Bush
94289C	1 Bush



NOTE:
Additional tools can be found in the Maintenance Manual of the defined engine.

2 Removal, handling and installation of Fuel injection valves

2.1 Overview, storage & handling

1) Protect the nozzle tip integrated in the injection valve against damage. Handle the whole injection valve with care. Fuel injector is delivered without nozzle tip, but with a dummy tip for transportation.

2) Store the injection valve in a dry place with no contamination of exhaust gases or any other corrosive atmosphere. Observe storage temperature -20 to +50 deg C.

3) Use white spirit for cleaning, e.g. Shellsol TD, Shellsol T or Solvent FP68. Always wear gloves and safety goggles with closed side frame!

CAUTION:
Do not open vacuum packed injection valve long before the installation on the engine.

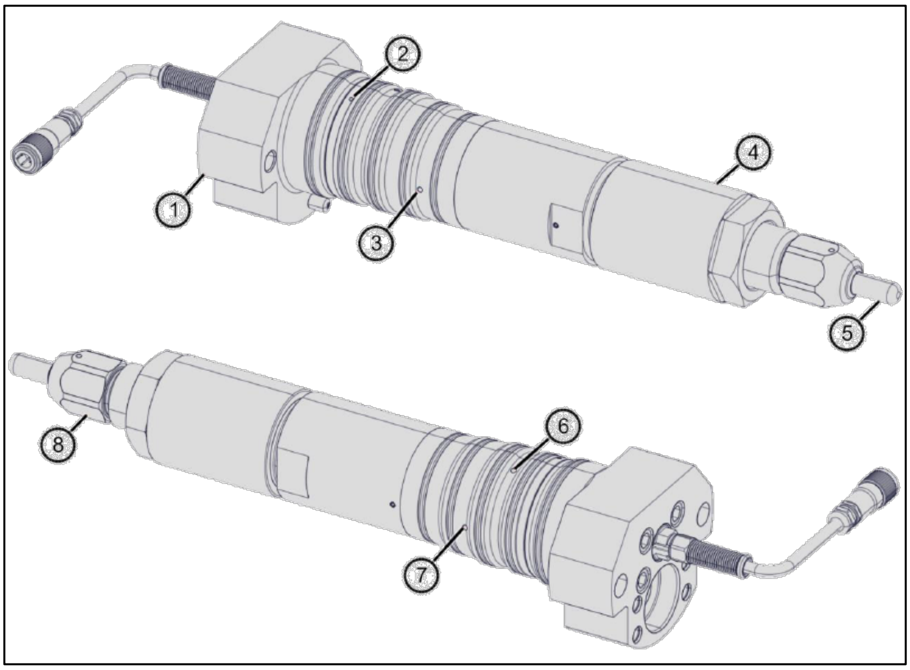


Figure 1: Overview of injector

Pos.	Name	Pos.	Name
1	Fuel injection valve/ Injection unit	5	Nozzle tip
2	Control fuel return	6	Fuel leakage
3	Lube oil supply	7	Lube oil return
4	Injection element nut	8	Nozzle tip nut

2.2 Removal of injection valve

1) Remove HP fuel pipe as follows:

1.1) Stop the engine (see the Operational Manual 4002-2).

1.2) Make sure there is no pressure in the fuel rail

a) Set to off the fuel booster pump (plant).

b) Operate the button on the pressure control (4, Fig.2) to release the pressure in the fuel rail.

c) On the Local Display Unit (LDU), make sure that the pressure shows zero.

1.3) Set to off the electrical trace heating system.

CAUTION:
Damage Hazard: Make sure that you do not damage the sealing faces or the HP injection pipes.

1.4) On the applicable HP injection pipe (2, Fig.2), disconnect the electrical connection (6, Fig.2).

1.5) Remove the applicable pipe bracket (1, Fig.2).

1.6) Remove the pipe bracket (5, Fig.2).

1.7) On the injection valve (3, Fig.2) remove the four screws (7, Fig.2) from the flange (8, Fig.2).

1.8) On the flange (11, Fig.2), remove the four screws (9, Fig.2).

1.9) Carefully remove the applicable HP injection pipe (2, Fig.2) from the injection valve (3, Fig.2) and the flow limiter valve (10, Fig.2)

1.10) Apply protection to the sealing faces (SF) and the open ends of the HP injection pipe (2, Fig.2).

CAUTION:
Be especially careful during the removal of the injector and handling of the nozzle tip. The injector's cable is also very sensitive. Pulling of the cable and improper handling can lead to cable connection damages and must be avoided.

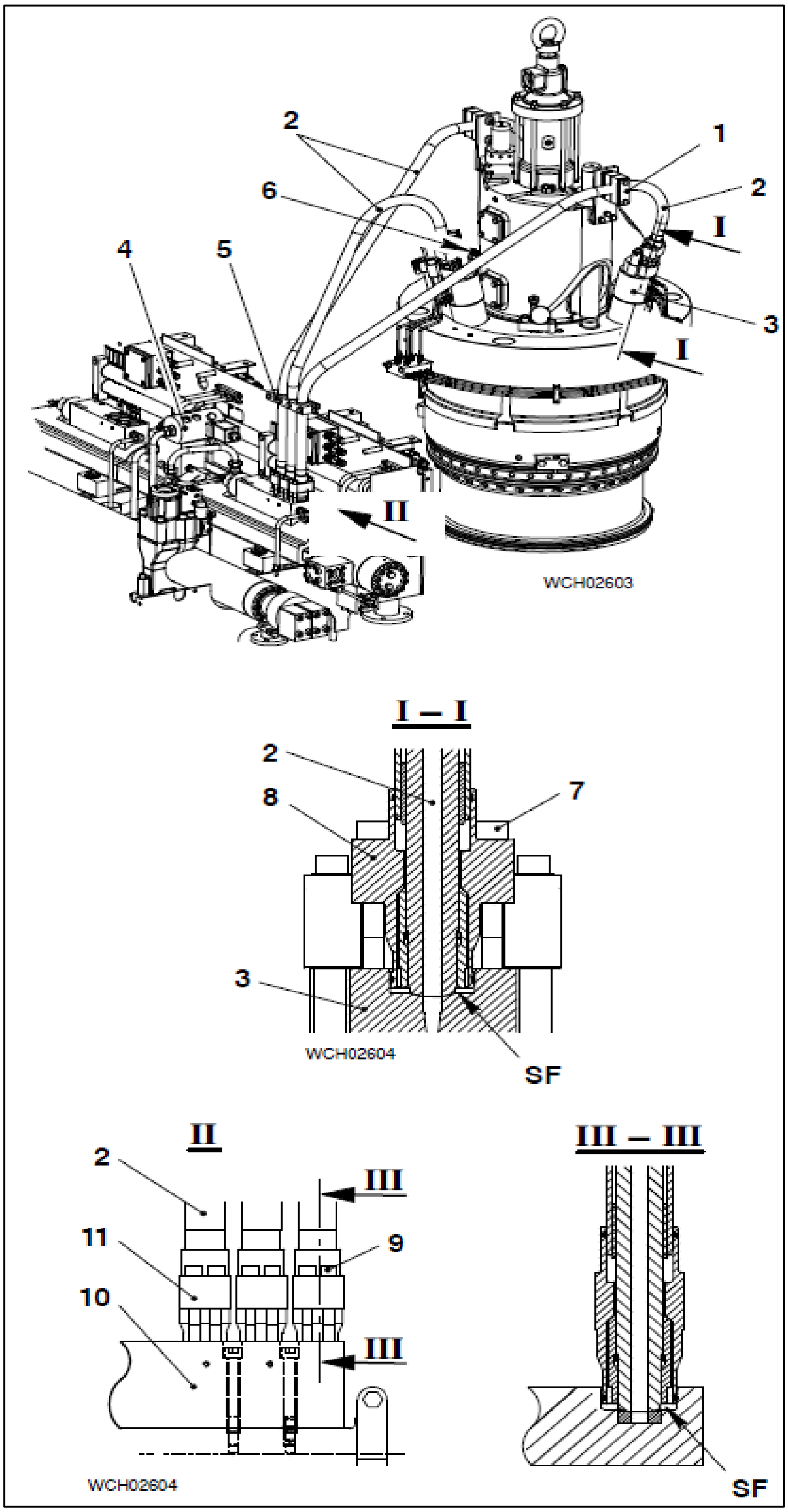


Figure 2: High pressure Injection pipes

2) Disconnect cable (4, Fig.3) at terminal box 95.4.

3) Make sure the lube oil circulation of the injection valve is stopped, see Operation Manual 8016-1, chapter 3.

4) Remove the screws (2, Fig.3) with their spring cage (3, Fig.3).

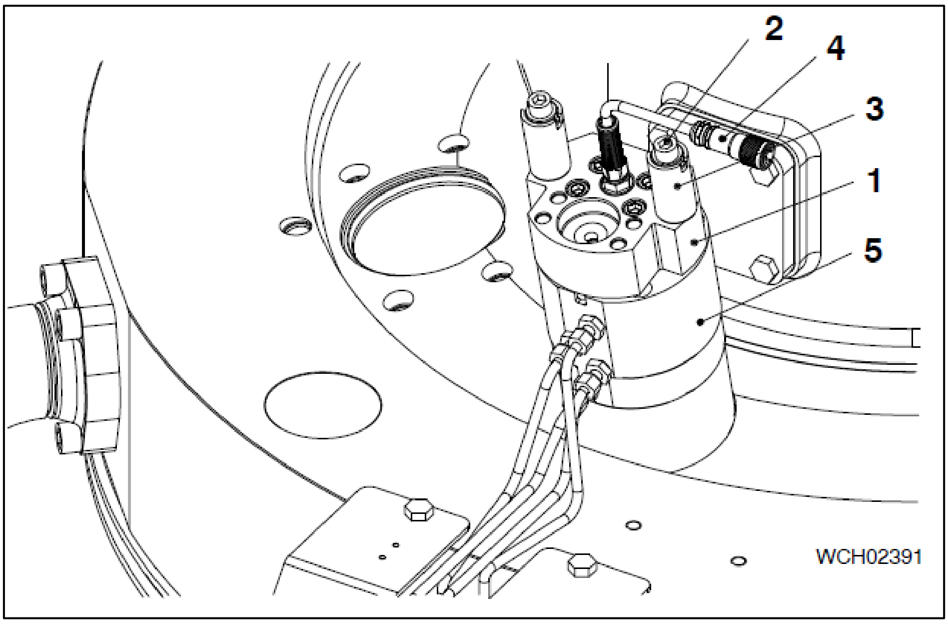


Figure 3: Fuel Injector detail

5) Put the two bolts 94270C in the position as shown in figure 4.

6) Turn the two bolts until they stop at the thread end in the valve bush (5, Fig.4).

7) Turn the two bolts equally to lift the injection valve.
When distance X is about 50 mm you should be able to lift the injection valve by hand (ca. 20 kg).

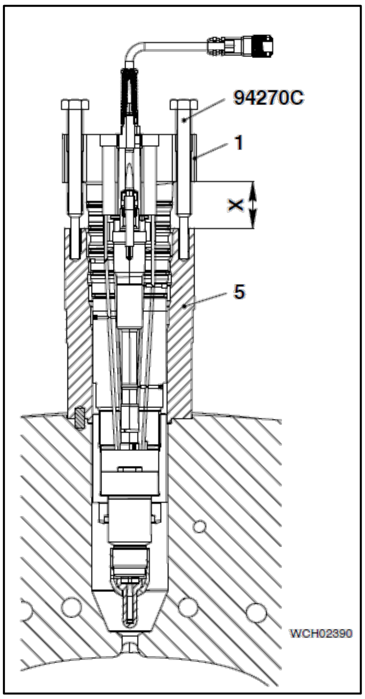


Figure 4: Distance X of injection valve

2.3 Installation of injection valve

Clean and check the condition of the sealing face in the cylinder cover (6, Fig. 5) and recut it if necessary, see Maintenance Manual 2708-3.

1) Replace the five O-rings 'OR' with new ones and apply grease to them before installing[1].
   - The spare (5) O-rings belong to the BX 96146 spare part set.
   - Ensure that the nozzle tip is installed correctly. Protection cap must be removed prior installation on the engine.
2) Place the injection valve carefully into the valve bush.
3) Place the two stud bolts 94270D as shown in Fig. 5 and turn them into the valve bush.
4) Insert the injection valve by turning the nuts (7, Fig.5) equally.
   - The injection valve is fully inserted when the distance X is 7.2 mm.

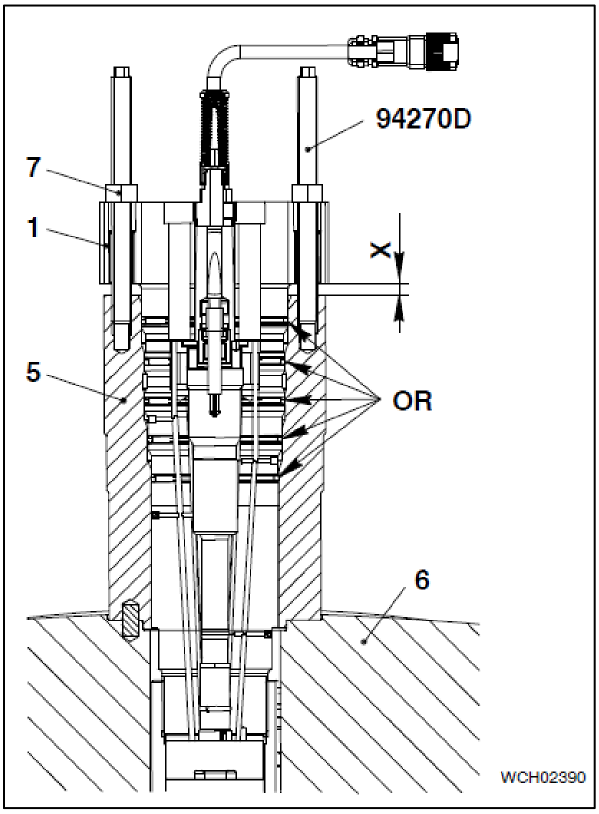


Figure 5: Inner parts of Injection valve

[1] If injection valve has already been in use before. If new injector, check for O-ring damages and if necessary, exchange them.

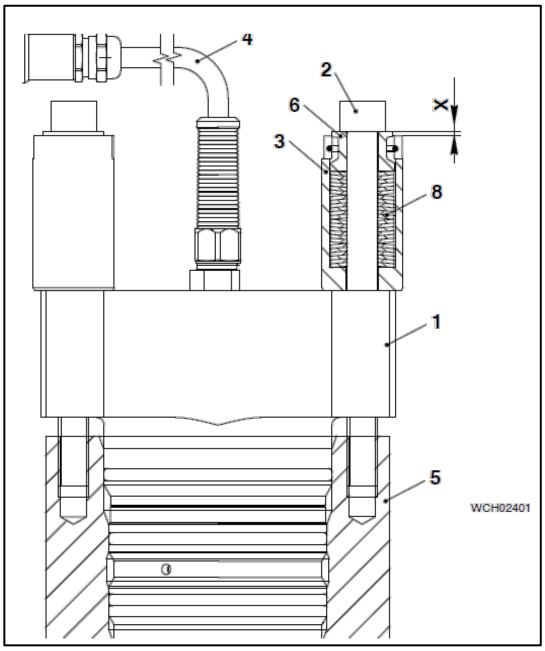


Figure 6: Details of upper part Injection valve

5) If the spring cage (3, Fig.6) was disassembled, make sure the cup springs (8, Fig.6) are fitted as shown in Fig. 6 (4x6 cup springs).

6) Apply Never-Seez NSBT to the threads and the seating surface of the screws (2, Fig.6).

7) Tighten the screws (2, Fig.6) equally until the spring guide (6, Fig.6) is flush with the spring cage, X = 0.

8) Connect the cable (4, Fig.6) to terminal box 95.4.

9) Install HP fuel pipe as follows:

   9.1) Remove all of the protection from the sealing faces (SF) in the injection valve (3, Fig.2) and the flow limiter valve (10, Fig. 2).

   9.2) Apply Never-Seez NSBT to threads of the screws (7 and 9, Fig. 2).

   9.3) Carefully put the HP injection pipe (2, Fig.2) in position in the injection valve (3, Fig.2) and the flow limiter valve (10, Fig.2).

   9.4) Torque symmetrically the four screws (7, Fig.2) to 60Nm.

   9.5) Torque symmetrically the four screws (9, Fig.2) to 60Nm.

   9.6) Install the pipe clamp (5, Fig.2).

   9.7) Install the applicable pipe clamp (1, Fig.2).

3 Maintenance / Parts exchange

3.1 Preparation

- Lifting gear
- Clamping bracket

1. Assemble lifting gear in valve body.

2. Transport fuel injection valve to clamping bracket using the lifting gear.

3. Insert and secure fuel injection valve in clamping bracket.

4. Remove lifting gear.

5. Rotate clamping bracket until nozzle points upwards.
Preparations for assembly/disassembly of injection valve are completed now.

Figure 7: Tool for valve body

3.2 Disassembly

3.2.1 Disassemble Nozzle tip

Remove nozzle tip nut

- Socket wrench
- Tool 94269C - 41

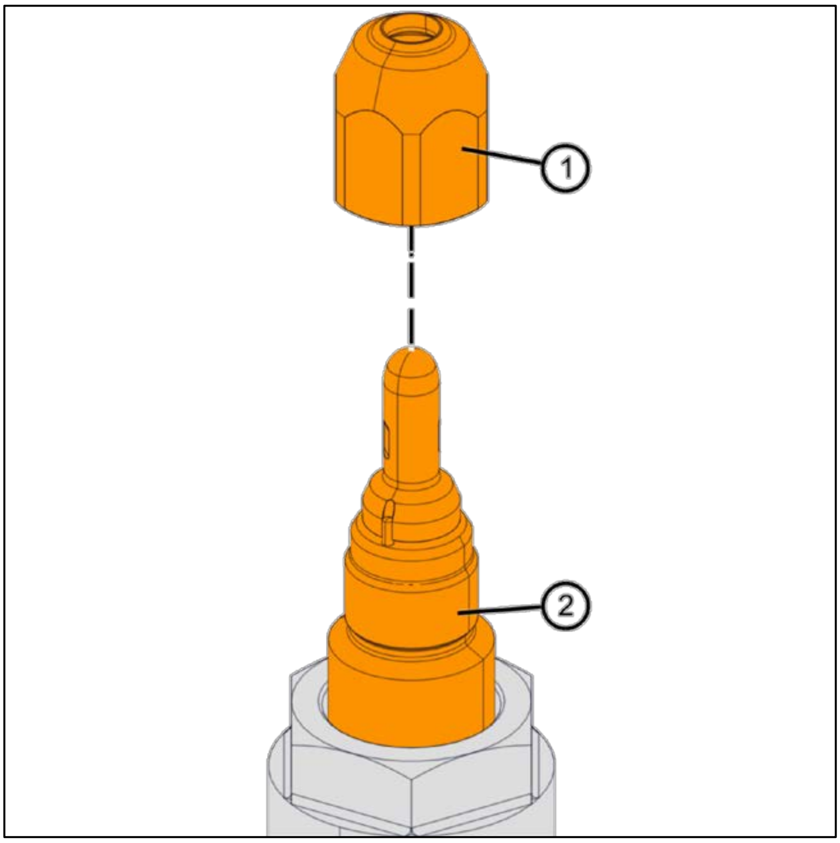


Figure 8: Injection valve nozzle tip

1. Loosen nozzle tip nut (1) from injection element (2).
2. Remove nozzle tip nut (1).

Remove nozzle tip

Disassembly Tool 94278A
Ring fork spanner width 50

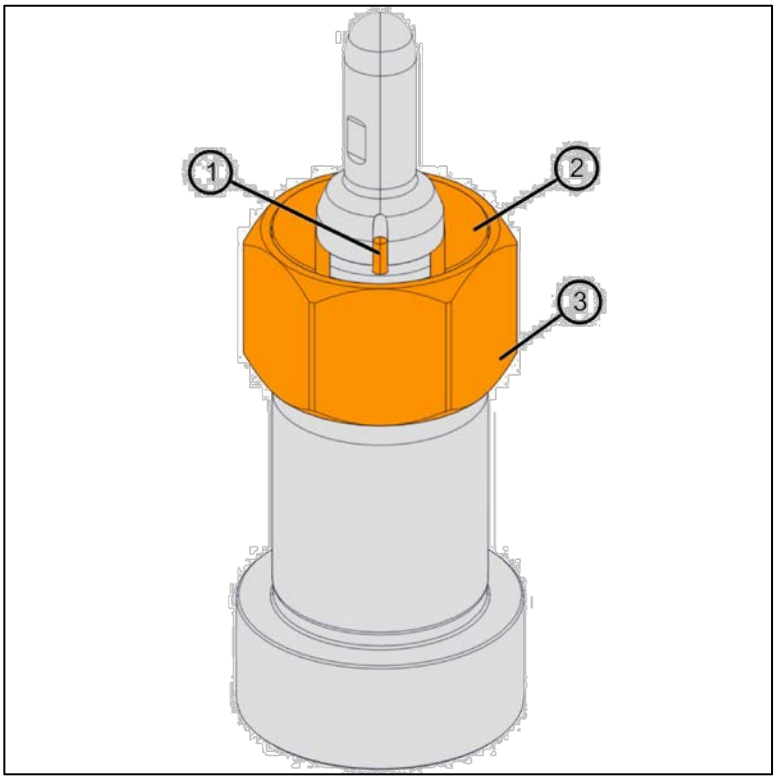


Figure 9: Nozzle tip

1. Screw assembly sleeve (3) on nozzle tip thread.
2. Put plate (2) on assembly sleeve (3).

NOTE:
Be careful with guiding pin (1) of nozzle tip.

3. Loosen and remove nozzle tip

3.2.2 Change nozzle tip positioning pin (if needed)

Drill out the part of broken positioning pin, when required (due to broken pin).

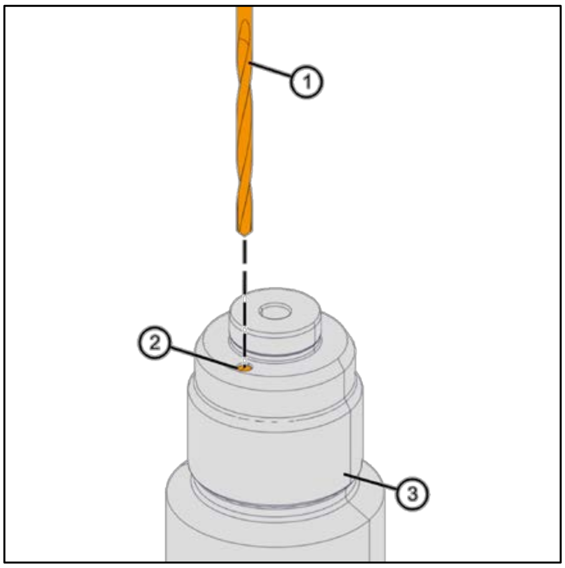


Figure 10[2]: Nozzle tip positioning pin

1. Drill out the remaining part of the broken positioning pin (2) carefully. (3 mm Twist drill).

NOTE:
The centre of the hole of the broken pin (2) to be in line with centre of driller (1)

2. Clean the hole of the positioning pin (2) from drilling chips.

[2] The figure 10 does not show the needle, which must be seen after disassembly of the nozzle tip

3.2.3 Disassemble injection element and pilot valve

Remove coupling nut

- Socket wrench
- Tool 94269A – 65

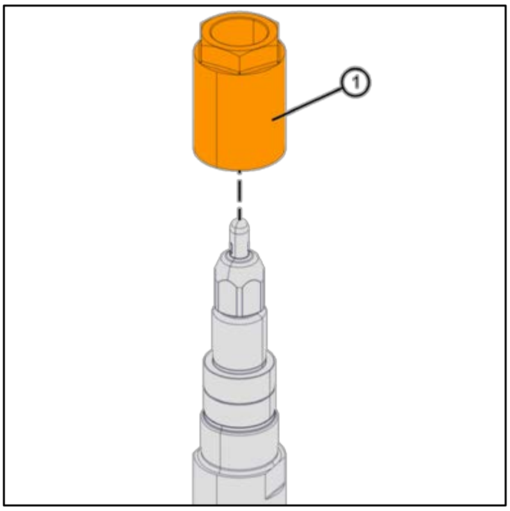


Figure 11: Coupling nut

1. Loosen and remove coupling nut (1).

Remove injection element

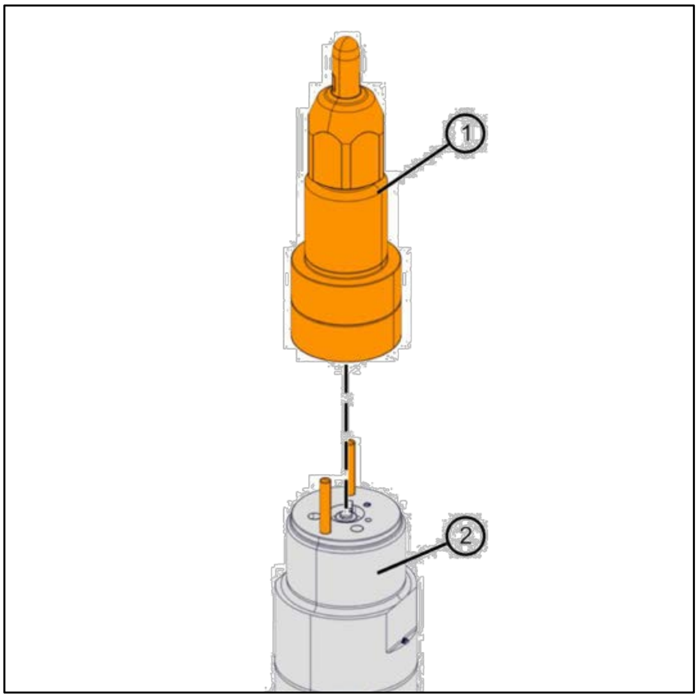


Figure 12: Injection element

1. Remove injection element (1) from injection valve (2).

NOTE:
The two dowel pin will be in most cases removed together with the injection element.

Remove Pilot valve

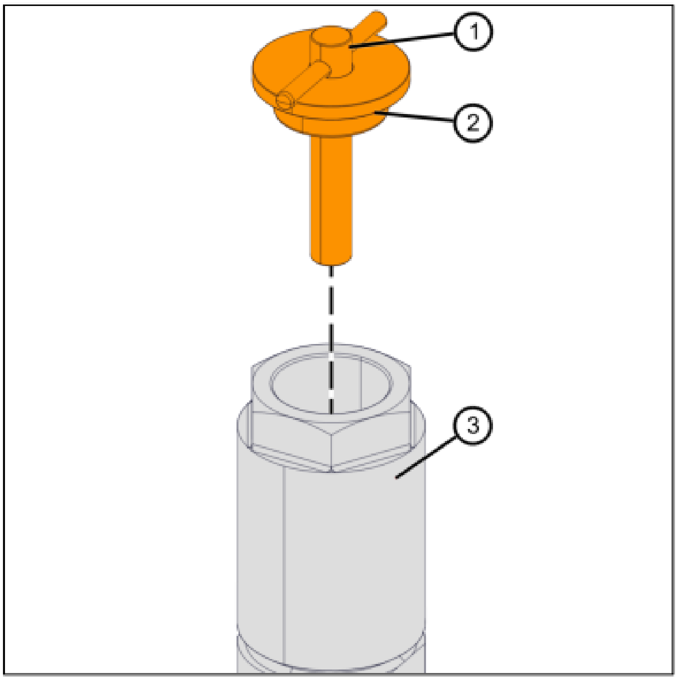


Figure 13: Pilot valve

1) Remove the pilot valve from the injection valve as follows:

   1.1) Screw nozzle nut (3) on valve body hand tight

   1.2) Attach the tool 94289C (2) on the nozzle nut.

   1.3) Insert assembly tool 94289A (1) into assembly tool 94289C (2) as shown.

   1.4) Push and screw assembly tool (1) on pilot valve

   1.5) Loosen and remove the nozzle nut (3) & pilot valve will be removed

NOTE:
After removal, the pilot valve must be either replaced or cleaned as stated in section "3.4 – Cleaning Pilot valve".
The pin may fall out of the pilot valve.

Remove valve plate from injection element

1) Loosen and remove screws (3) of the valve plate.

2) Remove the valve plate (2) from the injection element (1).

3) Place valve plate (2) and injection element (1) on a clean work surface

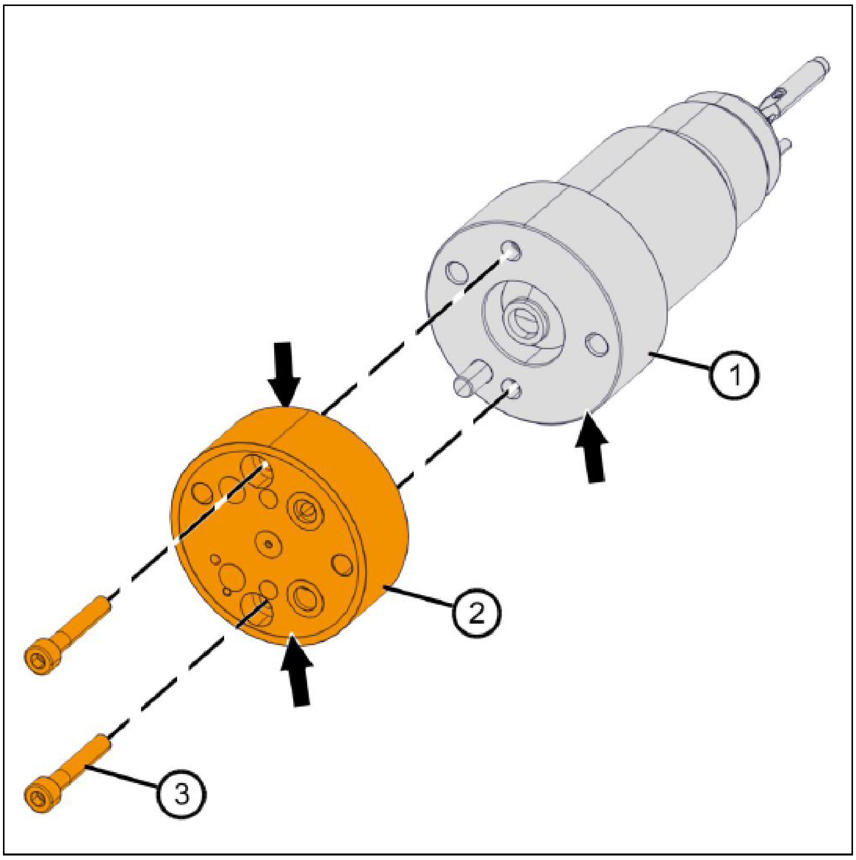


Figure 8: Valve plate

NOTE:
Scratches and other damages can lead to malfunction of the injector.

- Do not damage the sealing surfaces (marked with black arrows)
- Treat valve plate and nozzle carefully

Remove internal parts from injection element

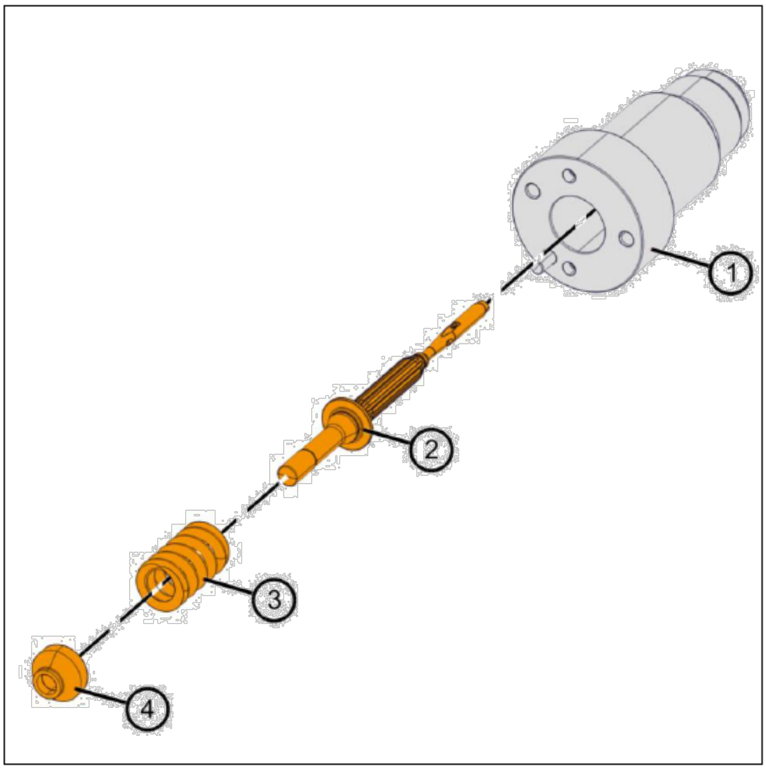


Figure 9: Inner parts of injection element

1) Remove the guide bushing 4, nozzle spring 3 and the needle 2.

3.3 Assembling

3.3.1 Mount new injection element and pilot valve

Mount new pilot valve

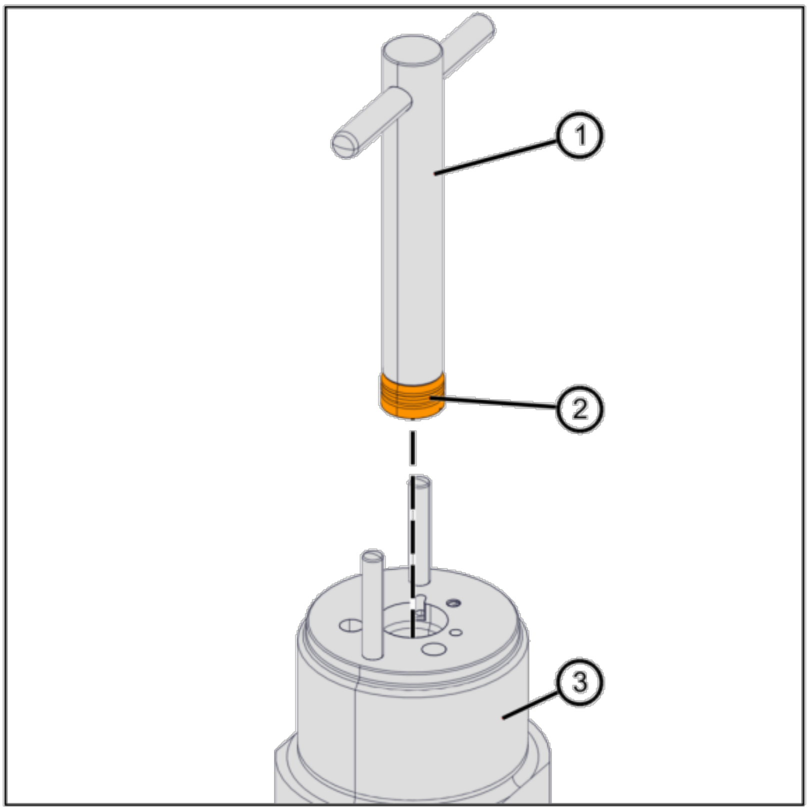


Figure 16: Pilot valve

1) Install the pilot valve (2) in the injection valve as follows:

1.1) Clean all contact surfaces

1.2) Lubricate pilot valve thread and O-ring with Never-Seez

1.3) Screw pilot valve on assembly tool 94289A (1)

Note: The pin may fall out of pilot valve

1.4) Press pilot valve (2) inside valve body (3) hand tight

1.5) Unscrew and remove assembly tool (1)

Mounting of new injection element

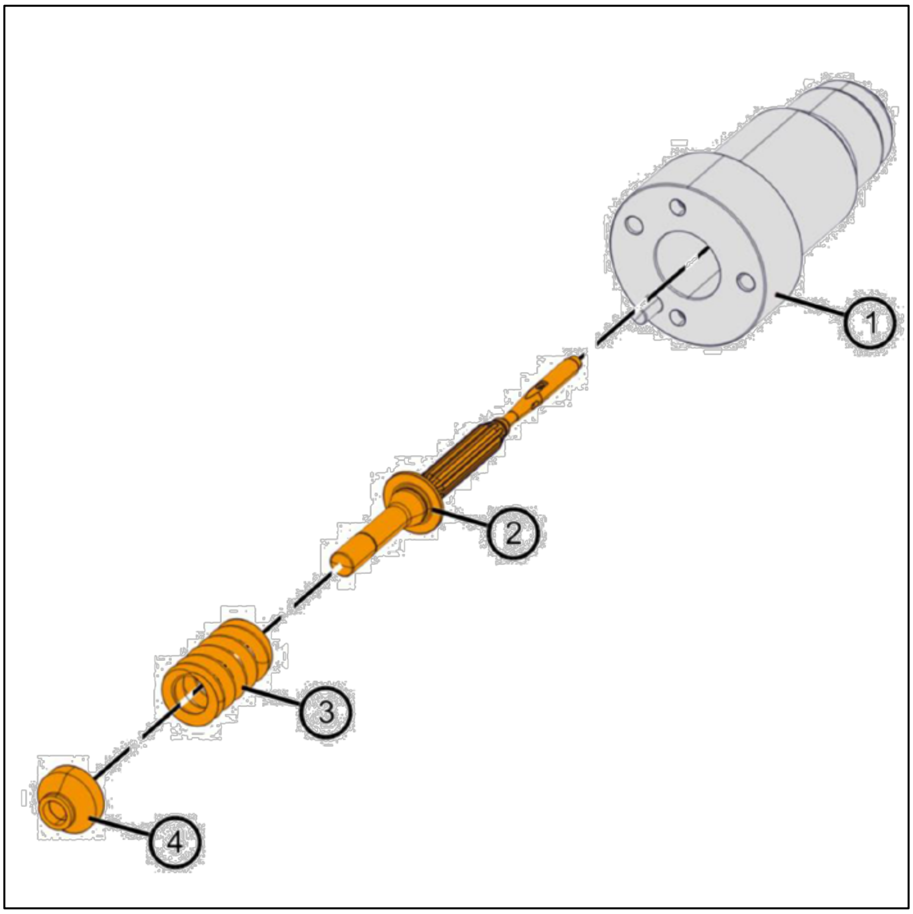


Figure 17: Injection element

1) Insert needle (2) and nozzle spring (3) in nozzle (1).

2) Mount guide bushing (4) to nozzle (1)

Assemble valve plate to injection element

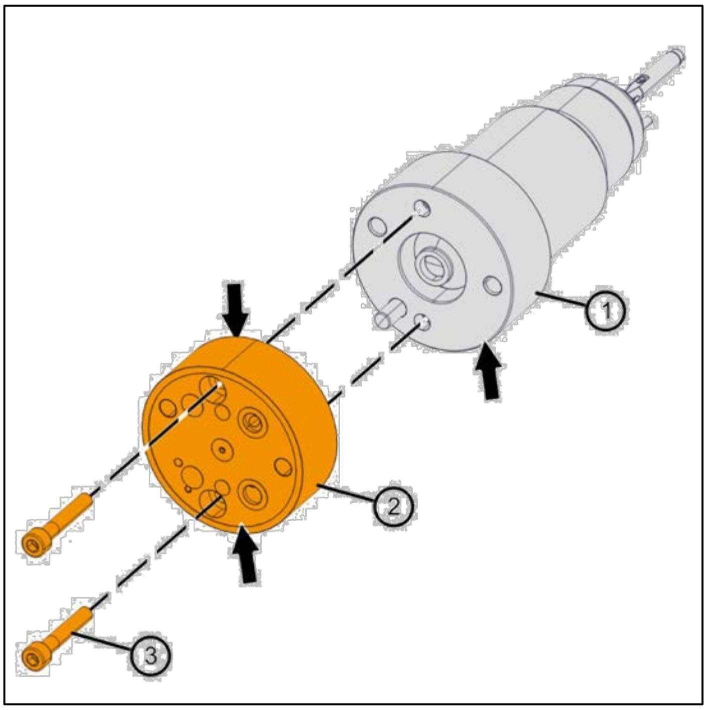


Figure 18: Valve plate and injection element

1. Mount valve plate (2) on injection element (1).

NOTE:
Use positioning pin for correct assembly.

2. Insert screws (3) in valve plate (2).

3. Tighten screws (3) to final torque.
Tightening torque: 5 Nm + 1 Nm

3.3.2 Lubrication with NeverSeez

Lubricate thread & shoulder of the nuts as below.

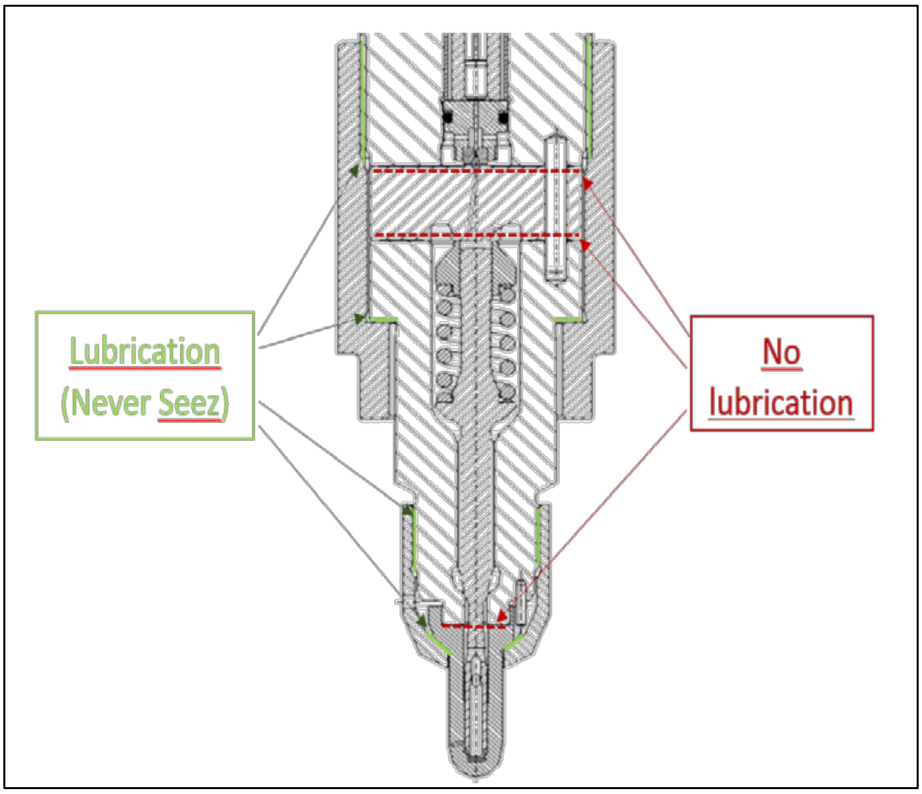


Figure 19: Lubrication instruction

3.3.3 **Fixation of injection element**

Required Tools: Tool 94269C – 65
Tool 94269A – 65
Tool 94269B

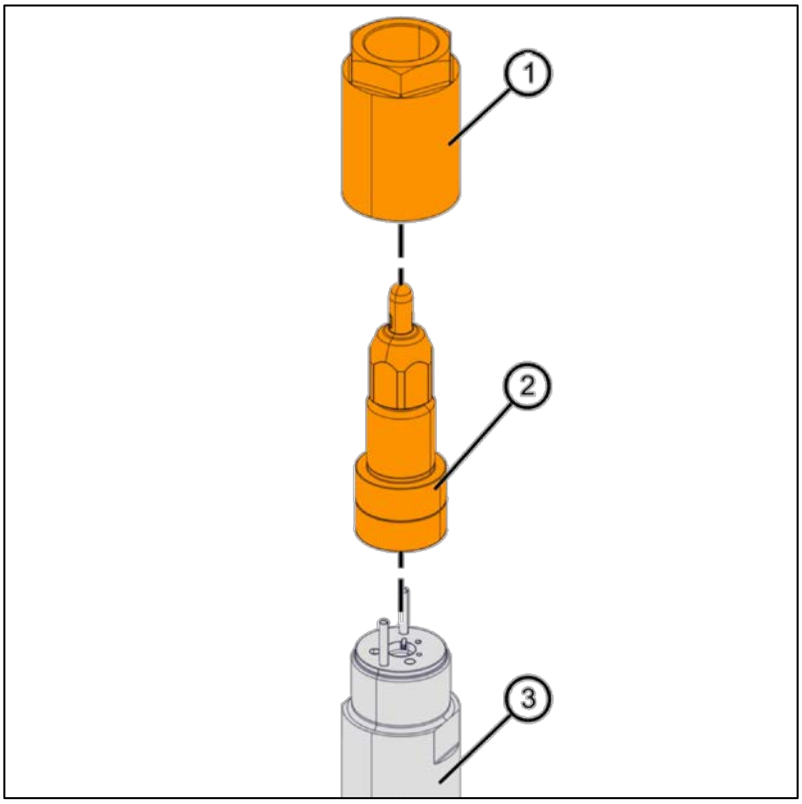


Figure 20[3]: Injection element

1. Clean contact surfaces.

2. Put injection element (2) on valve body (3).

3. Lubricate threads and shoulder of nozzle nut (1).

4. Screw and tight nozzle nut (1) on valve body (3); tool 94269C – 65.
Tightening torque: 100 Nm

5. Tighten nozzle nut (1) to final torque; tool 94269A – 65 & 94269B.
Torqueing angle of 35° – 40° (or tightening torque: 1000 Nm)

[3] Although the figure 20 shows the nozzle tip already assembled, the installation will be done after fixating the coupling nut.

3.3.4 Assemble Nozzle tip

Mount new positioning pin to nozzle (when required)

Required tools: Rubber mallet & 1x new positioning pin

1. Check hole of positioning pin for drilling chips.
2. Clean nozzle (2).
3. Insert positioning pin (1) in dedicated hole.
4. Hit positioning pin (1) down carefully using rubber mallet.

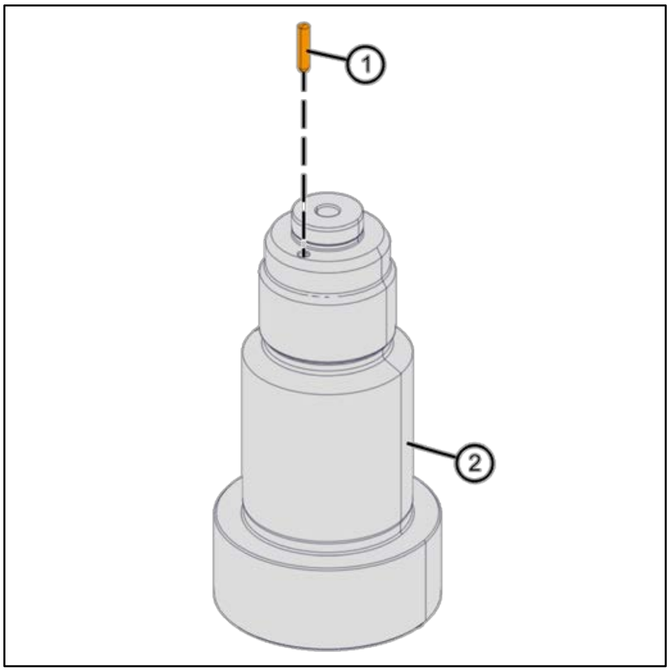


Figure 21[4]: Positioning pin on nozzle

[4] The figure 21 does not show the needle, which must be seen after assembly of the internal parts

Mount nozzle tip

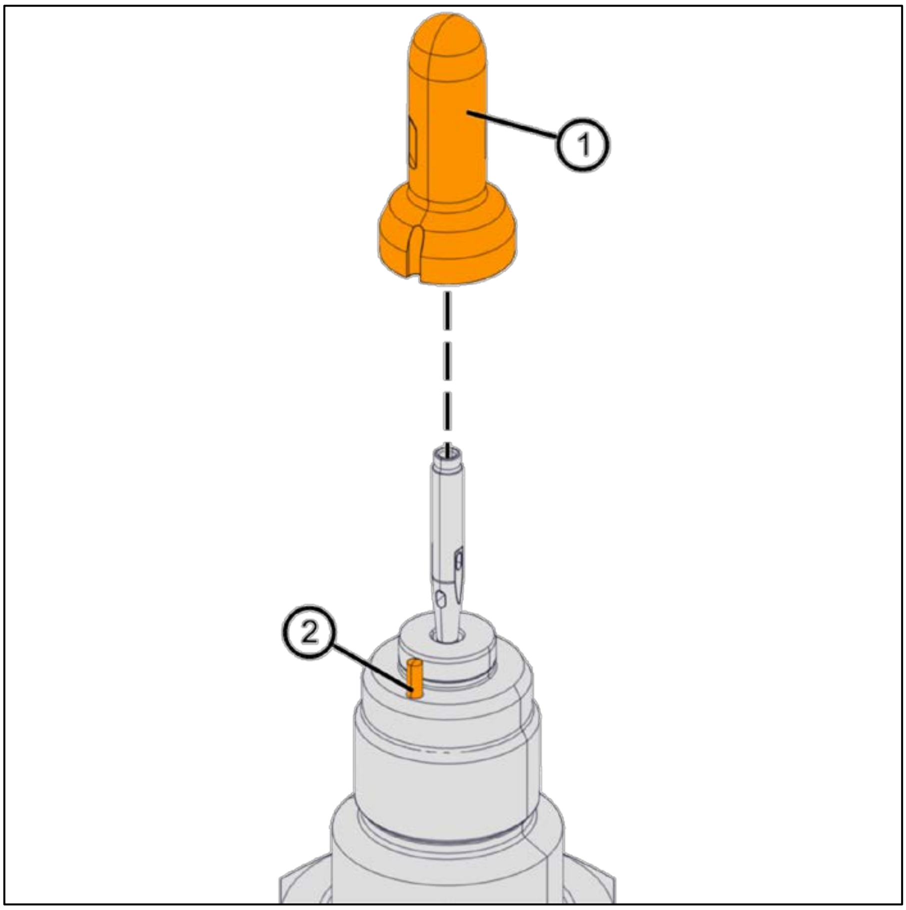


Figure 22: Nozzle tip

1. Clean contact surfaces.
2. Put nozzle tip (1) on nozzle tip body (needle).

NOTE:
Be careful with the guiding pin (2) on the nozzle tip.

Assemble nozzle tip

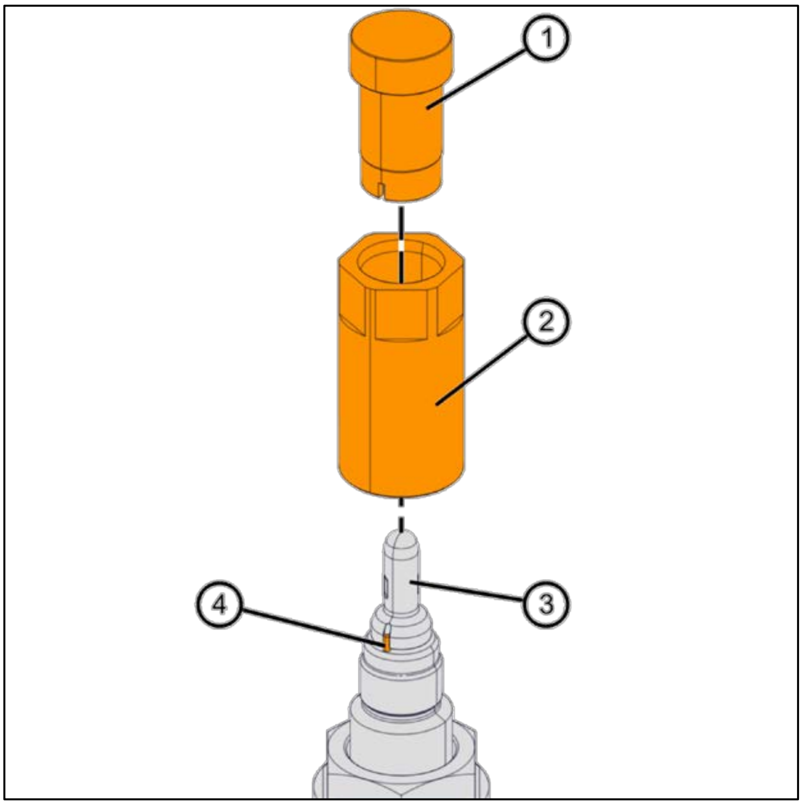


Figure 23: Nozzle tip details

1. Put and screw assembly sleeve 94278B/A2 (2) on nozzle tip body hand tight.

NOTE:
Be careful with guiding pin (4) of nozzle tip.

2. Put punch tool 94278B/A1 (1) on nozzle tip in guiding part of punch.

3. Use a cooper or rubber mallet to tap the punch tool fully down.

4. Unscrew and remove assembly sleeve (2) and punch (1).

Fixate nozzle tip

1. Lubricate thread and shoulder of nozzle tip nut.

2. Screw nozzle tip nut on nozzle tip body (3).
3. Tighten nozzle tip nut to final torque.
Tightening torque: 190 Nm.

3.4 Cleaning pilot valve

Cleaning of the pilot needs to be frequently done (see maintenance schedule, "L'Orange Fuel Injection Valves in W-X62 and W-X72 Engines" technical bulletin) as follows:

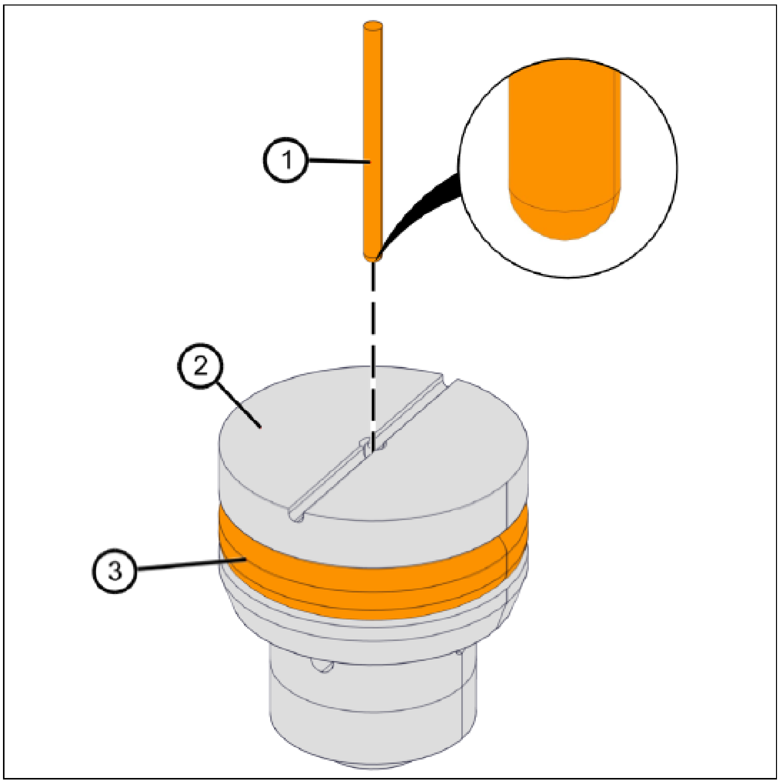


Figure 10: Pilot valve detail

1) Remove O-ring (3)
2) Heat-up pilot valve housing (2) to 60°C - 80°C in an oven or with a hot air gun.
3) Remove the rod (1) with tweezers.
4) Clean the pilot valve housing (2), rod (1) and O-ring (3) with cleaning solvent and a sponge.
5) Insert the control pin back into the pilot valve's orifice. The rounded surface of the pin must point down for a correct assembly.

CAUTION:
Make sure the pin is assembled as stated above. The position of the pin is crucial for a proper functionality of the control part.
The pin is very brittle. Do not bend it.
Do not exchange the pin from other control parts. The pin is ground to the guiding of the control part.

3.5 Cleaning injector needle and nozzle tip

To avoid sticking needle problems, it is recommended to clean injector's needle and nozzle tip with the same frequency as for the pilot valve (every 4000 hours or after each injector disassemble). The cleaning to be done using one of the following materials (recommended to start from option1 as it is the least abrasive):

Option1: Clean the needle using a piece of cloth

- Cleaning solvent.
- Fuzz-free cloth.

1) Clean the needle slider using cleaning solvent and a piece of cloth.
2) Wash the needle using cleaning solvent and scrubber if necessary.

Option2: Clean the needle using cooper wire hand brush

- Cleaning solvent.
- Cooper wire hand brush.

1) Clean the needle slider using a cooper wire hand brush.
2) Wash the needle using cleaning solvent and scrubber if necessary.

Option3: Clean the needle using sandpaper

- Cleaning solvent.
- Sandpaper (grain number higher than 1500)

1) Carefully clean the deposits on the needle slider using a sand paper.
2) A copper wire hand brush

CAUTION:
Too much cleaning of the needle with sandpaper could destroy the coating.
- Carbon deposits are soft and easily removable. Do not scrape excessively

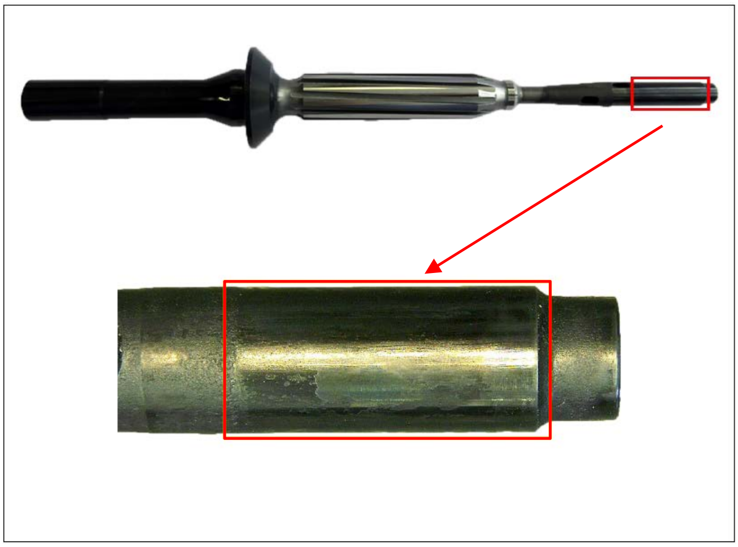


Figure 11: Injector needle

Clean the nozzle tip

Required Tools: - Cleaning solvent.
- Plastic borehole brush

1) Clean the nozzle tip using a plastic borehole brush and cleaning solvent to throw impurities away.

2) Wash the cleaned nozzle tip using cleaning solvent and scrubber if necessary.

Figure 12: Nozzle tip

4 Contacts

4.1 How to contact Wärtsilä

For questions about the content of this Technical Bulletin, or if you need Wärtsilä assistance, services, spare parts and/or tools, please contact your nearest Wärtsilä representative.

4.2 Contact details for emergency issues

4.2.1 Operational support

For questions concerning operational issues, please send your enquiry to:
TechnicalSupport.chts@Wartsila.com
or phone 24hrs support: +41 52 262 80 10.

4.2.2 Field service

If you need Wärtsilä Field Service, please send your enquiry to:
ch.FieldService@Wartsila.com
or phone 24hrs support: +41 79 255 68 80.

4.2.3 Spare parts

If you need Wärtsilä spare parts and/or tools, please contact your nearest Wärtsilä representative or your key account manager.

Fuel injection valve checks & testing instructions

Contents

1 Test Bench Instruction

The test bench is to be used for assembly/disassembly-related tasks (e.g. spare part installation, cleaning…) as well as to check injector's functionality in order to find out where the LPOP lies (Lowest Possible Opening/Operating Pressure, defined as the lowest pressure at which normal injection can take place), look for possible leakages and identify damaged inner parts. During injector checks, a calibration fluid meeting ISO 4113 and SAE J967D specifications (i.e. Shell Calibration Fluid S.9365, Univar Calibration Fluid 1487 should be used.

Table 1: Typical physical characteristics of calibration fluid

Kinematic Viscosity (at 40°C) [mm^2/s]	ASTM D445	2.6
Density at 15°C [kG/m^3]	ISO 12185	827
Pour Point [°C]	ISO 3016	-27

In cases where calibration fluid is not available, it is allowed to use clean diesel oil (gas oil). If clean diesel oil is used, install the injection valve immediately after check completion.

NOTE:
It is not recommended that diesel oil (gas oil) is used if the injection valve is put into storage after checks as it may corrode the injection valve.

1.1 Injector checks

ATTENTION:
Without inspection and cleaning, an injector which is failing on the test bench shall not be used on the engine. It is not allowed to use broken or damaged parts (e.g. bended/broken positioning pins).

Before performing injector checks it is necessary to remove combustion particles from the external parts of the nozzle by using a brass wire brush. Besides, a correct installation of the injector in the test bench must be carried out (refer to section 3.1.1. "Maintenance – Preparation").

Injector checks shall be performed as follows:

1) Mount the injector into the test bench.
2) Increase the pressure up to 600 bar (higher if test bench allows). Do not press "inject"; there should be no test fluid coming out of the nozzle holes.
3) Set 600 bar and press "inject" several times (suggested signal duration 10mS). At this point injection should take place[1].
4) Do not press inject for the next 60 seconds. During this period no fuel injection should take place.
5) Do a check of the seating surface between the needle seat and nozzle as follows:

- Keep the pressure in the test bench constant at approximately 400 bar and monitor the injection valve for 30 seconds. Observe if fuel comes out of the nozzle. If so, wrong needle seat-nozzle fitting exists and the assembly must be carried out according to the assembly instruction.

6) Check Lowest Possible Opening/Operation Pressure (LPOP)

- From 300 bar, increase pressure stepwise (e.g. 20bar step) and for each step press "inject". The first pressure level at which injection takes place will be identified as LPOP[2].

If an injector does not inject at the mentioned conditions it might be due to HFO coagulations in the control part. In such cases it may be helpful to increase the signal duration to 20mS and to use the highest possible supply pressure. If control fuel comes out of the return bore in the upper part of the injector but no injection starts, most likely the nozzle part is not working (exchange as per instruction in appendix). If even after several attempts there is no injection and no control fuel comes out of the return fuel pipe, the pilot valve could be stuck by cold HFO deposits (cleaning/exchanging pilot valve as per instruction in the appendix) or other parts in the upper part of the injector are not working (not serviceable by operator). In such cases contact WSCH.

[1] Dripping of some droplets from the nozzle tip after injection is normal and should stop shortly after injection (ca. 5 droplets maximum).
[2] The LPOP should lie between 350-500 bar. Too high or too low values are sign of abnormal injector operation. If LPOP is out of range, replace complete spare kit.

It should be noted that test fuel leakage coming out of the control fuel return pipe should take place only when injecting (it may take some injections to fill the internal bores until control fuel comes out). Refer to section 4 (Troubleshooting) in the Service Bulletin in case continuous leakage from return fuel pipe is detected.

Very little or even no fuel leakage is expected during the test at the fuel leakage port. No leakage must come out from the lube oil connections during the test.

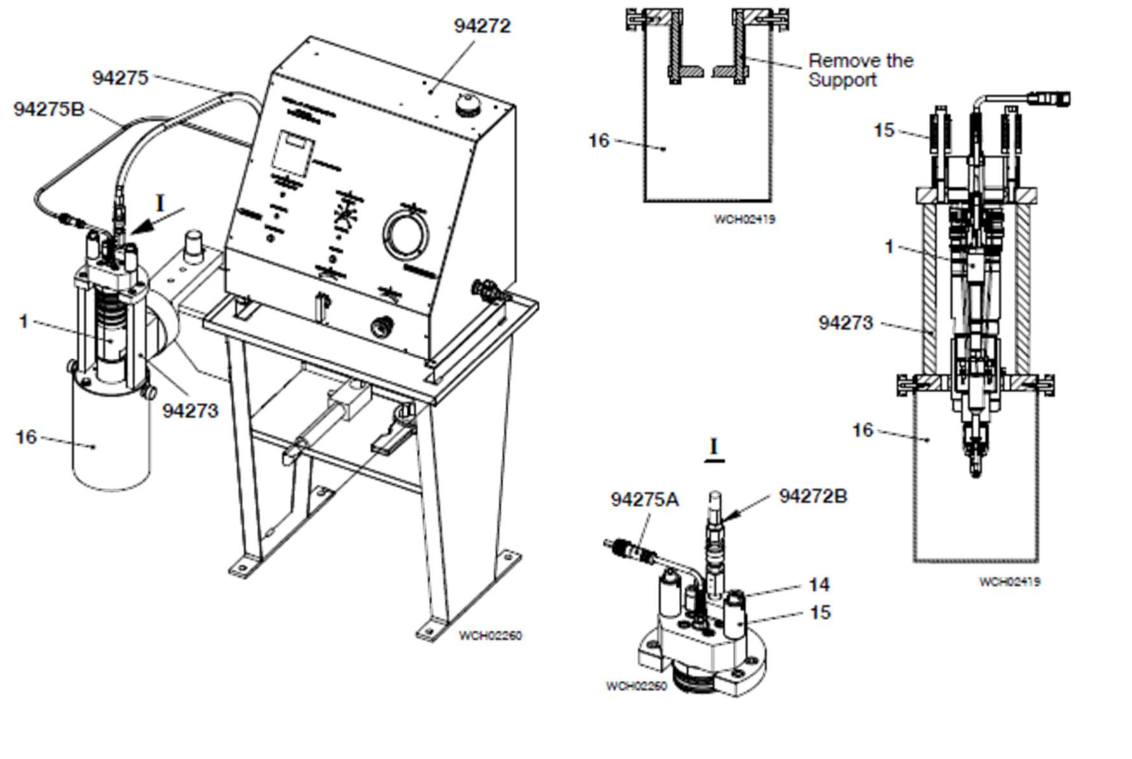


Figure 1: Test bench preparation

2 Contacts

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