FINISHED PLAN

DE014

COSFLYING LAKE

MAIN DIESEL ENGINE (2/5)

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DWG. NO. M-11 (2/5)

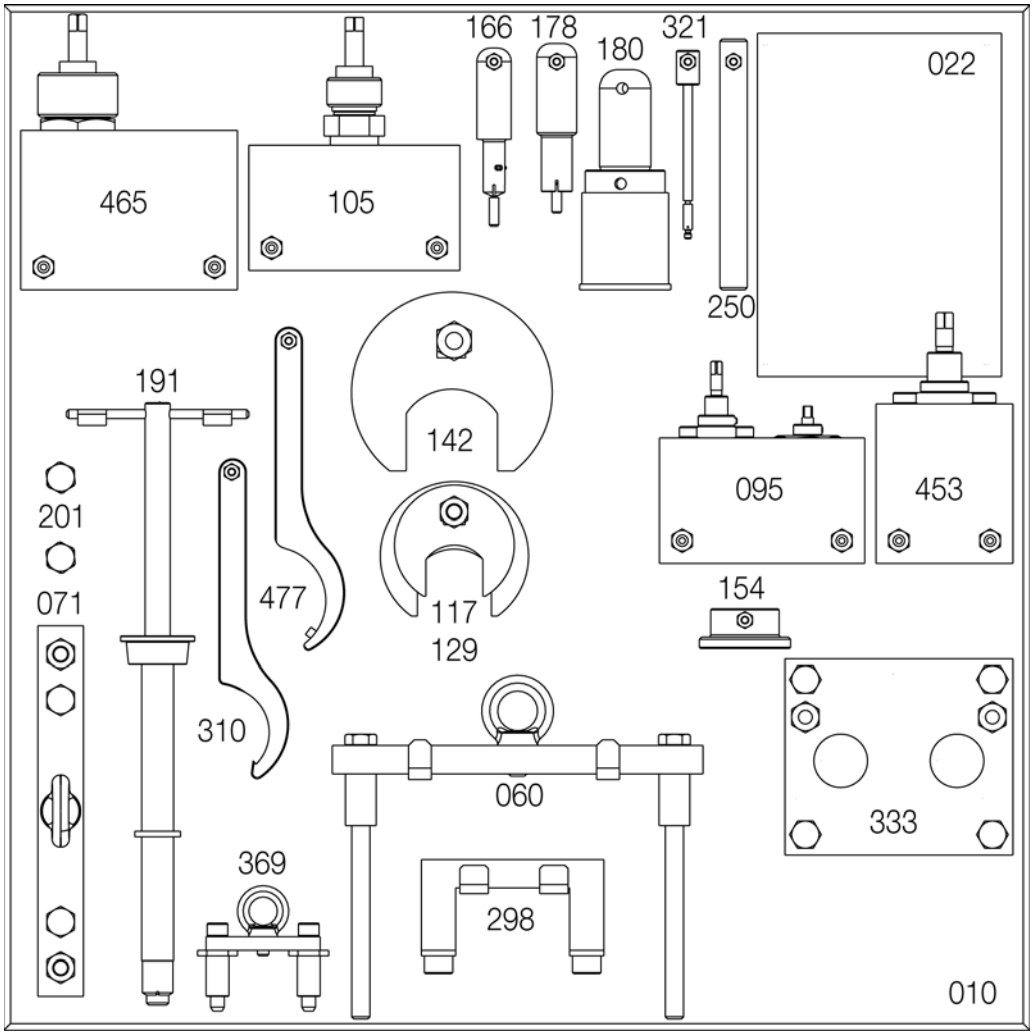
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SCALE: ----- JOB NO. : -----

DESIGN DEPARTMENT
DALIAN COSCO KHI
SHIP ENGINEERING CO., LTD.

DALIAN CHINA

SHEETS (INCL. COVER)


166
178
180
321
022
465
105
250
191
142
095
453
201
071
477
117
129
154
310
060
333
369
298
010

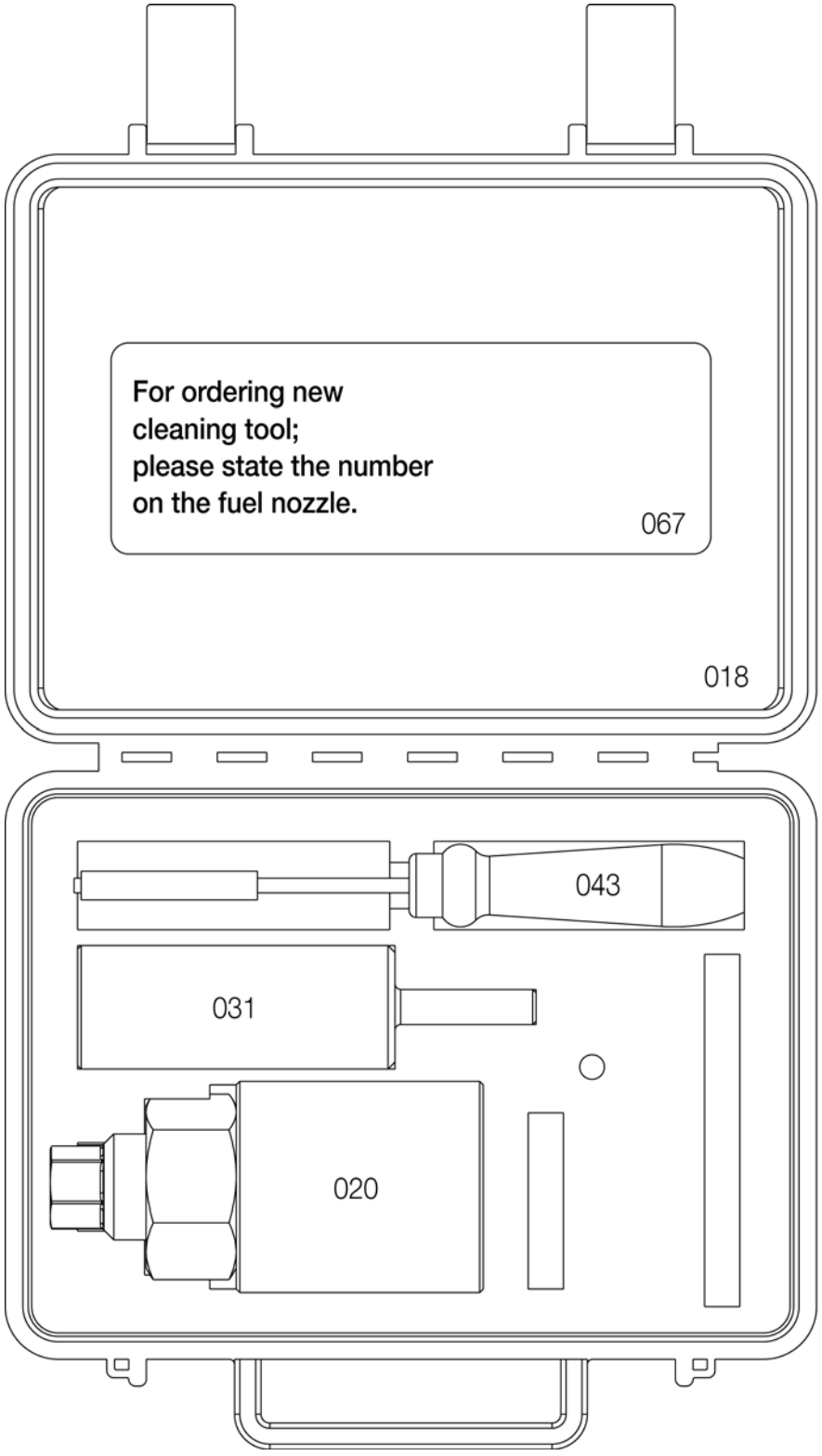
2011-05-25 - en

Fuel System Panel Tools

Plate 4270-0010-0013

Item no	Qty	Designation
010	-	Panel for tools
022	-	Name plate
060	-	Lifting tool for fuel pump
071	-	Lifting tool for fuel pump housing
095	-	Milling tool for fuel oil pipe seat
105	-	Milling tool for fuel oil pipe
117	-	Crowfoot wrench head
129	-	Crowfoot wrench head
142	-	Crowfoot wrench head
154	-	Flange for dismantling for non-return valve
166	-	Grinding mandrel for valve head
178	-	Grinding mandrel for thread spindel
180	-	Grinding mandrel for holder, outside
191	-	Grinding mandrel for holder, inside
201	-	Screw
250	-	Drift for spindle guide
298	-	Assembling tools
310	-	Hook wrench
321	-	Locking device
333	-	Flushing valve
369	-	Lifting tool for hydraulic plunger
453	-	Milling tool for fuel oil pipe seat
465	-	Milling tool for fuel oil pipe
477	-	Hook wrench

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209 { 018, 020, 031, 043, 067

Fuel Valve Nozzle Tools

Plate 4270-0210-0002

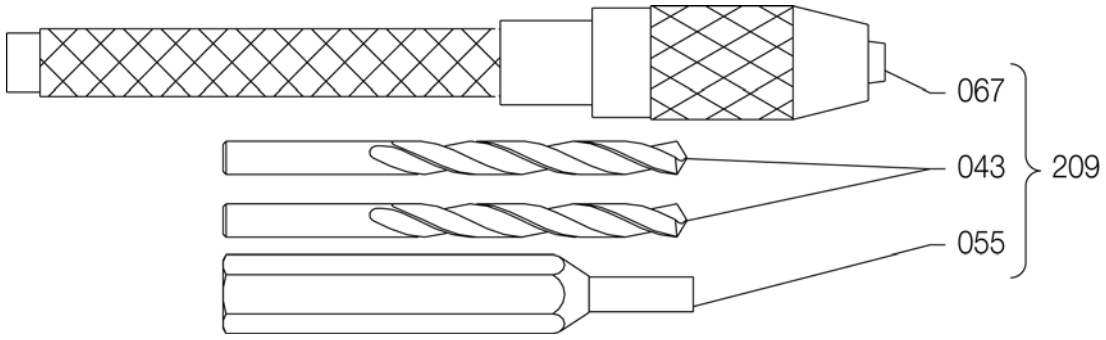
2010-09-07 - en

Fuel Valve Nozzle Tools

Plate 4270-0210-0002

Item no	Qty	Designation
018	-	Tool box
020	-	Extractor for atomizer
031	-	Drift for atomizer
043	-	Cleaning brush
067	-	Instruction plate
209	-	Cleaning tool for fuel nozzle, complete

2010-09-07 - en

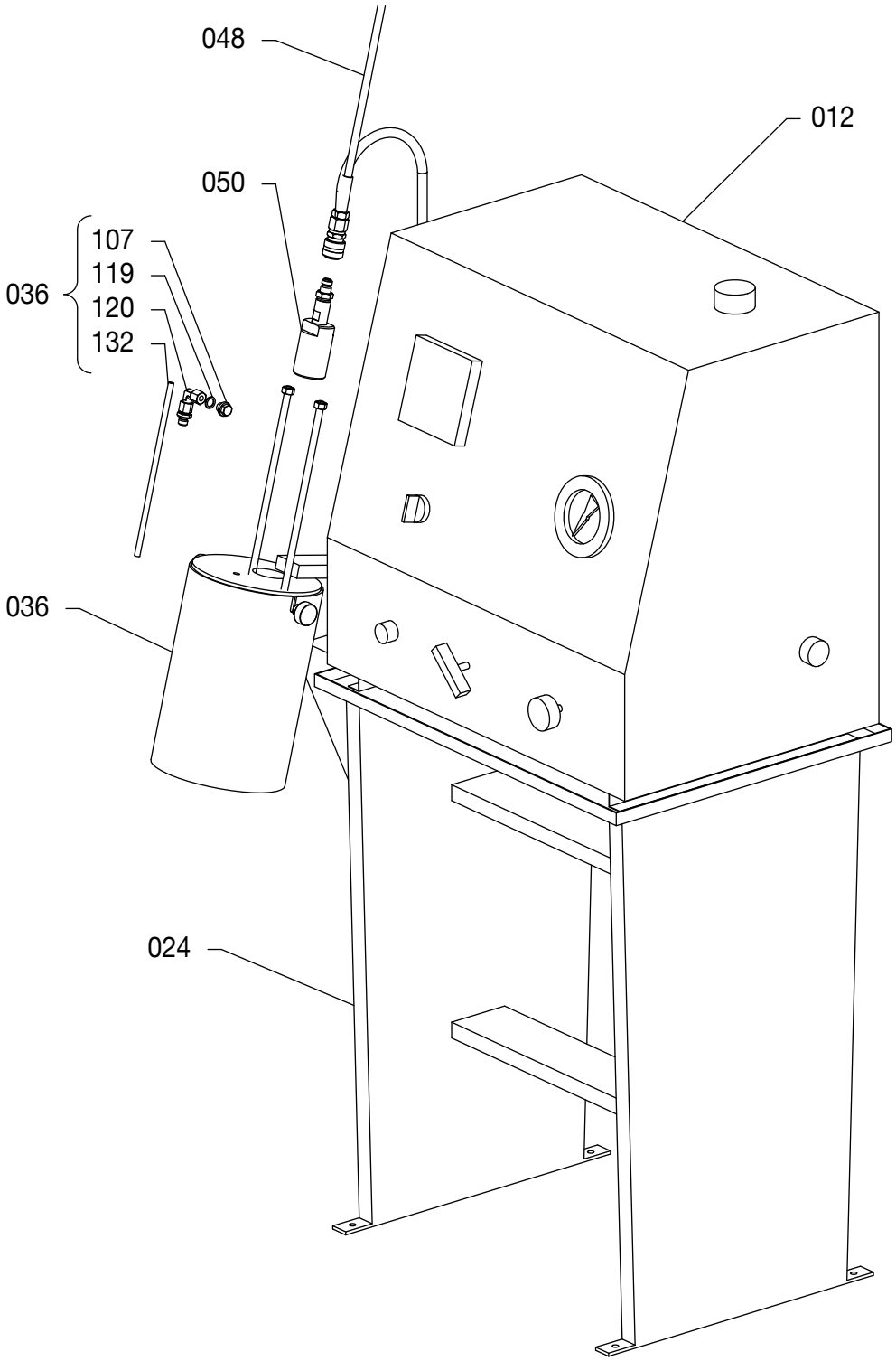


2011-08-18 - en

Item no	Qty	Designation
043	-	Twist drill for parallel*
055	-	Test mandrel*
067	-	Pin vice*
209	-	Cleaning tool set, complete

*Note: * When ordering new cleaning tool, please state P/N on fuel nozzle.*

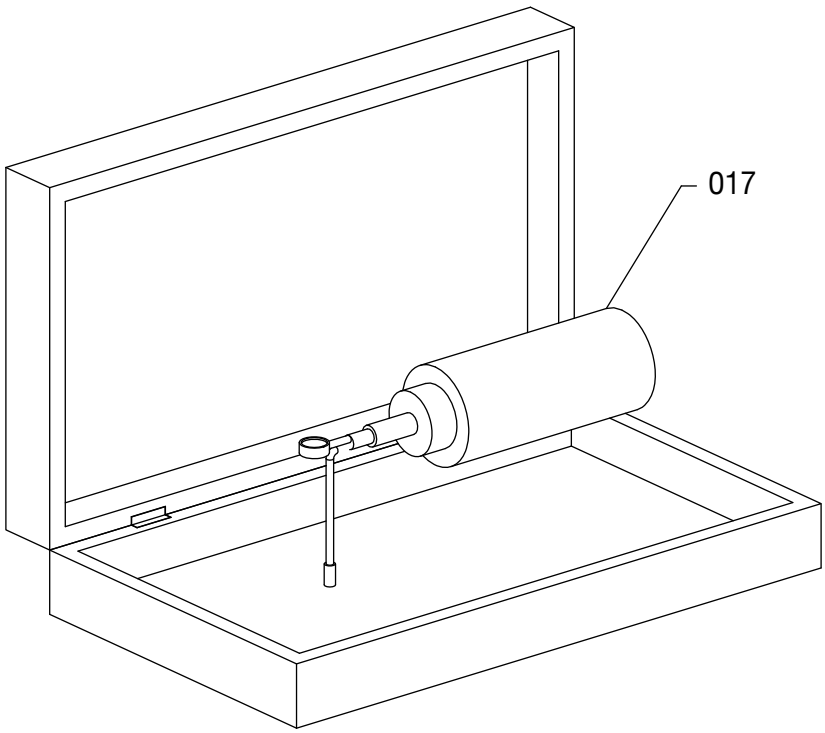
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Fuel Valve Testing Tools

Plate 4270-0220-0001.0

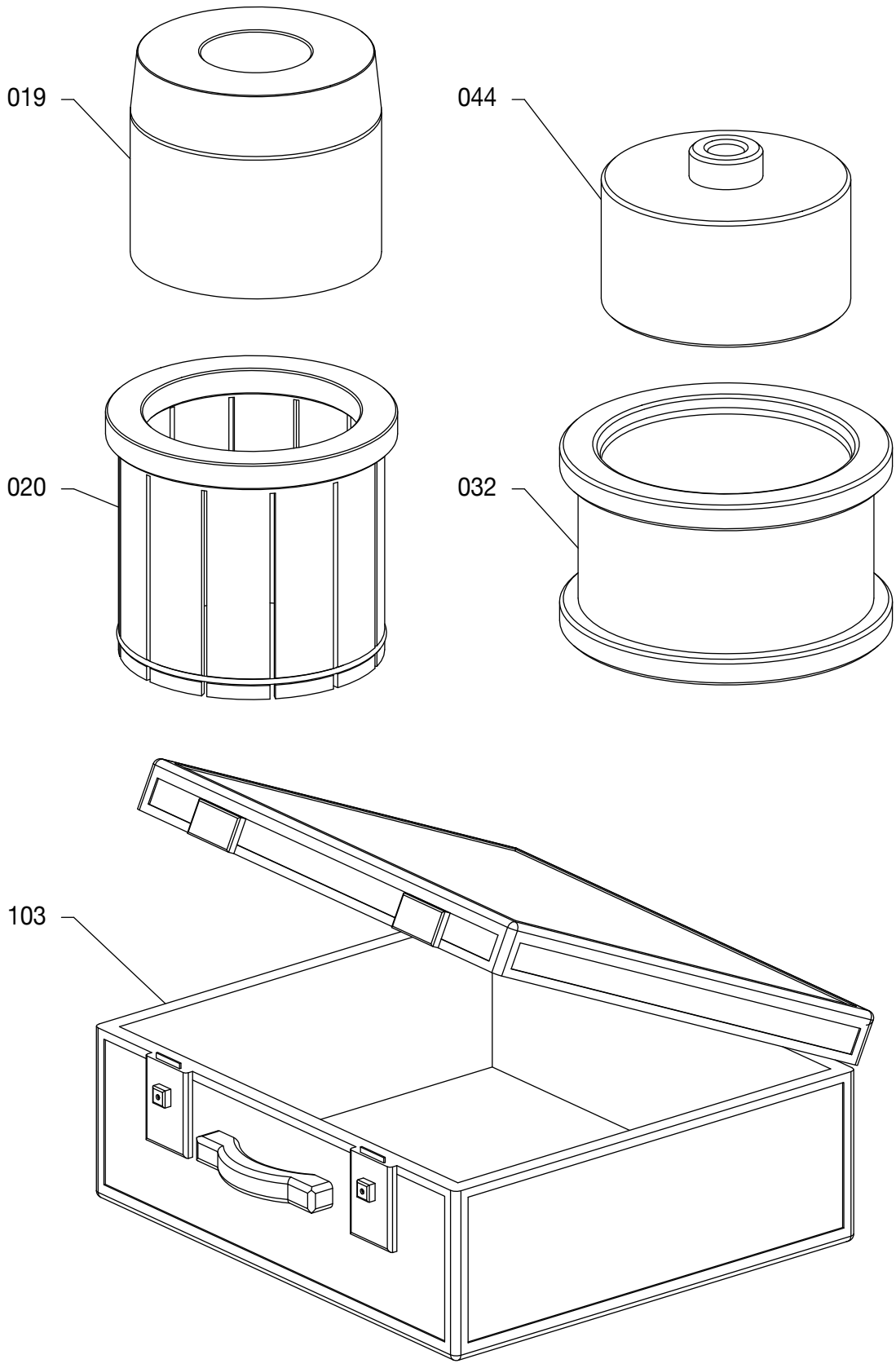
Item no	Qty	Designation
012	-	Pump, pneumatic and hydraulic
024	-	Worktable
036	-	Test rig, complete
048	-	Hose with unions
050	-	Thrust piece
107	-	Plug screw
119	-	Jacketed packing ring
120	-	Adjustable elbow coupling
132	-	Steel hose


017

Fuel Valve Inspection Tools

Plate 4270-0230-0001.0

Item no	Qty	Designation
017	-	Probelight



Fuel Pump Top Cover Tools

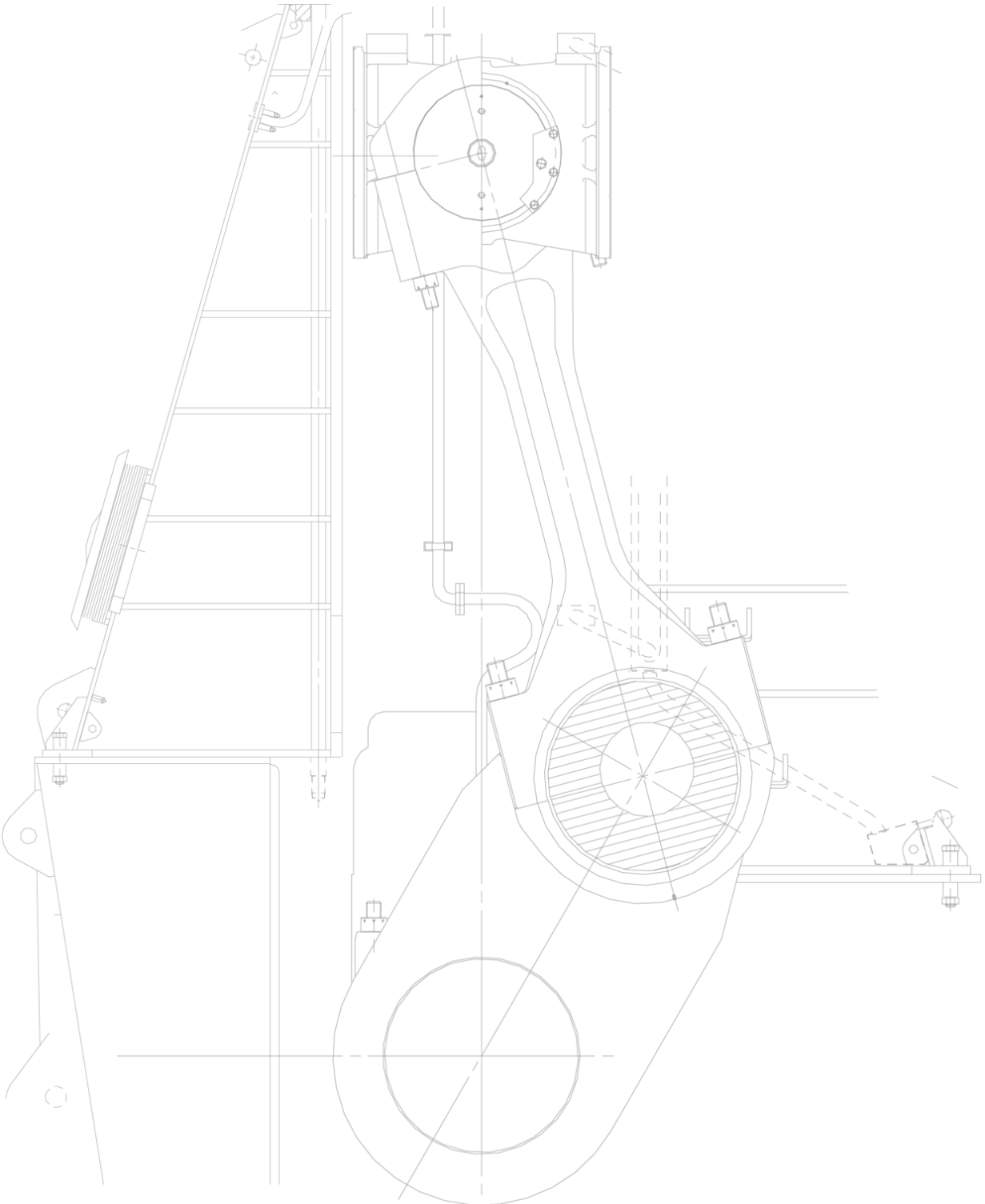
Plate 4270-0900-0001.0

Fuel Pump Top Cover Tools

Plate 4270-0900-0001.0

Item no	Qty	Designation
019	-	Cone for sealing ring
020	-	Pushing tool for sealing ring
032	-	Compression tool
044	-	Spacer ring
103	-	Tool box

Preface Chapter	Hydraulics	4540-0100-0002
Description	Hydraulic System ME Engine	4545-0150-0003
Drawing	EL Driven HPS, FIVA (3061145-2)	4555-0125-0001
	EL Driven HPS, FIVA (3061145-2)	4555-0125-0002
	Combined HPS, Common LPS, FIVA (take home pump) (3061154-7)	4555-0135-0001
	Combined HPS, Separat LPS, FIVA (take home pump) (3061155-9)	4555-0140-0001
	Gear Driven HPS, Common LPS ME Engine Version 5, Rexroth pumps	4555-0146-0002
	Gear Driven HPS, Common LPS ME Engine Version 5, Eaton Pumps	4555-0147-0002
	Leak Detection in Hydraulic System	4555-0150-0001
	Throttle Valve on Fuel Oil Pressure Booster	4555-0155-0002
	Drainholes in HCU Block	4555-0160-0001
	Level Switch on ME Cylinder Lubricator	4555-0165-0001
	Hydraulic Control Oil System (Separate LPS)	4555-0170-0001
	Piping	4555-0171-0002
Work Card	Exhaust Valve Actuator, Data	4565-0100-0003
	Exhaust Valve Actuator	4565-0101-0006
	Hydraulic Oil Pump, Data	4565-0200-0003
	Hydraulic Oil Pump	4565-0201-0004
	Hydraulic System, Data	4565-0300-0002
	Hydraulic System	4565-0301-0011
	Control Valves, Data	4565-0600-0002
	Control Valves	4565-0601-0004
	Hydraulic Power Supply Gearbox, Data	4565-1200-0001
	Hydraulic Power Supply Gearbox	4565-1201-0003
Tool Plate	Equipment for testing Accumulators	4570-0540-0001
	Accumulator Tools	4570-0550-0002
	Accumulator Tools	4570-0550-0004
	Accumulator Tools	4570-0550-0005
Plate	Exhaust Valve Actuator	4572-0100-0014
	Hydraulic Cylinder Unit	4572-0500-0016
	Hydraulic Cylinder Unit, Accumulator	4572-0550-0006
	Hydraulic Accumulator Block	4572-0700-0002
	Hydraulic Low-Pressure Supply System	4572-0800-0005
	Hydraulic High-Pressure Supply System	4572-0900-0005
	Hydraulic Power Supply Unit	4572-1000-0003
	Hydraulic Pump Station	4572-1100-0002
	Hydraulic Power Supply Gearbox	4572-1200-0001
	Hydraulic power supply gearbox, pipes	4572-1250-0013



Hydraulic Cylinder Unit

HCU

The Hydraulic Cylinder Unit (one per cylinder) consists of a distributor block, the electronically controlled fuel injection system and electronically controlled exhaust valve actuation.

FIVA

The design of the hydraulically-activated valve is similar to that on the MC engines, i.e. the exhaust valve is opened hydraulically and is closed by an 'air spring'. The Fuel Injection and Exhaust Valve Actuation fitted to each HCU consists of the FIVA 'on/off valve' and the two-stage hydraulic exhaust valve activator. The electronic FIVA 'on/off valve' (controlled by the ECS) opens the oil flow to the two-stage hydraulic actuator.

Exhaust Valve Actuator

The exhaust valve is closed by connecting the hydraulic piston to a drain via the FIVA valve and letting the air spring of the exhaust valve drive it to closed position. This movement also drives the pushrod oil back into the exhaust actuator preparing it for the next actuation.

Fuel Oil Pressure Booster

Each engine cylinder is equipped with its own fuel oil pressure booster, which is mounted corresponding to the cylinder concerned on the HCU. The booster housing is attached to the housing by studs and nuts.

Distributor Block

The distributor block serves as a mechanical support for the hydraulically-activated Fuel Oil Pressure Booster and exhaust valve actuator, each with an electronically controlled control valve, the FIVA valve.

The function of the distributor block is, as its name indicates, to distribute the hydraulic oil to the FIVA control valve mounted on the distributor block.

Accumulators

Fitted on the distributor block are hydraulic accumulators precharged with nitrogen. Their function is to ensure that the necessary hydraulic oil peak flow is available for the injection of fuel oil and actuation of the exhaust valve.

Manuel valves

Close to the FIVA valve are two manually operated valves. One valve connects the high-pressure inlet side while the other connects the accumulators to the bedplate (drain).

These manually operated valves are used to isolate individual HCUs during their overhaul. A manually activated valve connects the oil pushrod to its supply. This valve must be closed during overhaul of the exhaust valve.

Oil Filter

The main filter in the hydraulic power system is of the multi-cartridge, self-cleaning type, with automatic backflushing of the cartridges.

The backflushing of each cartridge is carried out with compressed air on a time basis, but is also activated if the pressure drop across the filter exceeds a certain level.

A redundant filter is mounted in parallel with the main filter and is used during overhaul of the main filter. Switching to the redundant filter and back again is done manually without interrupting the oil flow to the pumps.

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General

This chapter describes the system layout, components and operating principle of the hydraulic systems shown in Drawing 4555-0125, etc.

All position numbers are described and their intended use is explained.

Also shown is Drawing 4555-0150 used when detection of malfunctions and leaks in the hydraulic system can be useful (this document is general, and position numbers named in this document may not be used on your system).

1 ME Engine Concept and Mechanical Hydraulic System Layout

The ME engine concept primarily concerns the use of a mechanical hydraulic system for actuation of the fuel injection pumps and the exhaust valves, which are electronically controlled by a computer based control system. The starting air system is also controlled electronically by the ME control system.

Introduction of the hydraulic injection and exhaust actuation requires a hydraulic power supply, designed with all the necessary functionality needed. The hydraulic system used on the ME engine is outlined in the related diagrams on Drawing 4555-0125, etc.

With reference to these diagrams, the layout is explained in the following.

Main system lubricating oil is used as the hydraulic medium. The oil is filtered by the filter unit to the appropriate purity for use in an oil hydraulic system. The oil is then pressurised either by the Engine Driven Pumps or the Electrical Driven Pumps, when the engine is rotating, or by the Electrically Driven Pumps, when the engine is at standstill. In the Safety and Accumulator Block, pressurised oil is accumulated to ensure a stable oil supply to the Hydraulic Cylinder Units (HCU).

A HCU is fitted to each cylinder. The HCU comprises a distribution block, carrying the hydraulically activated Fuel Oil Pressure Booster and the exhaust valve actuator. The control valve the FIVA valve, and the necessary accumulators are mounted on the distributing block. The block connects the high-pressure oil supply to both the fuel oil injection system and the exhaust valve actuation system.

The fuel oil injection system consists of the hydraulically activated fuel oil pressure booster with associated control valve, high-pressure pipes and fuel valves.

The exhaust valve actuation system consists of an exhaust valve actuator with associated control valve, the oil push rod (high-pressure pipe), and finally the exhaust valve.

The fuel valves and the hydraulically activated exhaust valve itself are similar to those of the MC engines.

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The starting valves are pneumatically opened by activating the solenoid valves (ZV 1120 C, pos. 51) controlled by the Engine Control System, *see the related diagram "Pneumatic Manoeuvring System Diagram" Drawing 7055-0155.*

For cylinder lubrication, the ME Lube System is used, with lubricators located on the HCU.

2 Functional Description

2.1 Hydraulic Power Supply Unit

The function of the Hydraulic Power Supply (HPS) unit is to deliver the necessary high-pressure hydraulic oil flow to the fuel injection system and exhaust valve actuation when the engine is either at stand-by or running.

The HPS unit consists of:

2.1.1 Filter unit

2.1.2 Electrically driven start-up or start-up/back-up pumps

2.1.3 Engine driven pumps

2.1.4 Safety and accumulator block

2.1.5 High pressure piping

2.1.6 Drip pan with leak sensors

2.1.1 Filter Unit

The main filter (pos. 106) of the HPS unit is of the multi-cartridge, self-cleaning type with automatic back-flushing of the cartridges.

The back-flushing is performed with compressed air. It is effected regularly on a time basis, or if the pressure drop across the filter exceeds a pre-defined level.

A redundant filter (pos. 105) is installed in parallel with the main filter, and is used during overhaul of the main filter. Switching to the redundant filter and back is done manually without interrupting the oil flow to the pumps.

The butterfly valve (pos. 115) is closed during all normal service conditions. It is used in situations where cleaning of the entire supply of lubricating oil is required.

The ME filter unit has a 6 microns nominal mesh size. The redundant filter has 25 microns nominal mesh size. The conventional lubricating oil filter used for the engine has a nominal mesh size of 34 - 48 microns.

The ME filter is fitted with a differential pressure indicator and produces an output signal to activate an alarm if the pressure drop exceeds a certain limit.

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2.1.2 Electrically Driven Start-up or Start-up/Back-up Pumps

The Hydraulic power supply is available in three versions.

One version is the classic ME power supply where the hydraulic power is generated by engine driven pumps, and the start-up pressure is created by electrically driven pumps. The capacity of the start-up pumps is only sufficient to generate the start-up pressure. The engine cannot run with the engine driven pumps out of operation.

The second version is similar to version one, aside from the fact that the electrically driven start-up/back-up pumps have a capacity sufficient to give at least 15% engine power (Named “Combined”). The electric power consumption should be taken into consideration in the specification of the auxiliary machinery capacity.

The third version is the version with main Electrical Driven pumps all of the variable displacement type. In case when using 4-5 pumps one or two pumps is adjusted to 75% displacement all the time. During start-up one of the variable pumps is to be started one by one and when the engine has reached a predefined load the pump with full displacement will start. The number of pumps depending on the size of the cylinderbore.

The purpose of the electrically driven pumps is to ensure adequate hydraulic system pressure in situations where the main engine is not rotating, and thus not driving the engine driven pumps. The electrically driven pumps operate when there is no hydraulic oil consumption. Therefore, only a small capacity is needed, and the pumps are thus relatively small compared to the engine driven pumps.

The electrically driven pumps are either of the fixed or variable displacement type.

Following a situation where the system has been depressurised, for instance after an engine shutdown or a black-out, the electrically driven pumps must run for a certain period to build up an adequate system pressure for starting the engine. The length of this period is determined by the accumulator capacity in the system and the flow produced by the electrically driven highpressure pump.

When running with gear driven pumps, the pressure relief valves installed in the circuit limits the maximum pressure in the circuit and leads excessive oil back to the suction side of the pumps.

The operation of the high-pressure pumps is supervised by means of the pressure transducers (pos. 320).

2.1.3 Engine Driven Pumps

All engine driven, hydraulic oil pumps are of the variable displacement type and of the same size. The displacement is electronically controlled by the ECS via a built in control valve on the pumps.

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The pumps function when the engine is rotating, as they are mechanically driven by the gear assembly, which is permanently connected to the crankshaft. Their flow is determined by the actual displacement and rotational speed.

The pumps are designed to have two directions of rotation. This is necessary as most engines are reversible. Upon reversing of the engine, the displacement control of the ECS must activate the swash plate to keep the direction of the flow.

The engine driven pumps supply the hydraulic pressure for the engine when it is running.

In the event of failure of one pump, the remaining pumps are dimensioned to be capable of supplying sufficient hydraulic oil corresponding to 66% engine load.

In the event that the electric power to the pump displacement control valve is lost, the pump will mechanically go to maximum displacement in the AH direction. The non-return valves (pos. 215) are installed to protect the pump in case of the control system failing. The valve open and allow the pump to draw oil from the high pressure side and deliver the oil back to the suction side again.

2.1.4 Safety and Accumulator Block

The pre-charged accumulators of the Safety and Accumulator Block (on some newer engines the accumulators are mounted directly on the engine-driven pumps) are partly filled with a high pressure oil, ensuring a stable supply, without fluctuation, to the cylinder units.

The block contains pressure relief valves, which protects the high pressure system against excessive pressure.

The relief valves protect the electrically driven pumps and controls the maximum pressure in the system during pressure build-up before starting. This is done when operating on plants which require continuous boosting of the exhaust oil push rod (exhaust valve activation).

The valve (pos. 310) protects the engine driven pumps against a too high pressure. It is electrically controlled by the ECS and can be opened in different situations to feed the hydraulic oil back to the suction side of the engine driven pumps.

The valve (pos. 311) is the main system pressure relief valve protecting the entire system. This valve has the highest pressure setting of the relief valves (pos. 310, 311 and 312).

Non-return valves (pos. 304 and 305) are installed at the hydraulic oil outlet from the engine driven and electrically driven pumps, in order to prevent back-flow through any inactive pump.

The pressure transducers (pos. 320) are used by the ECS for controlling the engine driven and electrically driven pumps.

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The non-return valves (pos. 215) are related to the operation of a failing engine driven pump described above.

Pressure relief valves (pos. 310, 311 and 312) have safety functions as described above. The electrical actuation of the valves pos. 310 is duplicated (not shown on the diagram) to allow redundant control as implemented in the ECS.

2.1.5 High Pressure Piping

The hydraulic oil pipes between the Hydraulic Power Supply unit and the Hydraulic Cylinder Units employ piping or hoses. Single wall piping is also used for high pressure pipes between the individual HCU units.

On Drawing 4555-0171 the single wall pipe design is shown.

2.1.6 Drip pan with leak sensors

A drip pan is located just below the hydraulic power supply unit to collect leaking oil and lead it to a drain. In the drip pan, two leak detecting level switches (pos. 360 and 361) are installed. A small, yet significant leak from the HPS will, due to the restriction in the outlet, cause the level in the drip pan to rise and be detected by the lower level switch (pos. 360). This situation will activate an alarm. A severe leak will also be detected by the higher switch (pos. 361) and cause the ECS to shut down the engine.

3 Hydraulic Cylinder Unit

The Hydraulic Cylinder Unit (one per cylinder) consists of a distribution block, an electronically controlled fuel injection system and an electronically controlled exhaust valve actuation system. The distribution block serves as a mechanical support for the hydraulically activated fuel oil pressure booster (pos. 500) and exhaust valve actuator (pos. 515), each with their electronically controlled control valve ELFI/ELVA or common FIVA, respectively.

4 Distribution Block

The function of the distribution block, as its name implies, is to distribute the hydraulic oil to the ELFI/ELVA or FIVA control valves mounted on the distribution block.

Nitrogen pre-charged hydraulic accumulators (pos.450) are fitted on the distribution block. Their function is to ensure that the necessary hydraulic oil peak flow is available for injection of fuel oil and actuation of the exhaust valve.

Close to the ELFI/ELVA or FIVA valves, are two manually operated valves. One valve connects the high pressure inlet side (pos. 420) and the other (pos. 421) connects the accumulators to the bedplate (drain).

These manually operated valves are used for separating and blocking off the HCUs during overhaul.

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WARNING

To protect the accumulators from unnecessary stresses (fast accelleration of the membrane) and oil jets, the valve Pos. 420 must not be opened when the oil system is pressurized.

After check/overhaul or whatever situation where the valve Pos. 420 has been closed the opening procedure is:

1) The engine must be stopped (no oil pressure).
2) Open/Close all valves into normal running position.
3) Pressurise the system by starting the Start-up pumps.

The manually activated valve (pos. 531) connects pressure supply to the oil push rod. The valve must be closed during overhaul of the exhaust valve.

5 Electronically Controlled Fuel Injection

The electronically controlled fuel injection system consists of the hydraulically activated fuel oil pressure booster, its controlling valve (ELFI or FIVA) and the fuel valves.

The ELFI or FIVA valve (controlled by the ECS) is capable of fast and precise control of the oil flow to the fuel oil pressure booster. This oil flow pushes the hydraulic piston (pos. 502) and the fuel injection plunger (pos. 504), generating the injection pressure and hence, the injection.

When the injection is finished, the plunger and piston are returned to their starting positions by connecting the piston to a drain and driving the plunger back by means of the pressure in the fuel supply. The fuel oil pressure booster is then filled and ready for the next injection.

The design principle of the high pressure pipes and fuel valves is similar to that of the MC engines. The fuel system permits continuous circulation of the heated heavy fuel oil through the fuel oil pressure boosters and fuel valves. This keeps the system heated during engine standstill.

6 Functional description of the Throttle Valve on the Fuel Oil Pressure Booster

As seen in *Drawing 4555-0155*, a throttle valve is situated at the bottom of the Fuel Oil Pressure Booster Housing.

Via a bore from the housing bottom, the oil space underneath the Fuel Oil Pressure Booster Piston is vented through the throttle valve.

A small bore in the throttle valve piston ensures ventilation of the oil space at engine standstill (no oil pressure and low oil pressure at start-up), thereby keeping the engine ready for start without having to ventilate the system.

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When the Fuel Oil Pressure Booster is activated by the FIVA valve, the oil pressure in the space underneath the Fuel Oil Pressure Booster will rise significantly to lift the piston. At the same time, the high pressure oil will overcome the resistance of the spring in the throttle valve and the piston in the throttle valve will close.

In this way the oil amount vented from the space underneath the main piston is kept very low.

7 Electronic Exhaust Valve Actuation System

The design of the hydraulically activated exhaust valve is similar to that on the MC type engines, i.e. the exhaust valve is opened hydraulically and it is closed by an “air spring”.

The actuator system fitted to each HCU consists of the ELVA or FIVA and the two-stage hydraulic exhaust valve activator.

The electronic ELVA or FIVA (controlled by the ECS) opens for the oil flow to the two-stage hydraulic actuator.

In the first stage the activation piston (pos. 517) is driven by the hydraulic pressure acting on both the activation piston itself and the hydraulic piston (pos. 516). The first stage performs the initial valve opening against the cylinder pressure. In the second stage the movement of the hydraulic piston is stopped, and the activation piston performs the second stage, lower force, main stroke of the exhaust valve alone.

The exhaust valve is closed by connecting the activation piston to a drain via the ELVA or FIVA valve and letting the air spring of the exhaust valve drive it to closed position. This movement also drives the push rod oil back into the exhaust actuator, preparing it for the next actuation.

The HCU design ensures that a failing HCU can be disconnected from the high pressure system by manually operated valves, thereby enabling repair work while the engine is running on the remaining cylinders.

In the case that the control signal for the ELFI or FIVA valve is missing (pressurised or non-pressurised system), the control spring will position the valve so that the hydraulic piston oil from the space below is connected to tank. This is the fail-safe position, where the main spool in the FIVA is moved to the position Cfi to T, Cva to P.

With regard to the safety of the ship’s personnel and the engine, the highpressure fuel pipes are, as on the MC type engines, shielded by steel braiding.

8 Components

Pos. 101
Butterfly valve. Normally open. Used for shutting-off to the filter during overhauls at standstill.

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Pos. 103
Double stage, 3-way cock. Situated between the Automatic back flushing filter and the Stand-by filter. Used when Automatic filter elements are to be cleaned manually during normal engine running.

Pos. 104
Mini-mess valve installed at the filter unit inlet (For mounting of portable pressure gauge).

Pos. 105
Single filter. 25 microns filter mesh.

Pos. 106
Automatic back flushing filter. Boll filter. The main purpose of this filter is to keep the hydraulic oil clean, thereby avoiding small particles damaging movable parts of the hydraulic components. 6-microns filter mesh. 10-microns filter mesh on the first engines built (2003 - 2005).

Pos. 107
Mini-mess valve installed at the filter unit outlet (for connection of portable pressure gauge).

Pos. 108
Mini-mess valve installed at the system inlet. (for connection of portable pressure gauge).

Pos. 110
Rubber Compensator (optional).

Pos. 115
Butterfly valve. Normally closed. Used during flushing at the commissioning of the engine. Used after major overhauls and when found necessary.

Pos. 130
A pressure transducer measuring the oil pressure on the suction side of the main supply pumps. The output from the transducer is sent to the ECS of the engine. The suction pressure is continuously shown on the HPS screen on the MOP. An alarm is activated if the suction pressure is too low.

Pos. 131
An orifice, ø 0.5 mm, for previously mentioned pressure transducer (130) is installed to protect the transducer against pulsations and ensure a steady amount of oil to the transducer.

Pos. 155
Mini-mess valve installed in the low-pressure line (for connection of portable pressure gauge).

Pos. 201
High pressure Axial Piston Pumps. Type Rexroth A4VSO. Driven mechanically either by a gear or electric motors.

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Pos. 202
Mini-mess valve installed in the low pressure inlet before the pump (for connection of portable pressure gauge).

Pos. 203
Mini-mess valve installed in the high pressure pump outlet (for mounting of portable pressure gauge).

Pos. 204
Line break valve. Normally open. The valve protects the system in case of pilot line (Sp) failure.

Pos. 205
Safety coupling (el-motor, gear – Rexroth pump).

Pos. 206
Electric motor (driving the Rexroth pump).

Pos. 210
Electronically controlled proportional valve situated on the high pressure pump. The proportional valve controls the oil amount delivered by the pump. This is done by changing the swash plate angle. The larger the angle the more oil is delivered, a smaller angle gives less oil.

Pos. 210-2
On/Off valve for pump Nos.4 and 5 only. Only engines with more than 3 (three) engine driven pumps.

Pos. 215
Check valve – cartridge. Non return valve in use when the pump draws from the pressure side of the system (not used on engines with only electrically-driven pumps).

Pos. 220
A positional transducer situated on the pump. The transducer sends an electric current corresponding to the swash plate angle of the pump, thereby telling the ECS the exact amount of oil circulated by the pumps.

Pos. 226
(Only used on very few 1. edition ME engines). Pressure transducer on the start-up pump unit.

Pos. 227
(Only used on very few 1. edition ME engines). Orifice for pressure transducer pos. 226 above.

Pos. 230
Butterfly valve on the high pressure pump suction side. Normally open.

Pos. 235
Check valve. Only to be found in “Combined HPS” systems, and few “Gear Driven HPS” systems.

Pos. 236
Check valve. Only to be found in “Combined HPS” systems, and few “Gear Driven HPS” systems.

Pos. 240
Orifice. This component is only to be found in “Combined HPS” systems, and few “Gear Driven HPS” systems.

Pos. 241
Orifice. This component is only to be found in “Combined HPS” systems, and few “Gear Driven HPS” systems.

Pos. 276
Mini-mess valve installed on the start-up pump pressure side.

Pos. 277
Start-up pump. This position number is only shown on hydraulic diagrams for engines with “Combined HPS” systems where it is possible to use the start-up pumps as Back-up Pumps.

Pos. 277a
Throttle valve. This valve is only installed in connection with start-up pumps in “Combined HPS” systems where it is possible to use the start-up pumps as Back-up Pumps.

The valve is normally open and used in cases where failure on engine driven pumps or gear for engine driven pumps might occur. By manually closing this throttle valve, the pressure control function change from pressure relief valve 277b (adjusted to 225 bar) to pressure relief valve 277c (adjusted to 310 bar). In this way the oil amount delivered from the electrically driven Start-up/Back-up Pumps ensures a running of the engine at approximately 15% load (back-up power).

Should a failure situation occur, we recommend that you contact MAN Diesel & Turbo for a special running procedure for your specific engine.

Pos. 277b
Pressure relief valve. This relief valve is only installed in connection with start-up pumps in “Combined HPS” systems where it is possible to use the start-up pumps as Back-up Pumps. The valve function is as described under pos. 277a.

Pos. 277c
Pressure relief valve. This relief valve is only installed in connection with start-up pumps in “Combined HPS” systems where it is possible to use the start-up pumps as Back-up Pumps. The valve function is as described under pos. 277a.

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Pos. 278
Electric motor. This position number does only appear on the “Combined HPS” systems where it is possible to use the start-up pumps as Back-up Pumps.

Pos. 279
Coupling house. This position number does only appear on the “Combined HPS” systems where it is possible to use the start-up pumps as Back-up Pumps.

Pos. 280
Coupling. This position number does only appear on the “Combined HPS” systems where it is possible to use the start-up pumps as Back-up Pumps.

Pos. 280a
Coupling part. This position number does only appear on the “Combined HPS” systems where it is possible to use the start-up pumps as Back-up Pumps.

Pos. 285
Inlet valve at start-up pump unit. Normally open. The valve does only exist in “Gear driven HPS and FIVA” systems and ELFI and ELVA systems.

Pos. 304
Non-return valve. The non return valve is installed on the high pressure side of the pumps to separate the pump from the pressure side. The forces in the oil in pipe P2 is extremely high during normal running (pressure is high, oil amount is high, forces in accumulators are high).

Should an electric motor, driving one of the pumps, suddenly stop (electric failure, broken clutch) the forces from the other pump, together with the forces mentioned above, will try to force the stopped pump in the wrong direction creating a violent stress and possibly destroying the pump. This is avoided when the nonreturn valve closes immediately after pressure drop at pump standstill.

Pos. 305
Non-return valve. The nonreturn valve (placed by the accumulator block inlet) is installed on the start-up pump pressure side to protect the pump against high pressure when the engine is running on the engine driven pumps.

Pos. 309
Check valve – cartridge. Non return valve.

Pos. 310
Pressure relief valve (opening pressure 310 bar)

Pos. 310a
Pilot valves arrangement situated on pos. 310 pressure relief valve.

Pos. 310b
Orifice.

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Cyl. Bore	50	60	65	70	80	90	98	cm
Orifice dia.	8	10	10	12	15	18	22	mm

Pos. 311
Pressure relief valve. Normally closed. The pressure relief valve is mechanically adjusted to an opening pressure of 315 bar. If the pressure rises above 315 bar, the relief valve will open and lead the oil:

- the main tank (when running with electrically driven pumps).
- or
- the suction line (when running with gear driven pumps).

Pos. 312
Pressure relief valve. Normally closed. The pressure relief valve is mechanically adjusted to an opening pressure of 225 bar. The valve does only exists in ELFI and ELVA systems and “Gear driven HPS and FIVA” systems.

Pos. 315
Ball valve. Normally closed. Used when the system needs to be drained off during repairs, etc.

Pos. 316
Ball valve. Normally closed.
Must be opened for adjustment of pressure relieve valve 310.

Pos. 320
Pressure transducers. The system is supplied with three (3) transducers for redundancy reasons. During normal running, all three transducers send an analogue signal to the ECS. The average value is shown on the MOP.

Pos. 321
An orifice, ø 0.5 mm for the above pressure transducers (320), is installed to protect the transducers against pulsations and ensure a steady amount of oil to the transducers.

Pos. 335
Accumulators. Mounted on the Safety and Accumulator block or directly on the engine driven pumps to avoid oil pulsations in the hydraulic system and keeping the oil pressure steady at all engine loads. Manufacturer: HYDRO LEDUC.

Pos. 339
Mini-mess valves mounted at the main high pressure pipe (P1) for measuring the system pressure (for connection of portable pressure gauge). The valve does only exists in ELFI and ELVA systems and “Gear driven HPS and FIVA” systems.

Pos. 340
Mini-mess valves installed in the main high pressure pipe (P2) for measuring the system pressure. (for connection of portable pressure gauge). The valves does only exist in “Combined HPS and FIVA” systems and “El-driven HPS and FIVA” systems. Both with and without separate LPS.

Pos. 355
Leak indicator. In the event of a leak from the inner pipe, and the amount is high

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enough so that the small reservoir is filled, an alarm will be activated. This will not affect the running of the engine. However, but the engineer is now warned about the leak (searching for leaks is described in the procedure attached this document).

Pos. 360
Leak indicator. The Hydraulic Supply Unit is enclosed in a cabinet protecting against forceful oil spray if a leak should occur. In the event of a minor oil leak occurring inside the cabinet, a drip pan placed in the bottom of the cabinet will be filled and an alarm will be activated. The drip pan is fitted with an overflow pipe with a diameter size and a height in the drip pan that match the oil amount allowed to leak. This will not interferie with a safe oil delivery to the hydraulic system.

Pos. 361
Leak indicator. If the leakage described in Pos. 360 above increases, the drip pan will fill, and shut down of the engine will occur.

Pos. 405
Drain valve. Normally closed. Drain of oil to tank during repairs on HCU block. Opposite Drain valve 405 (see drawing). Return oil from the HCU block (during normal running) is led back to the main tank via an overflow pipe. This overflow ensures that the HCU block and the attached components are 'vented' and 'flooded' at all times.

Pos. 406
Drain valve.

Pos. 420
Inlet valve. Normally open. Main supply valve of highpressure oil to ELFI, ELVA or FIVA valves

WARNING

To protect the accumulators from unnecessary stresses (fast accelleration of the membrane) and oil jets, the valve Pos. 420 must not be opened when the oil system is pressurized.

After check/overhaul or whatever situation where the valve Pos. 420 has been closed the opening procedure is:

1) The engine must be stopped (no oil pressure).
2) Open/Close all valves into normal running position.
3) Pressurise the system by starting the Start-up pumps.

Pos. 421
Drain valve. Normally closed. Drain used during maintenance of ELFI/ELVA, Fuel Oil Pressure Booster, Exhaust Valve Actuator, Accumulators.

Pos. 425
Mini-mess valve fitted on the HCU block measuring the system pressure (for connection of portable pressure gauge).

Pos. 440
ELFI Valve or FIVA valve. ELectronic Fuel Injection valve or Fuel Injection Valve Actuation valve, which is capable of fast and precise control of the hydraulic oil flow to the fuel pump. The oil flow acts on the hydraulic piston and fuel injection plunger, generating the fuel injection pressure and hence the injection. Manufacturer: Curtis-Wright, Parker Hannifin, MAN Diesel & Turbo.

Pos. 445
Electric Linear Motor driving the ELFI valve (proportional type) and the fuel injection part in the FIVA valve. Manufacturer: Curtis-Wright.

Pos. 450
Accumulators. Mounted on the HCU block to boost flow during fuel injection and exhust valve opening. See section 4 in this description. Manufacturer: HYDRO LEDUC.

Pos. 455
Mini-mess valve fitted on the HCU block measuring the oil pressure at the inlet to the ELFI and FIVA valve (for connection of portable pressure gauge).

Pos. 456
Mini-mess valve fitted on the HCU block measuring the oil pressure at the inlet to the ELVA valve (for connection of portable pressure gauge).

Pos. 465
Mini-mess valve fitted on the HCU block measuring the oil pressure at the outlet from the HCU block (for connection of portable pressure gauge).

Pos. 470 ELVA valve. ELectronic Exhaust Valve Activation valve opens for the oil flow to the two-stage hydraulic actuator, which drives the pushrod oil to open the exhaust valve.
Manufacturer: Curtis-Wright

Pos. 475
High Response Valve. The High Response Valve is an electric on/off valve driving the ELVA valve.
Manufacturer: Curtis-Wright

Pos. 480
Airing Orifice.

Pos. 500
Fuel Oil Pressure Booster.

Pos. 501
Positional Transducer. Inductive sensor measuring the movement off the fuel plunger in the fuel oil pressure booster. Raises an alarm if the plunger movement is slower/faster than a predefined value stated in the ECS. The sensor has no influence on the opening/closing timing of the ELFI valve.

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Pos. 502
Hydraulic piston.

Pos. 503
Umbrella.

Pos. 504
Fuel plunger.

Pos. 505
Fuel injection pipes.

Pos. 510
Fuel injection valves.

Pos. 515
Exhaust Valve Actuator.

Pos. 516
Hydraulic piston.

Pos. 517
Activation piston.

Pos. 520
High Pressure Pipe (push rod pipe).

Pos. 525
Exhaust Valve Top.

Pos. 526
Positional Transducer. Inductive sensor measuring the movement of the exhaust valve spindle. Activates an alarm if the spindle movement is opening too low or slower/ faster than a predefined value stated in the ECS. The sensor has no influence of the opening/closing timing of the ELVA valve.

Pos. 527
Check valve. Non return valve from exhaust valve top outlet.

Pos. 528
Orifice from exhaust valve top inlet.

Pos. 530
Non-return valve. Oil from the Low Pressure System is always delivered to the High Pressure Pipe. Due to system leakage, the valve ensure the actuator piston to return to "start-position" after exhaust valve actuation. (see also Pos. 541).

Pos. 531
Supply valve. Normally open. See Pos. 530 above. This valve must be closed during overhaul of the Exhaust Valve Actuator and High Pressure Pipe. Also to be closed if FIVA valve is changed.

Pos. 540
Mini-mess valve fitted on the Exhaust Valve Actuator top measuring the oil pressure in the High Pressure Pipe (for connection of portable pressure gauge).

Pos. 541
(Only some ME engines). Orifice ø1.0 mm. The Exhaust Actuator is equipped with 3 (three) drains.

The lower drain pipe drains the space between the Hydraulic Piston (516) and the Activation Piston (517). Although the tolerances between the piston and the liner in the Exhaust Valve Actuator are very narrow, a very small amount of oil will always escape through this drain.

The upper drain drains the High Pressure Pipe during overhauls. The amount of oil in the High Pressure Pipe is rather high and oil spill will be too high if the pipe is loosened and removed too quickly. There will also be substantial cleaning after overhaul. This drain drains the oil from the High Pressure Pipe to the main tank. When the bolts at the top flange of the High Pressure Pipe are loosened and a light push loosens the pipe (so that air can escape) the oil will (in a few minutes) be drained to the tank.

The middle drain is designed with an orifice (541). This orifice ensures a stable change of the oil in the top of the actuator. The movement and damping of the oil in the actuator generates thermal energy in the top section of the actuator. This energy results in an oil temperature rise (that may be harmful and stress the material), which can be removed by changing a small amount of oil in the top of the actuator.

Pos. 545
Mini-mess valve fitted in the Exhaust Valve Actuator bottom for measuring the oil pressure activating the actuator activation piston (for connection of portable pressure gauge).

Pos. 550
Mini-mess valve fitted in the Fuel Oil Pressure Booster bottom measuring the oil pressure activating the Fuel Oil Pressure Booster hydraulic piston (for connection of portable pressure gauge).

Pos. 555
Leak Indicator. Placed underneath the drip pan for all HCU units. An alarm will be activated if an oil leak is too large.

Pos. 560
Connection valve. Normally open. Must be closed when working on cylinder lubricators.

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Pos. 565
Mini-mess valve fitted in the HCU block measuring the oil pressure activating the ME cylinder lubricator (for connection of portable pressure gauge).

The valve exists in all hydraulic systems – except the ELFI and ELVA systems.

Holes Pos.701, 702 and 'not numbered' (not shown on diagrams)

Functional description of drain holes Pos. No. 701, 702 and 'not numbered' all situated on both front-end and aft-end of the HCU Block.

As seen on Drawing 4555-0160, the HCU blocks have 3 drain holes on the sides. 702 on the aft end side and hole 701 and hole 'not numbered' on the fore end side. (Engines with port side manoeuvring side)

The hole 701 is a drain/peep hole connected through bores to the underside of the Fuel Oil Pressure Booster. Should the inner sealing ring under the Fuel Oil Pressure Booster leak, system oil is detected in the drain 701.

The hole 'not numbered' is a drain/peep hole from the drain surrounding the Fuel Oil Pressure Booster. (Eventually leaking oil is collected here and drained away to avoid oil filth)

The hole 702 is a drain/peep hole connected through bores to the underside of the Exhaust Valve Actuator. Should the sealing ring under the Exhaust Valve Actuator leak, system oil is detected in the drain 702.

ME Cylinder Lubricator (no pos.number)

Functional description of the Level Switch located on the HCU Block at the inlet pipe to the Cylinder Lubricator on ME Engines. (Inclusive the 3-way cock fitted on the inlet pipe to the Level Switch).

As shown on Drawing 4555-0165, a level switch is placed on the cylinder lubricating oil inlet pipe to the cylinder lubricator.

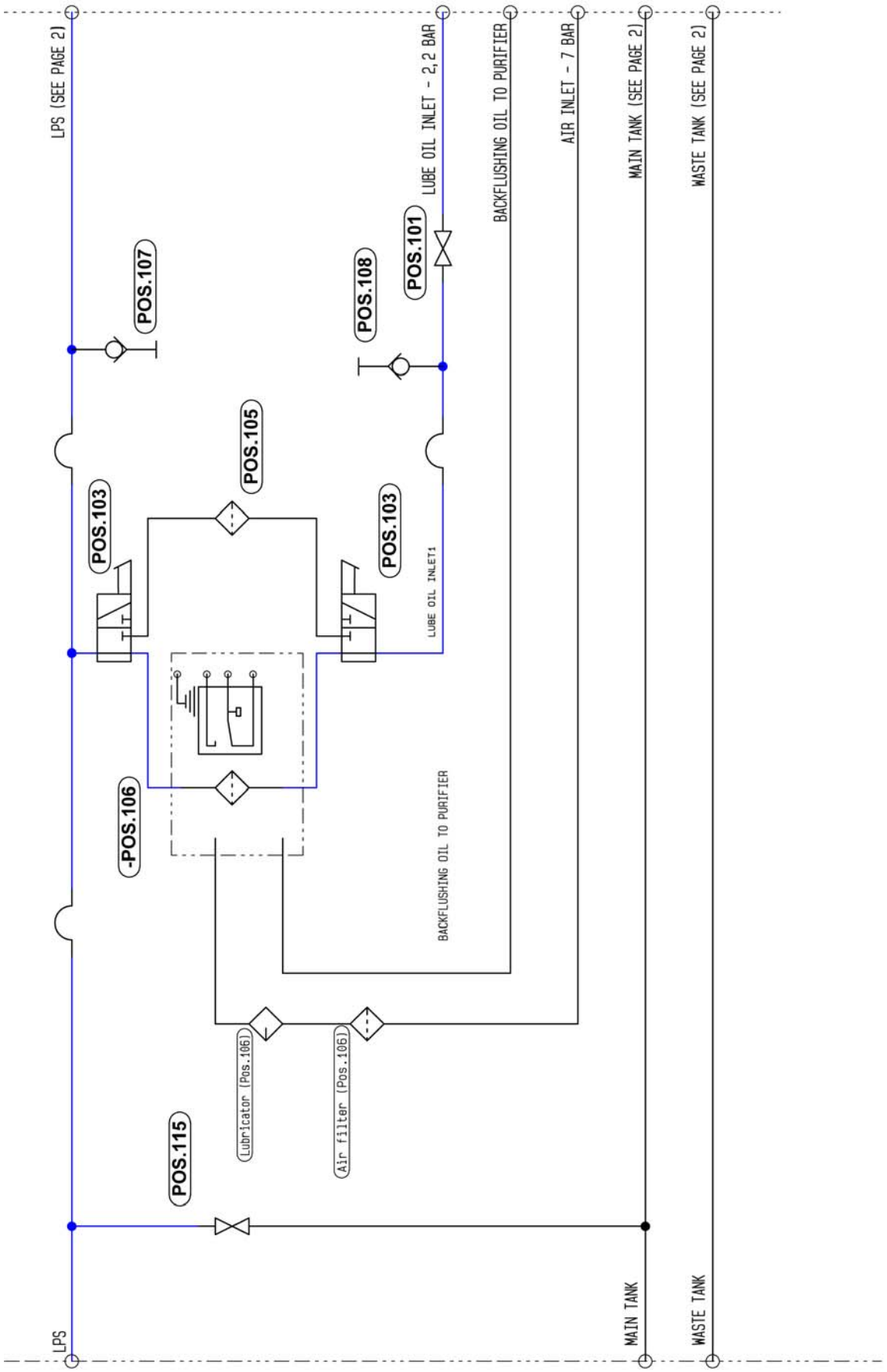
The function of the level switch is to keep the lubricator filled and ensure an oil flow to the lubricator at all times. If the feeler in the level switch is exposed (low oil level in the house) an alarm will be activated and a slow-down of the engine will occur.

The force of gravity and heated inlet lubricating oil pipes from the gravity tank to the lubricators keep the level switch and, thereby, the lubricator filled. The lubricating oil is kept at 45 degrees Celcius in the tank, and the inlet main pipe is insulated and heat traced to keep the same temperature at the inlet of the lubricator on the HCU block.

The 3-way cock on the inlet pipe before the level switch is closed when overhauling the lubricator (or level switch). When closing the 3-way cock, the level switch is vented to open air to ensure that the level switch and inlet pipe to the lubricator is pressure free and empty before overhaul (at the same time, the alarm is activated and the slow down function is checked).

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If the 3-way cock is closed by mistake during engine running, the venting to open air will ensure (because of normal consumption) that an alarm of no cylinder lubrication in the lubricator concerned is activated.



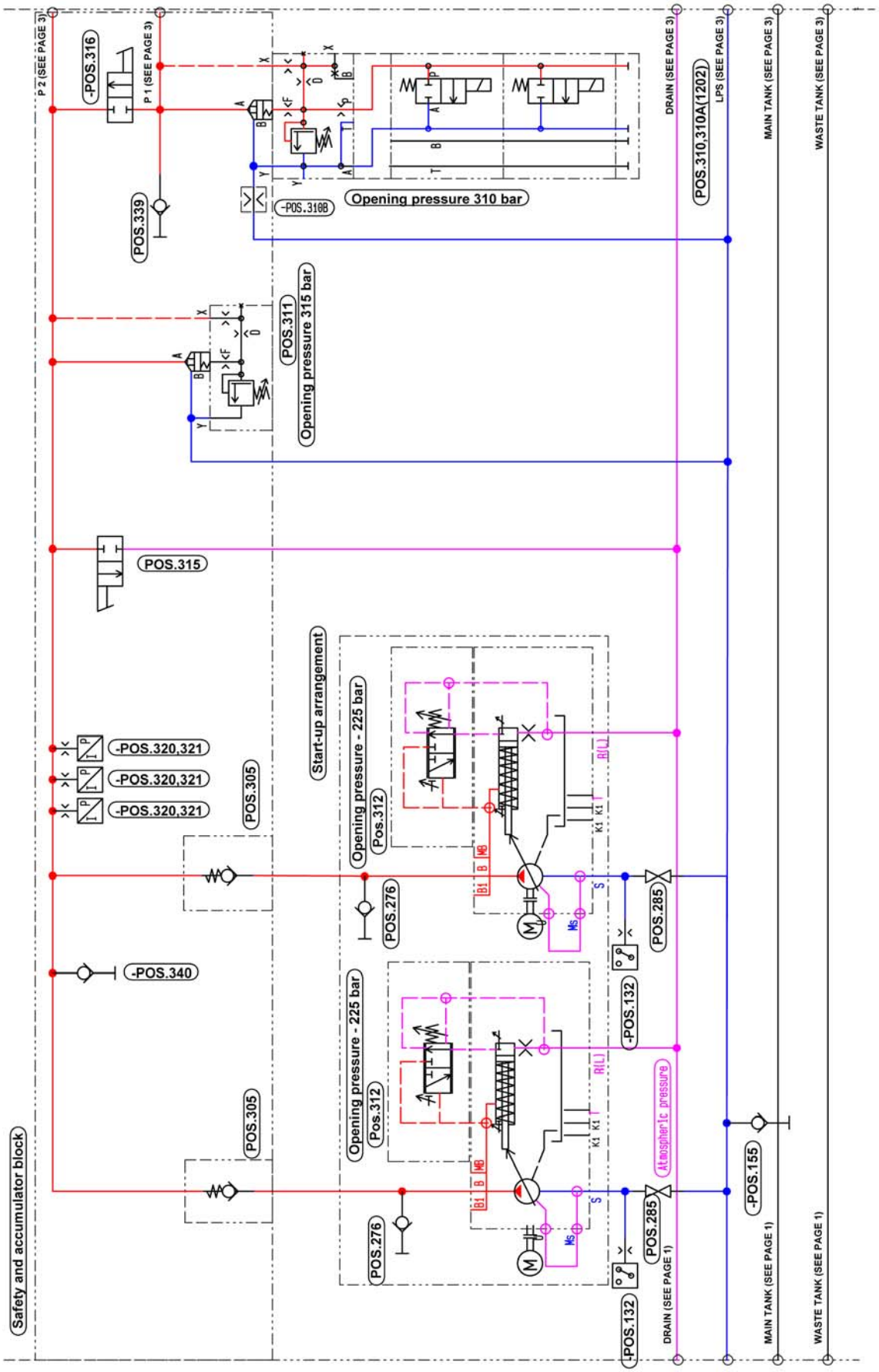
Drawing
4555-0146-0002

Gear Driven HPS and FIVA, Common LPS, ME Version 5, Rexroth Pumps - 300 bar

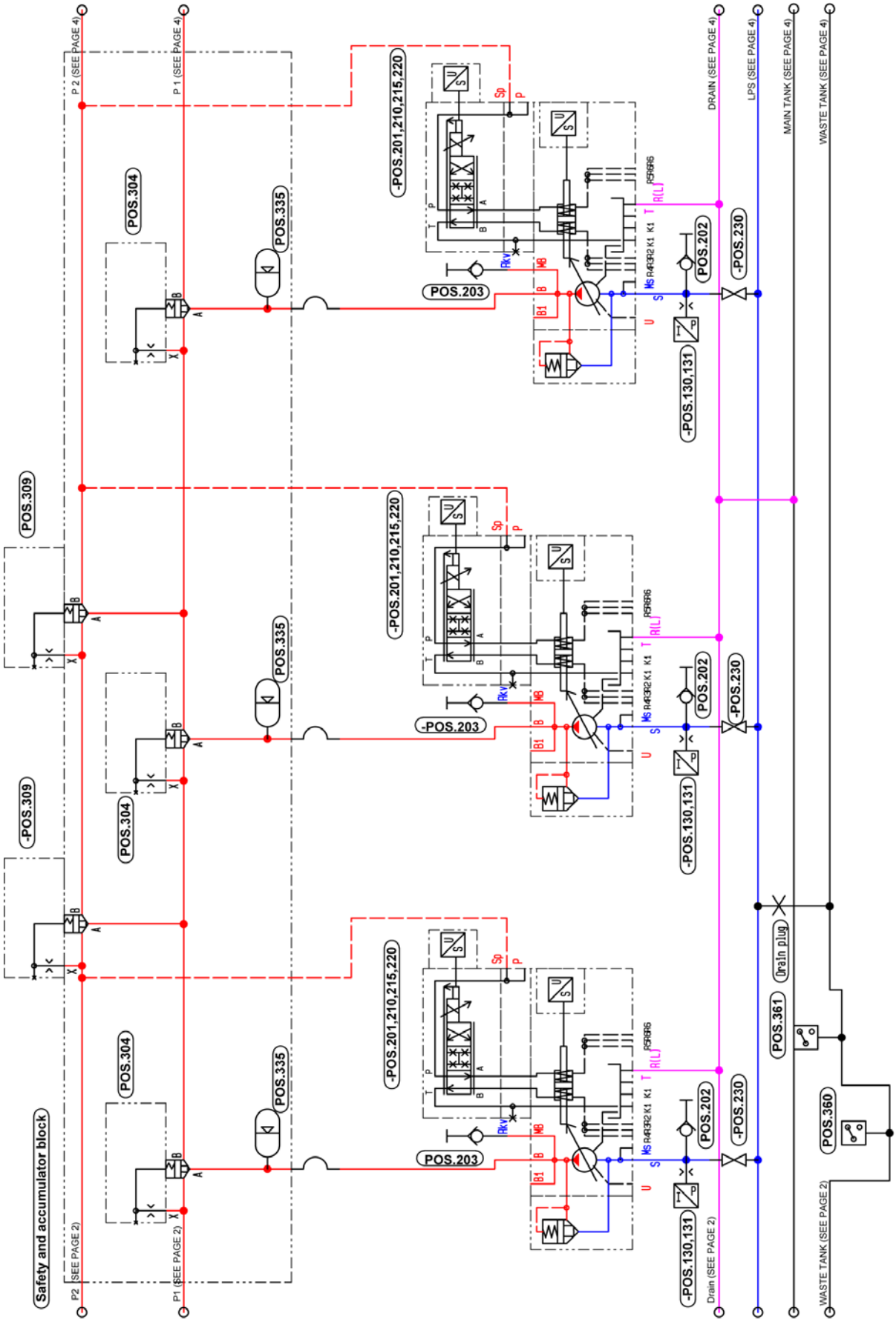
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Drawing
4555-0146-0002

Gear Driven HPS and FIVA, Common LPS, ME Version 5, Rexroth Pumps - 300 bar



2012-11-26 - en



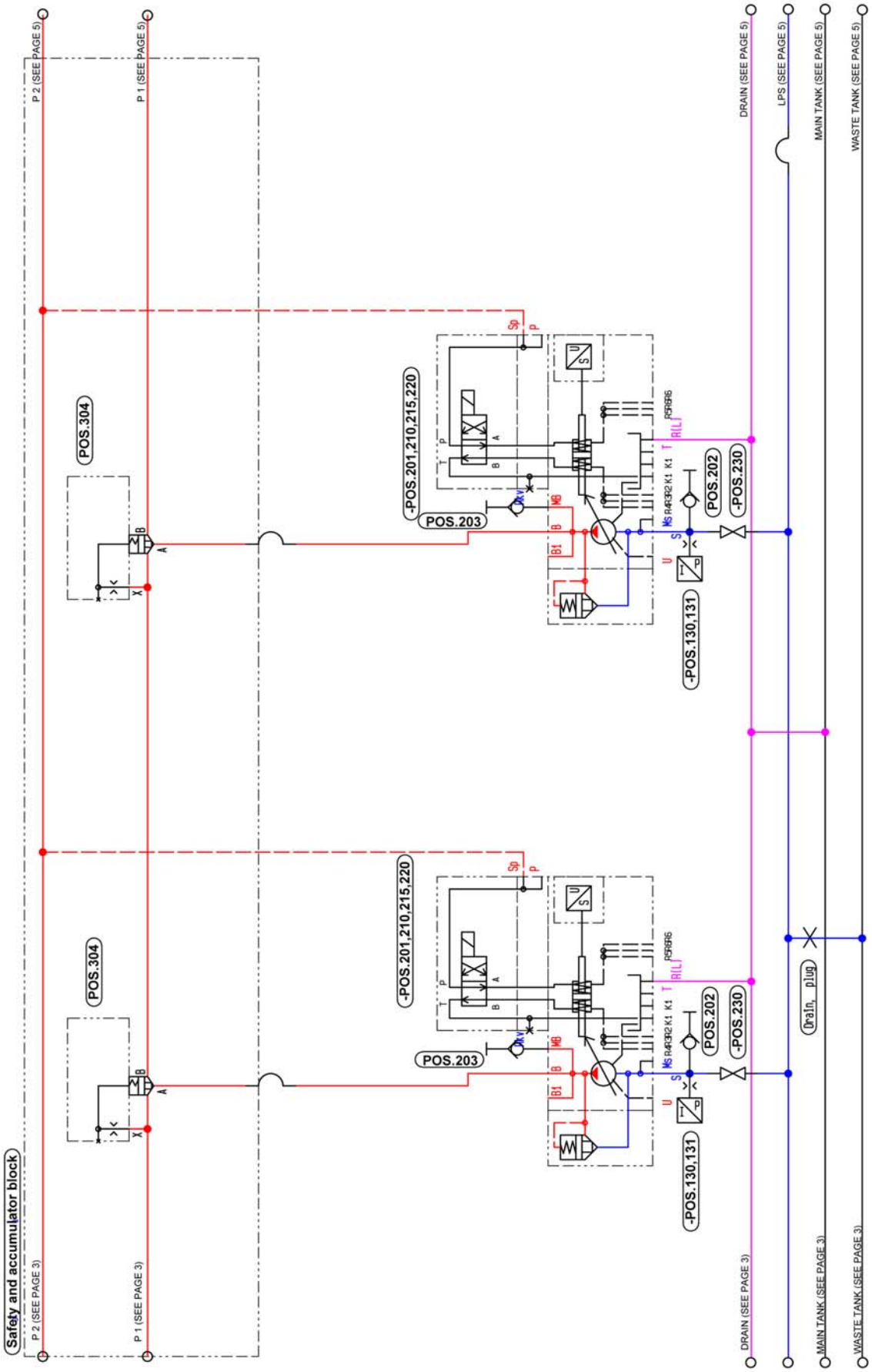
Drawing 4555-0146-0002

Gear Driven HPS and FIVA, Common LPS, ME Version 5, Rexroth Pumps - 300 bar

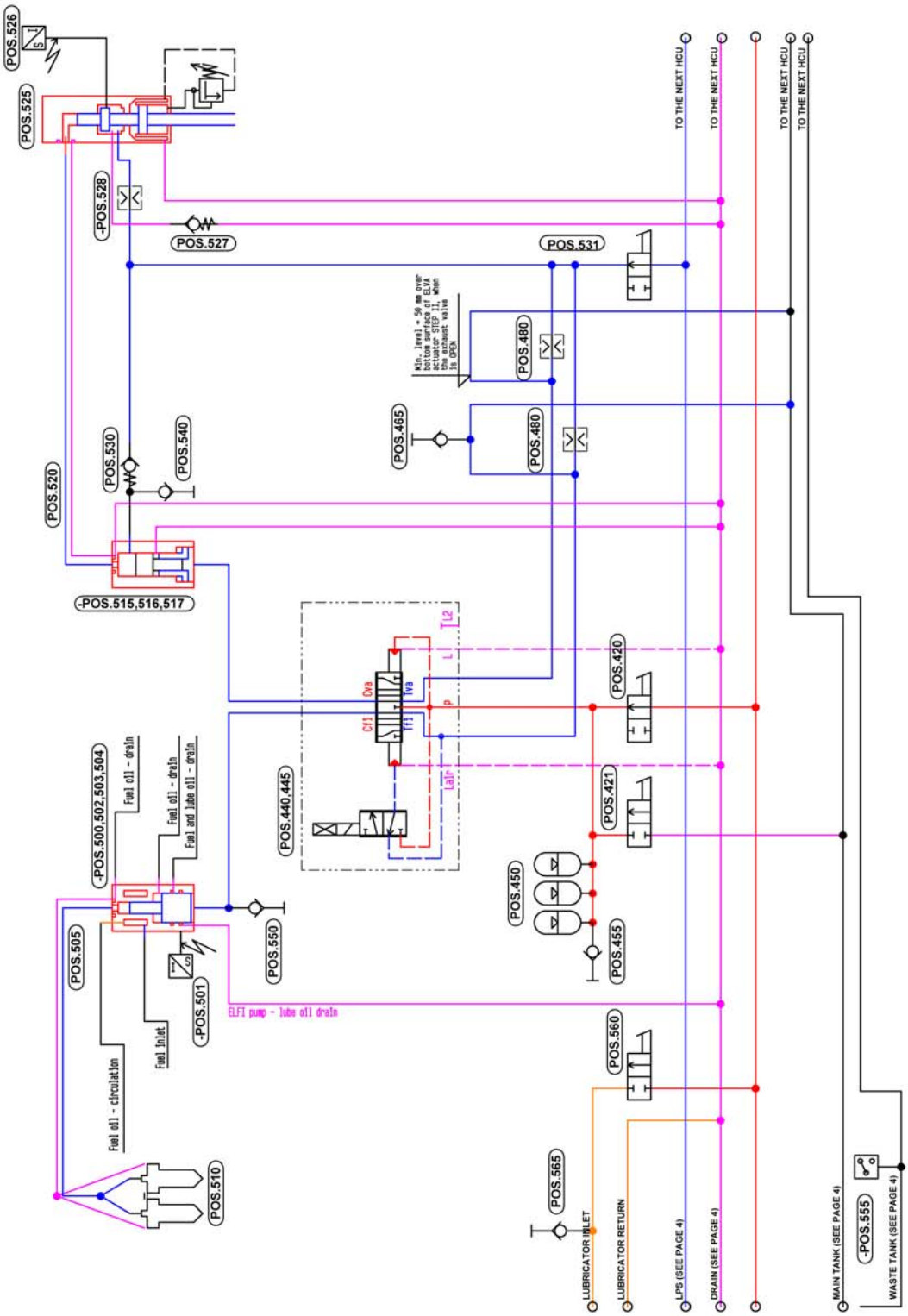
2012-11-26 - en

Drawing
4555-0146-0002

Gear Driven HPS and FIVA, Common LPS, ME Version 5, Rexroth Pumps - 300 bar



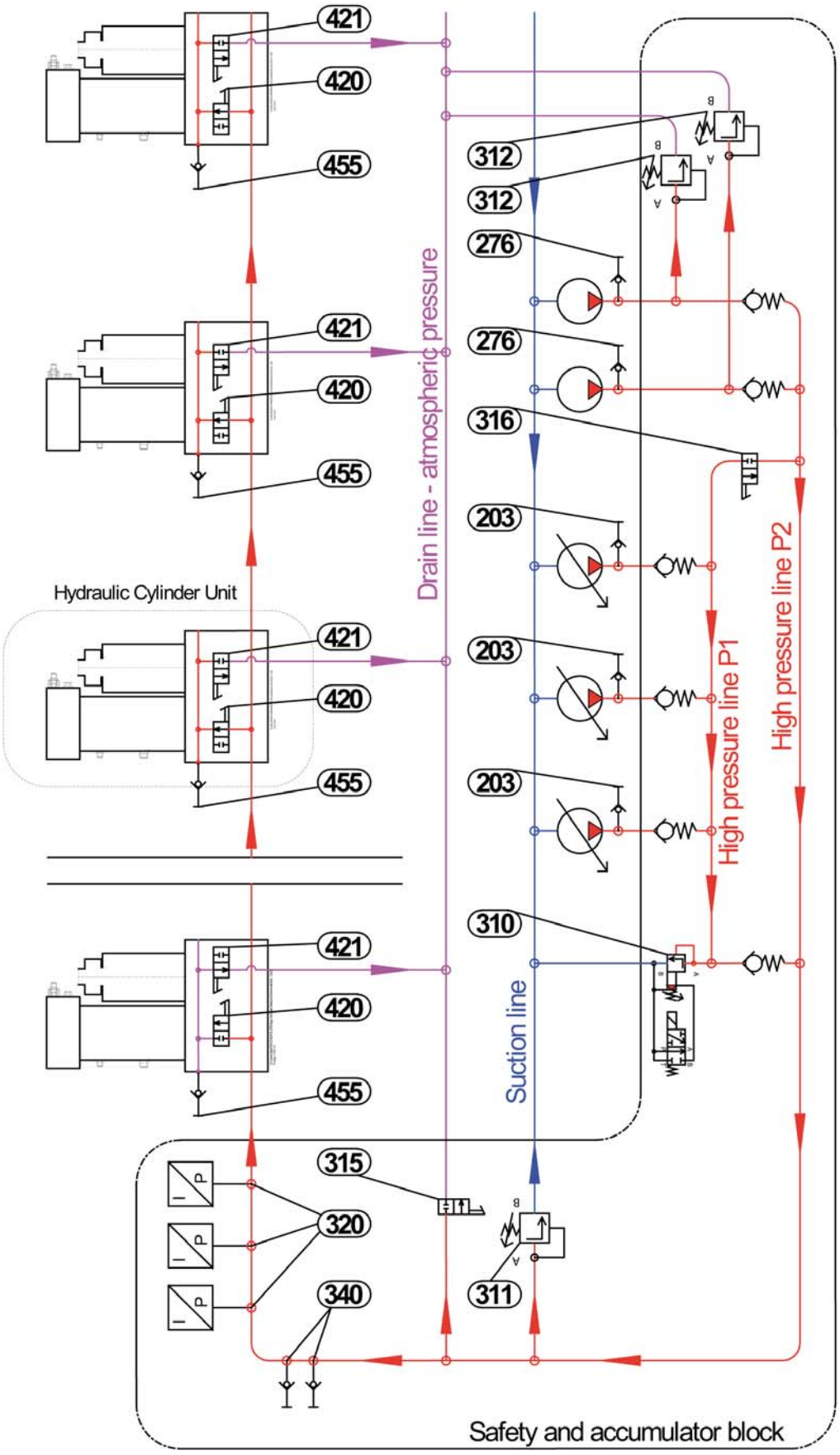
2012-11-26 - en



Drawing
4555-0146-0002

Gear Driven HPS and FIVA, Common LPS, ME Version 5, Rexroth Pumps - 300 bar

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Detection of Malfunction and Leaks in Hydraulic System

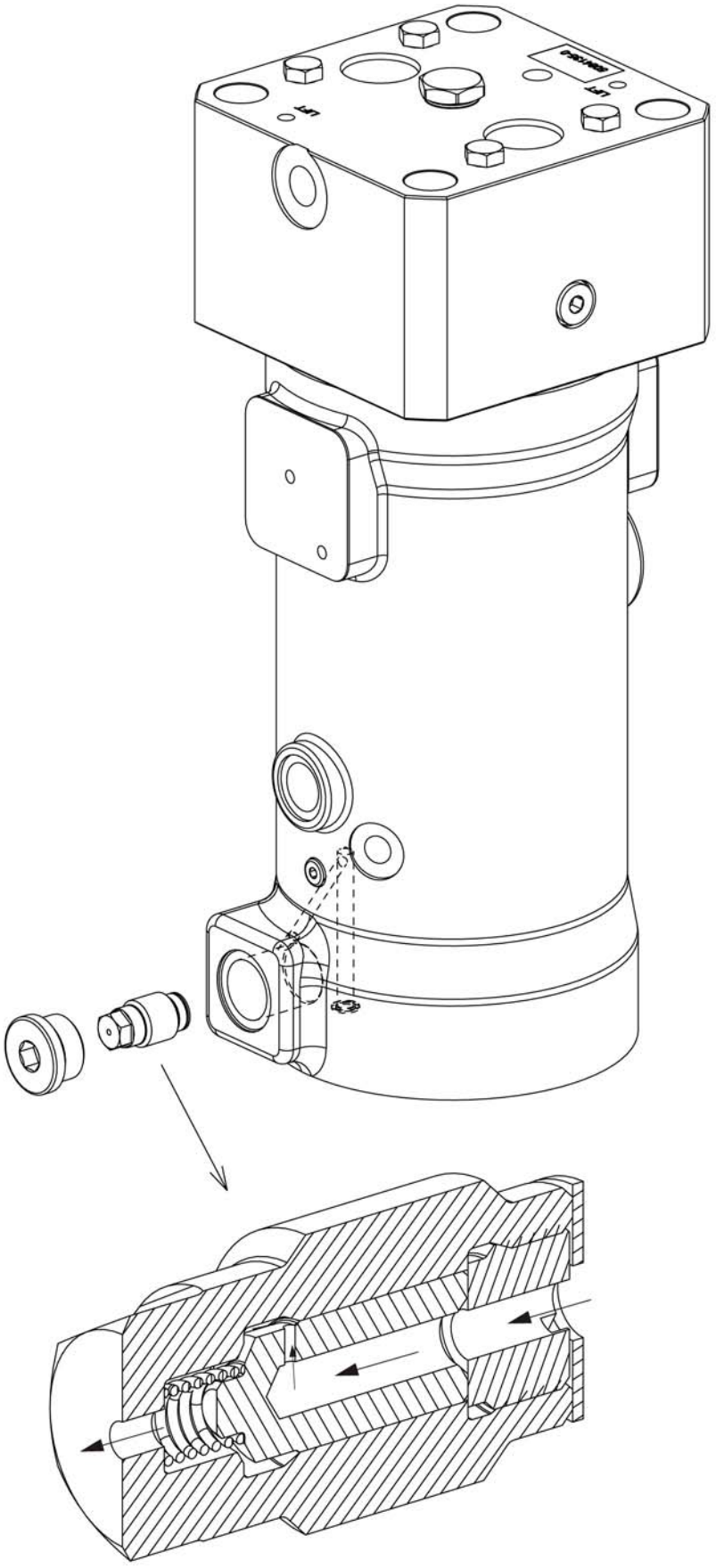
Drawing
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Basic Procedures

Item	Function	Possibilities	Remarks
Measuring point 276	Pressure in START-UP system arrangement.	Pressure adjustment at the valve 310, 311 and 312. Investigation of pressure building time. Investigation of pumps, pressure and displacement ability.	You can see this pressure at the MOP panel (Engine STAND-BY). Normal pressure adjusted to 225 bar. To adjust the pressure at the valve 310 - OPEN the valve 316.
Measuring point 203	Delivery pressure at the gear driven pumps.	Investigation of delivered pressure. Investigation of gear driven pumps, pressure and displacement ability.	You can always see this pressure at the MOP panel. Normal pressure = System pressure.
Measuring point 340	System Pressure.	Investigation of pressure and possible leakages.	You can always see this pressure at the MOP panel.
Leak detection. Measuring point 276 and 340	Procedure for leak detection on entire system.	Investigation of pressure and possible leakages. Investigation of pressure building time.	Stop the engine. Start the pressure building procedure with the START-UP pump arr. Normal pressure will increase to a pressure adjustet at the START-UP pump arrangement. (225 bar) If not, cut-out the Hydraulic Cylinder Unit, one by one, by closing the valve 420. When the pressure increase to expected level, the leakage position has been found.
Leak detection. Measuring point 455	Procedure for leak detection on one Hydraulic Cylinder Unit.	Investigation of pressure drop time.	Can be detected with engine in service. Cylinder cut-out (Electronically). CLOSE the valve 420 at the HCU and investigate the pressure drop time. Compare the pressure drop time to the same value at the next HCU. Can be investigated when the engine is stopped. Use the START-UP arrangement to build the prssure up at one HCU. Then compare the pressure building time to the same value at the next HCU.

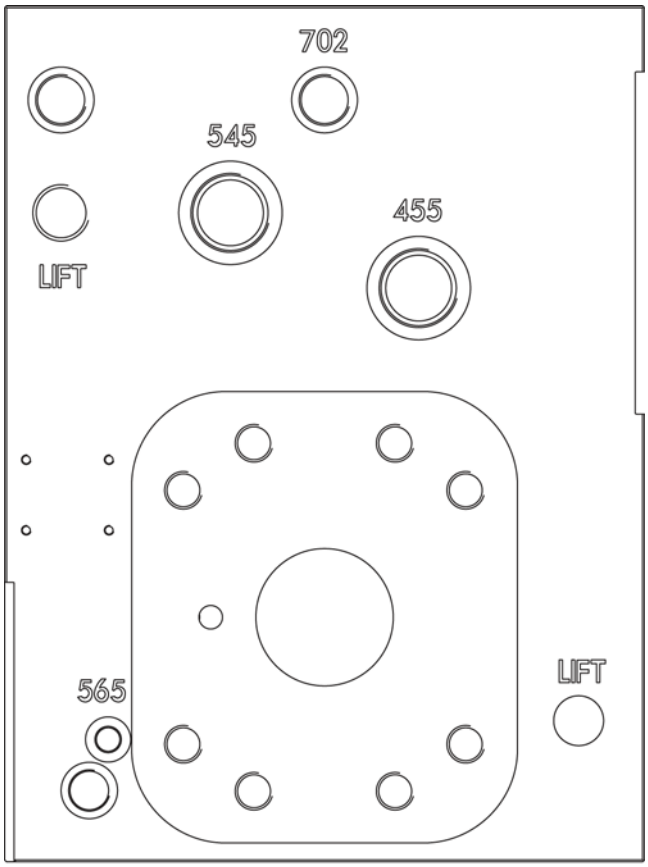
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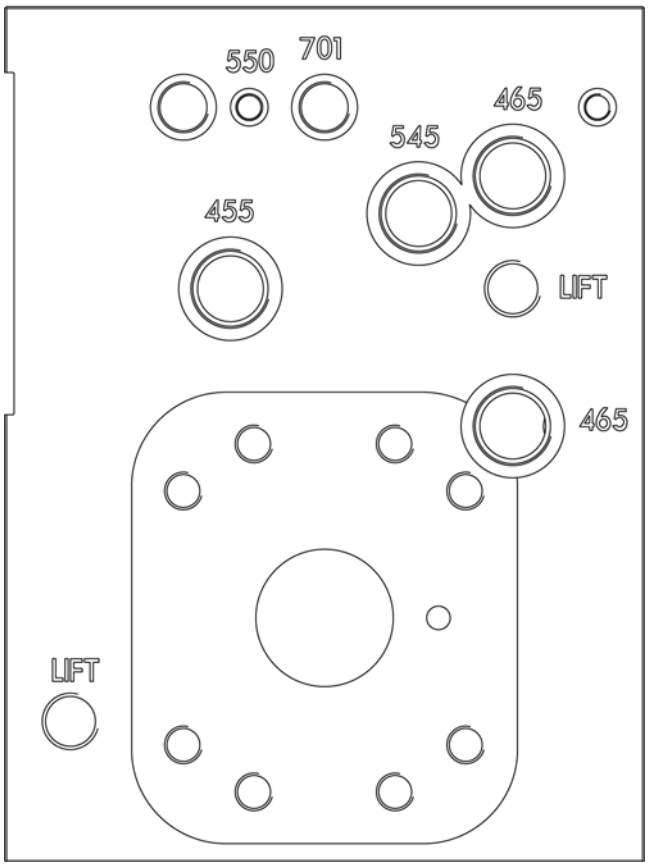


Throttle Valve on Fuel Oil Pressure Booster

Drawing
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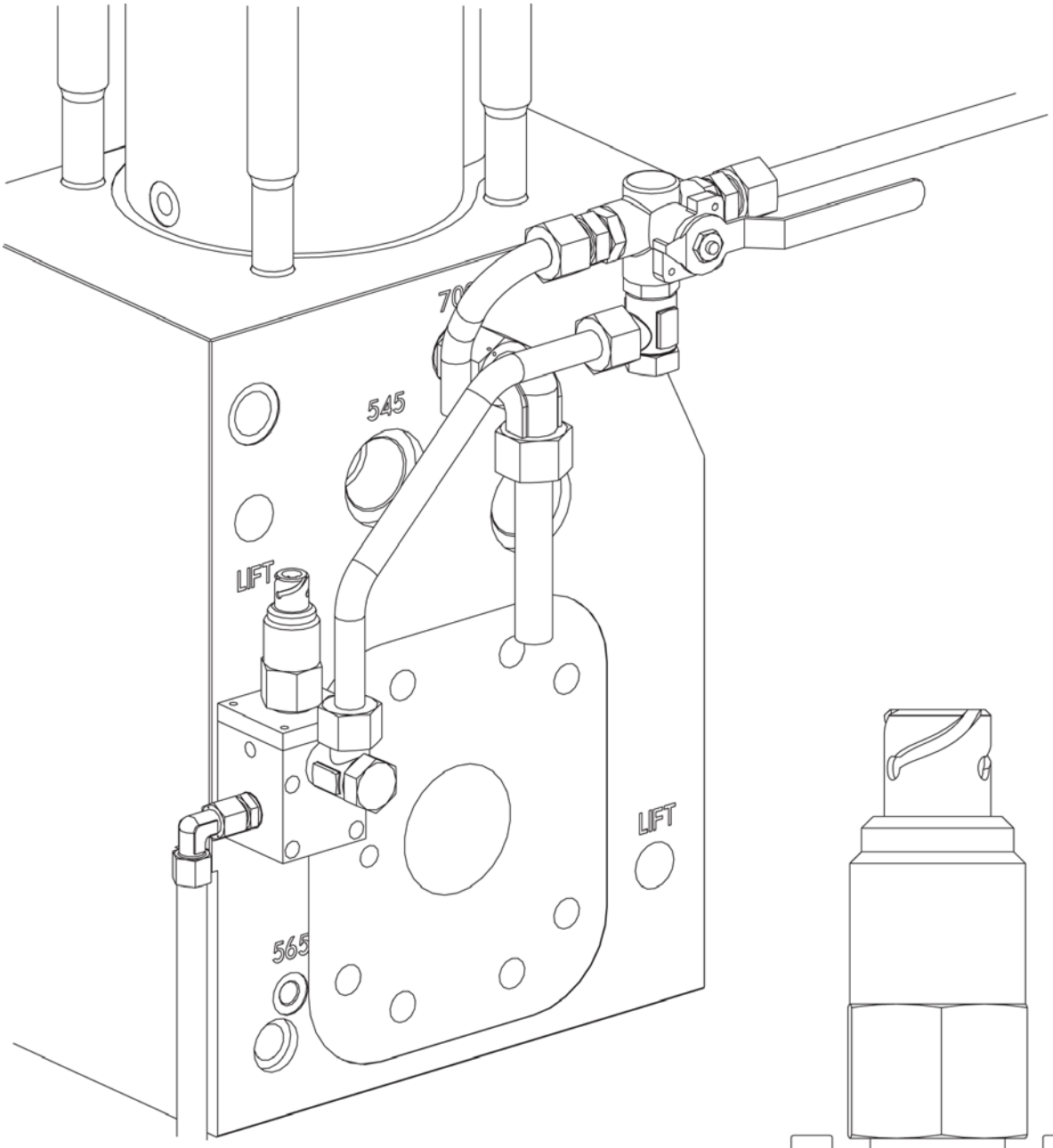


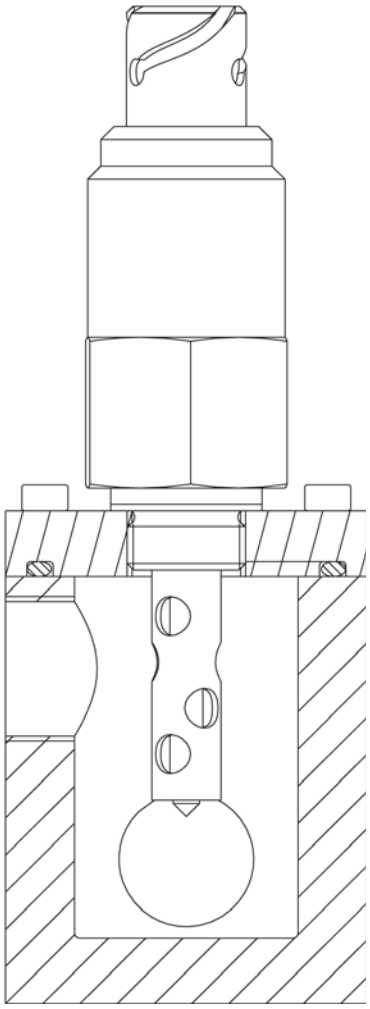


Drainholes in HCU Block

Drawing
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2012-11-28 - en

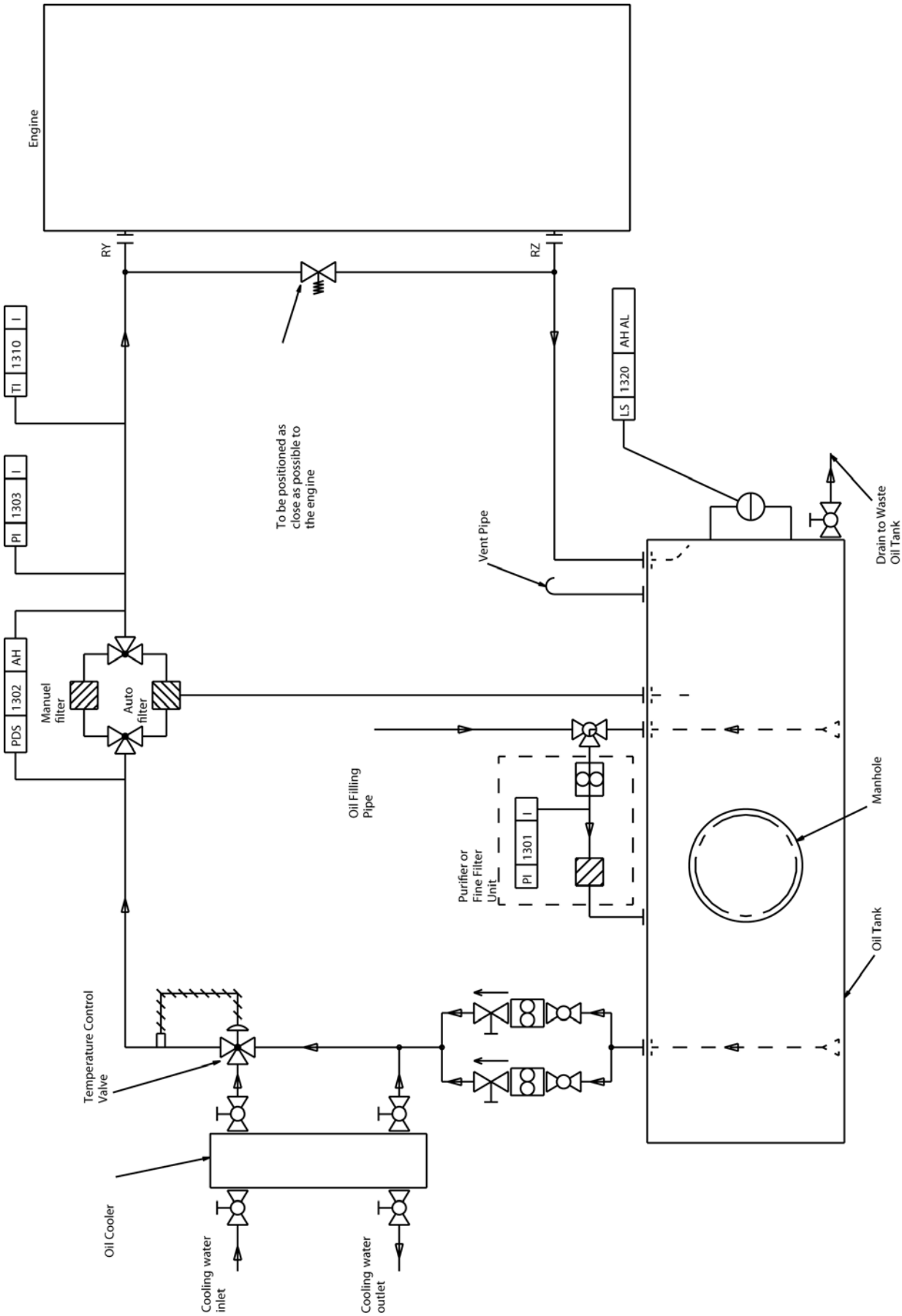




Level switch on ME Cylinder Lubricator

Drawing
4555-0165-0001

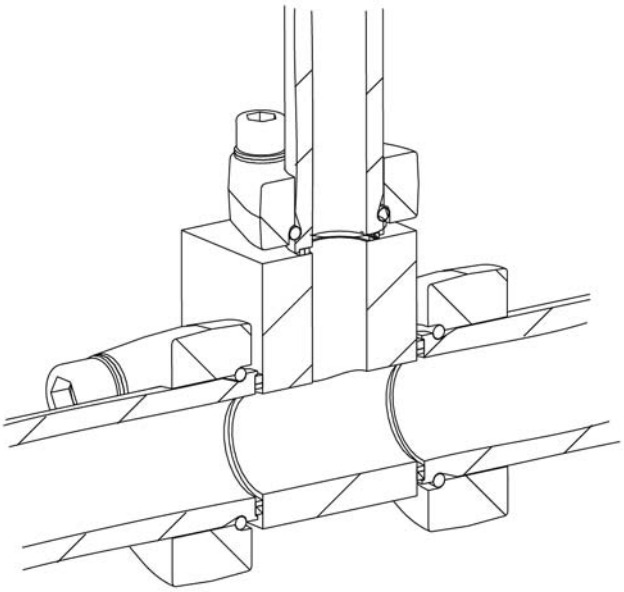
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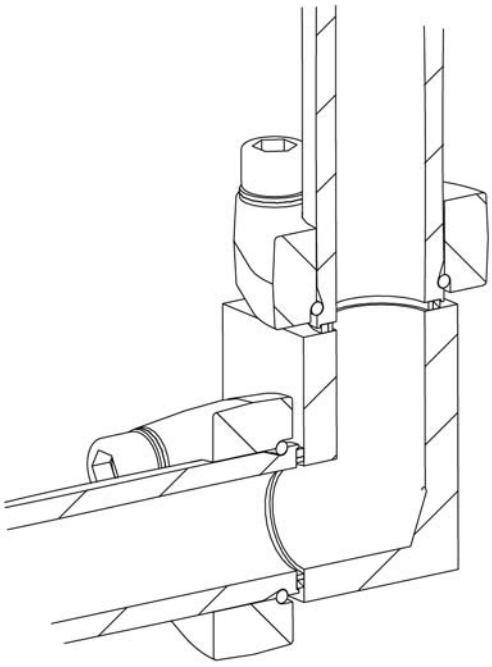


Hydraulic Control Oil System (Separate LPS)

Drawing
4555-0170-0001

Single wall piping





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Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off control air supply
O	Shut off air supply to exhaust valve - Only when stopped lubricating oil pumps
O	Engage turning gear
O	Stop lubricating oil supply
O	Shut down hydraulic power supply



Data

Ref.	Description	Value	Unit
T45-24	Hydraulic actuator	130	kg
T45-28	Top Flange	33	kg
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

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The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
7670-0200	-	Torque spanners
7670-0300	-	Lifting tools, etc
7670-0410	066	Slide caliper

Exhaust Valve Actuator

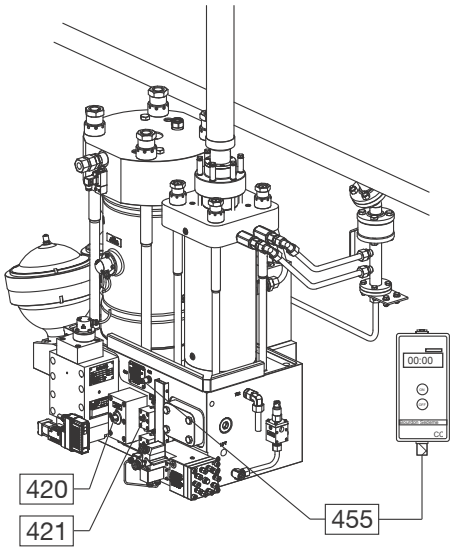
Stop the engine

Stop the engine and shut off the oil supply.

Fit a pressure gauge at ‘minimess’ point No. 455. Check the pressure.

Close valve 420 and open valve 421 on the hydraulic block for the cylinder concerned.

Check that the hydraulic cylinder unit is pressure free.



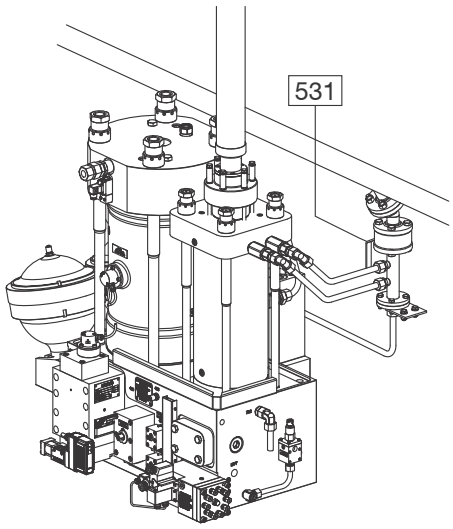
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NOTE

Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

Close valve 531

Close valve 531 for the actuator oil supply.

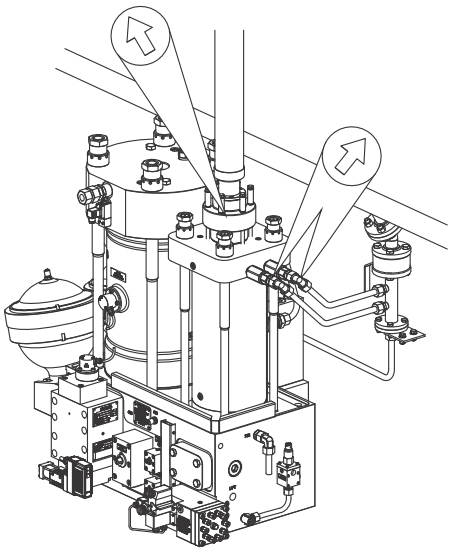


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High-pressure pipe

Remove the hydraulic high-pressure pipe.
See workcard 2265-0101.



4565-0101-0006D03

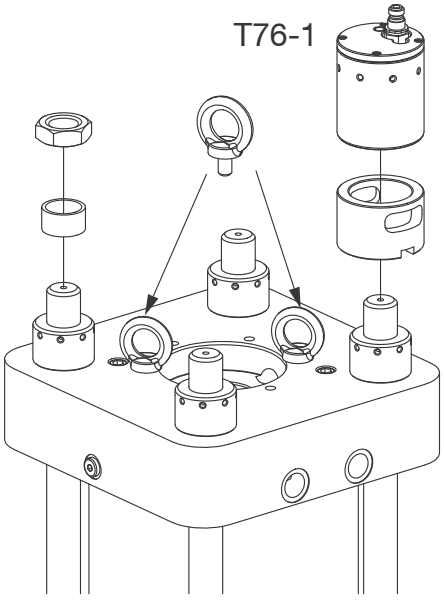
Loosen nuts

Remove The Pipes and Nuts protecting the threads.

Fit the spacer rings and the hydraulic jacks over the nuts. Pump up the hydraulic jacks to the dismantling pressure, as specified in data. loosen and remove the nuts.

For use of hydraulic tools, see also procedure 913-1.

Fit two eyebolts in the top flange of the actuator.



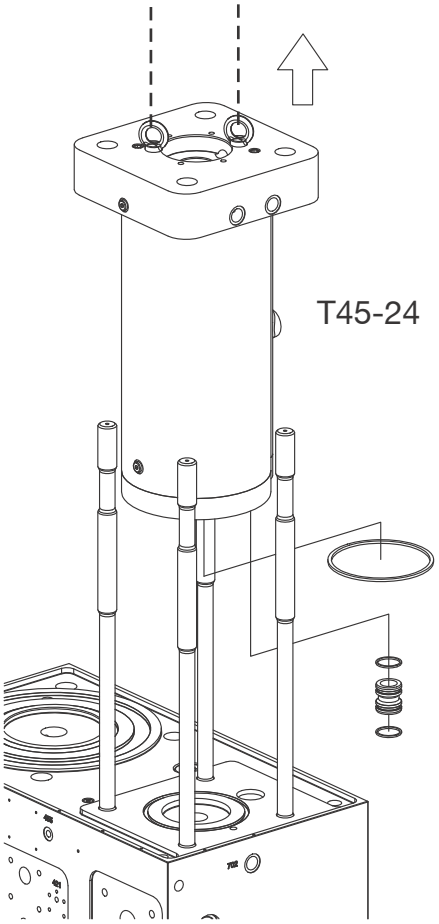
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Actuator unit

Lift the actuator clear of the hydraulic block.

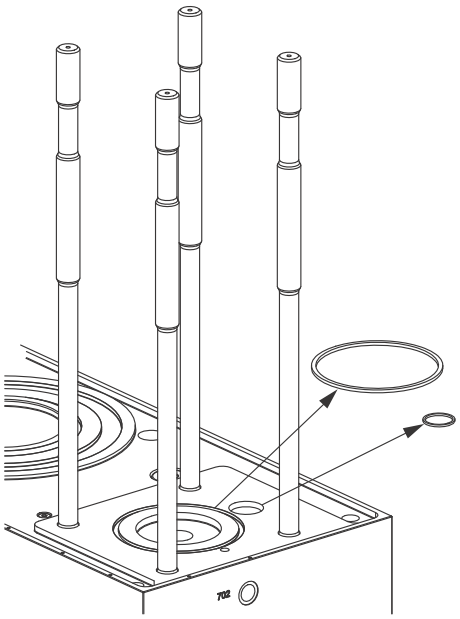
Remove the sealing ring from the bottom of the actuator, and discard it.



4565-0101-0006D06

Sealing ring

Remove and discard the sealing ring.
Clean the face on the hydraulic block.

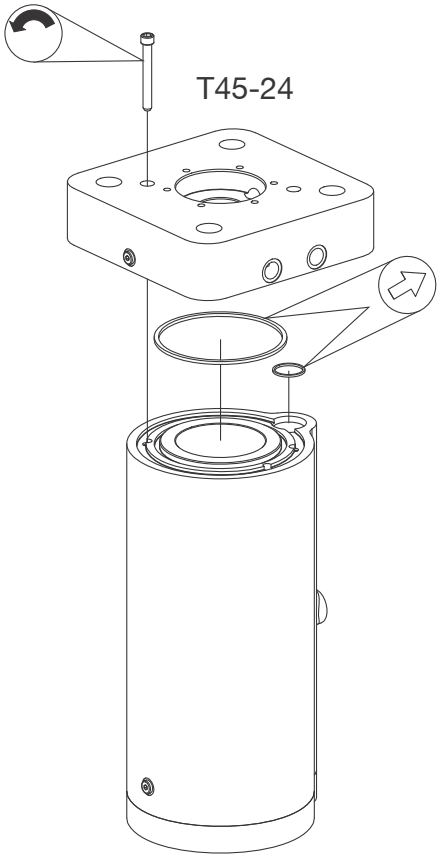


4565-0101-0006D07

Top flange

Remove the two screws which retain the top cover to the actuator housing.

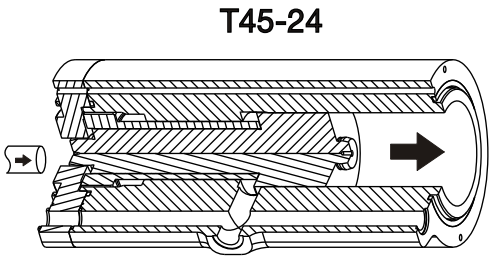
Lift away the top flange and discard the sealing rings.



4565-0101-0006O01

Dismount the piston

Place the actuator housing on the side. Push out the inner piston with a brass mandrel.

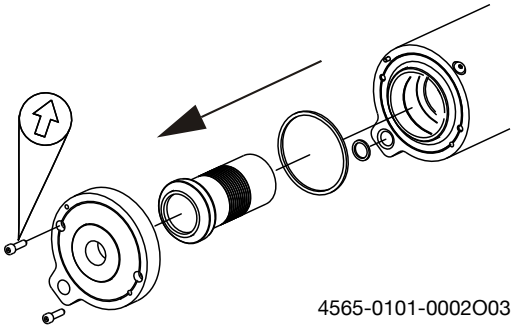


4565-0101-0004O02

Bottom plate

Remove the bottom plate and the outer piston from the oil cylinder.

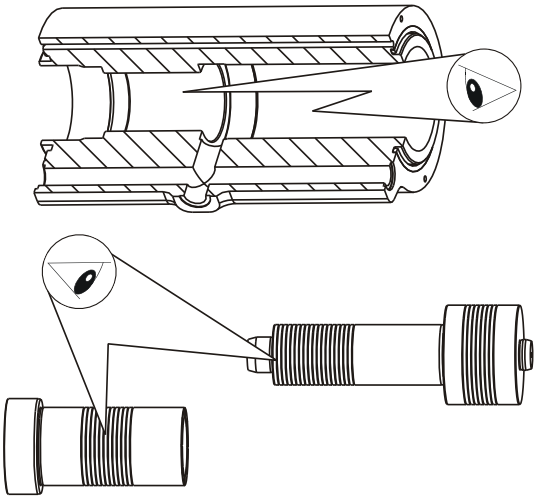
Remove and discard the sealing rings.



4565-0101-0002O03

Check and clean

Clean all parts and check all running surfaces for abnormal wear and scores.



4565-0101-0004O04

2009-02-10

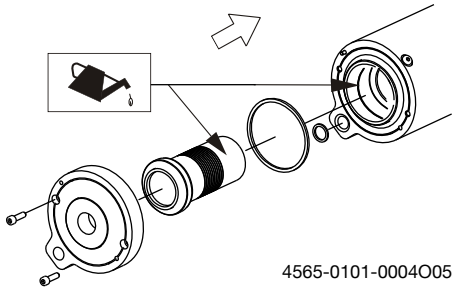
Mount outher piston

Lubricate the cylinder inside with lubricating oil.

Mount the outer piston in the actuator housing.

Mount new sealing rings.

Mount the bottom plate.



4565-0101-0004O05

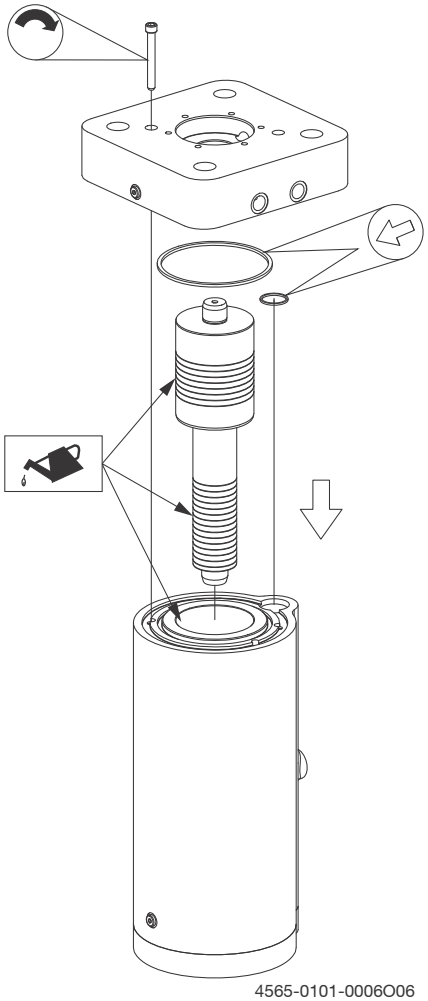
Mount top cover

Lubricate the upper piston on all sliding surfaces.

Mount the piston in the actuator housing

Mount new sealing rings.

Mount the top cover and tighten the screws.



4565-0101-0006O06

2009-02-10

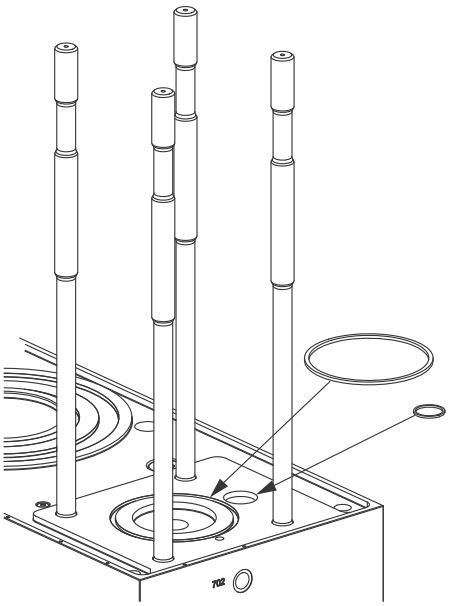
NOTE

Great care must be taken to ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

Mount Sealing rings

Mount new sealing ring on the oil hydraulic block.

Check that the face on the HCU is clean.



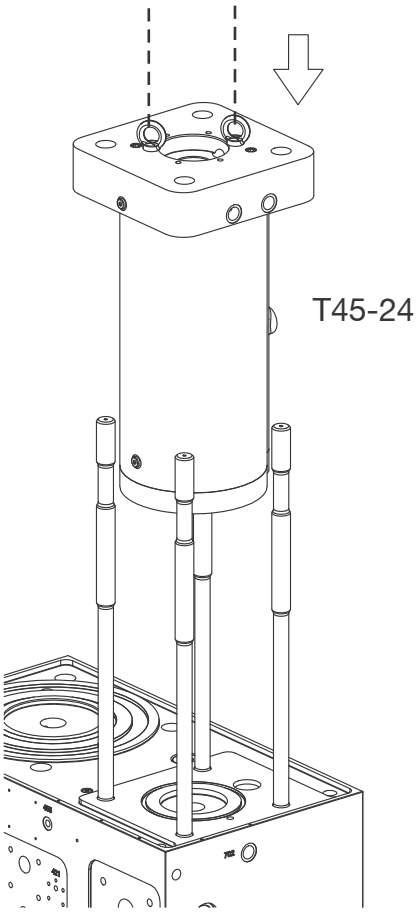
4565-0101-0006M01

Land actuator

Check the oil hole and the face of the hydraulic block, and the bottom of the hydraulic actuator, to see that they are clean and free of impurities.

Fit two eyebolts in the top of the actuator assembly.

Carefully land the actuator on the hydraulic block.



4565-0101-0006M02

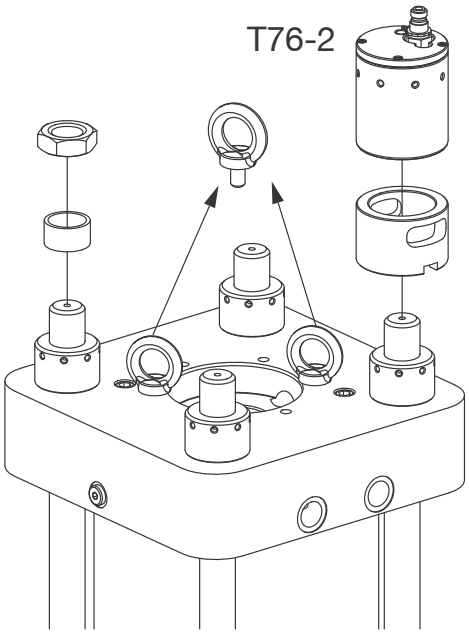
2009-02-10

Tighten nuts

Remove the eye bolts. Screw the nuts on the studs. Fit the spacer rings and the hydraulic jacks over the nuts. Pump up the jacks to the tightening pressure, as specified in data.Tighten the nuts, and remove the hydraulic jacks and spacer rings.

Mount the pipes on and the nuts protectingthe thread.

For Use of Hydraulic tools, see Workcard 2265-0101



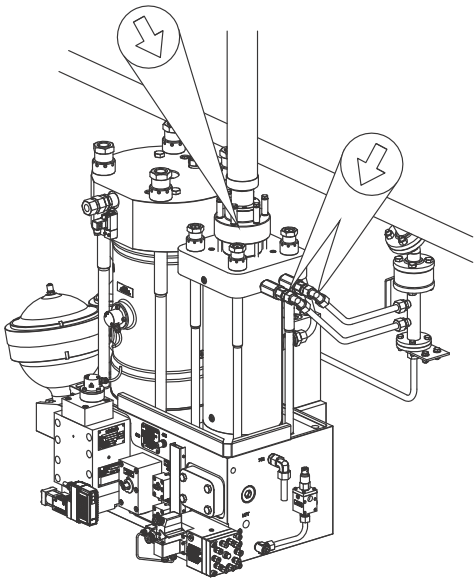
4565-0101-0006M04

Mount the oil pipe

Mount and tighten the oil pipe for oil supply.

Mount the hydraulic high-pressure pipe.

See Workcard 2265-0101.

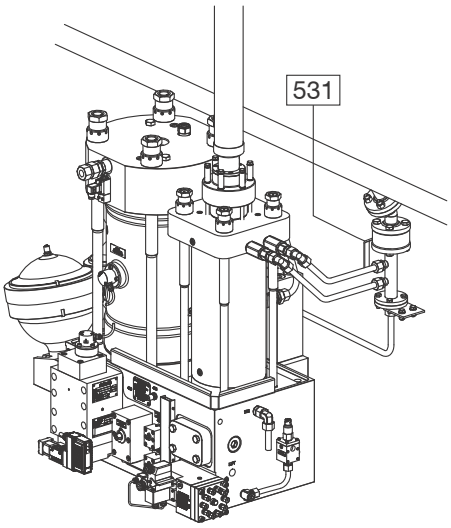


4565-0101-0006M05

2009-02-10

Open valve 531

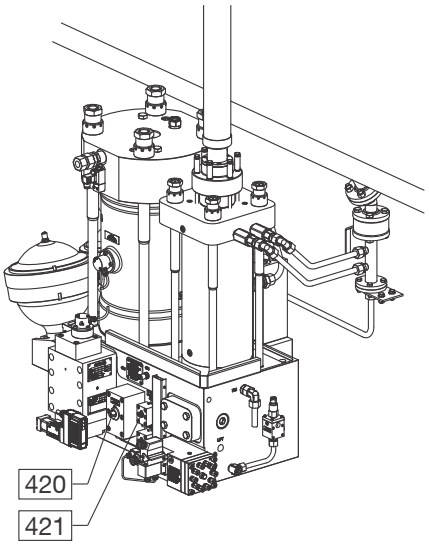
Open valve 531 for actuator oil supply.



4565-0101-0006D02

Close valve 421

Close valve 421, and open valve 420 on the hydraulic block.



4565-0101-0006M07

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off safety air supply - Not ME Engines
O	Shut off control air supply
O	Engage turning gear
O	Stop lubricating oil supply
O	Shut down hydraulic power supply



Data

Ref.	Description	Value	Unit
T45-03	Hydraulic pump	100	kg
T45-04	Internal drive shaft	17	kg

2013-02-20 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
7670-0300	-	Lifting tools, etc
7670-0410	-	Pressure gauge

Hydraulic Pumps

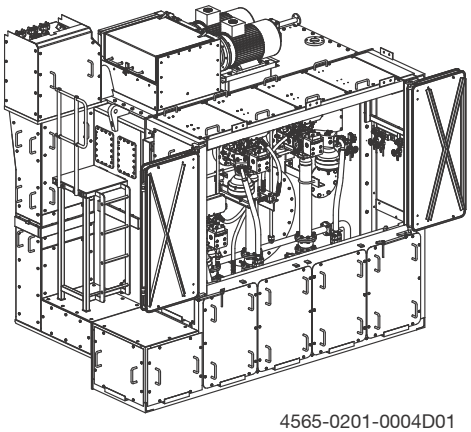
Check that startup and booster pumps are stopped before any part of the hydraulic system is disassembled.

NOTE

Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

Open the access to the pumps

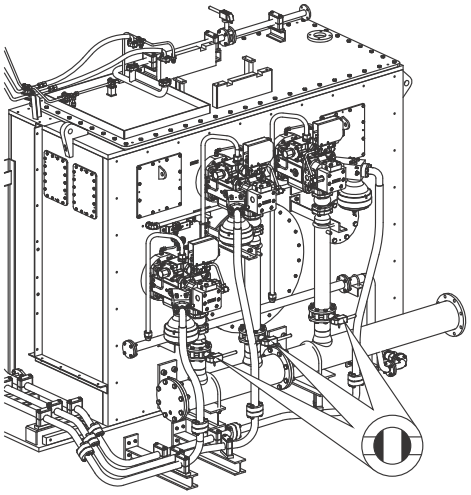
Open the access hatch to the hydraulic pumps.



4565-0201-0004D01

Close the suction valve

Close the suction valve for the relevant pump.



4565-0201-0004D02

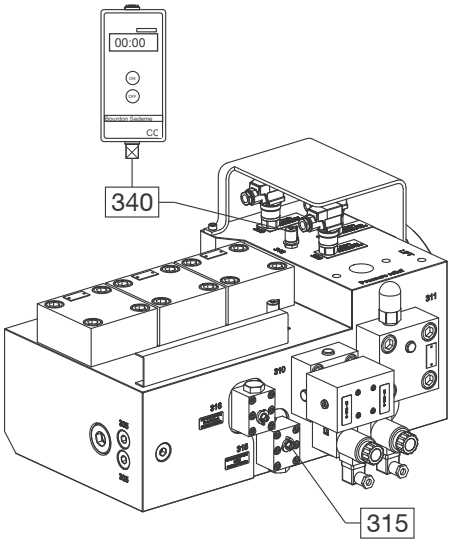
2008-12-03 - en

Release the hydraulic pressure from the system

Mount a pressure gauge on the »minimess« coupling No. 340. Check the pressure.

Open valve 315 to release the hydraulic pressure from the system.

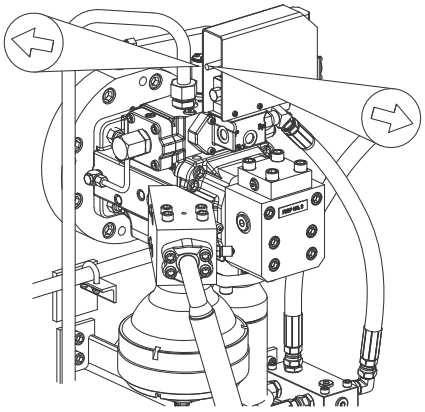
Check on the pressure gauge that the system is pressure free.



4565-0201-0004D03

Remove the electrical connections

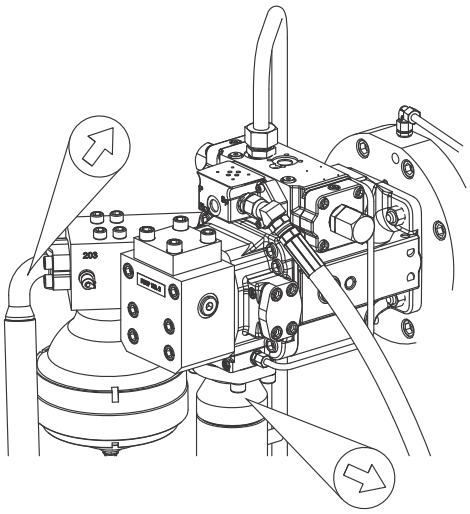
Unscrew the shield protecting, the solenoid valve and remove the electrical connections to the solenoid valves.



4565-0201-0004D04

Unscrew the bolts from the flange on the suction pipe

Unscrew the bolts from the discharge pipe and remove the HP-hose.

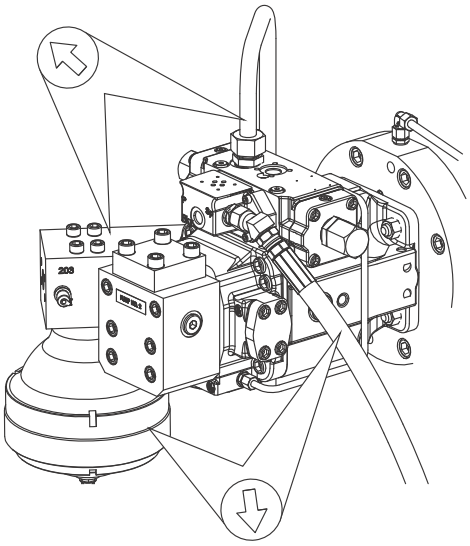


4565-0201-0004D05

Servo oil pipes

Unscrew the servo oil pipes and remove the pipes.

Remove the accumulator and the block connected.

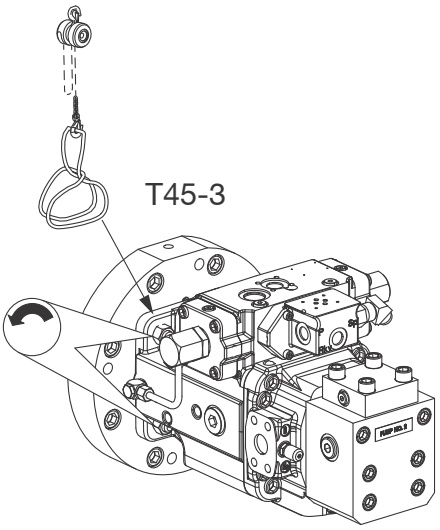


4565-0201-0004D06

Before lifting the pumps

Suspend a tackle above the hydraulic pump and put a strap around the pump.

Hook the tackle on to the strap and tighten up.



4565-0201-0004D07

NOTE

The pump must be in balance when it is lifted.

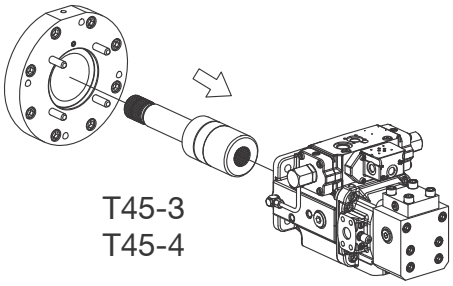
Unscrew the four nuts from studs in the end-flange.

Pull out the pumps

Carefully pull out the pump and the internal drive shaft. *See Data*.

For overhaul of the pump, send it to an authorized MAN workshop.

The internal drive shaft also functions as an overload protection. If it is necessary to renew the drive shaft, contact MAN Diesel for advice.



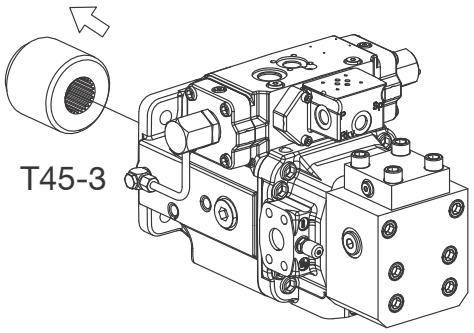
4565-0201-0004D08

2008-12-03 - en

When the internal drive shaft has been overloaded, it must be renewed.

Dismantle the hydraulic pump

Remove the broken end of the internal drive shaft.

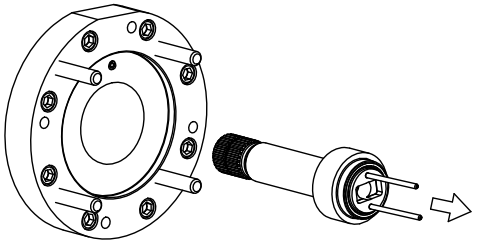


4565-0201-0004O01

Pull out the drive shaft

Screw two pieces of threaded rod into the threaded holes in the drive shaft and pull it out.

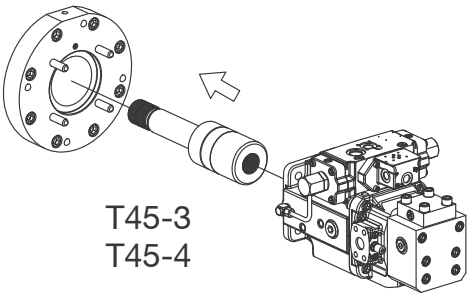
Discard the broken drive shaft.



4565-0201-0001O02

New drive shaft

Mount a new internal drive shaft and the hydraulic pump.



4565-0201-0004O03

2008-12-03 - en

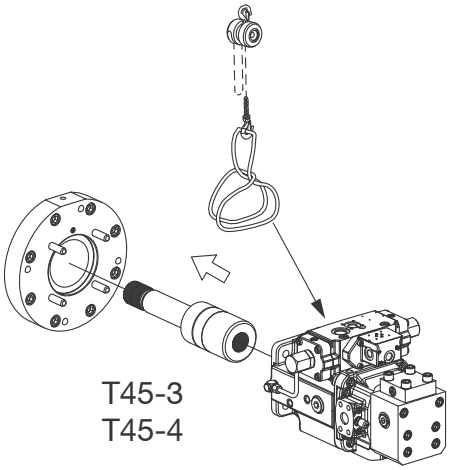
NOTE

Great care must be taken to ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

First

Mount the intermediate shaft in the gearbox. Suspend a tackle above the gear box and put a strap on the hydraulic pump.

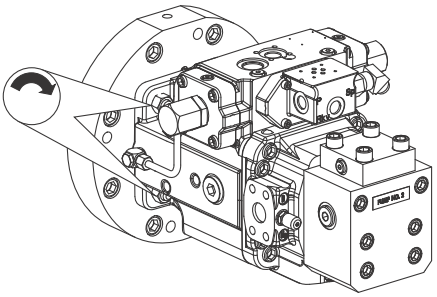
Lift up the pump in position, and carefully push in the pump to engage the pump shaft with the drive shaft.



4565-0201-0004M01

Mount and tighten the nuts

Mount and tighten the nuts on the pump flange.



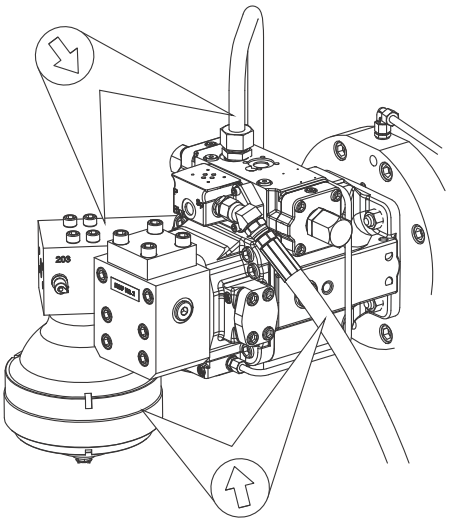
4565-0201-0004M02

2008-12-03 - en

Servo oil pipes

Mount the servo oil pipes.

Mount the block with accumulator.

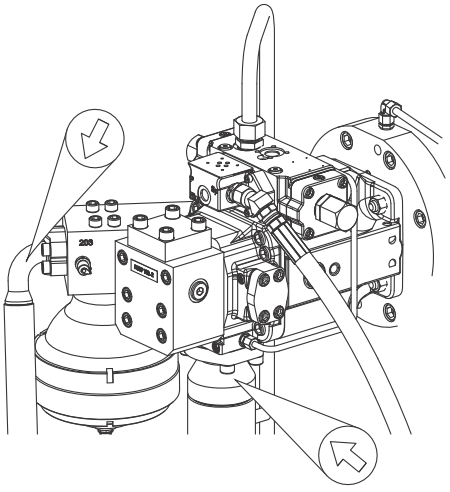


4565-0201-0004M03

Mount the bolts in the flange on the suction pipe

Mount the bolts in the flange on the suction pipe.

Mount the discharge pipe and tighten the bolts.

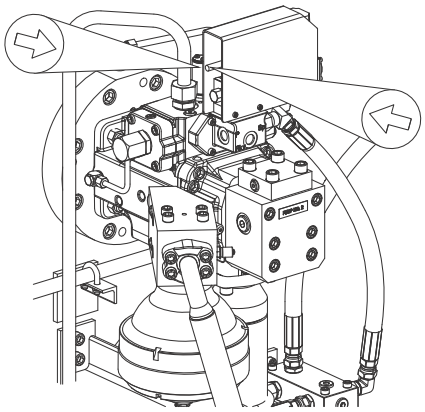


4565-0201-0004M04

2008-12-03 - en

Mount the electrical connections

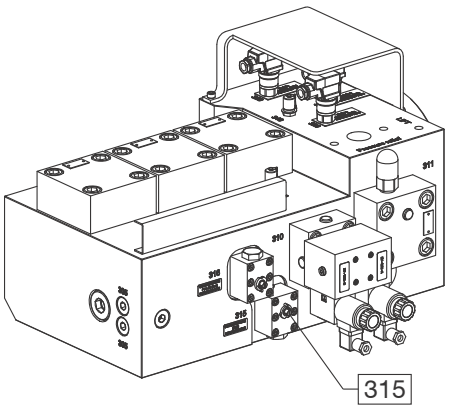
Mount the electrical connections to the solenoid valves and replace the protective shield.



4565-0201-0004M05

Close valve 315

Close valve 315 on the flange in the front end of the HCU line.

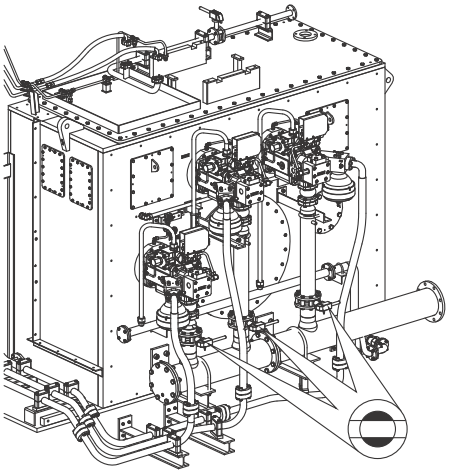


4565-0201-0004M06

The suction valve

Open up the suction valve for the relevant pump.

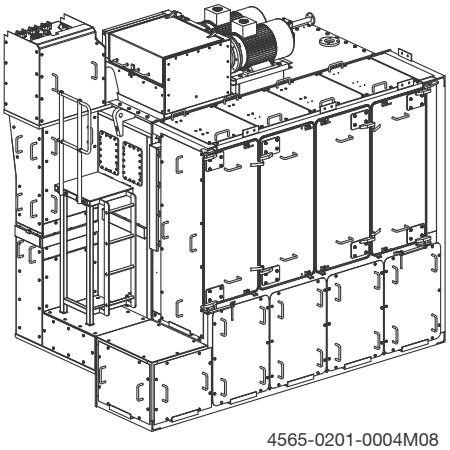
Remount the cover and cross member.



4565-0201-0004M07

Close the gallery access

Close the access covers plating on the gallery.



4565-0201-0004M08

2008-12-03 - en

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off control air supply
O	Engage turning gear



Data

Ref.	Description	Value	Unit
-	Table is empty on purpose. No Data needed.	-	-

2013-02-20 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
4270-0010	**333**	Flushing valve
7670-0300	**-**	Lifting tools, etc
7670-0410	**-**	Pressure gauge

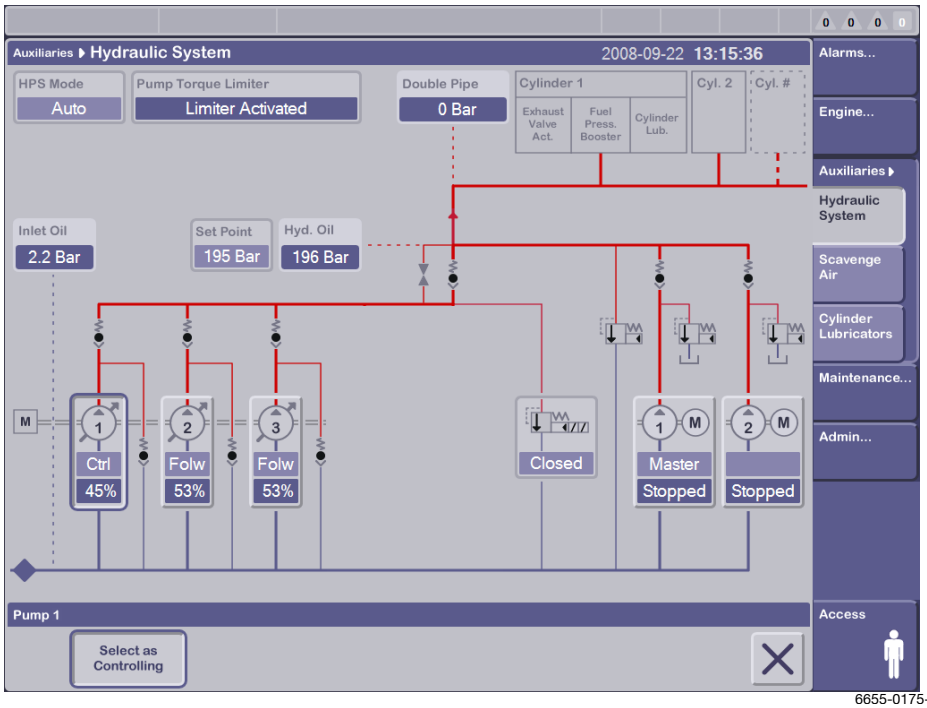
2013-02-20 - en

Remember

The integrity of the hydraulic system can be checked by observing the Hydraulic Presure Decay Time on the Main Operating Panel when stopping the engine.

If the graph moves into the yellow or red area, the leak has to be located and stopped.

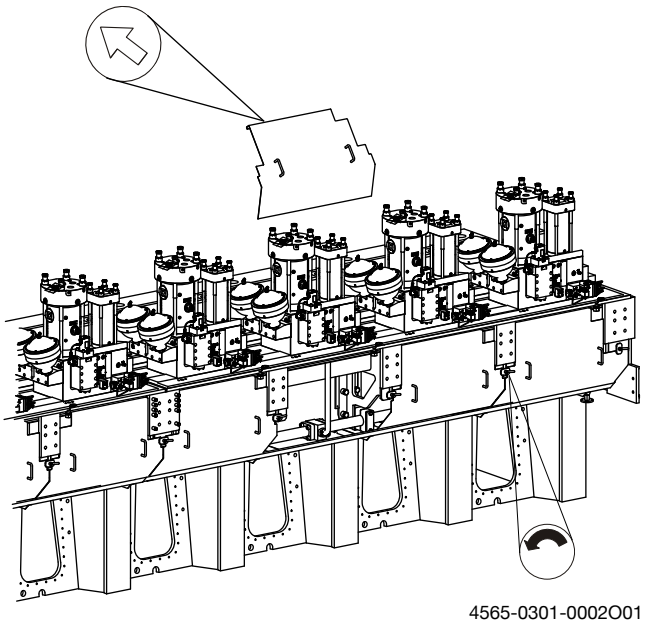
Leakage during operation may be observed by poor engine performance or visible leaks on the engine.



6655-0175-0002

Main High Pressure Pipe

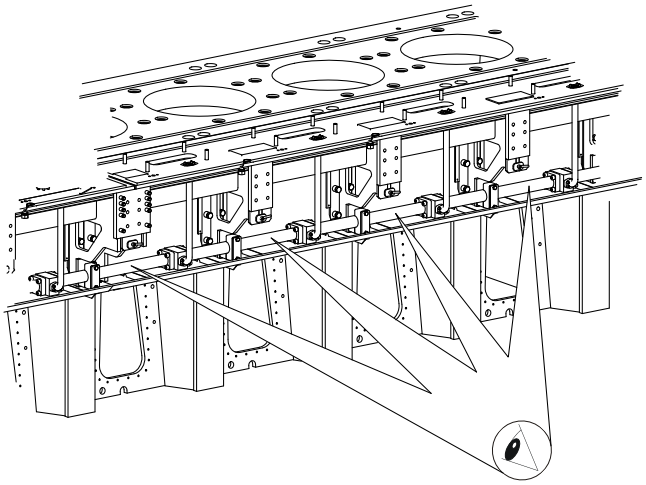
Remove the cover to access the main high-pressure pipe.



4565-0301-0002O01

Chech for visible leaks

Check the high pressure pipe connections for visible leaks.



4565-0301-0002O02

CAUTION

Do **not** use your hands to detect leakages! If necessary use a mirror on a stick.

2008-11-27 - en

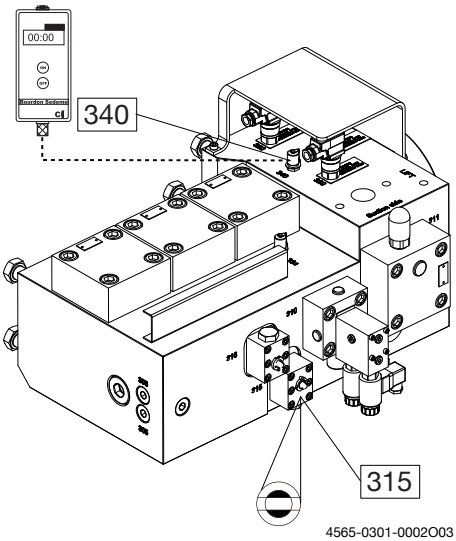
Pressure free system

Mount a pressure gauge on the “minimess” coupling No. 340.

Check the pressure.

Open valve 315 to relieve the system of hydraulic pressure.

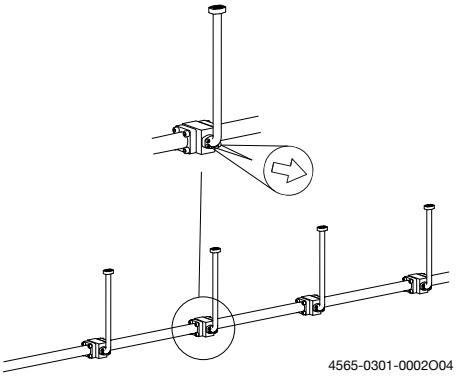
Check on the pressure gauge that the system is pressure free.



4565-0301-0002O03

Remove the bolts

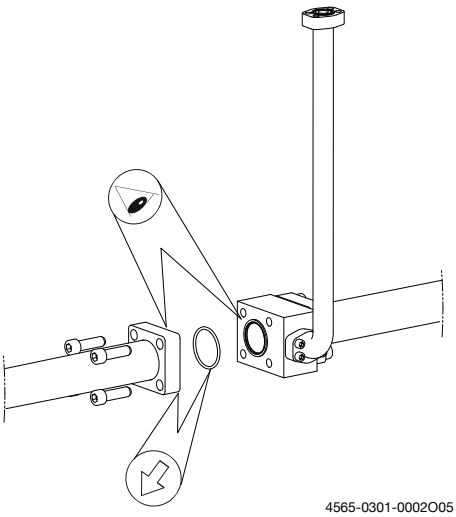
Loosen and remove the bolts from the pipe flanges on the high pressure pipe or hose concerned.


4565-0301-0002O04

Remove the sealing rings

Remove the sealing rings and clean the pipe flanges.

Inspect the flange and pipe visually.


4565-0301-0002O05

2008-11-27 - en

High-pressure pipes	Fit the high pressure pipes and new sealing rings.
Put covers back	Put covers back into place.
Valve 315	Close valve 315.
Test the pipe system	After renewing sealing rings or hoses on the high pressure system it is recommended to test the pipe system according to the “checking” section.

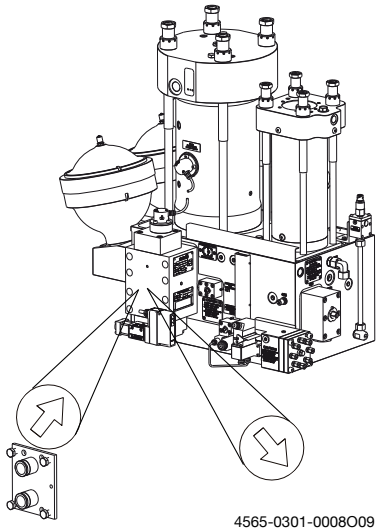
Flushing of HCU block

If large components on the HCU block has been renewed or if there is suspicion that the HCU block has been contaminated, it is recommended to flush it.

Remove the FIVA valve

Prior to flushing, remove the FIVA valve as described in *workcard 4565-0601.*

Mount the flushing valve on the HCU block. Connect a hose to the flushing valve in order to lead the flushing oil away.

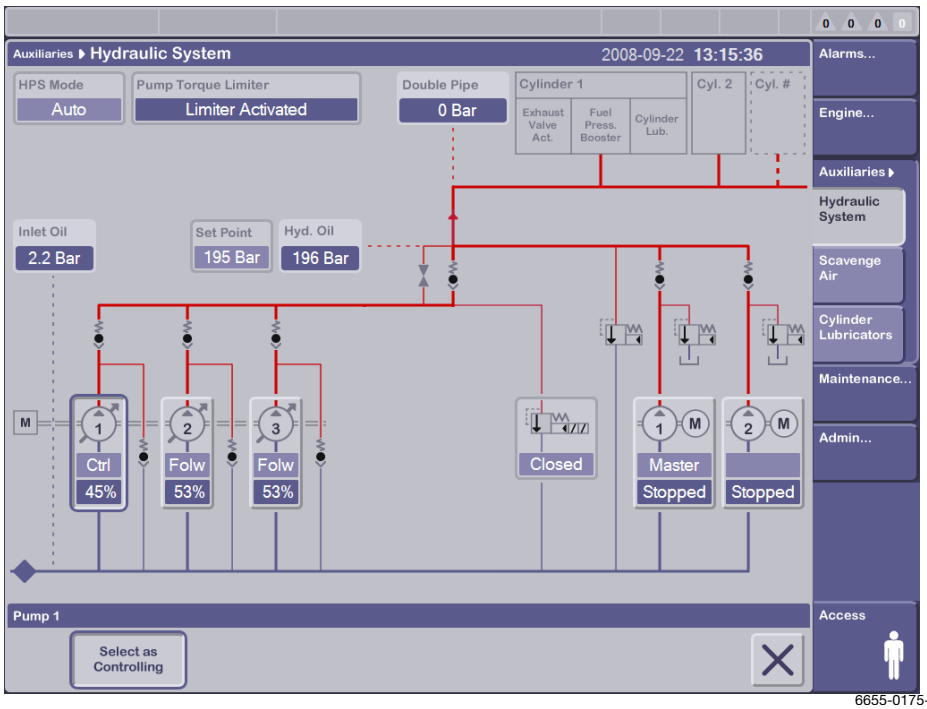


4565-0301-0008O09

Check the integrity of the hydraulic system

Check that the integrity of the hydraulic system has been restored.

See the checking section.



6655-0175-0002

Safety Precautions

for detailed sketch see 0545-0100

o	Stop the Engine
o	Shut down hydraulic power supply



Data

Ref.	Description	Value	Unit
T45-33	FIVA Control valve	72	kg
T45-34	Screw, FIVA valve to hydraulic cylinder unit	168	Nm

2013-01-30 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
7670-0200	-	Torque spanners
7670-0300	-	Lifting tools, etc

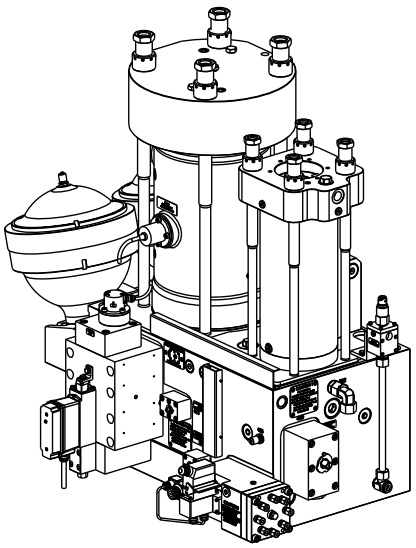
2013-01-30 - en

FIVA

The function of the **F**uel **I**njection and the **V**alve **A**ctivation Valve (FIVA) is continuously checked by the Engine Control System.

Malfunctions will be reported by the system to the MOP system and to the common alarm system.

Malfunctioning FIVA valves are to be overhauled by the supplier or by MAN Diesel.



4565-0601-0004C01

2009-01-15 - en

NOTE

Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

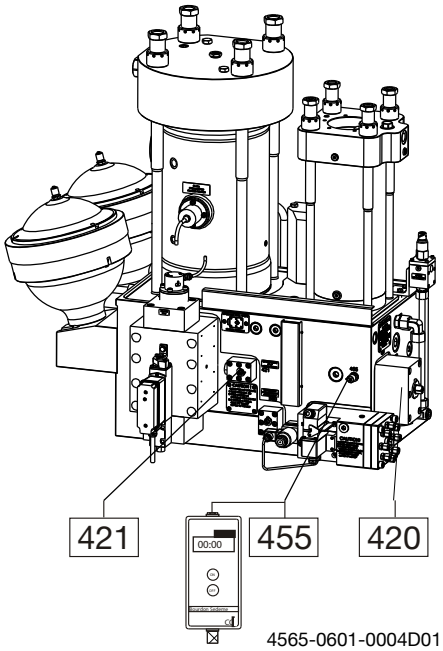
Before dismantling

Dismantling of the FIVA valve can only be carried out with stopped engine and stopped hydraulic power supply pumps.

Mount a pressure gauge at “minimess” point No. 455. Check the pressure.

Close the high pressure inlet valve 420 and open the high pressure outlet valve 421 to drain all oil out of the hydraulic cylinder unit.

Check that the hydraulic cylinder unit is pressure free.

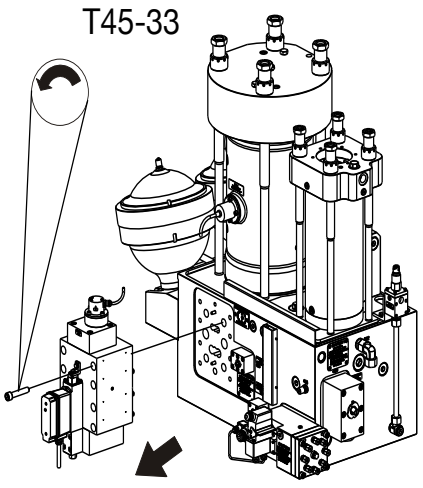


4565-0601-0004D01

Dismount valve

Use the two eyebolts mounted on the FIVA valve when handling the FIVA valve.

Dismount the eight screws and carefully pull the FIVA valve clear of the two guide pins.



4565-0601-0004D02

2009-01-15 - en

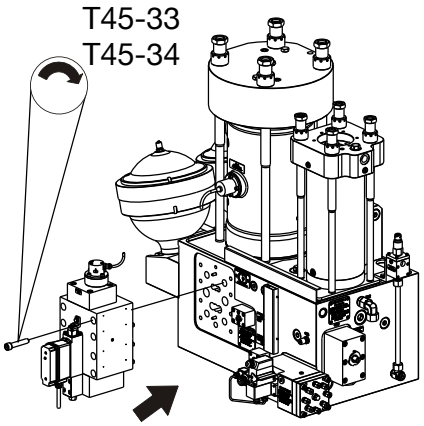
NOTE

Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

Mount new square section rings

Mount new square section sealing rings in the control valve.

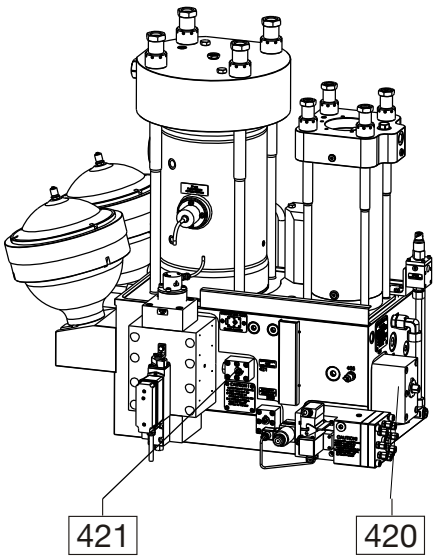
Mount the control valve on the two guide pins and tighten the eight screws.



4565-0601-0004M01

Close valve 421

Close the high pressure outlet valve 421 and open the high pressure inlet valve 420.



4565-0601-0004M02

2009-01-15 - en

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off safety air supply - Not ME Engines
O	Shut off control air supply
O	Shut off air supply to exhaust valve - Only when stopped lubricating oil pumps
O	Engage turning gear
O	Stop lubricating oil supply
O	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
-	Table is empty on purpose. No Data needed.	-	-

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

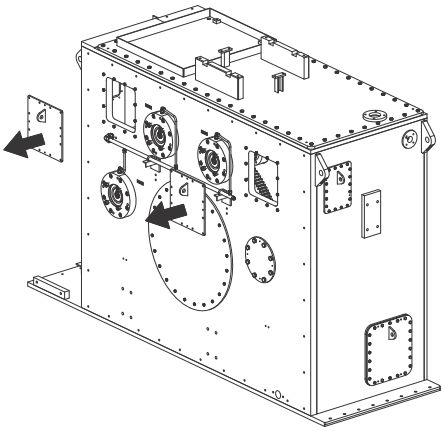
Tools

Plate	Item No.	Description
-	-	Table is empty on purpose. No special tools needed.

The cover on the exhaust and rear side

Remove the cover on the exhaust and rear side of the chain drive.

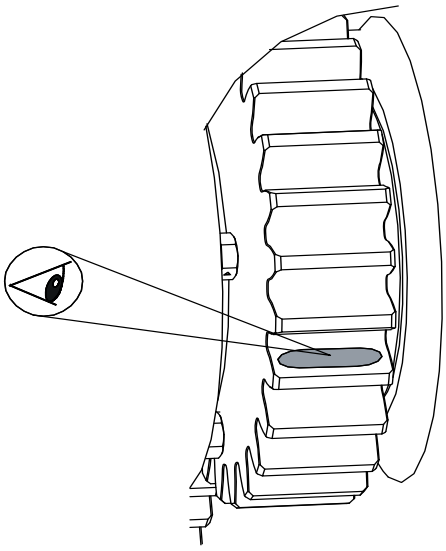
Carry out a visual inspection of the gear wheels.



4565-1201-0003C01

The contact face of the gear wheel tooth

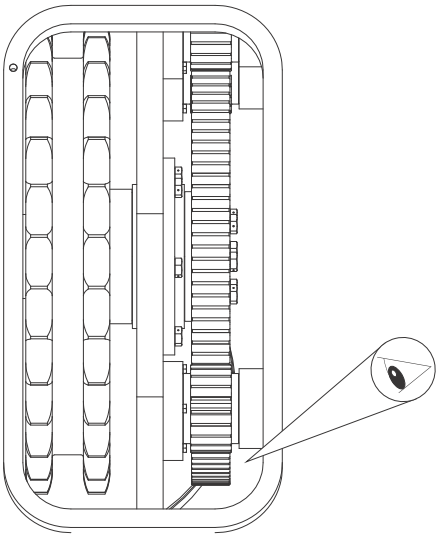
Check that there are no signs of abnormal wear on the contact faces of the gear wheel teeth.



4565-1201-0001C02

No abnormal particles below the bearings

Check that there are no particles of bearing material on the horizontal surfaces below the bearings.

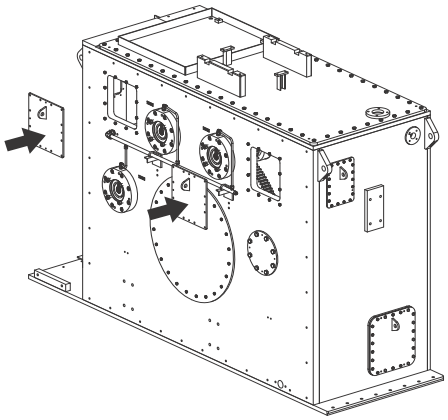


4565-1201-0003C03

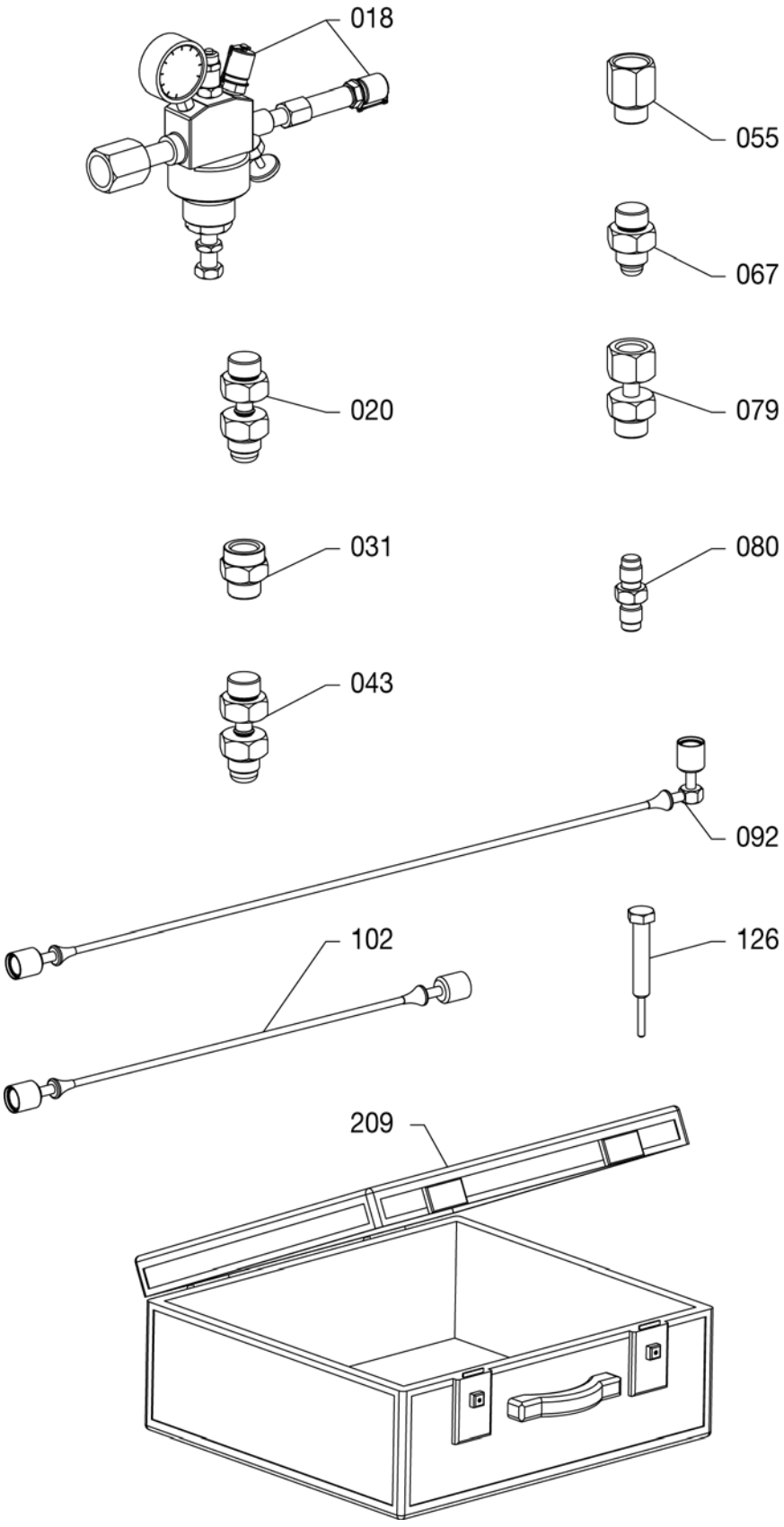
2008-11-25 - en

Refit covers

Fit the cover on the exhaust and rear side of the chain drive.



4565-1201-0003C04



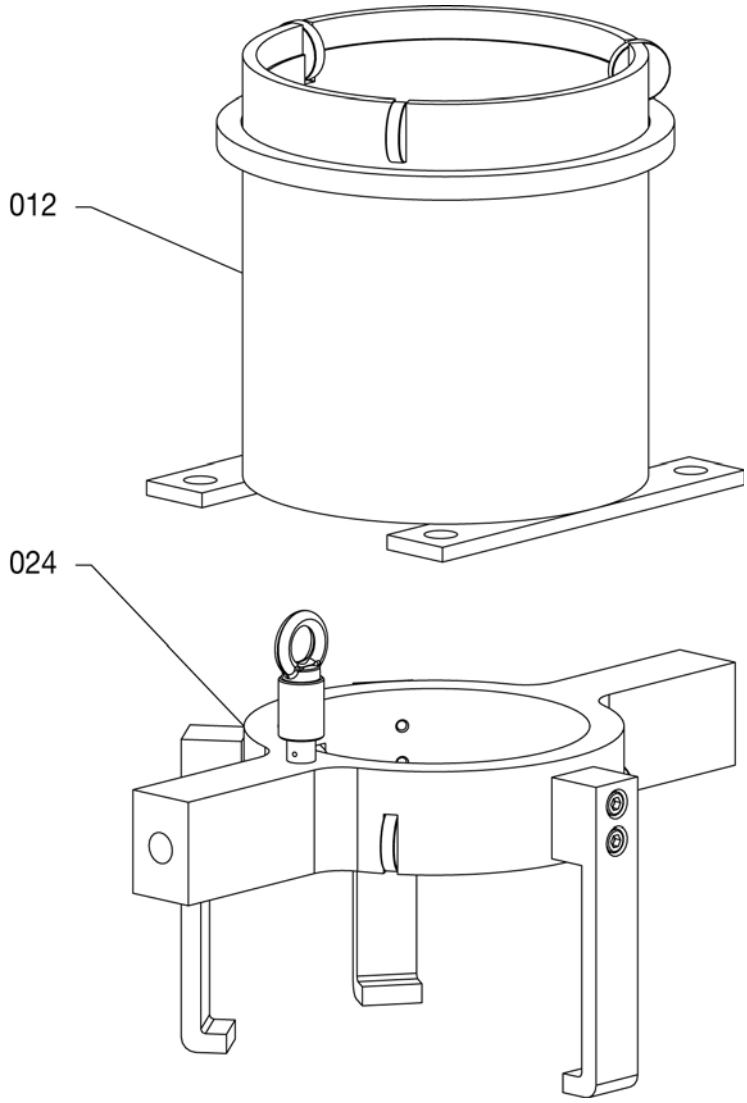
Equipment for Testing Accumulators

Plate
4570-0540-0001.0

Equipment for Testing Accumulators

Plate 4570-0540-0001.0

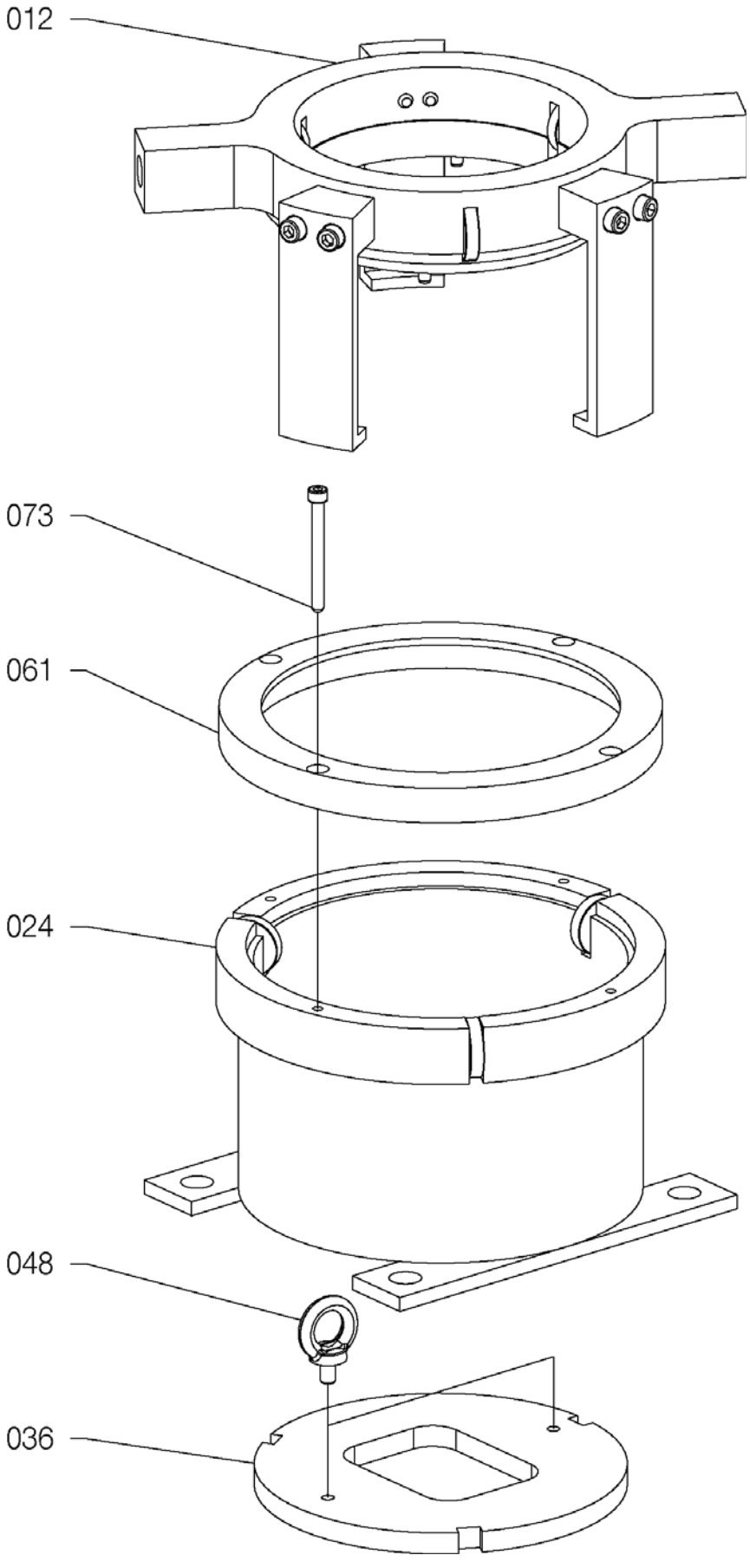
Item no	Qty	Designation
018	-	Reducing valve
020	-	Adaptor
031	-	Adaptor
043	-	Adaptor
055	-	Adaptor
067	-	Adaptor
079	-	Adaptor
080	-	Adaptor
092	-	Quick coupling, minimess
102	-	Quick coupling, minimess
126	-	Screw
209	-	Test equipment for accumulators set, complete


012
024

Accumulator Tools

Plate 4570-0550-0002.0

Item no	Qty	Designation
012	-	Pin wrench, special
024	-	Hook wrench



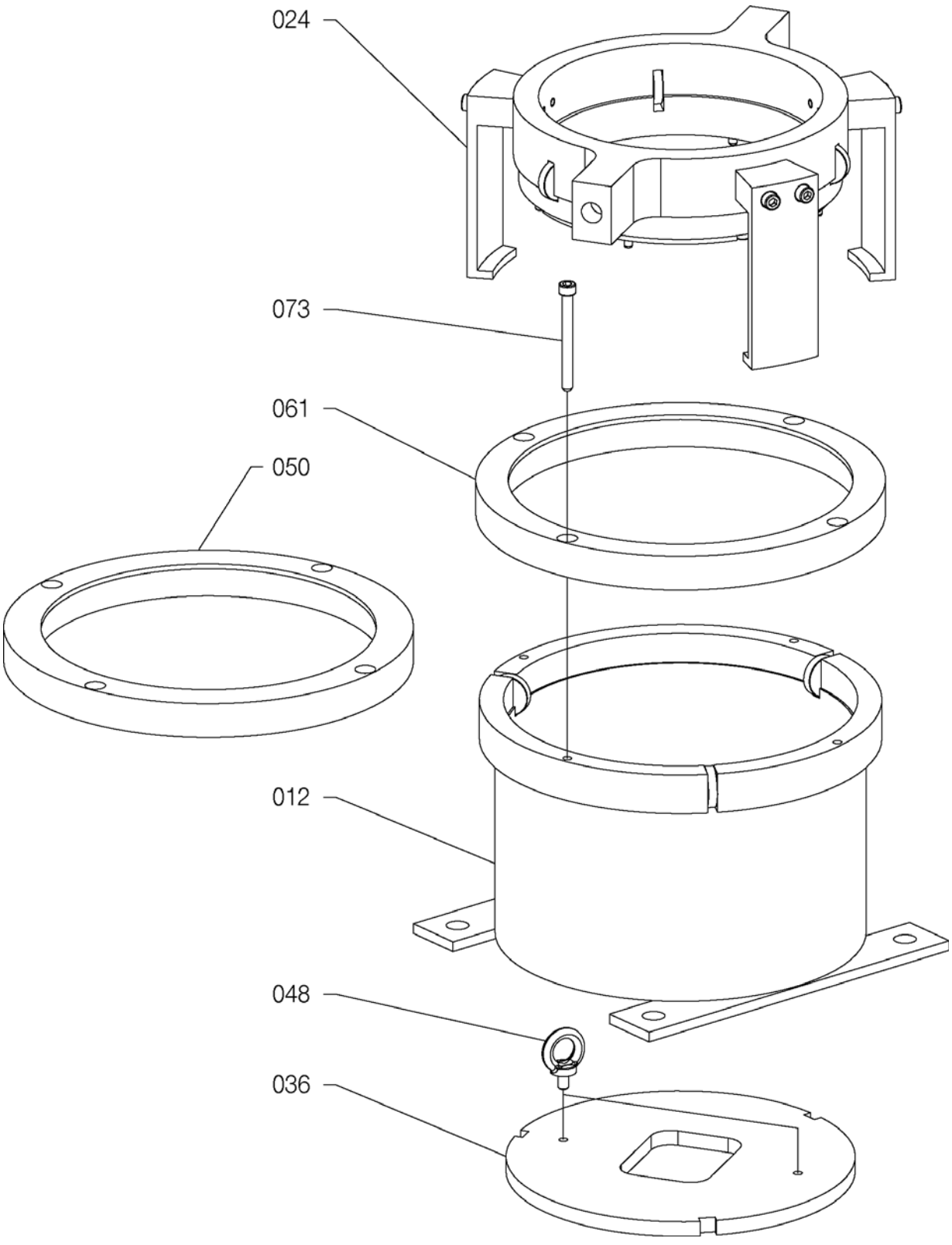
Accumulator Tools

Plate
4570-0550-0004

2013-08-19 - en

Item No.	Qty	Item designation
012	-	Hook wrench
024	-	Pin wrench, special
036	-	Plate
048	-	Eye bolt
061	-	Ring for Hanmi + Hydro LeDuc accumulator
073	-	Screw

2013-08-19 - en



Accumulator Tools

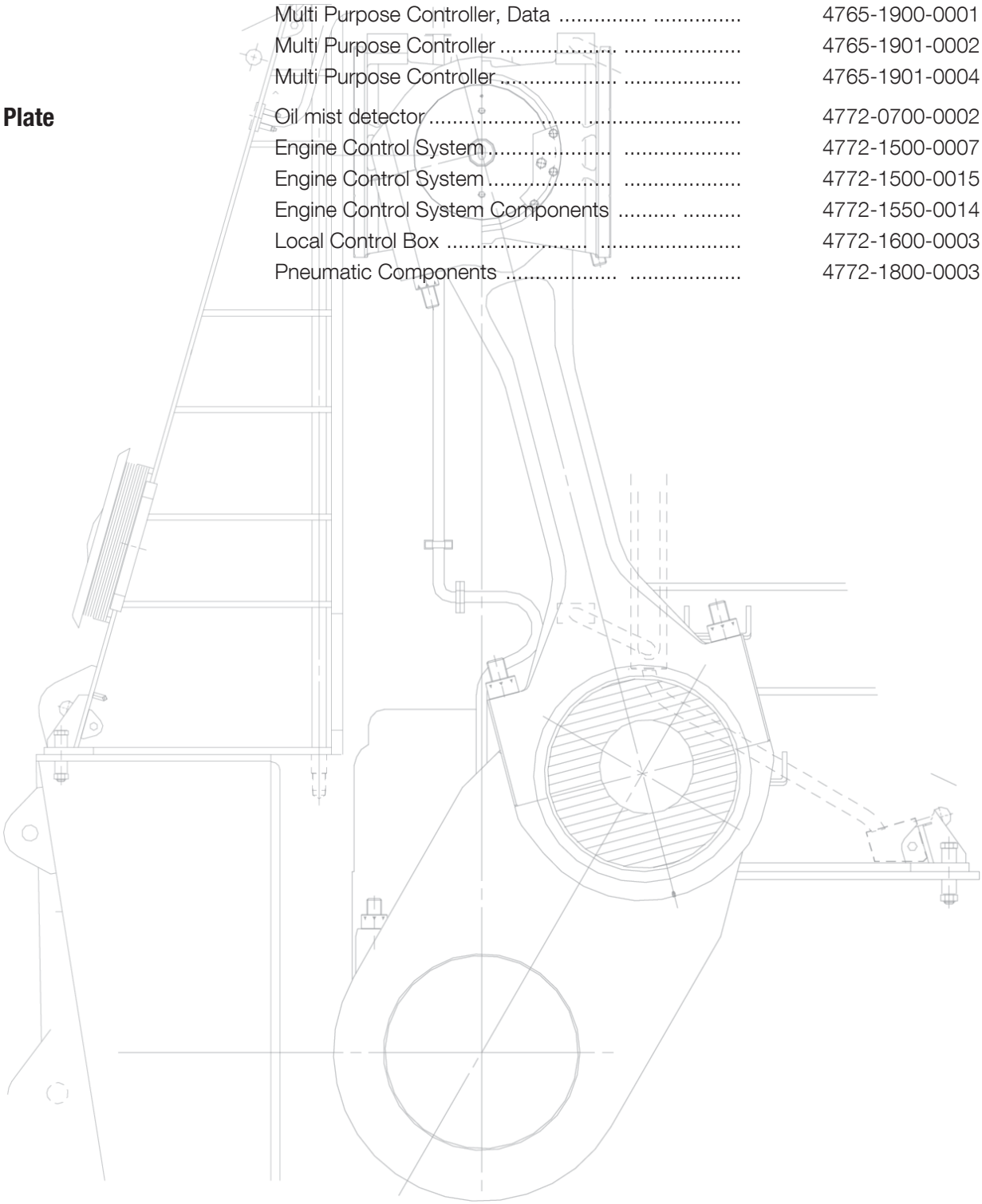
Plate 4570-0550-0005

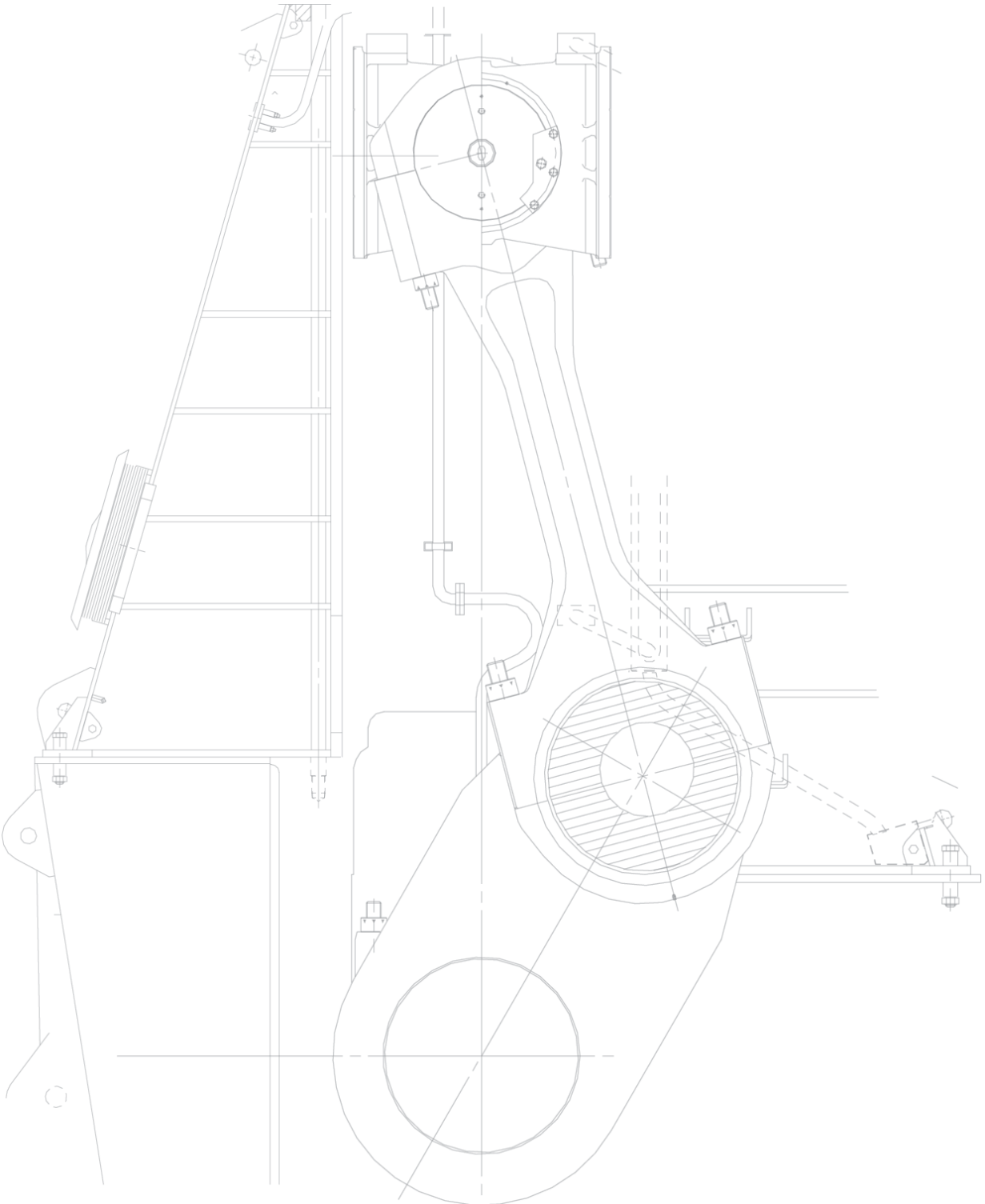
2013-08-19 - en

Item No.	Qty	Item designation
012	-	Pin wrench, special
024	-	Hook wrench
036	-	Plate
048	-	Eye bolt
050	-	Ring for Daeshin accumulator
061	-	Ring for Hydro LeDuc accumulator
073	-	Screw

2013-08-19 - en

Preface Chapter	Electronics	4740-0100-0002
Work Card	Cable Connections, Data	4765-1000-0001
	Cable Connections	4765-1001-0002
	Multi Purpose Controller, Data	4765-1900-0001
	Multi Purpose Controller	4765-1901-0002
	Multi Purpose Controller	4765-1901-0004
Plate	Oil mist detector	4772-0700-0002
	Engine Control System	4772-1500-0007
	Engine Control System	4772-1500-0015
	Engine Control System Components	4772-1550-0014
	Local Control Box	4772-1600-0003
	Pneumatic Components	4772-1800-0003





Electronics

This chapter of the instruction book is intended to provide the user with information regarding the various electronic components installed on the engine.

2012-11-29 - en

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Stop lubricating oil supply
O	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
-	Table is empty on purpose. No Data needed.	-	-

2013-01-30 - en

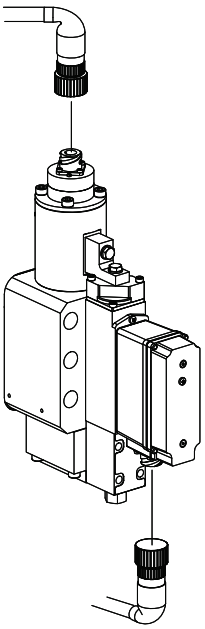
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
-	-	Table is empty on purpose. No special tools needed.

Electrical Connectors

Service experience has shown that a number of electrical faults can be avoided by using uniflow 8917© synthetic grease when assembling electrical connectors such as those on the control valves and angle encoders.



4765-1001-0002D01

Cleaning

Clean the electrical connectors using a lubricant-free contact cleaning spray, cotton swabs and pieces of non-fluffy cloth.

Wait for the connector to dry.

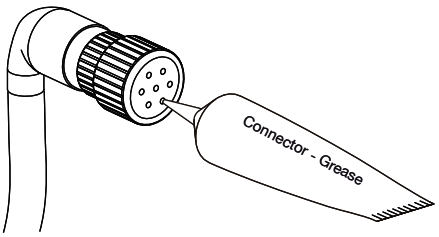
Place the nozzle of the grease tube in front of each female terminal and inject a small amount of grease.



4765-1001-0001O01

Assembling

Assemble and disassemble the connector a few times to distribute the grease evenly before final assembly.



4765-1001-0001O02

2009-06-09 - en

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine



Data

Ref.	Description	Value	Unit
-	Table is empty on purpose. No Data needed.	-	-

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

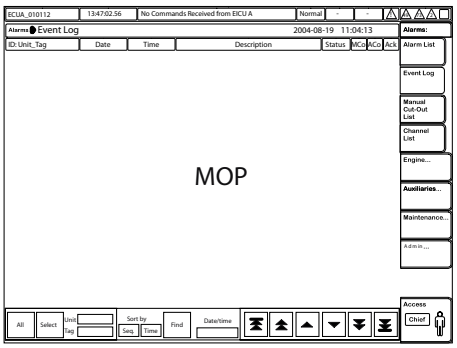
Tools

Plate	Item No.	Description
-	-	Table is empty on purpose. No special tools needed.

Multi Purpose Controller

Multi Purpose Controllers are used in CCU, ACU, ECU and EICU panels. Checking of the MPC is continuously performed by the MOP units.

See description in Chapter 6645 for a detailed view of the MOP panel screens.



4765-1901-0001C01

2010-02-01 - en

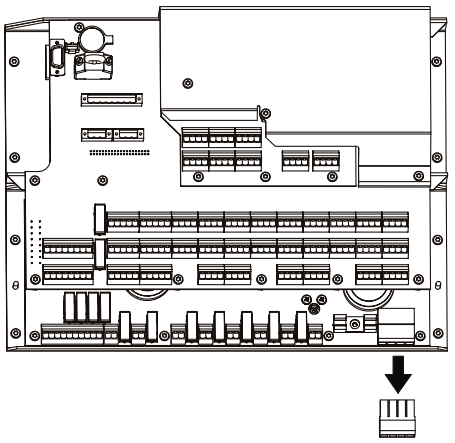
Dismantling of MPC board

WARNING

Static electricity may harm the MPC. When changing battery or doing other maintenance on the MPC it is important to level the electric potential between hand and frame. This is done immediately before any work on the MPC and MPC cabinet by simply touching any piece of non coated metal of the cabinet.

Power connector

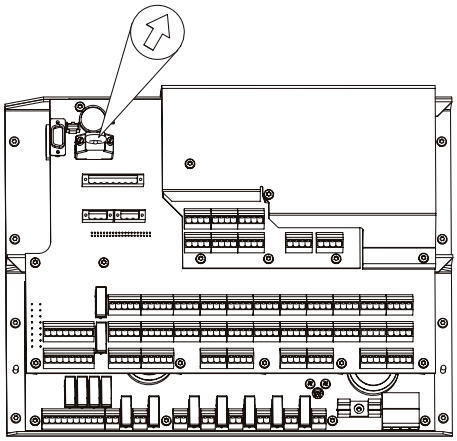
Disconnect the power connector.



4765-1901-0001D01

ID-key

Disconnect the ID-key.

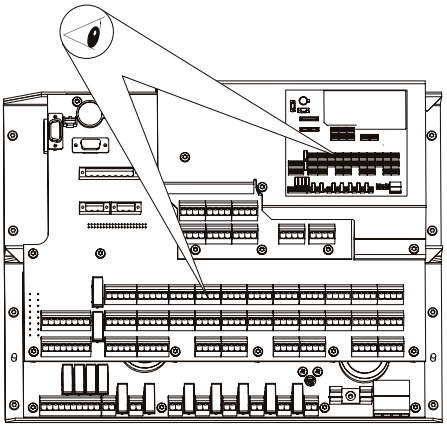


4765-1901-0001D02

2010-02-01 - en

MPC board

Check placement of connectors according to the table shown on the metal plate on the MPC board. If necessary, note down connector placement.



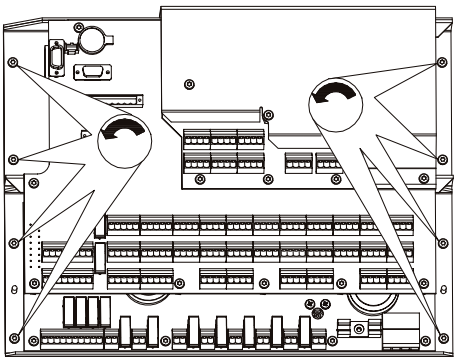
4765-1901-0001D03

Connectors

Disconnect all connectors on the MPC board.

Remove the MPC board

Unscrew the MPC board and remove it from the panel.



4765-1901-0001D05

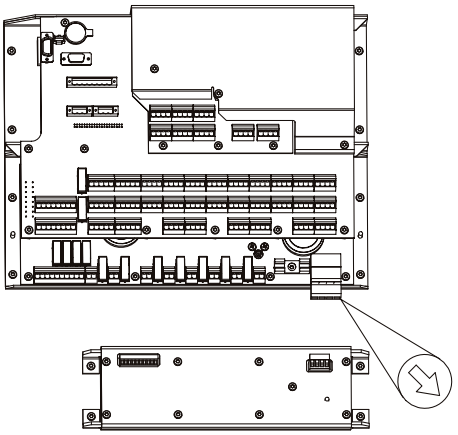
Dismantling of amplifier

In the CCU and ACU panels amplifiers are mounted below the MPC board.

2010-02-01 - en

Power connector

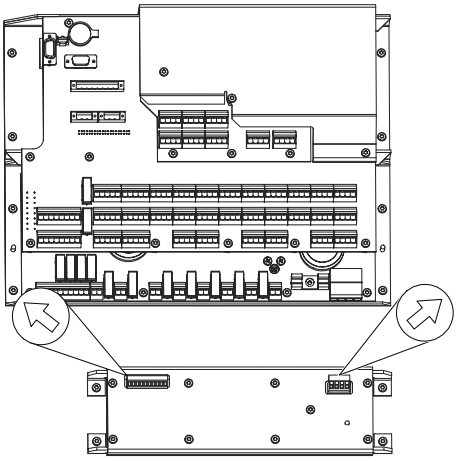
Unplug the power connector from the bottom of the MPC board.



4765-1901-0001D06

Amplifier

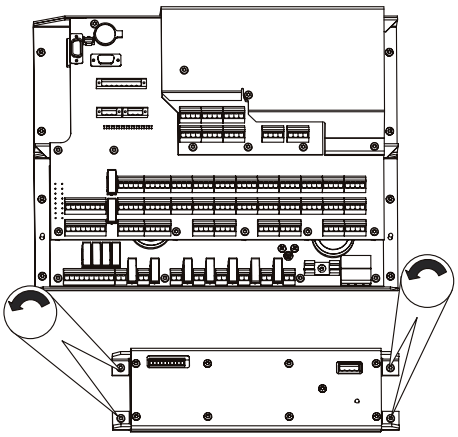
Unplug the two connectors on the amplifier.



4765-1901-0001D07

Amplifier

Unscrew the amplifier and remove it from the panel.

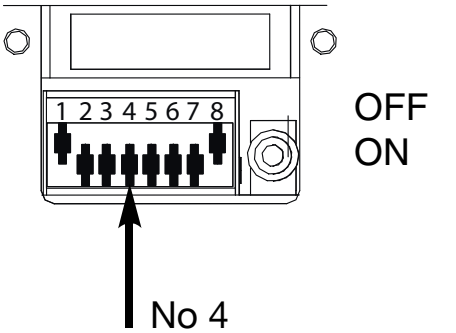


4765-1901-0001D08

2010-02-01 - en

Mounting the MPC board

If a spare MPC board has been used previously on another engine it is necessary to force the MPC to update software from the MOP panel.
This is done in the following way:
Set the yellow dip switch No. 4 on the side of the replacement MPC to OFF.
Mount the MPC as described.
Power on the MPC and let the MPC finish downloading.
When the MPC LED flashes 2 red and 3 green (APPLOAD_DIP see appendix), set the yellow dip switch No. 4 to ON.



4765-1901-0001M01

WARNING

NOTE

Do not mount an MPC board unless the backup battery is installed.

WARNING

Changing the battery of the Multi-Purpose Controller (MPC) may cause a reset and restart of the MPC.

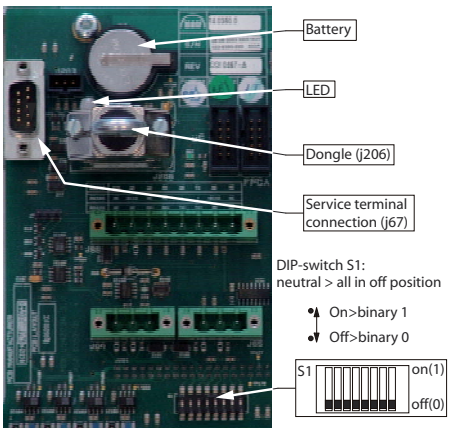
Therefore, only change the battery while:

- the ship is in harbour with engine stopped, or
- when sailing in unrestricted areas, where a restart of an MPC does not imply any risk for the ship or the engine.

The battery only serves as back-up supply for the built-in clock of the MPC, and a low battery level for several days until entering port is of no consequence to the safe operation of the engine.

Backup battery

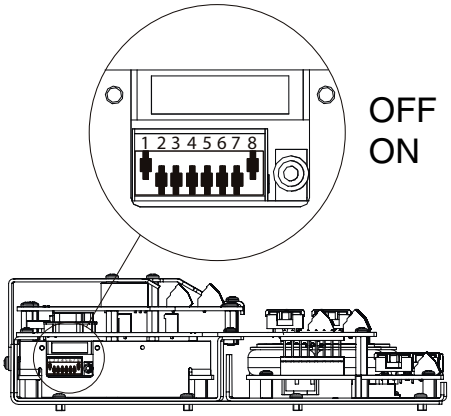
Check that the back-up battery is mounted and that the DIP switch S1 is in neutral position. This means all switches are in the »off« position. This is also known as binary »0«.



4765-1901-0001M02

DIP switches

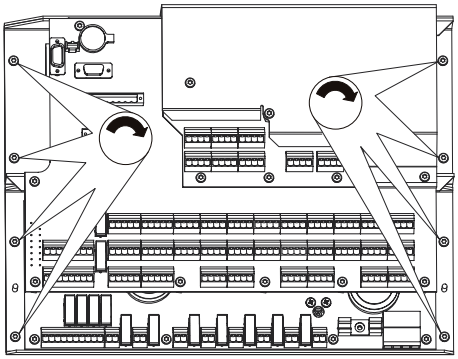
Check that the coloured DIP switches 1 and 8 on the side of the MPC board are set to the »off« position.



4765-1901-0001M03

MPC board

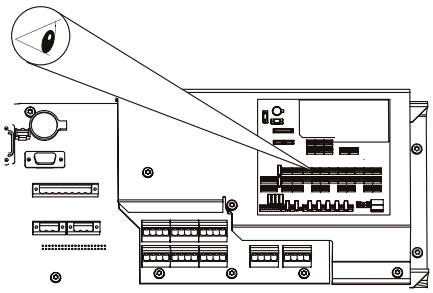
Mount the MPC board in the panel.



4765-1901-0001M04

Connectors

Mount the connectors according to the table shown on the metal plate on the MPC board.

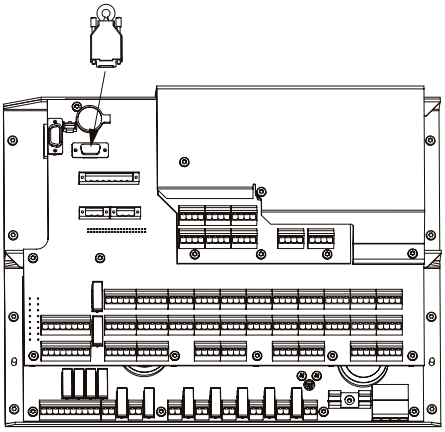


4765-1901-0001M12

2010-02-01 - en

ID-key

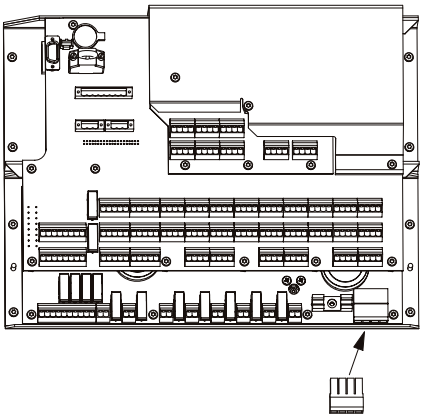
Mount the ID-key.



4765-1901-0001M05

Power connector

Mount the power connector.

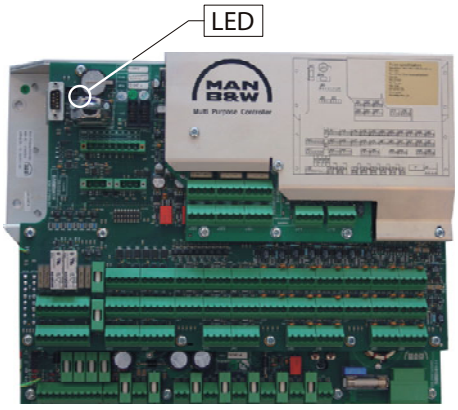


4765-1901-0001M06

Start-up process

During the start-up process, the LED will flash and the MPC board will reboot several times.

During start-up, the MPC verifies if the ID-key is connected. It reads the ID number and checks if the key ID is in the correct format and has a valid range, it reads the DIP-switch S1 value and verifies if it is 0 (Off). A new MPC board will download software and settings from the MOP panel during this process.



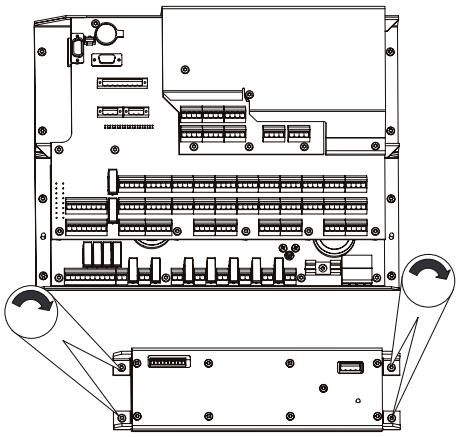
4765-1901-0001M07

The program completes the ID-key verification and is now ready to continue the boot sequence. Any deviations will send an error message via the LED. The start-up time of a new MPC board may vary but will take about 15 minutes.

When the LED shows green, the MPC board is running normally.
The MPC LED indications are shown on the appendix in this procedure.

Amplifier

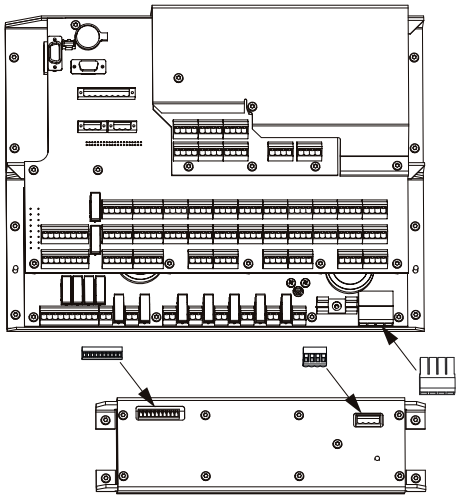
Mount the amplifier using the two screws.



4765-1901-0001M08

Connections

Connect the two connectors on the amplifier and the power connectors on the MPC board.



4765-1901-0001M09

The MPC LED flashes different sequences according to the process performed.

Some of these indications are for normal use and some are for service personnel use.

All of the LED indication sequences are shown in the diagram below.

This is to facilitate communication with MAN Diesel A/S service personnel if needed.

2010-02-01 - en

MPC LED Indication

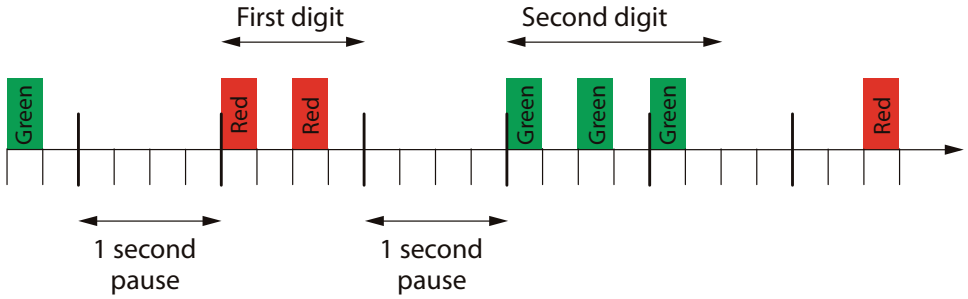
Description

The first part of the document describes the syntax of the LED indication and assigns a short description to each of the used indications. The second part presents a more detailed description of the different indications.

Syntax

The MPC LED may be issuing indications by either emitting constant light or by flashing. The LED indications are uniquely identified by the colour that the MPC LED emits.

A flashing LED indication consists of two pulse trains separated in time by a 1-second pause. Each of these pulse trains represents an integer. All pulses are set against a yellow background. The first pulse train will alternate between the yellow background and a red foreground, while the second will use green as foreground.



4765-1901-0001M10

For identification of the indication the user must therefore note the number of red and green pulses. The first digit is the number of red pulses and the second digit is the number of green pulses. In the illustration above, the indication code would thus be (2,3).

Indications

Constant

Colour	Short name	Short description
Red	ERROR	Either early initialization or fatal error
Orange	INIT	Initialization, no parameters available or non-normal node mode
Green	NORMAL	Application up and running

Flashing

Digits		Short name	Short description
Red	Green		
1	1	CTRL_PRG	Onboard control programming in progress
2	1	APPLOAD_SCAN	Application download in progress - sacnning for server
2	2	APPLOAD_DOWNLOAD	Application download in progress - downloading program
2	3	APPLOAD_DIP	Application download completed -reset yellow DIP switch set to ON
3	1	BOOTLOAD_SCAN	Bootloader download in progress - scanning for server
3	2	BOOTLOAD_DOWNLOAD	Bootloader download in progress - downloading program
4	1	DONGLE_VERIFY	Checking node ID-key
4	2	DONGLE_ERROR	ID-key erroe - missing, broken or not programmed
4	3	DONGLE_DIP	Node ID DIP switch not correctly reset - reset it to 0x00

4765-1901-0001M11

2010-02-01 - en

Detailed description of LED indications

ERROR (Red)	This code is used primarily for indicating if the MPC has experienced a fatal error. However, the MPC will also use this indication during early initialisation. Therefore, the user should only take this code as an indication of error if it persists more than 10 seconds.
INIT (Orange)	Generally, this code is used for indicating initialisation, but the MPC may also use this indication to signal one of the following conditions: No parameters: No valid parameters are available to the application software. Configuration or test mode: The MPC is in a non-normal node mode. Generally, if the INIT code is shown longer than 10 seconds this would indicate one of the latter conditions.
NORMAL (Green)	Application is up and running.
CTRL_PGM (1,1)	One of the on-board micro controllers is being programmed. This is a part of the MPC initialization process.
APPLOAD_SCAN (2,1)	The application software download program (bootloader) is trying to find a server from which it can download its application program. If this code persists it indicates either that no application program server is connected to the network or the network is broken.
APPLOAD_DOWNLOAD (2,2)	An application program is being downloaded.
APPLOAD_DIP (2,3	The yellow DIP-switch on the MPC CPU board can be used for forcing download of new application software. To avoid looping it is therefore required that the yellow DIP-switch be reset on completion of such a forced download. Reset it to ON/down.
BOOTLOAD_SCAN (3,1)	This indication is analogous to the APPLOAD_SCAN indication except that this code indicates that there is not server available from which the MPC can download a new bootloader. This code should only be indicated if attempts are being made to update the bootloader using the special update program.
BOOTLOAD_DOWNLOAD (3,2)	A new bootloader program is being downloaded and programmed.
DONGLE_VERIFY (4,1)	The ID-key is being checked. This should only take a couple of seconds.

2010-02-01 - en

DONGLE_ERROR (4,2)

A ID-key error has been identified. Either the ID-key is missing, broken or holds an invalid value. Try to reprogram it.

DONGLE_DIP (4,3)

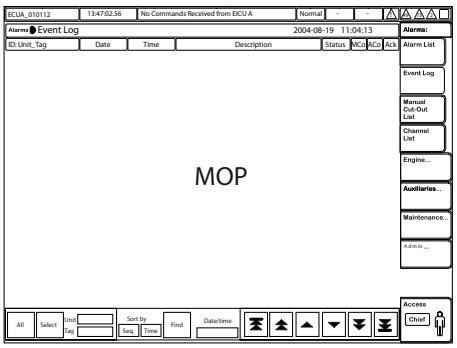
The DIP-switch mounted on the CMI/O board is used for programming the ID-key. The programming process requires that this DIP-switch be reset before completing. This code is used for indicating this to the user. Reset the CMI/O board DIP switches to OFF/down.

2010-02-01 - en

Multi Purpose Controller

MPC10 Controllers are used in the CCU panels. Checking of the MPC10 is continuously performed by the MOP units.

See description in Chapter 6645 for a detailed view of the MOP panel screens.



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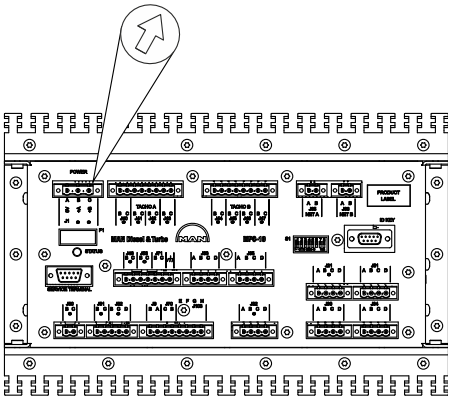
Dismantling of MPC board

WARNING

Static electricity may harm the MPC10. When changing battery or doing other maintenance on the MPC10 controller it is important to level the electric potential between hand and frame. This is done immediately before any work on the MPC10 and MPC10 cabinet by simply touching any piece of non coated metal of the cabinet.

Power connector

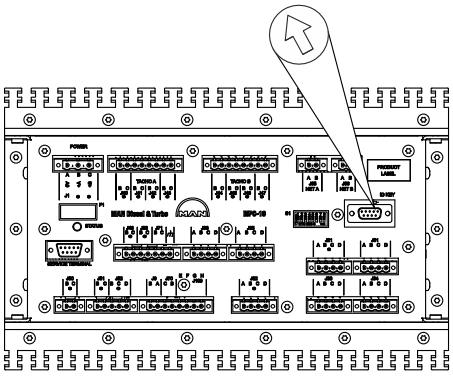
Disconnect the power connector.



4765-1901-0004D01

ID-key

Disconnect the ID-key.

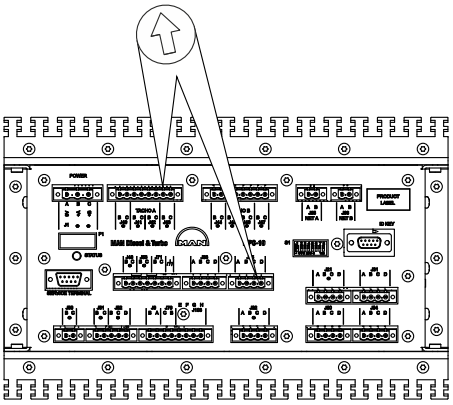


4765-1901-0004D02

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Connectors

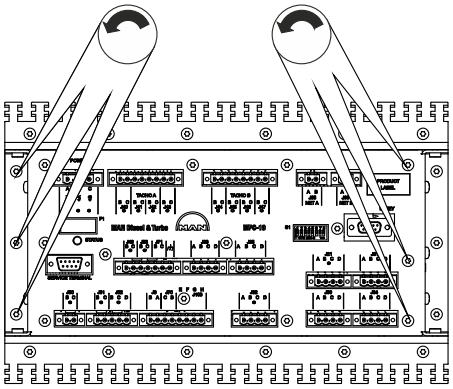
Disconnect all connectors from the MPC10.



4765-1901-0004D03

Remove the MPC10 controller

Unscrew the MPC10 and remove it from the panel.



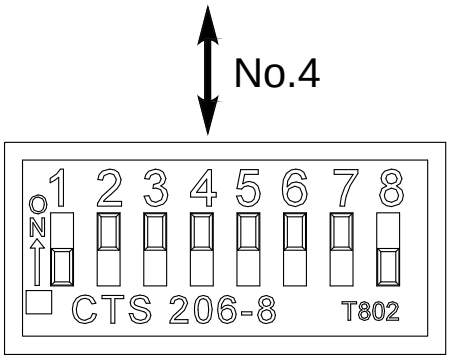
4765-1901-0004D04

2013-10-21 - en

Mounting the MPC10

WARNING

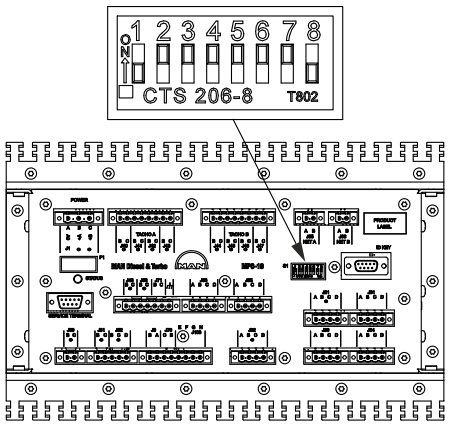
If a spare MPC10 unit has been used previously on another engine it is necessary to force the MPC10 to update software from the MOP panel.
This is done in the following way:
Set the dip switch no. 4 on the front of the replacement MPC10 to OFF.
Mount the MPC10 as described.
Power on the MPC10 and let the MPC10 finish downloading.
When the MPC LED flashes 2 red and 3 green (APPLOAD_DIP see appendix), set the dip switch no. 4 to ON.



4765-1901-0004M01

DIP switches

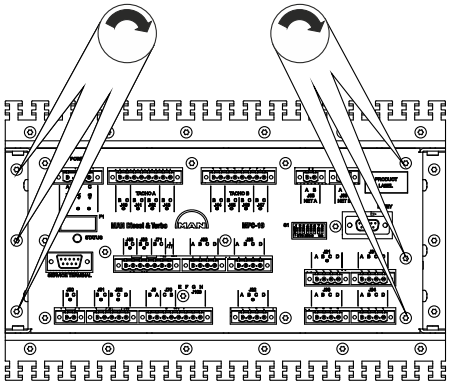
Check that the DIP switches no. 1 and 8 on the MPC10 controller are set to the »off« position.



4765-1901-0004M02

MPC10 controller

Mount the MPC10 in the panel.

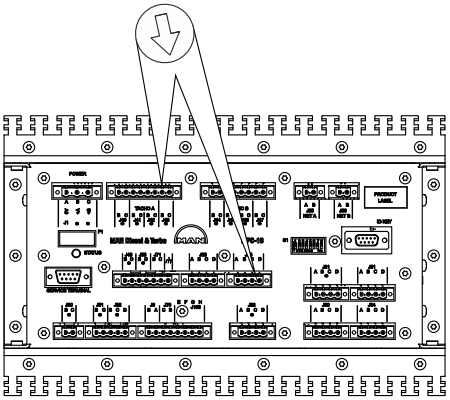


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Connectors

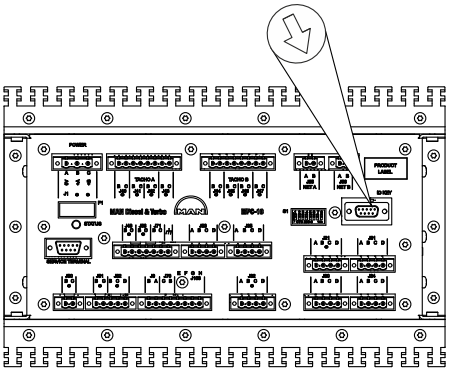
Mount the connectors according to the numbering printed on the metal plate on the front of the MPC10.



4765-1901-0004M04

ID-key

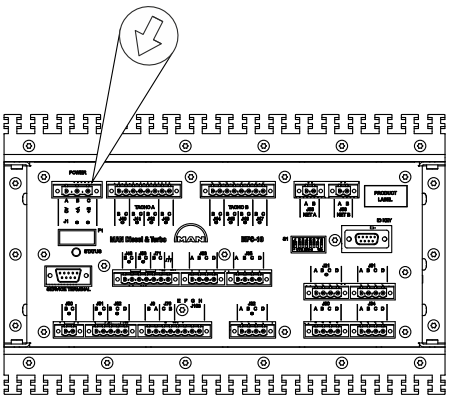
Mount the ID-key.



4765-1901-0004M05

Power connector

Mount the power connector.



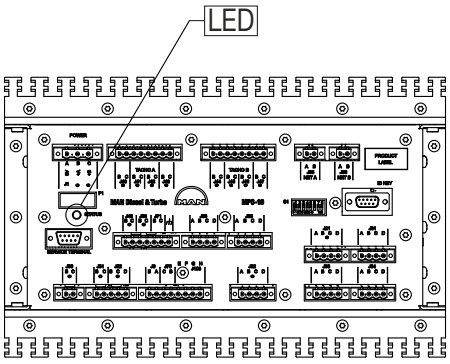
4765-1901-0004M06

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Start-up process

During the start-up process, the LED will flash and the MPC10 controller will reboot several times.

During start-up, the MPC verifies if the ID-key is connected. It reads the ID number and checks if the key ID is in the correct format and has a valid range, it reads the DIP-switch S1 value and verifies if it is 0 (Off). A new MPC10 controller will download software and settings from the MOP panel during this process.



4765-1901-0004M07

The program completes the ID-key verification and is now ready to continue the boot sequence. Any deviations will send an error message via the LED. The start-up time of a new MPC10 board may vary but will take about 15 minutes.

When the LED shows green, the MPC board is running normally.
The MPC10 LED indications are shown on the appendix in this procedure.

The MPC10 LED flashes different sequences according to the process performed.

Some of these indications are for normal use and some are for service personnel use.

All of the LED indication sequences are shown in the diagram below.

This is to facilitate communication with MAN Diesel A/S service personnel if needed.

MPC10 LED Indication

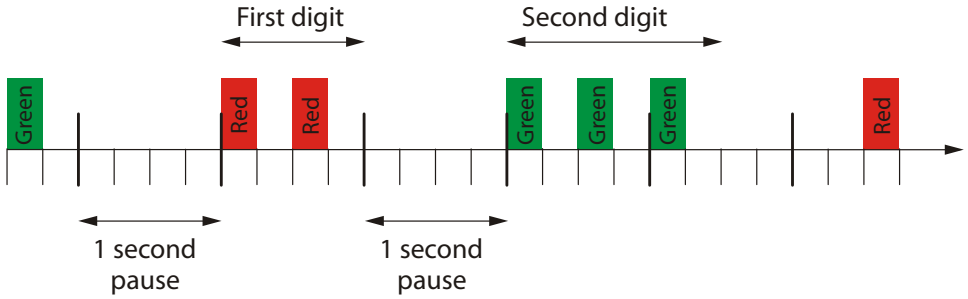
Description

The first part of the document describes the syntax of the LED indication and assigns a short description to each of the used indications. The second part presents a more detailed description of the different indications.

Syntax

The MPC10 LED may be issuing indications by either emitting constant light or by flashing. The LED indications are uniquely identified by the colour that the MPC10 LED emits.

A flashing LED indication consists of two pulse trains separated in time by a 1-second pause. Each of these pulse trains represents an integer. All pulses are set against a yellow background. The first pulse train will alternate between the yellow background and a red foreground, while the second will use green as foreground.



4765-1901-0001M10

For identification of the indication the user must therefore note the number of red and green pulses. The first digit is the number of red pulses and the second digit is the number of green pulses. In the illustration above, the indication code would thus be (2,3).

Indications

Constant

Colour	Short name	Short description
Red	ERROR	Either early initialization or fatal error
Orange	INIT	Initialization, no parameters available or non-normal node mode
Green	NORMAL	Application up and running

Flashing

Digits		Short name	Short description
Red	Green		
1	1	CTRL_PRG	Onboard control programming in progress
2	1	APPLOAD_SCAN	Application download in progress - sacnning for server
2	2	APPLOAD_DOWNLOAD	Application download in progress - downloading program
2	3	APPLOAD_DIP	Application download completed -reset yellow DIP switch set to ON
3	1	BOOTLOAD_SCAN	Bootloader download in progress - scanning for server
3	2	BOOTLOAD_DOWNLOAD	Bootloader download in progress - downloading program
4	1	DONGLE_VERIFY	Checking node ID-key
4	2	DONGLE_ERROR	ID-key error - missing, broken or not programmed
4	3	DONGLE_DIP	Node DIP switch S1 not correctly reset - set all switches to “OFF”
4	4	DONGLE_FORMAT	The ID-key needs to finalize the formatting process
4	5	DONGLE_DIP	ID Key EID number does not match MOP and/ or MPC

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2013-10-21 - en

Detailed description of LED indications

ERROR (Red)	This code is used primarily for indicating if the MPC10 has experienced a fatal error. However, the MPC10 will also use this indication during early initialisation. Therefore, the user should only take this code as an indication of error if it persists more than 10 seconds.
INIT (Orange)	Generally, this code is used for indicating initialisation, but the MPC10 may also use this indication to signal one of the following conditions: No parameters: No valid parameters are available to the application software. Configuration or test mode: The MPC10 is in a non-normal node mode. Generally, if the INIT code is shown longer than 10 seconds this would indicate one of the latter conditions.
NORMAL (Green)	Application is up and running.
CTRL_PGM (1,1)	One of the on-board micro controllers is being programmed. This is a part of the MPC10 initialization process.
APPLOAD_SCAN (2,1)	The application software download program (bootloader) is trying to find a server from which it can download its application program. If this code persists it indicates either that no application program server is connected to the network or the network is broken.
APPLOAD_DOWNLOAD (2,2)	An application program is being downloaded.
APPLOAD_DIP (2,3	The yellow DIP-switch on the MPC10 CPU controller can be used for forcing download of new application software. To avoid looping it is therefore required that the yellow DIP-switch be reset on completion of such a forced download. Reset it to ON/down.
BOOTLOAD_SCAN (3,1)	This indication is analogous to the APPLOAD_SCAN indication except that this code indicates that there is not server available from which the MPC10 can download a new bootloader. This code should only be indicated if attempts are being made to update the bootloader using the special update program.
BOOTLOAD_DOWNLOAD (3,2)	A new bootloader program is being downloaded and programmed.
DONGLE_VERIFY (4,1)	The ID-key is being checked. This should only take a couple of seconds.

2013-10-21 - en

DONGLE_ERROR (4,2)

An ID Key error has been identified. Either the ID Key is missing, broken or holds an invalid value. It may also indicate that a new ID Key is inserted.
Try to program the ID Key following the “Replacing an ID Key” procedure.

DONGLE_DIP (4,3)

The programming procedure requires that the DIP-switch S1 be reset before completing.
The operator must respond to this by setting all 8 switches on the DIP-switch S1 to “OFF” (Down).

DONGLE_FORMAT (4,4)

The ID Key needs to finalize the formatting process. This situation may occur for different reasons; it might be that the ID key or MPC10 have been replaced.

The operator must respond to this by setting the first (left) DIP-switch on S1 to “ON” (Up) in min. 2 sec.
Then put it back in “OFF” (Down).
This causes the final formatting of the ID key.

After this the MPC10 restarts.

DONGLE_DIP_CONFLICT (4,5)

ID Key EID number does not match MOP and/or MPC. This situation may occur when a new ID Key has been programmed and the old ID Key is inserted in the MPC10.
The operator should insert the newly programmed ID Key and reset the MPC10, or a new unused ID Key must be programmed following the “Replacing an ID Key” procedure.

Replacing an ID key

On the rare occasion, that an ID key fails, it can be replaced by a new one. The new key should be programmed as described in the following.

This key has to be formatted when the application use it for the first time and it will be reflected in a new parameter backup sent to the MOP. After that is done, the old key is no longer accepted.

Please go through the following steps:

- Power off the node.
- Remove the old ID Key.
- Set the DIP-switch S1 accordingly to table on page 11.
- Reconnect power to the node.
- Wait for the LED to indicate 4 red and 2 green blinks.
- Plug-in a new unused ID Key. Then the LED indicates 4 red and 3 green flashes.
- While the LED indicates 4 red and 3 green blinks, the operator must set all 8 switches on the DIP-switch S1 to “OFF” (Down).

2013-10-21 - en

Now the MPC10 proceeds with application program download and final formatting.

The MPC10 may start to download the application program while the LED indicates 2 red and 2 green flashes. This will take up to 5 minutes.

After this the MPC10 restarts and stops for an operator dialog. The LED indicates this with 4 red and 4 green flashes.

- The operator must respond to this by setting the first (left) DIP-switch on S1 to “ON” (Up) in min. 2 sec.
- Then put it back in “OFF” (Down).

This causes the final formatting of the ID key.
After this the MPC10 makes another restart before the application is executed.

Programming a blank ID key

This use case concerns the initial use of an installation, or the case that the ID Key for some reasons has been replaced with a new and blank ID Key.
When the ID Key is blank, it means that the internal flash memory had the data values, as was left from the factory test of the ID Key itself.

The way to define the network address for a new ID key is using the DIP switch on the MPC10 (all versions of BES and bootloader).

After this is done, the final formatting of the remaining fields in the ID key is done the first time an application program starts. User interaction is required to confirm this step.

Initializing a blank ID key from DIP switch

The service terminal can optionally be used to observe what is happening in the MPC10. The MOP is assumed to be running and connected to the MPC10.

As this is the first set-up with a blank ID Key, the DIP-switch 1 must have the node address coded before power up (241 in this example) please see page 11 for correct network adress.

NOTE

The ID Key must be unplugged before power up.

Please go through the following steps:

- At power up the LED indicates 4 red and 2 green blinks.
- Plug the blank ID Key in the current MPC10. Then the LED indicates 4 red and 3 green blinks.
- While the LED indicates 4 red and 3 green blinks, the operator must change the value in the DIP-switch to 0 in all bits.Then the LED indicates 2 red and 1 green blinks.

Now the MPC10 proceeds with application program download and final formatting.

2013-10-21 - en

Software download and final formatting of ID Key

Hereafter the MPC10 starts downloading the application program while the LED indicates 2 red and 2 green blinks.

After this the MPC10 restarts and stops for an operator dialog. The LED indicates 4 red and 4 green blinks in this state

The operator must respond to this by setting bit 1 of DIP-switch 1 to 1, and keeping it there for at least 2 seconds.

This causes the final formatting of the ID Key

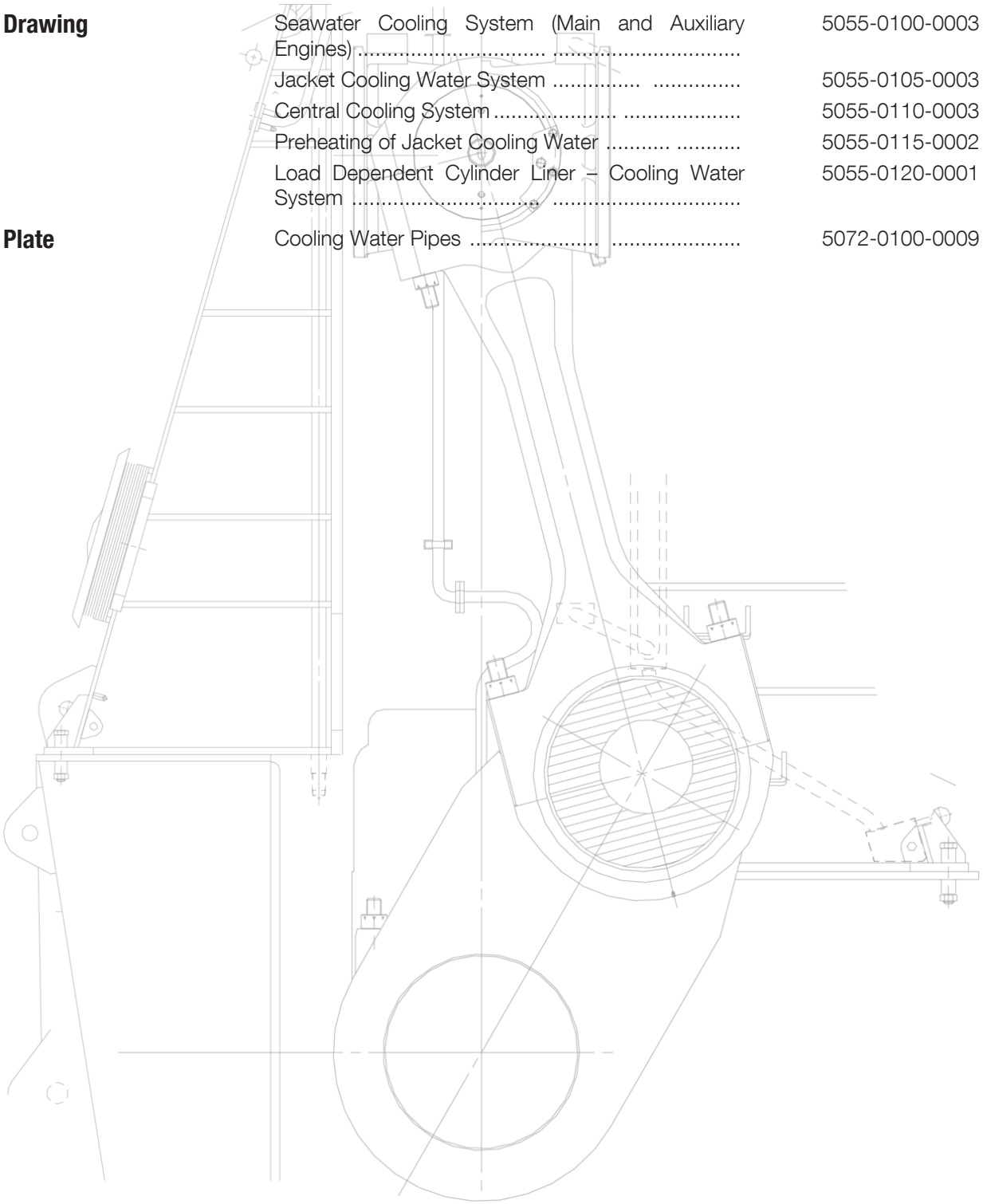
After this the MPC10 makes another restart before the application is executed.

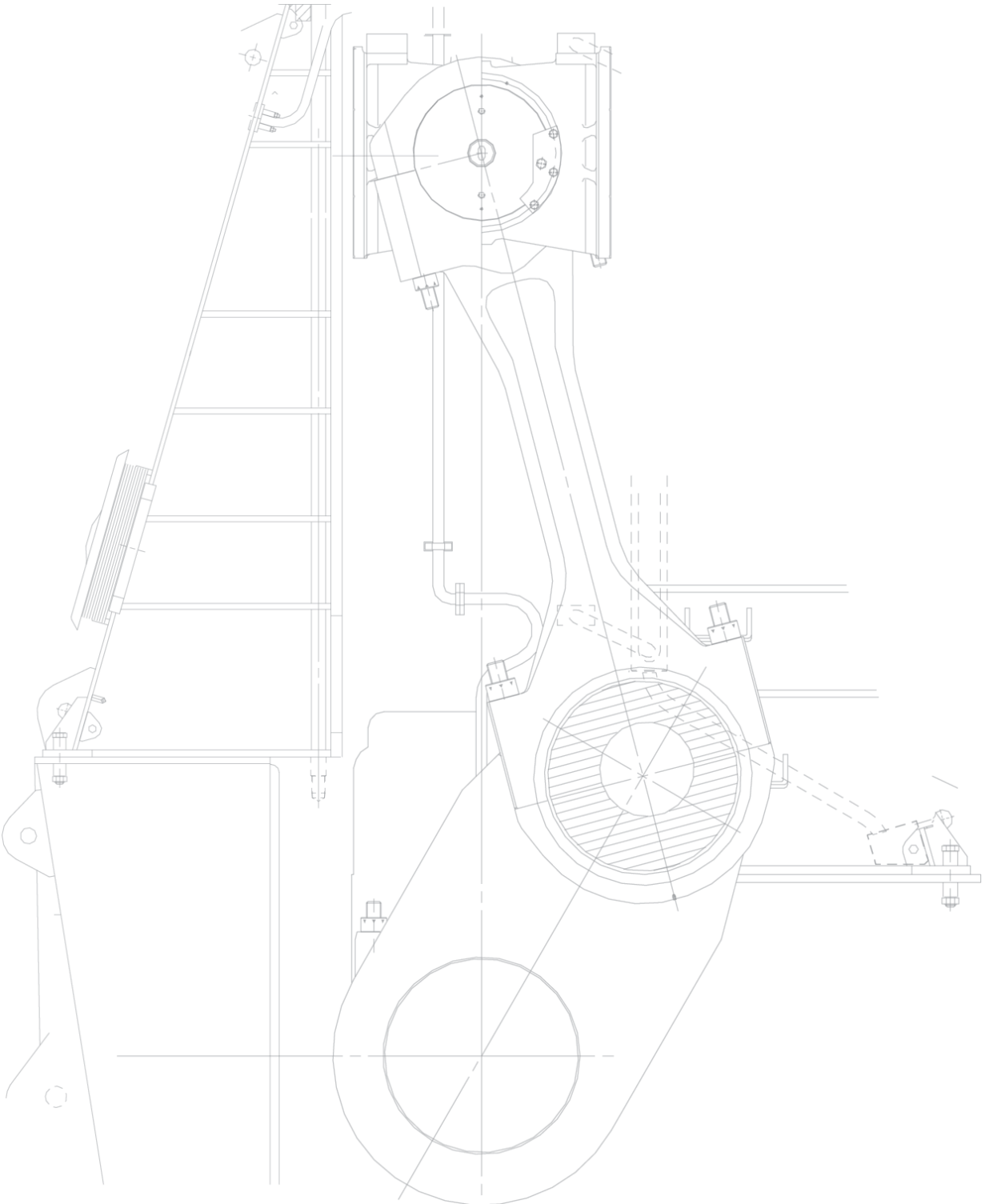
For correct settings of the DIP switch we refer to below table of network adresses:

	DIP switch bit No.	1	2	3	4	5	6	7	8
MPC	Network Addess								
CCU1	240	Off	Off	Off	Off	On	On	On	On
CCU2	241	On	Off	Off	Off	On	On	On	On
CCU3	242	Off	On	Off	Off	On	On	On	On
CCU4	243	On	On	Off	Off	On	On	On	On
CCU5	244	Off	Off	On	Off	On	On	On	On
CCU6	245	On	Off	On	Off	On	On	On	On
CCU7	246	Off	On	On	Off	On	On	On	On
CCU8	247	On	On	On	Off	On	On	On	On
CCU9	248	Off	Off	Off	On	On	On	On	On
CCU10	249	On	Off	Off	On	On	On	On	On
CCU11	250	Off	On	Off	On	On	On	On	On
CCU12	251	On	On	Off	On	On	On	On	On
CCU13	252	Off	Off	On	On	On	On	On	On
CCU14	253	On	Off	On	On	On	On	On	On
CCU15	254	Off	On	On	On	On	On	On	On
CCU16	255	On	On	On	On	On	On	On	On

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Preface Chapter	Cooling Water	5040-0100-0001
Description	Cooling Water System, Data	5045-0100-0004
	Cooling Water Treatment	5045-0200-0002
Drawing	Seawater Cooling System (Main and Auxiliary Engines)	5055-0100-0003
	Jacket Cooling Water System	5055-0105-0003
	Central Cooling System	5055-0110-0003
	Preheating of Jacket Cooling Water	5055-0115-0002
	Load Dependent Cylinder Liner – Cooling Water System	5055-0120-0001
Plate	Cooling Water Pipes	5072-0100-0009





Cooling Water System

This chapter contains informations on how to operate and maintain your cooling water system.

Please note that the pipe systems vary considerably from plant to plant.

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1 General

Pipe systems vary considerably from plant to plant. The following schematic pipe diagrams are included here, for guidance, to illustrate the essential principles of the circuits and their correlation.

NOTICE

For a specific plant, the correct details must be found in the piping diagrams supplied by the shipyard.

2 Seawater Cooling System

Drawing 5055-0100

The seawater cooling system is a lowtemperature system. However, to be sure that the lubricating oil is kept at a viscosity level suitable for heat transfer, a recirculation arrangement controlled by the thermostatic valve, item 3, ensures that the inlet temperature of the cooling water does not fall below 10 °C.

2.1 Operation at Sea

Drawing 5055-0100

Seawater is drawn by the seawater pump, item 2, through two separate inlets or “sea chests”, item 1, and pumped through the various coolers for both the main engine and the auxiliary engines.

The coolers incorporated in the system are the lubricating oil cooler, item 6, the scavenge air cooler(s), item 7, and a common jacket water cooler, item 8.

The air cooler(s) are supplied directly by the seawater pumps and are therefore cooled by the coldest water available in the system. This ensures the lowest possible scavenge air temperature, and thus optimum cooling is obtained with a view to the highest possible thermal efficiency of the engines.

Since the system is seawater cooled, all components are to be made of seawater resistant materials.

With both the main engine and one or more auxiliary engines in service, the seawater pump, item 2, supplies cooling water to all the coolers and, through non-return valve, item 5, to the auxiliary engines. The pump, item 4, is inactive.

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2.2 Operation in Port

Drawing 5055-0100

During operation in port, when the main engine is stopped but one or more auxiliary engines are running, a small seawater pump, item 4, is started up, instead of the large pump, item 2. The seawater is led from the pump to the auxiliary engine(s), through the common jacket water cooler, item 8 and is divided into two strings by the thermostatic valve item 3, either for recirculation or for discharge to the sea.

3 Jacket Water Cooling System

See drawing 5055-0105

The jacket water cooling system controls the temperature of the engines proper.

The jacket water must be inhibited to protect the surfaces of the cooling system against corrosion, corrosion fatigue, cavitation and the formation of scale. *See description 5045-0200.*

3.1 Operation at Sea

See drawing 5055-0105

The jacket water pump, item 1, circulates hot cooling water through the main engine to the freshwater generator, item 2, and from there to the jacket water cooler, item 3. Here a thermostatically controlled 3-way valve, item 4, mixes cooled and uncooled water to maintain an outlet temperature of 88-92 °C from the main engine.

An integrated loop in the auxiliary engines ensures a constant temperature of 80 °C at the outlet of the auxiliary engines.

There is one common expansion tank, item 6, for the main engine and the auxiliary engines.

To prevent the accumulation of air in the jacket water system, a deaerating tank, item 5, is to be installed. An alarm device is inserted between the deaerating tank and the expansion tank, so that the operating crew can be warned if excess air or gas is released, as this signals a malfunction of engine components.

3.2 Operation in Port

See drawing 5055-0105 and 5055-0115

The main engine is preheated by utilising hot water from the auxiliary engine(s). Depending on the size of main engine and auxiliary engines, an extra preheater may be necessary. This preheating is activated by *closing valve A and opening valve B*.

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Activating valves A and B will change the direction of flow, and the water will now be circulated by the auxiliary engine- driven pumps. From the auxiliary engines, the water flows through valve B directly to the main engine jacket outlet. When the water leaves the main engine, through the jacket inlet, it flows to the thermostatically controlled 3-way valve, item 4.

As the temperature sensor for the valve in this operating mode is measuring in a non-flow, low temperature piping, the valve will lead most of the cooling water to the jacket water cooler, item 3. The integrated loop in the auxiliary engines will ensure a constant temperature of 80 °C at the auxiliary engine outlet, the main engine will be preheated, and auxiliary engines on stand-by can also be preheated by operating valves F3 and F1.

4 Central Cooling System

See drawing 5055-0110

The central cooling system is an alternative to the seawater cooling system. It is based on the same design principles with regard to cooler locations, flow control and preheating, but has a central cooler and an additional set of pumps.

Maintenance work is minimised by the use of a central cooler, as this is the only component that is in direct contact with seawater. All other parts of the system use inhibited freshwater in accordance with MAN Diesel & Turbo specifications *See description 5045-0200*.

The low and high temperature systems are directly connected to gain the advantage of preheating the main and auxiliary engines during standstill.

As all fresh cooling water is inhibited and common for the central cooling system, only one common expansion tank, item 10, is necessary for deaeration of both the low and high temperature cooling systems. This tank accommodates the difference in water volume caused by changes in the temperature.

To prevent the accumulation of air in the cooling water system, a deaerating tank, item 11, is located below the expansion tank. An alarm device is inserted between the deaerating tank and the expansion tank so that the operating crew can be warned if excess air or gas is released, as this signals a malfunction of engine components.

4.1 Operation at Sea

See drawing 5055-0110

The seawater cooling pump, item 1, pumps seawater from the sea chests through the central cooler, item 2, and overboard. Alternatively, some shipyards use a pumpless scoop system. On the freshwater side, the central cooling water pump, item 3, circulates the low-temperature fresh water, in a cooling circuit, directly through the lubricating oil coolers, item 4, of the main engine, the auxiliary engines and the scavenge air coolers, item 5.

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The jacket water cooling system for the auxiliary engines is equipped with engine-driven pumps and a by-pass system integrated in the low-temperature system.

The main engine jacket system has an independent pump circuit with a jacket water pump, item 6, circulating the cooling water through the main engine to the fresh water generator, item 7, and the jacket water cooler, item 8.

A thermostatically controlled 3-way valve, item 9, at the jacket cooler outlet mixes cooled and uncooled water to maintain an outlet water temperature of 88-92 °C from the main engine.

4.2 Operation in Port

See drawing 5055-0110

During operation in port, when the main engine is stopped but one or more auxiliary engines are running, valves A are closed and valves B are open. A small central water pump, item 3, will circulate the necessary flow of water for the air cooler, the lubricating oil cooler, and the jacket cooler of the auxiliary engines. The auxiliary engine-driven pumps and the previously mentioned integrated loop ensure a satisfactory jacket cooling water temperature at the auxiliary engine outlet.

The main engine and the stopped auxiliary engines are preheated as described for the jacket water system, *item 3.2 and drawing 5055-0105*.

5 Preheating during Standstill

Preheat the engine in accordance with *See description 6645-0170*.

Preheat by means of:

- A built-in preheater, *see also drawing 5055-0115.*

  The capacity of the preheater pump should correspond to about 10% of the capacity of the jacket water main pump.

  The pressure drop across the preheater should be approx. 0.2 bar.

  The preheater pump and the main pump should be electrically interlocked to avoid the risk of simultaneous operation.
- Cooling water from the auxiliary engines, *see item 3.2, 'Operation in Port'*

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6 Jacket Water Cooling Failure

It is assumed that the temperature rise is not caused by defective measuring equipment or thermostatic valve. These components should be checked regularly to ensure correct functioning.

If the cooling water temperature, for a single cylinder or for the entire engine, rises to 93-100°C, follow this procedure:

Open the test cocks on the cylinder outlets.

Is the water coming out?		
YES	▪	Close the test cocks.
	▪	Re-establish the cooling water supply at once, or stop the engine for troubleshooting.

NO		*The cooling space is not completely filled with water. This results in local overheating, and hence the formation of steam.*
	▪	Close the test cocks.
	▪	Stop the engine.
	▪	Close the outlet valve on the overheated cylinder.
	▪	Open the indicator cocks.
	▪	Keep the auxiliary blowers and lub. oil pumps running.
	▪	Turn the piston of the cylinder concerned to BDC to slowly cool down the overheated area via the air flow through the cylinder and indicator cock.
	▪	Leave the engine to cool. This prevents extra shock heat stresses in cylinder liner, cover and exhaust valve housing, if the water should return too suddenly.
	▪	After 15 minutes, open the outlet valves a little so that the water can rise slowly in the cooling jackets. Check the level at the test cocks.
	▪	Find and remedy the cause of the cooling failure.
	▪	Check for proper inclination of the freshwater outlet pipe, and for proper deaeration from the forward end of the engine.
	▪	Make a scavenge port inspection to ensure that no internal leakage has occurred. *See also description 2245-0100.*
		Note: Slow-turn the engine with open indicator cocks before starting the engine.

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7 Load Dependent Cylinder Liner (LDCL)

In order to prevent cold corrosion in the cylinder liner, "Load Dependent Cylinder Liner" (LDCL) has been introduced on a number of engine designs.

To maintain a constant flow over the liner cooling jackets, a circulation circuit is connected to the liner cooling jacket. This circulation circuit has a different temperature, controlled by a split range valve and a variable setpoint three-way valve. The setpoint is determined by the engine load. This means that when the engine is running at low engine loads, the temperature of the circulated water will be increased compared to engines without LDCL. At high engine loads, the temperature will be as normal.

This means that the temperature interval will be very large, for instance from 70 to 130 degrees Celsius, depending on the engine load.

See drawing: 5055-0120.

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1 Reducing Service Difficulties

To reduce service difficulties to a minimum, we strongly recommend:

- effective protection against corrosion of the cooling water system by adding a chemical **corrosion inhibitor**. *See Item 1.2.*
- using the correct **cooling water quality**. *See Item 1.3*.
- effective **venting** of the system. *See Item 1.4*.
- Checking the system and water during service. *See Item 2.*
- Using the correct cleaning and inhibiting procedure. *See Items 3 and 4*.

1.1 Types of Damage

If the above-mentioned precautions are not taken, the following types of damage may occur:

- **corrosion**, which removes material from the attacked surface by a chemical process.
- **corrosion fatigue**, which may develop into cracks because of simultaneous corrosion and dynamic stresses.
- **cavitation**, which removes material because of local steam formation and subsequent condensation in the cooling water, due to high water velocity or vibrations.
- **scale formation**, which reduces the heat transfer, mostly due to lime deposits.

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

1.2 Corrosion Inhibitors

Various types of inhibitors are available but, generally, only nitrite-borate based inhibitors are recommended.

A number of products marketed by major companies are specified in the table on Page 10. The relevant dosages are also mentioned, and we recommend that these directions are strictly observed.

Cooling water treatment using inhibiting oils is not recommended, as such treatment involves the risk of uncontrolled deposits being formed on exposed surfaces, and furthermore represents an environmental problem.

NOTICE

The legislation for disposal of waste water, incl. cooling water, prohibits the use of chromate for cooling water treatment. Chromate inhibitors must not be used in plants connected to a freshwater generator.

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1.3 Cooling Water Quality

It is important to use the correct cooling water quality. We recommend to use deionized or distilled water (for example produced in the freshwater generator) as cooling water.

This prevents, to a wide extent, the formation of lime stone on cylinder liners and in cylinder covers, which would impair the heat transfer, and result in unacceptably high material temperatures.

Before use, check that the following values are not exceeded:

- Hardness: max. 10° dH (=10 ppm CaO)
- pH: 6.5-8.0 (at 20°C)
- Chloride: 50 ppm (50 mg/litre)
- Sulphate: 50 ppm (50 mg/litre)
- Silicate: 25 ppm (25 mg/litre)

Check that there is no content of:

- Sulphide
- Sulphide
- Ammonia

NOTICE

Softening of the water does not reduce its sulphate and chloride contents.

If deionized or distilled water cannot be obtained, normal drinking water can be used in exceptional cases.

Rain water, etc. must not be used, as it can be heavily contaminated.

1.4 Venting

The system is fitted with a deaerating tank with alarm and with venting pipes which lead to the expansion tank. *See description 5045-0100*.

2 Checking the System and Water during Service

We recommend to keep a record of all tests, to follow the condition and trend of the cooling water.

Check the cooling water system and the water at the intervals given below:

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2.1 Regularly

Whenever practical, check the cooling water system for sludge or deposits. *See also Item 2.5, 'Every Four-Five Years and after Long Time Out of Operation'*.

Check at the cooling pipes, cooling bores, at the top of the cylinder and cover and exhaust valve bottom piece.

Sludge and deposits can be due to:

- contaminated cooling water system,
- zinc galvanized coatings in the cooling water system.
  Experience has shown that zinc galvanized coatings in the freshwater cooling system are often very susceptible to corrosion, which results in heavy sludge formation, even if the cooling system is correctly inhibited.

  In addition, the initial descaling with acid will, to a great extent, remove any galvanized coating. Therefore, generally, we advise against the use of galvanized piping in the freshwater cooling system.

2.2 Once a Week

Take a water sample from the circulating system during running.
i.e. not from the expansion tank or the pipes leading to the tank.

Check the condition of the cooling water.
Test kits are normally available from the inhibitor supplier.

Check:

- *The concentration of inhibitor* must not fall below the value recommended by the supplier, as this will increase the risk of corrosion.

  When the supplier specifies a concentration range, we recommend to maintain the concentration in the upper end.
- *pH-value* should be within 8.5-10 at 20°C.

  A decrease of the pH-value (or an increase of the sulphate content, if measured) can indicate exhaust gas contamination (leakage).
  pH can be increased by adding inhibitor, however, if large quantities are necessary, we recommend to change the water.
- Chloride content should not exceed 50 ppm (mg/litre).

  In exceptional cases, a maximum of 100 ppm can be accepted, however, the upper limit specified by the inhibitor supplier must be adhered to. An increase of the chlorine content can indicate salt water ingress. Trace and repair any leakages at the first opportunity.

NOTICE

If out-of-specification results are found, repeat the tests more frequently.

2.3 Every Third Month

Take a water sample from the system during running, as described in Item 2.2, 'Once a week'.

Send the sample for laboratory analysis, in particular to ascertain the content of:

- inhibitor
- sulphate
- iron
- total salinity.

2.4 Once a Year

Empty, flush and refill the cooling water system. Add the inhibitor.
See also Item 4.5, 'Adding the Inhibitor', further on.

2.5 Every Four-Five Years and after Long Time Out of Operation

Based on the regular checks, see Item 2.1, clean the cooling water system for oil-sludge, rust and lime. Refill and add the inhibitor.
See Items 3 and 4 further on.

2.6 Water Losses and Overhauling

Replace evaporated cooling water with non-inhibited water.

Replace water from leakages with inhibited water.

After overhauling, e.g. of individual cylinders, add a new portion of inhibitor immediately after completing the job.

Check the inhibitor concentration any time a substantial amount of cooling water is changed or added.

3 Cleaning and Inhibiting

3.1 General

Carry out cleaning before inhibiting the cooling water system for the first time. This ensures uniform inhibitor protection of the surfaces and improves the heat transfer.

During service, carry out cleaning and inhibiting every 4-5 years and after long time out of operation, *see also Item 2.5*. Cleaning comprises degreasing to remove oil sludge and descaling to remove rust and lime deposits.

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3.2 Cleaning Agents

Special ready-mixed cleaning agents can be obtained from companies specialising in cooling water treatment, and from the supplier of inhibitors. *See item 5.1.*

These companies offer treatment, assistance and cooling water analysis. We point out that the directions given by the supplier should always be closely followed.

The cleaning agents must not be able to damage packings, seals, etc. It must also be ensured that the cleaning agents are compatible with all parts of the cooling system to avoid any damage.

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

For degreasing, agents emulsified in water, as well as slightly alkaline agents, can be used.

NOTICE

Ready-mixed agents which involve the risk of fire obviously must not be used

For descaling, agents based on amino-sulphonic acid, citric acid and tartaric acid are especially recommended.

NOTICE

Use only inhibited acidic cleaning agents

These acids are usually obtainable as solid substances, which are easily soluble in water, and do not emit poisonous vapours.

3.3 Inhibitors

See Item 1.2, 'Corrosion Inhibitors', earlier in this Chapter.

4 Cleaning and Inhibiting Procedure

4.1 General

NOTICE

The engine must be at a standstill during the cleaning procedure to avoid overheating during draining.

Normally, cleaning can be carried out without any dismantling of the engine.

Since cleaning can cause leaks to become apparent (in poorly assembled joints or partly defective gaskets), inspection should be carried out during the cleaning process.

4.2 Degreasing

NOTICE

Be careful. Use protective spectacles and gloves.

4.2.1 Prepare for degreasing

Does the cooling water contain inhibitor?	
YES	Drain the system. Fill up with clean tap water. Follow the procedure below.
NO	Follow the procedure below.

Heat the water to 60°C and circulate it continuously.
Drain to lowest water level in the expansion tank sight glass.

4.2.2 Add the degreasing agent

Add the degreasing agent, preferably at the suction side of the running jacket water pump.
Use the amount of agent specified by the supplier.

Drain again to the lowest level in the expansion tank if the cooling water system is filled-up, before all agent is applied.

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4.2.3 Circulate the solution

Circulate the agent for the period specified by the supplier.
Check and repair any leaks.

4.2.4 Drain and flush the system

Drain the system completely.
This will also flush out any oil or grease settled in the expansion tank.

Fill up with clean tap water.
Circulate the water for two hours.
Drain the system completely.
Proceed to the descaling procedure, *see Item 4.3, 'Descaling'.*

4.3 Descaling

On completing the degreasing procedure, see Item 4.2, 'Degreasing', apply this descaling procedure.

NOTICE

Be careful. Use protective spectacles and gloves.
To avoid polluting the discharge water with acid, it is recommended, if possible, to collect all the drained water that contains acid in a tank where it can be neutralised, for example by means of soda, before being disposed.

4.3.1 Prepare for descaling

Fill up with clean tap water.
Heat the water to a maximum of 70°C, and circulate it continuously.

NOTICE

Some ready-mixed cleaning agents are specified to be used at a lower temperature. This maximum temperature must be adhered to.

4.3.2 Add the acid solution

Dissolve the necessary dosage of acid compound in a clean iron drum, half filled with hot water. Stir vigorously, e.g. using a steam hose.
For engines that were treated before the sea trials, the lowest dosage recommended by the supplier will normally be sufficient.

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

The solubility of acids in water is often limited. This can necessitate descaling in two stages, with a new solution and clean water. Normally, the supplier specifies the maximum solubility.

Fill the drum completely with hot water while continuing to stir. Slowly add the acid compound at the suction side of the jacket water cooling pump.

Drain some water from the system, if necessary.

4.3.3 Circulate the acid solution

Keep the temperature of the water at the prescribed preheating temperature, and circulate it constantly.
The duration of the treatment will depend on the degree of fouling.

Normally, for engines that were treated before the sea trials, the shortest time recommended by the supplier will be sufficient.

For untreated engines, a longer time must be reckoned with.

Check every hour, for example with pH-paper, that the acid has not been neutralised.

A number of descaling preparations contain colour indicators which show the state of the solution.

If the acid content is exhausted, a new admixture dosage can be added, in which case the weakest recommended concentration should be used.

4.3.4 Neutralise any acid residues

After completing the descaling, drain the system and flush with water.
The flushing is necessary to remove any debris that may have formed during the cleaning.

Continue the flushing until the water is neutral (pH approx. 7).
Acid residues can be neutralised with clean tap water containing 10 kg soda per ton of water. As an alternative to soda, sodium carbonate or sodium phosphate can be used in the same concentration.

Circulate the mixture for 30 minutes.

Drain and flush the system.

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

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NOTICE

Check the acid content of the system oil directly after the descaling, and again 24 hours later. See description 3045-0130

4.4 Filling up with Water

To prevent the formation of rust on the cleaned surfaces, fill up with water immediately after the cleaning.

Fill up, with deionizer or distilled water, to the lowest level in the expansion tank. *See also Item 1.3, 'Cooling Water Quality'.*

4.5 Adding the Inhibitor

On account of the lack of hardness, the deionized or distilled water is relatively corrosive.

Add the corrosion inhibitor immediately after filling up.

Weigh out the quantity of inhibitors specified by the supplier. *See item 5.1.*

We recommend to use the maximum amount specified by the makers.

Dissolve the inhibitor in hot deionized or distilled water, using a *clean* iron drum.

Add the solution at the suction side of the running jacket water cooling pump or at another place where flow is ensured.

A liquid inhibitor may be entered directly into the system by equipment supplied by the maker. Follow the maker's instructions.

Fill up to *normal* water level, using deionized or distilled water.

Circulate the cooling water for not less than 24 hours. This ensures the forming of a stable protection of the cooling surfaces.

Check the cooling water with a test kit (available from the inhibitor supplier) to ensure that an adequate inhibitor concentration has been obtained.
See also Item 2.2, 'Once a Week', 'Check: Inhibition concentration'.

5 Central Cooling System, Cleaning and Inhibiting

It is important for the proper functioning of this system to remove existing deposits of lime, rust and/or oil sludge in order to minimise the risk of blocking the coolers, and to ensure a good heat transfer. Subsequent inhibiting shall, of course, be carried out.

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For central cooling water systems, which are arranged with separate high and low temperature freshwater circuits, the careful, regular checks which are necessary for the jacket cooling water (= high temperature freshwater circuit) are not necessary for the low temperature freshwater circuit.

5.1 Nitrite-borate Corrosion Inhibitors for Fresh Cooling Water Treatment

Company	Name of Inhibitor	Delivery Form	Maker's min. Recommended Dosage (*)
Castrol Ltd. Swindon Wiltshire, England	Castrol Solvex WT4 Castrol Solvex WT2	Powder Liquid	3 kg / 1.000 l 20 l / 1.000 l
Drew Ameriod Marine Boonton, N.J./USA	DEWT NC Liquidewt Maxiguard	Powder Liquid Liquid	3,2 kg / 1.000 l 8 l / 1.000 l 16 l / 1.000 l
Nalfloc Ltd. Northwich, Cheshire, England	NALFLEET 9-121 NALFLEET 9-108	Powder Powder Liquid	2,5 kg / 1.000 l 2,2 kg / 1.000 l 5 l / 1.000 l
Rohm & Haas (ex Duolite) Paris, France	RD11 DIAPROSIM RD25 DIA PROSIM	Powder Liquid	3 kg / 1.000 l 50 l / 1.000 l
Vecom Maassluis, Holland	CWT Diesel QC2	Liquid	12 l / 1.000 l
Wilhelsen Ships Service AS Lysaker, Norway	Unitor Dieselguard NB Unitor Rocor NB Liquid	Powder Liquid	2 kg / 1.000 l 9 l / 1.000 l

Generally we recommend 2000-2500 ppm Nitrite.
(*) Initial dosage may be larger.

5.2 Non Nitrite-borate Corrosion Inhibitors for Fresh Cooling Water Treatment

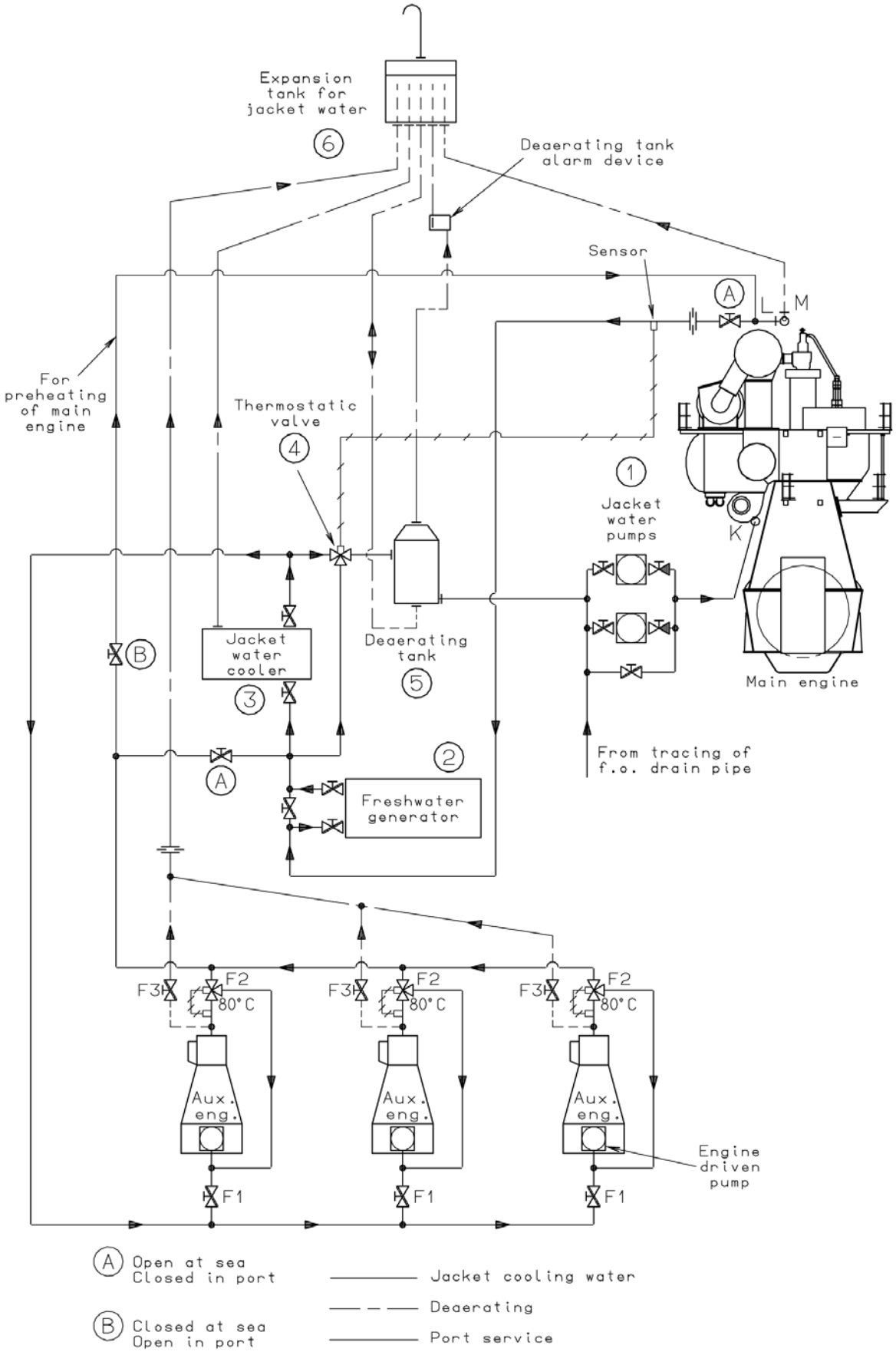
Company	Name of Inhibitor	Delivery Form	Maker's min. Recommended Dosage (*)
Chevron, Houston USA	Havoline XLI Havoline XLC	Liquid Liquid	50 l / 1.000 l 350 l / 1.000 l
Wilhelmsen Ships Service AS Lysaker, Norway	Unitor Cooltreat AL	Liquid	50 l / 1.000 l

(*) Initial dosage may be larger.

These lists are for guidance only and must not be considered complete. We undertake no responsibility for difficulties that might be caused by these or other water inhibitors/chemicals.

Suitable cleaners can normally also be supplied by these firms.

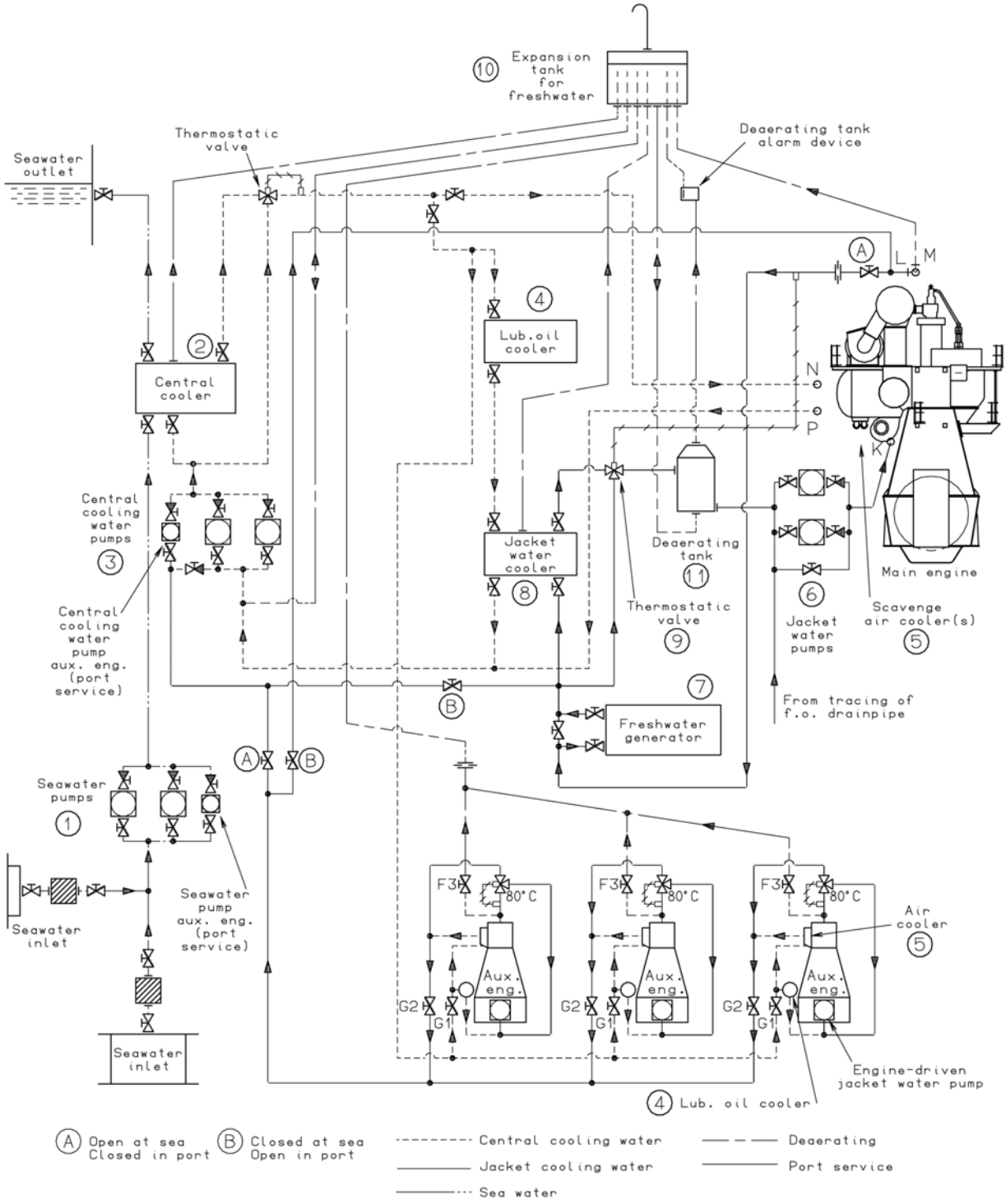
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Jacket Cooling Water System

Drawing 5055-0105-0003

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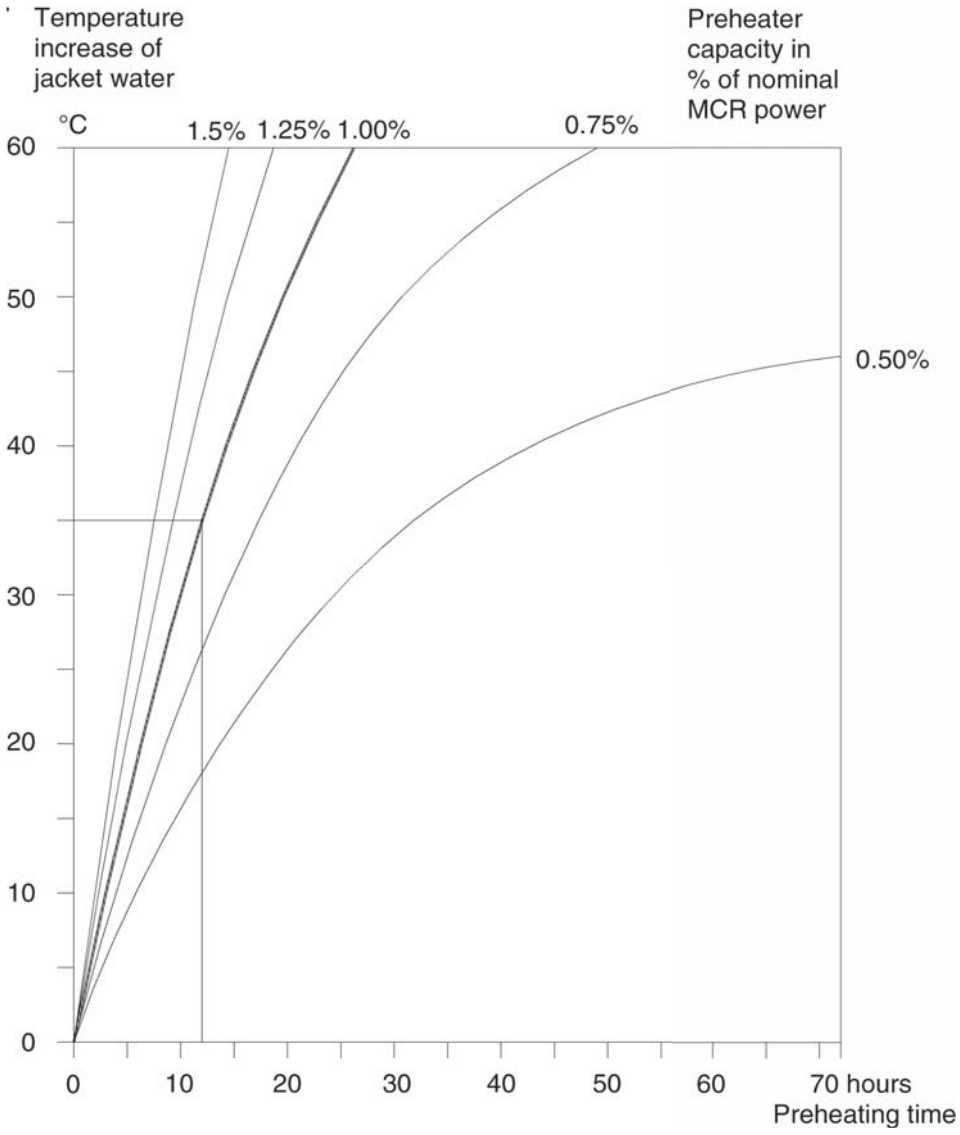


Central Cooling System

Drawing 5055-0110-0003

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Preheating of Jacket Cooling Water



If the cooling water is heated by means of a preheater installed in the freshwater system, the curves above can be used.

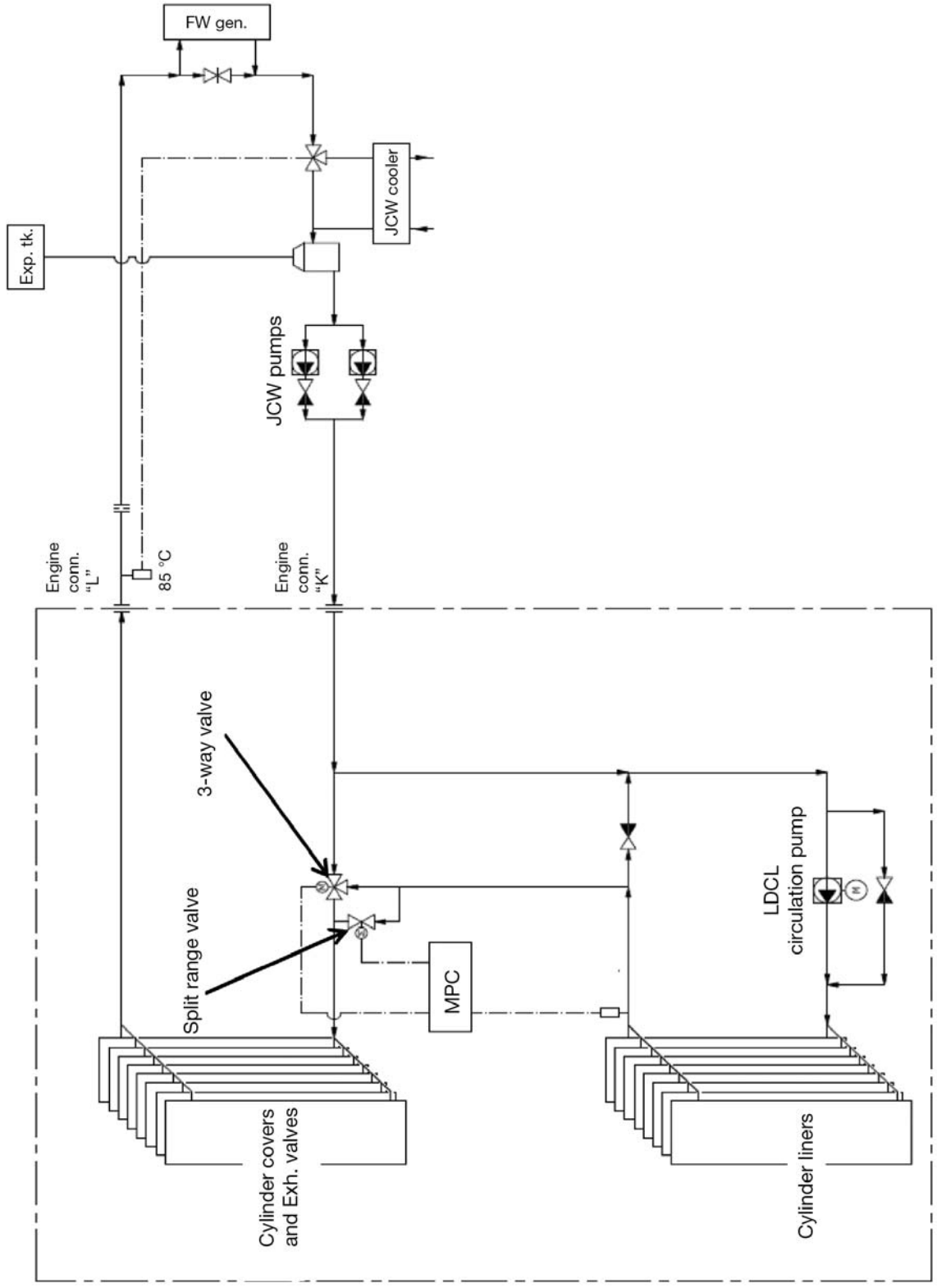
The curves are drawn on the basis that, at the start of preheating, the engine and engine-room temperatures are equal.

Example:
A freshwater preheater, with a heating capacity equal to 1% of nominal MCR engine shaft, output, is able to heat the engine 35°C (from 15°C to 50°C) in the course of 12 hours.

Cooling water preheating during standstill is described in *description 6645-0170*.

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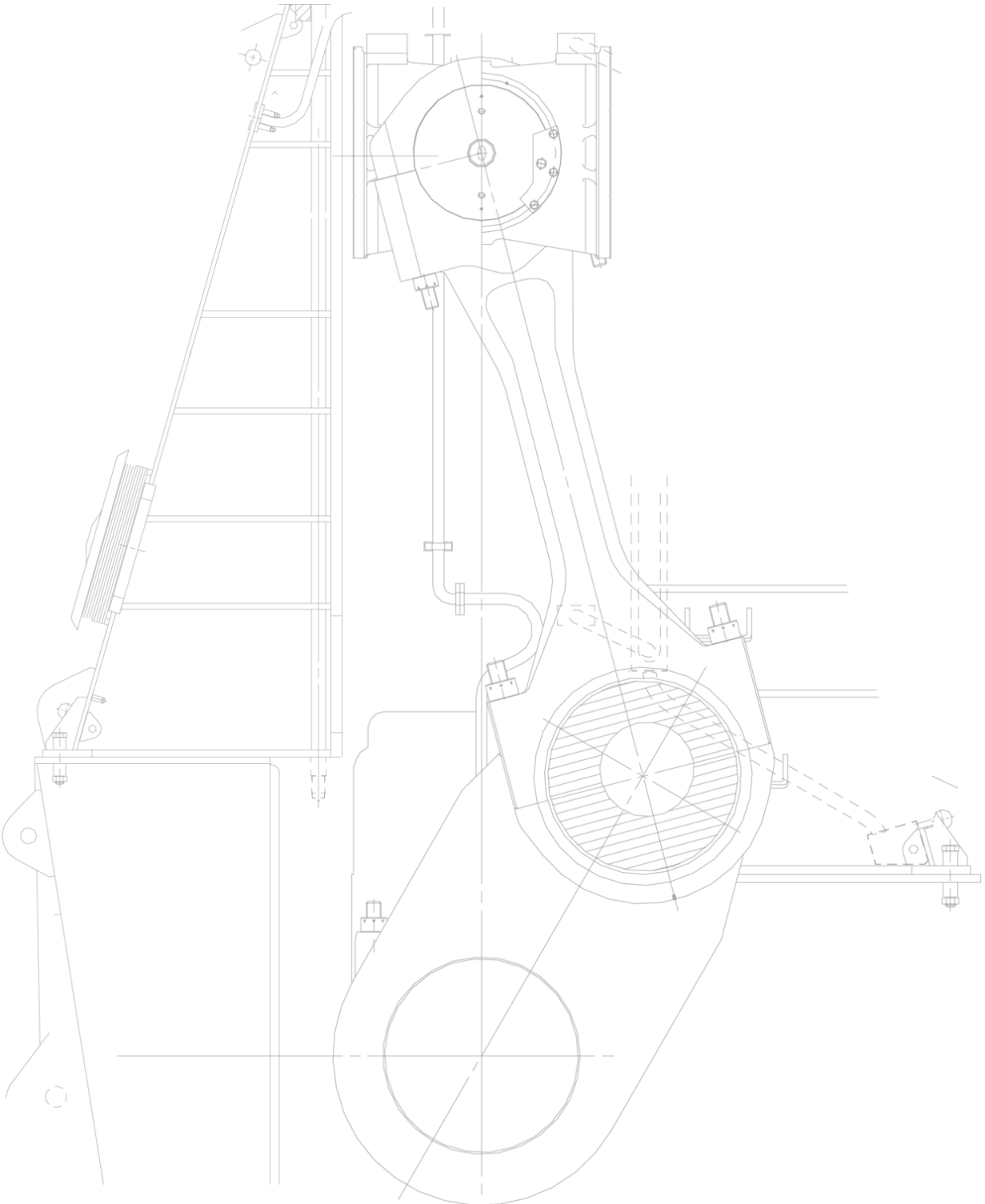
Schematic outline of the LDCL Cooling water system



Load Dependent Cylinder Liner - Cooling Water System

Drawing 5055-0120-0001

Preface Chapter	Exhaust Gas and Scavenge Air System	5440-0100-0001
Drawing	Scavenge Air Drain Pipes	5455-0100-0001
	Scavenge Air Spaces, Fire Extinguishing Systems	5455-0105-0001
	Dry Cleaning of Turbocharger - Turbine side	5455-0110-0003
	Wet Cleaning of Turbocharger - Turbine side	5455-0115-0002
	Air Cooler Cleaning System - Option	5455-0120-0001
Work Card	Scavenge Air Cooler Element, Data	5465-0100-0008
	Scavenge Air Cooler Element	5465-0101-0005
	Water Mist Catcher, Data	5465-0200-0003
	Water Mist Catcher	5465-0201-0002
	Scavenge Air Butterfly Valve, Data	5465-0300-0001
	Scavenge Air Butterfly Valve	5465-0301-0001
	Scavenge Air Non-Return Valve, Data	5465-0400-0001
	Scavenge Air Non-Return Valve	5465-0401-0002
	Auxiliary Blower, Data	5465-0500-0002
	Auxiliary Blower	5465-0501-0002
	Scavenge Air Safety Valve, Data	5465-0600-0001
	Scavenge Air Safety Valve	5465-0601-0001
	Turbocharger Cleaning, Data	5465-0700-0001
	Turbocharger Cleaning	5465-0701-0002
	Exhaust Gas Bypass Valve, Data	5465-0810-0003
	Exhaust Gas Bypass Valve	5465-0811-0001
Tool Plate	Scavenge Air Cooler Tools	5470-0110-0001
	Scavenge Air Cooler Tools	5470-0110-0002
	Scavenge Air Cooler Lifting Tools	5470-0120-0002
	Turbocharger Tools	5470-0700-0001
Plate	Scavenge Air Cooler	5472-0100-0006
	Scavenge Air Cooler Frame	5472-0110-0019
	Air Cooler Cleaning System	5472-0120-0004
	Air Cooler Pipe Connections	5472-0130-0009
	Water Mist Catcher	5472-0200-0002
	Butterfly Valve	5472-0300-0001
	Suction Pipe	5472-0350-0004
	Scavenge Air Cooler Non-Return Valve	5472-0400-0003
	Auxiliary Blower	5472-0500-0003
	Scavenge Air System	5472-0600-0005
	Scavenge Air Receiver, Safety Valve	5472-0620-0001
	Scavenge Air Pipe	5472-0630-0026
	Exhaust Gas Bypass System	5472-0800-0002
	Exhaust Gas Bypass Valve	5472-0810-0003
	Exhaust Reciever	5472-0900-0018



Air System

The engine is supplied with scavenge air from one or more turbochargers, depending on the engine type and layout.

The engine exhaust gas drives the turbine wheel of the turbocharger and, through a common shaft, the turbine wheel drives the compressor wheel.

The compressor draws air from the engine room, through the air filters. From the compressor outlet, the air passes through the charging air pipe to the charging air cooler where the air is cooled down.

The charging air pipe, with compensator, is insulated.

The air cooler incorporates a water mist catcher, which is designed to separate condensate from the air.

When the air has passed the water mist catcher, it is pressed into the scavenge air receiver through non-return valves. The non-return valves open by pressure from the turbocharger.

From the scavenge air receiver, the air flows to the cylinder through the scavenge air ports when the piston is in the bottom position. When the exhaust valves open, the exhaust gas is pressed into a common exhaust gas receiver, from where the gas drives the turbine of the turbocharger with an even and steady pressure

Charging Air Cooler

The charging air cooler insert is of the block type. It is mounted in a housing which is welded up of steel plates.

The cooler housing is provided with inspection covers.

The cooler is designed with an air reversing chamber which incorporates a water mist catcher. The water mist catcher is built up of a number of lamellas which separate the condensation water from the scavenge air during the pas sage of the airflow.

The separated water is collected in the bottom of the cooler housing from which it is moved by a drain system.

CAUTION

Check the drain

It is important to check that the drain functions correctly, as otherwise water droplets may enter the cylinders.
See Description 6345-0320.

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An alarm device for high water level in the drain system is installed.

Non-Return Valves

It is of the utmost importance that the non-return valves of the auxiliary blowers always function correctly and move easily. This can be checked either by moving the valves manually in connection with the regular scavenge port inspections, or via locally placed inspection covers.

The non-return valves protect the blowers and engine during:

- Start-up of the auxiliary blowers.
- Running with auxiliary blowers.

Starting the auxiliary blowers:

1. Owing to the relatively high starting current, the blowers start in sequence, with 6-10 seconds in between.

   The non-return valve of the blower that has not yet started must be in the closed position to prevent the blower from rotating backwards. Otherwise, there is a risk that the electric motor will burn out when it starts.
2. If an auxiliary blower fails to start, the non-return valve must be in the closed position. Otherwise, the operating blower will not be able to draw fresh air in through the turbocharger and air cooler. This is due to differences in the air flow resistance.

Running with auxiliary blowers:

If an auxiliary blower fails during running, the non-return valve must close to ensure the continued supply of fresh air to the engine.
See "Starting the auxiliary blowers", Item 2, above.

Auxiliary Blowers

The engine is provided with two or more auxiliary blowers. The suction sides are connected to the space after the water mist catcher. The discharge sides are connected to the scavenge air receiver. Separate non-return valves are in stalled at the suction side or discharge side of the auxiliary blowers, in order to prevent reversed air flow.
See also item, "Non-return valves", above.

El. panels for auxiliary blower

See special instructions supplied by the engine builder.

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Running with auxiliary blowers

During the starting of the engine, and when the engine is running at low load, the turbocharger is not able to supply enough air for the engine process. In these cases a pressure switch will automatically start the auxiliary blowers.

When the auxiliary blowers are operating, they draw air from the engine room through the turbocharger's air filter and compressor side.

WARNING

If the auxiliary blowers do not start during low-load running (because of faults, or because the switch for the blowers is not in "AUTO" position), unburned fuel oil may accumulate on top of the pistons. This will involve the risk of a scavenge air box fire. In order to avoid such a fire:
– obtain permission to stop the engine
– stop the engine
– remove any unburned fuel oil from the top of the pistons
– re-establish the supply of scavenge air
– start the engine

Note: the switch for the auxiliary blowers should be in "AUTO" position during all modes of engine control, i.e.:

– remote control
– control from engine side control console.

The non-return valves fitted after the water mist catcher are now closed as a result of partial vacuum and gravitation acting on the valve flaps.

There will be a lack of air supply if the non-return valves do not close.

Scavenge Air Receiver

The scavenge air receiver is a container having a large volume. The receiver is bolted on to the cylinder frame, or alternatively integrated into the cylinder frame, if welded. *See Chapter 10*.

Scavenge air is collected in the receiver after the air has passed through the cooler, the water mist catcher and the non-return valves.

The receiver and the cylinder frame communicate through large openings.

The scavenge air receiver is provided with manhole covers and a safety valve.

Safety Valve, Scavenge Air Receiver

The scavenge air receiver is fitted with a safety valve which is set to open should the pressure in the scavenge air receiver exceed a value somewhat higher than the normal scavenge air pressure of the engine.

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In some cases it may be necessary to open the valve manually,
see Description 6645-0310.

Exhaust Gas Receiver

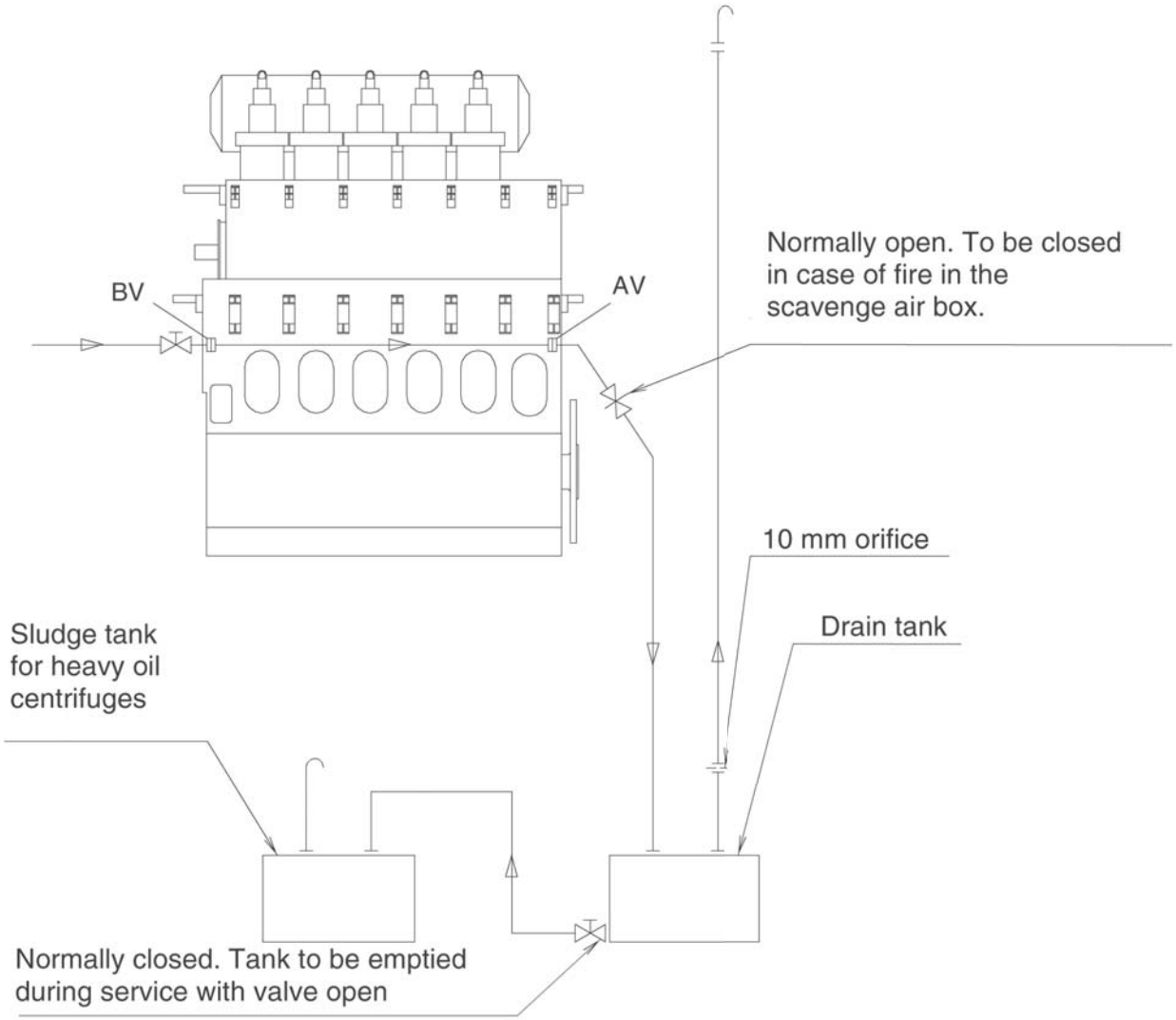
From the exhaust valves, the exhaust gas is led to the exhaust gas receiver where the pulsatory pressure from the individual exhaust valves is equalized and led to the turbocharger at a constant pressure.

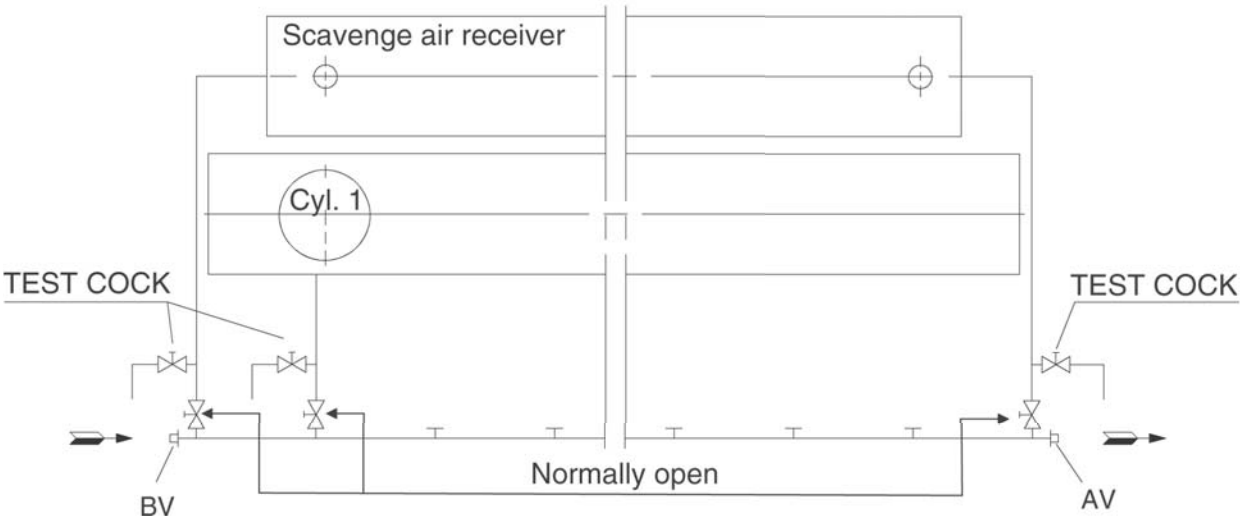
The exhaust gas receiver is fastened to the seating by flexible supports. Compensators are inserted between the receiver and the exhaust valves, and between the receiver and the turbocharger.

Inside the exhaust gas receiver, a protective grating is mounted before the turbocharger.

The exhaust gas receiver and the exhaust pipe are insulated.

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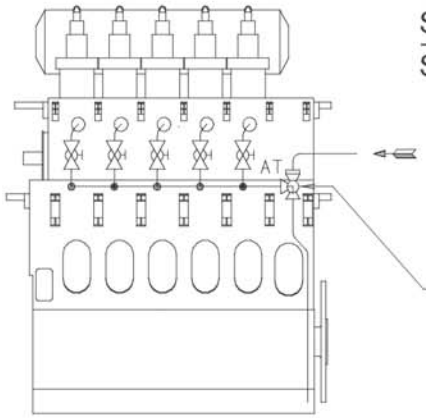




Scavenge Air Drain Pipes

Drawing 5455-0100-0001

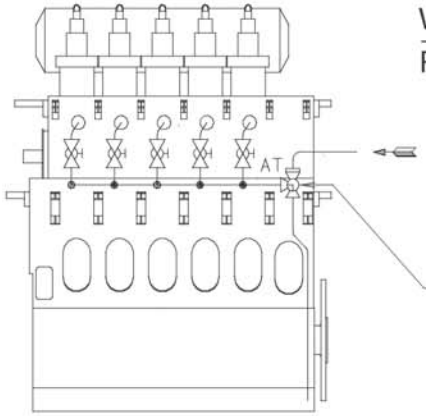
2012-12-14 - en



Steam extinguishing

Steam pressure 3-10 bar

Normally position
open to bilge

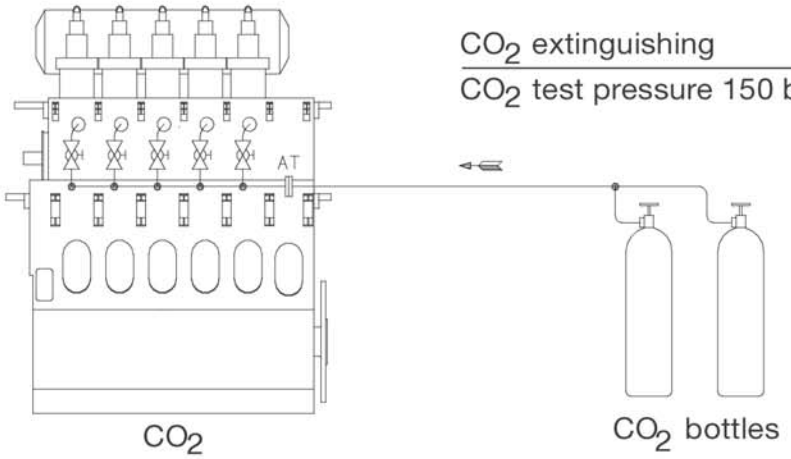


Water mist extinguishing

Raw water pressure min. 3.5 bar

Normally position
open to drain

To prevent the fire from spreading to the next cylinder(s), the ball-valve of the neighbouring cylinder(s) should be opened in the event of fire in one cylinder



CO_2 extinguishing

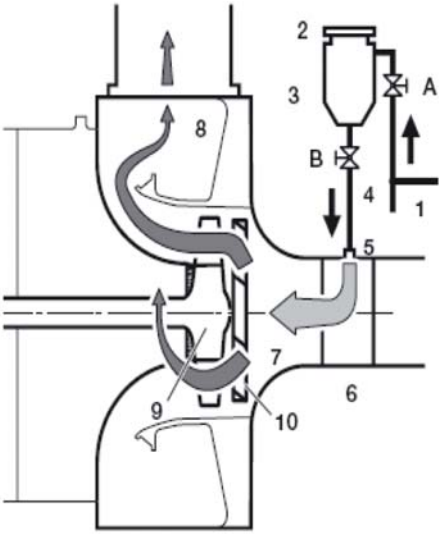
CO_2 test pressure 150 bar

At least two bottles ought to be installed.
In most cases, one bottle should be sufficient to extinguish fire in three cylinders, while two or more bottles would be required to extinguish fire in all cylinders

Turbine side

Dry cleaning is carried out under high engine load (50% - 100%).

It is recommended to perform the cleaning with granules every one to two days.



1. Compressed air pipe
2. Screw plug
3. Granulate container
4. Pipe
5. Connection flange
6. Adapter
7. Gas-admission casing
8. Gas outlet casing
9. Turbine wheel
10. Nozzle ring

A Stop cock (compressed air)

B Stop cock (exhaust gas)

Dry wash operation:

1. Open valve A and B, in order to vent the granulate container for possible deposits or condensate.
2. Close valve A and B. Fill the container with the specified amount of granules and shut the container tight.
3. Slowly open valve A. Then open valve B to blow the granulate into the turbine.
4. After 1 to 2 minutes, close valves B and A.

T/C type	Amount [liter]	T/C type	Amount [liter]	T/C type	Amount [liter]
TCR 14	0,1	TPL 61	0,5	MET 66	2,6
TCR 16	0,2	TPL 65	0,6	MET 71	3,0
TCR 18	0,2	TPL 69	0,9	MET 83	3,5
TCR 20	0,3	TPL 73	1,2	MET 90	3,5
TCR 22	0,5	TPL 77	1,5	-------	---
-------	---	TPL 80	2,0	A165-L	1,0
TCA 33	0,5	TPL 85	3,0	A170-L	1,5
TCA 44	0,5	TPL 91	3,5	A175-L	2,0
TCA 55	1,0	-------	---	A180-L	2,5
TCA 66	1,5	MET 33	0,4	A185-L	3,0
TCA 77	2,0	MET 42	0,7	A190-L	3,5
TCA 88	2,5	MET 53	1,6		
TCA 99	3,0	MET 60	2,1		

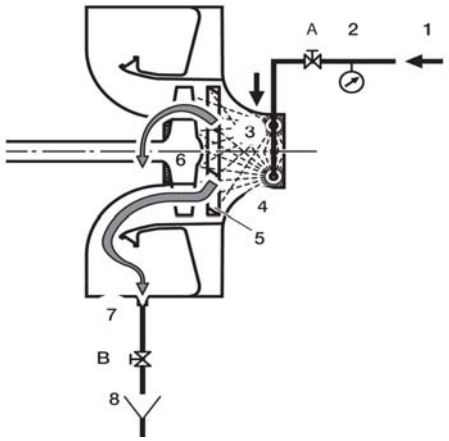
2013-06-24 - en

Turbine side

Wet cleaning of the turbine is carried out during operation at reduced engine load in order to avoid overstressing of the turbine blades (thermal shock)

A general recommendation is to perform cleaning every 250 operating hours.

Type	TCR 22	TCR 33	TCR 44	TCA 55	TCA 66	TCA 77	TCA 88	TCA 99
Exh. gas temperature before Turbine [°C]	≤ 320	≤ 320	≤ 320	≤ 320	≤ 320	≤ 320	≤ 320	≤ 320
Turbocharger Speed [rpm]	≤ 12 000	≤ 15 500	≤ 13 000	≤ 11 000	≤ 9 500	≤ 8 000	≤ 7 000	≤ 5 500



1. Washing water
2. Pressure gauge
3. Nozzles
4. Gas-admission casing
5. Nozzle ring
6. Turbine wheel
7. Washing water drain
8. Drain funnel

A Water stop cock

B Drainage cock

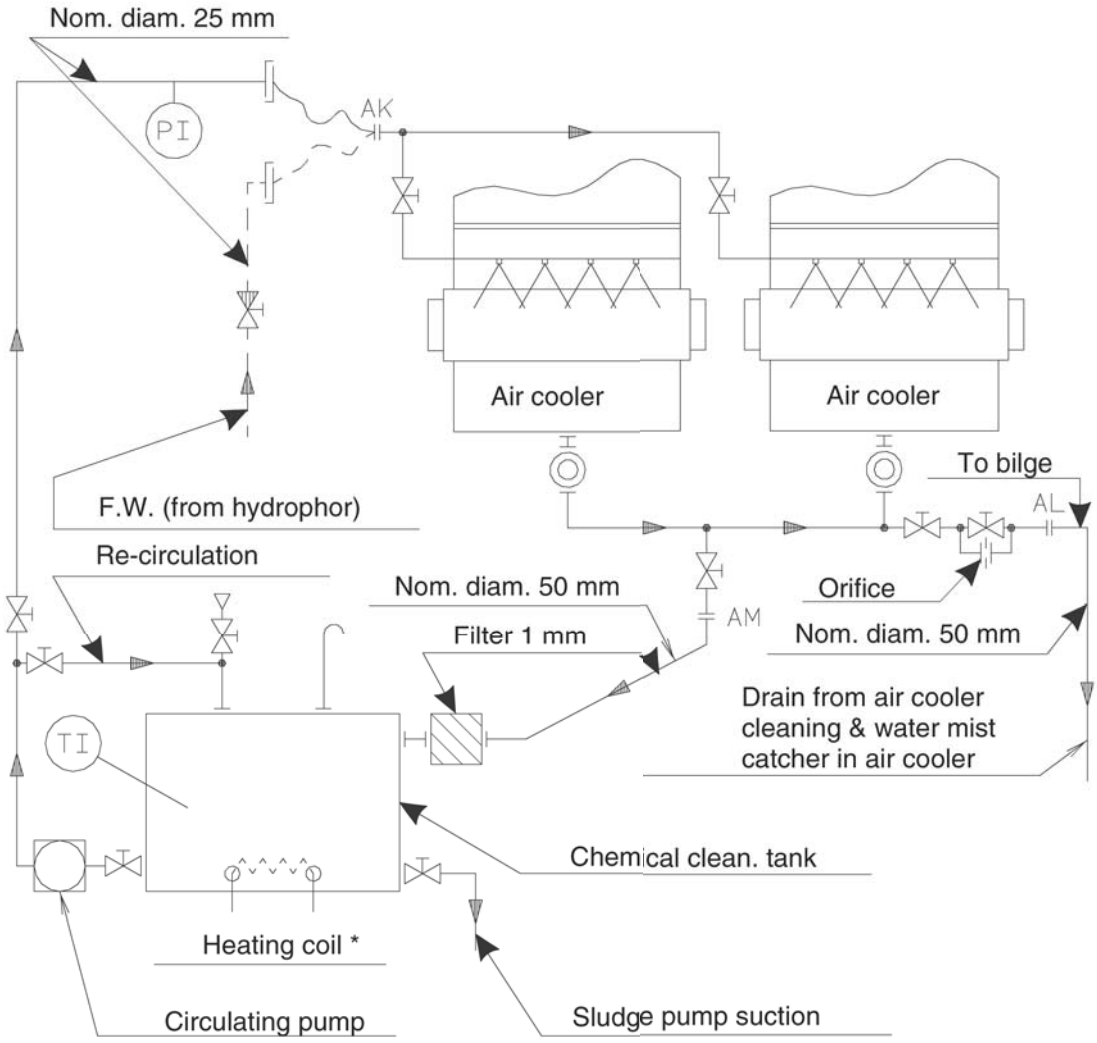
- Use fresh water without any chemical additives whatsoever.
- The washing duration is 10 to 20 minutes (until clean water comes out of the dirt-water outlet openings).

The wash water flows through the stop cock with a water pressure of 2-3 bar into the gas-admission casing. The washing nozzles spray the water in front of the turbine. The droplets of the washing water bounce against the nozzle ring and the turbine where they wear off contamination.

The washing water collects in the gas-outlet casing and runs through the washing water outlet and the drainage cock. The washing water is conducted via a funnel to a sediment tank and collected there.

The funnel enables the visual inspection of the washing water. The cleaning procedure is completed once the washing water remains clean.

2013-06-24 - en



* Capacity for heating coils according to requirement from supplier of the chemical

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Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off safety air supply - Not ME Engines
O	Shut off control air supply
O	Shut off cooling water



Data

Ref.	Description	Value	Unit
T54-04	Air cooler element, complete with covers, up to	2300	kg
T54-06	Reversing chamber	350	kg
T54-07	Water inlet/outlet cover	350	kg

2013-01-25 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
5470-0110	-	Scavenge air cooler tools
5470-0120	-	Scavenge air cooler lifting tools
7670-0300	-	Lifting tools, etc
7670-0310	013	Travelling Trolley

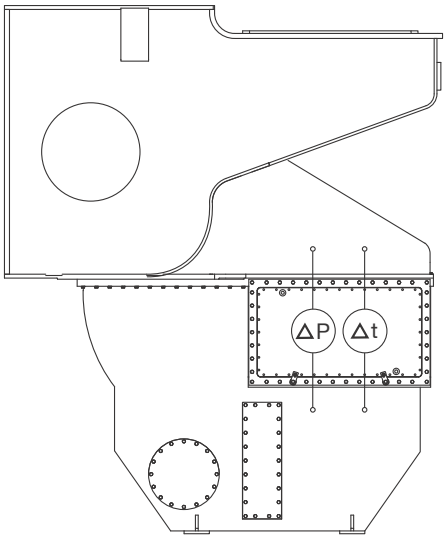
Pressure and temperature

For the day-to-day checking of the scavenge air cooler, measure the drop in pressure and temperature of the scavenge air across the cooler while the engine is running.

Compare these measurements with the testbed data.
For further evaluation of the measurements, see Description 6345-0320.

An increase in the air pressure drop across the scavenge air cooler indicates fouling of the air side of the cooler.

A decrease in the air temperature drop across the scavenge air cooler indicates fouling of the water side of the cooler.



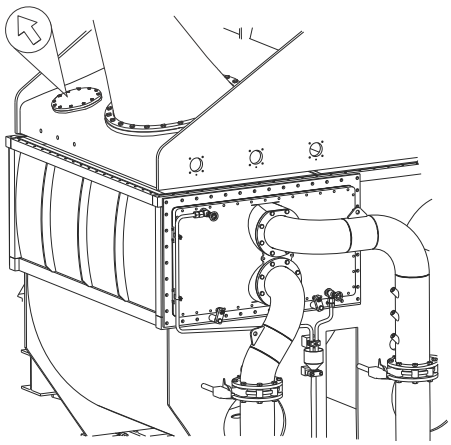
5465-0101-0005C01

If the measurements indicate fouling of the water side of the air cooler elements, the elements must be overhauled/cleaned.
See Overhaul.

If the measurements indicate fouling of the air side of the air cooler elements, it is recommended to inspect the air cooler elements as follows:

Access to the air cooler elements

Remove the top inspection cover of the air cooler.


5465-0101-0005C02

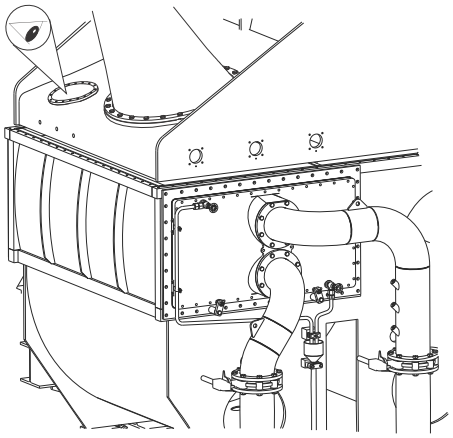
2012-10-26 - en

Visual inspection

Visually inspect the air cooler elements through the openings.

For further information, see Description 6645-0100 “Checks during Standstill Periods”.

If the air side of an element is fouled, clean the element using the spray pipe arrangement fitted above the air cooler element.
See Overhaul.



5465-0101-0005C03

The cooler elements normally does not need to be dismantled for inspection purposes. It is only in the event that a cooler element has suffered damage that it has to be dismantled and replaced.

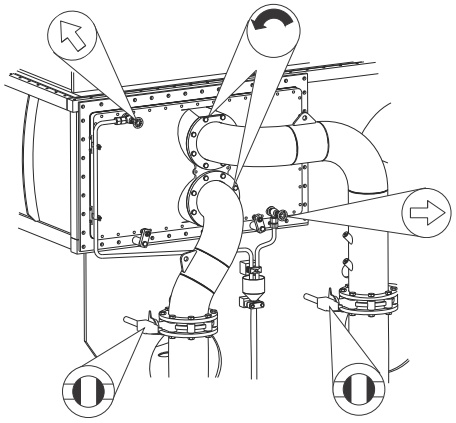
NOTE

During dismantling, take care not to damage the cooler element.

Cooling water pipes

Close the cooling water inlet and outlet valves. Open the drain cocks to drain off the cooling water and dismantle the drain pipes.

Dismount the screws which fasten the cooling water inlet and outlet flanges to the inlet/outlet cover.

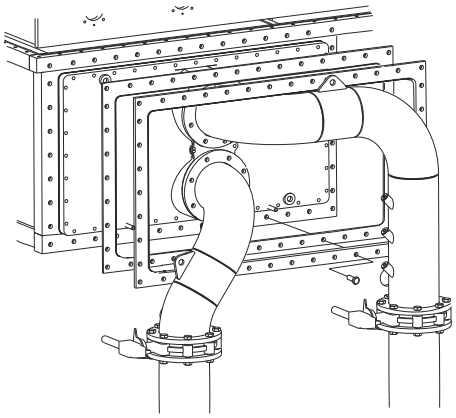


5465-0101-0005D01

Sealing flanges inlet/ outlet cover

Dismount the sealing flanges around the inlet/outlet cover.

For convenience, the sealing flanges may be left hanging on the cooling water pipes during dismantling and mounting of the cooler element.



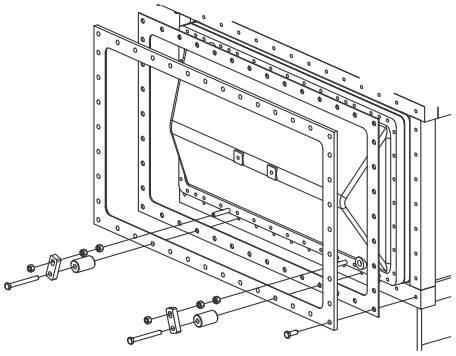
5465-0101-0005D02

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Sealing flanges reversing chamber

Dismount the brackets which control the longitudinal position of the air cooler element.

Dismount the sealing flanges around the reversing chamber.

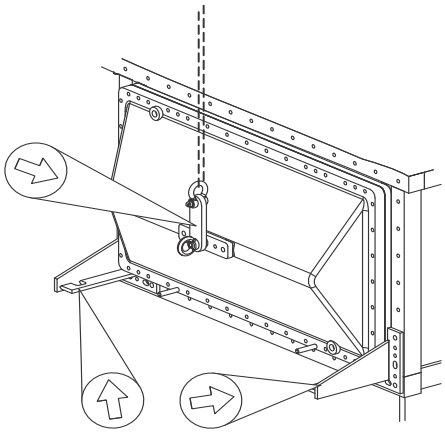


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Tools reversing chamber end

Mount the pair of guide rails on the reversing chamber end of the cooler housing and mount the lifting bracket on the cover.

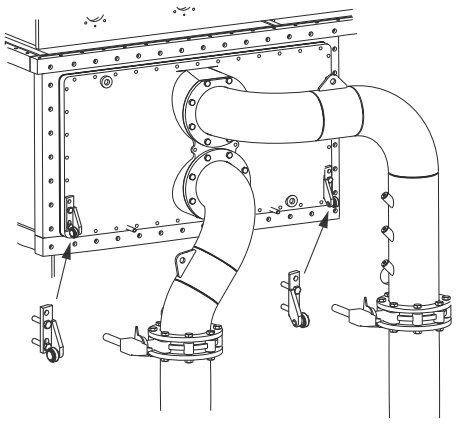
Mount a travelling trolley on the beam above the reversing chamber end of the scavenge air cooler. Attach a tackle between the travelling trolley and the lifting bracket, and haul tight.



5465-0101-0005D04

Guide wheels inlet/outlet cover

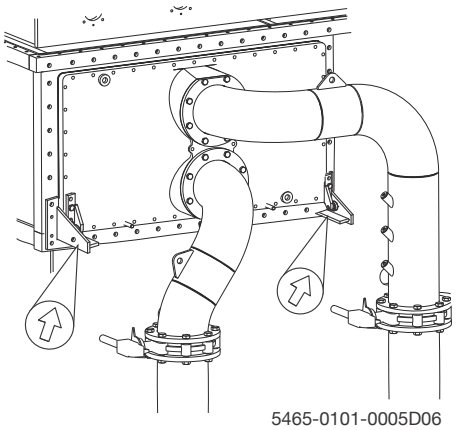
If the inlet/outlet cover is not equipped with wheels, then mount a pair of guide wheels on the cover.



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Guide rails inlet/outlet cover end

Mount a pair of guide rails on the inlet/ outlet cover end of the cooler housing.

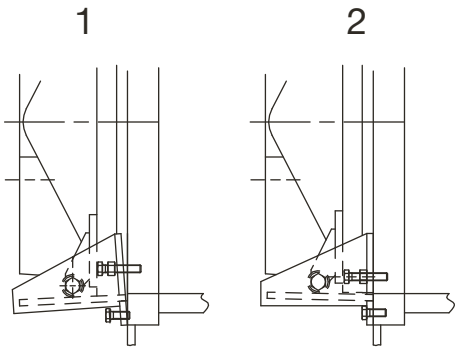


5465-0101-0005D06

Loosening and lifting the cooler element

When mounting the guide rails, hold them up against the wheels of the cooler element and mount, but do not tighten, the lowermost screws. Mount and tighten the uppermost screws.

Tighten the lowermost screws and the thrust nuts on the uppermost screws simultaneously. This results in loosening and lifting the cooler element.

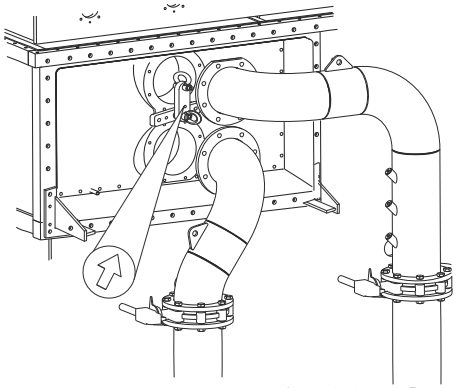


5465-0101-0002D07

Lifting bracket inlet/ outlet cover

Tighten the tackle until the reversing chamber end of the cooler element comes loose.

Pull out the cooler element far enough to allow a lifting bracket to be mounted on the inlet/outlet cover. Mount the lifting bracket.

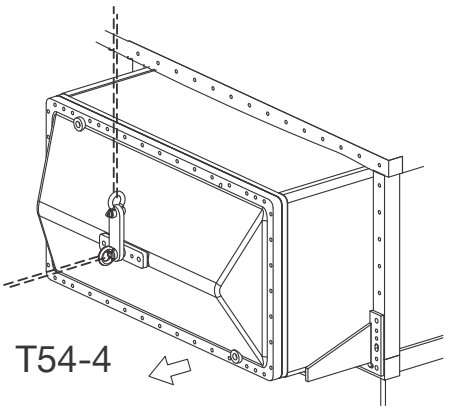


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Pulling the cooler element out of the housing

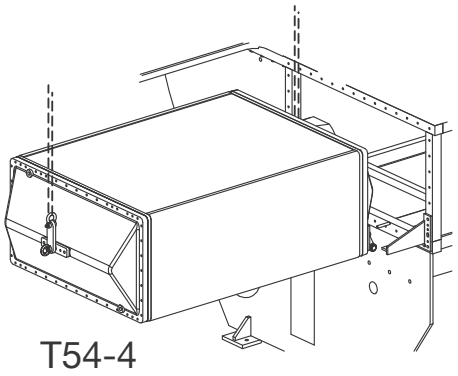
Pull the cooler element out of the cooler housing using the tackle until the wheels engage with the holes in the guide rails on the front of the cooler housing.



5465-0101-0005D09

Lifting the cooler element

Fit a tackle to the lifting bracket on the inlet/outlet cover and lift away the cooler element.



5465-0101-0005D10

NOTE

Depending on the engine and the engine room installation, it may be necessary to remove some pipes and floor plates.

2012-10-26 - en

Cleaning the air side

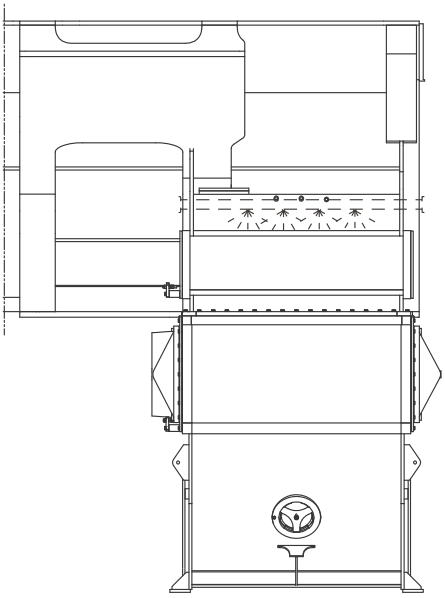
The air side of the cooler is cleaned by injecting a chemical fluid through the spray pipe arrangement fitted to the air chamber above the cooler element.

It is recommended to use one of the following cleaning fluids, or a similar product.

1) Product: ACC 9, produced by Drew Chemical Corp., New York, USA

2) Product: 80B, produced by Vecom Int., Maassluis, Holland

Cleaning should be carried out in the following sequence:



5465-0101-0004O01

NOTE

Do not start cleaning until the engine has been at a standstill for about 30 minutes. Do not disconnect the compressed air supply to the exhaust valve.

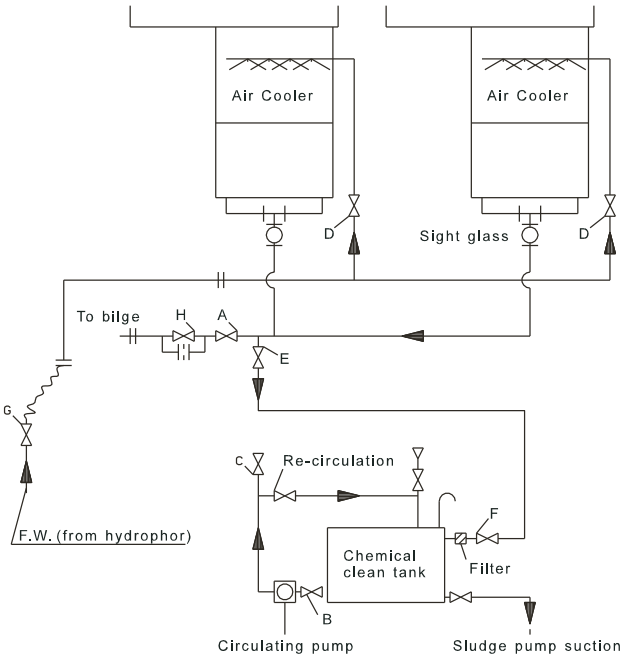
Cleaning instructions

Follow the detailed cleaning instructions displayed at the cleaning pipe on the engine. To ensure satisfactory spraying of the cleaning fluid, the circulating pump pressure must be at least 0.7 bar.

Continue the cleaning process for at least 30 minutes. The time required depends on the frequency with which cleaning is carried out and on the chemical product used.

After cleaning, flush the cooler with clean water until the water appearing in the sight glasses is clean and pure.

Inspect the elements either by removing the cover on top of the cooler or by dismantling the charging air pipe.



Cleaning condition

1) Chemical cleaning
Open: B,C,D,E,F
Close: A,G,H
Start the pump

Water flushing

2) Open: A,D,G,H
Close: B,C,E,F

Normal running condition

3) Open: A
Close: B, C, D, E, F, G, H
Close the inspection covers on the scavenge air receiver

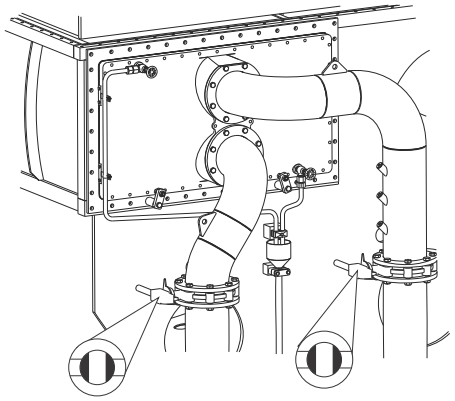
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Cleaning the water side

Cooling water pipes

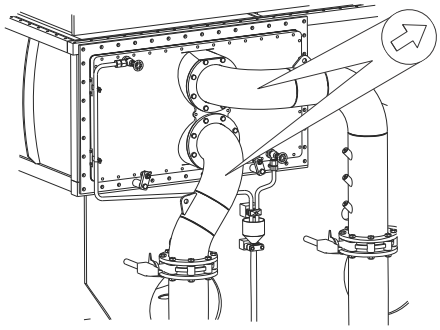
Close the cooling water inlet and outlet valves. Open the drain valves to drain off the cooling water from the element.



5465-0101-0005O03

Cooling water pipes dismantlling

Dismount the cooling water inlet and outlet pipes from the inlet/outlet cover.



5465-0101-0005O04

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Lifting tools

Mount travelling trolleys on the beams above the inlet/outlet cover and reversing chamber.

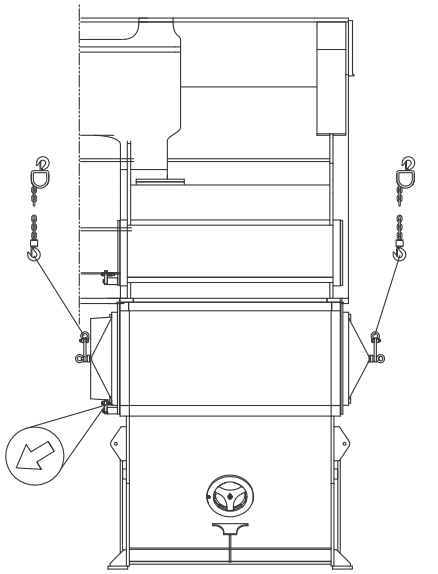
Dismount the brackets which control the longditudinal position of the air cooler element.

Tighten up

Mount the lifting tools on the two end covers and mount a shackle in each of the two lifting eyes.

Mount tackles on the travelling trolleys and lifting wire ropes between the tackles and the lifting tools.

Hook the tackles on to the shackles and tighten up.

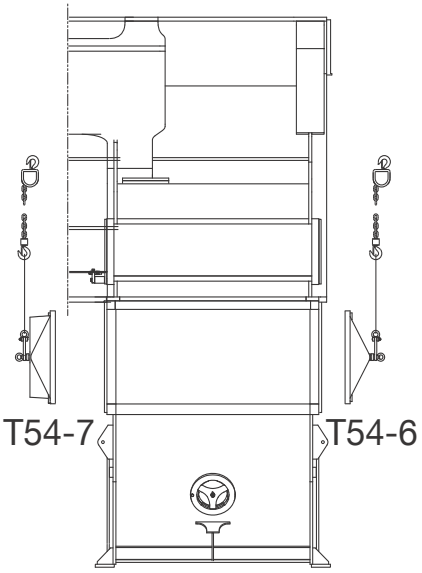


5465-0101-0004O09

Dismantling the end covers

Remove the screws of the inlet/outlet cover and reversing chamber.

Lower both covers and land them on a couple of wooden planks. Discard the gaskets.



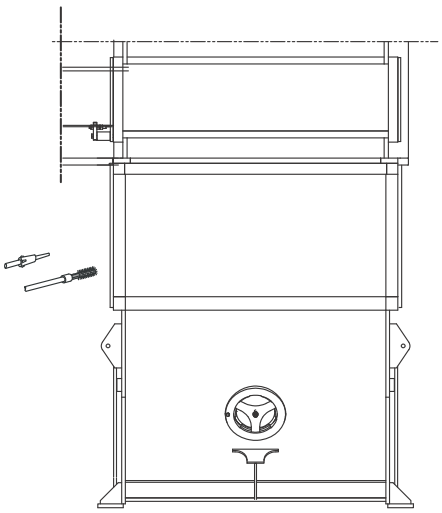
5465-0101-0004O10

Cleaning the tubes

Clean the inside of the tubes, using the cleaning brush (supplied by the cooler element manufacturer) mounted on a drilling machine. In the event of leakages between cooling tube and tube plate, the tubes are rolled with the tube expander (also supplied by the cooler element manufacturer).

Clean the covers inside with a stiff brush and then rinse them with fresh water.

Replace the anti-corrosion blocks, if necessary.



5465-0101-0004O11

NOTE

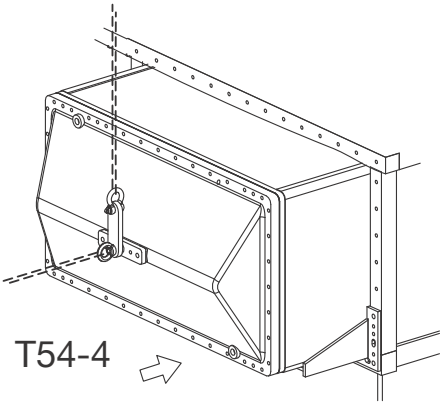
If damaged, the coating inside the covers is to be repaired with the original coating or a similar product.

When cleaning is complete, mount the covers in the reverse order to dismantling.

Landing the cooler element

Lift the air cooler element and land the inlet/outlet cover end of the element on the guide rails mounted on the reversing chamber end of the air cooler housing.

Remove the tackle from the inlet/outlet cover of the cooler element.

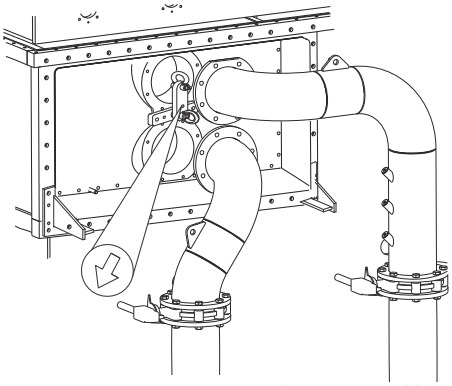


5465-0101-0005M01

Lifting bracket inlet/ outlet cover end

Push the air cooler element inwards approx. one metre.

Remove the lifting bracket from the inlet/ outlet cover.

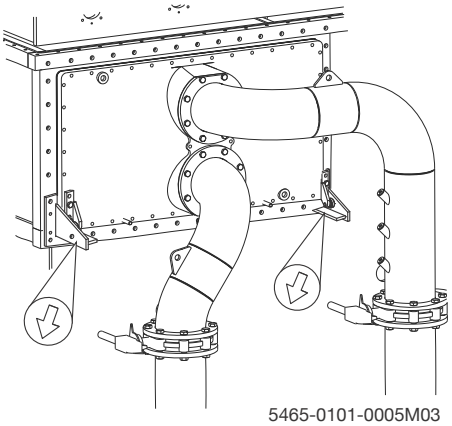


5465-0101-0005M02

Guide rails inlet/outlet cover end

Push the air cooler element fully into the air cooler housing

Remove the guide rails from the inlet/ outlet cover end of the air cooler housing.



5465-0101-0005M03

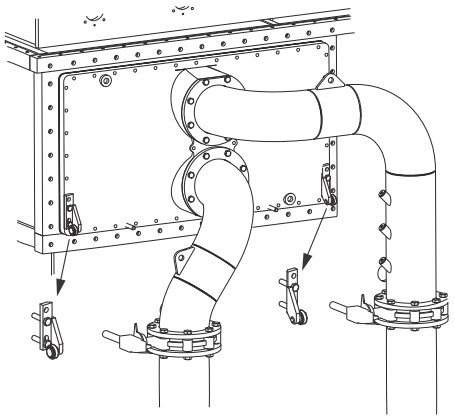
NOTE

Before pushing the air cooler element fully in, make sure that the sealing flanges and a new O-ring are in position, hanging on the cooling water pipes.

2012-10-26 - en

Guide wheels inlet/ outlet cover

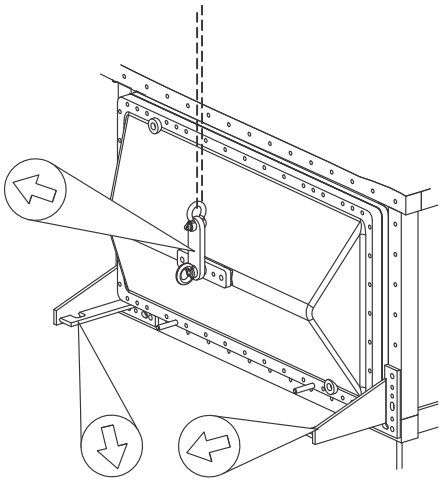
Remove the guide wheels from the inlet/ outlet cover.



5465-0101-0005M04

Tools reversing chamber end

Remove the guide rails and the lifting bracket from the reversing chamber end of the air cooler housing.

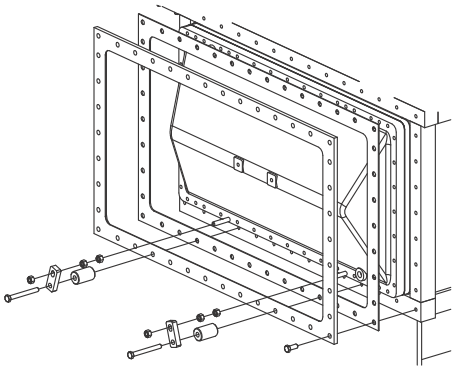


5465-0101-0005M05

Sealing flanges reversing chamber

Mount the sealing flange, a new O-ring and the frame around the reversing chamber.

Mount and tighten the brackets which control the longitudinal position of the air cooler element.



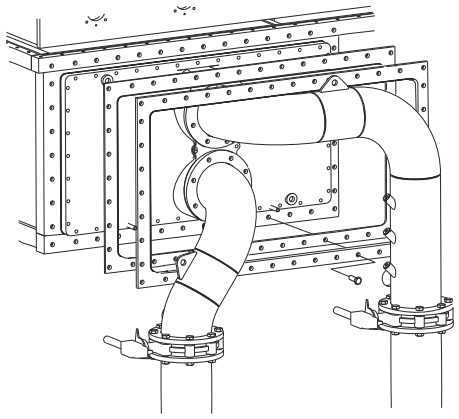
5465-0101-0005D03

2012-10-26 - en

Sealing flanges inlet/ outlet cover

Mount the sealing flange, a new O-ring and the frame around the inlet/outlet cover.

.



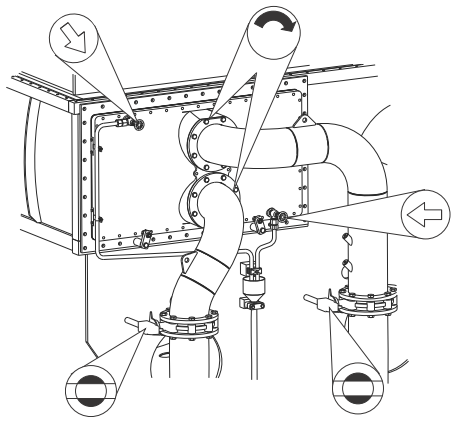
5465-0101-0005D02

Cooling water pipes

Insert new gaskets between the inlet/ outlet cover and the flanges of the cooling water pipes.

Mount and tighten the screws which fasten the cooling water inlet and outlet pipes to the inlet/outlet cover.

Mount the drain pipes, and open the cooling water inlet and outlet valves.



5465-0101-0005M08

NOTE

Remember to vent trapped air from the air cooler element.

2012-10-26 - en

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off control air supply
O	Shut off cooling water

Data

Ref.	Description	Value	Unit
T54-11	Water mist catcher	160	kg

2013-01-31 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

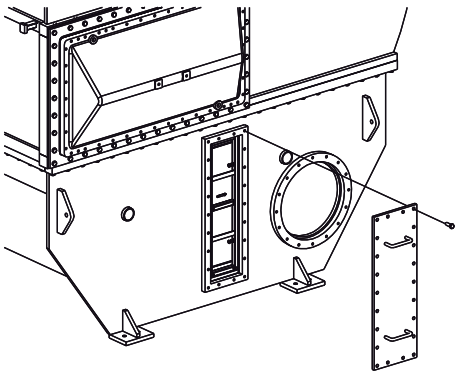
Tools

Plate	Item No.	Description
7670-0300	-	Lifting tools, etc

Dismantling of Covers

Normally it is not necessary to remove the water mist catcher element from the scavenge air cooler housing. If, however, the water mist catcher element has been fouled or damaged, it must be dismantled for cleaning or repair.

To dismantle the water mist catcher, dismantle the water mist catcher covers to give access to the air cooler housing.



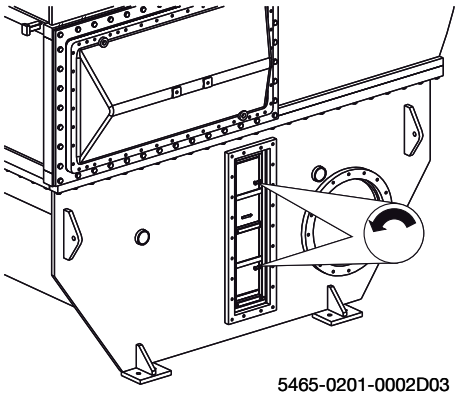
5465-0201-0002D02

NOTE

In some cases it is more practical to remove the water mist catcher from the other side.

Loosen the water mist catcher

Loosen the screws which press against the water mist catcher.



5465-0201-0002D03

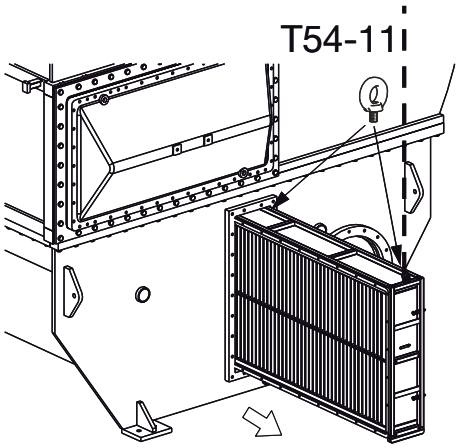
2009-02-17 - en

Pulling the water mist catcher out of the cooler housing

Pull the water mist catcher half way out and mount an eyebolt in the top of the water mist catcher.

Attach a tackle to the eyebolt and tighten up the tackle.

Pull the water mist catcher fully out of the scavenge air cooler housing and land it on a couple of wooden planks.

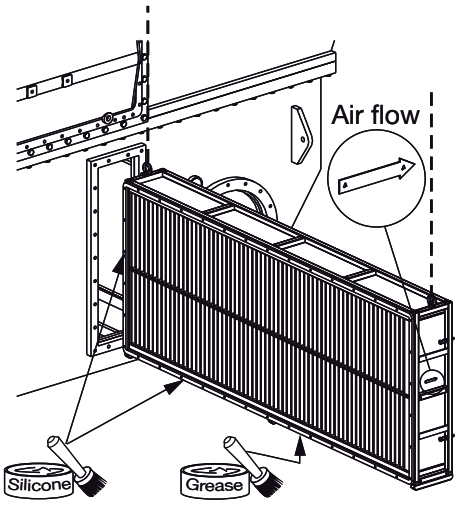


5465-0201-0002D04

Preparing mounting of water mist catcher

Lubricate the two supports on the underside of the water mist catcher with plenty of grease.

Apply a thin layer of silicone paste to the frame of the water mist catcher on the side which will face toward the sealing frame of the cooler housing.



5465-0201-0002M01

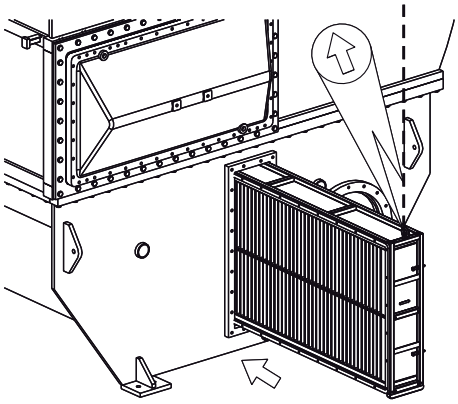
NOTE

Make sure to mount the water mist catcher correctly. *See the sketch.*

Sliding the water mist catcher into the cooler housing

Slide the water mist catcher into the scavenge air cooler housing.

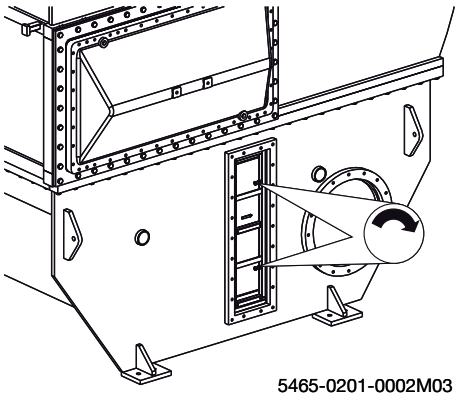
When the water mist catcher is half-way in, remove the tackle and the eyebolt, and push the water mist catcher fully into the scavenge air cooler housing.



5465-0201-0002M02

Tightening the water mist catcher

Tighten the screws which press against the water mist catcher.

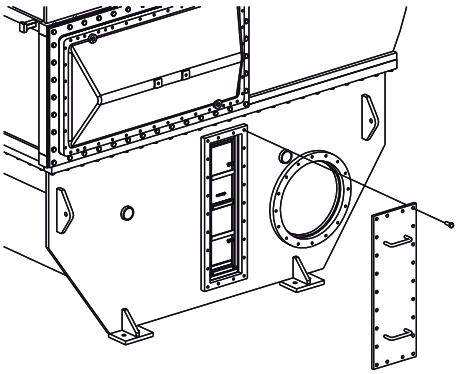


5465-0201-0002M03

2009-02-17 - en

Mounting the water mist catcher

Clean the water mist catcher cover and apply a thin layer of silicone paste along the edges of the cover. Mount the covers.



5465-0201-0002D02

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off safety air supply - Not ME Engines
O	Shut off control air supply
O	Shut off air supply to exhaust valve - Only when stopped lubricating oil pumps

Data

Ref.	Description	Value	Unit
-	Table is empty on purpose. No Data needed.	-	-

2013-01-31 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

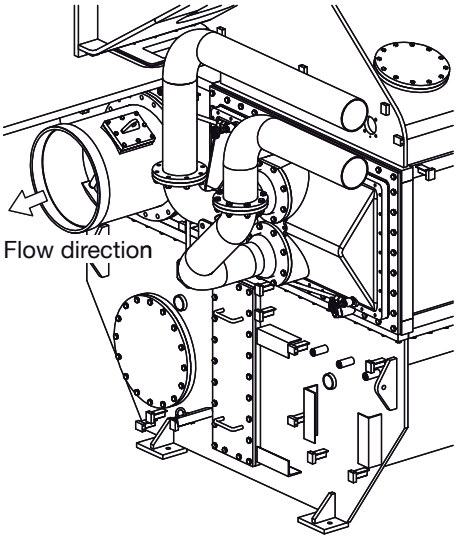
Plate	Item No.	Description
-	-	Table is empty on purpose. No special tools needed.

2013-01-31 - en

Valve Flaps

It is important that the automatic non-return valves (butterfly valves) are always able to function easily and unimpeded.

The movability of the valve flaps should therefore be checked at suitable intervals. The valves shall open for the air flow from the scavenge air cooler housings to the auxiliary blowers.



5465-0301-0001C01

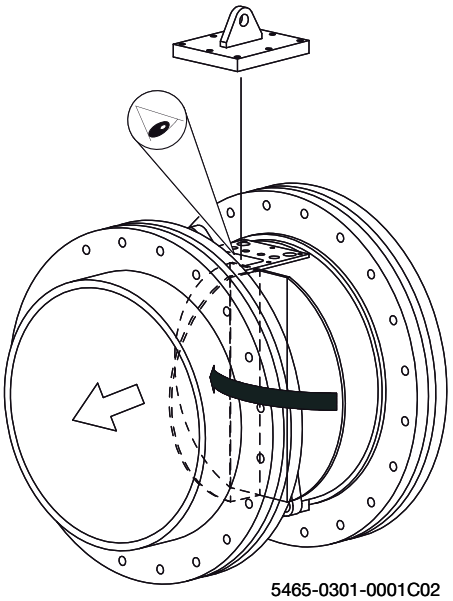
Checking of valve flaps

To check the valve, remove the cover on the top of the butterfly valve.

Reach down through the opening in the top of the valve and move the valve flaps.

If the valve flaps in one of the butterfly valves cannot be moved by a light touch of a fingertip, it must be dismantled and overhauled.

Re-mount the cover on the top of the butterfly valve.



5465-0301-0001C02

2009-01-28 - en

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off safety air supply - Not ME Engines
O	Shut off control air supply
O	Shut off air supply to exhaust valve - Only when stopped lubricating oil pumps



Data

Ref.	Description	Value	Unit
-	Table is empty on purpose. No Data needed.	-	-

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

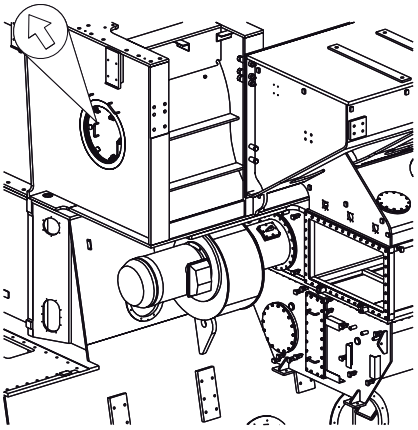
Plate	Item No.	Description
-	-	Table is empty on purpose. No special tools needed.

2013-07-18 - en

Access to the Non-Return Valve

This procedure treats the non-return valve.

The non-return valves are accessed via the scavenge air receiver through the round access hatch.



5465-0401-0002O01

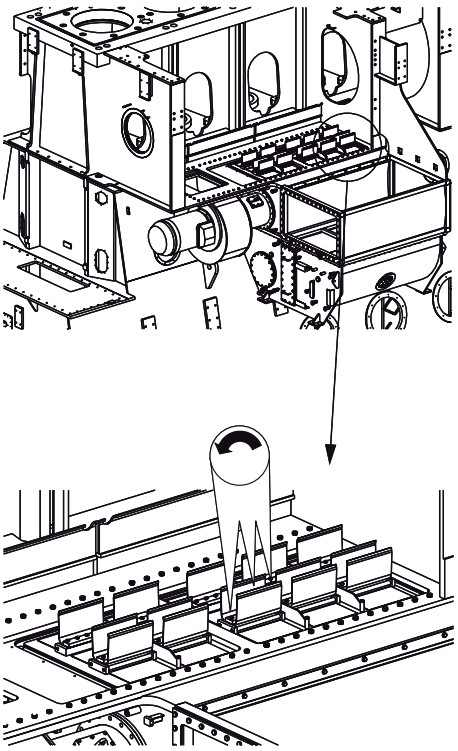
NOTE

Access to the scavenge air receiver must **not** be attempted until the air in the receiver is clean.

Remove the valve

Inside the scavenge air cooler housing, remove the middle and the two outer-most screws of the valve that is to be overhauled.

Remove the valve from the engine.



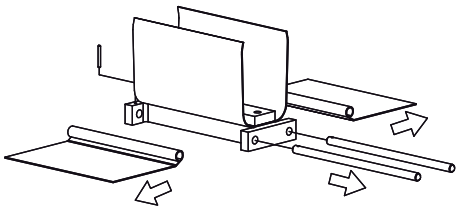
5465-0401-0002O02

2009-02-17 - en

Dismantling

Remove the spring pin from the valve shaft and knock the valve shaft out of the valve flap.

Clean the valve shaft and the slide bearings inside the valve flaps. Lubricate the valve shaft and the slide bearings with molybdenum disulphide (MoS_2).



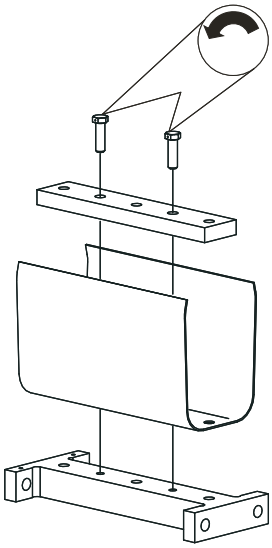
5465-0401-0002O03

Further dismantling

For further dismantling, remove the two screws which hold the supports and the clamp together as an assembly.

After the overhaul, it must be possible to move the valve flap by the light touch of a finger.

Assemble the valve and re-mount it in the scavenge air cooler housing.



5465-0401-0002O04

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off safety air supply - Not ME Engines
O	Shut off control air supply
O	Engage turning gear



Data

Ref.	Description	Value	Unit
T54-21	Electric motor, impeller and motorplate	1300	kg

2013-01-31 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
7670-0300	-	Lifting tools, etc

2013-01-31 - en

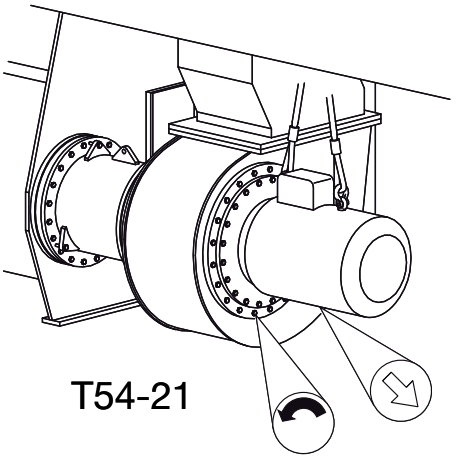
Blower Wheel and Electric Motor

Depending on the type of overhaul, disconnect the cable connections from one or both blower motors.

Dismantling of blower motor

When cleaning and inspecting the auxiliary blower, disengage the cable connections to the blower motor.

Wire ropes with shackle as well as two tackles suspended from mountings on the gallery bracket are to be hooked onto the blower flange, before removing the screws in the flange.



5465-0501-0002O02

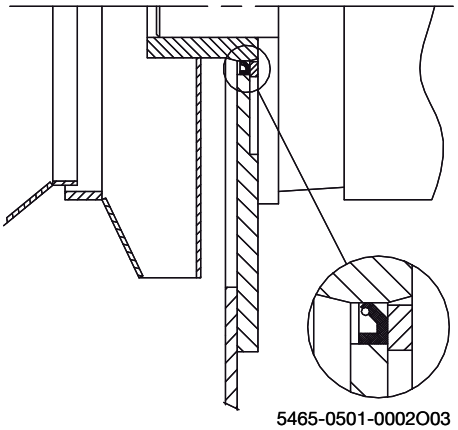
Cleaning of blower wheel

The end cover complete with blower can now be pulled free of the suction pipe by means of the two tackles.

While pulling out the end cover with the blower assembly, make sure that the blower housing disengages from the air pipe without deforming it.

Then inspect and clean the blower wheel as well as the blower housing.

For overhaul of blower wheel and bearings, see blower manufacturer's instructions.


5465-0501-0002O03

NOTE

Exercise care when mounting the electric motor with blower wheel, as the blower wheel is to "catch" the guide in the blower housing.

2008-11-05 - en

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off control air supply
O	Engage turning gear
O	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
-	Table is empty on purpose. No Data needed.	-	-

2013-01-31 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
-	-	Table is empty on purpose. No special tools needed.

The Scavenge Air Receiver Safety Valve

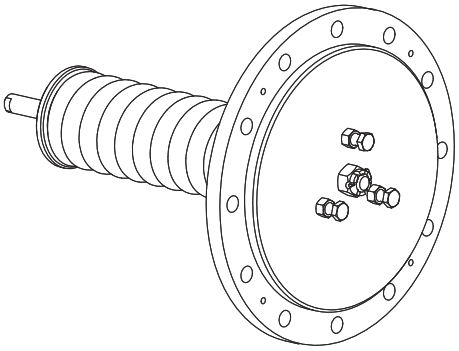
The scavenge air receiver safety valve is calibrated at the factory and does not require any adjustment.

Checking the scavenge air receiver safety valve

Check the scavenge air receiver safety valve by loosening the counter nut and turn the forced opening screw to open the valve approx. 10 millimetres.

Use a piece of cloth to wipe out any dirt from the O-ring packing and close the valve again. Tighten the counter nut.

If this operation cannot be performed smoothly, the safety valve must be dismantled and cleaned.

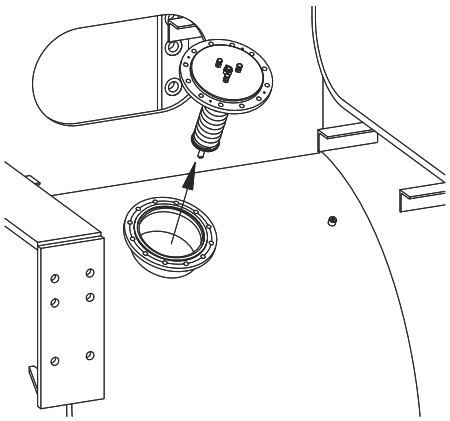


5465-0601-0001C02

2008-11-12 - en

Dismantle

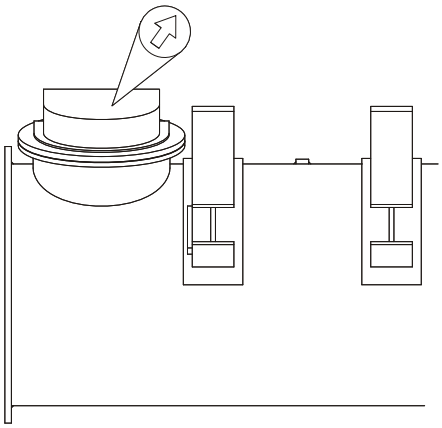
Dismantle the safety valve from the scavenge air receiver.



5465-0601-0001D01

Access to safety valve

On some engines a cover has to be removed in order to gain access to the safety valve.



5465-0601-0001D02

2008-11-12 - en

Remove

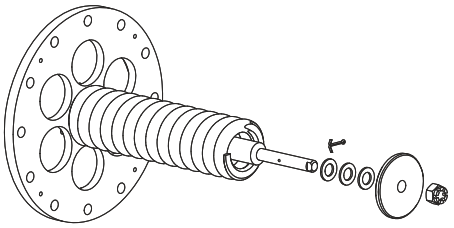
Remove the split pin.

Unscrew the nut thereby relieving the spring tension.

Remove the nut, spring retainer and washers.

Keep count of the washers.

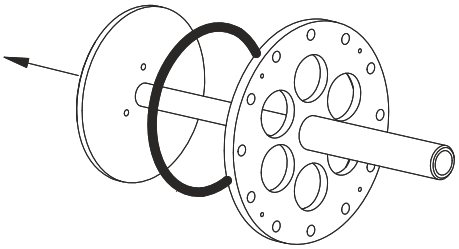
Pull out the spring.



5465-0601-0001O01

Valve flap

Pull out the valve flap with spindle. If the O-ring seal is damaged remove it without damaging the O-ring groove.



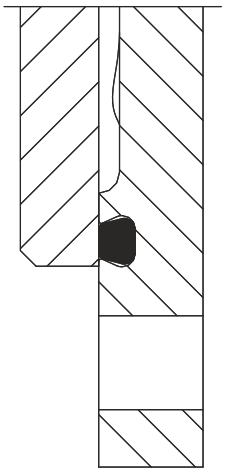
5465-0601-0001O02

Cleaning

Clean the metal surfaces thoroughly.

Loctite type AVX
Loctite type T

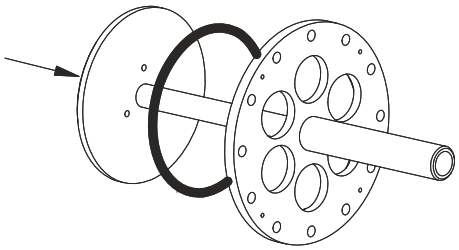
If the O-ring seal has been removed fit a new one using Loctite type AVX and Loctite activator type T or similar.



5465-0601-0001O04

Valve flap and spindle

Push in the valve flap and spindle while taking care not to damage the O-ring seal.

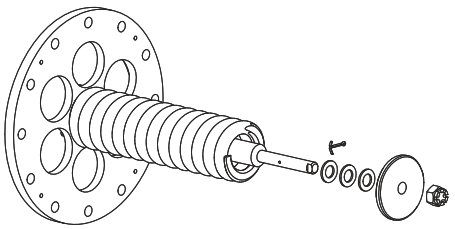


5465-0601-0001O05

Fitting

Mount the spring, spring retainer and all the washers.

Tighten the nut until the split pin can be mounted.



5465-0601-0001O01

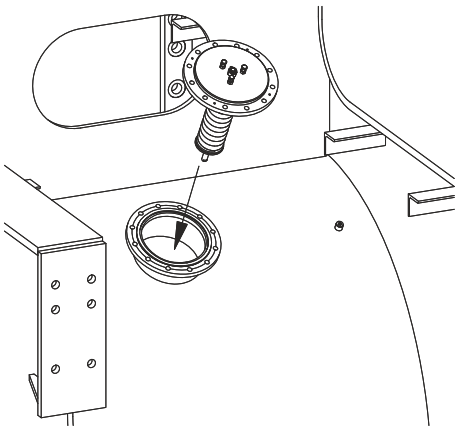
Checking

Check the valve according to checking.

2008-11-12 - en

Fitting the safety valve

Fit the safety valve on the scavenge air receiver.



5465-0601-0001M01

2008-11-12 - en

Safety Precautions

Data

Ref.	Description	Value	Unit
-	Table is empty on purpose. No Data needed.	-	-

2013-01-31 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
-	-	Table is empty on purpose. No special tools needed.

Dry Cleaning

The dry cleaning method employs compressed air to blow dry, solid, granules through the turbocharger, thus removing most of the deposits which may have formed on the nozzle vanes and turbine blades.

On account of their hardness, nut-shells, or broken or artificially shaped pieces of activated charcoal with a size of between 1.0 and max. 1.5 mm are particularly suited as blasting agents.

NOTE

We do not recommend the use of rice or grain as cleaning materials, as these may possibly stick in the exhaust gas boiler.

Removing thick deposits

It is not always possible to remove thick deposits with this dry cleaning method.

Therefore, in order to prevent the build-up of thick deposits, the turbine must be cleaned after every 24 to 50 hours of operation.

Generally, turbocharger cleaning can be carried out without, or with very little, reduction of the engine load.

Detailed information

More detailed information regarding the amount of granules to be used is stated on the instruction plate located close to the turbocharger.

NOTE

Regarding water washing of turbocharger turbine, see turbine manufacturer's instructions.
See also 5445-0100.

2008-11-18 - en

Cleaning Procedure

24-50 hours

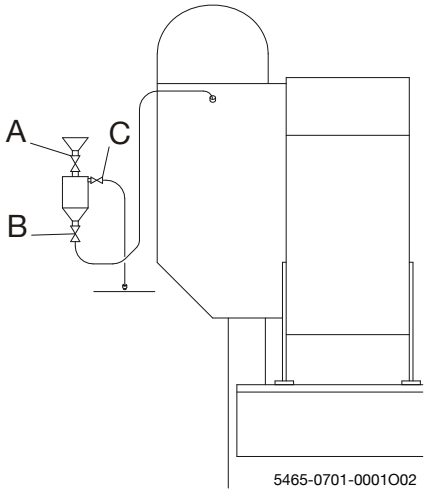
Carry out cleaning for every 24 to 50 hours of operation, based on observations.

TC type	Amount dm^3
TCR 14	0,1
TCR 16	0,2
TCR 18	0,2
TCR 20	0,3
TCR 22	0,5
TCA 33	0,5
TCA 44	0,5
TCA 55	1,0
TCA 66	1,5
TCA 77	2,0
TCA 88	2,5
TCA 99	3,0
TPL 61	0,5
TPL 65	0,6
TPL 69	0,9
TPL 73	1,2
TPL 77	1,5
TPL 80	2,0
TPL 85	3,0
MET 33	0,4
MET 42	0,7
MET 53	1,6
MET 60	2,1
MET 66	2,6
MET 71	3,0
MET 83	3,5
MET 90	3,5
A165-L	1,0
A170-L	1,5
A175-L	2,0
A180-L	2,5
A185-L	3,0
A190-L	3,5

5465-0701-0002O03

Preferably

Clean the turbocharger at full load. Do not clean below half load.



5465-0701-0001O02

2008-11-18 - en

Valve A	Close valve **A**.
Valve B/C	Open valves **B** and **C**, to blow out any deposits and/or condensate in the connecting pipe. After about two minutes, close valves **B** and **C**.
Relieve the pressure	Slowly open valve **A** to relieve the pressure in the tank.
Fill the tank	Fill the tank with the quantity of granules specified in the table.
Valve A	Close valve **A**.
Valve B/C	Open valves **B** and **C**, to blow-in the granules. After one to two minutes, close valves **B** and **C**.
Relieve the pressure in the tank	Slowly open valve **A** to relieve the pressure in the tank.

CAUTION

The drain openings in the gas casings must remain closed while dry cleaning the turbine.

It is possible that during dry cleaning of the turbine, some of the blown-in solid particles or sparks will escape through the funnel.

2008-11-18 - en

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off safety air supply - Not ME Engines
O	Shut off control air supply



Data

Ref.	Description	Value	Unit
T54-28	Gas By-Pass Valve	30	kg
T54-30	Max. Valve turning torque	Smooth torque ±5	Nm
T54-31	Assembly screws	25	Nm
T54-32	Valve seat screws	25	Nm
T54-33	Valve flap bolts	40	Nm

2013-01-25 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

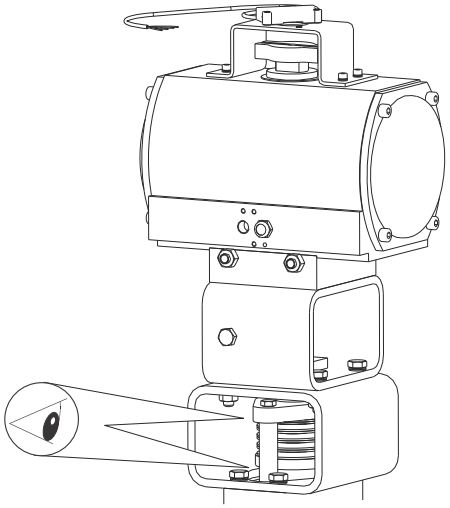
Tools

Plate	Item No.	Description
7670-0200	-	Torque spanners
7670-0300	-	Lifting tools, etc

Penumatic operation

Actuate the valve from the control panel. Look at the coupling and spindle operation to check that the actuator opens and closes the valve smooth and properly.

If the operation is erratic, the cause should be found and remedied.



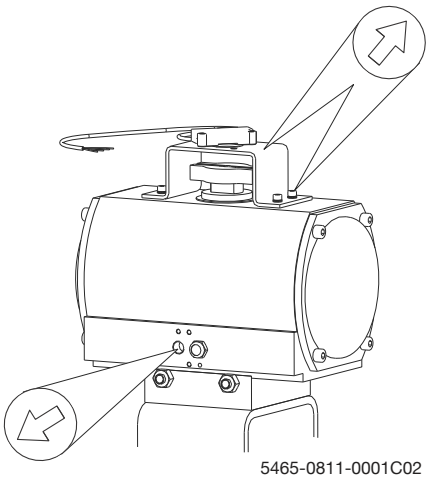
5465-0811-0001C01

Manual operation

Remove the air supply.

Remove position sensor (if mounted).

Remove the actuator.



5465-0811-0001C02

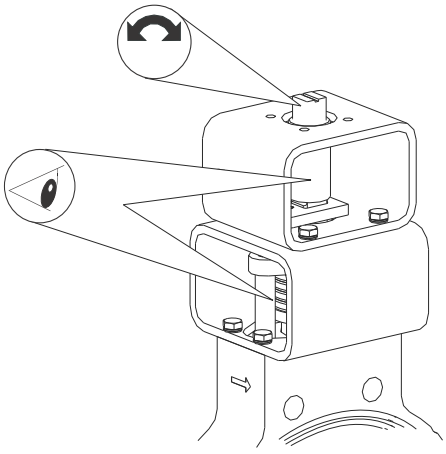
Turn the valve

Look at the coupling and spindle operation while turning the valve manually.

Check simultaneously that the valve opens and closes smooth and properly.

If the operation is erratic, the cause should be found and remedied.

Remount the actuator, pointer air supply and position sensor.



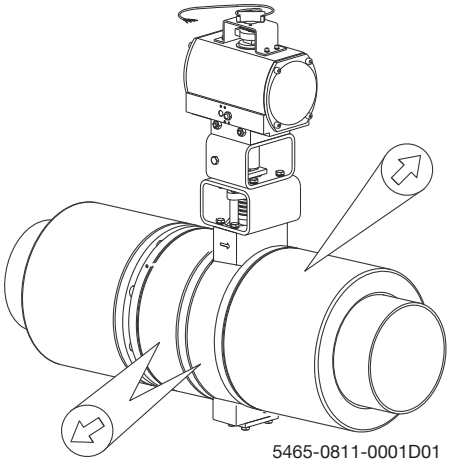
5465-0811-0001C03

2013-01-03 - en

Preperation

Remove the insulation from the valve.

Where applicable, remove the heat radiation shield, taking note of its position.



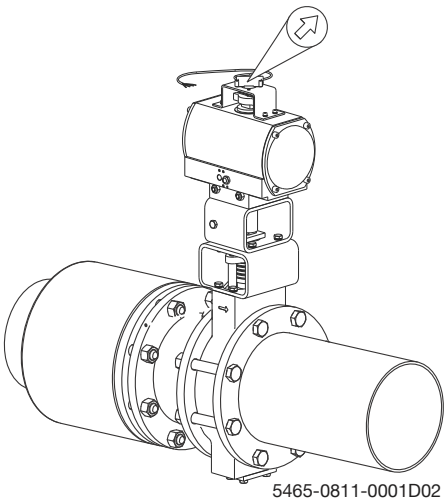
5465-0811-0001D01

Remember

Remove the air supply.

Remove position sensor (if mounted).

Mark off the position of the valve on the flange by means of punch marks or similar.



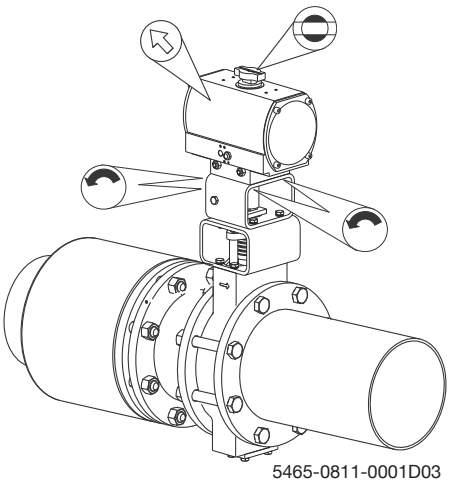
5465-0811-0001D02

Mount ½ ton chain tackle

Make sure that the valve is **open** position.

Loosen the actuator screws.

Remove the actuator.



5465-0811-0001D03

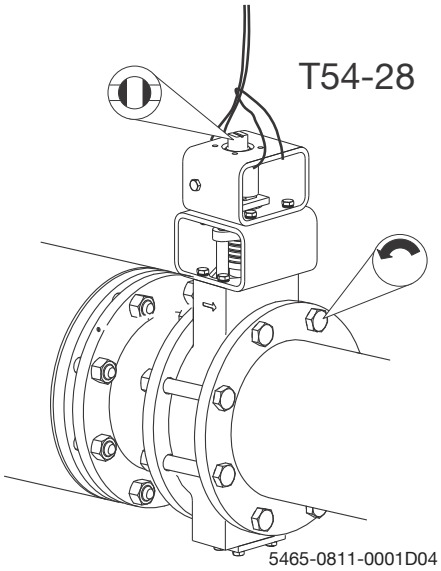
2013-01-03 - en

Finally

Close the valve.

Mount a wire sling through the actuator bracket and suspend it from the engine room crane.

Remove the flange bolts and lift away the valve to a workbench or similar. Place it so that it is accessible from both sides.



5465-0811-0001D04

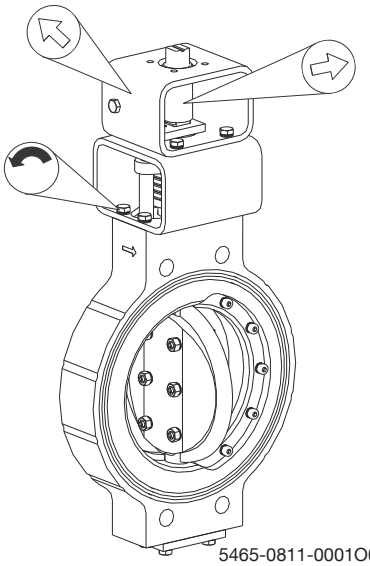
2013-01-03 - en

Remove bracket

Remove the spindle extention.

Remove the bolts holding the bracket.

Remove the bracket.



5465-0811-0001O01

Dismantling

Remove the screws of the valve seat.

Remove the valve seat.

Remove the valve flap bolts.

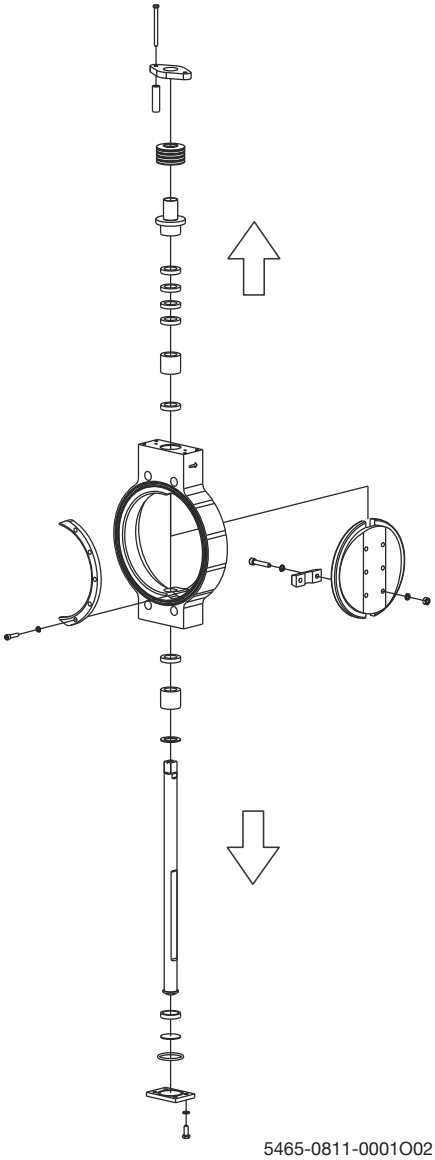
Remove the valve flaps.

Gradually loosen the bolts that hold the flanges. Remove the flanges, the tubular spacers, disc springs and thrust discs.

Pull out the spindles. If necessary, use a brass mandrel and a hammer to knock it out.

Remove the packings, seals, etc. and bushings from the housing.

Clean and inspect all parts, pay special attention to the valve seat and spindles. If necessary, minor wear marks may be ground or polished. Replace parts as necessary.



5465-0811-0001O02

Assembly

Preface

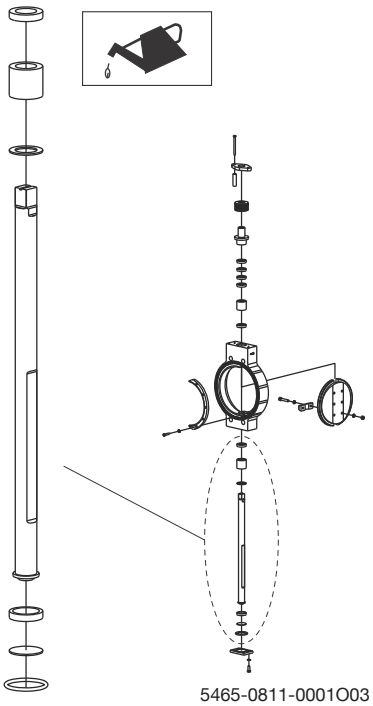
During the assembly process we recommend also to see *plate 5472-0810*.

Preparing valve spindle

Mount the thrust disc, bushing and the packing on the valve spindle.

NOTE

Lubricate the trust disc and the bushing throughly with grease containing graphite before assembly.



5465-0811-0001O03

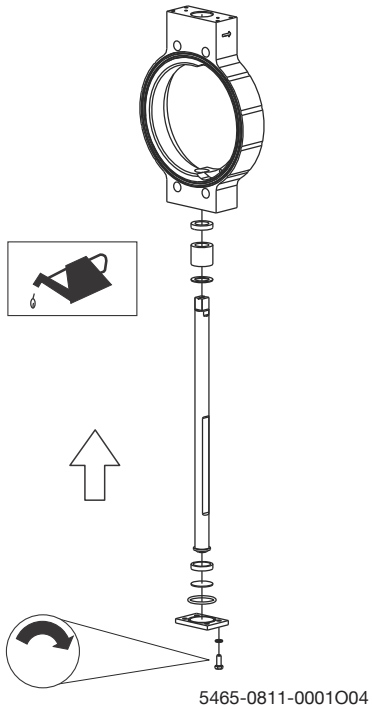
Assembly lower part

Mount the spindle in the valve housing.

Mount the distance pipe, thrust disc, packing and the end cover.

NOTE

Lubricate the distance pipe and the trust disc with grease containing graphite before assembly.



5465-0811-0001O04

Assembly upper part

Mount the packings, sealing rings, bushing and thrust disc.

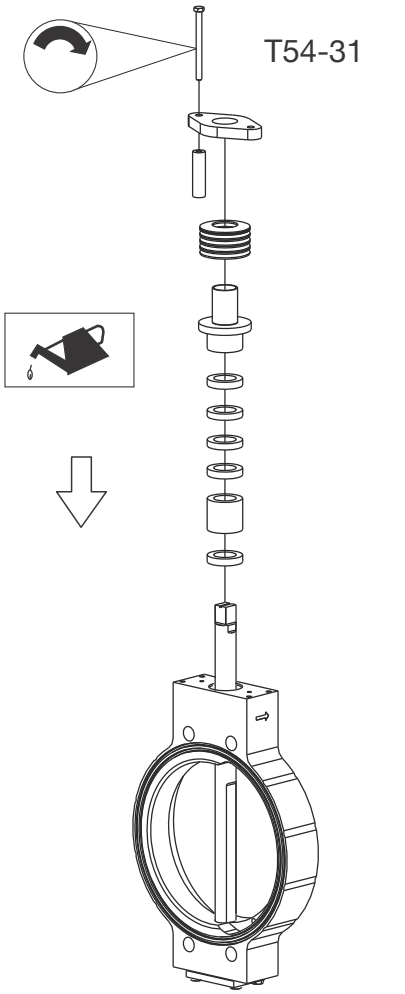
NOTE

Lubricate the trust disc and the bushing with grease containing graphite before assembly.

Mount the disc spring.

Mount the distance pipes, the flange and the screws.

Gradually tighten the screws according to *Data*.



5465-0811-0001O05

Valve seat

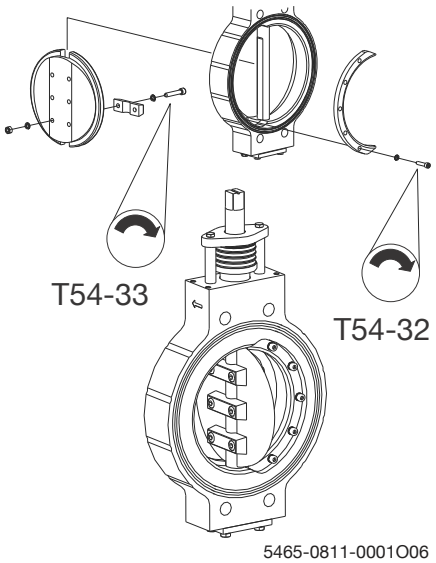
Mount the valve seats and the screws.

Tighten the screws as stated in *Data*.

Valve flap

Mount the valve flaps, camlock washers, screws and nuts.

Tighten the bolts as stated in *Data*.



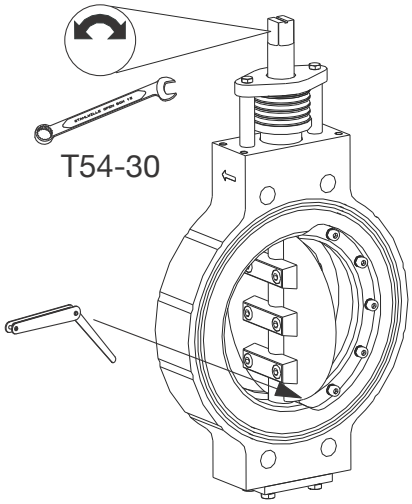
5465-0811-0001O06

2013-01-03 - en

Remove the valve

Activate the valve 50 times by turning the square spindle end with a spanner. This seats the seals.

Check the torque necessary to turn the valve. If data is exceeded, the cause should be found and remediate action taken.



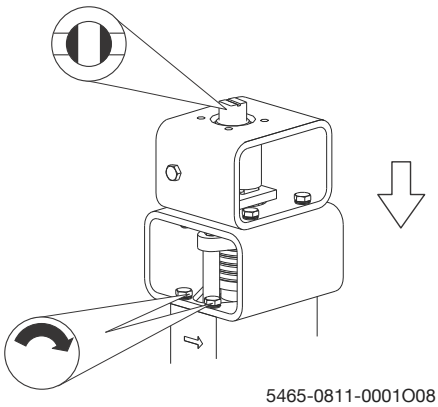
5465-0811-0001O07

Spindle extention

Close the valve.

Mount the bracket.

Mount the spindle extention.



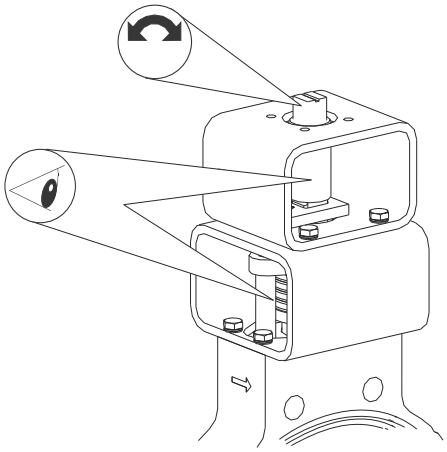
5465-0811-0001O08

2013-01-03 - en

Check before installation

Check that the valve opens and closes smoothly; if not, the cause should be found and remedied.

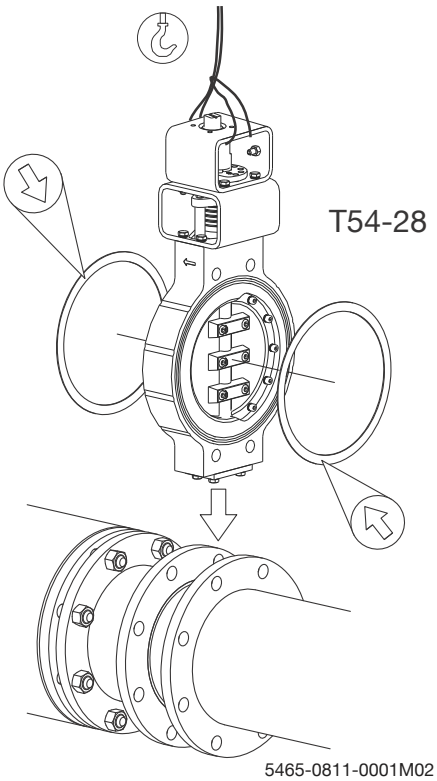
Make sure that the valve is in **close** position.



5465-0811-0001C03

Installation

Lift the valve and install it in the exact same position as when removed (use the punch marks as reference). Mount new gaskets on the flanges.

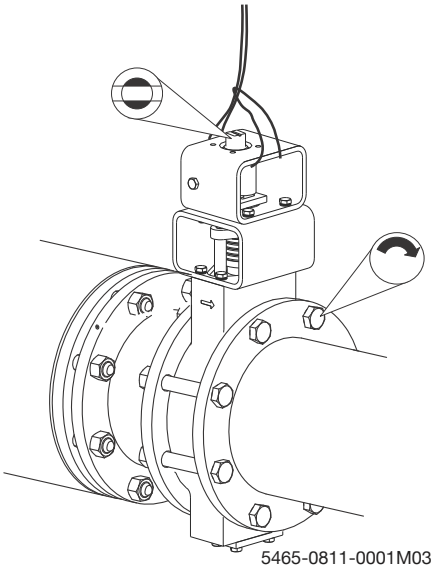


5465-0811-0001M02

Tighten the valve bolts

Mount and tighten all the flange bolts.

Open the valve.



5465-0811-0001M03

Final mountings

Mount the actuator.

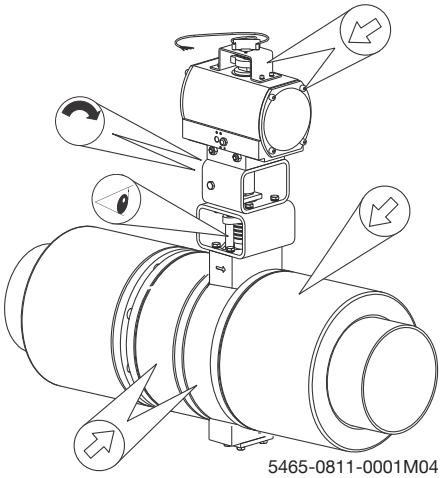
Mount and tighten the actuator screws.

Connect the air supply.

Mount position sensor.

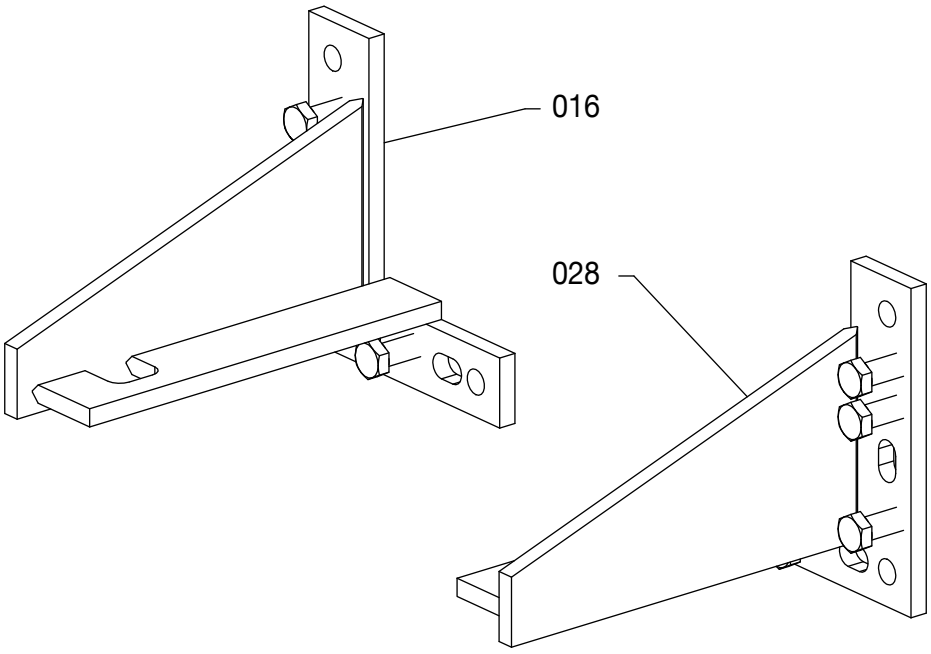
Check that the actuator opens and closes the valve smoothly and properly by looking at the spindle operation.

Mount the insulation.



5465-0811-0001M04

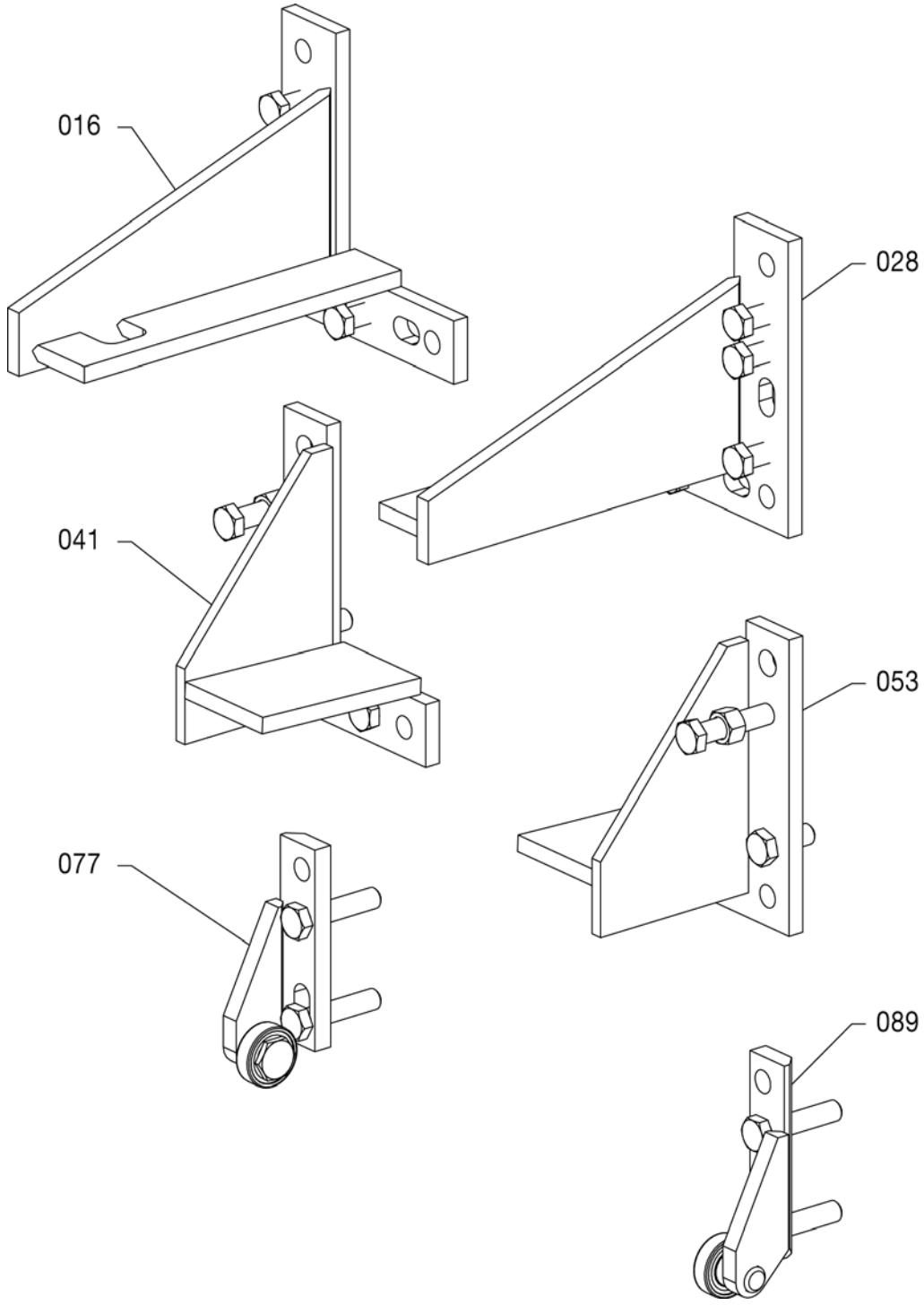
2013-01-03 - en


016
028

Scavenge Air Cooler Tools

Plate 5470-0110-0001.0

Item no	Qty	Designation
016	-	Guide rail for air cooler fore end
028	-	Guide rail for air cooler fore end



Scavenge Air Cooler Tools

Plate 5470-0110-0002

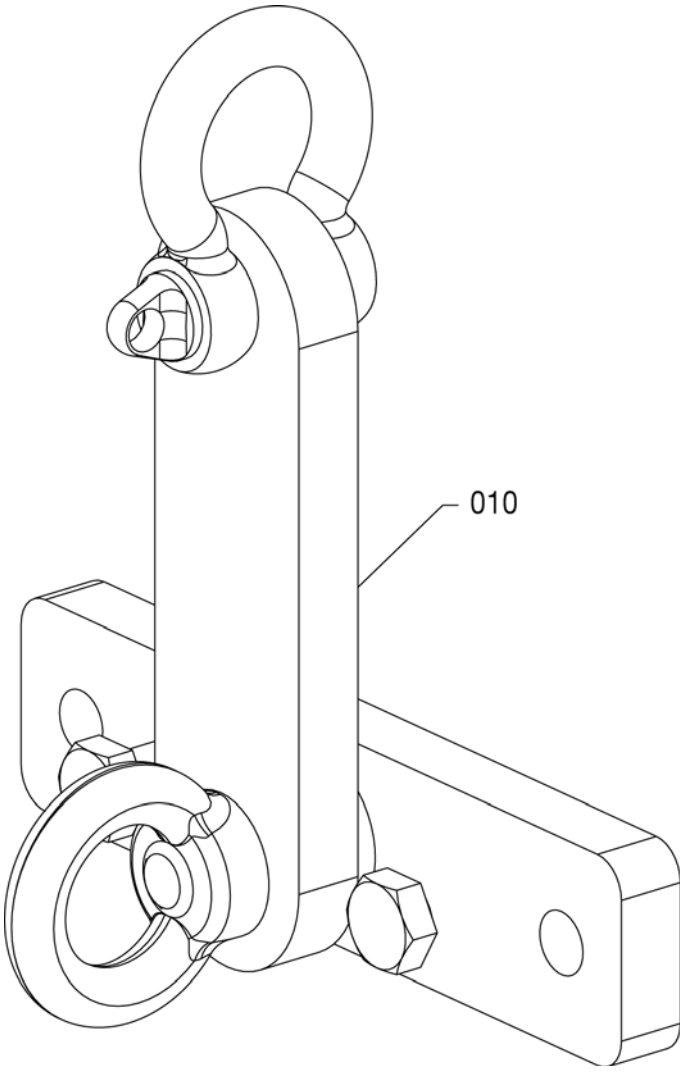
2008-07-23

Scavenge Air Cooler Tools

Plate 5470-0110-0002

Item no	Qty	Designation
016	-	Guide rail air cooler, fore end
028	-	Guide rail air cooler, fore end
041	-	Guide rail air cooler, rear end
053	-	Guide rail air cooler, rear end
077	-	Wheel for air cooler
089	-	Wheel for air cooler

2008-07-23



Scavenge Air Cooler Lifting Tools

Plate 5470-0120-0002

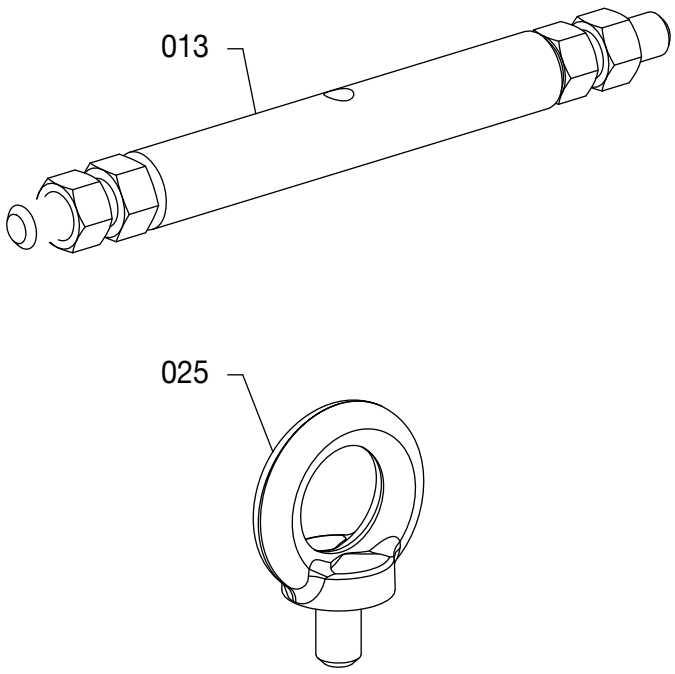
2008-07-22

Scavenge Air Cooler Lifting Tools

Plate 5470-0120-0002

Item no	Qty	Designation
010	-	Lifting attachement aircooler fore end

2008-07-22

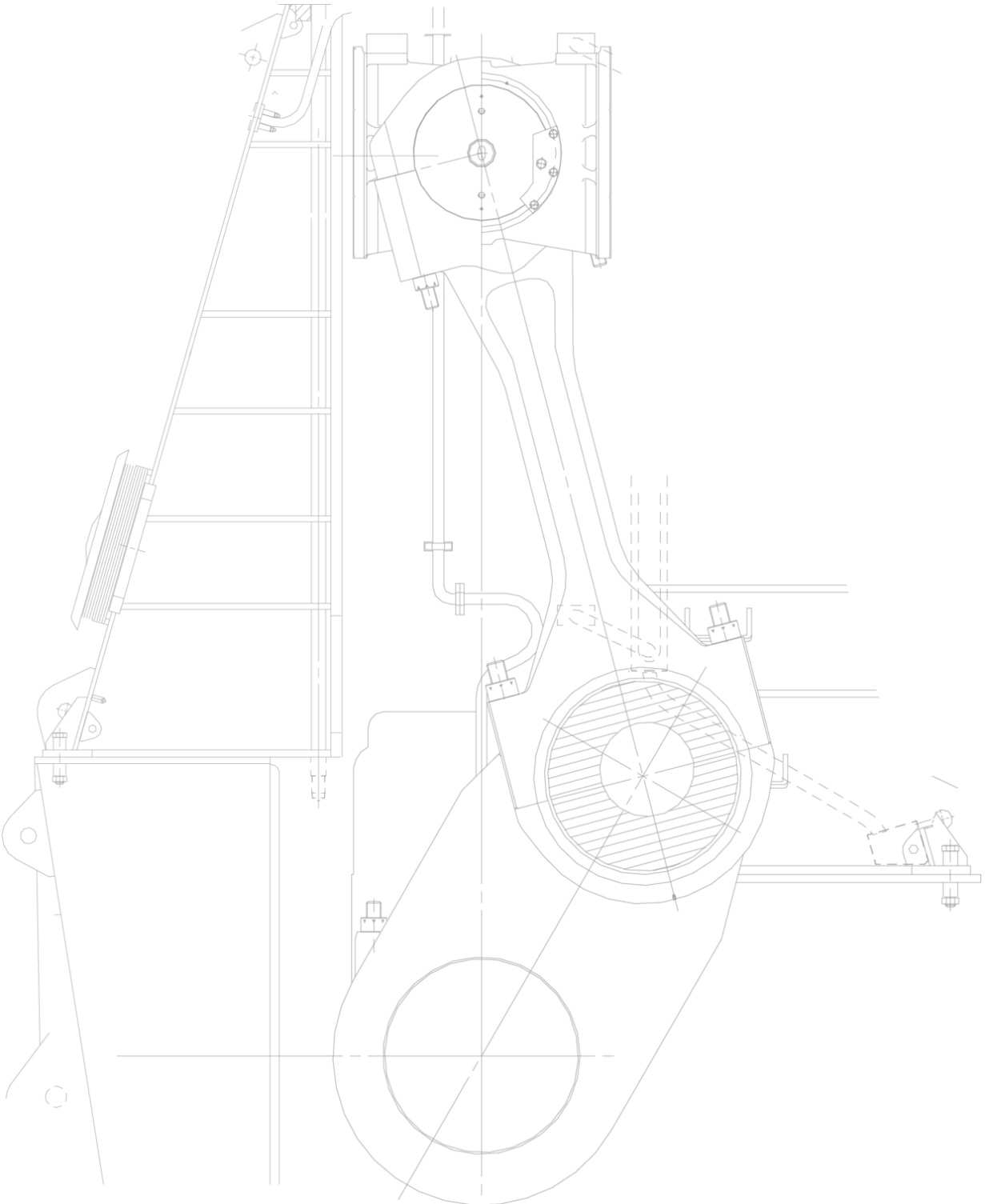

013
025

Turbocharger Tools

Plate 5470-0700-0001.0

Item no	Qty	Designation
013	-	Pulling tool
025	-	Eye bolt

Preface Chapter	Performance	6340-0100-0002
Description	Testbed Adjustments	6345-0100-0001
	IMO NOx Components	6345-0200-0002
	Observations during Operation	6345-0300-0002
	Evaluation of Records	6345-0310-0002
	Cleaning Turbochargers and Air Coolers	6345-0320-0003
	Measuring Instruments	6345-0330-0002
	Pressure Measurements and Engine Power Calculations	6345-0340-0002
	Correction of Perforemance Parameters	6345-0350-0002
	Turbocharger Efficiency	6345-0360-0002
	Estimation of the Effective Engine Power without Indicator Diagrams	6345-0370-0002
Drawing	Load Diagram for Propulsion alone	6355-0100-0002
	Load Diagram for Propulsion and Main Engine Driven Generator	6355-0105-0001
	Performance Observations	6355-0110-0001
	Readings relating to Thermodynamic Conditions	6355-0115-0001
	Synopsis Diagrams for Engine	6355-0120-0002
	Synopsis Diagrams for Engine - Pmax	6355-0125-0002
	Synopsis Diagrams for Engine - Pe	6355-0130-0002
	Synopsis Diagrams for Turbocharger	6355-0135-0002
	Synopsis Diagrams for Turbocharger Compressor and Turbine - Psav	6355-0140-0002
	Synopsis Diagrams for Air Cooler	6355-0145-0002
	Specific Fuel Oil Consumption	6355-0150-0002
	Normal Indicator Diagram	6355-0155-0001
	Correction to ISO Reference Ambient Conditions - Maximum Combustion Pressure	6355-0180-0003
	Correction to ISO Reference Ambient - Compession Pressure	6355-0205-0001
	Calculation of Turbocharger Efficiency	6355-0210-0001
	Power Estimation	6355-0215-0002
	Turbocharger Compressor Wheel Diameter and Slip Factor	6355-0220-0002



Performance

This chapter of the instruction book is intended to provide the user with comprehensive information regarding the performance of the engine. Information includes recording, calculation and evaluation of the performance.

2013-06-24 - en

TESTBED DATA (ME)	Engine Type:	Water Brake:	No.:	Constant, K: kW/Kg.RPM	MAN
	Engine Builder:	Engine No.:	Yard:		

Layout kW:	Layout RPM:	Engine Mode:	Sign.:	Test No.:

Turbocharger(s)	No. of TC:	Serial No.	No. of Cyl.:	Bore, m:	Stroke, m:
Make:	Type:	1	Cylinder Constant (kW,bar):	Mean Friction. Press., bar:	
Max. RPM:	Max. Temp., °C:	2	Lubrication Oil System (Tick box)		
Compr. Slip Factor:	Compr. Diam., m:	3	☐ Internal ☐ External from M. E. System	☐ External from Gravity Tank	
TC specification:		4			

Observation No:

Fuel Oil Viscosity:	at: °C		Brand	Type
Bunker Station:		Cylinder Oil		
Oil Brand:	Heat value, kJ/kg:	Circulating Oil		
Density kg/m³, at: °C	Sulphur, %:	Turbo Oil		

Test Date (yyyy-mm-dd)	Test Hour (hh:mm)	Load %	Ambient Pressure mbar	Water Brake Load Kg	Engine RPM	Fuel Index ECU %	Speed Setting RPM	
Effective Power kW	Indicated Power kW	Eff. Fuel Consumption g/kWh	Indicated Fuel Consumption g/kWh	MOP Estimated Engine Load %	MOP Pmax bar	MOP Pcomp bar	MOP Pcomp/Pscav	

Cylinder No.	All	1	2	3	4	5	6	7	8	9	10	11	12	13	14				Ave.
Pi, bar																			
Pmax, bar																			
Ref. Pmax, bar																			
Pcomp, bar																			
High Load Offset, %																			
Low Load Offset, %																			
Fuel Quality Adjust. (FQA), %																			
Pmax Offset, bar																			
Pcomp Ratio (Pcomp/Pscav)																			
Exh. Valve Open Timing, °CA (Correction value)																			
Exhaust Gas Temp., °C																			
Cool. Water Outlet Temp., °C																			
Piston Outlet Lub. Temp., °C																			

Cooling Water Temperature, °C				Exhaust Gas Temp., °C		Exhaust Pressure		Turbo Charger	Aux. Blower	Scavenge Air Pressure		
Air Cooler		Main Engine		Turbine		Receiver	Turb. Outl.			▲p Filter	▲p Cooler	Receiver
Inlet	Outlet	Inlet	Turb. Outlet	Inlet	Outlet	bar	mmWC	RPM	On/Off	mmWc	mmWc	bar
1	1		1	1	1		1	1		1	1	
		Seaw. Temp.				Variable XBP			Axial Vibration			Pscav
2	2		2	2	2	Actual, %	2	2		2	2	Set Point
									mm			bar
3	3		3	3	3	Variable XBP	3	3		3	3	
						Set Point, %						
4	4		4	4	4		4	4		4	4	
Ave.	Ave.		Ave.	Ave.	Ave.		Ave.	Ave.		Ave.	Ave.	

Scavenge Air Temperature, °C				Lubricating Oil			Fuel Oil Pressure	Hydraulic Pressure	
	Inlet Blower	Before Cooler	After Cooler	Pressure, bar	Temperature, °C		bar	bar	
Scav. Air Temp.	1	1	1	System Oil	TC Inlet / Blower end	TC Outlet / Turb. end	Before Filter	Before Filter	
	2	2	2	Cooling Oil	1	1	After Filter	After Filter	
	3	3	3	Turbine Oil	2	2	Temperature, °C Before Pumps	Main Pressure	
	4	4	4	Temperature, °C	3	3		Swash Plate Position, %	
	Ave.	Ave.	Ave.	Inlet Engine				1	2
					4	4			
				Thrust Segment				3	4
					Ave.	Ave.			

Remarks:

Rel. 2011-10-21

1. Check of IMO-ID, Markings on Components

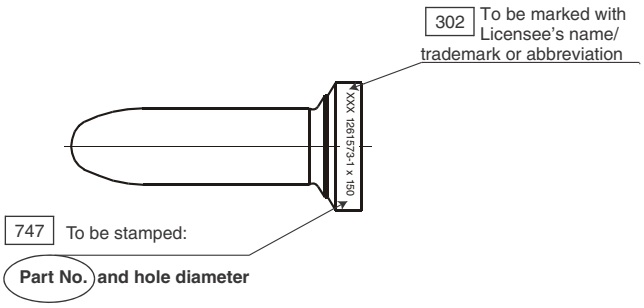
The components described in the following, have been marked with unambiguous identification numbers to enable the relevant drawing and certificate to be traced. The schematic drawings show where to find the markings on the individual component types. Information on the important dimensions for each component type in respect to the NOx characteristic can be found in the engine instruction book, see references in footnotes **) to Technical File (TF) Chapter 1.4.

The circled part ⬭ of the number is the only part of the entire number that is to be defined as the “IMO number”. The component marking may include a revision reference nnnnnnn-n.n, however, that reference is not part of the defining marking and should be ignored.

See also Production Specification No. 0742980-3 regarding marks and stamps on components for MAN Diesel two-stroke diesel engines.

NOTE

The items 6345-0200.02, 03, 07, 08, 09, 10 might not be used on your specific engine. Therefore, these items are marked with a designation, referring to the engine type where the item is used. The designations are: MC, ME, ME-B.



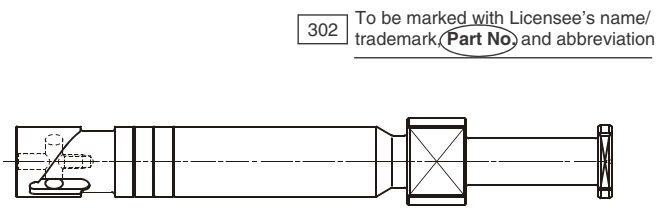
Certified markings:

Part No.

Marking instruction:

No. 0742639-1

Fig. 6345-0200.01 – Fuel Valve Nozzle



Certified markings:

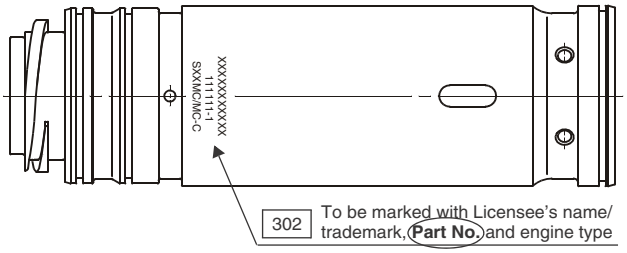
Part No.

Marking instruction:

No. 0742845-1

Fig. 6345-0200.02 – Fuel Pump Plunger (MC)

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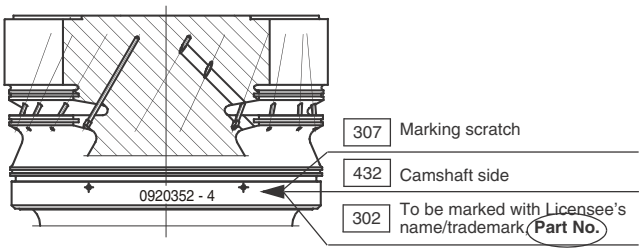
Certified markings:

Part No.

Marking instruction:

No. 0742843-8

Fig. 6345-0200.03 Fuel Pump Barrel (MC)



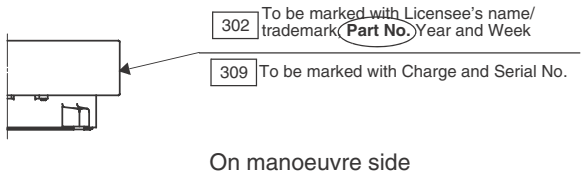
Certified markings:

Part No.

Marking instruction:

No. 0742637-8

Fig. 6345-0200.04 Cylinder Liner



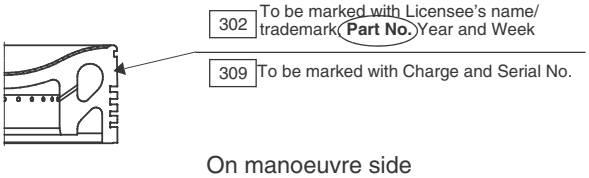
Certified markings:

Part No.

Marking instruction:

No. 0742634-2

Fig. 6345-0200.05 Cylinder Cover



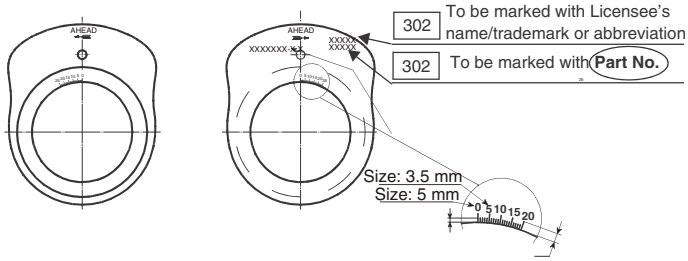
Certified markings:

Part No.

Marking instruction:

No. 0742392-0

Fig. 6345-0200.06 Piston Crown



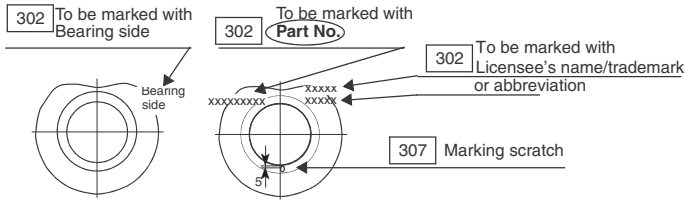
Certified markings:

Part No.

Marking instruction:

No. 0742635-4

Fig. 6345-0200.07 Exhaust Cam (MC, ME-B)



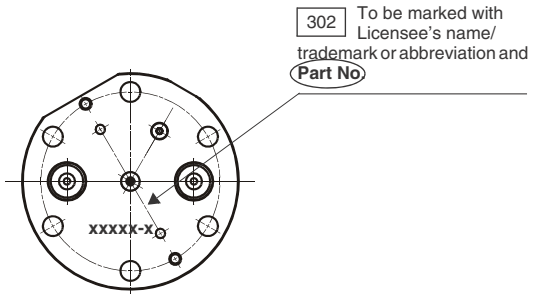
Certified markings:

Part No.

Marking instruction:

No. 0742636-6

Fig. 6345-0200.08 Fuel Cam (MC)



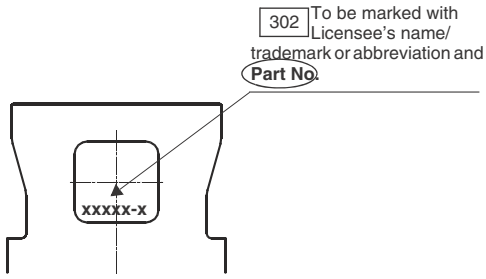
Certified markings:

Part No.

Marking instruction:

No. 0742962-4

Fig. 6345-0200.09 Fuel Oil Pressure Booster Top Cover (ME, ME-B)



Certified markings:

Part No.

Marking instruction:

No. 0742960-0.1

Fig. 6345-0200.10 Fuel Oil Pressure Booster Housing (ME, ME-B)

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2. Checking Setting Values (MC)

2.1 Checking the VIT-adjustments (Engines with VIT)

Load the engine

- Loading to 75% MCR or 100% MCR:
- Loading to the 'break-point':
  Electronically controlled VIT:
  Follow the instructions from the supplier of the engine control system

  Mechanically controlled VIT:
  Load the engine until the steel bar touches the pivoting points (F1 and F2) simultaneously, *see Fig. 6345-0200.11.*

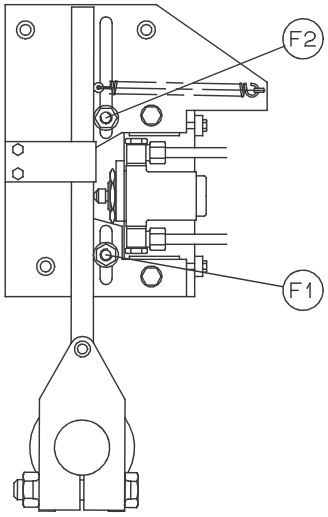


Fig. 6345-0200.11

Read the actual VIT-index

Read the actual VIT-index on the scale of the fuel pump timing racks, *see Fig. 6345-0200.12.*

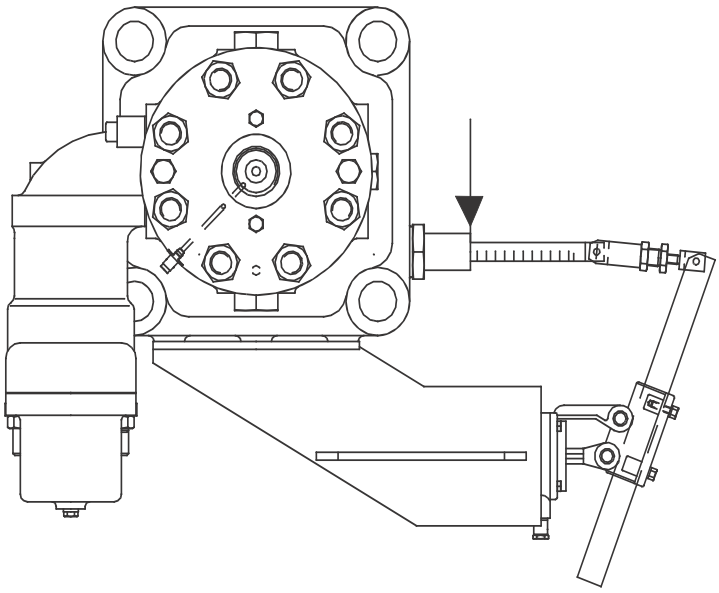


Fig. 6345-0200.12

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2.2 Checking the Shims (MC)

Number of shims in fuel pump (Injection timing)

For engines without VIT, visually check the number of shims between the fuel pump top cover and the pump housing. *See Fig. 6345-0200.13*

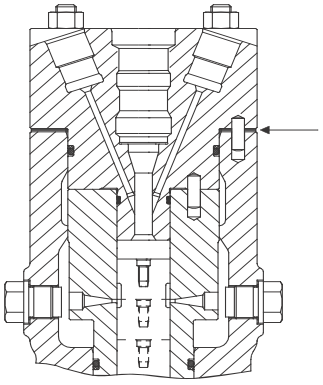


Fig. 6345-0200.13

Checking the shim thickness, t (compression volume) (MC, ME, ME-B)
Turn the crankthrow towards the exhaust side, to provide access for measuring the thickness of the shim which is inserted between piston rod and crosshead pin. *See Fig. 6345-0200.14*

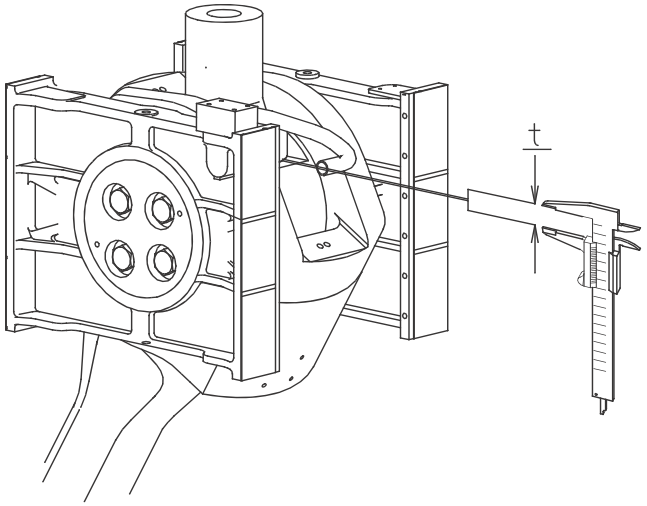


Fig. 6345-0200.14

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3. Nameplates

3.1 Turbocharger specifications (nameplate)

Manufacturer
Type
Serial number(s)
Manufacturing date
Specification
Max. cont. speed
Max. cont. gas temperature

3.2 Air cooler specifications (nameplate)

Manufacturer			
Type			
Contract number(s)			
Year build			
	Water side	Air side	
Operational gauge pressure			bar
Test gauge pressure			bar
Operational temperature			deg. C
Content			L

3.3 Auxiliary blower specifications (nameplate)

Manufacturer	
Model	Serial number(s)
Capacity	Speed
Pressure	Power
Temp.	Elec. source

3.4 ELFI/FIVA Valve

Manufacturer
Type
Serial number(s)
Manufacturing date
Specification
Max. cont. speed
Max. cont. gas temperature

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4. Survey Methods including on-board verification

4.1 IMO surveys

The flow chart in section 5.5 shows all the survey methods used in connection with IMO certification of a MAN Diesel two-stroke engine.

a. test-bed survey (engine pre-certification survey)
b. sea-trial survey (initial survey on board), and
c. on-board surveys (intermediate and periodical surveys)

On test bed, parent and the member engines are surveyed by the same procedures, except for the important difference that emission measurements are performed and surveyed on the parent engine, only. (The emissions data measured on the parent engine are used to establish the emission simulation for the on-board survey code to verify compliance based on standard performance data.)

On board, only the 'on-board' survey method shall be used for future 'intermediate' and 'periodical' surveys. (Provided that the required IMO certificates have been issued based on the engine 'pre-certification' and 'initial' surveys.)

The standard MAN Diesel on-board survey method is defined as a combination of performance parameter checks, and component and setting verification. The extend of the component and setting verification depends on different conditions, but, in general, can be reduced to the fuel nozzle, if the performance data are within the specified tolerances given in TF Table 1.3 and no component changes have been made to the engine.

The necessary performance parameters and corrections are specified in Chapter B.2 of the Technical File (TF). And a description with step-by-step procedures of the actual survey is presented in TF Section B.3.

4.2 Definitions and corrections

'Standard MAN Diesel performance check'

Table 4.2.1 on the next page, lists the parameters necessary as input for the survey code from a standard MAN Diesel performance check.

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Table 4.2.1: Input data for survey code *)

Engine Number	–
Vessel Name	–
T/C inlet temperature **	deg. C
Ambient temperature **	deg. C
Ambient pressure	mbar
Relative humidity of ambient air	rel. %
Scavenging-air temperature **	deg. C
Scavenging-air pressure **	bar
Sea-water (inlet) temperature **	deg. C
Turbine back pressure **	mm WC
Max. cylinder pressure **	bar
Max. compression pressure	bar
Power **, ***	kW
Engine speed	r/min
Turbocharger speed	r/min
Fuel pump index	–
VIT index *(if applicable)*	–
* See foot notes **) to TF Chapter 1.4 Comments on calibration of sensors and apparatus, and correction to ISO ambient conditions for these measurements ** These items are required in order to calculate the NO_x emission *** See comment in text on power estimation (TF section B.2.1.3.)	

Tolerances for 'load points'

The actual load points are attached a certain tolerance (see 'NO_x Technical Code,' Appendix 4.) However, due to propeller lay out or vessel trim a 'light or heavy propeller' may be experienced. In these cases MAN Diesel recommend to select the load point according to the actual measured mean effective pressure corresponding to the specified load point.

Power

The power is usually derived from torque and speed. If the torque is difficult to measure directly through torsion measurements, the Charts added in Fig. B.2 or B.3 of the Technical File, can be used to estimate the brake power. Alternatively the load could be derived from a MAN Diesel PMI system.

Back pressure

The usual variations in turbine back pressure have been shown only to have a minor influence on the NO_x emission and the measurement of the turbine back pressure, therefore, could be omitted during a NO_x compliance survey. However, the influence has been included in the survey code as well as in the following example due to the influence on the ISO correction on P_{max}.

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4.3 Survey cases

The different load points and cooling conditions lead to the following survey cases:

Load-point 'corrections'

Test-bed survey – All engines
Includes all four E3/E2-ISO cycle load points.

On board – Engine without VIT
The actual NOx compliance is estimated from performance data at 75% load only, assuming that the $NOx_{(test\ bed\ 75\%)}$ / $NOx_{(estimated\ 75\%)}$ ratio is identical for the ratio of the remaining load points, also.

On board – Engine with VIT
The actual NOx compliance assumes that the 25 to 75% load points contribute as without VIT, based on the 75% performance data. The 100% load point contribution is estimated from the actual performance at the measured load above the break point (from 85 to 100% loads), adjusting the $NOx_{(test\ bed\ 100\%)}$ for the same Pmax difference as the measured load, but for a Tscav and Pturb.back reflecting the 100% load:

1. $Pmax_{(100\%)} = Pmax_{(meas\ load\%)}$

2. $Tscav_{(100\%)} = Tscav_{(meas\ load\%)} + (100 - meas\ load\%) \times (Tscav.ref_{(100\%)} - Tscav.ref_{(75\%)}) / 25$

3. $Pturb.back_{(100\%)} = Pt.back_{(meas\ load\%)} + (100 - meas\ load\%) \times (Ptback.ref_{(100\%)} - Ptback.ref_{(75\%)}) / 25$

(If the VIT break point can not be reached, TF case B.2.2.1.3 is handled identical to TF case B.2.2.1.2.)

Scavenging-air temperature corrections on board
The correction for cooling-water temperature depends on the actual cooling system. In all cases, TF Table 1.3 specifies the actual reference scavenging-air temperature.

Sea-water cooling system (SW)
4. Relative scavenging-air temperature change
= (Tmeas.scav.air – Tref.scav. air) – (Tmeas.sea-water inlet – Tref.sea-water inlet)

Central cooling system – Optimal cooling (CC-O)
5. Relative scavenging-air temperature change
= (Tmeas.scav.air – Tref.scav. air) – (Tmeas.sea-water inlet – Tref.sea-water inlet)

Central cooling system – Fixed cooler out temperature (CC-F)
6. Relative scavenging-air temperature change = Tmeas.scav.air – Tref.scav. air

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Test-bed cooling system

The scavenging-air temperature is on test bed always adjusted similar to a CC-F cooling system with the appropriate Tscav.ref., since the actual cooling system is not available and different cooling-water adjustment possibilities usually exists on a test bed. (The actual air-cooler performance can be evaluated based on a heat balance for the system.)

All assumptions have been built into the MAN Diesel survey code.

4.4 Correction to ISO ambient conditions

Performance parameters correction to ISO ambient conditions

Some of the measured performance parameters need to be corrected to ISO ambient conditions in order to perform a reliable evaluation and compare with reference conditions. These parameters are Pmax, Pcomp and Pscav.

Correction equations:

7. $CorrP\ \max = P\ \max,m \cdot (100 - 0.2198 \cdot D Tinl + 0.081 \cdot D Tsc + 0.022 \cdot D Pamb - 0.005278 \cdot D Pback) /100$

8. $CorrPcomp = Pcomp,m \cdot (100 - 0.2954 \cdot D Tinl + 0.153 \cdot D Tsc + 0.0301 \cdot D Pamb - 0.007021 \cdot D Pback) /100$

9. $CorrPsc = Psc,m \cdot (100 - 0.2856 \cdot D Tinl + 0.222 \cdot D Tsc + 0.0293 \cdot D Pamb - 0.006788 \cdot D Pback) /100$

where: D refers to (reference – measured)

subscript m	measured
Tinl	T/C inlet temperature (deg.C)
Tsc	scavenging-air temperature (deg.C)
Pamb	ambient pressure (mmHg)
Pmax	maximum pressure (bar)
Pcomp	compression pressure (bar)
Psc	scavenging-air pressure (bar)
Pback	back pressure (mmWC)

NO_x emission correction to ISO ambient conditions

Based on simultaneous measurements of NO_x emission and performance parameters from several different MAN Diesel two-stroke engines, a special 'NO_x function' has been formulated to calculate NO_x as a function of specific engine parameters. Together with the MAN Diesel cycle simulation to predict dependent engine parameters (or simplified in the form of performance correction factors,) the 'NO_x function' can be used to calculate the tolerances on the most common performance parameters.

The measured data have also been used to formulate an equation to correct emissions at the given ambient conditions to the specified ISO ambient conditions in order to compare emission values at the same conditions (see Equation (10).)

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10. $$CorrNO_x(H_a, T_{amb}, p_{amb}) = \frac{1}{1 + C1 \cdot (H_a - 10.71) + C2 \cdot (T_{amb} - 298.15) + C3 \cdot (p_{amb} - 1000)}$$

where: H_a water content in scavenging air (gH_2O/kg dry air)
T_{amb} ambient-air temperature (K)
p_{amb} ambient pressure (mbar)
C1 to C3 coefficients depend on engine load (given in Table 4.4.1)

Table 4.4.1: ISO ambient correction coefficients

Engine load - %	C1	C2	C3
100	-0.00994	0.00144	-0.00007
75, 50 and 25	-0.00505	0.00145	-0.00011

H_a can be calculated the following way:

11. $$H^*_a = \frac{6.220 \cdot R_a \cdot p_a}{p_b - p_a \cdot R_a \cdot 10^{-2}}$$

12. $$H_{sc} = \frac{6.220 \cdot p_{sc} \cdot 100}{p_c - p_{ac}}$$

13. If $H^*_a \geq H_{sc}$ then $H_a = H_{sc}$ else $H_a = H^*_a$

where: H^*_a water content at ambient-air condition (gH_2O/kg dry air)
R_a relative humidity of intake air (rel. %)
p_a saturation vapour pressure at ambient-air condition (kPa)
p_b total barometric pressure (kPa)
H_{sc} water content at scavenging-air condition (gH2O/kg dry air)
p_c scavenging-air pressure (kPa)
p_{sc} saturation vapour pressure at scavenging-air condition (kPa)

The saturation vapour pressure is only a function of temperature and can be calculated the following ~~way:~~

14. $$p = 1.013 \cdot e^{19.008 - \frac{5325.35}{T}}$$

where T is the temperature in Kelvin (K).

The ISO corrected NO_x value is calculated using the equation for the average weighed NO_x emission ($IMONO_x$) given in the 'IMO-NO_x Technical Code:'

15. $$IMONO_x = \frac{\sum_{i=1}^{i=n} \text{Specific_emission(i)} \cdot \text{Power(i)} \cdot \text{WF(i)}}{\sum_{i=1}^{i=n} \text{Power(i)} \cdot \text{WF(i)}}$$

where n=4 represents the 4 load points of the E3/E2 cycle (please refer to the 'IMO-NOx Technical Code' for definition of E3/E2.) Using the weight factor (WF), the power (in kW) and the specific NOx emission (in g/kWh) for the 4 load points, the equation can also be written as Equation (16). However, for Equation (16) to be valid, the load points of the E3/E2 cycle must correspond exactly to 100, 75, 50 and 25% of MCR.

16. $$IMONO_x = 0.2909 \cdot NO_x(100\%) + 0.5455 \cdot NO_x(75\%) + 0.1091 \cdot NO_x(50\%) + 0.0545 \cdot NO_x(25\%)$$

4.5 Correction to reference performance conditions

The NOx function has also been used to derive a simplified method to calculate the variation in the ISO corrected NOx value as function of maximum cylinder pressure, scavenging-air temperature and turbine back pressure. The relative changes are shown in Table 4.5.1 at the four specific cycle-load conditions. *However, the simplified method will predict a slightly higher NOx emission than the NOx function.*

Table 4.5.1: Relative changes in NOx for Pmax, Tscav and Pturb.back

Power (%)	DNOx, Pmax [1] (gNOx/kWh pr. bar)	DNOx, Tscav [2] (gNOx/kWh pr. deg.C)	DNOx, Pturb.back [3] (gNOx/kWh pr. mmWC)
100	0.1816	0.0224	0.0004
75	0.1760	0.0209	0.0006
50	0.1760	0.0209	0.0006
25	0.1760	0.0209	0.0006

1. Relative increase in NOx value (corrected to ISO ambient conditions) resulting from a one bar increase in the cylinder maximum pressure.

2. Relative increase in NOx value (corrected to ISO ambient conditions) resulting from a one degree increase in the scavenging-air temperature.

3. Relative increase in NOx value (corrected to ISO ambient conditions) resulting from a one mmWC increase in the turbine back pressure.

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5. MAN Diesel Survey Procedures

MAN Diesel has defined a combination of performance parameter checks and, component and setting verification as the *on-board survey method*. TF Fig. 1 shows a flow chart of the on-board survey procedures only, whereas TF Fig. B.1 also shows the applications for test-bed and sea-trial surveys.

On board, the 'on-board survey' method checks with a minimum of component and adjustment verifications in order not to stop and dismantle the engine. The more extended component and setting adjustment verification can be used, when the engine is apart. Since a performance check can not be performed in dock, the 'missing' setting values are based on recorded data obtained within (a recommended) one-month period from a called (or anticipated) survey. *However, it is strongly recommended to perform a performance check to verify the setting values soonest possible after the docking to ensure continuing compliance.*

The parameter check method defined through the survey code accounts the influence of certain parameters, only. Through the cylinder pressure: adjustments of injection timing, VIT, compression shims and exhaust-valve timing, through the scavenging-air temperature: a deteriorated scavenging-air cooler performance, and through the back pressure: eventually blocking up of the exhaust heat exchanger.

5.1 On-board survey code

The on-board survey (parameter check) can be performed using the manufacturer supplied survey code as an easy tool to calculate and present the expected NOx emission. If a computer is not available, a manual evaluation can be performed following TF Section B.3.2. The procedure is based on a 'standard MAN Diesel performance check' (see necessary parameters in Table 4.2.1 and the comments in TF Chapter 1.4.)

Two versions of the code exist. The 'on-board' version is used as the standard survey method on board. And, the 'test-bed' version, a more detailed version, is used to show compliance on test bed for member engines. As described in TF Chapter B.2, the on-board version differs slightly for a sea-water and a central cooling-water system and, for an engine without VIT or with VIT.

To perform the survey, the following steps are to be taken (see TF flow Chart Fig. 1 or Fig. B.1,) independent of the survey-code version:

a. Inspect 'Technical File' (TF) and 'record book' (or pre-TF on test bed.)
b. Perform a 'performance check' (the extend follows the survey-code requirement) (for a load estimate see TF Section B.2.1.3.)
c. Estimate NOx for verifying compliance using the dedicated 'survey code.'
d. Check fuel nozzle (a spare fuel nozzle may suffice.)
e. Check other NOx components on test bed or in dock (or if considered necessary.)
f. Check setting adjustments on test bed or in dock (or if considered necessary.)
g. Add output from the survey code to the 'record book.'

The Tables in Enclosure 1 show input and output from the survey code based on the parent engine test-bed data, as an example. The actual estimated NOx

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will be compared in the plot with the measured (and corrected) parent engine data.

5.2 Manual procedure

All the steps in TF Section B.3.1 are followed except for execution of the survey code (B.3.1.c.)

To evaluate manually the NOx compliance, the following two steps have to be performed:

a. Evaluate the performance influence on the ISO corrected NOx values for each load condition (as specified in TF Chapter B.2 or in the following example in TF Section B.3.4 based on the parent engine data.) Performance data are corrected manually using Equations (7) to (9) in TF B.2.3.1 (or from Charts in the instruction book specified in foot notes **) to TF Chapter 1.4 Comments.)

b. Calculate the final average IMO NOx (Equations (15) or (16).)

5.3 Comments on component checks

The actual NOx components are specified in TF Chapter 1.1 (or in Enclosure 1, the last output page from the survey code,) and Appendix A specifies the necessary verification procedures. The extend of the component verification is discussed above.

Turbocharger, air cooler and auxiliary blower are verified through their nameplates *(also included in Appendix A)*. To verify the turbochargers internal parts (marked by the turbocharger manufacturer) dismantling is necessary *(procedures are not included).*

To verify the setting values, a performance check has to be performed using the on-board survey code (as described in the previous Section B.3.1 of TF.) When the specified performance data (see TF Table 1.3) corrected to ISO ambient conditions are within the given tolerances, the setting adjustments are within compliance.

For spare part changes (only components as listed in TF Table 1.1 are allowed) a review of the record book would normally be sufficient. Although a standard performance check will reveal changes to many NOx components, a new combustion chamber or a new fuel nozzle may not be discovered. *(The fuel nozzle is the most important component to affect the NOx emission from an engine).* Therefore, a review of the record book is necessary as a starting point for the survey, and a fuel nozzle should be inspected.

5.4 Survey example

Details of the NOx estimate to verify compliance for a testbed survey using a testbed cooling-water system are described in this Chapter as an example. The earlier Chapters describe modifications necessary for the slightly different survey cases.

The NOx emission can be estimated at each load conditions using the following calculation method:

1. Measure the maximum pressure, scavenging-air temperature, turbine back pressure and ambient conditions (see example in Table 5.4.1) at the required load points.

2. Correct maximum pressure to ISO conditions using Equation (7).

3. Derive the equivalent relative change in NOx emission (g/kWh) using Table 4.5.1 based on the actual performance in step 1 and reference conditions in TF Table 1.3.

Table 5.4.1: Calculation of expected NOx 'at site' performance and ISO ambient condition – test bed cooling-water system *(example only – identical to the results in Enclosure 1)*

Power (%)	Measured max. pressure (bar-abs)	Relative change in NOx (g/kWh)	Meas. 'seawater' temp. (deg.C)	Meas. scav. air temp. (deg.C)	Relative change in NOx (g/kWh)	Meas. turbback pressure (mmWC)	Relative change in NOx (g/kWh)	Expected site ISO-NOx (g/kWh)
100	148.8	-0.400	29	41	0.090	230	-0.028	13.83
75	130.7	-0.232	27	33	0.021	121	-0.035	14.70
50	99.3	-0.300	26	29	0.021	63	-0.014	12.32
25	70.8	-0.215	25	32	-0.021	19	-0.003	12.56
E3 cycle value								14.07

Example of calculation for 100% engine load and test bed cooling (the approach is similar for the other load conditions:)

Measured scavenging-air temperature	(Table 5.4.1)	41	deg.C
Reference scavenging-air temperature	(TF Table 1.3)	37	deg.C
Measured 'sea-water' inlet temperature	(Table 5.4.1)	29	deg.C
'Sea-water' reference temperature	(TF Table 1.3)	25	deg.C
Relative scavenging-air temperature change= Tmeas.scav.air – Tref.scav. air *)	= 41 – 37 =	4	deg.C
Delta NOx, Tscav	(Table 4.5.1)	0.0224	g/kWh pr. deg.C
Relative change in NOx due to Tscav difference	4 x 0.0224 =	0.090	g/kWh
Measured maximum pressure	(Table 5.4.1)	148.8	barabs
Reference maximum pressure	(TF Table 1.3)	151	barabs
Difference (measured – reference)		-2.2	barabs
Delta NOx, Pmax	(Table 4.5.1)	0.1816	g/kWh pr. barabs

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Relative change in NOx due to Pmax difference	*-2.2 x 0.1816 =*	*-0.400*	g/kWh
Measured turbine back pressure	(Table 5.4.1)	230	mmWC
Reference turbine back pressure	(TF Table 1.3)	300	mmWC
Difference (measured – reference)	*230 – 300 =*	*-70*	mmWC
Delta NOx, Pturb.back	(Table 4.5.1)	0.0004	g/kWh pr. mmWC
Relative change in NOx due to Pturb.back difference	*-70 x 0.0004 =*	*-0.0280*	g/kWh
Measured NOx, corr. ISO ambient and ref. performance	(TF Table 4.2.2)	14.17	g/kWh
NOx value, at ISO ambient and reference site conditions	*14.17 + 0.090 – 0.400 – 0.028 =*	*13.83*	g/kWh

**) Remember to change to the actual cooling-water system for on-board surveys*

4. Estimate the expected NOx emission at measured site performance but ISO ambient conditions for each load condition as a summation of the ISO corrected NOx value and the relative changes (see last column in Table 5.4.1) using Equation (16) to verify compliance.

IMO NOx = (0.2909 x *13.83)* **+ (0.5455 x** *14.70)* **+**
(0.1091 x *12.32)* **+ (0.0545 x** *12.56)* **= 14.07 g/kWh**

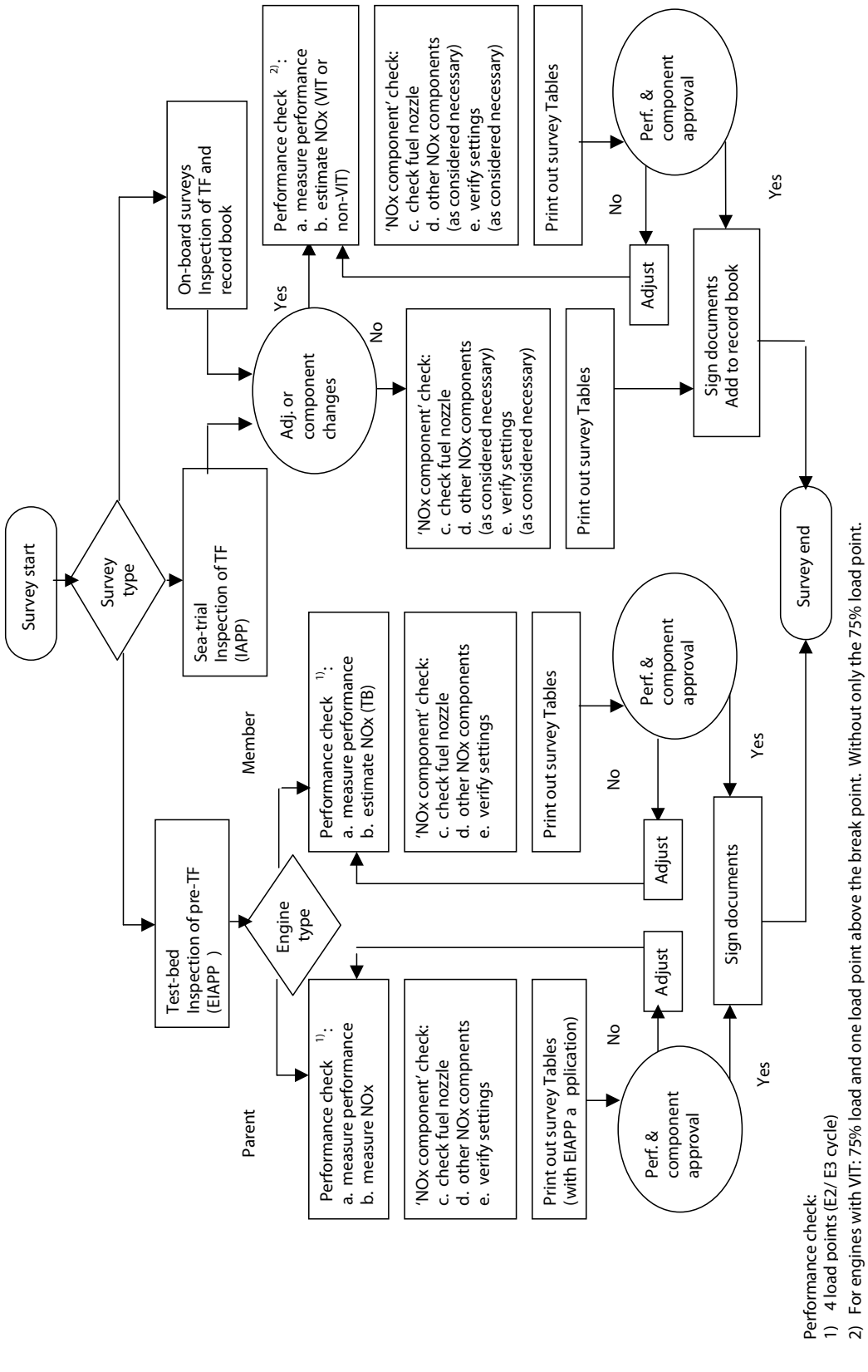
This method is used to check NOx compliance for varying measured values of maximum pressure, scavenging-air temperature and turbine back pressure. Since the maximum IMO-NOx value for this engine group is *15.1 g/kWh*, the engine fulfils the requirements. This is of course equivalent to the performance parameters being within the specified tolerances.

It should be emphasized that the survey code, unlike this example, uses Equation (15) (i.e. the measured load-point powers) to calculate the simulated NOx emission. And, the survey code will issue a warning, if the performance parameters are outside the allowed ranges, or the load point is more than ±5% off the ideal E3/E2 cycle value.

Performance check:
1) 4 load points (E2/E3 cycle)
2) For engines with VIT: 75% load and one load point above the break point. Without only the 75% load point.

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5.5 Flow Chart for Survey Methods



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1 Symbols and Units

The following designations are used:

Parameter	Symbol	Unit
Effective engine power	P_e	kW
Engine speed	speed	r/min
Indicated engine power	P_i	ikW
Fuel pump index	Index	%
Specific fuel oil consumption	SFOC	g/kWh
Fuel oil lower calorific value	LCV	kJ/kg
Turbocharger speed	T/C speed	r/min
Barometric pressure	p_{baro}	mbar
Pressure drop across T/C air filters	Δp_f	mbar
Pressure drop across air cooler	Δp_c	mbar
Scavenge air pressure	p_{scav}	bar
Mean indicated pressure	p_i	bar
Mean effective pressure	p_e	bar
Compression pressure	p_{comp}	bar
Maximum combustion pressure	p_{max}	bar
Exhaust receiver pressure	p_{exhrec}	bar
Pressure after turbine	p_{atc}	mbar
Air temperature before T/C filters	t_{ini}	°C
Air temperature before cooler	t_{bcoo}	°C
Cooling water inlet temp., air cooler	$t_{coolinl}$	°C
Cooling water outlet temp., air cooler	$t_{coolout}$	°C
Scavenge air temperature	t_{scav}	°C
Temperature after exhaust valve	t_{exhv}	°C
Temperature before turbine	t_{btc}	°C
Temperature after turbine	t_{atc}	°C

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1.1 Conversion factors

1 hp	= 0.736			[J/s]
1 bar = 10^5 Pa	= 1000 hPa	or	0.1 MPa / [N/m^2]	
1 mbar	= 0.001 bar	or	1.0	[hPa]
1 kg/cm^2	= 0.981 bar	or	980.7	[hPa]
1 kp/cm^2	= 0.981 bar	or	980.7	[hPa]
1 psi	= 0.070 bar	or	68.9	[hPa]
1mmHg	= 0.001 bar	or	1.3	[hPa]
1mWC	= 0.098 bar	or	98.1	[hPa]

π = 3.14159

NOTICE

Pressure stated in bar (or Pa) is the measured value, i.e. read from an ordinary pressure gauge.

Note: the official designation of bar (or Pa) is Absolute Pressure

2 Operating Range

2.1 Load Diagram

The specific ranges for continuous operation are given in the 'Load Diagrams':

- For propulsion alone
  See drawing 6355-0100.
- For propulsion and main engine driven generator
  See drawing 6355-0105.

Specific engine calculations (load diagrams) can be ordered by contacting MAN Diesel & Turbo.

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2.2 Definitions

The load diagram, in logarithmic scales *(see drawing 6355-0100 and/or drawing 6355-0105)* defines the power and speed limits for continuous as well as overload operation of an installed engine having a specified MCR (Maximum Continous Rating) point 'M' according to the ship's specification.

The service points of the installed engine incorporate the engine power required for ship propulsion, *see drawing 6355-0100*, and for main engine driven shaft generator, if installed, *see drawing 6355-0105.*

2.3 Limits for Continuous Operation

The continuous service range is limited by four lines:

Line 3: Represents the maximum speed which can be accepted for continuous operation.
Running at low load above 100% of the nominal speed of the engine is, however, to be avoided for extended periods.

Line 4: Represents the limit at which an ample air supply is available for combustion and gives a limitation on the maximum combination of torque and speed.

Line 5: Represents the maximum mean effective pressure (mep) level, which can be accepted for continuous operation.

Line 7: Represents the maximum power line for continuous operation.

2.4 Limits for Overload Operation

Many parameters influence the performance of the engine. Among these is: overloading. The overload service range is limited as follows:

Line 8: Represents the overload operation limitations.

The area between lines 4, 5, 7 and the heavy dotted line 8 is available as overload for limited periods only (1 hour per 12 hours).

2.5 Recommendations

Continuous operation without limitations is allowed only within the area limited by lines 4, 5, 7 and 3 of the load diagram.

The area between lines 4 and 1 is available for running conditions in shallow water, heavy weather and during acceleration, i.e. for non-steady operation without actual time limitation.

After some time in operation, the ship's hull and propeller will be fouled, resulting in heavier running of the propeller, i.e. loading the engine more. The propeller curve will move to the left from line 6 to line 2 and extra power is required for propulsion. The extent of heavy running of the propeller will indicate the need for cleaning the hull and possibly polishing the propeller.

NOTICE

Point A is a 100% speed and power reference point of the load diagram. Point M is normally equal to point A but may in special cases, for example sometimes when a shaft generator is installed, be placed to the right of point A on line 7.

2.6 Propeller Performance

Experience indicates that ships are – to a greater or lesser degree – sensitive to bad weather (especially with heavy waves, and with head winds and seas), sailing in shallow water with high speeds and during acceleration. It is advisable to notice the power/speed combination in the load diagram and to take precautions when approaching the limiting lines.

3 Performance Observations

3.1 General

During engine operation, several basic parameters need to be checked and evaluated at regular intervals.

The purpose is to follow alterations in:

- the combustion conditions,
- the general cylinder condition,
- the general engine condition

in order to discover any operational disturbances.

This enables the necessary precautions to be taken at an early stage, to prevent the further development of trouble.

This procedure will ensure optimum mechanical condition of the engine components, and optimum overall plant economy.

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3.2 Key Parameters

The key parameters in performance observations are:

- Barometric pressure
- Engine speed
- Ship's draught
- Mean indicated pressure
- Compression pressure
- Maximum combustion pressure
- Fuel pump index
- Exhaust gas pressures
- Exhaust gas temperatures
- Scavenge air pressure
- Scavenge air temperature
- Turbocharger speed
- Exhaust gas back pressure in exhaust pipe after turbocharger
- Air temperature before T/C fi lters
- Δp air filter (if pressure gauge installed)
- Δp air cooler
- Air and cooling water temperatures before and after scavenge air cooler.

3.3 Measuring Instruments

The measuring instruments for performance observations comprise:

- Thermometers,
- Pressure gauges,
- Tachometers,
- PMI – On/Off-line Cylinder pressure measurring equipment
- Eventually the engine diagnosis system CoCos-EDS or similar

It is important to check the measuring instruments for correct functioning.

Regarding check of thermometers and pressure gauges:
See description 6345-0330.

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3.4 Intervals between Checks

Constantly:	Temperature and pressure data should be constantly monitored, in order to protect the engine against overheating and failure. In general, automatic alarms and slow-down or shut-down equipment are installed for safety. Guiding values of permissible deviations from the normal service data are given in *description 7045-0100.*
Daily:	Fill-in the Performance Observation record. *See drawing 6355-0110.*
Every two weeks:	Take "Pressure Volume (P/V)" diagrams and fill in the complete Performance Observations record. *See drawing 6355-0110.*

3.5 Evaluation of Observations

Compare the observations to earlier observations and to the testbed / sea trial results.

From the trends, determine when cleaning, adjustment and overhaul should be carried out.

See description 7045-0100, regarding normal service values and alarm limits.

Not all parameters can be evaluated individually. This is because a change of one parameter can influence another parameter. For this reason, these parameters must be compared to the influencing parameters to ensure correct evaluations.

A simple method for evaluation of these parameters is presented in *description 6345-0310.*

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1 General

Record the performance observations as described in the previous *description 6345-0300..*

Use the synopsis diagrams to obtain the best and most simple method of plotting and evaluating the parameters:

Engine:	*See drawings: 6355-0120, 6355-0125 & 6355-0130*
Turbocharger:	*See drawings: 6355-0135 & 6355-0140*
Air cooler:	*See drawing: 6355-0145*

Drawings 6355-0120, 6355-0125 & 6355-0130 are sufficient to give a general impression of the overall engine condition.

The drawings comprise:

Model curve: shows the parameter as a function of the parameter on which it is most dependent (based on the testbed/commissioning test results).

Time based deviation curve: shows the deviation between the actual service observations and the model curve, as a function of time. The limits for max. recommended deviation is also shown. The limits are based on the MAN Diesel & Turbo CAPAsystem. (Computer Aided Performance Analysis).

From the deviation curves, it is possible to determine what engine components should be overhauled.

From the slope of the curves, it can be determined approximately when the overhaul should be carried out.

Blank sheets: Blank 'Time based deviation' sheets which can be copied. Use these sheets for plotting the deviation values for the specific engine.

The following Items describe the evaluation of each parameter in detail.

2 Engine Synopsis

A 6G70ME-C has been used in these examples.

2.1 Parameters related to the Mean Indicated Pressure (pi)

Drawing 6355-0120 and drawing 6355-0125 (engine synopsis diagrams) show model curves for engine parameters which are dependent upon the mean indicated pressure (p_i).

NOTICE

Drawing 6355-0120 also includes two charts for plotting the draught of the ship, and the average mean indicated pressure as a function of the engine running hours.

For calculation of the mean indicated pressure:
See description 6345-0340.

2.1.1 Mean Draught

The mean draught is depicted here because, for any particular engine speed, it will have an influence on the engine load.

2.1.2 Mean indicated Pressure (pi)

The average calculated value of the mean indicated pressure is depicted in order that an impression of the engine's load can be obtained.

Load balance: the mean indicated pressure for each cylinder should not deviate more than 0.5 bar from the average value for all cylinders.

NOTICE

The load balance must not be adjusted on the basis of the exhaust gas temperatures after each exhaust valve.

It is recommended to apply PMI-system for easy access to P-V-diagrams (work diagram), if the indicator drive is not installed.

2.1.3 Engine Speed (pi)

The model curve shows the relationship between the engine speed and the average mean indicated pressure (p_i).

The engine speed should be determined by counting the revolutions over a sufficiently long period of time.

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Deviations from the model curve show whether the propeller is light or heavy, i.e. whether the torque on the propeller is small or large for a specified speed. If this is compared with the draught (under the same weather conditions), *see remarks in description 6345-0300,* then it is possible to judge whether the alterations are owing to:

- changes in the draught,
- or an increase in the propulsion resistance, for instance due to fouling of the hull, shallow water, etc.

Valuable information is hereby obtained for determining a suitable docking schedule.

If the deviation from the model curve is large, (e.g. deviations from shop trial to sea trial), it is recommended to plot the results on the load diagram, *see description 6345-0300*, and from that judge the necessity of making alterations on the engine, or to the propeller.

2.1.4 Maximum Combustion Pressure (pmax - pi)

The model curve shows the relationship between the average p_{max} (corrected to ISO reference ambient conditions) and the average p_i.

NOTICE

For correction to reference conditions:
See description 6345-0350.

Deviations from the model curve are to be compared with deviations in the compression pressure and the fuel index *(see further on).*

Constant p_{max} in the upper load range is achieved by a combination of fuel injection timing and variation of the compression ratio (the latter by varying the timing of closing the exhaust valve).

If an individual p_{max} value deviates more than 3 bar from the average value, the reason should be found and the fault corrected.

The pressure rise p_{max} - p_{comp} must not exceed the specified limit, i.e. 40 bar.

2.1.5 Fuel Index (pi)

The model curve shows the relationship between the average index and the average p_i.

Deviations from the model curve give information on the condition of the fuel injection equipment.

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Worn fuel pumps, and leaking suction valves, will show up as an increased fuel index in relation to the mean pressure. Note, however, that the fuel index is also dependent on:

- The viscosity of the fuel oil, (i.e. the viscosity at the preheating temperature) Low viscosity will cause larger leakages in the fuel pump, and thereby necessitate higher indexes for injecting the same volume.
- The calorific value and the specific gravity of the fuel oil. These will determine the energy content per unit volume, and can therefore also influence the index.
- All parameters that affect the fuel oil consumption (ambient conditions, p_{max}, etc.)

Since there are many parameters that influence the index, and thereby also the p_{max}, it can be necessary to adjust the p_{max} from time to time.

It is recommended to overhaul (including change of plunger/barrell), the fuel pumps when the index has increased by about 10%.

In case the engine is operating with excessively worn fuel pumps, the starting performance of the engine will be seriously affected.

2.2 Parameters related to the Effective Engine Power (Pe)

Drawing 6355-0130 shows model curves for engine parameters which are dependent on the effective power (P_e).

Regarding the calculation of effective engine power:
See description 6345-0340.

It is recommended to apply PMI-system for easy access to P-V-diagrams (work diagrams) and thereby the effective engine power.

2.2.1 Exhaust Temperature (texhv - Pe)

The model curve shows the average exhaust temperatures (after the valves), corrected to reference conditions, and drawn up as a function of the effective engine power (P_e).

NOTICE

For correction to ISO reference ambient conditions:
See description 6345-0350.

Regarding maximum exhaust temperatures:
See description 6345-0350.

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The exhaust temperature is an important parameter, because the majority of faults in the air supply, combustion and gas systems manifest themselves as increases in the exhaust temperature level.

The most important parameters which influence the exhaust temperature are listed in the table on the next page, together with a method for direct diagnosing, where possible.

Increased Exhaust Temperature Level – Fault Diagnosing

Possible Causes	Diagnosing
a. Fuel injection equipment: ▪ Leaking or incorrectly working fuel valves (defective spindle and seat) ▪ Worn fuel pumps. If a high wear rate occurs, the cause for this must be found and remedied. Note: Inadequate cleaning of the fuel oil can cause defective fuel valves and worn fuel pumps.	As these faults occur in individual cylinders, compare: ▪ fuel indexes ▪ PMI readings *See description 6345-0340.* Check the fuel valves: ▪ visually ▪ by pressure testing
b. Cylinder condition: ▪ Blow-by, piston rings *See description 6645-0140, Running Difficulties', point 6.* ▪ Leaking exhaust valves *See description 6645-0140, Running Difficulties', point 5.*	These faults occur in individual cylinders. ▪ Compare the compression pressures with PMI. *See description 6345-0340.* ▪ During engine standstill: Carry out scavenge port inspection. Check the exhaust valves. *See description 2245-0100.*
c. Air coolers: ▪ Fouled air side ▪ Fouled water side	Check the cooling capability. *See description 6345-0310.*
d. Climatic conditions: ▪ Extreme conditions	Check cooling water and engine room temperatures. Correct t_{exhv} to reference conditions. *See description 6345-0350.*
e. Turbocharger: ▪ Fouling of turbine side ▪ Fouling of compressor side	Use the turbocharger synopsis methods for diagnosing. *See description 6345-0310.*
f. Fuel oil: ▪ Type ▪ Quality	Using heavy fuel oil will normally increase t_{exhv} by approx. 15°C, compared to the use of gas oil. Further increase of t_{exhv} will occur when using fuel oils with particularly poor combustion properties. In this case, a reduction of p_{max} can also occur.

2.2.2 Compression Pressure (Pcomp - Pe)

The model curve shows the relationship between the compression pressure p_{comp} (corrected to ISO reference ambient conditions) and the effective engine power P_e.

NOTICE

For correction to reference conditions:
see description 6345-0350.

Deviation from the model curve can be due to:

1. a scavenge air pressure reduction,
2. - mechanical defects in the engine components (blow-by past piston rings, defective exhaust valves, etc. – *see the table on the next page*)
   - excessive grinding of valve spindle and bottom piece.

It is therefore expedient and useful to distinguish between '1' and '2', and investigate how large a part of a possible compression reduction is due to '1' or '2'.

This distinguishing is based on the ratio between absolute compression pressure (p_{comp} + p_{baro}) and absolute scav. pressure (p_{scav} + p_{baro}) which, for a specific engine, is constant over the largest part of the load range (load diagram area).

Constant p_{max} in the upper load range is achieved by a combination of fuel injection timing and variation of the compression ratio (the latter by varying the timing of closing the exhaust valve).

The ratio is first calculated for the "new" engine, either from the testbed results, or from the model curve.

See the example below regarding:

- Calculating the ratio
- Determining the influence of mechanical defects.

It should be noted that, the measured compression pressure, for the individual cylinders, can deviate from the average, owing to the natural consequence of air/gas vibrations in the receivers. The deviations will, to some degree, be dependent on the load.

However, such deviations will be "typical" for the particular engine, and should not change during the normal operation.

When evaluating service data for individual cylinders, comparison must be made with the original compression pressure of the cylinder concerned, at the corresponding load.

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Example:

The following four values can be assumed read from the *model curves*:

The barometric pressure was:	1.00 bar
The scavenge pressure was:	2.25 bar
This gave an absolute scavenge pressure of:	3.25 bar
The average (or individual) compression pressure was:	115 bar
which gave an absolute compression pressure of 115 + 1.00 =	116 bar

$p_{comp\ abs}$ / $p_{scav\ abs}$ = 116 / 3.25 = 35.7 bar

This value is used as follows for evaluating the data read during service.

Service Values

p_{comp} : 101 bar (average or individual)

p_{scav} : 2.0 bar

p_{baro} : 1.02 bar

Calculated on the basis of p_{scav} and p_{baro}, the absolute compression pressure would be expected to be:

$p_{comp\ abs}$ = 35.7 × (2.0 + 1.02) = 107.8 bar

i.e. p_{comp} = 107.8 – 1.02 = 106.8 bar

The difference between the expected 106.8 bar and the measured 101 bar could be owing to *mechanical defects or grinding of exhaust valve spindle and bottom piece*.

Concerning the pressure rise p_{comp}-p_{max}, *see Item 2.1.4, 'Maximum Combustion Pressure* (p_{max} – p_i)'.

Mechanical Defects which can influence the Compression Pressure

Possible Causes	Diagnosis / Remedy
a. Piston rings: ▪ Leaking	Diagnosis: *See Table Increased Exhaust Temperature Level – Fault Diagnosing* Remedy: *See description 6645-0140.*
b. Piston crown: ▪ Burnt	Check the piston crown by means of the template. *See work card 2265-0401.*
c. Cylinder liner ▪ Worn	Check the liner by means of the measuring tool. *See work card 2265-0601.*

Possible Causes	Diagnosis / Remedy
d. Exhaust valve: ▪ Leaking ▪ The exhaust temperature rises ▪ A hissing sound can possibly be heard at reduced load ▪ Timing.	Remedy: *See description 6645-0140.* Check: ▪ Cam lead (ME-B Only) ▪ Hydraulic oil leakages, e.g. misalignment of high pressure pipe between exhaust valve actuator and hydraulic cylinder ▪ Damper arrangement for exhaust valve closing.
e. Piston rod stuffing box: ▪ Leaking ▪ Air is emitted from the check funnel from the stuffing box.	Small leakages may occur due to erosion of the bronze segments of the stuffing box, but this is normally considered a cosmetic phenomenon. Remedy: Stuffing box overhaul. *See work card 2265-0501.*

3 Turbocharger Synopsis

See Drawings 6355-0135 and 6355-0140 (Turbocharger synopsis diagrams)

NOTICE

Drawing 6355-0135 and 6355-0140 should be filled out in a number of copies which corresponds to the number of turbochargers.

Regarding cleaning of the turbochargers.
See description 6345-0320.

3.1

3.1.1 Scavenge Air Pressure (pscav – Pe)

The model curve shows the scavenge air pressure (corrected to reference conditions) as a function of the effective engine power (P_e).

See description 6345-0340 and 6345-0370 regarding the effective engine power.

NOTICE

For correction to ISO reference ambient conditions.
See description 6345-0350.

Deviations in the scavenge air pressure are, like the exhaust temperature, an important parameter for an overall estimation of the engine condition. A drop in the scavenge air pressure, for a given load, will cause an increase in the thermal loading of the combustion chamber components.

A simple diagnosis, made only from changes in scavenge air pressure, is difficult.

Fouled air filter, air coolers and turbochargers can greatly influence the scavenge air pressure.

Changes in the scavenge air pressure should thus be seen as a “consequential effect” which is closely connected with changes in:

- the air cooler condition
- the turbocharger condition
- the timing.

Reference is therefore made to the various sections covering these topics.

3.1.2 Turbocharger Speed (T/C speed – pscav)

The model curve shows the speed of the turbocharger as a function of the scavenge air pressure (p_{scav}).

Corroded nozzle ring or turbine blades will reduce the turbine speed. The same thing will happen in case of a too large clearance between the turbine blades and the shroud ring (MAN Diesel & Turbo) / cover ring ABB).

Deviation from the model curve, in the form of too high speed, can normally be attributed to a fouled air filter, scavenge air cooler, turbine side or compressor side.

A more thorough diagnosing of the turbocharger condition can be made as outlined in the ‘turbocharger efficiency’ section below.

3.1.3 Pressure Drop across Turbocharger Air Filter (Δpf – pscav)

The model curve shows the pressure drop across the air filter as a function of the scavenge air pressure (p_{scav}).

Deviations from this curve give direct information about the cleanliness of the air filter.

Like the air cooler, the filter condition is decisive for the scavenge air pressure and exhaust temperature levels.

The filter elements must be cleaned when the pressure drop is 50% higher than the testbed value.

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If a manometer is not standard, the cleaning interval is determined by visual inspection.

3.1.4 Turbocharger Efficiency (ηT/C)

The model curves show the compressor and turbine efficiencies as a function of the scavenge air pressure (p_{scav}).

In order to determine the condition of the turbocharger, the calculated efficiency values are compared with the model curves, and the deviations plotted.

Calculation of the efficiency is explained in *description 6345-0360.*

As the efficiencies have a great influence on the exhaust temperature, the condition of the turbocharger should be checked if the exhaust temperature tends to increase up to the prescribed limit.

Efficiency reductions can normally be related to “flow deterioration”, which can be counteracted by regular cleaning of the turbine side (and possibly compressor side).

4 Air Cooler Synopsis

The Drawing 6355-0145 (Air cooler synopsis diagrams)
The plate gives model curves for air cooler parameters, which are dependent on the scavenge air pressure (p_{scav}). Regarding cleaning of air coolers.
See description 6345-0320.

4.1

4.1.1 Temperature Difference between Air Outlet and Water Inlet (Δ t(air-water) – pscav)

The model curve shows the temperature difference between the air outlet and the cooling water inlet, as a function of the scavenge air pressure (p_{scav}).

This difference in temperature is a direct measure of the cooling ability, and as such an important parameter for the thermal load on the engine. The evaluation of this parameter is further discussed in Item 4.1, ‘Evaluation’.

4.1.2 Cooling Water Temperature Difference (Δ twater – pscav)

The model curve shows the cooling water temperature increase across the air cooler, as a function of the scavenge air pressure (p_{scav}).

This parameter is evaluated as indicated in Item 4.1.

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4.1.3 Pressure Drop across Air Cooler (Δpair – pscav)

The model curve shows the scavenge air pressure drop across the air cooler, as a function of the scavenge air pressure (p_{scav}).

This parameter is evaluated as indicated in Item 4.1, 'Evaluation'.

4.2 Evaluation

Generally, for the above three parameters, *changes of approx. 50% of the testbed value can be considered as a maximum.* However, the effect of the altered temperatures should be kept under observation in accordance with the remarks under Exhaust Temperature. *(Point 2.2 earlier in this Section).*

In the case of pressure drop across air cooler, for purposes of simplification, the mentioned "50% margin" includes deviations caused by alterations of the suction temperature, scavenge air temperature, and efficiency of the turbochargers.

Of the three parameters, *the temperature difference between air outlet and water inlet,* is to be regarded as the most essential one.

Deviations from the model curves, which are expressions of deteriorated cooling capability, can be due to:

1. Fouling of the air side
2. Fouling of the water side

1. Fouling of the air side: manifests itself as *an increased pressure drop across the air side.*

   Note however, that the heat transmission can also be influenced by an "oily film" on tubes and fins, and this will only give a minor increase in the pressure drop.

   Before cleaning the air side, it is recommended that the U-tube manometer is checked for tightness, and that the cooler is visually inspected for deposits.

   Make sure that the drainage system from the water mist catcher functions properly, as a high level of condensed water (condensate) – up to the lower measuring pipe – might greatly influence the Δp measuring.
   See descripton 6345-0320.

2. **Fouling of the water side:** Normally involves *a reduction of the cooling water temperature difference,* because the heat transmission (cooling ability) is reduced.

   Note however that, if the deposits reduce the cross sectional area of the tubes, so that the water quantity is reduced, the cooling water temperature difference may not be affected, whereby diagnosis is difficult (i.e. lower heat transmission, but also lower flow volume).

   Furthermore, a similar situation will arise if such tube deposits are present simultaneously with a fault in the salt water system, (corroded water pump, erroneous operation of valves, etc.). Here again the reduced water quantity will result in the temperature difference remaining approximately unaltered.

   In cases where it is suspected that the air cooler water side is obstructed, the resistance across the cooler can be checked by means of a differential pressure gauge.



A mercury manometer pressure gauge should not be used, because of environmental considerations.

Before dismantling the air cooler, for piercing of the tubes, it is recommended that the remaining raw water system is examined, and the cooling ability of the other heat exchangers checked.



Be careful when piercing, because the pipes are thin-walled.

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5 Specific Fuel Oil Consumption

Calculation of the specific fuel oil consumption (g/kWh) requires that engine power, and the consumed fuel oil amount (kg), are known for a certain period of time. *See drawing 6355-0150.*

The method of determining the engine power is illustrated in *description 6345-0340.*

The oil amount is measured as described below.

To achieve a reasonable measuring accuracy, it is recommended to measure over a suitably long period – dependent upon the method employed i.e.:

- If a day tank is used, the time for the consumption of the whole tank contents will be suitable.
- If a flow-meter is used, a minimum of 1 hour is recommended.

The measurements should always be made under constant load conditions.

Since both of the above-mentioned quantity measurements will be in volume units, it will be necessary to know the oil density, in order to convert to weight units. *The density is to correspond to the temperature at the measuring point* (i.e. in the day tank or flow-meter).

The specific gravity, (and thus density) can be determined by means of a hydrometer immersed in a sample taken at the measuring point, but the density can also be calculated on the basis of fuel specifications.

Normally, in fuel specifications, the specific gravity is indicated at 15°C/60°F.

The actual density (g/cm3) at the measuring point is determined by using the curve on *drawing 6355-0150,* where the change in density is shown as a function of temperature.

The consumed oil quantity in kg is obtained by multiplying the measured volume (in litres) by the density (in kg/litre).

In order to be able to compare consumption measurements carried out for various types of fuel oil, allowance must be made for the differences in the lower calorific value (LCV) of the fuel concerned.

Normally, on the testbed, gas oil will have been used, having a lower calorific value of approx. 42,707 kJ/kg. If no other instructions have been given by the ship owner, it is recommended to convert to this value.

Usually, the lower calorific value of a fuel oil is not specified by the oil companies. However, by means of the graph, *drawing 6355-0150,* the LCV can be determined with sufficient accuracy, on the basis of the sulphur content, and the specific gravity at 15°C.

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The corrected consumption can then be determined by multiplying the "measured consumption", by:

$$\frac{LCV}{42{,}707}$$ LCV = The specific lower calorific value, in kJ/kg, of the fuel oil concerned.

Example: (6G70ME-C9.2)

Effective engine power, P_e :	21,840 kW
Consumption of fuel oil, C_o :	13.145 m^3 over 3 hours
Measuring point temperature :	119°C
Fuel data: (Specific gravity at 15°C, 3% sulphur)	0.9364 g/cm^3
Density at 119°C: (ρ_{119} = 0.9364 -0.068) *(See drawing 6355-0150)*	0.8684 g/cm^3

$$\text{Specific consumption} = \frac{C_o \times p_{119} \times 10^6}{h \times P_e} \text{ [g/kWh]}$$

where:

C_o	= Fuel oil consumption over the period, m^3
ρ_{119}	= Corrected gravity, g/cm^3
h	= Measuring period, hours
P_e	= Brake power, kW

$$\text{Specific consumption} = \frac{13.145 \times 0.8684 \times 10^6}{3 \times 21{,}840} \text{ [g/kWh]}$$

Correction to ISO reference conditions regarding the *specific lower calorific value:*

LCV = 40,700 kJ/kg, derived from *drawing 6355-0150.*
Consumption corrected for calorific value:

$$\frac{174.2 \times 40{,}700}{42{,}707} = 166.0 \text{ [g/kWh]}$$

NOTICE

The ambient conditions (blower inlet temperature and pressure and scavenge air coolant temperature) will also influence the fuel consumption. Correction for ambient conditions is not considered important when comparing service measurements.

1 Turbocharger

1.1 General

We recommend to clean the turbochargers regularly during operation.

This prevents the build-up of heavy deposits on the rotating parts and keeps the turbochargers in the best running condition between manual overhauls.

The intervals between cleaning during operation should be determined from the degree of fouling of the turbocharger in the specific plant.

This is because the tendency to form deposits depends, among other things, on the combustion properties of the actual fuel oil.

Guiding intervals between cleaning are given for each cleaning method in the following items.

NOTICE

If the cleaning is not carried out at regular intervals, the deposits may not be removed uniformly. This will cause the rotor to be unbalanced, and excite vibrations.

If	Then
Vibrations occur after cleaning	Clean again
Vibrations occur after repeated cleaning	*See description 6645-0320* Clean the turbochargers manually at the first opportunity.

Manual overhauls are still necessary to remove deposits which the cleaning during operation does not remove, in particular on the non-rotating parts.

Regarding intervals between the manual overhauls, see the maker's instructions.

1.2 Cleaning the Turbine Side

1.2.1 Dry Cleaning

Intervals between cleaning: 24-50 hours of operation.
See drawing 5455-0110.

The cleaning is effected by injecting a specified volume of crushed nut shells or similar. The "grain size" is to be about 1.5 mm.

Since the cleaning is mechanical, the highest efficiency is obtained at full load, and cleaning should not be carried out below half load.

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Carry out the cleaning according to the instruction given on the “instruction plate” located at the turbocharger.
See drawing 5455-0110 and work card 5465-0701.

1.2.2 Water Cleaning (Not TCA, TCR and MET-Turbochargers)

Intervals between cleaning: Approx. every 50 to 500 operating hours.
See drawing 5455-0115.

The cleaning is effected by injecting atomised water through the gas inlet, at reduced engine load.

Carry out the cleaning according to the instruction given on the “instruction plate” located at the turbocharger.
See drawing 5455-0115.

Be aware that water cleaning can cause corrosion on the shroud ring surrounding the T/C turbine blading.

Note that, during normal running, some of the scavenge air is led through a three-way cock, from pipe No. 2 to pipe No. 1, at the turbine outlet drainage hole, whereby this pipe is kept clean.

1.3 Cleaning the Compressor Side

Guiding intervals between cleaning: 25-75 hours of operation.

NOTICE

Always refer to the maker’s special instruction.

The cleaning is effected by injecting water through a special pipe arrangement during running at high load and normal temperatures.

Regarding the cleaning procedure, see the maker’s special instructions.

NOTICE

If the deposits are heavy and hard, the compressor must be dismantled and cleaned manually.

If the in-service cleaning is carried out when the compressor side is too contaminated, the loosened deposits can be trapped in the narrow passages of the air cooler element. This reduces the air cooler effectiveness.

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Regarding air cooler cleaning, see Item 2., 'Air Cooler Cleaning System', below.

We recommend to wrap a thin foam filter gauze around the turbocharger intake filter, and fasten it by straps. This greatly reduces fouling of the compressor side, and even makes inservice cleaning unnecessary.

Replace and discard the filter gauze, when it becomes dirty.

2 Air Cooler Cleaning System

See drawing 5455-0120, and description 7045-0100 regarding the basis for intervals between cleaning.

NOTICE

Carry out the cleaning only when the engine is at standstill.

This is because the water mist catcher is not able to retain the cleaning fluid. Thus there would be a risk of fluid being blown into the cylinders, causing excessive liner wear.

Cleaning of the air side of the scavenge air cooler is effected by injecting a chemical fluid through 'AK' to a spray pipe arrangement fitted to the air chamber above the air cooler element.

The polluted chemical cleaning agent returns from 'AM', through a filter to the chemical cleaning tank.

The procedure is described in *work card 5465-0101.*

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3 Drain System for Water Mist Catcher

3.1 Condensation of Water

A combination of high air humidity and cold cooling water will cause an amount of condensed water to be separated from the scavenge air in the water mist catcher.

Estimation of condensate from the water mist catcher drain

The amount of condensate from the water mist catcher(s) can be estimated based on the below listed measurements and figure 1 and 2.

- Engine load (kW)
- Ambient air temperature (°C)
- Relative humidity of ambient air (%)
- Scavenge air pressure (Bar abs)
- Scavenge air temperature (°C)

Figures of water vapour in ambient and scavenge air can be seen in full figur on *drawing 2255-0135.*

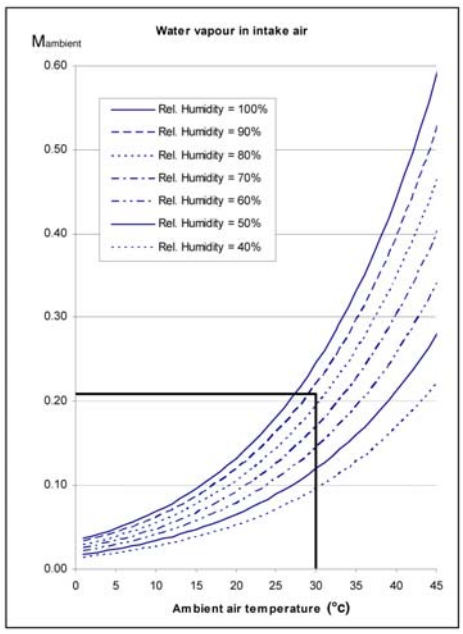


Figure 1

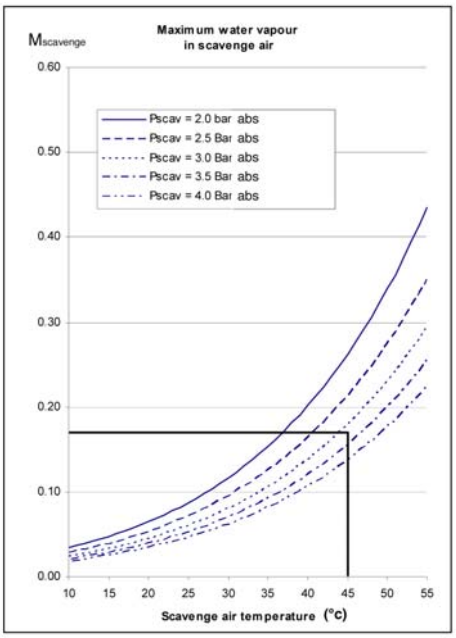


Figure 2

Calculation procedure

1. The amount of water vapour in the intake air ($M_{ambient}$) is found in *figure 1* based on measurements of ambient air temperature and relative humidity.
2. The maximum amount of water vapour in the scavenge air ($M_{scavenge}$) is found in *figure 2* based on measurements of scavenge air pressure and temperature.
3. The expected amount of condensate is calculated by:

   $M_{Condens}$ = k × Engine load × ($M_{ambient}$ - $M_{scavenge}$)* [kg/h]

   where,

   k = 1.05 for K80-K98 type engines
   k = 1.00 for S50-S90 and L50-L70 type engines
   k = 0.90 for S26-S46 and L35-L42 type engines

   *) The tolerance of the result is ± 10%
   No water condensation occurs, if the result is negative.

The sea water temperature may alternatively be used in *figure 1* instead of the ambient air temperature and relative humidity. The 100% relative humidity curve applies, if the sea water temperature is used.

Example of estimation of condensate amount:

Readings:	
Engine type:	7K80MC-C
Engine load:	22,700 kW
Ambient air temperature:	30 °C
Relative humidity:	85 %
Scavenge air pressure:	3.25 Bar abs
Scavenge air temperature:	45 °C

Calculation procedure:

1) $M_{ambient}$ = 0.21 kg/kWh found from *figure 1* (as outlined)

2) $M_{scavenge}$ = 0.17 kg/kWh found from *figure 2* (as outlined)

3a) k = 1.05 for K80 type engine

3b) $M_{condens}$ = 1.05 x 22700 x (0.21 - 0.17) = 953 kg/h

The condensate amount is estimated to be 950 kg/h (± 10%) or 22.8 t/day for the 7K80MC-C engine.

The estimation of condensate amount is based on nominal air amount for the engine and even distribution of the air outlet temperature from the scavenge air cooler. The expected condensate amount should, therefore, be taken as rough guidance in case of small amounts of condensate (between -0.01 and 0.01 kg/kWh).

3.2 Drain System

See drawing 5455-0120.

Condensed water will be drained off from the water mist catcher through the sight glass, the orifice and flange AL to bilge.

The size of the orifice in the drain system is designed to be able to drain off the amount of condensed water under average running conditions.

In case of running under special conditions with high humidity, it can be necessary to open the bypass valve on the discharge line a little.

Close the bypass valve when possible to reduce the loss of scavenge air.

A level-alarm *(description 7045-0100)* will set off alarm in case of too high water level at the drain.

Check the alarm device regularly to ensure correct functioning.

3.3 Checking the Drain System by the Sight Glass

1. A mixed flow of air and water indicates a correctly working system where condensation takes place.
2. A flow of water only, indicates malfunctioning of the system.
   Check the orifice for blocking.
   Check for any restrictions in the discharge pipe from AL.
   Check and overhaul the level alarm.
3. *A flow of air is only normal when running under dry ambient conditions*

NOTICE

A sight glass which is completely filled with clean water, and with no air flow, visually looks like an empty air-filled sight glass.

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1 Thermometers and Pressure Gauges

The thermometers and pressure gauges fitted on the engine are often duplicated with instruments for remote indication.

Owing to differences in the installation method, type and make of sensing elements, and design of pockets, the two sets of instruments cannot be expected to give exactly the same readings.

During shoptest and sea trials, readings are taken from the local instruments. Use these values as the basis for all evaluations.

NOTICE

In case the local and the remote sensors are installed i seperate pockets, a temperature difference of up to 50 ˚C can be expected. Consider this when evaluating performance measurements.

Check the thermometers and pressure gauges at intervals against calibrated control apparatus.

Thermometers should be shielded against air currents from the engine-room ventilation.

If the temperature permits, keep thermometer pockets filled with oil to ensure accurate indication.

Keep all U-tube manometers perfectly tight at the joints.

Check the tightness from time to time by using soap-water.

To avoid polluting the environment, do not use mercury instruments.

Check that there is no water accumulation in tube bends, as this could falsify the readings.

If cocks or throttle valves are incorporated in the measuring equipment, check these for free flow, prior to taking readings.

If an instrument suddenly gives values that differ from normal, consider the possibility of a defective instrument.

The easiest method of determining whether an instrument is faulty or not, is to exchange it for another.

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2 PMI System

The PMI System is designed to provide engineers and service personnel onboard ship and at power plants with a computerised tool for pressure measurements and analysis on two-stroke diesel engines. The main advantages of the system are:

- On-line measurement of cylinder pressure. Fully automated measurement routine for measurements conducted from engine control room.
- Graphic display and print out of PT, PV and Balance Diagrams, together with Mean Indicated Pressure and Max. Pressure deviation limits.
- Calculated values of Effective Power, Mean Indicated Pressure p_i, Compression Pressure p_{comp}, Max. Pressure p_{max}, and Scavenge Pressure p_{scav}, including proposed values for index adjustments, etc.
- Software interface for use with MAN Diesel & Turbo's engine performance and engine diagnostics software, e.g. CoCos-EDS.

3 Indicator Valve

During the running of the engine, soot and oil will accumulate in the indicator bore.

Clean the bore by opening the indicator valve for a moment.

To protect the valve against burning:

- Open the valve only partially,
- Close the valve after one or two ignitions.

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1 Calculation of the Indicated and Effective Engine Power

NOTICE

Regarding the diagrams and PMI system.
See description 6345-0330.

For engines without PMI-system.
See description 6345-0370

Calculation of the indicated and effective engine power consists of the following steps:

Calculate:

- The mean indicated pressure, p_i
- The mean effective pressure, p_e
- The cylinder constant, k_2
- The indicated engine power, P_i
- The effective engine power, P_e

The mean indicated pressure, p_i

$$p_i = \frac{A}{L \times C_s} = [bar]$$

where:

A [mm^2]	=	area of the indicator diagram, as found by planimetering.
L [mm]	=	length of the indicator diagram (= atmospheric line).
C_s [mm/bar]	=	spring constant (= vertical movement of the indicator stylus [mm] for a 1 [bar] pressure rise in the cylinder).

p_i corresponds to the height of a rectangle with the same area and length as the indicator diagram.

- I.e., if p_i was acting on the piston during the complete downwards stroke, the cylinder would produce the same total work as actually produced in one complete revolution.

The mean effective pressure, p_e

$p_e = p_i - k_1$ [bar]

where:
k_1 = the mean friction loss

The mean friction loss has proved to be practically independent of the engine load. By experience, k_1 has been found to be approx. 1 [bar].

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The cylinder constant, k_2

k_2 is determined by the dimensions of the engine, and the units in which the power is wanted.

For power in [kW] : $k_2 = 1{,}309 \times D^2 \times S$

D [m] = cylinder diameter
S [m] = piston stroke

Examples:

Engine type	For power in [kW] k_2
S50ME	0.6250
S50ME-C	0.6545
L60ME	0.9161
S60ME	1.0801
S60ME-C	1.1310
L70ME	1.4547
S70ME	1.7151
S70ME-C	1.7959
L80ME	2.1715
S80ME	2.5602
K80ME-C	1.9268
L90ME	3.0918
K90ME	2.7037
K90ME-C	2.4387
K98ME-C	3.0172

The indicated engine power, P_i

$P_i = k_2 \times n \times p_i$ [ikW]

where:
n [rpm] = engine speed.

The effective engine power, P_e

$P_e = k_2 \times n \times p_e$ [kW]

where:
n [rpm] = engine speed.

Due to the friction in the thrust bearing, the shaft power is up to 1% less than the effective engine power, depending on speed and load conditions and plant type (FPP/CPP).

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1 General

Some measured performance parameters need to be corrected to ISO ambient conditions to facilitate reliable evaluation.

These parameters are: p_{max}, t_{exhv}, p_{comp} and p_{scav}.
See description 6345-0300.

Making such corrections enables comparison to earlier (corrected) readings or model curves, regardless of deviations of the actual t_{inl} and $t_{coolinl}$ from reference conditions.

I.e. the correction provides the values which would have been measured if t_{inl} and $t_{coolinl}$ had been 25°C.

In extreme cases, the divergencies can be large.

Record the corrected value as described *in description 6345-0310.*

Use the following reference conditions:

t_{inl} = Air inlet temperature = 25°C

The air inlet temperature can vary greatly, depending on the position in which it is measured on the intake filter. Experience has shown that two thermometers situated at ten o'clock and four o'clock positions (i.e. 180° apart) and at the middle of the filter, give a good indication of the average temperature.

$t_{coolinl}$ = Cooling water inlet temp. to air cooler = 25°C.

See drawing 6355-0145, regarding Δt (t_{scav}- $t_{coolinl}$).
See description 6345-0300.

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2 Correction

The correction for deviations of t_{inl} and $t_{coolinl}$ from reference conditions can be carried out in two ways:

By reading

See drawing 6355-0180.

By calculation

The corrections can be determined by the general equation:

$$A_{corr} = (t_{meas} - t_{ref}) \times F \times (K + A_{meas})$$

where:

A_{corr} = the correction to be applied to the parameter, i.e. to p_{max}, t_{exh}, p_{comp} or p_{scav}.

t_{meas} = measured t_{inl} or $t_{coolinl}$.

t_{ref} = reference t_{inl} or $t_{coolinl}$ (in case of Standard Conditions, 25°C).

F_1, F_2 = constants, *see the table below*.

K = constant, *see the table below*.

A_{meas} = the measured parameter to be corrected, i.e. p_{max}, t_{exh}, p_{comp} or p_{scav}.

For instructions, how to use the formulas.
See drawing 6355-0180.

Parameter to be corrected	F_1: for air inlet temp	F_2: for cooling water inlet temp	K
t_{exhv}	$- 2.446 \times 10^{-3}$	$- 0.59 \times 10^{-3}$	273
p_{scav}	$+ 2.856 \times 10^{-3}$	$- 2.220 \times 10^{-3}$	p_{baro} = 1 bar or 750 mm Hg
p_{comp}	$+ 2.954 \times 10^{-3}$	$- 1.530 \times 10^{-3}$	p_{baro} = 1 bar or 750 mm Hg
p_{max}	$+ 2.198 \times 10^{-3}$	$- 0.810 \times 10^{-3}$	p_{baro} = 1 bar or 750 mm Hg

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3 Examples of calculations:

See drawing 6355-0180, which states a set of service readings.

1. Correction of t_{exhv} *(drawing 6355-0180).*

Measured:		
Exhaust temperature after valve	=	425°C
Air inlet temp.	=	42°C
Cooling water inlet temp.(air cooler)	=	40°C
Correction for air inlet temperature: $(42 - 25) \times (-2.466 \times 10^{-3}) \times (273 + 425)$	=	–29.3°C
Correction for cooling water inlet temperature: $(40 - 25) \times (-0.59 \times 10^{-3}) \times (273 + 425)$	=	–6.2°C
Corrected t_{exhv} value = 425 – 29.3 – 6.2	=	389.5°C

2. Correction of p_{scav} *(drawing 6355-0180).*

Measured:		
Scavenge air pressure	=	2.0 bar
Air inlet temp.	=	42 °C
Cooling water inlet temp. (air cooler)	=	40 °C
Correction for air inlet temp.: $(42 - 25) \times (2.856 \times 10^{-3}) \times (1 + 2.0)$	=	0.146 bar
Correction for cooling water inlet temp.: $(40 - 25) \times (-2.220 \times 10^{-3}) \times (1 + 2.0)$	=	–0.10 bar
Corrected p_{scav} value = 2.0 + 0.146 – 0.10	=	2.046 bar

Corrections of p_{comp} and p_{max} can be made in a similar manner.
See drawing 6355-0180.

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4 Maximum Exhaust Temperature

The engine is designed to allow a limited increase of the thermal loading, i.e. increase of t_{exhv}.

- This enables the engine to operate under climatic alterations and under normally deteriorated service condition.

Whether the engine exceeds this built-in safety margin for thermal loading can be evaluated as follows:

The factors contributing to increased exhaust temperature levels (and thereby thermal loads) and the largest permissible deviation values are:

Factor	Max. temp. increase
due to fouling of turbocharger (incl. air intake filters), and exhaust uptake. *See description 7045-0100 (PT8708)*	+ 30°C
due to fouling of air coolers	+ 10°C
due to deteriorated mechanical condition (estimate)	+ 10°C
due to climatic (ambient) conditions	+ 45°C
due to operation on heavy fuel, etc.	+ 15°C
Total	110°C

Regarding increasing exhaust temperatures.
See description 6345-0310.

For new engines it is not unusual to observe a temperature increase of 50-60°C from the shop test to sea trial.

- This is due to the operation on heavy fuel oil and altered climatic conditions.

If the temperature increases further during service:

- Find the cause of the temperature increase.
- Clean, repair or overhaul the components in question at the first opportunity, to improve the engine performance.

NOTICE

The exhaust temperature must not exceed the alarm limit.
See description 7045-0100 'Guidance Value Automation'.

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To evaluate the exhaust temperature correctly, it is important to distinguish between:

- Exhaust temperature increase due to fouling and mechanical condition, and
- Exhaust temperature increase due to climatic alterations.

The method to distinguish between the factors is shown in the example:

Example:
According to a model curve, the exhaust temperature (approx. 95% engine load) should be 375°C. The observed exhaust temperature is 425°C.

Correct t_{exhv} according to *drawing 6355-0180*:
Air inlet temp. (t_{inl}) = **42°C** corresponding to (42 - 25) = 17°C above the reference value.

Cooling water inlet temp. to the air cooler ($t_{coolinl}$) = **40°C**, corresponding to (40 - 25) = 15°C above the reference value.

Using the curves, the following temperature corrections are obtained:

Correction due to increased engine room temperature:	-27.0°C
Correction due to increased cooling water inlet temp.:	-6.0°C
Total	-33.0°C

Distinguish between the factors:
The total exhaust temp. increase of 425°C - 375°C = 50°C, is caused by:

- an increase of 33.0°C on account of climatic alterations,
- an increase of 50°C – 33°C = 17°C, due to mechanical conditions and operation on heavy fuel oil.

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1 General

To record the turbocharger efficiencies.
See description 6345-0310.

Drawing 6355-0140 shows model curves for compressor and turbine efficiencies, based on the scavenge air pressure.

For general evaluation of the engine performance, it is unnecessary to calculate turbocharger efficiencies.

However, if such calculations are desired, they can be carried out as described below.

2 Calculating the Efficiencies

The total turbocharger efficiency is the product of the compressor, turbine, and mechanical efficiencies.

However, the last one has almost no effect on the efficiency calculations, and is therefore omitted.

When calculating the turbocharger efficiency, it is necessary to distinguish between:

- Plants without turbo compound system (TCS) and exhaust by-pass.
- Plants with TCS and/or exhaust by-pass.

2.1 Plants without TCS and Exhaust By-Pass

Measure the parameters listed in Table 1.

It is essential that, as far as possible, the measurements are taken simultaneously.

Convert all pressures to the same unit.
About conversion factors, *see description 6345-0300.*

		Unit	Example of Measurements
Barometric pressure	p_{baro}	bar	1.022 bar
Pressure drop, air cooler	Δp_c	bar	0.0168 bar
Temperature before compr.	t_{inl}	°C	21°C
Turbocharger speed	n	rpm	11950 rpm
Scavenge air pressure	p_{scav}	bar	2.533 bar *)
Exhaust receiver pressure	p_{exh}	bar	2.393 bar *)

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		Unit	Example of Measurements
Pressure after turbine	p_{atc}	bar	0.026 bar *)
Temperature before turbine	t_{btc}	°C	400°C

Table: Measurements for calculation of efficiencies *) "Gauge" Pressure

Note that the official designation of bar (HPa) is "absolute pressure".

Total Efficiency: The total efficiency η_{tot} is given by the equation

Example:
M_F : Fuel mass flow injected for combustion: 0.88 kg/s
M_X : Exhaust gas mass flow through turbine: 48.05 kg/s
M_A : Air mass flow through compressor

$$M_A = M_X - M_F$$

$$\eta_{tot} = 0.9265 \times \frac{M_A \times T_1 \times (R_1^{0.286} - 1)}{M_x \times T_2 \times (1 - R_2^{0.265})}$$

if M_A or M_X unknown:

$$\frac{M_A}{M_x} \approx 0.9817$$

	Example of Calculation, η_{tot} See measurements in Table 1
$T_1 = t_{inl} + 273.15$	$T_1 = 21 + 273.15$ =
$R_1 = \frac{p_{baro} + p_{scav} + \Delta p_{cc}}{p_{baro}}$	$R_1 = \frac{1.022 + 2.533 + 0.017}{1.022}$
$T_2 = t_{btc} + 273.15$	$T_2 = 400 + 273.5$ =
$R_2 = \frac{p_{baro} + p_{atc}}{p_{baro} + p_{exh}}$	$R_2 = \frac{1.022 + 0.026}{1.022 + 2.393}$ = 0.307
$(R_1^{0.286} - 1)$*	$(R_1^{0.286} - 1)$ = 0.430
$(1 - R_2^{0.265})$*	$(1 - R_1^{0.265})$ = 0.269
	M_X = 48.05 kg/s
	$M_A = 48.05 - 0.88$ = 47.17 kg/s
$\eta_{tot} = 0.9265 \times \frac{M_A \times T_1 \times (R_1^{0.286} - 1)}{M_X \times T_2 \times (1 - R_2^{0.265})}$	η = $0.9265 \times \frac{47.17 \times 294.15 \times 0.430}{48.05 \times 673.15 \times 0.269}$
	η = = 0.635

Compressor efficiency:

The compressor efficiency η_{compr} is given by the equation

$$\eta_{compr} = \frac{3628800 \times T_1 \, (R_1^{0.286} - 1)}{\mu \times U^2}$$

μ = slip factor, *see drawing 6355-0220.*
U = (π x D x n) is the peripheral speed of the compressor wheel.
D = Diameter of compressor wheel, *see drawing 6355-0220.*
n = Turbocharger revelution per minute.

The turbocharger used in this example is a MAN Diesel & Turbo, type TCA77.

From *drawing 6355-0220* is taken:

D = 0.752 m
μ = 0.745

	Example of Calculation, η_{comp} See measurements in Table 1		
$T_1 = t_{inl} + 273.15$ °K	21 + 273.15	=	294.15
$R_1 = \frac{p_{baro} + p_{scav} + \Delta p_c}{p_{baro}}$	$\frac{1.022 + 2.533 + 0.017}{1.022}$	=	3.495
$(R_1^{0.286} - 1)$*		=	0.430
$U^2 = (\pi \times D \times n)^2$	$(\pi \times 0.656 \times 13350)^2$	=	797022356
$\eta_{compr} = \frac{3628800 \times T_1 \, (R_1^{0.286} - 1)}{\mu \times U^2}$	$\frac{3628800 \times 294 \times 0.430}{0.745 \times 797022356}$	=	0.77

* Determine the values of the expressions $(R_1^{0.286}-1)$ and $(1- R_2^{0.265})$.
Use a mathematical calculator or use the curves in drawing 6355-0205 and 6355-0210.

Turbine efficiency: The turbine efficiency η_{turb} appears from $\eta_{total} = \eta_{compr} \times \eta_{turb}$

$$\text{i.e. } \eta_{turb} = \frac{\eta_{total}}{\eta_{compr}} = \frac{0.64}{0.77} = 0.83$$

2.2 Plants with TCS and/or Exhaust By-Pass

The equation:

$$\eta_{tot} = 0.9265 \times \frac{M_A \times T_1 \times (R_1^{0.286} - 1)}{M_x \times T_2 \times (1 - R_2^{0.265})}$$

- stated in item 2.1 is based on a situation where the mass flow through the turbine is equal to the mass flow through the compressor plus the fuel oil amount.

If a TCS or an exhaust by-pass is fitted, the mass flow through the turbine is reduced by the mass flow through the TCS or the exhaust by-pass.

The mass flows through the turbine and the TCS or through the turbine and the exhaust by-pass are proportional to the effective areas in the turbines or the orifice in the exhaust by-pass.

Calculate the turbocharger efficiency as described in Item 2.1 'Plants without TCS and exhaust by-pass'. Then correct the results in accordance with the following:

Total efficiency:

$$\eta_{tot\ TCS/by\text{-}pass} = \eta_{tot} \times \frac{A_{eff} + a_{eff}}{A_{eff}}$$

where

A_{eff} = Effective area in turbocharger turbine
a_{eff} = Effective area in TCS or exhaust by-pass.
See 'Remarks', below

Turbine Efficiency:

$$\eta_{turb_{TCS/by\text{-}pass}} = \eta_{turb} \times \frac{A_{eff} + a_{eff}}{A_{eff}}$$

See also 'Remarks', below

Compressor Efficiency:

η_{compr} is unchanged, as it is not affected by whether the plant operates with TCS/ by-pass or not.

Remarks

The relation:

$$\frac{A_{eff} + a_{eff}}{A_{eff}}$$

- can vary from plant to plant, but is most often about 1.07. This value can be used when evaluating the trend of the effi ciency in service.

When using a computer program in which the relation $A_{eff} + a_{eff} / A_{eff}$ is not introduced, the value for η_{tot} and η_{turb} will have to be multiplied by the above-mentioned factor of about 1.07.

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1 General

The estimation is based on nomograms involving engine parameter measurements made on testbed.

The nomograms are shown in *drawing 6355-0215*. The following relationships are illustrated:

Chart I - fuel index and mean effective pressure.

Chart II - mean effective pressure and effective engine power (kW), with the engine speed as a parameter.

Chart III - turbocharger speed and effective engine power (kW), with the scavenge air temperature and ambient pressure as parameters.

A condition for using these charts is that the engine timing and turbocharger matching are unchanged from the testbed.

2 Methods

In the following refer to *drawing 6355-0215.*

2.1 Fuel Index(an approximate method)

Chart I: Draw a horizontal line from the observed fuel index to the nomogram curve, and then a vertical line down to the observed engine speed on

Chart II: From this intersection a horizontal line is drawn to the effective engine power scale, i.e. 12.100 kW.

This method should only be used as a quick (rough) estimation, because the fuel oil, as well as the condition of the fuel pump, may have great effect on the index. In particular, worn fuel pumps or suction valves tend to increase the index, and will thus result in a too high power estimation.

2.2 Turbocharger Speed(A more accurate method)

Chart III: Draw a horizontal line from the observed t_{scav} value and an inclined line from the observed turbocharger speed.
From the intersection point, draw a vertical line down to the nomogram curve and then a horizontal line to the vertical line from the observed ambient pressure (point x in the ambient pressure scale).

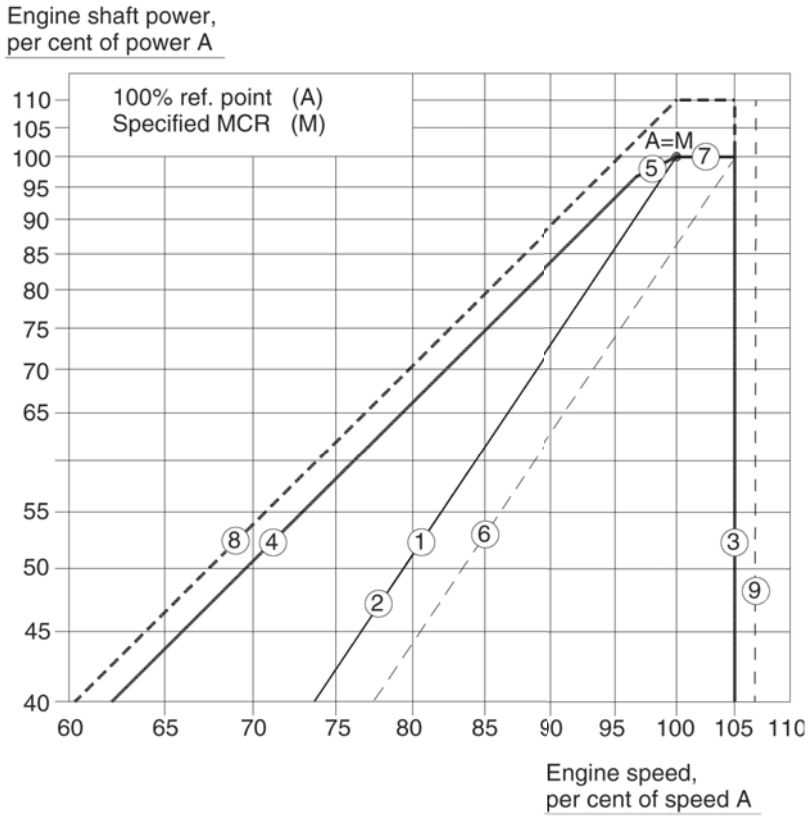
Finally, a line is drawn parallel with the inclined ‘ambient pressure correction’ lines. The effective engine power can then be read on the scale at the right hand side, i.e. 11.500 kW.

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This method is more reliable, and an accuracy to within ± 3% can be expected. However, the accuracy obtained will depend on the condition of the engine and turbocharger. A fouled or eroded turbocharger will in most cases tend to decrease the turbocharger speed, and thus result in a too low power estimation. This situation is characterized by increased exhaust gas temperatures and a decreased scavenge air pressure.

It is recommended to apply PMI-system, for easy access to P-V-diagrams (work diagrams) for power calculation.
See description 6345-0340.

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Line 1: Propeller curve through point A – layout curve for engine

Line 2: Propeller curve – heavy running, recommended limit for fouled hull at calm weather conditions

Line 3: Speed limit

Line 4: Torque/speed limit

Line 5: Mean effective pressure limit

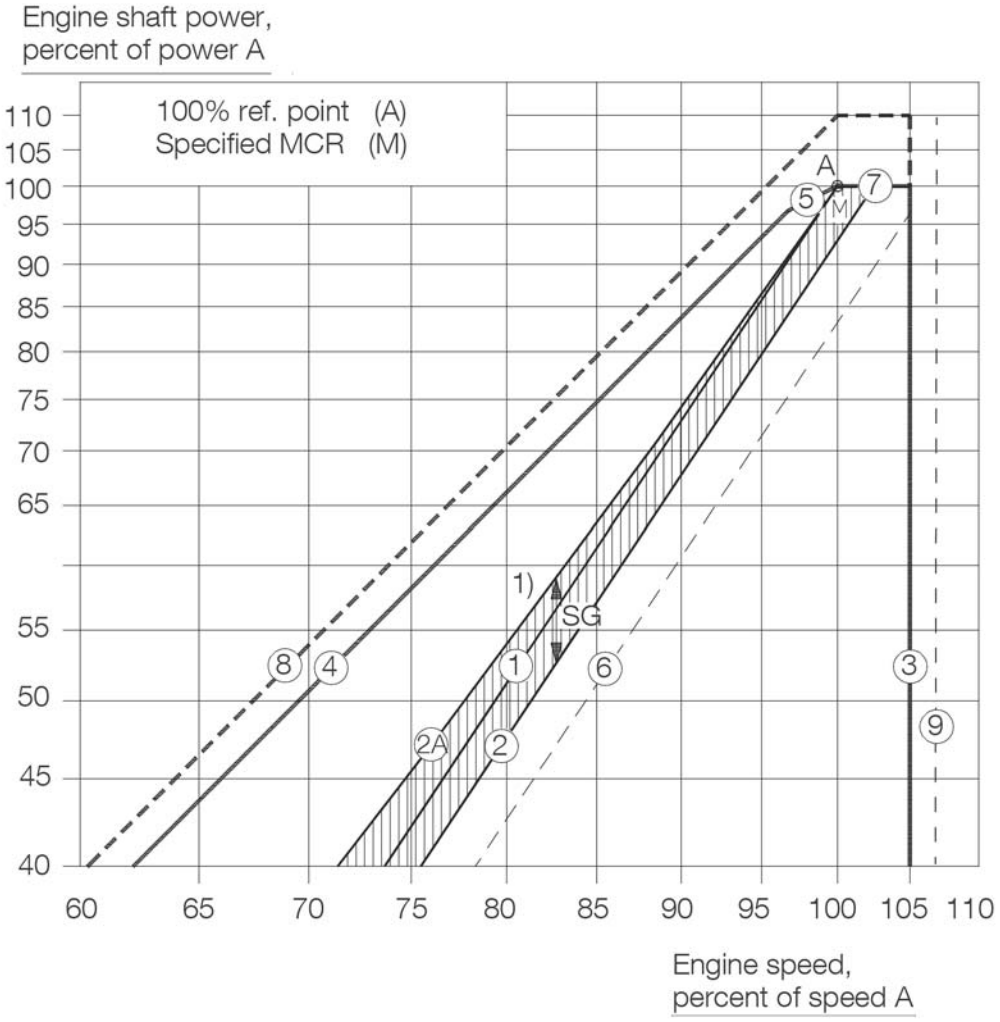
Line 6: Propeller curve – light running (range: 3.0-7.0%) for clean hull and calm weather conditions – for propeller layout

Line 7: Power limit for continuous running

Line 8: Overload limit

Line 9: Speed limit at sea trial

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Line 1:	Propeller curve through point A – layout curve for engine
Line 2:	Propeller curve – heavy running, recommended limit for fouled hull at calm weather conditions
Line 2A:	Engine service curve for heavy running propulsion (line 2) and shaft generator (SG)
Line 3:	Speed limit
Line 4:	Torque/speed limit
Line 5:	Mean effective pressure limit
Line 6:	Propeller curve – light running (range: 3.0-7.0%) for clean hull and calm weather conditions – for propeller layout
Line 7:	Power limit for continuous running
Line 8:	Overload limit
Line 9:	Speed limit at sea trial

Load Diagram for Propulsion and Main Engine Driven Generator

Drawing 6355-0105-0001

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NOTICE

The propeller curve for propulsion alone is found by subtracting the actual shaft generator power (incl. generator efficiency) from the effective engine power at maintained speed.

SERVICE DATA (ME)	Engine Type:	Name of vessel:		
	Engine Builder:	Engine No.:	Yard:	

Layout kW:	Layout RPM:	Engine Mode:	Sign.:	Test No.:

Turbocharger(s)	No. of TC:	Serial No.	No. of Cyl.:	Bore, m:	Stroke, m:
Make:	Type:	1	Cylinder Constant, (HP,bar):	Mean Friction. Press., bar:	
Max. RPM:	Max. Temp., °C:	2	Lubrication Oil System (Tick box)		
Compr. Slip Factor:	Compr. Diam., m:	3	☐ Internal	☐ External from M. E. System	☐ External from Gravity Tank
TC specification:		4			

Observation No :

Fuel Oil Viscosity:	at: °C		Brand	Type
Bunker Station:		Cylinder Oil		
Oil Brand:	Heat value, kcal/kg:	Circulating Oil		
Density at 15 °C:	Sulphur, %:	Turbo Oil		

Test Date (yyyy-mm-dd)	Test Hour (hh:mm)	Load %	Ambient Pressure mbar	Engine RPM	Total Running Hours	Fuel Index ECU %	Speed Setting RPM	VIT Control bar

Effective Power BHP	Effective Power kW	Indicated Power kW	Eff. Fuel Consumption g/BHPh	Eff. Fuel Consumption g/kWh	Draft Fore, m / Draft Aft, m	Log Knots / Obs. Knots	Wind, m/s / Wave Height, m	Direction, ° / Direction, °

Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Ave.
Pi, bar																			
Pmax, bar																			
Ref. Pmax, bar																			
Pcomp, bar																			
Fuel Index Offset, HIGH Load																			
Fuel Index Offset, LOW Load																			
Pmax Adjustment, bar																			
Pcomp Ratio (Pcomp/Pscav)																			
Exh. Valve Open Timing, °CA (Correction value)																			
Exhaust Gas Temp., °C																			
Cooling Water Outlet Temp., °C																			
Piston Outlet Lub. Temp., °C																			

Cooling Water Temperature, °C				Exhaust Gas Temp., °C		Exhaust Pressure		Turbo Charger	Aux. Blower	Scavenge Air Pressure		
Air Cooler		Main Engine		Turbine		Receiver	Turb. Outl.			▲p Filter	▲p Cooler	Receiver
Inlet	Outlet	Inlet	Turb. Outlet	Inlet	Outlet	bar	mmWC	RPM	On/Off	mmWc	mmWc	bar
1	1		1	1	1		1	1		1	1	
		Seaw. Temp.				mmHg			Axial Vibration			mmHg
2	2		2	2	2		2	2		2	2	
									mm			
3	3		3	3	3		3	3		3	3	
4	4		4	4	4		4	4		4	4	
Ave.	Ave.		Ave.	Ave.	Ave.		Ave.	Ave.		Ave.	Ave.	

Scavenge Air Temperature, °C				Lubricating Oil			Fuel Oil Pressure	Hydraulic Pressure	
Scav. Air Temp. °C	Inlet Blower	Before Cooler	After Cooler	Pressure, bar	Temperature, °C		bar	bar	
	1	1	1	System Oil	TC Inlet / Blower end	TC Outlet / Turb. end	Before Filter	Before Filter	
	2	2	2	Cooling Oil	1	1	After Filter	After Filter	
	3	3	3	Turbine Oil	2	2	Temperature, °C Before Pumps	Main Pressure	
	4	4	4	Temperature, °C Inlet Engine	3	3		Swash Plate Position, %	
	Ave.	Ave.	Ave.		4	4		1	2
				Thrust Segment				3	4
					Ave.	Ave.			

Remarks:

Performance Observations

Drawing 6355-0110-0001

TESTBED DATA	Engine Type:		Water Brake:		No.:	Constant, K:	BHP/Kg.RPM
	Engine Builder:		Engine No.:		Yard:		
Layout BHP:	Layout RPM:		Entry Date:		Sign:		Test No.:
Turbochargers(s):	Nos.:		Serial No.:		No. of cyl.:	Bore (m):	Stroke (m):
Make:		1			Cylinder Constant (HP,bar)		
Type:		2			Governor:	Type:	
Max. RPM:		3			TC specification:		
Max. Temp. °C:		4			MFP:	Compr. Slip Factor:	Compr. Diameter:
Lub. Oil System:							

Observation No:

Fuel Oil Viscosity:	at:	°C		Brand	Type
Bunker Station:			Cylinder Oil		
Oil Brand:	Heat value, kcal/kg:		Circulating Oil		
Density at 15 °C:	Sulphur, %:		Turbo Oil		

Test Date (yyyy-mm-dd)	Test Hour (hh:mm)	Load %	Ambient Pressure mbar	Water Brake Load Kg	Engine RPM	Governor Index	Speed Setting bar	VIT Control Press. bar

Effective Power BHP	Effective Power kW	Indicated Power kW	Eff. Fuel Consumption g/BHPh	Eff. Fuel Consumption g/kWh	Indicated Fuel Consumption g/IHPh	Indicated Fuel Consumption g/kWh

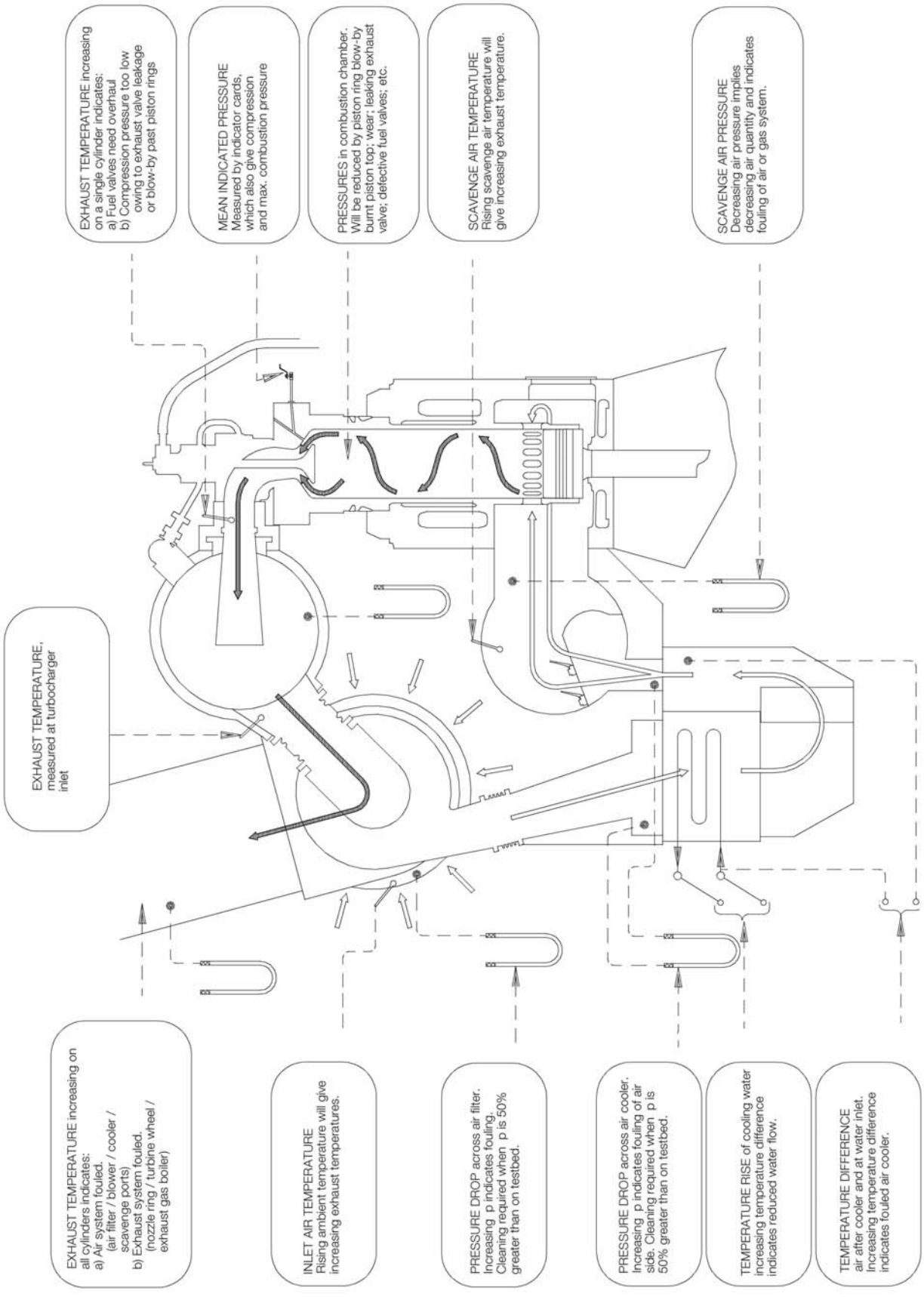
Cylinder No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Ave.
Pi, bar																			
Pmax, bar																			
Ref. Pmax, bar																			
Pcomp, bar																			
Fuel Pump Index																			
VIT Index																			
Exhaust Gas Temp. °C																			
Cooling Water Outlet Temp. °C																			
Piston Outlet Lub. Temp. °C																			

Cooling Water Temperature °C				Exhaust Gas Temp. °C		Exhaust Pressure		Turbo Charger	Aux. Blower	Scavenge Air Pressure		
Air Cooler		Main Engine		Turbine		Receiver	Turb. Outl.			▲p Filter	▲p Cooler	Receiver
Inlet	Outlet	Inlet	Turb. Outlet	Inlet	Outlet	bar	mmWC	RPM	On/Off	mmWc	mmWc	bar
1	1		1	1	1		1	1		1	1	
		Seaw. Temp.				mmHg			Axial Vibration			mmHg
2	2		2	2	2		2	2		2	2	
									mm			
3	3		3	3	3		3	3		3	3	
4	4		4	4	4		4	4		4	4	
Ave.	Ave.		Ave.	Ave.	Ave.		Ave.	Ave.		Ave.	Ave.	

Scavenge Air Temperature °C				Lubricating Oil				Fuel Oil Pressure
Scav. Air	Inlet Blower	Before Cooler	After Cooler	Pressure, bar	Temperature, °C	Temperature, °C		bar
	1	1	1	System Oil	Inlet Engine	TC Inlet / Blower end	TC Outlet / Turb. end	Before Filter
	2	2	2	Cooling Oil	Inlet Camshaft	1	1	After Filter
	3	3	3	Camshaft Oil	Outlet Camshaft	2	2	Temperature, °C
	4	4	4	Turbine Oil	Thrust Segment	3	3	Before Pumps
	Ave.	Ave.	Ave.			4	4	
						Ave.	Ave.	

Remarks:

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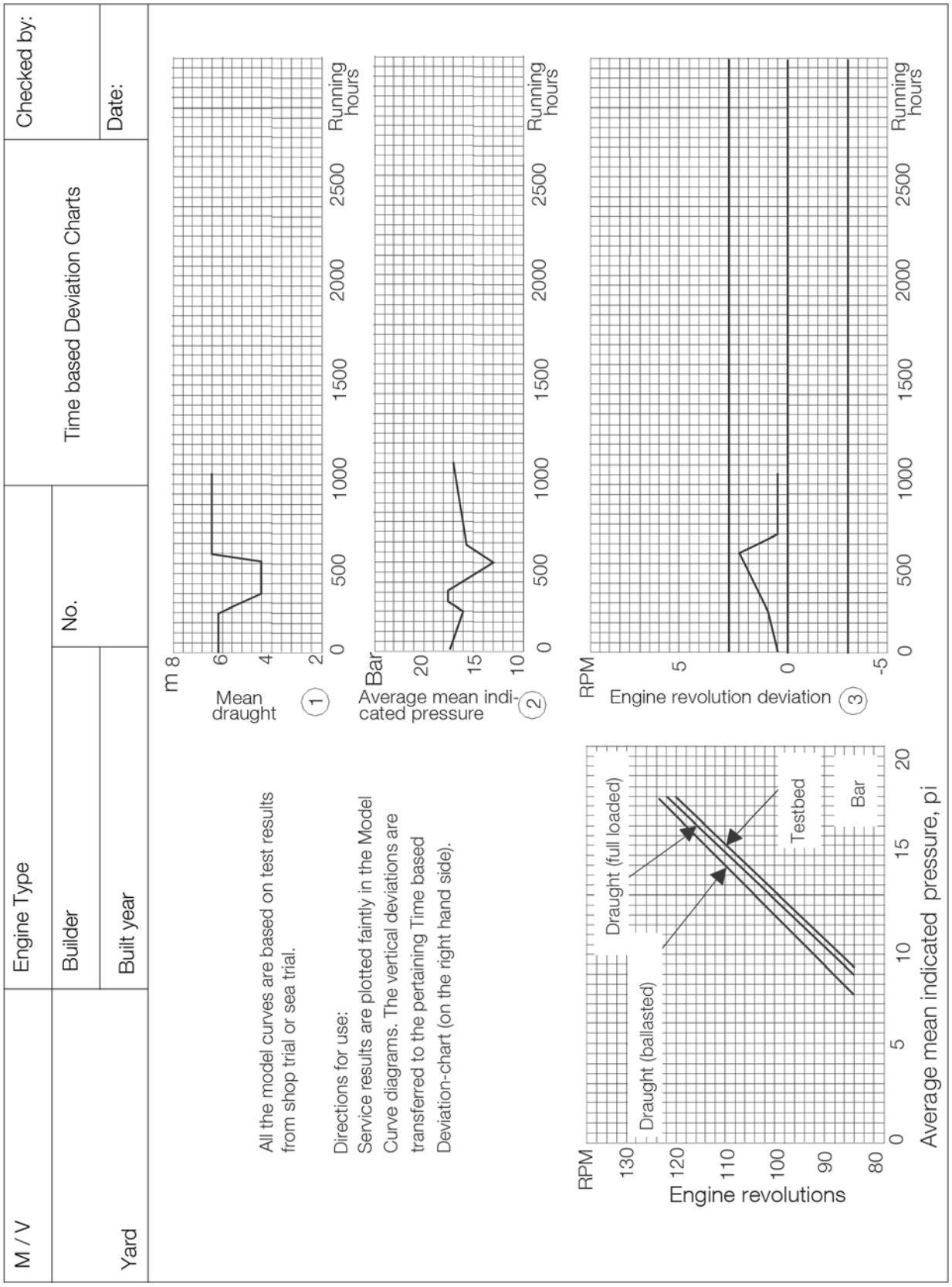


Readings relating to Thermodynamic Conditions

Drawing
6355-0115-0001

2013-10-21 - en

Time based deviation charts for: mean draught and average mean indicated pressure (p_i). Model curves + time based deviation chart for: r/min as a function of pi.



Synopsis Diagrams - for engine (Pi)

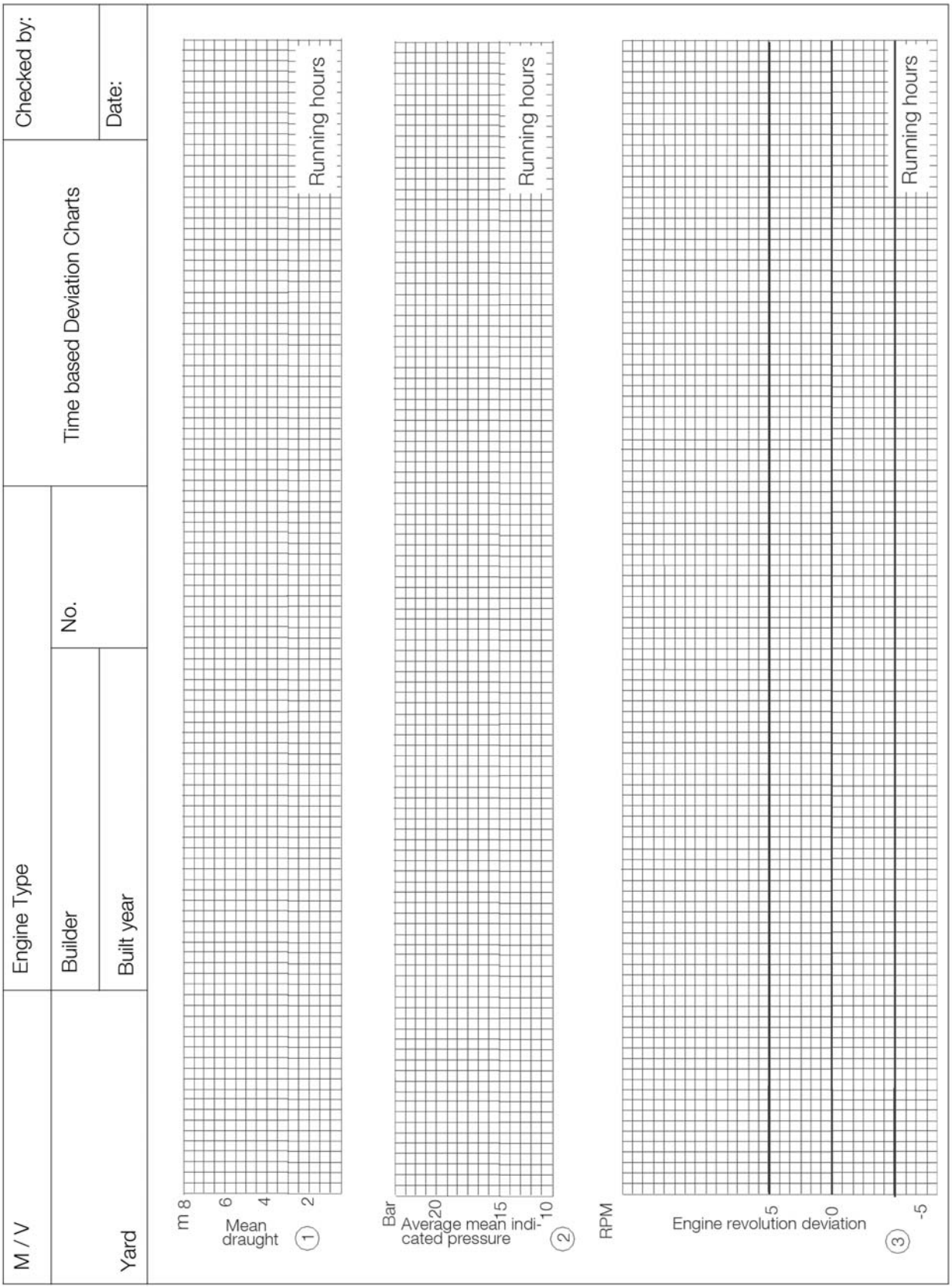
Drawing
6355-0120-0002

2013-10-21 - en

Synopsis Diagrams - for engine (Pi)

Drawing
6355-0120-0002

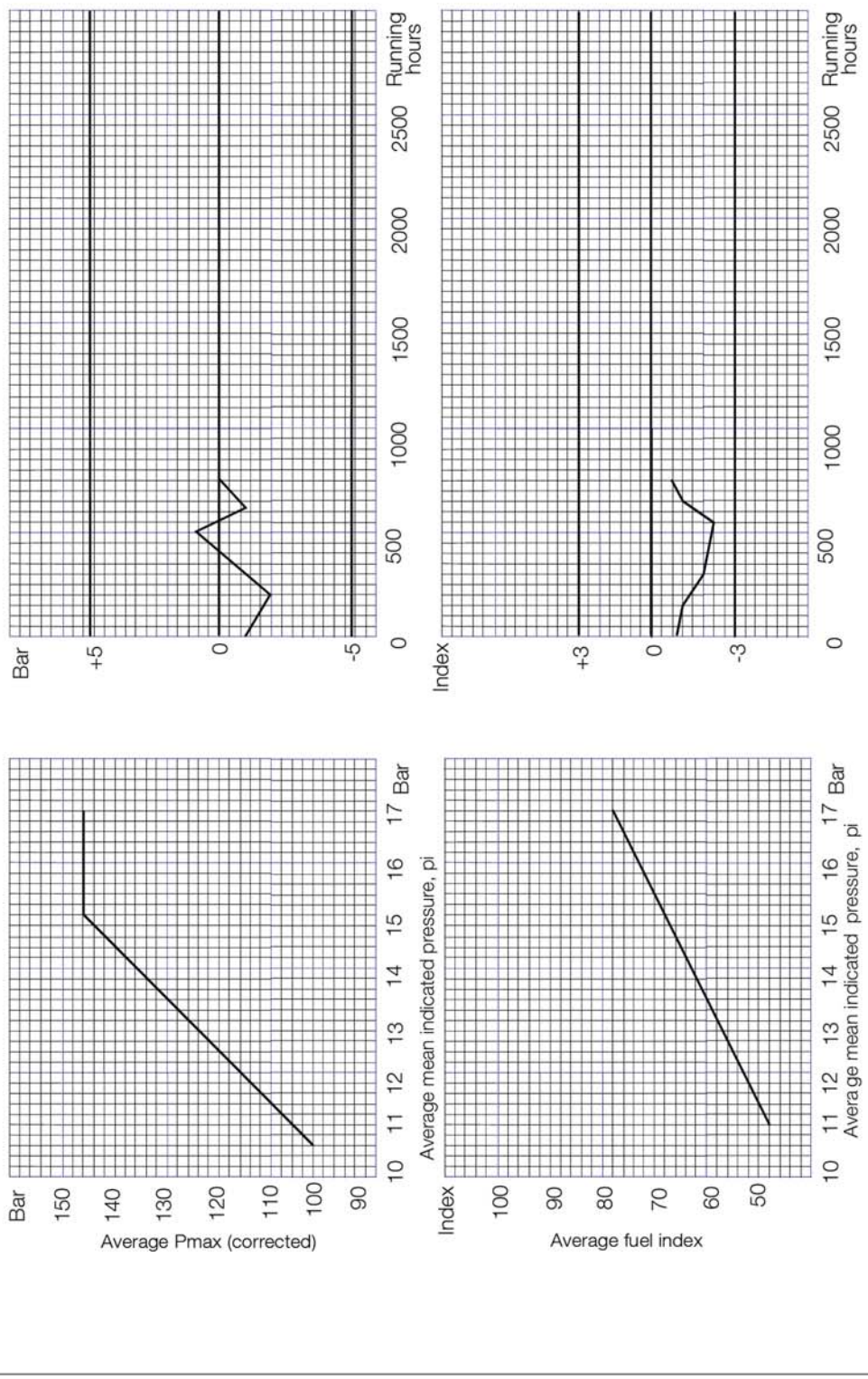
Time based deviation charts for: mean draught and average mean indicated pressure (p_i). Model curves + time based deviation chart for: r/min as a function of p_i.



2013-10-21 - en

Model curves and time based deviation chart for:
p_{max} and fuel index as a function of p_i

M / V	Engine Type		Time based Deviation Charts	Checked by:
	Builder	No.		Date:
Yard	Built year			



Synopsis Diagrams - for engine (Pmax)

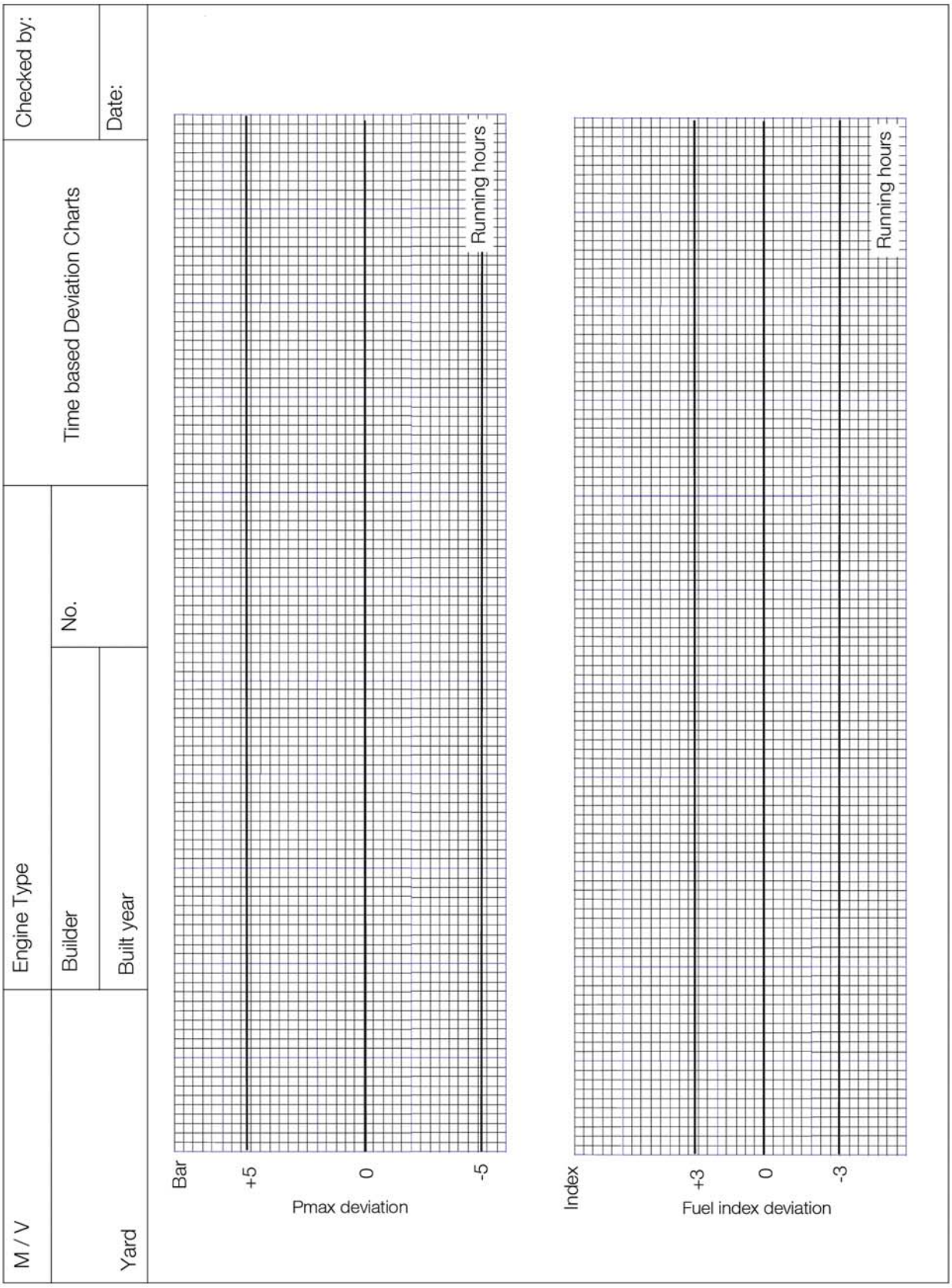
Drawing
6355-0125-0002

2013-10-21 - en

Synopsis Diagrams - for engine (Pmax)

Drawing
6355-0125-0002

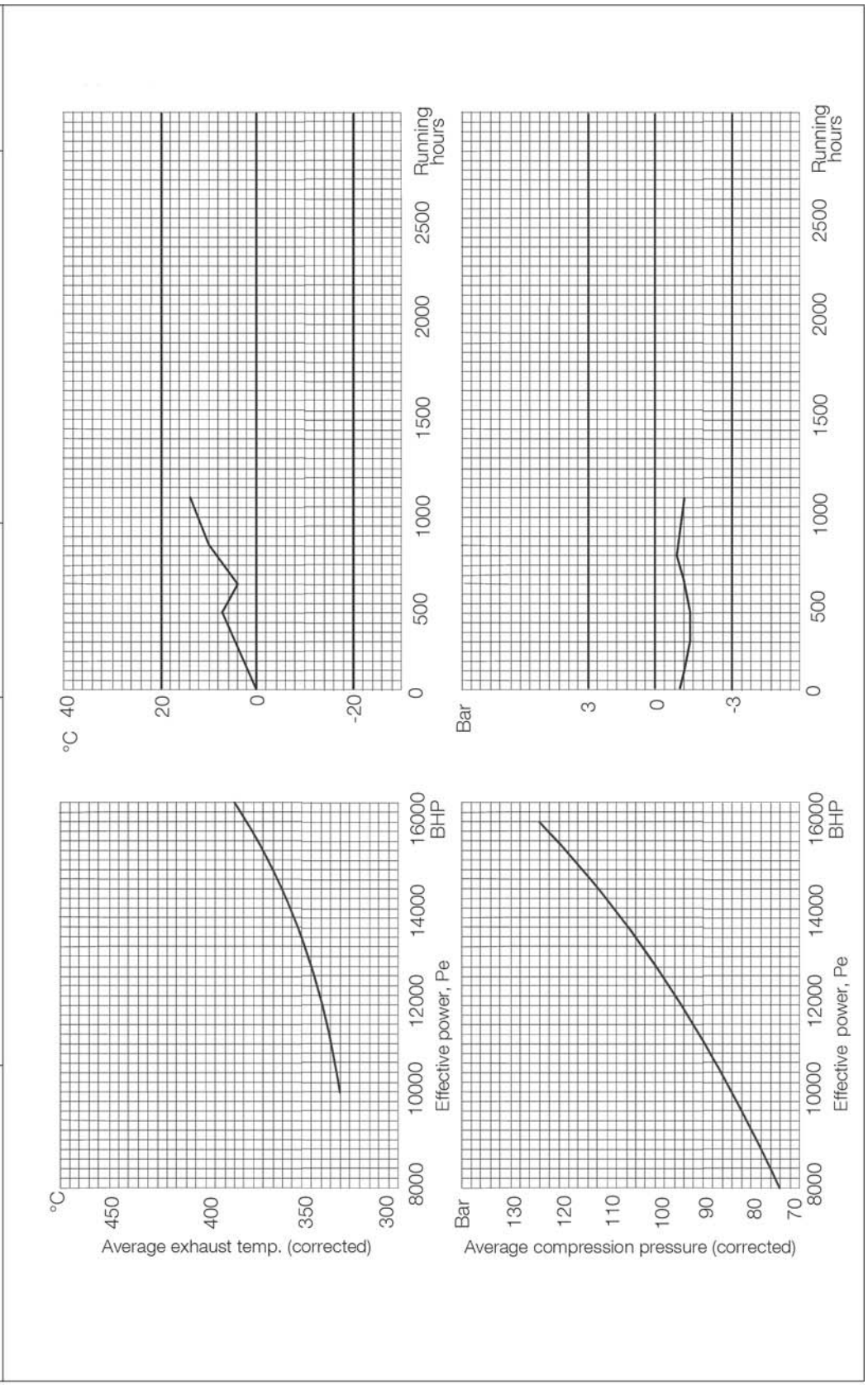
Time based deviation chart for:
p_{max} and fuel index



2013-10-21 - en

Model curves and time based deviation chart for:
t_{exhv} and pcomp as a function of p_e

M / V	Engine Type		Checked by:
	Builder	No.	
Yard	Built year	Time based Deviation Charts	Date:



Synopsis Diagrams - for engine (Pe)

Drawing
6355-0130-0002

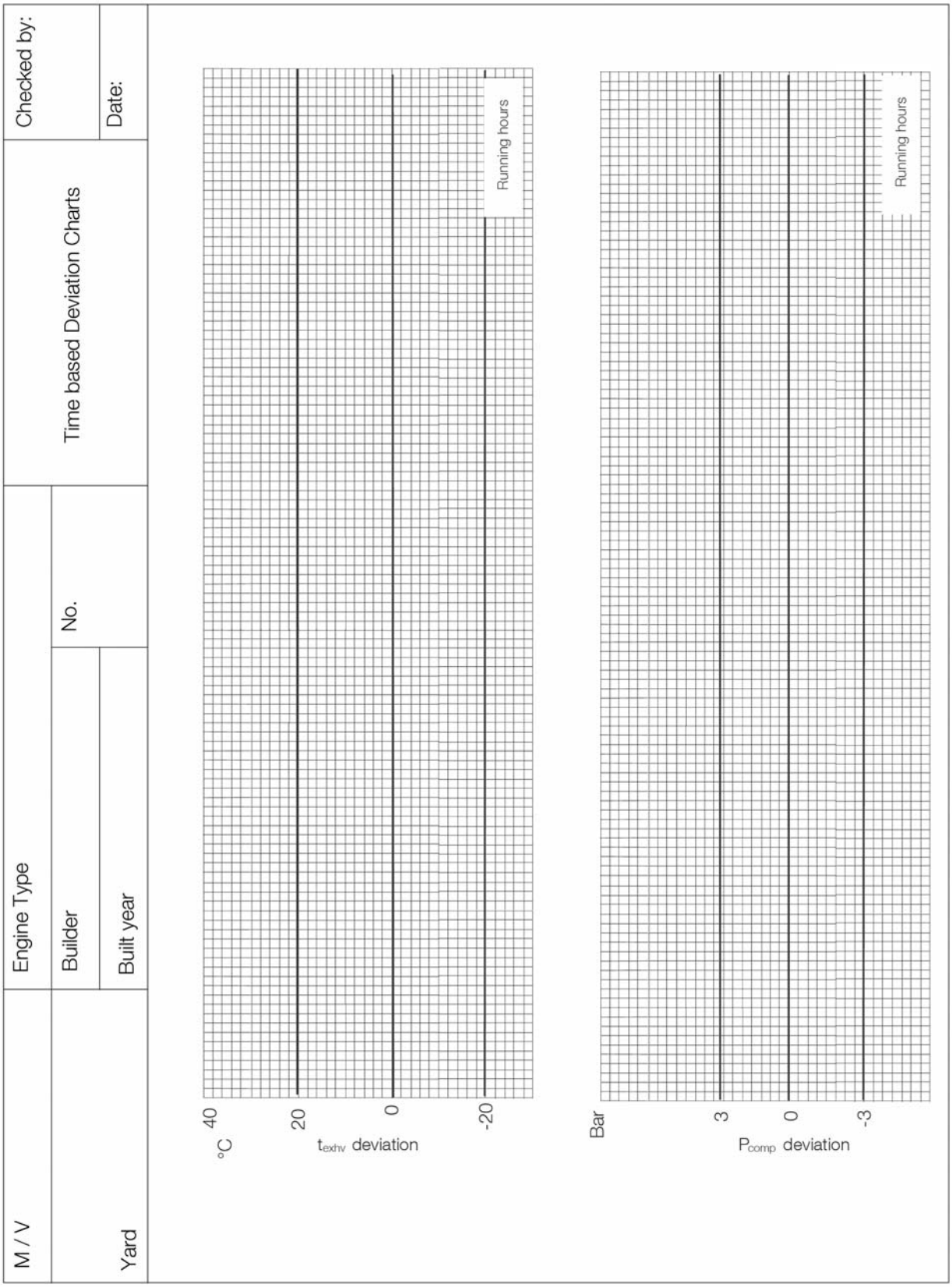
2013-10-21 - en

Synopsis Diagrams - for engine (Pe)

Drawing
6355-0130-0002

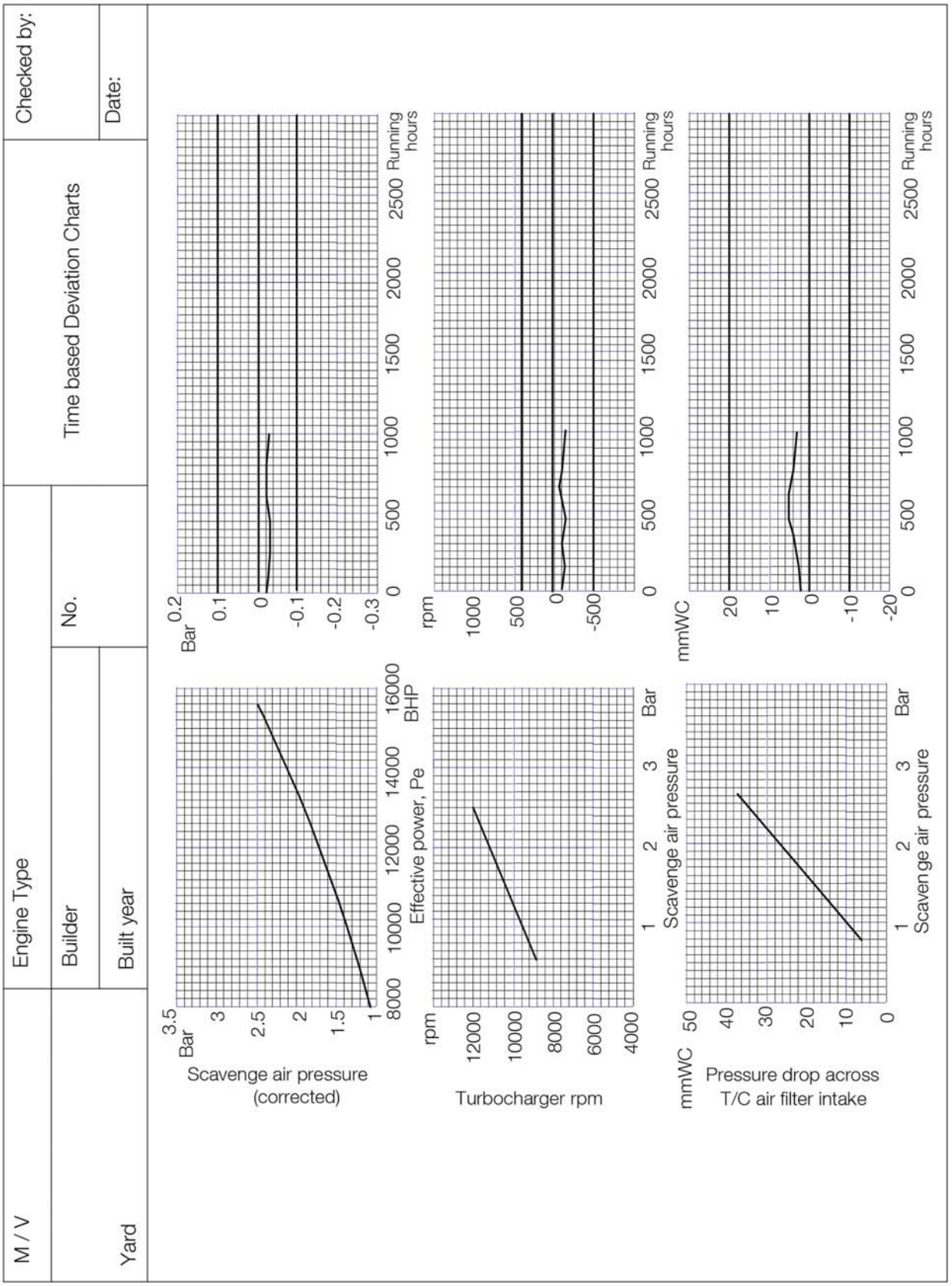
Time based deviation chart for:
t_{exhv} and p_{comp}

M / V	Engine Type		Time based Deviation Charts	Checked by:
Yard	Builder	No.		Date:
	Built year			



2013-10-21 - en

Model curves and time based deviation chart for:
p_{scav} as a function of pe T/C r/min and Δp_f as a function of p_{scav}



Synopsis Diagrams - for turbocharger (Pscav - Pe)

Drawing 6355-0135-0002

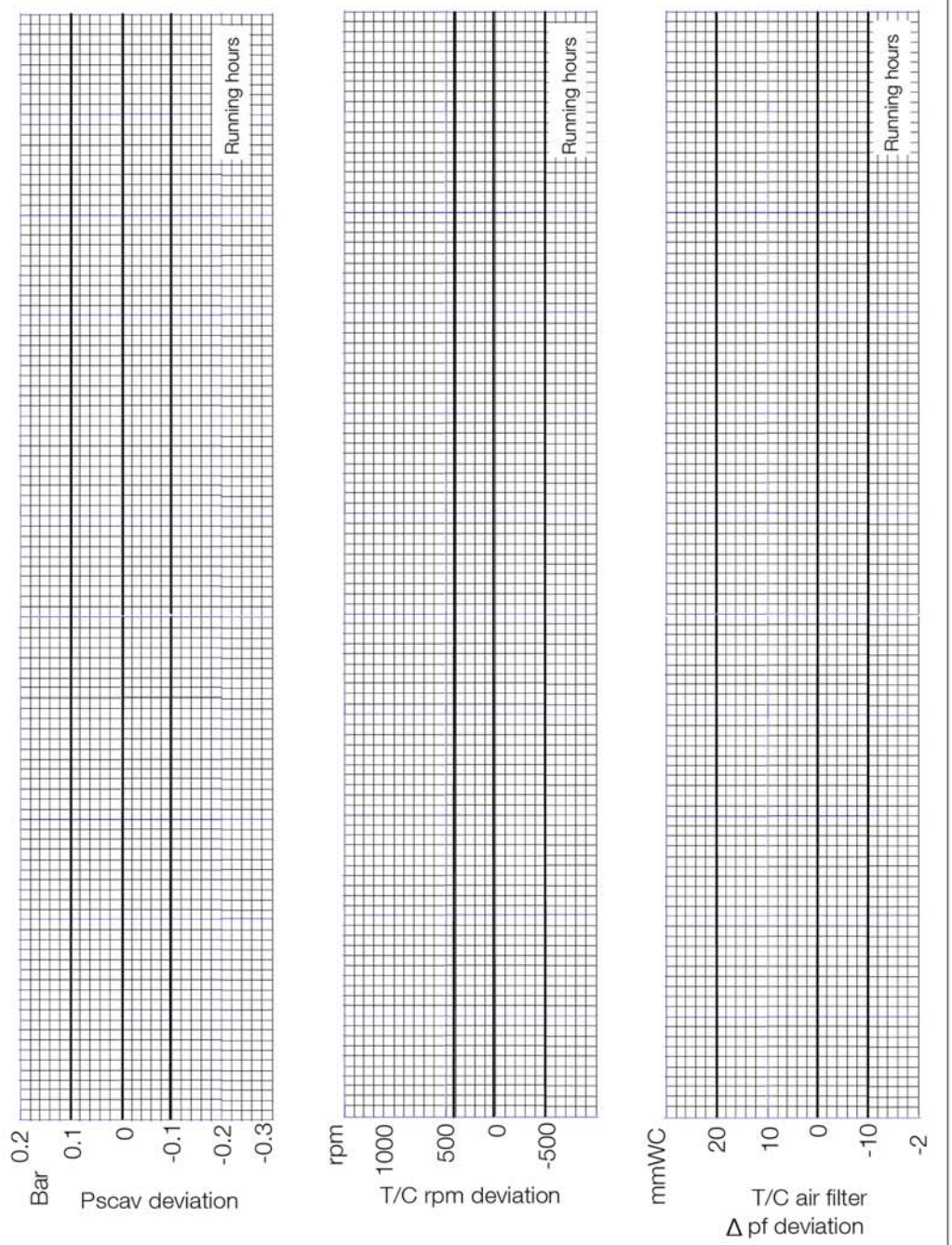
2013-10-21 - en

Synopsis Diagrams - for turbocharger (Pscav - Pe)

Drawing
6355-0135-0002

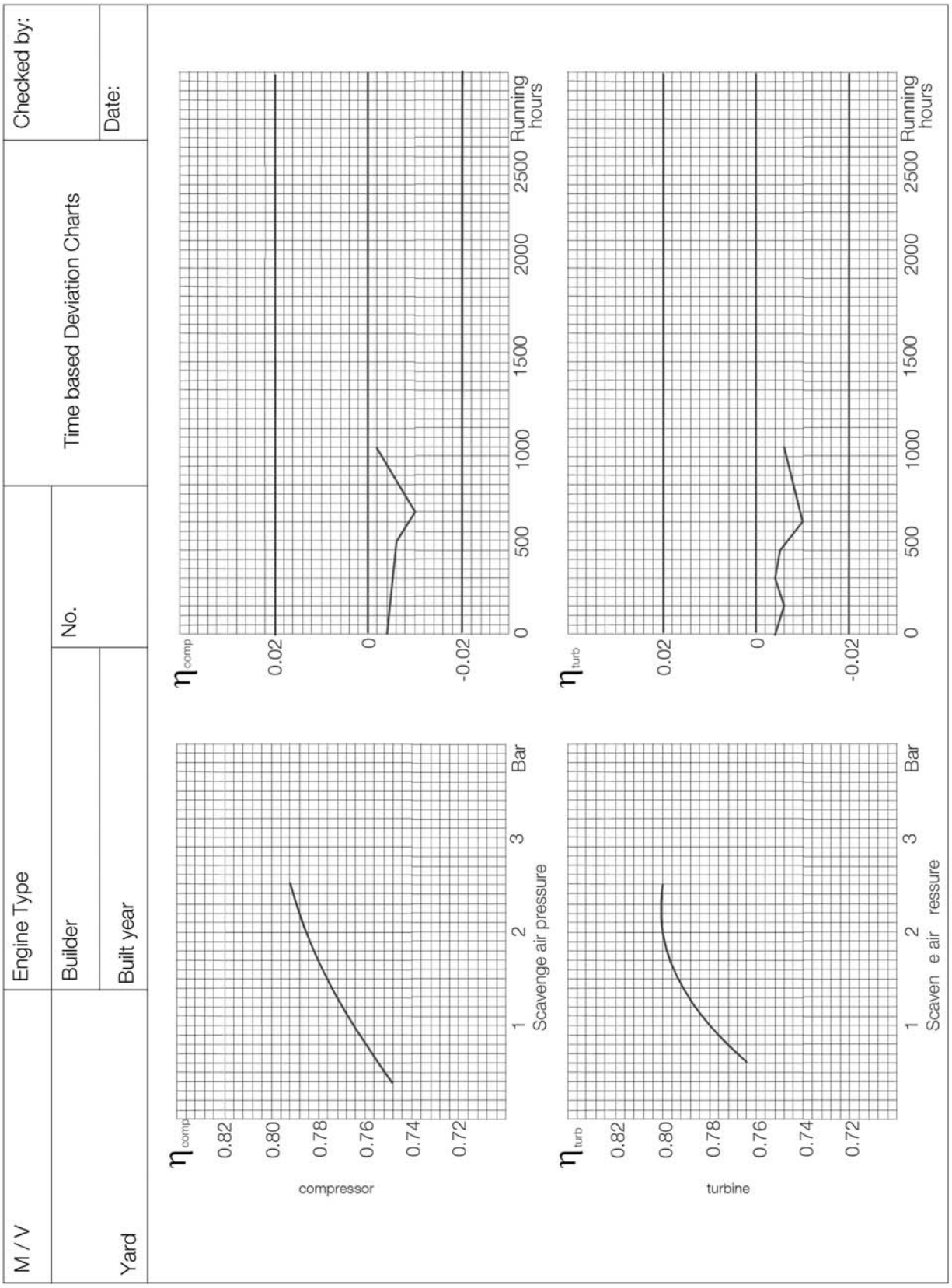
Time based deviation chart for:
p_{scav} T/C r/min and Δp_f

M / V	Engine Type		Time based Deviation Charts	Checked by:
	Builder	No.		Date:
Yard	Built year			



2013-10-21 - en

Model curves and time based deviation chart for:
Compressor and turbine efficiencies as a function of p_{scav}



Synopsis Diagrams - for turbocharger (Pscav - Compressor)

Drawing
6355-0140-0002

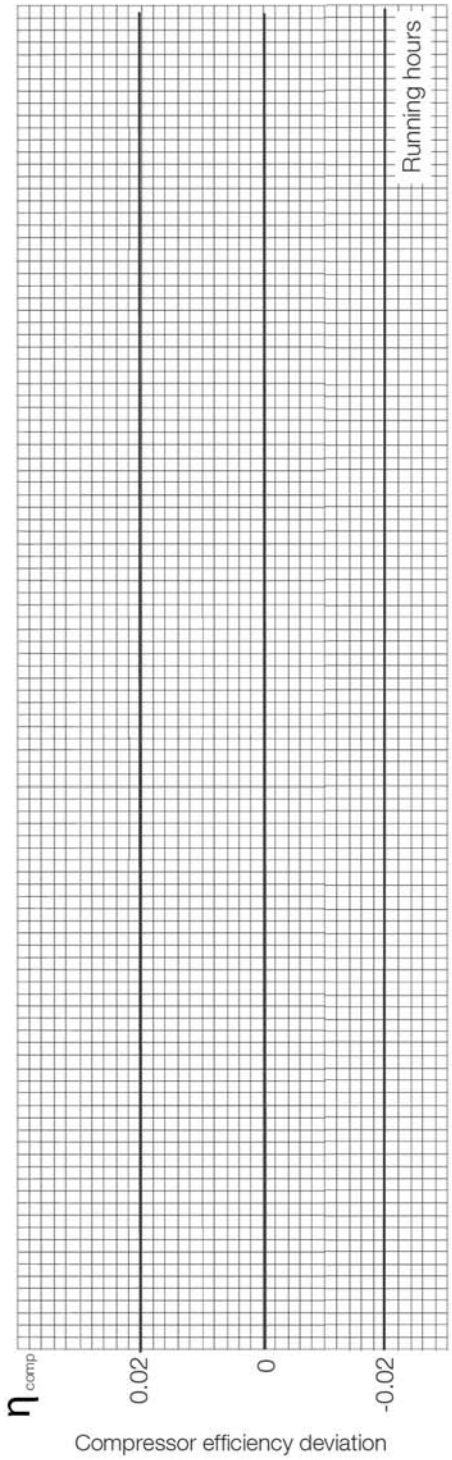
2013-10-21 - en

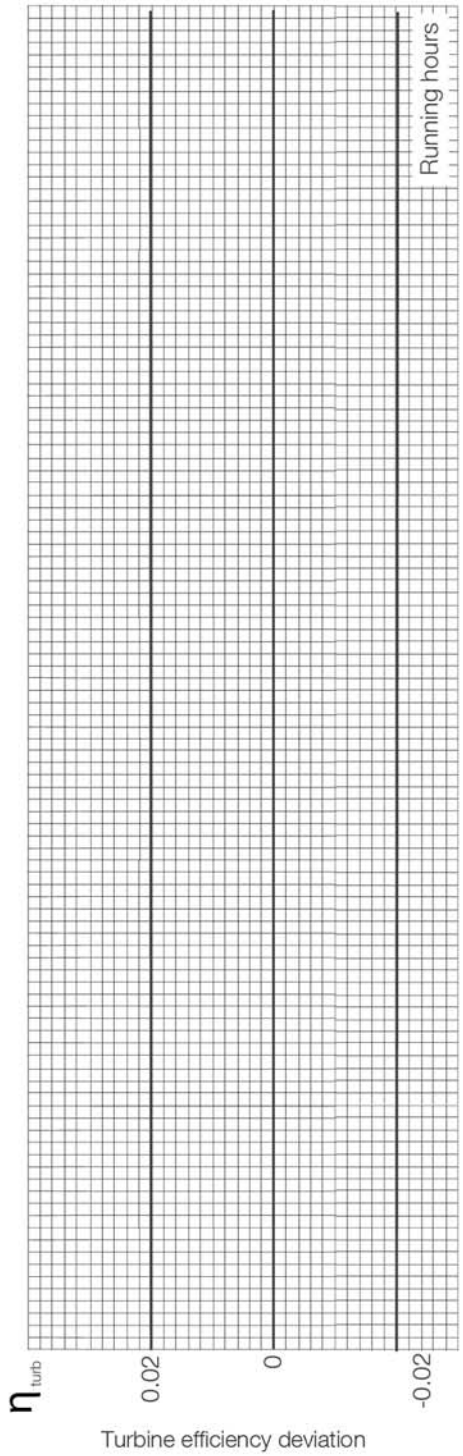
Drawing
6355-0140-0002

Synopsis Diagrams - for turbocharger (Pscav - Compressor)

Time based deviation chart for:
compressor and turbine efficiencies

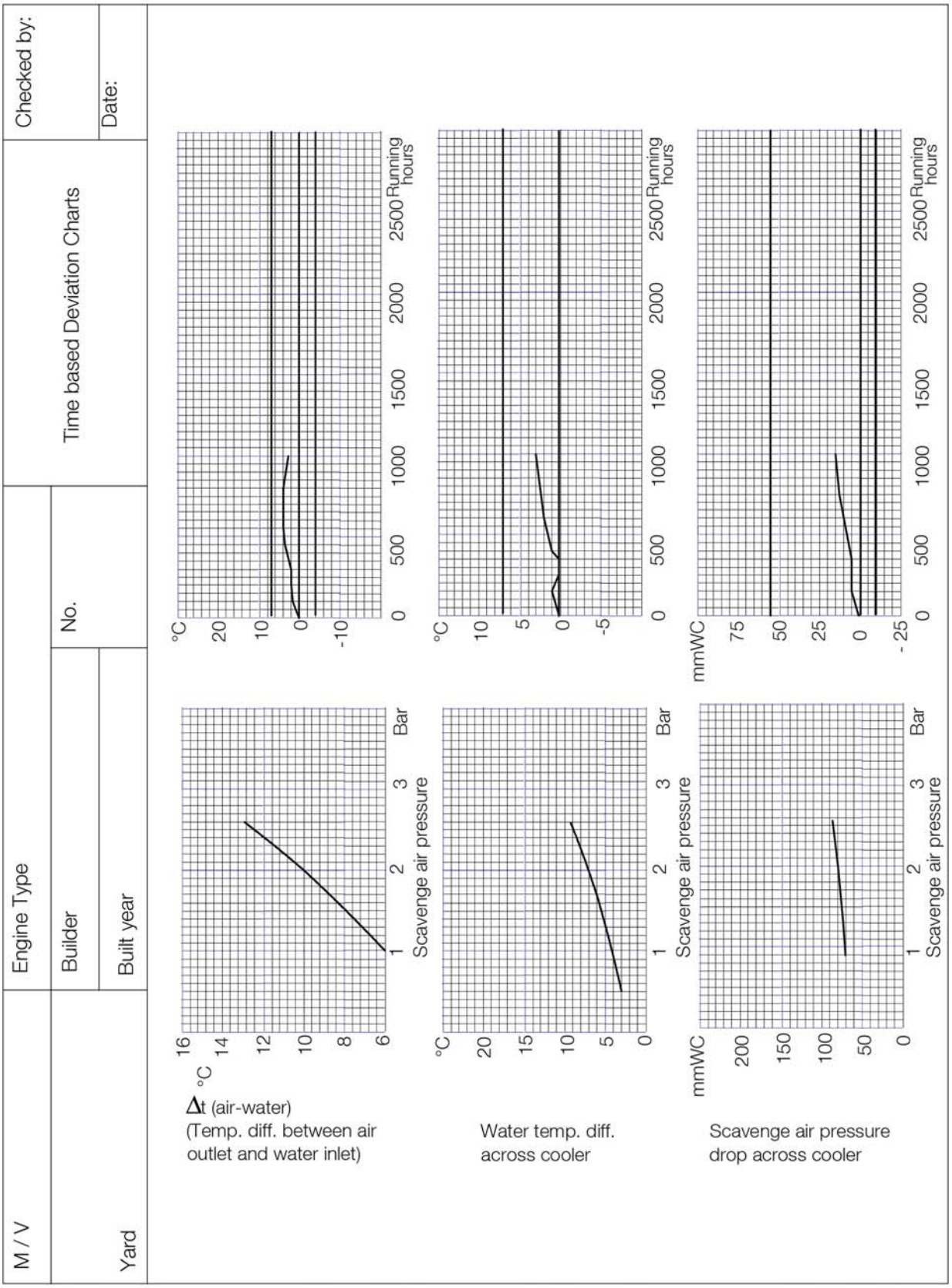
M / V	Engine Type		Time based Deviation Charts	Checked by:
	Builder	No.		
Yard	Built year			Date:





2013-10-21 - en

Model curves and time based deviation chart for:
$t_{air-water}$, t_{water} and p_{air}, as a function of p_{scav}



Synopsis Diagrams - for air cooler (Pscav - Tair)

Drawing
6355-0145-0002

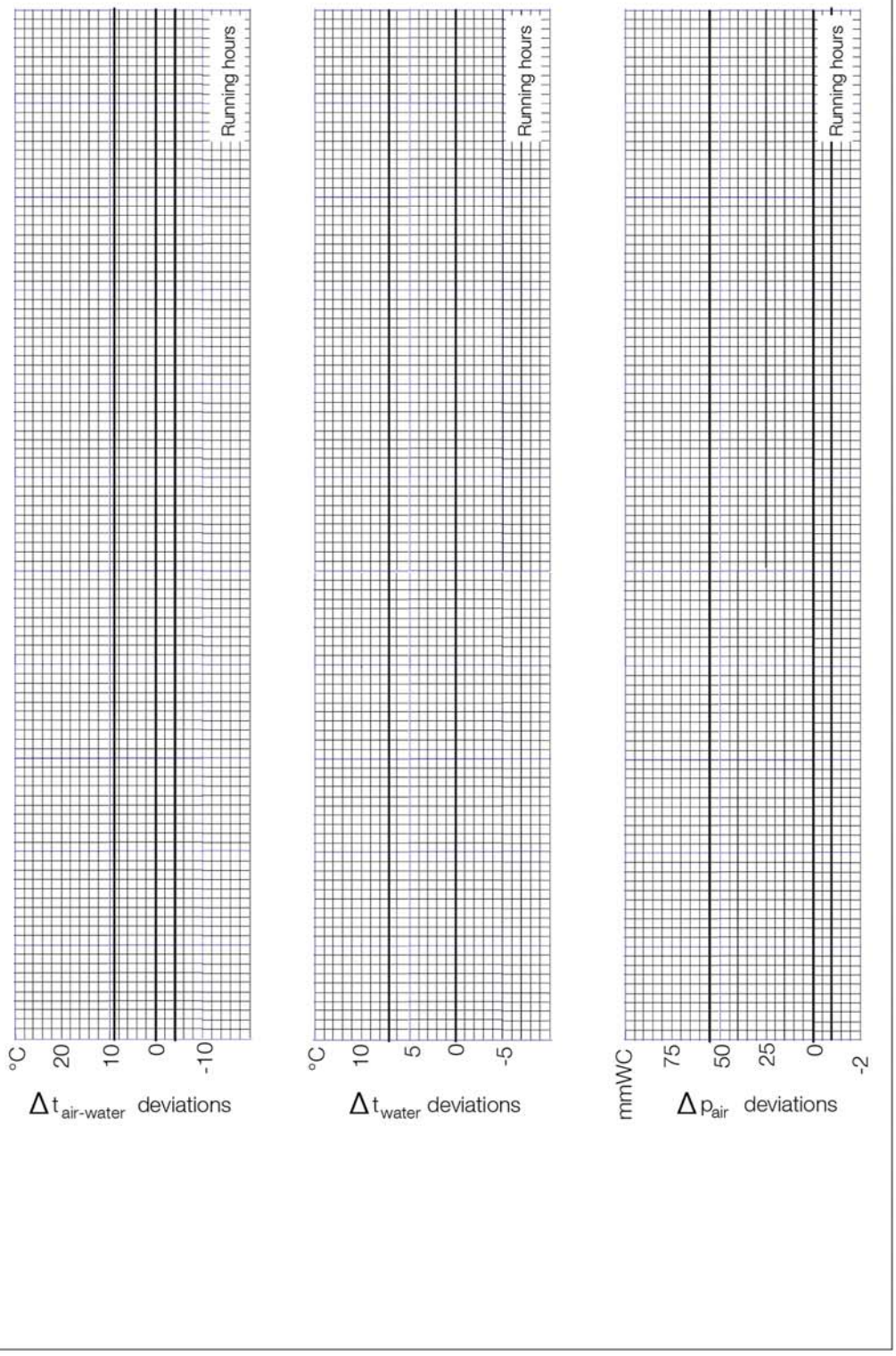
2013-10-21 - en

Synopsis Diagrams - for air cooler (Pscav - Tair)

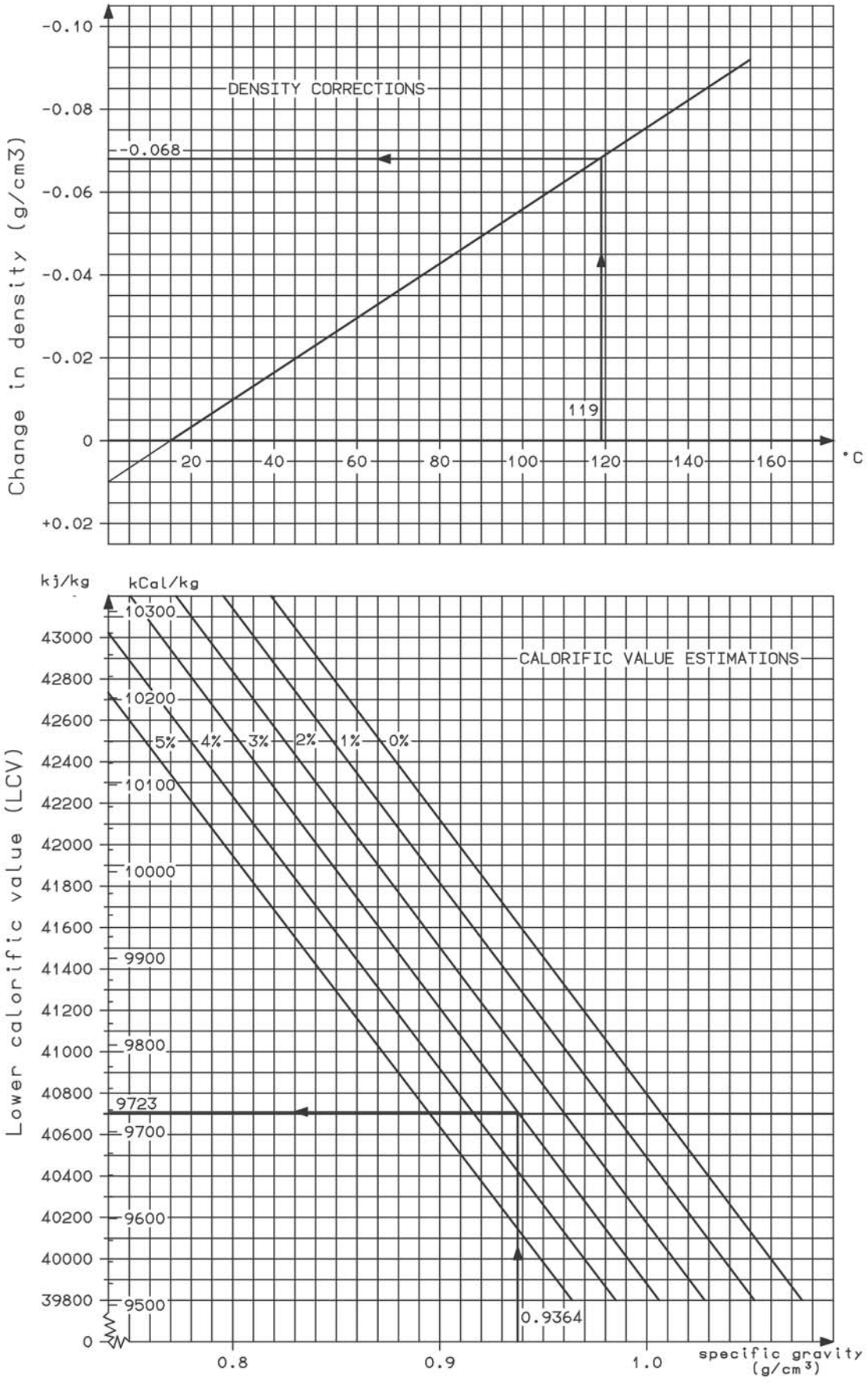
Drawing
6355-0145-0002

Time based deviation chart for:
$\Delta t_{air\text{-}water}$ Δt_{water} and Δp_{ai}

M / V	Engine Type		Time based Deviation Charts
Yard	Builder	No.	Checked by:
	Built year		Date:



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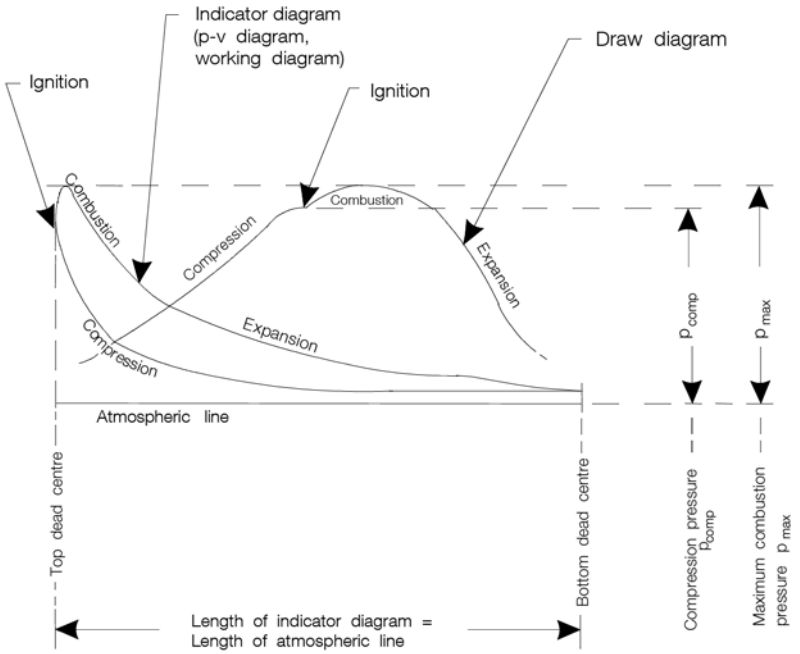


Specific Fuel Oil Consumption (Corrections)

Drawing
6355-0150-0002

2013-10-21 - en

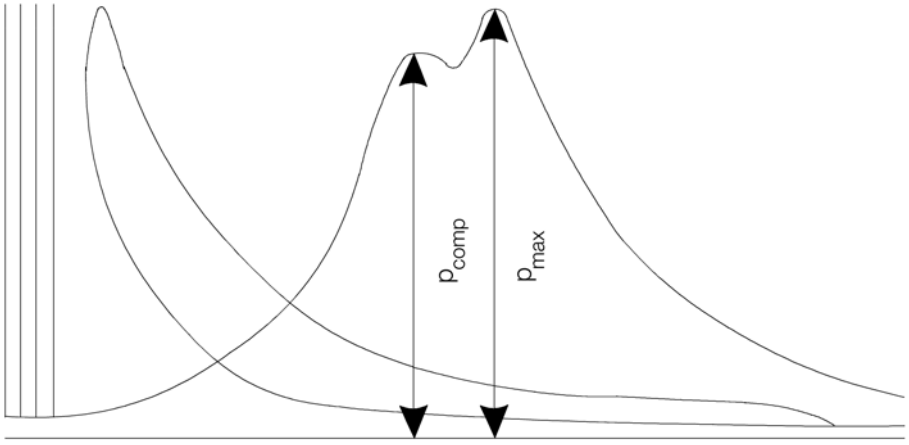
K/L-MC Engines:



S-MC Engines:

For this type of engine it has been necessary to delay the point of ignition to 2 - 3° after TDC, in order to keep the pressure rise, p_{comp} - p_{max}, within the specified 35 bar, while still maintaining optimum combustion and thereby low SFOC.

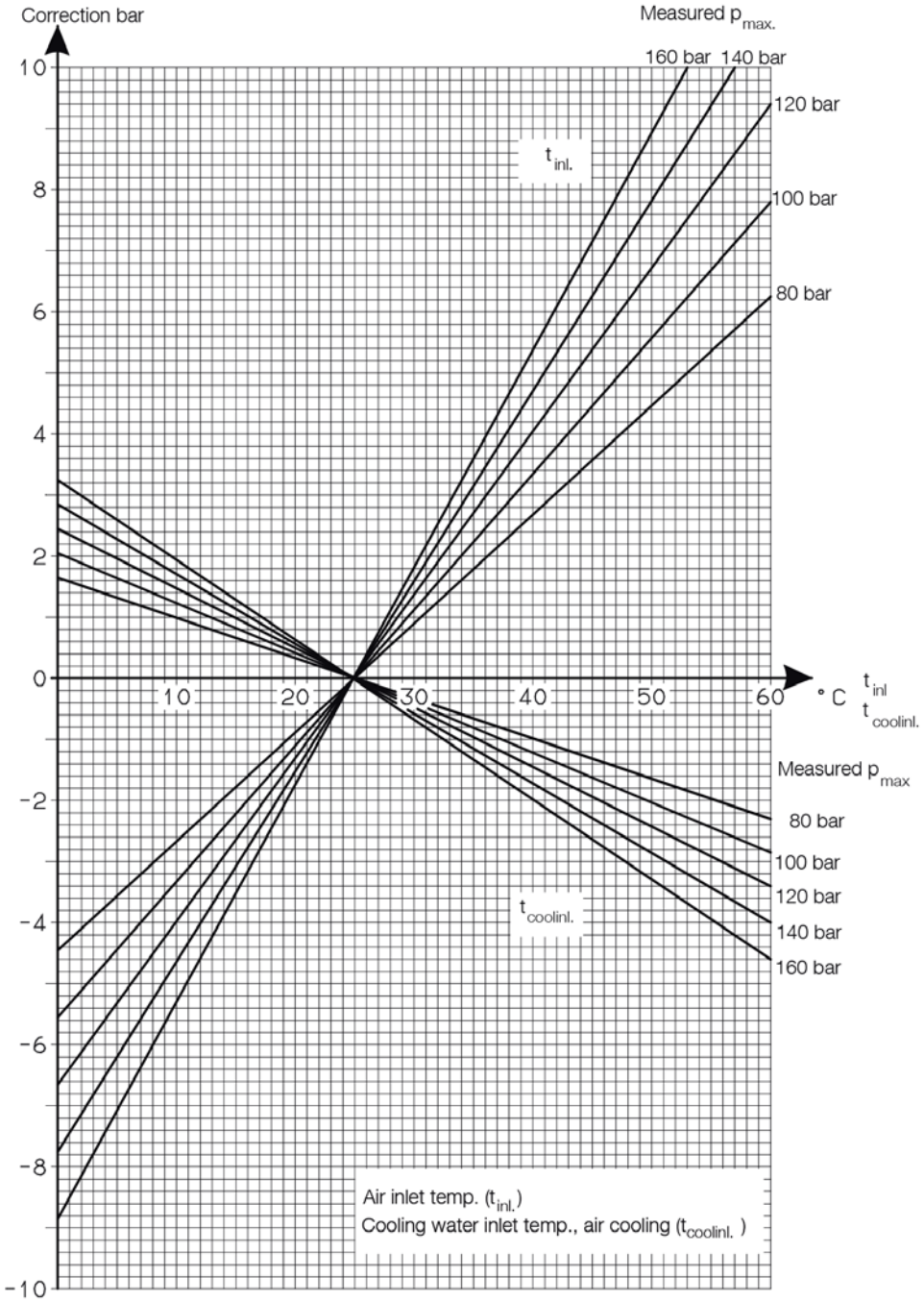
Due to this delay in ignition, the draw diagram will often show two pressure peaks, as shown in the figure below.



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Maximum Combustion Pressure

Correction of measured p_{max}
because of deviations between t_{inl} / $t_{coolinl}$ and standard conditions



Calculating the corrections:

t_{inl} : $A_{corr} = (t_{meas} - 25) \times 2.198 \times 10^{-3} \times (1 + A_{meas})$ Bar

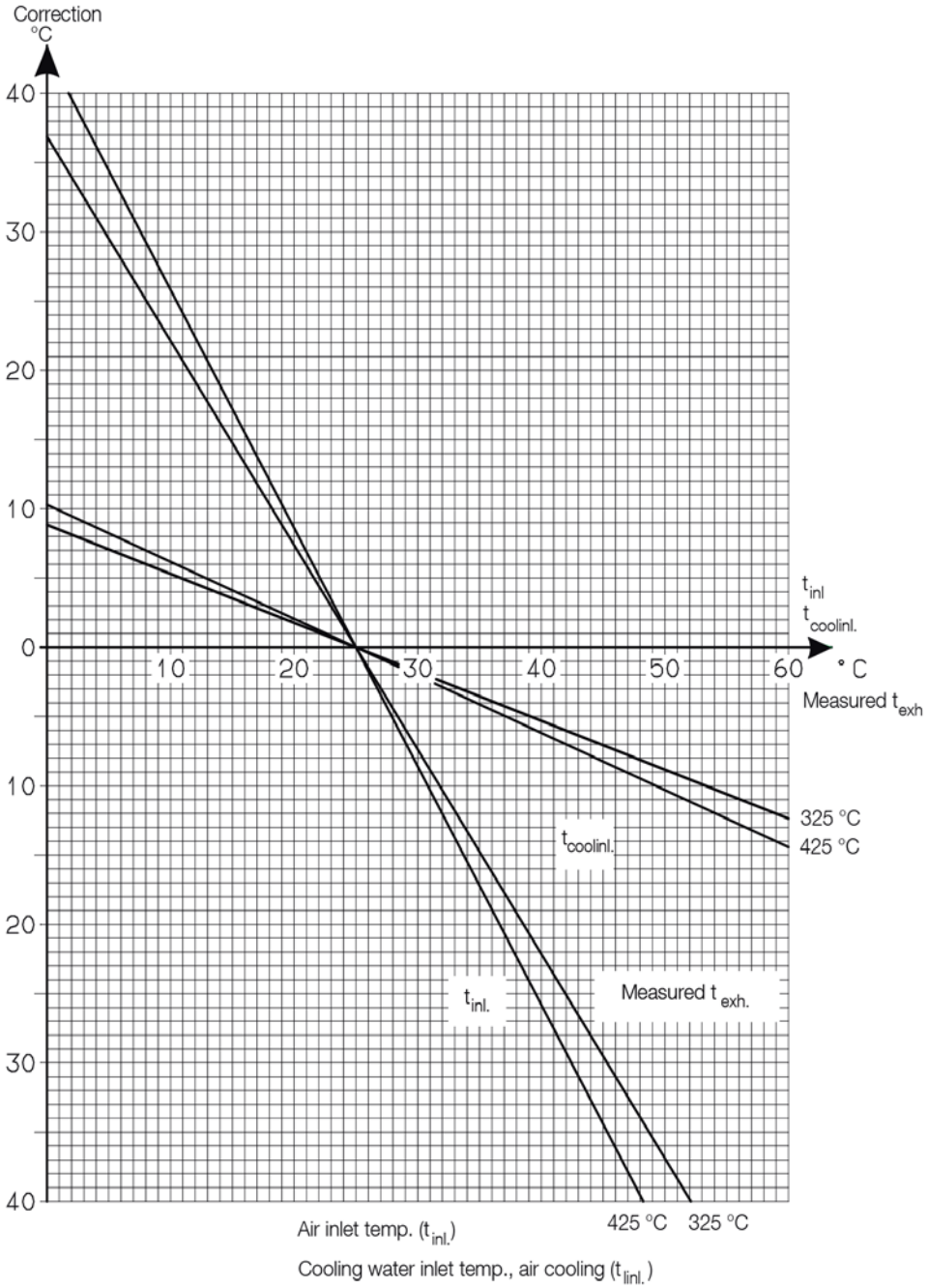
$t_{coolinl}$: $A_{corr} = (t_{meas} - 25) \times -0.810 \times 10^{-3} \times (1 + A_{meas})$ Bar

See page 5.

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Exhaust Temperature (after exhaust valves)

Correction of measured exhaust temperature (t_{exhv})
because of deviations between t_{inl} / $t_{coolinl}$ and standard conditions



Calculating the corrections:

t_{inl} : A_{corr} = $(t_{meas} - 25) \times 2.466 \times 10^{-3} \times (273 + A_{meas})$ °C

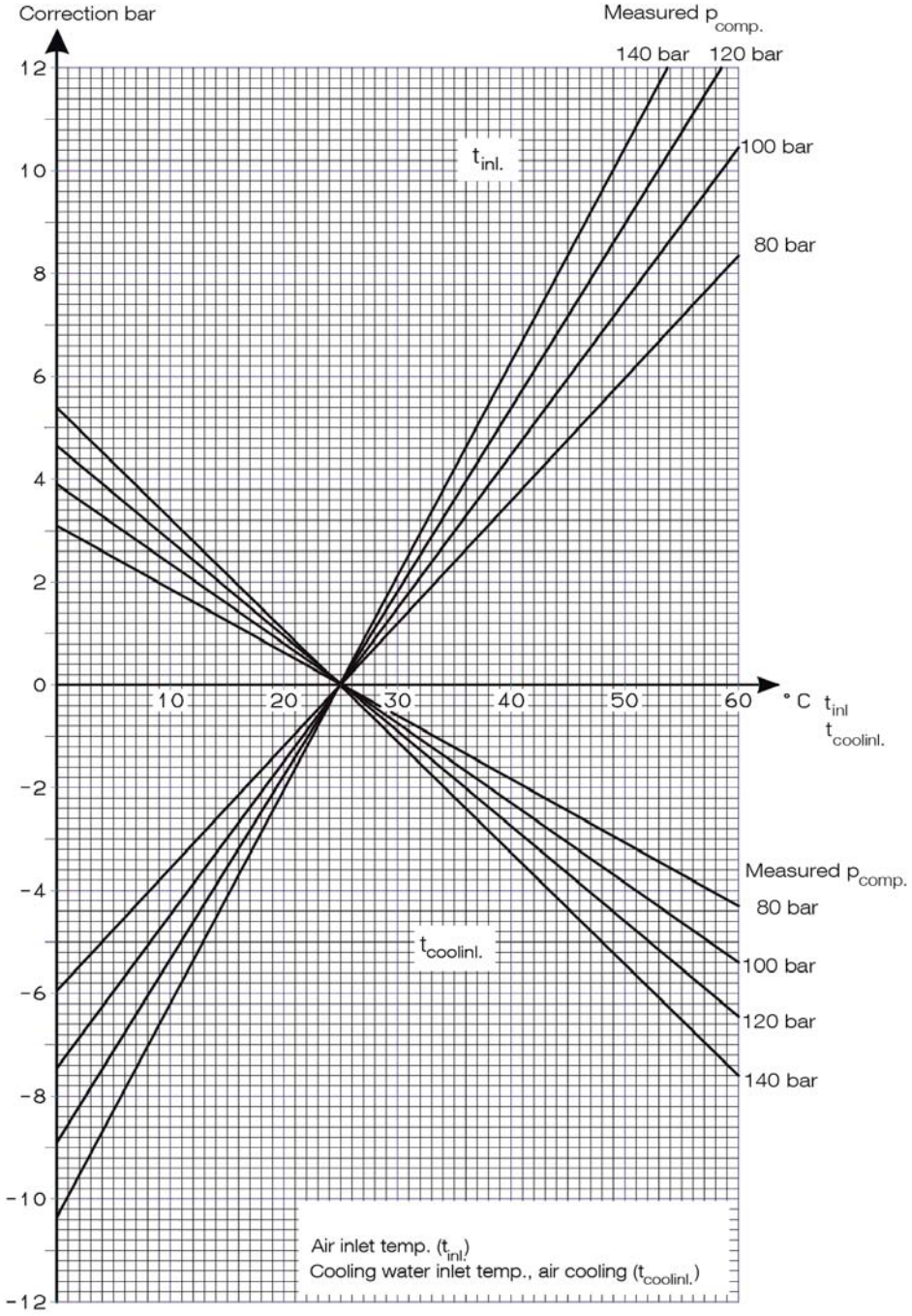
$t_{coolinl}$: A_{corr} = $(t_{meas} - 25) \times -0.590 \times 10^{-3} \times (273 + A_{meas})$ °C

See page 5.

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Maximum Combustion Pressure

Correction of measured p_{max}
because of deviations between t_{inl} / $t_{coolinl}$ and standard conditions



Calculating the corrections:

t_{inl} : $A_{corr} = (t_{meas} - 25) \times 2.954 \times 10^{-3} \times (1 + A_{meas})$ Bar

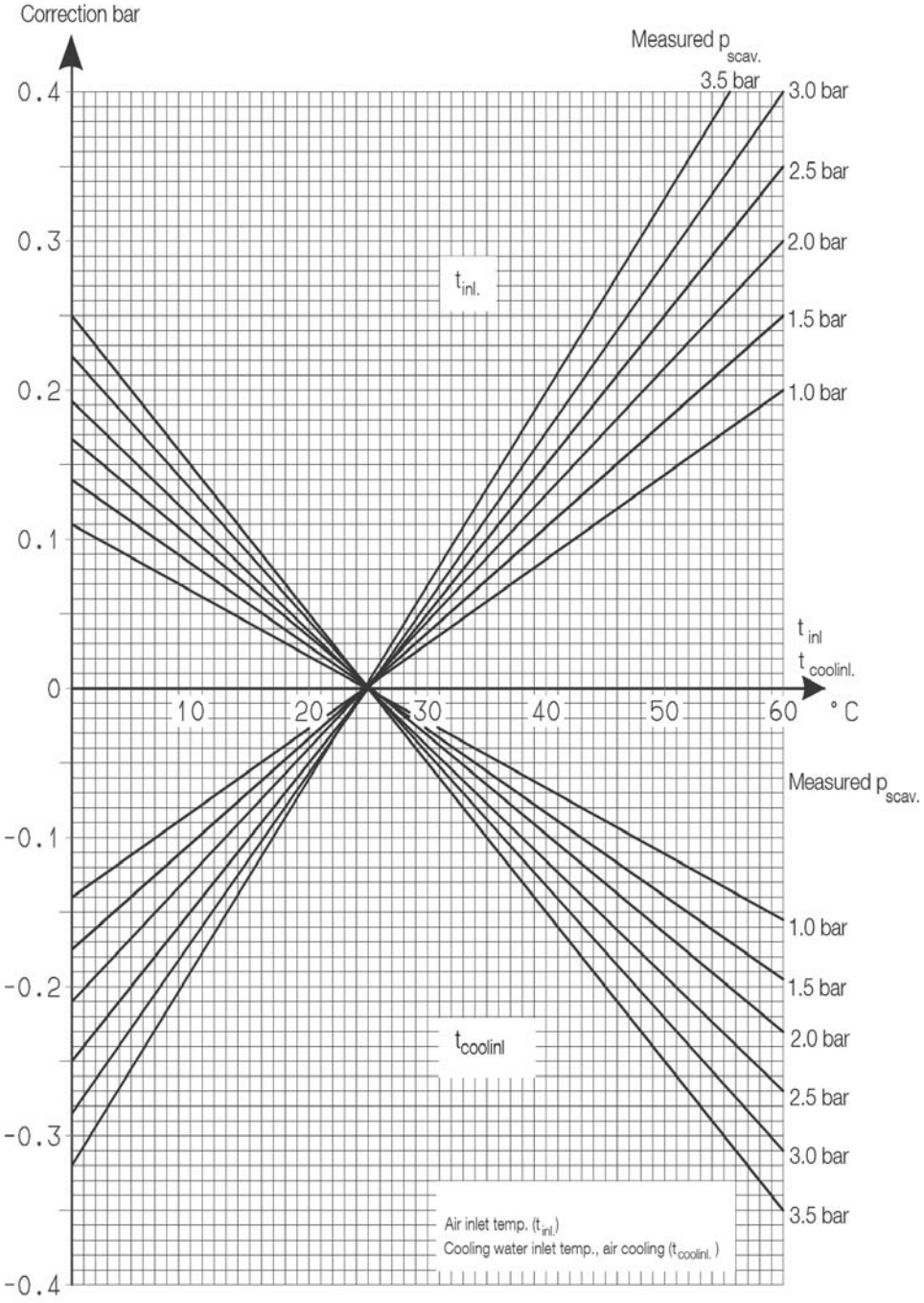
$t_{coolinl}$: $A_{corr} = (t_{meas} - 25) \times -1.530 \times 10^{-3} \times (1 + A_{meas})$ Bar

See page 5.

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Scavenge Pressure

Correction of measured scavenge pressure
because of deviations between t_{inl} / $t_{coolinl}$ and standard conditions



Calculating the corrections:

t_{inl} : $A_{corr} = (t_{meas} - 25) \times 2.856 \times 10^{-3} \times (1 + A_{meas})$ Bar

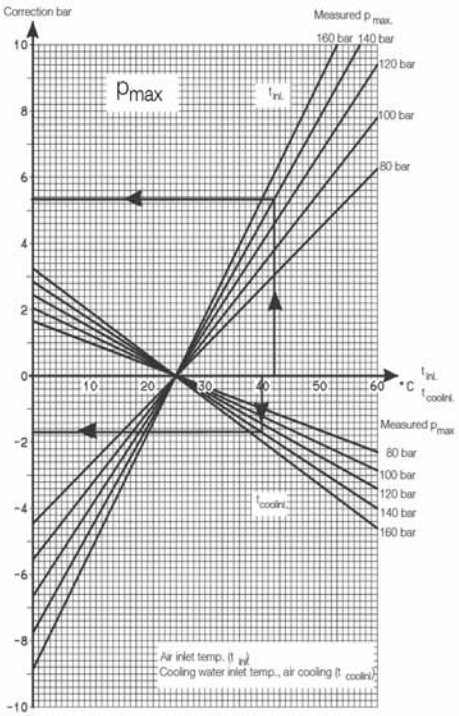
$t_{coolinl}$: $A_{corr} = (t_{meas} - 25) \times -2.220 \times 10^{-3} \times (1 + A_{meas})$ Bar

See page 5.

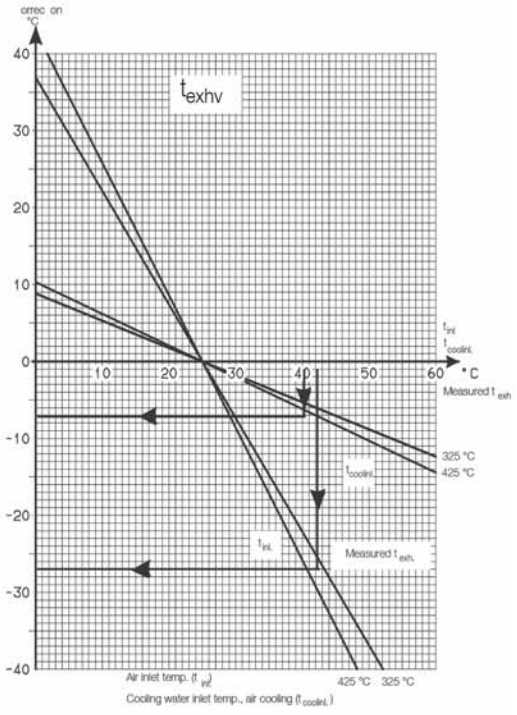
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Example of readings:

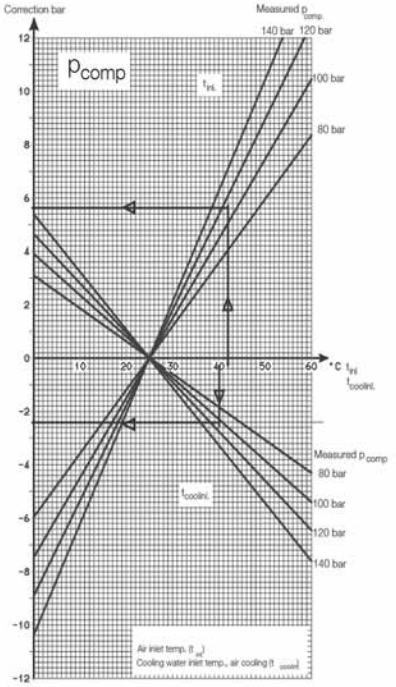
p_{max}	: 140 bar	p_{scav}	: 2.0 bar
t_{exhv}	: 425 °C	t_{inl}	: 42 °C
p_{comp}	: 110 bar	$p_{coolinl}$	: 40 °C



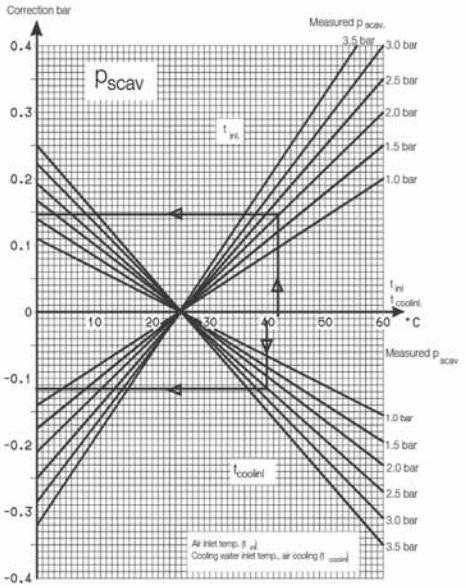
Correction for t_{inl} : +5.3 bar
Correction for $t_{coolinl}$: -1.7 bar
Correction 5.3 - 1.7 : +3.6 bar



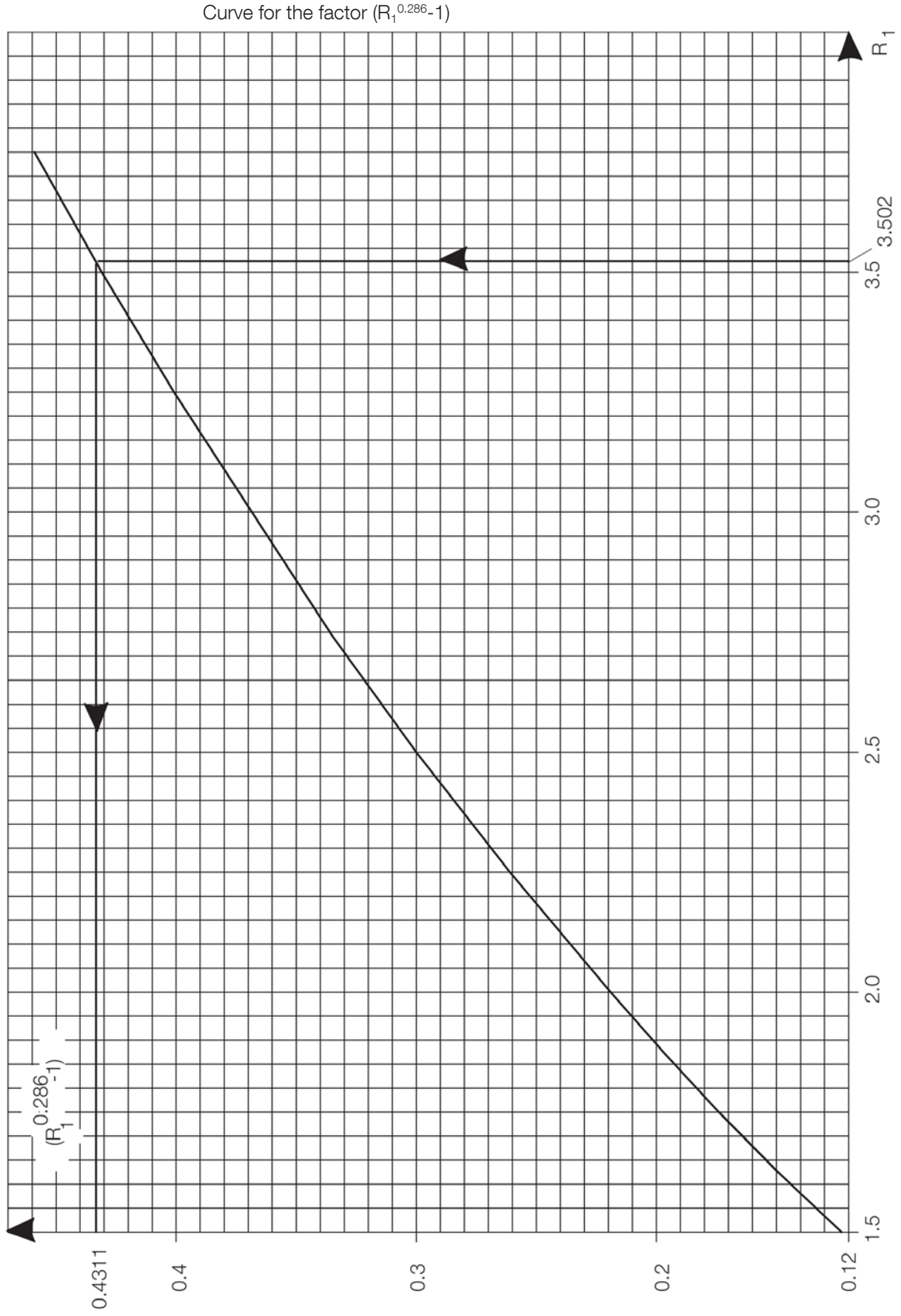
Correction for t_{inl} : -27 °C
Correction for $t_{coolinl}$: -6 °C
Correction -27 - 6 : -33 °C



Correction for t_{inl} : +5.6 bar
Correction for $t_{coolinl}$: -2.5 bar
Correction 5.6 - 2.5 : +3.1 bar



Correction for t_{inl} : +0.145 bar
Correction for $t_{coolinl}$: -0.1 bar
Correction 0.145 - 0.1: +0.045 bar

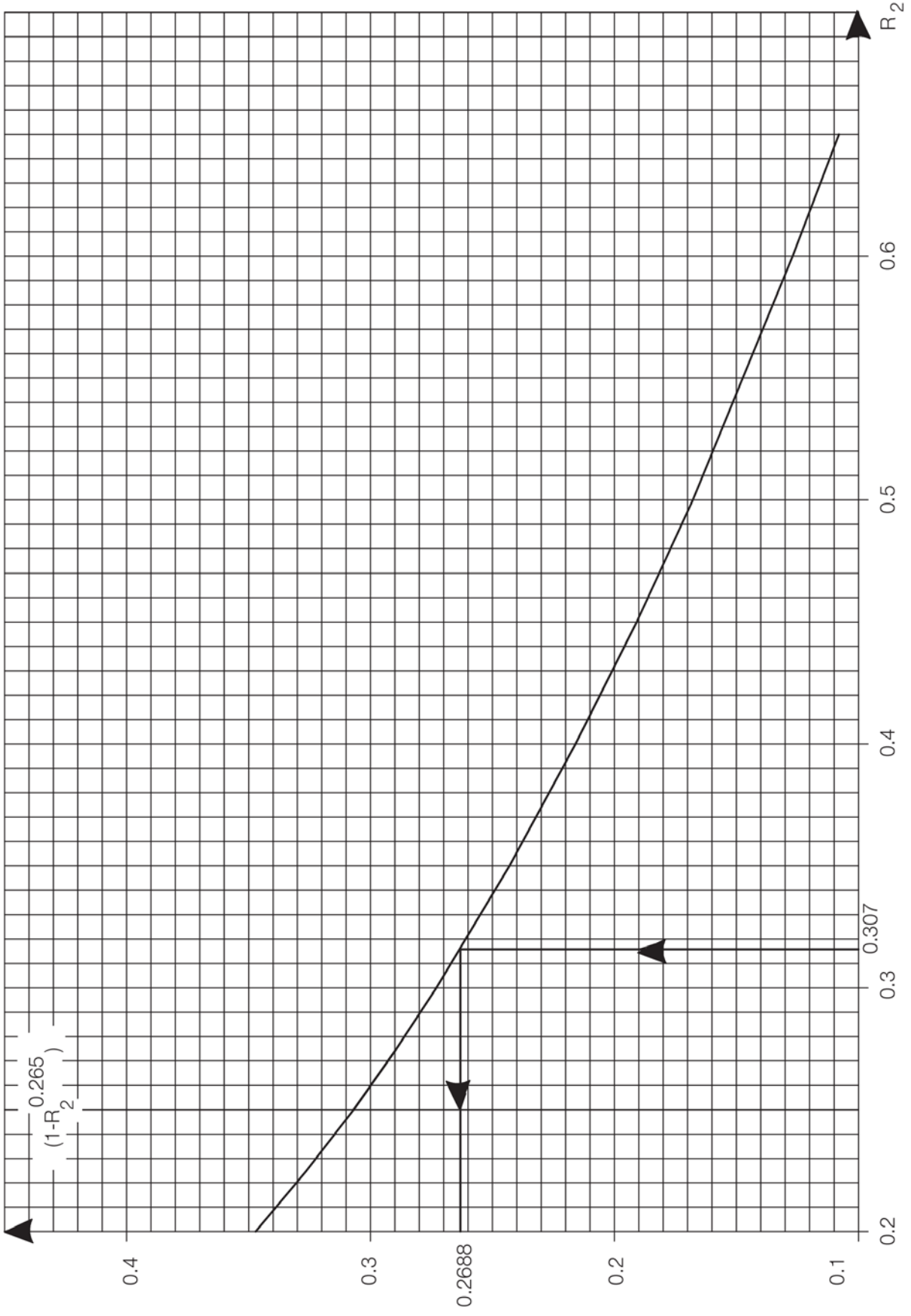


Calculation of Compressor Efficiency

Drawing
6355-0205-0001

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Curve for the factor $(1 - R_2^{0.265})$

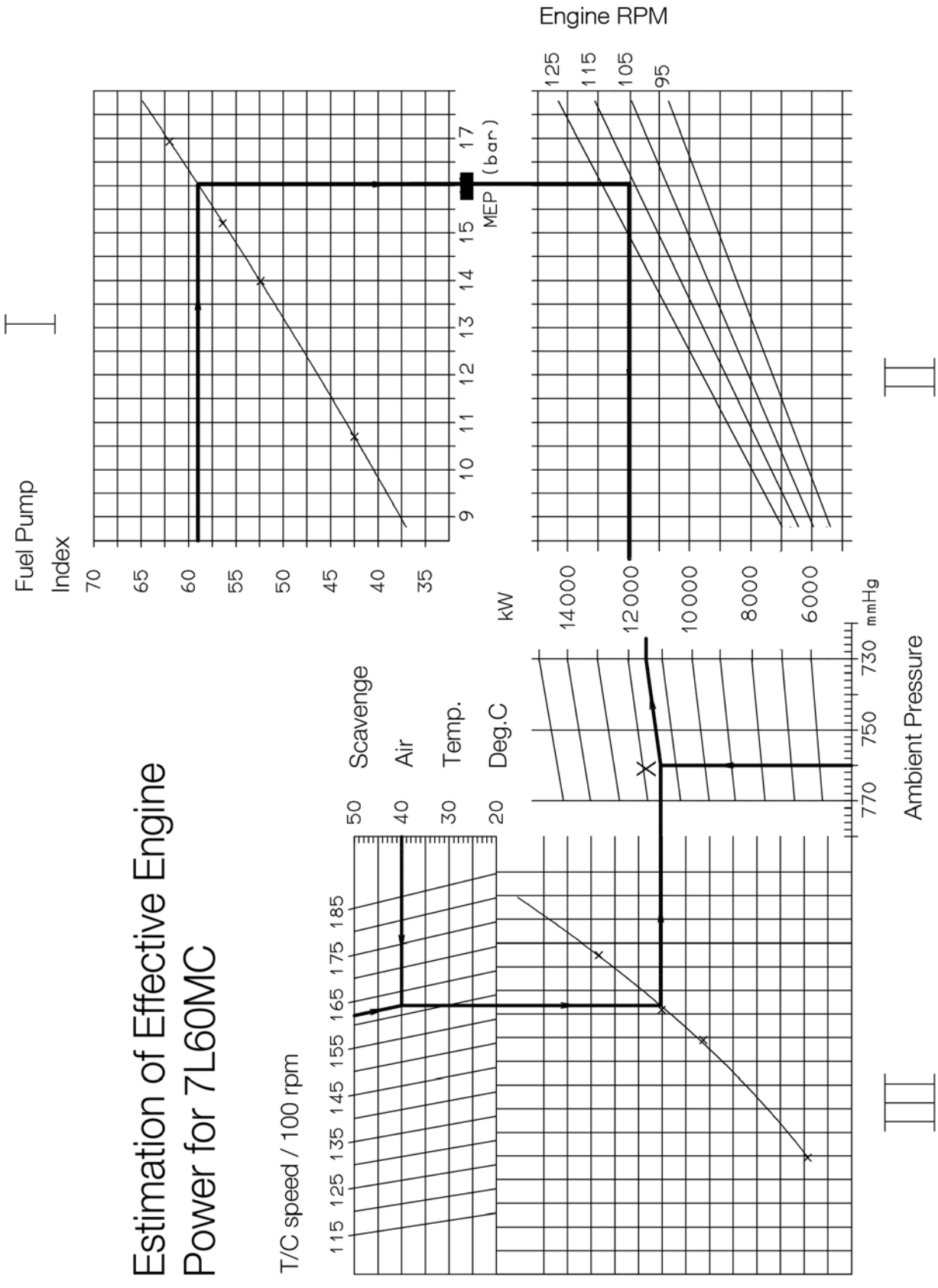


Calculation of Total Turbocharger Efficiency

Drawing
6355-0210-0001

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The Charts and values, in the example below, refer to a particular 7L60MC engine.
For a specific plant, see the actual Testbed Report concerned.



Estimation of Effective Engine Power for 7L60MC

Power Estimation

Drawing
6355-0215-0002

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Turbocharger Make: MAN Diesel & Turbo		
Type Designation	**Diameter, D(m)**	**Slip Factor μ**
TCR18	0.264	0.727
TCR20	0.318	
TCR22	0.415	
TCA44	0.449	0.745
TCA55	0.533	
TCA66	0.633	
TCA77	0.752	
TCA88	0.893	

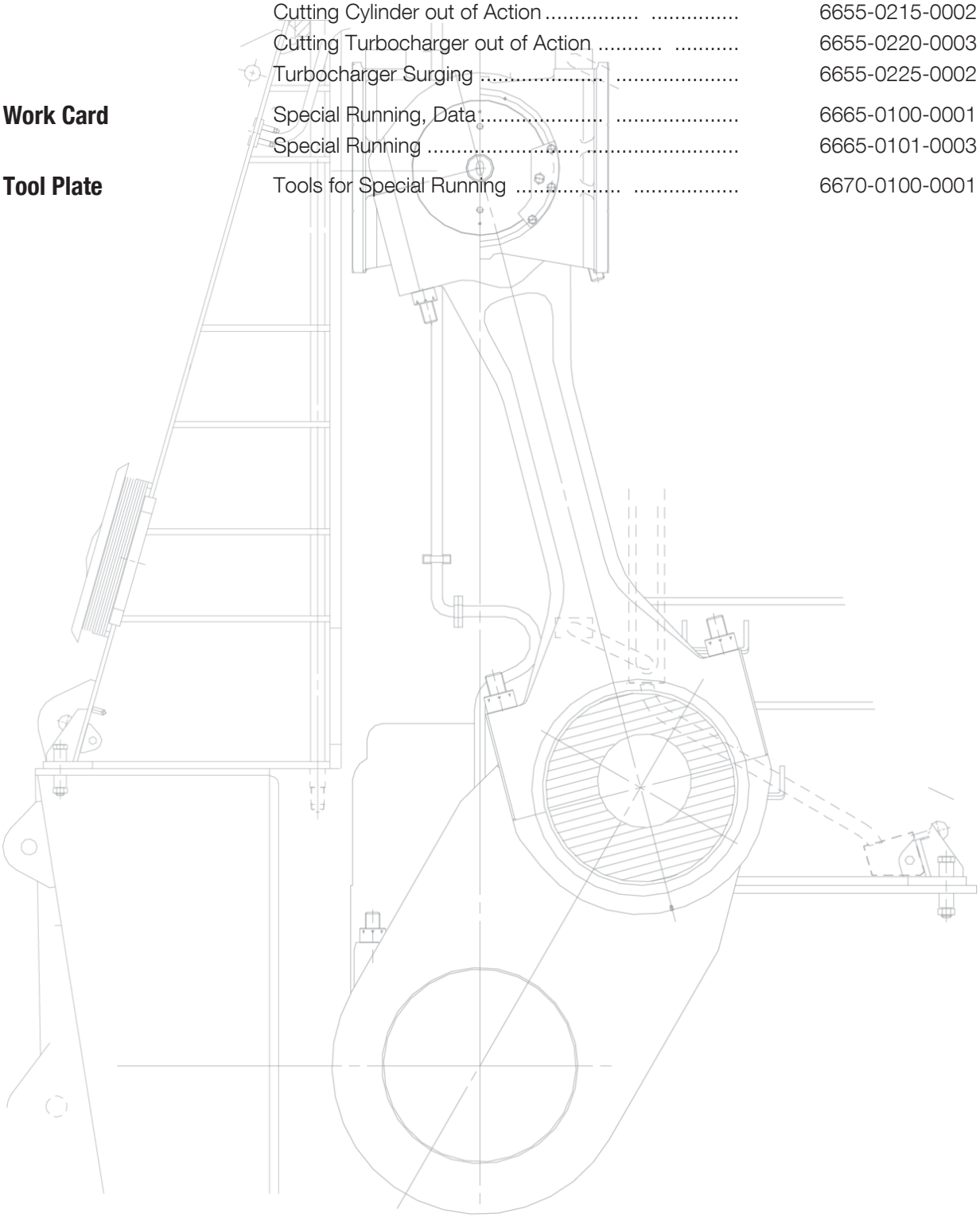
Turbocharger Make: Mitsubishi H.I. (MET)						
Type Designation	**Diameter, D(m)**		**Slip Factor μ**			
Impeller Profile	**All**		**V, Z, W**		**S, O or R**	
Impeller Size	**2**	**3**	**2**	**3**	**2**	**3**
MET33SD,SE	0.352	0.373	0.72		0.69	
MET42SD,SE	0.436	0.462				
MET53SD,SE	0.553	0.586				
MET60MA		0.652				
MET66SD,SE	0.689	0.730				
MET71SE		0.790				
MET83SD,SE	0.873	0.924				
MET90SE		1.020				

Turbocharger Make: ABB TPL					
Type Designation	**Diameter, D(m)**	**Slip Factor μ**	**Type Designation**	**Diameter, D(m)**	**Slip Factor μ**
TPL65-A10	0.3390	0.69	VTR254	0.2943	0.77
TPL69-BA10	0.3999		VTR304	0.3497	
TPL73-B11	0.4879		VTR354	0.4157	
TPL73-B12	0.5065		VTR454D-VA12	0.5233	
TPL77-B11	0.5799		VTR454D-VA13	0.5756	
TPL77-B12	0.6020		VTR564D-VA12	0.6588	
TPL80-B11	0.6729		VTR564D-VA13	0.7247	
TPL80-B12	0.6985		VTR714D-VA12	0.8294	
TPL85-B11	0.8239		VTR714D-VA13	0.9123	
TPL85-B12	0.8553				
TPL91-B12	0.9430				

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Preface Chapter	Operation	6640-0100-0002
Description	Checks during Standstill Periods	6645-0100-0002
	Preparation for Starting	6645-0110-0002
	Starting-up	6645-0120-0002
	Loading	6645-0130-0002
	Running	6645-0140-0003
	Preparations PRIOR to Arival in Port	6645-0150-0002
	Stopping	6645-0160-0002
	Operation AFTER Arrival in Port	6645-0170-0002
	Engine Control System, 50 - 108 ME/ME-C Engines	6645-0180-0003
	Trouble Shooting	6645-0182-0001
	MOP Description	6645-0190-0006
	Alarm Handling on MOP	6645-0240-0007
	Engine Operation	6645-0250-0005
	Auxilliaries	6645-0260-0007
	Maintenance	6645-0270-0005
	Admin	6645-0280-0005
	Fire in Scavenge Air Box	6645-0290-0001
	Ignition in Crankcase	6645-0300-0002
	Turbocharger Surging - Stalling	6645-0310-0001
	Running with Cylinders or Turbochargers out of Operation	6645-0320-0002
	Lubrication Back Up Signal - Special running	6645-0321-0002
	Running with Cracked Cylinder Cover Studs/Stay-bolts	6645-0330-0001
Drawing	Sequence Diagram - FPP Plant	6655-0115-0002
	Sequence Diagram - CPP Plant	6655-0120-0002
	MOP Overview	6655-0125-0004
	MOP Alarm List	6655-0130-0006
	MOP Event Log	6655-0135-0005
	MOP Manual Cut-Out List	6655-0140-0005
	MOP Channel List	6655-0145-0006
	MOP Operation	6655-0150-0004
	MOP Status	6655-0155-0002
	MOP Process Information	6655-0160-0004
	MOP Process Adjustment	6655-0161-0002
	MOP Chief Limiters	6655-0162-0002
	MOP Hydraulic System	6655-0175-0004
	MOP Scavenge Air	6655-0180-0005
	MOP Cylinder Lubricators	6655-0185-0004
	MOP System View - I/O Test	6655-0190-0005
	MOP Invalidated Inputs	6655-0195-0005
	MOP Network Status	6655-0200-0005
	MOP Function Test	6655-0203-0002

	MOP Troubleshooting	6655-0204-0002
	MOP Set Time	6655-0205-0005
	MOP Version	6655-0210-0005
	Cutting Cylinder out of Action	6655-0215-0002
	Cutting Turbocharger out of Action	6655-0220-0003
	Turbocharger Surging	6655-0225-0002
Work Card	Special Running, Data	6665-0100-0001
	Special Running	6665-0101-0003
Tool Plate	Tools for Special Running	6670-0100-0001



Operation

This chapter of the instruction book is intended to provide the user with information regarding operation of the engine. Information includes starting, running and stopping of the engine as well as descriptions of special running conditions.

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1 General

The present chapter describes how to check up on the condition of the engine while it is at a standstill.

To keep the engine-room staff well informed regarding the operational condition, we recommend recording the results of the inspections in writing.

The checks mentioned below follow a sequence which is suited to a forthcoming period of major repairs.

Checks 2.1-2.9
- should be made regularly at engine standstill during normal service.

Checks 2.1 to 2.9 should be coordinated and evaluated together with the measurements described in: *description 6345-0310, 'Engine Synopsis'.*

Checks 3.1-3.5
- should be made at engine standstill *during* the repairs.

Checks 4.1-4.7
- should be made at engine standstill *after* the repairs.

If repair or alignment of bearings, crankshaft, camshaft or pistons has been carried out, repeat checks 2.1, 2.2 and 2.6.

Checks to be made just before starting the engine are mentioned in *description 6645-0110.*

2 Regular Checks at Engine Standstill during Normal Service

The work should be adapted to the sailing schedule of the ship, such that it can be carried out at suitable intervals – for instance as suggested in the 'Checking and Maintenance Schedule'.
See Maintenance Schedule 0760-0300.

The maintenance intervals stated therein are normal for sound machinery. If, however, a period of operational disturbances occurs, or if the condition is unknown due to repairs or alterations, the relevant inspections should be repeated more frequently.

Based upon the results of Checks 2.1-2.9, combined with performance observations, it is determined if extra maintenance work (other than that scheduled) is necessary.

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2.1 Oil Flow

While the circulating oil pump is still running and the oil is warm, open up the crankcase and check that the oil is flowing freely from all crosshead, crankpin and main bearings.

The oil jets from the axial oil grooves in the crosshead bearing lower shells should be of uniform thickness and direction. Deviations may be a sign of "squeezed white-metal" or clogged-up grooves, *See description 2545-0100.*

By means of the sight glasses at the piston cooling oil outlets, check that the oil is passing through the pistons.

Check also the thrust bearing and step-up gear lubrication.

NOTICE

After a major overhaul of pistons, bearings, etc., this check 2.1 should be repeated before starting the engine.

2.2 Oil Pan, and Bearing Clearance

After stopping the circulating oil pump, check the bottom of the oil pan for fragments of white metal from the bearings.

Check crosshead, crankpin, main bearing and thrust bearing clearances with a feeler gauge, and note down the values, as described in *description 2545-0100.*

2.3 Filters

Open up all filters, (also automatic filters), to check that the wire gauze and/or other filtering material is intact, and that no foreign bodies are found, which could indicate a failure elsewhere.

2.4 Scavenge Port Inspection

Inspect the condition of the piston rings, cylinder liners, pistons, and piston rods, as detailed in *description 2245-0100.*

Note down the conditions as described in *description 2245-0100.*

During this inspection, circulate the cooling water and cooling oil through the engine so that leakages, if any, can be discovered.

Remove any coke and sludge from the scavenge air ports and boxes.

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(In case of prolonged port calls or similar, follow the precautions mentioned in point 4.2).

2.5 Exhaust Reciever

Open up the exhaust receiver and inspect for deposits and/or any metal fragments, (which could indicate a failure elsewhere). Examine also the gas grid to make sure that it is clean and undamaged.

2.6 Crankshaft

Take deflection measurements as described in *description 2545-0110.*

2.7 Circulating Oil Samples

Take an oil sample and send it to a laboratory for analysis and comments.
See description 3045-0130.

2.8 Turbocharger

Unscrew the drain plugs or open the cocks at the bottom of the turbocharger housings. Also drain from the drain box/pipe in the exhaust gas uptake (also used when cleaning the exhaust gas evaporator).

This prevents the possible accumulation of rain water, which could cause corrosion in the gas ducts, and partial wash-off of soot deposits, which again may result in unbalance of the turbocharger rotor.

Open inspection covers (if fitted) or remove the gas inlet pipe on the turbine side of the charger, and check for deposits on the turbine wheel and nozzle ring.

See Check 4.4 regarding precautions to avoid turbocharger bearing damage during engine standstill.

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2.9 Regular tests of the ME/ME-C control system

Most failures will be indicated by alarms or malfunction during daily use (malfunction which will not prevent continuous safe operation)

However the following tests listed below have to be carried out regularly in service, to secure proper operation and keeping the redundancy.

The tests are:

1. LOP lamp test.
2. Test of the pilot valves to the main start valve.
3. Function test of cylinder start valves.
4. Start up pumps.
5. HCU Safety by-pass.
6. Test of shut down signals to all MPC units.
7. Cylinder lubricator level sensor slow down function.
   (For plant with level sensor, flow sensor is tested automatically)
8. Leakage test of the hydraulic system.
9. Leakage test of pipes and alarm function (Hydraulic oil system).
10. Visual inspection of the inside of the electronic boxes and check of the tightening torque of the terminals.

See table on the next pages.

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Test	When	Preconditions and initial state	Action	Expected result
1	Weekly	Stopped Engine	Press the lamp test bottom and confirm that the light is on in all lamps (after some time).	
2	After arrival in Port	Stopped Engine Permission from the bridge before FWE	Activate the pilot valves one by one via the MOP-Screen: 'Engine Status', and confirm that the main start valve opens. *See drawing:* *7055-0155 pos. 93 and 94.* This test is to be made together with the cylinder starting valves test 3.	
3	After arrival in Port	Stopped Engine Permission from the bridge before FWE	Make a manual Slow Turn and Air run, via the MOP-Screen: 'Engine Operation', both more than one revolution. Confirm by visual inspection that the rotation has the same regularity during the full revolution.	
4	Monthly		Change master pump via the MOP-Screen: 'Auxiliaries -> Hydraulic System'.	
5	Every 6 month	Engine stopped. MOP Access level = Chief HPS Mode = manual Start-up pumps running.	Open manual connection valve 316 (P1-P2) From MOP-Screen: 'Auxiliaries -> Hydraulic System':	
			- Open Pump Bypass from ACU1	Pressure drops towards zero
			- Close Pump Bypass from ACU1	Pressure increases to 230 bar
			- Open Pump Bypass from ACU3	Pressure drops towards zero
			- Close Pump Bypass from ACU3 **NOTE: Valve 316 must be closed after the test is completed.**	Pressure increases to 230 bar
6	Every 6 month	Engine stopped	Activate emergency stop, check that both ECUA, ECUB and all CCU's gives alarm for shut down. MOP-Screen: 'Alarms -> Alarm List'.	
7	Every 6 month	Engine stopped	Close the manual valve for lube oil supply on all cylinders and activate from the MOP-Screen: 'Auxiliaries -> Cylinder Lubrication' the Lubricator Test Sequence for all cylinders. **NOTE: Lubricator Test Sequence must be All Off when checked**	Cylinder lube oil alarm for all cylinders. Slow Down request activated.
8	Every 6 month		*See work card 4565-0301*.	

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Test	When	Preconditions and initial state	Action	Expected result
9	Every 6 month		*See work card 4565-0301.*	
10		Engine stopped	As described above. *See chapter 0545-0100 Safety Precautions* regarding general cleanliness, order and tidiness.	

3 Checks at Engine Standstill during Repairs

3.1 Bolts, Studs and Nuts

Check all bolts, studs and nuts in the crankcase and chain casing to make sure that they have not worked loose.

The same applies to the holding-down bolts in the bedplate. Check that side and end chocks are properly positioned.
See work card 1065-0201.

Check all locking devices.
See work card 7665-0501.

3.2 Leakage and Drains

Remedy any water or oil leakages. Clean drain and vent pipes of possible blockages by blowing-through.

3.3 Pneumatic Valves in the Control Air System

Clean the filters.

3.4 Bottom Tank

If not done within the previous year, pump the oil out of the bottom tank and remove the sludge. After brushing the tank ceiling (to remove rust and scale), clean the tank and coat the ceiling with clean oil.

After brushing the tank ceiling (to remove rust and scale), clean the tank and coat the ceiling with clean oil.

4 Checks at Engine Standstill after Repairs

If repair or alignment of bearings, crankshaft, camshaft or pistons has been carried out, repeat Checks 2.1, 2.2 and 2.6.

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4.1 Flushing

If during repairs (involving opening-up of the engine or circulating oil system) sand or other impurities could have entered the engine, flush the oil system while bypassing the bearings, as described in *description 3045-0130*.
Continue the flushing until all dirt is removed.

4.2 Piston Rods

If the engine is to be out of service for a prolonged period, or under adverse temperature and moisture conditions, coat the piston rods with clean oil, and turn the engine while the circulating oil pump is running.

Repeat this procedure regularly in order to prevent corrosion attack on piston rods and crankcase surfaces.

4.3 Turning

After restoring normal oil circulation, check the movability of the engine by turning it one or more revolutions using the turning gear.

NOTICE

Before leading oil to the exhaust valve actuators, via the main lube oil pump, check that air supply is connected to the pneumatic pistons of the exhaust valves, and that the exhaust valves are closed.
***See description 6645-0110*.**

4.4 Turbocharger

Mount the drain plugs, (or close the cocks) and re-fit the inspection covers.

Make sure that the turbocharger shafts do not rotate during engine standstill, as the bearings may suffer damage if the shafts rotate while the lube oil supply is stopped.

4.5 Cylinder Lubricators

Check that all pipe connections and valves are tight.

Press the ‘Lubricator Test Sequence’ button on the MOP and inspect that all LED’s for feedback indication on the intermediate boxes are flashing. This indicates that the lubricators are functioning correctly. If in doubt, dismantle the pipe at the cylinder liner to observe the oil flow.
See description 6645-0260.

4.6 Air Cooler

With the cooling water pump running, check if water can be seen through the drain system sight glass or at the small drain pipe from the water mist catcher.

If water is found, the cooler element is probably leaking. In that case the element should be changed or repaired.

5 Laid-up Vessels

During the lay-up period, and also when preparing the engine for a long time out at service, we recommend that our special instructions for preservation of the main engine are followed.

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Generel:

The following descriptions cover the standard manoeuvring system for the engine.

Since the manoeuvring and hydraulic system supplied for a specific engine may differ from the standard system, 'Plant Installation Drawings' should always be consulted when dealing with questions regarding a specific plant.

See Chapter 4245-0120 regarding correct fuel oil temperature before starting.

Regarding checks to be made before starting, when cylinders are out of operation, see Chapter 6645-0320.

1. Air Systems

- Drain water, if any, from the starting air system. *See also Drawing 3455-0100*.
- Drain water, if any, from the control air system at the receivers.
- Pressurise the air systems. Check the pressures. *See also Chapter 0545-0100*, 'Safety Precautions'.
- Pressurise the air system to the pneumatic exhaust valves.

CAUTION

Air pressure must be applied **before** the lube oil pump is started. This is to prevent the exhaust valves from opening too much. *See also Chapter 6645-0100*.

Engage the lifting/rotation check rod mounted on each exhaust valve and check that the exhaust valves are closed.

2. Lube Oil Systems

1. Start the lube oil pumps for:
   - Engine
   - Turbochargers

If the turbochargers are equipped with a separate, built-in, lubrication system, check the oil levels through the sight-glasses.

Check the oil pressures. *See also Chapter 0545-0100*.

2. Check the oil flow, through the sight-glasses, for:
   - Piston cooling oil
   - Turbochargers
3. Check that the cylinder lubricator tank is filled with the correct type of oil. *See also drawing 3055-0110*.

CAUTION

If the regulating handle is put on STAND-BY, the ECS automatically initiates a cylinder prelubrication sequence. When PREPARE START is activated on the MOP, auxiliary blowers and cylinder prelubrication is started.

2008-08-27

3. Cooling Water Systems

CAUTION

*The engine must **not** be started if the jacket cooling water temperature is below 20°C.*

Preheat to minimum 20°C or, preferably, to 50°C. *See also chapter 6645-0130 and 6645-0170*.

- Start the cooling water pumps.
- Check the pressures. *See also chapter 0545-0100*.

4. Slow-Turning the Engine

This must be carried out to prevent damage caused by fluid in one of the cylinders.

Before beginning the slow-turning, obtain permission from the bridge.

CAUTION

Always carry out the slow-turning at the latest possible moment before starting and, under all circumstances, within the last 30 minutes. If it is more than 30 minutes since last rotation and the engine is in STAND-BY mode, at control room or bridge control, the slow turn is performed automatically.

The slow turning device is standard on ME and ME-B-engines, and the slow turning follows item 4.1. However it is still possible to turn the engine manually with the turning gear. See item 4.2.

4.1 Slow-turn with Slow-Turning Device

1. Disengage the turning gear.

   Check that it is locked in the out position.

   Check that the indicator lamp for TURNING GEAR DISENGAGED turns off.
2. Regulating handle is put from FINISHED WITH ENGINE to STAND-BY.
3. Lift the locking plate of the main starting valve to the SERVICE position. Check the indicator lamp.
   - The locking plate must remain in the upper position during running.
   - The locking plate must remain in the lower position during repairs.
4. Open the indicator valves.
5. Turn the slow-turning switch to SLOW-TURNING position.
6. Move the regulating handle to RUN position. Check to see if fluid flows out of any of the indicator valves.
7. When the engine has moved one revolution, move the handle back to STANDBY position.
8. Turn the slow-turning switch back to NORMAL position.
9. Close the indicator valves.

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4.2 Slow-turn with Turning Gear

1. Regulating handle must be in FINISHED WITH ENGINE state.
2. Open the indicator valves.
3. Turn the engine one revolution with the turning gear in the direction indicated by the regulating handle. Check to see if fluid flows out of any of the indicator valves.
4. Close the indicator valves.
5. Disengage the turning gear.
6. Check that it is locked in the out position. Check that the indicator lamp for TURNING GEAR ENGAGED turns off. This is seen on the MOP-panel in the control room.

5. Fuel Oil System

Regarding fuel oil temp. before starting, see chapter 4245-0120.

- Start the fuel oil supply pump and circulating pump. If the engine was running on heavy fuel oil until stop, the circulating pump is already running.

Check the pressures and temperatures.
See also chapter 0545-0100.

6. Hydraulic System. HPS – Hydraulic Power Supply

- Start the electrically driven hydraulic pumps. The ECS states if the oil pressure is correct.

7. Miscellaneous

Check that all drain valves from scavenge air receiver and boxes to drain tank are open and that test cocks are closed. *See drawing 5455-0100.*

Set switch for the auxiliary blowers in AUTO mode. The blowers will start at intervals of 6 sec.

NOTE

See the warning of scavenge air box fire due to incorrectly working auxiliary blowers i chapter 6645-0290

The engine is now ready to start.

NOTE

If the engine has been out of service for some time, starting-up is usually performed as a quay trial. Prior to this, it must be ascertained that:

1: The harbour authorities permit quay trials.
2: The moorings are sufficient.
3: A watch is kept on the bridge.

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1 Starting

Start the engine as described in MOP description.
See description 6645-0250.

CAUTION

If the engine has been out of service for some time, starting-up is usually performed as a quay trial.
Prior to this, it must be ascertained that:

1: The harbour authorities permit quay trials.
2: The moorings are sufficient.
3: A watch is kept on the bridge.

2 Starting Difficulties

Starting Difficulties – ***See also Item 3, 'Supplementary Comments'***

Difficulty	Point	Possible Cause	Remedy
Engine fails to turn on starting air after START order has been given Points marked with * are all monitored by the ECS and an error report will occur.	*1	Pressure in starting air receiver too low	Start the compressors. Check that they are working properly
	*2	Shut-off valve for solenoid valves is closed	Open the valve
	*3	Valve on starting air receiver closed	Open the valve
	*4	No pressure in the control air system	Check the pressure (normally 7 bar). If too low, change over to the other reducing valve and clean the filter
	*5	Main staring valve (ball valve) locked in closed position	Lift locking plate to working position
	6	Main starting valve (ball valve) sticking/ failing	Check the valve
	7	Spool in solenoid air valves sticking	Overhaul the solenoid
	8	Starting air valves in cylinder covers defective	Pressure test the valves. Replace or overhaul defective valves. *See description 6645-0170.*
Engine does not reverse when order is given.	9	Propeller blades are not in zeropitch (CPP-plants).	Set pitch to zero position.

Starting Difficulties – *See also Item 3, 'Supplementary Comments'*			
Difficulty	**Point**	**Possible Cause**	**Remedy**
Engine turns too slowly (or unevenly) on starting air.	10	Trigger/Marker signal missing.	Check signal.
	11	'Slow-turning' of engine adjusted to low.	Set the 'Slow-turning' adjustment screw so that the engine turns as slowly as possible without faltering.
	12	'Slow-turning' is not cancelled (automatic control).	*See the 'Bridge Control' instructions.*
	13	Main starting valve is not working properly.	Check valve.
	14	Sticking slow-turning valve (valve not returned).	Check valve.
Engine turns on starting air but stops after receiving order to run on fuel.	*15	Shut-down of engine (no rotation present).	Check pressure and temperature. Reset "shut-down".
	*16	Fuel Oil Pressure Booster, sticking.	Check Fuel Oil Pressure Booster.
	*17	NC valves not functioning.	Check NC valves.
	*18	Fuel pressure missing (an error is reported in the ECS).	Check fuel pressure.
Engine turns on fuel, but runs unevenly (unstable) and will not pickup rpm.	*19	Auxiliary blowers not functioning.	- Stop the engine. - Start the auxiliary blowers for 10 min. - Slow-turn the engine by air. - Start the engine.
	*20	Scavenge air limit set at too high or too low level.	Check level of scavenge air limiter. Check the scavenge air pressure and the exhaust gas pressure at the actual load. Compare the pressures with testbed or seatrial observations.
	21	Fuel filter blocked.	Clean the filter.
	*22	Too low fuel pressure.	Increase the pressure.
	*23	One or more cylinders not firing.	Check suction valves. *See MOP-panel description.* *If fault not found, check/change fuel valves.*

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3 Supplementary Comments

Item 2, 'Starting Difficulties' gives some possible causes of starting failures, on which the following supplementary information and comments can be given.

Point 1

The engine can usually start when the starting air pressure is above 10 bar. The compressors should, however, be started as soon as the pressure in the starting air receiver is below 25 bar.

Point 7

Examine whether there is voltage on the solenoid valve which controls the starting signal.

If the solenoid valve is correctly activated or the engine is being manually controlled, trace the fault by loosening one copper pipe at a time on the route of the signal through the system, until the valve blocking the signal has been found. The failure can be due to a defective valve, or to the causes mentioned under point 15.

Point 8

The testing procedure describing how to determine that all starting valves in the cylinder covers are closed and are not leaking is found in *description 6645-0170.* If a starting valve leaks during running of the engine, the starting air pipe concerned will become very hot. When this occurs, the starting valve must be replaced and overhauled, possibly replacing the spring. If the engine fails to start owing to the causes stated under point 8, this will usually occur in a certain position of the crankshaft.

If this occurs during manoeuvring, reversing must be made as quickly as possible in order to move the crankshaft to another position, after which the engine can be started again in the direction ordered by the telegraph.

Point 15

If the shut-down was caused by over-speed, cancel the shut-down impulse by moving the regulating handle to the STOP position, whereby the cancellation switch closes.

If the shut-down was caused by too low pressures or too high temperatures, bring these back to their normal level. The shut-down impulse can then be cancelled by actuating the appropriate "reset" switch on the alarm panel.

4 Checks during Starting

Make the following checks immediately after starting:

NOTICE

The start/stop logic in the ECS has already, before start, checked that the direction of rotation is corresponding to the telegraph order.
A live signal from the FIVA valves to the ECS states whether the exhausts valves are operating correctly.
If an error occurs an alarm will occur.

Check 1: Direction of Rotation

Ensure that the direction of propeller rotation corresponds to the telegraph order. The current direction of the propeller can be seen on the MOB screen.

Check 2: Exhaust Valves. - See that all exhaust valves are operating correctly.

Disengage the lifting/rotation indicators (If mounted) after checking the functioning. Check that the slide valve spindles of the sealing air control units protrude through the covers to ensure sealing air supply.

Check 3: Turbochargers

Ensure that all turbochargers are running.

Check 4: Circulating Oil

Check that the pressure and discharge are in order (main engine and turbochargers).

Check 5: Cylinders

Check that all cylinders are firing.

Check 6: Starting Valves on Cylinder Covers

Feel over the pipes. A hot pipe indicates leaking starting valve.
See work card 3465-0201.

Check 7: Pressures and Temperatures

See that everything is normal for the engine speed. In particular: the circulating oil (bearing lubrication and piston cooling), hydraulic oil pressure, fuel oil, cooling water, scavenge air, and control air.

Check 8: Cylinder Lubricators

Make sure that all lubricators are working by checking the feedback signal on the MOP. Follow the Alpha lubricator manual for checking and adjustment of the oil feed rate.

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1 Loading Sequence

Regarding load restrictions after repairs and during running-in, see check 10.

If there are no restrictions, load the engine according to this programme:

Is the cooling water temperature above 50°C?	
YES	▪ Increase gradually to: - FPP-plants: 90% of MCR speed - CPP-plants: 80% pitch ▪ Increase to 100% speed/pitch over a period of 30 minutes or more. *See drawings 6655-0115 and 6655-0120.*
NO	▪ See table below.

Is the cooling water temperature between 20°C and 50°C?	
YES	▪ Preferably, preheat to 50°C. ▪ If you start with a cooling water temperature below 50°C, increase gradually to: - FPP-plants: 90% of MCR speed - CPP-plants: 80% pitch. ▪ When the cooling water temperature reaches minimum 50°C, increase to 100% of MCR speed/pitch over a period of 30 minutes or more. ▪ The time it takes to reach 50°C will depend on the amount of water in the system and on the engine load. *See drawings 6655-0115 and 6655-0120.*
NO	▪ Do not start the engine. ▪ Preheat to minimum 20°C, or preferably to 50°C. When 20°C, or preferably 50°C, has been reached, start and load the engine as described above. *See description 6645-0110.*

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2 Checks during Loading

Check 9: Feel-over Sequence

If the condition of the machinery is uncertain (e.g. after repairs or alterations), the "feel-over sequence" should always be followed, i.e.:

A.	After 15-30 minutes' running on SLOW (depending on the engine size).
B.	Again after 1 hour's running.
C:	At sea, after 1 hour's running at service speed.

Stop the engine, open the crankcase, and feel-over the moving parts listed below (by hand or with a "Thermo-feel") on sliding surfaces where friction may have caused undue heating.



During feeling-over, the turning gear must be engaged, and the main starting valve must be blocked.
Use of safety harness is recommended.

Feel:

- Main, crankpin and crosshead bearings,
- Piston rods and stuffing boxes,
- Crosshead shoes,
- Telescopic pipes,
- Thrust bearing / guide bearing,
- Gear wheels on hydraulic pump gearbox, and chains (on some ME-engines)
- Axial vibration damper,
- Torsional vibration damper (if mounted).

After the last feel-over, repeat *'check 2.1'* as mentioned in *description 6645-0100 'Oil Flow'*: "While the circulating oil pump is still running and the oil is warm, open up the crankcase and check that the oil is flowing freely from all the crossheads, crankpin and main bearings".
See description 6645-0300.

Check 10: Running-in

For a new engine, or after:

- Repair or renewal of the large bearings,
- Renewal or reconditioning of cylinder liners and piston rings, Allowance must be made for a running-in period.

Regarding bearings: increase the load slowly, and apply the feel-over sequence, *see check 9*. Regarding liners/rings: *See description 2245-0100*.

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1 Running Difficulties

Difficulty	Point	Possible Cause	Remedy
Exhaust temperature rises *) a) All cylinders.	1	Increased scavenge air temperature owing to inadequate air cooler function.	*See description 6345-0310 The chapter entitled 'Evaluation of Records', item 4, 'Air Cooler Synopsis'.*
	2	Fouled air and gas passages.	Clean the turbine by means of dry cleaning/water washing. Clean the blowers and air coolers. *See description 6345-0320.* Check the back pressure in the exhaust gas system just after the T/C turbine side. *)
	3	Inadequate fuel oil cleaning, or altered combustion characteristics of fuel.	*See description 4245-0100 *)*
Exhaust temperature rises b) Single cylinder.	4	Defective fuel valves, or fuel nozzles.	*)
	5	Leaking exhaust valve	Replace or overhaul the valve. *)
	6	Blow-by in combustion chamber.	*)
	7	Falling scavenge air temperature.	Check that the seawater system thermostat valve is functioning correctly.
	8	Air/gas/steam in fuel system.	Check the fuel oil supply and circulating pump pressures. Check the function of the de-aerating valve. Check the suction side of the supply pumps for air leakages. Check the fuel oil preheater for steam leakages.
	9	Defective Fuel Oil Pressure Booster (FOPB) suction valve.	Repair the suction valve.
	10	Fuel Oil Pressure Booster (FOPB) plunger sticking or leaking. (an alarm will occur in the ECS)	Replace the fuel oil pressure booster plunger/barrel.
*) *See description 6645-0310 in particular the fault diagnosing table.*			

Table 1: Running Difficulties – See also Item 2. 'Supplementary Comments'

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Running Difficulties (continiued)

Difficulty	Point	Possible Cause	Remedy
Engine r/min decrease	11	Exhaust valve sticking in open position. (an alarm will occur in the ECS)	Replace the exhaust valve.
	12	Oil pressure before fuel oil pressure boosters too low.	Raise the supply and circulating pump pressures to the normal level.
	13	Air/gas/steam in the fuel oil.	*See point 8.*
	14	Defective fuel valve(s) or fuel oil pressure boosters.	Replace and overhaul the defective valve(s) and fuel oil pressure boosters.
	15	Fuel index limited by torque/ scavenge air limiters in the ECS due to abnormal engine load.	*See description 6345-0300.*
	16	Water in fuel oil.	Drain off the water and/or clean the fuel more effectively.
	17	Fire in scavenge air box.	*See description 6645-0290.*
	18	Slow-down or shut-down.	Check pressure and temperature levels. If these are in order, check for faults in the slow-down equipment.
	19	Combustion characteristics of fuel oil.	When changing from one fuel oil type to another, alterations can appear in the r/min, at the same booster index. Fuel index (MEP%) must be rectified with the fuel quality, so that correct MEP can be obtained.
	20	Fouling of hull. Sailing in shallow water.	*See description 6345-0300.*
Smoky exhaust	21	Turbocharger revolutions do not correspond with engine r/min.	Some smoke development during acceleration is normal; no measures called for. Heavy smoke during acceleration: Fault in ECS limiters setting.
	22	Air supply not sufficient.	*See reference quoted under point 1.* Check engine room ventilation.
	23	Defective fuel valves (incl. nozzles).	*See point 4, and description 6345-0340.*
	24	Fire in scavenge air box.	*See description 6645-0290.*

Table 2: Running Difficulties (Continued) - See also Item 2. 'Supplementary Comments

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2 Supplementary Comments

The previous paragraph, 'Running Difficulties' gives some possible causes of operational disturbances, on which the following supplementary information and comments can be given.

Point 5

A leaking exhaust valve manifests itself by an exhaust temperature rise, and a drop in the compression and maximum pressures.

In order to limit the damage, if possible, immediately replace the valve concerned, or, as a preliminary measure, cut out the fuel oil pressure booster.
See description 6645-0320.

Point 6

In serious cases, piston ring blow-by manifests itself in the same way as a leaking exhaust valve, but sometimes reveals itself at an earlier stage by a hissing sound. This is clearly heard when the drain cock from the scavenge air box is opened. At the same time, smoke and sparks may appear.

When checking, or when cleaning the drain pipe, keep clear of the line of ejection, as burning oil can be blown out.

With stopped engine, blow-by can be located by inspecting the condition of the piston rings, through the scavenge air ports. Piston and cylinder liner become black in the area of blow-by. Sludge, which has been blown into the scavenge air chamber, can also indicate the defective cylinder.
See description 2245-0100.

Since blow-by can be due to sticking of unbroken piston rings, there is a chance of gradually diminishing it, during running, by reducing the fuel oil pressure booster index for a few minutes and, at the same time, increasing the cylinder oil amount. If this is not effective, the fuel oil pressure booster index and the p_{max} must be reduced until the blow-by ceases.

The pressure rise p_{comp} - p_{max} must not exceed the value measured on testbed at the reduced mean effective pressure or fuel oil pressure booster index.
Regarding adjusting of p_{max}: *See MOP description 6645-0250.*

If the blow-by does not stop, the fuel oil pressure booster should be taken out of service (with the engine stopped), or the piston rings changed. The load limit can be reduced and the exhaust valve movement stopped individually on each cylinder, without stopping the engine.

Running with piston ring blow-by, even for a very limited period of time, can cause severe damage to the cylinder liner. This is due to thermal overheating of the liner. Furthermore, there is a risk of fire in the scavenge air boxes and scavenge air receiver.
See description 6645-0290.

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In case of severel blow-by, there is a general risk of starting troubles owing to too low compression pressure during the starting sequence.

Concerning the causes of blow-by, *See description 2245-0100,* where the regular maintenance is also described.

Points 8 and 13

Air/gas in the fuel oil system can be caused by a sticking fuel valve spindle, or because the spring has broken.

If a defective fuel valve is found, this must be replaced, and it should be checked that no fuel oil has accumulated on the piston crown.

Points 10 and 14

If, to obtain full load, it proves necessary to increase an individual fuel booster index by more than 10% (from sea trial value), then this in most cases indicates that the fuel oil pressure booster is worn out. This can usually be confirmed by inspecting the plunger. If the cut-off edge shows a dark-coloured eroded area, the fuel oil pressure booster plunger/barrel should be replaced.

3 Check during Running

Check 11: Thrust Bearing

Check measuring equipment.

Check 12: Chain Tighteners (if applicable)

Check the chain tighteners for the moment compensators (if applicable). The combined chain tighteners and hydraulic damping arrangements should be re-adjusted, when the red-coloured part of the wear indicators is reached.
See work card 1465-0501.

Check 13: Shut Down and Slow Down

Check measuring equipment.

Check 14: Pressure Alarms (Pressure Switches)

General:
The functioning and setting of the alarms should be checked.

It is essential to carefully check the functioning and setting of pressure sensors and temperature sensors.

They must be checked under circumstances for which the sensors are designed to set off alarm.

This means that sensors for low pressure/temperature should be tested with falling pressure/temperature, and sensors for high-pressure/temperature should be tested with rising pressure/temperature.

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Checking:
If no special testing equipment is available, the checking can be effected as follows:

a. The alarm pressure switches in the lubricating and cooling systems may be provided with a test cock, by means of which the pressure at the sensor may be decreased, and the alarm thereby tested.

b. If there is no such test cock, the alarm point must be displaced until the alarm is given. When the alarm has thus occurred it is checked that the pressure switch scale is in agreement with the actual pressure. (Some types of pressure switches have an adjustable scale).

   Then reset the pressure switch to the preselected alarm limit, which should cause the alarm signal to stop.

Check 15: Temperature Alarms (Thermostats)

See also Check 14, 'General'.

Most of the thermostatic valves in the cooling systems can likewise be tested by displacing the alarm point, so that the sensor responds to the actual temperature.

However, in some cases, the setting cannot be reduced sufficiently, and such valves must either be tested when the service temperature has been reached, or by heating the sensing element in a water bath, together with a reference thermometer.

Check 16: Oil Mist Detector

Check the oil mist detector.

Adjustment and testing of the alarm function is effected in accordance with the instructions given on the equipment, or in the separate Oil Mist Detector instruction book.

Check 17: Observations

Make a full set of observations, by means of the PMI-system. Check that pressures and temperatures are in order.
See drawing 6355-0110 ' Performance Observations' and description 6345-0330.

Check the load distribution between the cylinders.
See description 6345-0310.

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1 General

CAUTION

Scavenge port inspection

***See description 2245-0100,* regarding scavenge port inspection prior to arrival in port.**

1. Decide whether the harbour manoeuvres should be carried out on diesel oil or on heavy fuel oil.
   See description 4245-0120.

   Change-over should be carried out one hour before the first manoeuvres are expected.
   See description 4245-0120.

2. Start an additional auxiliary engine to ensure a power reserve for the manoeuvres.

3. Make a reversing test (FPP-plants). *This ensures that the starting valves and reversing mechanism are working*.

4. Blow-off any condensed water from the starting air and control air systems just before the manoeuvres.

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1 General

Always perform a stop manoeuvre before entering harbour/taking pilot on board to state that the ECS is functioning as intended.

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1 General

When the 'FINISHED WITH ENGINE' order is received in the control room:

1. Test the starting valves for leakage:
   - Obtain permission from the bridge.
   - Check that the turning gear is disengaged.

     Next step is because a leaky valve can cause the crankshaft to rotate.

   - Close the main air valve to the starting air distribution system.
   - Open the indicator valves.
   - Change-over to manual control from the LOP on the engine side.
   - Activate the START button.

     This admits starting air, but not control air, to the starting valves.

   - Check to see if air blows out from any of the indicator valves.
     In this event, the starting valve concerned is leaky.

     If the cylinder is in BDC, detection can be difficult, due to air escaping through the scavenge air ducts in the cylinder liner.

   - Replace or overhaul any defective starting valves.

2. Lock the main starting valve in its lowest position by means of the locking plate.

   Engage the turning gear.
   Check the indicator lamp.
   Check that the valve to the starting air distribution system is closed.

3. Close and vent the control air and safety air systems.

   Do not stop the air supply to the exhaust valve air cylinders, as air draught through an open exhaust valve may cause the turbocharger shaft to rotate, thus causing bearing damage, if the lube oil supply to the turbocharger is stopped.

4. Wait minimum 15 minutes after stopping the engine, then:

   Stop the lube oil pumps
   Stop the cooling water pumps.

   This prevents overheating of cooled surfaces in the combustion chambers, and counteracts the formation of carbon deposits in piston crowns.

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5. Fuel oil pumps:

Did the engine run on heavy fuel oil until STOP?	
YES	▪ Stop the fuel oil supply pumps. ▪ Do not stop the circulating pumps. ▪ Keep the fuel oil preheated. *The circulating oil temperature may be reduced during engine standstill.* *See description 4245-0120 'Fuel Preheating when in Port'.* *Cold heavy fuel oil is difficult or even impossible to pump.*
NO	▪ Stop the fuel oil supply and circulating pumps.

6. Freshwater preheating during standstill:

Will harbour stay exceed 4-5 days?	
YES	▪ Keep the engine preheated or unheated. *However, see description 6645-0110, item 3 and description 6645-0130, item 1.*
NO	▪ Keep the engine preheated to minimum 50°C. *This counteracts corrosive attack on the cylinder liners during starting-up.* ▪ Use a built-in preheater or the auxiliary engine cooling water for preheating of the engine. *See description 5045-0100 'Cooling Water System'.*

7. Switch-off other equipment which need not operate during engine standstill.

8. Regarding checks to be carried out during engine standstill.
See description 6645-0100.

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WARNING

Authorised personnel only!

Please note that access to the areas of the MOP computer behind the user interface screens shown in the appendix of this manual, is restricted to personnel authorised by MAN Diesel & Turbo.

Altering items in the restricted area of the MOP may result in engine failure.

1 General

The Engine Control System (ECS) consists of a set of controllers.
See Drawing 7055-0150.

Briefly described, the functions of the controllers are:

EICU	The Engine Interface Control Units handle the interface to external systems.
ECU	The Engine Control Units perform the engine control functions: engine speed, running modes and start sequence.
ACU	The Auxiliary Control Units control the pumps of the hydraulic system unit and the auxiliary blowers.
CCU	The Cylinder Control Units control the ELFI/ELVA and FIVA valves, starting air valves, and the ME cylinder lubricators.
SCU	The Scavenge Control Unit controls both the Exhaust Gas Bypass (both on/off as well as variable bypass) and VT- Variable Turbocharging. (Optional)
MOP	The engineers' interface to the ECS.

Normal Working Sequence

The following is an example of how the control units of the ECS work together during normal operation.

EICU

The EICUs receive navigational inputs from the control stations and select the active station based on signals given by the 'Remote Control' system.

The main navigational command is the speed set point (requested speed and direction of engine rotation).

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In the EICUs the raw speed set point is processed by a series of protective algorithms. These ensure that the speed set point from which the engine is controlled is never harmful to the engine. An example of such an algorithm is the 'Barred speed range'.

Now the processed speed set point and the selected engine running mode request are available via the control network to be used by the ECUs as a reference for the speed control and engine running mode control.

The two redundant EICU units operate in parallel.

ECU

The engine speed control requires that the amount of fuel is calculated for each cylinder firing. The calculation made by the speed controller (ECU) is initiated in relation to the crankshaft position, so that the execution is started just in time to make the fuel injection. This is controlled by the tacho function.

The output from the speed controller is a 'request for fuel amount' to be injected for the next combustion. This request is run through different protective algorithms – the fuel limiters – and the 'resulting amount of fuel command' is produced.

Based on the algorithm of the selected engine running mode, the injection profi le is selected, the timing parameters for the fuel injection and exhaust valve are calculated and the pressure set point for the hydraulic power supply derived.

Based on the user input of fuel sulphur content, minimum feed rate etc., the resulting cylinder lubrication feed rate for each individual cylinder unit is calculated.

The resulting amount of fuel command, the requested fuel injection profile, the timing parameters and the resulting cylinder lubrication feed rate amount are all sent to the CCU of the cylinder in question via the control network. Likewise, the hydrulic pressure set point is sent to all ACUs.

For redundancy purposes, the control system comprises two ECUs operating in parallel and performing the same task, one being a hot stand-by for the other. If one of the ECUs fail, the other unit will take over the control without any interruption.

CCU

In appropriate time for the next firing, the CCU ensures that it has received new valid data. Where after the injection profile start angle is set up using the tacho function.

On the correct start angle the injection is initiated and is controlled according to the fuel amount command and the injection profile command.

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When the injection is completed, the exhaust open and close angles are set up using the tacho function and the exhaust valve control signal is then activated on the appropriate crank angles.

The cylinder lubricator is activated according to the feed rate amount received from the ECU.

All of the CCUs are identical, and in the event of a failure of the CCU for one cylinder, only this cylinder will automatically be put out of operation. (Running with cylinders out of operation is explained in Chapter 6645-0320).

ACU

The ACUs control the pressure of the Hydraulic Power Supply system and the electrical start-up pumps using the 'Pressure Set point' given by the ECUs as a reference. Furthermore the start and stop of the auxiliary blowers are controlled according to the scavenge air pressure.

The control of the auxiliary equipment on the engine is normally divided among the ACUs so that, in the event of a failure of one unit, there is sufficient redundancy to permit continuous operation of the engine.

MOP

The Main Operating Panel (MOP) is the main information interface for the engineer operating the engine. The MOP communicates with the controllers of the ECS over the Control Network. However, the running of the engine is not dependant on the MOP, as all the commands from the local control stations are communicated directly to the EICU's/ECS.

The MOP is located in the engine control room. It is a PC with a touch screen as well as a trackball from where the engineer can carry out engine commands, adjust the engine parameters, select the running modes, and observe the status of the control system. A back-up MOP is also placed in the engine control room (*see Chapter 6645-0190 for detailed MOP-description*).

Control Stations

During normal operation the engine can be controlled from either the bridge, the engine control room or the Local Operation Panel (LOP).

The LOP control is to be considered as a substitute for the previous Engine Side-Control console mounted directly onto the MC-engine.

The LOP is as standard placed on the engine.

From the LOP, the basic functions are available, such as starting, engine speed control, stopping, reversing, and the most important engine data are displayed.

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2 Starting from LOP

To start and run the engine from the LOP, some conditions have to be fulfilled. Next to the LOP, a nameplate (containing the text, highlighted below) is placed. The name plate comprises the conditions that have to be fulfilled before start.

Main Engine Start from Local Operating Panel

In order to start/stop and operate the main engine from the Local Operation Panel (LOP), Localcontrol must be selected as the active control station. This is normally done via the request / acknowledge facility of the Remote Control System. However, it is possible to over-ride the normal change-over procedure by means of the 'Forced Take Command' push button. Activating this button will force the control to the local control station.

Before start, the hydraulic oil pressure must be higher than 150 or 205 bar, depending of the hydraulic system is at 200 or 300 bar. After shut down, the pressure has to be rebuild which may take 60 - 120 seconds.

To stop the engine: Activate STOP
(and reset shut down)

To start the engine: Change from STOP to START

If the auxiliary blowers are running, the Engine Control System will start the main engine automatically without delay.

If the auxiliary blowers are stopped, the Engine Control System delays the start until the auxiliary blowers are started and running. Then, the Engine Control System will start the main engine automatically.

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1 General

If you encounter difficulties while operating the ME-engine, this guide can be useful in solving the problems.

The information in this chapter will help you with:

1. Cylinder Components, Tests and Evaluation.
2. Test for Earth Failure in the ECS System.

1.1 Cylinder Components, Tests and Evaluation

This document describes the usage of troubleshooting diagrams and procedures. The procedures only focus on cylinder components (excluding cylinder lubricating components).

Cylinder Fault Diagram

The Cylinder Fault Diagram (CFD – pages 2 and 3 this section) describes the correlation between system failures and symptoms (alarms and other known symptoms). The crosses in the diagram indicate the symptoms that can be generated from a certain failure/ cause.

Cylinder Loop Test (flowchart)

The Cylinder Loop Test (CLT – pages 4 and 5 this section) is a description of a test procedure. The CLT can isolate failures on cylinders where it is known that there is an error.

The test categorises failures in: FIVA valve, FIVA sensor, cabling, MPC, exhaust valve system, exhaust valve sensor, fuel plunger system, fuel plunger sensor and hydraulics.

This makes reference to the below mentioned tests.

Please note that there are separate tests for different FIVA valve types.

Amplifier Test (flowchart)

The Amplifier Test (AT – page 6 this section) is a description of a test procedure. The AT should be used to isolate failures in the amplifier loop if it is known that there is an error.

The test categorises failures in: amplifier, power cabling, cabling to amplifier, FIVA and MPC.

The test is only applicable on systems with Curtiss Wright FIVA valves.

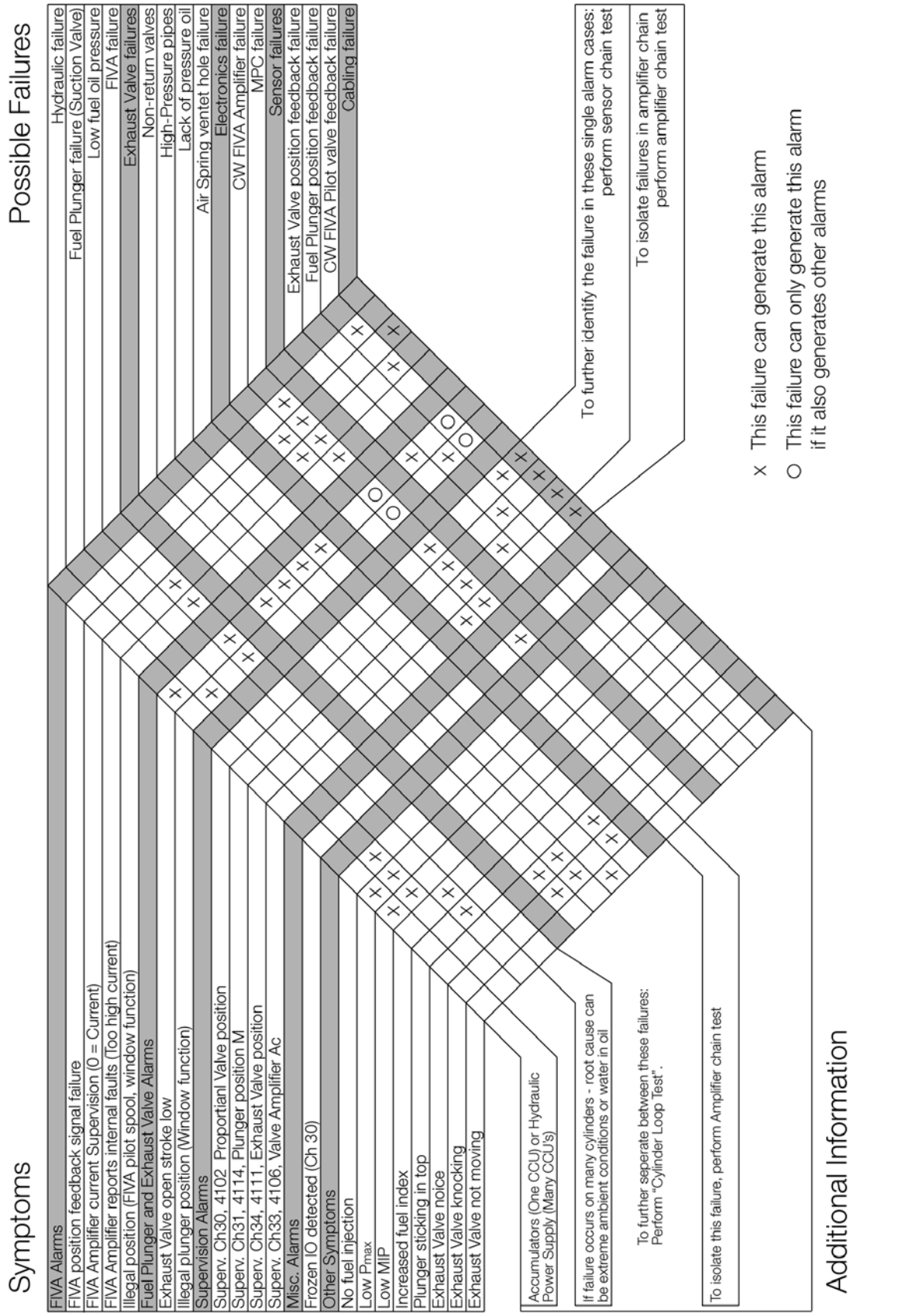
Sensor Chain Test (flowchart)

The Sensor Chain Test (SCT - page 7 this section) is a description of a test procedure. The SCT should be used to isolate failures in sensor chains where there is a supervision alarm or another error.

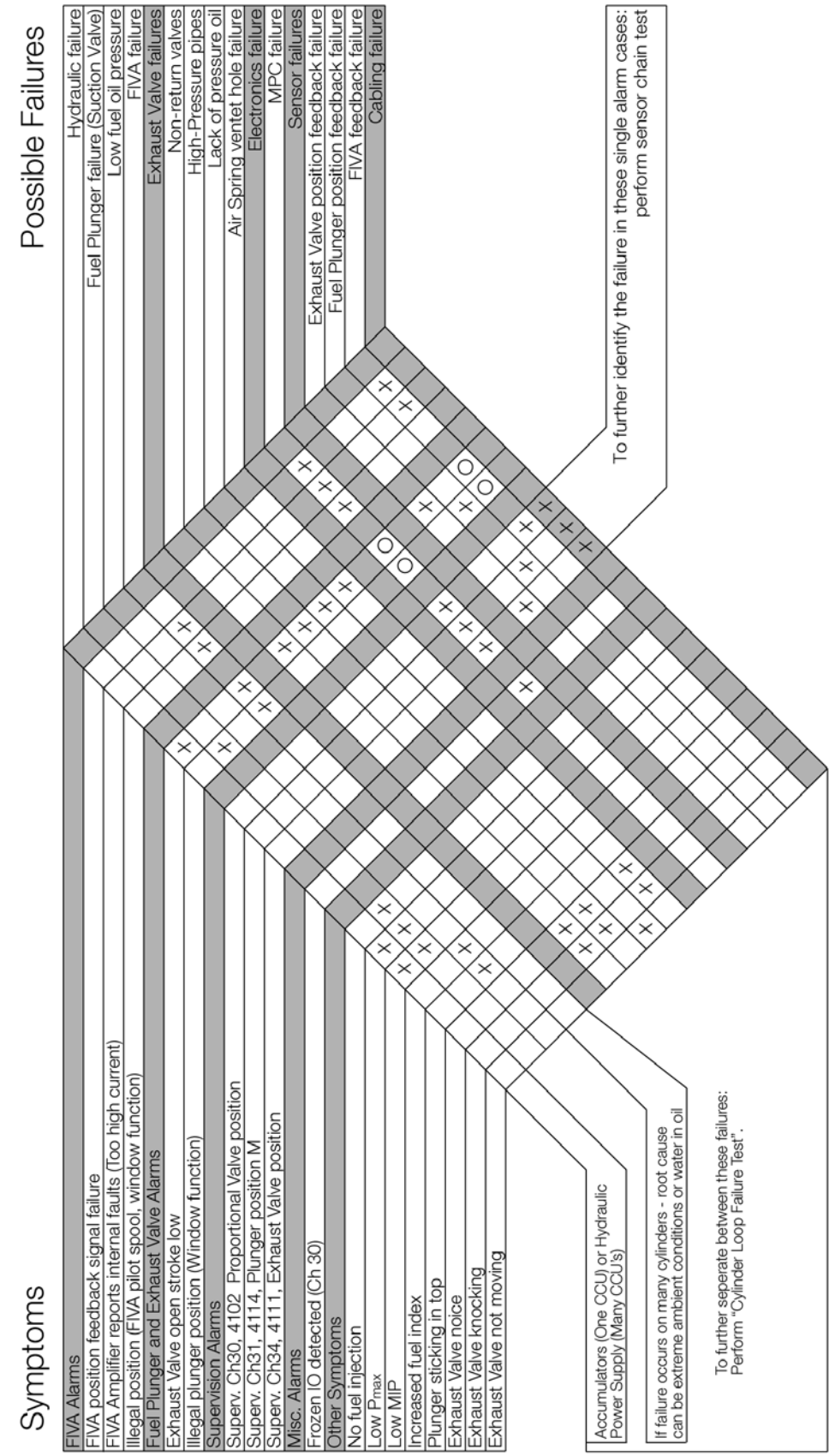
The test categorises failures in: sensor, cabling, MPC.

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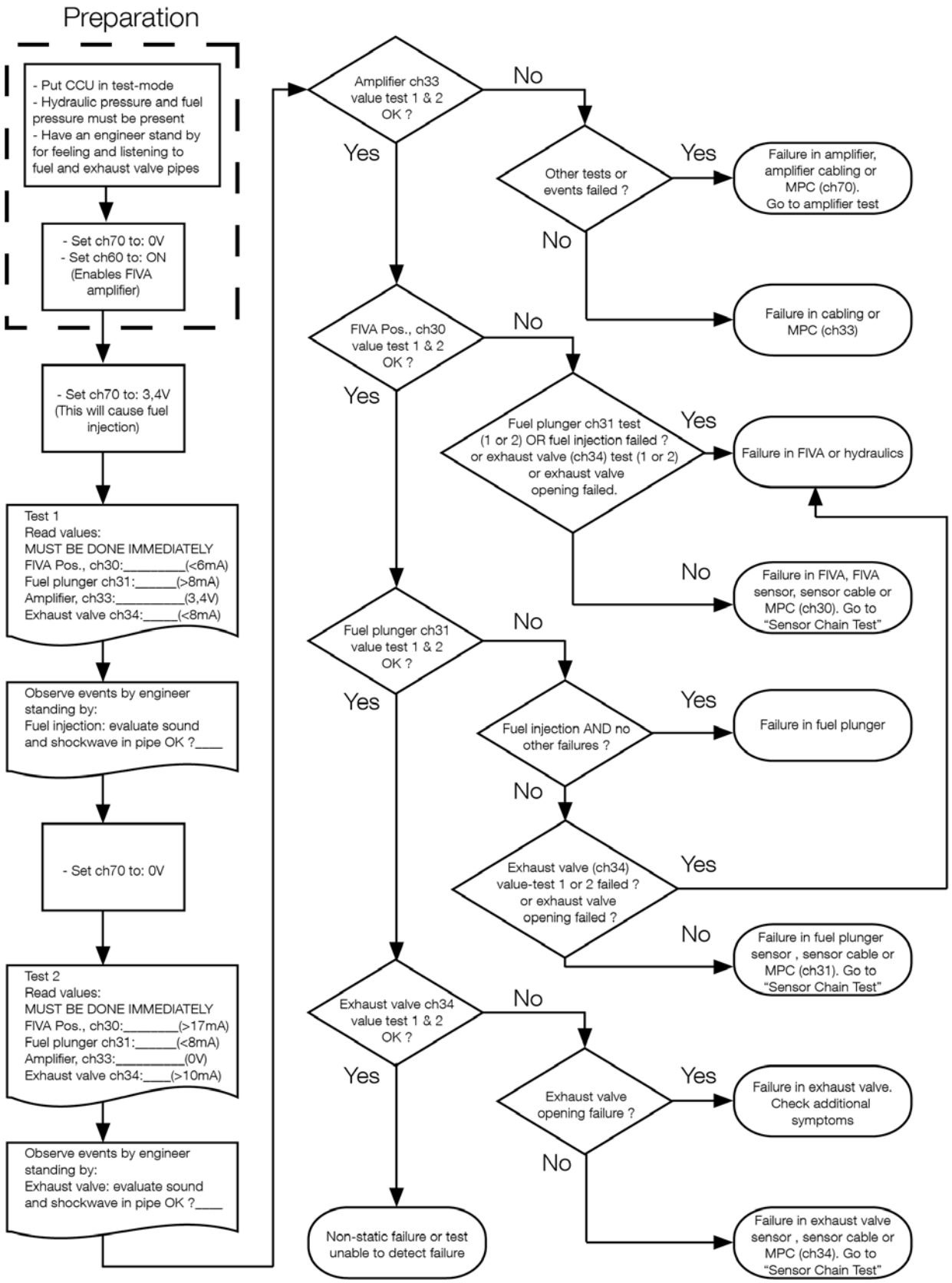
1.1.1 Cylinder Components Failure Tree (CFD - Curtiss Wright FIVA)



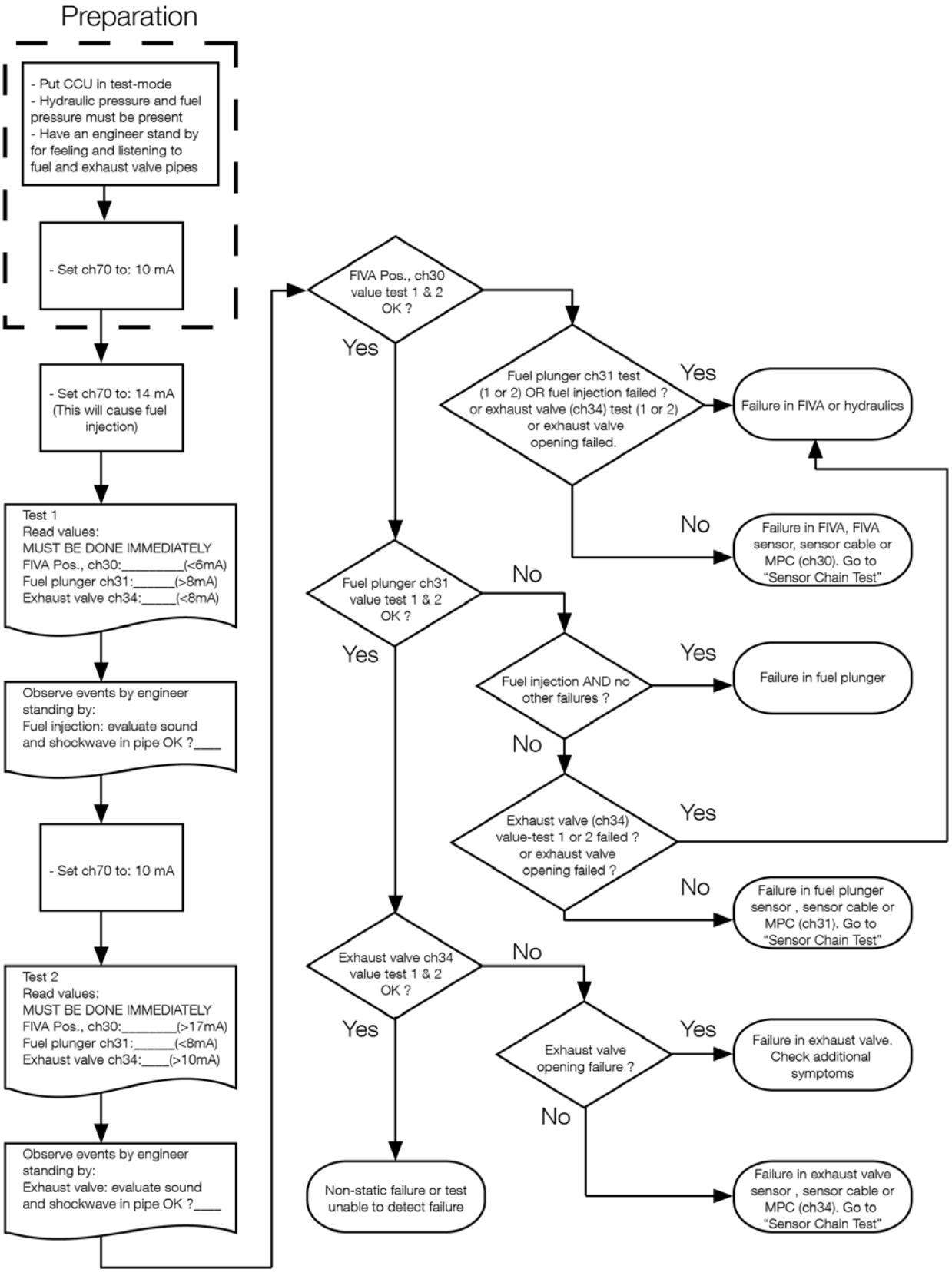
1.1.2 Cylinder Components Failure Tree (CFD – MBD Parker FIVA)



1.1.3 Cylinder Loop Test (CW - FIVA)

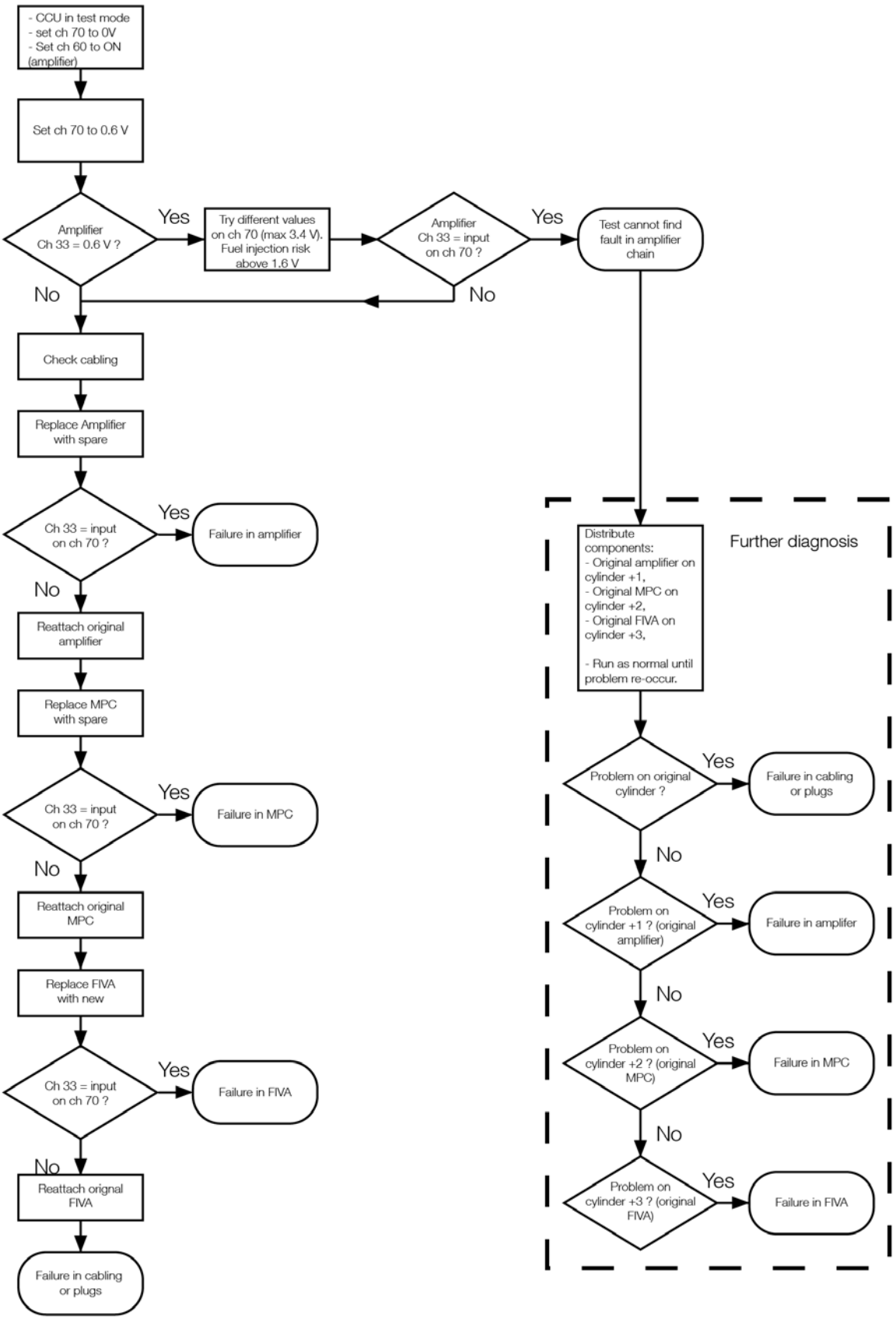


1.1.4 Cylinder Loop Test (MD – FIVA)

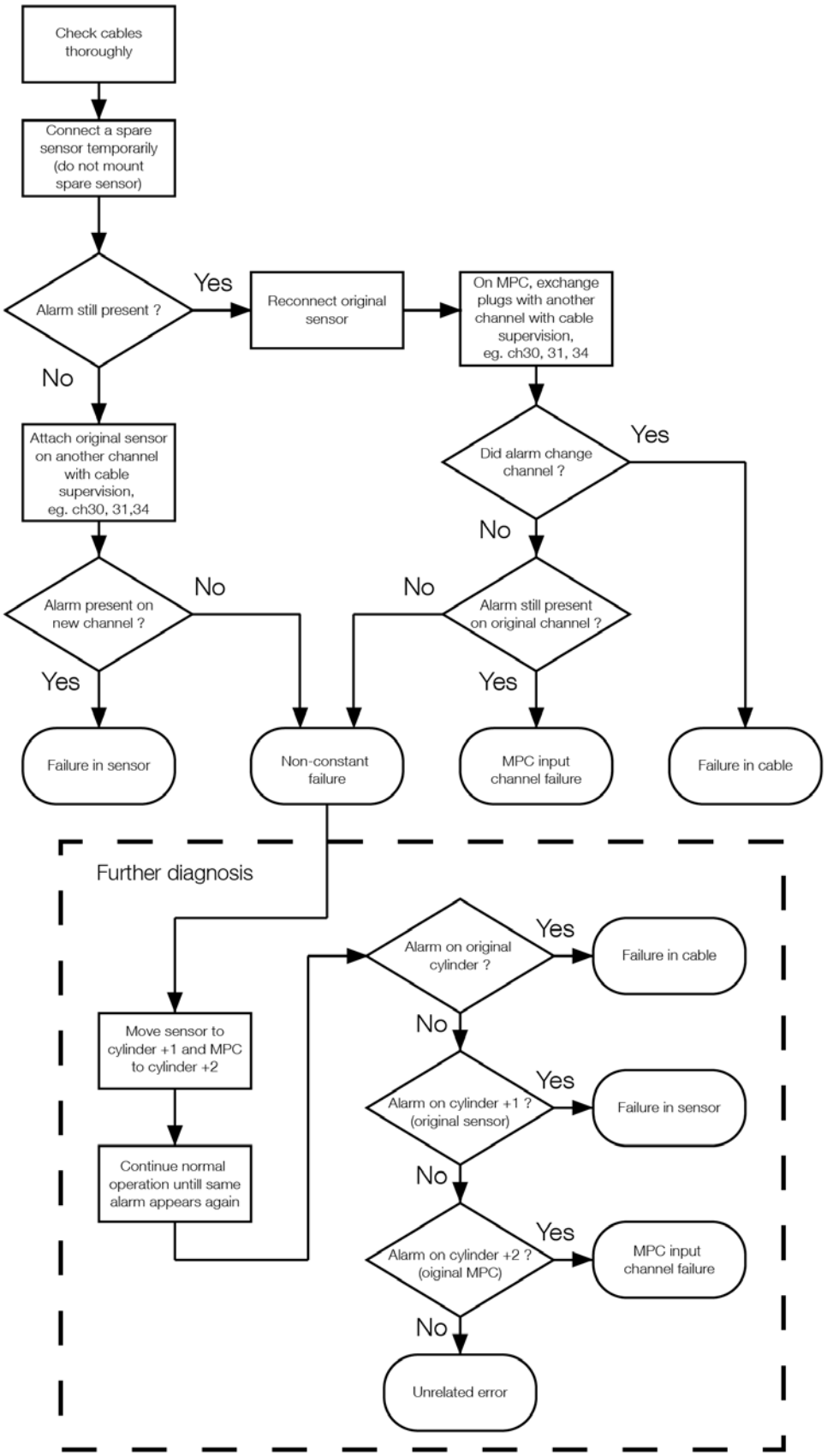


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1.1.5 Amplifier Test (CW – FIVA)



1.1.6 Sensor Chain Test



1.2 Test for Earth Failure in the ECS System

1.2.1 Method 1

Fault isolation of an earth ground failure.
A certain and fast method (compared to method 2 below).
Precondition: The engine must be stopped and in FWE.

1. Disconnect the isolation monitor unit (e.g. Bender xxx) from the power supply.

2. Measure the current between ground (a non-isolated point of the engine or ship steal structure) and 0 Volt, and ground and 24 Volt, respectively, by means of an ampere meter (a multimeter in current mode) in serial with a 2 kOhm resistor. The measurement can practically be done either in the power supply of the ECS or in the power distribution box on the engine. If any of the currents are higher than 0.2 mA, the isolation to ground is too low. In a properly isolated system, the current will be lower than 0.2 mA.

3. Disconnect the power plugs (J1) (which disconnects both 0 Volt and 24 Volt) for one MPC at a time until the MPC containing the isolation fault is found, i.e. when the current drops below 0.2 mA.

4. The power plug to the MPC causing the isolation failure is connected again, and the connectors for sensors and external signals are disconnected one at a time, until either a sensor is found that causes the isolation failure, or all connectors have been disconnected. Ground current must be checked as described in Item 2 between 0 Volt and 24 Volt, respectively, while each connector is disconnected.

5. If the isolation failure is located to a sensor, its cabling must be checked and perhaps the sensor must be exchanged.

6. If the isolation failure is still present after all connectors to external signals are disconnected, while the power connector is still connected to the MPC, the failure is probably in the MPC, which must then be exchanged.

When the problem has been rectified, all connectors and plugs are reinstalled, and the isolation monitor is reconnected. Check that the isolation monitor no longer initiates an alarm (note that failures might be present in more than one unit (MPC) at a time).

1.2.2 Method 2

A certain but slow method.
Precondition: The engine must be stopped and in FWE. 1.

1. Disconnect the power plug (J1) (which disconnects both 0 Volt and 24 Volt) in one of the MPCs .

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2. Wait one minute - check the isolation value on the isolation monitor (e.g. Bender xxxx) in power supply A. If the isolation value is still lower than 24 kOhm (the alarm level), then repeat point 1 in the next MPC. In a properly isolated system the isolation is higher than 100 kOhm.

3. Repeat point 1 and 2 for each MPC until the MPC containing the isolation fault is found, i.e. when the isolation comes above 100 kOhm.

4. The power plug to the MPC causing the isolation failure is connected again.

5. One of the connectors (J2 - J85) for the sensors and external signals is disconnected.

6. Wait one minute - check the isolation value on the isolation monitor as in point 2.

7. Repeat point 5 and 6 for each of the connectors for external signals until either a sensor is found that causes the isolation failure (the isolation comes above 100 kOhm), or all connectors have been disconnected.

8. As method 1 point 5 or point 6.

When the problem has been rectified, all connectors and plugs are reinstalled. Check that the isolation monitor no longer initiates and alarm (note that failures might be present in more than one unit (MPC) at a time).

1.2.3 Method 3

A faster, but uncertain method.
Precondition: The engine must be stopped and in FWE.

1. Disconnect the isolation monitor unit (e.g. Bender xxxx) from the power supply.

2. Connect a voltmeter between the 0 Volt and ground (a non-isolated point of the engine or ship steel structure) and, if possible, another voltmeter between 24 Volt and ground. Alternatively one voltmeter must be connected alternately between 0 Volt and 24 Volt. The measurement can practically be done either in the power supply of the ECS or in the power distribution box on the engine. When using this method both measured values should be within 10 - 16 V (+ or -) if the system has normal isolation to ground, while an isolation failure normally causes one of the measurement to be below 5 V and the other above 20 V.

3. The further procedure is similar to method 1 above, except that pin pointing of the isolation fault is based on the voltage measurements being in the isolation fault or normal range as specified in previous point 2.

When the problem has been rectified, all connectors and plugs are reinstalled, and the isolation monitor is reconnected. Check that the isolation monitor no longer initiates an alarm (note that failures might be present in more than one unit (MPC) at a time).

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1 Main Operation Panel (MOP)

The MOP is the Human Machine Interface (HMI), through which the Engine Control System (ECS) and thus the ME engine is operated. The HMI is described in sections 6645-0240 through 6645-0280.

The MOP is basically a marine approved and certified PC with 24V - DC supply and touch screen.

An actual installation comprises of two MOPs where both are placed in the engine control room (ECR). Typically MOP A is placed in a console opposite the manoeuvring handle (the normal operation position) and MOP B on a desk. The two MOPs are operationally fully redundant to each other. Though some of the more advanced troubleshooting facilities are only available on MOP B. Normally only MOP B has a keyboard connected.

1.1 Creating Screen Dumps

Creating screen dumps can be carried out on a MOP with an attached keyboard. To create a screen dump go to the screen in question and, press the [Prt Scr] button on the keyboard to capture the screen. Press Crtl + Esc to gain access to the windows menu and open a program like Wordpad or Paint and press Paste to copy the screen dump into the program.

1.1.1 Description

MOP A has no keyboard or mouse. Both may optionally be equipped; a trackball typically replaces the mouse.

A keyboard is essentially not required during normal engine operation and a virtual keyboard is displayed in case textual input (e.g. password) is needed.

Instead of traditional use of a mouse, the operator touches the graphic elements on the screen in order to interact with the ECS.

1.2 Service kit

The MOP comes with a service kit. The kit comprises of a CD-ROM drive (if not build-in), a keyboard and a CD with the operating system, and is setup specifically for this PC type.

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1.3 Issues to both MOP type

1.3.1 Ethernet connections

Only MOP B may be connected with an Ethernet connection to other systems such as CoCoS-EDS. Special care must be taken when connecting to networks of any kind to avoid virus and worms on the MOP. Connection to other systems is illustrated on Drawing 6655-0125 fig 1.

1.3.2 Unauthorised software

DISCLAIMER: MAN Diesel disclaim responsibility for any event or condition that originates from installation of unauthorised software. This includes, but is not limited to, virus.

To emphasize the disclamer, yellow stickers are placed at suitable places on the MOPs.

NOTICE

If it is necessary to extract data from a MOP, it is recommended to use the in-build CD-Rom burner, instead of a USB-stick.

1.3.3 Control Network

Each MOP is connected to the ECS by means of the Control Network that interconnects the nodes in the ECS. Control Network is implemented as two independent networks for redundancy as shown on Drawing 6655-0190.

1.3.4 Maintenance

Normal PC maintenance tools and cleaning detergents apply.

1.4 Software Scope of Supply

There are three different types of software supplied with the ECS:

1.4.1 Operating System

1.4.2 Engine Control System

1.4.3 Service Parameters

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This software is either stored on a set of CD-ROMs or on a pair of USB sticks. In either case it is important that the software is stored in a proper place where it is accessible and can be found on request. The recommended storage place is together with the engine manual.

In case the software is stored on USB sticks these might be equipped with a Read/Write selector. This switch should normally always be set to Read.

In addition to the above there will also be the following two types of software as a part of the software supply:

1.4.5 CoCoS EDS

1.4.6 PMI software

These last two types of software are not to be installed on the MOPs, but instead on a separate PC (see Drawing 6655-0125 fig. 1). However having these programs running correctly is essential to achieving optimal performance of the engine and ECS. Both of these programs include user manuals and instructions together with their installation.

1.4.1 Operating System

The Operating System is the software that is used for the MOPs. This is an embedded version of Windows XP. This is normally preinstalled by the MOP supplier and delivered together with the MOP hardware.

1.4.2 Engine Control System

The Engine Control System is a set of applications installed on the MOPs that enable them to perform their main function, i.e. it turns them into the MOPs.

A very important aspect of the Engine Control System is the version (e.g. “1008-4.1” or “0905-8.2”). It is critical that the version of the software stored on USB/ CD-ROMs is the same version that is currently installed. The currently installed version can be seen on the Version Screen on the MOPs (this screen is described in more detail in Chapter 6645-0280).

NOTICE

Always ensure the version of the installed ECS matches the version of ECS stored onboard.

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1.4.3 Service Parameters

The Service Parameters software functions of a backup in case of major system failure. Normally it should not be used as the MOPs automatically store backup versions of the parameters from the MPCs.

1.4.4 Use Cases for Software

The two normal use cases for the software stored onboard are:

A. The replacement of a MOP (by crew)

B. Service visit including update of parameters and/or ECS version

For case A (a new MOP) the Operating System will normally be preinstalled, so when the MOP powers up it will seem identical to a standard Windows PC. The task is then to install the Engine Control System.

This is done by inserting the software medium (USB or CD-ROM) into the PC and then locating the correct install script. There will normally be two options: “install_mopA_XPE.bat” and “install_mopB_XPE.bat”. These are both placed on the same CD-ROM/USB. It is important to select the script matching the MOP being installed.

After successful completion of the installation (follow the on-screen instructions) the MOP main application can be started using the “Start MOP” option in the Windows Start menu.

After starting this application the MOP will automatically acquire configuration information and parameter backups from the MPCs.

For case B (service visit where parameters and/or ECS version is changed) it is important that the visiting service engineer ensures that the ECS version and service parameters stored onboard are still correct. This either means supplying a new set of CD-ROMs or updating the data on the USB stick (momentarily changing the Read/Write selector to Write).

1.4.5 CoCoS EDS

This software is used for the data logging program that is collecting data from the ECS. It is to be installed on the same PC that is running the PMI software.

Always ensure that this software is running correctly since this will greatly enhance the options regarding troubleshooting and faultfinding available.

Since the CoCoS EDS interfaces to the ECS for data logging it is important to ensure that the versions are compatible. For instance in case of an update of the ECS, make sure that CoCoS EDS is also updated.

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The program DatGat is included with the CoCoS EDS software. This program is a valuable tool for extracting data from the ECS for use during troubleshooting. Instructions on how to use DatGat is included with the installation.

1.4.6 PMI Software

The PMI software comes in one of two versions: As minimum an offline version is delivered with the ECS. Alternatively the engine may be equipped with PMI Auto-tuning. In either case the PMI system is a valuable tool for performance measurements and as a basic for engine adjustments.

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1 HMI (Human Machine Interface)

The HMI consists of four fixed areas always shown.
See Drawing 6655-0125 Fig. 2.

1. An Alarm Status Bar showing the oldest non-Acknowledged alarm and Alarm status at the top of the screen.

2. A Navigation Bar at the right side of the screen.

3. A Toolbar at the bottom of the screen.

4. A Screen area (rest of the Screen)

The HMI operates with two password levels, which are Operator level and Chief level.

Operator level:
From the Operator level is it not possible to set any parameters. It is for normal operation and monitoring only.

Chief level:
In addition to the Operator level, this user level has privileges to set parameters (setpoints, engine states and engine modes). A password must be supplied in order to access Chief level.

There is no limit in the number of unsuccessful attempts to enter the correct password. The password is hard coded in the system and can therefore not be changed.

2 Alarm System

The alarms on the MOP panel are all related to the Engine Control System.

On Drawing 6655-0125 fig. 1 is shown the ECS and the possibilities to communicate with the ordinary alarm system, and the safety system. These three systems are able to interact with each other i.e. in case of a slow down and a shut down.

The shut down and slow down can be divided into two kinds – cancellable and non-cancellable.

If a cancellable shut or slow down occur the safety system will release an alarm prewarning and after timeout of the prewarning periode activate the shut/slow down.

If a non-cancellable shut or slow down occur the safety system must release the shut or slow down immediately.

3 Alarm Handling

Alarm handling is carried out from one of the following four screens

3.1 Alarm list

3.2 Event Log

3.3 Manual Cut-Out List

3.4 Channel List

These four Alarm Handling screens can be accessed via the secondary navigator by pressing the “Alarms” button in the main navigator. When pressing this button, the latest selected alarm screen will be shown on the screen. If no screen has previously been selected, the “Alarm List” is shown. The screen can then be changed via the secondary navigator.

3.1 Alarm List (See Drawing 6655-0130)

The Alarm List contains the central facility of the Alarm Handling, allowing for display, acknowledgement and cut-out of raised alarms. Detailed alarm explanation can be accessed for each of the alarm occurrences.

The alarms are displayed in chronological order, with the latest alarm at the top.

The Alarms might be grouped by the ECS if they are related to the same cause in order to simplify the overview of the alarm list. The group can be expanded by selecting a group and pressing the -/+ button on the toolbar. Not all alarms are grouped.

If there are too many alarms to be displayed at the same time on the screen, the remaining alarms can be accessed by pressing the Page-up/Page-down buttons on the Toolbar.

Alarms presented in the alarmlist can be found in three states:

1. Alarm non acknowledged
2. Alarm acknowledged
3. Normal non acknowledged

An alarm can only appear as "one line" in the alarm list. An acknowledged alarm going into normal or an alarm in the normal state being acknowledged, is immediately removed from the list.

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Acknowledgement of a single alarm or all alarms is allowed on both levels (operator or chief) from the “Ack“/“All” buttons on the toolbar at the bottom of the screen. (When pressing “Ack“/“All” only the alarms visible on the screen are acknowledged).

To see a detailed alarm explanation, press the relevant alarm line. The alarm line is then surrounded by a thick blue line showing that it has been selected. By pressing the button “Info” on the Toolbar, a window will appear just above the Toolbar. This window contains:

- Description
- Cause
- Effect
- Action

So the engineer is able to start troubleshooting on this particular alarm (The detailed alarm explanation is removed by pressing the same “Info” button).

3.1.1 Alarm Line Fields, Colours and Symbols (See Drawing 6655-0130)

Each alarm line is divided into the following fields:

Ack. The acknowledgement status field of non-acknowledged alarms contains an icon toggling between two states, alerting the operator of a non-acknowledged alarm.

The status of the alarm can also be identified by the background colour as well as the graphical identification in the Acknowledgement field on the Screen as shown below.

	Non-Acknowledged alarm in alarm state
	Non-Acknowledged alarm in normal state
	Transition from Non-acknowledge to acknowledge of an alarm in alarm state
	Acknowledged alarm in alarm state
	Unacknowledged alarm is cut out
	Alarm was previously unacknowledged in normal state. Now the state is not available
	Alarm was previously unacknowledged in alarm state. Now the state is not available

	Transition from Non-acknowledge to acknowledge of an alarm in normal state
	Alarm is acknowledged in normal state, and in the process of being removed from the alarmlist

At the upper right corner of the screen four small icons are shown which are (from left to right):

	Number of non-acknowledged alarms
	Number of active alarms
	Number of Manual Cut-out alarms
	Number of invalidated channels

From the toolbar at the bottom of the Alarm List screen, alarms can be cut-out. This feature is described in details in Section 3.3.

Description. This field contains the alarm text (e.g. »HCU oil leakage«)

Status. This field shows the status of the alarm as one of the following:

- Normal
- Alarm
- Low
- High
- Not Available
- Auto Cut-out
- Manual cut-out

ID. This field contains a unique alarm identity. (e.g. ECUA_010112). This ID must always be used for reference and reporting.

Time. This field shows the time of the first occurrence of the alarm, no matter the status changes. The time is shown in hours, minutes, seconds and 1/100 sec. (e.g.13:47:02.56)

3.2 Event Log (See Drawing 6655-0135)

The event log can be used for viewing the history of events and to support the operator in troubleshooting. Events stay in the log even after they have been

acknowledged and are no longer active. Alarms are logged with three events in the Event Log. The events are Alarm, Normal and Acknowledged. There can be up to 1 million events logged in the event log.

The events are stored in a database on the MOP's hard disc with both local and UTC time stamps. If more than 1 million events are logged, the oldest events are discarded.

Each event (with the most recent event on top) is shown as a single line and each event line is divided into the following fields:

ID Unit Tag. This field contains a unique event identity.

Date. This field contains the date of the event.

Time. This field shows the time of the event. The time is shown in hours, minutes, seconds and 1/100 sec.

Description. This field contains the alarm text (e.g. »HCU oil leakage«).

Status. This field shows either Normal or Alarm.

MCo. Shows whether the alarm is Manual Cut-Out or not.

ACo. Automatic Cut-Out.

Ack. The alarm is acknowledged.

3.2.1 Searching for an Event From a Specific Date and Time or by Tag Number.

This feature can be helpful when extracting information to external parties or when investigating an event.

When scrolling up or down on the Event Log screen is not sufficient, it is possible to search for a specific event by tag number by pressing the button "Unit/Tag Filter". When an alarm occurs, it is given a tag number that is stored together with the alarm event. By writing this number in the dialog box and pressing "Apply" the alarm event is shown on the screen.

Similarly, the button "Time Span Filter" sorting can be selected.

Enter the from/to date and time in the toolbar by using the popped up keyboard. Press "Apply" to execute. Note that the entered time has to be in UTC time. As a result the events, inside the selected timespan to the specified date and time, will be selected and shown on the screen.

From the button "Go to Time/Date", events which took place at/on a specific time/date can be displayed. Note that the entered time has to be in UTC time.

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When a filter is no longer needed, remember to remove it (by pressing the button again), otherwise it might seem like the event log is frozen and does not receive new events.

3.2.2 Exporting the Eventlog

From the toolbar “Export Event Log”, displayed when the “Export” button is pressed, it is possible to print a copy of the Event Log or make a back-up Dump used for information to external parties or the engine crew themselves.

Should external parties ask for an Event Log record (for trouble shooting purposes), the Event Log record can be saved on a USB memory stick (or Hard Disc Drive if no USB memory stick is available) as a zip file. Be aware of the risk of using USB-sticks generally.

The file name will be: EventLog<DateTime>.zip when the file is saved on a USB-memory stick.

(Is the Event Log dumped to a USB memory stick (or Hard disc Drive) the file name will be: EventLogDump<DateTime>.zip).

In both cases the DateTime is the UTC time when the file was saved.

The USB memory stick (containing the zip file) can then be handcarried to the ships mail PC and the zip file mailed to external parties for evaluation.

3.3 Manual Cut-Out List (See Drawing 6655-0140)

Manual Cut-Out of alarms may be used, for instance, if the engineer has observed a failure of a sensor that is not detected automatically (see below) or if, for instance, a Tacho pick-up is failing (the engine running on the redundant Tacho system) and is continuously giving an alarm and cannot be replaced immediately.

Alarms are sometimes cutted-out automatically. Automatic cut-out may be used by the system to suppress alarms which are unimportant in specific states, e.g. when a sensor is invalidated by the operator.

The manually cut-out alarms are shown in a separate list, which can be accessed from the navigation bar. The manual cut-out screen is in functionality equivalent to the channel list screen. An alarm can be cut-out manually from the screens Alarm List, Manual cut-out List or Channel list.

All alarm channels that have the status “Manual cut-out” are shown in the manual cut-out screen.

Removing (“Re-activating”) an entry from the Manual cut-out list is done by highlighting the alarm(s) involved on the screen and thereafter pressing the button “Reactivate” in the toolbar.

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3.4 Channel List (See Drawing 6655-0145)

The channel list screen contains status information of all alarm channels within the ECS, no matter the status of the individual alarm channel. As default, the alarm channels are listed in tag-name alphabetic order. From the channel list screen, it is possible to cut out (and re-activate) alarm channels.

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1 Engine

Engine operation and adjustment is carried out from one of the following five screens:

1.1 Operation

1.2 Status

1.3 Process Information

1.4 Process Adjustment

1.5 Chief Limiters

Screens 1.1, 1.2 and 1.3 are related to engine start-up preparations and daily running, 1.4 and 1.5 are related to engine adjustments.

The operator can access these five operation and adjustment screens via the secondary navigator by pressing the Engine button in the main navigator.

On the screen, the displays which can be activated (i.e. pushed like a button) are shown in 3-D graphic and the inactive displays are in 2-D graphic. Once activated, the display is highlighted with a blue line at the outer circumference

1.1 Operation (See Drawing 6655-0150)

Operation is the main screen for control of the engine during voyage.

On this screen, “prepare start” can be performed and “slow turn” can be enabled before start of the engine.

Drawing 6655-0150 shows the full screen. In the following, a detailed description of the individual fields will be given.

1.1.1 Main State Field

The main state field contains 3 status fields indicating the current sub-telegraph command states and the states of the engine.

The background colours on the graphics are specified as:

- Blue = Normal state
- Yellow = Warning state
- Red = Alarm state
- Grey/dimmed = Not in use

The top field indicates the current sub-telegraph command state, which can be one of the following:

– FWE (Finished With Engine)
– Standby
– At Sea

The middle field indicates the states of the engine:

– (Blank)
  - (engine is operative or blocked according to the sub-telegraph command
– Engine not blocked (with yellow background): if top field is in FWE condition, and not all conditions are fulfilled.
– Engine not ready (with yellow background): if top field is Standby or At Sea, and not all conditions are fulfilled.

The cause of the states “Engine not blocked” or “Engine not ready” can be seen in the Status screen, drawing 6655-0155, in the field Start Conditions.

The bottom field indicates, via yellow or red warnings, why the engine is not ready:

– (Blank) (engine is ready and increased limiter inactive)
– Increased limiter (yellow) is shown when active, (and engine status is not FWE, and neither Start Blocked or Shut down status is active). Increased limiter is a warning condition.
– Start Blocked (red) is shown when active, (and engine status is not FWE, and Shut down status is not active). Start Blocked is an alarm condition.
– Shut down (red) is shown when active. Shut down is an alarm condition.

1.1.2 Command [RPM]

The command indicator button contains six or eight status fi elds. Two fields high-lighted, indicating the current active control station (Bridge, ECR or LOP) and the

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actual speed command setting for each of the control stations. The actual selected control station is indicated by dark blue (normal selection) or yellow (take command) see below.

The Bridge Control and ECR stations are parts of the RCS (Remote Control System). Only one control station at a time is active.

The active control station is normally selected via the RCS request acknowledge-system. However, the selection may be overridden from either the ECR or LOP by the “take command” buttons, which are wired directly to the ECS (Engine Control System) and situated on the control station panels.

If the active control station selection is inconsistent, the ECS keeps the last valid active control station as the active station, until a new valid selection is available (possibly a “take command”).

In the event the “take command” signals from both the ECR and the LOP are selected simultaneously, the LOP has first priority and is selected.

1.1.3 RPM Fine Adjust

By pressing the Command [RPM] button, a RPM Fine Adjust toolbar is displayed. It allows the RPM setpoint to be adjusted in operator level. E.g. if the speed command setpoint is 83.8 RPM, it can be fine adjusted to 84 RPM. Moving the handle will disable the fine adjustment mode.

NOTICE

RPM fine adjustment can only be performed in ECR Command mode.

1.1.4 Running Mode and Governor Mode

The engine running mode and governor mode buttons each contains a status field indicating the current active running and governor modes.

Changing the running mode is done by pressing the running mode button. This brings up a toolbar. On the toolbar, the current running mode is selected.

The running modes are typically Economy and Emission. However, additional modes (TC Cut Out and Custom) may be available. If only Economy mode is available, the mode selection is not usable (dimmed).

The governor mode can be either RPM Control, Torque Control or Index Control.

Changing governor mode is done similar to changing running mode.

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1.1.5 Governor Mode

The speed controller can be requested to calculate the fuel index according to various methods.

Each method is referred to as a 'Governor Mode', and they represent various tolerances for maintaining the engine speed equal to the set point during load and/or set point variations.

For normal operation the following two modes are available:

- RPM control:
  'Speed' mode - provides the most rigid speed control, leading to large fuel index variations.
- Torque control:
  'Torque' mode – the speed control is dampened when the speed is close to the required speed, providing speed control without large index variations, but allowing larger speed variations.

A third mode exists for test purposes:

- Index control:
  'Fixed Fuel Index' Mode – A test mode where the index is kept constant as long as the speed is within a preset range. Only if the speed drifts outside this range, will the speed controller become active and regulate the index.

1.1.6 Pressure Indicators

The pressure indicators consists of a bar graph and a status field.

Both the bar graph and the status field indicate the actual pressure of the actual-medium.

1.1.7 Auxiliary System Status Indicators

The system status indicators display information of the operation mode of the auxiliary systems controlled by the ME ECS. These are all indicators and do not allow changing mode or status. Possible control is made on the panels for the actual systems. Indicators are:

- HPS (Hydraulic Power Supply): Manual, Auto.
- Lubricator: Running Stopped, Prelube, LCD (Load Change Dependent) On.

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- PTO (Power Take Off): Off, Request, Permit, Request (yellow and warning if a parameter for switching on the PTO is not fulfilled).
  Optional, only if the engine has PTO.
- Auxiliary Blowers represented by two status fields, one indicates the operation mode, which can be Auto or Manual. The other indicates the current status of the blowers, which can be Stopped, Starting, Running or Failed.
- Var. XBP (Variable Exhaust Gas Bypass): percentage open.
  Optional, only if XBP is installed.
- On/Off XBP (Exhaust Gas Bypass): Open or Closed.
  Optional, only if XBP is installed.
- VT (See separate manual for Variable Turbocharging System).
  Optional, only if VT is installed.
- WHR (Waste Heat Recovery) : Off, Allowed, Request, Request (with yellow and warning) and Permission. The WHR Is ready for use when »Allowed« is shown(see drawing 6655-0150).

1.1.8 Start Status Indicator

The start status indicator consists of a single display, showing information on the status of a start attempt.

The status shown can be one of the following:

- Stopped
- Running
- Repeated Start (yellow)
- Slow Turn Failed (red)
- Start Failed (red)

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1.1.9 Speed [RPM]

The speed indicator consists of a bar graph.

The set point and the actual running speed of the engine are shown in the two displays above the graph.

The uppermost display is the speed command modifier. The speed modifier is a function that may override the actual speed command and control the speed system set point for the engine speed. When the function is active, the control mode is shown in the Speed Indicator.

The available modes are:

Stabilizing	The stabilizing modifier defines a speed set point that ensures the starting of the engine.
Stop	The stopped modifier sets the speed set point to zero.
Minimum Speed	The minimum speed command modifier defines a minimum speed set point during operation of the engine.
Maximum Speed	The maximum speed command modifier defines a maximum speed set point during operation of the engine.
Fixed Speed Set	Fixed speed set is activated when running in pitch backup mode from bridge (option for CPP systems).
Shut Down	The shut down modifier sets the speed set point to zero.
Slow Down	The slow down modifier sets the speed set point to a predetermined slow down level.
PTO	The speed is kept higher than ordered to keep the shaft generator connected during start up of the auxiliary engines.
Speed Ramp	Increase of speed is limited by the ramp.
Load Program	The load control modifier defines a maximum speed set point that ensures the maximum fuel oil index limit is not exceeded.
Barred Speed range *	Indicates that the modifier has changed the preset from inside a barred range to either lower or upper limit of the ramp. The engine may have 0-2 barred speed range(s).
RPM Fine Adjust	The speed is being modified according to the setting entered in the RPM Fine Adjustment toolbar on the Operation screen.
Run Up/Down Prog.	When the chief increases or decreases the speed set significantly, the engine speed follows predefined curves. (Optional).
Chief Max Speed	If the user is at Chief level, it is possible to define a Maximum Engine Speed on the Chief limiter screen. See section 1.5
TC Cut Out	If the TC Cut Out option is installed, the speed will be limited, when the engine is running in TC Cut Out Mode.
WHR	The speed is kept higher than ordered to keep the shaft generator connected during start up of the auxiliary engines.

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* Barred Speed Range

If the function is used, the barred speed range(s) is marked on the side of the bar graph. Most engines have two barred ranges and the ranges are identical in the ahead and astern directions (FPP systems). When operating from ECR and Bridge, the speed set is automatically kept outside these range(s).

1.1.10 Pitch Indicator

The pitch indicator is only shown on ships with CPP systems. (see drawing 6655-0150)

The pitch indicator consists of a label and a bar graph, indicating the current pitch setting. The label uses + (plus) or – (minus) to indicate positive (forward) or negative (backwards) pitch. The bar graph is centred at 0 and positive and negative is up and down, respectively.

The pitch indicator bar graph uses a pointed graph to underline the direction (sign) of the current pitch.

1.1.11 Fuel Index Indicator [%]

The fuel index indicator consists of a bar graph and a set of status fields. The top status field indicates the current effective or nearest limiter. The electronic governor will limit the fuel index command according to the actual engine operating conditions. If no limiter is currently active the nearest limiter is displayed on a light blue background. When a limiter is active it is displayed on a dark blue background.

Available limiters are:

Start	The start limiter defines a fixed amount of fuel to be used for the first injections during start.
Chief	The chief limiter defines a maximum amount of fuel to be injected according to the settings done by the operator at the screen Chief limiters.
Scavenge Air Pressure	The scavenge air pressure limiter defines a maximum amount of fuel to be injected based on the actual scavenge air pressure, in order not to overfuel the engine.
Torque	The torque limiter defines a maximum amount of fuel to be injected according to actual engine speed. This is to ensure that the engine torque does not exceed recommended levels.
Hydraulic Power Supply	The hydraulic power supply pressure limiter defines a maximum amount of fuel oil to be injected according to actual hydraulic power supply requirements, in order to ensure that the hydraulic pressure does not drop below a minimum operation limit.
TC Cut Out	If the TC Cut Out option is installed, the fuel index will be limited, when the engine is running in TC Cut Out Mode.

Below the limiter status field is a set of dynamic labels displaying the actual fuel index and the current fuel index limit.

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1.1.12 Prepare Start Button

The prepare start function is normally to be activated before start if the engine has been stopped for some time. Pressing the button will start the cylinder pre-lubrication and the auxiliary blowers (if stopped).

When pressed, the button will stay down until the procedure is completed. If the engine has not been started within a certain time, the auxiliary blowers will automatically stop.

The command is available only when the engine is stopped and the prepare start-procedure is not running.

1.1.13 Slow Turn Button

Manual slow turn is used during preparations before start of the engine, and is normally to be used with the indicator cooks open. Slow turn is used for visual inspection of the blow out. When the button is selected, the engine is operated on starting air through the slow turn valve as long as the control handle is activated. If a manual prepared start has not been executed, the system will automatically perform one.

1.1.14 Auto Button

The auto button is pressed when start preparations are completed, and the engine has to be started. When selected the engine will perform a normal automatic start. If a manual prepared start has not been executed, the system will automatically perform one.

1.1.15 Air Run Button

The air run button function is only available in Chief level.

The air run button can be used in the following situations:

When checking the Tacho system (test), starting air valve test and after maintenance (and after check with the turning gear) to check the function and movement.

Air run function is similar to the slow turning, except that the main starting valve is open and the engine is running faster (still without fuel injection).

Slow Turn and Air Run are activated when the handle is in “run” position. This will rotate the engine until the handle is set to »stop« (or the engine is started by pressing the Auto button).

1.2 Status (See Drawing 6655-0155)

The engine status screen provides extended engine information specifically for use when changing the status of the engine, i.e. in the process from FWE to standby state or vice versa.

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1.2.1 Main State Field

The main state field shows exactly the same information as the main state field in the operation screen view, drawing 6655-0150. For detailed explanation, see 1.1.1 Main State Field, page 1 in this chapter.

1.2.2 Start Conditions

The Start Conditions field is a status list, showing if the engine is in the intended state (FWE or st.by/at sea). The conditions shown in bold must be fullfilled before the intended state can be obtained.

If a condition is shown with a green check mark, the condition is in accordance with the intended state.

If a condition is shown with a red background and a white exclamation mark the engine is not ready for starting.

If the condition is not relevant the background is dimmed, but a check mark or exclamation mark will still indicate the status of the condition.

The possible status indications of each field are listed below:

- Main Starting Valve in service position (Standby or At Sea)
  Yellow, when main starting valve is not in service position.
  Green, when main starting valve is in service position.
- Main Starting Valve Blocked (FWE)
  Yellow, when main starting valve is not blocked.
  Green, when main starting valve is blocked.
- Starting Air Distribution System in service (Standby or At Sea)
  Red, when Starting Air Distribution system is blocked.
  Yellow, when Starting Air Distribution system is not in service.
  Green, when Starting Air Distribution system is in service.
- Starting Air Distribution System blocked (FWE)
  Yellow, when Start Air Distribution system is not blocked.
  Green, when Start Air Distribution system is blocked.
- Starting Air Pressure (Standby or At Sea)
  Red, when starting air pressure is below level for bridge start.
  Green, when OK.
- Control Air Pressure (Standby or At Sea)
  Red, when control air is vented.
  Yellow, when control air pressure is low.
  Green, when control air pressure is OK.
- Control Air vented (FWE)
  Yellow, when control air is not vented.
  Green, when control air is vented.
- Turning Gear disengaged (Standby or At Sea)
  Red, when turning gear is not disengaged.
  Green, when turning gear is disengaged.
- Auxiliary Blowers (Standby or At Sea)
  Red, when blowers are not operational.
  Green, when blowers are operational.

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- Hydraulic Power Supply (Standby or At Sea) (Start-up pumps)
  Yellow, when HPS is not OK. (e.g. in manual mode)
  Green, when HPS is OK.
- Hydraulic Pressure (Standby or At Sea)
  Red, if pressure is too low.
  Green, if pressure is OK.
- Zero Pitch before starting (Standby or At Sea) (CPP systems only)
  Red, if pitch is not zero before starting.
  Green, if pitch is zero before starting.

1.2.3 Start Air

The starting air pressure indicator displays the system starting air pressure continuously.

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1.2.4 Turning Gear

The field shows either Engaged or Disengaged.

1.2.5 Control Air Pressure

The control air pressure indicator displays the system control air pressure continuously.

1.2.6 Blowers

Shows the status of the auxiliary blowers, which is either:

- Stopped
- Running
- Starting
- Failed

1.2.7 Hydraulic Oil

The hydraulic oil pressure indicator displays the system hydraulic oil pressure continuously.

1.2.8 Crankshaft

Shows the current position of the crankshaft when turning the engine (for maintenance purposes) with the turning gear, and allows checking of the position in case of malfunction of starting air valves.

1.2.9 Pitch Start Blocking Indicator (CPP Systems Only)

On the pitch start blocking indicator, it is possible to cancel the start blocking. (This could be relevant if the engine is stopped with the pitch in ahead or astern position, and return to zero is not possible due to failure).

Cancel of start blocking can only be performed from Chief Level. When blocking is cancelled this is shown with the text “Blocking Cancelled” on a red background.

1.2.10 Start Status Indicator

The start status indicator consists of a single field containing information on the current start status.
Three successive start attempt failures or a slow turn failure will cause Start – Blocked. The below conditions are indicated in the start status indicator:

- Stopped
- Running
- Repeated Start (warning)
- Slow Turn Failed (alarm)
- Start Failed (alarm)

1.2.11 Details

Pressing this button will display the individual readings of the Start Air, Control Air and Crank Shaft sensors.

1.2.12 Pneumatic Diagram

In addition to the information described above the screen contains a stylish diagram of the pneumatic starting and control air system. The diagram is intended to indicate the functionality of the system. For a specific engine, further details can be found in the plant installation drawings supplied by the engine builder.

The pilot valves A, B and Slow Turning, can and must be activated to test that the main starting valve and the slow turning valve open and the tightness of the starting air valves in the cylinders. (This test is performed regularly with stopped engine, see Chapter 6645-0100).

Pressing the field, encircling the pilot valves, opens a tool bar from which activation of the pilot valves is possible.

1.3 Process Information (See Drawing 6655-0160)

This screen gives the user a quick overview of the possible limiters/governors used. The screen always shows the values currently in use.

It is important to realise that the values on a light blue background (e.g. Pcomp/Pscav ratio or Estimated Engine Load) are set points or estimates, where as those on a dark blue background (e.g. Speed Actual or Hyd. Oil Actual) are actual measurements. Due to the inherent difficulties of estimating process values there will often be some deviations between the set points and the values that can be measured using e.g. PMI equipment.

1.3.1 Running Mode

This field is the same as described in 1.1.4 - Running Mode and Governor Mode Field.

An engine running mode is based on an algorithm which continuously determines the fuel injection and exhaust parameters that influence the cylinder process. By controlling the cylinder process (maximum cylinder pressure, compression ratio and blow back), fuel efficiency and emissions can be controlled to a certain extent.

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For the ME engine, several running modes may exist. These contain different algorithms, and provide various fuel efficiency and emission characteristics. The running modes are commissioned during test bed running.

1.3.2 Speed Control

This field is the same list of speed modifiers described in Section 1.1.9 Speed Indicator.

The Index Limiter field is the same list of index limiters described in Section 1.1.11 Fuel Index Indicator.

1.4 Process Adjustment (See Drawing 6655-0161)

ECS offers two methods for adjustment of the combustion process:

- Auto Tuning for easy tuning of the cylinder pressures for best engine performance

- Manual adjustment of process offsets for cylinder pressures and FO quality

Auto-tuning is described in section 1.4.1. For detailed information and use of auto-tuning is referred to the “PMI Auto-tuning, Operation, User’s Reference Guide”, included in the PMI installation.

NOTICE

Auto-tuning functions are available only for engines for which the PMI Auto-tuning option has been selected.

Manual adjustment of process offsets is described in section 1.4.2 and is intended for engines equipped with PMI Offline or for adjusting cylinder pressures during operating conditions that do not allow for auto-tuning.

1.4.1 Auto Tuning (Optional)

Auto-tuning reduces the workload required for operating the engine continuously at the design conditions, according to the actual running mode and engine load ordered by ME-ECS. Auto-tuning covers adjustment of maximum, compression and mean indicated pressures and is made available as “continuous auto-tuning” (fully automatic) and as “user-controlled auto-tuning” (each auto-adjustment session commanded by the operator).

Auto-tuning Status

With following conditions fulfilled:

– Index is stable: Engine is in steady state operation, indicated by a stable governor index
– Index is sufficient: Index is above minimum required level (app. 25% load, can be plant dependent)

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– Sensor values: Valid sensor values are available from the PMI auto-tuning system and deviation between cylinders as well as towards the reference are not too large

The functions for auto-tuning are available, informed in the status bar as “Tuning allowed” (green).
If one or more conditions are not met, the status bar will display “Tuning not available”, and indicate the reason here fore (yellow or red).

Continuous Auto-tuning

With continuous auto-tuning selected by the operator, the mean pressure level will automatically be adjusted in order to minimise the deviation between ordered and measured mean value. The continuous function is only active if the above conditions are fulfilled and will adjust only within narrower limits than available to manual adjustment. The adjustment offsets applied by the continuous function are displayed in the lower right corner of the “Mean” field.

User-controlled Auto-tuning

The cylinder pressures are automatically adjusted once, each time the operator presses the command button in the toolbar. This is available for adjusting either the engine balance or the mean pressure level:

– Balancing
By pressing the “Deviation” field ... The operator can command an auto-balancing, that will balance the engine in respect to one or all of the key parameters Pmax, Pcomp or Pi.

– Mean Deviation
The operator can command an auto-mean deviation adjustment. The result will be a minimised deviation between the ordered and the actual mean pressure. This function should be used when de viation is larger than allowed to be adjusted automatically by the continuous auto-tuning function.

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NOTICE

The user-controlled mean deviation function is intended only for adjustments in relation to fuel property changes, and only when engine is running above Pmax Break Point. Executed at lower loads, it is required for safe engine operation to check the maximum pressures and re-adjust if necessary when engine load is increased.

⚠ CAUTION

Applying an offset in Pmax at low load (<BP), may lead to too high Pmax at high engine loads.

1.4.2 Manual Adjustment of Process Offsets

The cylinder pressures can be adjusted by manually setting the corresponding process offsets for control of fuel injection timing and exhaust valve closing time.

Cylinder load

From the “Cylinder load” tab, the operator can adjust the load limit on any cylinder, adjust the load balance as well as cut out one or more cylinder units, however only at Chief level. Before taking a cylinder out of operation the restriction in chapter 6645-0320 in the Operation Manual must be taken into consideration.

Cylinder pressure

From the “Cylinder pressure” tab, the operator can manually adjust Pmax level and balance, Pcomp-Pscav ratio and exhaust valve open timing.

NOTICE

The “PMax offset all” function is intended used when engine is running above Pmax Break Point. Executed at lower loads, it is required for safe engine operation to check the maximum pressures and re-adjust if necessary when engine load is increased.

CAUTION

Applying an offset in Pmax at low load (<BP), may lead to too high Pmax at high engine load

1.4.3 Fuel Quality

On this screen a function for in- or decreased fuel oil index for all cylinders (FQA = Fuel Quality Adjustment) is available, e.g. in case of changed fuel quality. The specific calorific value and fuel oil density must be checked in the actual fuel oil specification delivered with the fuel samples at bunkering.

When entering new bunker values the ME system will suggest a new value for Fuel Quality Offset. The 'Suggested Fuel Quality Offset' does not influence the engine in any way. In order to change the actual running conditions it is necessary to change the 'Applied Fuel Quality Offset'. Adjusting the 'Applied Fuel Quality Offset' is required in order to make sure that the internally calculated ME-ECS load (as displayed on the process information screen, see drawing 6655-0160) corresponds to actual engine load (as estimated by e.g. PMI equipment).

Ensuring this match in internal and external power estimation is an important aspect of getting correct functioning of the ME system.

The 'Suggested Fuel Quality Offset' is a good starting point for finding the correct 'Applied Fuel Quality Offset' however the final value must be found in an iterative process where internal load estimation and external load estimation are compared and 'Applied Fuel Quality Offset' is adjusted.

NOTICE

Mismatch between internal and external load estimation can give rise to a wide range of problems. Including, but not limited to, too restrictive fuel index limiters, wrong cylinder pressures and wrong CLO usage.

1.5 Chief Limiters (See Drawing 6655-0162)

This screen gives the engineer the opportunity to set the following parameters:

1. Maximum Engine Speed.
2. Manual limitation of index at all cylinders.
3. Cut Out of one or more cylinders.
4. See status of all HCU and is able to reset a HCU in case of failure.

In Chief Index Limit [%] press down the cylinder bar graph involved. A tool bar at the bottom of the screen allows the operator to limit fuel injection on the chosen

cylinder. When the cylinder is to be reenabled, the bar graph of the cylinder involved is pressed down and the fuel injection is raised to the previous value using the arrows on the tool bar followed by [apply].

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1 Auxiliaries

The Hydraulic System, Scavenge Air and Cylinder Lubrication are monitored in the Auxiliaries main navigator.

From each menu, the operator can control and monitor these systems.
The screens are:

1.1 Hydraulic System

1.2 Scavenge Air, also including WHR, VT and Exhaust Gas by-pass if these are installed.

1.3 Exhaust Gas Bypass and VT System (engine dependent)

1.4 Cylinder Lubrication

1.1 Hydraulic System (See Drawing 6655-0175)

This screen shows a simple schematic drawing of the HPS (Hydraulic Power Supply). The screen shows from three to five engine-driven pumps (depending on engine layout) and two electrically driven start-up pumps. A bypass valve from pump pressure side to suction side is also shown.

EL-HPS: On some plants the main HPS pumps are not engine-driven but instead electrically driven (EL-HPS). In this case there will be no start-up pumps or bypass valve. Apart from that the following description is valid also for EL-HPS, just ignore the word 'engine-driven'.

If, for some reason, control signal to an engine-driven pump is lost, the pump swash plate is deflected to 100% in ahead direction. Thereby ensuring adequate hydraulic power for running ahead.

NOTICE

On engines with 4 or 5 engine-driven pumps, pump 4 is controlled from ECUA and pump 5 is controlled from ECUB
See drawing 7055-0150.

The following buttons can also be activated directly from the screen in Chief level:

- HPS Mode
- Pump Torque Limiter
- Set Point
- Bypass

1.1.1 HPS Mode

Pressing the HPS Mode button activates a toolbar at the bottom of the screen. At Chief level, it is possible to switch between Auto and Manual mode.

In Auto mode it is possible to perform the following commands (both Operator and Chief level)

1. Select one of the electrically driven pumps as master.
2. Select one of the engine-driven pumps as pressure controlling pump.

In Manual mode (Chief level) the additional command features are:

1. Adjustment of the current hydraulic pressure set point (see Section 1.1.3 in this Chapter).
2. Operate engine-driven pumps bypass valve using either ACU1 or ACU3 (Bypass valve to be tested for movement every 6 months, at stopped engine, see 1.1.5 in this Chapter).
3. Start/stop of the electric start-up pumps.

1.1.2 Pump Torque Limiter

In this field, it is possible to cancel the Pump Torque Limiter. (Chief-Level)

The torque limiter has two functions:

1. The total torque to the engine-driven pumps must not exceed a level that can harm gear and chain. Hence, to protect gear and chain, the sum of the swash plate positions must not exceed a predefined value. (Engine specific).
2. To protect the individual pumps from breakdown or damage.

By pressing the Pump Torque Limiter field, a toolbar will appear, where the limiter can be either activated or cancelled. (Cancellation of the limiter will raise an alarm on the MOP).

When the limiter is cancelled, the electrically controlled swash plates in the pumps are allowed to deflect to the mechanical limitation, if the need is there. (When the limiter is active, they are only allowed to deflect to an electrically controlled maximum position).

1.1.3 Set Point and Hydraulic Oil

Adjustment of the oil pressure set point can be done from the Set Point display, where the actual set point is always shown. The engine must be running. The actual oil pressure is shown at the display as Hydraulic oil

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NOTICE

Adjustment of the Set Point (Chief level and manual mode) is only intended as an option in test or failure situations.

As default, the normal operating pressure is in the 200-300 bar range and is set at commissioning. The engine shutdown level is approximately 140 - 180 bars, also set at engine commissioning. Both the operating pressure and the shutdown pressure is engine dependent.

The pressure set point is only relevant for the engine-driven swash plate pumps, as the pressure of the start-up pumps is limited via mechanical adjusted pressure limiting valves. The start-up pumps are automatically stopped or startet as needed.

1.1.4 Double Pipe (Engine dependent)

This display shows the pressure in the outer pipes of the high pressure double pipes. Normally, this pressure should be in the 0-10 bar range, depending on the specific engine layout. See chapter 4545-0150 for more details of the hydraulic system.

1.1.5 Bypass Valve

On the main pressure line from the engine-driven pumps, a bypass valve is installed.

At normal running with HPS mode in “Auto”, the bypass will open in the event of shutdown of the engine (wind milling can occur). This ensures oil return to the suction side of the pumps and thereby avoids cavitation and unintended wear on the pump parts.

Also, if the shutdown is due to a leakage at the high pressure side, and the engine keeps turning due to wind milling, the amount of oil spilled can be reduced by leading the oil back to the suction side.

By checking the valve manually, it is ensured that the valve is working properly. (The valve is to be checked manually every 6 months.) See chapter 6645-0100.

The bypass valve is tested at engine still stand, in Chief level and the HPS mode in manual. For redundancy reasons the bypass valve is controlled both via ACU1 and ACU3.

1.2 Scavenge Air (See Drawing 6655-0180)

The scavenge air screen contains information and controls for monitoring and operating the auxiliary blowers, exhaust gas bypass and VT System. (engine dependent).

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By pressing the “Details” button, indication of the current scavenge air pressure is shown for each individual scavenge air sensor.

The blowers are normally operating in Auto mode. Operating conditions are:

The blowers are started when :

- “Prepare start” button is pressed (Operation Screen)
- Manoeuvring handle is moved to start position, prompting the system to perform an automatic prepare start (engine start is delayed until blowers are running and pressure is correct)
- Engine is running but the scavenge air pressure is below a certain value (e.g. during manoeuvring)

The blowers are stopped when

- Engine is shut down
- The current sub-telegraph command state is moved to FWE position
- 10 minutes after engine has been stopped (adjustable)
- Engine is running and the scavenge air pressure is above a specified level
- After prepare start if no start has occured within the pre-determined time

If a switch to manual operation is required, this is done by pressing the “Blowers Mode” push button (see drawing 6655-0180). By pressing the individual blower 3D display at chief level and manual mode, it is possible to start or stop the individual blower.

The screen contains 2 to 5 blowers, depending on the engine layout. The state of each blower is shown. Status is either stopped, starting, running or failed.

NOTICE

Manual operation of the blower is mainly intended for use during fault-finding and test situations. Selecting Manual Mode will therefore also raise an alarm on the MOP.

1.3 Exhaust Gas Bypass and VT System (engine dependent)

Monitoring of the Exhaust Gas Bypass Systems and VT System is performed from the Scavenge Air screen.

The actual positions and settings of the on/off bypass, the variable controlled bypass valves and VT System are always shown on the screen.

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By pressing the “Bypass Mode” push button (chief level), the bypass valve modes can be changed between automatic and manual.

In manual mode (chief level), the variable controlled bypass valve can be opened / closed or set to the angle desired.

In manual mode (chief level), the on/off bypass can be opened or closed.

For a detailed description of the VT System and Exhaust Bypass System see separate manuals.

1.4 Cylinder Lubricators (see Drawing 6655-0185) ME Lube

The ME lube Control System provides the operational monitoring and control of the ME cylinder lubrication plant which lubricates the cylinders in the ME type engine.

The following displays can be monitored:

1.5.1 Flow (l/h)

1.5.2 Basic Feed Rate (g/kwh)

1.5.3 Actual Feed Rate (g/kWh)

The following displays can be operated at Chief level.

1.5.4 Total

1.5.5 Prelube

1.5.6 LCD

1.5.7 S% (Sulphur Content)

1.5.8 Feed Rate Factor

1.5.9 Min. Feed Rate (g/kWh)

1.5.10 Feed Rate Adjust Factor

1.5.11 Running In (g/kWh)

1.5.12 Lubricator Test Sequence

NOTICE

The latest Service Letter from MAN Diesel & Turbo should be consulted with regards to feedrate adjustments and settings.

1.4.1 Flow

The Flow display shows the ordered lube oil amount in litres/hour.

NOTICE

If one or more lubricators are malfunctioning (e.g. Feedback Failure) the actual amount applied will differ.

1.4.2 Basic Feed Rate

The Basic Feed Rate is a calculated rate for the complete lubricator system in g/kWh shown with two (2) decimals. The formula for calculating the Basic Feed Rate is = S% x (FEED RATE FACTOR).

1.4.3 Actual Feed Rate (each cylinder)

The bar graphs for each individual LCD shows the actual feed rate per cylinder. When running at low load the full bar is barred and the upper display on the bar graph shows “Low Load”.

1.4.4 Total

The Total display shows the total ordered amount of lubricating oil used since last power up of the ECU involved. Pressing this display opens a toolbar with the option to reset the total amount of lubricating oil.

Both of the values Flow and Total are based on the ordered numbers of lubrication strokes and the displaced amount per stroke.

1.4.5 Prelube (for test purpose)

As stated above this button is mainly used for test purposes, since the prepare start will cause the system to automatically perform a prelube.

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When the “Prelube” button is pressed a toolbar is shown on the screen. Pressing the button “ON” triggers a prelubrication on all cylinders and evaluates feedback from the lubricators.

NOTICE

Prelubrication can only be activated if hydraulic pressure is present. This demands that the engine (Sub-telegraph) is put in the state “Standby” or that the Hydraulic start-up pumps are set at manual operation and started.

1.4.6 LCD

The LCD display shows whether the LCD (Load Change Dependent) lubrication is on or off. When the LCD button is pressed, a toolbar will be displayed which will allow the operator to disable the LCD.

1.4.7 S %

Activating the display S % enables adjustment of the Sulphur content equal to the sulphur content in the HFO used. The range is between 0.00 to 5.00 S % and is not adjustable outside this range.

1.4.8 Feed Rate Factor

Activating the display Feed Rate Factor enables adjustment of the feed rate for all cylinders. The display shows the feed rate with 2 decimals and is “g/kWh%S”.

1.4.9 Min. Feed Rate

The display Min. Feed Rate enables adjustment of the minimum feed rate for all cylinders. The value is displayed in g/kWh and is normally set to 60% of the basic recommended feed rate.

1.4.10 Feed Rate Adjust Factor

Activating the display Feed Rate Adjust Factor enables adjustment of the feed rate for each cylinder separately.

1.4.11 Running in [g/kWh]

When a cylinder is being run-in, the feed rate can be entered by this display. Running- in of a single cylinder is described in chapter 2245-0100. The latest service letter from MAN Diesel & Turbo should be consulted as mentioned earlier.

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1.4.12 Lubricator Test Sequence

Pressing the Lubricator Test Sequence starts a continuous activation of the lubricator at predefined injection rate (different from “Prelube” 1.4.5 where the injection of oil is done at the fastest possible speed.)

This feature is used after repairs, etc. on the lubricator(s), enabling the engineer to manually check the lubricator for leaks and injection.

If a single button (cylinder 1, 2, 3, etc.) is pressed, a toolbar is shown on the screen. The toolbar enables the engineer to start test of the lubrication on the particular cylinder concerned or on all lubricators.

In case of CCU failure (and the CCU can not be replaced immediately) please see description 6645-0321 for how to obtain the back-up signal for lubrication.

NOTICE

The lubricator test can only be activated if hydraulic pressure is present. This requires that the engine (Telegraph) is put in state “Standby” or that the Hydraulic start-up pumps are set at manual operation and started.

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1 Maintenance

The maintenance screens give an overall view of the status of the ECS system seen on the following three screens. Drawings 6655-0190 - 6655-0195 - 6655-0200.

1.1 MPC description

1.2 System View I/O Test

1.3 Invalidated Inputs

1.4 Network Status

1.5 Function Test

1.6 Troubleshooting

The above-mentioned five maintenance screens can be accessed via the secondary navigator by pressing the “Maintenance” button in the main navigator. They are mainly used at engine commissioning, during fault finding on I/O cabling / channels and external connections to sensors and during engine operation. The use of these screens is therefore relevant for engine crew as well.

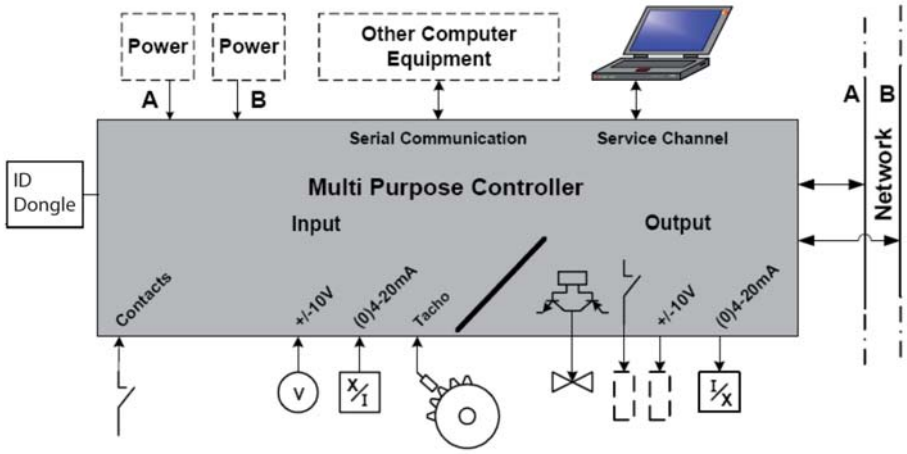
1.1 MPC description

To understand the use of this screen, an explanation of the layout of the Multi Purpose Controller (MPC) is appropriate.

The MPC is a computer unit which has no user interface such as a display or a keyboard, but has a wide variety of inputs/outputs (I/O) for interfacing to sensors and actuators of the engine, e.g.: (see drawing next page).

- Inputs for e.g. tacho signals, standard (0)4-20mA transducers, ±10V signals, switches and 24V binary signals.
- Outputs such as (0)4-20mA and ±10V signals, contacts and high-speed semiconductor switches.
- Duplicated Control Network for security.
- Serial communication controller for either a Remote I/O Network or point-to point serial communication.
- Service channel to be connected to a laptop PC for service purposes.

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The main processor of the Multi Purpose Controller is a Motorola 68332, which is a 32-bit processor »borrowed« from the automotive industry. It includes an on-chip timing co-processor for synchronisation with the crankshaft rotation and speed measurement.

To ease the production of the Multi Purpose Controller, all programmable components are in-circuit programmable, which also allows field update of the controller by means of relatively simple tools. The MPC contains no harddisk or other sensitive mechanical components, and the software is stored in a non-volatile Flash-PROM memory, i.e. the application software may be sent to and programmed into the Multi Purpose Controller through the network, and thereby restore the functionality after the Multi Purpose Controller has been exchanged with a spare unit from stock.

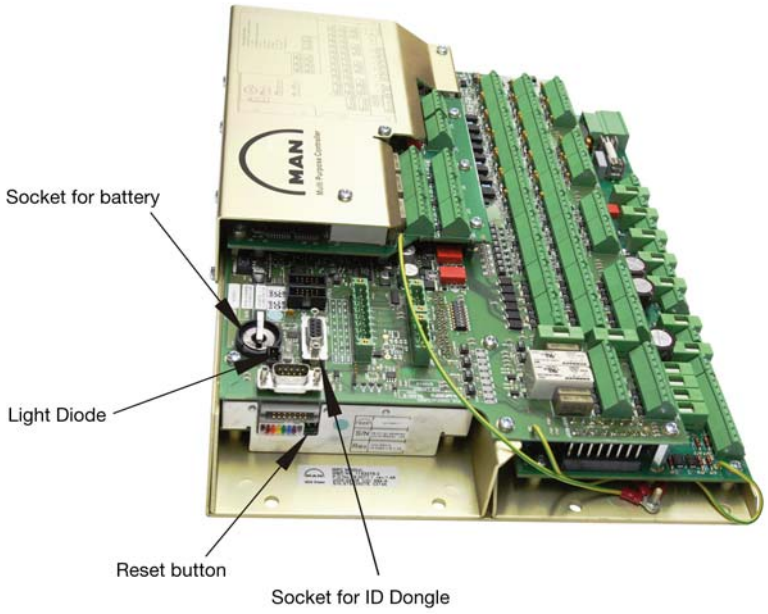
The MPC is, as shown on the picture below equipped with a battery. This battery is used for Back-up power to the clock – watch of the MPC in the event that the 24 V power is turned-off. All clocks of all MPC's are synchronised via the network. Synchronisation is done regularly and always after power is on after a possible power off. Regarding battery in MPC: See workcard 4765-1901.

When a new MPC is mounted in the cabinet, the dongle in the cabinet is mounted in the dongle plug-in, after reconnection of all wires. The dongle tells the "new" MPC in which cabinet it is mounted and, in that way, which software and parameters it should upload from the MOP harddisk (e.g. CCU1, ACU 3 or EICUA).

The MPC is also equipped with a light diode, capable of showing green, yellow or red light. This light tells the engineer in what status the MPC is.

During normal running the diode is green. When the diode is yellow, the MPC is rebooting or is in Test or Configuration Mode. When the diode is red, the MPC is unavailable. If resetting does not solve the problem with the red diode then replacement of the MPC might be neccesary.

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1.2 System View I/O (See Drawing 6655-0190)

The icons (see drawing 6655-0190 1(4)) shown on the controllers, show the status of each single controller, e.g. whether it is in mode:

Active	
Controlling	Ctrl
Test	T
Configuration	C
Blocked	B
Not accessible	

By pressing a single controller on this screen (in this case CCU1 is pressed and shown on drawing 6655-0190 2(4)), the actual inputs/outputs on the selected controller are shown.

The screen shows Info, ID and Descriptions and process values of each single channel on the MPC.

It is possible to see each single channel in both Normal and Test Mode, but to set an output channel manually, Test Mode has to be chosen.

CAUTION

Changing to TEST Mode will STOP the MPC from controlling the system.

By pressing the channel number to the left of the individual channel, for instance screen 3(4) on drawing 6655-0190, a single channel is shown (in this case, channel 30 on CCU1). The status and values of this channel are listed on this screen.

From this screen, input channels can be invalidated and validated again see page 4(4) on drawing 6655-0190 (Chief Level).

CAUTION

Changing the status of a channel may cause the system to malfunction.

The reason for alarm on an input could for instance be a defective sensor or loose wiring from the sensor to the MPC.

If a channel is invalidated, the ECS will continue to operate in the best possible way, without the invalidated input sensor value.

1.3 Invalidated Inputs (See Drawing 6655-0195)

If an input channel is invalidated (as described in Section 1.2 above), it is listed on the screen “Invalidated Inputs”. ID number, signal ID and a short description to easily overview and recognise the channel(s) involved are shown on this screen.

The reason for alarm on an input could for instance be a defective sensor or loose wiring from the sensor to the MPC. If a channel is invalidated, the ECS will continue to operate in the best possible way, without the invalidated input sensor value.

Input Channels Invalidated can be validated from this screen (Chief Level).

CAUTION

Changing the status of a channel may cause the system to malfunction.

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1.4 Network Status (See Drawing 6655-0200)

This screen gives the engineer an overall view and exact status of the Control Network of the ECS

From this screen, it is possible to see the status of the Network using the icons named below: (Icons are visible at drawing 6655-0200, bottom)

- OK 
- This MOP 
- No Reply Single Channel 
- No Communication 
- Not Accessible 
- On-line But No Information 
- Not Relevant 
- Reference 
- Cross Connection 

When all fields are shown with a green √ (check mark) everything is okay.

1.5 Function Test (See Drawing 6655-0203)

The Function Test tab consists of 3 items (submenus).

1.5.1 HCU for each cylinder

1.5.2 Tacho Equipment

1.5.3 HPS for each pump

The main purpose of these three screens, is to provide the engine personnel with a tool to test the function of the HCU, HPS and tacho equipment and their related components. Also the function test screens are used when replaced components are to be calibrated, e.g. in case of replacement of a fuel plunger sensor.

The function test screens are made as a step-by-step procedure, guiding the engine personnel through the tests. Each test begins with a few preparation steps in order to ensure the right conditions before commencing the actual test. The MOP must be in CHIEF access level and if not otherwise stated, the engine must be stopped before commencing the test.

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NOTICE

When rebooting an MPC in test mode, multiple alarms irrelevant to the test may occur.

1.5.1 HCU

The HCU tab is focusing on the FIVA valve. Depending on the configuration, the list contains three or two function tests. Only the FIVA valves with external amplifier have the option of an Amplifier Test. In the following all three function tests are explained.

NOTICE

As the HCU function test list is longer than the height of the screen a scrollbar is placed to the right.

Preparation of HCU Test

To begin the function test press the button START and follow the steps on the screen.

NOTICE

In order to varify that the fuel booster or exhaust valve are functioning as expected, an assistant must be stationed on the engine top at the unit in question during the test. For this test fuel pressure must be present.

Test of FIVA valve and calibration of Fuel Plunger

If the CCU MPC is not in test mode when the START button is pressed, the engineer is prompted to switch to test mode and reboot the MPC. Once the MPC has been rebooted, the function test will continue.

⚠ CAUTION

For testing of the fuel injection components, the FIVA will make one fuel injection.

The fuel injection is verified by the assistant on the engine top by feeling the shock-wave on the respective fuel injection pipe, and feeling on the high pressure pipes.

For testing the exhaust valve components, the FIVA will activate the respective exhaust valve once. This is verified by the assistant, by listening for the ”thump” sound of the exhaust valve opening and closing.

The test values listed on blue background in the far right column when the function test is finished and will under normal circumstances be within the default reference range listed next to the test value column.

If for some reason the test value differs from the reference value, this will be shown in one of the following ways:

x.xV	Signal and value ok.
– – –	Signal not present. (check if the MPC is connected to the network)
x.x mA	Signal value outside reference range. (Value electrically out of range or wire-break)
x.xV	Signal value outside reference range. (Signal ok, unit mechanically out of range)

If the test is successfully completed then the user has the option to use the SAVE button to upload the new calibration setpoints to the MPCs. Should this operation fail then another attempt should be made after approximately 30 seconds.

Amplifier test (only applicable to Curtis Wright FIVA valves)

This amplifier test enables the engineer to test the FIVA amplifier. When the START button is pressed a set of adjustment buttons will appear on the toolbar.

The adjustment voltage range for channel 70 lies between -3.6V to +3.6V. If signal value field for ch. 70 turns red, this normally indicates that something is wrong with the MPC.

The signal value field for ch. 33 has the same different types of error indications as shown above. If any of these are triggered then this most likely indicates that something is wrong with either the amplifier or the connections to the amplifier.

Cycle Test of Exhaust Valve and / or fuel injections

When START button is pressed, a set of buttons will appear on the toolbar, which enables the engineer to start a repeated cyclic test of the exhaust valve, in other words, the exhaust valve will continue opening and closing until the STOP button is pressed. Also for the fuel booster a single injection test is possible (both during the cyclic test and independent of this).

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CAUTION

Activation of ”single injection” will lead to one full MCR fuel Injection in the cylinder. Several activation will lead to filling of the combustion chamber with fuel oil.

Reboot of CCU

Reboot the CCU MPC to test mode in order to continue with tests or reboot to set the CCU MPC to normal operating mode (finished with function tests).

1.5.2 Tacho

The Tacho Test allows for the verification of the angles of the Tacho Pick-Ups and angle encoder fine adjustment of certain parameters.

Test of Tacho Signals

Press Start and follow the instructions on the screen. Make sure that an assistant is standing by to activate the Turning Gear, and verify the crankshaft position.

During the test the following is displayed on the screen:

A: xx B: xx (blue background):
If the crank has been turned to the prescribed angle when the background is blue, then the value is correct. Continue to next step.

A: xx B: xx (yellow background):
If the crank has been turned to the prescribed angle and the background is still yellow, then the test has failed. Continuation of the test is not possible. By pressing the details button, specific information regarding the failure is displayed. Check and adjust the Tacho arrangement.

The x in the test can be either T or F

Setting of Fine Adjustment Parameters

As indicated on the screen a certain minimum engine speed is required in order for the ME system to measure a correct ‘delta Tacho-B’ value.

The ’Trigg Offset AH’ value that is to be entered must be taken from the PMI equipment (see PMI manual). The ‘Trigg Offset AH’ value is not measured by the ME system, that is why a PMI-0 diagram is required as part of the setting of the final Tacho parameters.

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1.5.3 HPS

The HPS function Test allows for the test and calibration of the hydraulic pumps. Up to 5 pumps can be present depending on system configuration, each tab corresponds to a pump.

Preparation

To start the test press ” Start ” and make sure that a start-up pump is in local control on the starter cabinet, and running so that the necessary hydraulic pressure can be maintained.

Test

Press ” Start ” and follow the instructions on the screen. Make sure an assistant is standing by at the pump to check the swash plate angle.

During the test the following is shown on the screen:

Icons with background colours can be seen in chapter 1.5.1.

x.x mA (blue background):- Value ok - go to next step.

x.x mA (red background):- Value is outside the measurement interval (4-20mA) continuation of the test not possible - check the sensor and cables.

x.x mA (yellow background):- Value differentiates from the reference value. Continuation of the test not possible. Check the sensor.

If all of the steps are satisfactory calibration of the specific pump is carried out by pressing ” Save ”. The test is concluded by rebooting the MPC back to Normal Mode.

1.6 Troubleshooting (See Drawing 6655-0204)

This screen is used for performing troubleshooting on the Hydraulic Cylinder Unit and the Hydraulic Pressure System. The HCU Events and HPS Events are used to show the actual movements of FIVA valve, plunger positions, exhaust valve movements and swash plate positions as trend graphs.

1.6.1 HCU (See Drawing 6655-0204 page 1-5)

On this screen FIVA activation can be performed to execute fuel plunger and exhaust valve movement to check whether the system is working correctly.

Activation of the FIVA is performed by changing MPC Mode into Test Mode and activating the buttons displayed in the toolbar.

The cyclic test is only a cyclic activation of the exhaust valve.

CAUTION

Activation must only be performed with stopped engine. Each activation of the fuel plunger results in a fuel injection into the cylinder.

1.6.2 HPS (See Drawing 6655-0204 page 6)

On this screen the swash plate position for each pump can be regulated to check whether the system is working correctly.

Activation of the swash plate position is performed by changing MPC Mode into Test Mode and activating the buttons displayed in the toolbar.

The swash plate position can be seen on input ch 34 and compared with the desired setpoint.

When finish testing put MPC back to normal mode.

1.6.3 HCU and HPS Events (See Drawing 6655-0204 page 7-8) (Only available on MOP B)

These screens are an aid for the engineer and are used to monitor the actual movements of the HCU and HPS related signal. E.g. used to identify trouble in case of a malfunction of the electrical and mechanical components.

The HCU and HPS Events include a lot of very useful information for e.g. trouble-shooting.

It can however in certain cases be difficult to make quantitative conclusions based on HCU and/or HPS Events logs taken during a situation where problems are present (e.g. deviating cylinder pressures, hunting hydraulic pressure, etc.).

In those cases it is very helpful to have HCU and HPS Events logs from periods where there were no problems or irregularities. By comparing these logs with logs from situations where problems are present it is often possible to make qualitative conclusions regarding the current problems.

Therefore it is recommended to take manual HCU and HPS Events logs from time to time when no problems or malfunctions are present.

A suggested procedure is to make a note regarding the current speed, index and internal estimated power together with the names of the HCU and HPS Event logs

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and then save these on either a USB stick or some other computer (so the logs are still available even if MOP-B is later replaced).

NOTICE

Always ensure that any USB memory stick inserted into the MOP is scanned and cleaned of any malware.

A list of available dumps can be found in the upper left part of the list - newest on top. To display the contents mark an element in the list and press ”Show Sequence”.

Both manual dumps (Log Manually) and automatic dumps can be performed for special failures / alarms.
The event which caused the dump is described in the text above the graph area. The time of alarm is shown as a vertical dashed line. The display of measured values can be turned on and off by pressing the buttons on the left side of the screen.

By clicking and holding (the cursor turns into a hand) in the area left of the Y- axis or in the area below the X - axis, the graph can be moved vertically or horizontally.

Zooming can be carried out by drawing a square in the graph area while ”default view” can be recalled by pressing ” Zoom to fit ”

Storing both PMI diagrams and HCU Events logs from days with no problems, will greatly improve the options available for later troubleshooting. Therefore it is a good idea to take the HCU Events logs together with Performance Measurements and then save it all together.

1.6.4 CoCoS EDS

As described on drawing 6655-0125 MOP B is connected to the CoCoS EDS PC (which also runs the PMI software).

CoCoS EDS is not a part of the ECS, however it is an essential tool with regards to troubleshooting and diagnostics.

Therefore it is important that CoCoS EDS is running correctly and that the connection is functioning. All the time.

The CoCoS EDS installation includes guidance on how to evaluate and troubleshoot the connection.

1.6.5 Data logging

In the case that assistance from external parties is needed, it is essential for trouble shooting that following data is delivered to external parties:

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- A clear description of the case
- ECS Alarm/Event Log
- ECS parameter file (Spaf)
- ECS HCU data logger files
- ECS HPS data logger files
- EDS data logger files

Al this information can be gathered automatically with a program called “Dat-Gat.exe” that is found on the CoCoS-EDS CD. A description on how to use the “DatGat.exe” program can also be found on the CoCoS-EDS CD. The program can also be downloaded from the following adress:
Https//dieselport.mandiesel.com

NOTICE

The above mentioned data and logfiles will contribute to speed up the troubleshooting process, and are for that reason very important for external parties

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1 System

The screens are:

1.1 Set Time

1.2 Version (software and IMO Check Sum)

1.1 Set Time (See Drawing 6655-0205)

At the Set Time screen, the operator is able to set the time/date for UTC (Chief Level required) or to set the time offset for Local Time in intervals down to 5 minutes.

Pressing on either button “UTC Date/Time” or button “Local Date/Time” will display toolbars (shown on drawing 6655-0205). From these toolbars, Date and Time can be set.

Pressing the buttons “UTC Time displayed” or “Local Time Displayed” enables the operator to choose between the time to be displayed at the MOP panel (upper right corner) and in the lists (alarm list, event log etc.)

Alarms and logs are recorded with both Local Time/Date and UTC Time/Date regardless of which time/date is selected for displayed .

NOTICE

Always ensure a correct setting of UTC. The ECS has no connections to the ship`s master clock

1.2 Version (See Drawing 6655-0210)

1.2.1 Background

This screen displays the version type of the ECS controlling the ME engine. It is used to obtain the configuration information of the Electronic Control System (ECS) in an ME engine. It displays, in table format, all the controllers that comprise the system, including specific information relating to each controller.

1.2.2 Screen Items

In the upper system information line, general information of the ECS system for this particular engine is shown. The fields are: (See drawing 6655-0210)

Product Name & Version	The name and version of the ECS software
Engine Group No.	The Engine number of the engine builder
IMO No.	Engine IMO number (former Lloyds number)
Engine Builder	Name of engine builder
Eng. No.	Engine Serial number

1.2.3 Controller information

In the Controller information panel, data for each Controller in the system is dis-layed. The pane contains the following:

1.2.4 Controller unit

ID	Name of MPC (controller)
Addr.	Network Address of MPC
Type	Application group the MPC belongs to (ACU, CCU, ECU, EICU or SCU)

1.2.5 Parameters Check Sums

The Parameter Check Sums are indications of the current parameter values in the ME system. They are used as a method for determining if parameters have been changed. Especially the IMO Design parameters must not be changed compared to shop trial values, since they control emission and performance relevant parame-ters.

No changes made on the MOP will change the IMO Design Parameters Check Sums.

NOTICE

It is not possible to recreate the parameters of the ME system from the Check Sums, therefore sending a screen dump of this screen is not sufficient for external parties who inquire about specific parameter values.

1.2.6 Using the Screen

When the screen is first displayed, no information appears on the table. Press the “Refresh” button to retrieve the system information and parameter checksums of all controllers connected to the ECS. (See drawing 6655-0210.)

If at least one controller supplies information on the system that does not agree with the other controllers, a warning message is displayed in yellow in the specific controller unit and at the toolbar.

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Pressing the Export button generates a hardcopy of the information displayed in the table that can be saved to a hard drive or USB memory stick. This exported file is compressed in Zip format and must be unpacked to be readable. The file format is:

SWVersNParamChecksums on <Date & Time> for <MOP> <SW-version> on IMO <IMO number> Engine no <Engine number>.zip

NOTICE

Always ensure that any USB memory stick inserted into the MOP is scanned and cleaned of any malware.

1.3 Power Off

The Power Off button acts the same way as the “Shut Down” button in Windows Operating Systems on PCs.

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1 Cause

If flakes of burning or glowing carbon deposits drop into the oil sludge at the bottom of the scavenge air box, this sludge can be ignited and serious damage can be done to the piston rod and the scavenge air box walls, possibly reducing the tension of the staybolts.

Ignition of carbon deposits in the scavenge air box can be caused by:

- prolonged blow-by,
- "slow combustion" in the cylinder, owing to incorrect atomization, incorrect type of fuel valve nozzle, or "misaligned" fuel jets.
- "blow-back" through the scavenge air ports, due to an incorrectly adjusted exhaust cam disc or large resistance in the exhaust system (back pressure).

  To keep the exhaust resistance low, heavy deposits must not be allowed to collect on protective gratings, nozzle rings and turbine blades, in addition the back pressure after the turbocharger must not exceed 350 mm WC.

2 Warning of Fire

⚠ WARNING

If the auxiliary blowers do not start during low-load running, on account of a fault, or the switch for the blowers not being in "Auto"-position, unburned fuel oil may accumulate on top of the pistons. This will involve the risk of a scavenge air box fire.

In order to avoid such fires:

- obtain permission to stop the engine
- stop the engine
- remove any unburned fuel oil from the top of the pistons
- re-instate the supply of scavenge air
- start the engine

⚠ CAUTION

The switch for the auxiliary blowers should be in "AUTO"-position during all modes of engine control, i.e.:

- remote control
- control from engine side control console

A fire in the scavenge box is indicated by:

- an increase in the exhaust temperature of the affected cylinder,
- the turbocharger may surge,
- smoke from the turbocharger air inlet filters when the surging occurs,
- the scavenge air box being noticeably hotter.

CAUTION

If the engine stops on shut-down or if the operator performs a safety stop, the auxiliary blowers are stopped independently of the operating mode (automatic or manual).

If the fire is violent, smoky exhaust and decreasing engine revolutions will occur.

Violent blow-by will cause smoke, sparks and even flames to be blown out when the corresponding scavenge box drain cock is opened – therefore keep clear of the line of ejection.

Monitoring devices, in the scavenge air space give alarm and slow-down at abnormal temperature increase.
See description 7045-0100,

For CPP-plants with shaft generator engaged, an auxiliary engine will be started automatically and coupled to the grid before the shaft generator is disengaged and the engine speed reduced.
See drawing 6655-0120.

3 Measures to be taken

Owing to the possible risk of a crankcase explosion, do not stand near the relief valves – violent flames can suddenly be emitted.

1. Reduce speed/pitch to SLOW, if not already carried out automatically, see above, and ask bridge for permission to stop.
2. When the engine STOP order is received, stop the engine and switch-off the auxiliary blowers.
3. Stop the fuel oil supply.
4. Stop the lub. oil supply.
5. Put the scavenge air box fire extinguishing equipment into function. To prevent the fire from spreading to adjacent cylinder(s), the ball valve of the neighbouring cylinder(s) should be opened in case of fire in one cylinder.
See drawing 5455-0105.

WARNING

Keep clear of possible fresh spurts of flame.

Do not open the scavenge air box or crankcase before the site of the fire has cooled down to under 100°C.
When opening, keep clear of possible fresh spurts of flame.

Ventilate the scavenge air reciver thoroughly before entering.

6. Remove dry deposits and sludge from all the scavenge air boxes.
See description 7045-0100.
7. Clean the respective piston rods and cylinder liners, and inspect their surface condition, alignment, and whether distorted. If in order, coat with oil.

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Continue checking and concentrate on piston crown and skirt, while the engine is being turned (cooling oil and water on). Inspect the stuffing box and bottom of scavenge box for possible cracks.

8. If a piston caused the fire, and this piston cannot be overhauled at once, take the precautions referred to in *description 6645-0120.*

   If the scavenge air box walls have been heated considerably, the staybolts should be retightened at the first opportunity.

   Before retightening, all engine parts must be returned to normal operating temperature.

4 Scavenge Air Drain Pipes

See drawing 5455-0100.

To ensure proper draining of oil sludge from the scavenge air boxes, thereby reducing the risk of fire in the scavenge air boxes, we recommend:

- Daily check with the engine running
- Cleaning of drain pipes at regular intervals

4.1 Daily checks with the engine running:

1. Open the valve between the drain tank and the sludge tank.
2. Close the valve when the drain tank is empty.
3. Check the pipes from flange AV to the drain tank venting pipe:

   Does air escape from the drain-tank venting pipe?

   – YES:
   This indicates free passage from flange AV to the drain tank venting pipe.

   – NO:
   Clean the pipes as described below, at the first opportunity.

4. Check the pipes from the test-cocks to flange AV:

   Open the test cocks, one by one, between the main drain pipe and the scavenge air boxes and between the main drain pipe and the scavenge air receiver/ auxiliary blowers.

   Begin at flange AV, and proceed towards flange BV.

   See Item 4.2 in order to locate any blockages.

   Does air or oil blow-out from the individual test-cock?

   – AIR:
   The scavenge air space is being drained correctly.
   This indicates free passage from the actual test cock to flange AV.

   – OIL:
   The scavenge air space is not being drained correctly.

   This indicates that the main drain pipe is blocked between the test cock which blows-out oil, and the neighbouring test cock near the flange AV.

   Clean the drain pipe as described below, at the first opportunity.

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4.2 Cleaning of drain pipes at regular intervals:

The intervals should be determined for the actual plant, so as to prevent blocking-up of the drain system.

Clean the main drain pipe and the drain-tank discharge pipe by applying air, hot water or steam during engine standstill.

NOTICE

If leaking valves are suspected, dismantle and clean the main drain pipe manually.

If hot water or steam is used, the risk of corrosion on the piston rods must be considered, if a valve is leaking.

1. Check that the valve between flange AV and the main drain pipe is open.
2. Close all valves between the main drain pipe and the scavenge air boxes, and between the main drain pipe and the scavenge air receiver/auxiliary blowers.

   If hot water or steam is used, it is very important to close all valves, to prevent corrosion on the piston rods.
3. Open the valve at flange BV on the main drain pipe.

   This channels the cleaning medium to the main drain pipe.
4. When the main drain pipe is sufficiently clean, open the valve between the drain-tank and the sludge tank.

   This will clean the drain tank discharge pipe.
5. When the drain tank discharge pipe is sufficiently clean, close the valve between the drain tank and the sludge tank.
6. Close the valve at flange BV.
7. Finally, open all valves between the main drain pipe and the scavenge air boxes, and between the main drain pipe and the scavenge air receiver/auxiliary blowers.

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1 Cause

When the engine is running, the air in the crankcase contains the same types of gas (N_2-O_2-CO_2) in the same proportions as the ambient air, but there is also a heavy shower of coarse oil droplets that are flung around everywhere in the crankcase.

If abnormal friction occurs between the sliding surfaces, or heat is otherwise transmitted to the crankcase (for instance from a scavenge air fire via the piston rod/ stuffing box, or through the intermediate bottom), “Hot spots” can occur on the heated surfaces which in turn will cause the oil droplets falling on them to evaporate.

When the oil vapour condenses again, countless minute droplets are formed which are suspended in the air, i.e. a *milky-white* oil mist develops, which is able to feed and propagate a flame if ignition occurs. The ignition can be caused by the same “hot spot” which caused the oil mist.

If a large amount of oil mist has developed before ignition, the burning can cause a tremendous rise of pressure in the crankcase (explosion), which forces a momentary opening of the relief valves. In isolated cases, when the entire crankcase has presumably been filled with oil mist, the resulting explosion blows off the crankcase doors and sets fire to the engine room.

⚠ CAUTION

In the event that a crankcase explosion has occurred, the complete flame arrester of the relief valves must be replaced.

- Similar explosions can also occur in the chain casing and scavenge air box or gear box (if applied).

Every precaution should therefore be taken to:

- avoid “hot spots” - (A)
- detect the oil mist in time. - (B)

1.1 "Hot Spots" in Crankcase - (A)

Well-maintained bearings only overheat if the oil supply fails, or if the bearing journal surfaces become too rough (owing to the lubricating oil becoming corrosive or being polluted by abrasive particles).

For these reasons, it is very important to:

- purify the lubricating oil correctly,
- make frequent control analyses *(see description 2245-0100 and 3045-0100)*,
- ensure that the filter gauze is maintained intact.

Due to the high frictional speed of the thrust bearing, special care has been taken to ensure the oil supply to this bearing.

Monitoring equipment is included to give an alarm in the event of low circulating oil pressure and/or high temperature of thrust bearing segments. Keep this equipment in tip-top condition.
See description 7045-0100.

Feel over moving parts (by hand or with a “thermo-feel”) at suitable intervals (15-30 minutes after starting, one hour later, and again at full load. *See description 6645-0130*.

The checks in description 6645-0100 are still the best safeguard against “hot spots” when starting up after repairs or alterations affecting the moving parts, and should never be neglected. *If in doubt, stop and feel over*.

1.2 Oil Mist in Crankcase - (B)

In order to ensure a fast and reliable warning of oil mist formation in the crankcase, constant monitoring is provided using an “Oil Mist Detector”, which samples air from each crankcase compartment.

The detector gives alarm and slow-down, *see description 7045-0100*, at a mist concentration which is less than the lower explosion limit, LEL, to gain time for stopping the engine before ignition of the oil mist can take place.

For adjustment of oil mist detectors:
Oil mist detector sensors will over time be slightly polluted on the measuring device, and must be cleaned on the photocell and light source, carry out this cleaning before adjustment.

Generally the alarm set point should be as low as possible - without generating false alarms. Before deciding the actual alarm level, the normal oil mist level at MCR must be measured.

Pre-alarm and shutdown alarm must be set according to the MCR level eg.
- Pre-alarm level = 1,5 – 3 x MCR level,
- Shut down alarm level = 2 – 5 x MCR level but preferably not exceeding 2.0mg/l.

CAUTION

MAN Diesel & Turbo recommend the set point to be adjusted according to makers instruction.

For CPP-plants with shaft generator engaged, an auxiliary engine will be started automatically and coupled to the grid, before the shaft generator is disengaged and the engine speed reduced.
See drawing 6655-0120.

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2 Measures to be taken when Oil Mist has Occured

WARNING

Do not stand near crankcase doors or relief valves, nor in corridors near doors to the engine room, in the event of an alarm for:

- a. oil mist
- b. high lube oil temperature
- c. no piston cooling oil flow, or
- d. scavenge box fire

Alarms b, c and d should be considered as pre-warnings of a possible increasing oil mist level.
See also our Service Letters SL97-348/ERO and SL00-377/CEE

1. Reduce speed/pitch to slow-down level, if not already carried out automatically, see above.
   See description 7045-0100.
2. Contact the bridge for permission to stop.
3. When the engine STOP order is received:
   - stop the engine
   - close the fuel oil supply.
4. Switch-off the auxiliary blowers and engine room ventilation.
5. Open the skylight(s) and/or “stores hatch”.
6. Leave the engine room.
7. Lock the engine room doors and keep away from them.
8. Prepare the fire-fighting equipment.

   Do not open the crankcase until at least 20 minutes after stopping the engine. When opening up, keep clear of possible spurts of flame. Do not use naked lights and do not smoke.

9. Stop the circulating oil pump. Take off/open all the lowermost doors on one side of the crankcase. Cut off the starting air, and engage the turning gear.
10. Locate the “hot spot”. Use powerful lamps from the start.

    Feel over, by hand or with a “thermo-feel”, all the sliding surfaces (bearings, thrust bearing, piston rods, stuffing boxes, crossheads, telescopic pipes, vibration dampers, moment compensators, etc.).
    See point 14.

    Look for signs of squeezed-out bearing metal and discolouration caused by heat (blistered paint, burnt oil, oxidized steel). Keep possible bearing metal found at bottom of oil tray for later analyzing.
11. Prevent further “hot spots” by preferably making a permanent repair. In case of bearings running hot.
    See description 2545-0100 and description 0545-0100.

    Ensure that the respective sliding surfaces are in good condition. Take special care to check that the circulating oil supply is in order.

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12. Start the circulating oil pump and turn the engine by means of the turning gear.

    Check the oil flow from all bearings, spray pipes and spray nozzles in the crankcase, chaincase and thrust bearing.
    See description 6645-0100.

    Check for possible leakages from pistons or piston rods.

13. Start the engine.

    After:

    – 15-30 minutes,
    – one hour later,
    – when full load is reached:
    – Stop and feel over.
    – Look for oil mist.

    Especially feel over (by hand or with a “thermo-feel”) the sliding surfaces which caused the overheating.
    See description 6645-0130.

14. In cases where it has not been possible to locate the “hot spot”, the procedure according to Point 10 above should be repeated and intensified until the cause of the oil mist has been found and remedied.

    There is a possibility that the oil mist is due to “atomization” of the circulating oil, caused by a jet of air/gas, e.g. by a combination of the following:

    – Stuffing box leakages (not air tight).
    – Blow-by through a cracked piston crown or piston rod (with direct connection to crankcase via the cooling oil outlet pipe).
    – An oil mist could also develop as a result of heat from a scavenge fire being transmitted down the piston rod or via the stuffing box. Hot air jets or flames could also have passed through the stuffing box into the crankcase.

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1 General

During normal operation, a few sporadic surges will often occur, e.g. at crash stop or other abrupt manoeuvrings. Such surges are normally harmless, provided the turbocharger bearings are in a good service condition.

However, continuous surges must be avoided, as there is a risk of damaging the rotor, especially the compressor blades.

All cases of turbocharger surging can be divided into three main categories:

1. Restriction and fouling in the air/gas system.
2. Malfunction in the fuel system.
3. Rapid variations in engine load.

WARNING

Avoid standing close to the turbo charger in case of surging or use safety goggles to prevent dust and air blowing into the eyes.

However, for convenience, the points in the “check lists” below are grouped according to specific engine systems.
See drawing 6655-0225.

2 Causes

2.1 Fuel Oil System

- Low circulating or supply pump pressure.
- Air in fuel oil.
- Water in fuel oil.
- Low preheating temperature.
- Malfunctioning of deaerating valve on top of venting tank.
- Defective suction valve.
- Defective puncture valve.
- Sticking fuel pump plunger.
- Sticking fuel valve spindle.
- Damaged fuel valve nozzle.
- Defect in overflow valve in fuel return pipe.
- Faulty load distribution (this will be monitored in the ECS).

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2.2 Exhaust System

- Exhaust valve not opening correctly.
- Damaged or blocked protective grating before turbocharger.
- Increased back pressure after T.C.
- Pressure pulsations after T.C.
- Pressure pulsations in exhaust receiver.
- Damaged compensator before T.C.

2.3 Turbocharger

- Fouled or damaged turbine side.
- Fouled or damaged compressor side.
- Fouled air filter boxes.
- Damaged silencer.
- Bearing failure.

2.4 Scavenge Air System

- Fouled air cooler, water mist catcher, and/or ducts.
- Stopped water circulation to cooler.
- Coke in scavenge ports.
- Too high receiver temperature.

2.5 Miscellaneous

- Rapid changes in engine load.
- Too rapid rpm change:
  - when running on high load.
  - during manoeuvring.
  - at shut downs/slow downs.
  - when running ASTERN.
  - due to “propeller racing” in bad weather.

3 Countermeasure

Continuous surging can be temporarily counteracted by “blowing-off” from the valve at the top of the air receiver. However, when doing this the exhaust temperatures will increase and must not be allowed to exceed the limiting values.
See description 7045-0100.

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1. General

The engine is designed and balanced to run with all cylinders as well as all turbochargers working. If a breakdown occurs which disables one or more cylinders, or turbochargers, repair should preferably be carried out immediately.

If this is not possible, the engine can be operated with one or more cylinders or turbochargers out of operation, but with reduced speed owing to the following:

1. As, in such cases, the air supply is no longer optimal, the thermal load will be higher.

   Therefore, depending upon the actual circumstances, the engine will have to be operated according to the restrictions mentioned in Items 4 and 5 further on in this chapter.

NOTE

Sometimes high exhaust temperatures can occur at about 30-40% load, corresponding to 67-73% of MCR speed. Avoiding to operate the engine with in this range may be necessary.

2. Pressure pulsations may occur in the scavenge and exhaust receivers, which can give a reduced air supply to any one of the cylinders, and as a result cause the respective exhaust temperatures to increase.

   The fuel pump index for these cylinders must therefore be reduced to keep the exhaust temperatures (after valves) below the value stated in *Chapter 7045-0100. However, see "Note" in item 1 above.*

3. Since the turbochargers will be working outside their normal range, surging may occur.

   This can generally be remedied by "blowing off from the scavenge air receiver. The increased temperature level caused by this must be compensated for by reducing the engine revolutions, until the exhaust temperatures are in accordance with the values stated in *Chapter 7045-0100.*

   If more than one cylinder must be cut out of operation, and the engine has two or more turbochargers, it may be advantageous to cut out one of the turbochargers. However, *see "Note" in item 1 above*.

4. When cylinders are out of operation, hunting may occur. When this happens, the load limit must be limited on the MOP.

5. With one or more cylinders out of operation, torsional vibrations, as well as other mechanical vibrations, may occur at certain engine speeds.

   The standard torsional vibration calculations cover the following conditions:

   - normal running
   - misfiring of one cylinder

   The latter leads to load limitations, *see Item 4*, which in most cases are irrespective of the torsional vibration conditions; additional restrictions may occur depending on the specific conditions.

   The above-mentioned calculations do not deal with the situation where reciprocating masses are removed from the engine or where the exhaust

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valve remains open. In such specific cases the engine maker has to be contacted.

Should unusual noise or extreme vibrations occur at the chosen speed, the speed must be further reduced.

Because the engine is no longer in balance, increased stresses occur in crankshaft, chain and camshaft. However, if no abnormal vibrations occur, the engine can usually be run for a short period (for instance some days) without suffering damage.

If the engine is to be run for a prolonged period with cylinders out of operation, the engine builder should always be contacted in order to obtain advice concerning possible recommended barred speed ranges.

When only the fuel for the respective cylinders is cut off, and the starting air connections remain intact, the engine is fully manoeuvrable.

In cases where the starting air supply has to be cut off to some cylinders, starting in all crankshaft positions cannot always be expected.

If the engine does not turn on starting air in a certain crankshaft position, it must be immediately started for a short period in the opposite direction, after which reversal is to be made to the required direction of rotation.

Should this not give the desired result, it will be necessary to turn the engine to a better starting position, by means of the turning gear. Remember to cut off the starting air before turning and to open the indicator cocks.

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2. How to Put Cylinders Out of Operation.

See Chapter 6645-0250.

The following points **(A-E)** describe five different "methods" of putting a single cylinder out of operation.

The extent of the work to be carried out depends, of course, on the nature of the trouble.

NOTE

In cases where the crosshead and crankpin bearings are operative, the oil inlet to the crosshead must not be blanked-off, as the bearings are lubricated through the crosshead.

A summary of the various cases is given on *Drawing 6655-0215*.

A. Combustion cut out. Piston and exhaust valve gear still working Compression on

Reasons:
Preliminary measure in the event of, for instance: blow-by at piston rings or exhaust valve; bearing failures which necessitate reduction of bearing load; faults in the injection system.

Procedure:
Cut out the fuel pump *(see Chapter 6645-0250).*

NOTE

The piston cooling oil and cylinder cooling water must not be cut off. *See also Item 4*.

B. Combustion and compression cut out. Piston still working in cylinder

Reasons:
This method is permitted in the event of, for instance, water leaking into the cylinder from the cooling jacket/liner or cylinder cover.

Running with the above it must be superseded as soon as possible by the precautions mentioned under D or E. See also Item 3.

Procedure:

1. Cut out the fuel pump
   (see Chapter 6645-0250).
2. Put the exhaust valve out of action and lock it in **open** position.
   (see Chapter 6665-0101).

   Shut-off the air supply to the exhaust valve and stop the lube oil pumps. Dismantle and block the actuator oil pipe.

   Restart the lube oil pumps.
3. Close the cooling water inlet and outlet valves for the cylinder. If necessary, drain the cooling water spaces completely.

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4. Dismantle the starting air pipe, and blank off the main pipe and the control air pipe for the pertaining cylinder.

5. When operating in this manner, the speed should not exceed 55% of MCR speed. *See also 'Note' below*.

NOTE

The joints in the crosshead and crankpin bearings have a strength that, for a short time, will accept the loads at full speed without compression in the cylinder.

However, to avoid unnecessary wear and pitting at the joint faces when running a unit continuously with the compression cut-out, it is recommended that the engine speed is reduced to 55% of MCR speed, which is normally sufficient for manoeuvring the vessel.

During manoeuvres, if found necessary, the engine speed can be raised to 80% of MCR speed for a short period, for example 15 minutes.

In order to ensure that the engine speed is kept within a safe upper limit under these circumstances, the over-speed level of the engine must be lowered to 83% of MCR speed.

C. Combustion cut out. Exhaust valve closed. Piston still working in cylinder.

Reasons:
This measure may be used if, for instance, the exhaust valve or the actuator is defective. *See also Item 4*.

Procedure:

1. Cut out the fuel pump *(see Chapter 6645-0250)*.

2. Put the exhaust valve out of action *(see Work Card 1465-0701)* so that the valve remains closed. (Stop the oil supply and remove the hydraulic pipe).

NOTE

The cylinder cooling water and piston cooling oil must not be cut off.

D. Piston, piston rod and crosshead suspended in the engine. Connecting rod out.

Reasons:
For instance, serious defects in piston, piston rod, connecting rod, cylinder cover, cylinder liner and crosshead. *See also Item 3.*

Procedure:

1. Cut out the fuel pump *(see Chapter 6645-0250)*

2. Put the exhaust valve out of action *(see Work Card 1465-0701)* so that the valve remains closed.

3. Dismantle the starting air pipe. Blank off the main pipe and the control air pipe for the pertaining cylinder.

NOTE

In this case the blanking-off of the starting air supply is particularly important, as otherwise the supply of starting air will blow down the suspended engine components.

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4. Suspend the piston, piston rod and crosshead, and take the connecting rod out of the crankcase, in accordance with the directions in *Chapter 2540.*

5. Blank off the oil inlet to the crosshead.

6. Set the cylinder lubricator for the actual cylinder, to “zero” delivery.

E. Piston, piston rod, crosshead, connecting rod and telescopic pipe out

Reasons:
This method is only used if lack of spare parts makes it necessary to repair the defective parts during the voyage. *See also Item 3.*

Procedure:

1. Cut out the fuel pump *Chapter 6645-0250.*

2. Put the exhaust valve out of action *(See Work Card 1465-0701)* so that the valve remains closed.

3. Dismantle the starting air pipe, and then blank off the main pipe and the control air pipe for the actual cylinder.

4. Dismantle piston with piston rod and stuffing box, crosshead, connecting rod and crankpin bearing. Blank off the stuffing box opening with two plates (towards scavenge air box and crankcase). Minimum plate thickness 5 mm.

5. Blank off the oil inlet hole from the telescopic pipe.

6. Set the cylinder lubricator for the actual cylinder to “zero” delivery.

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3. Starting After Putting Cylinders Out of Operation

After carrying out any of the procedures described under points B, C, D and E, it is absolutely necessary before starting to check the oil flow through the bearings, and the tightness of blanked-off openings.

After 10 minutes' running, and again after one hour, the crankcase must be opened for checking:

- the bearings,
- the temporarily secured parts,
- the oil flow through bearings,
- the tightness of blanked-off openings.

Load Restrictions:

Cases A and C, see Item 4 below. Cases B, D and E, always contact the engine builder for calculation of allowable output and possible barred speed range.

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4. Running with one (1) Cylinder Misfiring (Cases A and C)

Misfiring is defined as:

- no injection and
- compression present.

If only **one** cylinder is misfiring, it **may** be possible to run the engine with the remaining and working cylinders, under two restrictions:

1. The thermal load of the cylinders.
2. The torsional vibration in the propeller shaft system.

Ad 1) Thermal load restriction: The following r/min and shaft powers may be obtained with a fixed pitch propeller given by the thermal load of the cylinders:

Total No. of Cylinders	% r/min (of MCR)	% Load (of MCR)
4	83	57
5	86	63
6	88	67
7	89	71
8	90	73
9	91	75
10	91	77
11	92	78
12	92	78
14	93	80

Ad 2) Torsional vibration restrictions: These restrictions, given as barred speed range, may be found from the class-approved report on the torsional vibration of the actual propeller shaft system.

NOTE

Only valid for misfiring, i.e. Item 2, cases A and C.
See also Drawing 6655-0215.

With a CP-propeller, the same restrictions apply when running according to the design pitch. During the misfire operation keep the CP-propeller pitch fixed at the design pitch.

If more than one cylinder is misfiring, the engine builder must be contacted.

Running limitations in Cases B, D and E
In cases B, D and E, the engine builder must always be contacted for calculation of allowable output and possible barred speed range.

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5. How to Put Turbochargers Out of Operation

(See also special instruction book for turbochargers).

If heavy vibrations, bearing failure or other troubles occur in a turbocharger, preliminary measures can be taken in one of the following ways:

A. If the ship must be instantly manoeuvrable:

Reduce the load until the vibrations cease.

B. If the ship must be instantly manoeuvrable, but the damaged turbocharger cannot run even at reduced load:

NOTE

This mode of operation is only recommended if no time is available for carrying out the procedures described in Item 'C', Running for an extended period with a Turbocharger out of Operation'.

Refer to the T/C manual regarding the maximum time of operation in condition '**B**', before the bearings will be damaged.

Engines with **one** turbocharger:

1. Stop the engine.
2. Lock the rotor of the defective turbocharger. *(See T/C manual).*
3. Remove the compensator between the compressor outlet and the scavenge air duct. *This reduces the suction resistance.*
4. **Load restrictions:** *See Drawing 6655-0220*

Engines with **two or more** turbochargers:

1. Stop the engine.
2. Lock the rotor of the defective turbocharger. *(See T/C manual).*
3. Insert an orifice plate in the compressor outlet.
   A small air flow is required through the compressor to cool the impeller.
4. **Load restrictions:** *See Drawing 6655-0220.*

NOTE

The load limit can be increased considerably if an orifice plate is also inserted in the turbine inlet, as described in Item **C**, 'Engines with **two or more** Turbo-chargers'.

C. Running for an extended period with a turbocharger out of operation

Engines with **one** turbocharger:

- Engines with exhaust by-pass (Option).

NOTE

The blanking plates mentioned in item 3 below, are optional for ABB TPL and MHI turbochargers.

1. Stop the engine.
2. Lock the turbocharger rotor. (See T/C manual).
3. Remove the blanking plate from the exhaust by-pass pipe.

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4. Remove the compensator between the compressor outlet and the scavenge air duct. This reduces the suction resistance.
5. **Load restrictions:** *See Drawing 6655-0220.*

- Engines without exhaust by-pass.

1. Stop the engine.
2. Remove the rotor and nozzle ring of the turbocharger. (See T/C manual)
3. Insert blanking plates. *(See T/C manual)*
4. Remove the compensator between the compressor outlet and the scavenge air duct. This reduces the suction resistance.
5. ***Load restrictions:*** *See Drawing 6655-0220.*

Engines **with two or more** turbochargers:

1. Stop the engine.
2. Lock the rotor of the defective turbocharger. *(See T/C manual)*
3. Insert orifice plates in the compressor outlet and the turbine inlet.
   A small air flow is required to cool the impeller, and a small gas flow is desirable to prevent corrosion.
4. **Load restrictions:** *See Drawing 6655-0220.*

D. Repair to be carried out during voyage.

Engines with **two or more** turbochargers:

1. Stop the engine.
2. Insert blanking plates in compressor outlet, turbine inlet and turbine outlet.
3. **Load restrictions**: *See Drawing 6655-0220.*

Engines with **one** turbocharger. equipped with exhaust by-pass (Option):

1. Stop the engine.
2. Insert blanking plates in turbine inlet and turbine outlet.
3. Remove the blanking plate from the exhaust by-pass pipe.
4. Remove the compensator between the compressor outlet and the scavenge air duct.
5. **Load restrictions:** *See Item **C**, 'Engines with exhaust by-pass (Option)'.*

6. Putting an Auxiliary Blower Out of Operation

If one of the auxiliary blowers becomes inoperative, it is automatically cut out by the built-in non-return valve, and there are no restrictions in the operation of the engine. *See Work Card 5465*.

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1 Special instruction

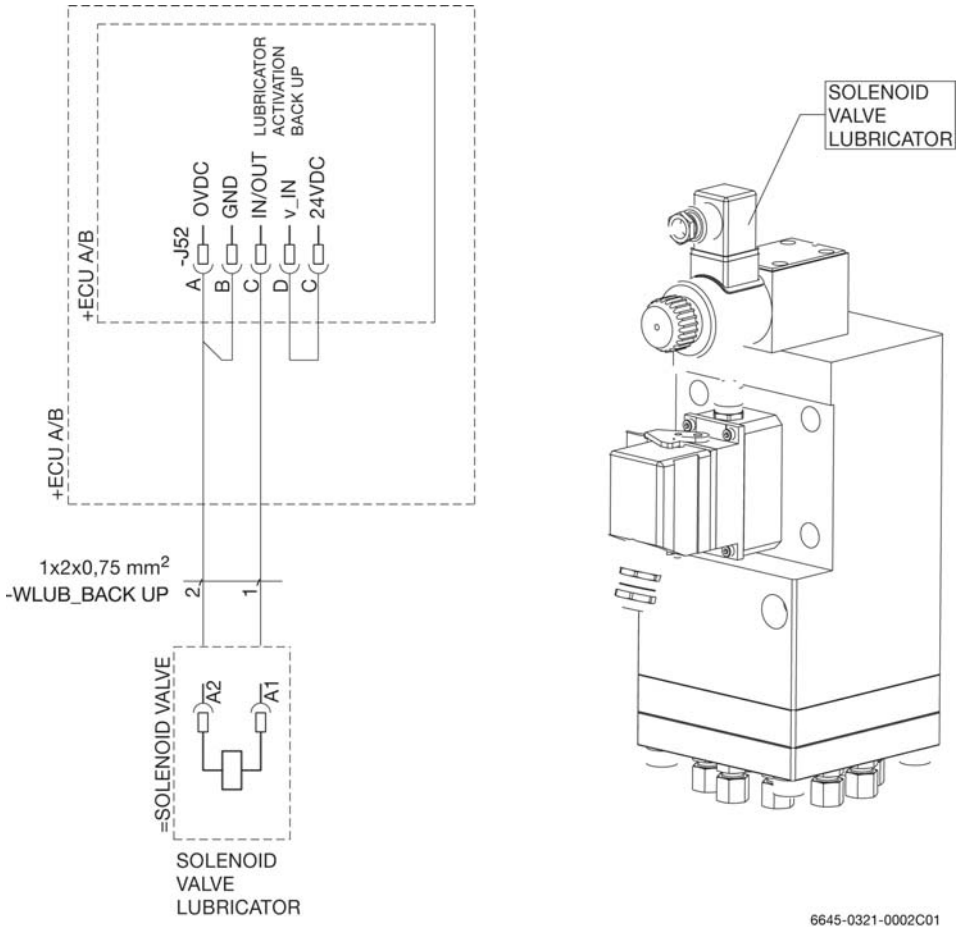
In case of CCU failure (and the CCU can not be changed immediately), activation of the ME lubricator can be achieved as follows.

NOTICE

In case of CCU failure, the engine is running at “Slow Down” mode.

A temporary cable from ECU A or B plug J52 is connected to solenoid valve on the lubricator of the failing CCU.

See below. The activation signal from J52 on ECUA/B is random.



1. Cylinder Cover Studs

- 8 studs; one stud cracked, reduce cylinder pressure to 85 % of p_{max}
- 8 studs; two studs cracked, reduce cylinder pressure to 75 % of p_{max}
- 16 studs; one stud cracked, no reduction
- 16 studs; two studs cracked, reduce cylinder pressure to 85 % of p_{max}

Always ensure that no gasleak occurs from the cylinder with cracked bolts. Gas-leaks will cause burnings on the joint surfaces of the cylinder cover and liner.

2. Staybolts, Mono and Twin Staybolts

- Engine end staybolts; one bolt cracked (located ahead of cylinder No. 1 or the aft cylinder), reduce the cylinder pressure in the nearest cylinder to 75 % of p_{max}.
- Staybolts in between cylinder No. 1 and the aftmost cylinder, including the bolts located by the chain drive at the centre; reduce the cylinder pressure in the both adjacent cylinders to 80 % of p_{max} (by the centre chain drive, only the nearest cylinder is affected).

Cylinder cover studs and staybolts must be replaced at first opportunity. For end mono-staybolts we recommend that both staybolts (manoeuvring side and exhaust side) are replaced.

In all other situations (than the above-mentioned) involving cracked cylinder cover studs or staybolts, MAN Diesel or the engine builder must be contacted.

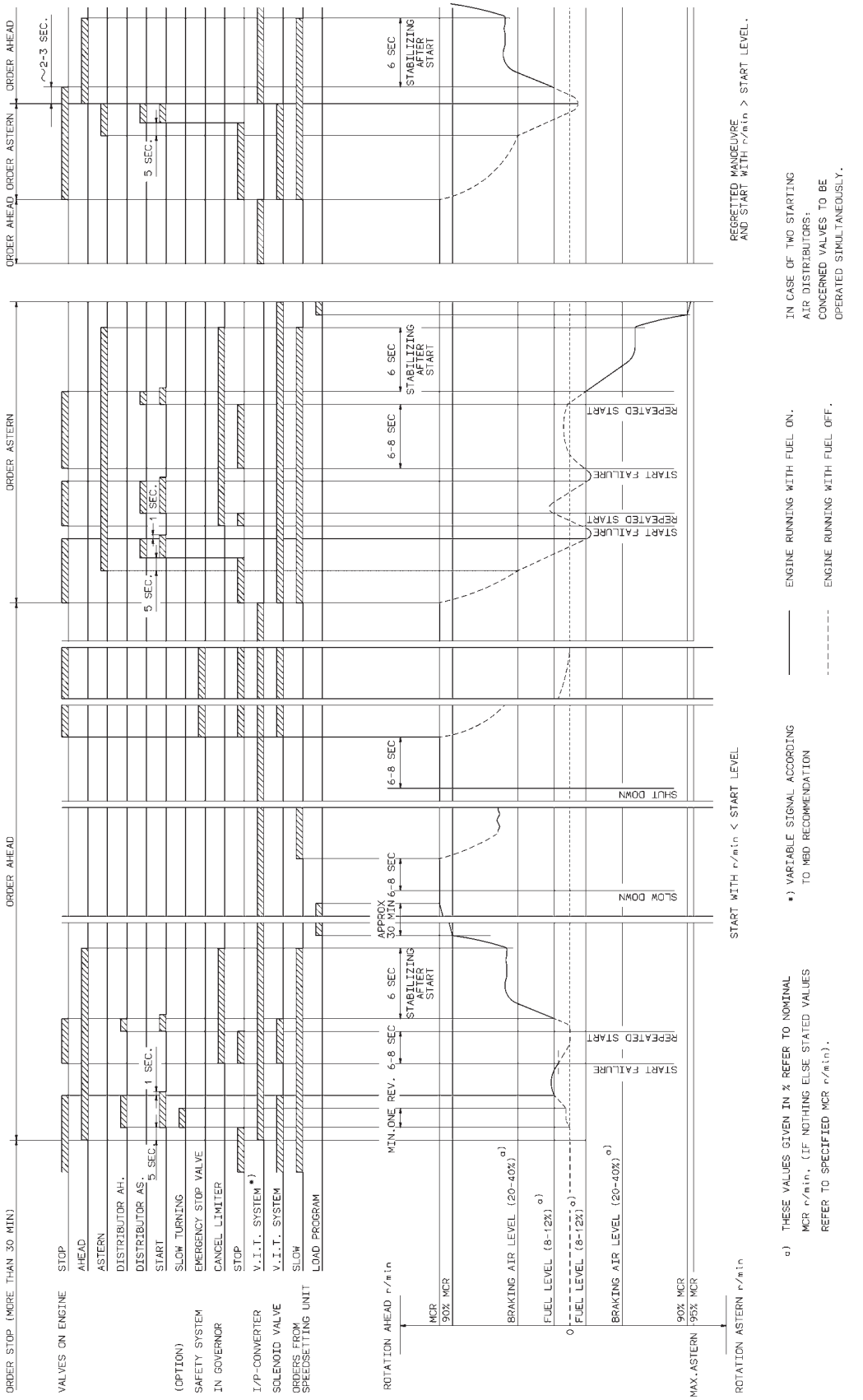
NOTE

If a crack in a cylinder cover stud/ staybolt occurs, replacement should preferably be carried out immediately.

If this is not possible, the engine can still be operated at reduced speed according to the guidelines specified above.

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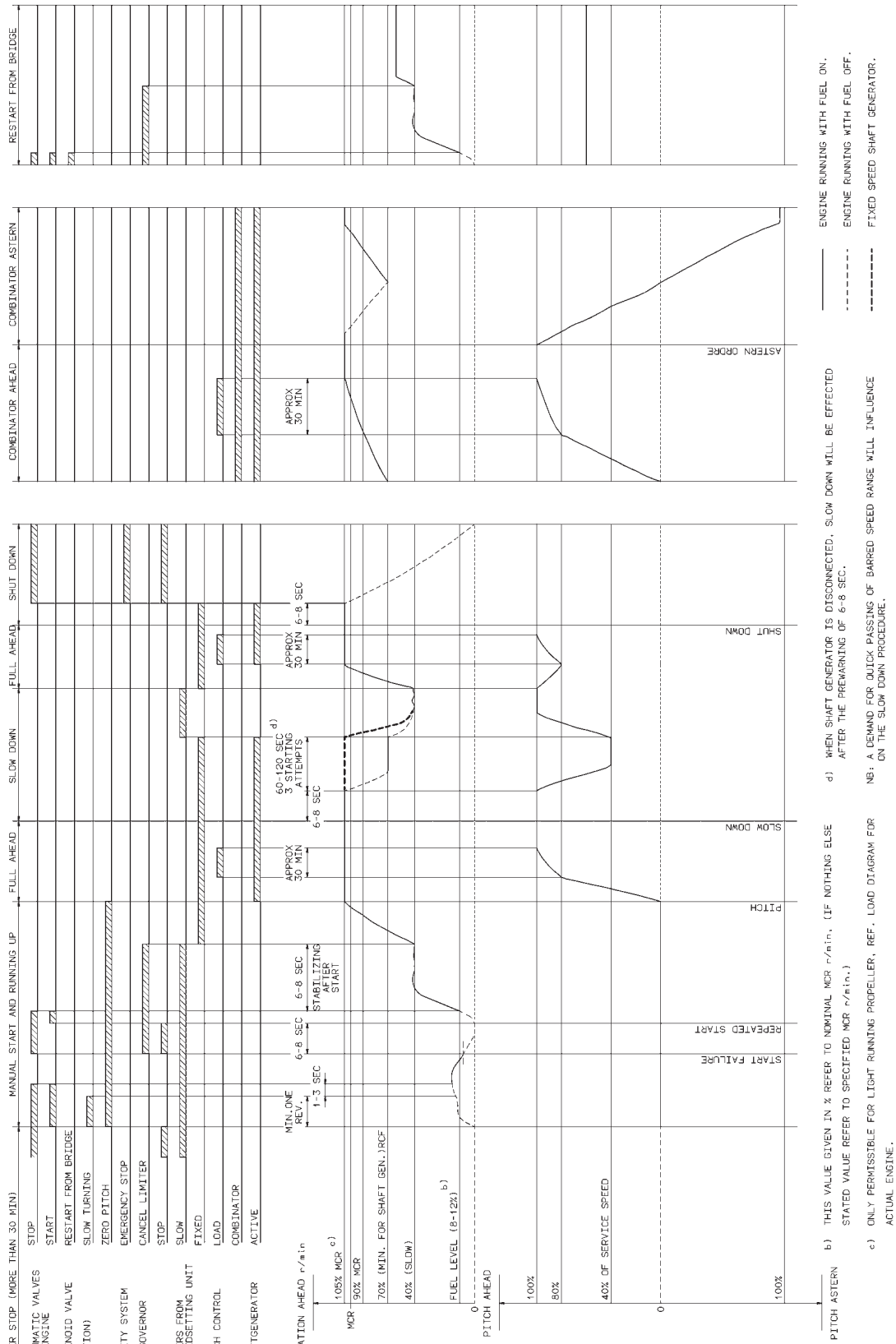
Drawing 6655-0115-0002 Sequence Diagram, FPP Plant



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Sequence Diagram, CPP Plant

Drawing
6655-0120-0002



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Fig. 1

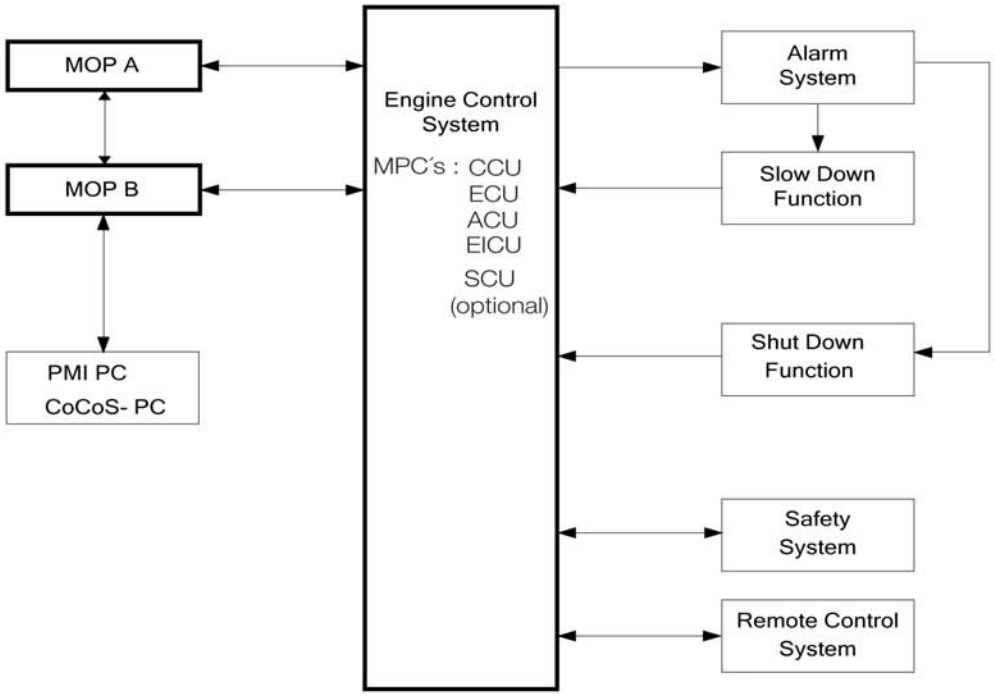
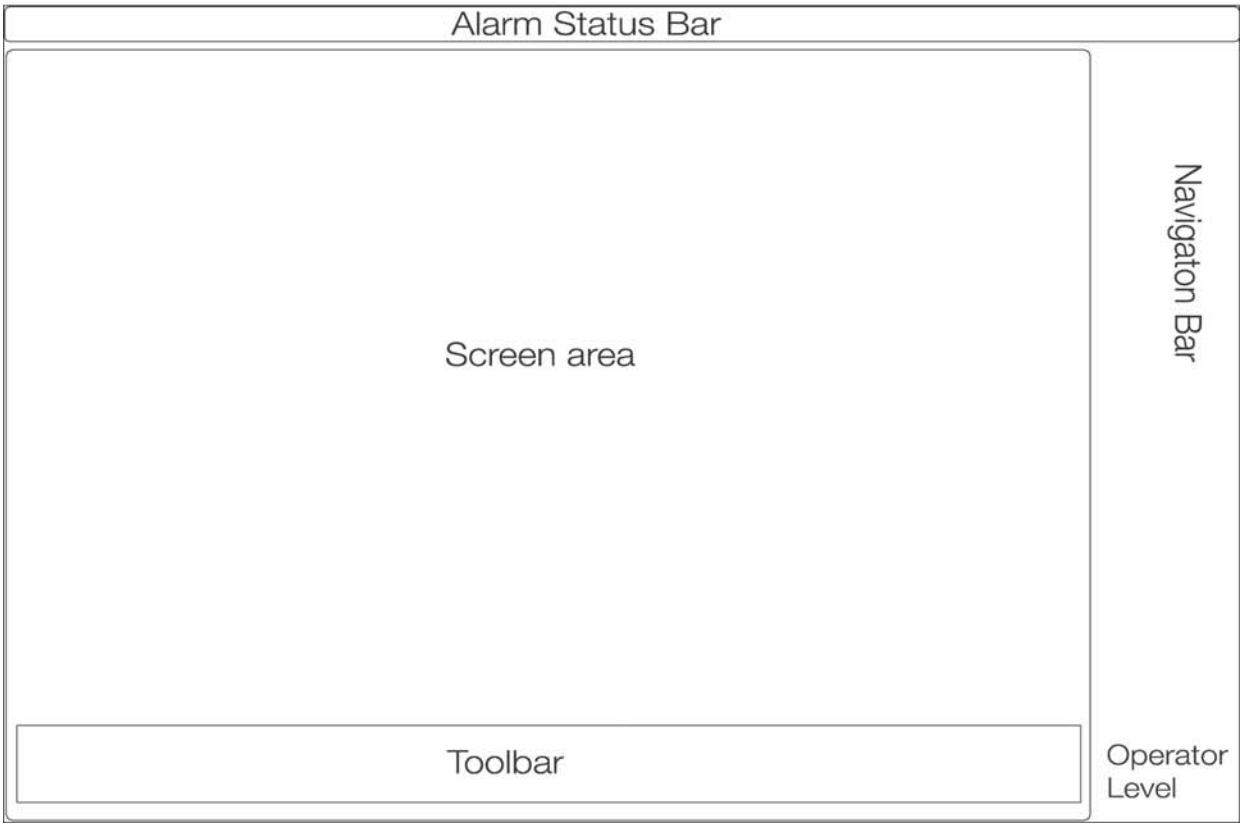


Fig. 2



2012-09-07 - en



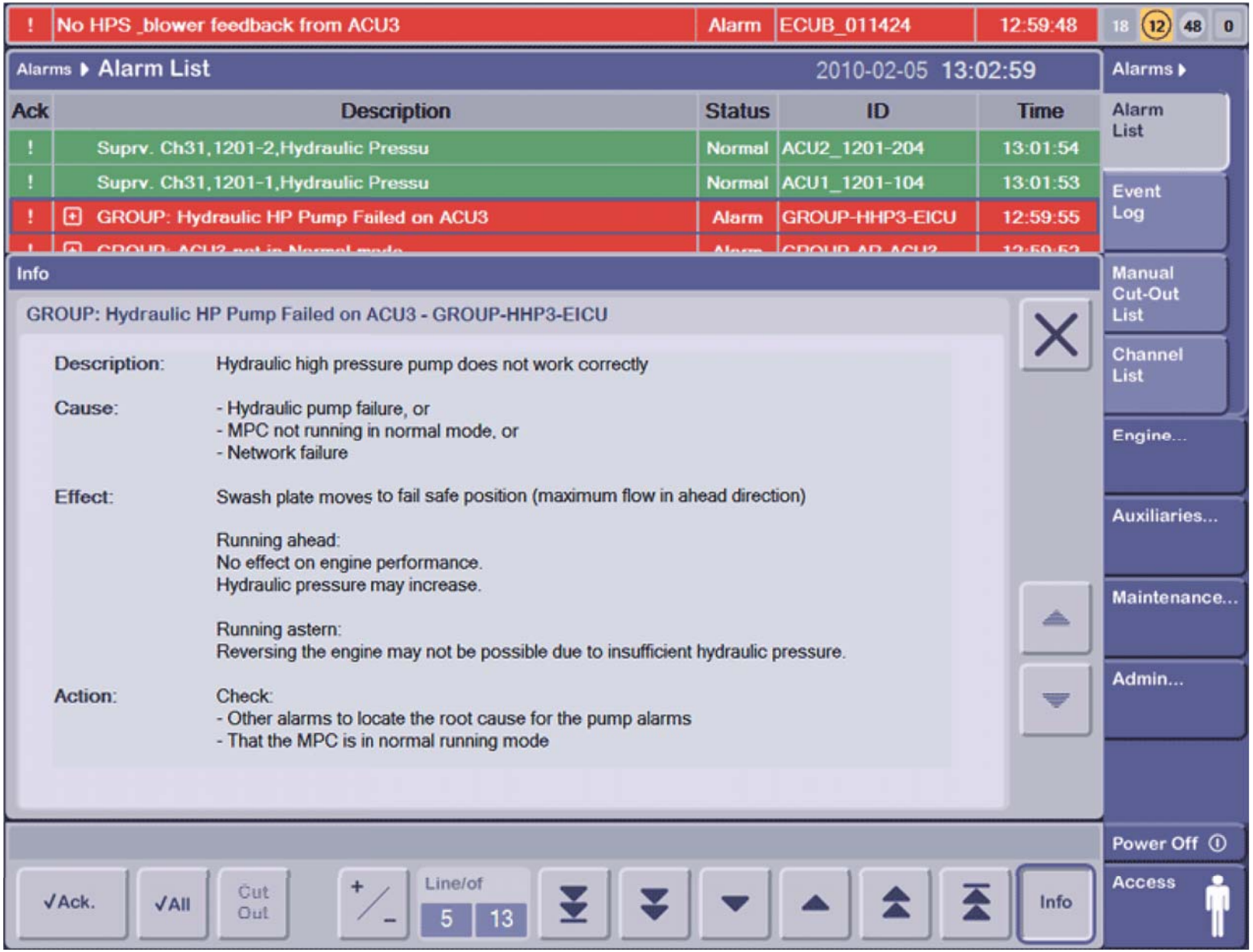
Drawing **MOP Alarm List**

6655-0130-0006

Drawing

6655-0130-0006

MOP Alarm List





ID: Unit_Tag	Date	Time	Description	Status	MCo	ACo	Ack
MOPB_WATCHDOG	*2010-02-05*	*12:38:53,52*	*Watchdog enabled*	*Event*			
MOPB_WATCHDOG	2010-02-05	12:38:53,52	pmi_bridge 192.168.0.103 1000 208 209 started. Not su	Event			
MOPB_WATCHDOG	2010-02-05	12:38:53,52	MainApp started. Not supervised <*>	Event			
MOPB_WATCHDOG	2010-02-05	12:38:46,55	esyxdjob started. Waiting for threads <*>	Event			
MOPB_WATCHDOG	2010-02-05	12:38:41,04	bes_server 203 - 2 started. Waiting for threads <*>	Event			
MOPB_WATCHDOG	2010-02-05	12:38:41,04	MOPLock -h -c started. Not supervised <*>	Event			
MOPB_WATCHDOG	2010-02-05	12:38:40,54	Contact with hardware established	Event			
MOPB_WATCHDOG	2010-02-05	12:38:36,16	HW Watchdog disabled	Event			
EICUB_RCSVarAA	2010-02-04	18:38:47,17	RCS communication failure	Normal			X
EICUB_SMBsTOAI	2010-02-04	18:38:45,54	RCS serial communication fail	Normal			X
EICUB_0931	2010-02-04	18:38:40,91	FWE-STANDBY-AT_SEA Inconsistency	Normal			X
EICUB_0660	2010-02-04	18:38:40,90	No Ctrl Station Selected	Normal			X
EICUB_0158	2010-02-04	18:38:40,89	Lock in Last 'Stop Cmd Bridge'	Normal			X
EICUB_0156	2010-02-04	18:38:40,89	Lock in Last 'Speed Set Bridge'	Normal			X
EICUB_0155	2010-02-04	18:38:40,79	Lock in Last 'Slow Down Cmd'	Normal			X
EICUA_0931	2010-02-04	18:38:40,68	FWE-STANDBY-AT_SEA Inconsistency	Normal			X
EICUA_0660	2010-02-04	18:38:40,67	No Ctrl Station Selected	Normal			X
EICUA_0158	2010-02-04	18:38:40,66	Lock in Last 'Stop Cmd Bridge'	Normal			X
EICUA_0156	2010-02-04	18:38:40,66	Lock in Last 'Speed Set Bridge'	Normal			X
EICUA_0155	2010-02-04	18:38:40,66	Lock in Last 'Slow Down Cmd'	Normal			X

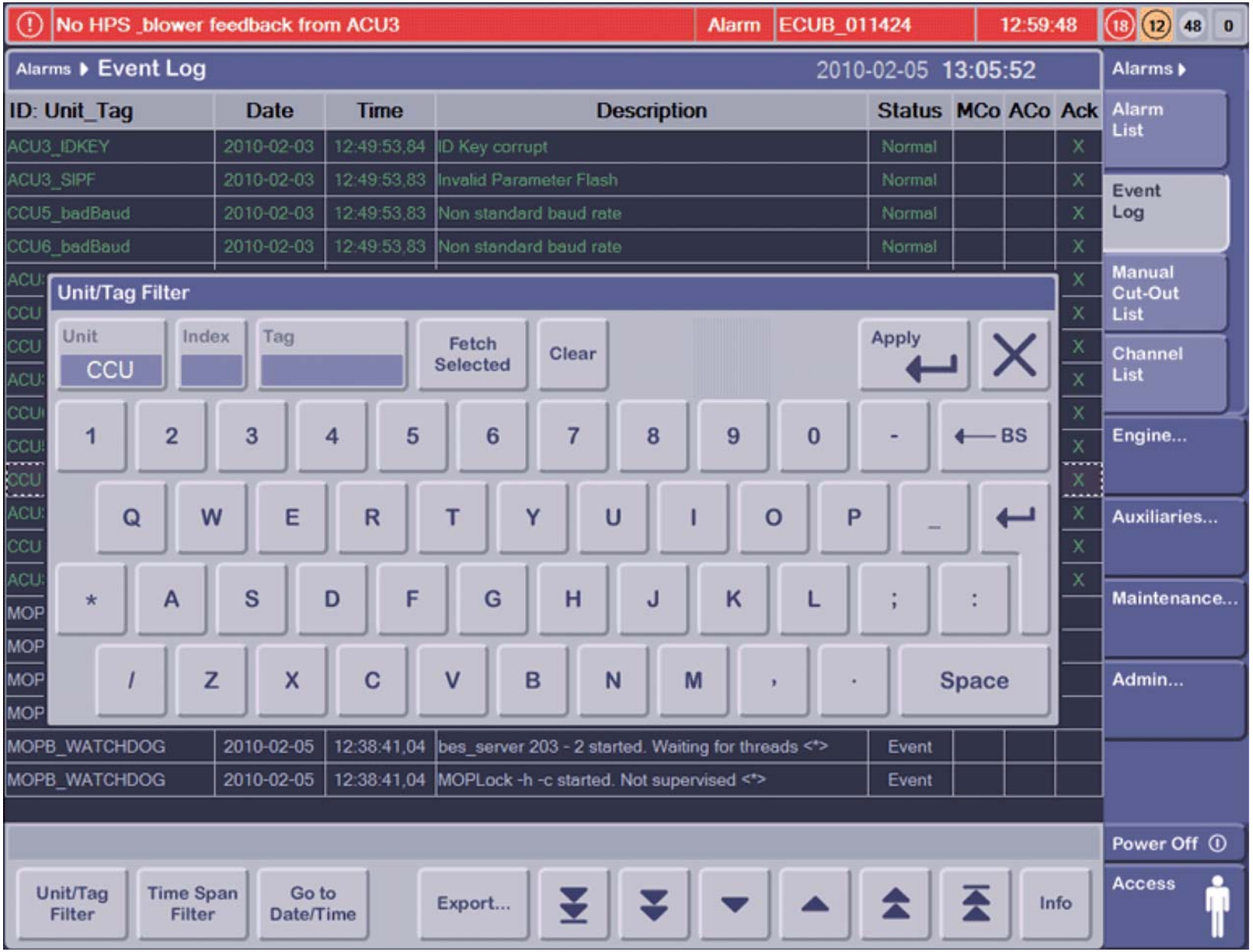
Drawing **MOP Event Log**

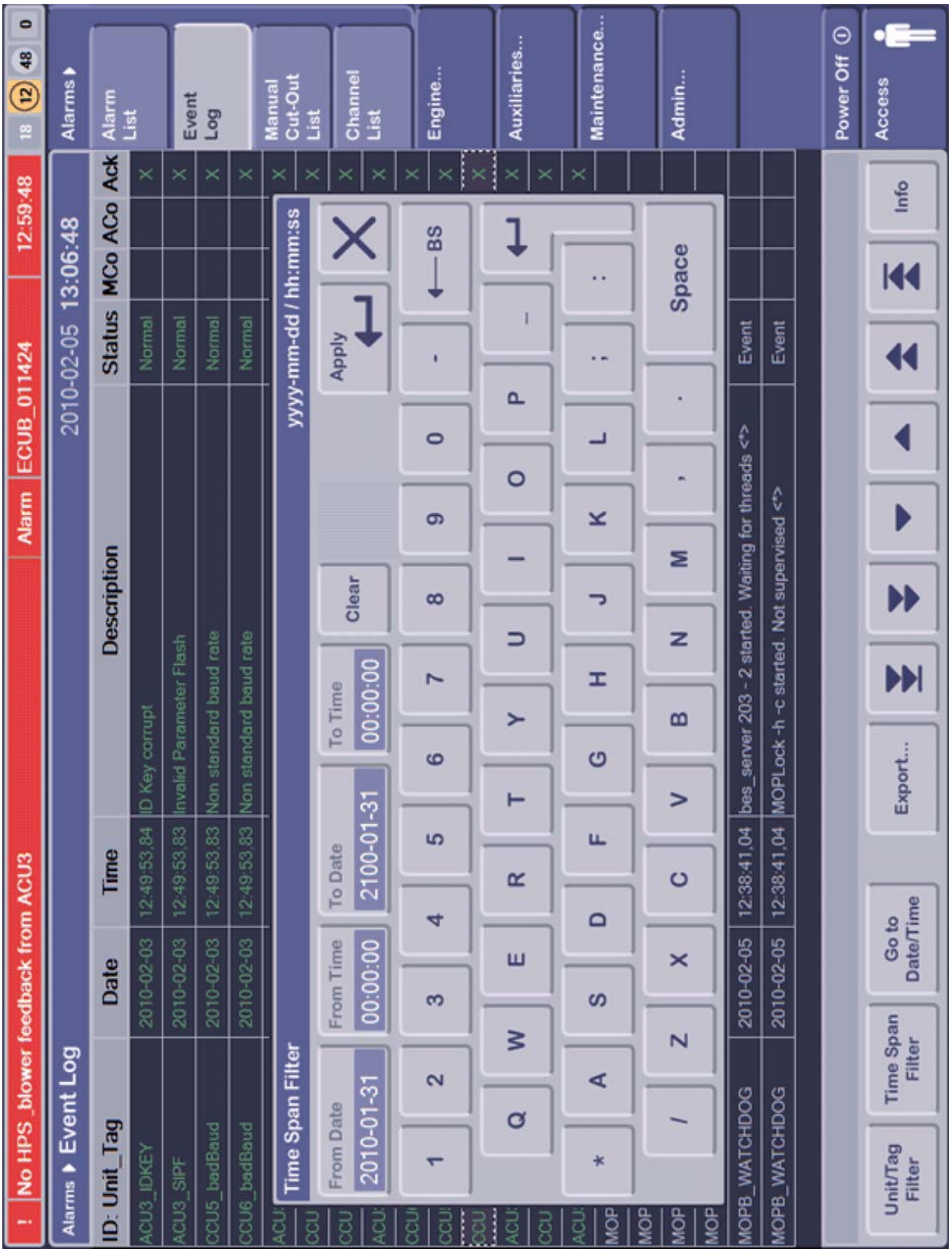
6655-0135-0005

Drawing

6655-0135-0005

MOP Event Log





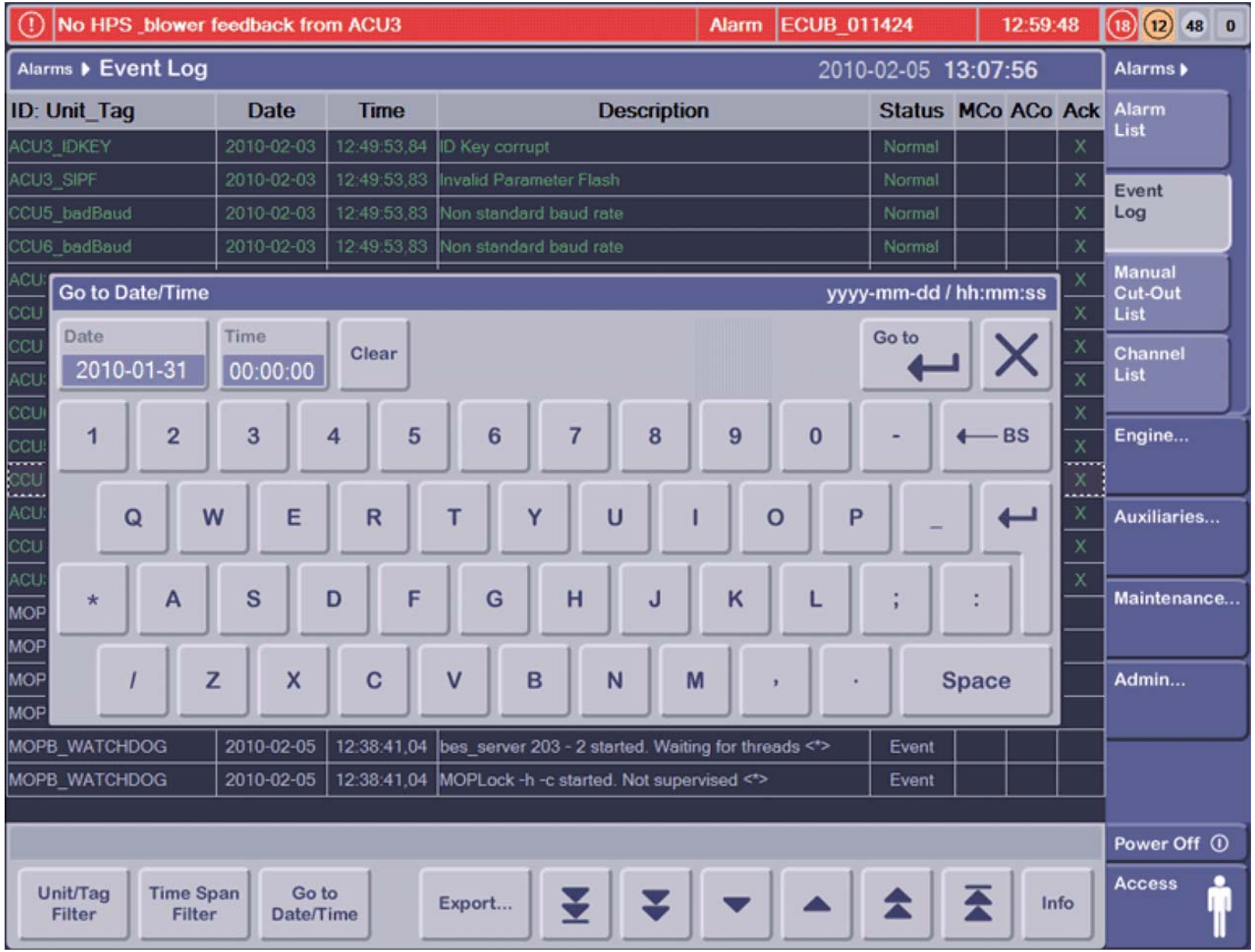
Drawing
6655-0135-0005

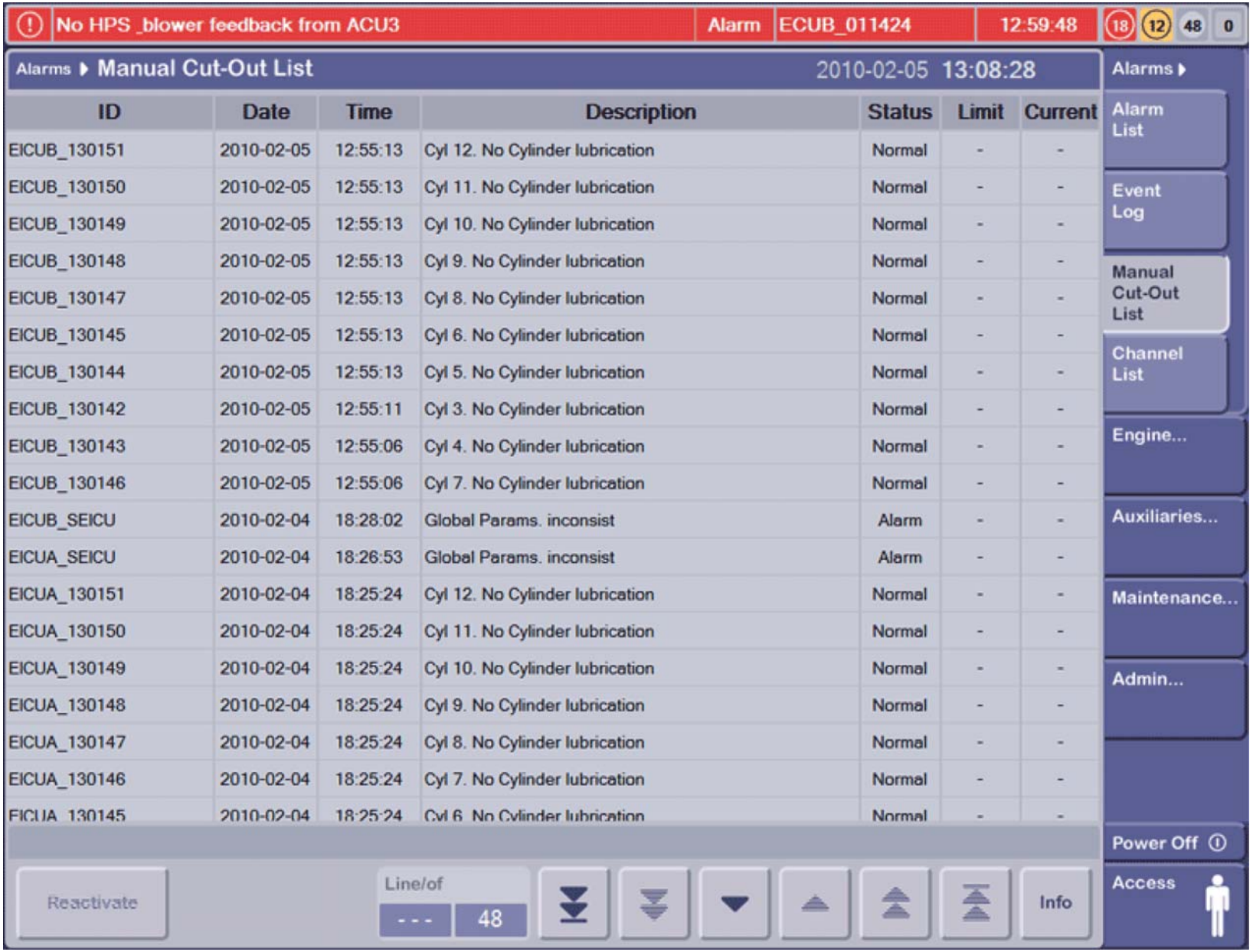
MOP Event Log

Drawing

6655-0135-0005

MOP Event Log





ID	Date	Time	Description	Status	Limit	Current
EICUB_130151	2010-02-05	12:55:13	Cyl 12. No Cylinder lubrication	Normal	-	-
EICUB_130150	2010-02-05	12:55:13	Cyl 11. No Cylinder lubrication	Normal	-	-
EICUB_130149	2010-02-05	12:55:13	Cyl 10. No Cylinder lubrication	Normal	-	-
EICUB_130148	2010-02-05	12:55:13	Cyl 9. No Cylinder lubrication	Normal	-	-
EICUB_130147	2010-02-05	12:55:13	Cyl 8. No Cylinder lubrication	Normal	-	-
EICUB_130145	2010-02-05	12:55:13	Cyl 6. No Cylinder lubrication	Normal	-	-
EICUB_130144	2010-02-05	12:55:13	Cyl 5. No Cylinder lubrication	Normal	-	-
EICUB_130142	2010-02-05	12:55:11	Cyl 3. No Cylinder lubrication	Normal	-	-
EICUB_130143	2010-02-05	12:55:06	Cyl 4. No Cylinder lubrication	Normal	-	-
EICUB_130146	2010-02-05	12:55:06	Cyl 7. No Cylinder lubrication	Normal	-	-
EICUB_SEICU	2010-02-04	18:28:02	Global Params. inconsist	Alarm	-	-
EICUA_SEICU	2010-02-04	18:26:53	Global Params. inconsist	Alarm	-	-
EICUA_130151	2010-02-04	18:25:24	Cyl 12. No Cylinder lubrication	Normal	-	-
EICUA_130150	2010-02-04	18:25:24	Cyl 11. No Cylinder lubrication	Normal	-	-
EICUA_130149	2010-02-04	18:25:24	Cyl 10. No Cylinder lubrication	Normal	-	-
EICUA_130148	2010-02-04	18:25:24	Cyl 9. No Cylinder lubrication	Normal	-	-
EICUA_130147	2010-02-04	18:25:24	Cyl 8. No Cylinder lubrication	Normal	-	-
EICUA_130146	2010-02-04	18:25:24	Cyl 7. No Cylinder lubrication	Normal	-	-
EICUA_130145	2010-02-04	18:25:24	Cyl 6. No Cylinder lubrication	Normal	-	-

Drawing
6655-0140-0005

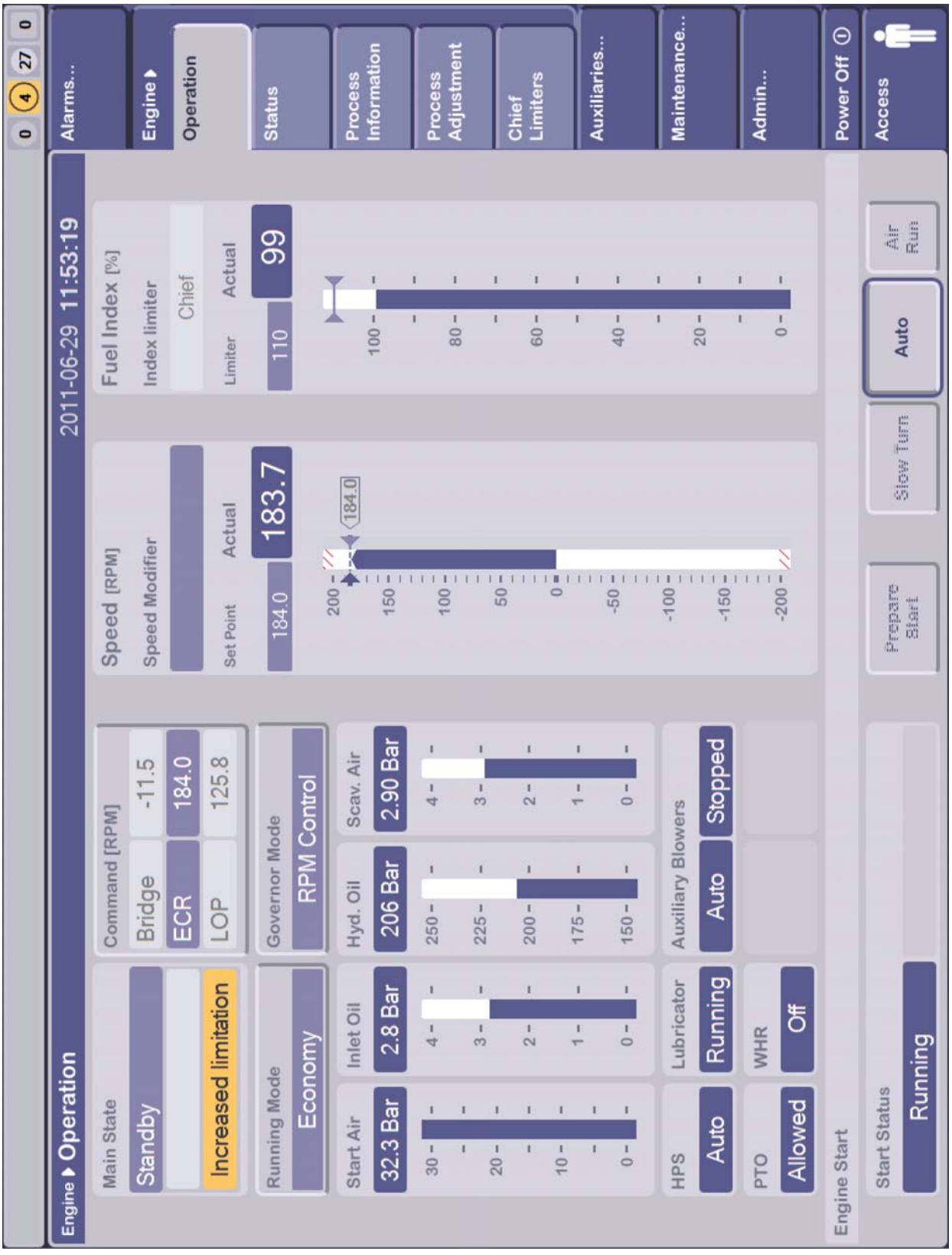
MOP Manual Cut-Out List



ID	Date	Time	Description	Status	MCo	ACo	Ack
ACU1_010110	2010-02-03	12:51:39	No Commands from ECU A	Normal			X
ACU1_010111	2010-02-05	12:56:16	No Commands from ECU B	Normal			X
ACU1_0210	2010-02-03	16:28:25	Blower 1 Ctrl Failed	Normal			X
ACU1_0510	2010-02-03	16:28:25	Blower 4 Ctrl Failed	Normal			X
ACU1_070119	2010-02-03	12:50:03	Pump ctrl failure	Normal			X
ACU1_070210	2010-02-03	14:23:14	Startup Pump Ctrl Failed	Normal			X
ACU1_0708	2010-02-05	10:18:37	Hydraulic leakage (shutdown level)	Normal			X
ACU1_0724	2010-02-03	12:50:04	Double pipe press. high	Normal			X
ACU1_0725	2010-02-03	12:50:04	Double pipe press. low	Normal			X
ACU1_1109-A04	2010-02-03	12:49:58	Suprv. Ch23,1109-A,Turning gear dis	Normal			X
ACU1_1110-A04	2010-02-03	12:49:58	Suprv. Ch22,1110-A,Turning gear eng	Normal			X
ACU1_1111-A04	2010-02-03	12:49:58	Suprv. Ch21,1111-A,Main start valve	Normal			X
ACU1_1112-A04	2010-02-03	14:10:12	Suprv. Ch24,1112-A,Main start valve	Normal			X
ACU1_1116-A04	2010-02-03	12:49:58	Suprv. Ch25,1116-A,Start air dist l	Normal			X
ACU1_1201-104	2010-02-05	13:02:15	Suprv. Ch31,1201-1,Hydraulic Pressu	Normal			
ACU1_1202-A03	2010-02-03	12:50:00	Suprv. Ch80,1202-A,System bypass op	Normal			X
ACU1_1204-104	2010-02-03	12:49:59	Suprv. Ch32,1204-1,Lube oil pressur	Normal			X
ACU1_123604	2010-02-03	12:49:58	Suprv. Ch27,1236,Hyd. leak shutdown	Normal			X
ACU1_8501-A04	2010-02-04	16:58:21	Suprv. Ch37,8501-A,Starting air pre	Normal			X
ACU1_8503-A04	2010-02-04	14:41:18	Suprv. Ch36,8503-A,Control air pres	Normal			X
ACU1 IDKEY	2010-02-03	12:49:56	ID Key corrupt	Normal			X

Drawing
6655-0145-0006

MOP Channel List



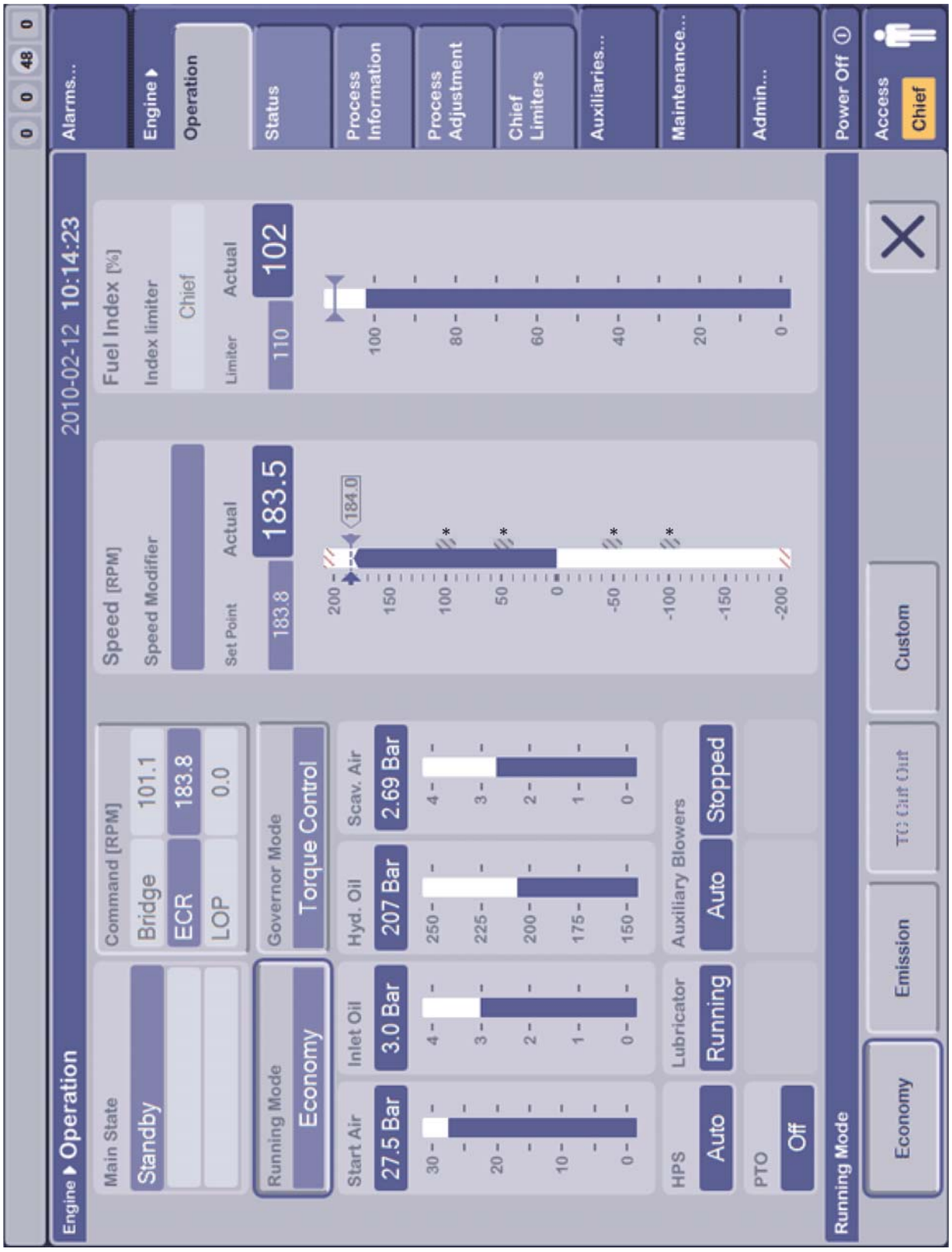
Drawing
6655-0150-0004

MOP Operation

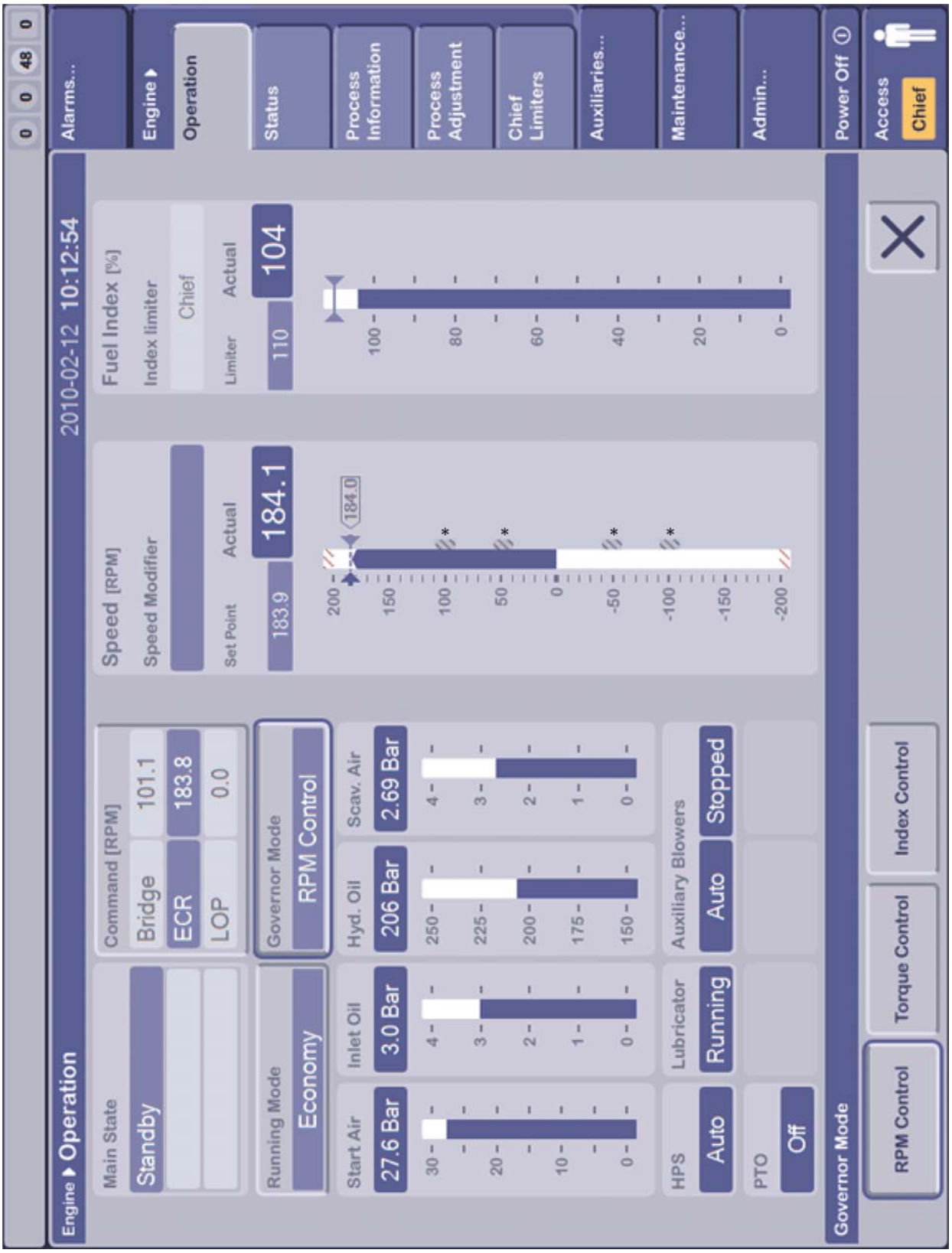
2012-09-07 - en

Drawing
6655-0150-0004

MOP Operation



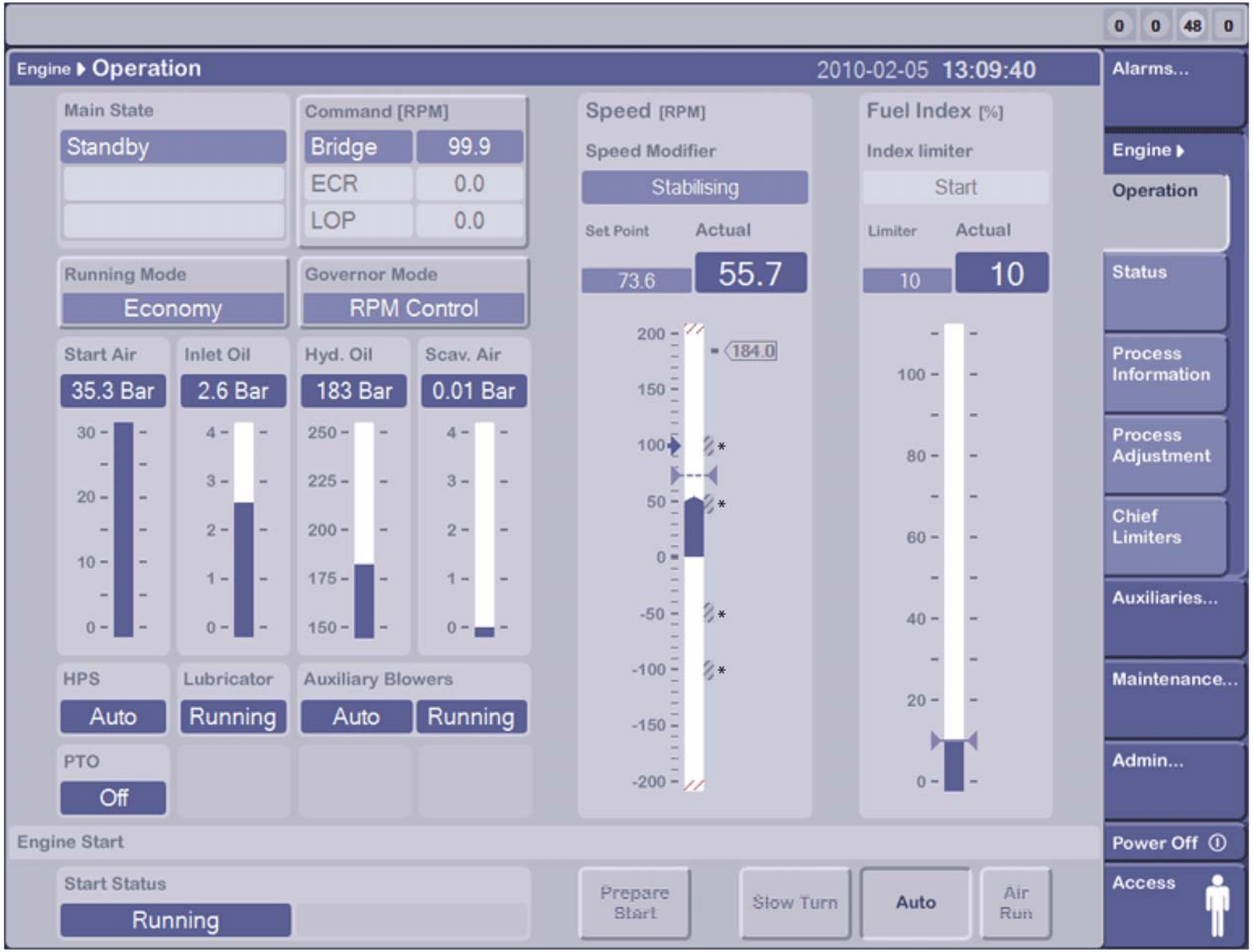
2012-09-07 - en

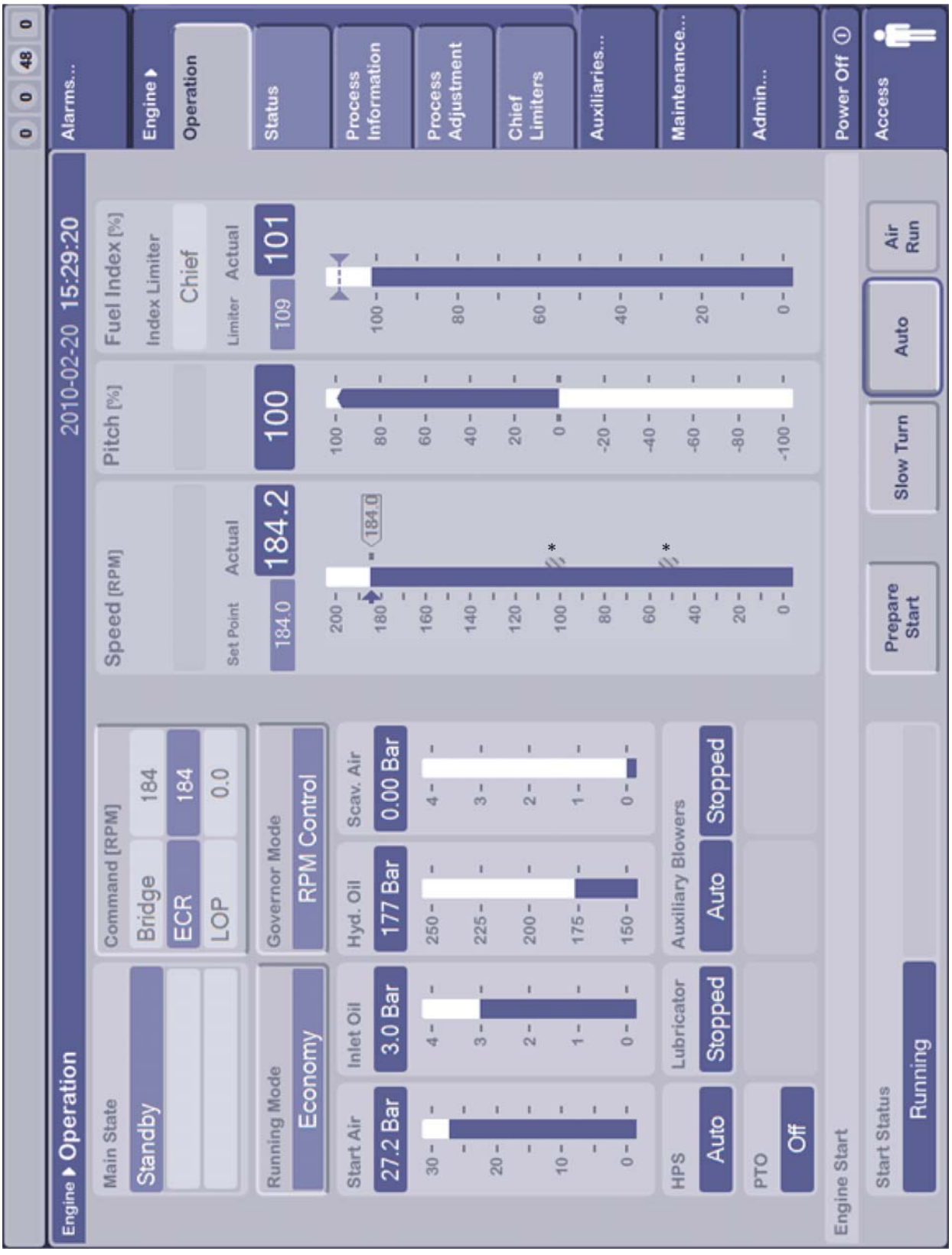


Drawing
6655-0150-0004

MOP Operation

2012-09-07 - en

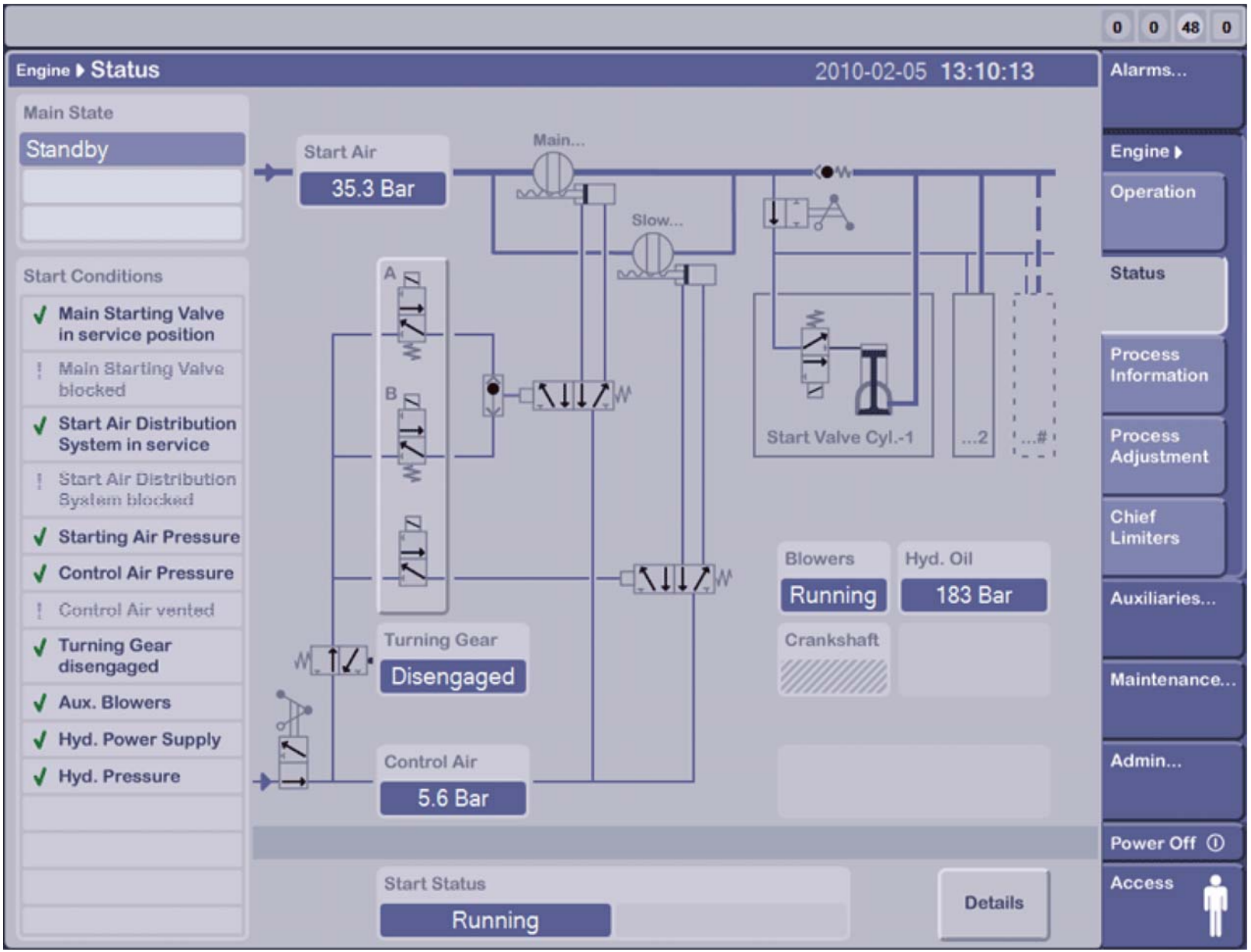

0 0 48 0
Engine ▸ Operation
2010-02-05 13:09:40
Alarms...
Engine ▸
Operation
Status
Process Information
Process Adjustment
Chief Limiters
Auxiliaries...
Maintenance...
Admin...
Power Off
Access
Main State
Standby
Command [RPM]
Bridge 99.9
ECR 0.0
LOP 0.0
Running Mode
Economy
Governor Mode
RPM Control
Speed [RPM]
Speed Modifier
Stabilising
Set Point
Actual
73.6
55.7
184.0
Fuel Index [%]
Index limiter
Start
Limiter
Actual
10
10
Start Air
35.3 Bar
Inlet Oil
2.6 Bar
Hyd. Oil
183 Bar
Scav. Air
0.01 Bar
HPS
Auto
Lubricator
Running
Auxiliary Blowers
Auto
Running
PTO
Off
Engine Start
Start Status
Running
Prepare Start
Slow Turn
Auto
Air Run



Drawing
6655-0150-0004

MOP Operation

2012-09-07 - en



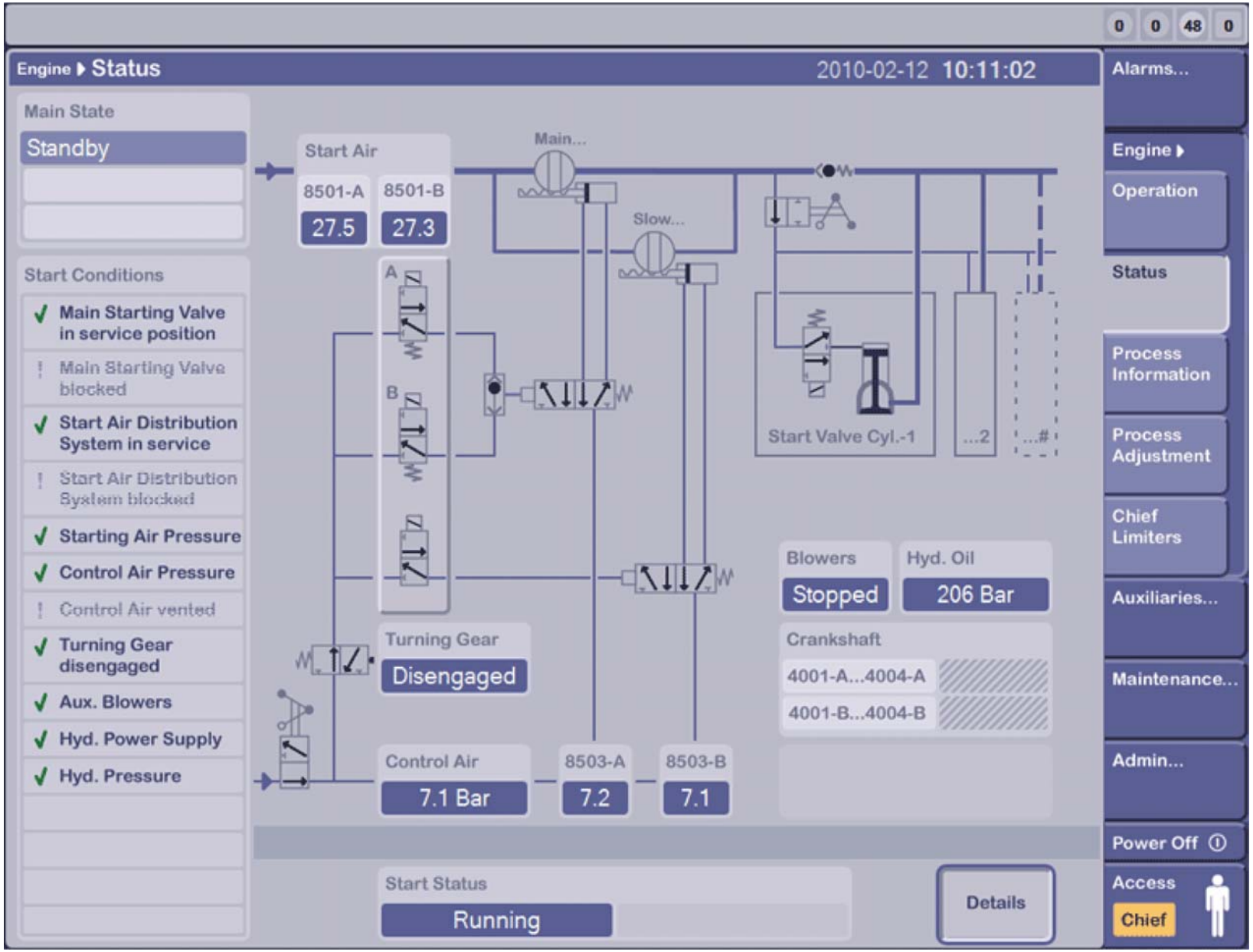
Drawing **MOP Status**

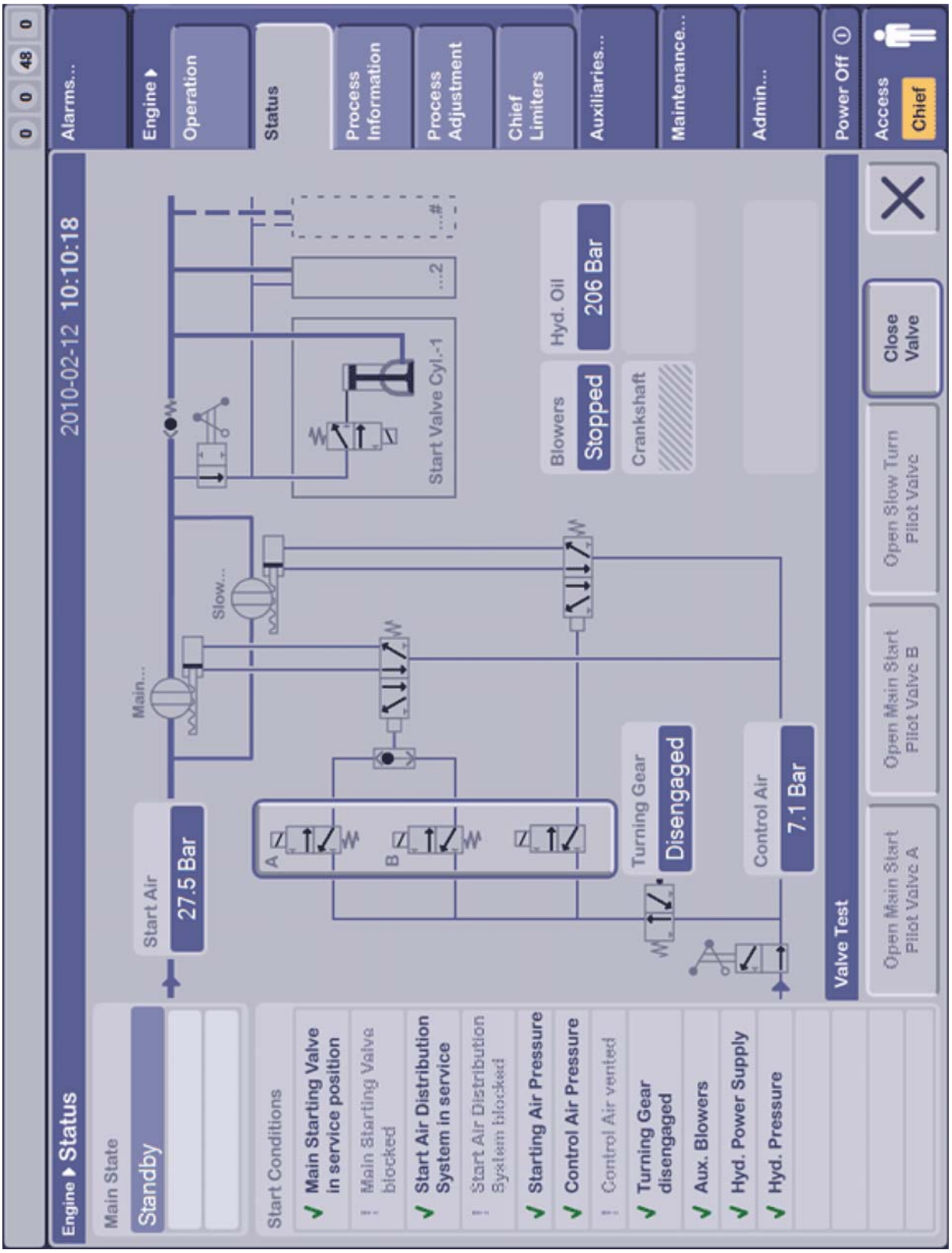
6655-0155-0002

Drawing

6655-0155-0002

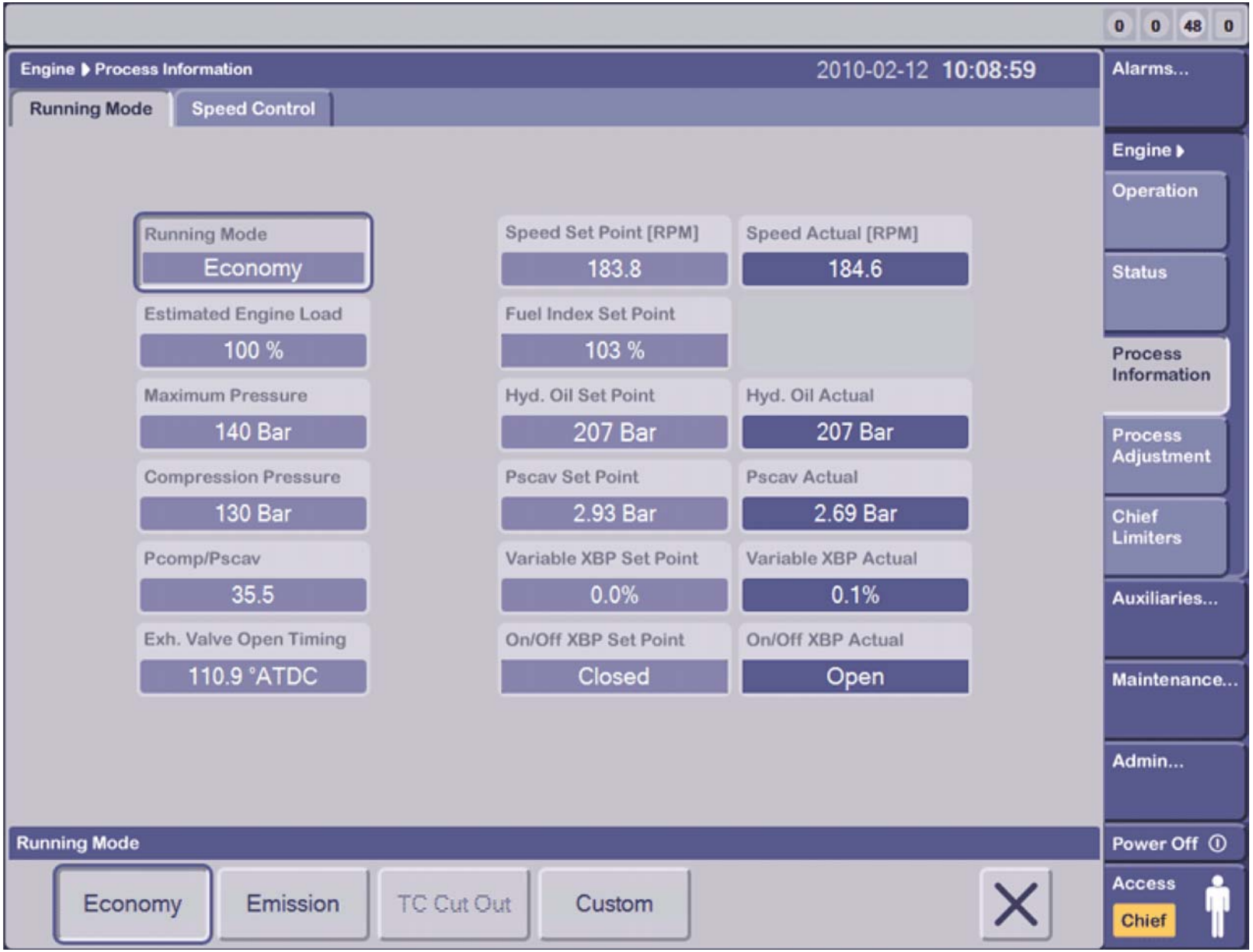
MOP Status





Drawing
6655-0155-0002

MOP Status

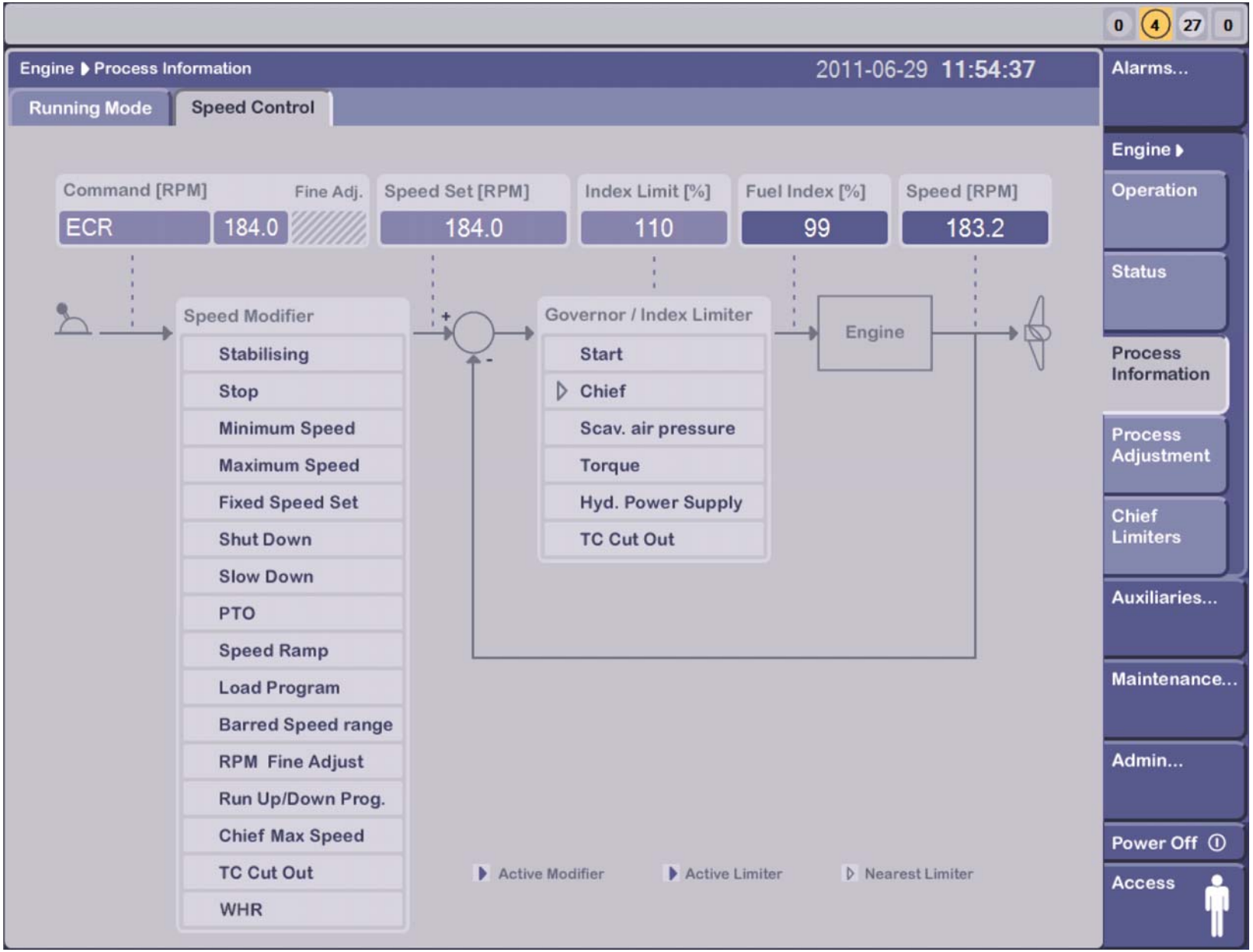


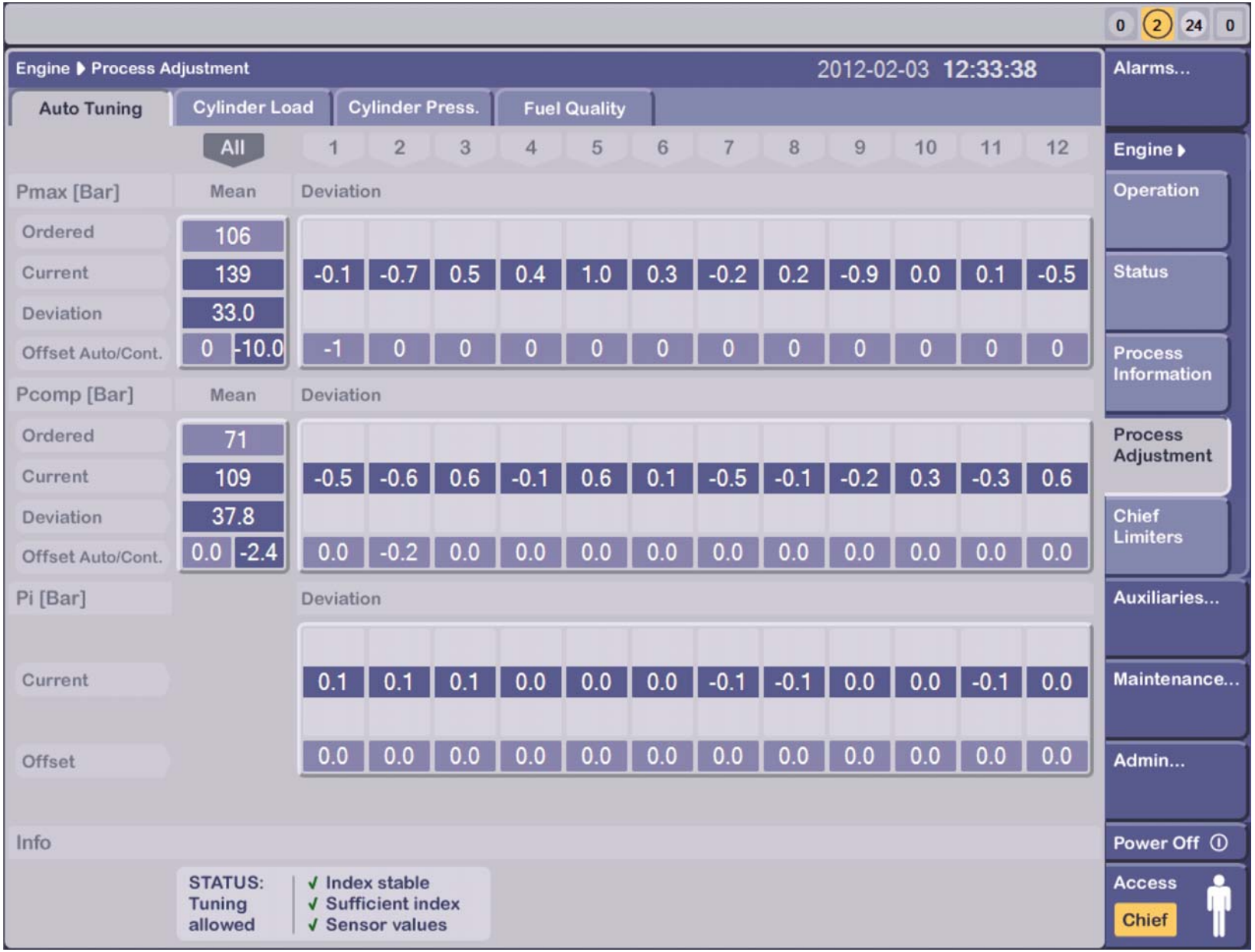
Drawing **MOP Process Information**

6655-0160-0004

Drawing
6655-0160-0004

MOP Process Information



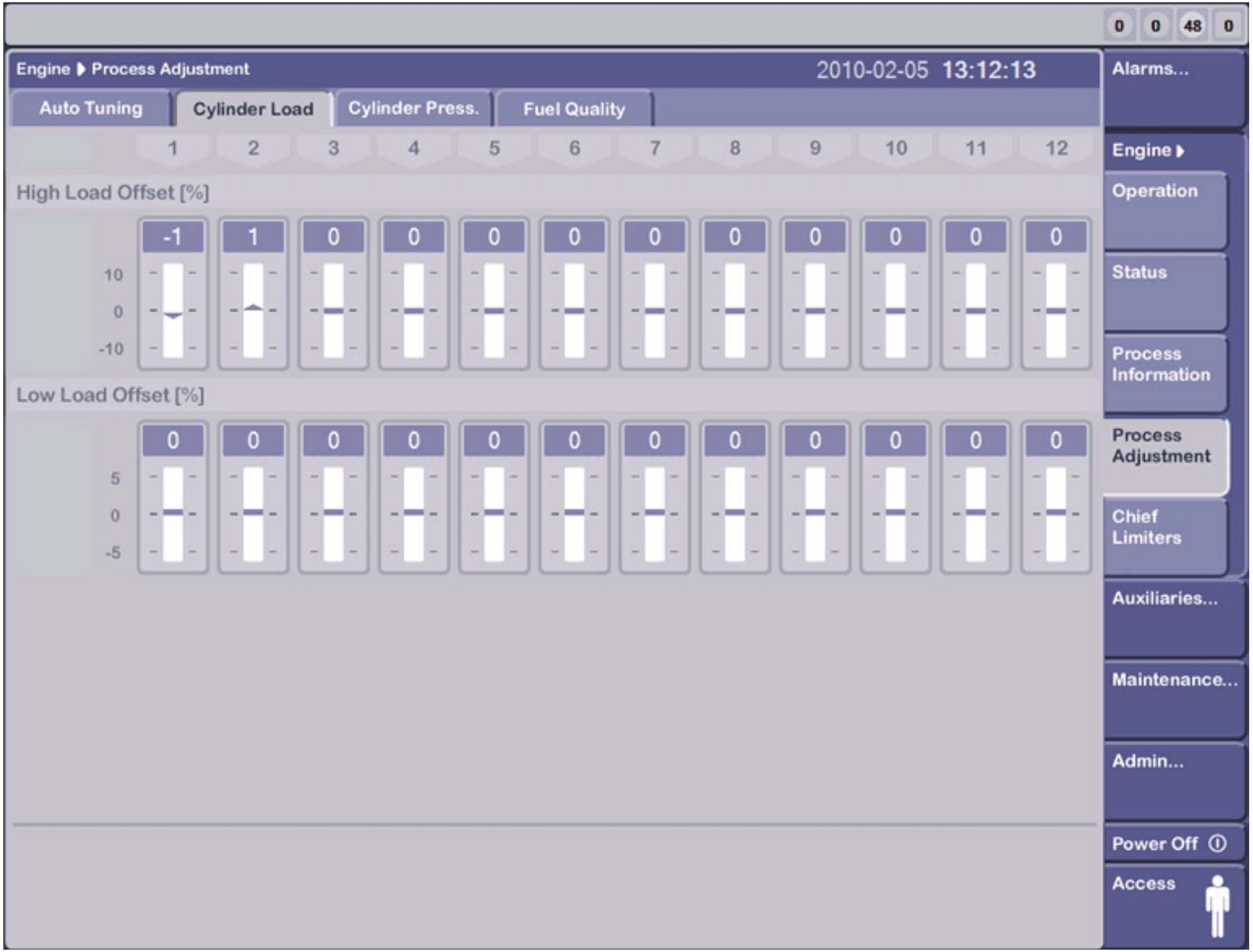


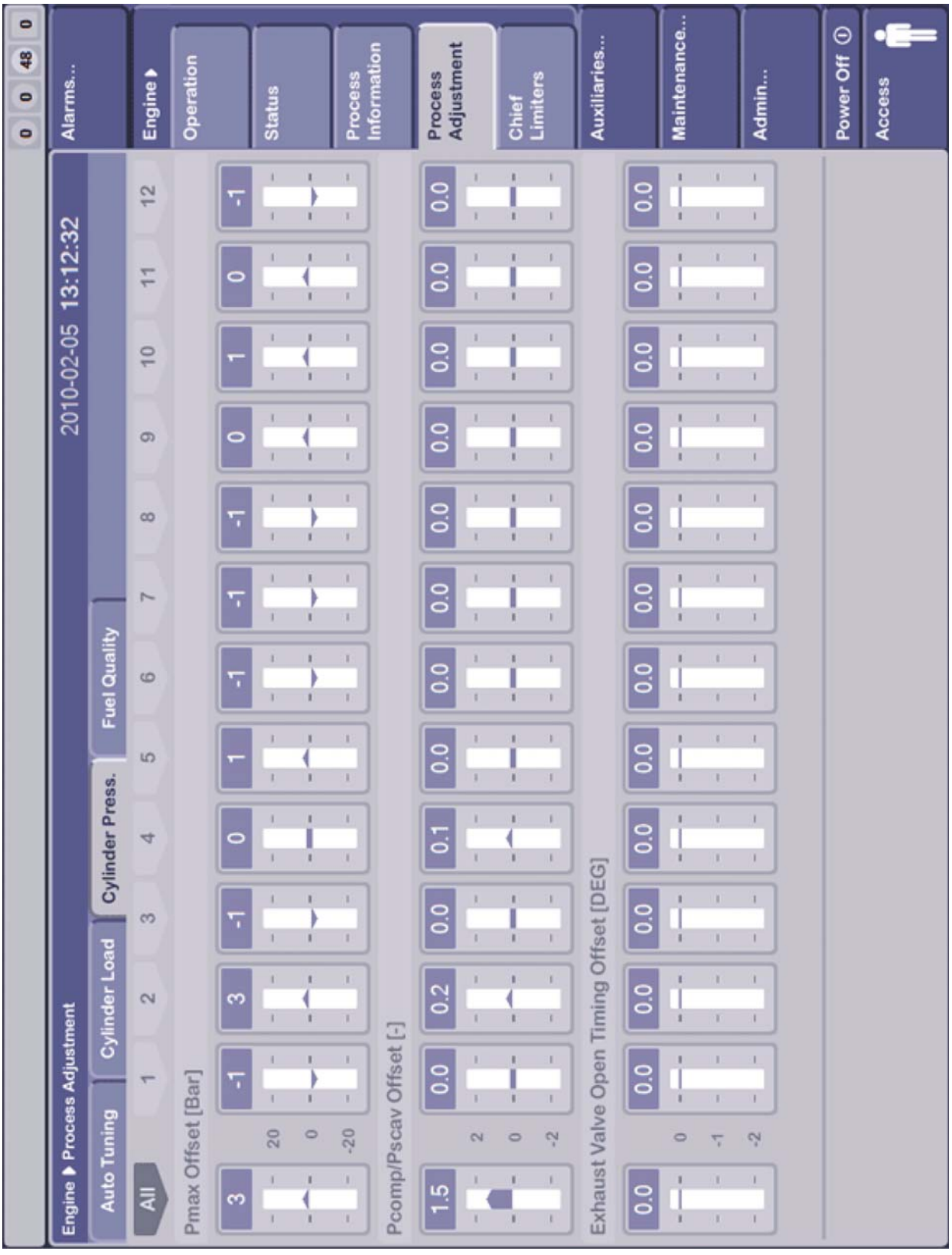
Drawing
6655-0161-0002

MOP Process Adjustment

Drawing
6655-0161-0002

MOP Process Adjustment





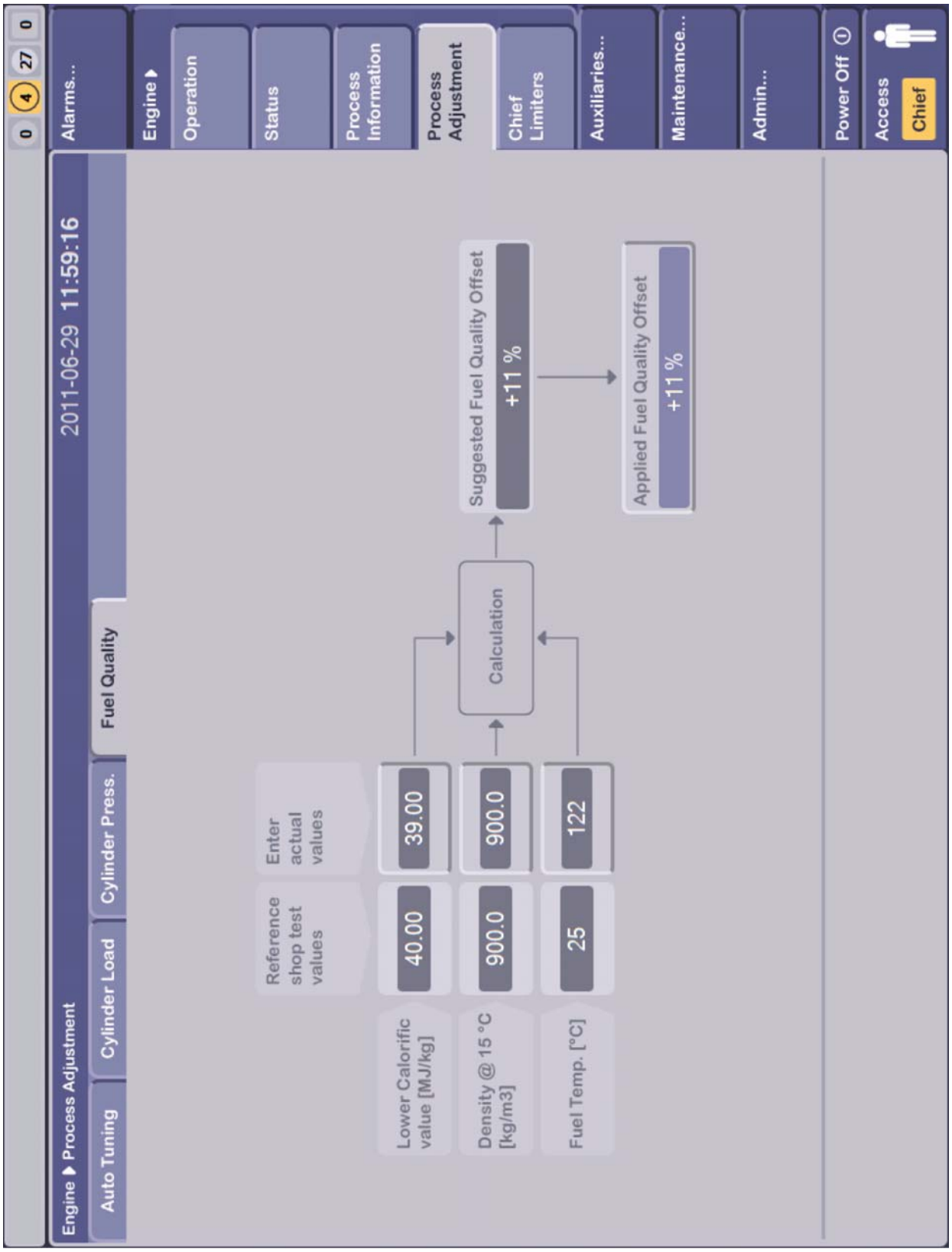
Drawing
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MOP Process Adjustment

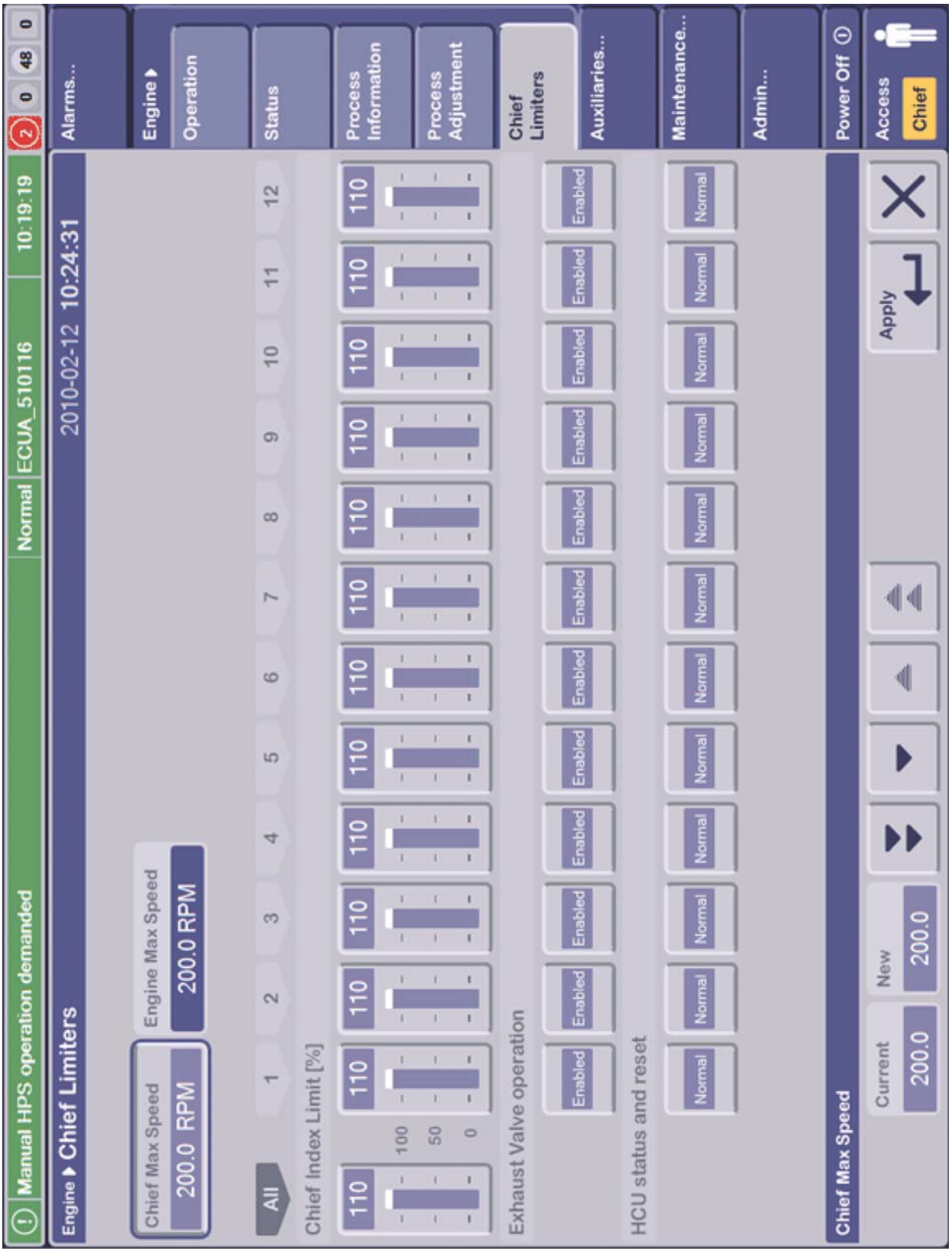
2012-09-07 - en

Drawing
6655-0161-0002

MOP Process Adjustment



2012-09-07 - en



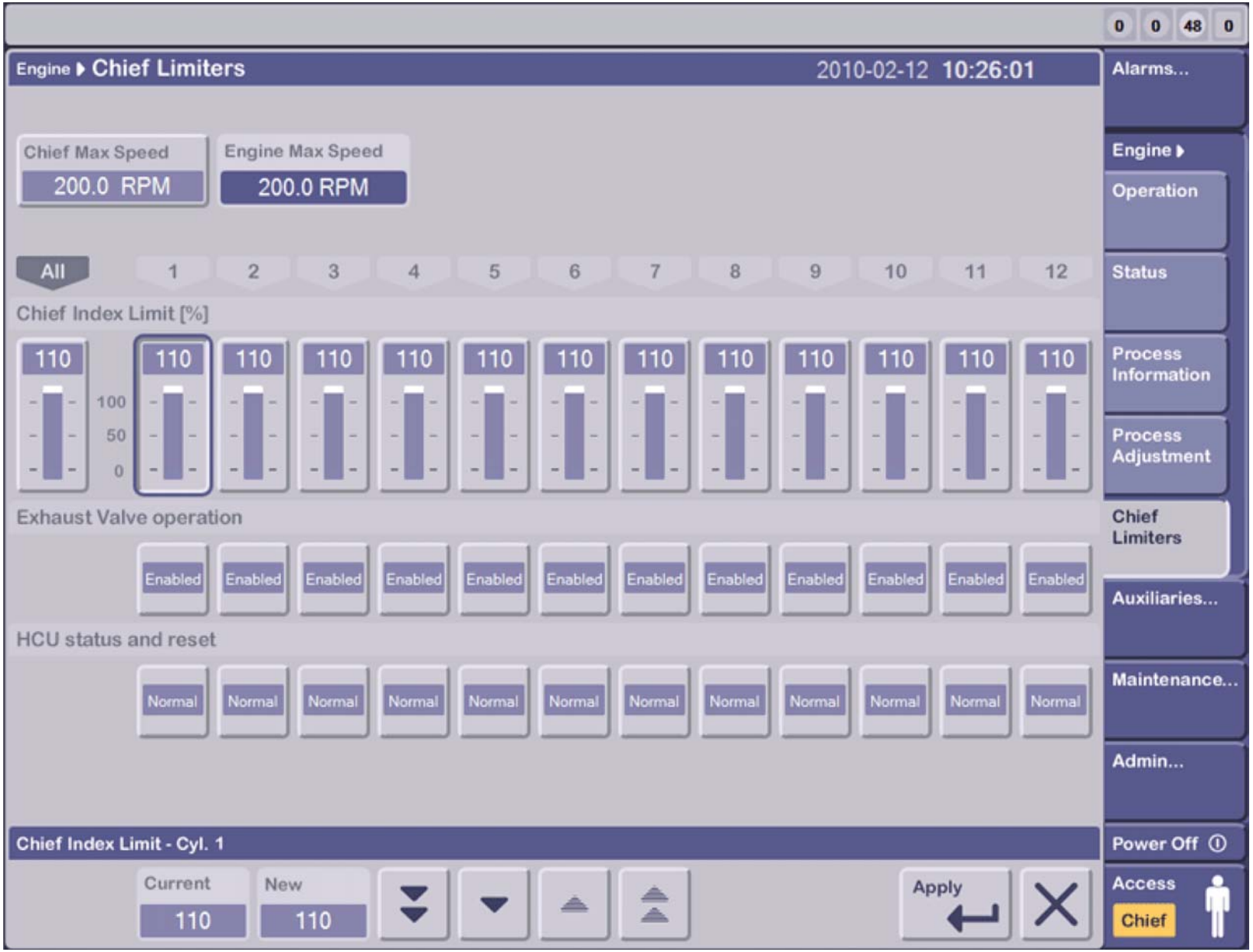
Drawing
6655-0162-0002

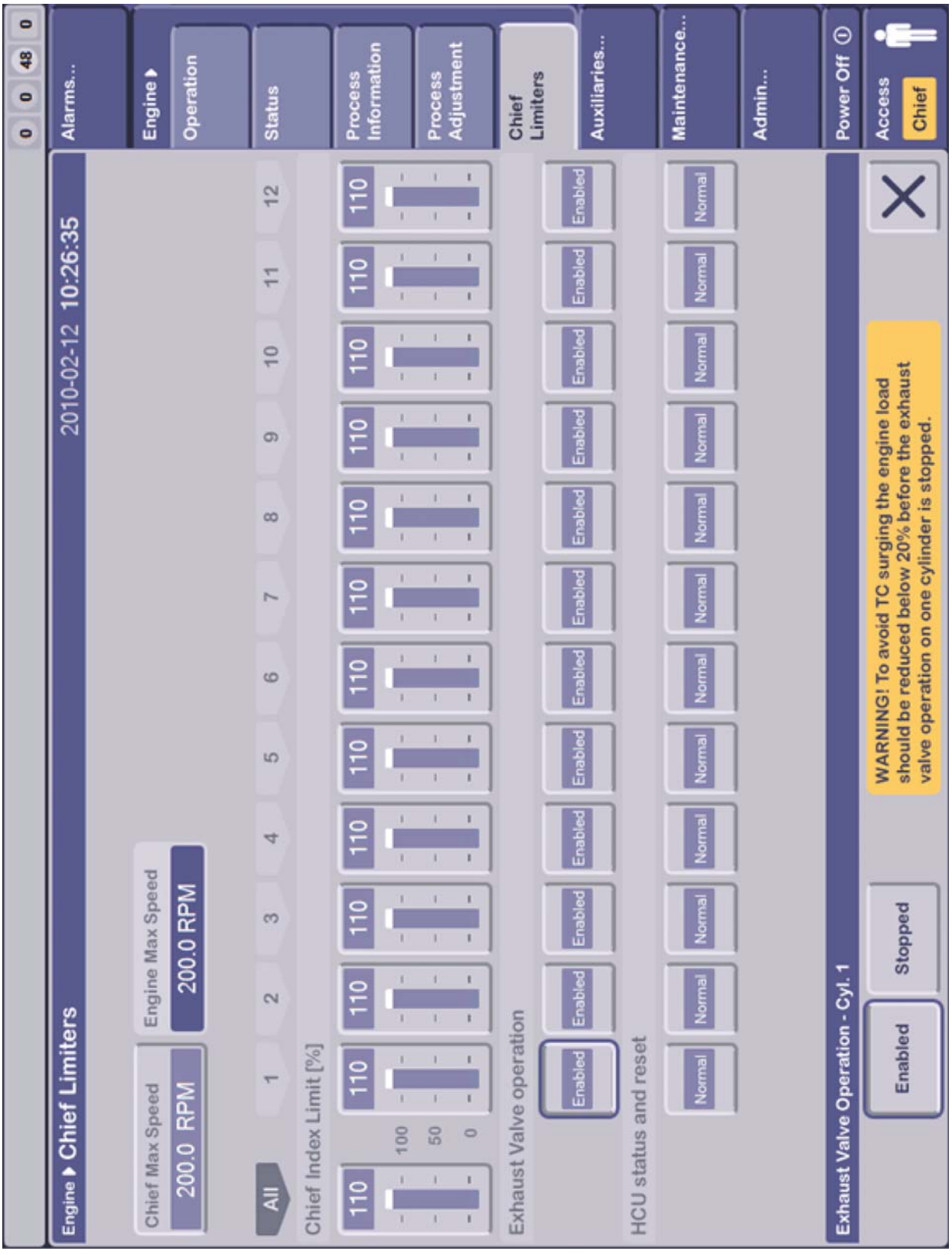
MOP Chief Limiters

2012-09-07 - en

Drawing
6655-0162-0002

MOP Chief Limiters





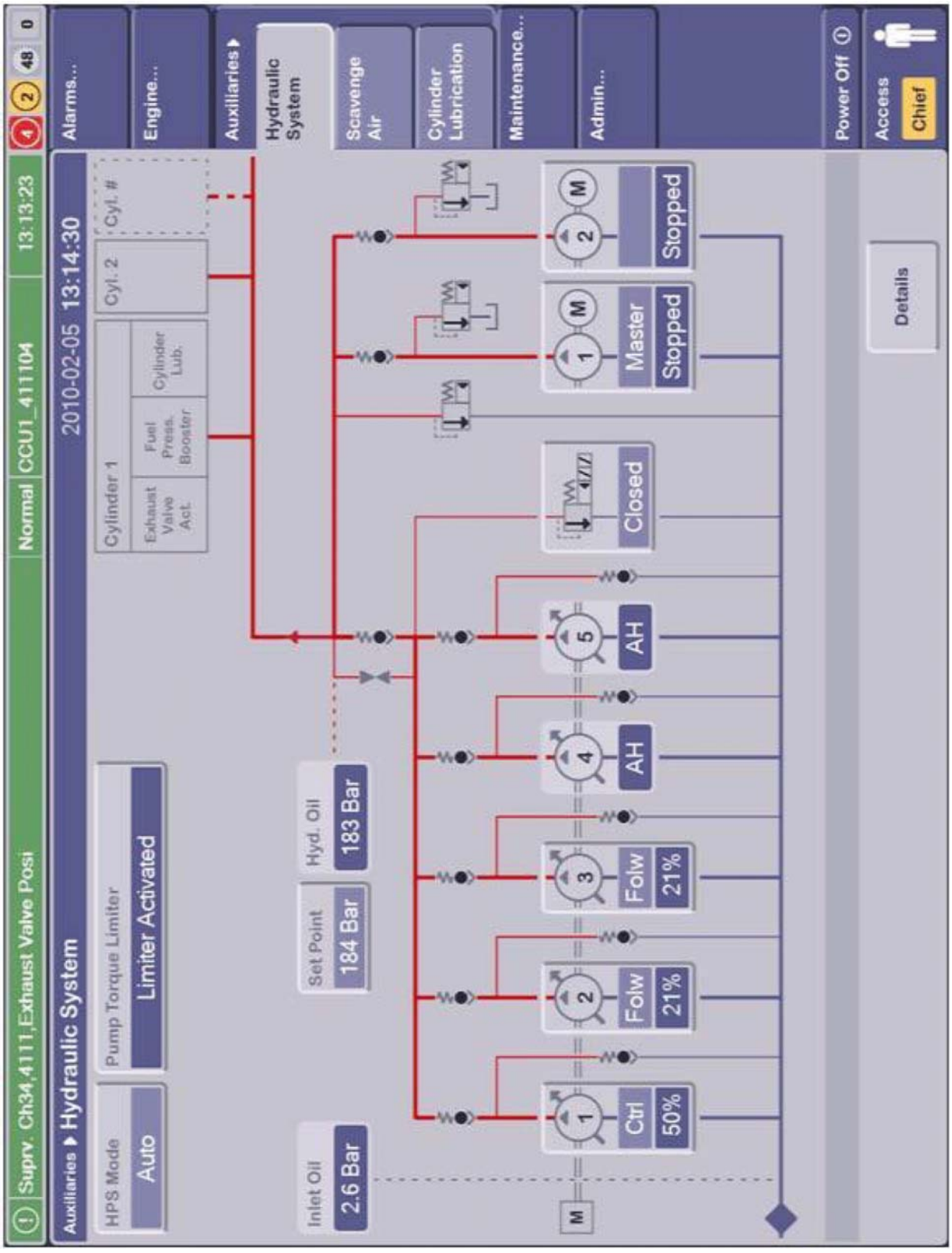
Drawing
6655-0162-0002

MOP Chief Limiters

Drawing
6655-0162-0002

MOP Chief Limiters





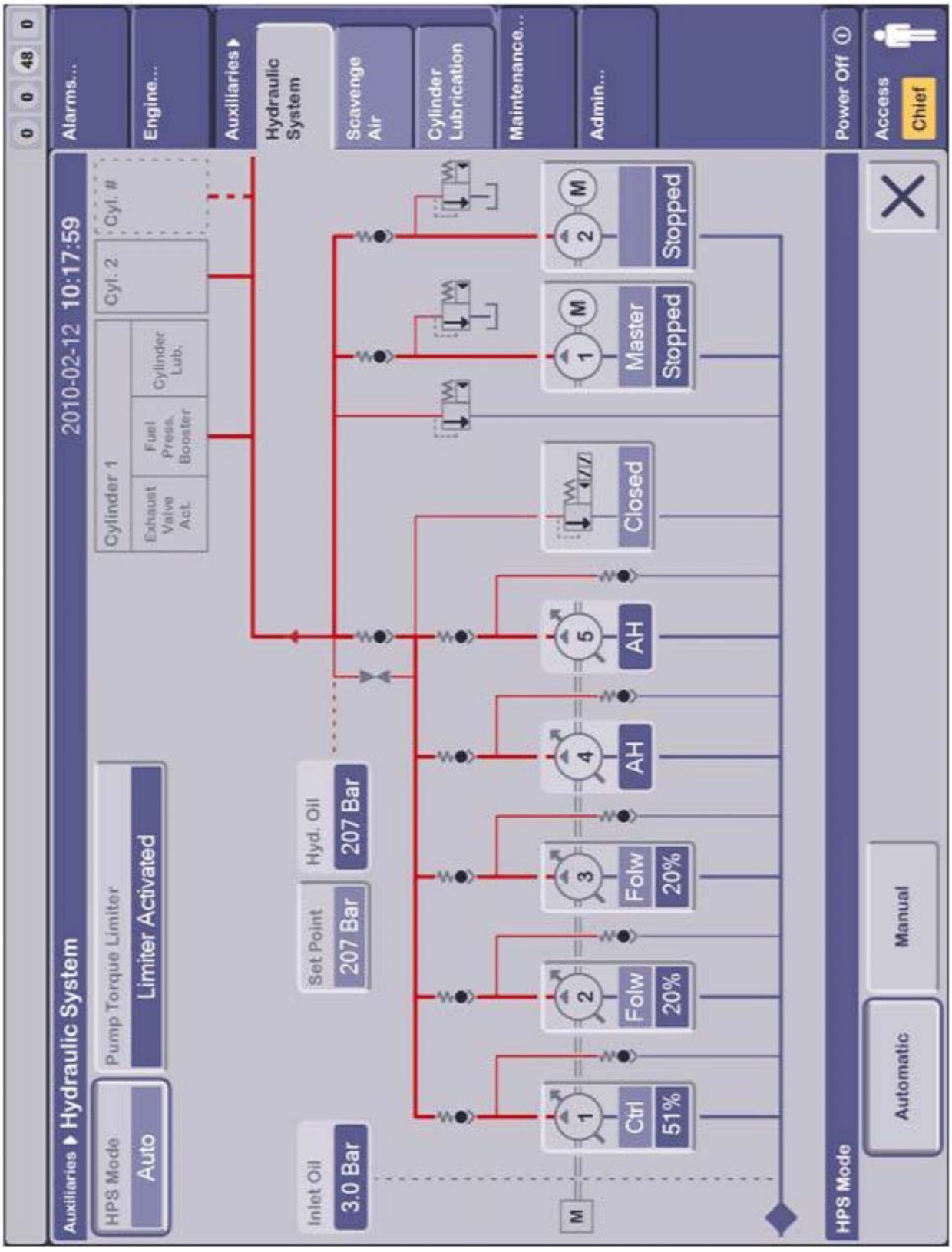
Drawing
6655-0175-0004

MOP Hydraulic System

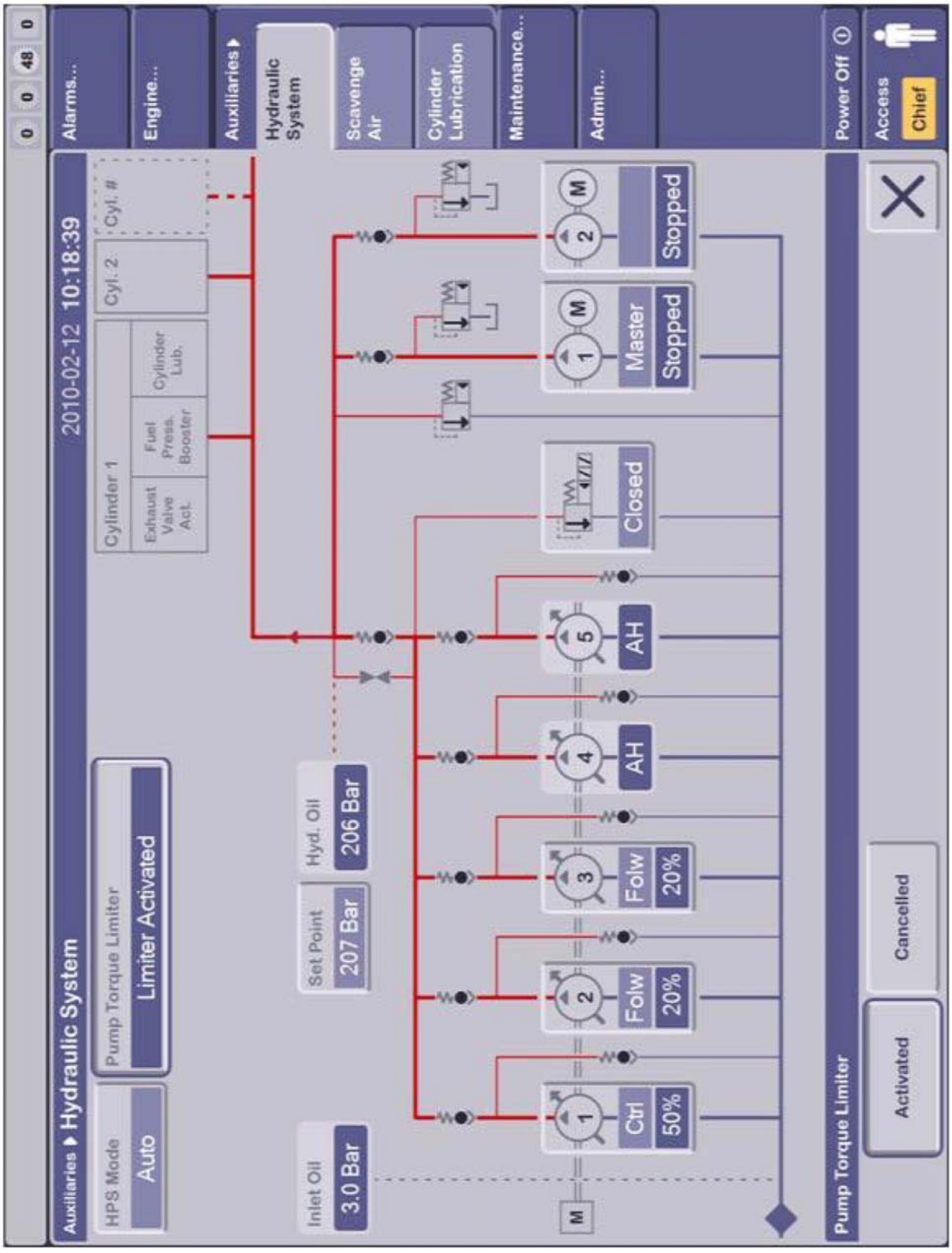
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Drawing
6655-0175-0004

MOP Hydraulic System



2012-09-07 - en



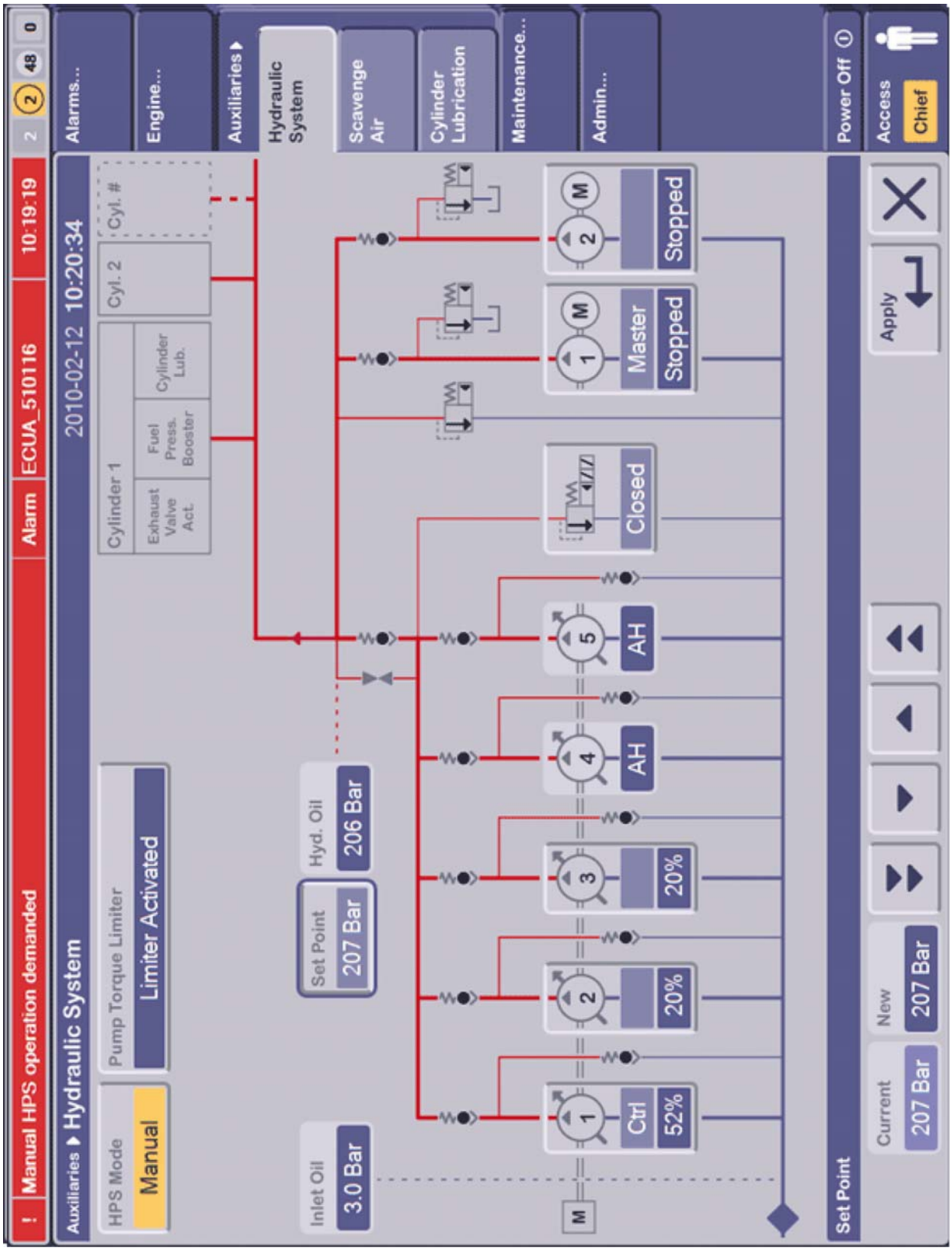
Drawing
6655-0175-0004

MOP Hydraulic System

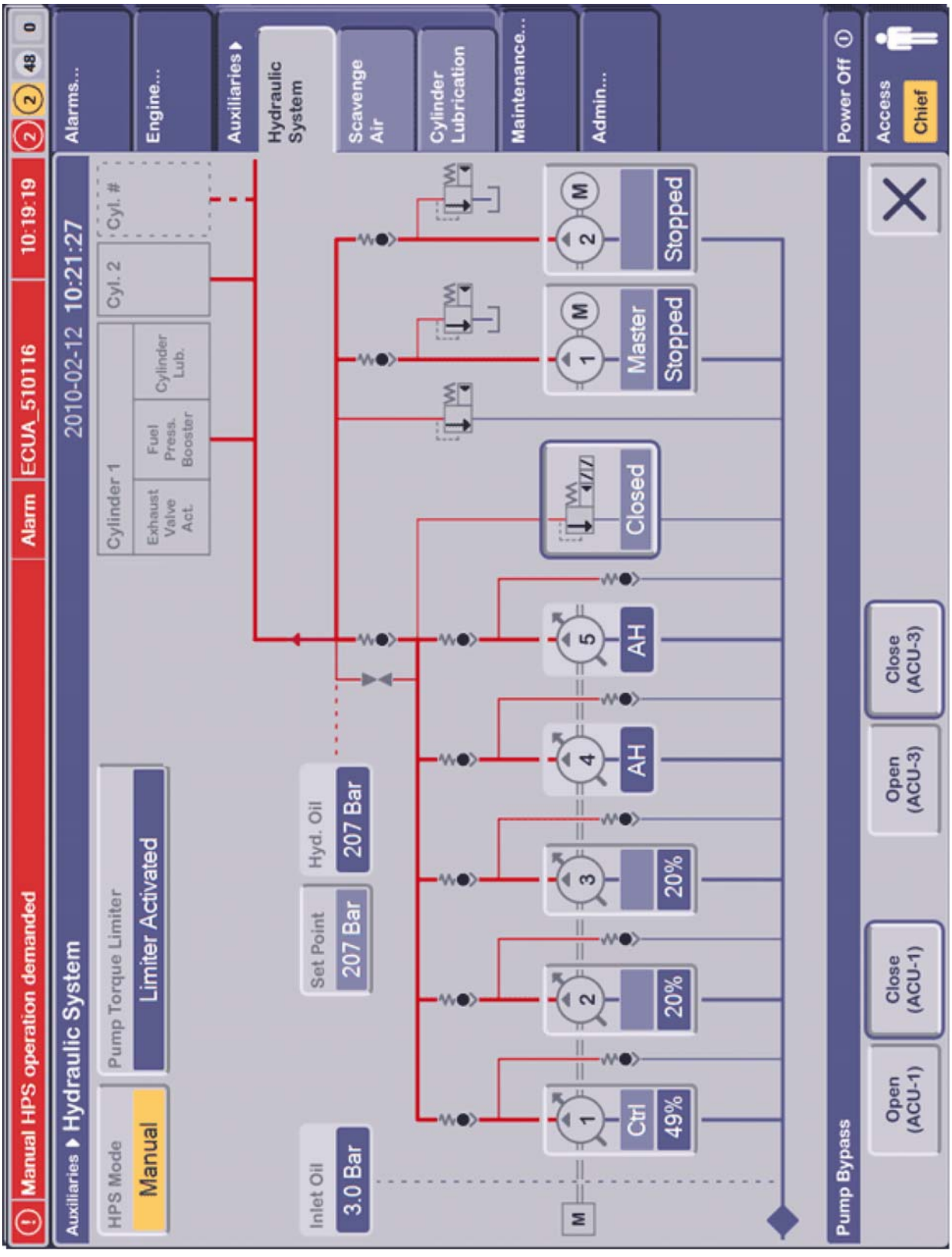
2012-09-07 - en

Drawing
6655-0175-0004

MOP Hydraulic System



2012-09-07 - en

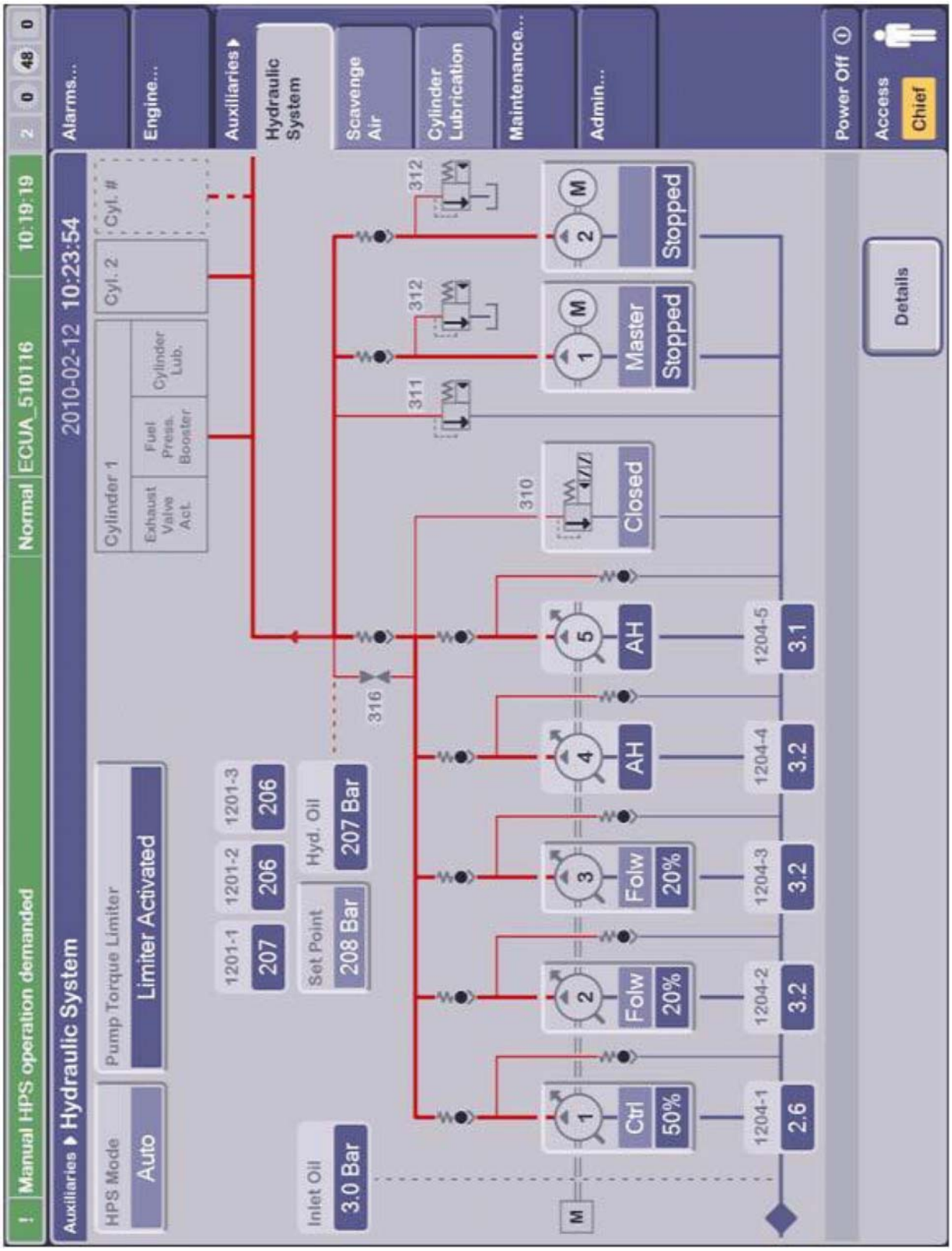


Drawing
6655-0175-0004

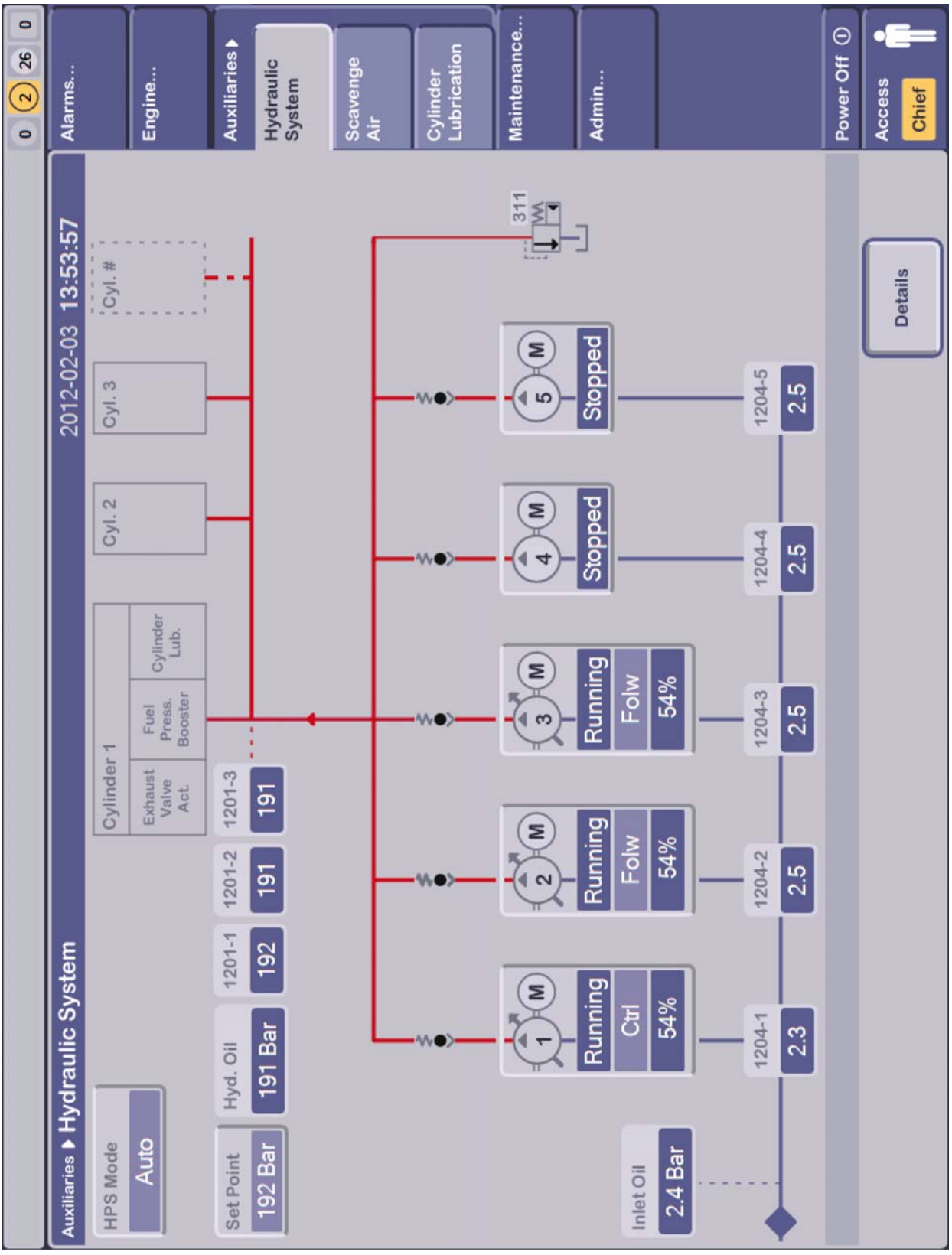
MOP Hydraulic System

Drawing
6655-0175-0004

MOP Hydraulic System



2012-09-07 - en



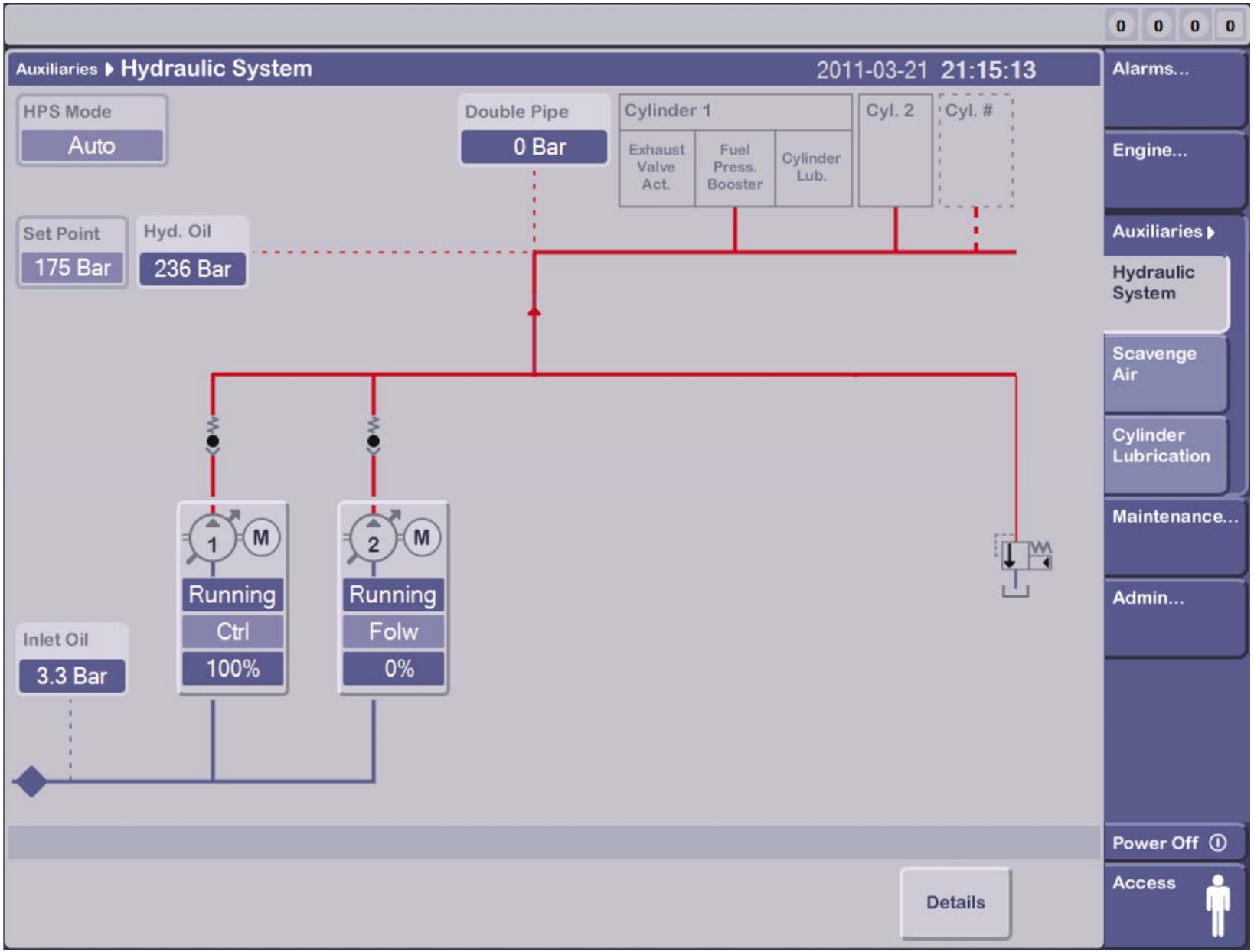
Drawing
6655-0175-0004

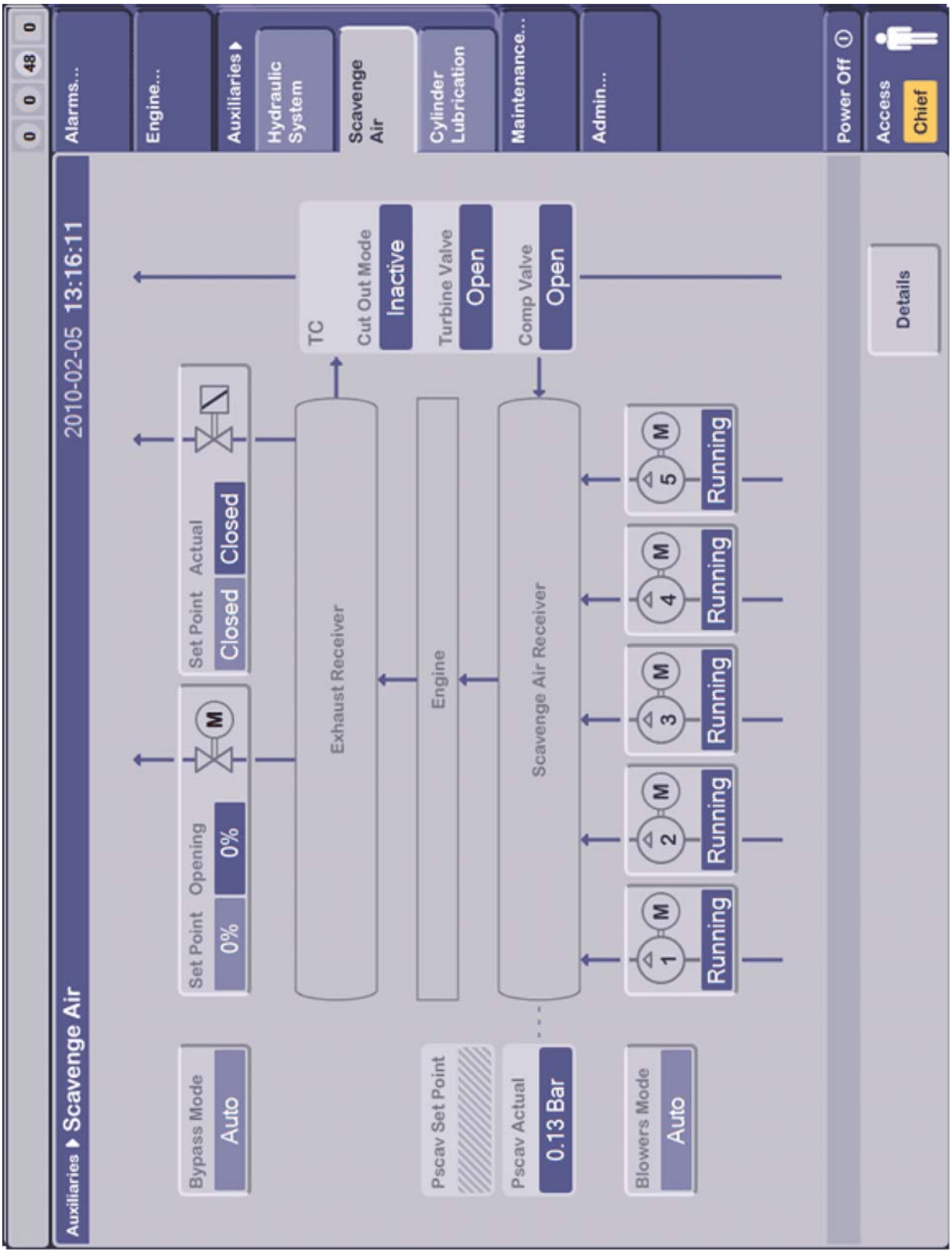
MOP Hydraulic System

2012-09-07 - en

Drawing
6655-0175-0004

MOP Hydraulic System



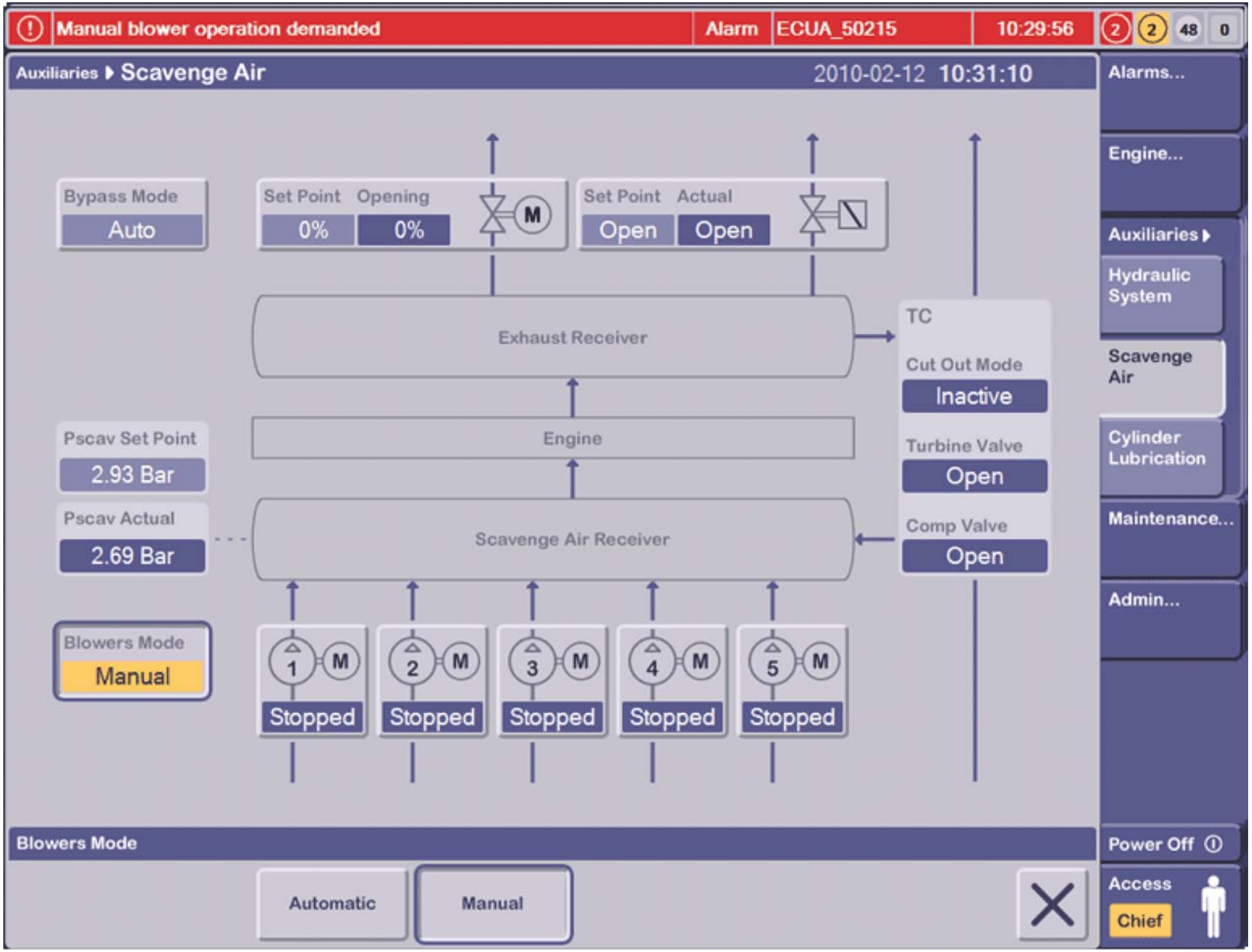


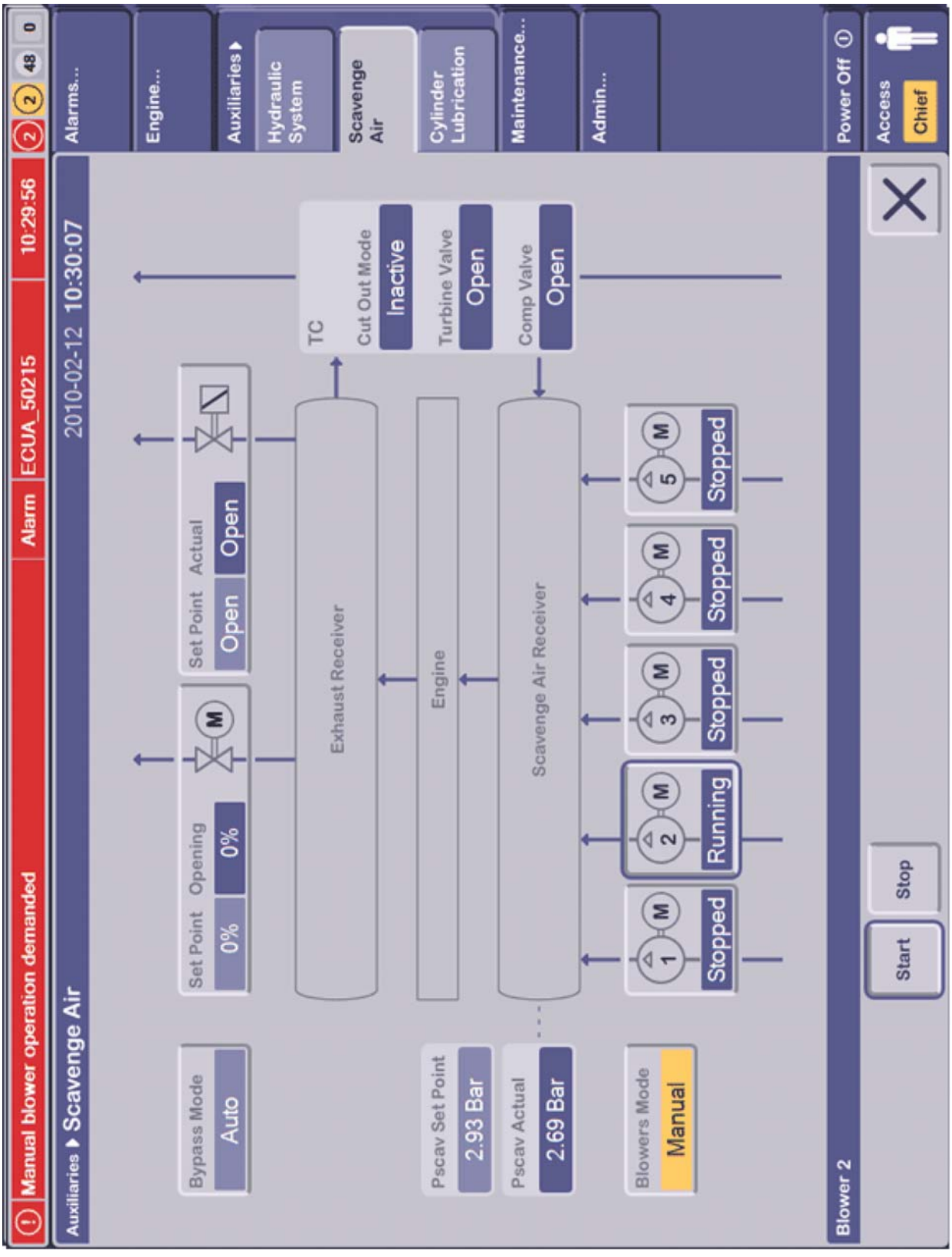
Drawing
6655-0180-0005

MOP Scavenge Air

Drawing
6655-0180-0005

MOP Scavenge Air





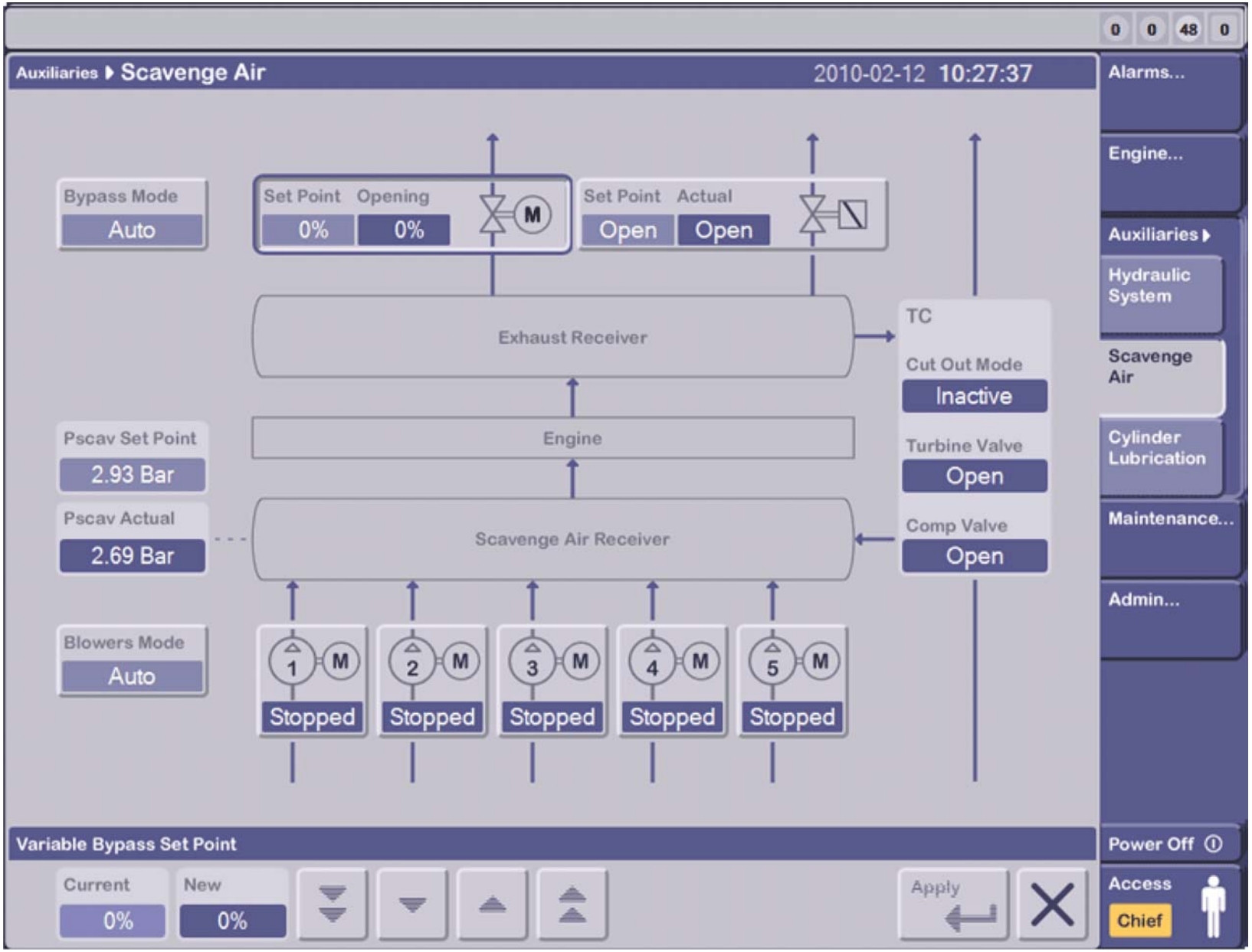
Drawing
6655-0180-0005

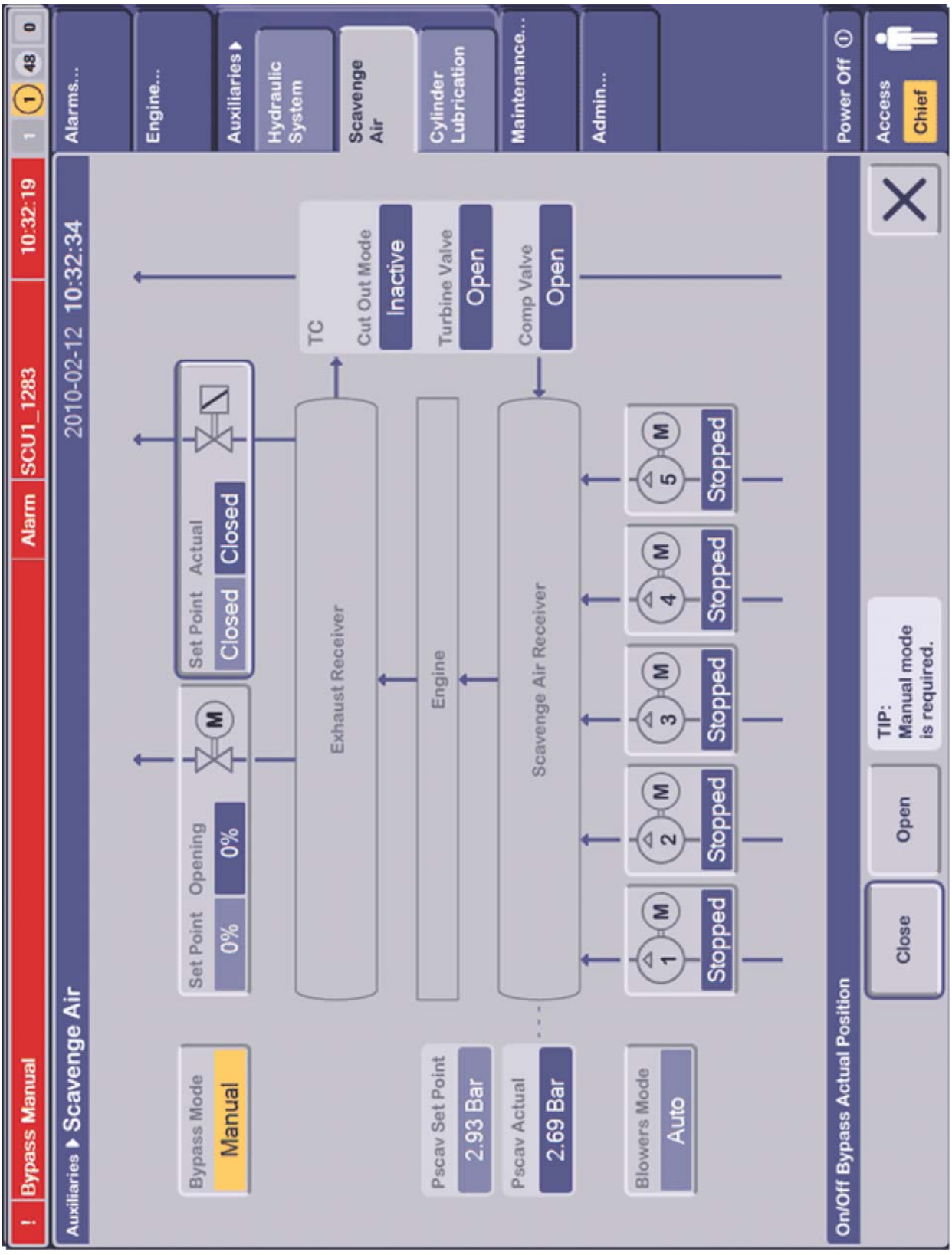
MOP Scavenge Air

2012-09-07 - en

Drawing
6655-0180-0005

MOP Scavenge Air



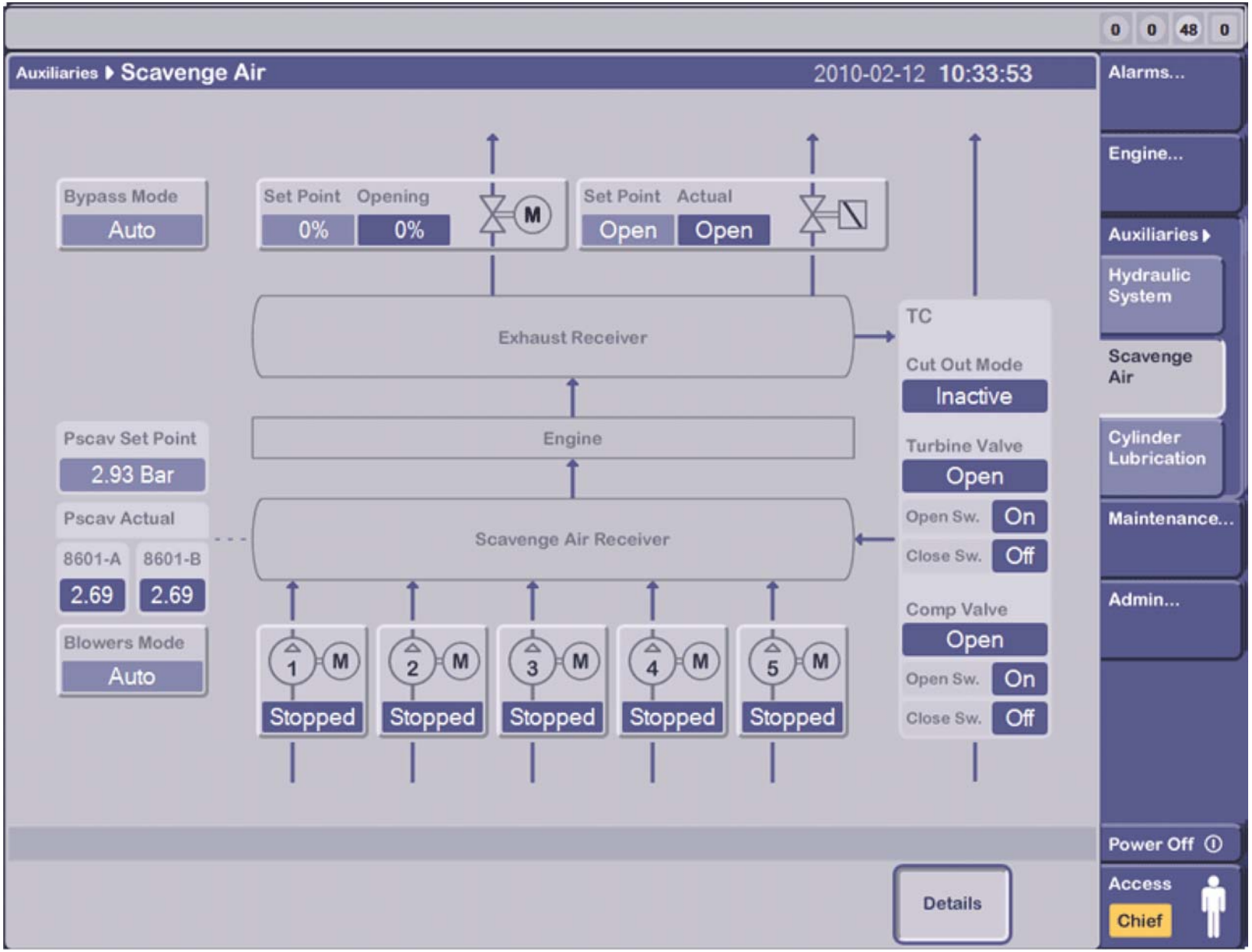


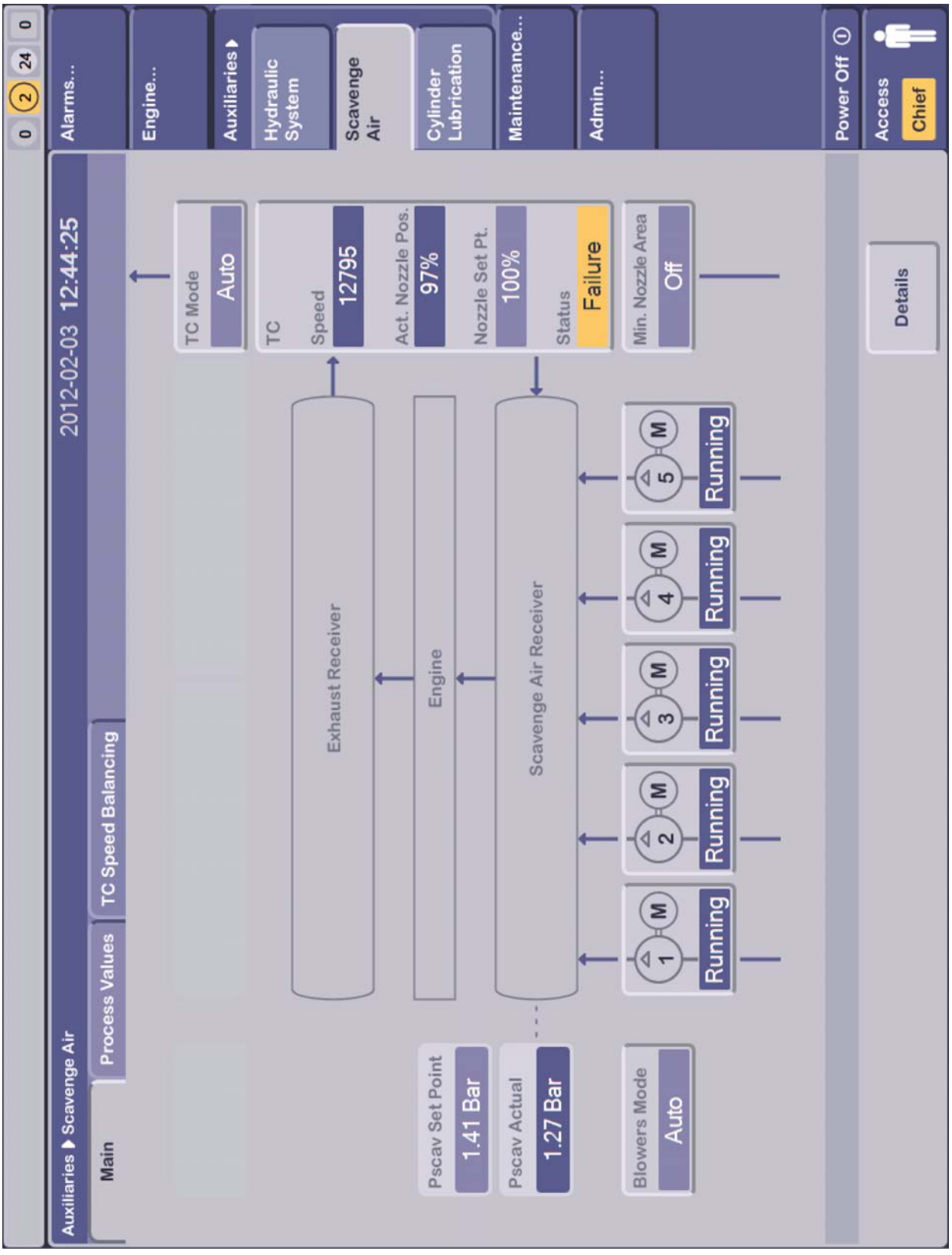
Drawing
6655-0180-0005

MOP Scavenge Air

Drawing
6655-0180-0005

MOP Scavenge Air



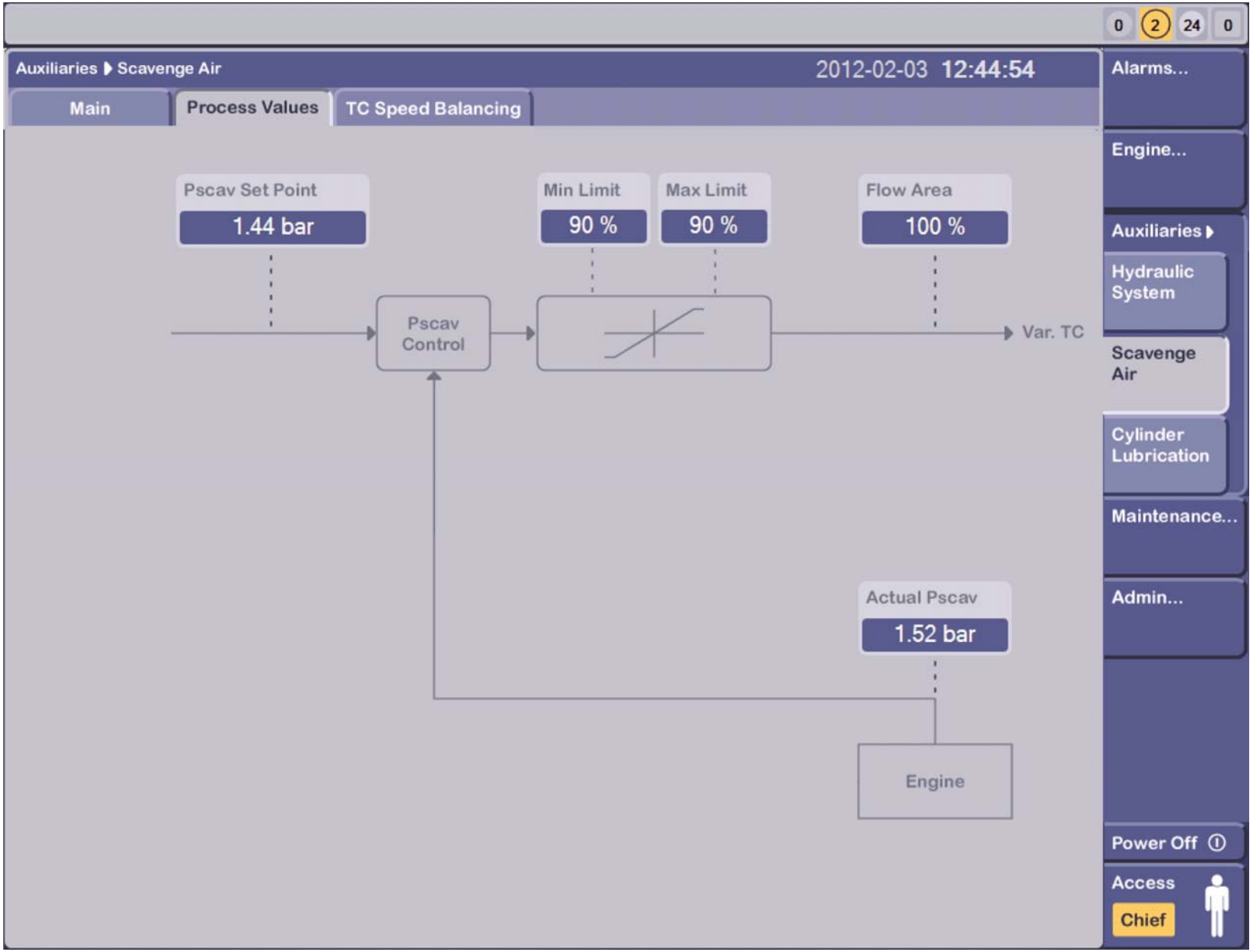


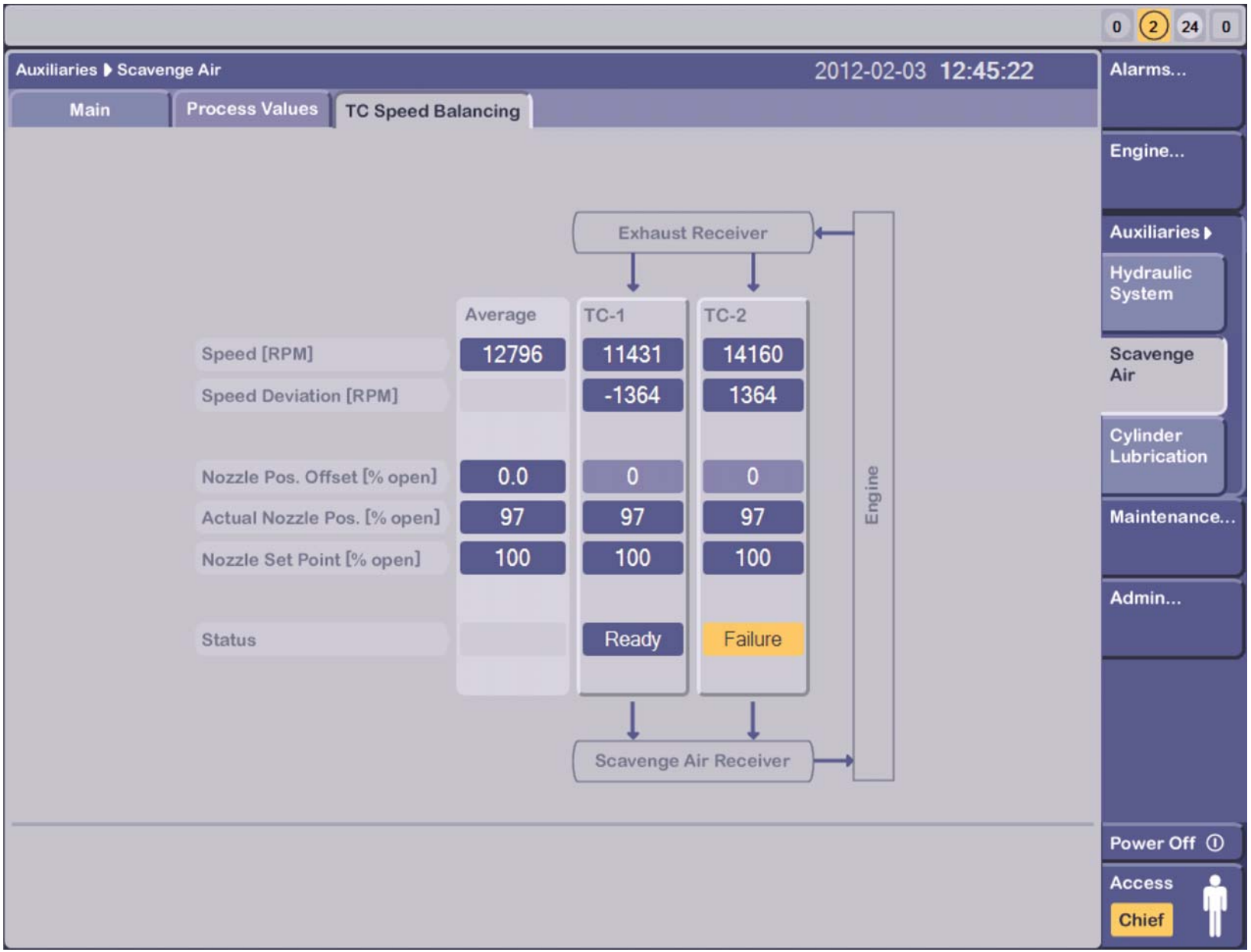
Drawing
6655-0180-0005

MOP Scavenge Air

Drawing
6655-0180-0005

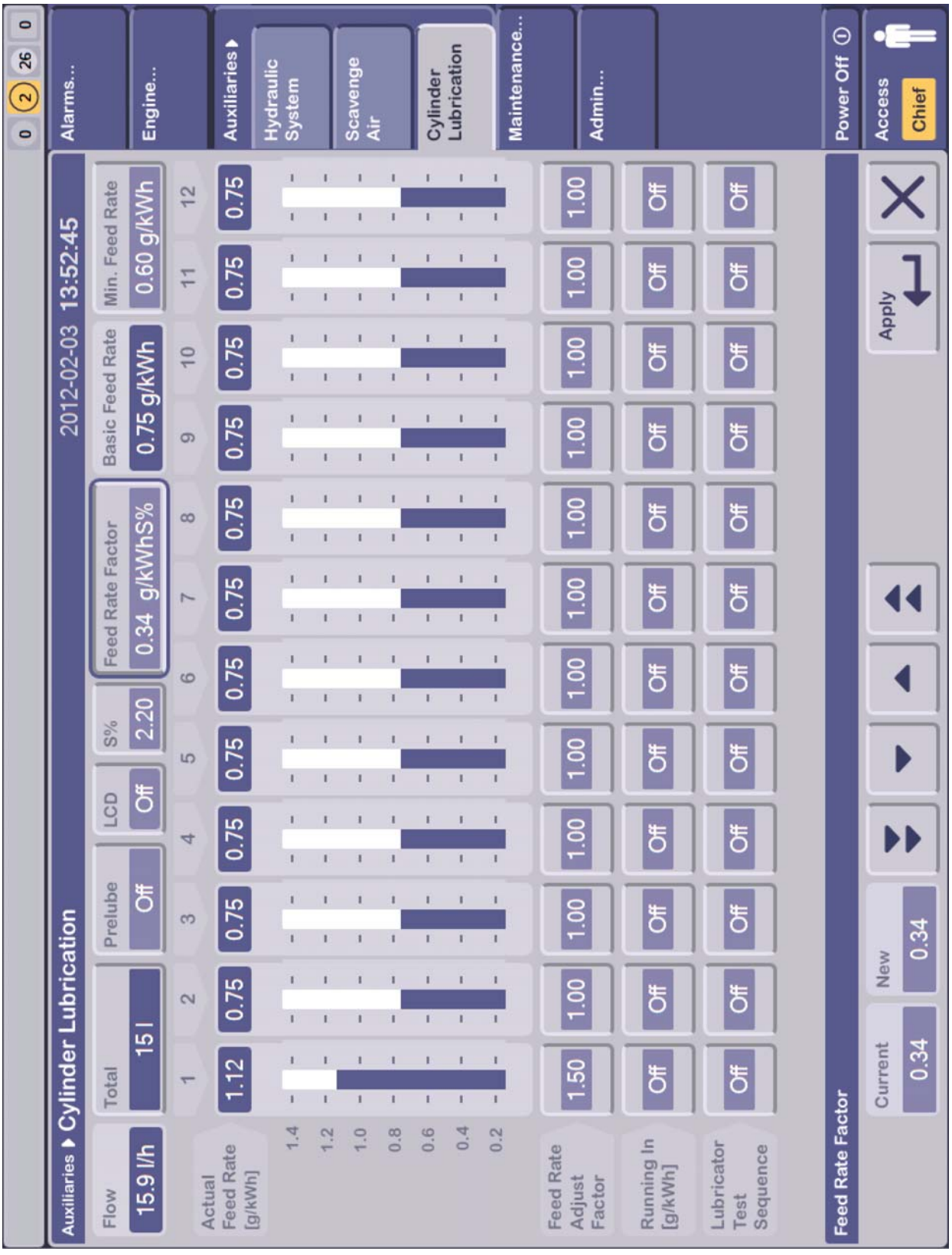
MOP Scavenge Air





Drawing **MOP Scavenge Air**

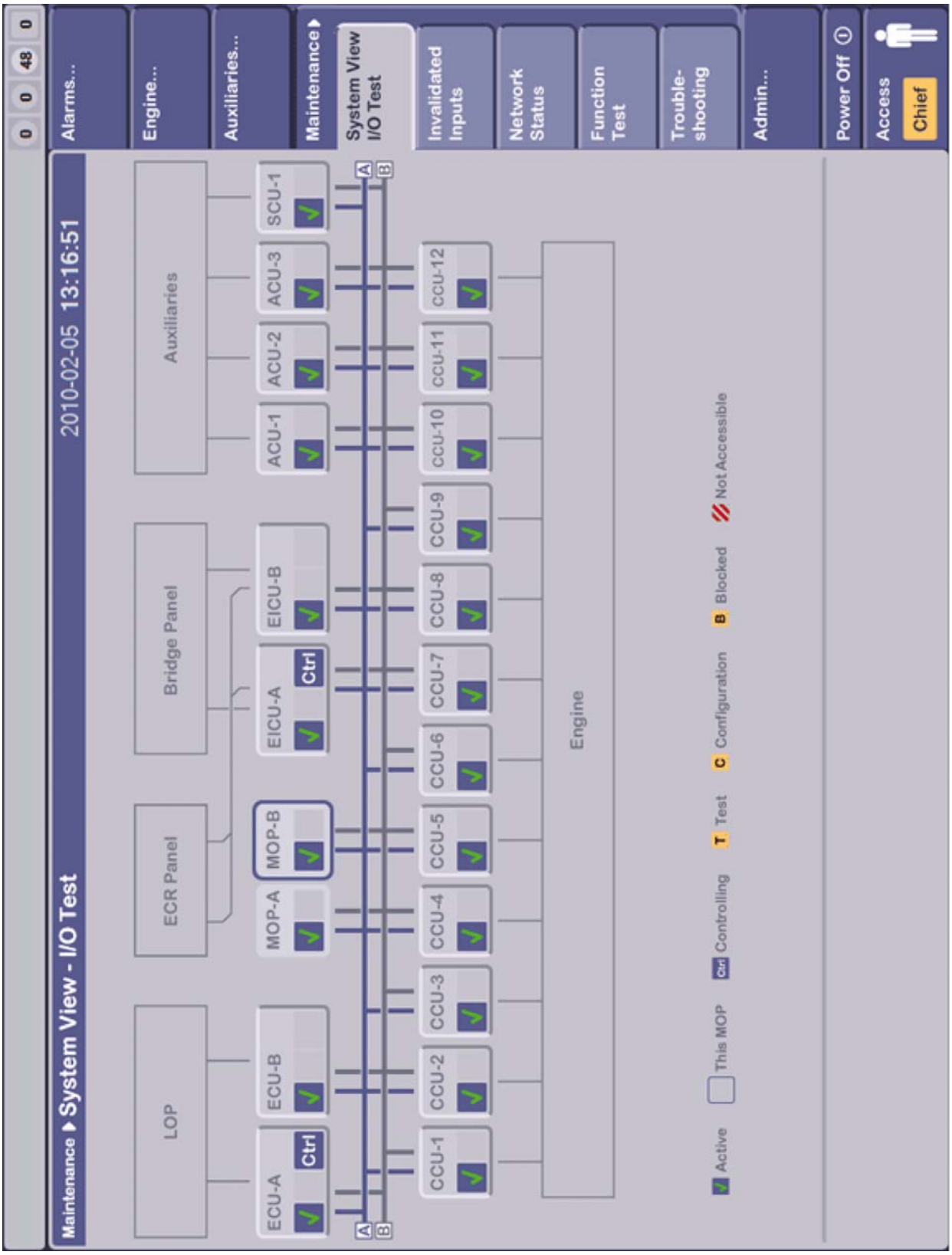
6655-0180-0005



Drawing
6655-0185-0004

MOP Cylinder Lubrication

2012-09-07 - en



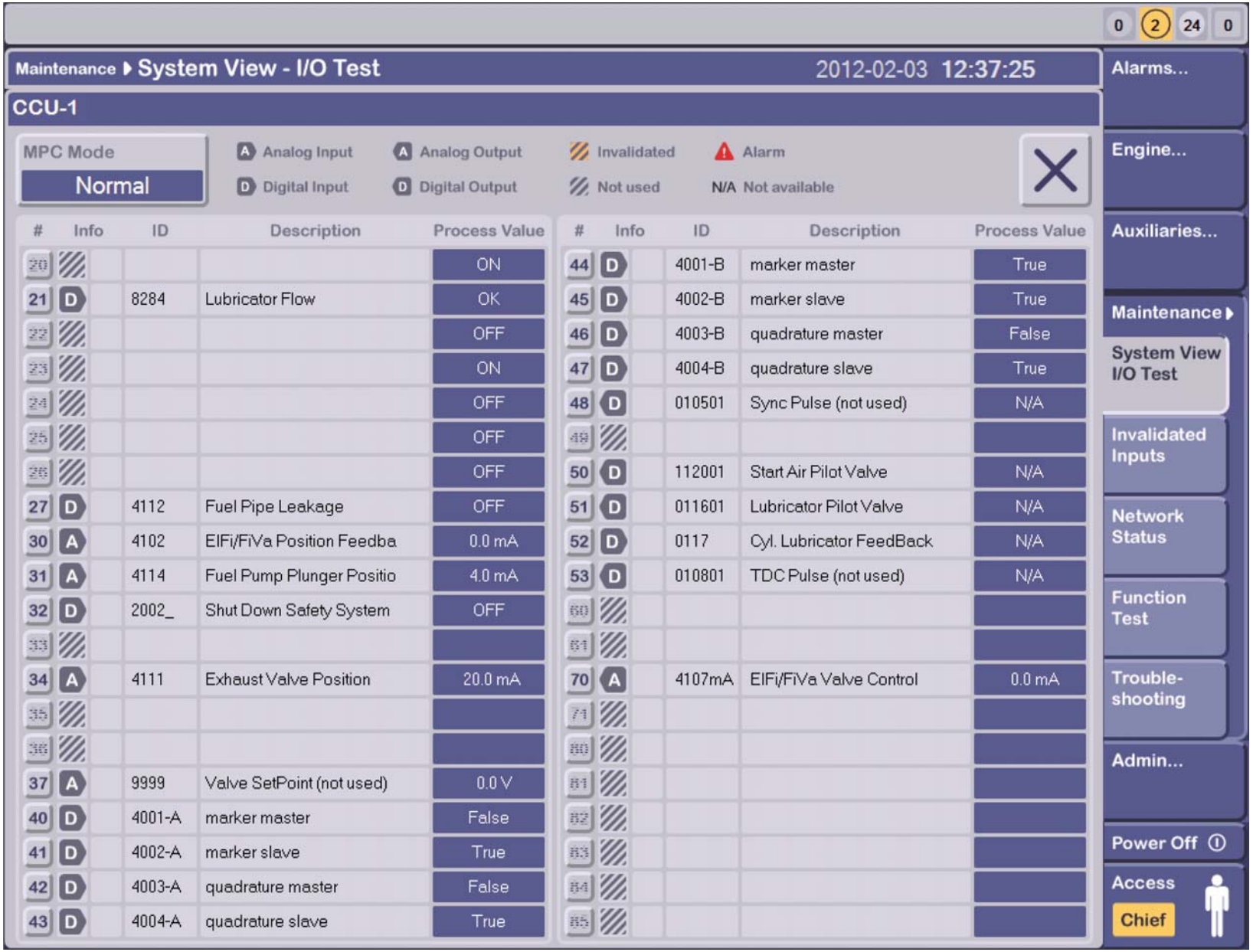
Drawing
6655-0190-0005

MOP System View I/O Test

2012-09-07 - en

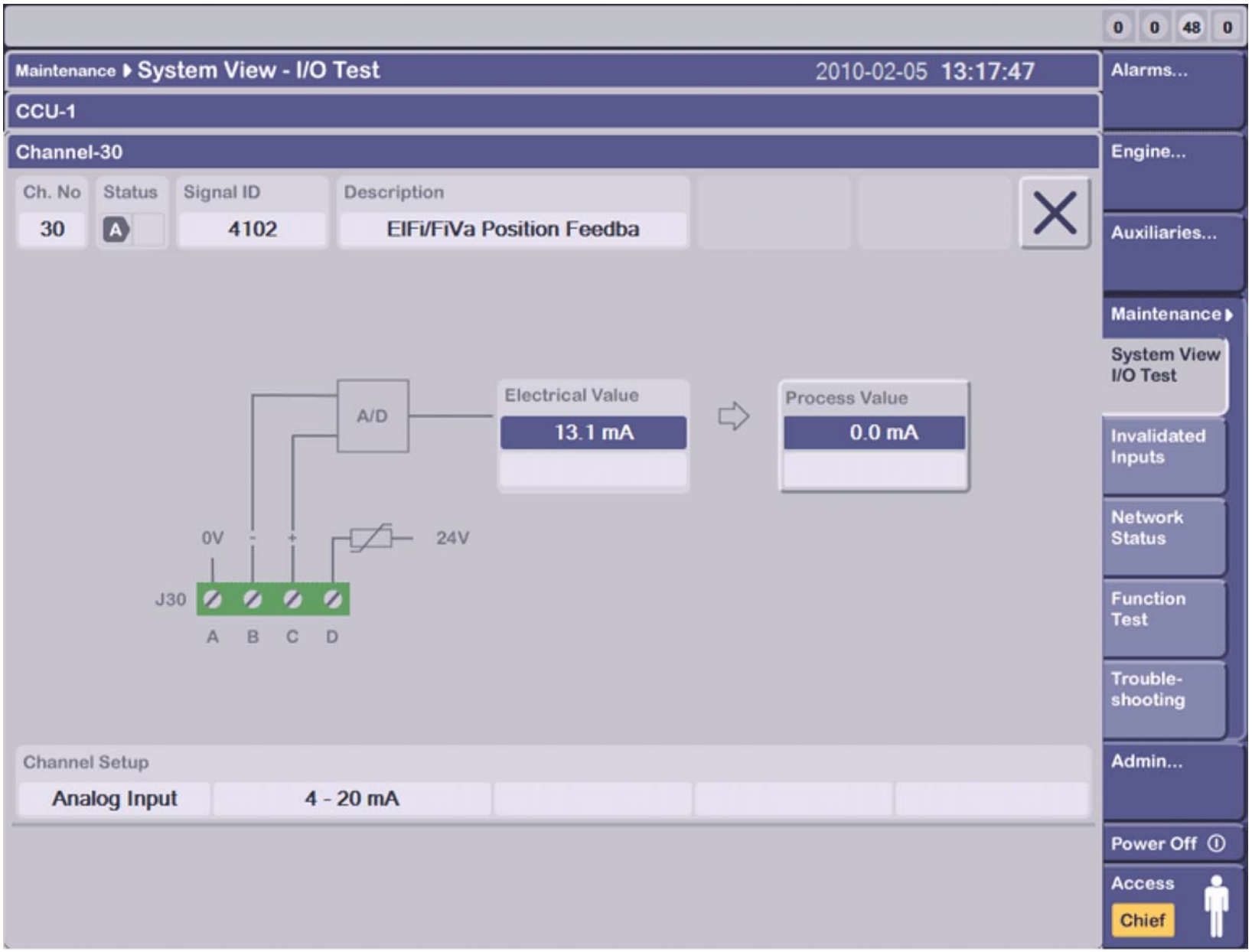
Drawing
6655-0190-0005

MOP System View I/O Test



#	Info	ID	Description	Process Value
20				ON
21	D	8284	Lubricator Flow	OK
22				OFF
23				ON
24				OFF
25				OFF
26				OFF
27	D	4112	Fuel Pipe Leakage	OFF
30	A	4102	ElFi/FiVa Position Feedba	0.0 mA
31	A	4114	Fuel Pump Plunger Positio	4.0 mA
32	D	2002_	Shut Down Safety System	OFF
33				
34	A	4111	Exhaust Valve Position	20.0 mA
35				
36				
37	A	9999	Valve SetPoint (not used)	0.0 V
40	D	4001-A	marker master	False
41	D	4002-A	marker slave	True
42	D	4003-A	quadrature master	False
43	D	4004-A	quadrature slave	True

#	Info	ID	Description	Process Value
44	D	4001-B	marker master	True
45	D	4002-B	marker slave	True
46	D	4003-B	quadrature master	False
47	D	4004-B	quadrature slave	True
48	D	010501	Sync Pulse (not used)	N/A
49				
50	D	112001	Start Air Pilot Valve	N/A
51	D	011601	Lubricator Pilot Valve	N/A
52	D	0117	Cyl. Lubricator FeedBack	N/A
53	D	010801	TDC Pulse (not used)	N/A
60				
61				
70	A	4107mA	ElFi/FiVa Valve Control	0.0 mA
71				
80				
81				
82				
83				
84				
85				

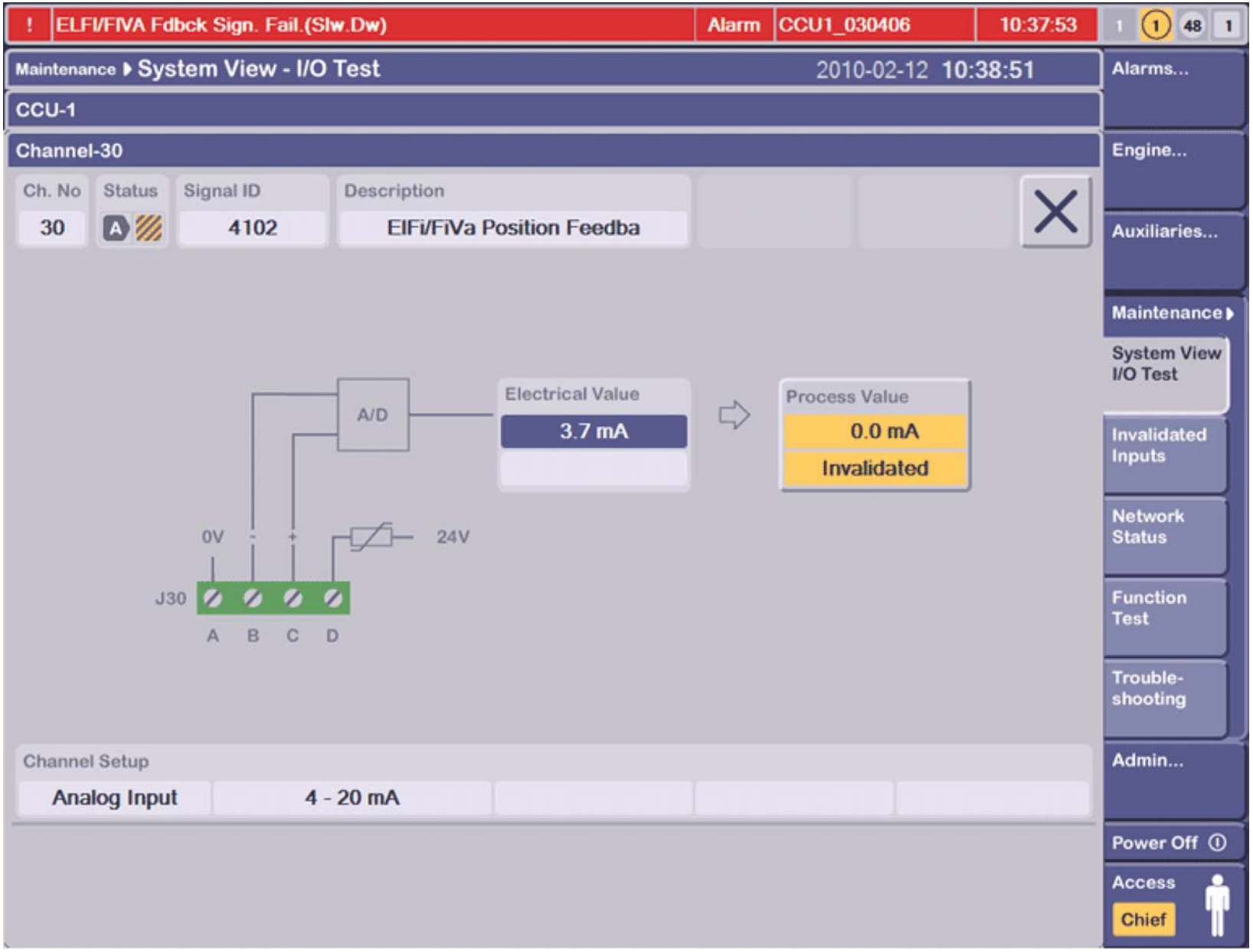


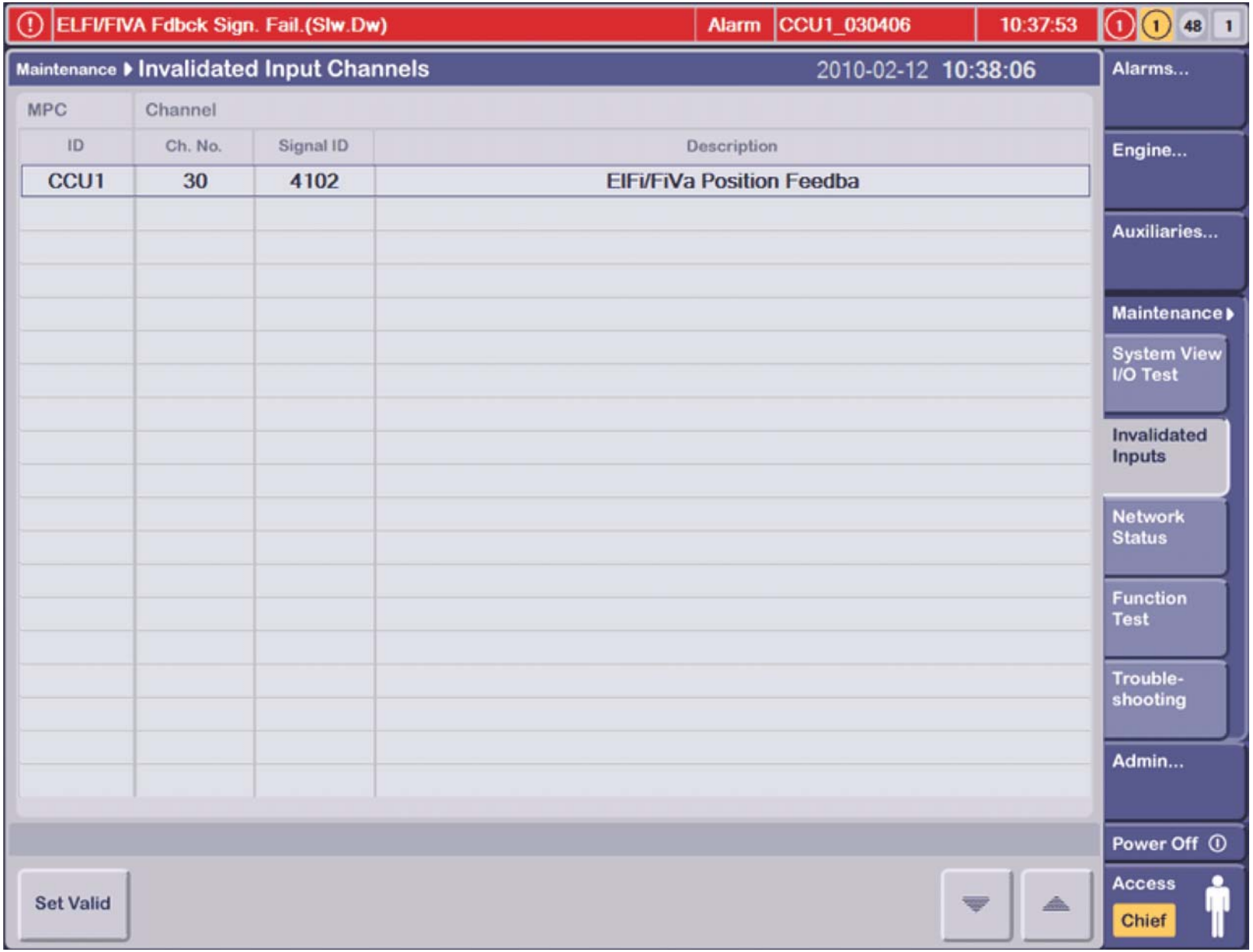
Drawing
6655-0190-0005

MOP System View I/O Test

Drawing
6655-0190-0005

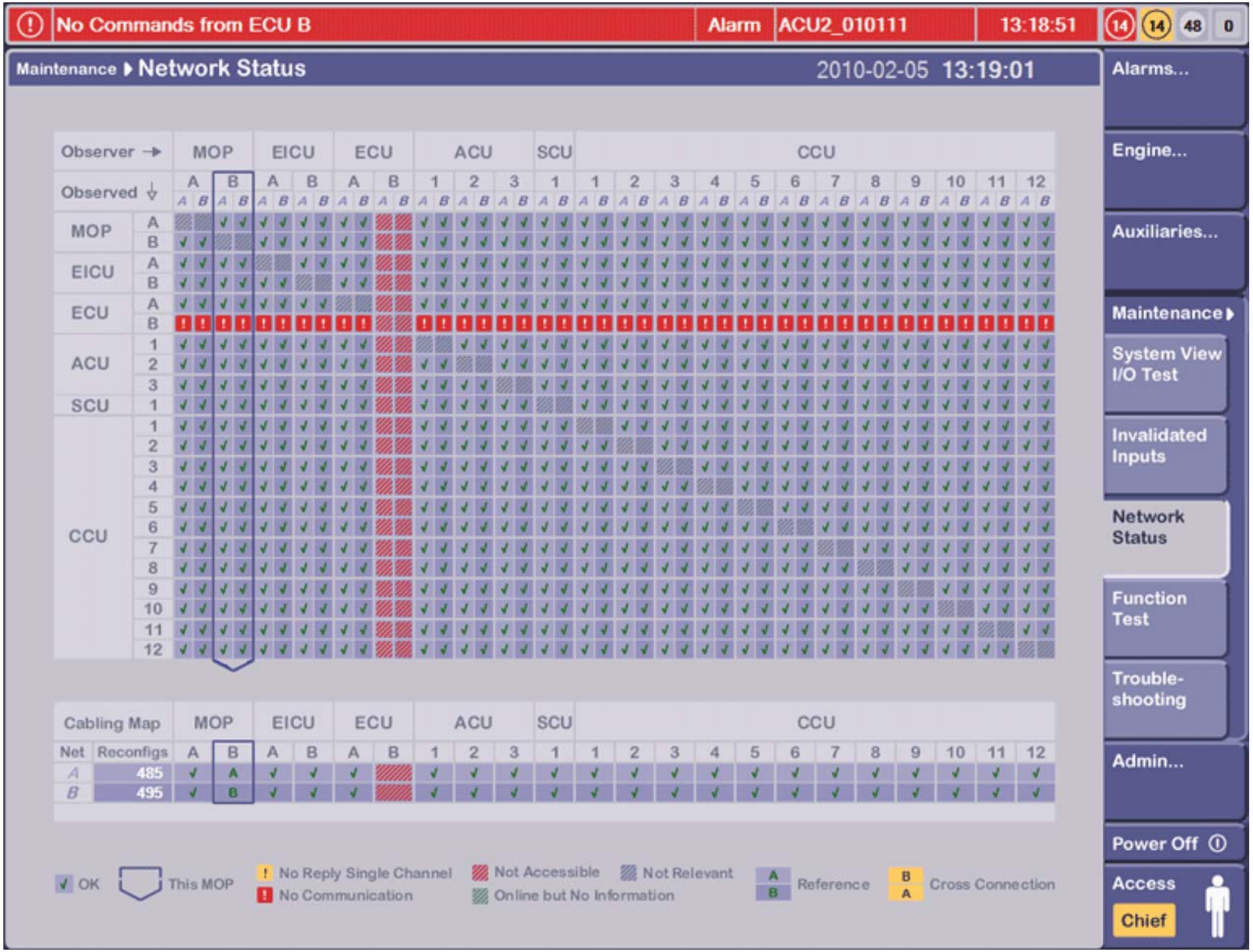
MOP System View I/O Test





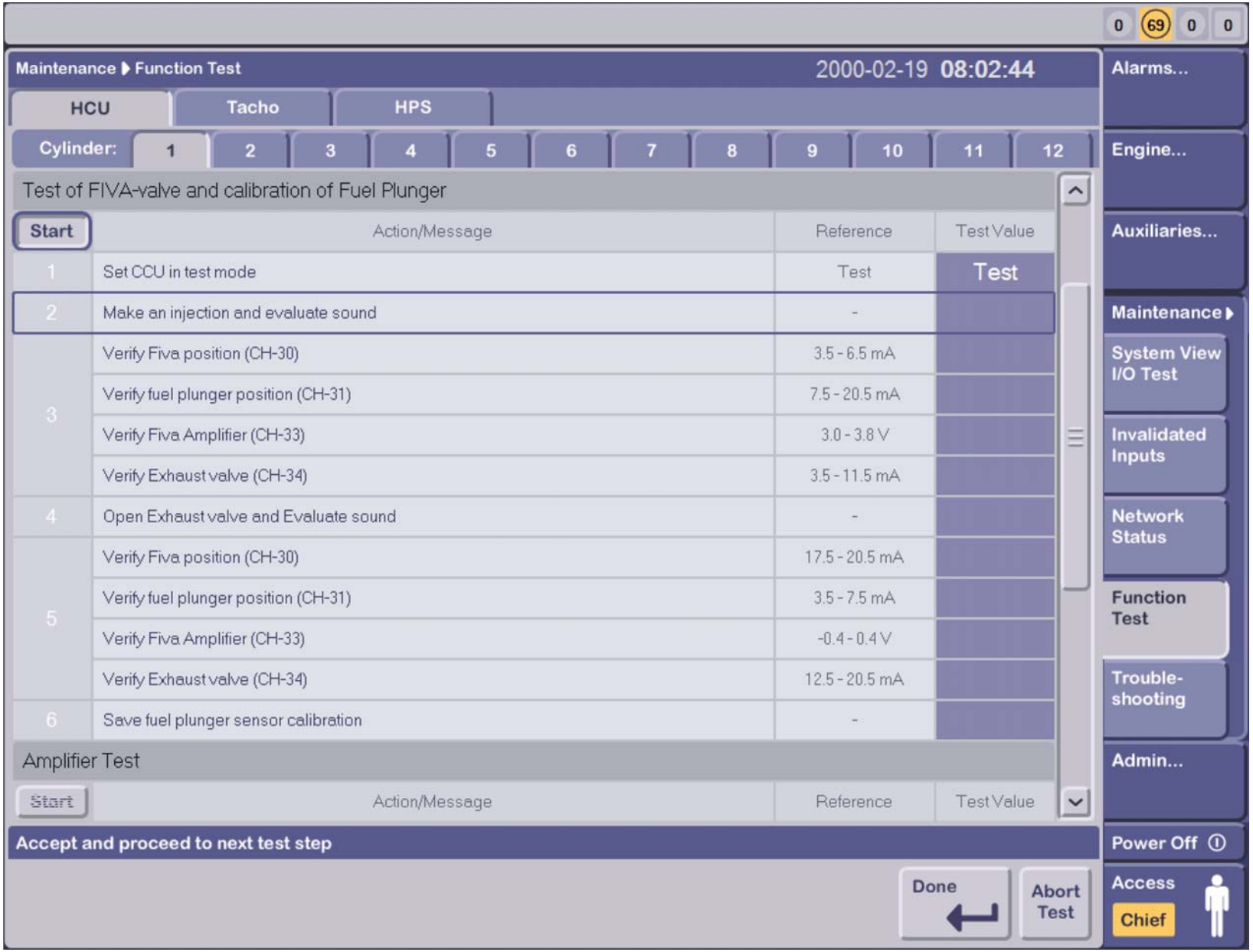
Drawing **MOP Invalidated Inputs**

6655-0195-0005



Drawing **MOP Network Status**

6655-0200-0005

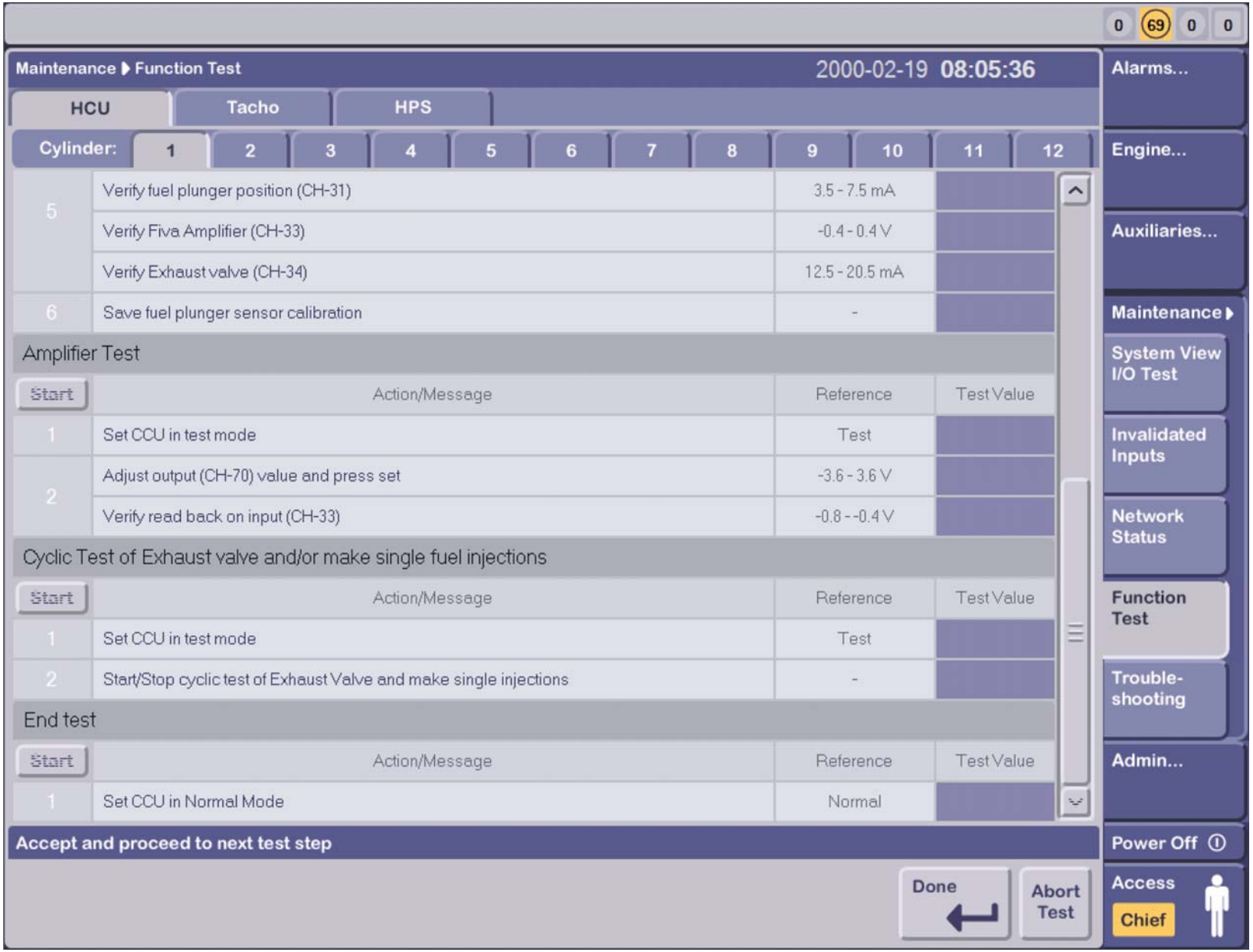


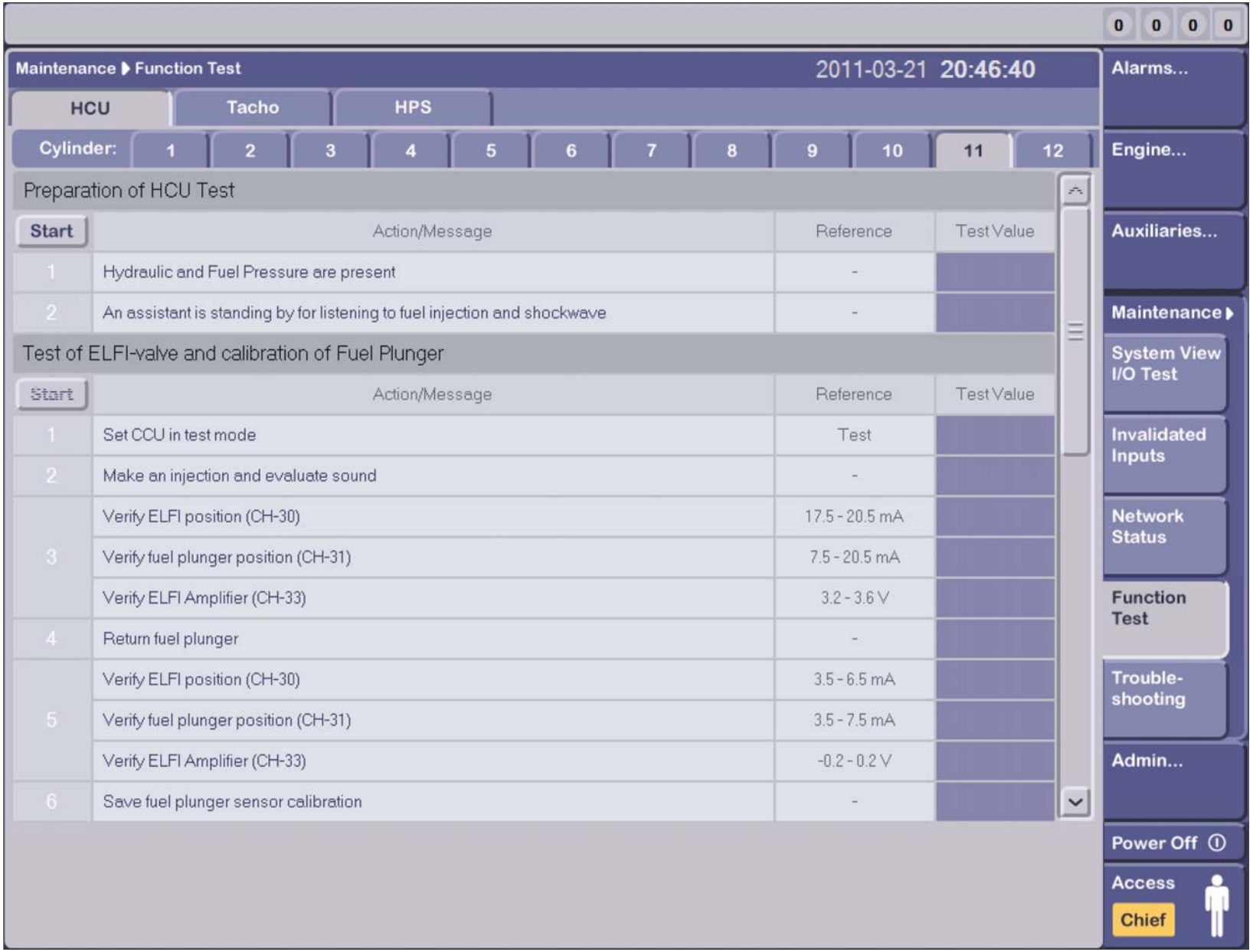
Drawing **MOP Function Test**

6655-0203-0002

Drawing
6655-0203-0002

MOP Function Test



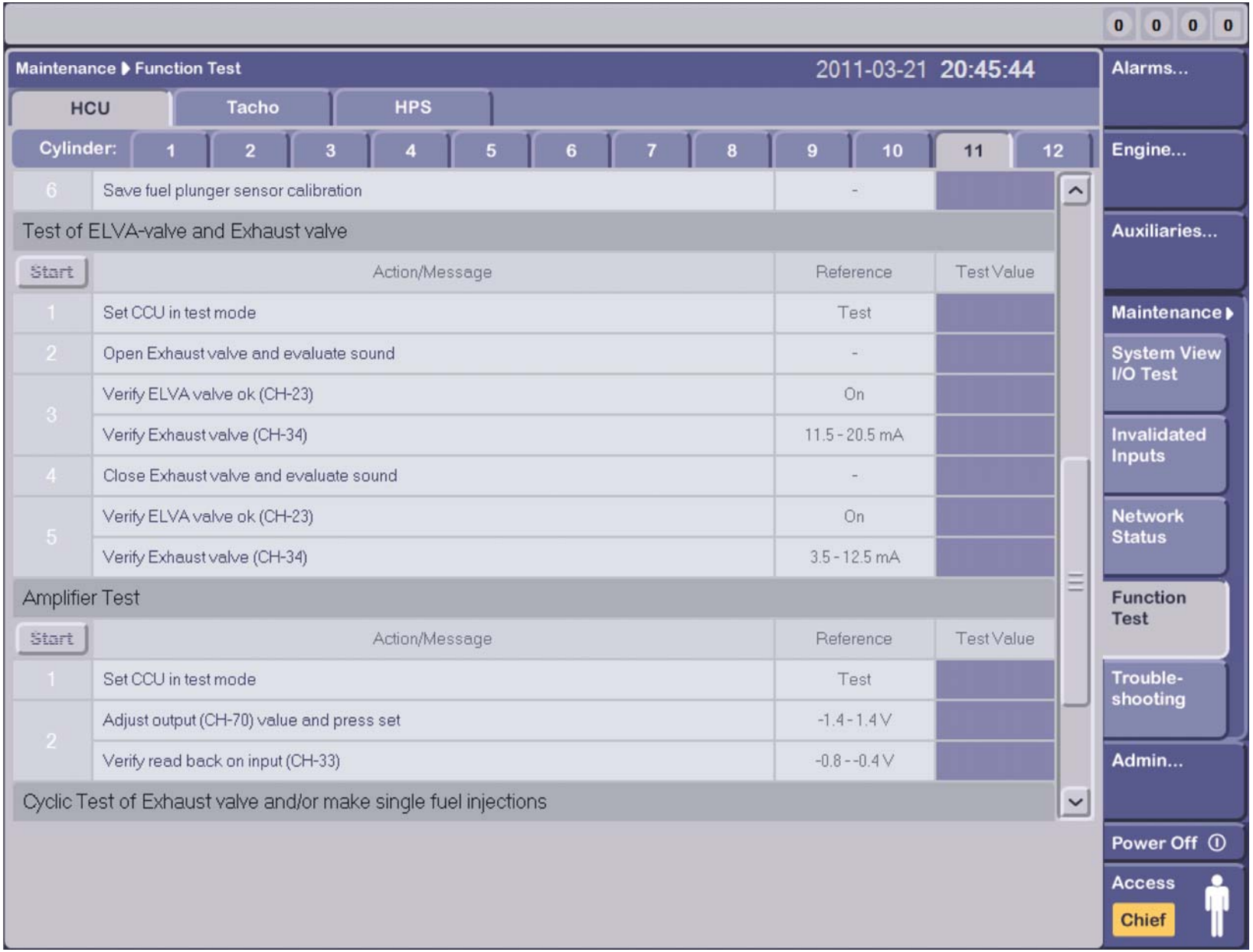


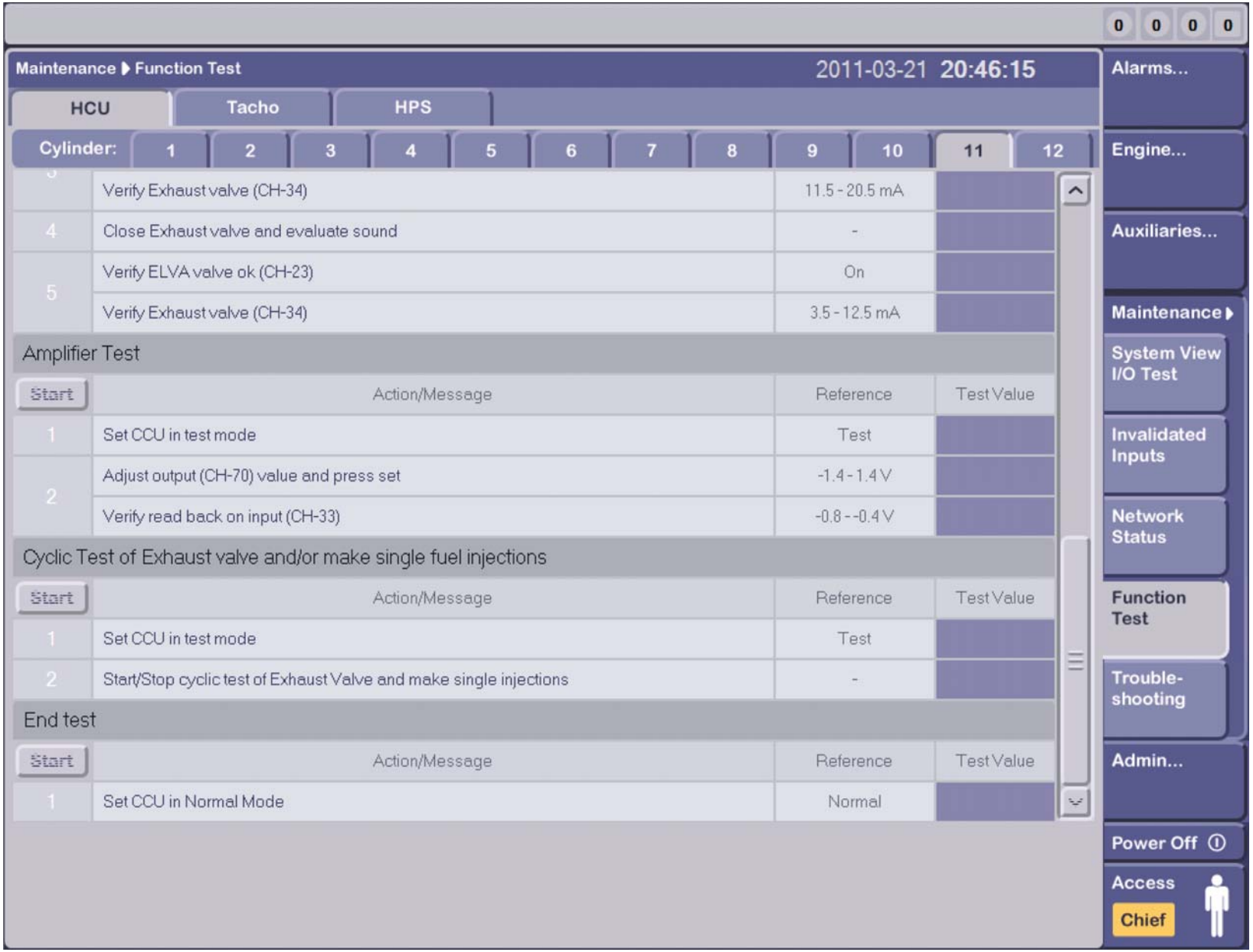
Drawing **MOP Function Test**

6655-0203-0002

Drawing
6655-0203-0002

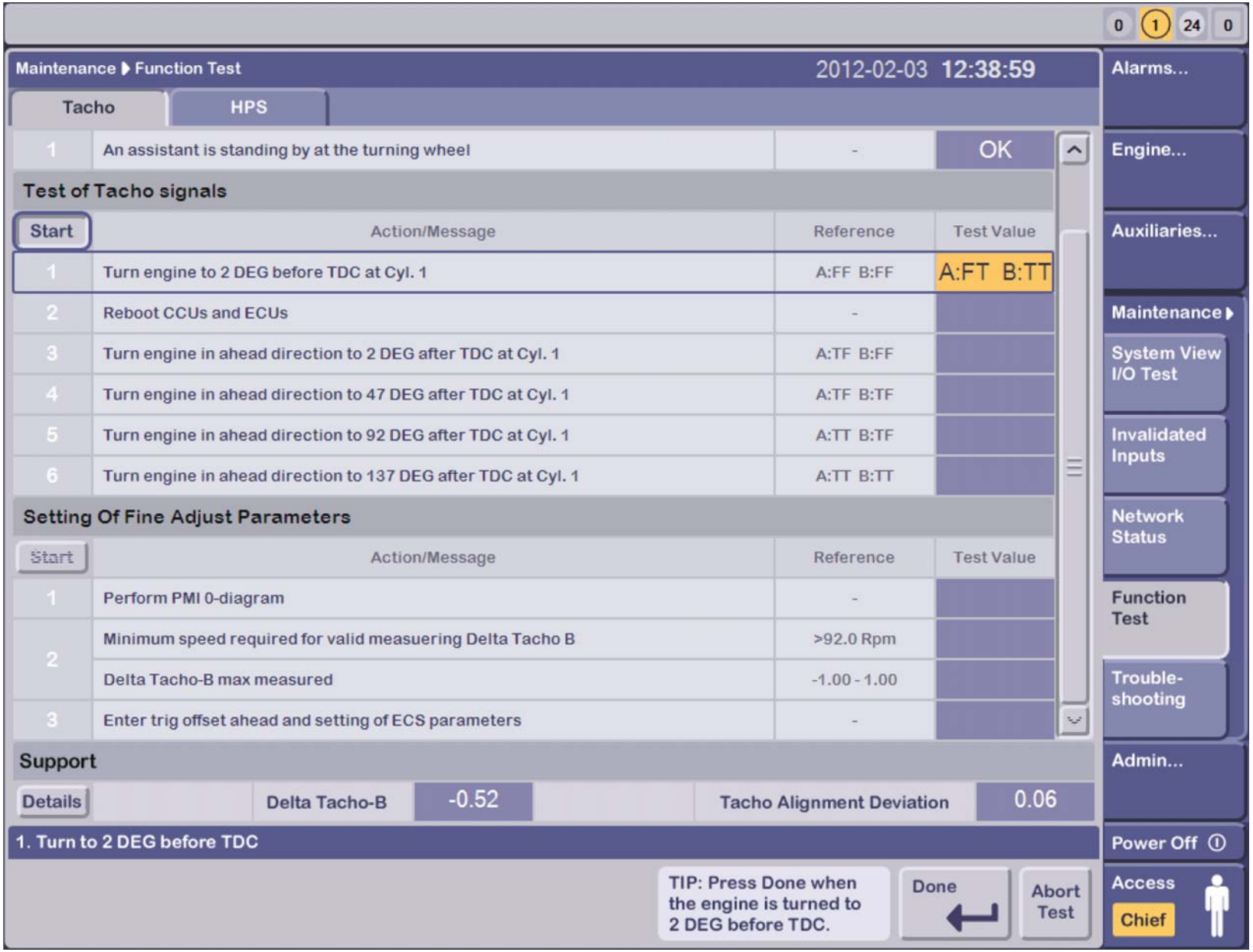
MOP Function Test

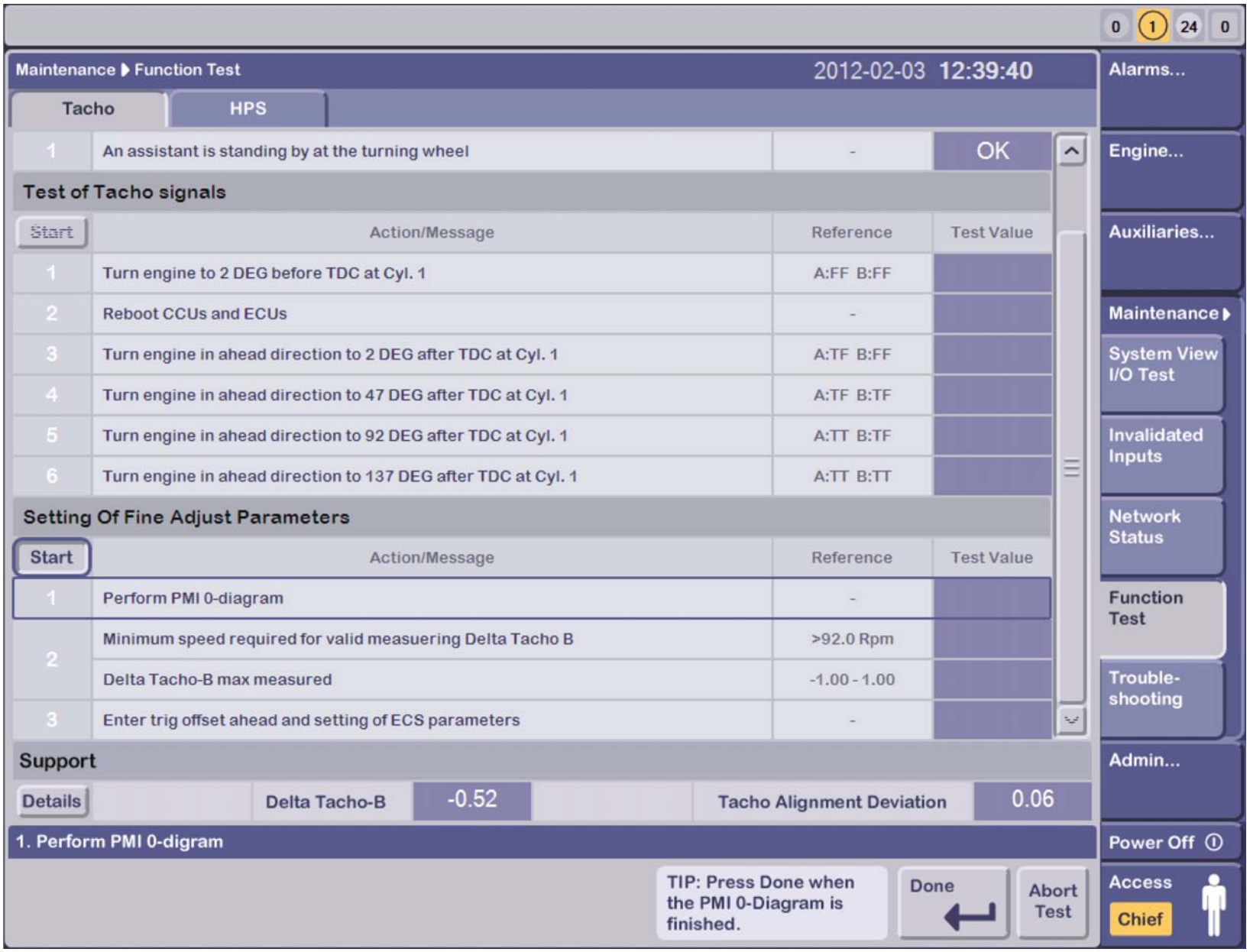




Drawing **MOP Function Test**

6655-0203-0002


0 1 24 0
Maintenance ▸ Function Test
2012-02-03 12:38:59
Tacho
HPS
1 An assistant is standing by at the turning wheel - OK
Test of Tacho signals
Start
Action/Message
Reference
Test Value
1 Turn engine to 2 DEG before TDC at Cyl. 1 A:FF B:FF A:FT B:TT
2 Reboot CCUs and ECUs -
3 Turn engine in ahead direction to 2 DEG after TDC at Cyl. 1 A:TF B:FF
4 Turn engine in ahead direction to 47 DEG after TDC at Cyl. 1 A:TF B:TF
5 Turn engine in ahead direction to 92 DEG after TDC at Cyl. 1 A:TT B:TF
6 Turn engine in ahead direction to 137 DEG after TDC at Cyl. 1 A:TT B:TT
Setting Of Fine Adjust Parameters
Start
Action/Message
Reference
Test Value
1 Perform PMI 0-diagram -
2 Minimum speed required for valid measuering Delta Tacho B >92.0 Rpm
Delta Tacho-B max measured -1.00 - 1.00
3 Enter trig offset ahead and setting of ECS parameters -
Support
Details
Delta Tacho-B -0.52
Tacho Alignment Deviation 0.06
1. Turn to 2 DEG before TDC
TIP: Press Done when the engine is turned to 2 DEG before TDC.
Done
Abort Test
Alarms...
Engine...
Auxiliaries...
Maintenance ▸
System View I/O Test
Invalidated Inputs
Network Status
Function Test
Trouble-shooting
Admin...
Power Off
Access
Chief



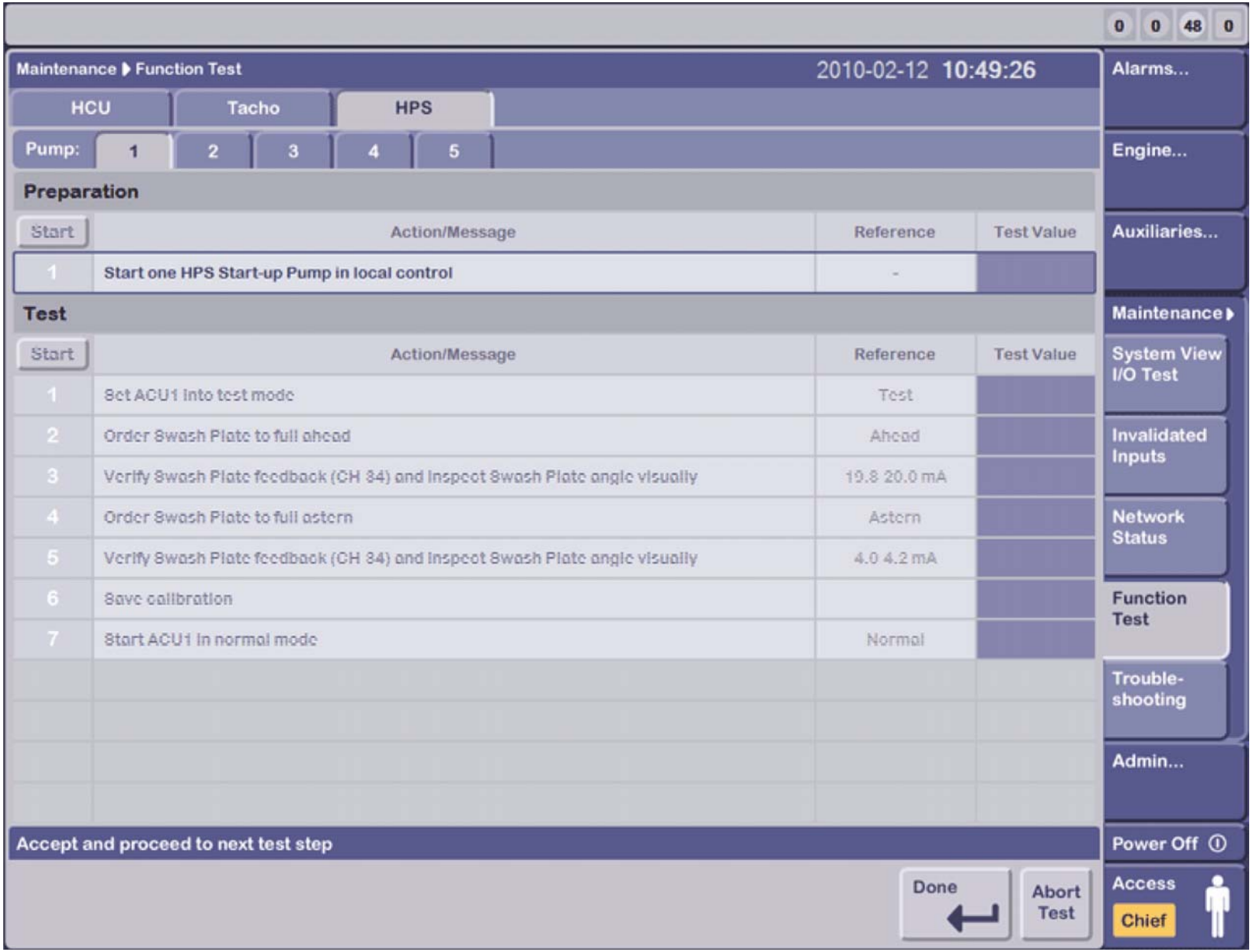
Drawing **MOP Function Test**

6655-0203-0002

Drawing
6655-0203-0002

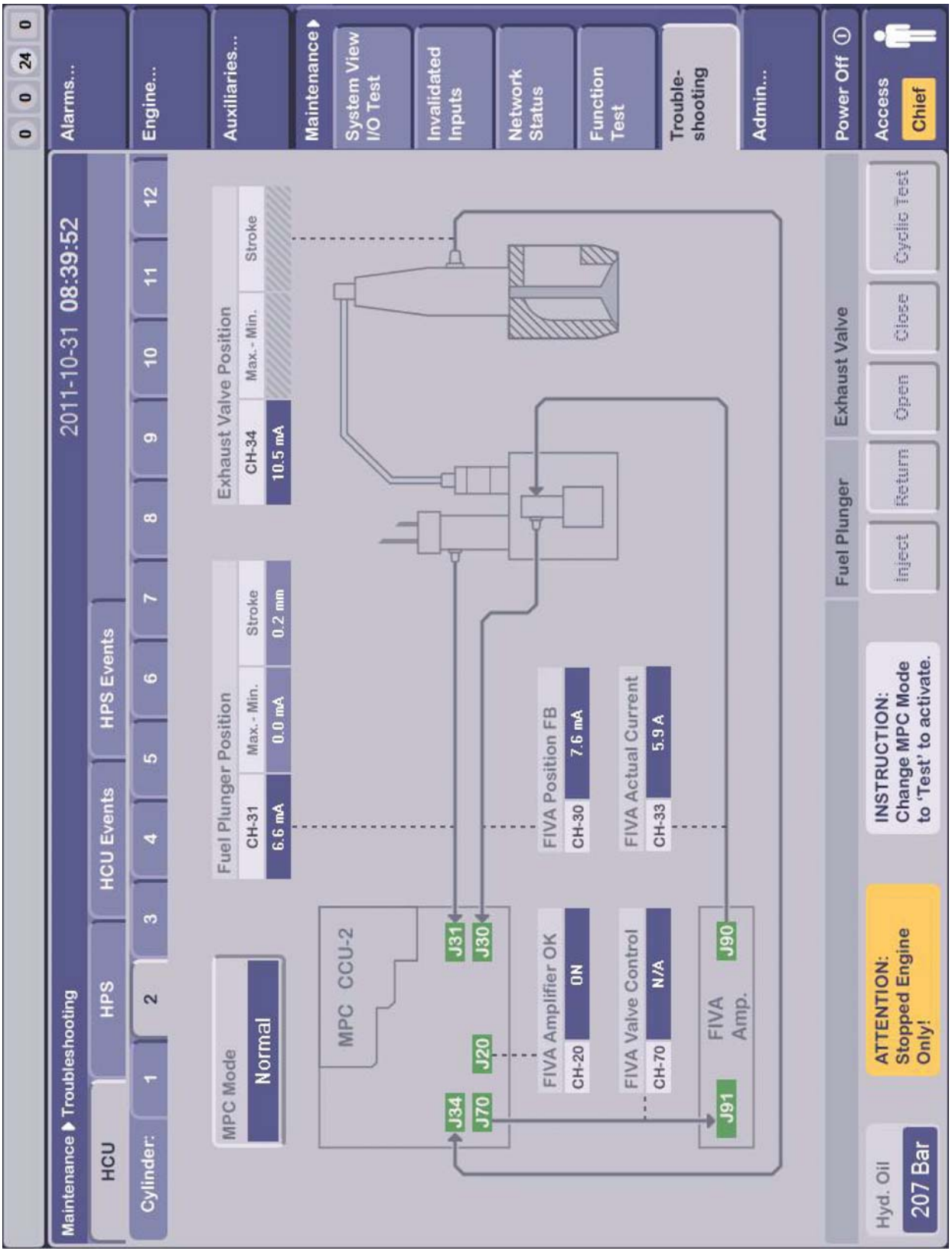
MOP Function Test





Drawing **MOP Function Test**

6655-0203-0002

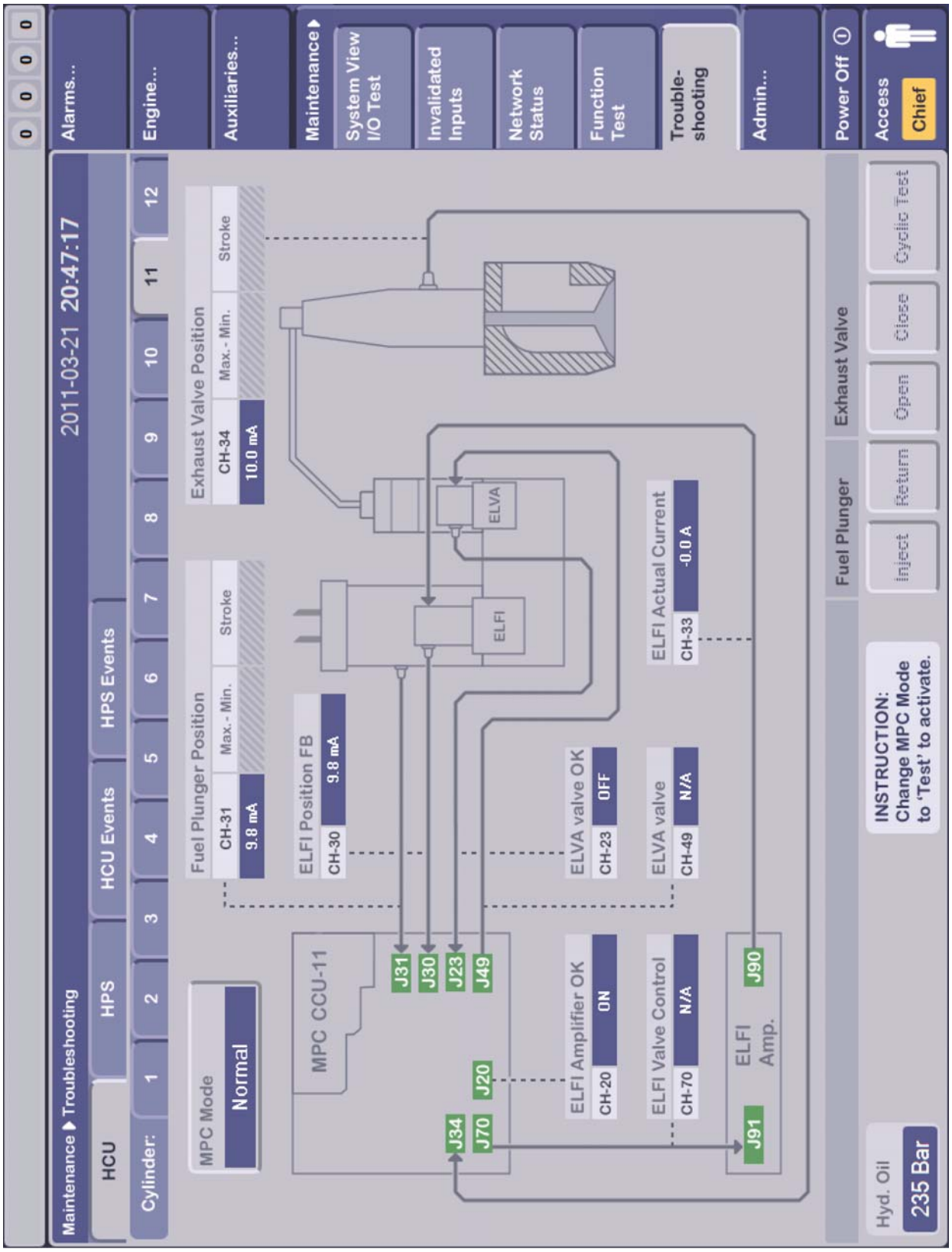


Drawing
6655-0204-0002

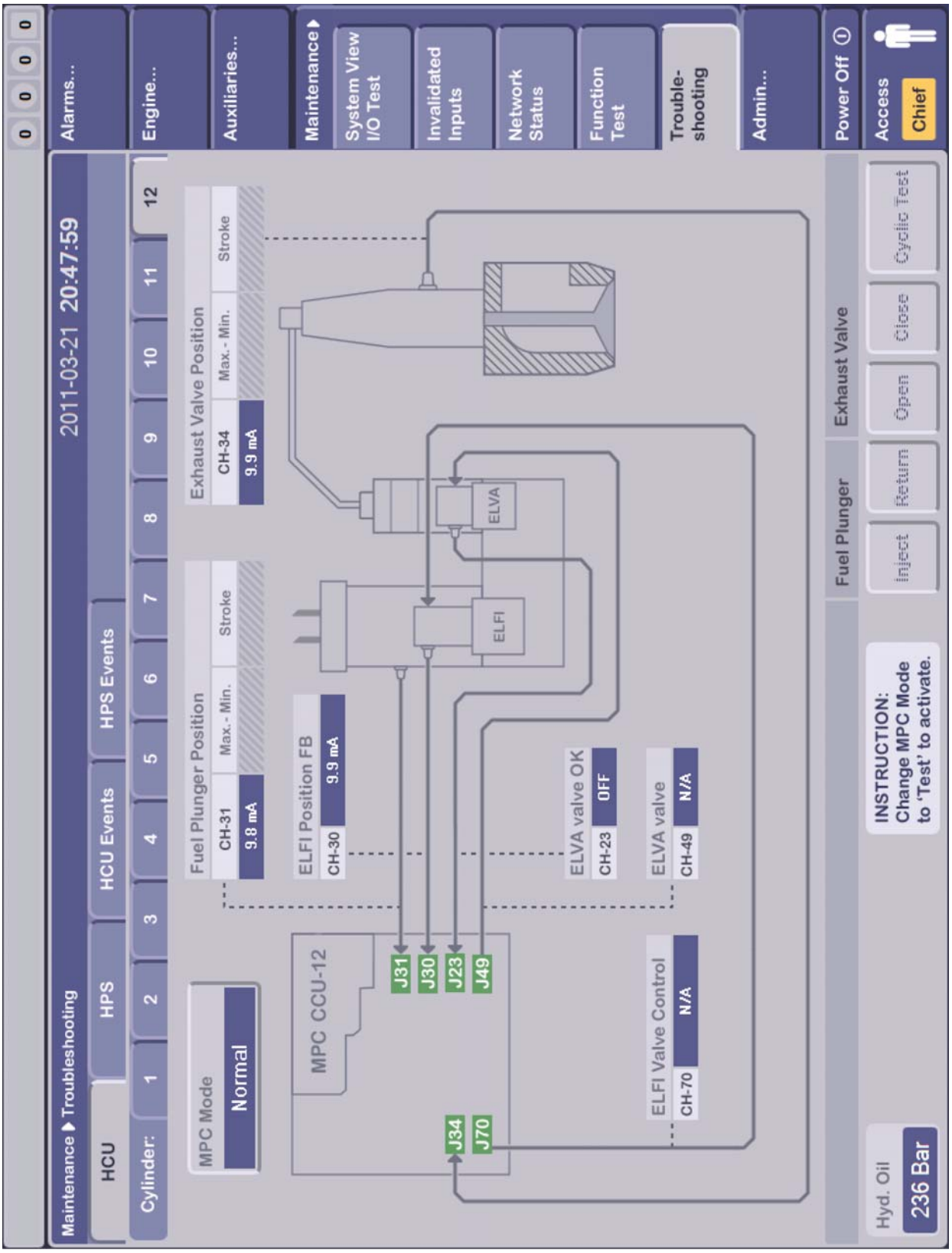
MOP Troubleshooting

Drawing
6655-0204-0002

MOP Troubleshooting

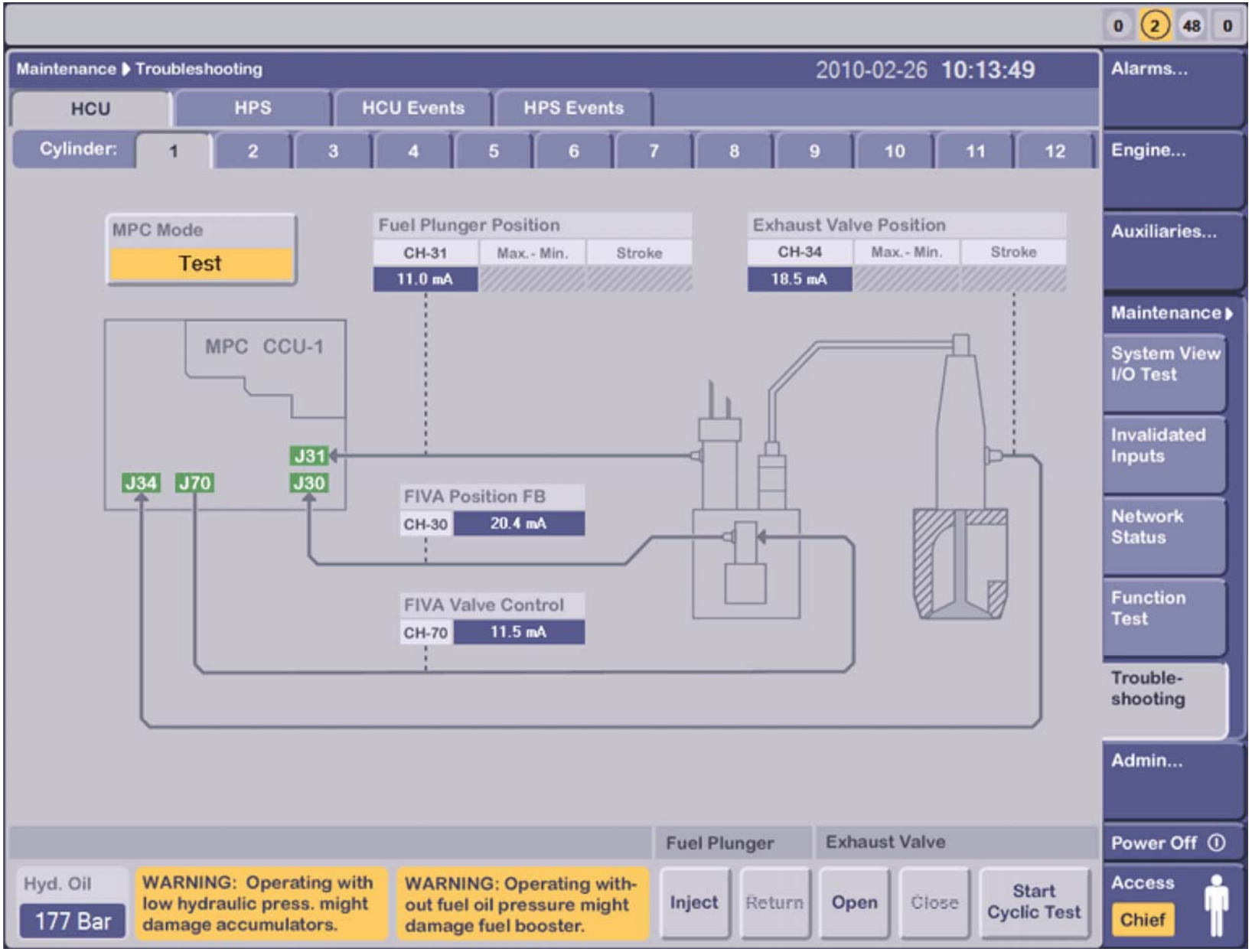


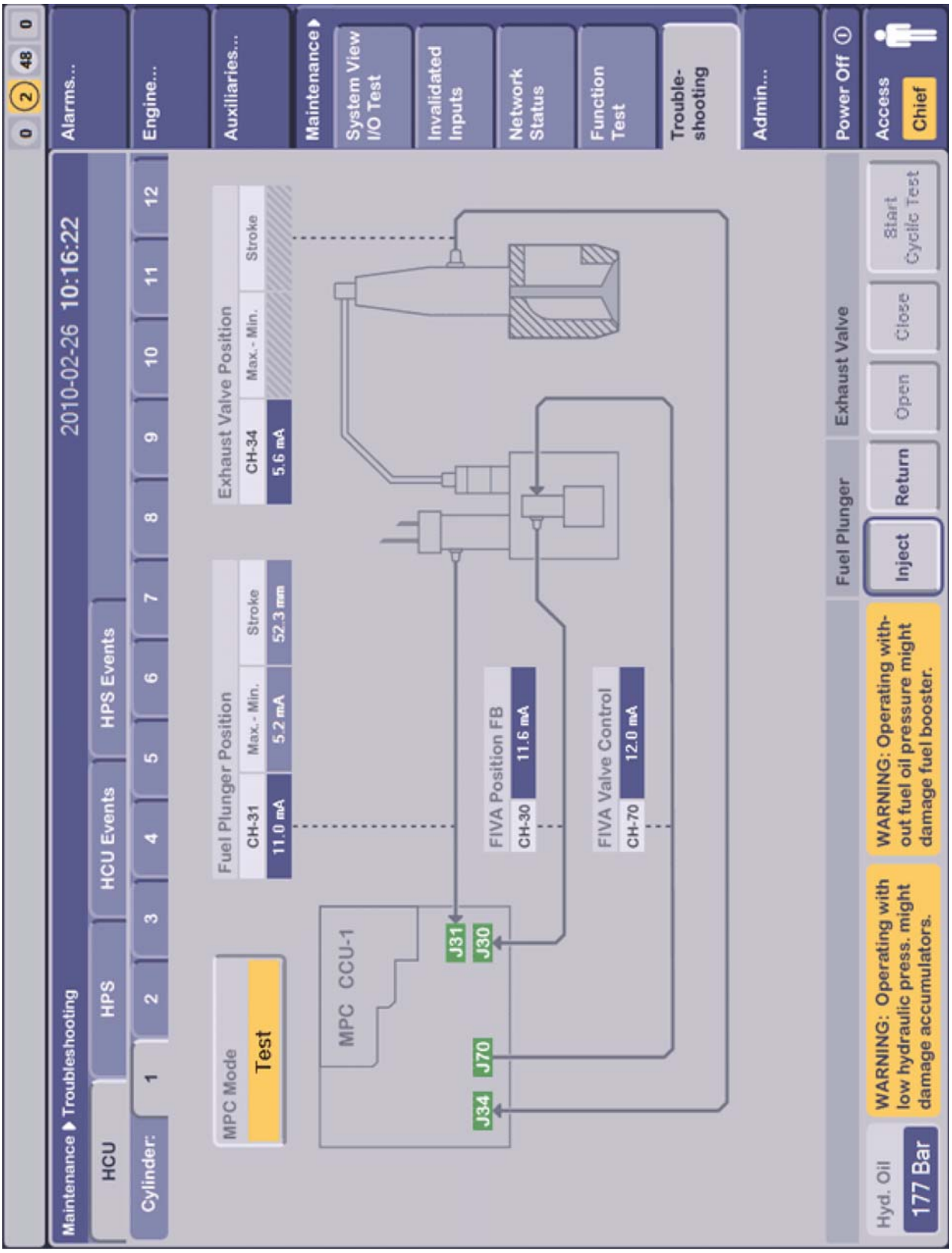
2012-09-07 - en



Drawing 6655-0204-0002

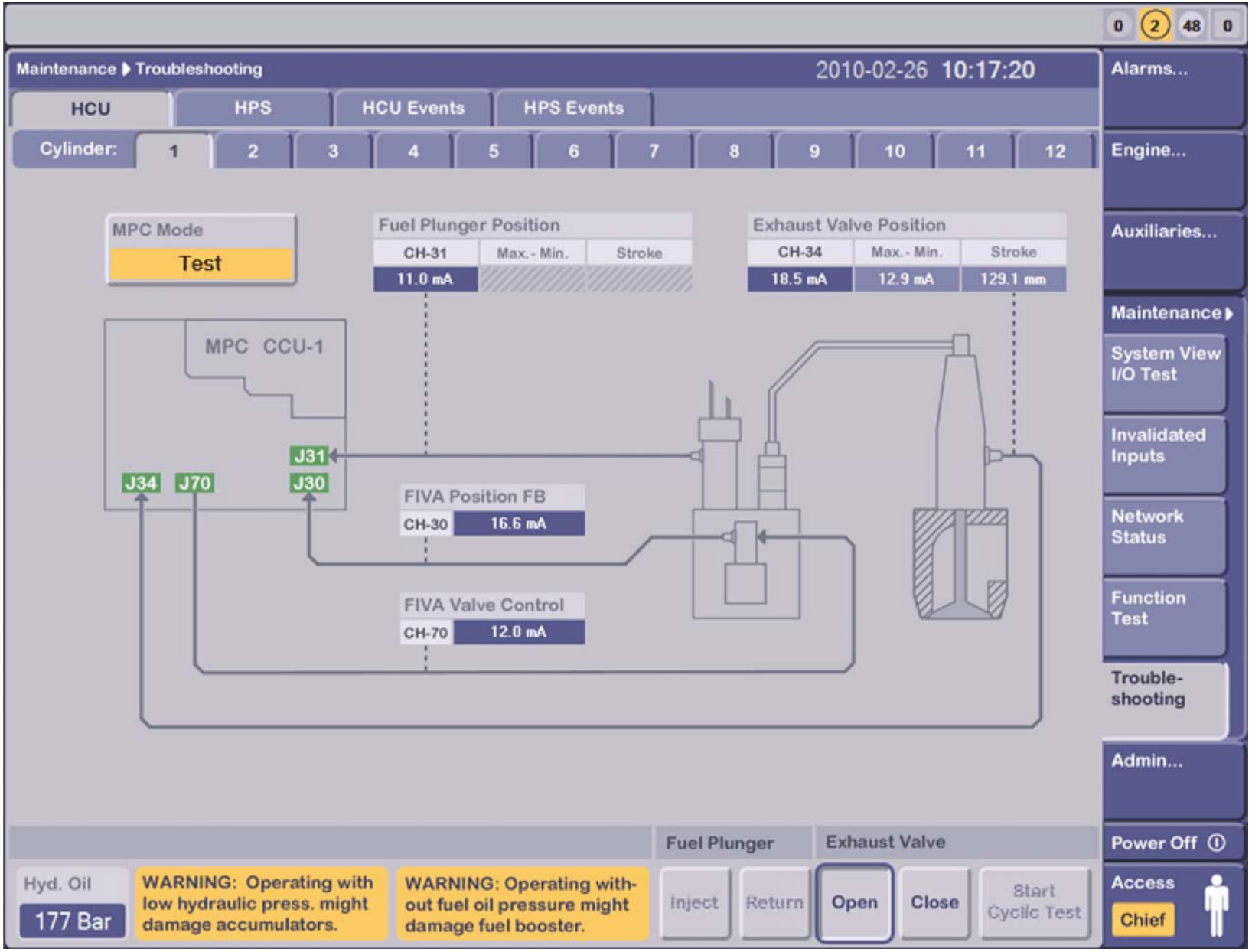
MOP Troubleshooting

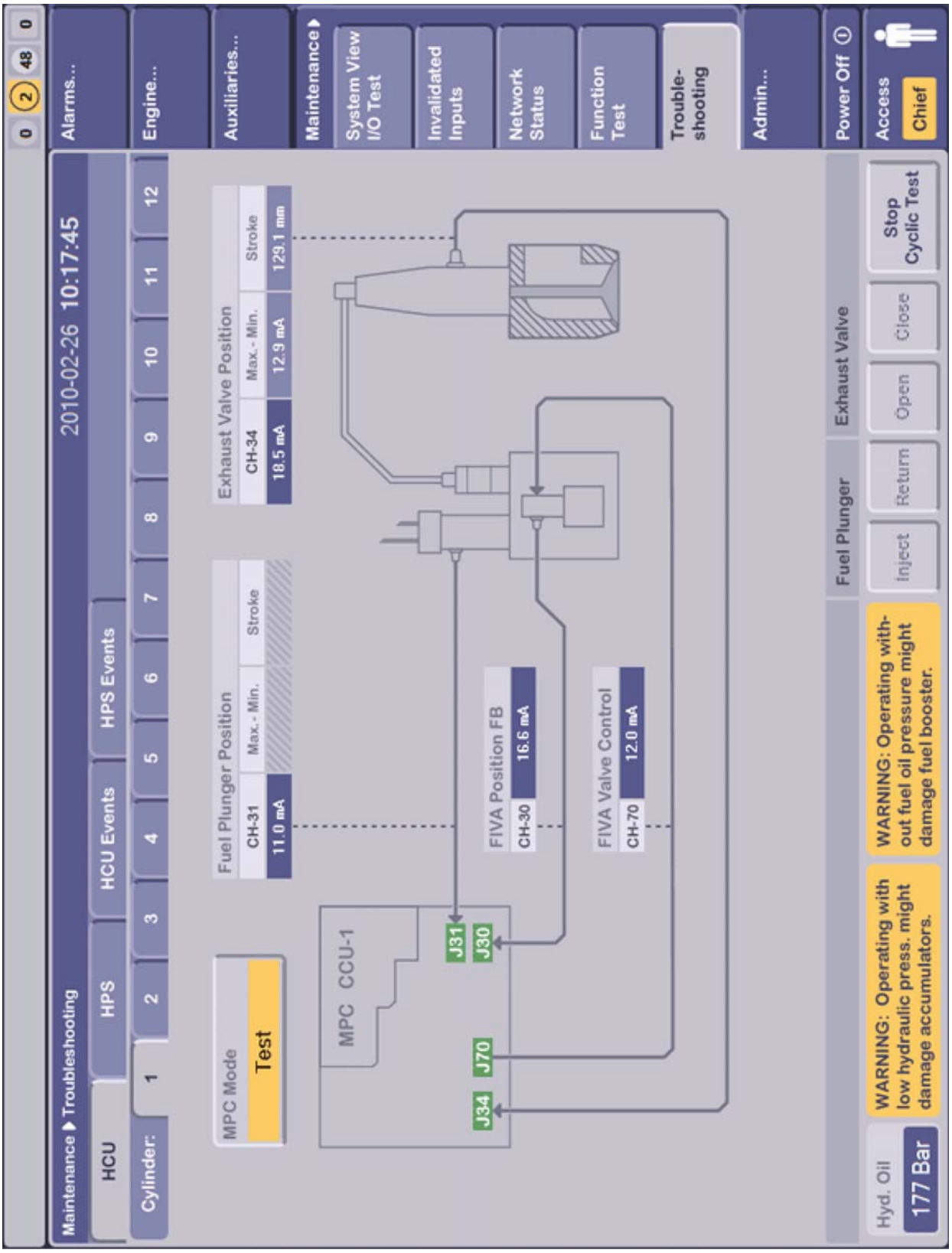

0 2 48 0
Maintenance ▸ Troubleshooting
2010-02-26 10:13:49
HCU
HPS
HCU Events
HPS Events
Cylinder: 1 2 3 4 5 6 7 8 9 10 11 12
MPC Mode
Test
Fuel Plunger Position
CH-31
Max. - Min.
Stroke
11.0 mA
Exhaust Valve Position
CH-34
Max. - Min.
Stroke
18.5 mA
MPC CCU-1
J31
J34
J70
J30
FIVA Position FB
CH-30
20.4 mA
FIVA Valve Control
CH-70
11.5 mA
Alarms...
Engine...
Auxiliaries...
Maintenance ▸
System View I/O Test
Invalidated Inputs
Network Status
Function Test
Trouble-shooting
Admin...
Power Off
Access
Chief
Fuel Plunger
Exhaust Valve
Hyd. Oil
177 Bar
WARNING: Operating with low hydraulic press. might damage accumulators.
WARNING: Operating without fuel oil pressure might damage fuel booster.
Inject
Return
Open
Close
Start Cyclic Test



Drawing
6655-0204-0002

MOP Troubleshooting

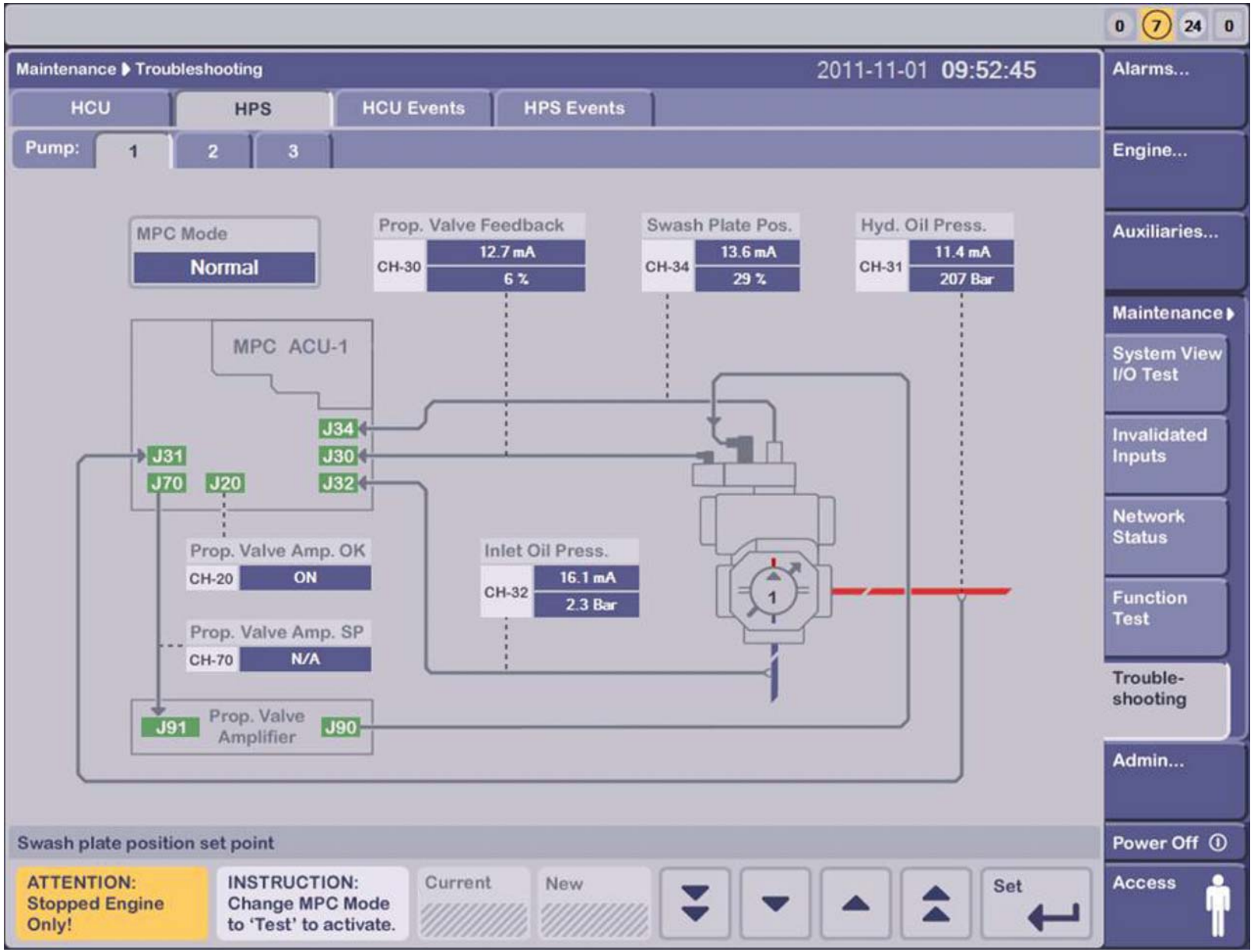

0 2 48 0
Maintenance ▸ Troubleshooting
2010-02-26 10:17:20
HCU
HPS
HCU Events
HPS Events
Cylinder: 1 2 3 4 5 6 7 8 9 10 11 12
MPC Mode
Test
Fuel Plunger Position
CH-31 Max. - Min. Stroke
11.0 mA
Exhaust Valve Position
CH-34 Max. - Min. Stroke
18.5 mA 12.9 mA 129.1 mm
MPC CCU-1
J31
J34 J70 J30
FIVA Position FB
CH-30 16.6 mA
FIVA Valve Control
CH-70 12.0 mA
Alarms...
Engine...
Auxiliaries...
Maintenance ▸
System View I/O Test
Invalidated Inputs
Network Status
Function Test
Trouble-shooting
Admin...
Power Off
Access
Chief
Fuel Plunger
Exhaust Valve
Hyd. Oil
177 Bar
WARNING: Operating with low hydraulic press. might damage accumulators.
WARNING: Operating without fuel oil pressure might damage fuel booster.
Inject
Return
Open
Close
Start Cyclic Test

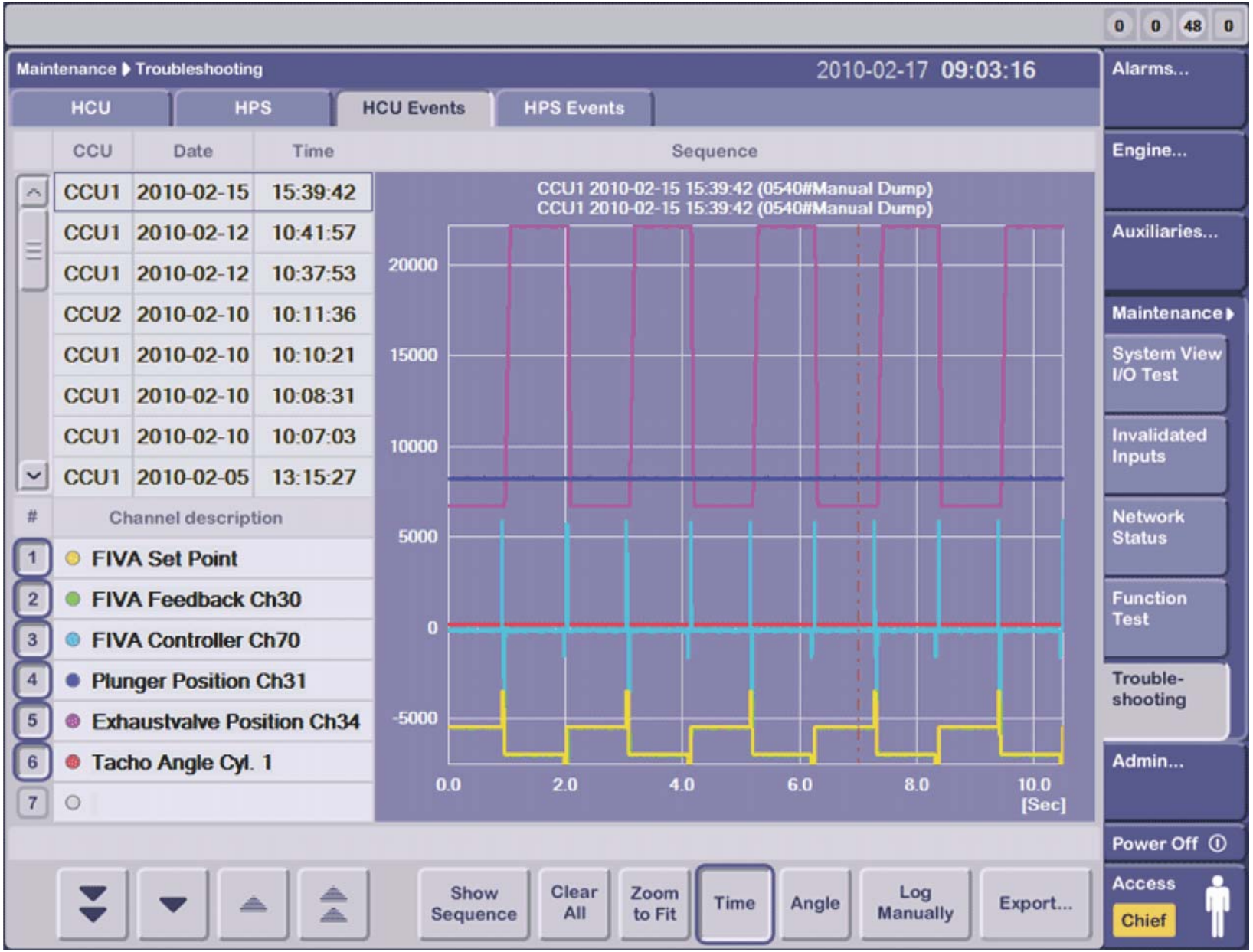


Drawing
6655-0204-0002

MOP Troubleshooting

2012-09-07 - en

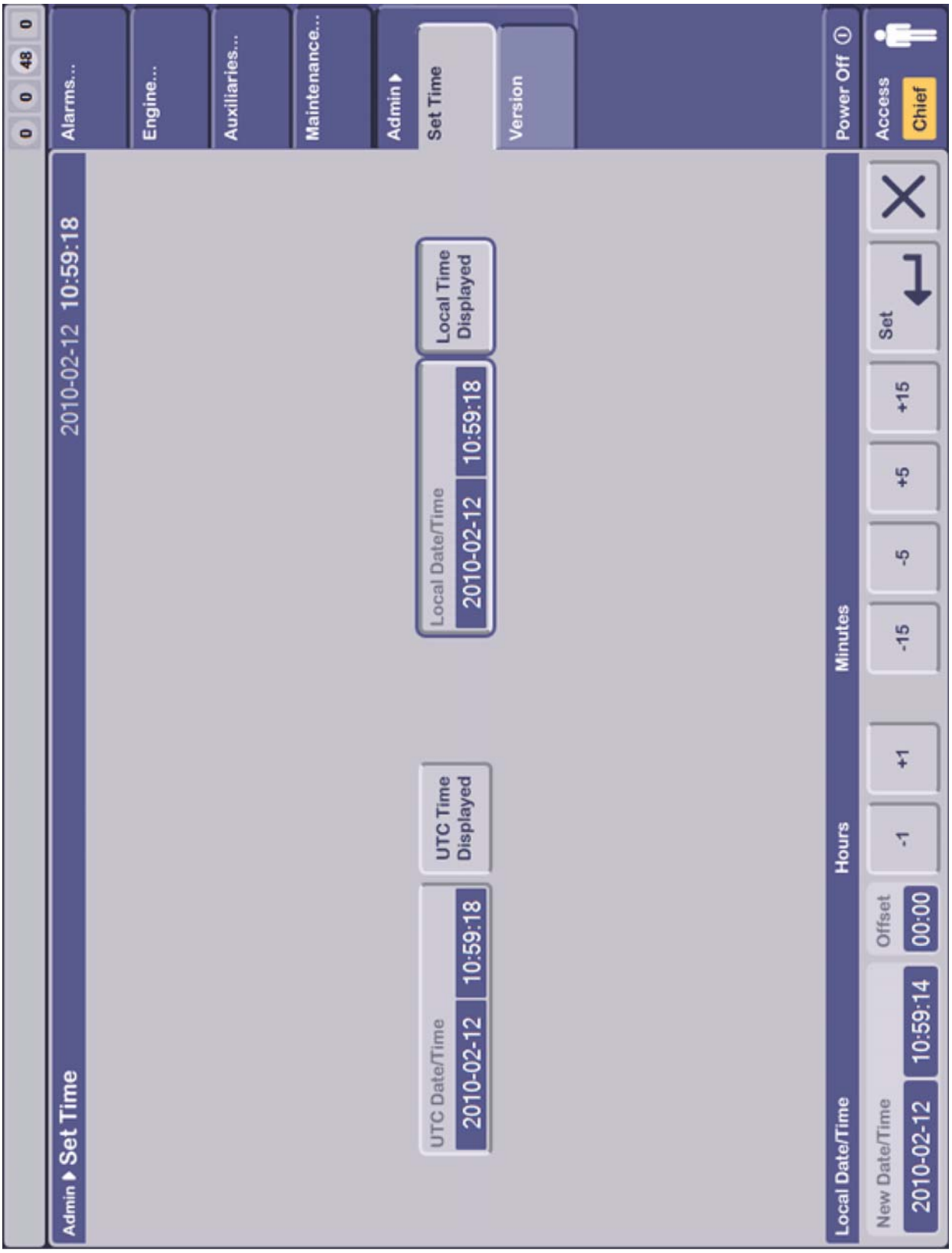

0 7 24 0
Maintenance ▸ Troubleshooting
2011-11-01 09:52:45
HCU
HPS
HCU Events
HPS Events
Pump: 1 2 3
MPC Mode
Normal
Prop. Valve Feedback
CH-30 12.7 mA 6 %
Swash Plate Pos.
CH-34 13.6 mA 29 %
Hyd. Oil Press.
CH-31 11.4 mA 207 Bar
MPC ACU-1
J34
J31
J30
J70
J20
J32
Prop. Valve Amp. OK
CH-20 ON
Inlet Oil Press.
CH-32 16.1 mA 2.3 Bar
Prop. Valve Amp. SP
CH-70 N/A
J91
Prop. Valve Amplifier
J90
Swash plate position set point
ATTENTION: Stopped Engine Only!
INSTRUCTION: Change MPC Mode to 'Test' to activate.
Current
New
Set
Alarms...
Engine...
Auxiliaries...
Maintenance ▸
System View I/O Test
Invalidated Inputs
Network Status
Function Test
Trouble-shooting
Admin...
Power Off
Access



Drawing **MOP Troubleshooting**

6655-0204-0002

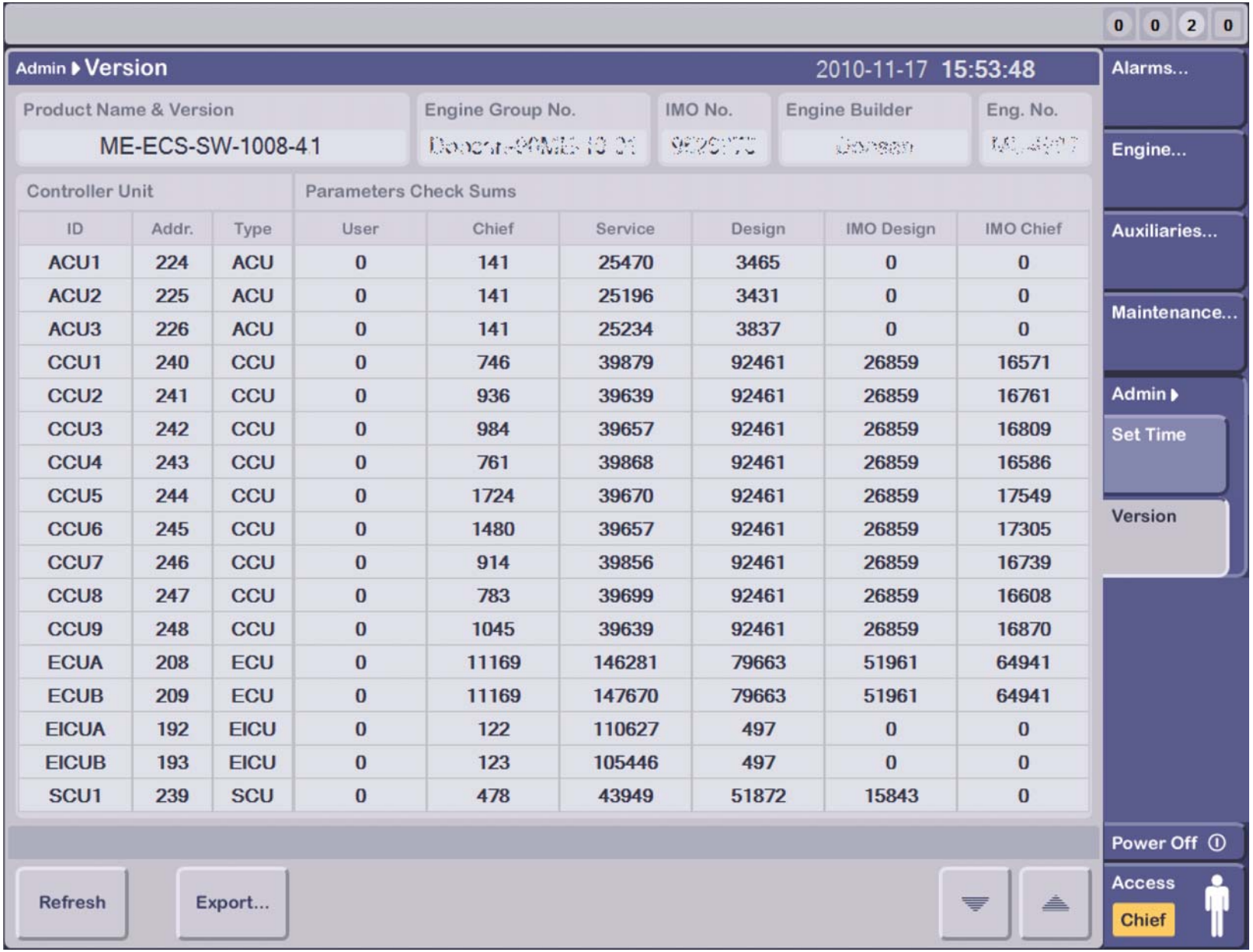

0 0 48 0
Maintenance ▸ Troubleshooting
2010-02-17 09:05:06
HCU
HPS
HCU Events
HPS Events
ACU Date Time
ACU2 2010-02-01 11:12:02
ACU2 2010-02-01 11:11:15
ACU2 2010-02-01 11:10:40
ACU2 2010-02-01 11:10:01
ACU2 2010-02-01 11:09:41
ACU2 2010-02-01 11:08:56
ACU2 2010-02-01 10:58:51
ACU2 2010-02-01 10:56:58
Channel description
1 Hydraulic Pressure Setpoint
2 Hydraulic Pressure Ch31
3 SwashPlate Setpoint
4 SwashPlate Position Ch34
5 Internal Propvalve Setpoint
6 Int. Propvalve Position Ch30
7 Controler Output Ch70
Sequence
ACU2 2010-02-01 11:12:30 (070119#Pump ctrl failure)
ACU2 2010-02-16 13:31:21 (070119#Pump ctrl failure)
ACU2 2010-02-09 10:29:38 (070119#Pump ctrl failure)
ACU2 2010-02-01 11:10:01 (070119#Pump ctrl failure)
30000
25000
20000
15000
10000
5000
0
0.00 2.00 4.00 6.00 8.00
[Sec]
Alarms...
Engine...
Auxiliaries...
Maintenance ▸
System View I/O Test
Invalidated Inputs
Network Status
Function Test
Trouble-shooting
Admin...
Power Off
Access
Chief
Show Sequence
Clear All
Zoom to Fit
Log Manually
Export...



Drawing
6655-0205-0005

MOP Set Time

2012-09-07 - en



Product Name & Version: ME-ECS-SW-1008-41

Engine Group No.: [illegible]

IMO No.: [illegible]

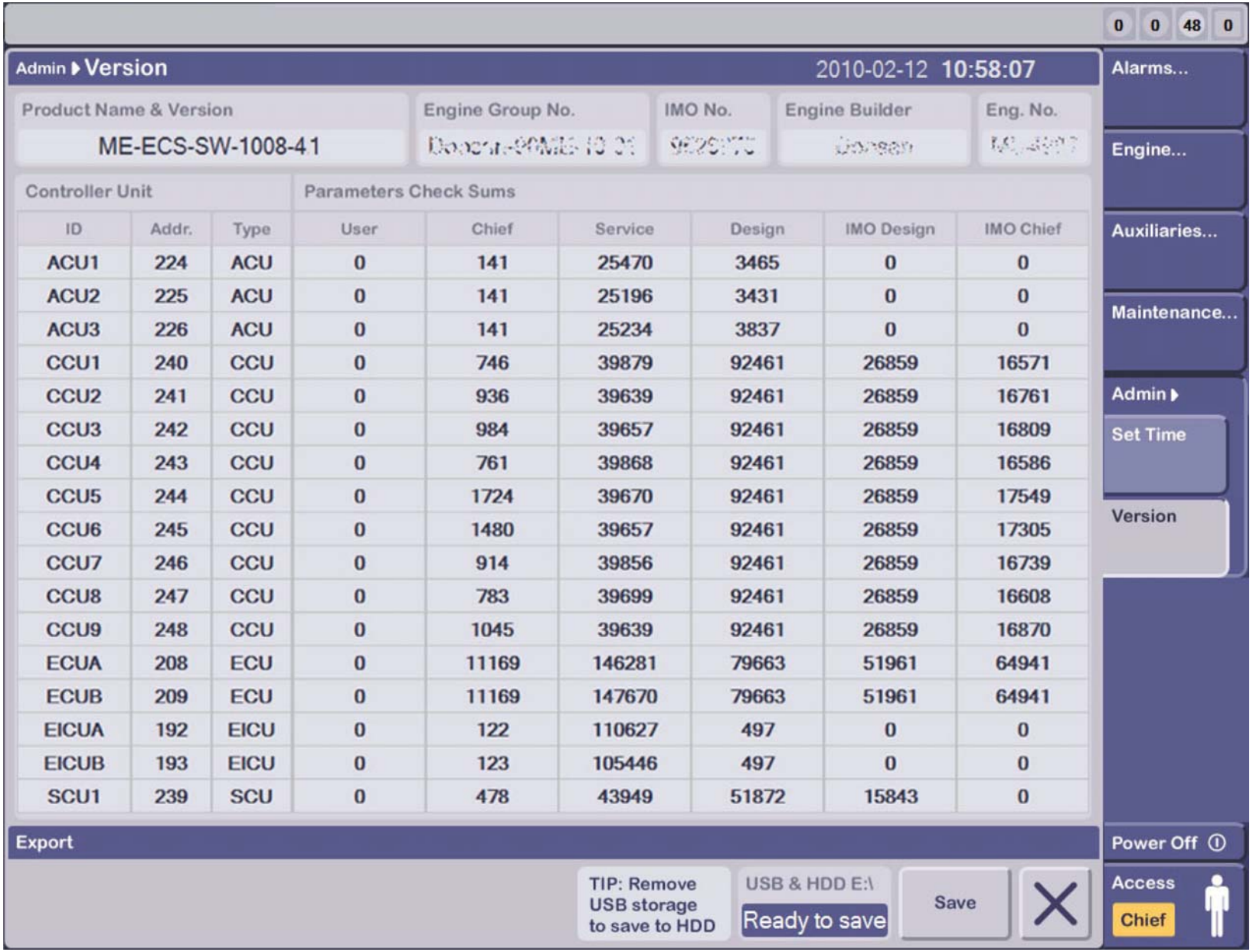
Engine Builder: [illegible]

Eng. No.: [illegible]

Controller Unit			Parameters Check Sums					
ID	Addr.	Type	User	Chief	Service	Design	IMO Design	IMO Chief
ACU1	224	ACU	0	141	25470	3465	0	0
ACU2	225	ACU	0	141	25196	3431	0	0
ACU3	226	ACU	0	141	25234	3837	0	0
CCU1	240	CCU	0	746	39879	92461	26859	16571
CCU2	241	CCU	0	936	39639	92461	26859	16761
CCU3	242	CCU	0	984	39657	92461	26859	16809
CCU4	243	CCU	0	761	39868	92461	26859	16586
CCU5	244	CCU	0	1724	39670	92461	26859	17549
CCU6	245	CCU	0	1480	39657	92461	26859	17305
CCU7	246	CCU	0	914	39856	92461	26859	16739
CCU8	247	CCU	0	783	39699	92461	26859	16608
CCU9	248	CCU	0	1045	39639	92461	26859	16870
ECUA	208	ECU	0	11169	146281	79663	51961	64941
ECUB	209	ECU	0	11169	147670	79663	51961	64941
EICUA	192	EICU	0	122	110627	497	0	0
EICUB	193	EICU	0	123	105446	497	0	0
SCU1	239	SCU	0	478	43949	51872	15843	0

Drawing **MOP Version**

6655-0210-0005


0 0 48 0
Admin ▸ Version
2010-02-12 10:58:07
Alarms...
Engine...
Auxiliaries...
Maintenance...
Admin ▸
Set Time
Version
Power Off
Access
Chief
Product Name & Version
ME-ECS-SW-1008-41
Engine Group No.
IMO No.
Engine Builder
Eng. No.
Controller Unit
Parameters Check Sums
ID Addr. Type User Chief Service Design IMO Design IMO Chief
ACU1 224 ACU 0 141 25470 3465 0 0
ACU2 225 ACU 0 141 25196 3431 0 0
ACU3 226 ACU 0 141 25234 3837 0 0
CCU1 240 CCU 0 746 39879 92461 26859 16571
CCU2 241 CCU 0 936 39639 92461 26859 16761
CCU3 242 CCU 0 984 39657 92461 26859 16809
CCU4 243 CCU 0 761 39868 92461 26859 16586
CCU5 244 CCU 0 1724 39670 92461 26859 17549
CCU6 245 CCU 0 1480 39657 92461 26859 17305
CCU7 246 CCU 0 914 39856 92461 26859 16739
CCU8 247 CCU 0 783 39699 92461 26859 16608
CCU9 248 CCU 0 1045 39639 92461 26859 16870
ECUA 208 ECU 0 11169 146281 79663 51961 64941
ECUB 209 ECU 0 11169 147670 79663 51961 64941
EICUA 192 EICU 0 122 110627 497 0 0
EICUB 193 EICU 0 123 105446 497 0 0
SCU1 239 SCU 0 478 43949 51872 15843 0
Export
TIP: Remove USB storage to save to HDD
USB & HDD E:\
Ready to save
Save

	Case A	Case B	Case C	Case D	Case E
Nature of the action	Combustion to be stopped	Compression and combustion to be stopped	Combustion to be stopped (due to faulty exhaust valve)	All reciprocating parts suspended or out	All reciprocating parts out
Some reasons for the action	Blow-by at piston rings or exhaust valve. Reduction of load on bearings. Faulty injection equipment.	Leaking cylinder cover or liner	Exhaust valve, or exhaust valve actuator, malfunction	Quickest and safest measure in the event of faults in large moving parts, or cylinder cover or cylinder liner	Only of interest if spare parts are not available
FIVA (fuel pump)	Cut out	Cut out	Cut out	Cut out	Cut out
Exhaust valve	Working	Held open	Closed	Closed	Closed
Air for air spring	Open	Closed	Open	Open	Open
FIVA (Exhaust valve)	Working	Cut out	Cut out	Cut out	Cut out
Starting valve	Working	Blanked	Working	Blanked	Blanked
Piston with rod	Moving	Moving	Moving	Suspended	Out
Crosshead	Moving	Moving	Moving	Suspended	Out
Connecting rod	Moving	Moving	Moving	Out	Out
Crankpin bearing	Moving	Moving	Moving	Out	Out
Oil inlet to crosshead	Open	Open	Open	Blanked	Blanked
Cooling oil outlet from crosshead	Open	Open	Open		
Cylinder lubricators	Working	Working	Working	Stopped	Stopped

Cutting Cylinders out of Action

Drawing 6655-0215-0002

2008-09-16

Component	Case B		Case C[1]			Case D
	Engines with one T/C	Engines with two or more T/C	Engines with one T/C		Engines with two or more T/C	(Engines with two or more T/C)
			With by-pass	Without by-pass		
Rotor[2]	Locked	Locked	Locked	Removed	Locked	
Nozzle ring [2]				Removed		
Compressor outlet		Orifice plate			Orifice plate	Blanking plates
Turbo inlet					Orifice plate	Blanking plates
Turbo outlet						Blanking plates
Compensator after compressor	Removed		Removed	Removed		
By-pass blanking plate			Removed			
T/C housing [2]				Blanking plates		
Max % of MCR load/ (speed):						
1 T/C of 1	15/(53) [3]	-	20-/(58) [4] 20-25 [4] (58-63)	15/(53) [3]	-	-
1 T/C of 2 [9]	-	15/(53) [3] [5]	-	-	50/(79) [3] [6]	50/(79) [3] [6]
1 T/C of 3*	-	20/(58) [3] [5]	-	-	66/(87) [3] [6]	66/(87) [3] [6]
1 T/C of 4*	-	20/(58) [3] [5]	-	-	75/(91) [3] [6]	75/(91) [3] [6]
1 Aux.bl. of 2 [7]	10/(46) [4]	10/(46) [4]	15/(53) [4]	10/(46) [4]	[8]	[8]
1 Aux.bl. of 3 [7] *	-	15/(53) [4]	-	-	[8]	[8]
1 Aux.bl. of 4 [7] *	-	15/(53) [4]	-	-	[8]	[8]

*) These items are NOT valid for engines 26-46 bore

1) The engine builder will, in each specific case, be able to give further information about engine load possibilities and temperature levels.

2) See T/C manual.

3) The exhaust temperatures must not exceed the value(s) stated in description 7045-0100. Also see the note in description 6645-0320, Item 1, 'General'.

4) The exhaust temperature must not exceed a) 430°C b) 400°C for 26 - 46 bore engines.

5) This is due to the loss of exhaust gas through the damaged turbocharger.

6) The mentioned exhaust temperature limit is an average value for the whole load range.

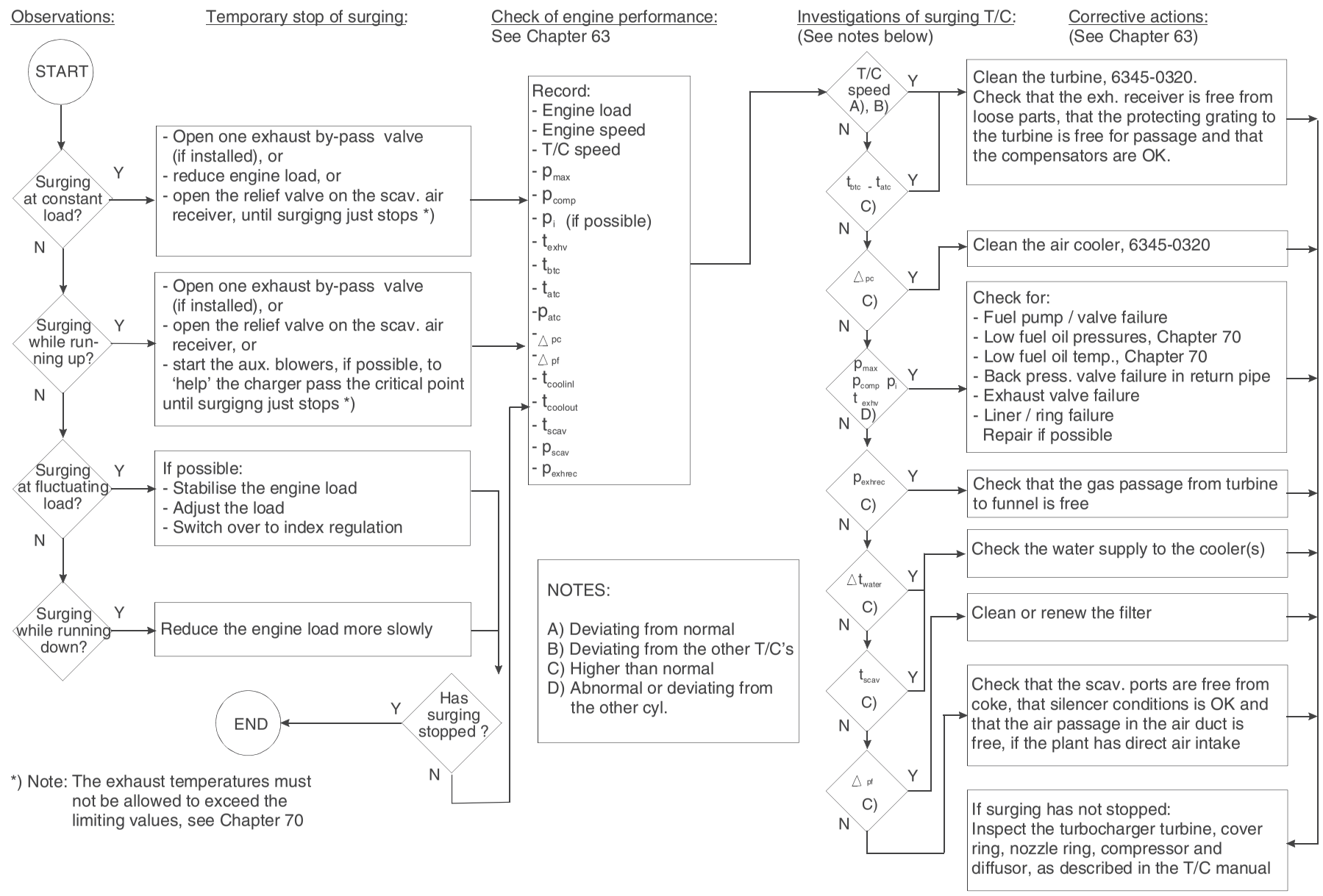
7) Simultaneous with 1 T/C out of operation. There are no load restrictions with 1 aux. blower out of operation and all T/C's in operation.

8) See the limits given under '1 T/C of 2', '1 T/C of 3', and '1 T/C of 4', above.

9) Running with one T/C out of two increases the cylinder pressure at low load and may increase the torsional stresses with approx. 30%. The torsional vibrations in the shafting system should therefore be evaluated with this increase. Engines with barred speed range can be operated below the barred speed range. In case of

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emergency running it can be necessary to pass the barred speed range. To protect the intermediate shaft, the number of passages should be kept to a minimum – preferably one time up and one time down. Once the vessel gets close to port speed should be kept below the barred speed range.



Drawing
6655-0225-0002

Turbocharger Surging

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off control air supply
O	Shut off air supply to exhaust valve - Only when stopped lubricating oil pumps
O	Shut off fuel oil



Data

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The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
2270-0200	**125**	Tool for emergency opening exhaust valve
6670-0100	**013**	Cable, complete

Exhaust Valve

For all special running conditions, *see Volume I, Chapter 704.*

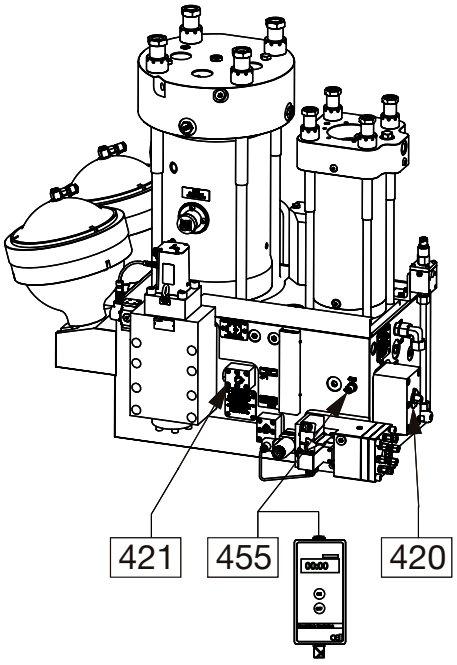
Under conditions where it is necessary to run the engine with an open exhaust valve, an exhaust emergency opening tool must be fitted as follows.

Stop the engine

Fit a pressure gauge at “minimess” point No. 455. Check the pressure.

Close valve 420 and open valve 421 on the hydraulic block for the cylinder concerned.

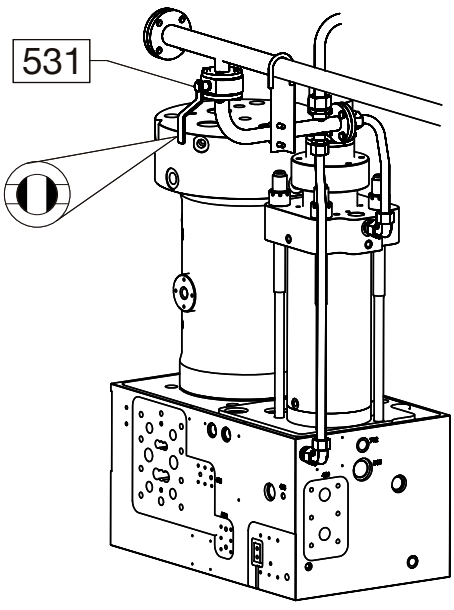
Check that the hydraulic cylinder unit is pressure free.



6665-0101-0003O01

Close valve 531

Shut off the oil damper oil supply by closing valve 531 on the hydraulic cylinder unit.



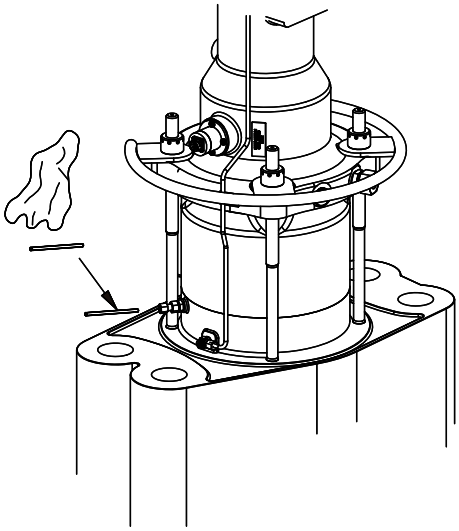
6665-0101-0003O02

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Disconnect the exhaust valve

Shut off and disconnect the exhaust valve air supply.

Use a mandrel to puncture the non-return valve. Cover the valve with a cloth to protect against oil spray.



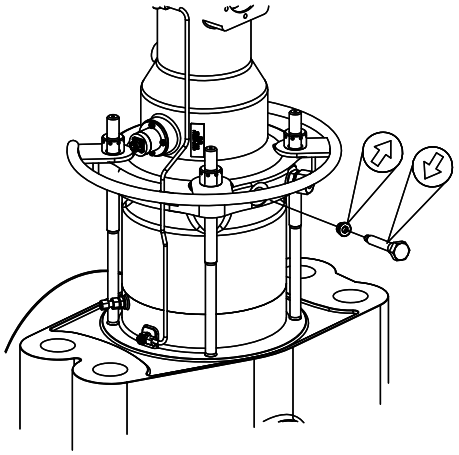
6665-0101-0003O03

MOP panel

Check on the MOP panel that the exhaust valve spindle has moved to the open position.

Mount the emergency opening tool

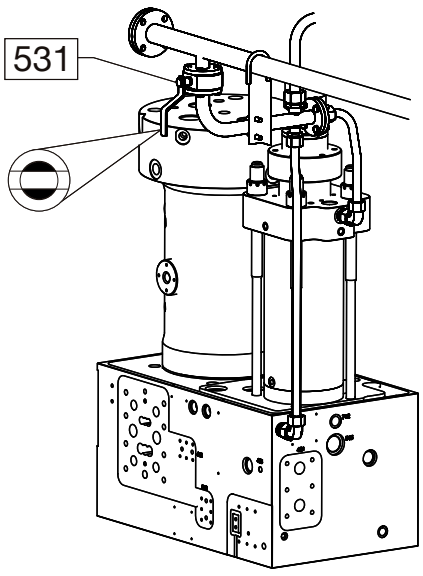
Remove the plug screw and mount the tool for emergency opening of exhaust valve.



6665-0101-0003O05

Open oil damper oil supply

Open the oil damper oil supply by opening valve 531 on the hydraulic block.

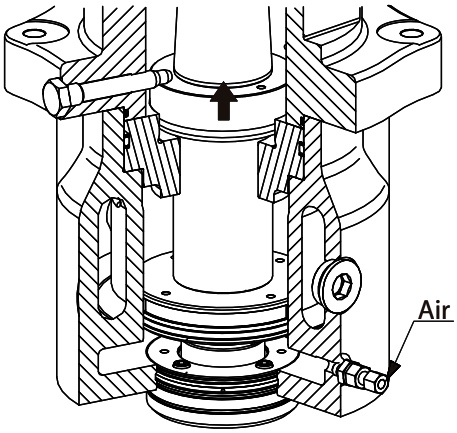


6665-0101-0003O06

2008-11-06 - en

Reconnection

Reconnect the exhaust valve air supply.



6665-0101-0003O07

CCU Failure:

In case of CCU failure (and the CCU can not be changed immediately), activation of the ME lubricator can be achieved as follows.

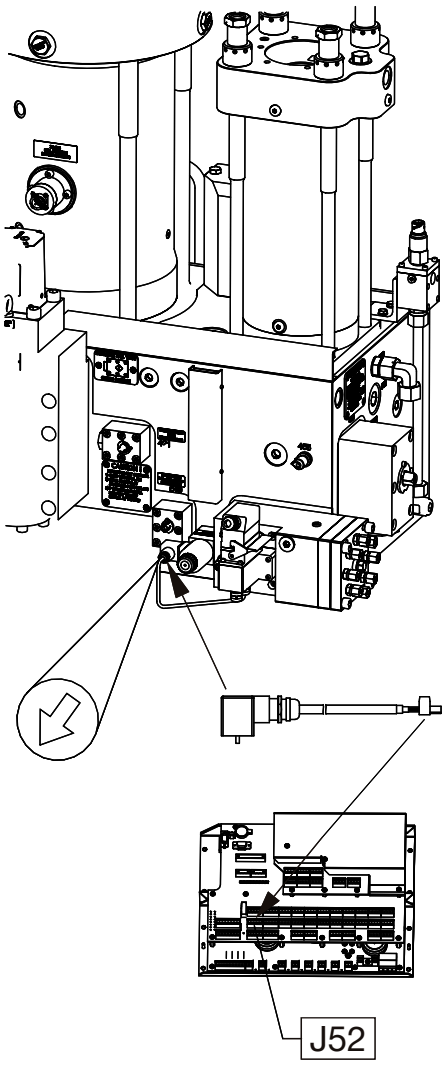
NOTE

In case of CCU failure, the engine is running in “Slow Down” mode.

Connect the plug on the ECU temp. cable

Remove the plug from the cylinder lubricator solenoid valve. Connect the plug on the ECU temporary backup cable for lubricator with the solenoid valve.

Connect the other end of the ECU temporary backup cable with the ECU **A** or **B** MPC board.



6665-0101-0003O09

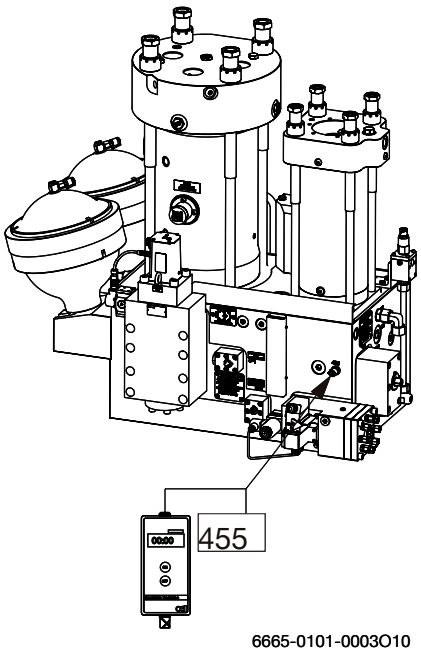
Return to normal

When the special running with open exhaust valve is finished, the engine must be brought back to normal operation condition.

Stop the engine

Mount a pressure gauge at “minimess” point No. 455. Check that the hydraulic cylinder unit is pressureless.

Check that valve 531 is closed.



6665-0101-0003O10

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Shut off and disconnect the exhaust valve air supply

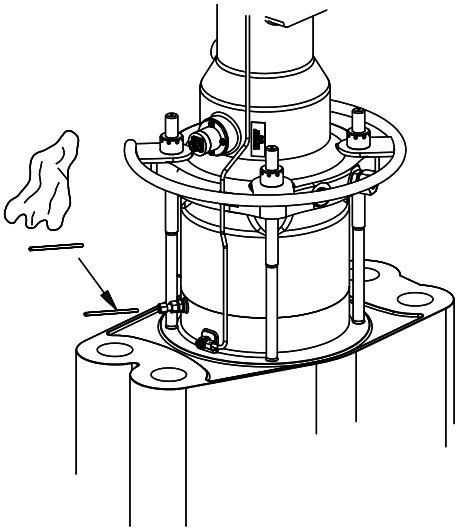
Use a mandrel to puncture the non-return valve. Cover the valve with a cloth to protect against oil spray.

Check exhaust valve spindle

Check that the exhaust valve spindle has moved to the open position.

Remove the tool for emergency opening

Remove the tool for emergency opening of exhaust valve and remount the plug screw.



6665-0101-0003O03

Open valve 531

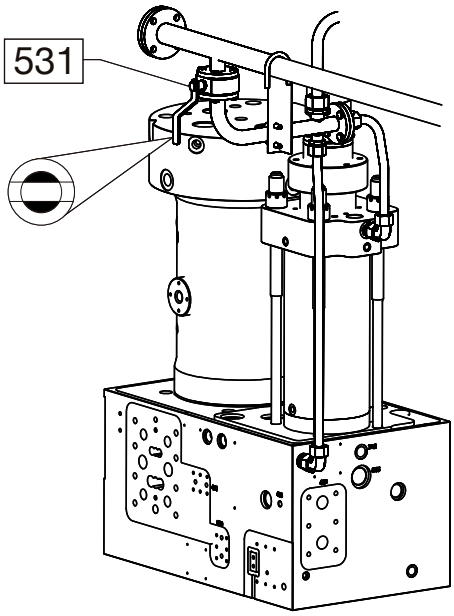
Open the oil damper oil supply by opening valve 531 on the hydraulic block.

Exhaust valve air

Reconnect the exhaust valve air supply.

Close valve 421 and open valve 420

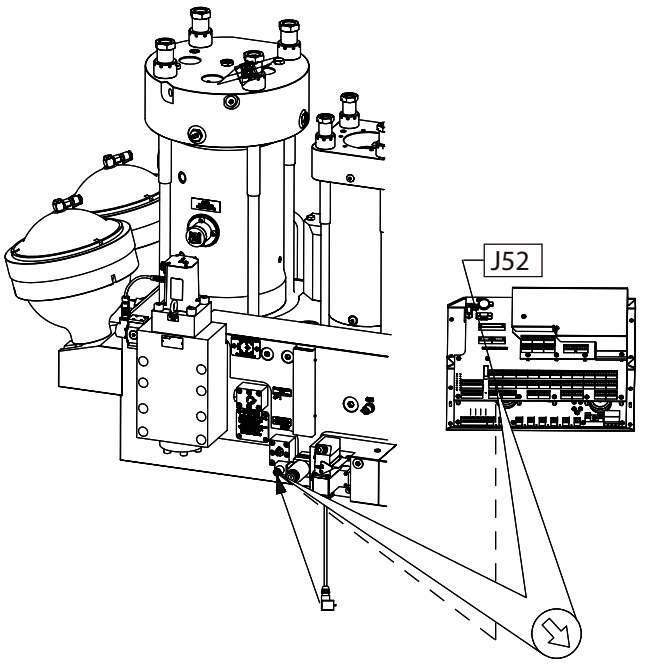
Close valve 421 and open valve 420 on the hydraulic block for the cylinder concerned.



6665-0101-0003O06

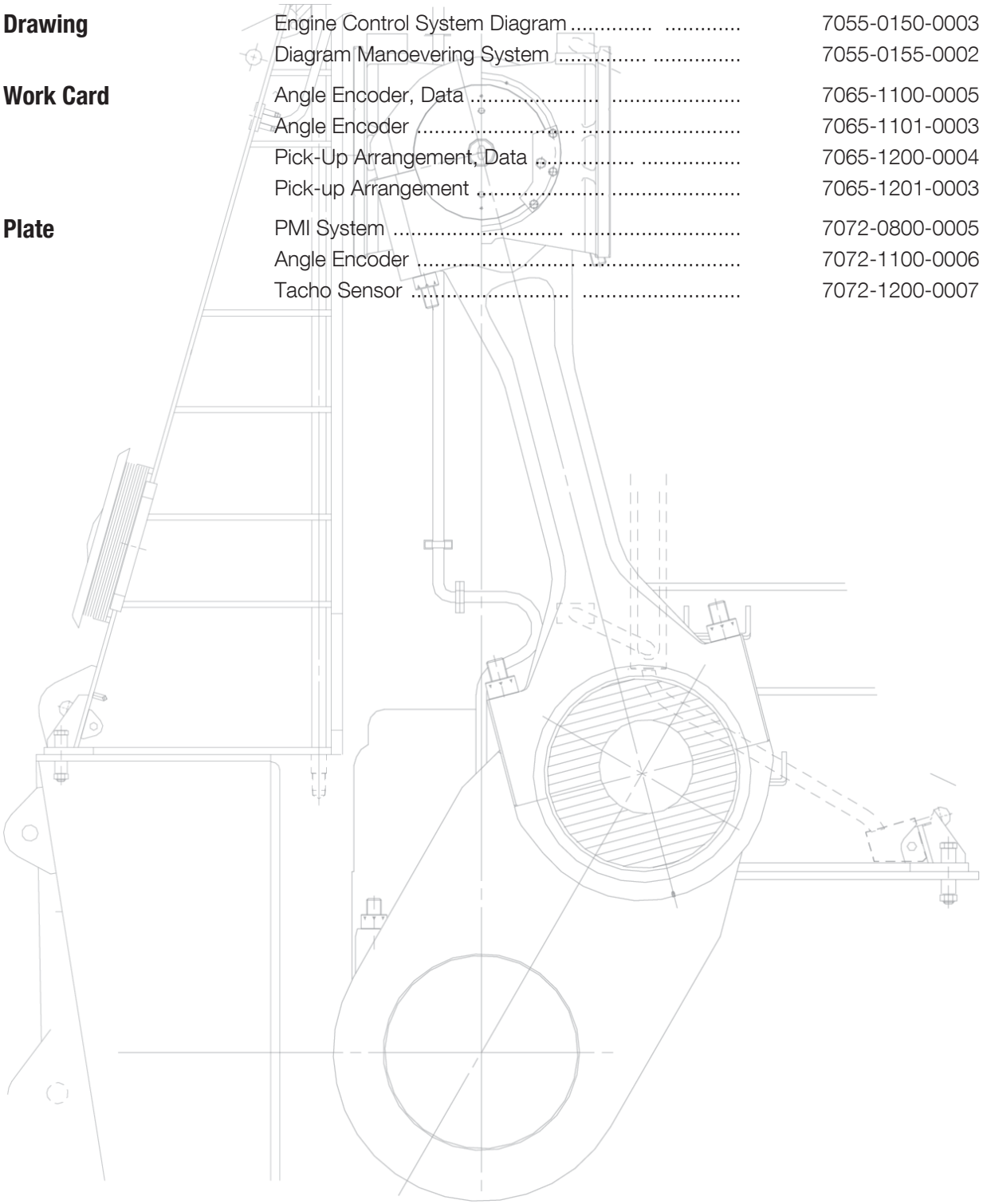
Restore the cylinder lubricator to normal

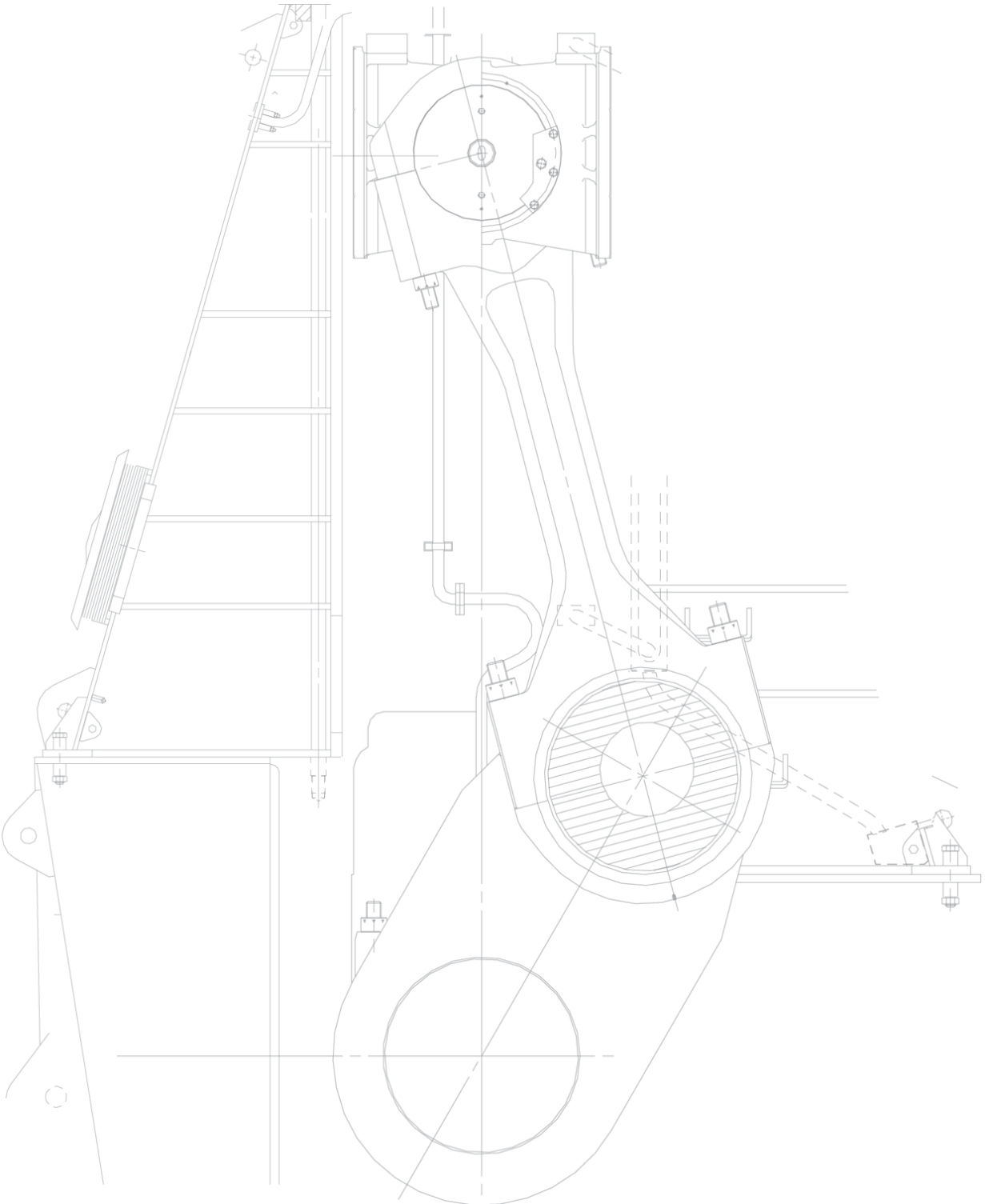
When the CCU has been replaced, restore the cylinder lubricator to normal by removing the ECU temporary backup cable and reconnecting the normal plug with the cylinder lubricator solenoid valve.



6665-1010-0003O17

Preface Chapter	Control System	7040-0100-0001
Description	Guidance Value Automation	7045-0100-0008
	Instrumentation	7045-0200-0003
Drawing	Engine Control System Diagram	7055-0150-0003
	Diagram Manoevering System	7055-0155-0002
Work Card	Angle Encoder, Data	7065-1100-0005
	Angle Encoder	7065-1101-0003
	Pick-Up Arrangement, Data	7065-1200-0004
	Pick-up Arrangement	7065-1201-0003
Plate	PMI System	7072-0800-0005
	Angle Encoder	7072-1100-0006
	Tacho Sensor	7072-1200-0007





PMI-System

See separate instructions for operating the PMI-system (option).

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1 General Basis for Guidance Values

The values stated in the list on the following pages refer to layout point L1, (Nominal max. continiuous rating "'MCR"' and are for engines running with UNI-Lubricating oil system without lubricating oil booster pump and with common turbocharger lubricating oil system.

Furthermore, the lubrication oil inlet pressure sensors Nos. 8108 and 8109, refer to a level 1800 mm above crankshaft centre line. In case sensor(s) is(are) placed at a different level the alarm slow down and shut down setpoints are to be corrected correspondingly.

NOTICE

The values are for guidance only, in connection with the 'List of Capacities of Auxiliary Machinery' for dimensioning of auxiliary systems, and must not be used for determining the extent of the alarms or actions.

The item numbers refer to the drawings showing the extent and placement of sensors for standard alarms and indicators on the engine, if the signal equipment is fitted. *See description 7045-0200*, further on.

For sensors placed in the systems outside the engine, see the actual pipe arrangements in the appropriate chapters.

If the engine is provided with special equipment, some values may differ from this list. The correct values shall in such a case be obtained from the Plant Installation Drawings.

The engine slow-down level corresponds to 40% of nominal MCR r/min.

Unless otherwise specified, the pressures are stated in bar gauge.

Engines specified and optimised at derated power may have other normal service values depending on layout power/revolutions and application.

For derated engines, the testbed/trial values should be used.

CAUTION

Attention must be paid to the temperature levels stated under Nos. 8120 to 8125 (incl.), as two different values have been indicated, one value for metal temperature and another for oil outlet temperature.

When setting the limits, maximum limits must be set at rising parameter and minimum limits at falling parameter.

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2 Guidance Alarm Limits and Measuring Values

Guidance Alarm Limits and Measuring Values (at max. continuous rating with engine running steadily).

The list applies to ME/ME-C Engines. For items marked with an *, further details are given in note below.

2.1 Fuel Oil System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PT 8001	I – AL	Fuel oil Inlet (after filter)*	bar	7 – 10	6.5		
PT 8002	AL	Fuel oil before filter*	bar		6.5		
PDI 8003	I	Fuel oil filter (pressure drop)*	bar	0.2 – 0.5			
VT 8004	AH AL	Fuel oil viscosity (at inlet engine, after filter.)*	cSt	10 – 15	20 7		
TE 8005	I	Fuel oil inlet (after filter)*	°C	T			
LS 8006	AH	Leakage from high pressure pipes			Level high		

Sensor Code	Note!
PT 8001	Fuel viscosity max. 700 cSt. at 50 °C measured at fuel pump level.
PT 8002	Yard supply. Fuel viscosity max. 700 cST at 50 °C.
PDT 8003	Yard supply.
VT 8004	Yard supply. Viscosity to be monitored and alarm given off by sensor built into the Viscorator. *See description 4245-0100.*
TE 8005	*See description 4245-0100.*

2.2 Lubricating Oil System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PT 8103	I – AL	Lub. oil inlet to turbocharger	bar	1.5 - 2.2	1.2		
TE 8106	I - AH Y	Thrust bearing segment	°C	55 - 70	75	 80	
TE 8107	Z	Thrust bearing segment	°C				90
PT 8108	I - AL Y	Lubrication oil inlet* *S50 ME-C*	bar	1.8 - 2.4	1.6	 1.4	

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Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PT 8108	I - AL Y	Lubrication oil inlet* *L/S/G60 ME-C* *S65 ME-C* *L70 ME-C* *K80 ME-C*	bar	1.9 - 2.5	1.7	1.5	
PT 8108	I - AL Y	Lubrication oil inlet* *S/G70 ME-C* *K98 ME/ME-C*	bar	2.0 - 2.6	1.8	1.6	
PT 8108	I - AL Y	Lubrication oil inlet* *G80 ME-C* *S90 ME-C 8.2*	bar	2.1 - 2.7	1.9	1.7	
PT 8108	I - AL Y	Lubrication oil inlet* *S90 ME-C 9.2*	bar	2.3 - 2.9	2.1	1.9	
PT/PS 8109	Z	Lubrication oil inlet* *S50 ME-C*	bar	1.8 - 2.4			1.2
PT/PS 8109	Z	Lubrication oil inlet* *L/S/G60 ME-C* *S65 ME-C* *L70 ME-C* *K80 ME-C*	bar	1.9 - 2.5			1.3
PT/PS 8109	Z	Lubrication oil inlet* *S/G70 ME-C* *K98 ME/ME-C*	bar	2.0 - 2.6			1.4
PT/PS 8109	Z	Lubrication oil inlet* *G80 ME-C* *S90 ME-C 8.2*	bar	2.1 - 2.7			1.5
PT/PS 8109	Z	Lubrication oil inlet* *S90 ME-C 9.2*	bar	2.3 - 2.9			1.7
TE 8112	I - AH AL Y	Lubrication oil inlet to engine	°C	40 - 47	55 35	60	
TE 8113	I - AH Y	Piston cooling oil outlet/cylinder	°C	50 - 65	70	75	
FS 8114	AL Y	Piston cooling oil outlet/cylinder			No flow	No flow	
TE 8117	I - AH Z	Lub. oil outlet from turbocharger/TC *MAN/TCA COM* *MHI/MET COM* *ABB/TPL COM*	°C	 70 - 90 70 - 80 70 - 90	 95 85 110	120	
TE 8118	I - AH	Lub. oil outlet from engine (inlet to oil cooler)	°C	50 - 60	65		
TE 8120	I - AH Y	Main bearing metal temperature*	°C	50 - 70	75	80	

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Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
TE 8121	I - AH Y	Crankpin bearing metal temperature*	°C	50 - 70	75	 80	
TE 8122	I - AH Y	Crosshead bearing metal temperature*	°C	50 - 70	75	 80	
TE 8123	I AL - AH Y Y	Main bearing oil outlet* Deviation from average Deviation from average	°C	50 - 60	65 -5/+5	 70 -7/+7	
TE 8124	I AL - AH Y Y	Crankpin bearing oil outlet* Deviation from average Deviation from average	°C	50 - 60	65 -5/+5	 70 -7/+7	
TE 8125	I AL - AH Y Y	Croshead bearing oil outlet* Deviation from average Deviation from average	°C	50 - 60	65 -5/+5	 70 -7/+7	
XC 8126	AH - Y	Bearing Wear			On/Off	On/Off	
XC 8127	XC	Bearing wear system failure			On/Off	On/Off	
LS 8130	AL - Y	Lub. oil level in tank*			Low level	Low level	
PDS 8140	AH	Diff. press. Lub. oil filter (Boll & Kirch)	Bar	0 - 0.6	0.8		
XS 8150	AH	Water in lubrication oil (WIO sensor)	WA *	0 - 0.45	0.5		
XS 8151	AH	Water in lubrication oil - level too high (WIO sensor)	WA *	0 - 0.45	0.9		
XS 8152	A	Water in lubrication oil / WIO sensor not ready			Fail		

Sensor Code	Note
PT 8108, PT8109	Measured by pressure gauge placed 1.8 m above crankshaft centreline. For Lub. oil pumps of centrifugal type, the pressure at stopped engine will be about 0.2 bar lower. (The difference in pressure at stopped and running engine is mainly caused by influence of oscillation forces, especially in piston cooling space.).
TE 8117	Inlet reference, see sensor TE 8112. ABB-TPL: Diff. between in/outlet should not exceed.

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Sensor Code	Note
TE 8120 – TE 8125	NOTE that the “Normal service value” is to be stated at sea trial, but, in between the range stated. With regard to the “Alarm”, “Slow down” and “Shut down” levels they should be 5°C, 10°C and 20°C above the sea trial finding respectively, however, maximum the value stated.
TE 8124 and TE 8125	Cut off at stopped engine. Cut off to remain until 3 minutes after start.
LS 8130	For separate lubricating system of the turbochargers.
XS 8150, 8151	WA: Water Actvity (relative to saturation point)

2.3 Cylinder Lubricating Oil System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
TE 8202	AH AL	Cylinder Lub. oil inlet pressure	°C	40 - 60	70		
XC 8212	AL	Small box for heating element			Low level		
TS 8213	C	Cylinder lubricating heating	°C		40		

2.4 Cooling Water System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PT 8401	I - AL Y	Jacket cooling water inlet*	bar	4 - 5	3.5	2.5	
PS 8402	Z	Jacket cooling water inlet*	bar		X		0.1
PDT 8403	AL Y	Jacket cooling water pressure loss across engine*	bar	0.8 - 1.4	X	X - 0.2	
TE 8407	I – AL	Jacket cooling water inlet	°C	75 - 90	67		
TE 8408	I - AH Y	Jacket cooling water outlet pr. cylinder*1 *L/S/G60ME-C* *S65ME-C* *L/S/G70ME-C* *K/S/G80ME-C* *S90ME-C* *K98ME/ME-C*	°C	88 - 92	95	98	

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
TE 8408	I - AH Y	Jacket cooling water outlet pr. cylinder*2 *L/S/G60ME-C* *S65ME-C* *L/S/G70ME-C* *K/S/G80ME-C* *S90ME-C* *K98ME/ME-C*	°C	80 - 92	95	98	
TT 8408	I - AH Y	Jacket cooling water outlet pr. cylinder*3. *G60ME-C* *G70ME-C* *G80ME-C* *S80ME-C* *S90ME-C*	°C	80 - 92	3	6	
TT 8408	I - AH Y	Jacket cooling water outlet pr. cylinder*4. *G60ME-C* *G70ME-C* *G80ME-C* *S80ME-C* *S90ME-C*	°C	80 - 85	5	10	
TE 8408	I - AH Y	Jacket cooling water outlet pr. cylinder*3 & *4. *G60ME-C* *G70ME-C* *G80ME-C* *S80ME-C* *S90ME-C*	°C	85 - 130	5 -/+20	10	
TE 8409	I - AH	Jacket cooling water outlet turbocharger*1	°C	88 - 92	95		
TE 8409	I - AH	Jacket cooling water outlet turbocharger*2	°C	80 - 92	95		
TT 8410	I -AH Y	Jacket cooling water outlet pr. cylinder cover*4. *G60ME-C* *G70ME-C* *G80ME-C* *S80ME-C* *S90ME-C*	°C	80 - 85	90	95	
TI 8411	I	Jacket cooling water outlet exhaust valve	°C	80 - 120			
LS 8412	AL	Jacket cooling water de-aerating tank.			Low level		

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PT 8413	I	Jacket cooling water outlet common pipe*	bar	2.6 - 4.2			
XC 8419	C	Alarm, LDCL/LDHT			Low level		
PT 8421	I - AL	Cooling water inlet to air cooler(s)*	bar		1.0		
	AH	Sea water cooling system		2 - 4.5X	5.5		
	AH	Central water cooling system		2 - 2.5X	3.5		
TE/TI 8422	I	Cooling water inlet to air cooler(s)	°C				
	AH	Sea water cooling system		10 - 32	40		
	AH	Central water cooling system		10 - 36	40		
TE/TI 8423	I	Cooling water inlet to air cooler(s)	°C				
		Sea water cooling system		10 - 50			
		Central water cooling system		10 - 63			
PDT 8424	I	Pressure drop of cooling water across air cooler	bar	0.25 - 0.8			
TE 8431	I - AL	Cooling water inlet to lub. oil cooler(s)	°C	11 - 32	10		
PT 8440	I	Cooling water inlet air cooler (s) (WHR)	bar	3.5 - 4.5			

Sensor Code	Note	
PT 8401, PT 8413	The expansion tank must be located 15 m above the top of the exhaust gas valves.	
PS 8402	X = With stopped cooling water pump, the set point for the sensor is the static pressure plus the stated value.	
PDT 8403	X = To be stated on sea-trial. Slow-down 0.2 bar below alarm value.	
PT 8421	X = To be stated on sea-trial.	
TE 8408, TE 8409	*1	Standard rated
	*2	Load dependent set-point
	*3	For LDHT cooling water systems. - Alarm high and Slow down values are ΔT relative to commissioned values.
	*4	For LDCL cooling water systems. - Alarm high and Slow down values are ΔT relative to commissioned values.

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2.5 Compressed Air System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PT 8501	I – AL	Starting air inlet pressure	bar	30	15		
PT 8503	I - C AH AL	Control air inlet*	bar	6.5 - 7.5	 5.5 0.5		
PT 8505	I - AL	Air inlet to air cylinder for exhaust valve	bar	6.5 - 7.5	5.5		

Sensor Code	Note
PT 8503	AH at finished with engine.

2.6 Scavenge Air System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PT 8601	I - C	Scavenge air receiver pressure (abs)*	bar				
TE 8605	I	Scavenge air temperature in receiver*	°C	170 - 210			
PDI 8606	I	Scavenge air pressure drop across each air cooler*	bar	X	XX		
PDT 8607	I - AH	Scavenge air pressure drop across filter*	bar	X	XX		
TE 8608	I	Scavenge air temperature after each air cooler*	°C				
TE 8609	I - AH Y	Scavenge air temperature in receiver*	°C		55	 65	
TE 8610	AH Y	Scavenge air boxfire alarm/cyl.	°C		80	 120	
LS 8611	AH	Water mist catcher - water level			High level		
TE 8612	I	Compressor inlet temperature/turbocharger	°C	-10 - +45			

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Sensor Code	Note
PT 8601	The set point of scavenge air pressure depends on the engine load and layout. The set point must be set during sea trial.
TE 8605	Value based on MCR, depending on engine load and ambient conditions.
PDI 8606, PDT 8607	X = according to shop trial results XX = 50% increase according to shop trial results.
TE 8608	TE 8422 + 12 °C
TE 8609	Normal service value above water inlet temp. air cooler. TE 8422 + 15 °C

2.7 Exhaust Gas System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
TI / TT 8701	I - AH Y	Exhaust gas temperature before turbocharger*	°C	380 - 500	X	X	
TI / TT 8702	I - AH Y AL - AH Y	Exhaust gas temperature after valves. (average)* Deviation from average Deviation from average	°C	320 - 430	450 +/- 50	470 +/- 60	
TC 8704	I	Exhaust gas temperature in receiver	°C	100 - 500			
PI 8706	I	Exhaust gas pressure in receiver (abs.)*	bar	3.4			
TI/TT 8707	I - AH	Exhaust gas temperature after each turbocharger*	°C	220 - 300	350		
PT 8708	I - AH	Exhaust gas pressure after each T/C at MCR	mm WC	300	450		
PDI 8709	I	Exhaust gas pressure drop across boiler at MCR	mm WC	150			
ZT 8721	I	Exhaust gas bypass valve angle position	°	0 - 90			

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Sensor Code	Note
TC 8701	Normal exhaust gas temperatures depend on the actual engine load and ambient condition. NOTE: Regarding alarm for high turbine inlet temperature: This alarm is not an MAN Diesel & Turbo requirement, as alarms for high gas temperatures, are given by cylinder exhaust as well as for turbine outlet temperature alarms. Some Classification Societies require alarm for high turbine inlet temperature. In such cases we recommend set point equivalent to the maximum temperature for continuous operation shown on the turbocharger name plate. (Some Turbocharger manufacturers shows two (2) maximum temperatures on the name plate. It is the lowest shown temperature that must be used as set point - if alarm is required. The high maximum temperature is only allowed at short over-load tests at test-bed) X = Turbocharger dependent.
TC 8702	Normal exhaust gas temperatures depend on the actual engine load and ambient condition. When operating below 200 °C average temperature deviation alarm is cut off.
PT 8706	Normal exhaust gas temperatures depend on the actual engine load and ambient condition.
TC 8707	The service values apply under the following conditions: - Ambient temperature in engine room 25 °C. - Scavenge air temperature in receiver 35 °C.

2.8 Hydraulic Power Supply

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PS 1204	C	Lub. oil pressure after filter (suction side)	bar	1	0.7		
XC 1231	AH	Filter failure (Boll & Kirch)	bar	0 - 0.6	0.8		
TE 1270	AH	HPS bearing temperature*	°C	55 - 60	70		

Sensor Code	Note
TE 1270	Only for engines with centre mounted HPS

2.9 Hydraulic Control Oil System (separate oil to HPS)

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PI 1301	I	Fine filter unit indicator	bar				
PDS 1302	AH	Lub. Oil difference pressure, across filter (Boll & Kirch)	bar		High		

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Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PT 1303	I	Lub. Oil pressure engine inlet, same as value PT 8108	bar				
TI/TE 1310	I - AH Y	Lub Oil temp. at engine inlet	°C	40 - 55	60	65	
LS 1320	AL	Level alarm in tank			Low level		
XS 1350	AH	WIO water in hydraulic oil system	WA *	0 - 0.45	0.5		
XS 1351	AH	WIO water in hydraulic oil system too high	WA *	0 - 0.45	0.9		
XS 1352	A	WIO sensor not ready			Fail		

Sensor Code	Note
XS 1350, 1351	WA: Water Actvity (relative to saturation point)

2.10 Top Bracing Pressure

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PT 1501	AL	Top Bracing accumulator pressure	bar	6 - 8	4		

2.11 MECS to/from Safety System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
XC 2001	Z	Emergency stop to engine control units					Activated
XC 2002	Z	Shut down to Cylinder Control Units Emergency stop					Activated
XC 2005	C	Reset shut down			Activated		
XC 2020	Z	Shut down (Non-cancellable)					Activated
XC 2021	Z	Shut down (cancellable)					Activated

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2.12 MECS to/from Alarm System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
XC 2201	A	Power failure			Fail		
XC 2202	A	ME common failure			Fail		
XC 2205	A	Slow-down pre-warning			Aciva-ted		
XC 2206	A	Slow down Request (manual)					
XC 2207	C	Slow down Request (non-cancellable)			Aciva-ted		
XC 2210	A	Engine stopped			Aciva-ted		

2.13 Power Supply Units to Alarm System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
XC 2901	AL AH	High/Low voltage cut out ME power supply A	V	24	18 31		
XC 2902	AL AH	High/Low voltage cut out ME power supply B	V	24	18 31		
XC 2903	AL	Earth failure ME power supply	Kohm	70 - 1000	24		

2.14 Tacho / Crankshaft Position System

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
ZT 4020	Z	Tacho for safety	r/min				MCR x 1.09

2.15 ME cylinder components

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
PS 4112	C - AH	Leakage from cylin-der units/pipe	bar	0	0.6		

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2.16 Miscellaneous

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
ZT 8801	I - AH	Turbocharger speed, each unit*	r/min	X	X		
PT 8802	I	Engine room pressure (abs.)	bar	0.95 - 1.05			
PI 8803	I	Air inlet for dry cleaning, turbocharger	bar	4.5 - 10			
PI 8804	I	Water for cleaning, turbocharger*	bar	min. 0.5 X			
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5S50ME-C		0 - 1.56	2.09	2.6	
		6S50ME-C		0 - 1.87	2.5	3.1	
		7S50ME-C		0 - 2.17	2.9	3.6	
		8S50ME-C		0 - 2.55	3.41	4.3	
		9S50ME-C		0 - 2.86	3.84	4.8	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5S60ME-C		0 - 1.88	2.51	3.1	
		6S60ME-C		0 - 2.25	3	3.8	
		7S60ME-C		0 - 2.61	3.49	4.4	
		8S60ME-C		0 - 3.07	4.1	5.1	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5L60ME-C		0 - 1.49	1.99	2.5	
		6L60ME-C		0 - 1.77	2.37	3	
		7L60ME-C		0 - 2.07	2.76	3.5	
		8L60ME-C		0 - 2.36	3.15	3.9	
		9L60ME-C		0 - 2.66	3.54	4.4	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5G60ME-C		0 - 2.16	2.89	3.6	
		6G60ME-C		0 - 2.58	3.45	4.3	
		7G60ME-C		0 - 3	4.01	5	
		8G60ME-C		0 - 3.43	4.58	5.7	
		9G60ME-C		0 - 3.85	5.14	6.4	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5S65ME-C		0 - 2.28	3.04	3.8	
		6S65ME-C		0 - 2.72	3.63	4.5	
		7S65ME-C		0 - 3.17	4.23	5.3	
		8S65ME-C		0 - 4.06	5.42	6.8	

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Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5S70ME-C		0 - 2.19	2.92	3.7	
		6S70ME-C		0 - 2.62	3.5	4.4	
		7S70ME-C		0 - 3.05	4.07	5.1	
		8S70ME-C		0 - 3.58	4.78	6	
		9S70ME-C		0 - 3.03	5.37	6.7	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5L70ME-C		0 - 1.74	2.32	2.9	
		6L70ME-C		0 - 2.08	2.78	3.5	
		7L70ME-C		0 - 2.42	3.23	4	
		8L70ME-C		0 - 2.76	3.68	4.6	
		9L70ME-C		0 - 3.11	4.14	5.2	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5G70ME-C		0 - 2.53	3.37	4.2	
		6G70ME-C		0 - 3.02	4.03	5	
		7G70ME-C		0 - 3.52	4.69	5.9	
		8G70ME-C		0 - 4.01	5.35	6.7	
		9G70ME-C		0 - 4.5	6.01	7.5	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		6S80ME-C8.2		0 - 2.99	3.98	5	
		6S80ME-C9.2		0 - 3.46	4.62	5.8	
		7S80ME-C8.2		0 - 3.45	4.59	5.7	
		7S80ME-C9.2		0 - 4.03	5.37	6.7	
		8S80ME-C8.2		0 - 4.06	5.4	6.8	
		8S80ME-C9.2		0 - 4.59	6.12	7.7	
		9S80ME-C8.2		0 - 5.16	6.88	8.6	
		9S80ME-C9.2		0 - 4.56	6.08	7.6	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		6K80ME-C		0 - 2.28	3.8	3.8	
		7K80ME-C		0 - 3.65	3.53	4.4	
		8K80ME-C		0 - 3.02	4.03	5	
		9K80ME-C		0 - 3.39	4.52	5.7	
		10K80ME-C		0 - 3.77	5.02	6.3	
		11K80ME-C		0 - 4.14	5.52	6.9	
		12K80ME-C		0 - 4.51	6.02	7.5	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5G80ME-C		0 - 3.57	4.77	6	
		6G80ME-C		0 - 4.27	5.7	7.1	
		7G80ME-C		0 - 4.97	6.63	8.3	
		8G80ME-C		0 - 5.67	7.57	9.5	
		9G80ME-C		0 - 6.37	8.5	11	

Sensor Code	Function	Designation	Unit	Normal Service Value	Alarm	SLD	SHD
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		5S90ME-C9.2		0 - 2.35	3.14	3.9	
		6S90ME-C8.2		0 - 3.24	4.33	5.4	
		6S90ME-C9.2		0 - 2.81	3.75	4.7	
		7S90ME-C8.2		0 - 3.78	5.04	6.3	
		7S90ME-C9.2		0 - 3.27	4.36	5.5	
		8S90ME-C8.2		0 - 4.32	5.76	7.2	
		8S90ME-C9.2		0 - 3.72	4.97	6.2	
		9S90ME-C8.2		0 - 4.86	6.48	8.1	
		9S90ME-C9.2		0 - 4.19	5.59	7	
		10S90ME-C9.2		0 - 4.65	6.2	7.8	
		11S90ME-C9.2		0 - 5.11	6.82	8.5	
		12S90ME-C9.2		0 - 5.57	7.43	9.3	
		14S90ME-C9.2		0 - 6.5	8.67	11	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		6K98ME		0 - 2.28	3.05	3.8	
		7K98ME		0 - 2.66	3.55	4.4	
		8K98ME		0 - 3.03	4.05	5.1	
		9K98ME		0 - 3.41	4.55	5.7	
		10K98ME		0 - 3.78	5.05	6.3	
		11K98ME		0 - 4.16	5.55	6.9	
		12K98ME		0 - 4.54	6.06	7.6	
		14K98ME		0 - 5.3	7.06	8.8	
WT 8812	I-AH-Y	Axial vibration monitor	mm				
		6K98ME-C		0 - 1.88	2.51	3.1	
		7K98ME-C		0 - 2.19	2.92	3.7	
		8K98ME-C		0 - 2.49	3.33	4.2	
		9K98ME-C		0 - 2.8	3.74	4.7	
		10K98ME-C		0 - 3.11	4.15	5.2	
		11K98ME-C		0 - 3.42	4.56	5.7	
		12K98ME-C		0 - 3.72	4.97	6.2	
		14K98ME-C		0 - 4.34	5.79	7.2	
XS 8813	AH - Y Z	Oil mist in crank-case each cyl.	Fixed or mg/l	0	High density or 0.5	High density or 0.5	
XS 8814	AL	Oil mist detector, failure			Fail		
XC 8816	I - AH	Shaftline earthing device	mV	0 - 50	80		
XS/XT 8817	Y	Turbocharger over-speed*					
TE 8820	AH	Cylinder liner moni-toring, each cylin-der*	°C	100 - 150	+/- 20		

Sensor Code	Note
ZT 8801	X = according to the manufacturer.
PI 8804	X = higher than exhaust gas pressure.

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Sensor Code	Note
XS/XT 8817	Values according to TC manufacturer Applied in case of: - VTA/VTG (Variable turbocharger) - WHR (Waste heat recovery system) - EGB (Exhaust gas by pass system) - TCO (Turbocharger Cut Out system)
TE 8820	Cut out below 100°C - Deviation to be stated at seatrail - Max. Deviation 50°C

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1. Measuring Instruments, Identification

Remote Indication

Codes for identification of instruments and signal-related functions

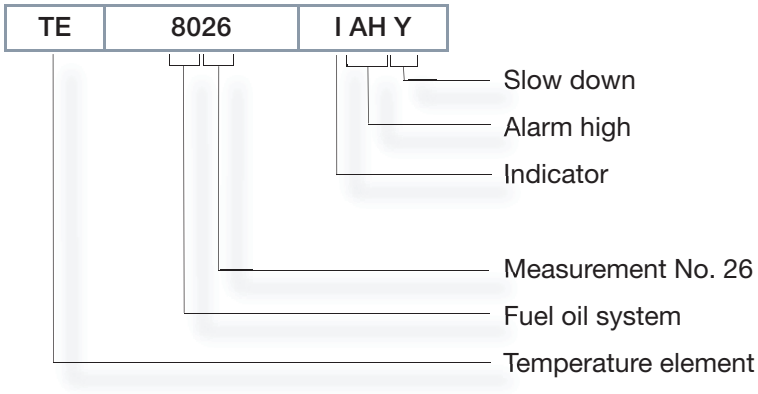
PT	8108	AH

First letters		Identification number		Secondary letters	
Measured or indicating variable		*The first two digits indicate the point of measurement, the next two are serial numbers*		*Function*	
DS:	Density switch	11.	Manoeuvrring system	A:	Alarm
DT:	Density transmitter	12.	Hydraulic power supply	C:	Control
GT:	Gauging transmitter (load/index transmitter)	14.	Combustin pressure supervision	H:	High
		20.	ECS to/from safety system	I:	Indication (remote)
FT:	Flow transmitter	21.	ECS to/from remote control system		
FS:	Flow switch	22.	ECS to/from alarm system	L:	Low
LS:	Level switcch	30.	ECS Miscellaneous input/output values	R:	Recording
LI:	Level indication (local)			S:	Switching
LT:	Level transmitter	40.	Tacho/crankshaft pos. sytem	Y:	Slow-down
PDI:	Pressure difference indication (local)	41.	Engine cylinder components	X:	Unclassified function
		50.	VOC: supply system		
PDS:	Pressure difference switch	51.	VOC: sealing oil system	Z:	Shut-down
PDT:	Pressure difference transmitter	52.	VOC: control oil system		
		53.	Other VOC related systems		
PI:	Pressure indication (local)	54.	VOC engine related components		
PS:	Pressure switch	80.	Fuel oil system		
PT:	Pressure transmitter	81.	Lubrication oil system		
ST:	Speed transmitter	82.	Cylinder lub. oil system		
TC:	Thermo couple (NiCr-Ni)	83.	Stuffing box drain system		
TE:	Temperature element (Pt-100)	84.	Cooling water system		
TI:	Temperature indication (local)		e.g. central cooling water		
TS:	Temperature switch		e.g. sea cooling water		
WS:	Vibration switch		e.g. jacket cooling water		
WT:	Vibration transmitter	85.	Compressed air supply system		
VS:	Viscosity switch		e.g. control air		
VT:	Viscosity transmitter		e.g. starting air		
ZV:	Position valve (solenoid valve)	86.	Scavenge air		
ZS:	Position switch (limit switch)	87.	Exhaust gas system		
ZT:	Position transmitter (e.g. proximity sensor)	88.	Miscellaneous functions		
			e.g. axial vibration		
XC:	Unclassified control	90.	Project specific		
XS:	Unclassified switch	Note:			
XT:	Unclassified transmitter	ECS: Engine Control System			
		VOC: Volatile Organic Compound			

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The first link (first letter) indicates what is measured or the indicating variable. The second link is the Ident. No., in which the first two digits indicate the point of measurement or the indicating variable, followed by a serial number. The third link (secondary letter(s)) indicates the function of the measured value.

Example

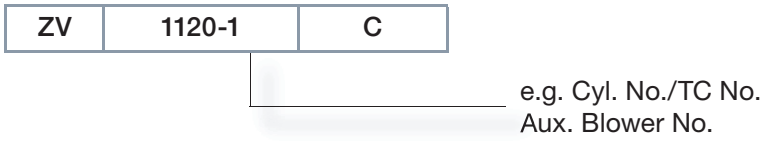


Repeated signals:

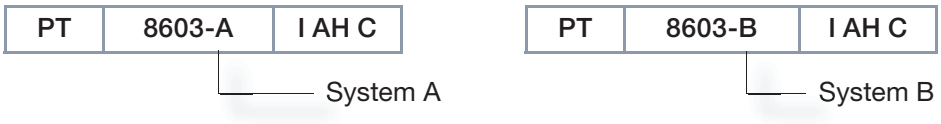
Signals which are repeated, such as per cylinder measurement or per turbocharger measurement, etc. are provided with a suffix number. The suffix number is identical with the place of measurement, such as 1 for cylinder 1, etc. Where signals are redundant, suffix A or B may be used.

Examples

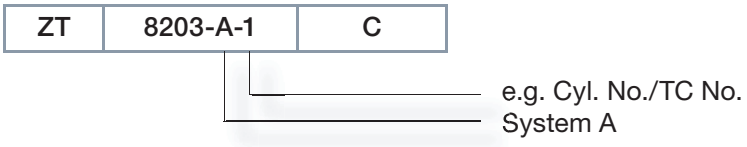
Cylinder or Turbocharger-related Signals



Redundant Signals



Cylinder-related Redundant Signals



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Graphical presentation in PI-diagrams according to ISO 1219 I - II

2. List of Instruments

Fuel Oil System

PI	8001	Fuel oil, inlet engine
PT	8001	Fuel oil, inlet engine (After filter) (Alarm low)
TI	8005	Fuel oil, inlet engine (After filter)
TE	8005	Fuel oil, inlet engine (After filter)
LS	8006	Leakage from high pressure pipes (Alarm high)
VZ	8020	Fuel Oil Cut Out (Shut-down)

Lubrication Oil System

PI	8103	Lubricating oil inlet to T/C
PT	8103	Lubricating oil inlet to T/C (Alarm low)
TE	8106	Thrust bearing segment (Alarm high + slow down)
TS	8107	Thrust bearing segment (Shut down)
PI	8108	System lubricating oil inlet 1800 above cl. of crankshaft
PT	8108	Lubricating oil inlet to main bearing and thrust bearing (Alarm low + Slow down)
PS	8109	Lubricating oil inlet to main bearing and thrust bearing (Shut down)
TI	8112	System lubricating oil inlet
TE	8112	System lubricating oil inlet (Alarm high/low + Slow down)
TI	8113	Piston cooling oil outlet, cylinder depend
TE	8113	Piston cooling oil outlet, cylinder depend (Alarm high + Slow down)
FS	8114	Piston cooling oil outlet, cylinder depend (Alarm low + Slow down)
TI	8117	Lubricating oil outlet Turbocharger/Turbocharger
TE	8117	Lubricating oil outlet Turbocharger/Turbocharger (Alarm high + Slow down))
TE	8123	Main Bearing Oil Outlet Temp. Cylinder depend. (Cyl no. + 2)
XS	8150	Water In Oil sensor, system lub. oil inlet

Electronic Cylinder Lub.Oil System, *Alpha cylinder lubricators*

TE	8202	Cylinder lub. oil temperature
ZT	8203	Confirm cylinder lubricator piston movement (cyl/cyl)
ZV	8204	Activate cylinder lubricator
LS	8208	Level switch (Alarm)
TS	8213	Cylinder lubrication, heating

Cooling Water System

PI	8401	Jacket cooling water inlet (At local manoeuvring console, LOP)
PT	8401	Jacket cooling water inlet (Alarm Low + Slow Down)
PT	8402	Jacket cooling water inlet (At manifold)
PDS	8403	Jacket cooling water across engine (Alarm Low)
TI	8407	Jacket cooling water inlet
TE	8407	Jacket cooling water inlet (Alarm Low)
TI	8408	Jacket cooling water outlet, cylinder depend
TC	8408	Jacket cooling water outlet, cylinder depend (Alarm High + Slow Down)
PI	8421	Cooling water inlet air cooler (At local manoeuvring console, LOP)
PT	8421	Cooling water inlet air cooler (Alarm Low)

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TI	8422	Cooling water inlet air cooler
TE	8422	Cooling water inlet air cooler (Alarm High)
TI	8423	Cooling water outlet air cooler/air cooler
TE	8423	Cooling water outlet air cooler/air cooler

Compressed Air Supply System, *Control, starting air*

PI	8501	Starting air to main starting valve (At local manoeuvring console)
PT	8501 A + B	Starting air inlet (Alarm Low)
PI	8503	Control air inlet (At local manoeuvring console)
PT	8503 A + B	Control air inlet (Alarm Low)
PT	8505	Air inlet to air cylinder for exhaust valve (Alarm Low)

Scavenge Air

PI	8601	Scavenge air receiver (At local manoeuvring console)
PI	8601	Scavenge air receiver (Combined with instrument panel PI 8706)
PT	8601 A + B	Scavenge air receiver
TI	8605	Scavenge air before air cooler/air cooler
TE	8605	Scavenge air before air cooler/air cooler
PDI	8606	Pressure drop of air across air cooler
TI	8608	Scavenge air after air cooler/air cooler
TE	8608	Scavenge air after air cooler/air cooler
TI	8609	Scavenge air receiver
TE	8609	Scavenge air receiver (Alarm High + Slow Down)
TE	8610	Scavenge air box-fire alarm, cylinder depend (Alarm High + Slow Down)
LS	8611	Water mist catcher – water level (Alarm High)

Exhaust Gas System

TI/TC	8701	Exhaust gas before turbocharger (Alarm High + Slow Down)
TI/TC	8702	Exhaust gas after exhaust valve, cylinder dep. (Alarm High + Slow Down)
PI	8706	Exhaust gas receiver (Combined with instrument panel PI 8601)
TI/TC	8707	Exhaust gas outlet turbocharger (Alarm High)

Manoeuvring System

PS	1101-1	Stop signal given
PS	1101-2	Stop signal given
PS	1106	Reset shut down function during emergency control - RS system
PS	1118-1	Manoeuvring system on emergency control - CCU 1
PS	1118-2	Manoeuvring system on emergency control - RS system
PS	1130-1	Manoeuvring system on remote control - CCU 2
PS	1130-2	Manoeuvring system on remote control - RS system

2008-09-08

Pneumatic System

ZS	1109	Turning gear -disengaged
ZS	1110	Turning gear –engaged
ZS	1111	Main starting valve – blocked
ZS	1112	Main starting valve – Open
ZV	1114	Slow turning valve
ZS	1116	Pilot air to starting valve-open
ZS	1117	Pilot air to starting valve-closed
ZV	1120	Activate pilot pressure air to starting valve/cyl.
ZV	1121	Activate main starting valve open

Hydraulic

PT	1201	Pressure after non return
ZV	1202	Pressure relief valve
PT	1204	Lub. oil pressure after filter
XC	1222	Swashplate for high pressure pump
XC	1231	Filter failure (Boll & Kirch)
LS	1235	Leakage from hydrauliv system
LS	1236	Leakage from hydrauliv system
XS	1238	Proportional valve for high pressure pump
TE	1270	HPS bearing temperature

XC	4101	Bosch-Rexroth Cylinder control unit
XC	4102	Bosch-Rexroth Cylinder control unit
ZT	4111	Exhaust valve position sensor
LS	4112	Leakage from HCU
ZT	4114	Fuel injection plunger position

Miscellaneous

E	1180	Aux. Blower
E	1181	Turning gear
E	1185	LOP, local Operator Panel

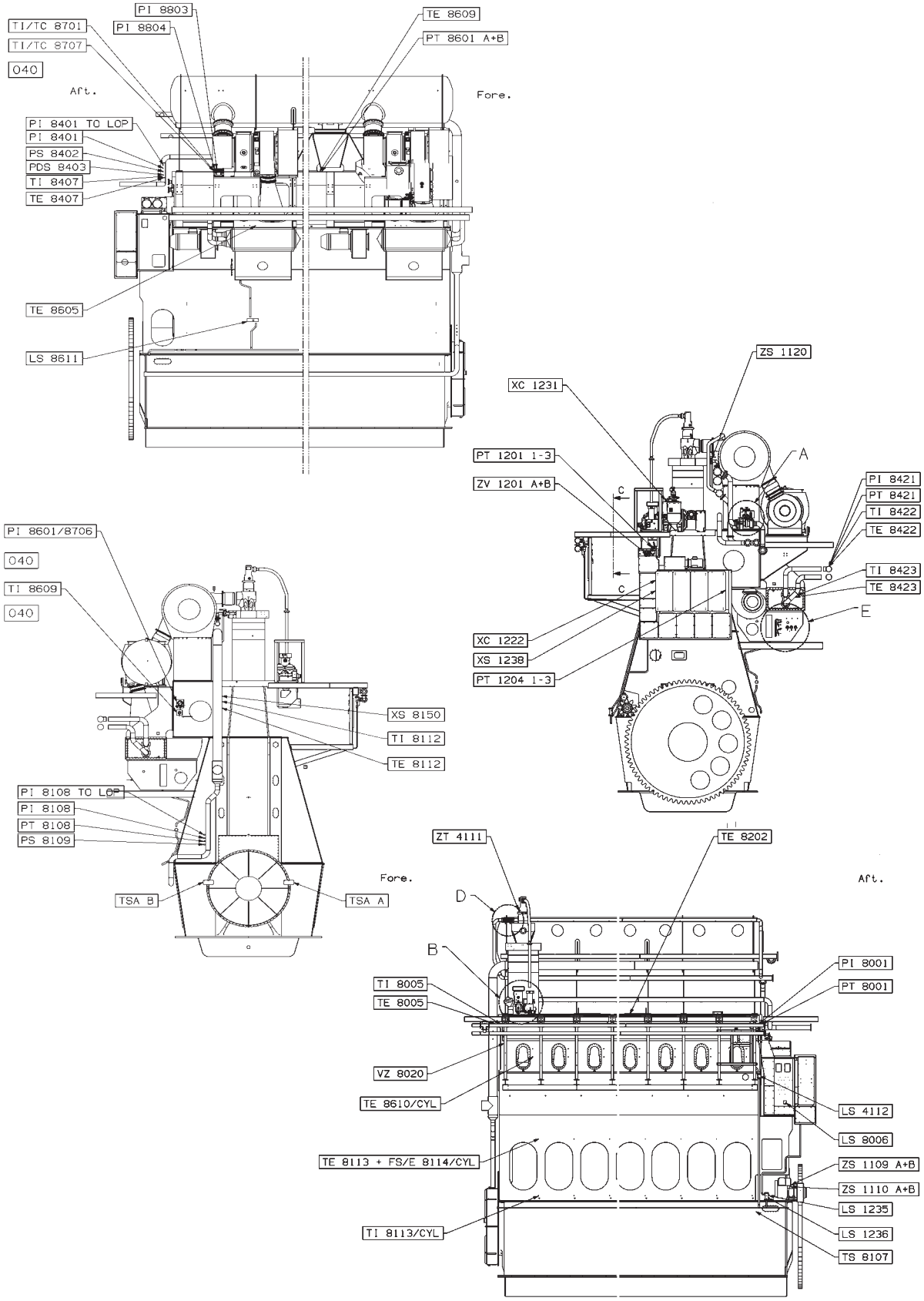
ST	8801	Turbocharger speed/turbocharger
PI	8803	Air inlet for dry cleaning of turbocharger
PI	8804	Cleaning water inlet to turbocharger
WT	8812	Axial vibration monitor (Alarm High + Slow Down)
WI	8812	Axial vibration monitor
XS	8813	Oil mist in crankcase/cylinder (Alarm High + Slow Down)

Tacho/Crankshaft Pos. System

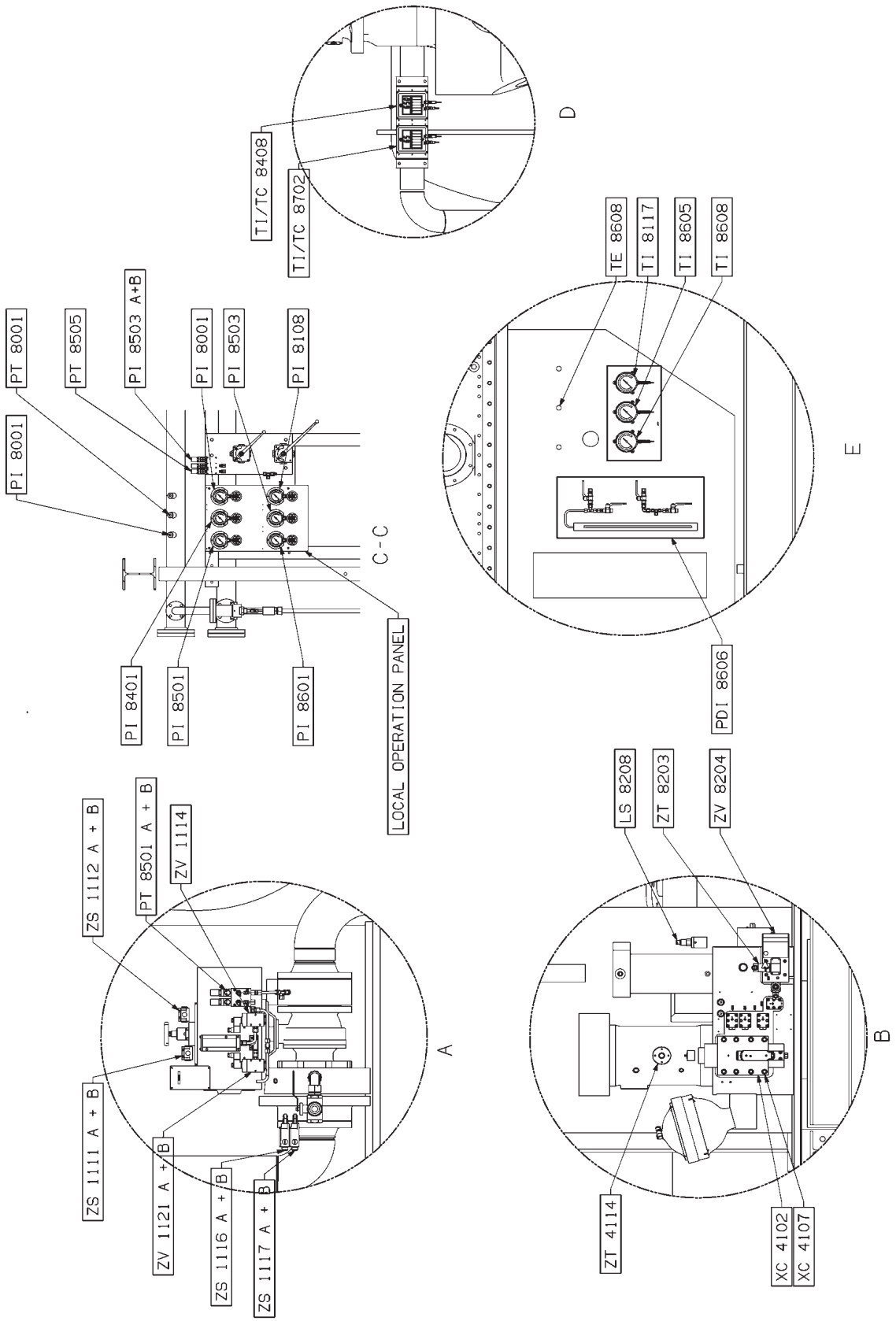
ZT	4020	Tacho for safety
TSA-A		Tacho box A, Tacho system for ME engines with encoder
TSA-B		Tacho box B, Tacho system for ME engines with encoder

2008-09-08

3. Instrumentation on Engine



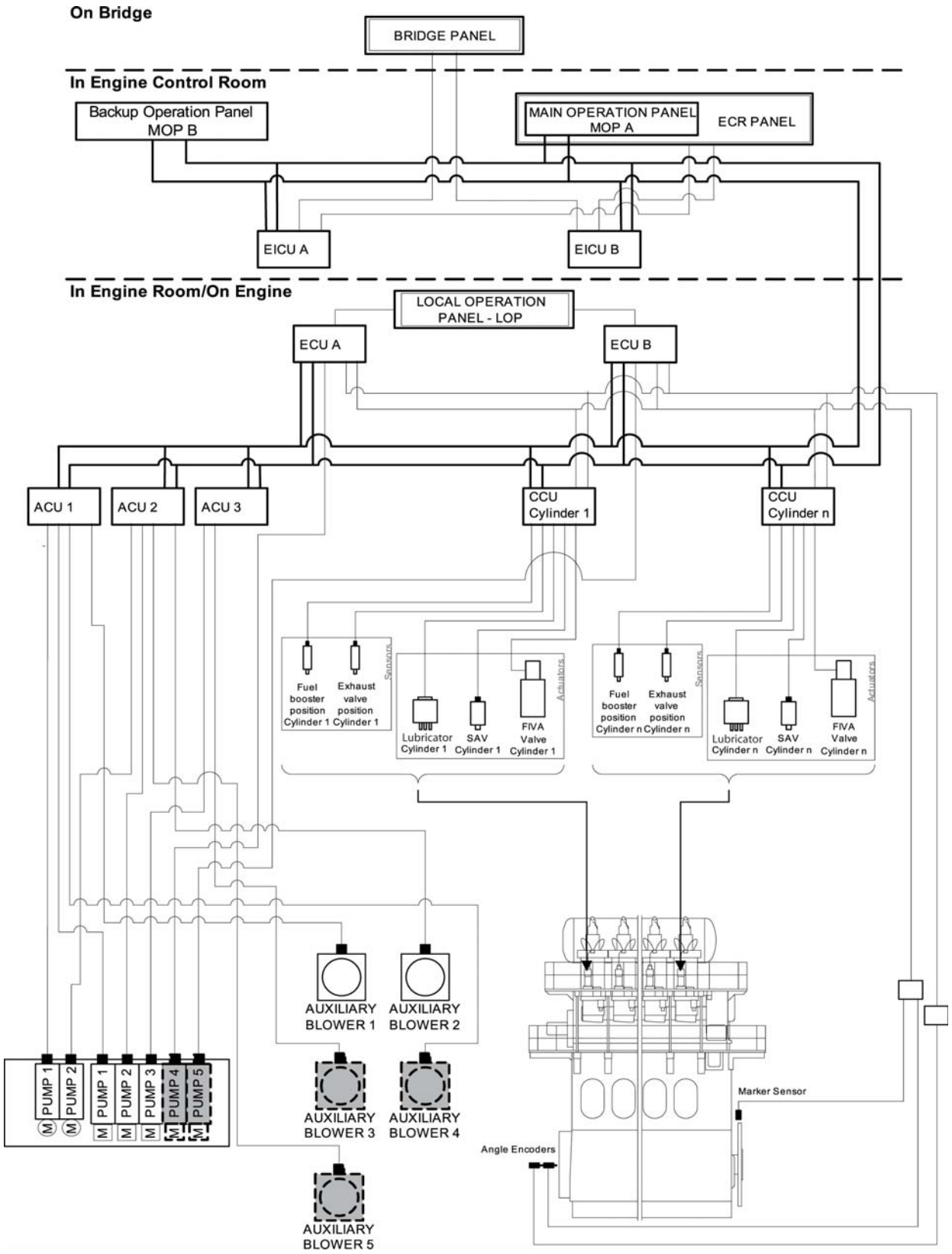
2008-09-03



Instrumentation

Description
7045-0200-0003

2008-09-03



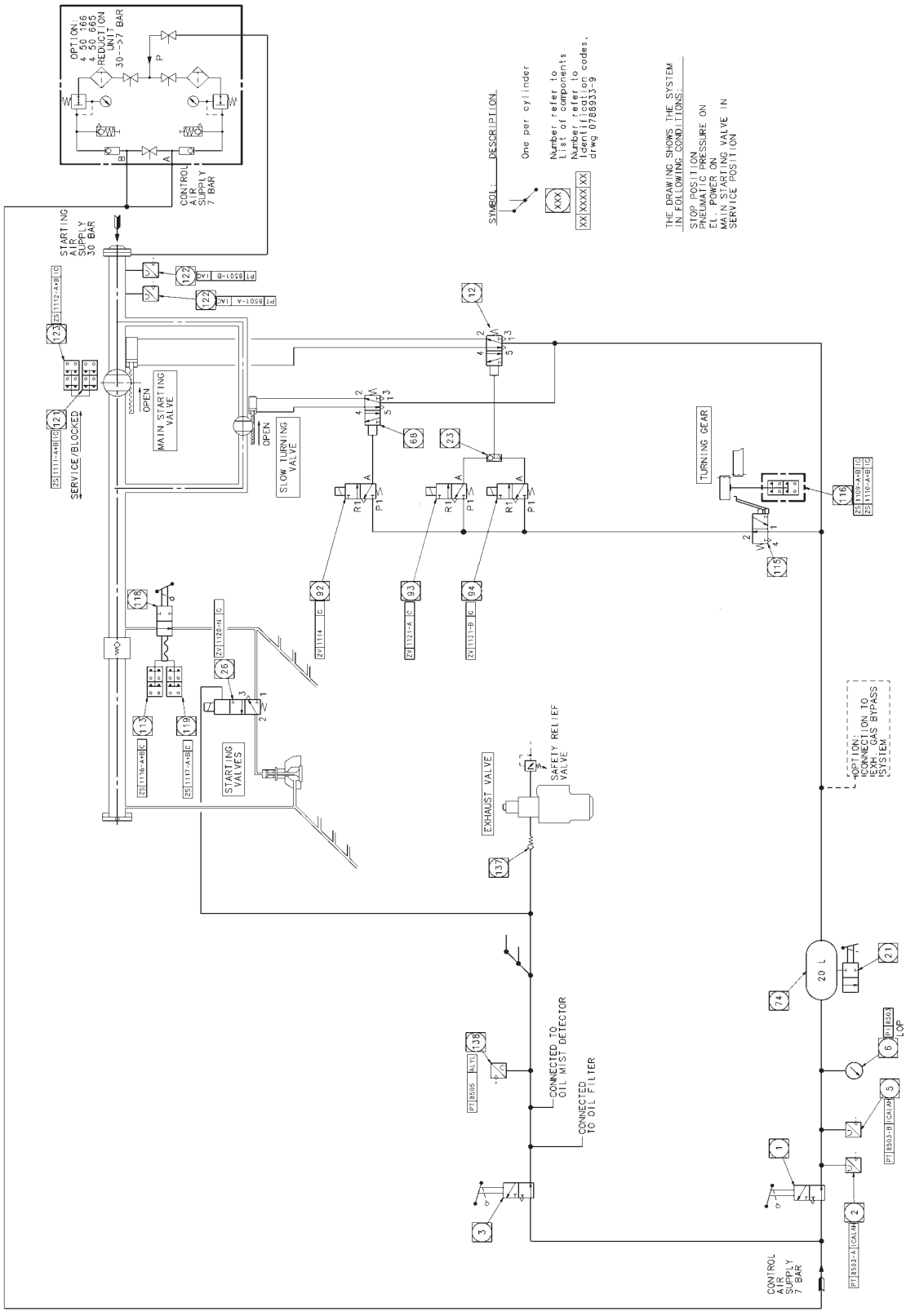
Engine Control System Diagram

Drawing 7055-0150-0003

2012-09-07 - en

Diagram of Manoeuvring System

Drawing
7055-0155-0002



2008-08-25

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off safety air supply - Not ME Engines
O	Shut off control air supply
O	Engage turning gear
O	Stop lubricating oil supply

Data

Ref.	Description	Value	Unit
T70-01	Angle encoder cover	20	kg
T70-02	Angle encoder bracket	35	kg
T70-10	Shaft alignment, maximum deviation	0.3	mm
T70-11	Shaft, tightening torque	170	Nm
T70-12	Bracket alignment, maximum deviation	0.3	mm

2013-04-10 - en

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
7670-0200	-	Torque spanners
7670-0300	-	Lifting tools, etc
7670-0410	**078**	Dial gauge and stand tool

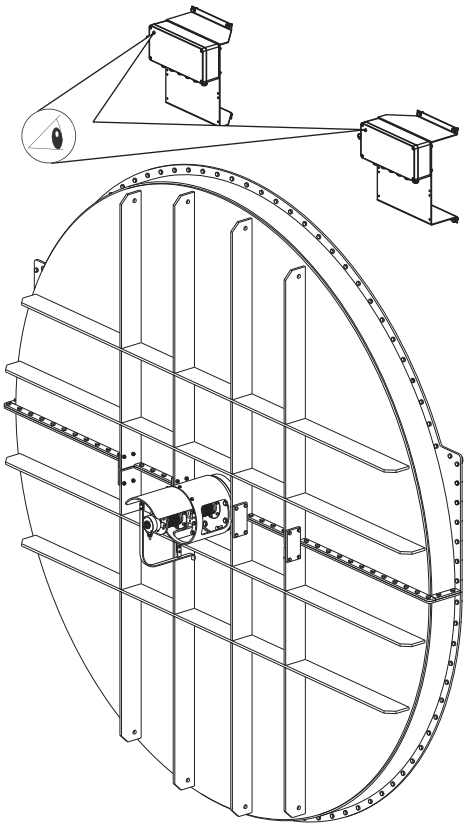
2013-04-10 - en

TSA-A

Check that power is supplied to the **T**acho **S**ignal **A**mplifier box.

Turn the crankthrow for cylinder 1 towards TDC. Check that the LED indicator on TSA-A lights up when TDC is reached.

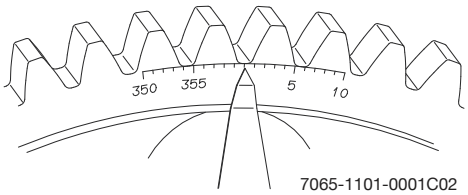
If the LED indicator on the TSA-A does not light up when TDC is reached, adjust the inner angle encoder.
See: overhaul / adjustment.



7065-1101-0003C01

TDC

Check the TDC of cylinder 1 against the mark on the turning wheel.



7065-1101-0001C02

TSA-B

Turn the engine a further 45 degrees in the engines rotational direction. The LED on TSA-B should now light up.

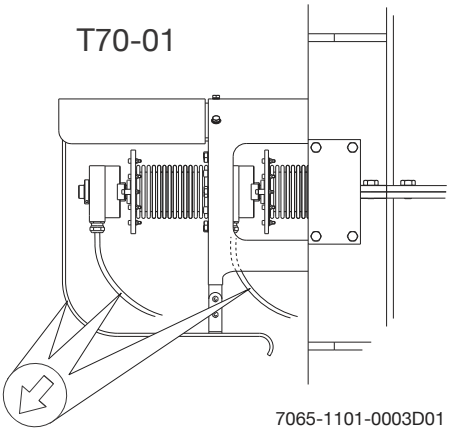
If the LED indicator on the TSA-B does not light up when TDC +45 degrees is reached, adjust the outer angle encoder.
See overhaul / adjustment.

2013-04-12

Preperation

Tag the electical plugs “Inner encoder” and “Outer encoder” **before** disconnecting them.

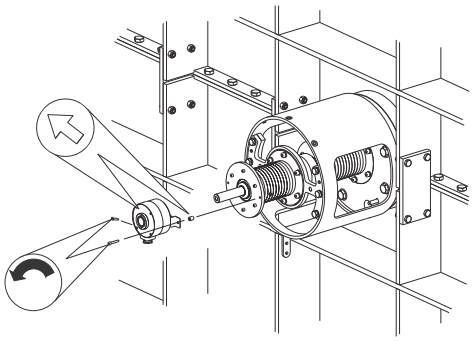
Remove the bracket.



7065-1101-0003D01

Remove the encoder

Loosen the screws as shown and pull the outer encoder off.



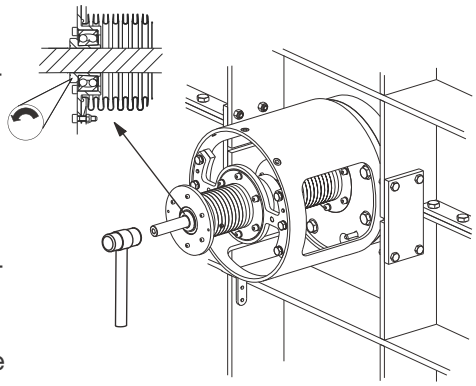
7065-1101-0003D02

Locking nut and washer

Loosen the locking washer and use a hook wrench to unscrew the locking nut on the bearing adapter sleeve. The locking nut should be unscrewed so far that the nut covers the thread on the end of the sleeve.

Slide a piece of pipe onto the axel. Tap the end of the pipe with a mallet to loosen the bearing adapter sleeve.

Unscrew the locking nut and remove the locking washer.



7065-1101-0003D03

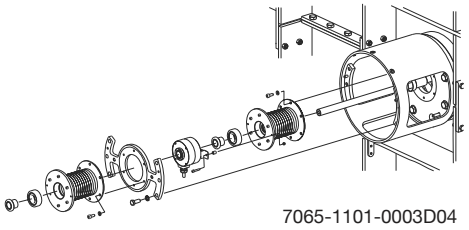
2013-04-12

Compensator

Unscrew the outer screws on the flange and remove the compesator.

Encoder

Dismount the outer compensator and flange.



7065-1101-0003D04

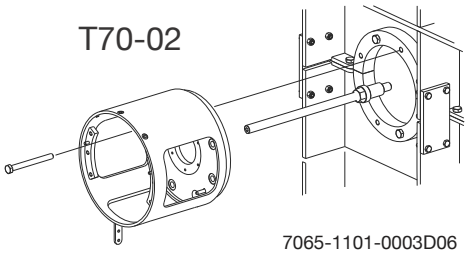
The inner encoder and compensator is dismantled in the same way as the outer encoder and compensator.

Bracket

If it is necessary the mounting bracket can be dismantled.

Use a tackle and lifting strap to secure the bracket.

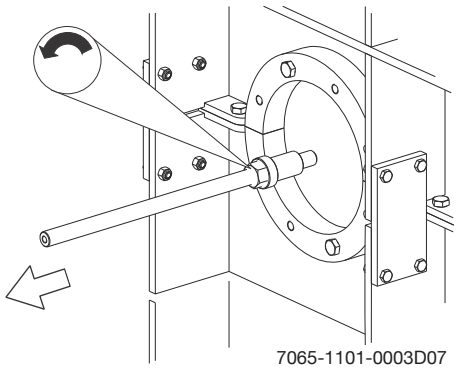
Unscrew the screws in the base plate and remove the bracket.



7065-1101-0003D06

Shaft

If necessary, unscrew and remove the shaft.



7065-1101-0003D07

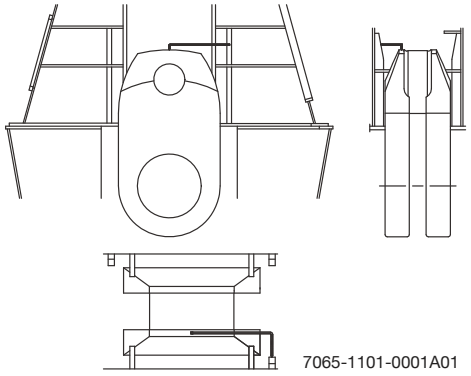
NOTE

Due to the need for realignment the shaft and the mounting bracket should only be dismounted when it is absolutely necessesary.

2013-04-12

Adjustment

- Turn the crankthrow for cylinder 1 to TDC.
- Check the TDC position with the pin gauge on the crankthrow.



7065-1101-0001A01

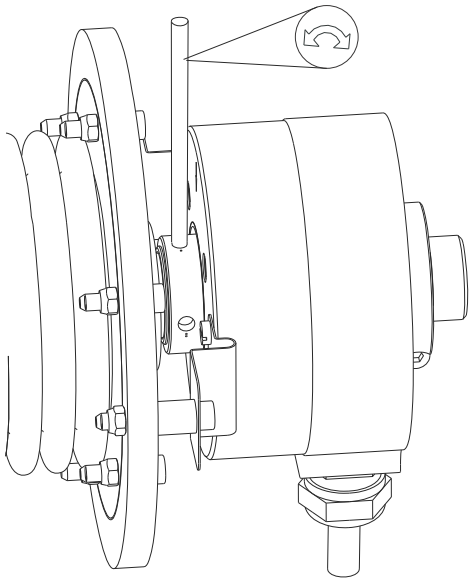
NOTE

Before using the pin gauge, check the measurement from tip to tip with the value stamped on the pin gauge, and/ or the check-marks stamped on the fore end of the cylinder frame.

- Loosen the clamping ring on the inner encoder (TSA-A).
- Use a mandrel or a drill to turn the encoder hollow shaft in the ahead direction until the indicator light turns on.

If the indicator light allready is on, turn in the ahead direction until it goes off and then until it turns on again. Tighten the clamping ring.

- Turn the engine 45 degrees in the engines rotational direction and repeat the procedure 4 on the outer angle encoder (TSA-B).



7065-1101-0003O04

NOTE

When adjusting the outer angle encoder a CLOCKWISE turning engine must be turned 45 degrees in the CLOCKWISE direction and an ANTICLOCKWISE turning engine must be turned 45 degrees in the ANTICLOCKWISE direction.

This concludes the mechanical adjustment of the angle encoders.

If the software settings need to be adjusted please contact MAN Diesel & Turbo.

After the adjustment, re-check the angle encoder. *See: Checking*.

2013-04-12

Shaft

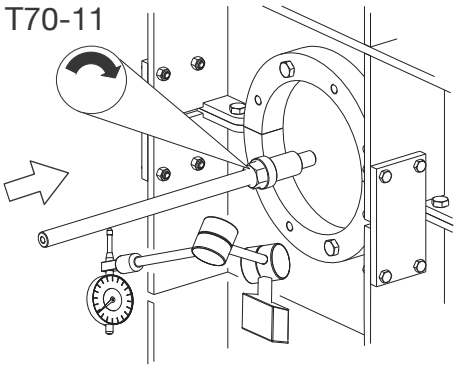
Re-mount the shaft.

Check the shaft adjustment using a dial gauge as shown.

Turn the engine one rotation.

Tighten the shaft as stated in *Data*.

T70-10
T70-11



7065-1101-0003M03

Bracket

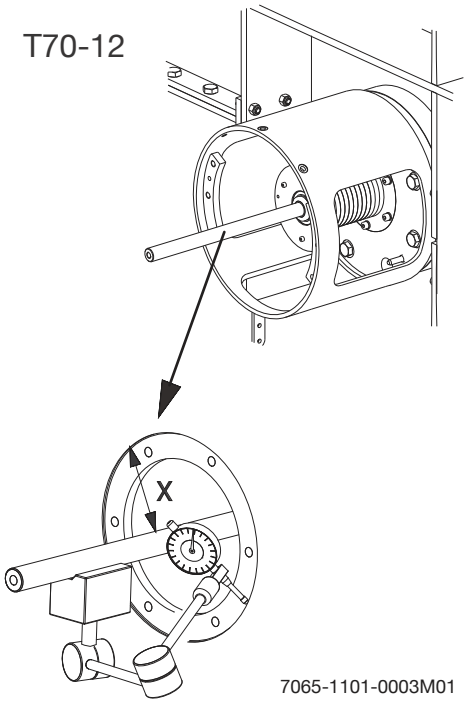
Mount the bracket.

Ensure that the pins are in place.

Mount the mounting bracket. Use a dial gauge caliper to ensure a maximum deviation from “X” of the value stated in *Data T70-12* around the center shaft.

“X” is the distance between the center shaft and the rim of the compensator mounting recess on the flange.

T70-12



7065-1101-0003M01

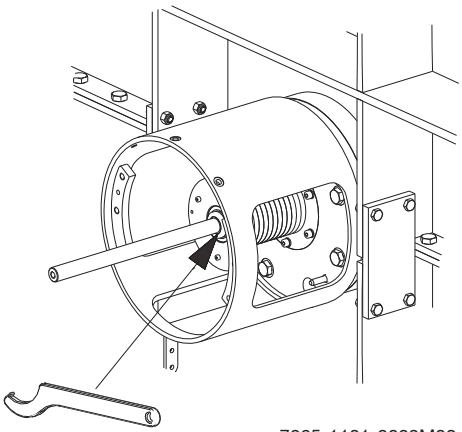
Bearing

Loosely assemble the bearing sleeve, locking nut and compensator. Slide the assembly onto the axel and mount the screws.

Tighten the locking nut to surface contact, then tighten a further 60° using a hook wrench.

Then unscrew the nut, place the locking washer in position and tighten the nut firmly again.

Lock the not by bending one of the locking washer tabs into one of the nut slots.

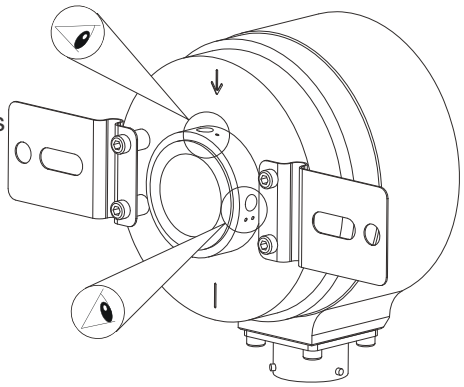


7065-1101-0003M02

2013-04-12

Basic adjustment

Perform a basic adjustment of the angle encoder by turning the hollow shaft to a position where the dot; in case of a clockwise turning engine or the two dots in case of a counter clockwise turning engine, are in line with the arrow.

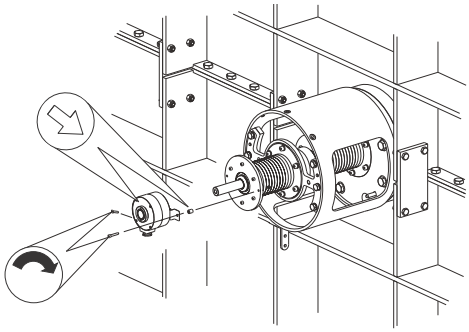


7065-1101-0001M03

Inner encoder

Mount the inner encoder on the shaft.

Adjust the encoder according to the adjustment / overhaul section.



7065-1101-0003M06

Outer encoder

Mount the outer compensator with bearing in the same way as shown for the inner encoder.

Basic adjustment

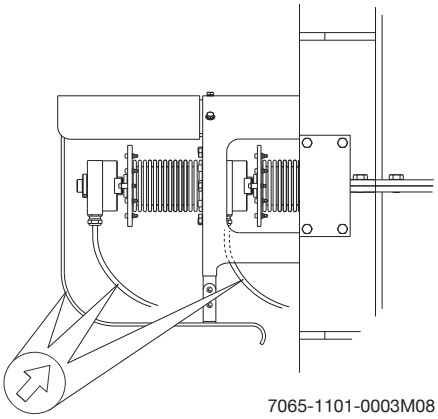
Perform a basic adjustment on the outer encoder as shown earlier and mount the encoder on the shaft.

Adjust the encoder according to the adjustment / overhaul section.

Finaly

Mount the electrical connections.

Mount the bracket.



7065-1101-0003M08

2013-04-12

Safety Precautions

for detailed sketch see 0545-0100

O	Stop the Engine
O	Shut off starting air supply - At starting air receiver
O	Block the main starting valve
O	Shut off starting air distributor/distributing system supply
O	Shut off safety air supply - Not ME Engines
O	Shut off control air supply
O	Engage turning gear
O	Stop lubricating oil supply
O	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
T70-05	Check distance, pick-up arrangement	2.0-3.0	mm

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
7670-0410	**066**	Slide caliper

Pick-up configurations

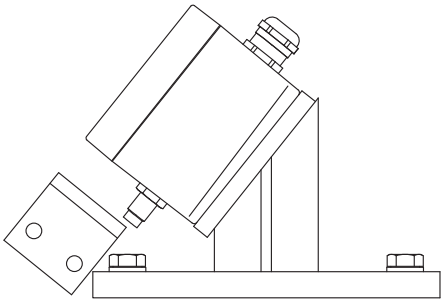
The pick-up arrangement may vary from engine to engine to match the configuration of the control system installed on the specific engines.

The pick-up arrangement usually consists of one or more of the following pick-up systems:

TDC pick-up system

The TDC pick-up arrangement normally consists of one or two sensors mounted on a bracket between the engine frame and the turning wheel. The sensors are normally triggered by a bracket (profile iron) bolted onto the turning wheel.

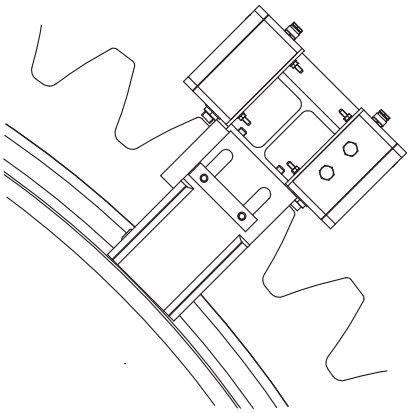
The purpose of the TDC pick-up system is for the engine control system to monitor when the crank throw for cylinder No. 1 reaches TDC.



Control pick-up system

The control pick-up arrangement normally consists of one or more brackets bolted onto the engine frame, each mounted with two sensors. The sensors are triggered by the teeth of the turning wheel or by a trigger ring.

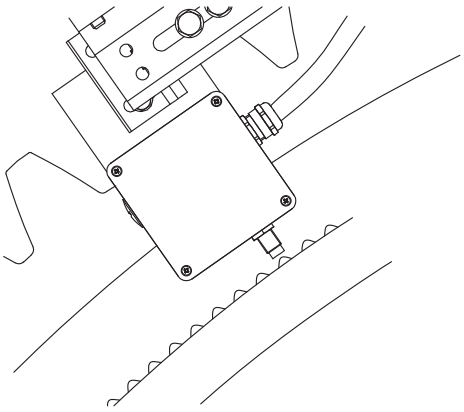
The purpose of the control pick-up system is for the engine control system to continually monitor the position of the crankshaft and the direction of rotation.



Safety pick-up system

The safety pick-up arrangement normally consists of two pick-ups mounted on a bracket. The sensors are triggered by the teeth of the turning wheel or by a trigger ring.

The purpose of the safety pick-up system is for the engine safety system to continually monitor the rpm of the engine.



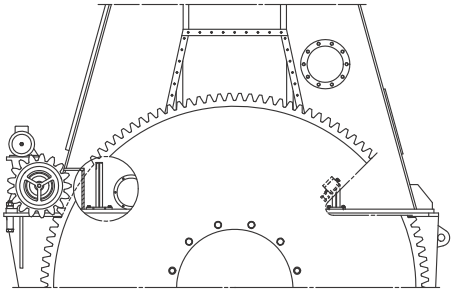
7065-1201-0003C01

NOTE

The drawings in this procedure are for guidance only and may vary from the actual engine configuration

The sensors in the pick-up arrangement are continuously checked by the system itself and will activate an alarm on the main operating panel if a failure occurs.

Manual checking is to be carried out as described in the Adjustment chapter.

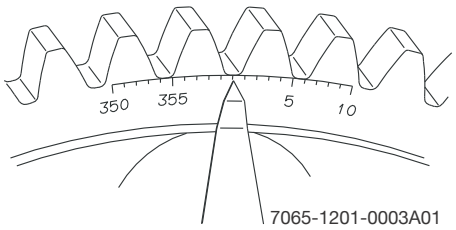


7065-1201-0003C02

2010-10-08 - en

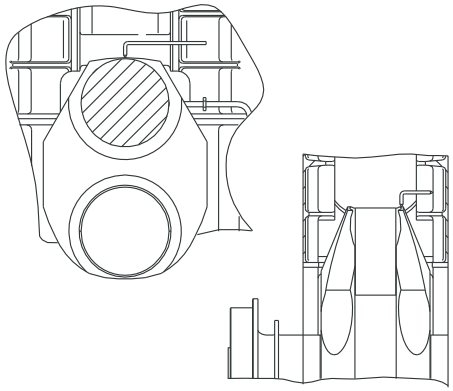
Adjustment of the TDC pick-up system

Turn the crank throw for cylinder No. 1 to TDC. Check the TDC of cylinder No. 1 against the “zero” degree mark on the turning wheel.

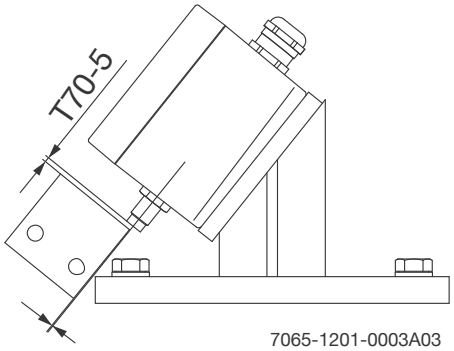


7065-1201-0003A01

Check the TDC position with the pin gauge on the crank throw.


7065-1201-0003A02

Check the clearance between the sensor tip and the bracket, and compare with the figures in the datasheet. Make sure the centreline of the sensor is aligned with the edge of the bracket.



7065-1201-0003A03

NOTE

The figures in the datasheet are standard values.

If necessary, adjust the position of the sensor.

If correct signal does not occur, adjust the clearence in steps of 0.2 mm, until correct signal is obtained.

NOTE

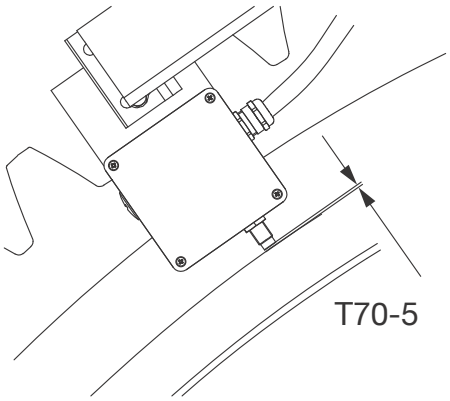
Make sure that the sensor tip does not touch the bracket while turning.

For further details and data regarding adjustment of the TDC pick-up system, see subsupplier’s instructions.

Adjustment of the Control / Safety pick-up system

Turn the engine to center the highest point of the turning wheel/trigger ring below the sensor.

Check the clearance between the sensor tip and the turning wheel/trigger ring and compare with the figures in the datasheet.



7065-1201-0003A04

NOTE

The figures in the datasheet are standard values.

If necessary adjust the position of the sensors.

If correct signal does not occur, adjust the clearence in steps of 0.2 mm, until correct signal is obtained.

NOTE

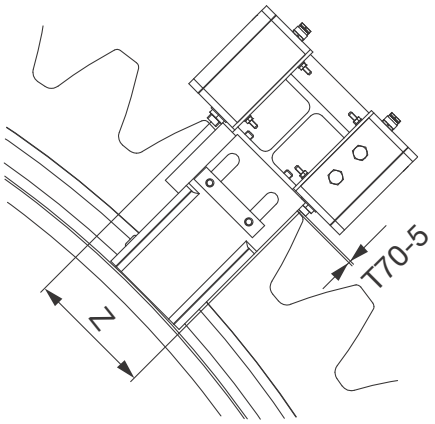
Make sure that the sensor tip does not touch the turning wheel/trigger ring while turning.

For further details and data regarding adjustment of the control/safety pick-up system, see subsupplier's instructions.

Pick-up configurations with more than one sensor installed may require adjustment of the distance (Z) between the sensors.

Check and, if necessary, adjust the distance between the sensors according to subsupplier's instructions.

For further details and data regarding adjustment of the control/safety pick-up system, see subsupplier's instructions.



7065-1201-0003A05

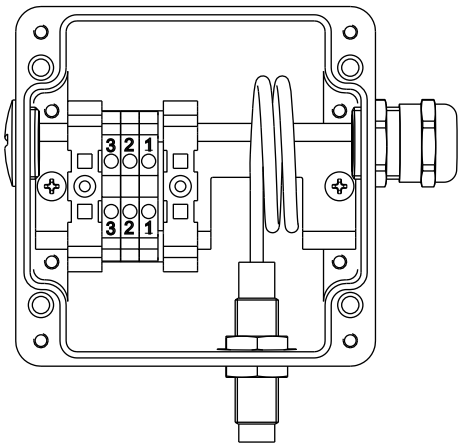
2010-10-08 - en

Replacement of sensors

Prepare the sensor cable with sleeves and markings (BN to be marked 1, BU to be marked 2 and BK to be marked 3).*

Turn the engine to center the highest point of the turning wheel/trigger ring below the sensor.

Open the sensor box, check cable colours and markings. Remove the old sensor. Do not dismantle or move the sensor box.

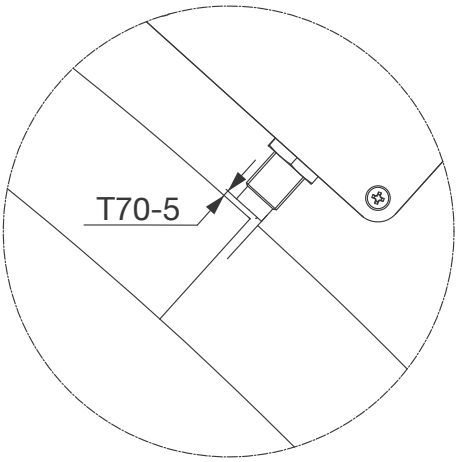


7065-1201-0001O01

Fit the new sensor into the sensor box. Make sure the distance is adjusted as described in the datasheet. Secure the sensor with Loctite ® metal glue.

After tightening, check position and clearance.

Install the sensor cable in accordance with the drawing. BN to terminal 1, BU to terminal 2 and BK to terminal 3.



7065-1201-0003A07

NOTE

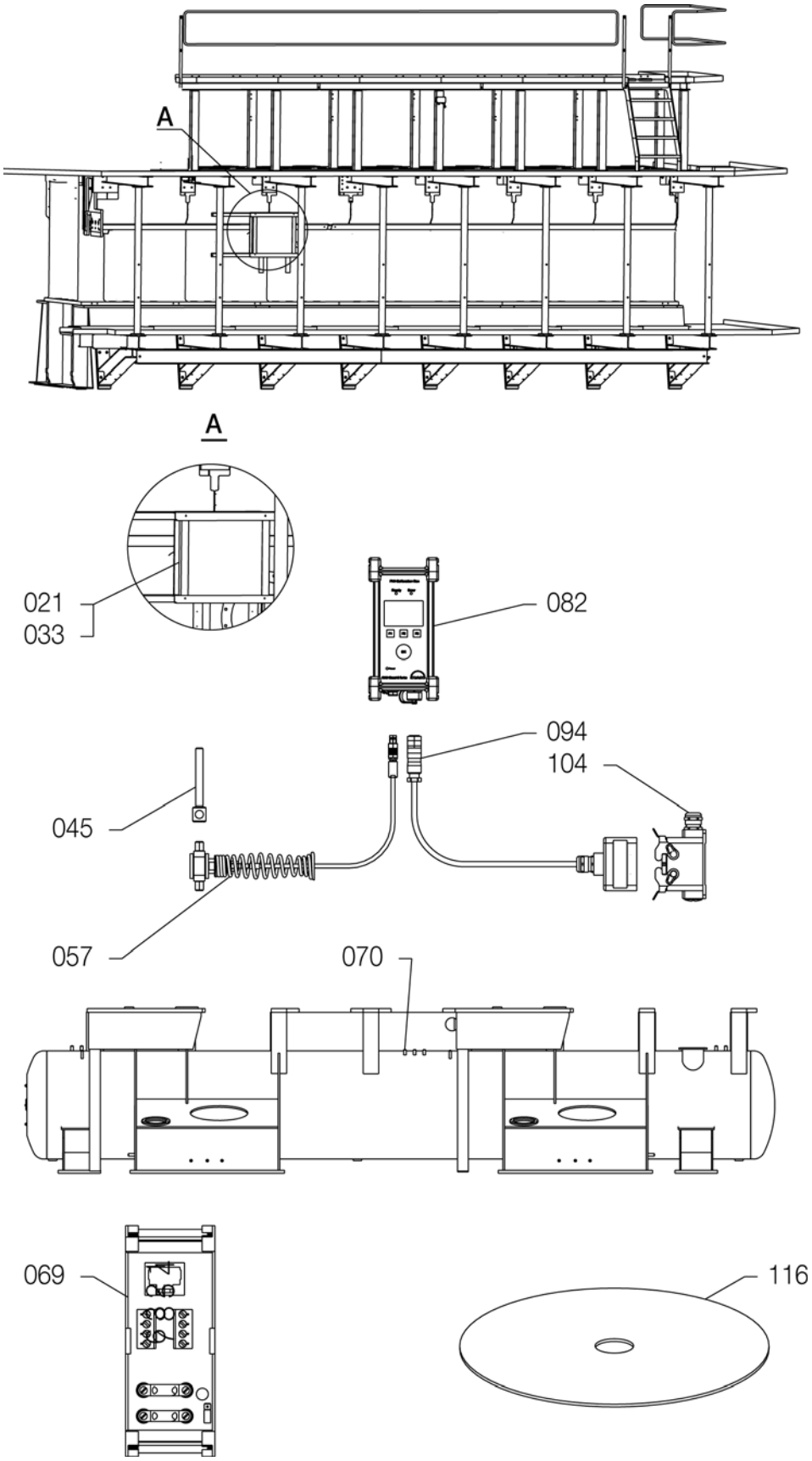
For sensors not mounted in a box, the cable conection box is located on the aft end of the engine frame box.

Turn the engine to see if the sensor light diode flashes, if not, stop turning. Move a piece of steel near the sensor head and check that the diode light changes.

Test the signal in the service terminal in the same way.

* BN = +24v. BU = 0v. and BK = OUT

2010-10-08 - en



PMI System

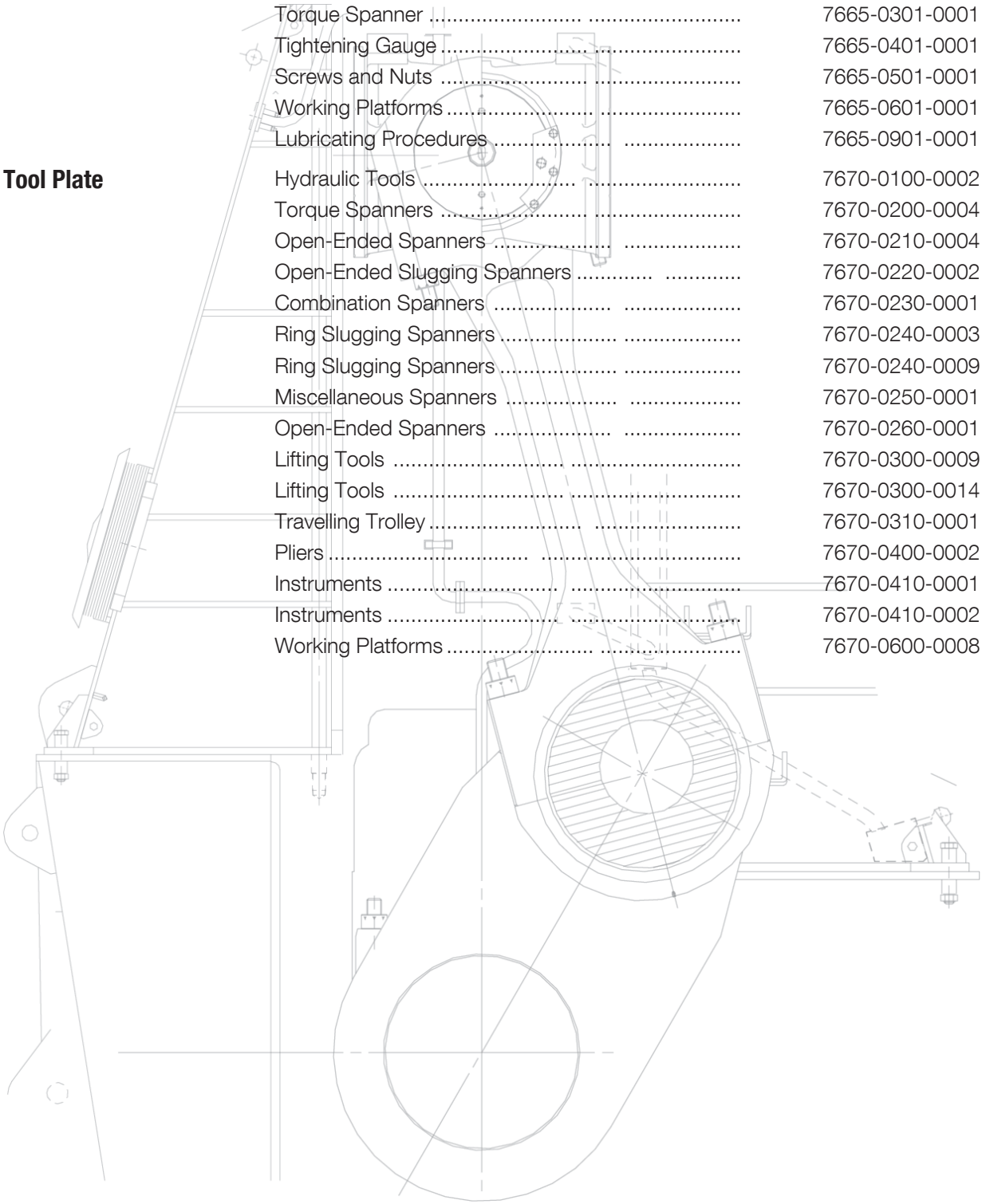
Plate
7072-0800-0005

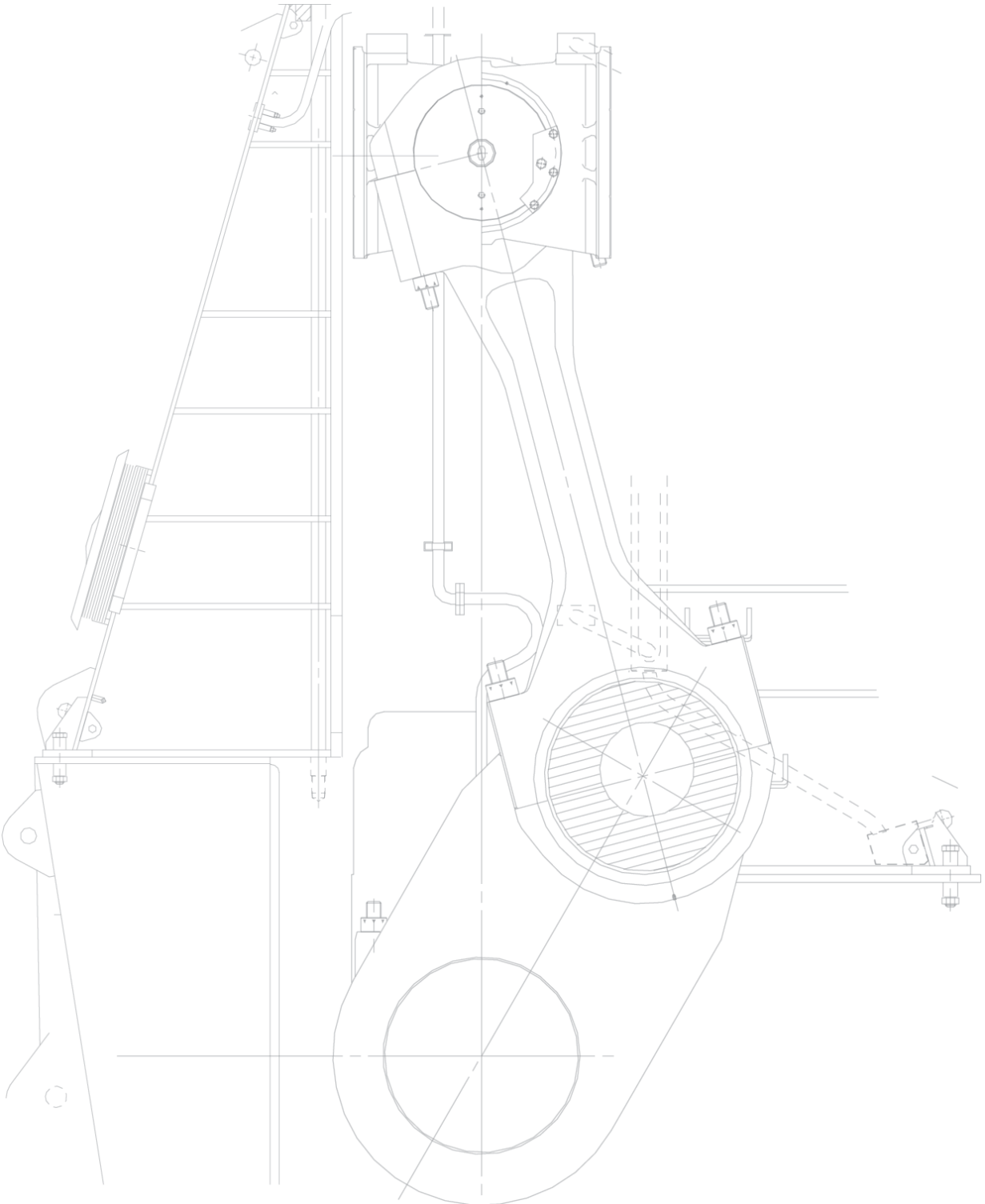
2012-01-12 - en

Item no	Qty	Designation
021	-	Data acquisition unit
033	-	Support for enclosures
045	-	Handle
057	-	Pressure transducer for calibration
069	-	Adapter module
070	-	Scavenging Air Receiver Pressure
082	-	PMI calibration box
094	-	Cable
104	-	Calibration junction box
116	-	PMI software

2012-01-12 - en

Preface Chapter	Tools	7640-0100-0002
Work Card	Hydraulic Tools	7665-0101-0005
	Standard Tightening Torque	7665-0201-0002
	Torque Spanner	7665-0301-0001
	Tightening Gauge	7665-0401-0001
	Screws and Nuts	7665-0501-0001
	Working Platforms	7665-0601-0001
	Lubricating Procedures	7665-0901-0001
Tool Plate	Hydraulic Tools	7670-0100-0002
	Torque Spanners	7670-0200-0004
	Open-Ended Spanners	7670-0210-0004
	Open-Ended Slugging Spanners	7670-0220-0002
	Combination Spanners	7670-0230-0001
	Ring Slugging Spanners	7670-0240-0003
	Ring Slugging Spanners	7670-0240-0009
	Miscellaneous Spanners	7670-0250-0001
	Open-Ended Spanners	7670-0260-0001
	Lifting Tools	7670-0300-0009
	Lifting Tools	7670-0300-0014
	Travelling Trolley	7670-0310-0001
	Pliers	7670-0400-0002
	Instruments	7670-0410-0001
	Instruments	7670-0410-0002
	Working Platforms	7670-0600-0008





Tools

This chapter of the instruction book is intended to provide the user with information regarding all the special tools and standard tools necessary for correct maintenance of the engine.

Information includes operation and maintenance of hydraulic tools, tightening and locking of screws and nuts as well as tool plates to be used when ordering spare tools.

In addition tool plates relevant only to specific parts of the engine may be found in the back of each chapter of the instruction book.

2009-09-04-en

The Hydraulic Tools consists of:

A. Lifting bracket
B. Cover
C. Snap-on coupling
D. Bleed screw
E. Piston Return Spring
F. Guide pin
G. Overstroke valve
H. Piston
I. Sealing rings
J. Cylinder
K. Support ring
L. Nut
M. Stud
N. Tommy bar
O. Milled recess for feeler gauge
P. Extension stud
Q. Support
S. Clearance

Studs or bolts provided with threads for attaching hydraulic tools and with circular nuts must only be loosened and tightened up by means of the hydraulic tools supplied.

The jack(s) is/are connected, via a distributor block, to a high-pressure pump, which is able to deliver hydraulic oil at the pressure indicated on the jack and on the data sheet in the relevant section of this instruction book. The stud or bolt concerned is thereby lengthened relative to the oil pressure applied and the piston area, and the nut can be loosened or tightened, as required, with the aid of a tommy bar.

The jacks must not be exposed to blows or impacts.

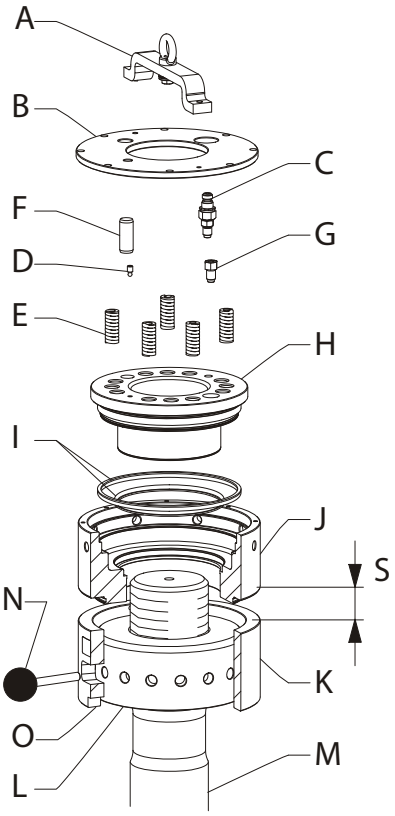
The jacks are marked with a “Max. lift”, which can be measured on the protruding guide pin on top of the jack *(see picture 4).*

The hydraulic jacks are fitted with piston return springs to ensure the correct retraction af the piston when pressure is released.

2008-12-08 - en

The purpose of the hydraulic tools

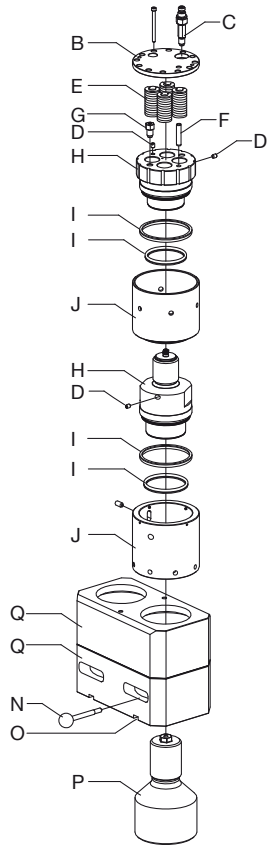
The hydraulic tools consist of a set of jacks with an internal thread to suit the tool attachment thread on the stud or bolt, and a support rings.



7665-0101-0002C01

For main bearings

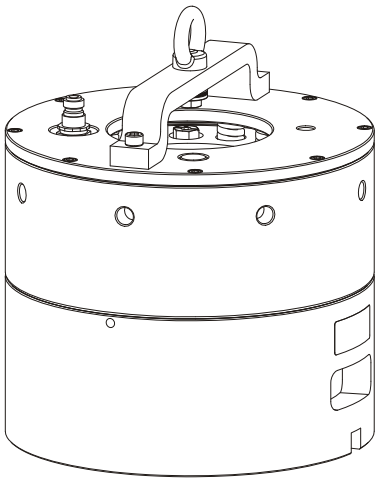
For the main bearings, the hydraulic tools consist of four hydraulic double jacks with extension studs, and two double support tools.



7665-0101-0005C02

For cylinder cover

For the cylinder cover, the hydraulic tool consists of eight individual jacks suspended from a common lifting tool. The support rings are mounted below each jack using spring pins.



7665-0101-0002C03

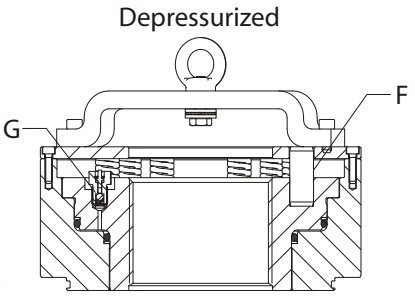
NOTE

It is not necessary to dismount the support rings when overhauling the cylinder cover jacks.

Operation of the cylinder cover jacks is identical to the operation of the single hydraulic jacks.

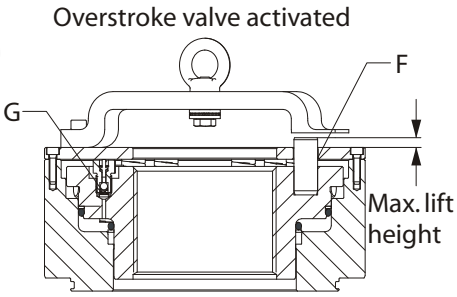
The design of the hydraulic jacks

The hydraulic jacks are so designed that, in the event that the “Max. lift” limit is exceeded, the pressure is relieved by an overstroke valve mounted in the piston. The overstroke valve releases the oil pressure into the cavity beneath the cover. The oil can then be seen seeping out of the openings in the jack.



NOTE

If the overstroke valve has been activated, it may be necessary to overhaul the valve, *see Maintenance 7665-0101.*



7665-0101-0002C04

The oil used must be pure hydraulic oil or turbine oil (with a viscosity of about SAE 20). Oils such as, for instance, lubricating oil (system oil) or cylinder lubricating oil must **not** be used, as these oils are normally alkaline and can thus damage the back-up rings.

The following instructions must be closely followed to prevent accidents or damage, and after use the jacks should be cleaned and kept in the wooden boxes supplied.

WARNING

Eye protectors and gloves **must be** used when using hydraulic tools.

2008-12-08 - en

Loosening of Nuts

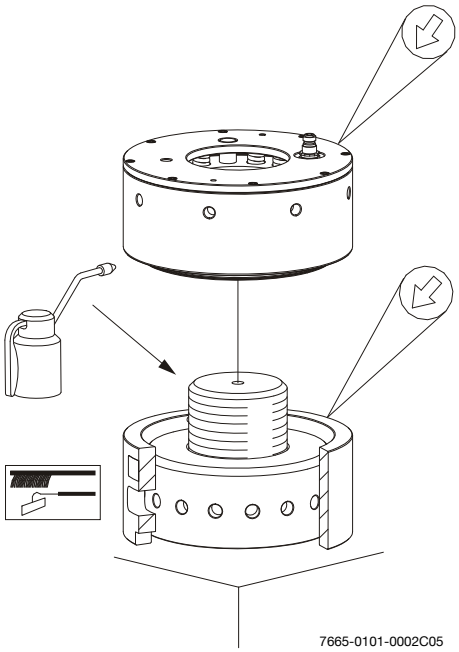
Single Hydraulic Jack

Clean the tool/nut

Carefully clean the tool attachment thread, the nut and the surrounding parts.

Grease the tool attachment thread with molybdenum disulphide grease or with graphite and oil or similar.

Place the support ring around the nut in such a position that the tommy bar can be applied through the slot when the nut is to be loosened.



7665-0101-0002C05

Mounting

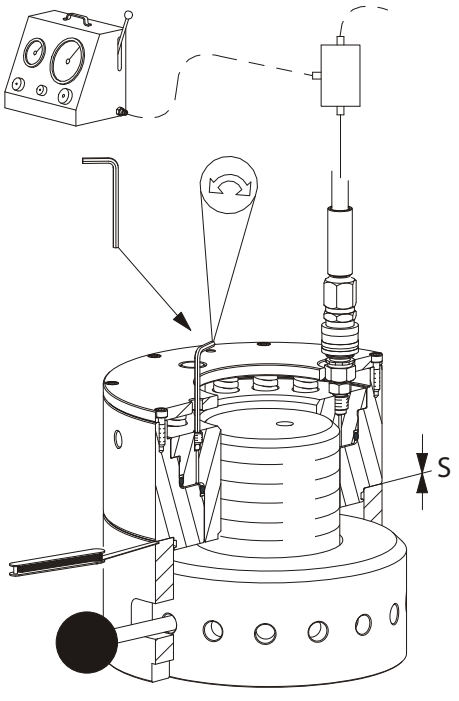
Screw the jack on to the tool attachment thread of the bolt/stud, until the cylinder of the jack bears firmly against the support ring.

Connect the hydraulic jack, the distributor block and the high pressure pump by means of high pressure hoses.

Unscrew the jack ¾ of a turn to create a clearance between the jack and support ring. When loosening nuts on staybolts it is necessary to unscrew the jack 2,5 turns.

The clearance between the jack and support ring ensures dismounting of the jack after loosening the nut.

Loosen the bleed screw in the jack and fill up the system with oil until oil without bubbles, flows out of the bleed hole. Then tighten the bleed screw again.



7665-0101-0002C06

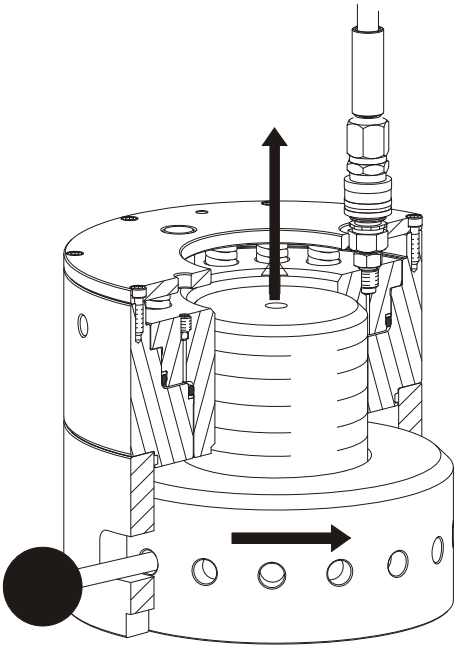
The clearance between the jack and support ring ensures dismantling of the jack after loosening the nut.

After adjustment, check that the parts are guided correctly together and that there is no clearance between the piston and cylinder of the jack.

2008-12-08 - en

During work

Increase the oil pressure to the prescribed value. Use the tommy bar during the pressure increase to determine when the nut is loose. If the nut does not come loose, the pressure may be increased by 10% of the working pressure marked on the jack.



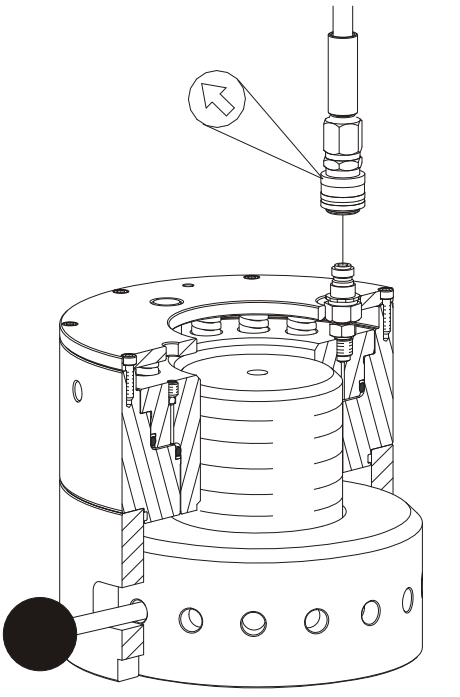
7665-0101-0002C07

Unscrew the nut

Unscrew the nut with the tommy bar, making sure that the nut is not screwed up against the jack.

Disconnect the high-pressure pump

Relieve the system of pressure, disconnect the high-pressure pump, and remove the hydraulic tools.

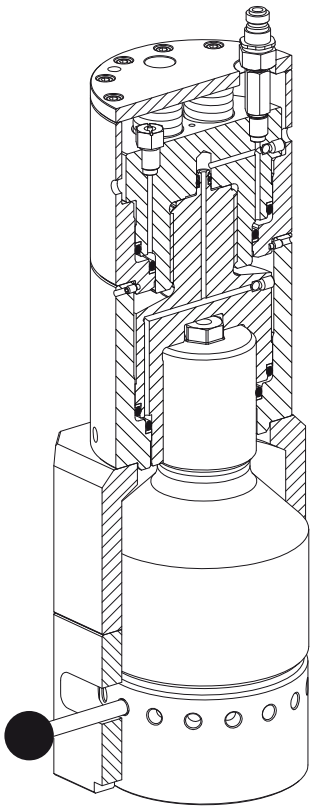


7665-0101-0002C08

2008-12-08 - en

Double hydraulic jack

Carefully clean the main bearing studs, the nuts and the surrounding parts. Make sure that the extension studs are screwed all the way down on the main bearing studs. Use the lifting handle to lift the double supports onto the main bearing nuts and mount the jacks on the studs.



7665-0101-0005D05

Mounting

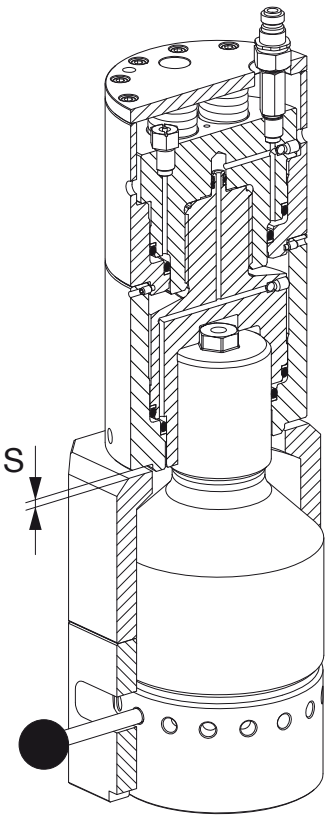
Turn the jacks ¾ of a turn back making a clearance “S”.

The clearance between the jack and the supports ensures dismounting of the jack after loosening the nut.

Connect the hydraulic jacks, the distributor block and the high pressure pump by means of high pressure hoses.

Loosen the bleed screws in both jacks, and fill up the system with oil until oil, without bubbles, flows out of the bleed holes.

Re-tighten the bleed screws.



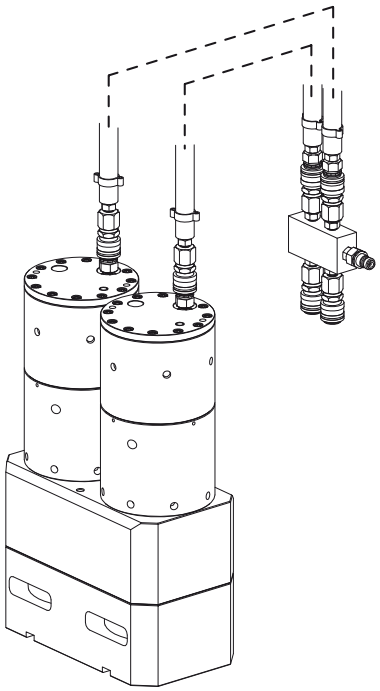
7665-0101-0005D06

2008-12-08 - en

During work

Increase the oil pressure to the prescribed value. Use the tommy bar during the pressure increase to determine when the nut is loose. If the nut does not come loose, the pressure may be increased by 10% of the working pressure marked on the jack.

Unscrew the nut with the tommy bar, making sure that the nut is not screwed up against the jack.



7665-0101-0005D07

Disconnect the high-pressure pump

Relieve the system of pressure, disconnect the high-pressure pump, and unscrew the hydraulic jack.

Disassemble the hydraulic tools and use the lifting handle to lift the tools out of the crankcase.

2008-12-08 - en

Tightening of Nuts

Single hydraulic jack

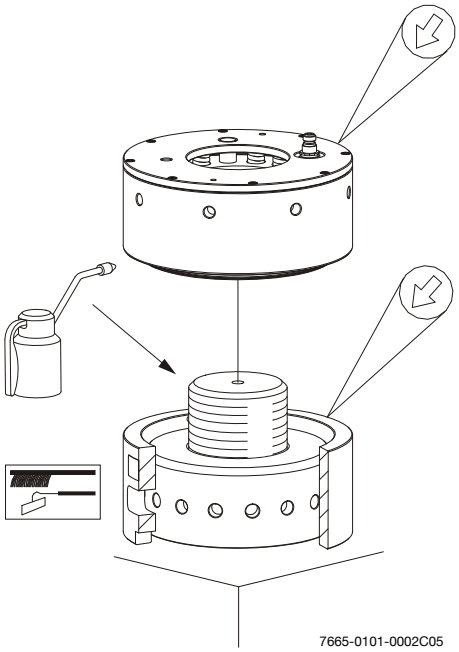
Clean the tool and nut

Thoroughly clean the nut, the thread, the contact faces, and the surrounding parts. Clean and lubricate the tool attachment thread and the thread in the nut with molybdenum disulphide grease or with graphite and oil or similar.

Fit the round nut on the thread and tighten it with the tommy bar.

Check with a feeler gauge that the contact face of the nut bears on the entire circumference.

Place the support ring around the nut in such a position that the tommy bar can be applied through the slot for the purpose of tightening the nut.



7665-0101-0002C05

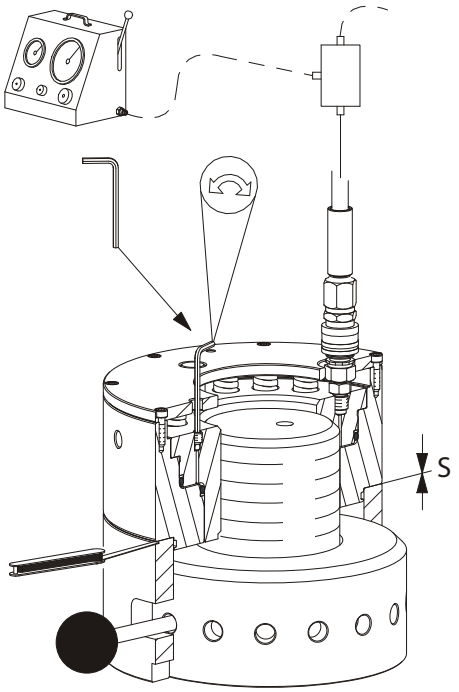
Mounting

Screw the hydraulic jack on to the stud. Make sure that the jack bears firmly against the support ring and that the parts are guided correctly together.

Connect the hydraulic jack, the distributor block and the high-pressure pump by means of high-pressure hoses.

Loosen the bleed screw in the jack and fill up the system with oil, until oil without bubbles flows out of the bleed hole.

Re-tighten the bleed screw.

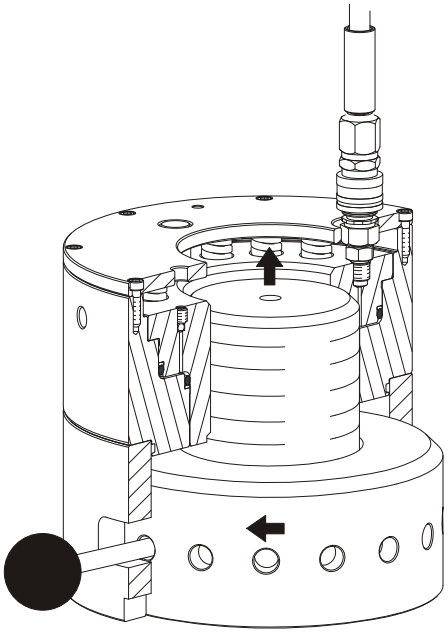


7665-0101-0002C06

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During work

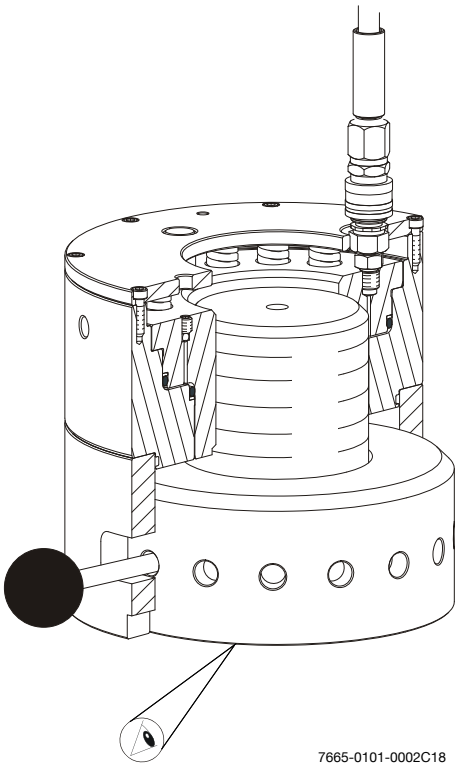
Increase the oil pressure to the prescribed value, and tighten the nut by means of the tommy bar applied through the slot of the support ring. Depressurize and pump up to the prescribed pressure again.



7665-0101-0005M03

Check with a feeler gauge

While maintaining the pressure, check with a feeler gauge introduced through the recess at the bottom of the support ring that the nut bears against the contact face.



7665-0101-0002C18

Disconnect the high-pressure pump

Relieve the system of pressure, disconnect the pump, and remove the hydraulic jack.

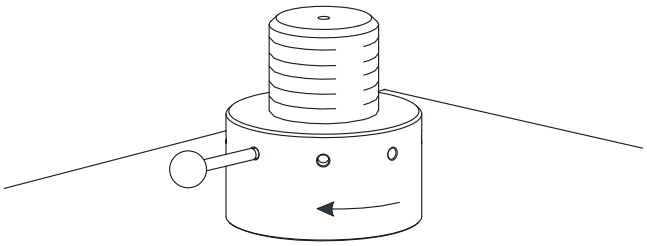
2008-12-08 - en

Tightening of Nuts

Double hydraulic jack

Clean the tool and nut

Thoroughly clean the nut, the thread, the contact faces, and the surrounding parts. Clean and lubricate the tool attachment thread and the thread in the nut with molybdenum disulphide grease or with graphite and oil or similar. Mount the nuts and tighten till face contact.



7665-0101-0002C20

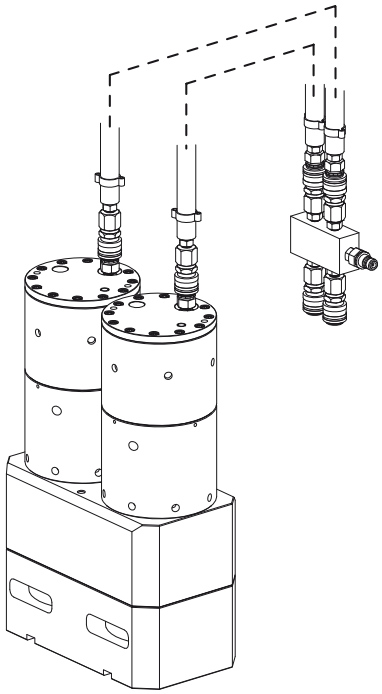
Bleed the screws

Screw the extension studs all the way down on the main bearing studs. Lift the double supports onto the main bearing nuts and mount the jacks on the studs.

Connect the hydraulic jacks, the distributorblock and the high pressure pump by means of high pressure hoses.

Loosen the bleed screws in both jacks, and fill up the system with oil until oil, without bubbles, flows out of the bleed holes.

Re-tighten the bleed screws.

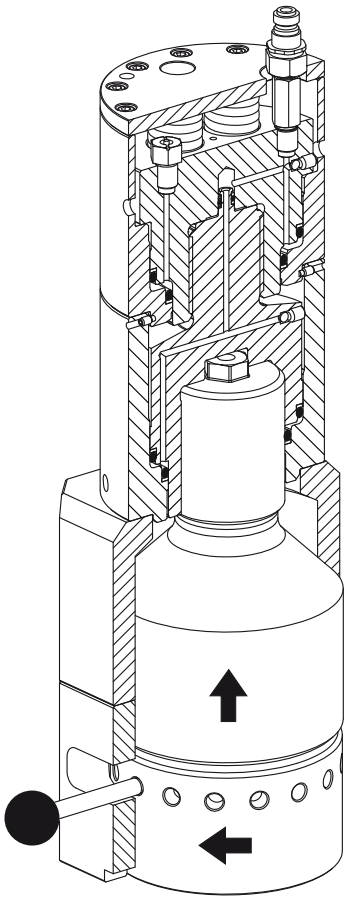


7665-0101-0005M03

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Equal tightening

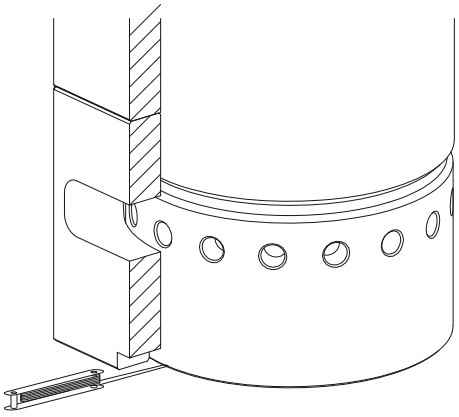
Increase the oil pressure to the prescribed value, and tighten the nuts by means of the tommy bar applied through the slots of the supports. Depressurize and pump up to the prescribed pressure again. Keep count of how many holes the nuts are turned to assure equal tightening



7665-0101-0005M07

Check with a feeler gauge

While maintaining the pressure, check with a feeler gauge introduced through the recesses at the bottom of the support tool that the nuts bear against the contact face.



7665-0101-0005M08

Disconnect the high-ppressure pump

Relieve the system of pressure, disconnect the pump, and unscrew the extension studs from the main bearing studs.

Remove the jacks

Use the lifting handle to remove the hydraulic jacks from the crankcase.

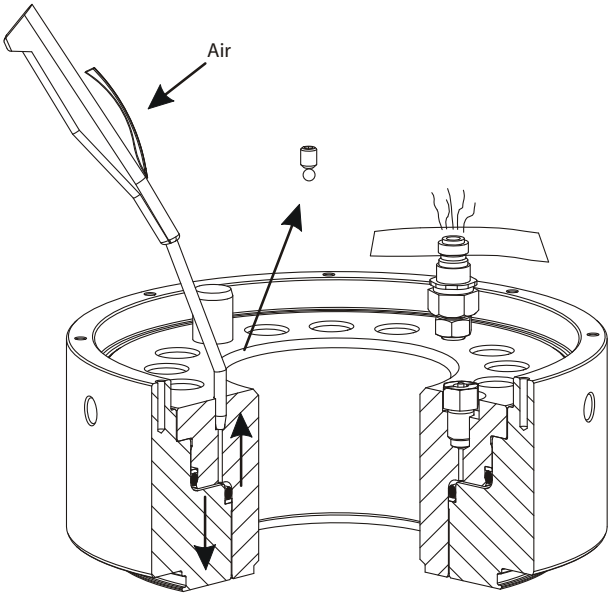
2008-12-08 - en

Maintenance

Requirement

The hydraulic jacks require no maintenance except cleaning of overstroke valve and replacement of defective sealing rings, each of which consists of an O-ring and a back-up ring fitted in ring grooves in the piston and cylinder.

The piston and cylinder are easily separated by taking off the cover and piston return spring, removing the bleed screw with ball and pressing the parts apart with the help of compressed air.



7665-0101-0002C27

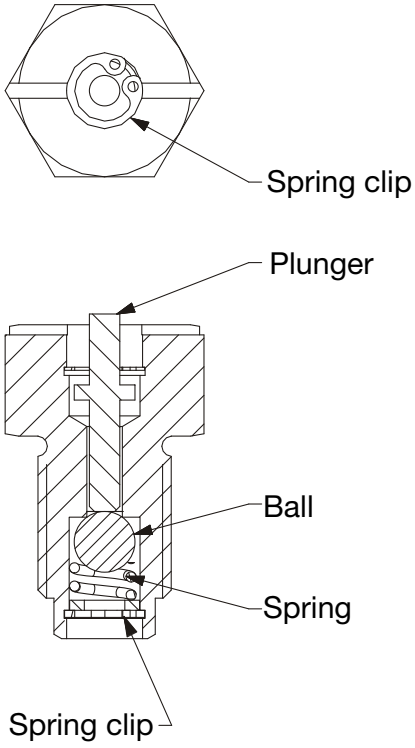
Make sure that there are no marks or scratches on the sliding surfaces of the parts. The presence of metal particles will damage the sealing rings.

Keep the sliding surfaces and O-rings coated with molybdenum disulphide grease.

Remember

If the overstroke valve leaks oil without being activated the hydraulic jack has to be dismounted and disassembled. Disassembly is done by removing the two spring clips. Take care not to loose the ball and spring. Clean the overstroke valve with compressed air. If this does not remedy the fault the Overstroke valve has to be replaced.

The pistons and cylinders of the double jacks are separated in the same easy way as described for the single jack.



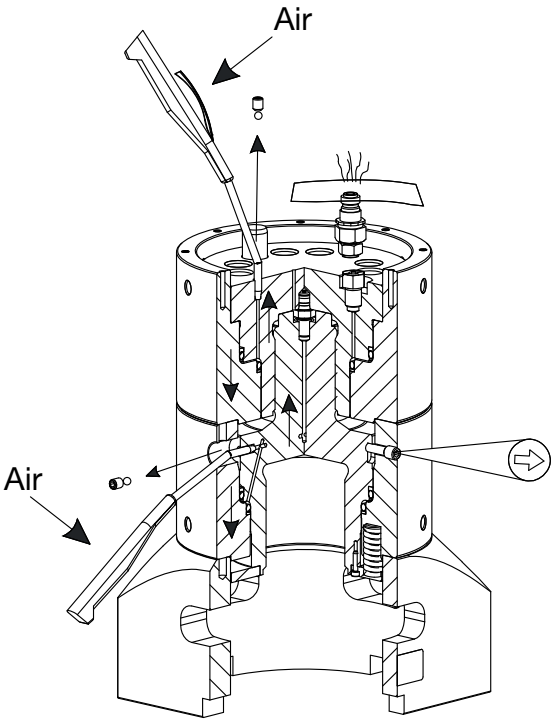
7665-0101-0002C28

WARNING

Always use eye protection when working with compressed air.

The piston and cylinder

The piston and cylinder of the double jacks are separated in the same way as described for the single jack.

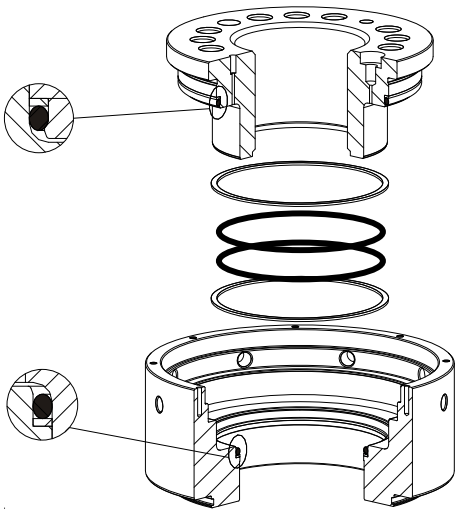


7665-0101-0002C29

Sealing rings

When changing the sealing rings, first mount the back-up ring and then the O-ring.

See the sketch for the correct mounting of both the upper and the lower sealing rings. The same principle applies to all the jacks.


7665-0101-0002C30

Fitting the sealing rings

After fitting the sealing rings, coat the piston and cylinder with molybdenum disulphide grease and press the piston and cylinder together. See that the rings do not get stuck between the piston and cylinder.

Tightening Torques

When tightening screws, studs or nuts for which no torque is specified in the instruction procedure or the related data sheet, the standard torques specified in this procedure are to be applied.

Standard

Standard screws and nuts lubricated with a Molybdenum Disulphide (MoS_2) based lubricant.

Thread	Tightening torque	Thread	Tightening torque
M8	17 Nm	M22	400 Nm
M10	35 Nm	M24	460 Nm
M12	50 Nm	M27	610 Nm
M14	80 Nm	M30	950 Nm
M16	135 Nm	M33	1200 Nm
M18	190 Nm	M36	1650 Nm
M20	260 Nm	M39	2100 Nm

Self-locking

Self-locking nuts.

Thread	Tightening torque	Thread	Tightening torque
M8	20 Nm	M22	430 Nm
M10	40 Nm	M24	490 Nm
M12	60 Nm	M27	650 Nm
M14	90 Nm	M30	1000 Nm
M16	150 Nm	M33	1250 Nm
M18	210 Nm	M36	1700 Nm
M20	290 Nm	M39	2200 Nm

With glue/Loctite

Screws and nuts locked with glue/Loctite.

Thread	Tightening torque	Thread	Tightening torque
M8	23 Nm	M22	580 Nm
M10	50 Nm	M24	680 Nm
M12	70 Nm	M27	900 Nm
M14	115 Nm	M30	1350 Nm
M16	190 Nm	M33	1700 Nm
M18	270 Nm	M36	2350 Nm
M20	380 Nm	M39	3000 Nm

2008-11-05 - en

Camlock washers

Screws and nuts locked with camlock washers.

For correct fitting of washers, *see word card 7665-0501*

Thread	Tightening torque	Thread	Tightening torque
M8	20 Nm	M22	470 Nm
M10	40 Nm	M24	550 Nm
M12	70 Nm	M27	800 Nm
M14	110 Nm	M30	1100 Nm
M16	165 Nm	M33	1500 Nm
M18	230 Nm	M36	1900 Nm
M20	320 Nm	M39	2500 Nm

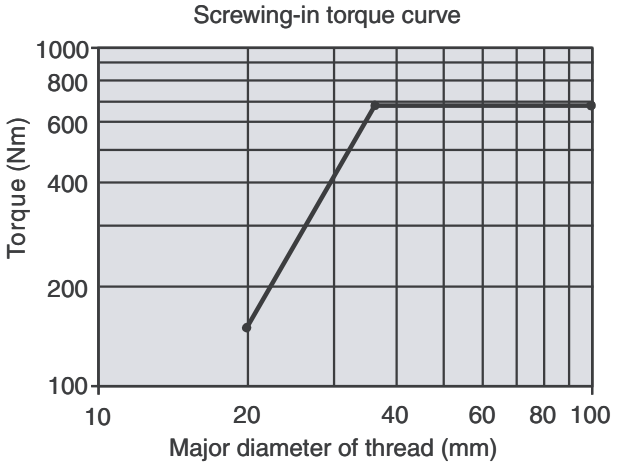
Screwing-in

Screwing-in of studs.

The intention of this procedure is to ensure that the studs are screwed right to the bottom of the threaded holes.

Carefully clean off any burrs and loose particles from the thread and contact faces, and coat the thread with a lubricant having a particle size of approx. 0.5 µm, for instance MoS_2 (molybdenum disulphide) or a non-synthetic graphite mixed with oil.

The studs are to be screwed-in applying the torque specified in the instruction procedure in use. If nothing is mentioned in the instruction procedure, the figure below indicates the torque. For thread sizes > M36 the curve indicates a screwing-in torque of 680 Nm



7665-0201-0001C04

2008-11-05 - en

Preparing

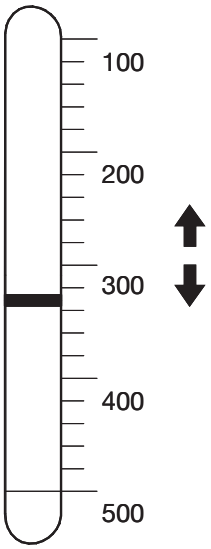
Before screwing the nuts on, the threads and the contact faces should be greased with a mixture of graphite and oil or molybdenum disulphide with a friction coefficient μ = 0.1-0.12 (e.g. MOLYKOTE paste type G).

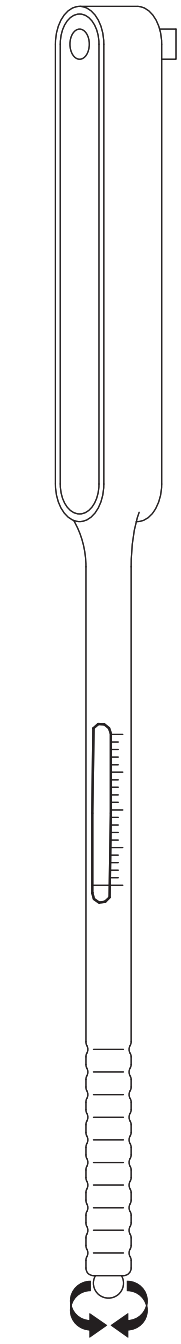
The nuts should fit easily on the thread, and it should be checked that they bear on the entire contact face.

In the case of new nuts and studs, the nuts are to be tightened and loosened two or three times so that the thread may assume its definite shape; thus obviating the risk of loose nuts.

Nuts secured with a split pin are to be tightened to the stated torque and then to the next split-pin hole.

The torque spanner must not be used for torques higher than those stamped on it, and it must not be damaged by hammering on it or the like.





7665-0301-0001C01

Rahsol Torque Spanner

The handle of the torque spanner is provided with a scale indicating the torques at which the spanner can be set.

For setting the spanner at the required torque, there is a ball on a small arm at the end of the handle.

When the ball is pulled, a small crank handle appears. A spring-loaded slide in the handle is provided with a mark which, when the crank handle is turned, can be set at the required torque on the scale. The torque spanner works as follows:

The above-mentioned spring acts on a pawl system in the handle. When the pre-set torque has been reached, the pawl system is released, at which moment a small jerk is felt in the spanner, and a small click is heard.

When the torque spanner is not in use, the spring inside should be released by adjusting to minimum torque.

2008-11-11 - en

Preparations

Before screwing on the nuts, grease the threads and the contact faces with a mixture of graphite and oil or molybdenum disulphide with a friction coefficient.

μ = 0.1-0.12 (e.g. MOLYKOTE paste type G)

The nuts should fit easily on the thread, and it should be checked that they bear on the entire contact face.

Pre-tightening with a torque spanner

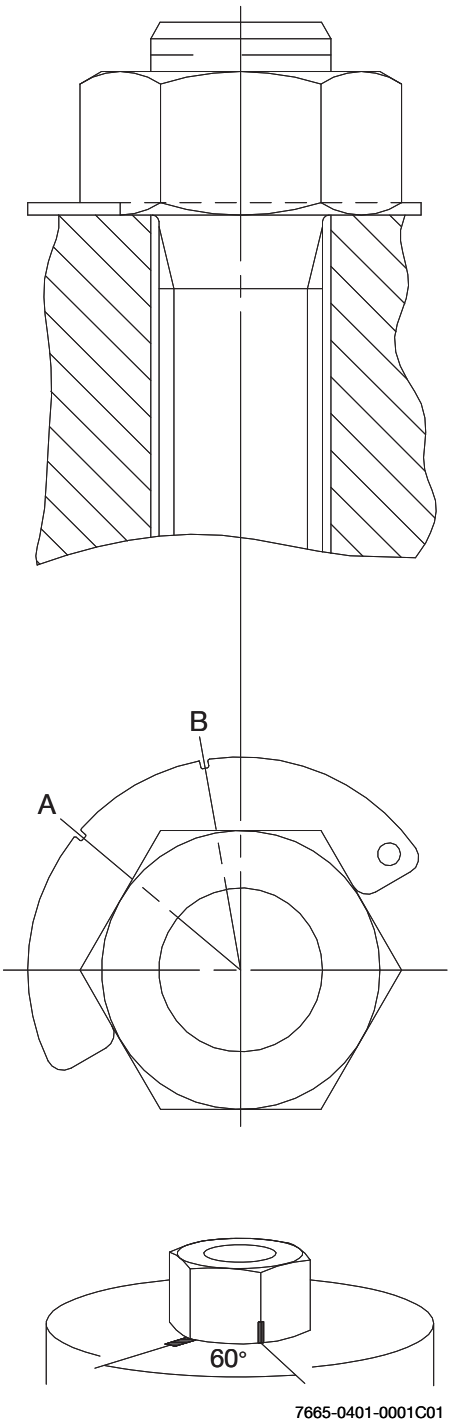
Before tightening the nuts according to a tightening gauge or tightening angle, they must be pre-tightened with a torque spanner.
See Workcard 7665-0301.

Apply a pre-tightening torque of:
- thread M8 - M20 = 50 Nm
- thread M22 - M27 = 100 Nm
- thread M30 - M39 = 150 Nm
- thread M42 - M48 = 200 Nm

This is in order to ensure a uniform basis for the subsequent tightening with gauge or tightening angle.

Tightening with a tightening gauge

After pre-tightening, place the tightening gauge round the nut, and mark off with chalk on the nut at slot **A** on the tightening gauge, and make another chalk mark on the contact face at slot **B**. Then tighten the nut until the two chalk marks coincide.



7665-0401-0001C01

2008-10-16 - en

Tightening without a tightening gauge

For tightening angles of e.g. 30°-45° and 60°, we usually do not deliver a tightening gauge. Therefore, after pre-tightening, mark the angle on a corner of the nut and on the contact face, respectively. Then tighten the nut until the two marks coincide.

When tightening new studs or bolts for the first time, loosen again and repeat the procedure -including pre-tightening with a torque spanner, to allow the parts to settle.

2008-10-16 - en

Locking Devices

Some screwed and bolted connections on the engine, as well as some movable joints, are secured against untimely loosening by means of different types of locking devices.

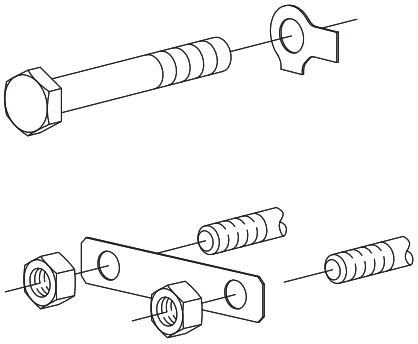
When reassembling the engine after overhauls, it is vital that all such screws and nuts are again locked correctly.

NOTE

Make sure only to mount locking devices on nuts and screws which have been mounted with locking devices by the engine manufacturer.

Lock Washers

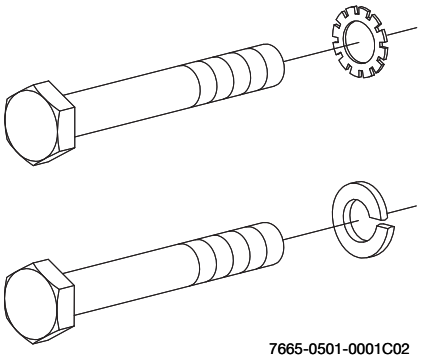
Lock washers, tab washers, locking plates, etc., must always be replaced. The tab-like projections, etc., on the washers are to be bent back over one of the flats of the screw or nut concerned.



7665-0501-0001C01

Spring Washers

Used spring washers must be replaced.

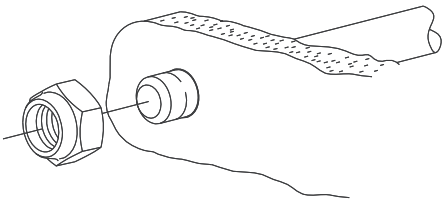


7665-0501-0001C02

Self-Locking nuts

Self-locking nuts may only be used five times. Therefore, give the nut a centre punch mark each time it is loosened.

To tighten a self-locking nut to a specific torque, first measure the torque required to turn the nut itself, and then add this torque to the torque value stated on the data sheet of a procedure.



7665-0501-0001C03

2008-11-04 - en

Locking wire

Locking wire should be fitted after the screws or nuts have been tightened to the correct torque. Do not overtighten or loosen the units to get a correct alignment of the wire holes. Always fit new wire after tightening-up the units.

Any tendency of the screws or nuts to loosen will be counteracted by a tightening of the locking wire. Do not secure more than four units in a series, unless otherwise specified.

Fig 1 Insert wire, grasp the upper end of the wire and bend it around the head of the screw, then under the other end of the wire, be sure that the wire is tight around the head.

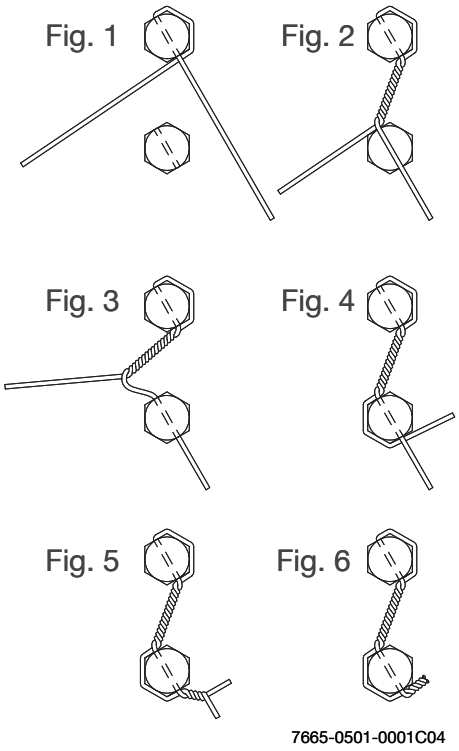
Fig. 2 Twist the wire clockwise until it is just short of the hole in the second screw. Keeping the wire under tension, twist it until tight. When the wire is tight, the wire shall have approximately 7-10 twists per 25 mm. One twist is a twist of the wires through an arc of 180°, equal to half of a complete turn.

Fig. 3 Insert the uppermost wire in the second screw, and pull it tight.

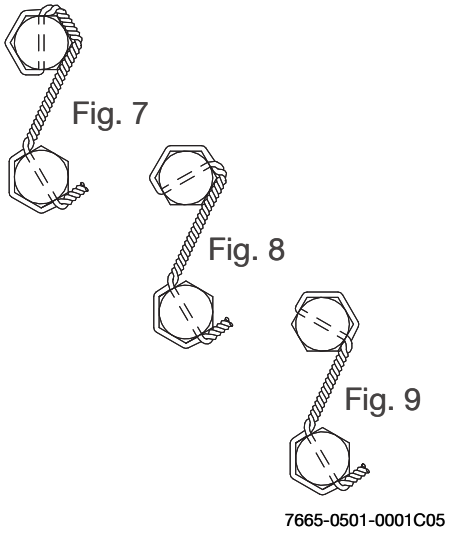
Fig. 4 Bend the lower wire around the screw, and under the end protruding from the screw.

Fig. 5 Keeping the wire under tension, twist it min. 3 twists, counterclockwise until tight.

Fig 6 During the final twisting motion, bend the wire along the screw head. Cut off excess wire.



Figs. 7-9 Show the preferred ways of mounting the locking wire on screws with wire holes oriented in different angles.



2008-11-04 - en

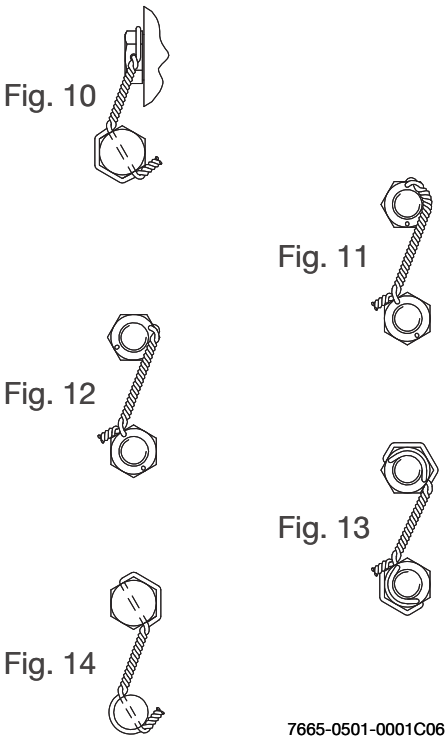
Fig. 10 Shows how to route the locking wire on screws in different planes.

Fig. 11 Wire that passes over the top of a nut is an acceptable alternative only if it routes around the protruding screw thread.

Fig. 12 Wire that passes over the top of a nut is also an acceptable alternative if the hole is located as shown in the figure.

Fig. 13 Where drilling of locking wire holes has caused a thin wall section, route the wire as shown in the figure, to prevent damage to the nut.

Fig. 14 Locking wire can be mounted to any other part of the assembly if nothing else is possible.

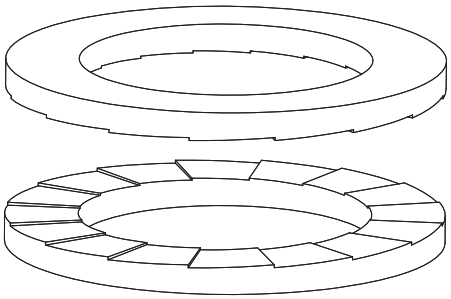


7665-0501-0001C06

Cam Lock Washers Cam lock washers with rising cams on one side and radial teeth on the other.

Fig. 15 The washers are installed in pairs, cam face to cam face. When the bolt and/or nut is tightened the teeth grip and seat the mating surfaces. The cam lock washer is locked in place, allowing movement only across the face of the cams. Any attempt from the bolt/nut to rotate loose is blocked by the wedge effect on the cams.

Fig. 15



7665-0501-0001C07

Fig. 16 Different uses of the cam lock washers.

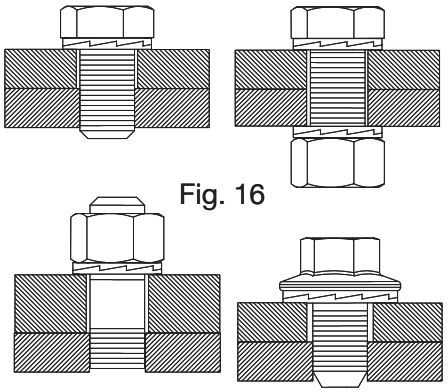
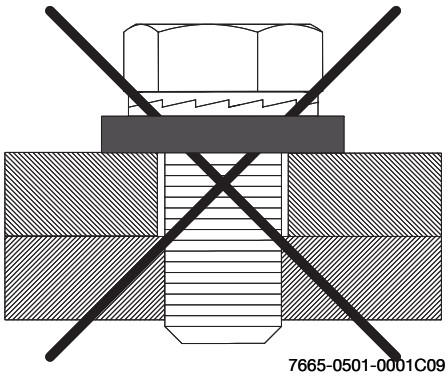


Fig. 16

7665-0501-0001C08

Fig. 17 Don not use the cam lock washers in conjunction with other loose washers.

Fig. 17



7665-0501-0001C09

NOTE

Cam lock washers must be installed in pairs and are not to be substituted by other types of washers.

Before Checking and Overhaul Procedures

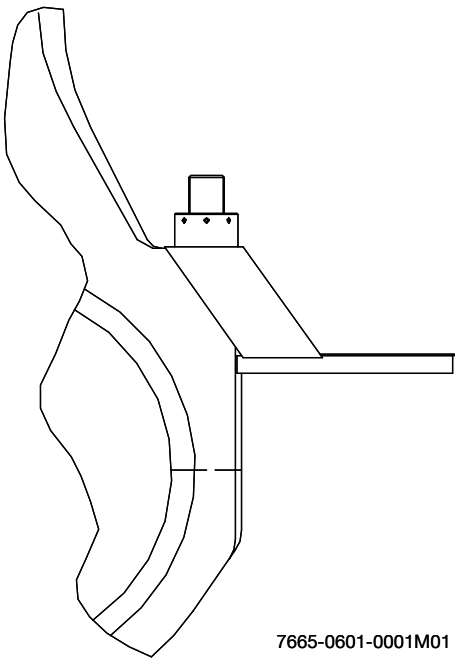
Before carrying out the checking and overhaul procedures underlined below in Items 1, 2 and 4, platform boards should be mounted inside the engine crankcase.

During mounting of the platforms, always use the harness, lanyard and fall arrester. It is always recommended to clean and wipe off oil from steps, crankthrow, doorways and assembling surfaces.

The platform boards are placed inside the engine as shown in the following.

Checking the crankshaft alignment, using an Autolog

Turn the engine into a position where it is possible to place the ladder on the crankpin bearing stud nuts.

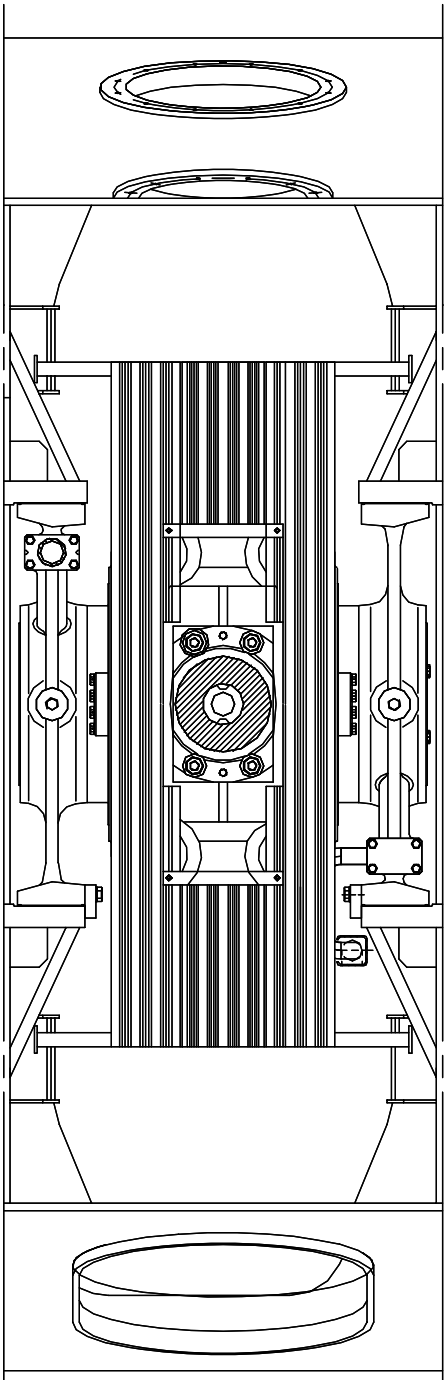


7665-0601-0001M01

2008-12-16 - en

Piston rod stuffing box and telescopic pipe

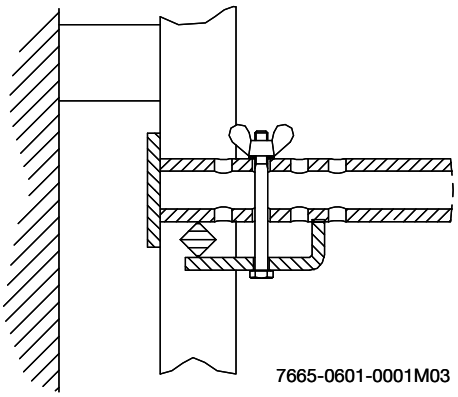
Put in the standard platform board as a floor as shown on the sketch. Turn the engine to BDC. Mount the platform board from the exhaust side of the engine as shown.



7665-0601-0001M02

Mounting of the working platform support

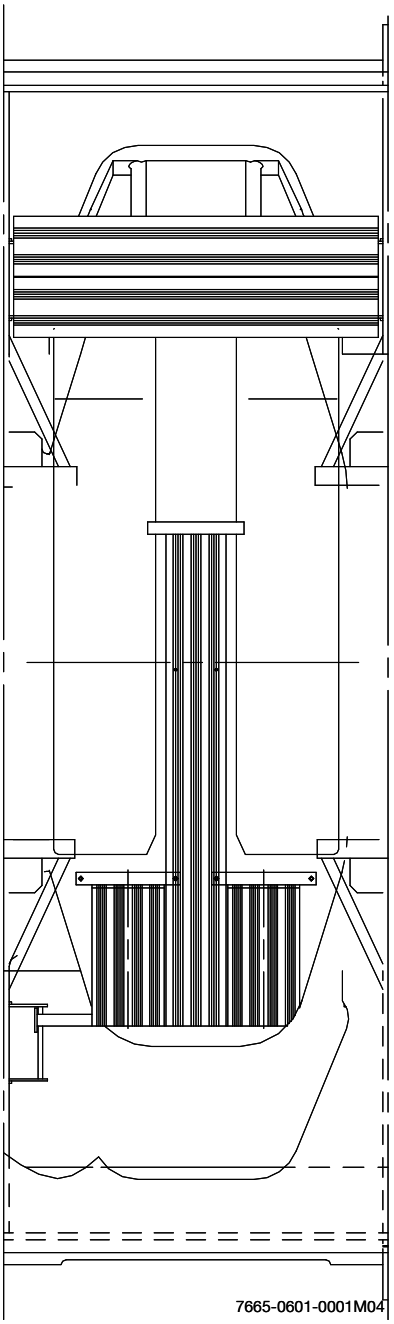
The working platform support is mounted as shown in sketch 7665-0601-0001M03.



7665-0601-0001M03

Main bearing dismantling

Turn the engine to 80° after TDC. Mount the platform support in a longitudinal direction on the steps in the bedplate.



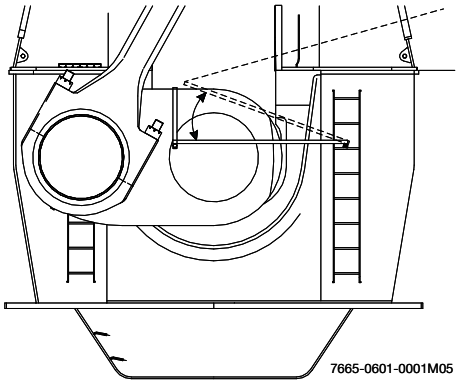
7665-0601-0001M04

2008-12-16 - en

Mount the longest platform board

Mount the longest platform board, with the ladder attached, on the support and, by means of a rope, lower the platform support ladder into place on the crankthrow.

The double platform board can now be placed on the support and the long platform board.



NOTE

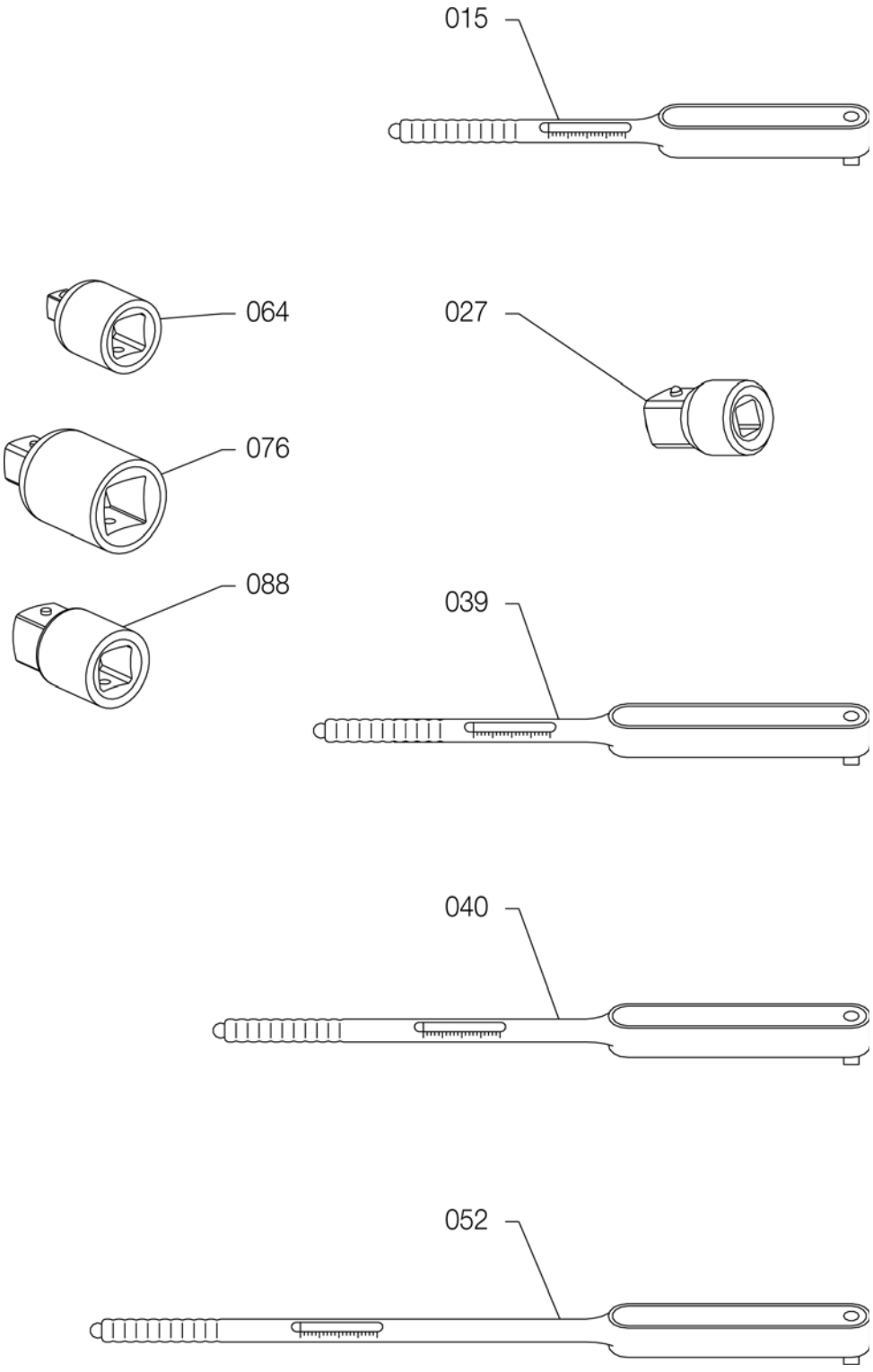
Always remember to remove the platform boards on completion of each working procedure or before turning the engine.

Molybdenum Disulphide (MoS_2)

The following procedure is to be followed prior to the mounting of metal surfaced parts which are to function as seals.

- Clean the surface with a cleaning fluid and ensure that the entire surface is completely free of grease.
- Allow 5 minutes for the cleaning fluid to evaporate.
- With a clean leathercloth, and using circular movements, rub a mixture of finegrained particles of Molybdenum Disulphide (MoS_2) and mineral oil (e.g. Moly-cote G-n Plus, or the like) hard onto the metal surface.
- Remove any excessive paste and ensure that the metal surface is only coated with a thin, uniform, layer of the above mixture.
- Protect the wet paste and cloth from dust or other foreign particles.

2008-10-13 - en



Torque Spanners

Plate 7670-0200-0004

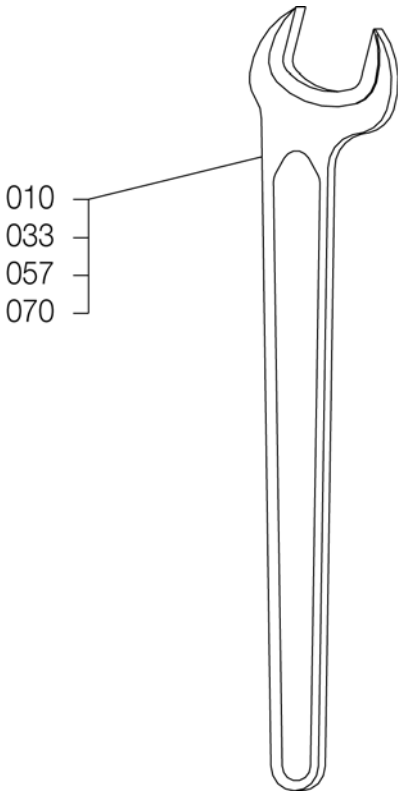
2012-11-23 - en

Torque Spanners

Plate 7670-0200-0004

Item no	Qty	Designation
015	-	Torque wrench, 8-40Nm
027	-	Adapter for socket wrench, 12.5/10
039	-	Torque wrench, 40-200Nm
040	-	Torque wrench, 140-760Nm
052	-	Torque wrench, 750-2000Nm
064	-	Adapter for socket wrench, 12.5/20
076	-	Adapter for socket wrench, 20.0/25
088	-	Adapter for socket wrench, 25.0/20

2012-11-23 - en



Open-Ended Spanners

Plate 7670-0210-0004

2010-06-17 - en

Open-Ended Spanners

Plate 7670-0210-0004

Item no	Qty	Designation
010	-	Open-ended spanner, size 65mm
033	-	Open-ended spanner, size 75mm
057	-	Open-ended spanner, size 85mm
070	-	Open-ended spanner, size 95mm

2010-06-17 - en

Open Ended Slugging Spanners

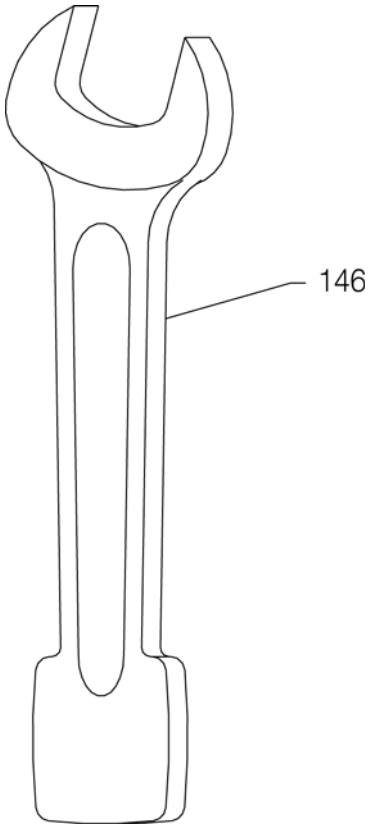


Plate 7670-0220-0002

2010-06-17 - en

Open Ended Slugging Spanners

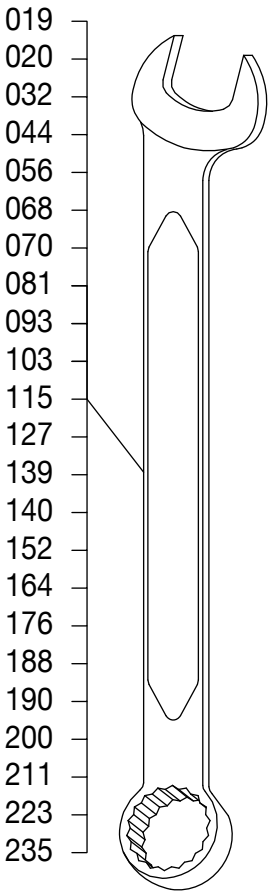
Item no	Qty	Designation
146	-	Open-ended slugging spanner, size 95mm

Plate 7670-0220-0002

2010-06-17 - en

Combination Spanner

Plate 7670-0230-0001.0



Combination Spanner

Plate 7670-0230-0001.0

Item no	Qty	Designation
019	-	Combination spanner, size 10mm
020	-	Combination spanner, size 11mm
032	-	Combination spanner, size 12mm
044	-	Combination spanner, size 13mm
056	-	Combination spanner, size 14mm
068	-	Combination spanner, size 15mm
070	-	Combination spanner, size 16mm
081	-	Combination spanner, size 17mm
093	-	Combination spanner, size 18mm
103	-	Combination spanner, size 19mm
115	-	Combination spanner, size 21mm
127	-	Combination spanner, size 22mm
139	-	Combination spanner, size 24mm
140	-	Combination spanner, size 27mm
152	-	Combination spanner, size 30mm
164	-	Combination spanner, size 32mm
176	-	Combination spanner, size 34mm
188	-	Combination spanner, size 36mm
190	-	Combination spanner, size 41mm
200	-	Combination spanner, size 46mm
211	-	Combination spanner, size 50mm
223	-	Combination spanner, size 55mm
235	-	Combination spanner, size 60mm

Ring Slugging Spanner

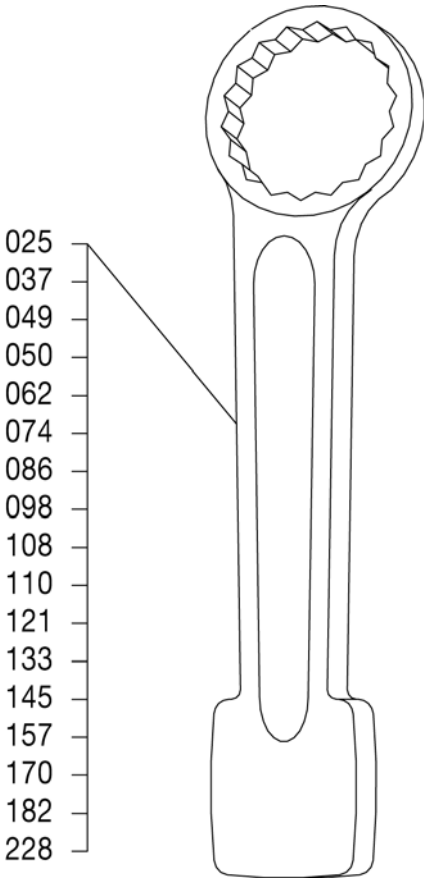


Plate 7670-0240-0003

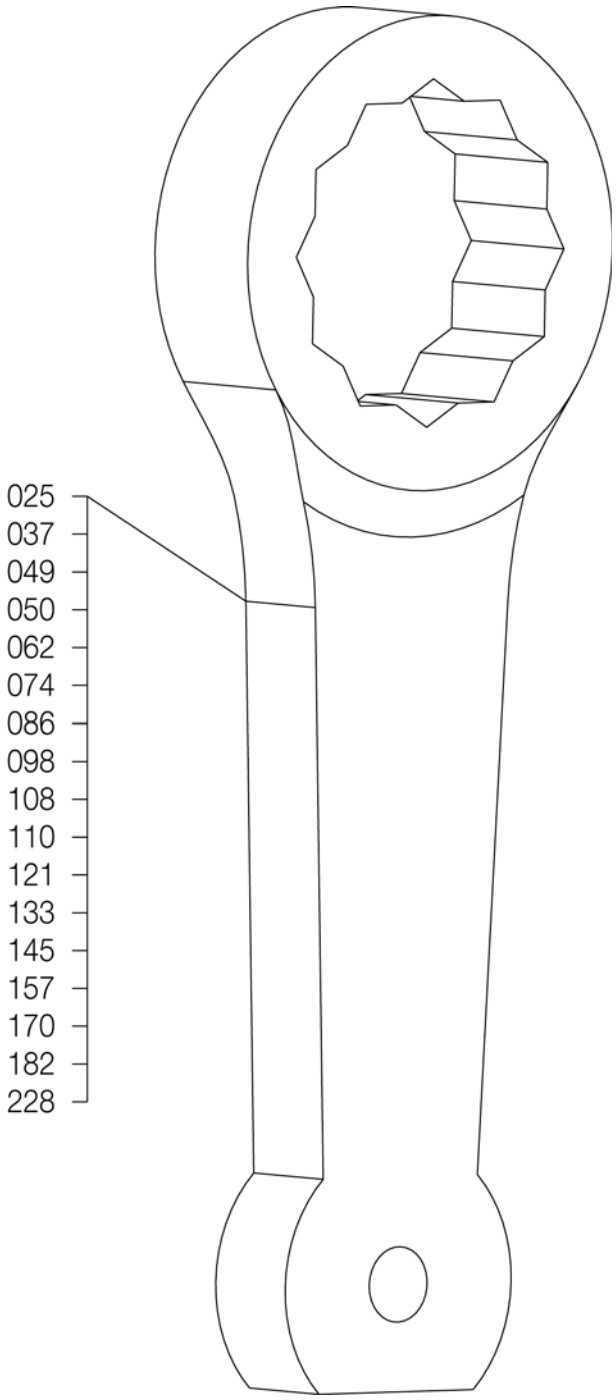
2008-07-24

Ring Slugging Spanner

Plate 7670-0240-0003

Item no	Qty	Designation
025	-	Ring impact spanner, ring size 30mm
037	-	Ring impact spanner, ring size 32mm
049	-	Ring impact spanner, ring size 34mm
050	-	Ring impact spanner, ring size 36mm
062	-	Ring impact spanner, ring size 41mm
074	-	Ring impact spanner, ring size 46mm
086	-	Ring impact spanner, ring size 50mm
098	-	Ring impact spanner, ring size 55mm
108	-	Ring impact spanner, ring size 60mm
110	-	Ring impact spanner, ring size 65mm
121	-	Ring impact spanner, ring size 70mm
133	-	Ring impact spanner, ring size 75mm
145	-	Ring impact spanner, ring size 80mm
157	-	Ring impact spanner, ring size 85mm
170	-	Ring impact spanner, ring size 95mm
182	-	Ring impact spanner, ring size 100mm
228	-	Ring impact spanner, ring size 120mm

2008-07-24



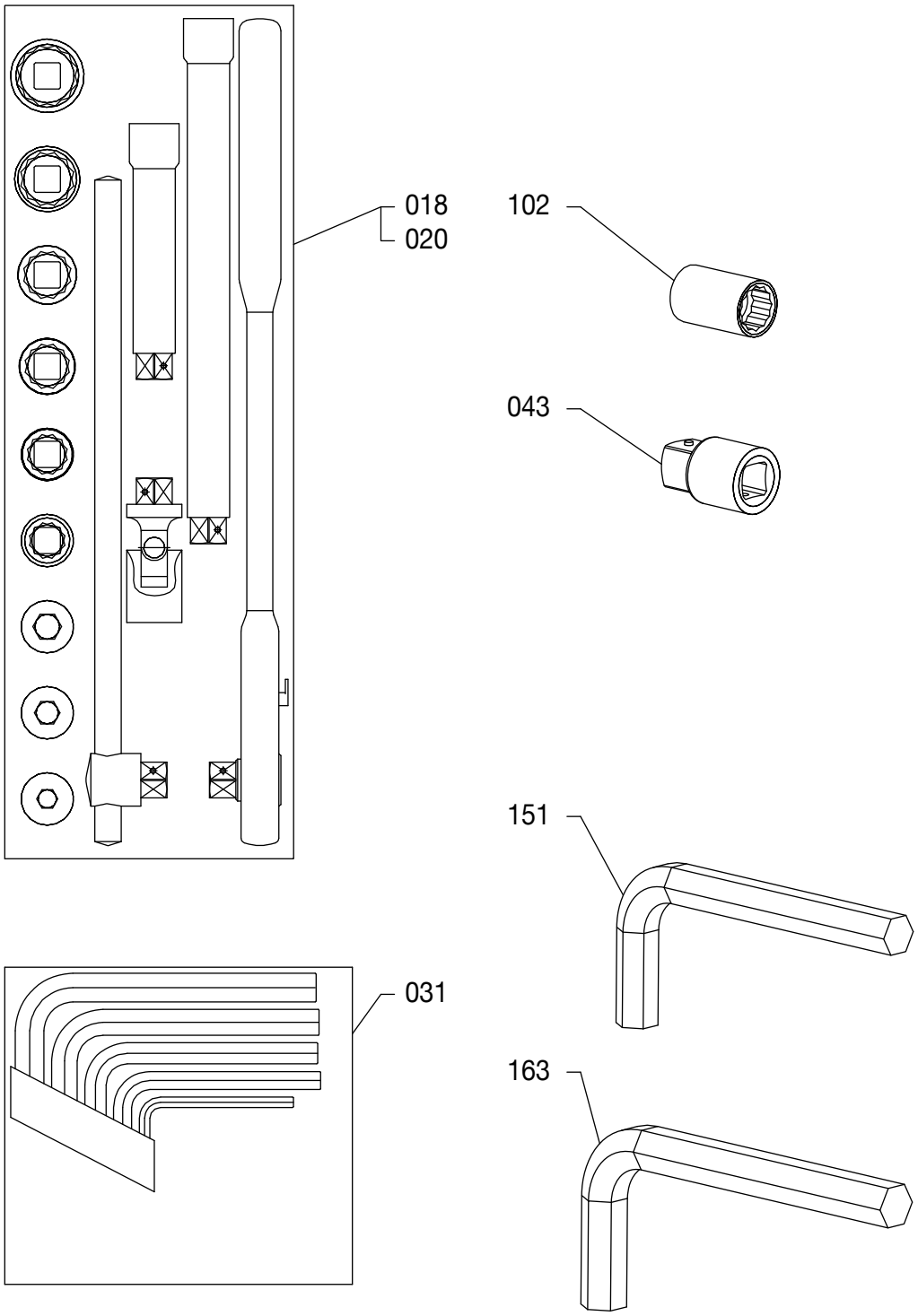
Ring Slugging Spanners

Plate 7670-0240-0009

2013-10-22 - en

Item No.	Qty	Item Designation
025	-	Ring impact spanner,ring size 30mm
037	-	Ring impact spanner,ring size 32mm
049	-	Ring impact spanner,ring size 34mm
050	-	Ring impact spanner,ring size 36mm
062	-	Ring impact spanner,ring size 41mm
074	-	Ring impact spanner,ring size 46mm
086	-	Ring impact spanner,ring size 50mm
098	-	Ring impact spanner,ring size 55mm
108	-	Ring impact spanner,ring size 60mm
110	-	Ring impact spanner,ring size 65mm
121	-	Ring impact spanner,ring size 70mm
133	-	Ring impact spanner,ring size 75mm
145	-	Ring impact spanner,ring size 80mm
157	-	Ring impact spanner,ring size 85mm
170	-	Ring impact spanner,ring size 95mm
182	-	Ring impact spanner,ring size 100mm
228	-	Ring impact spanner,ring size 120mm

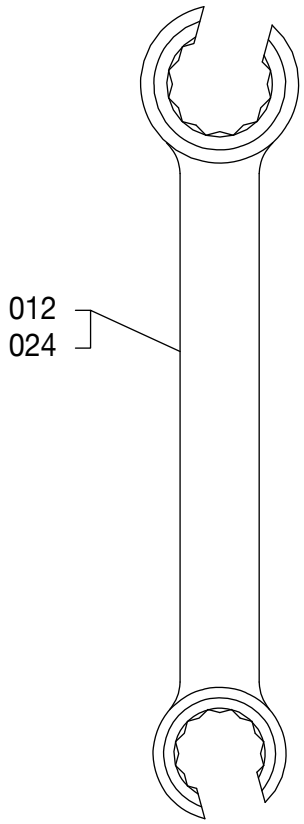
2013-10-22 - en


018
020
102
043
151
031
163

Miscellaneous Spanners

Plate 7670-0250-0001.0

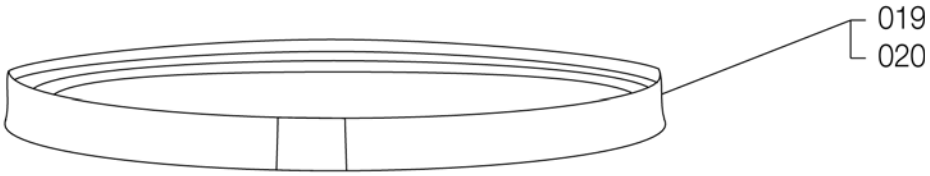
Item no	Qty	Designation
018	-	Tool set, complete, size 10-22mm
020	-	Tool set, complete, size 24-46mm
031	-	Hex key tool set, complete
043	-	Adapter for socket wrench
102	-	Hex key, size 22mm
163	-	Hex key, size 24mm

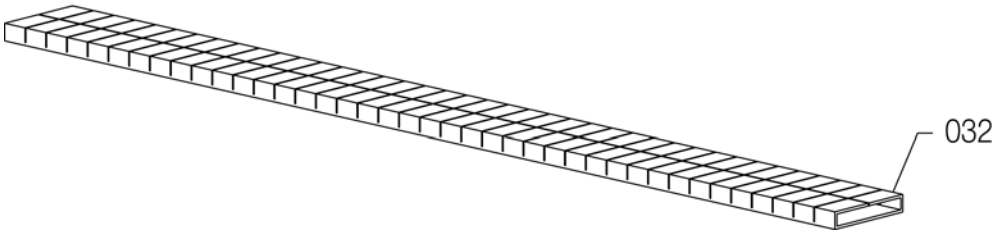

012
024

Open-ended spanners

Plate 7670-0260-0001.0

Item no	Qty	Designation
012	-	Open-ended ring wrench, size 14/17mm
024	-	Open-ended ring wrench, size 19/22mm

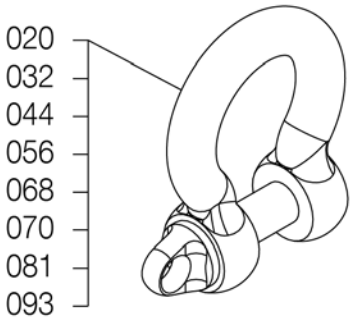


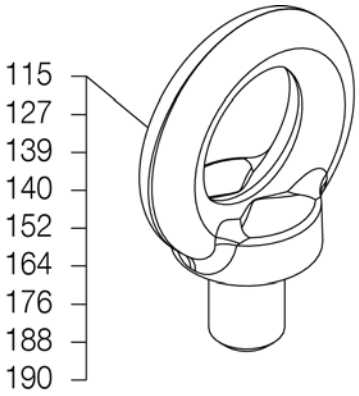


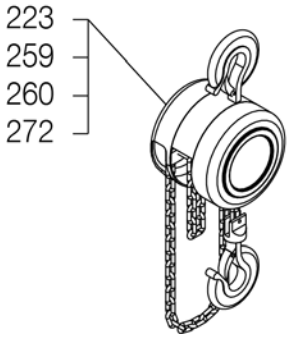
2011-10-31 - en

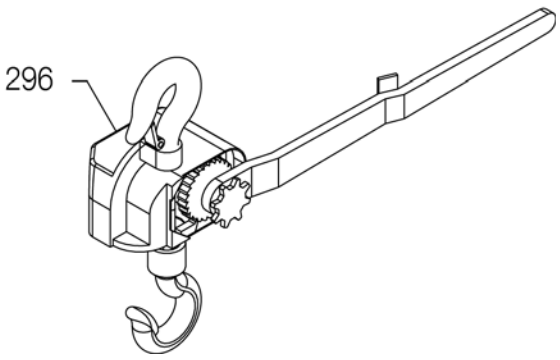
Item no	Qty	Designation
019	-	Roundsling, 7000kg
020	-	Roundsling, 1500kg
032	-	Chafing device for roundslings

2011-10-31 - en


020
032
044
056
068
070
081
093


115
127
139
140
152
164
176
188
190

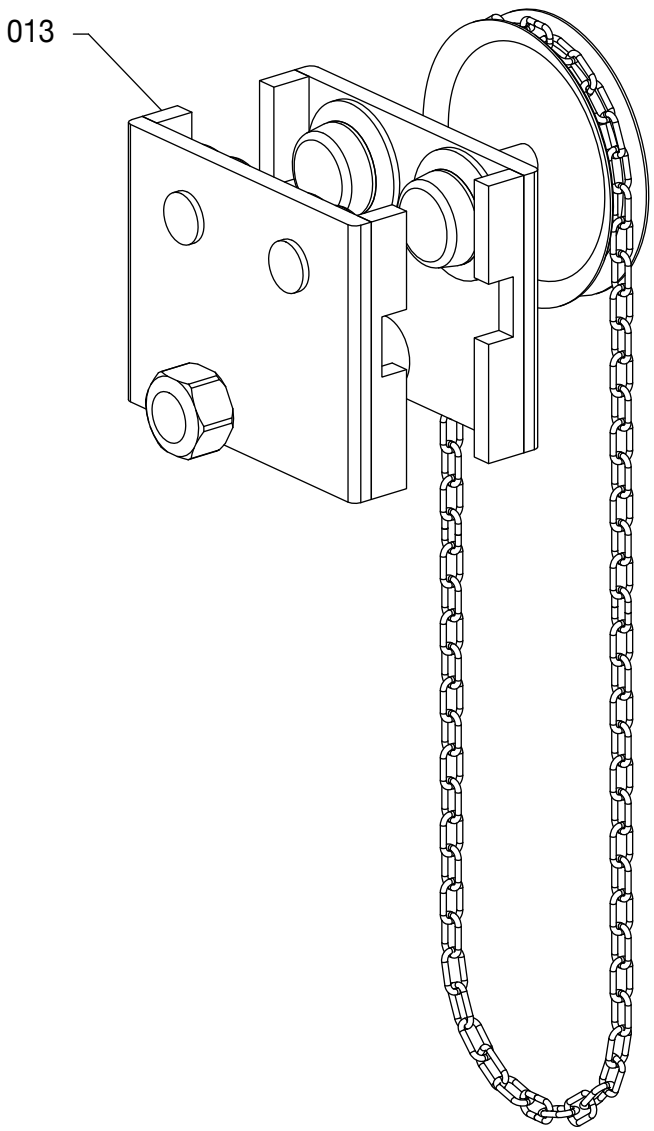

223
259
260
272


296

2013-02-20 - en

Item no	Qty	Designation
020	-	Forged-bent screw shackle, 10mm
032	-	Forged-bent screw shackle, 12mm
044	-	Forged-bent screw shackle, 16mm
056	-	Forged-bent screw shackle, 20mm
068	-	Forged-bent screw shackle, 24mm
070	-	Forged-bent screw shackle, 30mm
081	-	Forged-bent screw shackle, 33mm
093	-	Forged-bent screw shackle, 42mm
115	-	Eye bolt, 10mm
127	-	Eye bolt, 12mm
139	-	Eye bolt, 16mm
140	-	Eye bolt, 20mm
152	-	Eye bolt, 24mm
164	-	Eye bolt, 30mm
176	-	Eye bolt, 36mm
188	-	Eye bolt, 42mm
190	-	Eye bolt, 8mm
223	-	Chain tackle, 1 Ton
259	-	Chain tackle, 3 Tons
260	-	Chain tackle, 5 Tons
272	-	Chain tackle, 8 Tons
296	-	Pull lift, 3 Tons

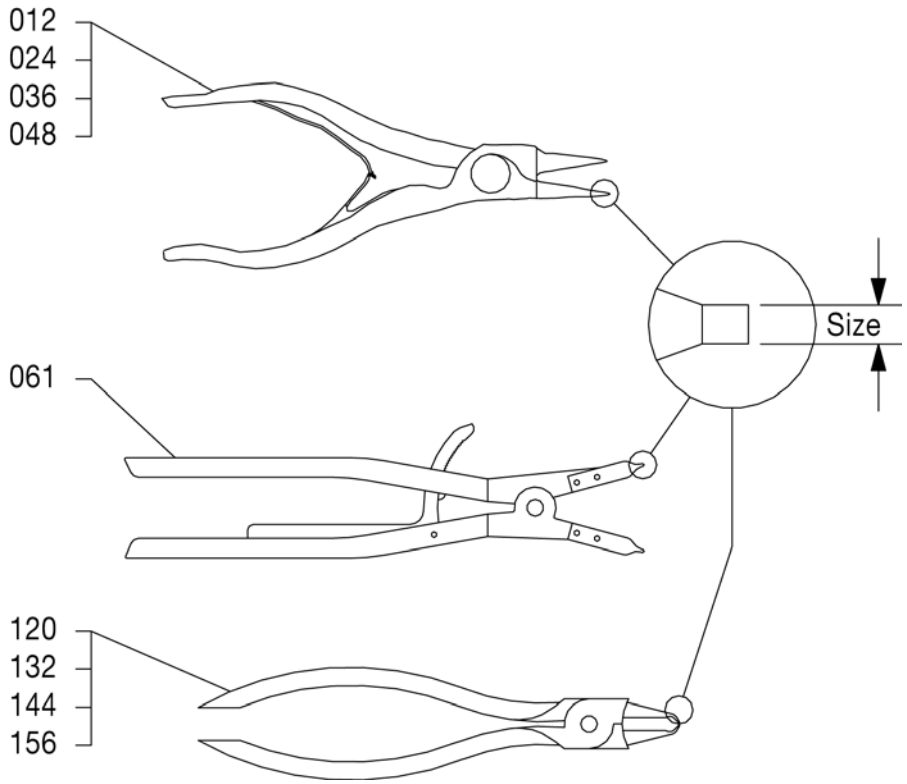
2013-02-20 - en


013

Traveling Trolley

Plate 7670-0310-0001.0

Item no	Qty	Designation
013	-	Travelling Trolley



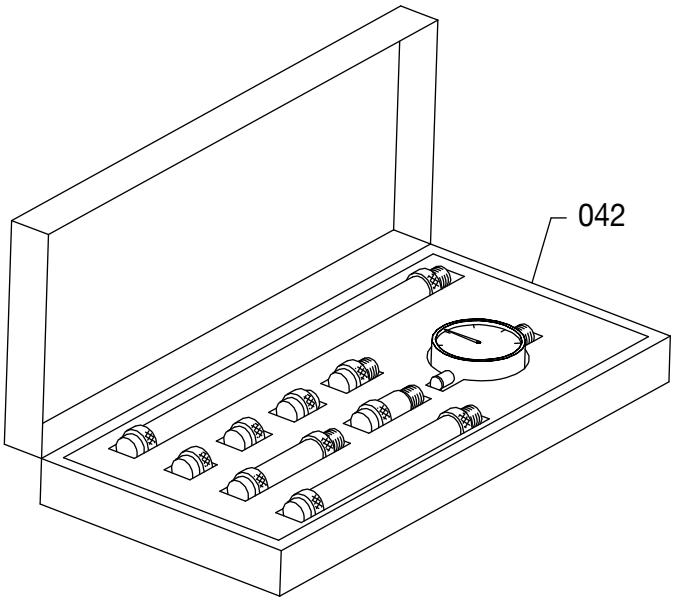
2008-07-25

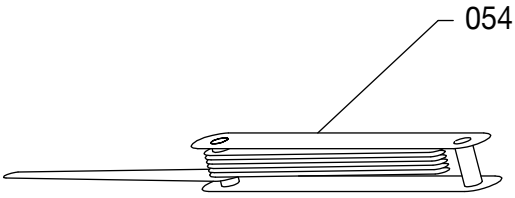
Pliers

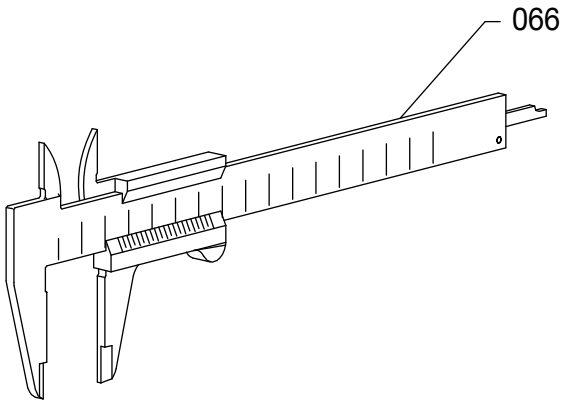
Item no	Qty	Designation
012	-	Pliers for retaining ring, 0.9mm
024	-	Pliers for retaining ring, 1.3mm
036	-	Pliers for retaining ring, 1.8mm
048	-	Pliers for retaining ring, 2.3mm
061	-	Pliers for retaining ring, 3.5mm
120	-	Pliers for retaining ring, 1.1mm
132	-	Pliers for retaining ring, 1.8mm
144	-	Pliers for retaining ring, 2.3mm
156	-	Pliers for retaining ring, 3.2mm

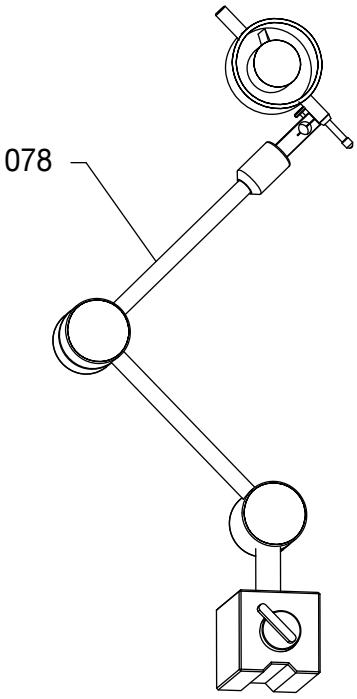
Plate 7670-0400-0002

2008-07-25

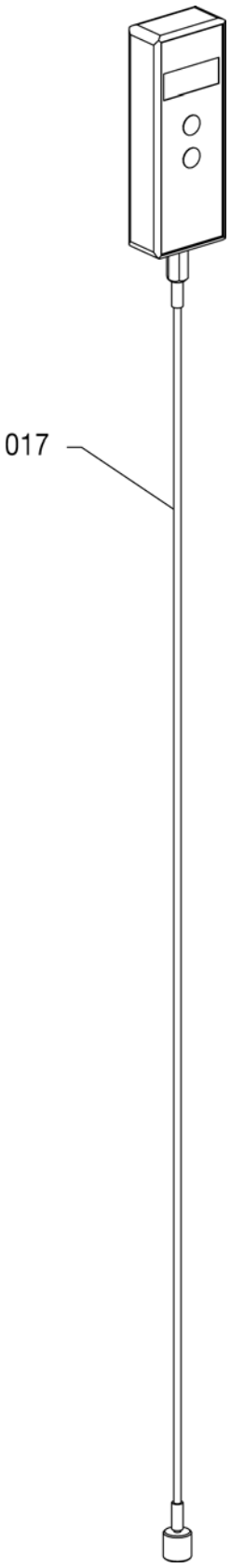

042


054


066


078

Item no	Qty	Designation
042	-	Autolog, measuring tool for crankshaft
054	-	Feeler gauge
066	-	Slide caliper
078	-	Dial gauge and stand tool



Instruments

Plate 7670-0410-0002

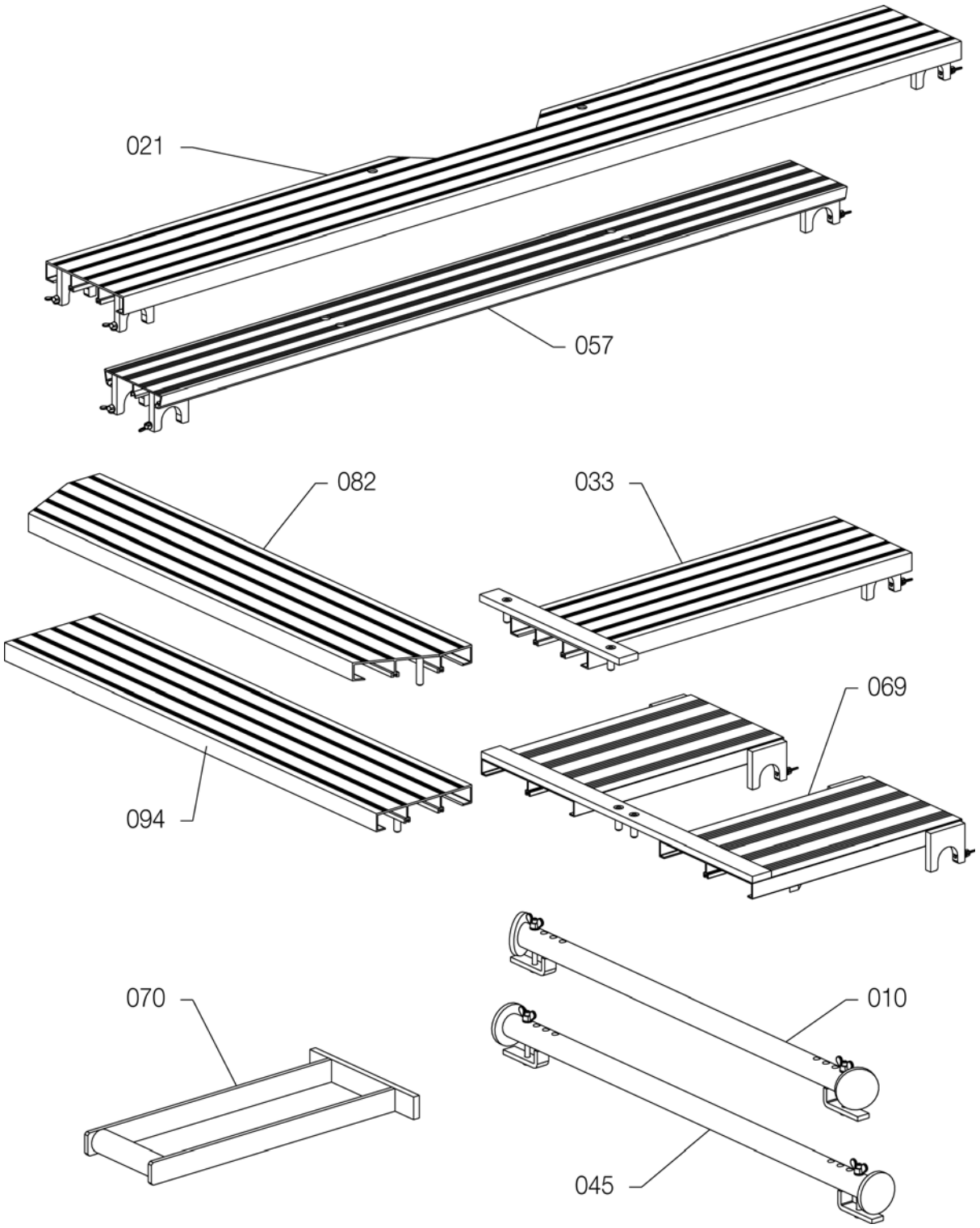
2008-07-25

Instruments

Plate 7670-0410-0002

Item no	Qty	Designation
017	-	Pressure gauge

2008-07-25



Working Platforms

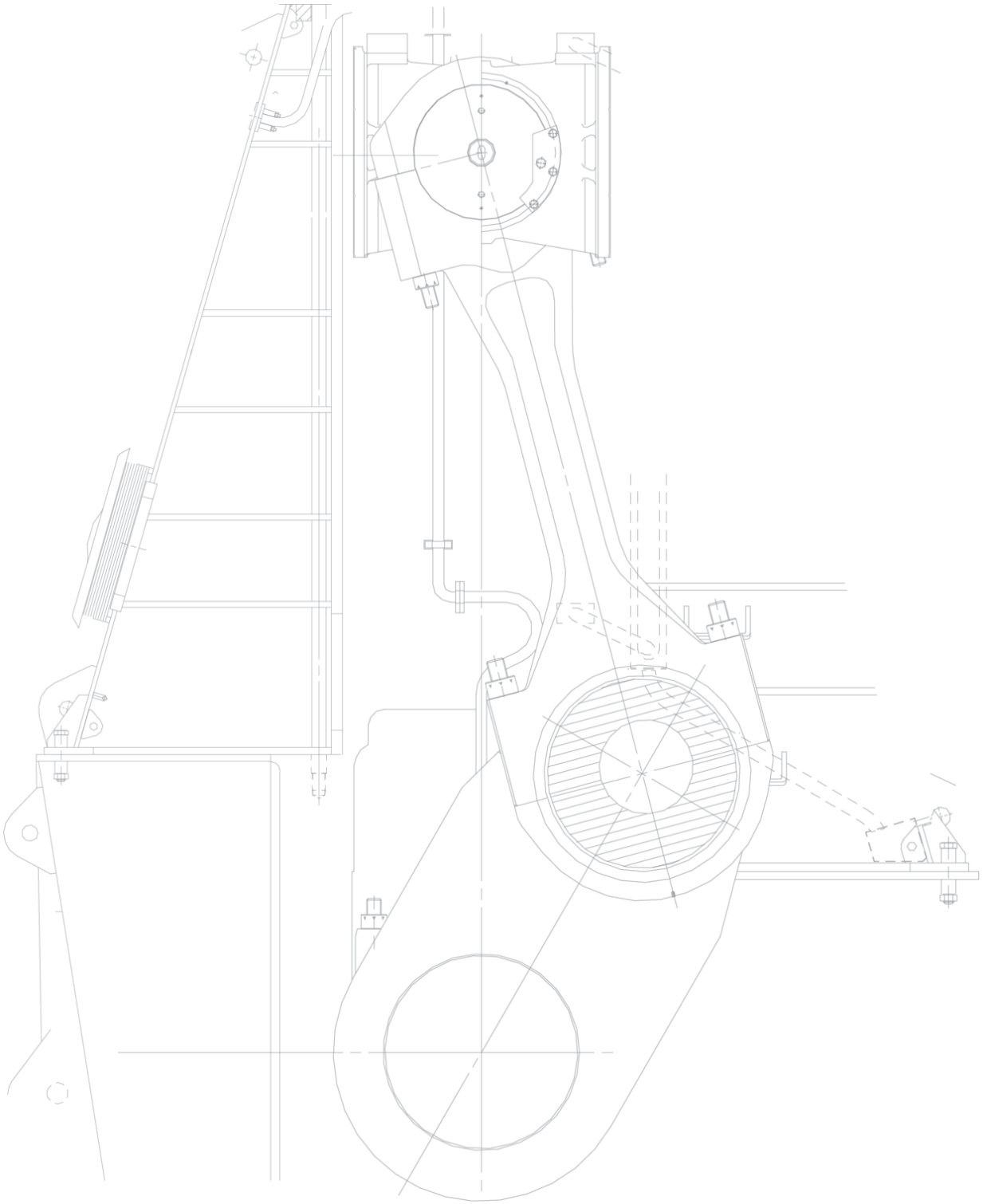
Plate 7670-0600-0008

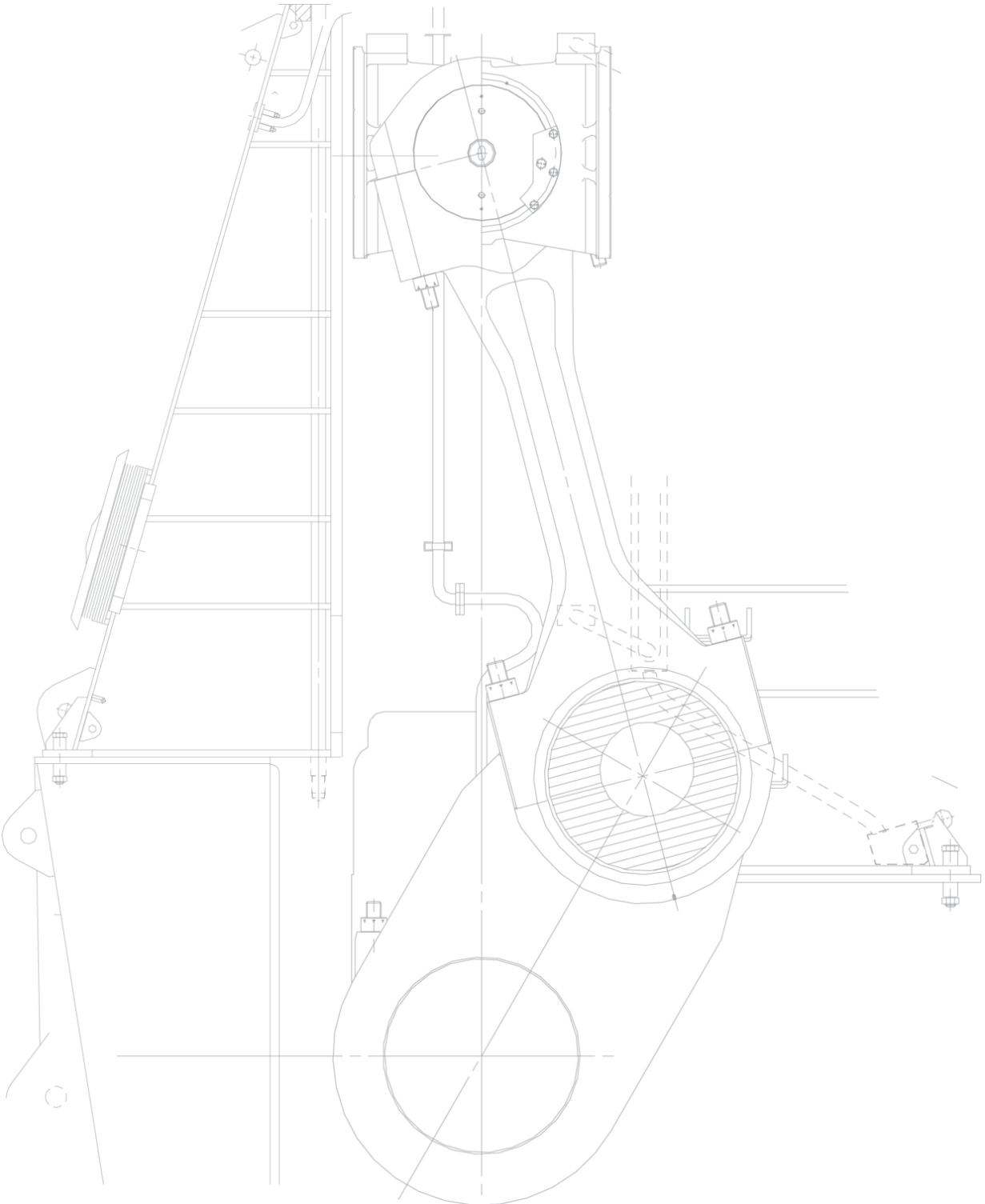
2012-06-14 - en

Item no	Qty	Designation
010	-	Working platform support
021	-	Platform board
033	-	Platform board
045	-	Working platform support
057	-	Platform board
069	-	Platform board
070	-	Working platform support
082	-	Platform board
094	-	Platform board

2012-06-14 - en

Preface Chapter Spare Parts 7940-0100-0002





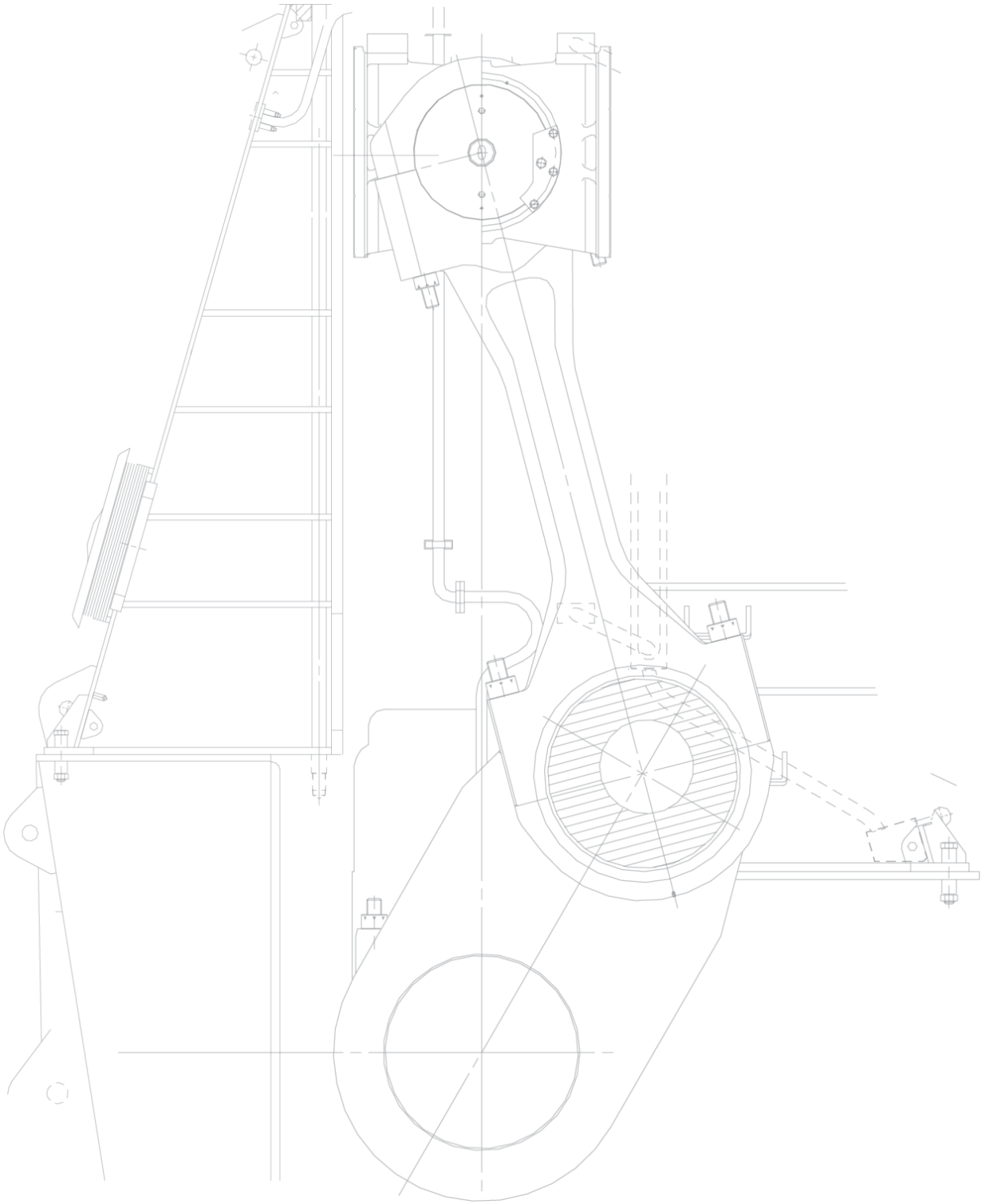
Spare Parts

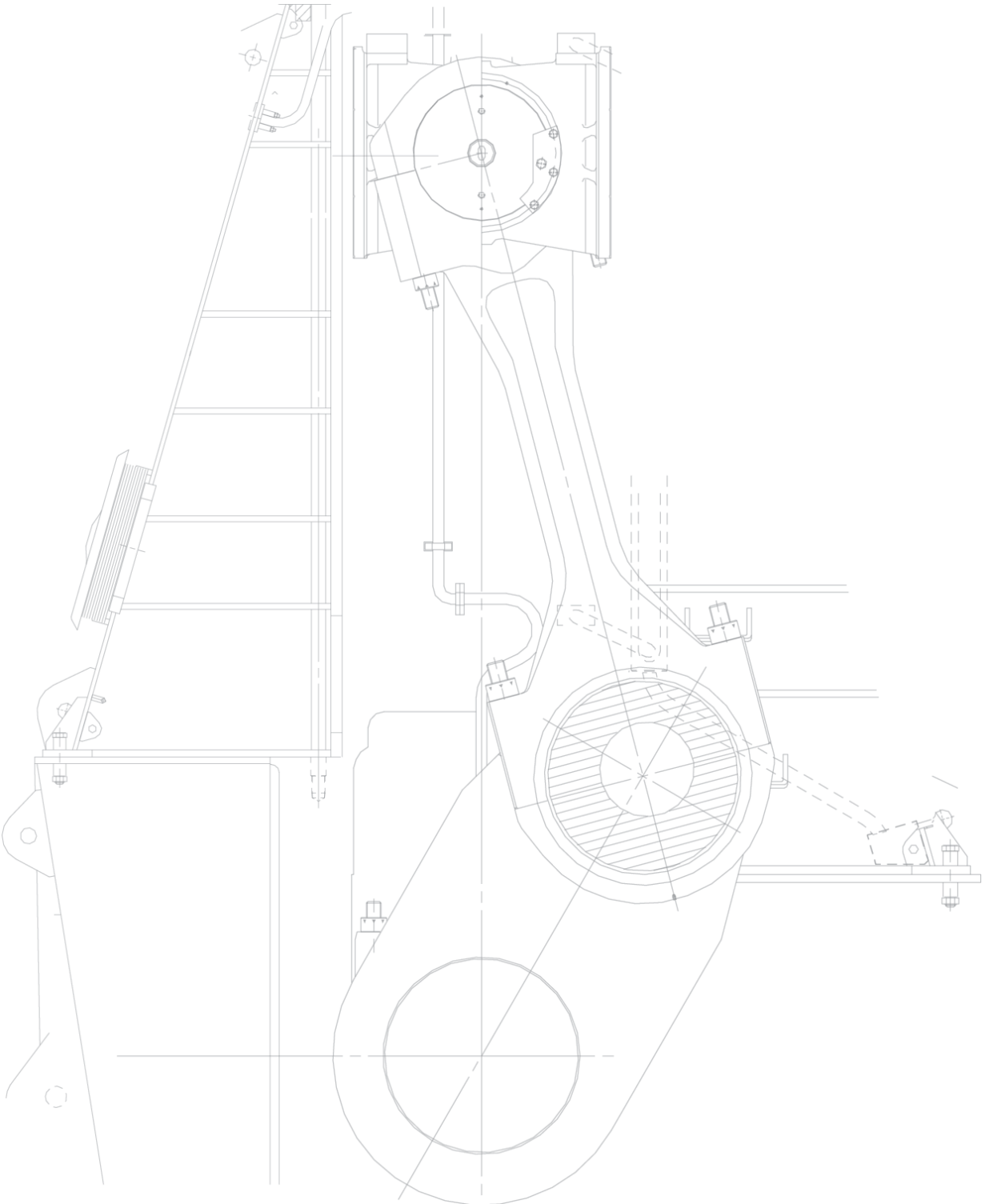
This chapter of the instruction book is intended to provide the user with information regarding spare parts and the ordering of spare parts.

Please not that spare part plates are also found in the back of all relevant chapters of the instruction book.

2009-09-04-en

Preface Chapter Installation 8240-0100-0002



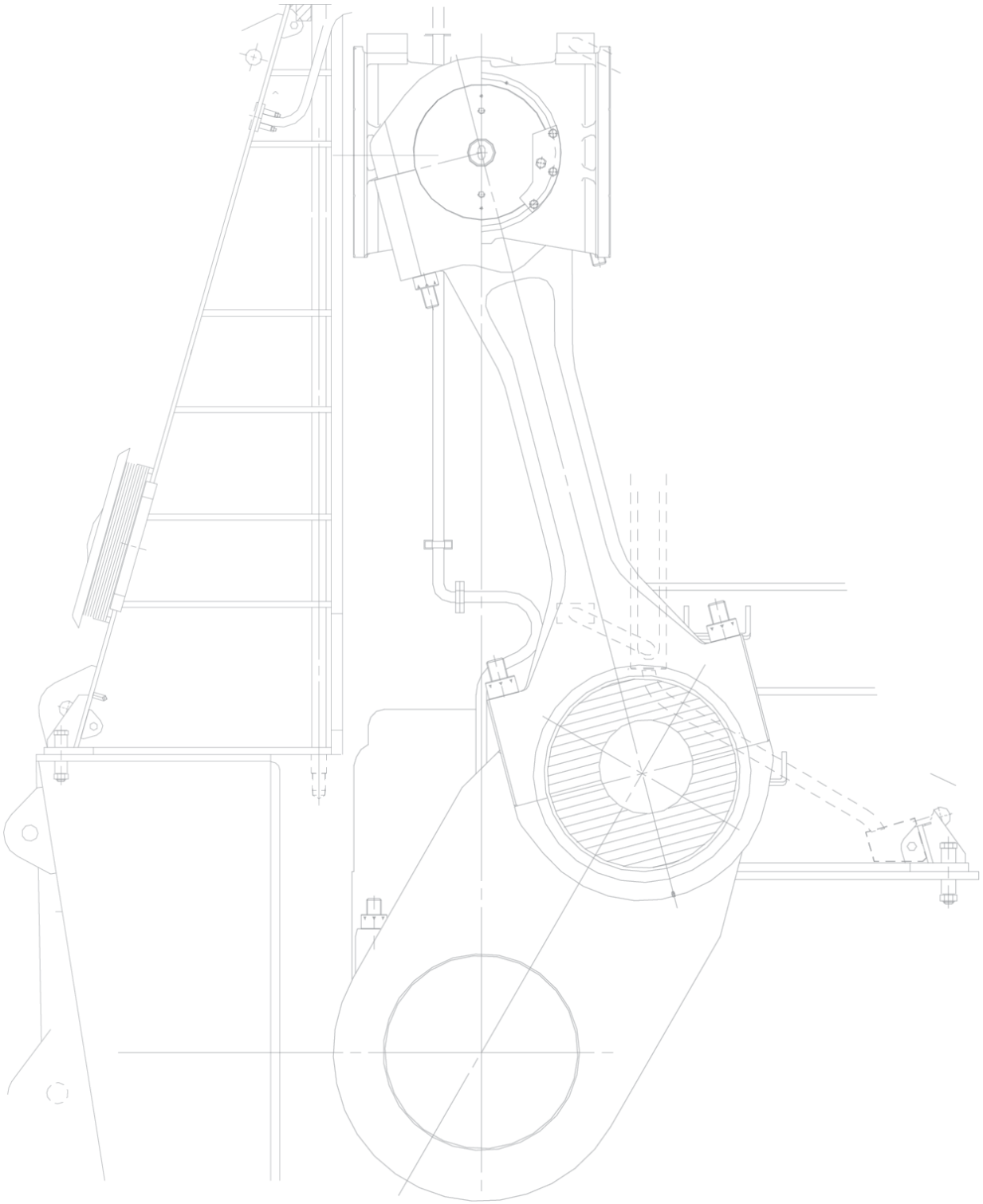


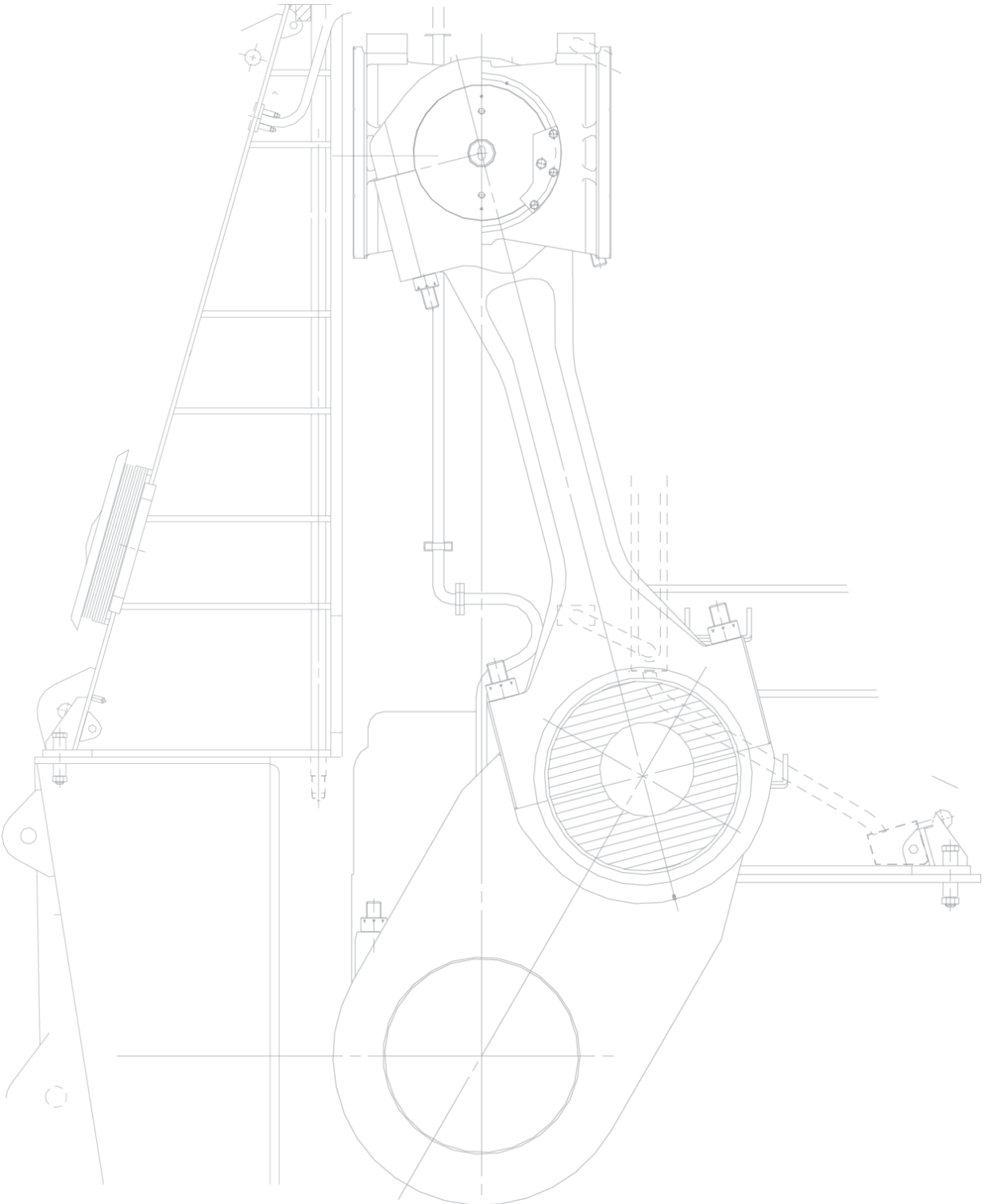
Installation

This chapter of the instruction book is intended for information related to the installation of the engine in the vessel (or power plant).

2009-09-04-en

Preface Chapter Delivery 8540-0100-0002



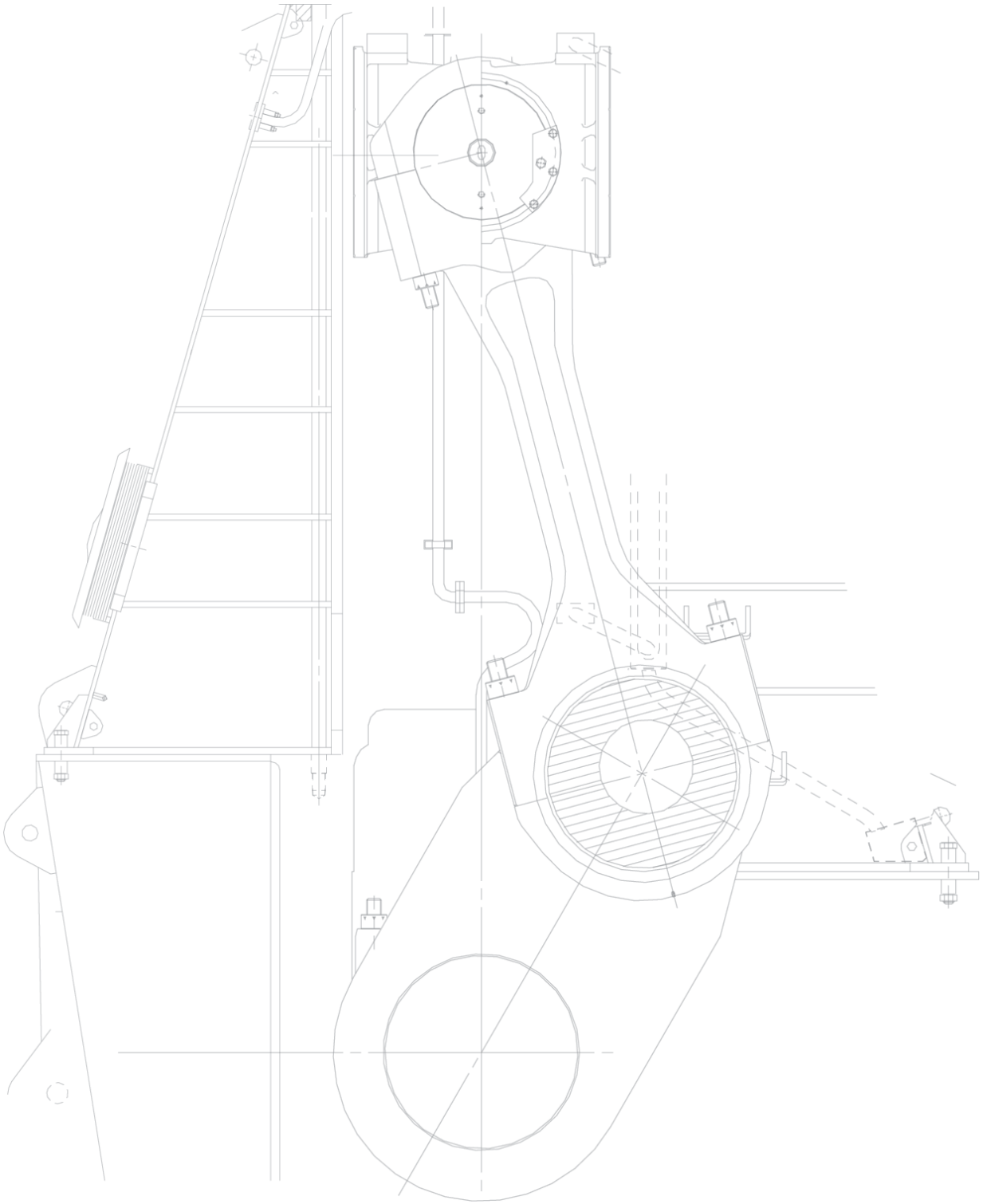


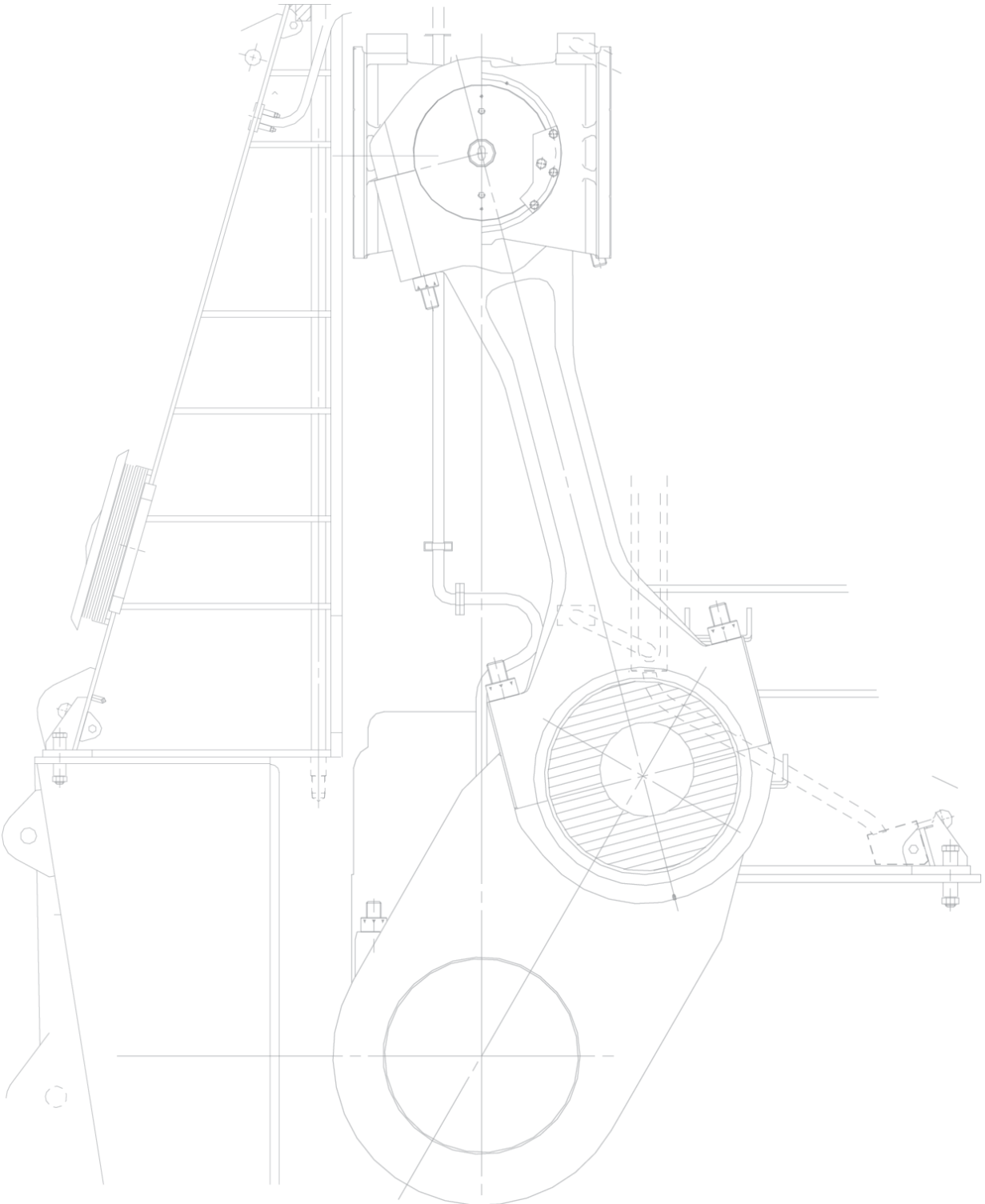
Delivery

This chapter of the instruction book is intended for information related to the delivery of the engine to the ship yard (or power plant).

2009-09-04-en

Preface Chapter Service Info 8840-0100-0002

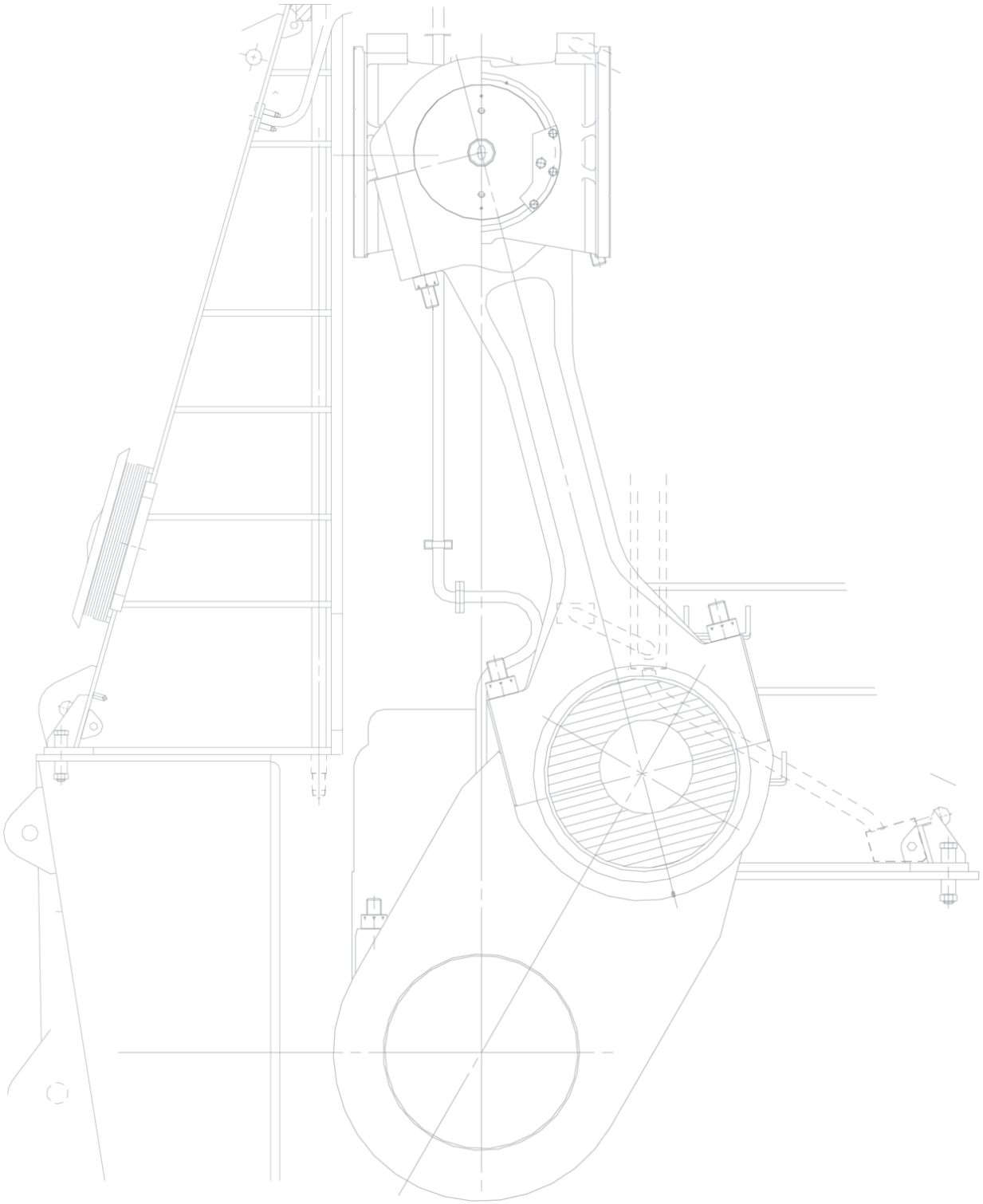


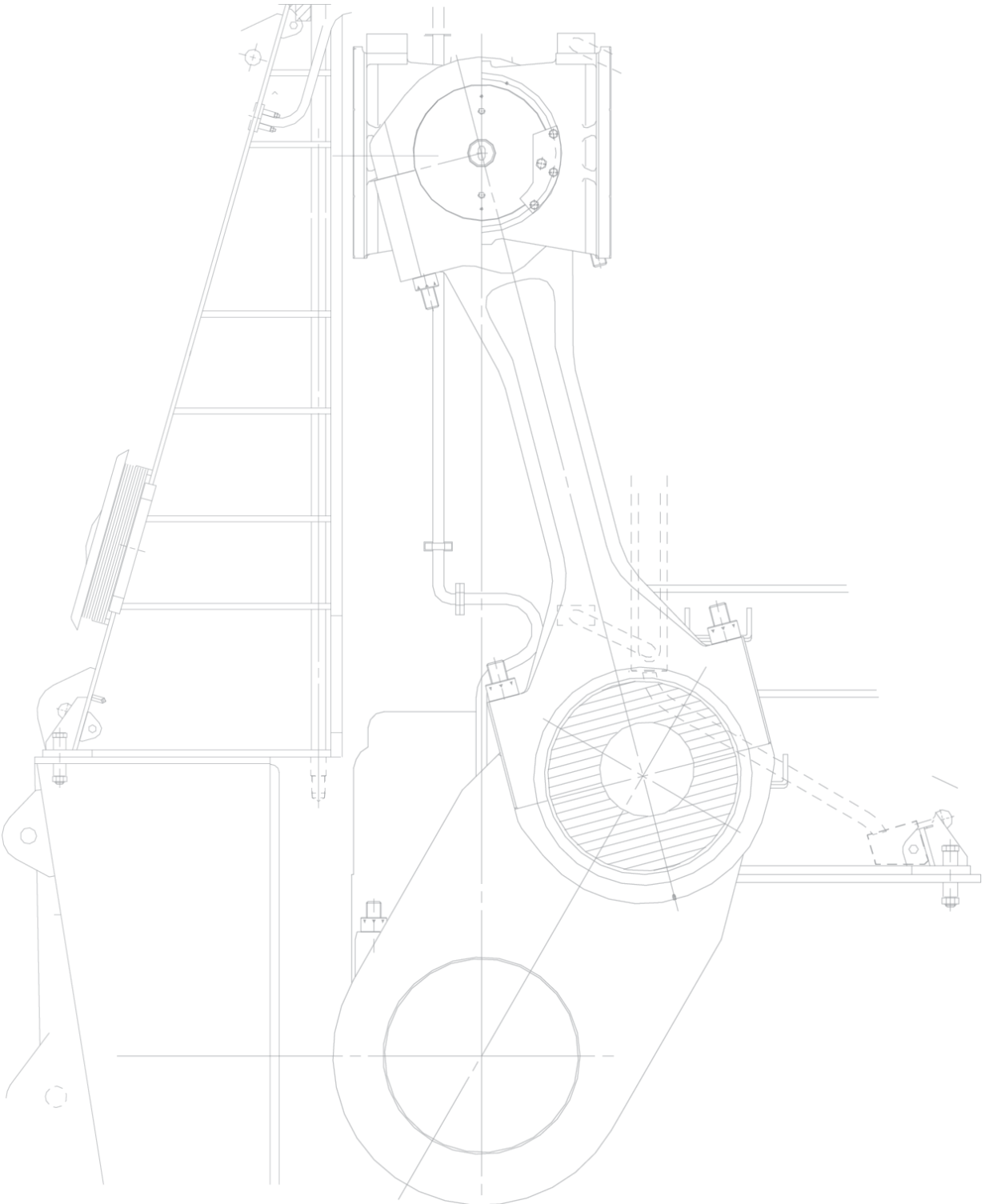


This chapter is intended for service documentation supplied by MAN Diesel after the initial delivery of the engine.

2009-09-04 - en

Preface Chapter Supplier's Info 9140-0100-0002





This chapter is intended for documentation regarding units on the complete MAN Diesel product which is not documented by MAN Diesel (MAN Diesel's Sub-suppliers), supplied by the Engine builder.

2009-09-04 - en