FINISHED PLAN

DE014

COSFLYING LAKE

MAIN DIESEL ENGINE (1/5)

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DWG. NO.
M-11(1/5)

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

DALIAN CHINA

SHEETS (INCL. COVER)

⚠ WARNING

It is important that all MAN Diesel engines are operated within the given specifications and performance tolerances specified in the engines‘ Technical Files and are maintained according to the MAN Diesel maintenance instructions, in order to comply with given emission regulations.

In accordance with Chapter I of the code of Federal Regulations, Part 94, Subpart C, §94.211, NOTICE is hereby given, that Chapter I of the Code of Federal Regulations, Part 94, Subpart K, §94.1004 requires that the emissions related maintenance of the diesel en- gine, shall be performed as specified in MAN Diesel instructions, including, but not limited to, the instructions to that effect included in the Technical File.

Technical Documentation

MAN B&W S80ME-C9

Design Specification: 4207522-9 4205663-2

Original instructions

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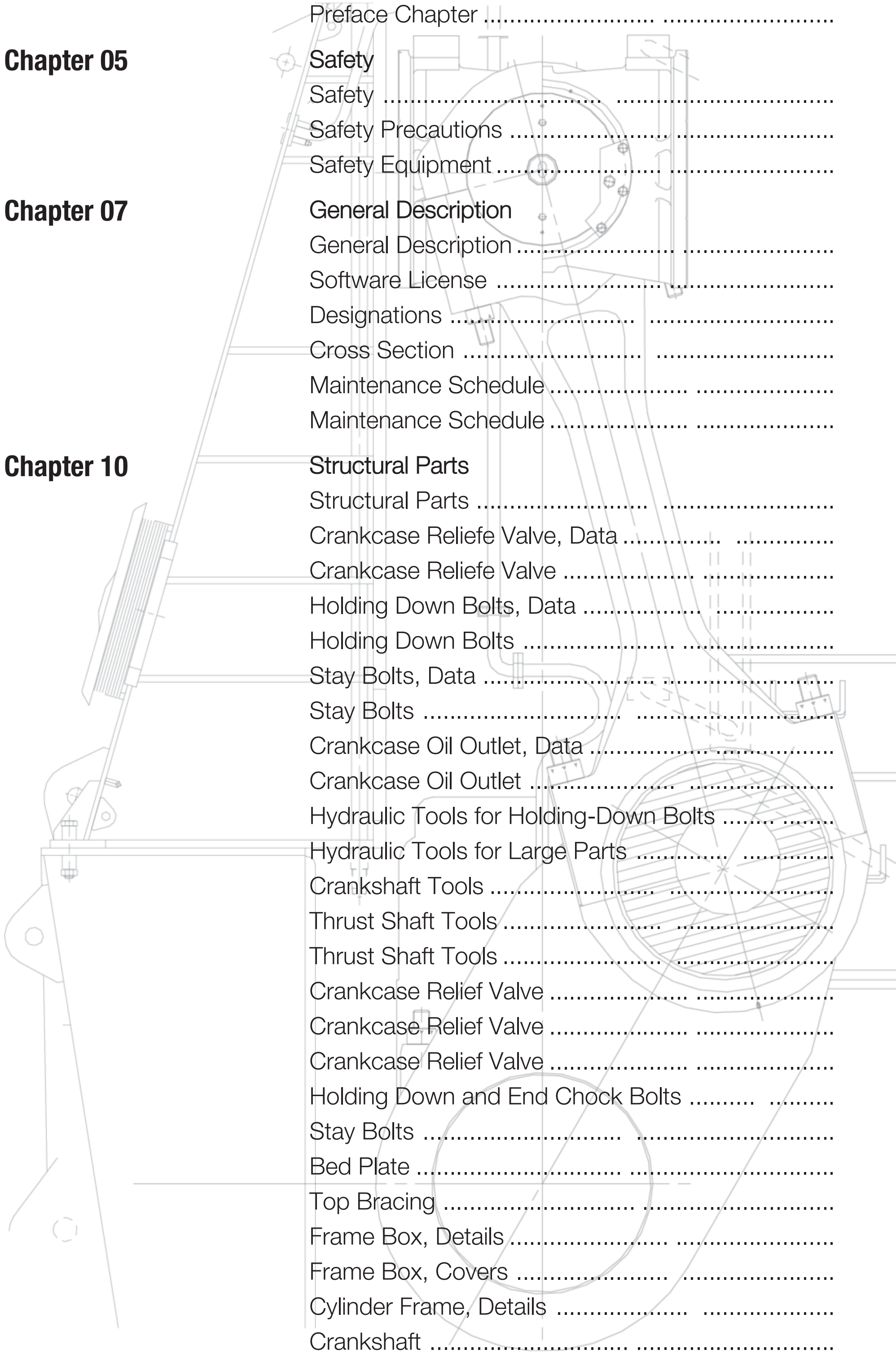
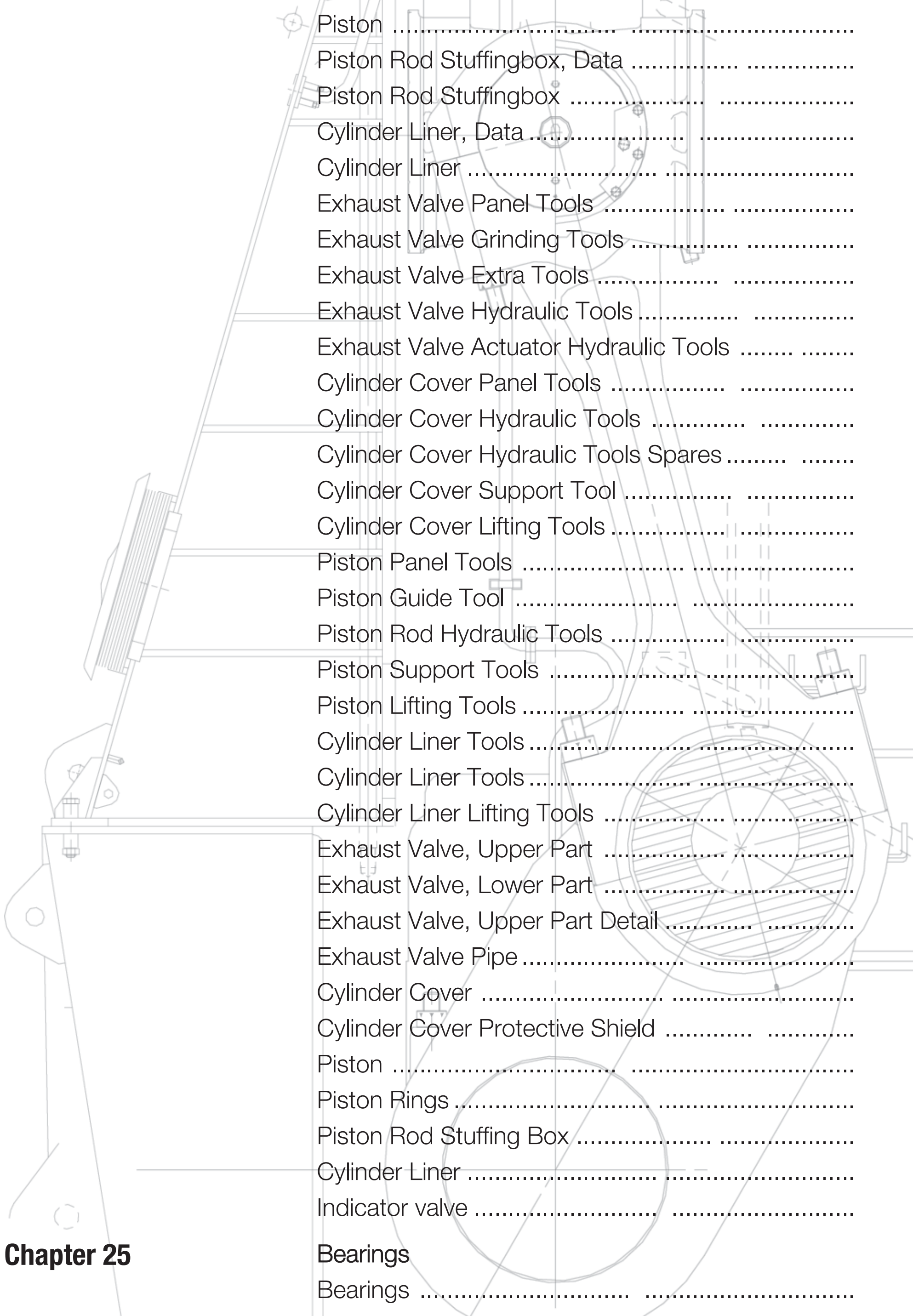


Chapter	Warning	0205-0100-0001
Chapter 02	Table of Content and Introduction	
	Introduction	0220-0100-0001
	Preface Chapter	0240-0100-0002
Chapter 05	Safety	
	Safety	0540-0100-0002
	Safety Precautions	0545-0100-0008
	Safety Equipment	0570-0100-0002
Chapter 07	General Description	
	General Description	0740-0100-0002
	Software License	0745-0150-0002
	Designations	0745-0500-0001
	Cross Section	0745-0800-0002
	Maintenance Schedule	0760-0300-0002
	Maintenance Schedule	0760-0301-0007
Chapter 10	Structural Parts	
	Structural Parts	1040-0100-0002
	Crankcase Reliefe Valve, Data	1065-0100-0001
	Crankcase Reliefe Valve	1065-0101-0002
	Holding Down Bolts, Data	1065-0200-0002
	Holding Down Bolts	1065-0201-0002
	Stay Bolts, Data	1065-0300-0006
	Stay Bolts	1065-0301-0003
	Crankcase Oil Outlet, Data	1065-0400-0001
	Crankcase Oil Outlet	1065-0401-0001
	Hydraulic Tools for Holding-Down Bolts	1070-0220-0003
	Hydraulic Tools for Large Parts	1070-0300-0006
	Crankshaft Tools	1070-1030-0005
	Thrust Shaft Tools	1070-1040-0004
	Thrust Shaft Tools	1070-1040-0006
	Crankcase Relief Valve	1072-0100-0001
	Crankcase Relief Valve	1072-0100-0002
	Crankcase Relief Valve	1072-0100-0003
	Holding Down and End Chock Bolts	1072-0200-0002
	Stay Bolts	1072-0300-0001
	Bed Plate	1072-0400-0009
	Top Bracing	1072-0500-0003
	Frame Box, Details	1072-0630-0005
	Frame Box, Covers	1072-0640-0028
	Cylinder Frame, Details	1072-0710-0006
	Crankshaft	1072-1000-0006
	Turning Gear	1072-1100-0002
	Turning Wheel	1072-1200-0003
	Piston Cooling Arrangement	1072-1400-0002

Chapter 14 Driving Gear
Driving Gear 1440-0100-0002
Reciprocating Parts, Data 1465-0100-0005
Reciprocating Parts 1465-0101-0002
Crosshead, Data 1465-0200-0003
Crosshead 1465-0201-0002
Connecting Rod, Data 1465-0300-0003
Connecting Rod 1465-0301-0002
Chain, Data 1465-0400-0002
Chain 1465-0401-0005
Chain Tighener, Data 1465-0500-0002
Chain Tighener 1465-0501-0008
Connecting Rod and Crosshead Tool Panel 1470-0300-0011
Connecting Rod Hydraulic Tools 1470-0310-0003
Connecting Rod Tools 1470-0315-0001
Chain Tightener Hydraulic Tools 1470-0500-0006
Crosshead Hydraulic Tools 1470-0510-0003
Chain Drive Tools Panel 1470-1400-0008
Chain Drive Tools Panel 1470-1400-0015
Connecting rod 1472-0300-0005
Connecting rod, Compression Shim 1472-0310-0007
Chain Tightener 1472-0500-0005
Chain 1472-0400-0003
Chain Drive Guidebars 1472-1420-0005

Chapter 18 Vibration Control
Vibration Control 1840-0100-0001
Axial Vibration Damper, Data 1865-0100-0006
Axial Vibration Damper 1865-0101-0005
Axial Vibration Damper 1872-0100-0006
Axial Vibration Monitor 1872-0150-0003
Arrangement of Fore End 1872-0600-0031

Chapter 22 Cylinder Unit
Cylinder Unit 2240-0100-0002
Cylinder Condition 2245-0100-0005
Inspection of Nimonic Exhaust Valve Spindles 2245-0200-0004
Inspection through Scavenge Ports 2255-0100-0004
Factors Influencing Cylinder Wear 2255-0105-0003
Cylinder Oil Feed Rate During Running-in 2255-0125-0003
Cylinder Condition Report 2255-0130-0003
Calculation of Condensate Amount 2255-0135-0002
Running-in Load 2255-0140-0003
Overview Of Piston Rings 2255-0145-0001
Liner Condition 2255-0150-0001
Exhaust Valve High-Pressure Pipe, Data 2265-0100-0009
Exhaust Valve High-Pressure Pipe 2265-0101-0003



Exhaust Valve, Data 2265-0200-0014
Exhaust Valve 2265-0201-0009
Cylinder Cover, Data 2265-0300-0003
Cylinder Cover 2265-0301-0011
Piston, Data 2265-0400-0016
Piston 2265-0401-0016
Piston Rod Stuffingbox, Data 2265-0500-0003
Piston Rod Stuffingbox 2265-0501-0007
Cylinder Liner, Data 2265-0600-0012
Cylinder Liner 2265-0601-0010
Exhaust Valve Panel Tools 2270-0200-0010
Exhaust Valve Grinding Tools 2270-0210-0003
Exhaust Valve Extra Tools 2270-0220-0002
Exhaust Valve Hydraulic Tools 2270-0240-0001
Exhaust Valve Actuator Hydraulic Tools 2270-0247-0001
Cylinder Cover Panel Tools 2270-0300-0004
Cylinder Cover Hydraulic Tools 2270-0310-0002
Cylinder Cover Hydraulic Tools Spares 2270-0315-0001
Cylinder Cover Support Tool 2270-0330-0003
Cylinder Cover Lifting Tools 2270-0350-0001
Piston Panel Tools 2270-0400-0024
Piston Guide Tool 2270-0430-0002
Piston Rod Hydraulic Tools 2270-0440-0002
Piston Support Tools 2270-0470-0009
Piston Lifting Tools 2270-0480-0002
Cylinder Liner Tools 2270-0610-0003
Cylinder Liner Tools 2270-0610-0004
Cylinder Liner Lifting Tools 2270-0640-0003
Exhaust Valve, Upper Part 2272-0200-0011
Exhaust Valve, Lower Part 2272-0210-0008
Exhaust Valve, Upper Part Detail 2272-0230-0008
Exhaust Valve Pipe 2272-0240-0004
Cylinder Cover 2272-0300-0007
Cylinder Cover Protective Shield 2272-0320-0005
Piston 2272-0400-0002
Piston Rings 2272-0420-0002
Piston Rod Stuffing Box 2272-0500-0009
Cylinder Liner 2272-0600-0004
Indicator valve 2272-1000-0009

Chapter 25

Bearings
Bearings 2540-0100-0002
Bearings 2545-0100-0004
Alignment of Main Bearings 2545-0110-0002
Main Bearing, Thick Shell Design 2555-0100-0003
Main Bearing, Thin Shell Design 2555-0105-0004

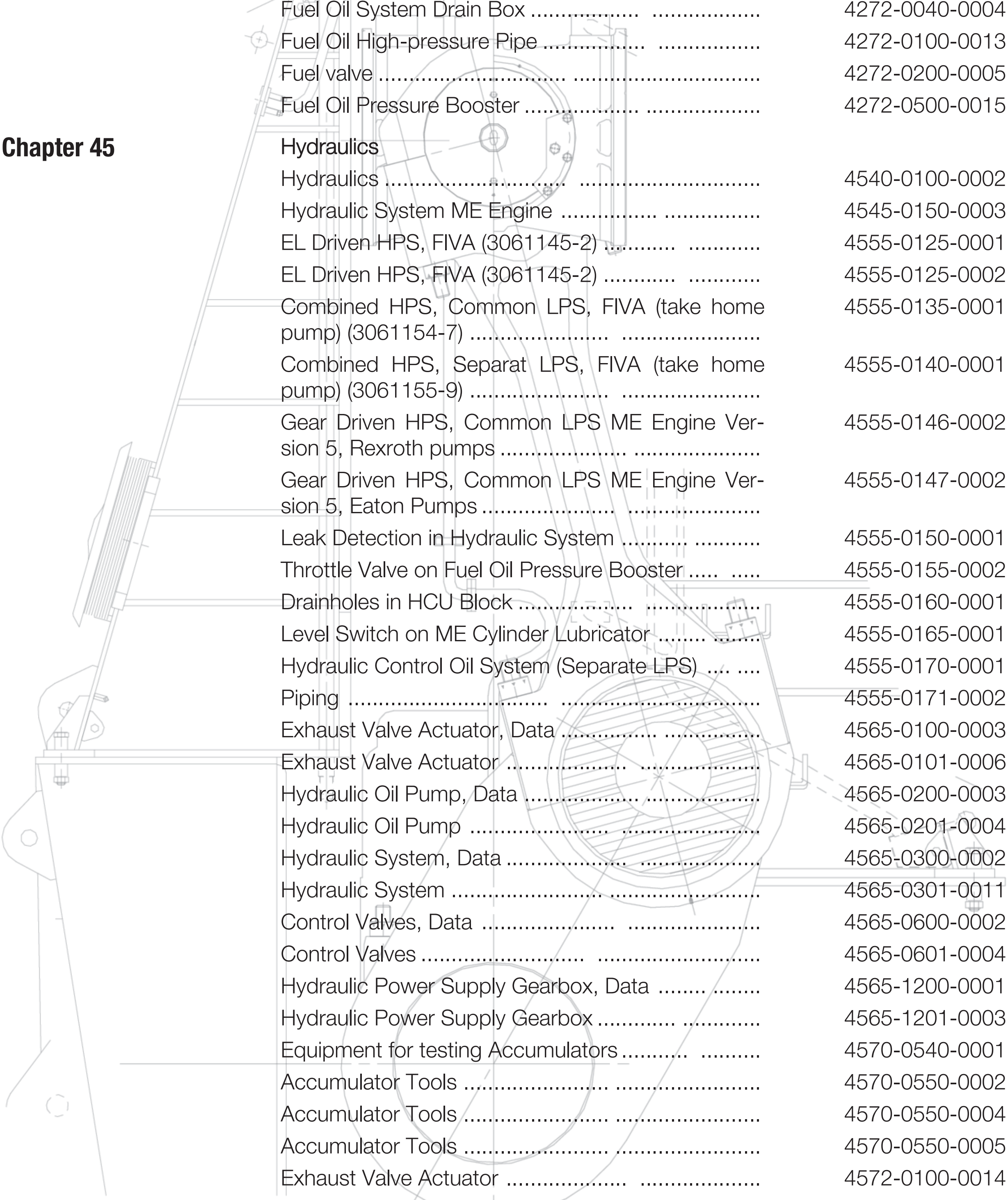
Crosshead Bearing 2555-0110-0004
Crankpin Bearing 2555-0115-0002
Main Bearing Assemblies 2555-0120-0002
Guide Shoes and Strips 2555-0125-0005
Thrust Bearing Assembly 2555-0130-0003
Bearing Wear Monitor 2555-0136-0002
Propeller Shaft Earthing Device 2555-0137-0002
Inspection of Bearings - Recording Observations . . 2555-0140-0003
Acceptance Criteria for Tin-Aluminium Bearings with overlayer 2555-0150-0004
Report: Crankshaft Deflections - (Autolog) 2555-0175-0004
Cranksh Deflection, Limits 2555-0180-0006
Check Measurements 2555-0185-0002
Crosshead Bearing, Data 2565-0200-0012
Crosshead Bearing 2565-0201-0007
Crankpin Bearing, Data 2565-0300-0013
Crankpin Bearing 2565-0301-0007
Main Bearing, Data 2565-0400-0011
Main Bearing 2565-0401-0013
Journal Bearing, Data 2565-0500-0011
Journal Bearing 2565-0501-0007
Thrust Bearing, Data 2565-0600-0005
Thrust Bearing 2565-0601-0003
Bearing Panel Tools 2570-0010-0009
Main Bearing Hydraulic Tools 2570-0400-0004
Main Bearing Shell Tools 2570-0420-0001
Main Bearing Measuring Tools 2570-0430-0003
Crosshead Bearing 2572-0200-0002
Connecting Rod Bearing 2572-0300-0002
Main Bearing 2572-0400-0002
Thrust Bearing, Segments 2572-0600-0003
Thrust Bearing, Miscellaneous 2572-0650-0016

Chapter 30

Lubricating Oil System

Lubricating Oil System 3040-0100-0001
Cylinder Lubrication 3045-0110-0009
Circulating Oil and Oil System 3045-0120-0002
Maintenance of Circulating Oil System 3045-0130-0005
Turbocharger Lubrication 3045-0140-0002
Cylinder Lubricating Oil Pipes 3055-0110-0002
Circulatiing Oil System - Outside Engine (Engines with Uni-Lube System) 3055-0115-0002
Circulatiing Oil System - Inside Engine 3055-0125-0003
Flushing of Main Lubricating Oil System - Location of Chackbag and Blank Flanges 3055-0130-0003
Cleaning System - Stuffing Box Drain Oil (Option) . 3055-0135-0002
Turbocharger Lubrating Oil Pipes 3055-0155-0002

	Cylinder Lubricator, Data	3065-0600-0001
	Cylinder Lubricator	3065-0601-0006
	Cylinder Lubricator	3072-0600-0002
	Chain Drive Lubrication	3072-0700-0004
Chapter 34	Compressed Air System	
	Compressed Air System	3440-0100-0002
	Starting Air System	3455-0100-0002
	Starting Air Valve, Data	3465-0200-0002
	Starting Air Valve	3465-0201-0002
	Starting Air System, Air Reciever	3472-0150-0002
	Starting Air Valve	3472-0200-0003
	Main Starting Air Valve	3472-0300-0004
	Starting Air Safety Cap	3472-0900-0005
	Control Air System	3472-0250-0001
Chapter 42	Fuel System	
	Fuel System	4240-0100-0002
	Fuel Oil	4245-0100-0003
	Pressurised Fuel Oil System	4245-0110-0003
	Fuel Treatment	4245-0120-0003
	Residual Fuel Standards	4255-0100-0003
	Fuel Oil System	4255-0105-0003
	Fuel Pipes on Engine	4255-0110-0002
	Fuel Oil Centrifuges - Mode of Operation	4255-0115-0003
	Centrifuge Flow Rate and Separation Temperature - Preheating	4255-0120-0002
	Preheating of Heavy Fuel Oil (Prior to Injection)	4255-0125-0002
	Fuel Oil High-Pressure Pipe, Data	4265-0100-0013
	Fuel Oil High-Pressure Pipe	4265-0101-0016
	Fuel Valve, Data	4265-0200-0003
	Fuel Valve	4265-0201-0002
	Fuel Valve Spindle Guide, Data	4265-0300-0001
	Fuel Valve Spindle Guide	4265-0301-0001
	Fuel Valve Non-return valve, Data	4265-0400-0001
	Fuel Valve Non-return valve	4265-0401-0003
	Fuel Oil Pressure Booster, Data	4265-0500-0009
	Fuel Oil Pressure Booster	4265-0501-0014
	Fuel Oil Pressure Booster Top Cover, Data	4265-0600-0009
	Fuel Oil Pressure Booster Top Cover	4265-0601-0013
	Fuel Oil Pressure Booster Suction Valve, Data	4265-0700-0002
	Fuel Oil Pressure Booster Suction Valve	4265-0701-0010
	Fuel System Panel Tools	4270-0010-0013
	Fuel Valve Nozzle Tools	4270-0210-0002
	Fuel Valve Nozzle Tools	4270-0210-0003
	Fuel Valve Testing Tools	4270-0220-0001
	Fuel Valve inspection Tools	4270-0230-0001



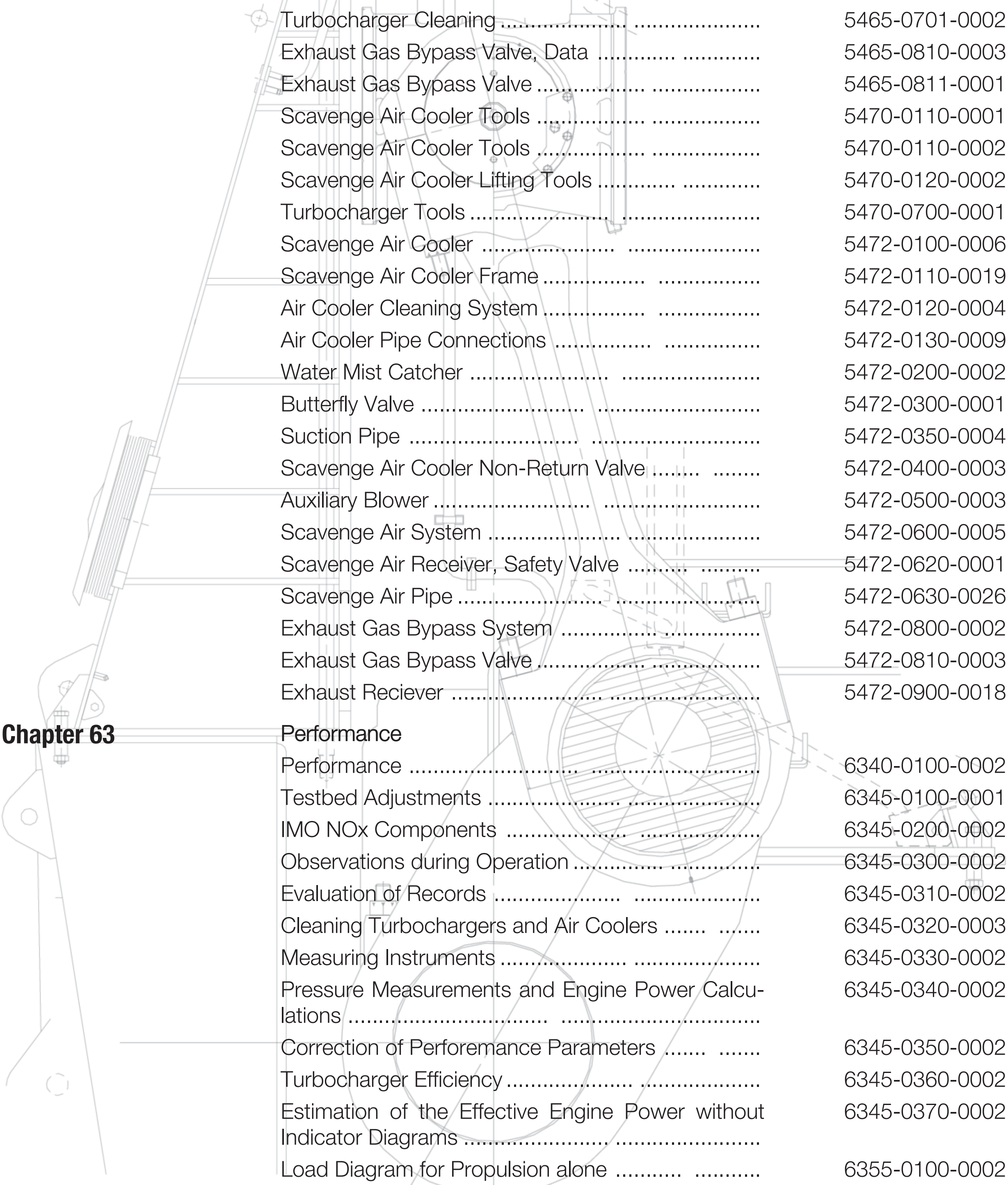
Fuel Pump Top Cover Tools 4270-0900-0001
Fuel Oil System 4272-0010-0009
Fuel Oil System By-pass Valve 4272-0030-0003
Fuel Oil System Drain Box 4272-0040-0002
Fuel Oil System Drain Box 4272-0040-0004
Fuel Oil High-pressure Pipe 4272-0100-0013
Fuel valve 4272-0200-0005
Fuel Oil Pressure Booster 4272-0500-0015

Chapter 45

Hydraulics

Hydraulics 4540-0100-0002
Hydraulic System ME Engine 4545-0150-0003
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
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
Equipment for testing Accumulators 4570-0540-0001
Accumulator Tools 4570-0550-0002
Accumulator Tools 4570-0550-0004
Accumulator Tools 4570-0550-0005
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
Chapter 47	Electronics	
	Electronics	4740-0100-0002
	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
	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
Chapter 50	Cooling Water System	
	Cooling Water	5040-0100-0001
	Cooling Water System, Data	5045-0100-0004
	Cooling Water Treatment	5045-0200-0002
	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
	Cooling Water Pipes	5072-0100-0009
Chapter 54	Exhaust Gas and Scavenge Air System	
	Exhaust Gas and Scavenge Air System	5440-0100-0001
	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
	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
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
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

Chapter 63 Performance

Performance 6340-0100-0002
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
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

Chapter 66 Operation
Operation 6640-0100-0002
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/Staybolts 6645-0330-0001
Sequence Diagram - FPP Plant 6655-0115-0002
Sequence Diagram - CPP Plant 6655-0120-0002

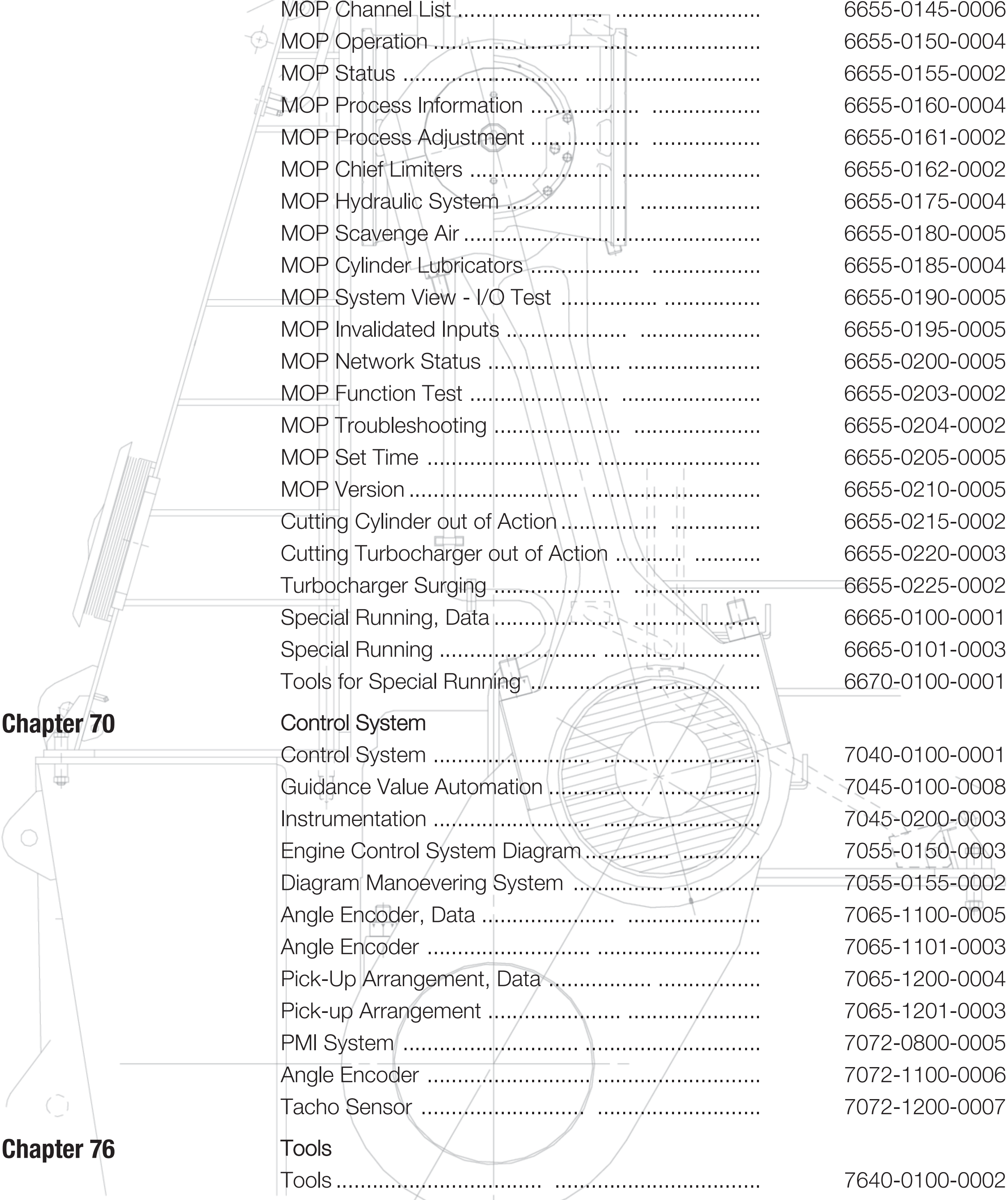
MOP Overview 6655-0125-0004
MOP Alarm List 6655-0130-0006
MOP Event Log 6655-0135-0005
MOP Manual Cut-Out List 6655-0140-0005
MOP Channel List 6655-0145-0006
MOP Operation 6655-0150-0004
MOP Status 6655-0155-0002
MOP Process Information 6655-0160-0004
MOP Process Adjustment 6655-0161-0002
MOP Chief Limiters 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
Special Running, Data 6665-0100-0001
Special Running 6665-0101-0003
Tools for Special Running 6670-0100-0001

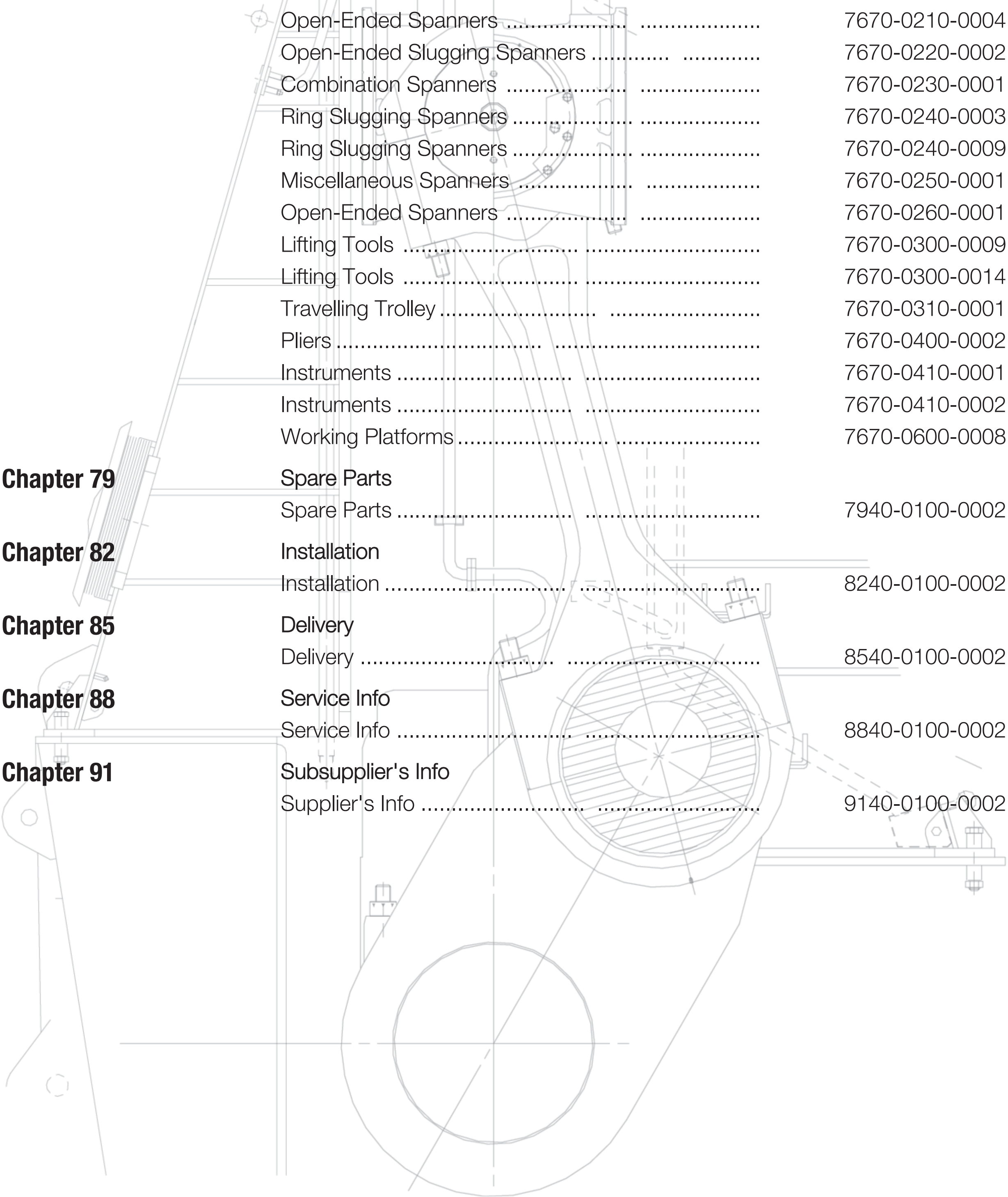
Chapter 70 Control System

Control System 7040-0100-0001
Guidance Value Automation 7045-0100-0008
Instrumentation 7045-0200-0003
Engine Control System Diagram 7055-0150-0003
Diagram Manoevering System 7055-0155-0002
Angle Encoder, Data 7065-1100-0005
Angle Encoder 7065-1101-0003
Pick-Up Arrangement, Data 7065-1200-0004
Pick-up Arrangement 7065-1201-0003
PMI System 7072-0800-0005
Angle Encoder 7072-1100-0006
Tacho Sensor 7072-1200-0007

Chapter 76 Tools

Tools 7640-0100-0002
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
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

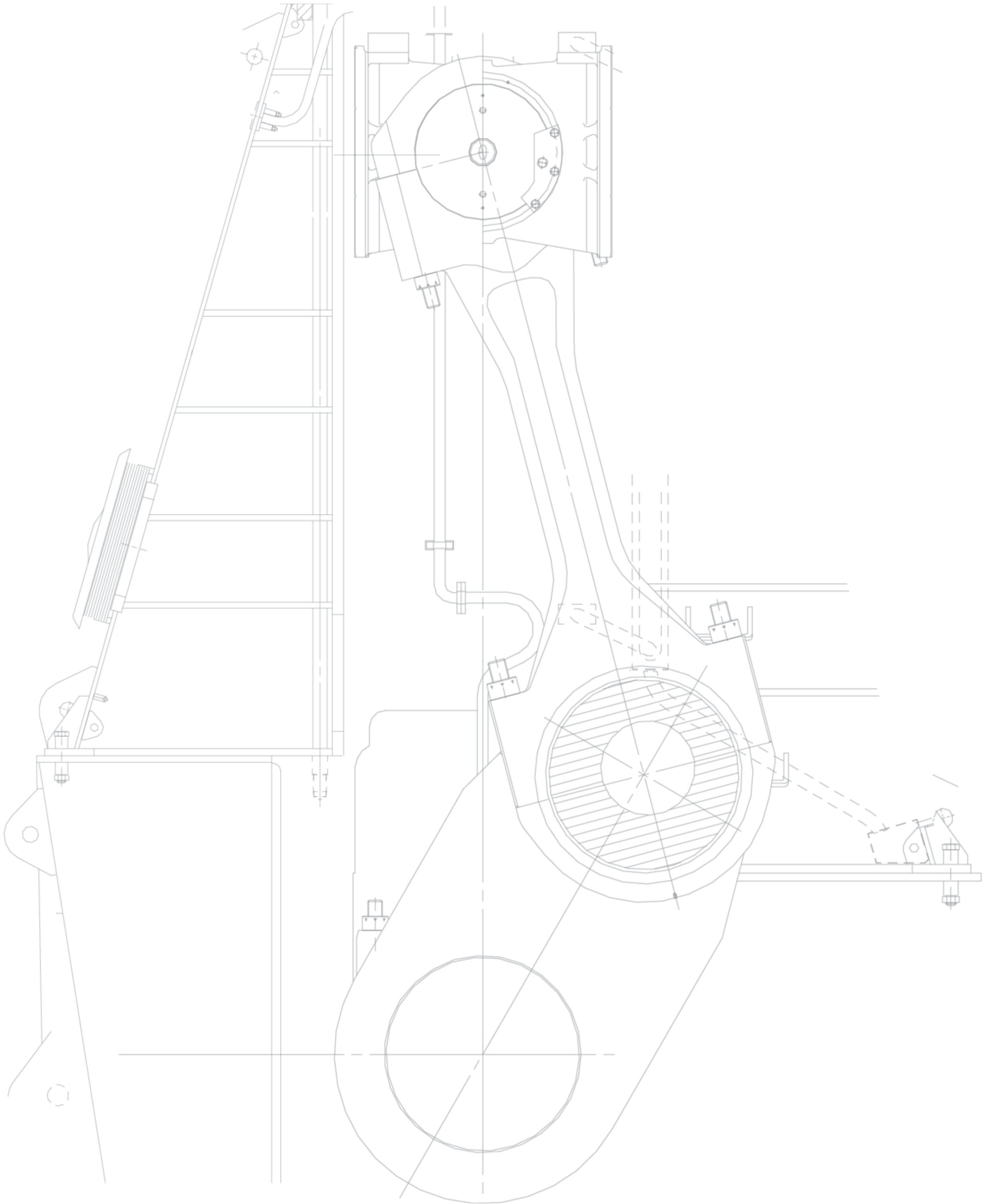
Chapter 79 Spare Parts
Spare Parts 7940-0100-0002

Chapter 82 Installation
Installation 8240-0100-0002

Chapter 85 Delivery
Delivery 8540-0100-0002

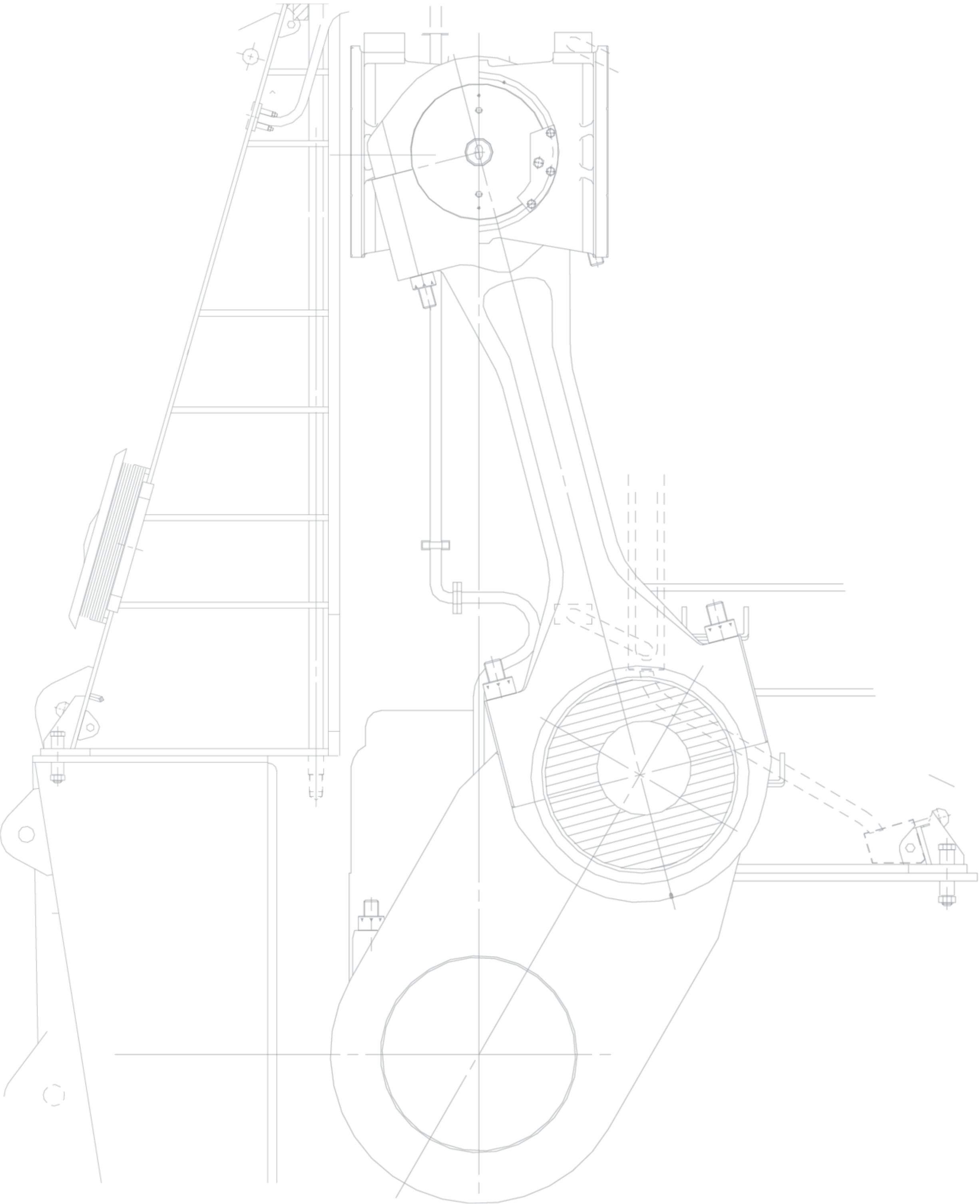
Chapter 88 Service Info
Service Info 8840-0100-0002

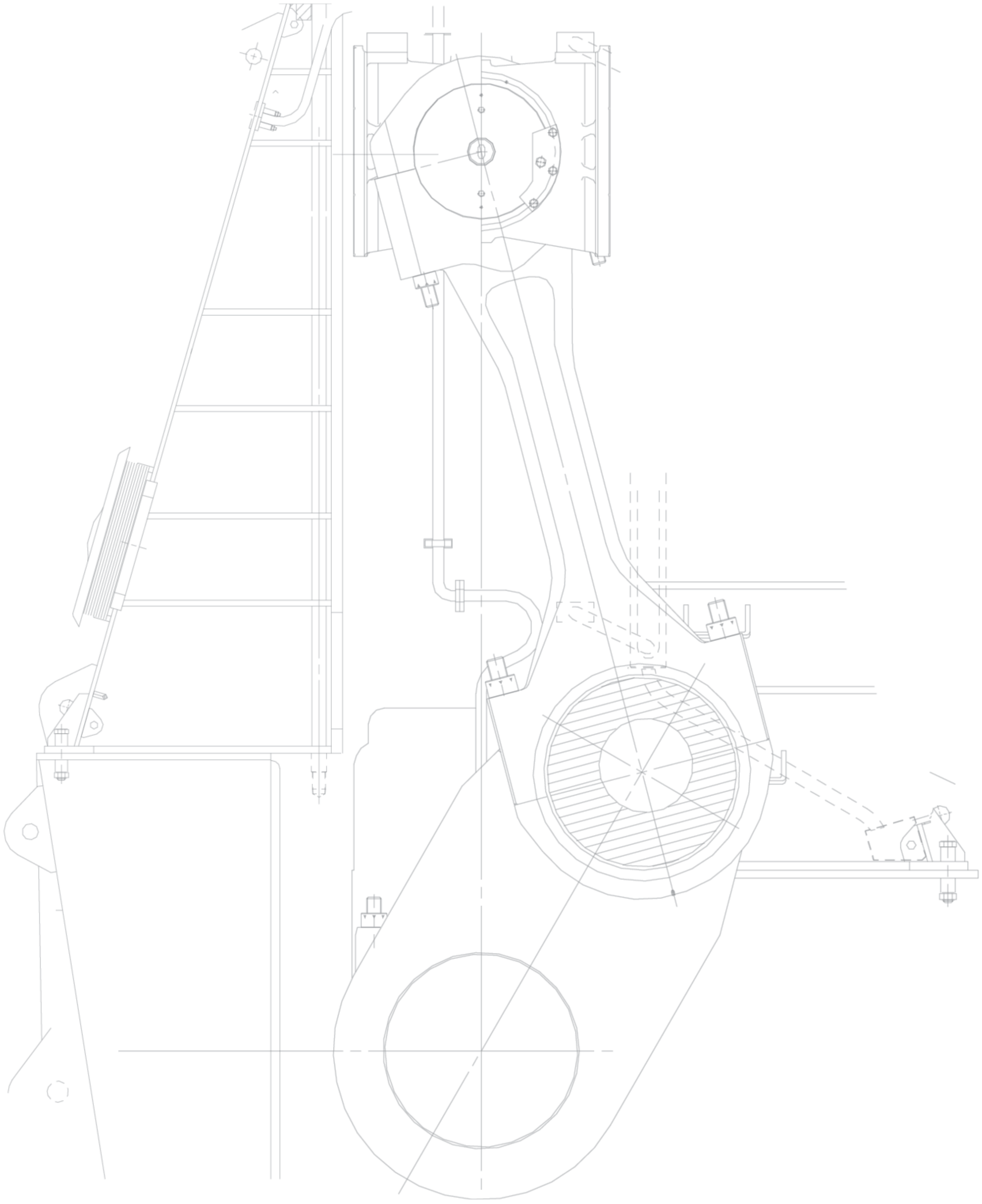
Chapter 91 Subsupplier's Info
Supplier's Info 9140-0100-0002



Preface Introduction 0220-0100-0001

Preface Chapter Preface Chapter 0240-0100-0002





Introduction

MAN Diesel & Turbo | PrimeServ

The MAN Diesel & Turbo Group offers worldwide round-the-clock service, 365 days a year. Apart from the MAN Diesel & Turbo service headquarters in Augsburg, Copenhagen, Frederikshavn, Holeby, Stockport, St. Nazaire, Turbocharger and service centres on all continents provide comprehensive and continuous support. The long service life associated with MAN Diesel & Turbo engines dictates a spare parts programme that ensures components are available for engines in operation for decades. Based on high-capacity machines, MAN Diesel & Turbo service production facilities are able to comply with special customer requests with the utmost precision and flexibility.

24-hour hotline number:

+49 1801 15 15 15

http://www.mandieselturbo.com/primeserv

The manual

The purpose of this manual is to provide general guidance regarding the operation and maintenance, of a standard version of a MAN Diesel & Turbo product e.g. a main engine, auxilliary engine or propeller as well as to describe the design features of such a product. This manual is of guidance only and if any doubt should arise regarding any data stated in this manual then the engine builder’s documentation should be reffered to and/or MAN Diesel & Turbo contacted.

Deviations from a MAN Diesel & Turbo product may be found in a specific plant. If so such deviations should be noted when ordering spare parts.

Reliable and economical operation of the MAN Diesel & Turbo product is conditional upon its correct operation and maintenance in accordance with MAN Diesel & Turbo’s instructions and recommendations/guides. Consequently, it is essential that the engine room personnel are fully acquainted with the content of this manual.

Furthermore, to ensure optimum efficiency, reliability and lifetime of the product and its components, only original spare parts should be used when replacing parts of the engine.

The manual structure

This manual is divided in to several chapters. Each chapter covering the complete documentation for its relevant content.

Each chapter is made up from several document types e.g. 1065-0100-0001. The documentation type number is the third and fourth digit.

Examples of document types are as follows.

15 - Preface

45 - Description

55 - Drawings

65 - Maintenance Workcard

70-90 - Spare part plates.

The following 5-8 digits are the Identification (ID) number of the document in the relevant chapter of a certain document type.

The last 4 digits form the edition number.

Example:
2272-0420-0028

22	72	0420	0028
Chapter	Document Type	ID Number	Edition

Data designations

Designations in a Workcard starting with a "T" or "F" refer to the information given on the data sheets inserted in the beginning of the relevant Workcard.

Referring to this manual

When contacting MAN Diesel & Turbo referring to this instruction manual, please include title, edition no., and, if relevant, page no.

Example:
Piston - 2265-0401-0028 - Page 2

For a specific engine, also specify the name of the vessel, IMO number, engine number and engine builder.

Example:
Bow Firda - 9250751 - 052024 - MAN Diesel & Turbo - 2272-0420-0028

Ordering of Spareparts

When ordering/requesting spare parts for any product by MAN Diesel & Turbo, add the following information to ensure delivery of correct parts for the specific engine: Document ID, Part Number, Quantity and Description. Notice that a part number can also be a Sensor code identification number (e.g. PT 8501) as described in *chapter 70 – Control System.*

Example: Bow Firda - 9250751 - 052024 - MAN Diesel & Turbo - 2272-0420-0028-017 - 8 pcs - (Piston ring no. 1)

NB! Item no. “000” orders the complete assembly as displayed on the plate.

Service Letters

In order to ensure up-to-date manuals on operation and maintenance, MAN Diesel & Turbo and its licensees, regularly send out Service Letters, containing first-hand information regarding accumulated service experience.

Service Letters can either deal with specific product types or contain general instructions and recommendations for all products in a product range, and are used as a reference when we prepare up-dated instruction manual editions.

Therefore, since new Service Letters could be of great importance to the operation of the plant, we recommend that the engine staff file them to supplement the relevant chapters of this manual or add them to chapter *88 - Service Info.*

Internet services

MAN Diesel & Turbo is always working on new and better ways to provide up-to-date information and documentation for its customers. Visit our homepage for further details about the current services offered and how to access these.

Additional Information

Further details may be found in:

- Sub-supplier manuals
- Plant Installation drawings
- Shop trial report
- Sea trial report
- EIAPP Technical File

Copyrights

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CVR. No.: 31 61 17 92

Table of Content

This chapter of the instruction book is intended to provide the user with a table of where the various instructions are located.

Introduction

In addition this chapter is intended to provide the user with a guide of how to use the instruction book as well as a description of the logical structure of the instruction book.

Preface Chapter Safety 0540-0100-0002
Description Safety Precautions 0545-0100-0008
Tool Plate Safety Equipment 0570-0100-0002

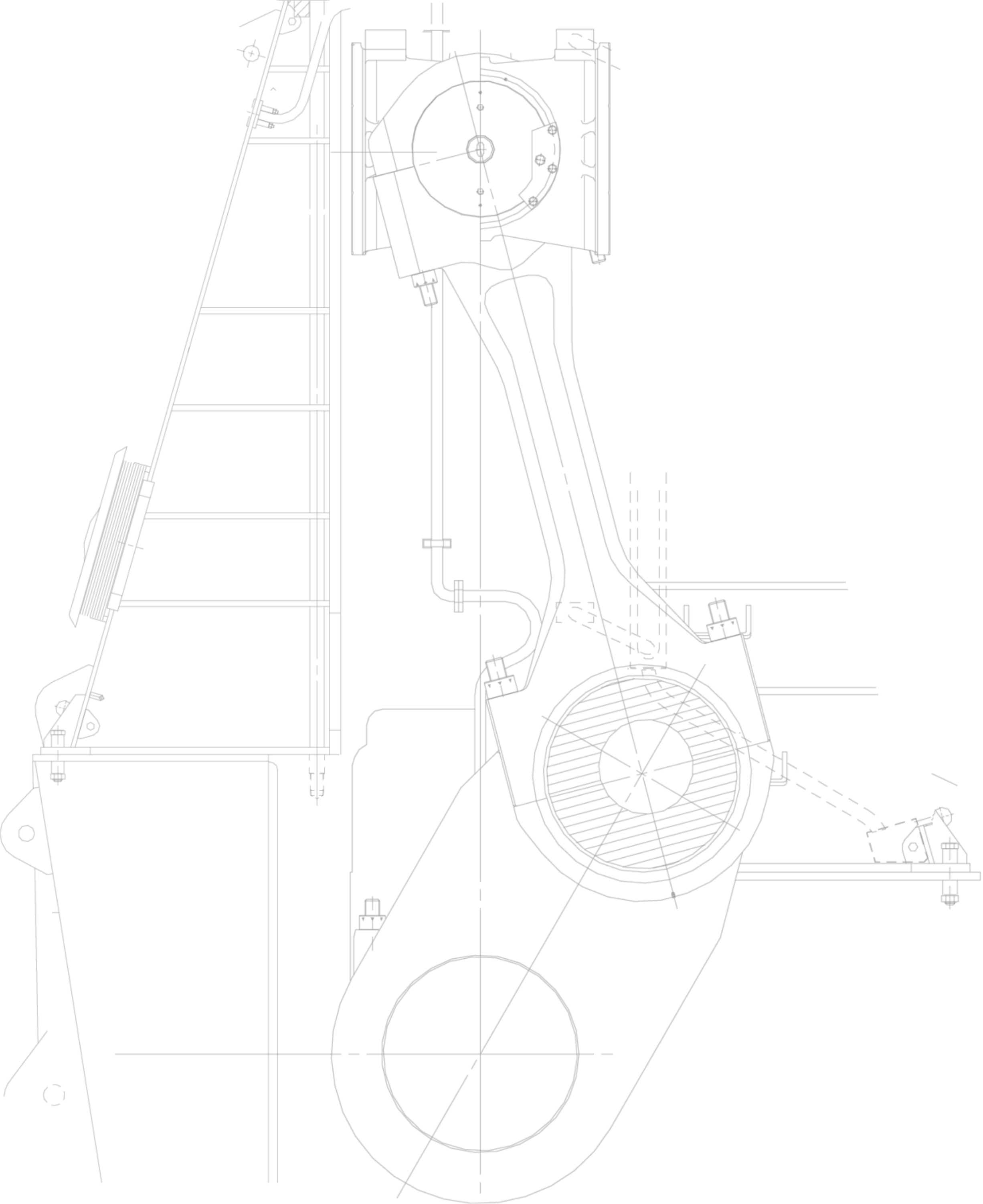
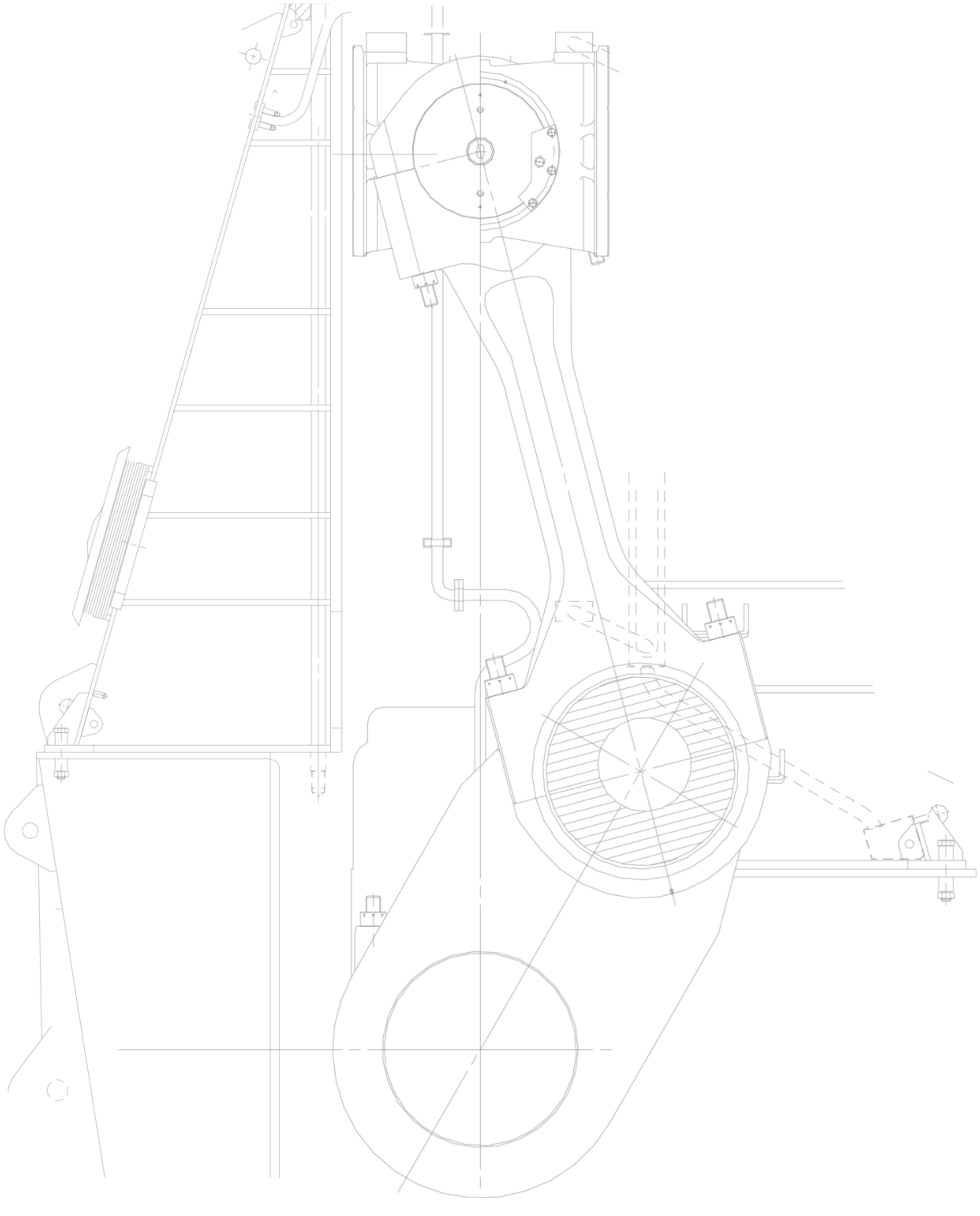


Table of contents



Safety

This chapter of the instruction book is intended to provide the user with relevant details of all the safety precautions which must be observed during operation and maintenance of the engine in order to obtain safe and reliable conditions.

1 General

Correct operation and maintenance, which is the aim of this book, are crucial points for obtaining optimum safety in the engine room. The general measures mentioned here should therefore be routine practice for the entire engine crew.

2 Engine Room Staff

Operation and Maintenance of MAN B&W engines is to be carried out exclusively by qualified professional personnel.

Minimum personal safety equipment requirements:

1. Safety shoes.
2. Hearing protection.
3. Boiler suit or other similar protective wear.

3 Special Dangers

WARNING

Numerous situations may lead to risks of serious injuries to the body. The following recommendations must always be observed:

- Keep clear of the space below a crane with load.
- Before opening of cocks, always observe which way liquids, gases or flames will move, and keep clear.
- Dismantling of parts may also cause the release of springs.
- Do not stand near turbochargers in case of any abnormal running.
- Do not stand near crankcase doors or relief valves - nor in corridors near doors to the engine room - if an alarm for oil mist, high lube oil temperature, no piston cooling oil flow, or scavenge box fire is set off. *See also Description 6645.*

4 Turning Gear

Before engaging the turning gear, ensure that the starting air supply is shut off, the main starting and slow turning valves are blocked, and that the indicator cocks are open.

When the turning gear is engaged, check that the indicator lamp “Turning gear in” has switched on.

The turning gear remote control is a critical device and should always be kept in optimal working condition. Any fault in the device or cable must be rectified before use.

When operating the turning gear it is important to note the following:

The turning gear must be operated by the remote control and only by the person working on the engine.

Warnings must be given before each turning. Operation of the turning gear from the switchboard must not take place while maintenance work is in progress inside the engine.

Block the switch or place a “Do not touch” sign.

5 Entering the Crankcase or Cylinder

⚠ **WARNING**

Always ensure that the turning gear is engaged and the brake is active, to prevent external forces or unbalance of the crankshaft from turning the crankshaft.

Check that the starting air supply to the engine and the starting air distributor is shut off and that the main starting valve is locked.

In case of oil mist alarm, precautions must be taken before opening the doors to the crankcase (*see description 6645-0300*). Before entering, ventilate the crankcase for about 30 minutes after stopping the engine.

Work inside the crankcase requires the use of fall protection harness and arrestor equipment.

Work inside the crankcase is as minimum a two-man job, and good communication must be maintained at all times.

The turning gear must always be operated exclusively by the person(s) who enters the crankcase or cylinders.

6 Cleanliness

The engine and engine room should always be kept clean and tidy.

Oily rags must never be left around the engine room spaces as they are highly flamable and slippery.

Remove any oil spill at once.

If there is a risk of grit or sand blowing into the engine room, stop the ventilation and close the ventilating ducts, skylights and engine room doors.

Welding or other work that causes spreading of grit and/or swarf must not be carried out near the engine unless it is closed or protected and the turbocharger air intake filters are covered.

The exterior of the engine should be kept clean, and the paintwork maintained, so that leakages can be easily detected.

7 Fire

⚠ WARNING

Keep the areas around the relief valves free of oil, grease, etc. to prevent the risk of fire caused by the emitted hot air/gas if the relief valves open.

Do not weld or use naked lights in the engine room until it has been ascertained that no explosive gases, vapour or liquids are present.

If the crankcase is opened before the engine has cooled down, welding and the use of naked flames will result in the risk of explosions and fire. The same applies to inspection of oil tanks and of the spaces below the floor.

Attention is furthermore drawn to the danger of fire when using paint and solvents with a low flash point. Porous insulating material, soaked with oil from leakages, is easily inflammable and should be renewed. See also description 6645-0290, 6645-0300 and ‘Sealing Materials’ in this chapter

8 Order/Tidiness

Hand tools should be securely fastened and placed on easily accessible tool panels. Special tools should be fastened in the engine room, close to the area to be used.

Do not leave major objects unfastened, and keep floor and passages clear at all times.

9 Spares

Large spare parts should, as far as possible, be placed near the area to be used, well secured, and accessible by crane.

All spares should be protected against corrosion and mechanical damage. The stock should be checked at intervals and replenished in good time.

10 Lighting

Ample working light should be permanently installed at appropriate places in the engine room spaces, and portable working light should be obtainable everywhere. 24v safety lamps must be available for use inside the engine.

11 Harmful Materials

Always follow the manufacturer's specific instructions, i.e. the material safety data sheet.

Use protective gloves, goggles, breathing mask and any other recommended protective gear, as stated in the material safety data sheet.

While handling harmful materials it is important to secure proper ventilation and shielding if needed.

In the event of leaks or spillage, spread binding agents immediately. Disposal of the binding agents, according to the material safety data sheet.

12 Lifting Precautions

Plan lifting of engine components through all steps of the lifting procedure.

Use tackles between engine room crane and components, when lifting loads below 500 kg.

Make sure lifting attachments are tightened into full contact with the component to be lifted.

Only use designated lifting points, see Instruction Manual for guidance.

Never exceed the lowest Safe Working Load (SWL) of the lifting equipment in the lifting chain.

Keep lifting equipment clear of sharp edges.

Make sure to attach the load correctly on the crane hook.

Always keep clear of the space below a crane carrying a load.

13 Working Air

Use of working air requires safety goggles and gloves.

Avoid blowing pressurised air directly at any part of the body especially exposed skin.

14 Sealing Materials

Use gloves made of neopren or PVC when removing O-rings and other rubber/plastic-based sealing materials which have been subjected to abnormally high temperatures.

First aid measures in the event of skin contact:

- Rinse with plenty of water
- Remove all contaminated clothing
- Consult a doctor
- Dispose of all material and gloves in accordance with laws and regulations.

15 Hot Surfaces

Beware of hot surfaces and always use gloves.

16 Alarms

It is important that all alarms lead to prompt investigation and remedy of the error. No alarm is insignificant. The most serious alarms are equipped with slow-down and/or shut-down functions. It is therefore important that all engine operation personnel are familiar with and well trained in the use and importance of the alarm system.

17 Subsuppliers and external equipment

Please check the special instructions concerning subsupplier delivery and external equipment for specific warnings!

18 Safety notes

⚠ DANGER

This warning is used when an operation, procedure, or use may cause personal injury or loss of life.

⚠ WARNING

This warning is used when an operation, procedure, or use may cause a latently dangerous state of personal injury or loss of life.

⚠ CAUTION

This warning is used when an operation, procedure, or use may cause damage to or destruction of equipment and a slight or serious injury.

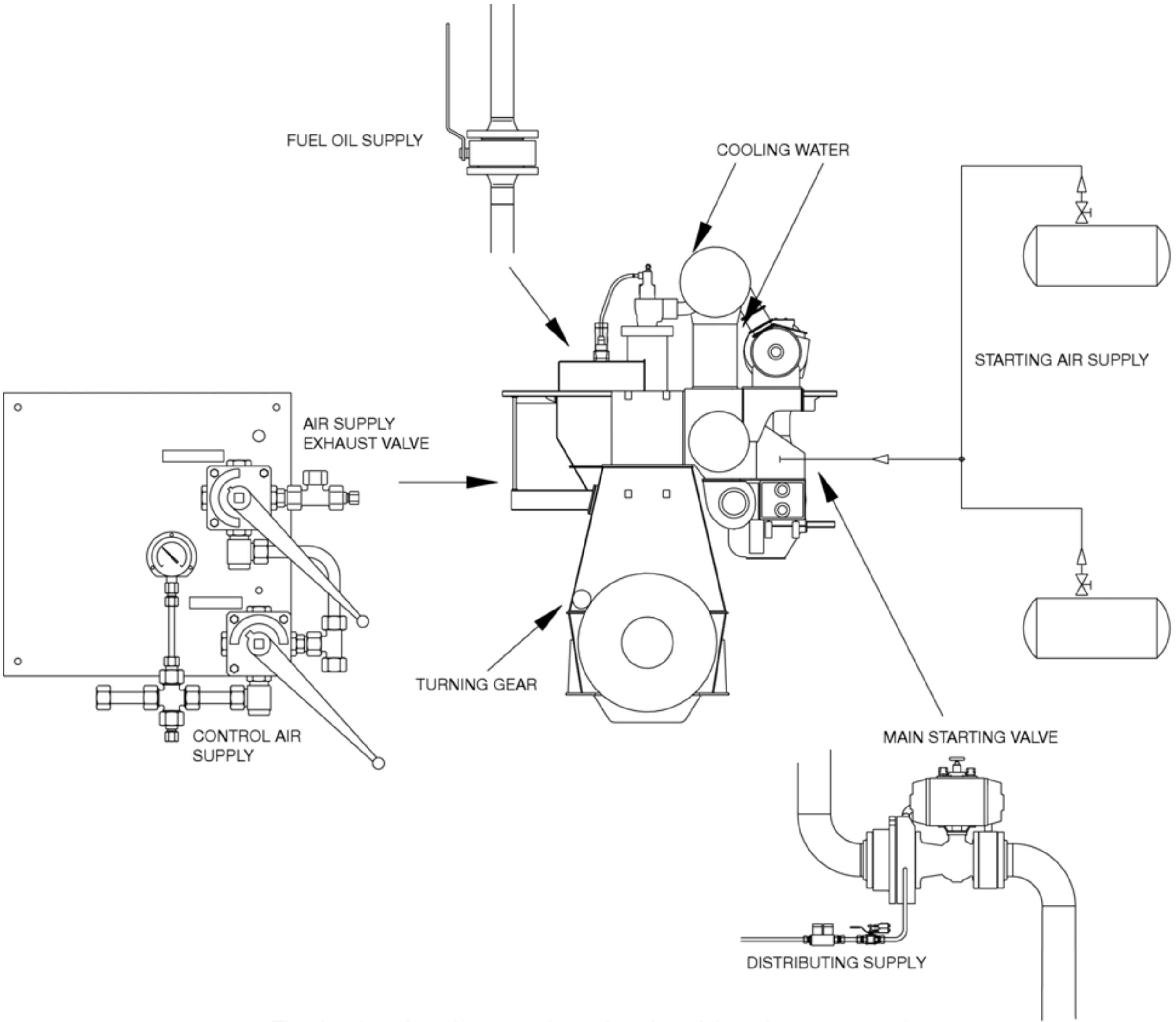
NOTICE

This warning is used when an operation, procedure, or use may cause damage to or destruction of equipment.

19 Safety Precautions at Maintenance

Before carrying out maintenance work stop and block the engine according to the safety precautions given on the specific Work Card.

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



The drawing gives the approximate location of the valves concerned

0545-0100-0006C02

20 Data Sheet Signs

Data sheets may include warning signs for special dangers that could arise in connection with the maintenance procedures.

Warning signs		Mandatory action signs	
General warning sign		General mandatory action sign	
Explosive material		Wear ear protection	
Drop (fall)		Wear eye protection	
Slippery surface		Wear safety footwear	
Electricity		Wear protective gloves	
Overhead load		Wear face shield	
Hot surface		Wear head protection	
Crushing		Wear mask	
Overhead obstacle		Wear respitory protection	
Flammable		Wear safety harness	
Crushing of hands		Disconnect before carrying out maintenance	
Pressurized cylinder			
Pressurized device			

Safety Equipment

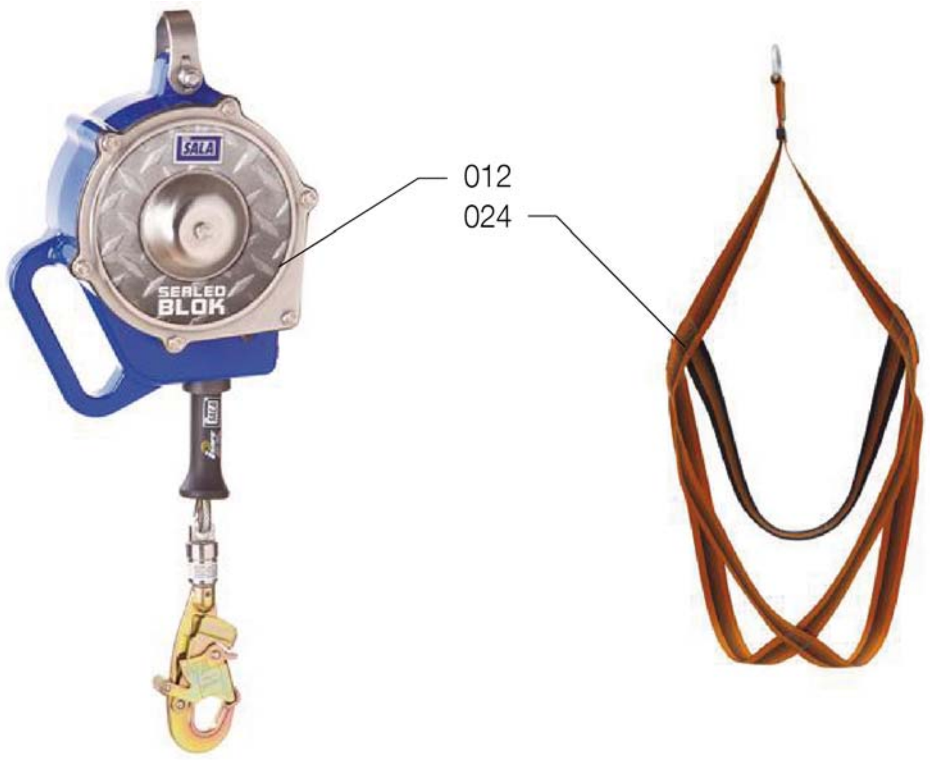


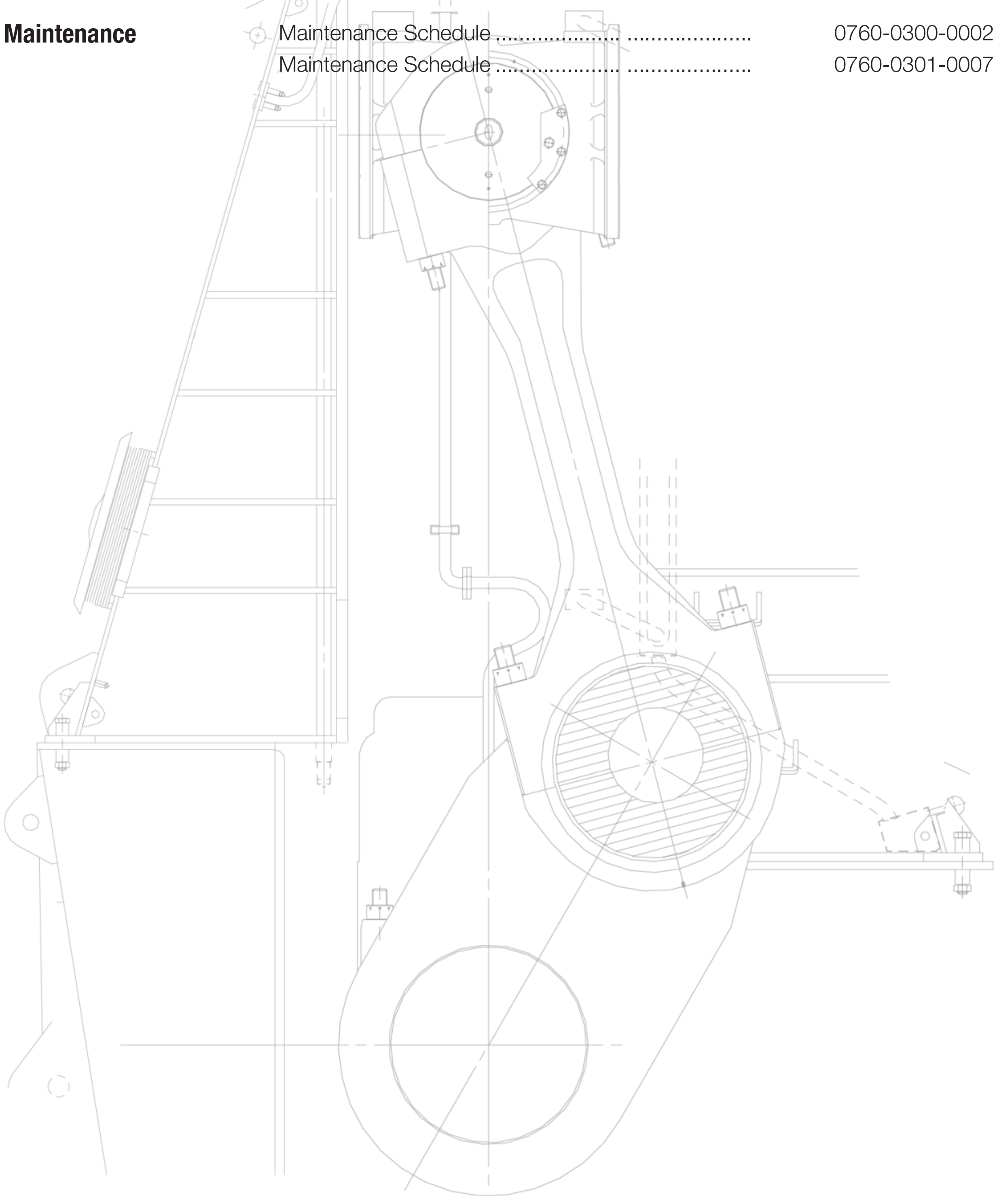
Plate 0570-0100-0002

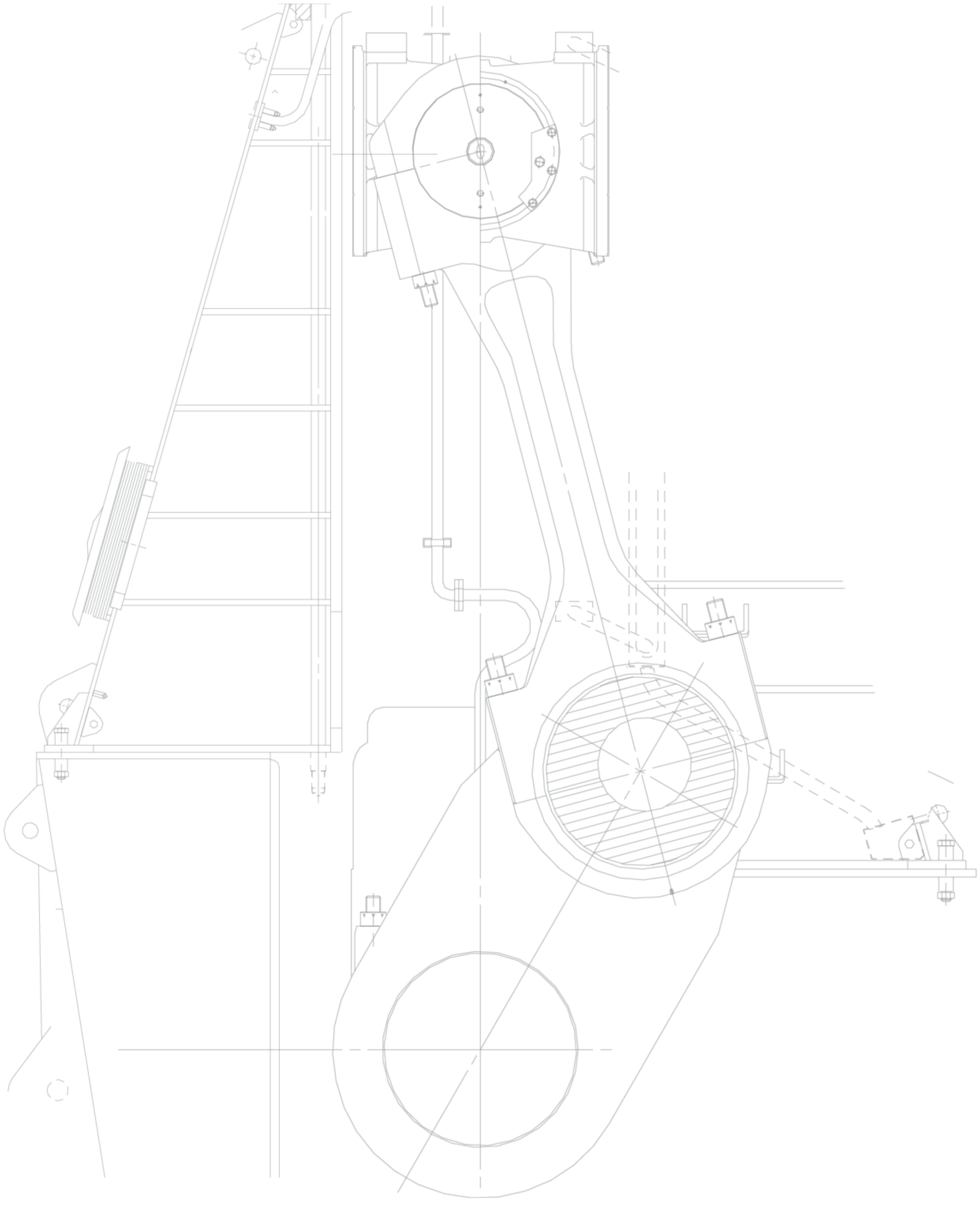
Item no	Qty	Designation
012	-	Fall arrest block
024	-	Rescue Harness

Preface Chapter General Description 0740-0100-0002

Description Software License 0745-0150-0002
Designations 0745-0500-0001
Cross Section 0745-0800-0002

Maintenance Maintenance Schedule 0760-0300-0002
Maintenance Schedule 0760-0301-0007





General Description

This chapter of the instruction book is intended to provide the user with information regarding the software license which applies to this instruction book. In addition various naming conventions (designations) used in the instruction book are explained.

Standard Conditions of Software Licence

Software supplied by MAN Diesel & Turbo separately or included as a part of any system or embedded in any device is licensed by MAN Diesel & Turbo A/S ("MAN Diesel & Turbo") subject to the customer's acceptance of the following standard conditions of licence.

TAKING THE SOFTWARE IN USE WILL INDICATE THE CUSTOMER'S ACCEPTANCE OF THESE CONDITIONS.

1 Right of Ownership

Software is delivered under a non-exclusive and non-transferable user's licence from MAN Diesel & Turbo against a once-for-all fee. MAN Diesel & Turbo and its software suppliers retain the right of ownership to the software.

If the engine plant - for which the software is acquired - is transferred to a third party the customer has the right to assign the licence to this third party, provided that the third party agrees to the terms of this licence agreement and provided that the customer does not retain any copies of the software.

2 Copyright

The customer must not copy the software or any part thereof. Furthermore the customer is not allowed to make the software available to a third party or to reverse engineer, decompile or disassemble the software.

3 Support

If required by the customer MAN Diesel & Turbo shall provide technical support for installation and training in use of the software against separate payment.

4 Updating

The non-exclusive user's licence does not include any updating of the software. If and to the extent MAN Diesel & Turbo updates the programs or develops new versions, such updates or new versions shall be made available to the customer against separate payment.

5 Warranty & Liability

MAN Diesel & Turbo warrants that the software and data media containing the software are free of defects in material and workmanship at the time of delivery. If the software and data media are found to be defective and are returned to MAN Diesel & Turbo within 90 days from the date of delivery, they will be replaced free of charge.

Except as stated above, MAN Diesel & Turbo disclaims liability for breach of conditions or warranties, either expressed or implied, with respect to the software and data media, including warranties of suitability and applicability for a particular purpose.

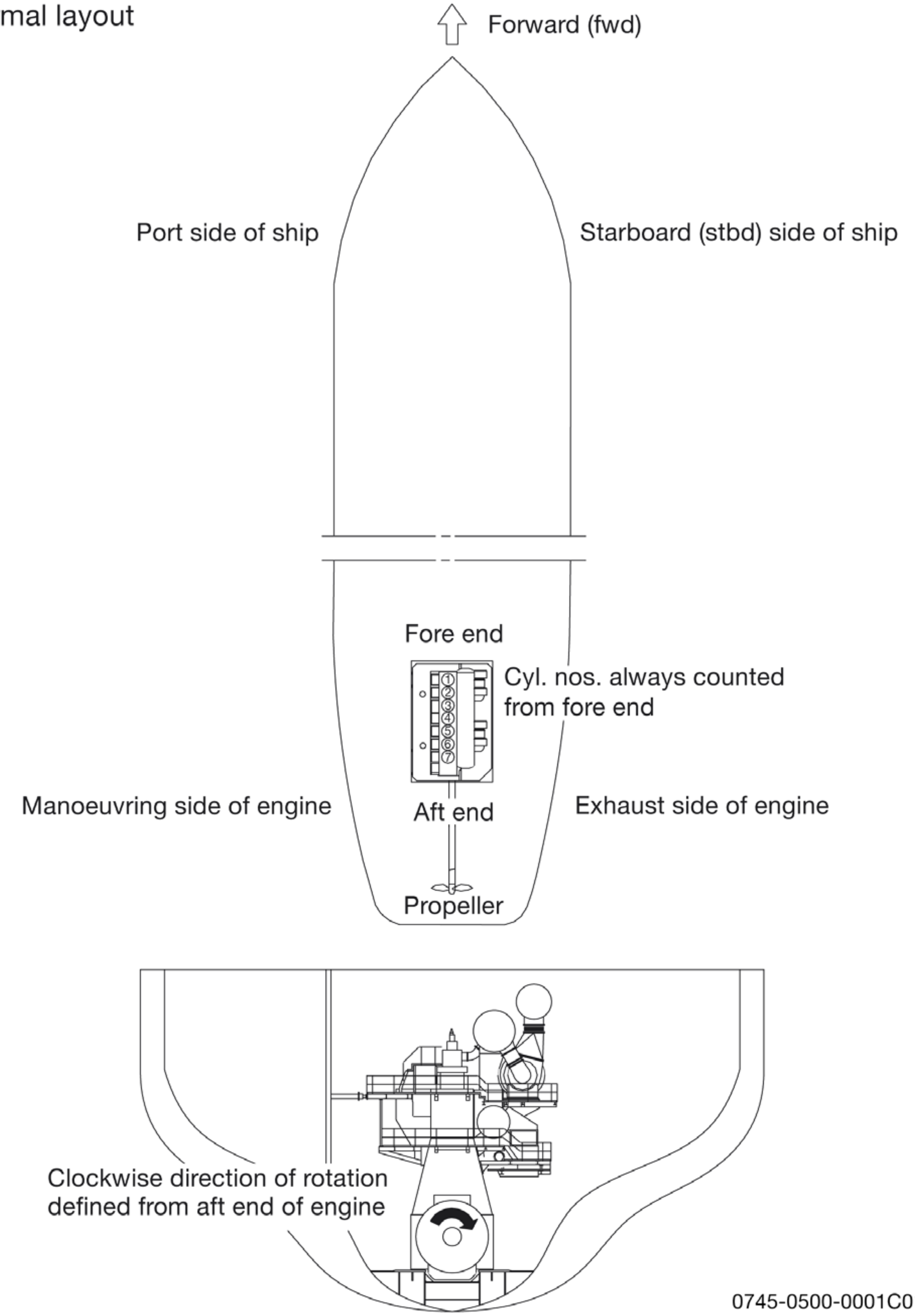
MAN Diesel & Turbo's liability for damages to the customer for any cause whatsoever, regardless of the form of any claim or action, shall not exceed the total licence fee paid by the customer for the license to use this software under this license agreement. MAN Diesel & Turbo shall in no event be liable for any damages resulting from loss of data, profits or use of equipment, or for any special, incidental consequential damages arising out of or in connection with the use or performance of the software.

The limitations in liability stipulated above in this clause 0 shall also apply to MAN Diesel & Turbo's software suppliers.

6 Law

MAN Diesel & Turbo's tenders and contracts with customers regarding delivery of data and programs, including the present licence agreement, shall be interpreted according to Danish Law.

Normal layout



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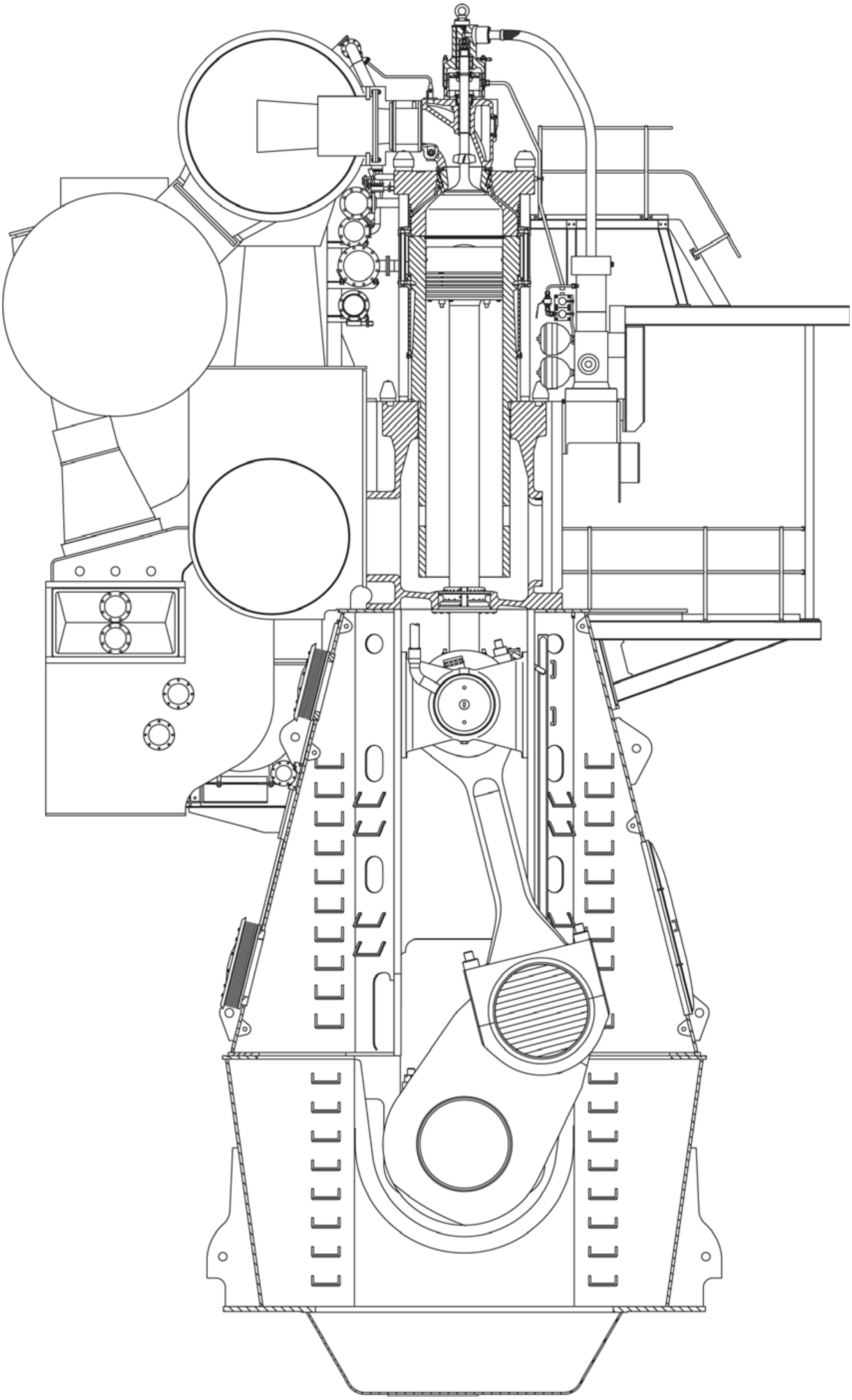


General

The Checking and Maintenance Schedules indicate the intervals at which it is deemed appropriate to inspect the individual components of the engine and to carry out overhauls, if necessary, based on the engine condition or a criterion of time.

NOTICE

The Checking and Maintenance Schedules are intended for use with multiple engine types. Therefore the Checking and Maintenance Schedules may include components which are not installed on a specific plant/vessel. In such cases the »extra« components shown in the schedules are to be ignored.

The stated Regular checks or Service interval are intended primarily as a guide, as differences in the actual service conditions, the quality of the fuel oil or lubricating oil, the treatment of cooling water, etc., will decisively influence the actual service results, and thus the intervals between necessary overhauling.

Design modifications may necessitate a revision of the instructions, in which case the revised instructions and changed overhauling intervals, if any, will apply and supersede those originally issued *(see e.g our Service Letters)*.

In addition to the checking and overhauling intervals stated in this schedule, please note that the periodical survey requirements of the classification society may require additional checks and reference is made to be carried out. For further information reference is made to the classification society.

The Checking and Maintenance Schedules consist of two sets of work procedures :

Duties During Operation

Minor work and inspection procedures which are carried out on a regular basis during the normal operation of the engine. Note that operation also includes the situation where the engine is routinely stopped, e.g. during stay in port.

Most duties during operation, with the exception of port inspection, can be carried out without entering into or dismantling the engine. Typically no tools or just basic hand tools are required for the procedures.

Major Overhaul

Major work and overhaul procedures which are carried out after a fixed number of running hours, except for situations where observations require a procedure to be carried out before the fixed number of running hours is reached.

Most major overhaul procedures require the engine to be shut down, as entering into the engine or dismantling engine components is involved.

Additionally most major overhaul procedures require the supplies of fuel oil, lubricating oil, compressed air and/or cooling water to be shut off. Typically specialised tools in addition to hand tools and lifting equipment are required for the procedures.

The procedures are divided into five categories:

Time-based condition checking procedures

Marked with a C, under the heading Regular checks or Service interval, deal with the service condition of a number of engine components, and form the basis for estimating whether further overhauling is necessary. In a number of cases the condition checking procedures refer to the operation chapter of the instruction book, in which more detailed descriptions and working procedures can be found.

Condition-based overhauling procedures

Marked with an O, under the heading Regular checks or Service interval. Under the heading Refer to (column P), a reference to additional information is stated.

This procedure number normally refers to one of the above condition checking procedures which form the basis of the overhaul. For this reason, the intervals stated are for guidance only.

Time-based overhauling procedures

Also marked with an O, under the headings Regular checks or Service interval or Based on observations, are the procedures where an actual basis for estimation is lacking. It is recommended, therefore, to carry out these procedures at the overhauling intervals stated as a basis.

The letters O or C in Based on observations (column B), indicate that special service conditions may make checking or overhauling necessary beyond the actual standard schedules indicated.

Initial checking procedures (Major Overhaul only)

Marked with a C, under the heading Check new/overhauled parts at 500, 1000 and 1500 hours (column H), deal with initial checks that must be carried out on a new engine, or when parts have been replaced.

After the three initial checks have been completed, checks need only be carried out as per heading Regular checks or Service interval.

When using electronic maintenance planning systems, special attention should be paid to all initial checking procedures, as handling of such procedures often can not be done automatically. Instead such procedures must be handled manually.

Initial adjustment procedures (Major Overhaul only)

Marked with an A, under the heading Check new/overhauled parts at 500, 1000 and 1500 hours (column H), deal with initial adjustment that must be carried out on a new engine, or when parts have been replaced.

After the three initial adjustments have been completed, adjustments need only be carried out as per headings Regular checks or Service interval.

When using electronic maintenance planning systems, special attention should be paid to all initial adjustment procedures, as handling of such procedures often can not be done automatically. Instead such procedures must be handled manually.

NOTICE

Special attention should be paid to the chain tightener, which must be adjusted three times (at 500, 1000 and 1500 hours of operation) on a new engine, or when chains or chain wheels have been replaced

2013-08-27 - en

V : See description
A : Adjustment to be carried out
H : Check new/overhauled parts at 500, 1000 and 1500 hours

M : See maker's instruction
O : Overhaul to be carried out
C : Check the condition

R : Parts to be replaced
B : Based on observations
P : refer to

No.	Procedure	H	Service interval (x1000 hours of operation)										B	P
			1	2	4	6	8	12	16	24	32			
10	**Structural Parts**													
1065-0101	Crankcase Relief Valve						C						O	M
1065-0201	Holding Down and End Chock Bolts	C					C							
1065-0301	Stay Bolts	C									C			
1065-0401	Crankcase Oil Outlet										C, R		R	
1065-0501	Top Bracings	C					C						O	
	Crankcase						C^1							
	Counter Weights										C, O^5		C, O^5	
14	**Driving Gear**													
1465-0101	Reciprocating Parts	C											C, O	
1465-0201	Crosshead	C									O^{2,3}		C, O	V^4
1465-0301	Connecting Rod												O	
1465-0401	Chains	C			C								R	V
1465-0501	Chain Tightener	C, A			C, A								A	
	Chain wheel, spray nozzles and guide bars	C			C								R	

Comments :
1 : Check for loose nuts and bearing material fragments.
2 : Overhaul may be omitted if Bearing Wear Monitoring equipment is installed.
3 : Overhaul at 32,000 hours OR when the piston has been dismantled three times.
4 : See description 2545-0100 and service letter regardingbearing wear monitoring.
5 : Check and re-tighten, if installed.

Maintenance Schedule

0760-0301-0007

80-98 ME/ME-C Engines, Major Overhaul

Maintenance Schedule

0760-0301-0007

80-98 ME/ME-C Engines, Major Overhaul

V : See description
A : Adjustment to be carried out
H : Check new/overhauled parts at 500, 1000 and 1500 hours

M : See maker's instruction
O : Overhaul to be carried out
C : Check the condition

R : Parts to be replaced
B : Based on observations
P : refer to

			Service interval (x1000 hours of operation)										
No.	Procedure	H	1	2	4	6	8	12	16	24	32	B	P
18	**Vibration Control**												
1865-0101	Axial Vibration Damper						C					O	
1865-0201	Moment Compensator	C			C							C, A	
1865-0301	Torsional Vibration Damper	C					C						M
22	**Cylinder Unit**												
2265-0101	Exhaust Valve High-Pressure Pipe											O	
2265-0201	Exhaust Valve					C^1					C, O	O	
2265-0301	Cylinder Cover					C^1					C^2	O	
	Indicator Cock											O	
2265-0401	Piston									C, O			
2265-0501	Piston Rod Stuffing Box									C, O		O	
2265-0601	Cylinder Liner									C, O		O, R	
25	**Bearings**												
2565-0201	Crosshead Bearing	C^3					C^3				$O^{4,5}$	C, O	V
2565-0301	Crankpin Bearing	C^3					C^3				$O^{4,5}$	C, O	V
2565-0401	Main Bearing	C^3					C^3					C, O	
2565-0501	Journal Bearing	C^3					C^3					C, O	
2565-0601	Thrust Bearing	C					C					C, O	
2565-0701	Guide Bearing	C					C					C, O	

Comments :
1 : Initial check only
2 : Check whenever exhaust valve is removed
3 : Bearings should only be opened if bearing material fragments fall out or top clearance is outside allowable limits.
4 : Overhaul may be omitted if Bearing Wear Monitoring equipment is installed.
5 : Overhaul at 32,000 hours OR when the piston has been dismantled three times.

V : See description
A : Adjustment to be carried out
H : Check new/overhauled parts at 500, 1000 and 1500 hours

M : See maker's instruction
O : Overhaul to be carried out
C : Check the condition

R : Parts to be replaced
B : Based on observations
P : refer to

			Service interval (x1000 hours of operation)										
No.	Procedure	H	1	2	4	6	8	12	16	24	32	B	P
30	**Lubricating Oil System**												
3065-0601	Cylinder Lubricator									C, O		A	V, M
	Cylinder Lubricator Level Sensor				C							O	V, M
3065-0651	Cylinder Lubrication Non-Return Valve											O	
	System Lubricating Oil Bottom Tank										O[1]		
34	**Compressed Air System**												
3465-0201	Starting Air Valve							C, O					
42	**Fuel System**												
4265-0101	Fuel Oil High-Pressure Pipe											O	
4265-0201	Fuel Valve						C, O						
	Fuel Nozzle						C		R			R	
4265-0301	Fuel Valve Spindle Guide						C		R				
4265-0401	Fuel Valve Non-Return Valve						O						
4265-0501	Fuel Oil Pressure Booster										O	O	
4265-0601	Fuel Oil Pressure Booster Top Cover											O	
4265-0701	Fuel Oil Pressure Booster Suction Valve						C, O					O	
4265-1301	Fuel System Shock Absorber						C, O					O	

Comments :
1 : Empty and clean tank.

Maintenance Schedule

0760-0301-0007

80-98 ME/ME-C Engines, Major Overhaul

V : See description
A : Adjustment to be carried out
H : Check new/overhauled parts at 500, 1000 and 1500 hours
M : See maker's instruction
O : Overhaul to be carried out
C : Check the condition
R : Parts to be replaced
B : Based on observations
P : refer to

			Service interval (x1000 hours of operation)										
No.	Procedure	H	1	2	4	6	8	12	16	24	32	B	P
45	**Hydraulics**												
4565-0101	Exhaust Valve Actuator										O		
	Valve Actuator Safety Valve						C, A						
4565-0201	Hydraulic Oil Pump										C	R	M
4565-0301	Hydraulic System										C	O	
4565-0401	Hydraulic Cylinder Unit											C, O	
4565-0501	Accumulator			C							O	A, O	
4565-0551	Control Valves										C	R	M
4565-0601	Hydraulic Power Supply Unit											O	
4565-1001	Hydraulic System Leakage Test				C							O	V
	Hydraulic Oil Fine Filter								C			O	M
	Hydraulic High-Pressure Hose										R^1	R^1	M
	Rubber Compensator Before Hydraulic Pump										R^1	R^1	M
4565-1201	Hydraulic Power Supply Gear Box	C				C						R	V

Comments :
1 : 32,000 hours or max. 5 years (Including shelf-life).

V : See description
A : Adjustment to be carried out
H : Check new/overhauled parts at 500, 1000 and 1500 hours

M : See maker's instruction
O : Overhaul to be carried out
C : Check the condition

R : Parts to be replaced
B : Based on observations
P : refer to

			Service interval (x1000 hours of operation)										
No.	Procedure	H	1	2	4	6	8	12	16	24	32	B	P
47	**Electronics**												
4765-0101	Pressure Sensors					C						R, A	V, M
4765-0151	Pressure Controllers					C						R, A	V, M
4765-0201	Temperature Sensors					C						R, A	V, M
4765-0251	Temperature Controller					C						R, A	V, M
4765-0301	Level Sensors					C						R, A	V, M
4765-0401	Proximity Sensors					C						R, A	V, M
4765-0601	Displacement Sensors					C						R, A	V, M
4765-1001	Cable Connections	C					C					O	V
4765-1201	Flow Sensors					C						R, O	V, M
4765-1901	Multi-Purpose Controller					C						R	V[1]
	Electronic Boxes					C						O	V
	Thrust Bearing Alarm System						C					O	
	Turning Gear Switch						C					A	M

Comments :
1 : See Description 6645-0200.

Maintenance Schedule

80-98 ME/ME-C Engines, Major Overhaul

0760-0301-0007

V : See description
A : Adjustment to be carried out
H : Check new/overhauled parts at 500, 1000 and 1500 hours

M : See maker's instruction
O : Overhaul to be carried out
C : Check the condition

R : Parts to be replaced
B : Based on observations
P : refer to

			Service interval (x1000 hours of operation)										
No.	Procedure	H	1	2	4	6	8	12	16	24	32	B	P
54	**Exhaust Gas and Scavenge Air System**												
5465-0101	Air Cooler Element											C, O	V
5465-0201	Water Mist Catcher											C, O	
5465-0301	Axiliary Blower Non-Return Valve											O	
5465-0401	Scavenge Air Cooler Non-Return Valve											O	
5465-0501	Auxiliary Blower											O	
5465-0601	Scavenge Air Reciever Safety Valve						C					O	
5465-0701	Turbocharger						C					C, O	V, M
5465-0801	Gas By-Pass Valve						C					O	
5465-0901	Exhaust Reciever						C[1]					O	
56	**Emission Control**												
5665-0201	EGR Water Mist Catcher					C						C, O	
5665-0301	EGR Cooler					C						C, O	
5665-0401	EGR Scrubber					C						C, O	
5665-0501	EGR Blower					C		O[2]			O[3]	C, O	M
5665-1001	EGR Valves					C						C, O	
5665-1501	EGR Measuring System					C						C, O	
	EGR Drains					C						C, O	
	EGR Pipes					C						C, O	
	EGR Mixing Chamber					C						C, O	

Comments :
1 : Check protective grid before turbocharger(s).
2 : Small overhaul (»service 1«) as per maker's instructions. NOTE : 12.000 running hours of engine, NOT running hours of EGR blower.
3 : Large overhaul (»service 2«) as per maker's instructions. NOTE : 32.000 running hours of EGR blower, NOT running hours of engine.

V : See description
A : Adjustment to be carried out
H : Check new/overhauled parts at 500, 1000 and 1500 hours

M : See maker's instruction
O : Overhaul to be carried out
C : Check the condition

R : Parts to be replaced
B : Based on observations
P : refer to

			Service interval (x1000 hours of operation)									
No.	Procedure	H	1	2	4	6	8	12	16	24	32	B	P
66	**Operation**												
6665-0101	Exhaust Valve Special Running											O	
70	**Control System**												
7065-1101	Angle Encoder					C						C, A	V, M
7065-1201	Tacho Sensor					C						C, A	V, M
7065-1501	MPC Unit					C							
76	**Tools**												
7665-0101	Hydraulic Tools						C					O	M
7665-0201	Standard Tightening Torques												
7665-0301	Torque Spanner												
7665-0401	Tighening Gauge												
7665-0501	Screws and Nuts												
7665-0601	Working Platforms												
7665-0701	Hydraulic Nut												
7665-0801	Hydraulic Ring												
7665-0901	Lubricating Procedure												

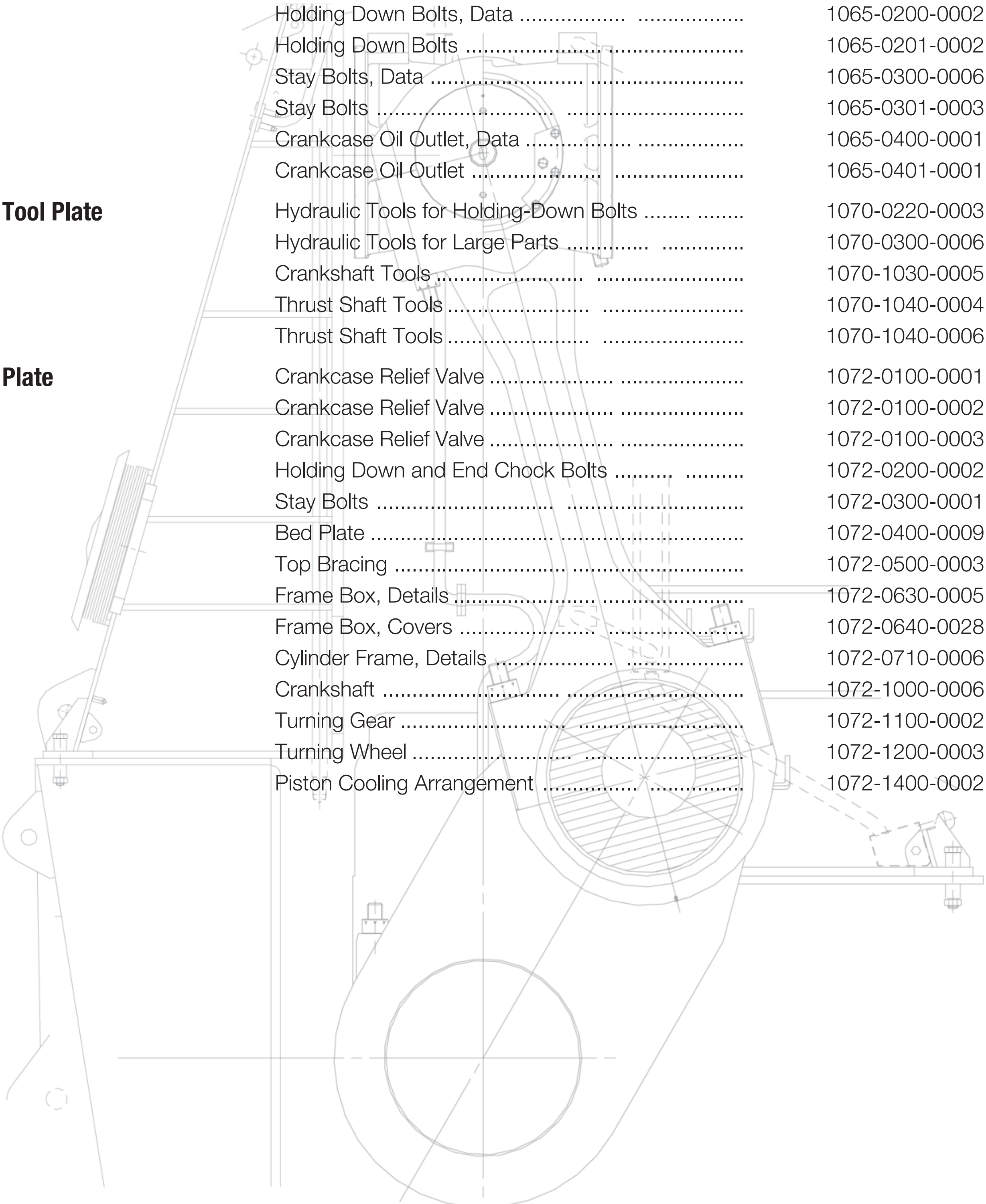
Comments :

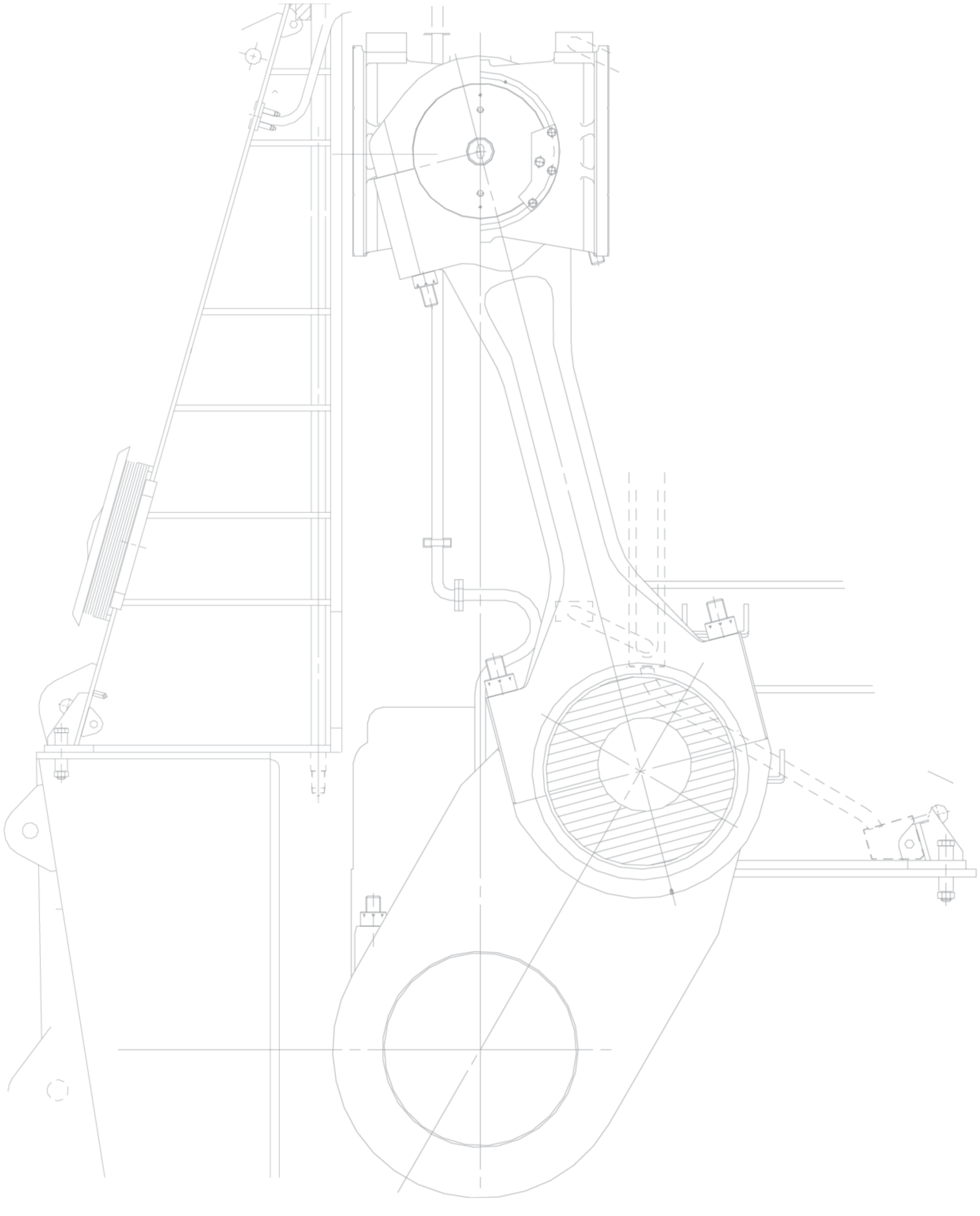
Maintenance Schedule

0760-0301-0007

80-98 ME/ME-C Engines, Major Overhaul

Preface Chapter	Structural Parts	1040-0100-0002
Work Card	Crankcase Reliefe Valve, Data	1065-0100-0001
	Crankcase Reliefe Valve	1065-0101-0002
	Holding Down Bolts, Data	1065-0200-0002
	Holding Down Bolts	1065-0201-0002
	Stay Bolts, Data	1065-0300-0006
	Stay Bolts	1065-0301-0003
	Crankcase Oil Outlet, Data	1065-0400-0001
	Crankcase Oil Outlet	1065-0401-0001
Tool Plate	Hydraulic Tools for Holding-Down Bolts	1070-0220-0003
	Hydraulic Tools for Large Parts	1070-0300-0006
	Crankshaft Tools	1070-1030-0005
	Thrust Shaft Tools	1070-1040-0004
	Thrust Shaft Tools	1070-1040-0006
Plate	Crankcase Relief Valve	1072-0100-0001
	Crankcase Relief Valve	1072-0100-0002
	Crankcase Relief Valve	1072-0100-0003
	Holding Down and End Chock Bolts	1072-0200-0002
	Stay Bolts	1072-0300-0001
	Bed Plate	1072-0400-0009
	Top Bracing	1072-0500-0003
	Frame Box, Details	1072-0630-0005
	Frame Box, Covers	1072-0640-0028
	Cylinder Frame, Details	1072-0710-0006
	Crankshaft	1072-1000-0006
	Turning Gear	1072-1100-0002
	Turning Wheel	1072-1200-0003
	Piston Cooling Arrangement	1072-1400-0002





General

Engine Seating

Section: 10XX-01YY
Regarding the engine seating for the specific engine, see the supplier's special instructions.

Holding down bolts

Section: 10XX-02YY
The bedplate is secured to the bottom of the ship by means of holding down bolts.

Staybolts

Section: 10XX-03YY
The bedplate, framebox and the cylinder frame are tightened together to form one unit by means of staybolts.

Bedplate

Section: 10XX-04YY
The bedplate is made in one section. The bedplate consists of two welded, longitudinal girders and a number of cross girders which support the main bearings. Each main bearing has one main bearing cap which are secured by studs and nuts, designed for tightening with hydraulic tools.
See also Description 2545-0100 and Chapter 25 "Bearings".

The bedplate is fitted with an axial vibration damper. For the design and functioning of the axial vibration damper, *see also Chapter 18 "Vibration Control".*

Framebox

Section: 10XX-06YY
A framebox is bolted to the top of the bedplate. The framebox is made in one piece. Together, the bedplate and the framebox constitute the crankcase of the engine.

The framebox is fitted with steelplate doors for access to the crossheads and to the main and crankpin bearings.

For each cylinder, the framebox is equipped with a slotted pipe in which the piston cooling oil outlet pipe is fitted to the crosshead shoe is able to travel. From the slotted pipe the cooling oil is, through an outlet pipe, led to the oil tray of the bedplate.

Equipment for local checking of the cooling oil temperature and flow, and for temperature and flow alarms, is installed in conjunction with the outlet pipe. *See also Description 7045-0100.*

Relief Valves

On the exhaust side of the engine a number of spring loaded relief valves are fitted, which will open in the event of excessive pressure in the crankcase/ chain casing, for instance as a result of the ignition of oil mist.

⚠ WARNING

Keep the areas around the relief valves free of oil, grease, etc. to prevent the risk of fire caused by hot air/gas emitted in the event that the relief valves open.

Regarding how to:

- avoid evaporation of the lubricating oil in the crankcase,

- detect oil mist in the crankcase using an ‘Oil Mist Detector’.

See Description 6645-0300.

WARNING

Do not stand near crankcase doors or relief valves – or in corridors near doors to the engine room casing 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 Letter SL97-348/ERO.

NOTICE

If there has been a crankcase explosion, the complete flame arrester of the relief valves must be replaced.

Cylinder Frame

Section: 10XX-07YY

The cylinder frame is designed wih an integrated camshaft housing. The cylinder section is tightened together with the engine framebox and the bedplate by means of stay bolts. Alternatively as a complete welded assembly integrating the scavenge air receiver into the cylinder frame.

Bores and openings

Central bores at the top of the cylinder frame enclose the cylinder liners. Central bores in the bottom of the cylinder frame enclose the piston rod stuffing boxes. On the exhaust side of the cylinder frame there are openings which connect the scavenge air space around the cylinder liner with the longitudinal scavenge air receiver of the engine. There are also inlet pipes for cooling and lubricating oil. The cylinder frame is provided with cleaning and inspection covers giving access to the scavenge air spaces.

Cylinder cover studs

Studs for fastening the cylinder cover are mounted in the cylinder frame.

Crankshaft

The crankshaft is either of the semi-built type, where the parts are shrunk together.

The main bearings are lubricated via a main lubricating oil pipe that branches off to the individual bearings, whereas oil for lubricating the crankpin bearings is supplied from the crossheads through bores in the connecting rods.

The crankshaft is provided with a chain wheel for the camshaft drive and a turning wheel. Furthermore, a tuning wheel, a torsional vibration damper and a chain wheel drive for 2nd order moment compensators are installed, if required according to vibration calculations. *See chapter 18 “Vibration Control”.*

Marine engines (except geared plants):
At the aftmost end of the engine, a thrust bearing is fitted. *See chapter 25 “Bearings”.*

Stationary engines and geared marine plants:
The crankshaft is provided with a collar for the guide bearing. The purpose of the guide bearing is to keep the crankshaft in its proper position in the axial direction.

Turning Gear

The turning gear is fastened to the engine bedplate and is driven by an electric motor.

Via a worm gear and a following planetary gearing, the motor drives a horizontal shaft equipped with a gear wheel, which can be axially displaced manually so as to engage with the turning wheel of the engine.

This displacement is performed by means of a big vertical lever placed on the protecting shield of the gear wheel. A small vertical lever, placed on the end cover of the protecting shield of the turning gear, locks the position of the big lever in, respectively, engaged and disengaged position between the gear wheel and turning wheel.

Locking is performed by engagement of a tap of the small lever into two notches of the big vertical lever.

When the big lever is in its most forward position, the turning gear is not engaged with the turning wheel.

Engagement of the gear wheel with the turning wheel is achieved by moving the big lever to its most aftwards position. In this position, an interlock valve inserted in the starting air system of the engine is actuated by the big lever. This interlock prevents starting air from being supplied to the engine as long as the turning gear is in the engaged position.

Through an inspection groove at the top of the protecting shield, it must always be ensured that the gear wheel is in correct position according to the planned operation of the turning gear.

Always ensure that any of the two positions of the big lever (engagement/disengagement of the turning wheel) is locked by the small lever.
See also Description 6645-0120.

⚠ WARNING

Dismantling of working parts:
During any dismantling of working parts of the engine, the turning gear must be in the engaged position in order to prevent outside forces from turning the engine, thus causing injuries to personnel or damage to the machinery. See Workcards, Datapages.

⚠ WARNING

Pressure testing of starting valves:
The turning gear must be in the disengaged position during pressure testing of starting valves, as a leaky valve may cause the engine to rotate, and damage the turning gear. See Description 6645-0170.

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
-	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

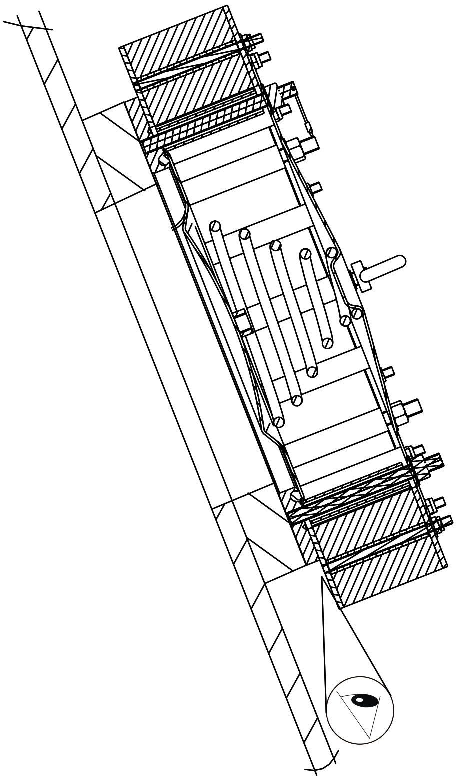
Plate	Item No.	Description
-	**-**	Table is empty on purpose. No special tools needed.

Leaks During Running

During running of the engine, check if there are any leaks.

If a leak occurs, replace the O-ring inside the relief valve.

See separate instructions from the valve manufacturer.



1065-0101-0002C01

Checking the plates

If work involving risks of mechanical damage to the flame arrester has taken place, a visual inspection of the flame arrester should always be performed before starting the engine.

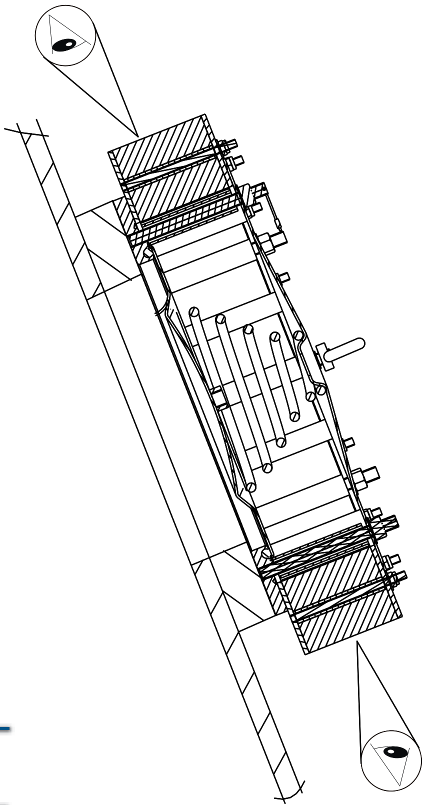
Check on the whole circumference that all the plates in the flame arrester are evenly distributed and that no local openings exist.

If one or more plates in the flame arrester are damaged, the relief valve must be disassembled and the flame arrester replaced.

See separate instructions from the valve manufacturer.

NOTE

The complete flame arrester has to be replaced after a crankcase explosion.



1065-0101-0002C02

Safety Precautions

for detailed sketch see 0545-0100

○ Stop the Engine

Data

Ref.	Description	Value	Unit
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

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
1070-0200	**-**	Hydraulic Tools for End-Chock Bolts
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**047**	Hose with unions, 1500 mm

Tightening the Holding Down and End Chock Bolts

NOTE

The hydraulic jack used for tightening the holding down bolts is marked with:

For: Holding down bolts

The larger jack used for tightening the end chock bolts is marked with:

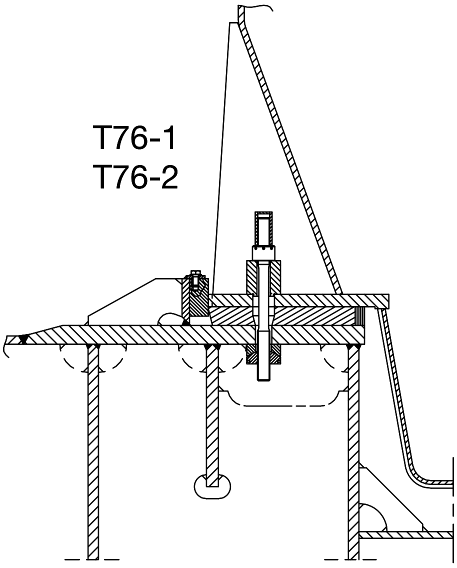
For: End chock bolts

Hydraulic tightening of holding down bolts and end chock bolts is carried out as detailed in 7665-0101. The normal tightening pressure is indicated on the Data sheet and is also stamped on the tightening tool.

Checking the bolt tightening

The holding down bolts and end chock bolts must be checked for correct tightness at the intervals indicated on the Data sheet.

For this purpose, raise the pressure on the hydraulic tool slowly while constantly attempting to loosen the nut with the tommy bar. The oil pressure indicated on the pressure gauge when the nut comes loose ('loosening pressure') is to be noted in the checking tables, see pages 4 and 5, following which the bolts are tightened to the normal tightening pressure.



1065-0201-0001C01

The condition of the bolted joints, and thus the general condition of the foundation, can be effectively checked by comparing the tables from successive bolt checks.

If the 'loosening pressure' is below 80 per cent of the tightening pressure, the relative chocks shall always be checked for possible defects. If the chocks are in position and in order, the bolts should be taken out for inspection of threads and contact faces.

Checking of epoxy supporting chocks

If a number of measuring pins have been welded to the tanktop, the heights of the epoxy supporting chocks are to be checked immediately after finishing the checking of the loosening pressures of the holding down bolts and the retightening of these.

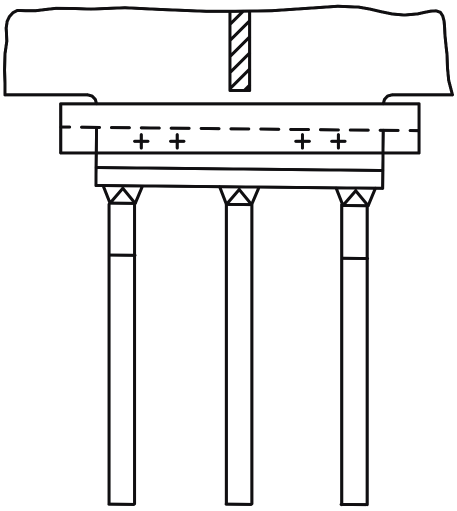
The distance between the measuring pins and the bedplate is to be measured with a blade gauge and noted down. Any possible settling of the chocks during the intervals between measurements can thereby be followed.

Side chocks and side chock liners

After fitting the liners to an 80 per cent contact area on both sides of the liners, knock the liners a further 3 to 4 mm inwards.

The liners located in way of each main bearing on either side of the engine must be fitted and knocked into position simultaneously.

The first time the ship is sailing in a fully-loaded condition after the engine has been operating for 1,000 hours, all side chocks should be checked to see whether the liners can be knocked further inward.



1065-0201-0001C03

The fit of the side chock liners should be checked with a feeler gauge each time the loosening pressure of the holding down bolts is checked, and thus at the same time intervals.

The feeler gauge is applied at the 7 points indicated in the table on page 5, and the measurements found are to be entered in the relevant table. These results are used to determine whether refitting or, possibly, replacement of the liners is necessary.

If the measurements at 3 points or more have increased 5/100 mm or more from the initial results, we recommend that the following procedure is followed:

1. Loosen the hexagon screws.
2. Try to knock the liner further inward.
3. Measure again at the 7 points indicated in the table.

If this procedure does not improve the situation, the liner must be removed, and it must be checked that the actual contact area is more than 80 per cent of the possible contact surface areas on both sides of the liner.

The liners are secured in their correct position by means of hexagon socket set screws with cup point.

Holding down bolts

Engine frame No.	Bolt No.	Port side			Cylinder No.	Starboard side			Bolt No.	Engine frame No.
		pressure	% dev.	remarks		pressure	% dev.	remarks		
1	1								1	1
	2								2	
	3								3	
	4				1				4	
2	1								1	2
	2								2	
	3								3	
	4				2				4	
3	1								1	3
	2								2	
	3								3	
	4				3				4	
4	1								1	4
	2								2	
	3								3	
	4								4	
5	1								1	5
	2								2	
	3								3	
	4								4	
6	1								1	6
	2								2	
	3								3	
	4								4	
7	1								1	7
	2								2	
	3								3	
	4								4	
8	1								1	8
	2								2	
	3								3	
	4								4	
9	1								1	9
	2								2	
	3								3	
	4								4	
10	1								1	10
	2								2	
	3								3	
	4								4	
11	1								1	11
	2								2	
	3								3	
	4								4	
12	1								1	12
	2								2	
	3								3	
	4								4	
13	1								1	13
	2								2	
	3								3	
	4								4	
14	1								1	14
	2								2	
	3								3	
	4								4	
	1								1	

1065-0201-0001C04

Side chocks and
end chock bolts

Port side								Starboard side							
Chock No.	Point							Cylinder No.	Point							Chock No.
	A	B	c	d	e	f	g		A	B	c	d	e	f	g	
1								1								1
2								2								2
3								3								3
4																4
5																5
6																6
7																7
8																8
9																9
10																10
11																11
12																12
13																13
14																14

Port side									Starboard side									
Ch No.	Bolt No.	Pressure (kp/cm^2) bar	Deviation %	Point					Point					Deviation %	Pressure (kp/cm^2) bar	Bolt No.	Ch No.
				a	b	c	d	e	a	b	c	d	e				
E	1															1	E
	2															2	

1065-0201-0001C05

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T10-07	Check measurement	236±3	mm
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

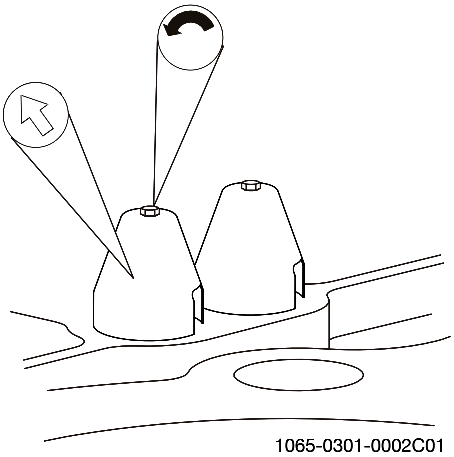
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
2570-0400	**010**	Hydraulic jack, complete
2570-0400	**021**	Support for hydraulic jack
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**047**	Hose with unions, 1500 mm
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**106**	5-way distributor block, complete

NOTE

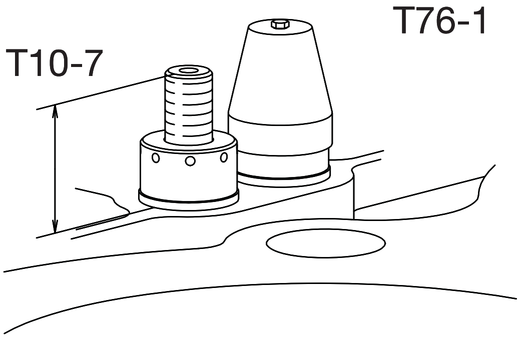
The first time this check is performed it has to be completed in one operation. The following checks have to be completed within a 500-hour period.



1065-0301-0002C01

Remove Caps

Before retightening the stay bolts, remove the protective caps.



1065-0301-0001C03

Check for loose nuts

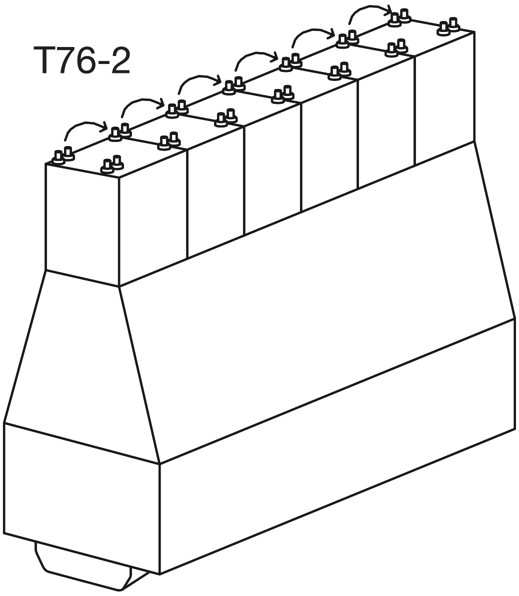
Check for loose staybolt nuts with the tommy bar.

If a loose nut is found, unscrew the nut until a gap occurs between cylinder frame and nut.

Loosen and unscrew the nut on the opposite stay bolt.

Check for the correct mounting of the stay bolt by comparing with the check measurement on the data sheet.

If the check measurement is not reached, indicating that the stay bolt is not screwed properly down in the thread of the bedplate, apply a screw and a counternut in the thread in the top of the stay bolt, and turn the stay bolt until the check measurement data is met.



1065-0301-0001C04

Tightening sequence

Retighten the stay bolt in pairs (athwarthship), working from aft to fore of the engine.

Placing of hydraulic tools

Clean the contact faces and mount the hydraulic tools on a pair of stay bolts positioned opposite each other.

Connect the high-pressure pump by means of the high-pressure hoses, so that the two stay bolts are tightened in one pair.

Tightening stay bolts

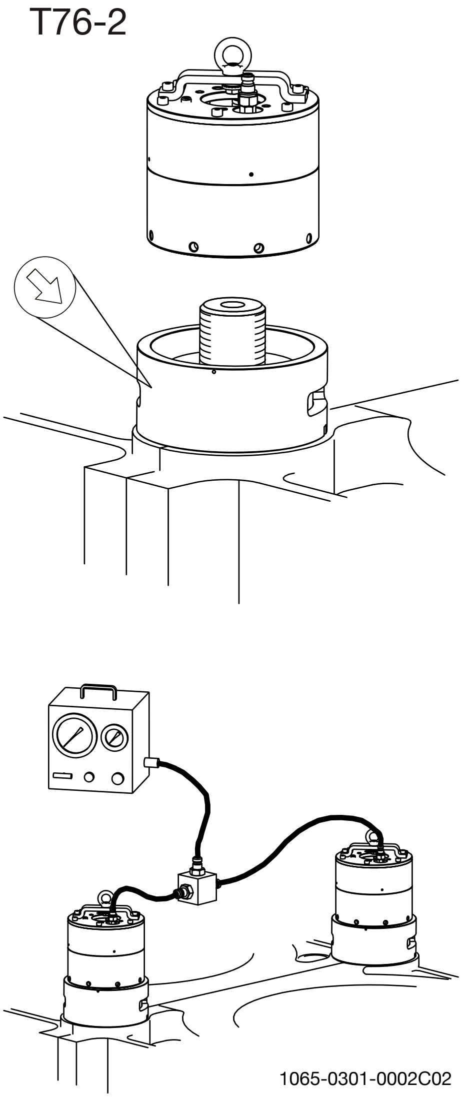
Reconnect the hydraulic tools to the pair of stay bolts first tightened. Tighten to 10% below T76-2 and check if the nut is loose.

If the nut is **not** loose:

Tighten the stay bolts to T76-2.

If the nut is loose:

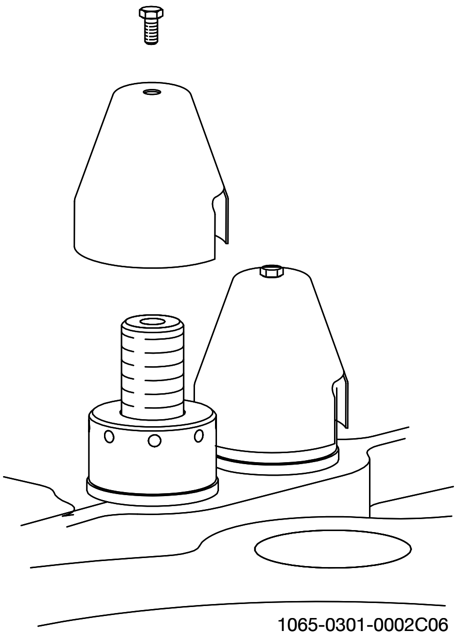
Tighten **all** stay bolts once again to T76-2.



1065-0301-0002C02

On completion

After completing the retightening procedure, mount the protective caps.



1065-0301-0002C06

Crankcase Oil Outlet, Data

Work Card
1065-0400-0001

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T10-10	Metal bellow, up to	15	Kg

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.

Crankcase Oil Outlets

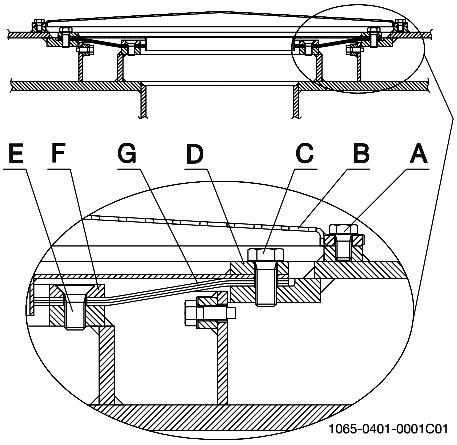
The crankcase oil outlets guide the lubricating oil from the crankcase to the lubricating oil bottom tank. The sealing of the crankcase oil outlets must be checked at regular intervals, for example during dockings. The crankcase oil outlets may be equipped with either rubber diaphragm sealing or metal bellow sealing.

NOTE

If the water content of the main engine lube oil is rising, this may indicate that the crankcase oil outlet sealings are fractured..

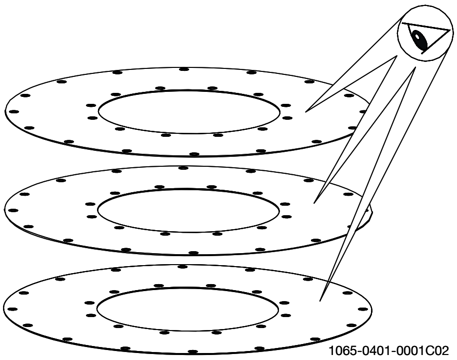
Rubber diaphragm dismantling

To access the rubber diaphragm sealing remove:
Screws A
Grating B
Screws C
Cover plate D
Screws E
Steel ring F.



Rubber diaphragm replacement

Lift away the rubber sealing diaphragms G and examine each diaphragm closely. In case of any rips or tears in the diaphragms, they must be replaced.



NOTE

It is strongly recommended always to replace the diaphragms during inspection. If unavailable, new diaphragms may be made from three layers of 2 mm thick oil and temperature resistant rubber.

Rubber diaphragm mounting

Mount:
Rubber sealing diaphragms G
Steel ring F
Screws E
Cover plate D
Screws C
Grating B
Screws A.

NOTE

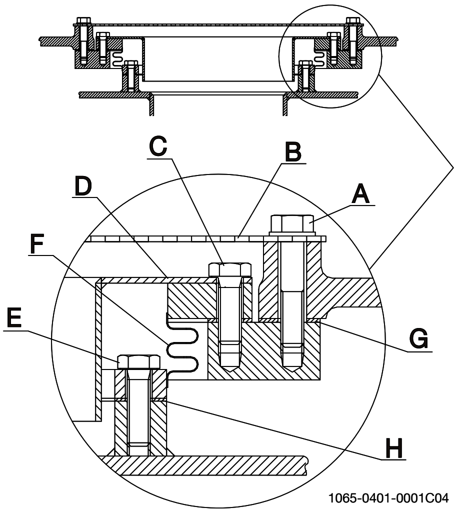
Remember to fit new locking plates at screws A.

Metal bellow dismantling

Remove all screws A and grating B.

Remount four of the screws A at diametrically opposite positions.

Remove:
Screws C
Cover plate D
Screws E.



1065-0401-0001C04

Metal bellow replacement

Lift away metal bellow sealing F and examine it closely. If any cracks or punctures are found in the metal bellow sealing, it must be replaced.

NOTE

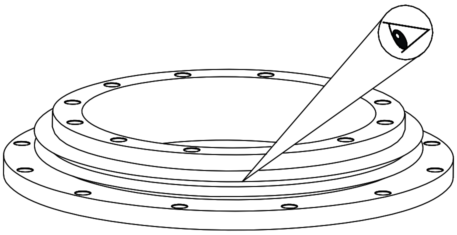
It is recommended to always replace the metal bellow sealing during inspection.

Metal bellow mounting

Replace gaskets G and H.

Mount metal bellow sealing F.

Mount:
Screws E
Cover plate D
Screws C



1065-0401-0001C07

Remove the four screws A
Mount grating B
Mount all screws A.

Hydraulic Tools for Holding-Down Bolts

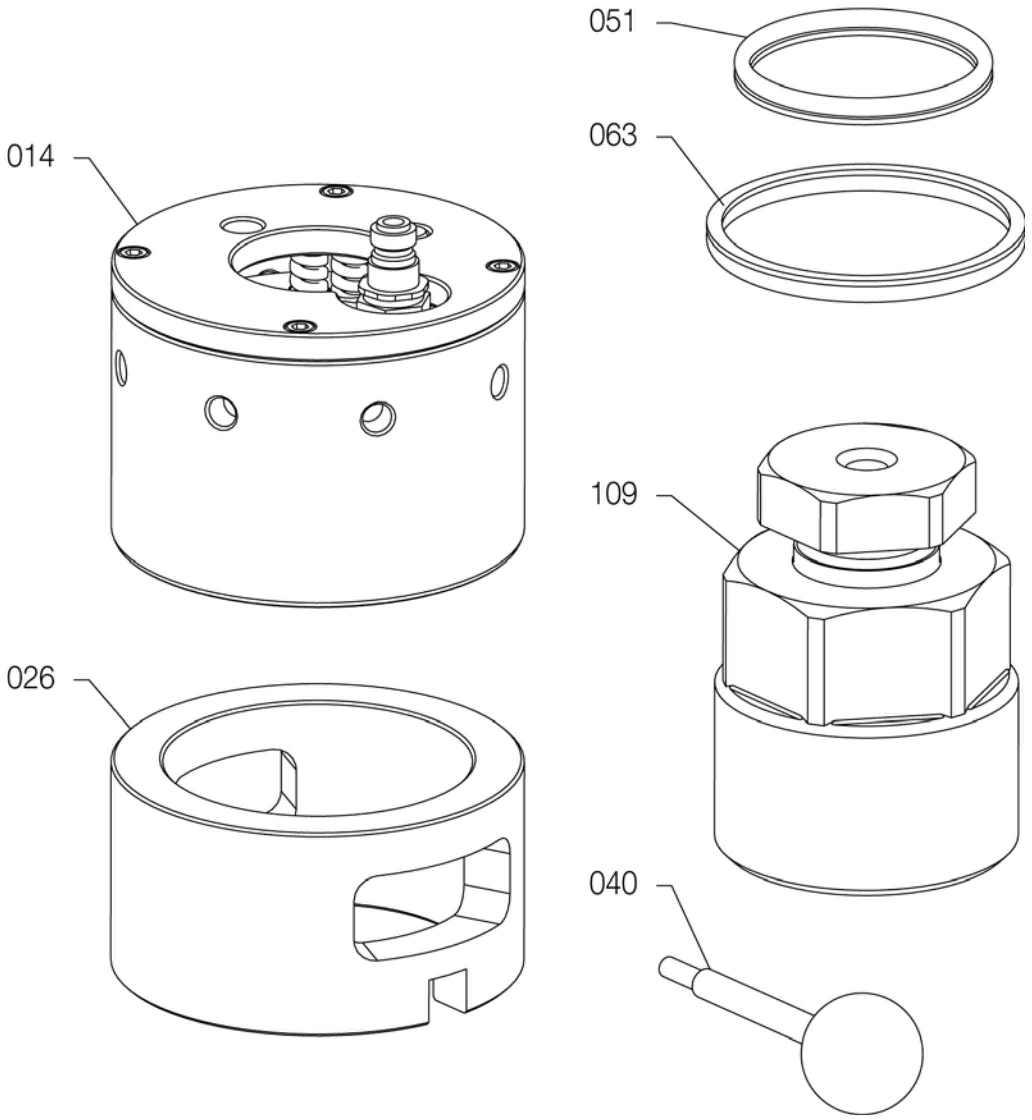
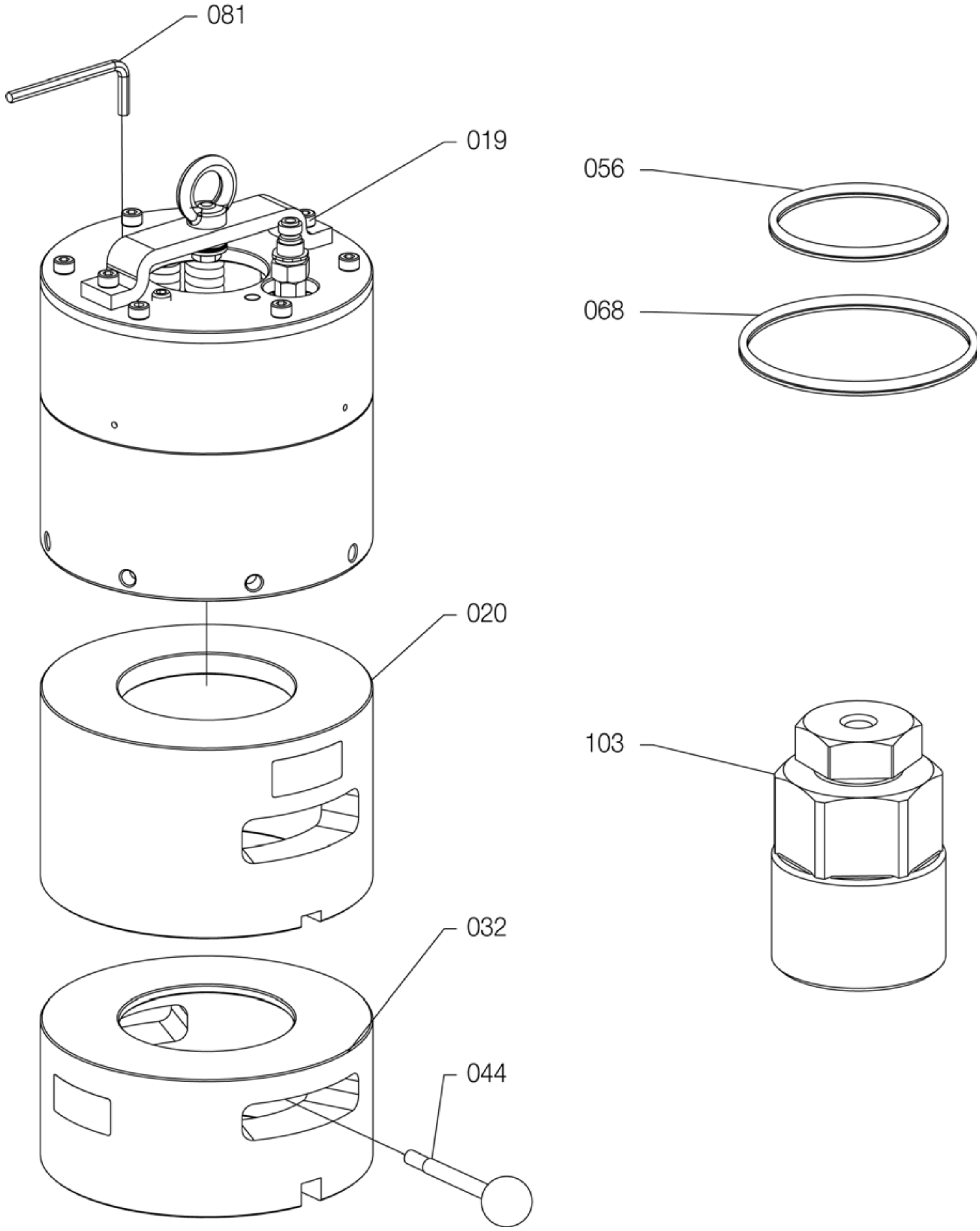


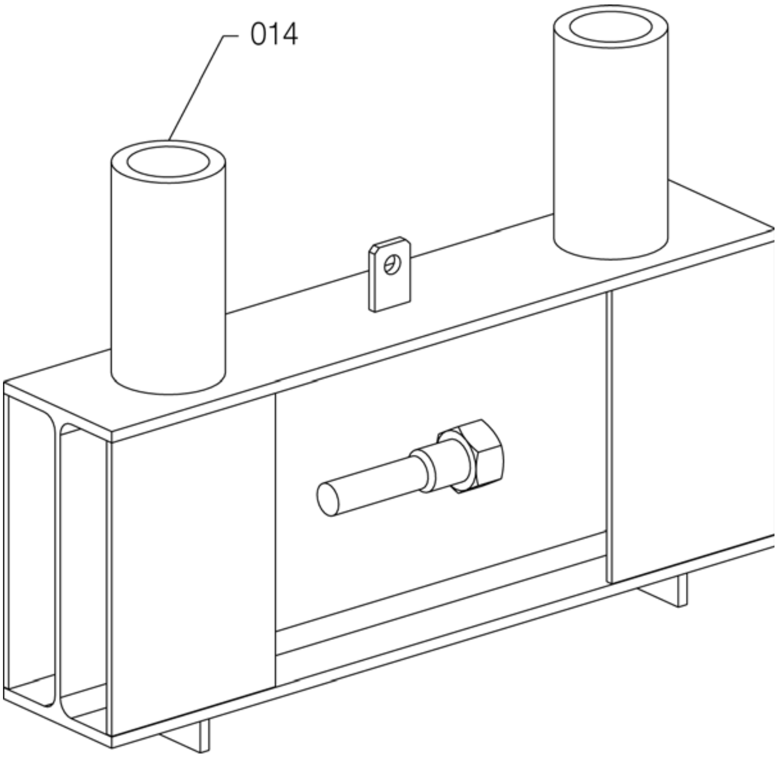
Plate
1070-0220-0003

2010-12-10 - en

Item no	Qty	Designation
014	-	Hydraulic Jack, complete
026	-	Hydraulic jack, support
040	-	Ball handle
051	-	Sealing ring with back-up
063	-	Sealing ring with back-up
109	-	Stud setter


081
019
056
068
020
103
032
044

Item no	Qty	Designation
019	-	Hydraulic jack, complete
020	-	Support for hydraulic jack
032	-	Support, hydraulic jack
044	-	Ball handle
056	-	Sealing ring with back-up ring
068	-	Sealing ring with back-up ring
081	-	Hex key
103	-	Stud setter


014

Item no	Qty	Designation
014	-	Lifting tool for crankshaft

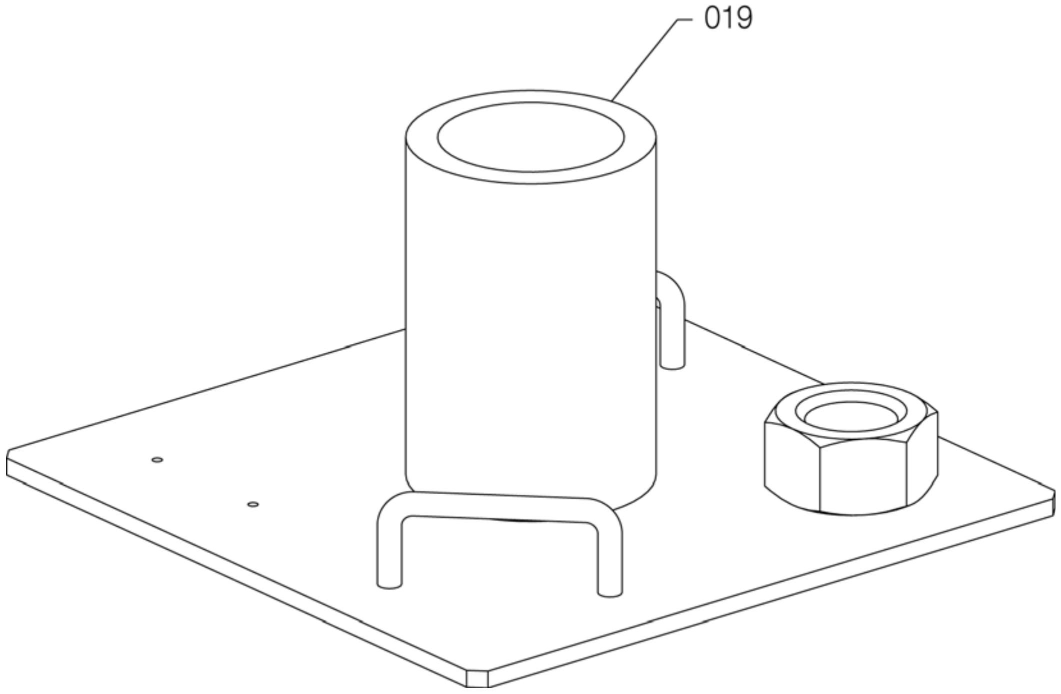
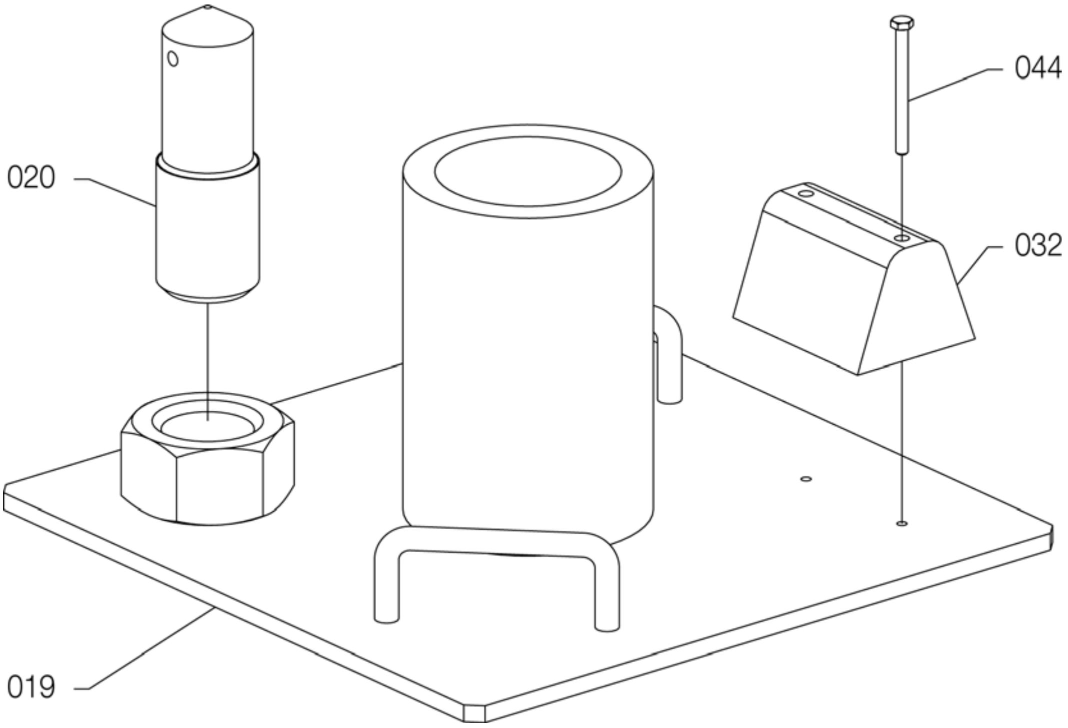


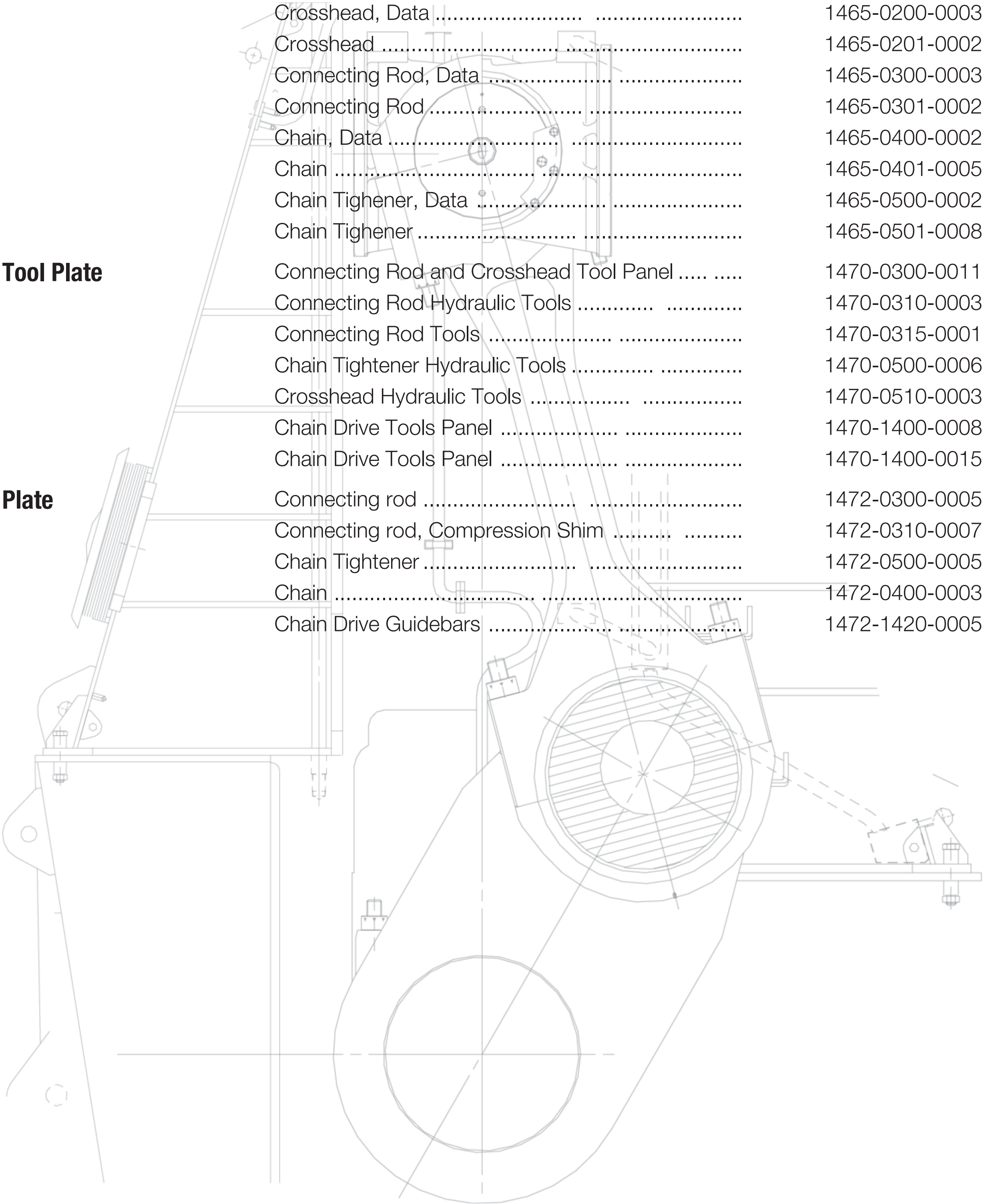
Plate
1070-1040-0004

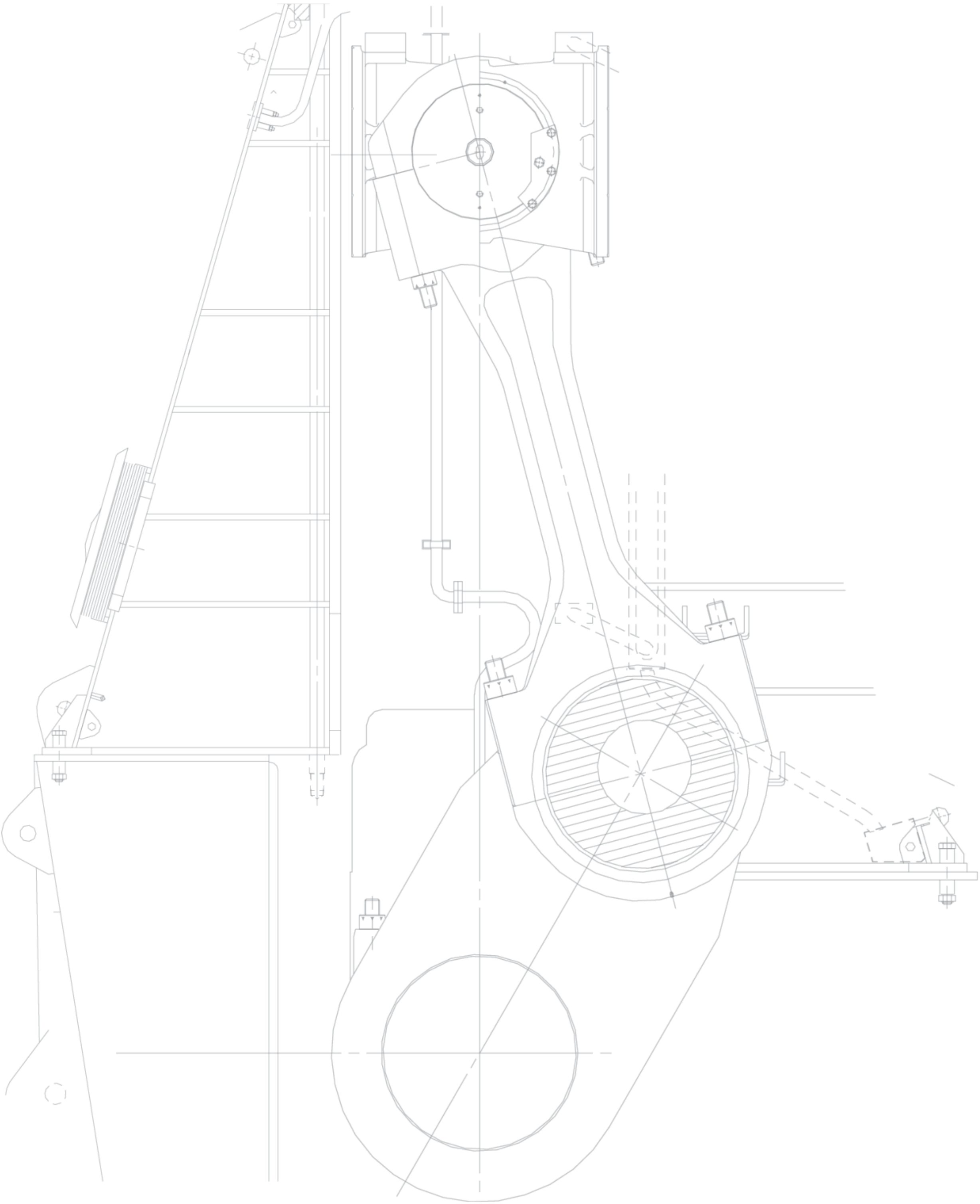
Item no	Qty	Designation
019	-	Lifting tool for thrust shaft


044
020
032
019

Item no	Qty	Designation
019	-	Lifting tool for thrust shaft
020	-	Screw with special head
032	-	Support
044	-	Screw

Preface Chapter	Driving Gear	1440-0100-0002
Work Card	Reciprocating Parts, Data	1465-0100-0005
	Reciprocating Parts	1465-0101-0002
	Crosshead, Data	1465-0200-0003
	Crosshead	1465-0201-0002
	Connecting Rod, Data	1465-0300-0003
	Connecting Rod	1465-0301-0002
	Chain, Data	1465-0400-0002
	Chain	1465-0401-0005
	Chain Tighener, Data	1465-0500-0002
	Chain Tighener	1465-0501-0008
Tool Plate	Connecting Rod and Crosshead Tool Panel	1470-0300-0011
	Connecting Rod Hydraulic Tools	1470-0310-0003
	Connecting Rod Tools	1470-0315-0001
	Chain Tightener Hydraulic Tools	1470-0500-0006
	Crosshead Hydraulic Tools	1470-0510-0003
	Chain Drive Tools Panel	1470-1400-0008
	Chain Drive Tools Panel	1470-1400-0015
Plate	Connecting rod	1472-0300-0005
	Connecting rod, Compression Shim	1472-0310-0007
	Chain Tightener	1472-0500-0005
	Chain	1472-0400-0003
	Chain Drive Guidebars	1472-1420-0005





General

Crosshead

Section: 14XX-02YY
The crosshead is provided with two guide shoes fitted on the crosshead ends.

The centre part of the crosshead is designed as a bearing journal which is housed in the crosshead bearing.

The crosshead bearing cap is provided with a cut-out enabling the piston rod to be assembled with the crosshead journal. *See also Description 2545-0100 and Chapter 25 "Bearings".*

Piston rod foot

The piston rod foot is fastened to the crosshead. To match different engine lay outs, a shim of predetermined thickness is inserted between the piston rod and the crosshead.

Lubrication

The crosshead is provided with bores for distributing the oil supplied through the telescopic pipe, partly as cooling oil for the piston, partly as lubricating oil for the crosshead bearing and guide shoes and – through a bore in the connecting rod – for lubricating the crankpin bearing.

The piston cooling oil outlet is led through a control device for each cylinder for the purpose of checking the temperature and flow before the oil is passed on to the lube oil tank.

Guide shoes

The sliding faces of the guide shoes are lined with cast-on bearing metal.

The guide shoes are guided by crosshead guides in the engine framebox and properly secured against displacement by guide strips fastened to the guide shoes.

On some engines, the guide shoes are provided with counterweights.

Tightening

The crosshead bearing is held together by studs and nuts. The nuts are tightened with hydraulic tools.

The crankpin bearing is fitted with steel shells lined with bearing metal and assembled in the same way as the crosshead bearing.

Chain Drive

Section: 14XX-04YY
The chain drive consists of one or more roller chains running on chain wheels fitted on the crankshaft and the camshaft. The chain is kept tightened by a chain tightener placed in the chain casing between the crankshaft and the camshaft.

The long free lengths of the chain are guided by rubber-clad guide bars. Lubricating oil is supplied through spray pipes fitted at the guide bars and chain wheels.

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	Shut off cooling water
O	Stop lubricating oil supply
O	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
-	Acceptance criteria with piston in centre (F-A direction)	-	-
T14-01	PF+PA, N max.	0.85	mm
T14-02	PF+PA, O max.	1.35	mm
T14-04	E+G, H+F, N max.	0.7	mm
T14-05	E+G, H+F, N min.	0.2	mm
T14-06	E+G, H+F, O max.	0.9	mm
T14-10	J+C, L+D, K+C, M+D, N max.	1.2	mm
T14-11	J+C, L+D, K+C, M+D, N min.	0.6	mm
T14-12	J+C, L+D, K+C, M+D, O max.	1.4	mm
T14-17	ZF/ZA O min.	5	mm
T14-22	Crankshaft position (after BDC)	95	°
T14-23	Piston inclination R1-R2, O max.	0.55	mm
--	N: New and cold engine with staybolts tightened (less than 100 running hours).	-	-
--	O: Engine in service.	-	-

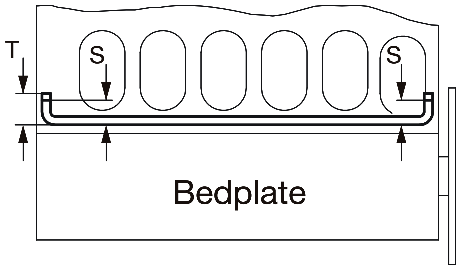
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
7670-0410	**054**	Feeler gauge set
7670-0410	**078**	Dial gauge and stand tool

Trim the Ship

In order to achieve uniform measuring conditions on board, the ship's trim must be as close as possible to 0°.



1465-0101-0002C01

Mount a transparent plastic tube along the length of the bedplate.

Bend each end approx. 250 mm up the framebox side. *See* **T**.

Fill the tube with water (preferably coloured) until the water level is approx. 100 mm from the end of the tube.

Trim the ship until the difference between the water level **S** fore and aft is less than 1.5 mm per 1000 mm.

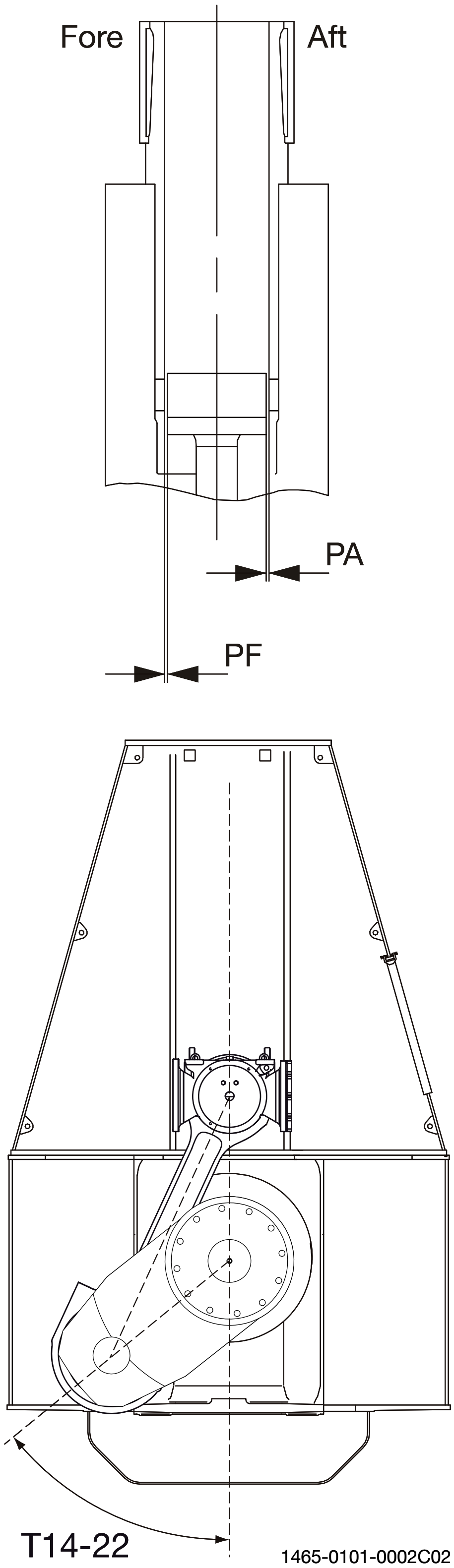
Measurements are to be taken with a ruler.

The piston and the cylinder liner

Turn the crankshaft in ASTERN direction to T14-22 (see data) degrees after BDC (the guide shoe must rest against the crosshead guide).

Check the centering of the piston in the cylinder liner by measuring the clearance (use a long feeler gauge from the scavenge air space) between the piston skirt and the cylinder liner in the Fore and Aft positions (**PF-PA**).

Make sure that the piston is clear of the cylinder liner in the fore and aft directions.

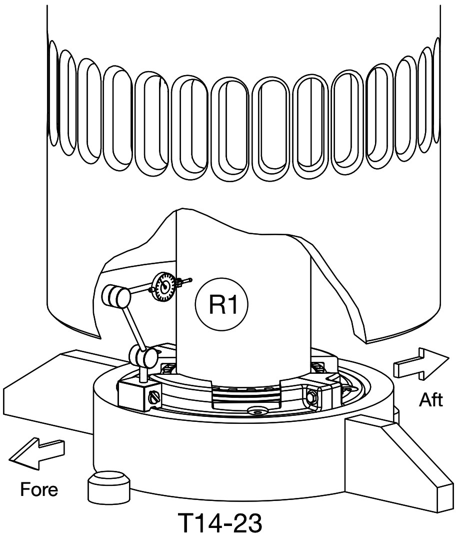


1465-0101-0002C02

Fit a dial gauge

Fit a dial gauge in the bottom of the scavenge air space to the front of the piston rod with the tip of the dial gauge against the piston rod.

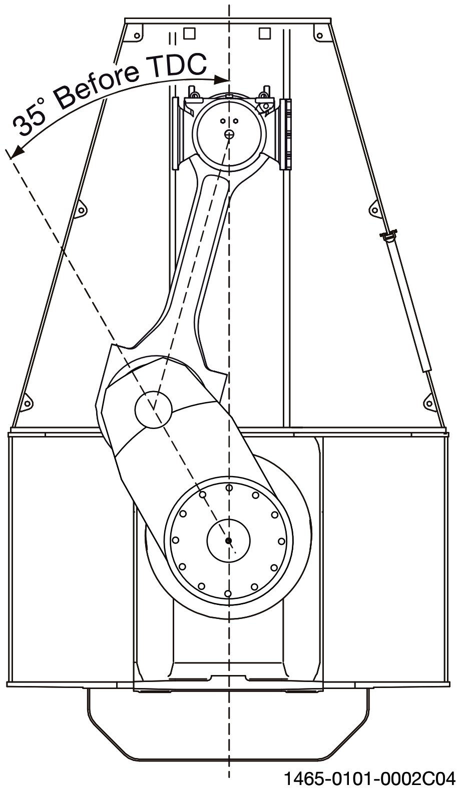
Note down the reading of the dial gauge R1.



1465-0101-0002C03

Turn the crankshaft

Turn the crankshaft in ASTERN direction to 35° before TDC.

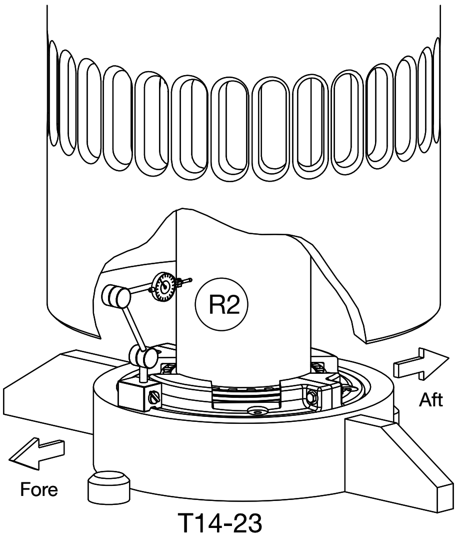


1465-0101-0002C04

Piston inclination

Note down the reading of the dial gauge R2.

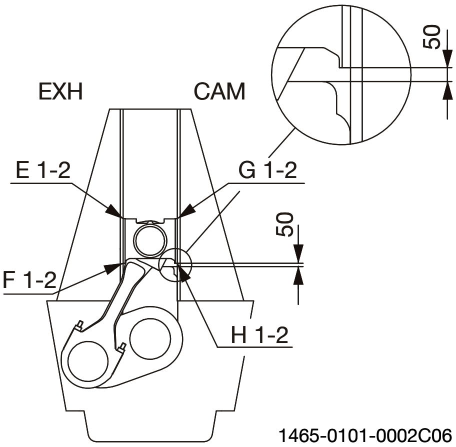
Calculate the piston inclination R1-R2.



1465-0101-0002C05

Turn the crankshaft

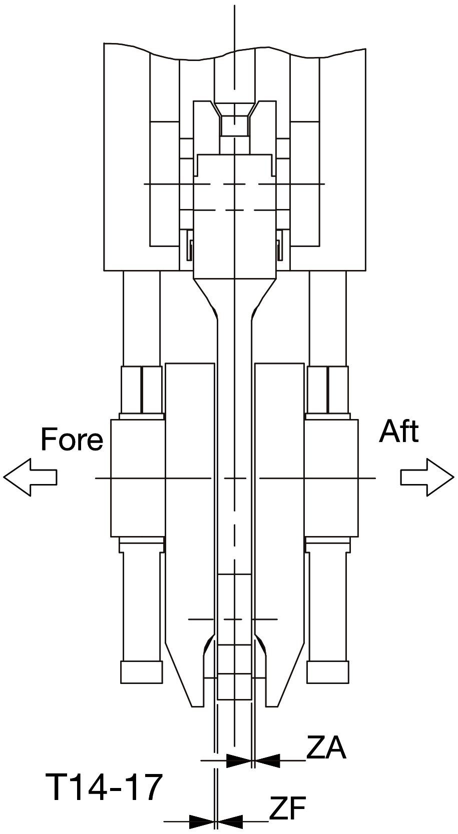
Turn in astern direction until the bottom of the guide shoe is 50 mm above the top of the cut-out in the web plate.



1465-0101-0002C06

Measure the clearance ZF/ZA

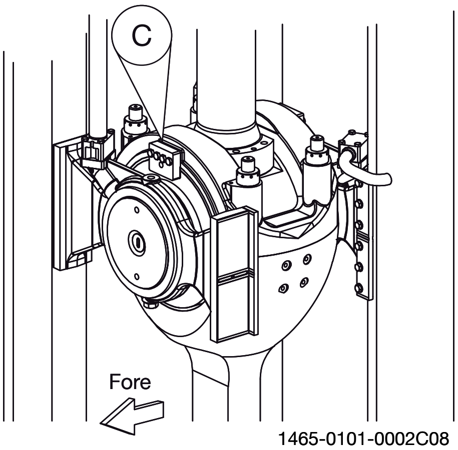
Measure the fore and aft clearances ZF and ZA between the crankthrow and the connecting rod.



1465-0101-0002C07

Measure the clearance C

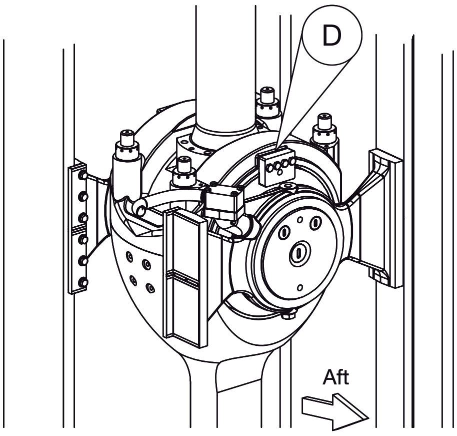
Measure the clearance C, between the foremost stop plate and the crosshead.



1465-0101-0002C08

Measure the clearance D

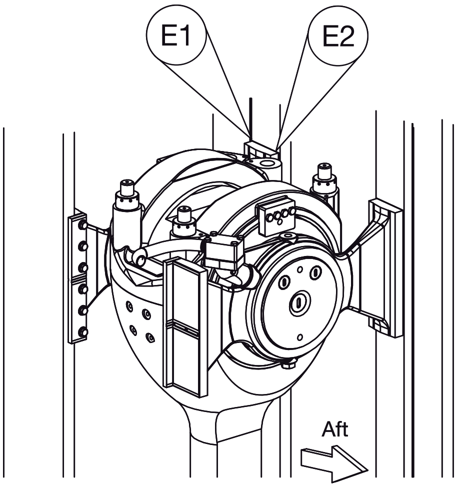
Measure the clearance D, between the aftmost stop plate and the crosshead.



1465-0101-0002C09

Measure the clearance E1/E2

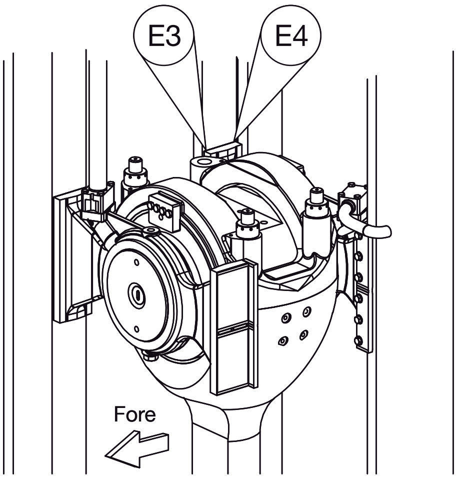
Measure the clearances E1 and E2 between the top of the foremost guide shoe and the exhaust-side crosshead guide.



1465-0101-0002C10

Measure the clearance E3/E4

Measure the clearances E3 and E4 between the top of the aftmost guide shoe and the exhaust-side crosshead guide.

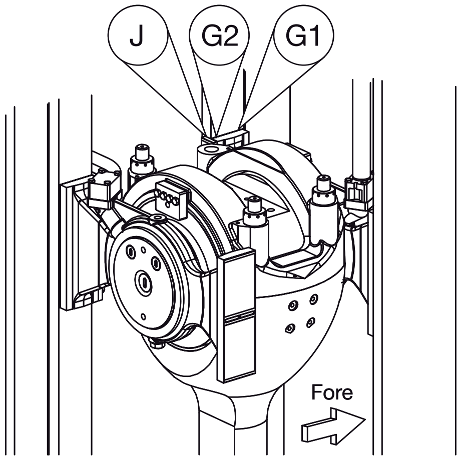


1465-0101-0002C11

Measure the clearance G1/G2

Measure the clearances G1 and G2 between the top of the foremost guide shoe and the manoeuvring-side crosshead guide.

Measure the clearance J between the top of the foremost guide strip and the manoeuvring-side crosshead guide.

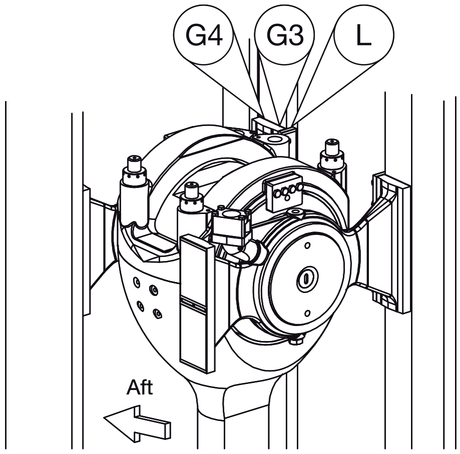


1465-0101-0002C12

Measure the clearance G3/G4

Measure the clearances G3 and G4 between the top of the aftmost guide shoe and the manoeuvring-side crosshead guide.

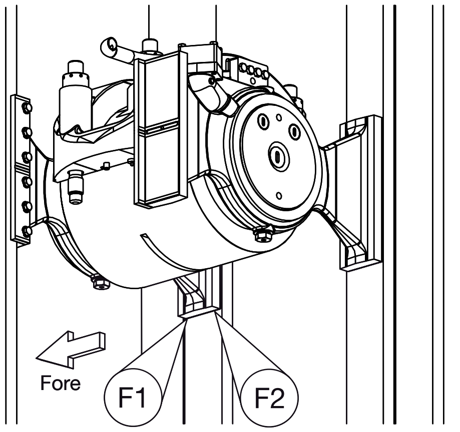
Measure the clearance L between the top of the aftmost guide strip and the manoeuvring-side crosshead guide.



1465-0101-0002C13

Measure the clearance F1/F2

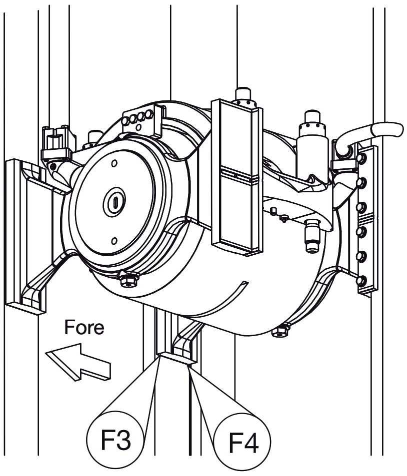
Measure the clearances F1 and F2 between the bottom of the foremost guide shoe and the exhaust-side crosshead guide.



1465-0101-0002C14

Measure the clearance F3/F3

Measure the clearances F3 and F4 between the bottom of the aftmost guide shoe and the exhaust-side crosshead guide.

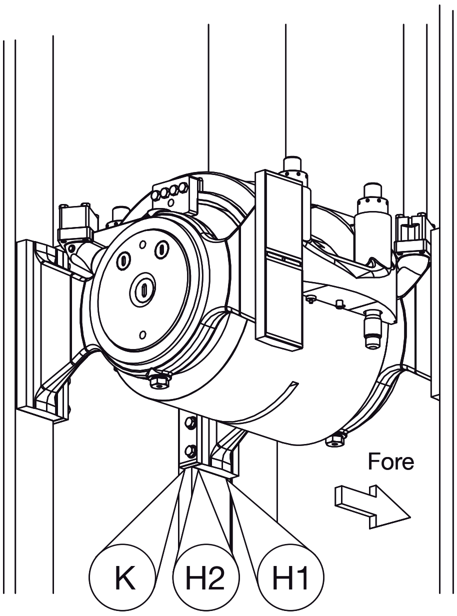


1465-0101-0002C15

Measure the clearance H1/H2

Measure the clearances H1 and H2 between the bottom of the foremost guide shoe and the manoeuvring-side crosshead guide.

Measure the clearance K between the bottom of the foremost guide strip and the manoeuvring-side crosshead guide.

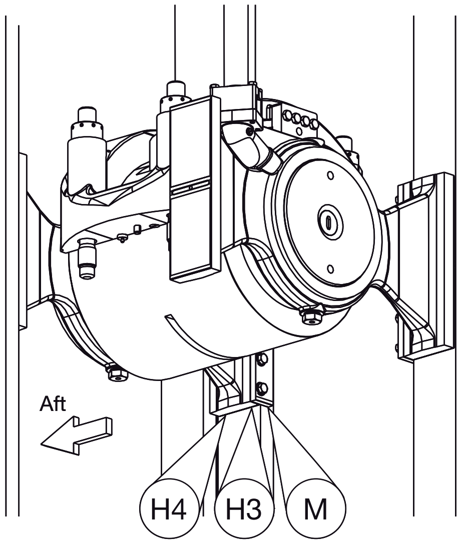


1465-0101-0002C16

Measure the clearance H3/H4

Measure the clearances H3 and H4 between the bottom of the aftmost guide shoe and the manoeuvring-side crosshead guide.

Measure the clearance M between the bottom of the aftmost guide strip and the manoeuvring-side crosshead guide.



1465-0101-0002C17

The result

The guide strip clearance, calculated as **J+C**, **K+C**, **L+D** and **M+D**, is adjusted by the insertion of shims so that it is symmetrical in relation to the clearance between the piston skirt and the cylinder liner.

Parallelism between the guide strip and guide is to be kept within a tolerance of 0.2 mm per 1000 mm.

Recommended

It is recommended that the measured results are noted down so that possible later changes can be ascertained.

Compare the measured results with the values stated on the data sheet.

Unit mm	Cyl.	1	2	3
Piston/Liner	PF			
	PA			
Framebox	E1			
	E2			
	E3			
	E4			
	F1			
	F2			
	F3			
	F4			
	G1			
	G2			
	G3			
	G4			
	H1			
	H2			
	H3			
	H4			
	J			
	K			
	L			
	M			
	C			
	D			
Piston Rod	R1			
	R2			
Crankthrow	ZF			
	ZA			

1465-0101-0002C18

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	Shut off cooling water
O	Stop lubricating oil supply
O	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
T14-24	Cooling oil outlet pipe, tighetning torque	260	Nm
T14-30	Guide strip screws, tightening torque	650	Nm
T14-33	Telescopic pipe, tightening torque	260	Nm
T14-35	Thrust piece tightening torque	460	Nm
T14-37	Stuffing box, telescopic pipe, tightening	140	Nm
T14-42	Crosshead complete	4700	kg
T14-43	Guide shoe	500	kg
T14-45	Cooling oil outlet pipe	15	kg
T14-46	Telescopic pipe	54	kg
T14-49	Crosshead without guide shoes	3700	kg
T14-53	Connecting rod, without bearing caps	4000	kg
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

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.

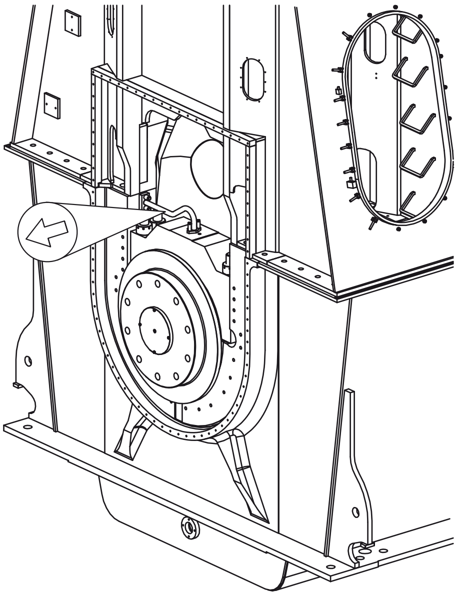
Tools

Plate	Item No.	Description
1470-0200	**-**	Guide shoe extractor
1470-0300	**041**	Wire guide
1470-0300	**053**	Lifting attachment for connecting rod
1470-0300	**065**	Lifting tools for crosshead
1470-0300	**089**	Retaining tool for telescope pipe
1470-0300	**090**	Bracket, support of crosshead
1470-0300	**219**	Torque wrench offset tool
1470-0300	**220**	Alignment tools
1470-0510	**-**	Crosshead, hydraulic tools
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**047**	Hose with unions, 1500 mm
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**106**	5-way distributor block, complete
7670-0200	**-**	Torque spanners
7670-0300	**-**	Lifting tools, etc

Dismantling of Oil Pipes

Dismantle the piston.
See work card 2265-0401.

Dismantle the main bearing lubricating oil pipes.



1465-0201-0002D02

Dismantling of cooling oil pipes

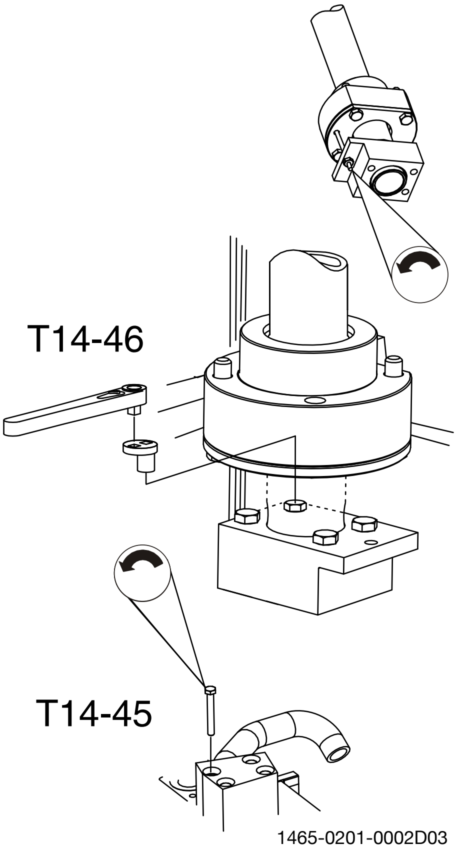
Dismantle the cooling oil outlet pipe from the guide shoe and the drain oil slotted pipe.

Loosen and remove the screws which secure the telescopic pipe to the guide shoe.

In order to reach the screw in the corner behind the telescopic pipe, use the off-set tool along with a socket wrench.

Lift up and suspend the telescopic pipe by means of the tool.

Unscrew and remove the oil outlet pipe for the piston cooling oil.



1465-0201-0002D03

Mounting of hydraulic tools

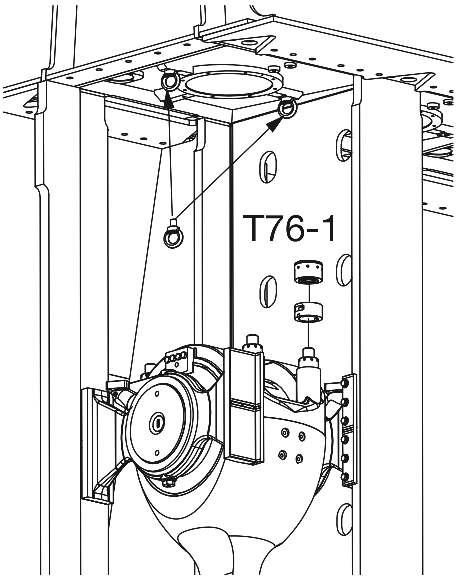
Turn the crankshaft to gain access to the nuts on the crosshead bearing studs.

Mount two eyebolts in the top of the crankcase in the fore-and-aft direction.

Mount the spacer rings and the hydraulic jacks for loosening the nuts on the crosshead bearing studs.

For operation of the hydraulic tools, see work card 7665-0101.

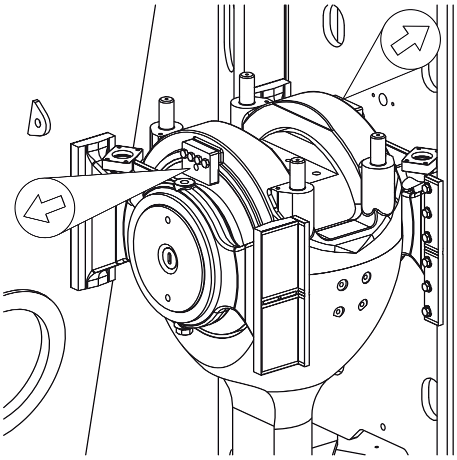
Loosen the nuts, remove the hydraulic jacks and unscrew the nuts.



1465-0201-0002D04

Thrust piece dismantling

Remove both thrust pieces on the crosshead bearing cap.

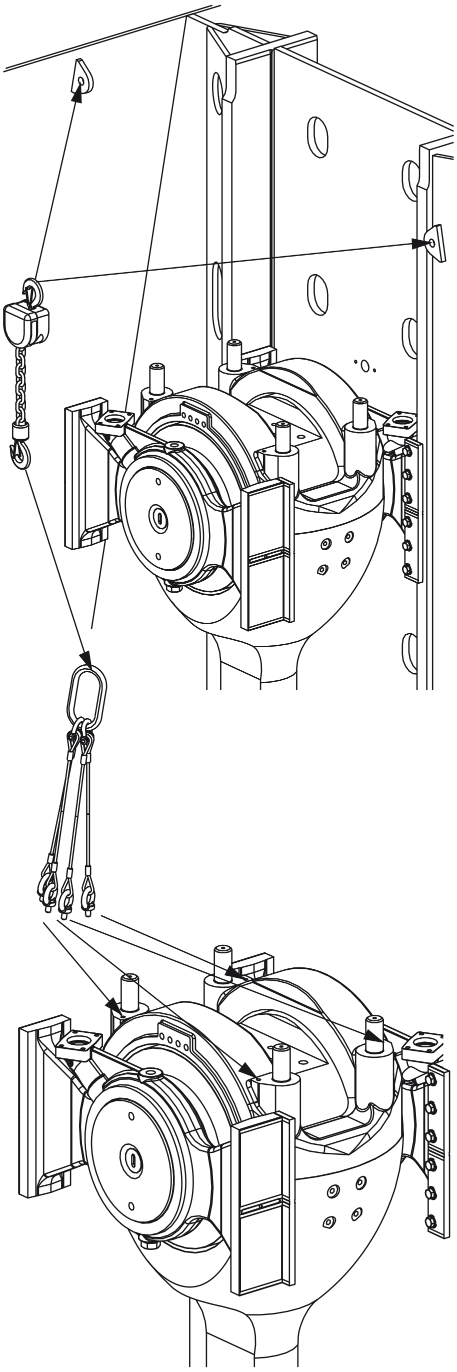


1465-0201-0002D05

Mount tackles

Suspend two tackles from the lifting brackets in the athwarthship direction.

Fit the lifting tool on the top of the crosshead bearing cap.



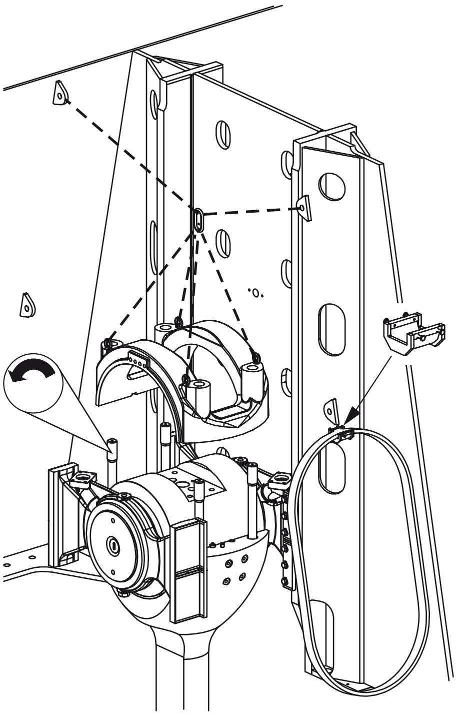
1465-0201-0002D06

Dismantling of bearing cap

Dismantle the bearing cap and lift it out of the engine.

Unscrew and remove the studs for the crosshead bearing.

Mount the wire guide in the doorway.



1465-0201-0002D07

Mounting of lifting tools

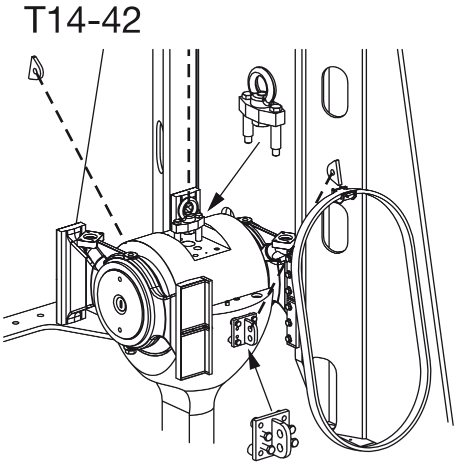
Mount the special lifting tool on the crosshead.

Mount the lifting attachments for fixing the connecting rod on the connecting rod head.

Fasten tackles to the lifting brackets on the frame box wall and attach the tackle hooks to the lifting attachments. Haul the tackles tight.

Attach the flat-plaited wire strap to the engine room crane.

Hook the engine room crane on to the lifting tool on the crosshead, and lift the crosshead.



1465-0201-0002D08

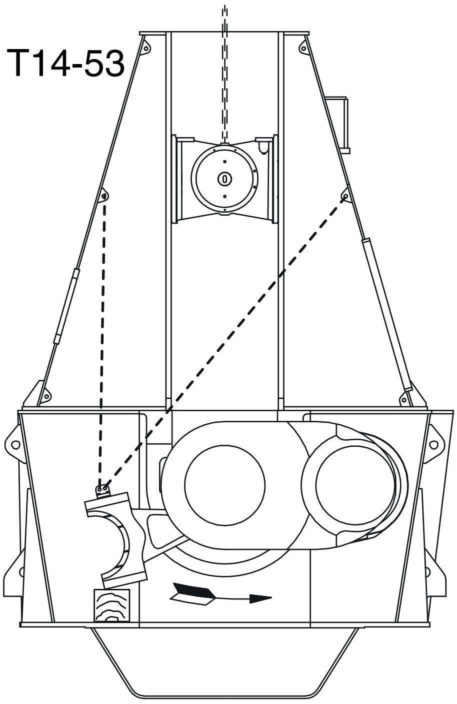
Lowering the connecting rod

Using the tackles, tilt the connecting rod towards the exhaust side, while turning the crank throw towards the manoeuvring side.

Transfer the tackles from one lifting attachment to another as necessary.

When the crank throw is 90° after BDC, stop turning.

By alternate use of the tackles, tilt the connecting rod until it rests against a couple of wooden planks in the bottom of the bedplate.



1465-0201-0002D09

Loosening the crosshead from the guide shoes

Lower the crosshead to a position just above the main bearing caps.

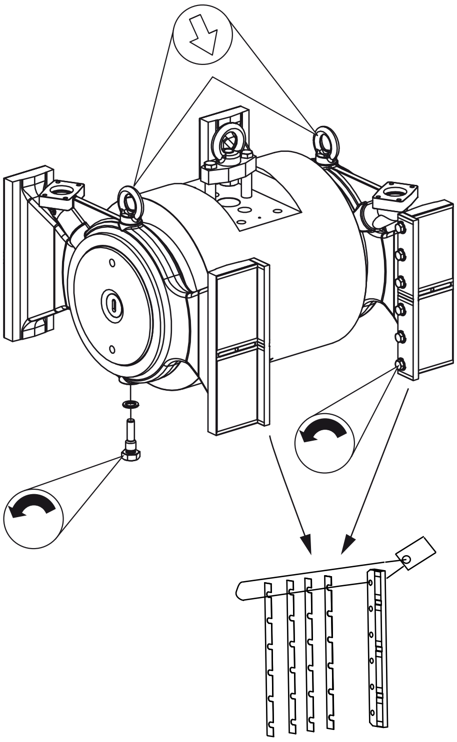
Remove the guide strips and both guide plates from the guide shoes.

Unscrew the stop bolt from the bottom of the guide shoes.

NOTE

It is recommended to tag the guide strips and shims to avoid mixing them.

Mount lifting eyebolts in both guide shoes.



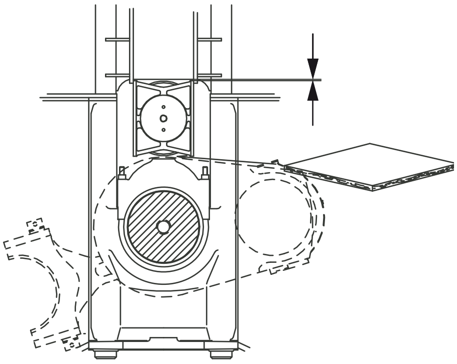
1465-0201-0002D10

Lowering the crosshead

Lower the crosshead so that the guide shoes are just below the cutout in the side walls of the frame box.

NOTE

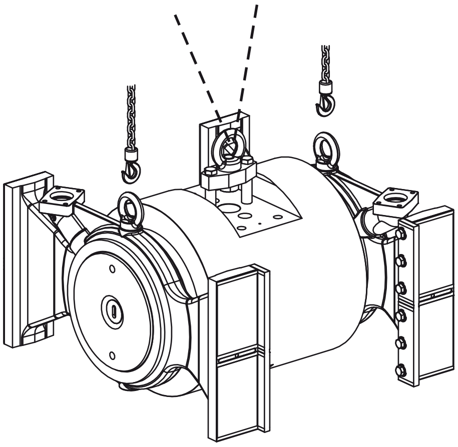
Make sure that the crosshead journal does not touch the crank.



1465-0201-0002D11

Securing the guide shoes

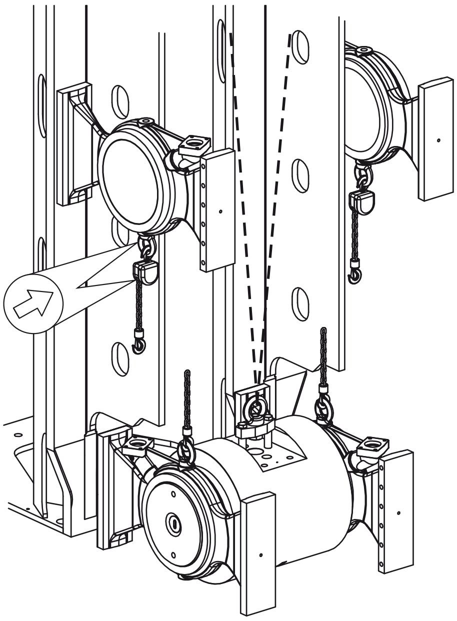
Hook the tackles on to the eyebolts in the guide shoes.



1465-0201-0002D12

Adjacent cylinder guide shoes

Mount two eyebolts in the holes for stop screws in the guide shoes in the adjacent cylinder units, and suspend two tackles from the eyebolts.

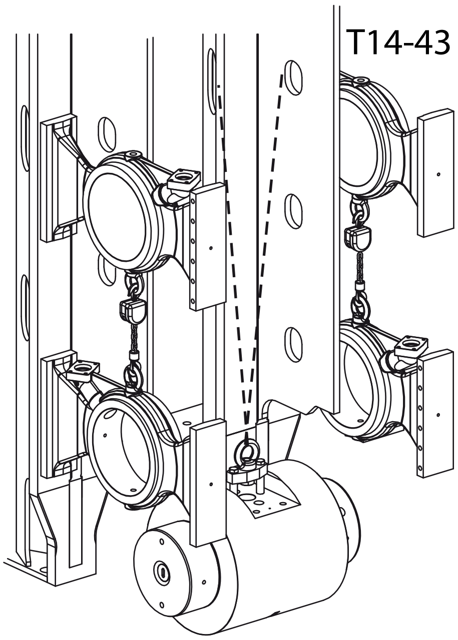


1465-0201-0002D13

Removing the guide shoes

Haul tight the tackles for the guide shoes and, at the same time, pull the guide shoes sideways until they are free of the crosshead.

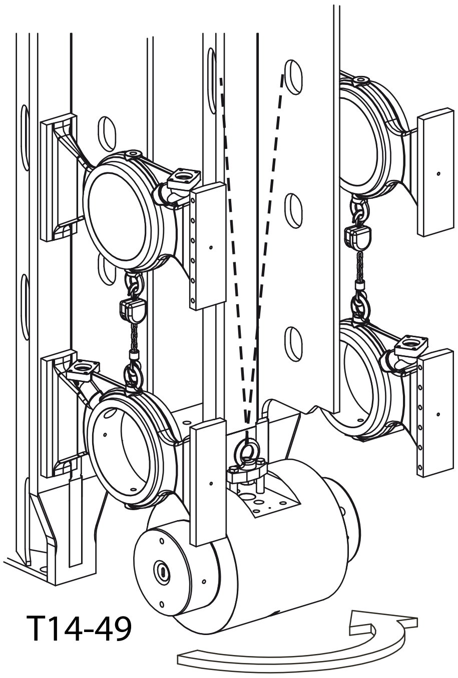
Take the guide shoes through the openings in the side walls by means of the tackles in the two adjacent cylinders. Lift the guide shoes to provide space for turning the crosshead.



1465-0201-0002D14

Crosshead turning

Turn the crosshead 90°.



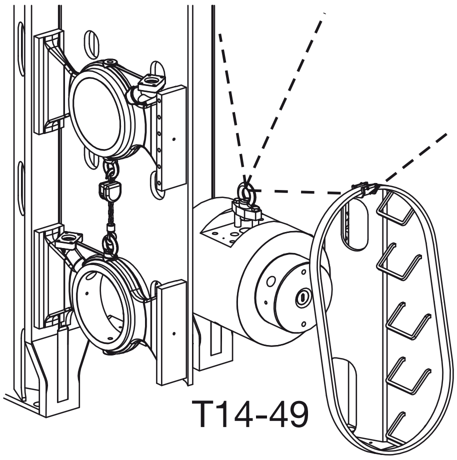
1465-0201-0002D15

Crosshead removal

Mount a tackle outside the engine and, by means of wire rope and tackle, remove the crosshead from the engine.

Land and protect the crosshead outside the engine.

Remove the guide shoes from the engine and tag them.



1465-0201-0002D16

NOTE

Take care that the crosshead does not bump into anything as this will damage the sliding surfaces of the crosshead.

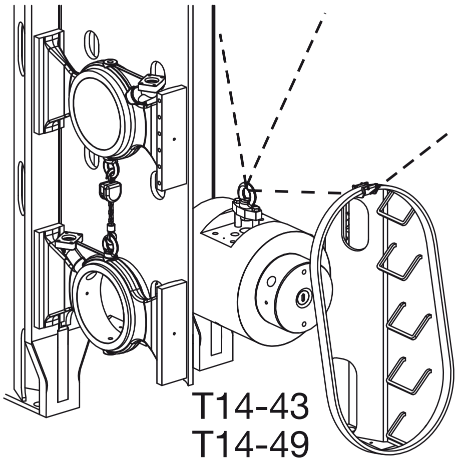
Lift the crosshead into the engine

Clean the crosshead and mount the lifting tool with shackle and wire ropes.

Mount the wire guide tool in the frame box door opening.

Suspend two tackles from the top of the frame box between the guides.

Suspend two tackles from the top lifting brackets in the frame box and use them in conjunction with a tackle mounted outside the engine to carefully lift the crosshead and ease it into the crankcase.



1465-0201-0002M01

Turn the crosshead into position

Turn the crosshead 90° to enable mounting of the guide shoes.

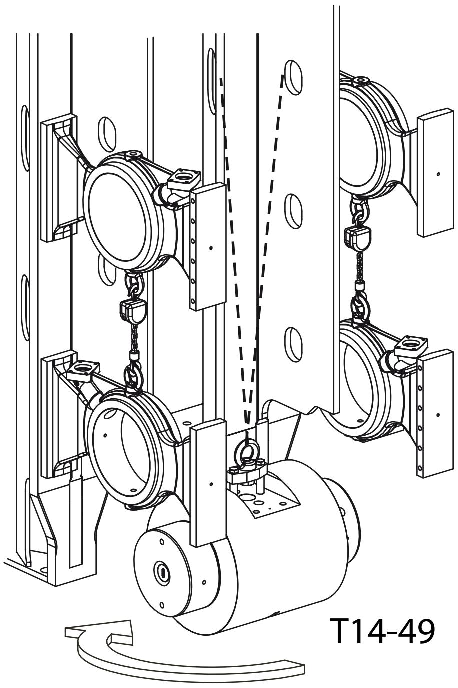
CAUTION

The ends of the crosshead are marked »Fore« and »Aft«.

The markings »Fore« and »Aft« on the crosshead may be reversed on engines with port side configuration.

The oil inlet hole in the crosshead (large diameter) must face towards the guide shoe where the telescopic pipe is mounted.

The oil outlet hole in the crosshead (small diameter) must face towards the guide shoe where the outlet pipe is mounted.



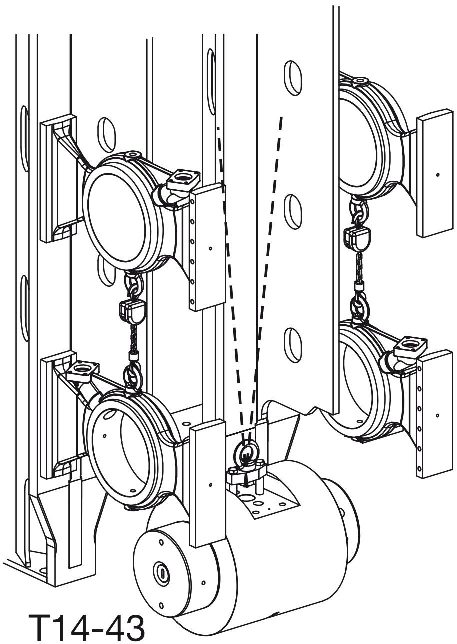
1465-0201-0002M02

NOTE

When handling the crosshead, take great care that its surfaces are not scratched or damaged. If necessary, protect the crosshead with a cloth.

Lower the guide shoes

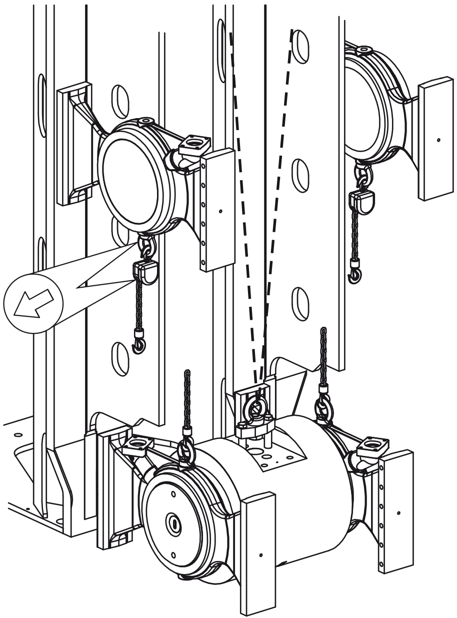
Lower the guide shoes into position.



1465-0201-0002M03

Mount the guide shoes

Lubricate the sliding surfaces of the guide shoes and the crosshead with plenty of clean lubricating oil, and push the guide shoes into position through the openings in the side walls.



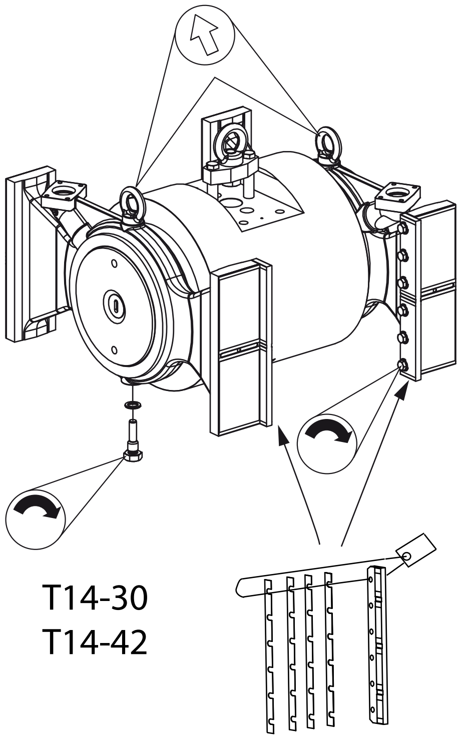
1465-0201-0002M04

Guide strips and shims

Use the tackles in the top of the frame box to lift the crosshead into a suitable position and mount the guide strips and shims on the sides of the guide shoes.

Screw the stop bolts into the bottom of the guide shoes.

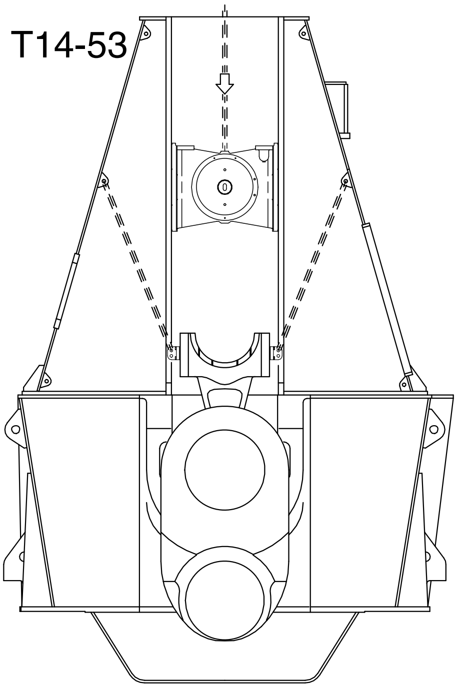
Remove the tackles and the eyebolts from the guide shoes.



1465-0201-0002M05

Connecting rod

Using the tackles, lift the connecting rod to a vertical position while turning the crankthrow to BDC.



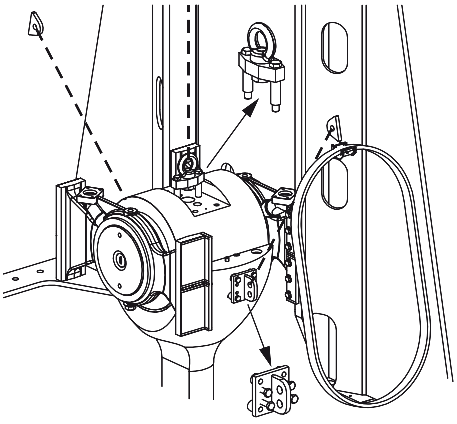
1465-0201-0002M06

Land the crosshead

When the connecting rod is in a vertical position, lower the crosshead and land it on the connecting rod.

Remove the lifting attachments from the connecting rod head.

Remove the lifting tool from the crosshead.



1465-0201-0002M07

Bearing cap mounting

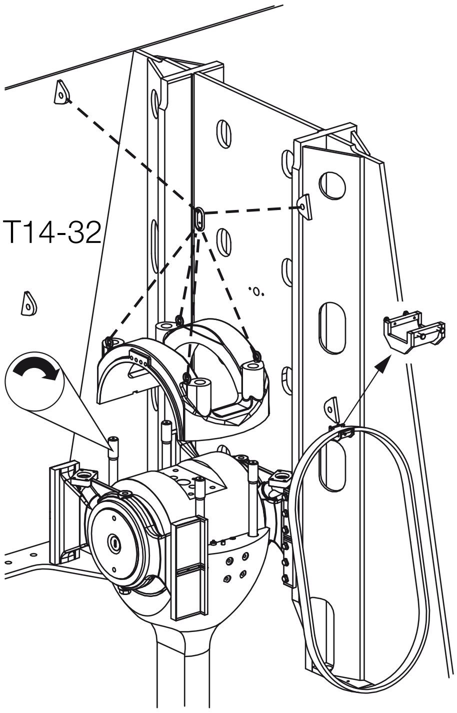
Refit the studs for the crosshead bearing

for tightening. *See data*.
See work card 7665-0301.

Lift the crosshead bearing cap into the

engine. *See work card 2565-0201.*

Remove the wire guide from the doorway.

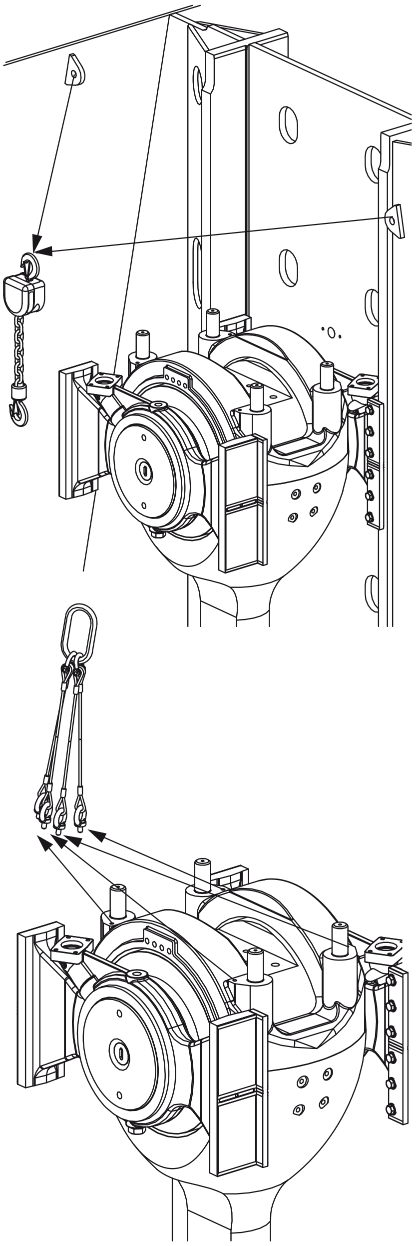


1465-0201-0002M08

Tools removal

Remove all tackles from the crankcase.

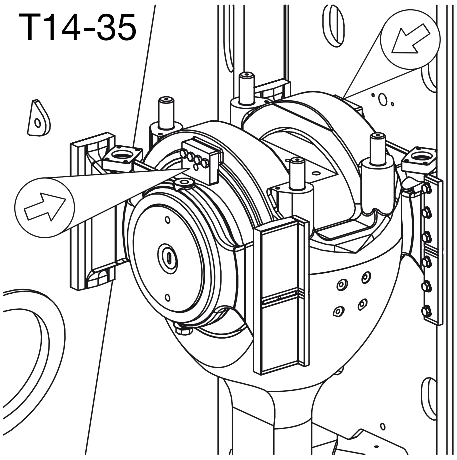
Remove the lifting tool from the crosshead bearing cap.



1465-0201-0002M09

Thrust piece mounting

Mount the thrust pieces on the bearing cap.



1465-0201-0002M10

NOTE

Make sure that there is clearance between the thrust piece and the crosshead, fore and aft, before any tightening of the thrust piece.

Tighten the bolts to the torque stated in Data.

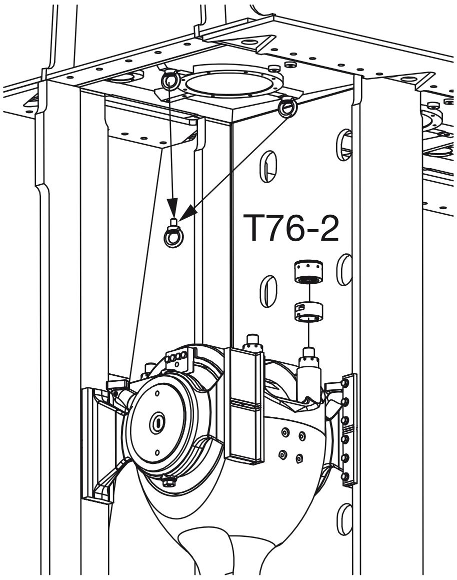
For correct tightening, see also work card 7665-0301.

Hydraulic nuts

Mount the spacer rings and the hydraulic jacks for tightening the nuts on the crosshead bearing studs.

For operation of the hydraulic tools, see work card 7665-0101.

Remove the lifting eyebolts.



1465-0201-0002M11

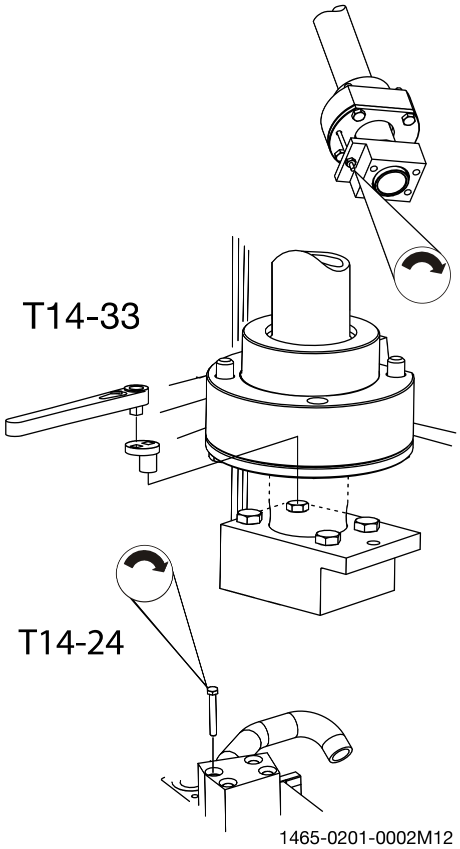
Telescopic pipe

Turn the crankshaft to TDC.

Land the telescopic pipe on the guide shoe.

For tightening the bolt in the corner behind the telescopic pipe, use the offset tool along with the torque wrench.

Mount the drain oil slotted pipe and the cooling oil outlet pipe on the guide shoe.



1465-0201-0002M12

Lubricating oil pipes

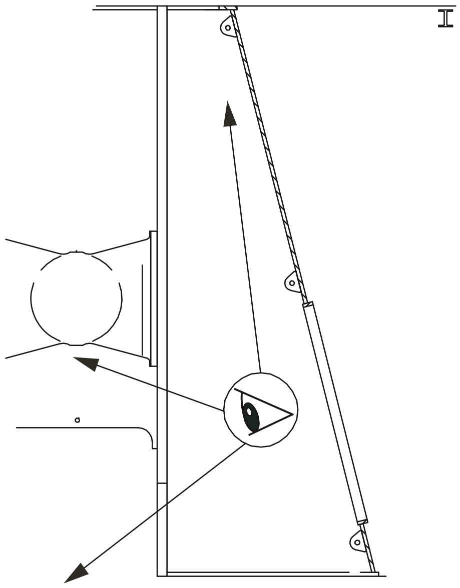
Mount the lubricating oil pipes on the main bearing caps.

Piston

Mount the piston. *See work card 2265-0401.*

Final check

Check that all tools have been removed from the crankcase.



1465-0201-0002M13

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T14-52	Connecting rod studs, screwing-in torque	500	Nm
T14-53	Connecting rod, without bearing caps	3900	kg
T14-54	Connecting rod complete	5200	kg
T14-55	Crosshead bearing stud	16	kg
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

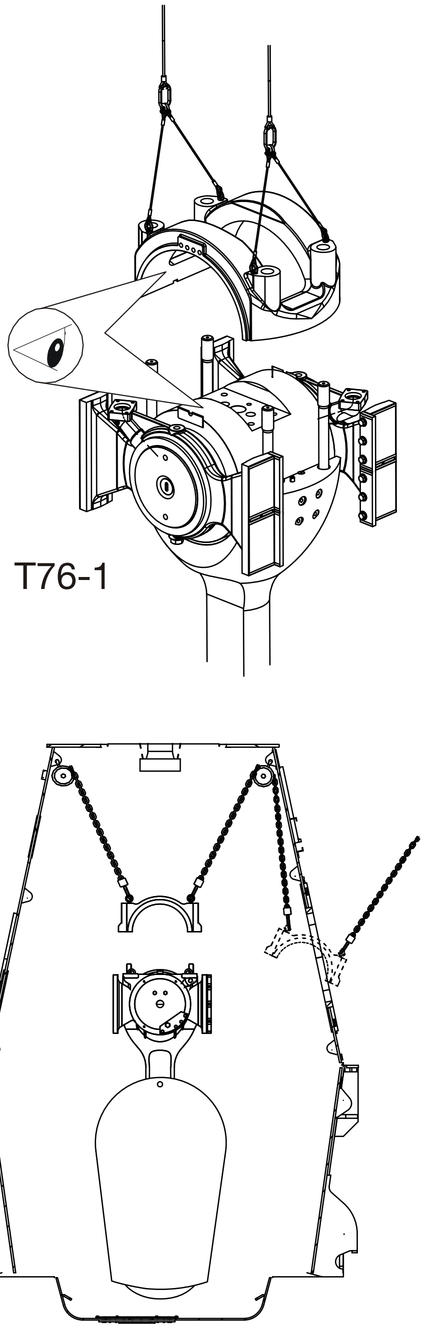
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
1470-0300	**041**	Wire guide
1470-0300	**053**	Lifting attachment for connecting rod
1470-0300	**077**	Chain for suspending piston
1470-0300	**090**	Bracket, support of crosshead
1470-0310	**-**	Connecting rod, hydraulic tools
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**047**	Hose with unions, 1500 mm
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**106**	5-way distributor block, complete
7670-0100	**118**	3-way distributor block, complete
7670-0200	**-**	Torque spanners
7670-0300	**-**	Lifting tools, etc

Piston Rod

Suspend the piston rod and dismount the crosshead bearing cap.
See work card 2565-0201.

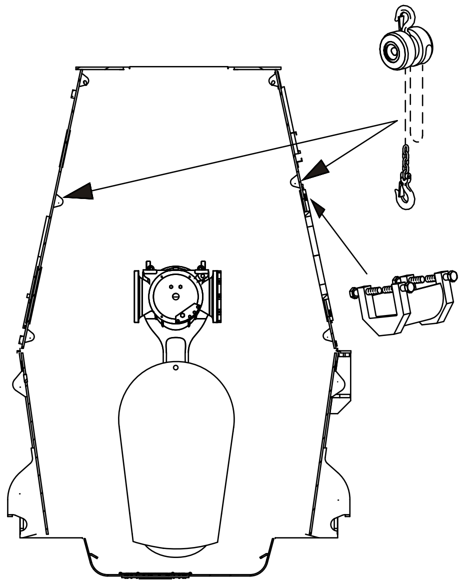


1465-0301-0002D01

Tackles

Suspend two tackles from the two lifting brackets at the sides of the frame box.

Mount the wire guide in the top of the crankcase doorway.

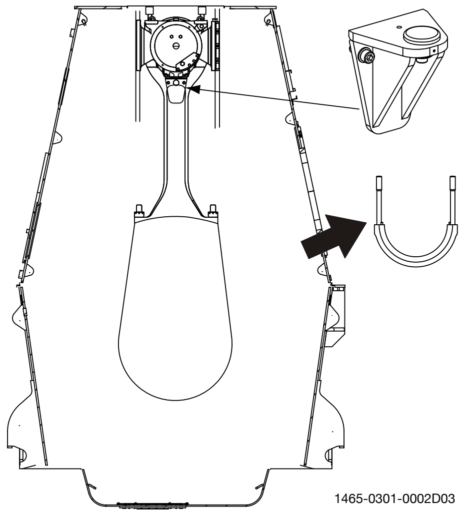


1465-0301-0002D02

Turn the crank to TDC

Dismantle the crankpin bearing cap, and remove it from the engine.
See work card 2565-0301.

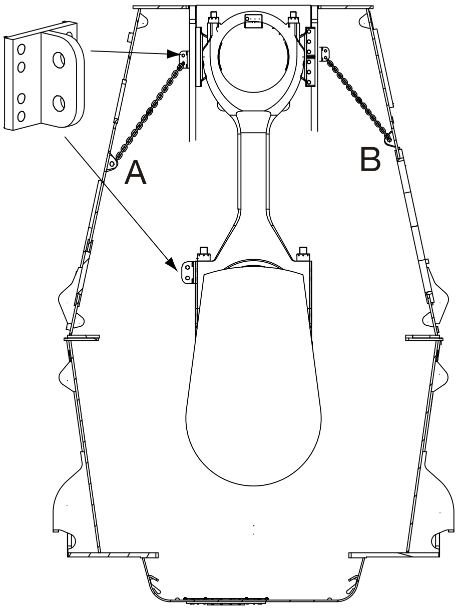
Mount the support brackets for guide shoes on the web plates.



1465-0301-0002D03

Lifting attachments

Mount the lifting attachments for fixing the connecting rod on the head of the connecting rod.



1465-0301-0002D04

NOTE

There are different lifting attachments for each end of the connecting rod.

Use the tackles fastened to lifting brackets **A** and **B** on the frame box wall, and attach the tackle hooks to the mentioned lifting attachments on the connecting rod.

Haul the tackles tight.

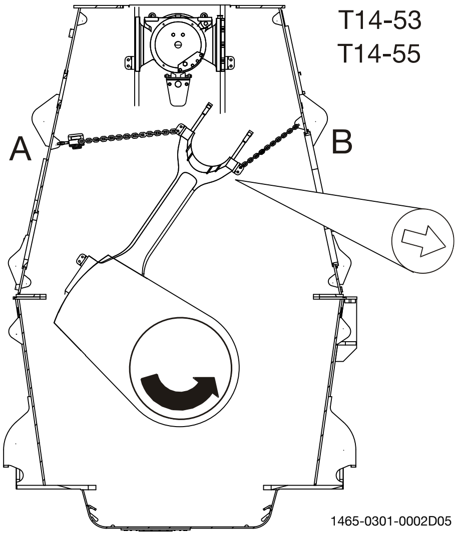
Also mount a lifting attachment in the crankpin end of the connecting rod, on the exhaust side.

Carefully turn the crank down towards the exhaust side, until the crosshead shoes rest on the supports.

Adjust the support brackets to the guide shoes so that the weight of the crosshead is evenly distributed on the two supports.

Turn the crank BDC

Turn the crankthrow towards BDC while “following” with the tackles, thus continuously supporting the connecting rod.



1465-0301-0002D05

Turn the crank 90°

Turn the crankthrow to 90° before BDC.

Remove the four studs from the connecting rod.

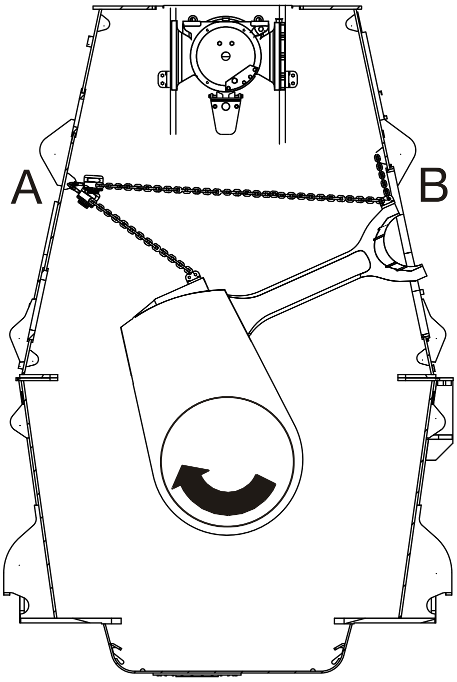
Shift the hook of the tackle attached to lifting bracket **B** from the lifting attachment on the lowermost side of the connecting rod to the lifting attachment on the uppermost side.

Tilt the connecting rod

By means of the tackle from lifting bracket **A**, tilt the connecting rod towards the manoeuvre side until the connecting rod is leaning out of the doorway.

Attach a tackle to lifting bracket **A** on the frame box wall and connect the tackle hook to the lifting attachment at the lower end of the connecting rod.

Turn the crank **carefully** upwards while "following" with the tackles, guiding the head of the connecting rod out of the doorway.



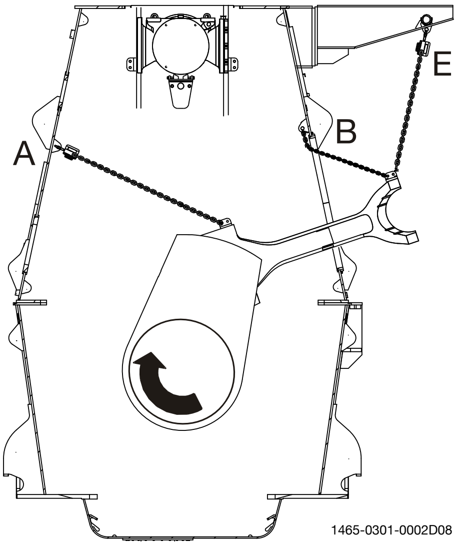
1465-0301-0002D07

Attach a tackle

Attach a tackle to the gallery-mounted lifting bracket **E**, and hook on to the lifting attachment on the connecting rod.

Shift the tackles from one lifting bracket/attachment to the other, as required.

Remove the floor chequer plate for the pertaining cylinder.



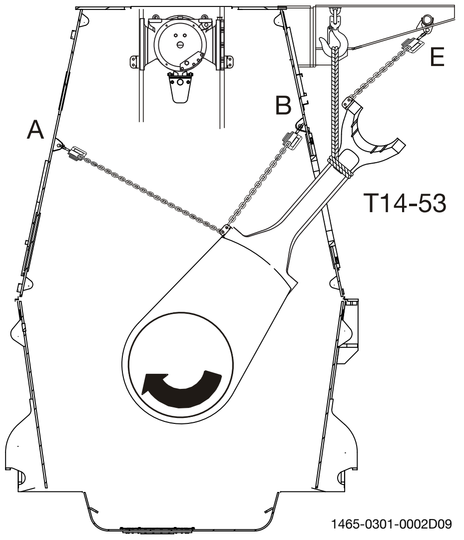
1465-0301-0002D08

Lifting the connecting rod out of the engine

Place a plated wire rope round the connecting rod, hook on the engine room crane and haul tight.

Continue turning upwards till about 30° after TDC, while “following” with the tackles and the engine room crane.

Lift the connecting rod out of the engine using the engine room crane and the tackles.

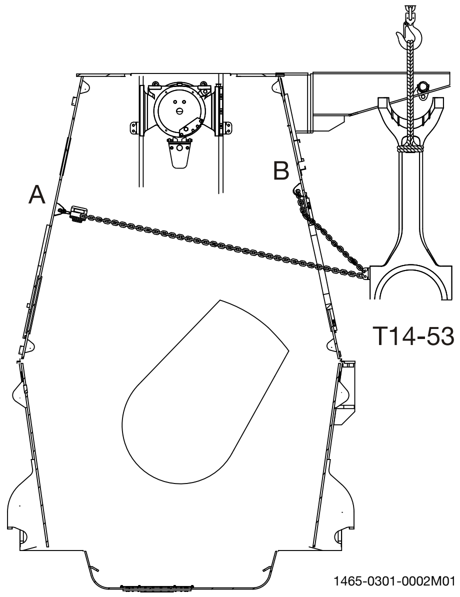


Apply oil to the bearing shell

Equip the connecting rod with the same lifting attachments as mentioned under dismantling.

Turn the crank to a position about 30° past TDC on the manoeuvre side.

Apply clean lubricating oil to the crank-pin bearing shell and journal.

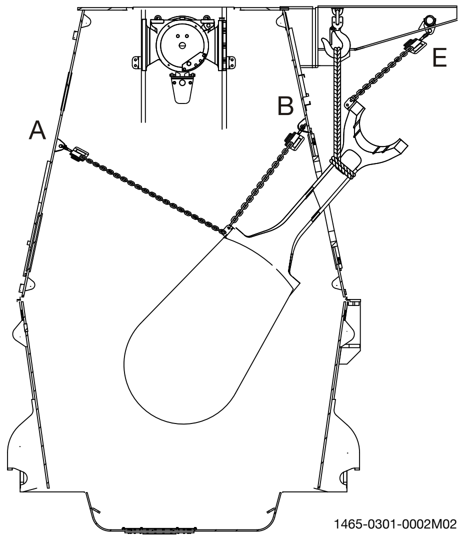


1465-0301-0002M01

Moving the connecting rod into the crankcase

Lift the connecting rod carefully into the crankcase by alternate use of the engine room crane and the tackles attached to lifting brackets **A** and **B.**

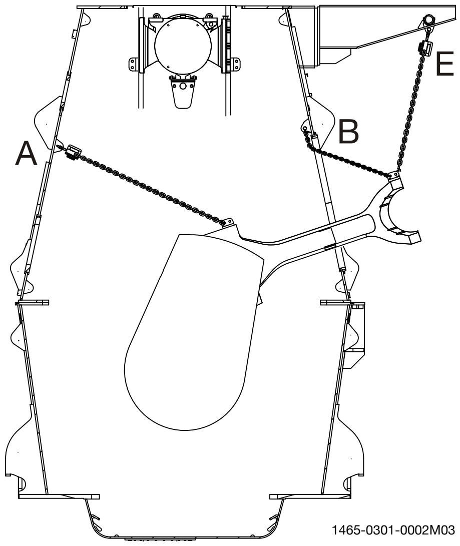
Attach a tackle to bracket **E** and the upper end of the connecting rod.



1465-0301-0002M02

The connecting rod rests on the crank pin journal

When the end of the connecting rod rests on the crankpin journal, shift tackle **B** from the lower end to the upper end of the connecting rod.

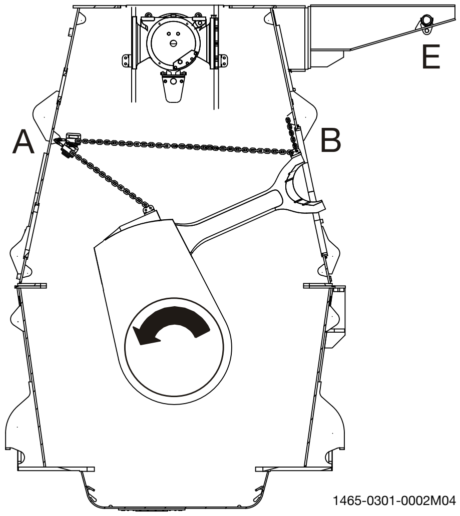


1465-0301-0002M03

Engine room crane

Turn the crankthrow towards BDC, past TDC, while 'following' with the tackles. Lower the engine room crane and remove the strap around the connecting rod.

When the uppermost lifting bracket on the connecting rod is just below lifting point **B**, remove the tackle from lifting point **E,** fit a tackle between lifting point **A** and the upper end of the connecting rod.



1465-0301-0002M04

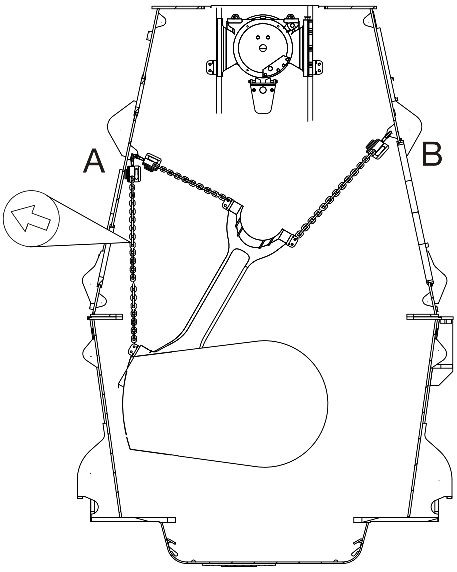
Lifting attachments

Turn the crankthrow to 90° before BDC, and use the tackles to raise the connecting rod to an upright position.

Shift tackle **B** from the lifting attachment on one side to the other side of the connecting rod.

Remove tackle **A** from the lower end of the connecting rod.

Remove the lifting attachment at the lower end of the connecting rod.

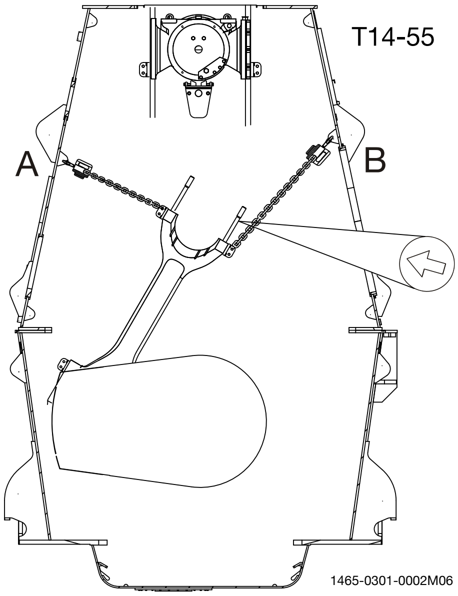


1465-0301-0002M05

Connecting rod studs

Screw the studs into the connecting rod. Using the stud setter and a torque wrench, tighten the studs.

Lubricate the crosshead bearing shell and journal.



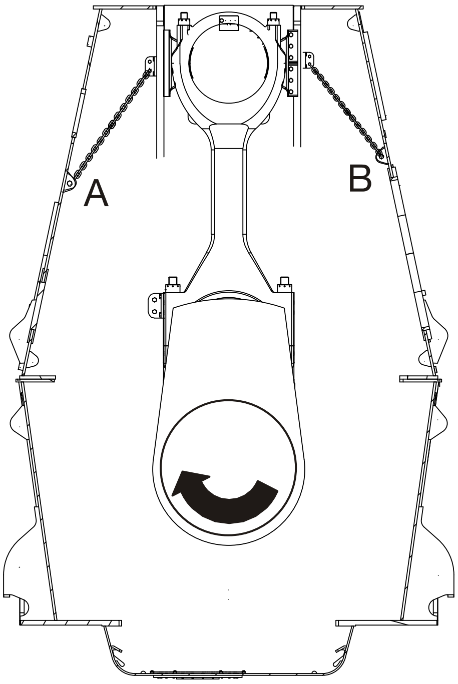
1465-0301-0002M06

Landing the crosshead on the connecting rod

Turn the crankthrow towards TDC while ‘following’ with the tackles, carefully land the crosshead on the connecting rod.

NOTE

Take care that the studs do not damage the crosshead bearing journal.



1465-0301-0002M07

The crankpin bearing cap

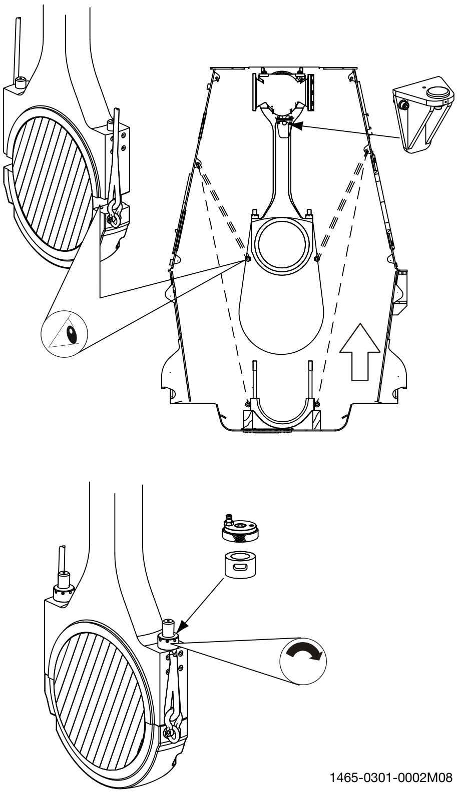
When the crank is in TDC, mount the crankpin bearing cap.

See work card 2565-0301.

Remove the crosshead supports.

Turn to BDC and mount the crosshead bearing cap and the piston.

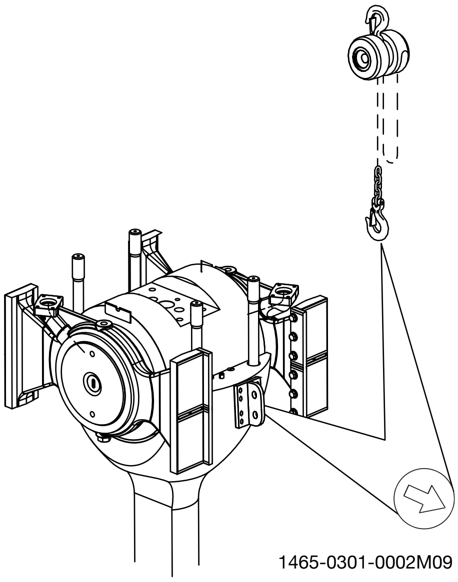
See work card 2565-0201.



1465-0301-0002M08

Tackles and lifting attachments

Remove the tackles and lifting attachments.

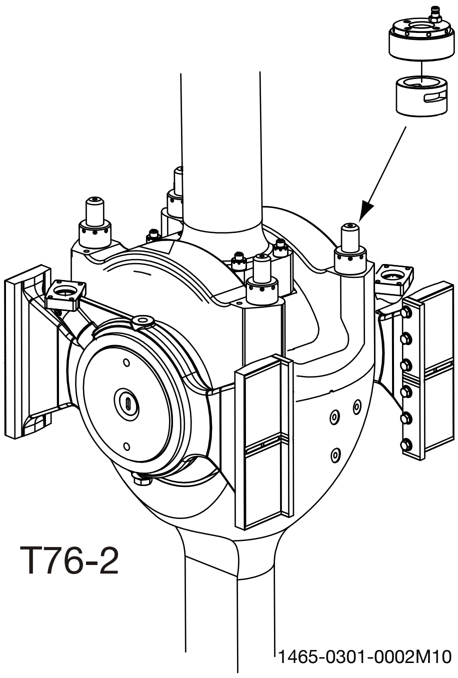


1465-0301-0002M09

Turn the crosshead to BDC

Tighten all four crosshead bearing cap nuts simultaneously. *See Data*.

For use of hydraulic jacks, see work card 7665-0101.



1465-0301-0002M10

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	Shut off cooling water
O	Stop lubricating oil supply
O	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
T14-60	2.0" Chain		
T14-61	Teeth on chain wheel, max. wear	2.1	mm
T14-62	Original length (chain pitch x 10 links)	508	mm
T14-63	10 links measurements + 1% of a tensioned chain = scrapping of chain	559	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
1470-1000	**079**	Chain assembling tool
1470-1000	**080**	Chain disassembling tool
7670-0300	**-**	Lifting tools, etc

General Inspection

Make a general inspection for loose bolts and screws.

Inspect lube oil pipes for damage, and check jet nozzles for possible stoppages or deformations.

Examine the rubber track of the guideways for cracks or other damage.

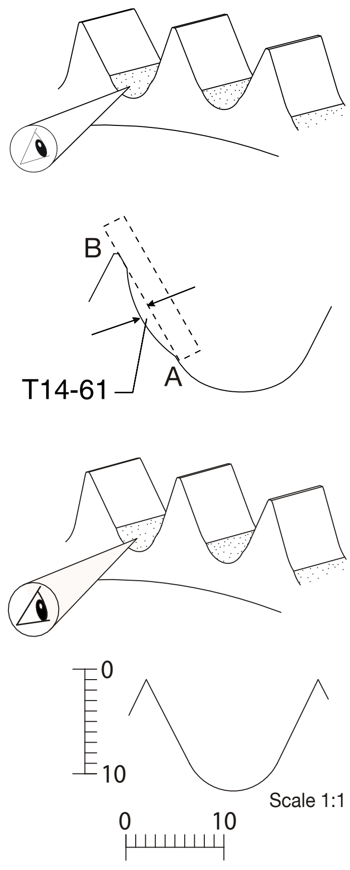
Replace the guideway if bits have started to be “plucked out” of the rubber track.

Wear check & measurements

Check the teeth of the chain wheels. If abnormal wear is found, take a measurement (see Data).

Measurements are best taken by placing a short straight-edge over points **A** and **B** and then measuring the distance T14-61.

If abnormal wear is observed at the bottom of the teeth, make a drawing in scale 1:1 of the teeth and wear profile.



1465-0401-0002C01

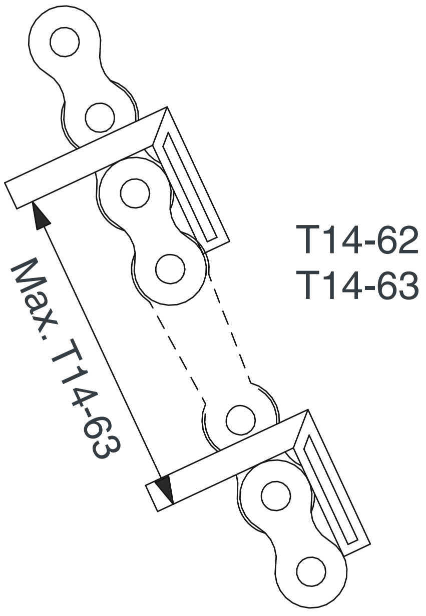
For assessing the measurement results, contact MAN Diesel.

In most cases, scratches caused by the side plates of the chain will be found on the sides of the teeth. Such scratches can generally be considered normal.

Chain's marking

The chains for the camshaft drive are matched together to ensure an even load distribution.

To keep such matching chains in their pairs, the side plates of the outer link nearest to the assembled link have been marked with year, month, day and chain number.



1465-0401-0001C07

Example:

No. 1 order,
840520 1A
840520 1B
(840520 1C, possible 3rd chain)

No. 2 order,
840520 2A
840520 2B
(840520 2C, possible 3rd chain)

On the same links there is an arrow (->) which indicates the mounting direction.

Check the chains for cracks on possibly defective rollers and side plates.

Check that the chain rollers can run freely and that the chain links can freely move on the pin and bushing (that they are not "seized" between the pin and the bushing).

It is normal, however, that the rollers get light, circumferential scratches during the running-in period. These fine scratches are of no importance and need not be considered.

It is recommended that each single link is checked.

Compare the length of 10 chain links

Check chain wear by measuring the length of 10 chain links. Use two master squares and a steel measuring tape as shown on the sketch. Compare the result with the values given in Data.

If necessary, adjust the chain tightener.
See Procedure 1465-0401.

The Chain

It may become necessary to disassemble the chain if, for instance, cracked rollers or seizures between pin and bushing have been discovered during the inspection. *See "Checking"*.

NOTE

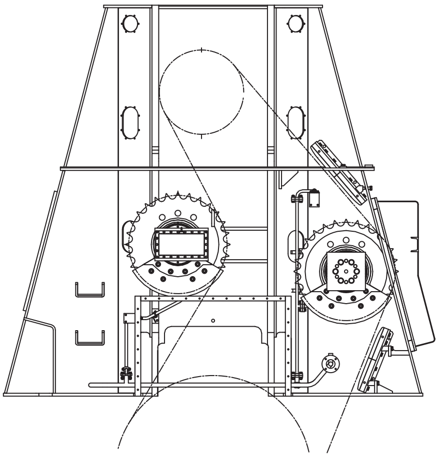
Every time a chain link is disassembled, a new link must **always** be fitted as the link pin press-fit is destroyed when breaking the chain.
When a new link is fitted in one chain, the corresponding link in the other chain must also be renewed.

Loosen the chain tightener

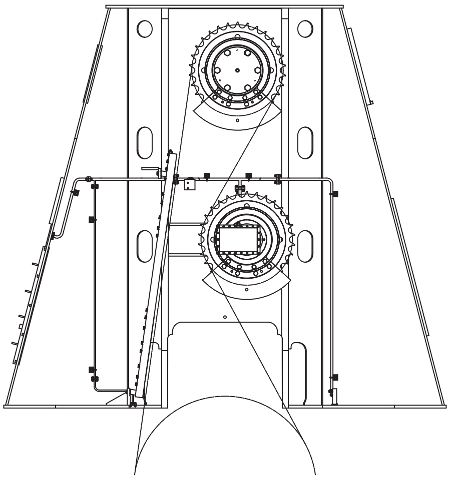
Remove the tension on the chain by loosening the chain tightener.
See Procedure 1465-0401.

Turn the engine until the slack part of the chain, with the chain link that is to be disassembled, is in a favourable position for the work. If the engine is equipped with balanceweights, continue the turning until the balanceweights are hanging vertically downwards, as shown in the sketch.

With compensator



With compensator

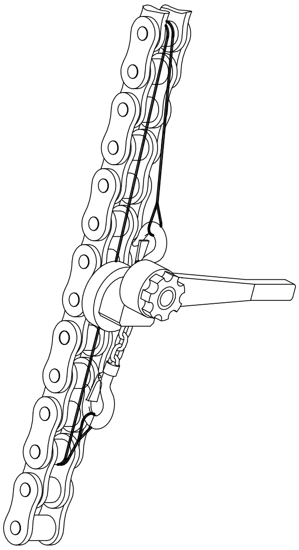


1465-0401-0005D01

Mount a wire round the link rollers

Mount a wire round the link rollers a short distance from the disassembly point, and tighten the wire lightly with a tackle.

Protect the link rollers over which the wire is wrapped.



1465-0401-0001D02

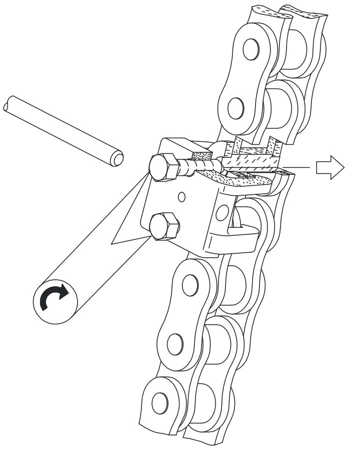
NOTE

If the chain is to be completely removed, contact MAN Diesel for further information.

The riveting of the pins that are to be pressed out is to be chiselled or ground away.

Chain bursting tool

Place the chain bursting tool over the outer chain link, and dismantle the link by alternately tightening the screws on the tool.



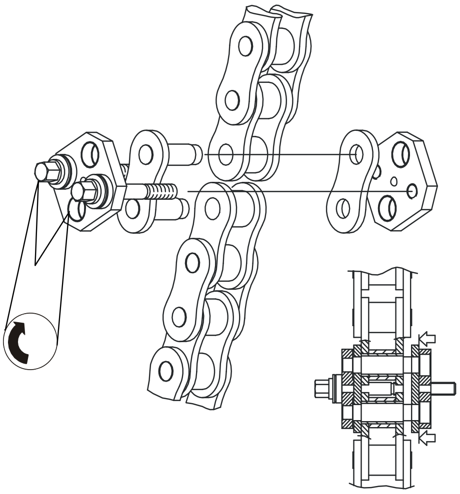
1465-0401-0001D03

Before assembling the inner and outer links, clean the pins and bushings.

Compression tool

Combine the inner chain link with the outer chain link and mount the compression tool.

Force the loose side plate of the outer link into place by alternately tightening the screws on the compression tool.



1465-0401-0001M01

Remove the tools

When the link has been assembled, remove the compression tool and lock the pin ends by riveting.

Repeat this procedure until the chain has been assembled.

Remove the tackle and wire and adjust the chain tension.
(See Data and Procedure 1465-0401).

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

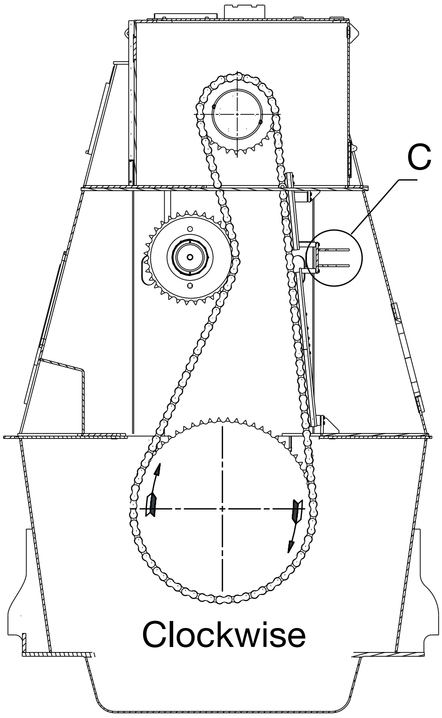
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
1470-0500	**-**	Hydraulic tools - chain tightener
7670-0100	**106**	3-way distributor block
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**023**	Hydraulic pump, hand operated
7670-0100	**047**	Hose with unions, 1500 mm
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**060**	Hose with unions, 5000 mm
7670-0100	**118**	5-way distributor block

Turn the Engine

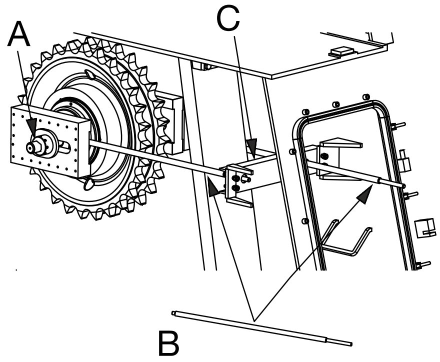
Turn the engine in the clockwise direction to get the slack part of the chain to the tightening wheel.



1465-0501-0008O01

Remove the chain tightener cover

Mount the tightening tool studs **B** in the threaded holes in the tightener wheel shaft. This is done through the opening in the supports on the guide bar **C,** alternatively the covers of the door.



1465-0501-0008O02

Hydraulic nut A

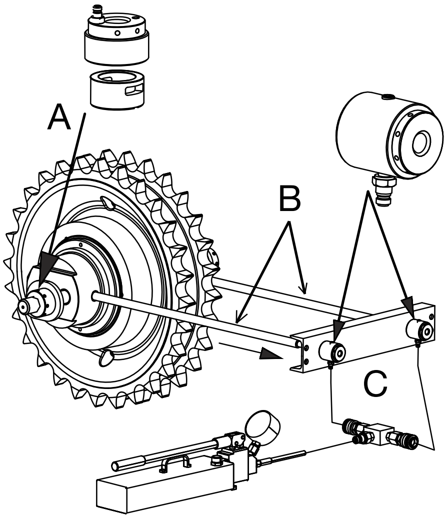
Mount the chain tightener tool hydraulic jacks on the studs **B**. Loosen the hydraulic nut **A**.

For operation of the hydraulic tools, see work card 7665-01.

Hydraulic nut C

Apply hydraulic pressure and tighten both hydraulic jacks simultaneously to the value stated in Data T76-2.

Use the hand operated hydraulic pump for this operation.



1465-0501-0008O04

Hydraulic nut A

Maintain hydraulic pressure to the chain tightening tool. Tighten the hydraulic nut **A** to the value stated in data T76-2. Use the hydraulic pump for this operation.

Remove the tool

Loosen the hydraulic chain tightener tools and remove the tools from the engine.

Connecting Rod and Crosshead Tool Panel

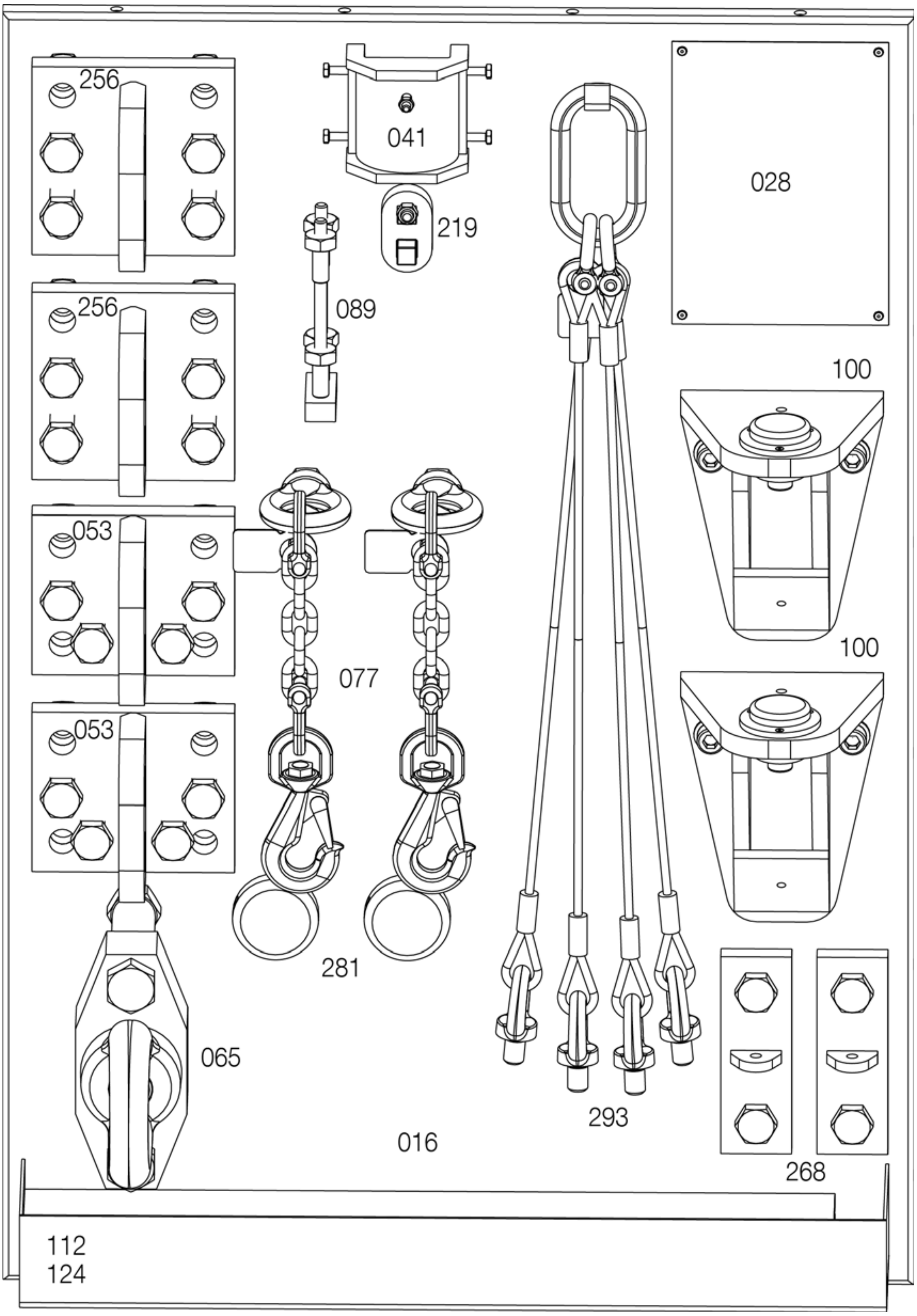
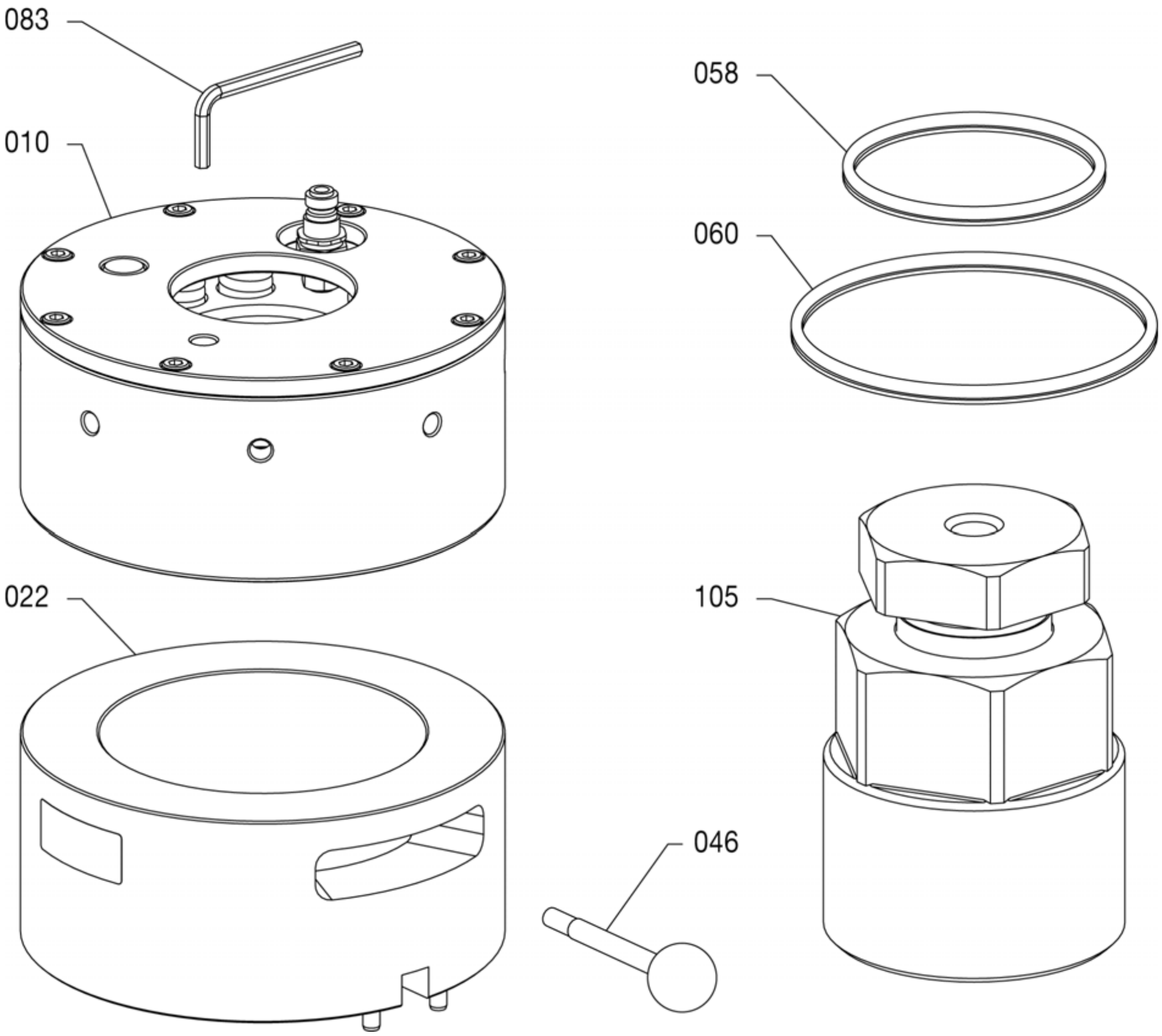


Plate 1470-0300-0011

Item no	Qty	Designation
016	-	Panel for tools
028	-	Name plate
041	-	Wire guide
053	-	Lifting attachment for connecting rod
065	-	Lifting tool for crosshead
077	-	Chain for suspending piston
089	-	Retaining tool for telescope pipe
100	-	Bracket for support of crosshead
112	-	Rubber cover for crosshead
124	-	Rubber cover for crosshead
219	-	Torque wrench offset tool
256	-	Lifting attachment for connecting rod
268	-	Lifting attachment
281	-	Protective screw
293	-	Wire sling

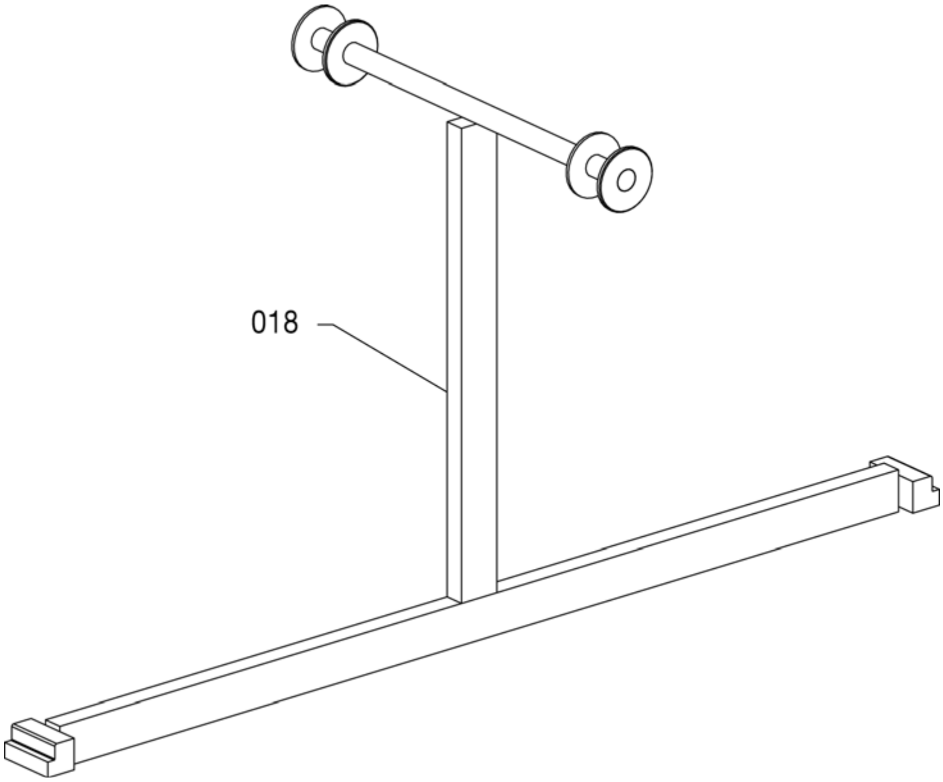
Connecting Rod Hydraulic Tools



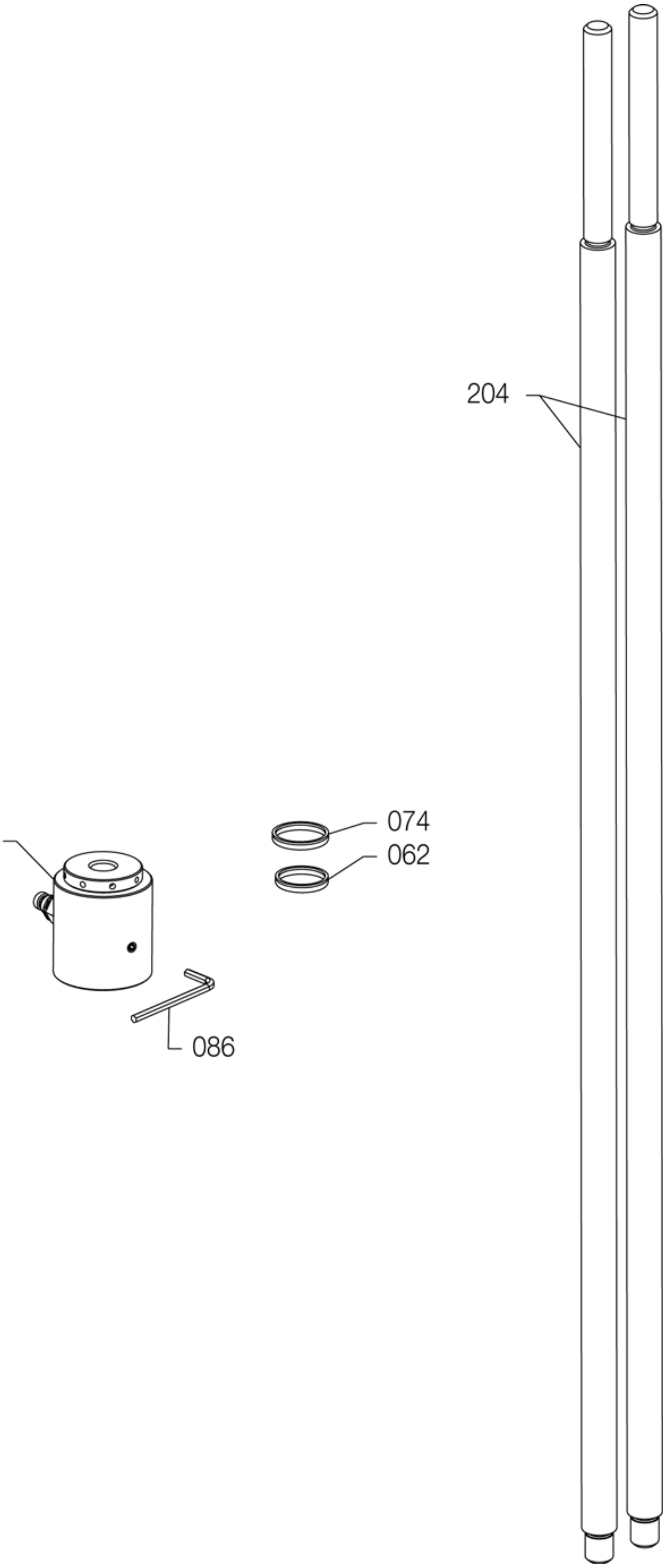
2008-07-30

Plate 1470-0310-0003

Item no	Qty	Designation
010	-	Hydraulic jack, complete
022	-	Support for hydraulic jack
046	-	Ball handle
058	-	Sealing ring with back-up
060	-	Sealing ring with back-up
083	-	Hex key
105	-	Stud setter


018

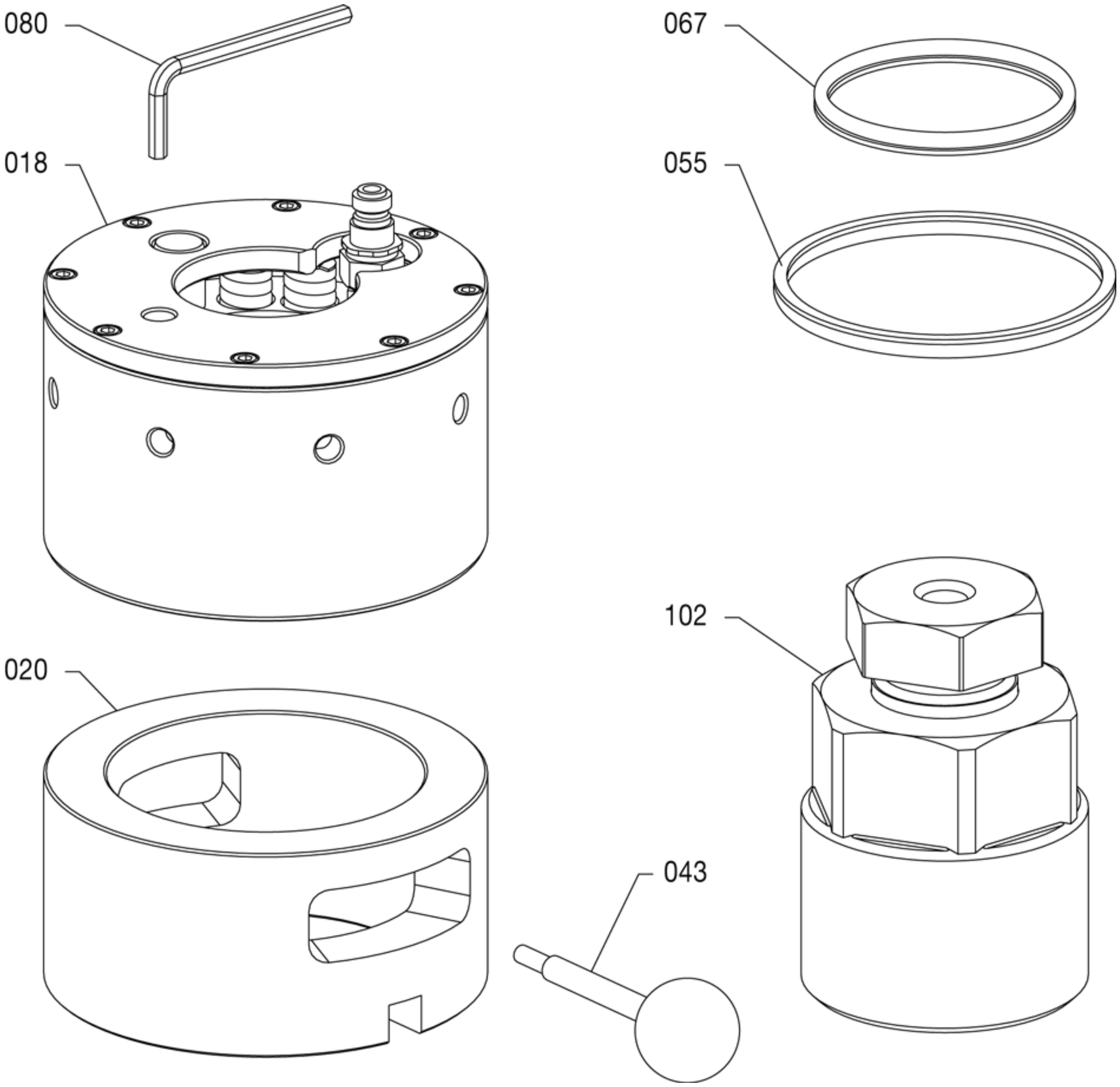
Item no	Qty	Designation
018	-	Lifting tool for crankpin shell



Chain Tightener Hydraulic Tools

Plate 1470-0500-0006

Item no	Qty	Designation
025	-	Hydraulic jack
062	-	Sealing ring with back-up
074	-	Sealing ring with back-up
086	-	Hex key
204	-	Stud



2008-07-30

Plate
1470-0510-0003

Item no	Qty	Designation
018	-	Hydraulic jack
020	-	Support for hydraulic jack
043	-	Ball handle
055	-	Sealing ring with back-up
067	-	Sealing ring with back-up
080	-	Hex key
102	-	Stud setter

Chain Drive Tools Panel

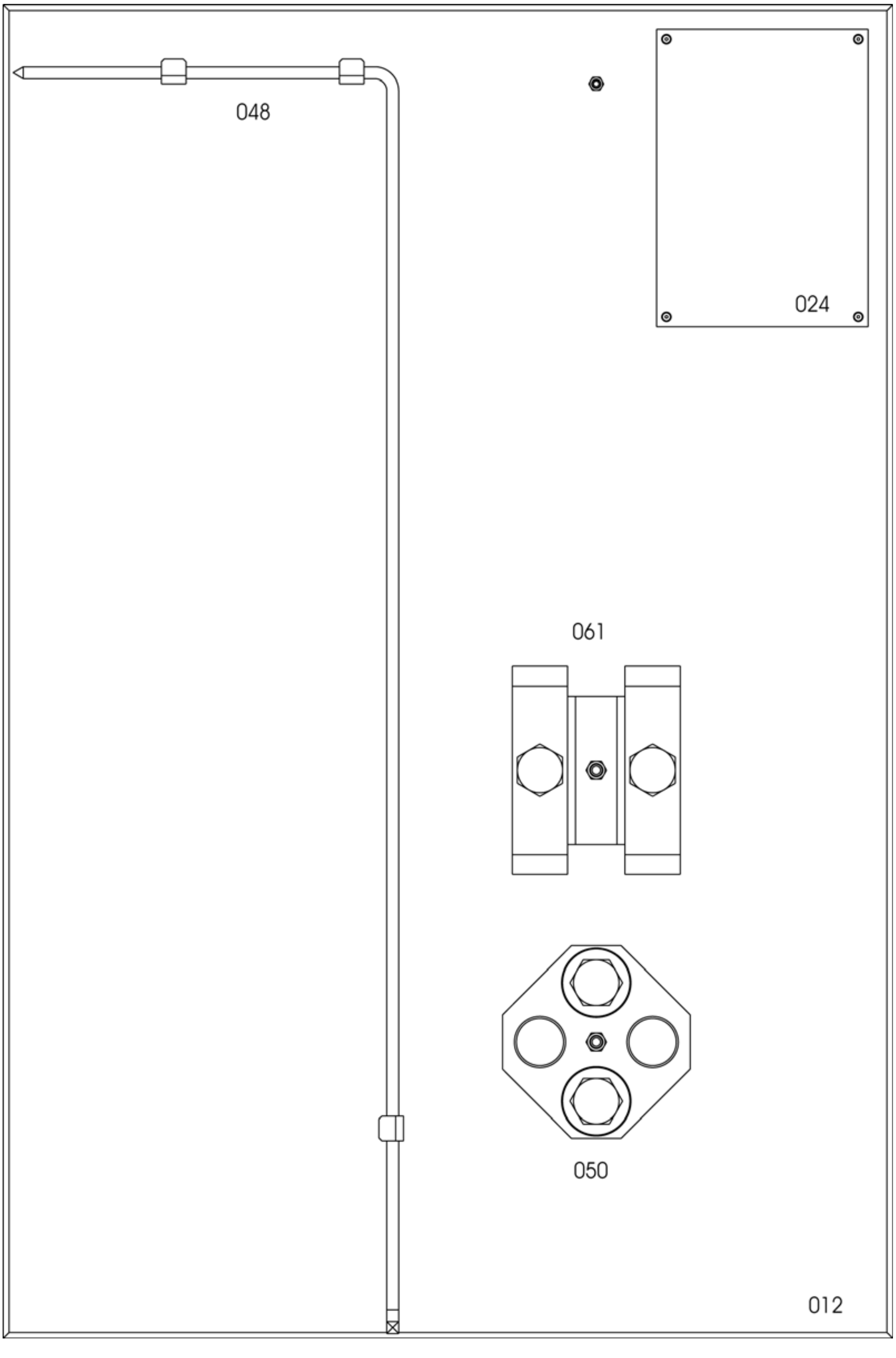


Plate 1470-1400-0008

Chain Drive Tools Panel

Plate
1470-1400-0008

Item no	Qty	Designation
012	-	Panel for tools
024	-	Name plate
048	-	Pin gauge for crankshaft
050	-	Chain assembling tool
061	-	Chain disassembling tool

Chain Drive Tools Panel

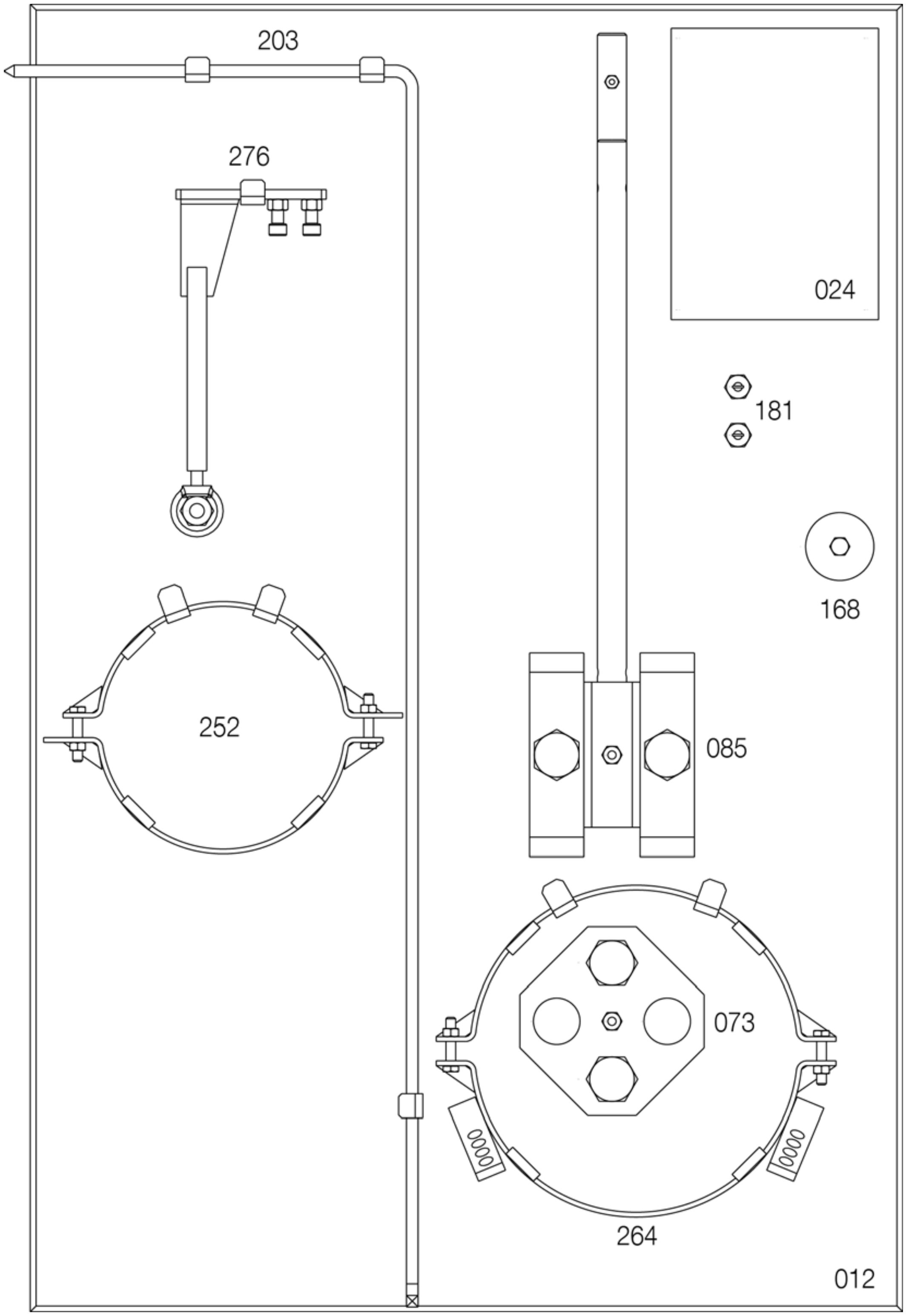


Plate 1470-1400-0015

Item no	Qty	Designation
012	-	Panel for tools
024	-	Name plate
073	-	Chain assembling tool
085	-	Chain disassembling tool
168	-	Guide pin
181	-	Stud
203	-	Pin gauge for crankshaft
252	-	Lifting attachment
264	-	Lifting attachment
276	-	Lifting attachment

Vibration Control

Table of contents

Preface Chapter Vibration Control 1840-0100-0001

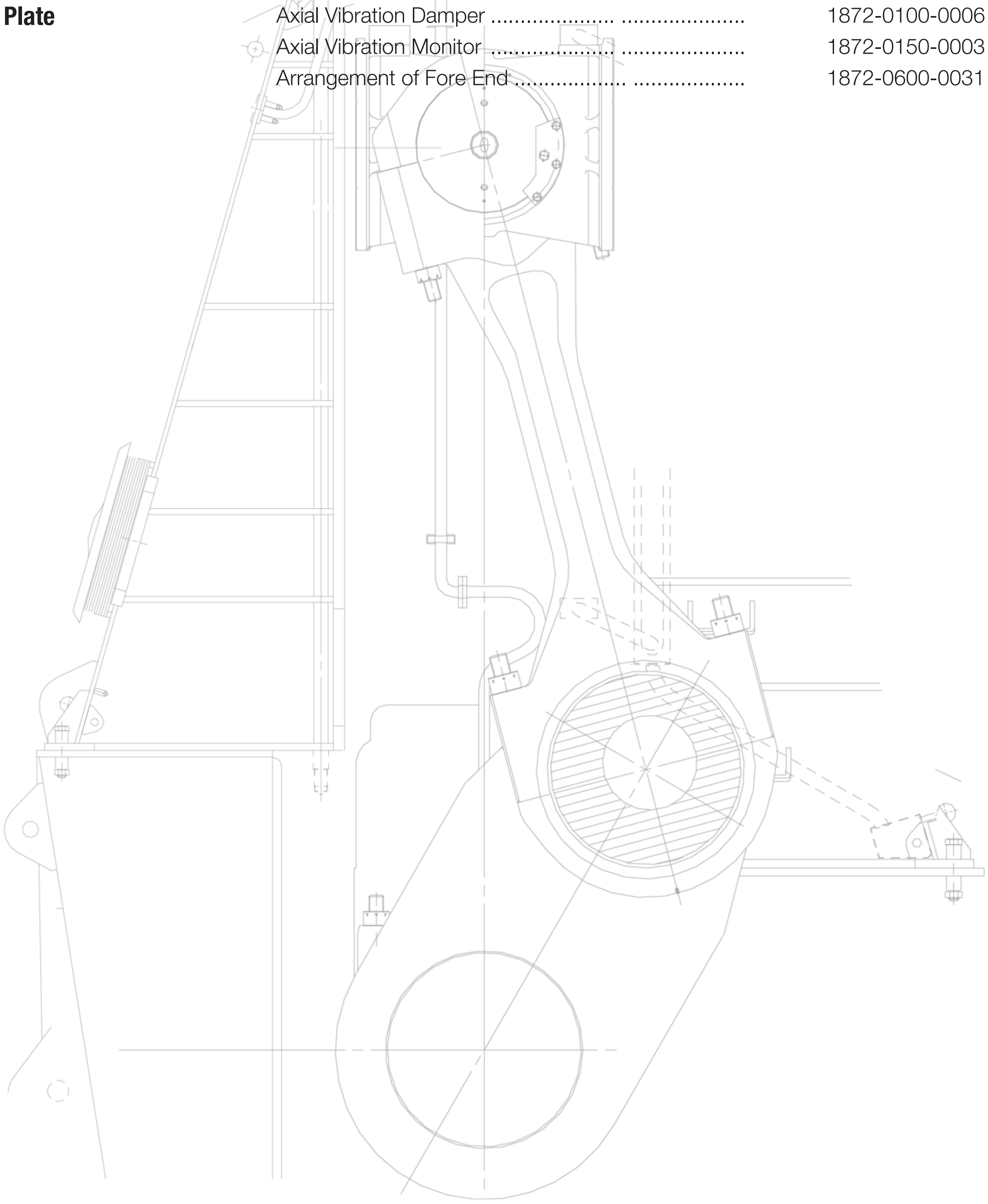
Work Card Axial Vibration Damper, Data 1865-0100-0006

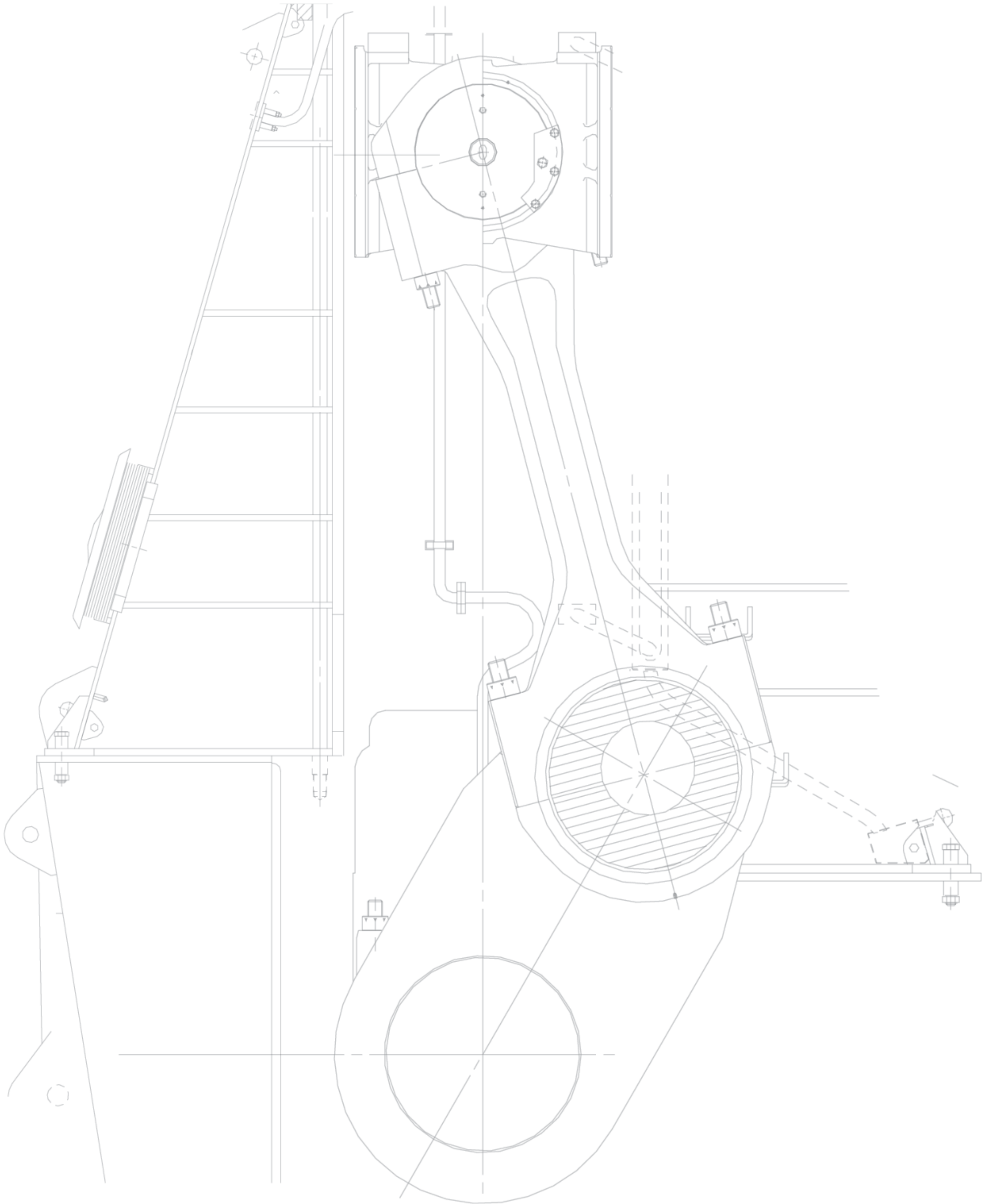
Axial Vibration Damper 1865-0101-0005

Plate Axial Vibration Damper 1872-0100-0006

Axial Vibration Monitor 1872-0150-0003

Arrangement of Fore End 1872-0600-0031





General

Axial Vibration Damper

Section: 18XX-01YY
To counteract heavy axial vibrations, and any resultant adverse forces and vibrations, the crankshaft is provided with an axial vibration damper.

The damper consists of a 'piston' and a slit-type housing. The 'piston' is made as an integrated collar on one of the main bearing journals, and the housing is mounted on the pertaining main bearing support.

The axial movement is damped as a result of the 'restrictions' incorporated in the bores which interconnect the oil-filled chambers on the two sides of the 'piston'.

Lubricating oil is supplied to both sides of the 'piston' from the main system.

Moment Compensators

Section: 18XX-02YY
On the basis of calculations, the engine may be provided with fly weights to counteract engine forces and moments.

⚠ CAUTION

If the chain drives for the compensators have been dismantled, the flyweights must be positioned correctly in relation to the crankshaft. *See Workcard 1865-0200.*

Incorrectly fitted moment compensators may excite heavy vibrations.

1st order moment

Applicable on 4-cylinder engines. The moment compensator is arranged as adjustable flyweights on both ends of the crankshaft.

Alternatively, the 1st order moment compensator can be positioned in the main chain drive.

This moment compensator consists of a (new) chaintightener wheel with an incorporated flyweight and a flyweight rotating with the crank shaft.

Safety Precautions

for detailed sketch see 0545-0100

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
T18-02	Inner studs, screwing-in torque	410	Nm
T18-03	Nuts on inner studs, tightening torque	950	Nm
T18-04	Nuts on inner studs, tightening torque+angle	150+125	Nm+°
T18-06	Outer studs, screwing-in torque	410	Nm
T18-07	Horizontal screws, tightening torque	950	Nm
T18-08	Horizontal screws, tightening torque+angle	150+55	Nm+°
T18-09	Damper housing, upper part	1500	kg
T18-10	Nuts on outer studs, tightening torque	950	Nm
T18-11	Nuts on outer studs, tightening torque+angle	150+125	Nm+°
T18-25	Lower studs, screwing-in torque	410	Nm
T18-26	Nuts on lower studs, tightening torque	950	Nm
T18-27	Nuts on lower studs, tightening torque+angle	150+85	Nm+°

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

Checking the Effectiveness of the Axial Vibration Damper

For checking the effectiveness of the axial vibration damper, it is necessary to measure the longitudinal movements of the fore end of the crankshaft during running.

The measurement (or reading) should be taken at the same r/min as during the sea trials. (Preferably 90% and 100% of MCR.)

As different equipment can have been mounted on the specific engines, the checking procedure describes two different systems:

A: Electronic, with Axial Vibration Monitor

B: Mechanical.

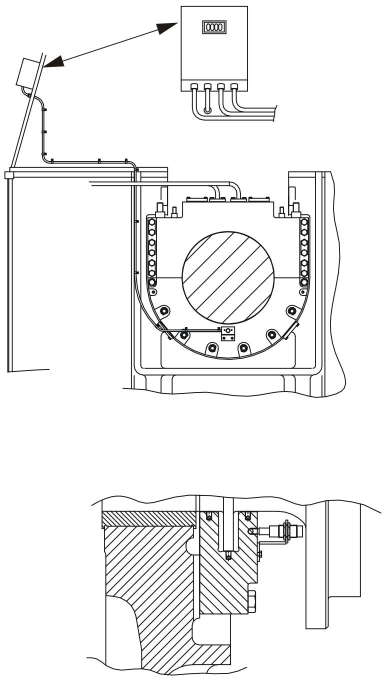
A: Electronic, with axial vibration monitor

A proximeter probe is built on to the lower part of the damper housing. The probe is connected to a control unit which displays peak-to-peak movements and sends signals to the engine control system.

Concerning overhaul and setting of the electronic device, refer to makers instructions and 7045-0100.

The peak-to-peak values displayed in mm are to be compared with the original values obtained during sea trial and the limits given in 7045-0100.

If the peak-to-peak value exceeds the *Normal Service Value*, it is necessary to overhaul the axial vibration damper, *see work card 1865-0101, overhaul.*

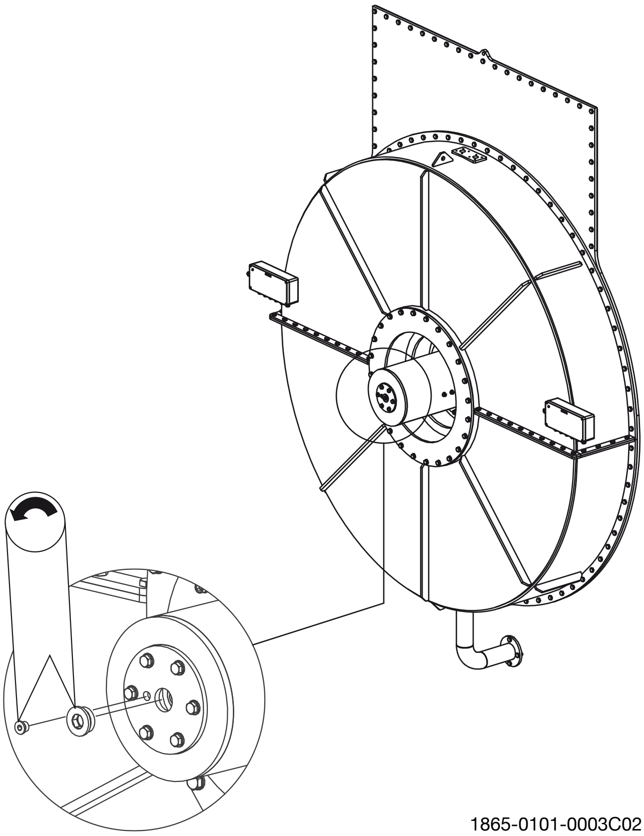


1865-0101-0003C01

B: Mechanical

Stop the engine

Unscrew the two plugs from the cover at the front of the engine.



1865-0101-0003C02

Crankshaft

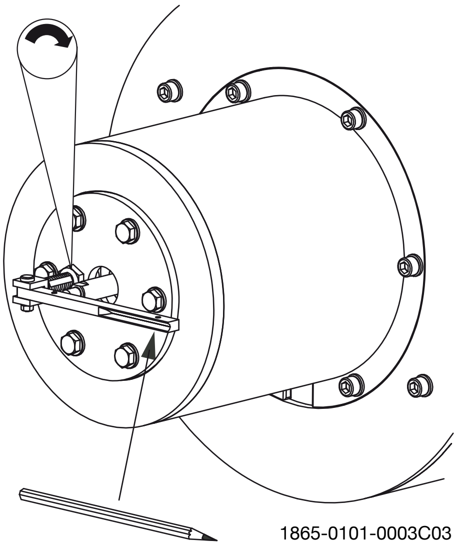
Mount the shaft piece in the end of the crankshaft.

Screw the measuring arm into the small threaded hole beside the centre hole, so that the arm is perpendicular to the shaft piece. Tighten the lock nut.

Attach a pencil to the arm.

NOTE

To obtain a correct measurement, the tip of the pencil should protrude **10 mm** from the end of the arm.



1865-0101-0003C03

Start the engine

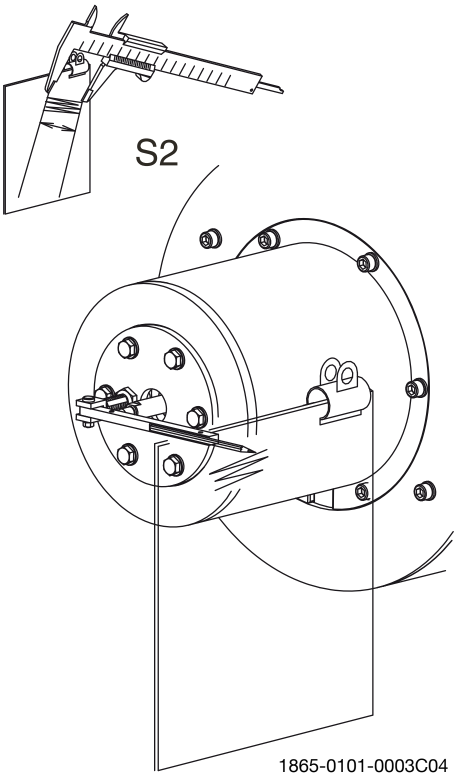
Start the engine, and let the speed rise to the number of revolutions at which the measurement is to be taken. (Preferably 90% and 100% of MCR.)

When measuring, press the measuring arm against the shaft piece with the one hand. With the other hand, move a sheet/block of paper, clipped on to a solid backing plate, lightly downwards against the tip of the pencil.

To ensure a certain inertia, the backing plate should have a mass of approx. 1-2 kg.

The axial movements (S2) recorded on the paper must be measured with a slide calliper as shown in the sketch.

Before comparing the measured value (S2) with the *Normal Service Value (S1), stated in 7045-0100,* it is necessary to compensate for the ratio in the tool.



1865-0101-0003C04

Standard measuring tool

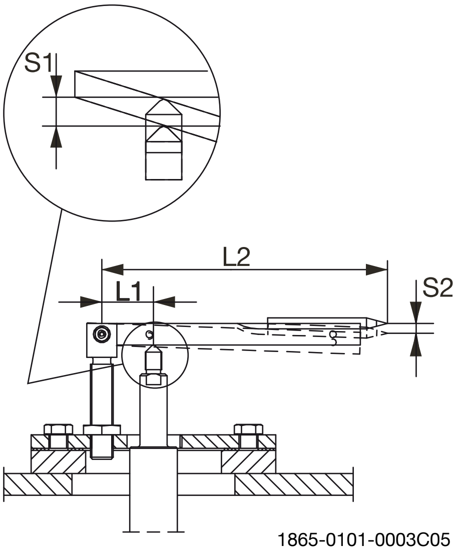
For a standard measuring tool (L1 = 38 mm and L2 = 200 mm), the ratio is 5.3. Therefore, S1 can be calculated as follows:

$$S1 = \frac{S2}{5.3}$$

If a non-standard tool is used, S1 can be calculated as follows:

$$S1 = S2 \times \frac{L_1}{L_2}$$

If the peak-to-peak value exceeds the *Normal Service Value*, it is necessary to overhaul the axial vibration damper, *see work card 1865-0101, overhaul.*

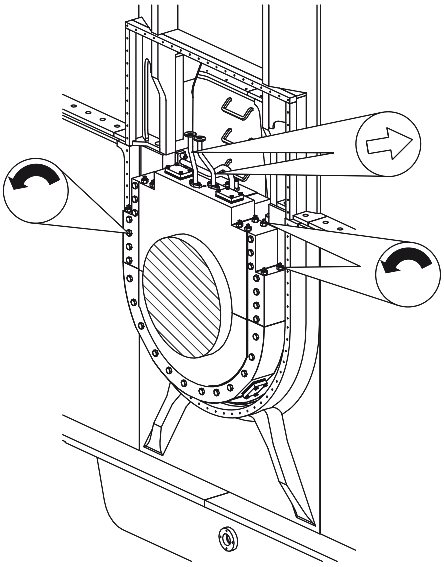


1865-0101-0003C05

NOTE

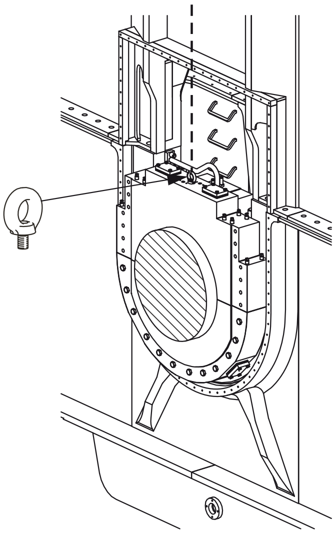
Dismantling of the axial vibration damper is carried out from the crankcase of cyl. No. 1.

Turn the engine to 90º after TDC	Remove the lubricating oil pipes for the axial vibration damper Loosen and remove the nuts from the inner and outer studs. Loosen and remove the horizontal screws. Only the upper part of the housing needs to be removed, while the lower half remains mounted on the bedplate.



1865-0101-0005D01

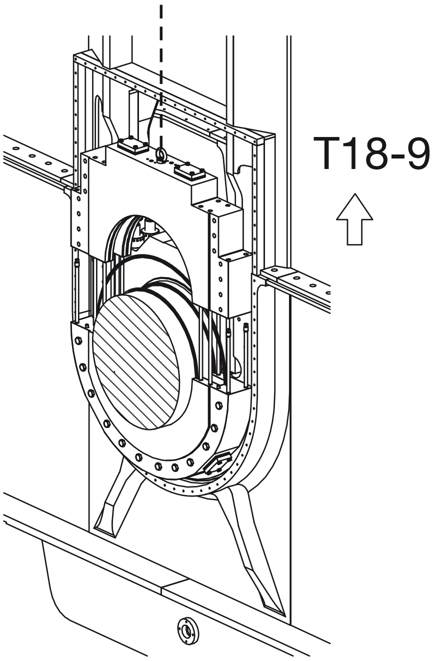
Eyebolt	Screw in an eyebolt in the centre lifting hole on the upper part.
Engines with chain box fore	Fit a tackle in the bracket above the axial vibration damper inside the chain box.
Engines without chainbox fore	Fit a tackle below the fore end platform, and remove the cover on the lifting hole above the axial vibration damper.



1865-0101-0005D02

Raising the upper part of the damper

By means of the tackle and a wire rope, separate and raise the upper part of the damper housing to a position at which it is possible to change the oil seals and springs.



1865-0101-0005D03

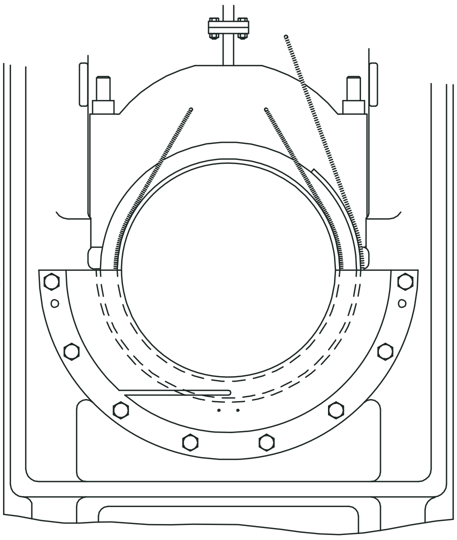
WARNING

Before starting the work under the suspended upper part, secure the upper part with, e.g. a wire rope or another tackle.

Oil sealing rings

Dismantle and remove the springs from the oil sealing rings.

Remove the oil sealing rings.



1865-0101-0003O01

NOTE

It is recommended to discard both the springs and the oil sealing rings.

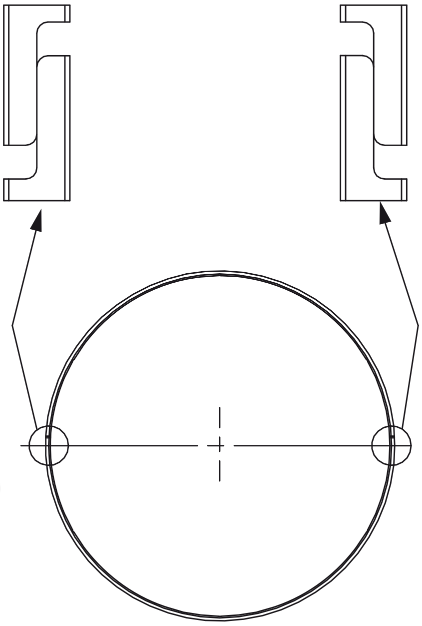
When mounting the new oil sealing rings, first insert the lower half of the rings in the lower housing.

Then press the tension springs into the groove between the oil sealing ring half and the housing.

Hook the new tension springs

Fit all the upper halves of the oil sealing rings in such a way that the clearance at both joints on each oil sealing ring is the same.

Now hook the new tension springs into place, ensuring that they are centered in the grooves of the oil sealing rings.



1865-0101-0003O02

NOTE

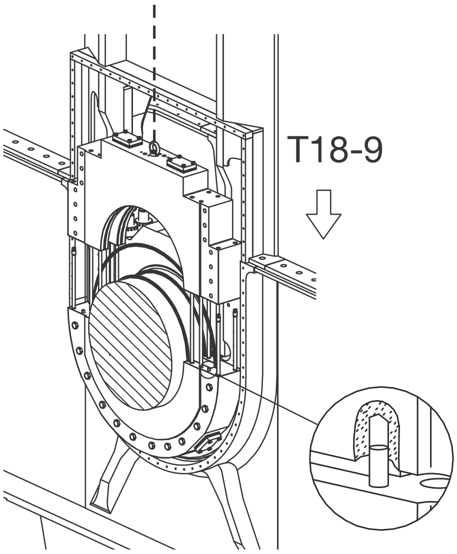
The lower half of the oil sealing rings will protrude above the centreline.

Damper housing

Release and carefully lower the upper part of the damper housing.

When reaching the oil sealing rings, take care that the rings enter the sealing ring grooves correctly.

Before landing the upper part on the lower part, be sure that the guide pins have entered the guide pin holes.



Vertical nuts

Mount and tighten the vertical nuts.
See Data.

Mount and tighten the horizontal screws.
See Data.

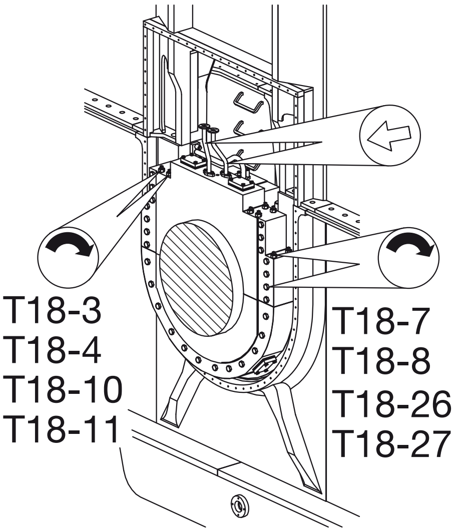
NOTE

Search the crankcase to ensure that there are no tools, shackles or rags left behind.

Connect the lubricating oil pipes.

Engines without chainbox fore

Mount the cover for the lifting hole above the axial vibration damper.



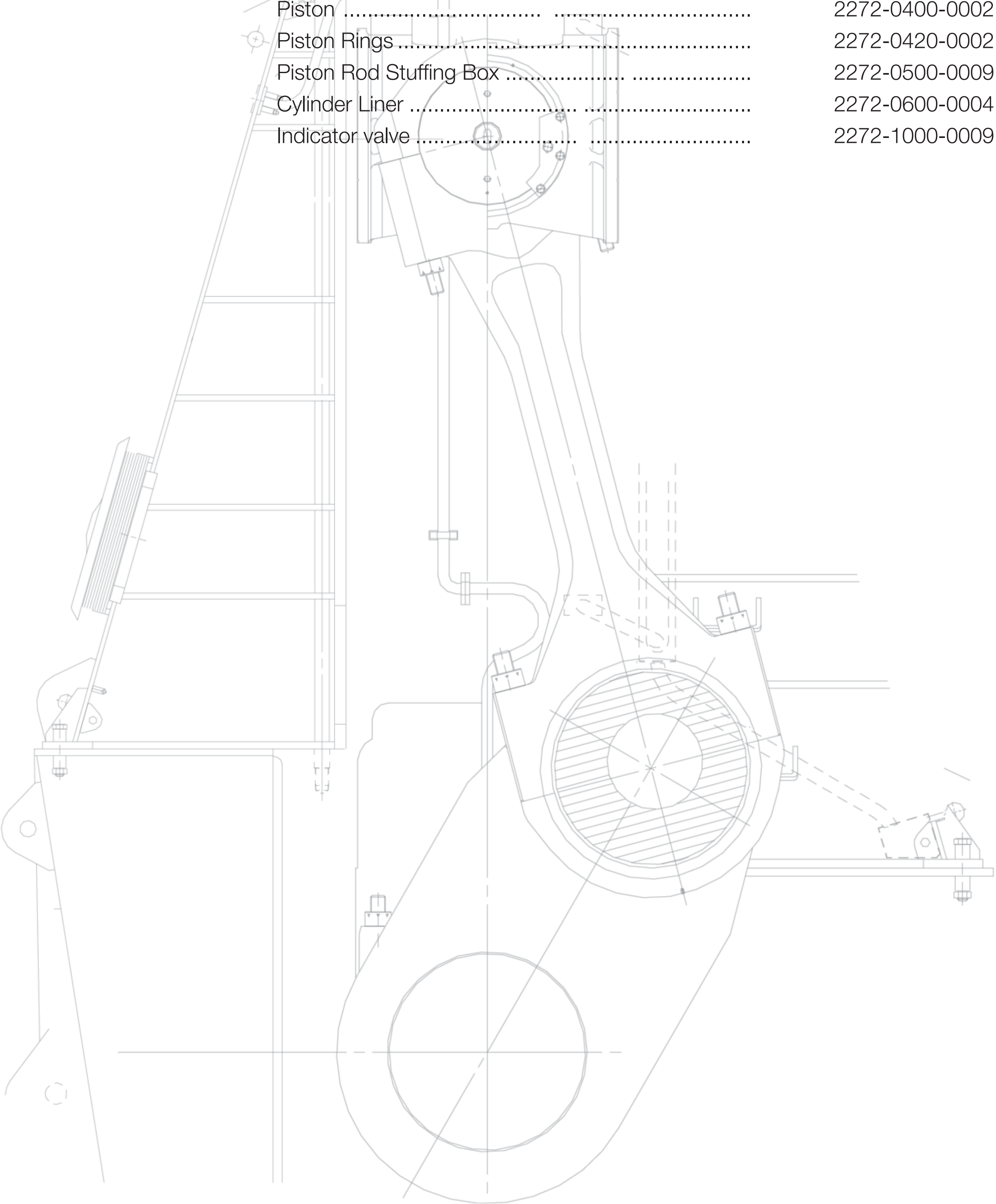
1865-0101-0005M02

NOTE

After overhaul of the axial vibration damper, it is recommended to check the axial vibration. *See work card 1865-0101.*

Preface Chapter	Cylinder Unit	2240-0100-0002
Description	Cylinder Condition	2245-0100-0005
	Inspection of Nimonic Exhaust Valve Spindles	2245-0200-0004
Drawing	Inspection through Scavenge Ports	2255-0100-0004
	Factors Influencing Cylinder Wear	2255-0105-0003
	Cylinder Oil Feed Rate During Running-in	2255-0125-0003
	Cylinder Condition Report	2255-0130-0003
	Calculation of Condensate Amount	2255-0135-0002
	Running-in Load	2255-0140-0003
	Overview Of Piston Rings	2255-0145-0001
	Liner Condition	2255-0150-0001
Work Card	Exhaust Valve High-Pressure Pipe, Data	2265-0100-0009
	Exhaust Valve High-Pressure Pipe	2265-0101-0003
	Exhaust Valve, Data	2265-0200-0014
	Exhaust Valve	2265-0201-0009
	Cylinder Cover, Data	2265-0300-0003
	Cylinder Cover	2265-0301-0011
	Piston, Data	2265-0400-0016
	Piston	2265-0401-0016
	Piston Rod Stuffingbox, Data	2265-0500-0003
	Piston Rod Stuffingbox	2265-0501-0007
	Cylinder Liner, Data	2265-0600-0012
	Cylinder Liner	2265-0601-0010
Tool Plate	Exhaust Valve Panel Tools	2270-0200-0010
	Exhaust Valve Grinding Tools	2270-0210-0003
	Exhaust Valve Extra Tools	2270-0220-0002
	Exhaust Valve Hydraulic Tools	2270-0240-0001
	Exhaust Valve Actuator Hydraulic Tools	2270-0247-0001
	Cylinder Cover Panel Tools	2270-0300-0004
	Cylinder Cover Hydraulic Tools	2270-0310-0002
	Cylinder Cover Hydraulic Tools Spares	2270-0315-0001
	Cylinder Cover Support Tool	2270-0330-0003
	Cylinder Cover Lifting Tools	2270-0350-0001
	Piston Panel Tools	2270-0400-0024
	Piston Guide Tool	2270-0430-0002
	Piston Rod Hydraulic Tools	2270-0440-0002
	Piston Support Tools	2270-0470-0009
	Piston Lifting Tools	2270-0480-0002
	Cylinder Liner Tools	2270-0610-0003
	Cylinder Liner Tools	2270-0610-0004
	Cylinder Liner Lifting Tools	2270-0640-0003
Plate	Exhaust Valve, Upper Part	2272-0200-0011
	Exhaust Valve, Lower Part	2272-0210-0008

Exhaust Valve, Upper Part Detail	2272-0230-0008
Exhaust Valve Pipe	2272-0240-0004
Cylinder Cover	2272-0300-0007
Cylinder Cover Protective Shield	2272-0320-0005
Piston	2272-0400-0002
Piston Rings	2272-0420-0002
Piston Rod Stuffing Box	2272-0500-0009
Cylinder Liner	2272-0600-0004
Indicator valve	2272-1000-0009



General

Exhaust Valve

Each cylinder is equipped with an exhaust valve, which is mounted in a central bore in the cylinder cover. The valve housing is attached with four studs and nuts to form a gastight seal against a seat in the cylinder cover.

Valve housing

The valve housing has an exchangeable bottom piece. The bore for the valve spindle is provided with an exchangeable spindle guide liner.

The valve housing is water cooled. The cooling water is passed to the valve housing after it has passed the cylinder cover. The water is discharged from the upper part of the valve housing.

On the front of the valve housing there is a cleaning cover through which the cooling water space can be checked and cleaned.

Valve spindle

The part of the spindle stem which travels within the sealing arrangement of the air cylinder is coated with a wear resistant mixture of metal carbide and super alloy, applied by the HVOF process.

On the lower cylindrical part of the valve spindle a vane wheel is fitted which causes the valve spindle to rotate while the engine is running.

Lifting/rotation check rod:
To enable checking the functioning of the exhaust valve while the engine is running, a ‘lifting/rotation check rod’ is mounted on top of the hydraulic cylinder on the exhaust valve. Spindle rotation is indicated by regular changes in the top and bottom positions of the check rod.

NOTICE

This check rod is only for checking purposes, and must not be permanently activated.

Pistons:
At the top of the spindle, two pistons are fitted:

1. Air piston.
The piston serves to close the exhaust valve. The piston is locked to the spindle by a two-piece conical ring.

2. Hydraulic piston.
The piston serves to open the exhaust valve. The hydraulic piston has two piston rings and a damper arrangement, de signed to dampen the closing of the valve. The damper arrangement is the self-adjusting type.

Air cylinder

The air cylinder is mounted on top of the valve housing. Air for closing the exhaust valve is supplied through a non-return valve to the space below the piston.

A safety valve is mounted in the bottom of the air cylinder. The safety valve is connected to the drain pipe which leads to the camshaft housing.

Hydraulic cylinder

The hydraulic cylinder is attached with studs and nuts on the air cylinder on top of the exhaust valve housing.

The exhaust valve is opened by the valve spindle being forced down by the piston in the hydraulic cylinder. A throttle valve designed for deaerating the oil system is fitted at the top of the cylinder.

The Control Oil Level (COL) system incoporated into the design of the hydraulic cylinder housing ensures that air chamber under the air piston is air tight.

Piston

The piston consists of two main parts:

- Piston Crown

- Piston Skirt

The piston crown is tightened to the upper end of the piston rod, and the piston skirt is tightened to the piston crown.

The piston crown is provided with three small grooves for the fitting of lifting tools.

The piston crown is provided with chromium plated grooves for four piston rings.

Piston ring No. 1 is a Controlled Pressure Relief ring (CPR).

Piston ring No. 2, 3 and 4 have oblique cuts:

- piston ring No. 3 has a right-hand cut, and

- piston rings Nos. 2 and 4 have left-hand cuts.

On the ME series the piston rings are provided with Alu-coating to improve the running-in stability and to reduce the running-in period. Handle with care, as impact may cause the coating to crack and peel off.

Piston Rod

The piston rod has a through-going bore for the cooling oil pipe, which is se cured to the piston rod top.

Cooling oil is supplied through a telescopic pipe connection on the guideshoe or on the crosshead and passed through a bore in the piston rod foot and through the cooling oil pipe in the piston rod, to the piston crown.

The oil is passed on, through a number of bores in the thrust part of the piston crown, to the space around the cooling oil pipe in the piston rod.

From the bore in the piston rod foot, the oil is led through the crosshead to a discharge spout and to a slotted pipe inside the engine framebox as well as through a control device for checking the flow and temperature.

Crosshead

The piston rod foot rests on a face cut out in the crosshead pin.

A shim is inserted between the piston rod and the crosshead. The thickness of the shim is predetermined to match the actual engine layout.

The piston rod is fastened to the crosshead pin with screws or studs and nuts. The nuts are tightened with hydraulic tools.

Stuffing Box

The bore for the piston rod between the scavenge air space and the crankcase is fitted with a piston rod stuffing box, which is designed to prevent the lubricating oil in the crankcase from being drawn up into the scavenge air space.

The stuffing box also prevents scavenge air (in the scavenge air space) from leaking into the crankcase. The stuffing box housing consists of two parts, which are bolted together.

Scraper/sealing rings

The housing is provided with a number of machined ring grooves:

The uppermost groove holds a scraper ring with oblique edges, which serves to prevent sludge from the scavenge box from being drawn down to the other rings.

Furthermore, a sealing ring is fitted below the scraper ring (except on 35MC type engines).

- The ring grooves in the middle are fitted with sealing rings.

- The lowermost ring grooves are fitted with scraper rings which scrape the lubricating oil off the piston rod.

Oil which is scraped off the piston rod is returned to the crankcase through bores in the stuffing box housing.

Through bores in the housing and a pipe, the stuffing box communicates with a control funnel on the outside of the engine, which enables the sealing/scraping performance to be checked.

Gaps at the ends of the ring segments ensure that the rings will bear against the piston rod even in worn condition.

Cylinder Liner and Cooling Jacket

The cylinder liner is fitted with a cooling jacket. The cooling water is supplied at the lower part of the cooling jacket.

On slimtype liners, the water continues directly to the upper part of the cooling jacket, whereas on the borecooled type liner, the water first passes through the cooling bores. From the top of the cooling jackets, the water flows through water connections to the cooling jacket on the lower part of the cylinder cover.

Leakage of cooling water is prevented by silicone rubber rings.

The cylinder liner is tightened against the top of the cylinder frame by the tensioning force from the cylinder cover studs being transmitted via the cylinder cover.

Scavenge air ports

The part of the cylinder liner which is located in the scavenge air space of the cylinder frame is provided with a number of scavenge air ports, which are uncovered by the piston when this is in its bottom position. The scavenge air ports are bored at an oblique angle to the axis of the cylinder liner so as to give the scavenge air a rotary movement in the cylinder.

Cylinder lubrication

In the free part of the cylinder liner, between the cooling jacket and the cylinder frame, there are a number of bores with non-return valves for the supply of lubricating oil to the cylinder.
See also Chapter 30 “Lubricating System”.

PC-ring

A piston cleaning (PC) ring is mounted at the top of the cylinder liner. The purpose of the PC-ring is to prevent the building up of deposits on the piston topland and, in turn, prevent the wiping away of the cylinder lubricating oil. Consequently, the PC-ring contributes to reducing the wear of liners and rings.

Cylinder Cover

The cover has a central bore for the exhaust valve, which is attached by means of four studs and nuts. The cover furthermore has bores for the fuel valves, starting valve, starting air inlet and indicator cock.

Cooling

A cooling jacket is mounted on the lower part of the cylinder cover, whereby a cooling water space is formed.

Another cooling water space is formed around the exhaust valve seat, when the exhaust valve is installed. These two spaces communicate through a large number of cooling bores in the cover.

The water is supplied from the cooling jacket surrounding the cylinder liner and passes through water connections to the cooling jacket surrounding the cylinder cover and, further on, through the cooling bores, to the space around the exhaust valve seat.

From here the water is discharged to the main cooling water outlet pipe.
See also Chapter 50 “Cooling Water System”.

Tightening

The cylinder cover is tightened against the top of the cylinder liner with nuts and long studs fitted in the cylinder frame. The nuts are tightened with hydraulic tools.

Sealing between the cylinder cover and cylinder liner is obtained by means of a sealing ring of mild steel.

Indicator Valve

Each cylinder is fitted with an indicator valve, which communicates with the combustion chamber of the cylinder through a bore.

Operating Instructions!

When opening the indicator valve, the spindle must be screwed right back to the stop in order to avoid burns and carbon in the guide.

NOTICE

For indicator valves of the double-seated design with a spring-loaded closing face:

In order to prevent overstressing, close the valve lightly before starting the engine, and retighten the valve when the engine has reached its normal service temperature.

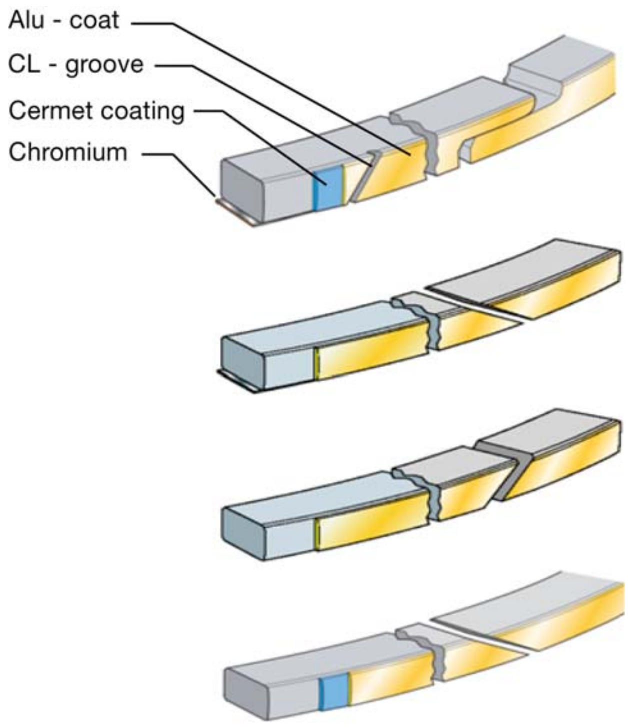
1 General

It is important to keep the engine crew updated with information from the latest Service Letters issued by MAN Diesel & Turbo.

To obtain and maintain a good cylinder condition involves the control of many factors. Since most of these factors can change during the service period – and can be influenced by service parameters within and outside the control of the engine room staff – it is of great importance that running conditions and changes are followed as closely as possible. By means of continual monitoring, it is normally possible to discover abnormalities quickly and thereby, take countermeasures at an early stage. In particular, it is advisable to regularly check the cylinder condition by means of inspection through the scavenge ports from the scavenge air receiver (35-98 bore) and via the small covers on the manoeuvring side as well – especially concentrating on the piston ring condition.

2 Piston Ring Function

All MAN B&W two-stroke engines are equipped with four piston rings made in a cast iron alloy. The function of the piston ring is to give a gas-tight sealing of the clearance between the piston and cylinder liner. This seal is brought about by the gas pressure above and behind the piston ring, which forces it downwards, against the bottom of the ring groove, and outwards against the cylinder wall. In order to ensure optimum sealing, it is therefore important that the piston rings, the grooves, and the cylinder walls, are of proper shape, and that the rings can move freely in the grooves (since the piston will also make small horizontal movements during the stroke). The lubrication of the piston rings influences the sealing as well as the wear and deposits.



Large bore ring pack configuration (most 80-98 engine types): Four rings with Alu-coat for running-in, a CPR top ring, Cermet coating on ring Nos. 1 and 4 and Chromium on the lower face of ring Nos. 1 and 2. Most other engine types are normally configured without Cermet coating and Chromium, but always with Alu-coat as standard.

Experience has shown that unsatisfactory piston ring function is one of the main factors contributing to poor cylinder condition. For this reason, regular scavenge port observations are strongly recommended as a means of judging the ring condition.

The ring pack consist of one high ring with double S-lock (the uppermost) and three low rings with oblique cut ring ends.

In order to make the uppermost piston ring more resistant against ring breakage, especially at the ring lock, it is approx. 30 % higher than ring 2 – 3 – 4 which are all of the same height, and alternating cut left and right.

Coating

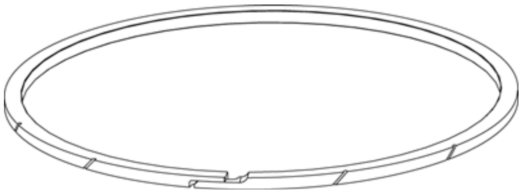
To ease running-in, all piston rings have a 0.3 mm layer of aluminium bronze. This reduces the running-in time considerably, on the test-bed, at the sea trial and in service, as well as after piston overhaul.

Large bore engines (80-98) have hard coating on the uppermost ring and on ring No. 4, so as to ensure a long-term satisfactory cylinder condition and to increase the tribological stability / scuffing margin, see drawing 2255-0145.

Furthermore, some rings have Cr plating on the lower face on ring No. 1 (uppermost) and ring No. 2 to endure higher levels of abrasive particles. By hard-chrome plating the lower face, the surface structure becomes smooth and prevents abrasive particles from being trapped, thereby reducing the ring groove wear.

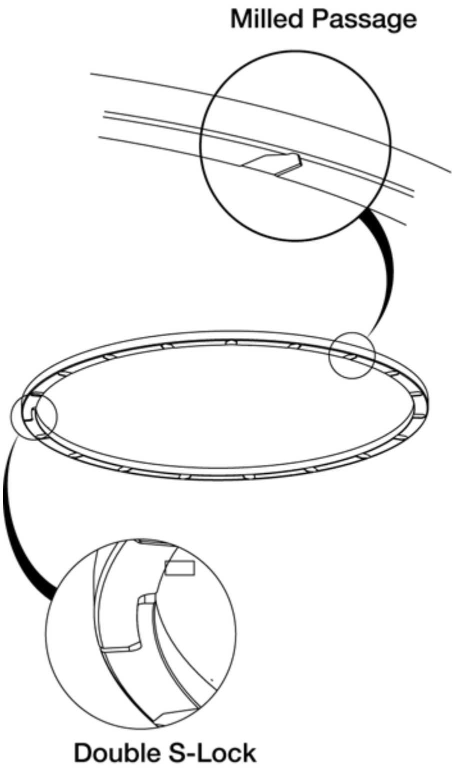
The hard coating (cermet coating) on the uppermost piston ring is introduced to reduce the wear on the top ring and to ensure that the CL (controlled leakage) grooves in extreme cases are not prematurely worn out.

CPR (controlled pressure relief) Ring, CL and POP Versions



CPR-CL

In order to control the pressure drop across the ring pack and, especially, to avoid too high pressure a drop across the upper most ring socalled CL (controlled leakage) grooves are used on the uppermost piston ring on all large bore engines (60 -98). The number of grooves, the distribution on the circumference and the depths depend on the cylinder bore.



CPR-POP

For small bore engines (26-50), the depths of the grooves would not be deep enough to accept a reasonable wear potential. Instead, rings with grooves placed on the lower face are used. The designation for this ring type is POP. (port on plane).

3 Scavenge Port Inspection

3.1 General

The scavenge port inspection provides useful information about the condition of cylinders, pistons, skirts, piston rods and rings.

The inspection consists of a visual examination of the piston, piston skirts, rods, piston rings and the lower part of the cylinder liner directly through the scavenge air ports, and measurements of the ring clearance, the CL grooves, the POP grove opening and the thickness of possible piston ring coating.

To reduce the risk of a scavenge box fire, even though this phenomenon is very rare on modern engines, remove any oil sludge and carbon deposits in the scavenge air box and receiver in connection with the inspection. With the relevant pumps running an evaluation can be made of the fuel valves sealing tightness, the piston tightness for lube oil and the cylinder cover's sealing tightness for cooling water.

The port inspection should be carried out at the first stop after a long voyage, e.g. by anchoring if possible, to obtain the most reliable result with regard to the effectiveness and sufficiency of the cylinder lubrication and the combustion cycle (complete or incomplete). A misleading result may be obtained if the port inspection is carried out after arrival at harbour, since manoeuvring to the quay and low-load running, e.g. river or canal passage, requires increased cylinder oil dosage, i.e. the cylinders are excessively lubricated. Further, during low load, the combustion cycle might not be as effective and complete as expected, due to the actual fuel oil qualities and service (running) condition of the fuel injection equipment. It is highly recommended to take this information into consideration when evaluating the cylinder condition.

The inspection must take place at least twice a month. If in port anyway.

3.2 Procedure

For the Inspection procedure see work card 2265-0401.

Scavenge port inspections are best carried out by two persons. The more experienced person inspects the surfaces and states his observations to an assistant, who records them and later enters them in MAN Diesel & Turbo standard forms. Keep cooling water, fuel oil and cooling oil circulating, so that possible leakages can be detected.

⚠ WARNING

ALWAYS bring the turning gear switch into the scavenge air receiver during inspection.

Block the starting air supply to the main starting valve. Open the indicator valves.
Block the hatch cover to the receiver to prevent it from closing by accident.
Bring in bottles with drinking water for consumption in the scavenge air receiver. Take care when moving around in the receiver and bring proper lighting. Pockets for thermometers are placed in head level. Hard hat is also recommended. Remember to take breaks to replenish fluid lost from sweating, especially in hot climates.

Engage the turning gear. Remove the inspection covers on the fuel pump side of the cylinder frame, and clean the openings. Open the doors or the cover(s) on the scavenge air receiver. Do not enter the scavenge air receiver before it has been thoroughly ventilated. Begin the inspection on the cylinder with the piston nearest BDC. Inspect the piston, skirts, rods, rings, and cylinder wall. Wipe the running surfaces clean with a rag to ensure correct assessment of the piston ring condition.

Use a powerful lamp to obtain a true impression of the details. Bring in a small camera to make documentation of the condition of the scavenge port inspection etc. Instead of flash use the lamp as the light source.

Record the results on drawing 2255-0100 and use the symbols as shown to ensure easy interpretation of the observations.

Keep the records to form a log book of the cylinder condition. Measure the total clearance between the piston rings and the ring grooves. Measure the CL-groove depths and the thickness of the ring coating, if applicable. Continue the inspection on the next cylinder with its piston nearest BDC, and so on according to the firing order. Note down the order of inspection for use at later inspections. Check the non-return valves (flap valves/butterfly valves) in the auxiliary blower system for easy movement and possible damage and inspect the condition of the water mist catcher. Remove any oil sludge and carbon deposits in the scavenge air boxes and receiver. If fuel oil or excessive system oil is found, the fuel valve or pulled pistons should be pressure tested. Record the observations on drawing 2255-0100.

3.3 Observations

3.3.1 Scavenge Receiver Condition

Check and note the condition of the scavenge receiver.

Scavenge Receiver, NO SLUDGE

Note: Water washing from defect water mist catcher could cause a very clean scavenge air receiver.

Scavenge Receiver, SLUDGE – S

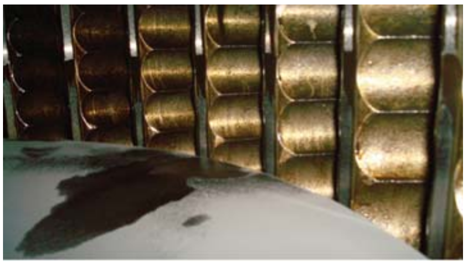
Normal picture. Indicates good cylinder condition.

Scavenge Receiver, MUCH SLUDGE – MS

Remove any oil sludge and carbon deposits in scavenge receiver.

3.3.2 Leakage

Check the piston crown top for any leakages (remember to keep cooling water, fuel oil and lubricating oil circulating during the inspection).



Leaking oil - LO

If oil is found on the piston, determine if it is fuel oil or lube oil. Fuel oil will be black and sticky, indicating a fuel valve is leaking. Lube oil will be brown and non-sticky, indicating it could be from an exhaust valve.

Leaking water - LW

Water on a piston indicates a cooling system leak. If water is found, it is important to determine what the cause is. Use either a mirror or photo, to establish if the leak is from the cylinder cover, exhaust valve or a cracked liner.

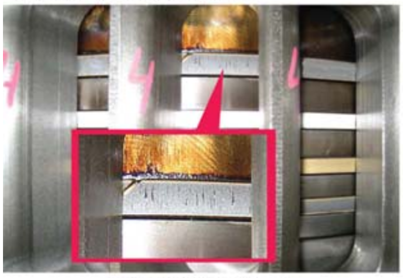
3.3.3 Piston rings: in good condition

When good and steady service conditions have been achieved, the running surfaces of the piston rings and cylinder liner will be worn bright (this also applies to the ring undersides and the “floor” of the ring grooves which, however, cannot be seen until a piston is pulled).

In addition, the rings will move freely in the grooves and also be well oiled, intact, and not unduly worn. The ring edges will be sharp when the original roundings have been worn away, but should be without burrs.

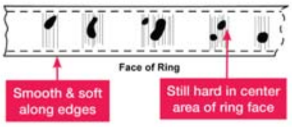
3.3.4 Piston rings: micro-seizure

LOCAL & ALL OVER MICRO-SEIZURES



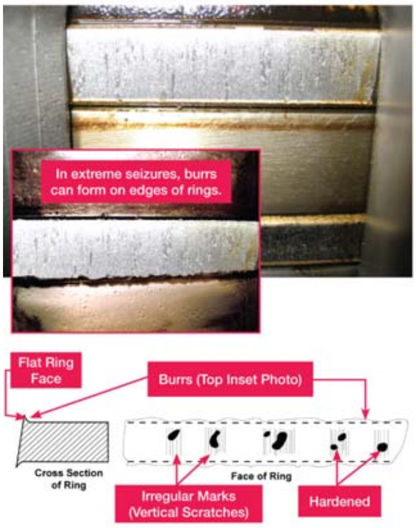
LOCAL MICRO-SEIZURES – mz

STILL ACTIVE MICRO-SEIZURES – MAZ



OLD MICRO-SEIZURES – OZ

ACTIVE & INACTIVE MICRO-SEIZURES



Temperarily increase the cylinder oil dosage; If seizures are observed.

If micro-seizures as observed on the piston rings are not properly attended, by reducing the p_{max} and engine load on the respective unit, and by increasing the lubrication feed rate, according to instructions (1.2 g/kWh), scuffing of the cylinder liner can occur, causing momentarily high wear of all combustion chamber parts.

If, over a period of time, the oil film is partially interrupted or disappearing, so that dry areas are formed on the cylinder wall, these areas and the piston ring surfaces will, by frictional interaction, become finely scuffed and hardened, i.e. the good “mirror surface” will have deteriorated.

In case of extreme micro-seizures (for scuffing see item 5.6.1) , sharp burrs may form on the edges of the piston rings.

A seized surface, which has a characteristic vertically-striped appearance, will be relatively hard, and may cause excessive cylinder wear. Due to this hardness, the damaged areas will only slowly disappear (run-in again) if and when the oil film is restored.

As long as the seizure is allowed to continue, the local wear will tend to be excessive. Seizure may initially be limited to part of the ring circumference, but, since the rings are free to “turn” in their grooves, it may eventually spread over the entire running face of the ring.

The fact that the rings move in their grooves will also tend to transmit the local seizure all the way around the liner surface.

If extreme seizures (for scuffing see item 5.6.1) have been observed, it is recommended that the cyl. oil feedrate is temporarily increased to 1.2 g/kWh.

If load reduction of more than one unit is required, please contact MAN Diesel & Turbo for advice.

3.3.5 Piston rings: scratcing

Scratching is caused by hard abrasive particles originating from the ring itself or, more likely, from the fuel oil or air intake. With regards to liner and ring wear, the actual scratching is not necessarily a serious problem, but the particles can have serious consequences elsewhere (see Item 5.5).

3.3.6 Piston rings: sticking

If, due to thick and hard deposits of carbon, the piston rings cannot move freely in their grooves, dark areas will often appear on the upper part of the cylinder wall (this may not be visible at the port inspection). This indicates a lack of sealing, i.e. combustion gas blow-by between piston rings and cylinder liner.

The blow-by will provoke oil film breakdown, which in turn will increase cylinder liner wear. Sticking piston rings will often lead to broken piston rings. The free movement of the rings in the grooves is essential and can be checked either by pressing them with a wooden stick (through the scavenge ports) or by turning the engine alternately clockwise and counter-clockwise to check the free vertical movement.

3.3.7 Piston rings: breaking/collapse

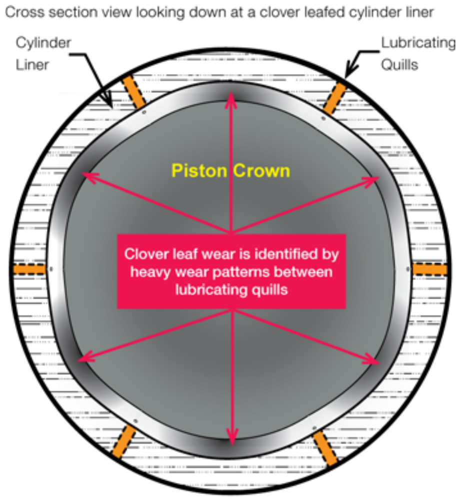
Broken piston rings manifest themselves during the scavenge port inspection by their:

- lack of elastic tension when the rings are pressed into the groove with a stick
- blackish appearance
- fractured rings
- missing rings or missing ring parts.

Piston ring breakage is caused by a phenomenon known as “ring collapse”. However, breakage may also occur due to continual striking against wear ridges on the cylinder liner TDC area, or other irregularities on the cylinder wall. Collapse occurs if the gas pressure behind the ring is built up too slowly and, thereby, exerts an inadequate outward pressure. In such cases, the combustion gas can penetrate between the liner and ring, and violently force the ring inwards in the groove. This type of sudden “shock” loading will eventually lead to fracture – especially if the ring ends “slam” against each other. This phenomenon is, however, seldomly observed on modern engines.

The mentioned slow pressure build-up behind the rings can be due to:

- carbon deposits in the ring groove
- too small vertical ring clearance
- partial sticking
- poor sealing between the ring and the groove floor
- “clover-leafing” (see below).



CLOVER LEAF WEAR – CL

"Clover-leafing" is a term used to describe longitudinal corrosive liner wear at several separate points around the liner circumference – i.e. in some cases the liner bore may assume a "clover-leaf" shape.

3.3.8 Piston Rings: Blow-by

Leakage of combustion gas past the piston rings (blow-by) is a consequence of sticking, collapsed or broken of rings.

At the later stages, when a complete blow-by occurs, it is usually due to sticking rings or ring breakage caused by collapse.

Blow-by is indicated by black, dry areas on the rings and also by larger black dry zones on the upper part of the liner wall. This can only be seen when overhauling the piston or when exchanging the exhaust valve.

3.3.9 Deposits on pistons

Usually, some deposits from the cylinder oil will accumulate on the side of the piston crown (top land). Carbon deposits on the ring lands (the area on the pistons between the piston rings) indicate lack of gas sealing at the respective rings, see drawing 2255-0100. The piston cleaning ring between the cylinder cover and liner normally remove superfluous and harmful deposits on the pistons.

If the deposits are abnormally thick, their surfaces may be smooth and shiny from rubbing against the cylinder wall. Such contact may locally wipe away or absorb the cylinder oil film, resulting in bore polish, micro-seizure and increased wear of liner and rings. In some instances, mechanical clover-leafing can occur, i.e. vertical grooves of slightly higher wear in between the lubricating quills.

Such conditions may also be the result of a combustion condition which overheats the cylinder oil film. This could be due to faulty or defective fuel valves or insufficient turbocharger efficiency.

3.3.10 Lubricating Condition

Note if the "oil film" on the cylinder wall and piston rings appears to be adequate, see Item 3.1. Black or brownish coloured areas may sometimes be seen on the liner surface. This indicates corrosive wear, usually from sulphuric acid (see Item 5.4), and should not be confused with grey-black areas, which indicates blow-by.

These deposits are often only of cosmetic nature and will not lead to wear issues.

The phenomenon is often connected to humidity in the scavenge air and may disappear when the vessel enters cold and less humid areas.

See Item 5.4 and chapter 3045-0110.

3.4 Replacement of piston rings

It is recommended to replace the complete set of piston rings at each piston overhaul to ensure that the rings always work under optimal service conditions, thereby giving the best ring performance. Stretching the rings lead to stress and care must be taken not to open the rings more than necessary when installing them on the piston.

4 Cylinder Overhaul

To ensure correct recording of all relevant information, it is recommended that the “Cylinder Condition Report” (drawing 2255-0130) is used.

4.1 Intervals between piston overhaul

It is recommend to decide the interval between piston overhaul based on the condition of the units observed at scavenge port inspections and not on fixed intervals. In other words: It is not a good idea to pull piston No. 4, based on running hours, if it is piston No. 6 that needs overhaul.

Also base the actual intervals between piston overhauls on the previous wear measurements and observations from scavenge port inspections. Often the guiding intervals between piston overhauls can be prolonged considerably without any harm to the cylinder condition, provided frequent scavenge port inspections are carried out.

Regarding procedures for the dismantling and mounting of pistons, see work card 2265-0501. Remove the piston cleaning (PC) ring between the liner and the cylinder cover, and mark the position of the ring to allow fitting of the PC-ring in the same position as it is worn together with the liner. Carefully remove any coke deposits and wear ridges from the upper part of the liner before fitting the piston.

Regarding procedure for checking the PC-ring, see work card 2265-0601. The PC-ring is part of the liner and will not need to be exchanged unless it is broken.

4.2 Initial inspection and removal of the piston rings when the piston has been pulled

Only use the standard MAN Diesel & Turbo ring opener for fitting and removal of piston rings. Only expand the rings sufficiently to fit over the piston. This opener prevents local overstressing of the ring material, which in turn would often result in permanent deformation causing blow-by and broken rings. Straps to expand the ring gap, or tools working on the same principle, should never be used.

4.3 Cleaning

Clean the piston rings. Clean all ring grooves carefully. If carbon deposits remain, they may prevent the ring from forming a perfect seal against the floor of the groove. Remove deposits on the piston crown and ring lands. Remove any remaining coke deposits from the upper section of the liner.

4.4 Measurement of ring wear

Please refer to work card 2265-0501

4.5 Inspection of cylinder liner

The aim is to obtain controlled corrosive wear (0.03 - 0.05mm / 1000h) of the liner surface by applying different cylinder oil feed rates, depending on the fuel oil sulphur content (Alpha ACC lubrication algorithm), to avoid liner polishing and subsequent seizures.

4.5.1 Cylinder wear measurements

See work card 2265-0601

Before measuring the cylinder wear with a pin gauge:

- ensure that the tool and cylinder liner temperature values are close
- record the tool and cylinder liner temperatures on drawing 2255-0130 to enable correction
- Íf possible take a “zero” measurement

Measure the wear with the pin gauge at the vertical positions marked on the guide rail. Measure in both transverse and longitudinal directions. The guide rail ensures that the wear is always measured at the same positions. Record the measurements on drawing 2255-0130.

Tools with electronic measurement equipment can be used through the scavenge ports if dismantling of the cylinder cover is not possible.

4.5.2 Correction of wear measurements

Correct the actual wear measurements by multiplying with the following factors, if the temperature of the cylinder liner is higher than the temperature of the tool. This enables a comparison to be made with earlier wear measurements.

Δt° (Tliner - Ttool)	C Factor
10	0.99998
20	0.99976
30	0.99964
40	0.99952
50	0.99940

Example (90 bore):

Δt measured: 30 °C

Corrected value: 901.3 × 0.99964 = 900.98 (i.e. a reduction of 901.3-900.98 = 0.32 mm)

However, a zero measurement can be made in the top of the cylinder liner, above ring No. 1 (TDC), where there is no wear. The wear can then be calculated.

4.5.3 Maximum wear

The maximum allowable wear of cylinder liners is in the interval of 0.4% to 0.8% of the nominal diameter, depending on the actual cylinder and piston ring performance. When the interval between necessary piston overhauls becomes too short, for instance due to ovality, it is time to renew the liner and the PC ring.

4.5.4 Checking liner surface

Inspect the liner wall for scratches, micro-seizures, wear ridges, corrosive wear, and surface structure if possible.

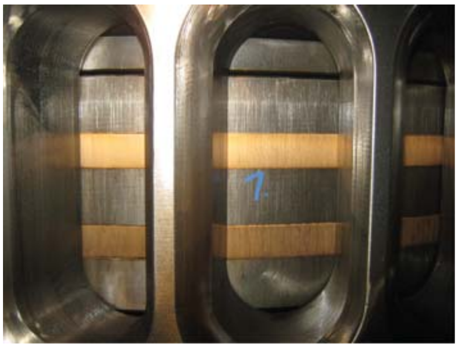
If corrosive wear is suspected, or if a ring is found broken, take extra wear measurements around the circumference at the upper part of the liner. Press a new piston ring into the cylinder. Use a feeler gauge to check for local clearances between the ring and liner. This can reveal any “uneven” corrosive wear, see Item 3.3.

Be aware that if the liner is not ovally worn and the highest wear does not exceed 0.3% of the liner diameter, it is possible to increase the expected service life of the liner by re-establishing the wave cut shape on the running surface by machining either in situ or at one of the MAN Diesel & Turbo service centres. However, please note, wave-cut machining (by grinding) does not compensate for liner ovality. To compensate for liner ovality, causing premature ring breakage, liner honing is recommended.

Black shiny areas are often found on the liner surface just above the scavenge air ports. These areas of black deposits, called lacquer formations, are harmless and are formed by a combination of water in the scavenge air and cylinder oil. The layer can be rather difficult to remove and can be left as it is.

4.6 Piston skirt, crown and cooling space

The piston skirt is made of cast iron and is equipped with two bronze rings to reduce the risk of scuffing. Some engines have a special molybdenum coating on the skirts instead of the two bronze rings.



Scuffing of the skirt is rare and mostly of cosmetic nature, and is not always a sufficient reason for exchange.

If the burning/corrosion condition of the piston crown exceeds the maximum permissible, send the piston crown for reconditioning. The maximum permissible burning, see work card 2265-0401

Inspect the crown for cracks by dye checking or similar.

Pressure-test the piston assembly to check for possible cooling oil leakages.

If the piston is taken apart, for instance due to oil leakage, check the condition of the joints between the crown, the piston rod, and the skirt. Inspect the cooling space and clean off any carbon/coke deposits.

Replace the O-rings. Check that the surfaces of the O-ring grooves are smooth. This is to prevent twisting and breakage of the O-rings. Polish the grooves with emmery paper if leakages are found and new O-rings must be installed. Pressure test the piston after assembling.

For safety reasons, the measurements of the burning of the crowns must not take place with the piston and cylinder cover in situ by placing the template on the crown via the scavenge ports. The cylinder cover must be dismantled or the piston pulled.

4.7 Piston ring grooves

Check the piston ring grooves as described in work card 2265-0401

If the ring groove wear exceeds the values stated in data sheet 2265-0400, send the piston crown ashore for reconditioning (new chrome plating).

If the ringgroove wear is exceeding the limits the ring grooves may need re-welding and machining before re-chroming.

4.7.1 Chrome plating macro cracks

The hard chrome plating of the ring groves is defined to be micro cracked. This ensures that the strong tensile residual stresses in the plated chrome layer are partly released.

During operation (thermal influence), the chrome plating in the piston ring grooves may crack into a macro pattern. This is normal and acceptable and not expected to cause further deterioration. More macro cracks may develop during operation.

4.8 Reconditioning of the running surfaces of liner and skirt

If there are micro-seized areas on the liner or skirt:

- Scratch-over manually with a coarse carborundum stone (grindstone), moving the grindstone crosswise at an angle of 20 to 30 degrees in horizontal direction. This is done to break up the hard surface glaze.
- Leave the “scratch marks” as rough as possible. It is not necessary to completely remove all signs of “vertical stripes” (micro-seizure).

If horizontal wear ridges are found in the cylinder liner, by the top ring TDC position it is recommended to create a circumferential groove by milling or grinding. The groove serves to prevent the build-up of a new wear ridge and protect the new top ring from breakage.

Two methods (grinding and milling) of removing wear ridges are described in word card 2265-0601.

4.9 Piston ring gap (new rings)

Check the gap as described in work card 2265-0401.

4.10 Fitting of piston rings

Fit the piston rings. See also item 3.4. Push the ring back and forth in the groove to make sure that it moves freely.

Only use the MAN Diesel & Turbo standard piston ring opener and do not open the gap excessively, see also item 4.2.

4.11 Piston ring clearance

When the rings are in place, check and record the vertical clearance between the ring and ring groove.

Furthermore, insert a feeler gauge of the thickness specified in work card 2265-0401, and move it all the way round the groove both above and below each piston ring. Its free movement will confirm the proper clearances as well as cleanliness.

4.12 Cylinder lubrication (Alpha and ME Lubricator) and mounting of piston

Check the cylinder lubrication during piston overhaul:

With the piston dismantled, press Pre-lubrication on the HMI panel and check that pipes and joints are leak-proof and that oil sprays out from each lubricating orifice on the liner.

If any of the above-mentioned inspection points have indicated that the cylinder oil amount should be increased or decreased adjust the feed rate as described in chapter 3045-0110.

Mount the piston,see work card 2265-0401.

Before mounting the overhauled piston, remove any remaining deposits from the upper part of the liner.

- With the piston dismantled, press Pre-lubrication on the HMI panel and check that pipes and joints are leak-proof and that oil sprays out from each lubricating orifice on the liner.
- If any of the above-mentioned inspection points have indicated that the cylinder oil amount should be increased or decreased adjust the feed rate accordingly as described in Chapter 3045-0110.
- Coat the piston and liner with clean cylinder oil.
- Before mounting the overhauled piston, remove any remaining deposits from the upper part of the liner.

See the separate instruction book for Alpha Lubricator.

4.13 Running-in

If new or reconditioned cylinder liners and/or piston rings are installed, allowance must be made for a running-in period.

4.13.1 Running-in of cylinder liners and rings

The following text refer to drawing 2255-0125 and the mentioned feed rates are valid for a cylinder oil of BN70 standard. The actual obtained feed rate should always be corrected according to the actual BN. In the following the terms “High topland” and “Semi high topland” are used for the pistons. The topland is the designation for the top of the piston crown from the uppermost piston ring groove to the top of the piston.

For the semi high topland the whole area from the uppermost piston ring groove to the top of the piston can be observed at the same time through the scavenge ports. For the high topland pistons only part of the topland can be observed. The previous engine types were in many cases equipped with pistons with low topland, where the whole topland and a number of the rings could be observed at the same time through the scavenge ports.

4.13.1.1 Large bore engines (60-98)

Running-in periods are classified in three categories:

1. Breaking-in (0-500h)
2. Running-in, phase 1. (500-1500 h)
3. Running-in, phase 2. (1500-3000 h)
4. After conclusion of running in

The purpose of adding extra lubricating oil during the running-in period is to:

- flush away wear particles
- build up an oil film in a not yet run-in cylinder

The running-in process has been eased and shortened considerably with alu-coat running-in coating on all four piston rings. Cylinder liner running-in is facilitated by semi-honed liner surface.

It is recommended to carry out frequent scavenge port inspections during the first 2500 hours.

Breaking-in (0-500 hours)

Piston ring and liner breaking-in takes 500 running hours maximum. A fixed, relatively high lubrication feed rate during the breaking-in period is recommended.

During breaking-in, the running-in coating on the piston rings will gradually wear off, and the plateaus of the wave shape of the cylinder liner running surface will smoothen. During this process extra lubricating oil is required to flush away wear particles and build a satisfactory oil film between the still relatively rough sliding surfaces.

During breaking-in, it is recommended to check the piston rings through the scavenge ports every 100 hours. Do not proceed to the next lubrication step if the scavenge air port inspection reveals seizures or other irregularities.

A five hour stepvise load increase from 50% load to max load is recommended. When running in new piston rings in well running liners, 5-hour load-up from 50% load to max load is also recommended. The load limitation can be set for a single cylinder unit by adjusting the individual fuel pump index.

Running-in phase 1 (500-1500 hours)

After the first 500 running hours, standard sulphur-dependent lubrication can be applied and the Alpha ACC algorithm can take over the lubrication control.

For a BN70 oil, MAN Diesel & Turbo recommends a running-in phase 1 feed rate of 0.26 g/kWh x fuel oil sulphur content in %.

At approx. 1500 hours, alu-coating is usually worn through and the base material or the cermet coating on the top and bottom rings is visible.

When reaching 1500 running hours, carefully check the piston rings and the cylinder liner through the scavenge ports. If the alu-coating is worn through, proceed to running-in, phase 2.

Running-in phase 2 (1500 – 3000 hours)

If no irregularities are found, a feed rate reduction to 0.23 g/kWh x sulphur % (BN70 oil) is reccommened.

Inspect the piston rings and the cylinder liner through the scavenge air ports at 3000 running hours. If no irregularities are found, it is recommend to reduce to a feed rate of 0.20 g/kWh x sulphur % (BN70 oil).

If, at any point, signs of micro-seizures or high wear are found it is recommended to switch to the previous setting, i.e. 0.26 g/kWh (BN70 oil).

After conclusion of running in

After reaching the actual final feed rate setting this should be continuously verified by regular inspections of the components wear condition. If signs of micro seizures or high wear is found, it is recommended to switch to the previous setting providing established stable conditions.

4.13.1.2 Small bore engines (26-50 bore)

The following text refers to drawing 2255-0125, and the feed rates are valid for a cylinder oil of BN70 standard. The actual feed rate obtained should always be corrected according to the actual BN as stated in the mentioned table.

Running-in

During the first running-in, a relatively high fixed dosage is recommended: 1.5 g/kWh for the first 250 hours succeeded by 1.2 g /kWh for another 250 hours. After these 500 hours of initial running-in, where ample oil is used for flushing away wear particles from the sliding surfaces, ACC running with the factor 0.34g/kWh x S% should be introduced.

The next 2000 hours should be used for a gradual reduction towards the basic setting, i.e. the ACC factor 0.26 g/kWh x S%.

Regulation from the upper ACC factor of 0.34 g/kWh x S % to the basic setting of 0.26 g/kWh x S% should take place stepvise over a 2000 hour period. The size of the steps may depend on the evaluation of the actual lubrication and deposit condition appearing from scavenge port inspections.

After reaching the actual final feed rate setting, this should be continuously verified by regular inspections of the components wear condition. If signs of micro-seizures or high wear are found, it is recommended to switch to the previous setting providing established stable conditions.

4.13.2 Running-in of a single cylinder

If only one cylinder has been overhauled, the fuel pump index for the cylinder in question can be decreased in proportion to the required load reduction, under the condition that the torsional vibration in the propeller shaft will allow it.

As the vibration condition due to the reduction of the fuel pump index of one cylinder is very similar to running the engine with one cylinder in misfire, a barred engine speed range may apply. Consult the class-approved report on the torsional vibration of the actual propeller shaft system and avoid any barred speed range during running-in.

Before starting the engine, fix the fuel rack for the pertaining cylinder at 16% of MCR index.

Increase the index stepwise in accordance with the breaking-in schedule.

Regarding the pressure rise p_{comp} - p_{max}, see comp. max., see chapter 6645-0140. If the engine is fitted with the Turbo Compound System (TCS), the TCS must be out of operation if running-in with reduced index is chosen so as to safeguard the TCS gear equipment.

Manoeuvring and low load

See drawing 2255-0140.

In practice, the engine must be able to operate freely in the whole manoeuvring range. The situation where a low load has to be maintained for an extended period, the breaking-in programme should be suspended until higher loads are continued. At this point the running in programme should also be continued.

4.13.3 Running-in of rings after a piston overhaul

When running-in new piston rings in already run-in and well running liners based on standard BN70 cylinder oil, the breaking-in time is recommended to 5 hours from 50% to 100% load. The cylinder oil feed rate should be increased by 25% for the first 24 running hours.

4.13.4 Feed rates

Feed rate recommendations for different engine types may be found in our latest service letters.

Current latest service letter:

Cylinder oil feed rate	
Engine type	Service letter
All ME/ME-C/ME-B/ME/MC/MC-C and ME-GI engines with electronically controlled lubricators.	SL013-571 "Guiding ACC values for all engines".
60-80 bore types MC/MC-C and ME/ME-C with high top-land and Alpha Lubricator or ME Lube.	SL09-507 "Guiding ACC Feed Rates for Alpha Lubricator and ME Lube"
26-50 bore types MC/MC-C and ME/ME-B/ME-C and 60-98 bore types MC/MC-C and ME/ME-C without high top-land, and with Alpha Lubricator or ME Lube. All mk.6 and higher.	SL07-479 "New ACC Guidelines, all MC/MC-C and ME/ME-C type engines Mk6 and higher, with Alpha ACC system"
26-98 bore types MC/MC-C with mechanical lubricator. 26-50 MC/MC-C engines with low topland.	SL00-385 "Cylinder Oil Dosage, Marine MC-Engines"

26-50 MC/MC-C engines with high top-land and mechanical lubricator.	SL12-553 "Cylinder Lubrication Guidelines, Small bore MC/MC-C engines"
NOTE: Always check for the latest service letters from MAN B&W.	

5 Factors Influencing Cylinder Wear

5.1 General

Drawing 2255-0105 gives a summary of the most common causes of cylinder wear. The following gives a brief explanation of the most important aspects, and of the precautions to be taken to counteract them.

5.2 Materials

Check that the combination of piston ring type and cylinder liner material complies with the engine builder's recommendations. For engines in guarantee, always follow the engine builder's recommendations.

5.3 Cylinder oil

Check that the quality and feed rate are in accordance with the recommendations in chapter 3045-0110.

5.4 Corrosive wear

5.4.1 The influence of sulphur in the fuel

Corrosive wear is caused by formation and condensation of water and sulphuric acid on the cylinder wall.

In order to minimise condensation, the engine design incorporates optimised temperature level of the liner wall, based on the actual engine layout.

To reduce the risk of corrosive attack:

- Keep the cooling water outlet temperatures within the specified interval, see Chapter 4265.
- Use only approved alkaline cylinder lubricating oils, see chapter 3045-0110.
- Preheat the engine before starting, as described in chapter 6645.
- Check that the drain from the water mist catcher(s) functions properly, and water droplets are prevented from entering the cylinders, see item 5.4.4.
- Check the condition of the water mist catcher(s) for cracks in the frame and correct mounting at every inspection through scavenge ports. Check for correct mounting through inspection and mounting covers twice a year.

It is important that any corrosion tendency is ascertained as soon as possible. If corrosion is prevailing:

- Check cylinder feed rate, see item 5.3.
- Increase feed rate
- Check alkalinity, see item 5.3.
- Check timing of the cylinder oil injection.
- Check cooling water temperatures and the drain from the water mist catcher, as above. The amount of described condensate can be read from drawing 2255-0135.

In case of too small cylinder oil feed rate or too low alkalinity, the alkaline additives may be neutralised too quickly or unevenly, during the circumferential distribution of the oil across the liner wall. This systematic variation in alkalinity may produce “uneven” corrosive wear on the liner wall, see item 3.3.7 regarding ‘clover-leafing’.

5.4.2 Sodium chloride (salt)

Seawater (or salt) in the intake air, in the fuel, or in the cylinder oils, will involve the risk of corrosive cylinder wear. The corrosion is caused by sodium chloride (salt), which forms hydrochloric acid.

To prevent salt water from entering the cylinder, via the fuel and cylinder oil:

- Centrifuge the fuel carefully (run two centrifuges in parallel with reduced flow)
- Do not use the bunker tanks for ballast water.

5.4.3 Cleaning agents (air cooler) (to be used with stopped engine only)

The air side of the scavenge air cooler can, if the necessary equipment is installed, be cleaned by means of cleaning agents dissolved in freshwater.

Follow the supplier’s instructions strictly for:

- Dosage of the agent
- Use of the cleaning system

After using chemical agents, flush with clean freshwater to remove the agent from the cooler and air ducts.

Cleaning of the air side of the air cooler must only be carried out during engine standstill. During cleaning care should be taken to avoid cleaning agents from entering the scavenge air receiver and air box, causing condensation and piston rod corrosion.

5.4.4 Water condensation on air cooler tubes

Depending on the temperature and humidity of the ambient air and the temperature of the seawater, water may condense on the coldest air cooler tubes.

Water mist catchers are installed directly after the air coolers on all MAN B&W engines to prevent water droplets from being carried into the cylinders.

If water enters the cylinders, the oil film may be ruptured and cause scuffing and wear (clover leafing) on the liner surfaces between the cylinder lube oil inlets. It is very important that the water mist catcher drains function properly!

5.5 Abrasive wear

5.5.1 Particles

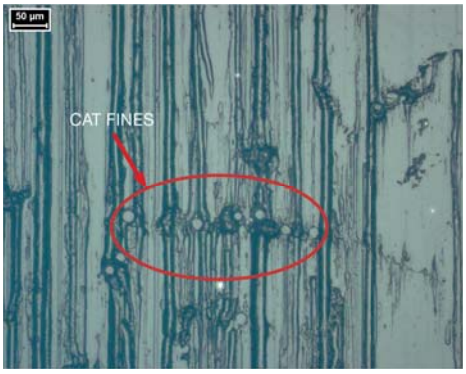
Abrasive cylinder wear can be caused by hard particles entering the cylinder via the fuel oil, e.g. catalytic fines, or air, e.g dust/sand, or the cylinder oil due to insufficient cleaning of the storage tank, see item 5.5.2, ‘Fuel Oil Treatment.

Catalytic fines originating from the refinery process are in fact one of the most common reasons for abrasive liner wear as well as piston crown ring groove wear. These particles consist of aluminium oxide and silicon oxide, which are both heavily abrasive. The catalytic fines are in fact reused as mush as possible at the refineries, but it may happen that a batch disappeares at the final link in the refinery process, i.e. into the residual heavy fuel.

The size of the particles vary from submicron up to 30 micron, and the shape is often close to being circular.

The limit for catalytic fines in fuel oils (aluminium + silicon) delivered onboard is 60 ppm (weight) according to the latest ISO 8217 fuel standard. By using the fuel cleaning systems onboard (centrifuges), the amount of catalytic fines should be reduced by 80%, i.e. a fuel containing 60 ppm should not contain more than 12 ppm at the engine inlet. For bunkers containing less cat fines we expect a proportional reduction at the engine inlet.

A suspicion that catalytic fines are the reason for a sudden liner and ring wear can be confirmed (or be denied) by taking replicas of worn liner and/or piston ring surfaces. PrimeServ, Copenhagen can assist with expertise in such matters. The investigation also include judgement of the liner surface structure (open graphite, closed graphite).



The occurrence of the particles is unpredictable. Therefore, always clean the fuel oil as thoroughly as possible by centrifuging with a slow flow rate, to remove the abrasive particles, i.e. if two centrifuges are running they should run in parallel.

Abrasive wear can occur on:

1. The running surfaces of the liner and piston rings.

   Scratching on the piston ring running surface is one of the first signs of abrasive particles and can be observed during scavenge port inspections or piston overhauls. Scratching is often seen as a large number of rather deep “trumpet shaped” grooves (see drawing 2255-0145).

   Usually, micro-seizures do not occur, i.e. the ring surface remains soft. However, if excessive micro-seizures (scuffing) do occur, the ring surface becomes hard. This can be checked with a file (a file test can only take place when the piston is pulled, and rings have been dismantled).
2. The upper and lower sides of the piston rings.

   Particles caught between the upper horizontal ring/groove surfaces will cause pitting – “pock-marks” – on the upper ring surface (see drawing 2255-0145). “Pock-marks” may also arise during a prolonged period of ring collapse. Even if the running surface of the top ring has a satisfactory appearance, the condition of the ring's upper surface will reveal the presence of abrasive particles coming with the fuel.
3. The upper edge of the piston rings.

When particles pass down the ring pack via the ring joint gaps, they will cause a “sand blasting” effect on the upper edge of the ring below, that protrudes from the piston ring groove, i.e. this is only seen on ring No's. 2, 3, and 4.

5.5.2 Fuel oil treatment

Correct fuel oil treatment and proper maintenance of the centrifuges are of the utmost importance for cylinder condition, exhaust valves and fuel injection equipment. Water and abrasive particles are removed by means of the centrifuges:

- The ability to separate water, depends largely on the specific gravity of the fuel oil relative to the water at the separation temperature. Other influencing factors are the fuel oil viscosity (at separation temp.) and the flow rate. Keep the separation temperature as high as possible, i.e. always above 98 degrees
- The ability to separate abrasive particles depends on the size and specific weight of the smallest impurities that are to be removed and, in particular, on the fuel oil viscosity (at separation temp.) and the flow rate through the centrifuge.
- Keep the flow rate as low as possible. Run centrifuges in parallel.
- If in doubt about the efficiency of the centrifuges call in a service engineer from the manufacturer. It is worthwhile.
- It should be noted that the viscosity of the fuel have a high impact on the separation. For example, if the fuel temperature is lowered by approximately 3 degrees celcius, the efficiency of the cleaning drops to almost half.

For more information on fuel oil see chapter 4245.

5.6 Adhesive wear

5.6.1 Scuffing

Apart from the factors mentioned under item 3.3 (blow-by, deposits, cylinder oil deficiencies, etc.) scuffing can be due to:

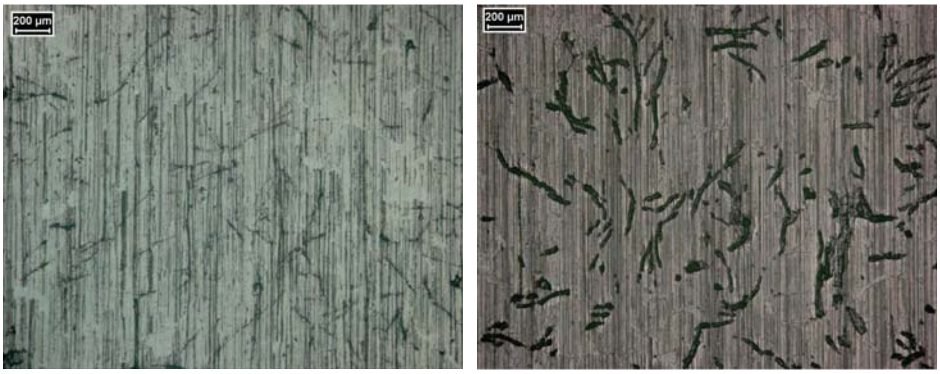
- Unsatisfactory running-in conditions (especially if previous micro-seizures have not been successfully counteracted during a cylinder overhaul). As regards running-in, see item 4.13
- Incorrect and too high lubrication feed rate (chemical bore polish)
- Too rapid changing of engine load
- Water intrusion
- Presence of vast amounts of particles, e.g. cat fines
- Excessive wear of CPR top ring CL-grooves, beyond minimum depth
- PC-ring malfunction, topland deposits interacting with cylinder liner surface (mechanical bore polish).

5.6.2 Bore polish

Bore polish as a result of over-lubrication and excessive neutralisation of the sulphuric acid, or as a result of top land deposits, will result in a closed graphite structure and reduce the ability of the running surface to maintain a proper oil film. A closed graphite structure will furthermore be less capable of reducing the extension and spreading of seizures, compared to an open structure.

When there is limited corrosive liner wear, e.g. 0.03-0.05 mm/1000 hours, the structure normally becomes open and, hereby, the risk of seizure is drastically reduced. Therefore, it is an advantage to have a certain amount of controlled corrosive wear.

Cylinder liner surface



Closed grafite structure

Open grafite structure

Introduction

These instructions are a supplement to *workcard 2265-0201*, and should be used in combination with that Procedure during inspection and overhaul of all Nimonic spindles on MAN Diesel & Turbo engines.

All general data, including specified wear limits for the spindle used on your engine type, are given in *"data 2265-0200"*. Note down the actual engine data in the “data”-box in the relevant chapters of these instructions.

The procedure is divided into the following eight sections:

1	Spindle identification
2	Inspection intervals
3	Inspecting the contact condition of the seat
4	Checking the seat for gas leakage
5	Cleaning and evaluation
6	Inspecting the valve stem wear layer
7	Grinding the spindle seat
8	Exhaust Valve Condition Report

Sections 3 to 7 are each divided into four steps:

- What to do
- Acceptance criteria
- Remarks
- Further action

1 Spindle Identification

Markings:

The tops of Nimonic spindles are marked:
“Nim”, “Nim80A”, “N80A”,”N80”, or “NCF80A”.

If in doubt, please contact MAN Diesel & Turbo, Copenhagen.

2 Inspection Intervals

Inspection	Inspections:		
	Initial	Second	Subsequent
Normal hours of service:	After 6,000 hours	After 24,000 hours (35-40 ME-B, only 16,000 hours)	Every 24,000 hours (35-40 ME-B, only 16,000 hours)
Recommended:	After 6,000 hours (50-60 ME/MC 3-6,000 hours)	Based on condition at initial inspection	Based on condition at initial and second inspections *)

*) If the spindle condition is very good, the condition of other exhaust valve parts may prove to be the decisive factor in determining the future overhaul/inspection intervals.

Also see 'Checking and Maintenance Schedule', chapter 0760-0301.

3 Inspecting the Contact Condition of the Seat

What to do:

NOTICE

Do not clean the spindle disc before inspection !

Visually check that there is inner contact.

Fig. 1 shows inner contact between the seats of the spindle and bottom piece, corresponding to slow/low-load/manoeuvring condition.

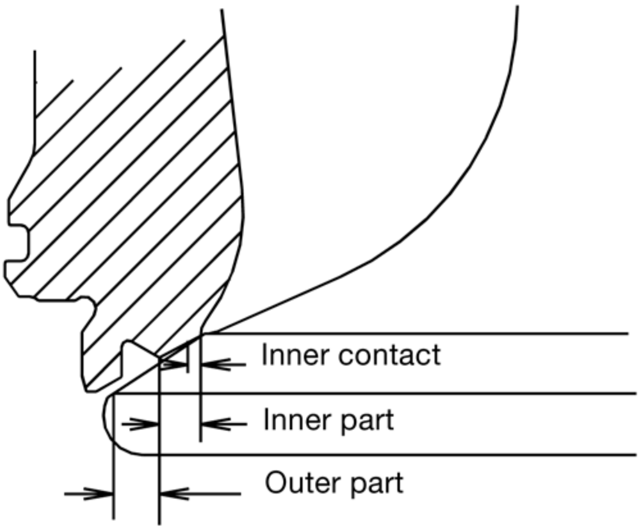


Figure 1: Inner contact, and zone designation

Acceptance criteria:

There must be contact around the entire inner circumference of the seat.

Remarks:

When the valve heats up in service, the angular difference between the spindle and bottom piece seatings will decrease. At steady, full load, the seatings will be parallel, as shown in Fig. 2. Thus, inner contact must be maintained in order to be sure of parallel contact during running.

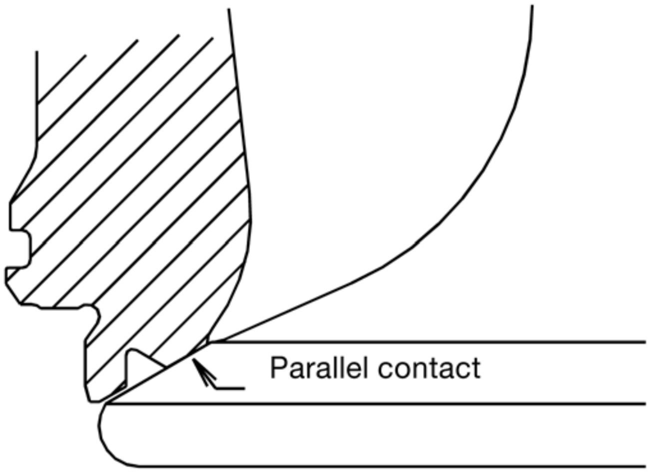


Figure 2: Contact condition during running

If there is no inner contact, outer contact (Fig. 3) will occur during running, and this will increase the risk of blow-by.

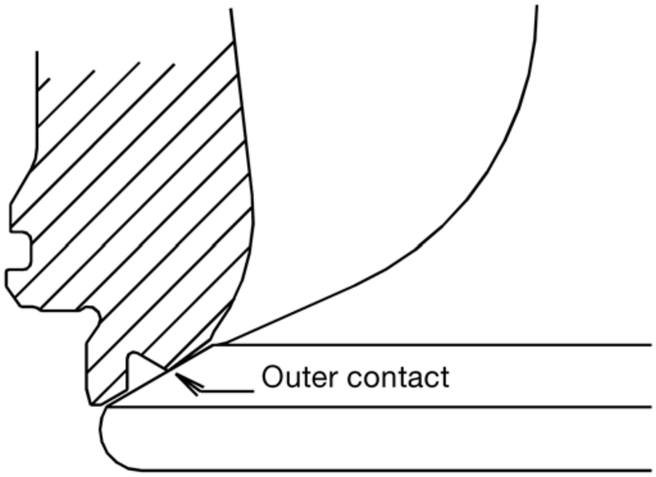


Figure 3: Outer contact, increased risk of blow-by

Further action:

✍ Fill in section 8 ‘Exhaust Valve Condition Report’.

If the seat contact is incorrect, grind the spindle seating, as described in section 7. However, before grinding, proceed to section 4, 5 and 6.

4 Checking the Seat for Gas Leakage

What to do

NOTICE

Do not clean the spindle disc before inspection !

Visually check the inner part of the seating for blow-by (Fig. 4 and Photo 1).

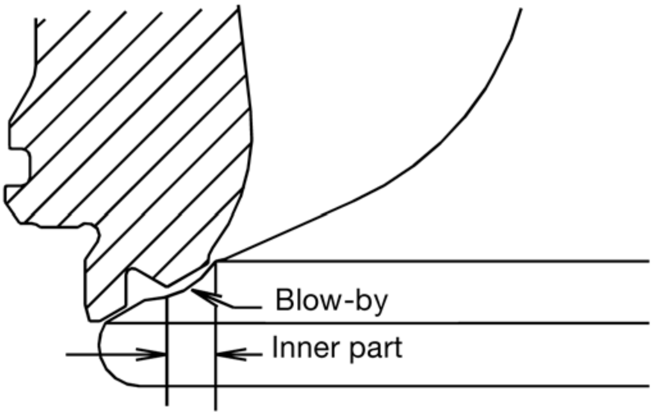


Figure 4: Blow-by

Photo 1. Blow-by

Acceptance criteria:

There must be no blow-by “tracks” across the inner part of the seat *(Figs. 1 + 4, and Photo 1).*

Remarks:

Blow-by indications may be associated with large/deep dent marks, and will often form a “gas-jet-fan” in the deposits on the disc cone (Photo 1).

The surface of a serious blow-by track/groove will usually show signs of hot corrosion, i.e. it will have an “elephant skin” texture.

Minor leakages. Small, faint, fan-shaped leakage indications on the spindle cone, just inside the seat area (Photo 2), are harmless.

Photo 2: Minor leakages, and "fans"

Further action:

✍ Fill in section 8: ‘Exhaust Valve Condition Report’.

If blow-by has been found, then grind the seat, as described in section 7. However, before grinding, proceed to sections 5 and 6.

5 Cleaning and Evaluation

What to do:

- Clean the seat with coarse emery cloth. Observe and note down the size and number of dent marks. Also note any possible crack indications.
- Check the outer part of the seat for high temperature corrosion (Fig. 1 and Photo 3).

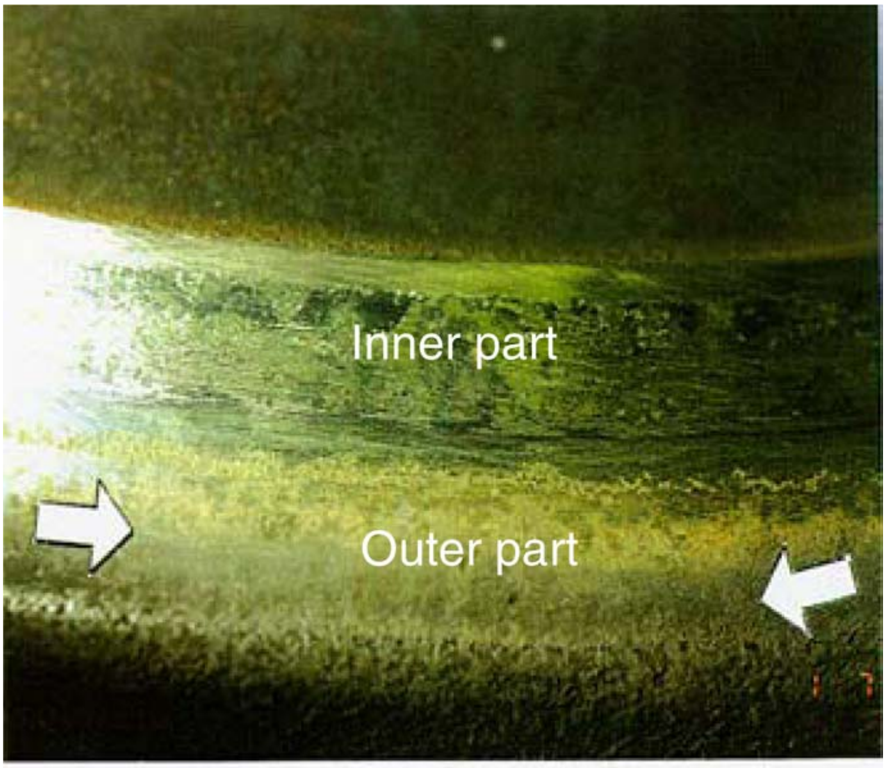


Photo 3: Example of high-temperature corrosion at outer part after 33,000 hours

- Clean the contact faces on which the measuring template is to be applied, and measure:

  – the burn-off on the disc underside,
  – the total amount the seat has been ground.

(See work card 2265-0201)

Acceptance criteria:

Dent marks, of varying number and size (up to 8-10 mm), will be seen on the seating after a few thousand service hours. The first marks may appear as early as after testbed running. In general, dent marks are acceptable and should not necessitate grinding of the seat. If, however, the marks have caused blow-by, then the seat must be ground/reconditioned.

Cracks. Any indications of cracks in the seat area should be checked carefully. If cracking is confirmed, contact MAN Diesel & Turbo.

High-temperature corrosion on the outer part of the seat may result in a measurable difference in level between the inner and outer seat zones. In that case the spindle must be ground. However, this will not normally happen before 20 – 30,000 hours after the previous grinding.

Wear Allowances:

Fill in data from wc 2265-0201
F_1: G_1:

- Burn-off on disc underside, (F1)
- Total grinding of seat, (G1).

Remarks:

Burn-off rate (disc underside). The number of service hours before shore-side reconditioning usually depends upon the burn-off rate of the disc underside

Engine type: *)	Max. permissible burn-off (mm)
26MC	5
35MC 35ME-B	6
40ME-B	6
42MC	7
46MC-C	8
50MC/MC-C 50ME/ME-C	8
60MC/MC-C 60ME/ME-C	9
65ME-C	9
70MC/MC-C 70ME/ME-C	10
80MC/MC-C 80ME/ME-C	14
90MC/MC-C 90ME/ME-C	17
98MC/MC-C 98ME/ME-C	20

**) Also valid for stationary engines (power plants)*

Further action:

✍ Fill in section 8: ‘Exhaust Valve Condition Report’.

If the burn-off or grinding limits have been reached, contact MAN Diesel & Turbo for advice on reconditioning.

If the seat and the disc underside are acceptable with respect to section 3, 4, and 5, then the spindle can be reinstalled without grinding after section 6 has been carried out. Otherwise, proceed to section 6 and 7.

6 Inspecting the Valve Stem Wear Layer

What to do:

- Clean the valve spindle stem.
- Measure the diameter of the spindle stem in the area shown in word card 2265-0201.
- Check the surface condition of the chrome-plated/HVOF-coated area.

Acceptance criteria:

Min. diameter: Must not be less than that stated in work card 2265-0201,**Cracking ("meshwork cracking") of chrome/HVOF:** Slight cracking of the lowermost part of the chrome plating/HVOF-coating (Photo 4) has no significance, and is therefore acceptable.

Peeling-off: The chrome plating/HVOF-coating must not show peeling-off.

Fill in data from wc 2265-0201
D-____________: min. diameter of spindle stem:

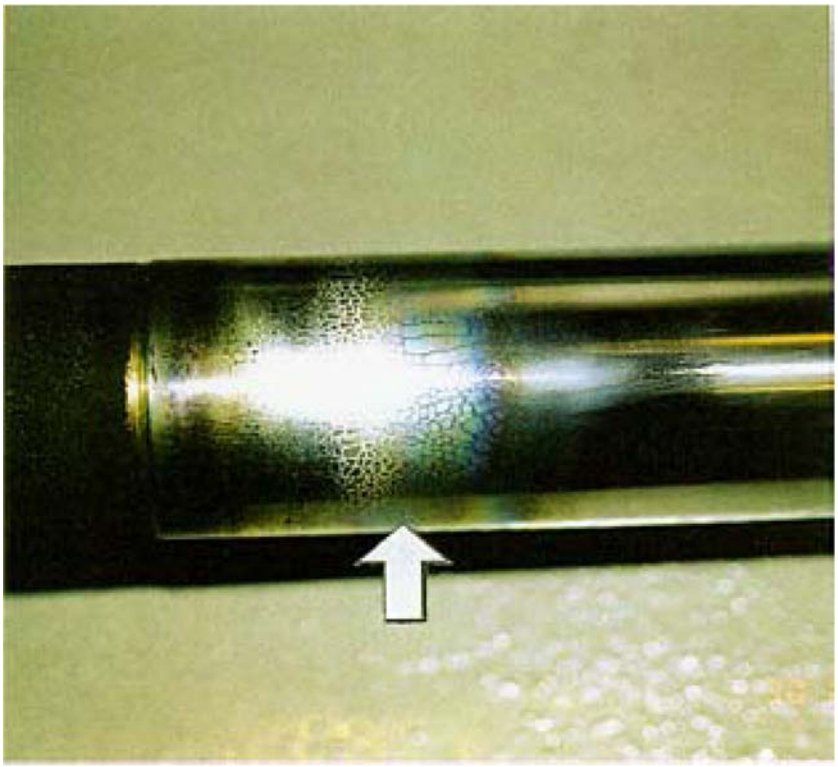


Photo 4: Slight cracking ("meshwork cracking") of wear layer

Further action:

✍ Fill in section 8: ‘Exhaust Valve Condition Report’.

If the spindle stem is acceptable, proceed to section 7. Otherwise, contact MAN Diesel & Turbo for advice on reconditioning.

7 Grinding the Spindle Seat

What to do:

- Mount the spindle in the grinding machine and, using the dial-gauge positioned just inside the area of inner contact, (see Fig. 5), true-up to within a maximum of 0.05 mm. This is done in order to minimize the amount of material removed during grinding.

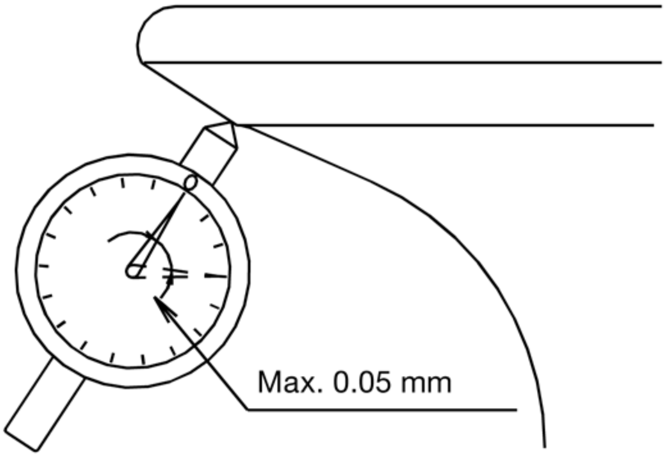


Figure 5: Truing-up the spindle

Grind the seat according to the special instructions from the grinding machine supplier.

See also MAN Diesel & Turbo Service Letter SL95-332/UM, “Grinding of Nimonic Exhaust Valve Spindles”.

Fill in data from wc 2265-0201
D-____________: Offset angle:

Keep the grinding to a minimum!

After full contact between grindstone and seat is reached at the beginning of the grinding process:	
Normally	Limit the grinding to 0.2 mm.
Rare cases	Remove 0.3 mm or more.
Blow-by	Continue the grinding until the blow-by marks are removed.
Dent marks	It is not necessary to continue grinding until all dent marks have been removed.

Photo 5 shows an overhauled Nimonic valve spindle which is ready for further service.

Photo 5: Acceptable seat condition after grinding

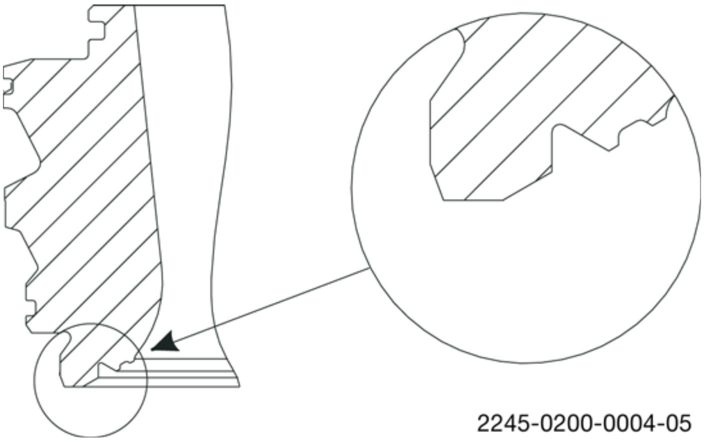
Acceptance criteria:

The ground surface. The grindstone must have removed material from the whole width and the whole circumference of the seat. There must be no signs of blow-by.

Fill in data from wc 2265-0201
G_1:

Max. grinding depth: must not exceed the limit (G1) stated in *work card: 2265-0201.*

If the seat surface is still not acceptable when the max. grinding depth has been reached, contact MAN Diesel & Turbo for advice on reconditioning.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8 Exhaust Valve Condition Report

Exhaust Valve Condition Report

Vessel: | No.:

Eng. builder: | Eng. no.: | No. of cyl.: | Eng. type:

Valve no.: | Valve hours: | Kept as spare (yes/no): | Test (yes/no):

Valve dismounted from cyl.: | Date (yymmdd): | Engine hours (total):

Valve checked/overhauled by: | Date (yymmdd): | Engine hours (Total):

Valve mounted on cyl.: | Date (yymmdd): | Engine hours (total):

Remarks:

BOTTOM PIECE

Type: | Marking: | Seat material:

Drawing no.: | Hours since last overhaul: | Hours total:

Cracks (yes/no): | Blow-by (yes/no): | Seat contact (inner/outer/parallel):

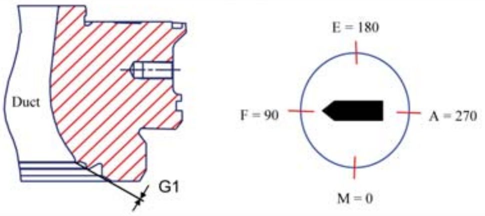
No. of dent marks larger than Ø = 7 mm: | Seat ground: Total grinding, G1 (mm): at hrs.:

Deposit in chamber: Extend on circumference (mm): | Maximum deposit thickness in duct (mm):

Angular position of max. deposit (0° = manouvre side):

Deposit in way of fuel valves (yes/no):

Remarks



SPINDLE

Marking: | Base material: | Disc underside material:

Seat material: | Stem surface: | Drawing no.:

Hours since last overhaul: | Hours total:

Cracks (yes/no): | Blow-by (yes/no): | Seat contact (inner/outer/parallel):

Spindle disc max burn-off (mm): | at position (A, B, C, D or E): | Burn-off rate (mm/1000 hrs):

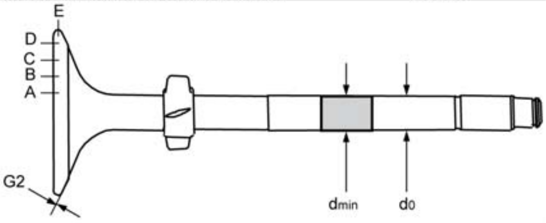
No. of dent marks larger than Ø = 7 mm: | Seat ground: Total grinding, G2 (mm): at hrs.:

Stem diameter d_0 above sealing area (mm):

Min. stem diameter d_{min} at sealings (mm):

Wear of stem sealing ring (%):

Remarks



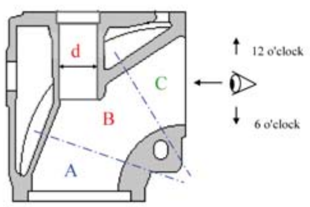
HOUSING

Marking: | Drawing no.: | Hours since last overhaul: | Hours total:

Spindle guide diameter				Spindle guide, hours total
Minimum / Top (mm)		Maximum / Top (mm)		
Minimum / Bottom (mm)		Maximum / Bottom (mm)		

Corrosion

Section	A		B		C	
mm						
Position (o'clock)						



Remarks:

Inspection through Scavenge Ports

Vessel: IMO nr.: Builder/no.:

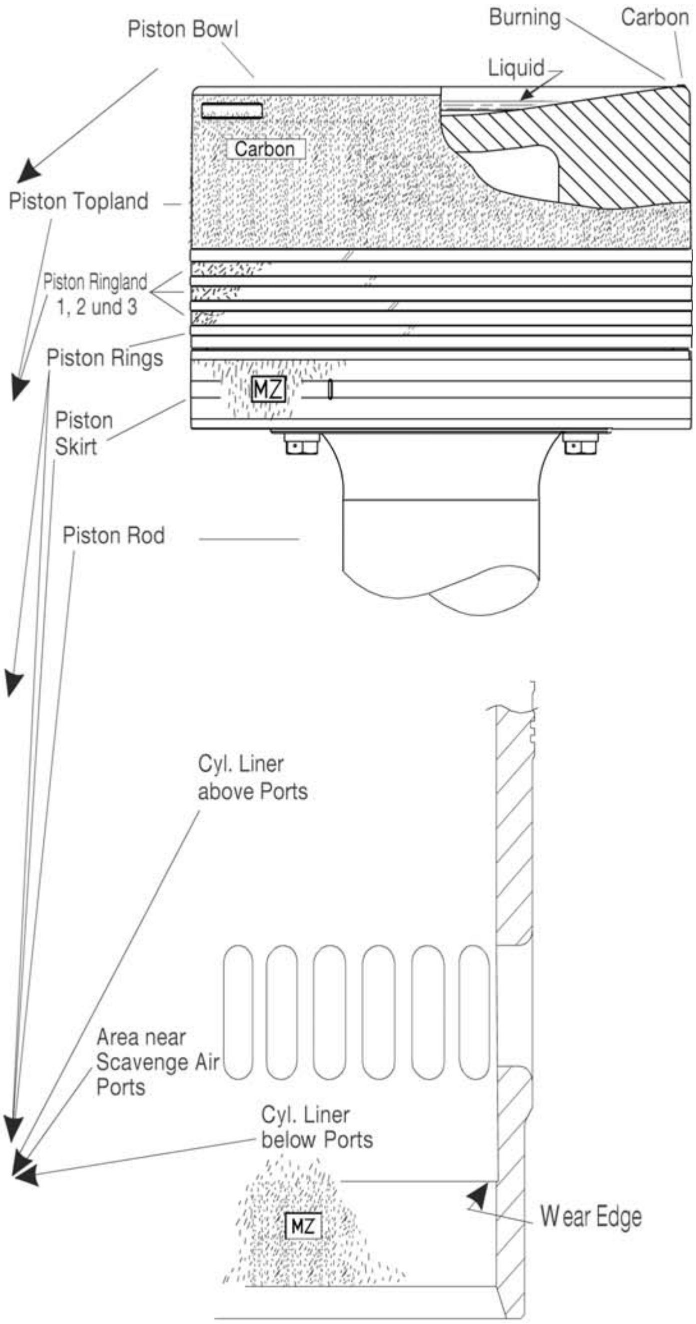
Number of cylinders: Eng. type: Eng. hrs.: Checked by: Date:

Weeks pr. port calls: Normal service load (% of MCR): MEP lubricator type (Y/N):

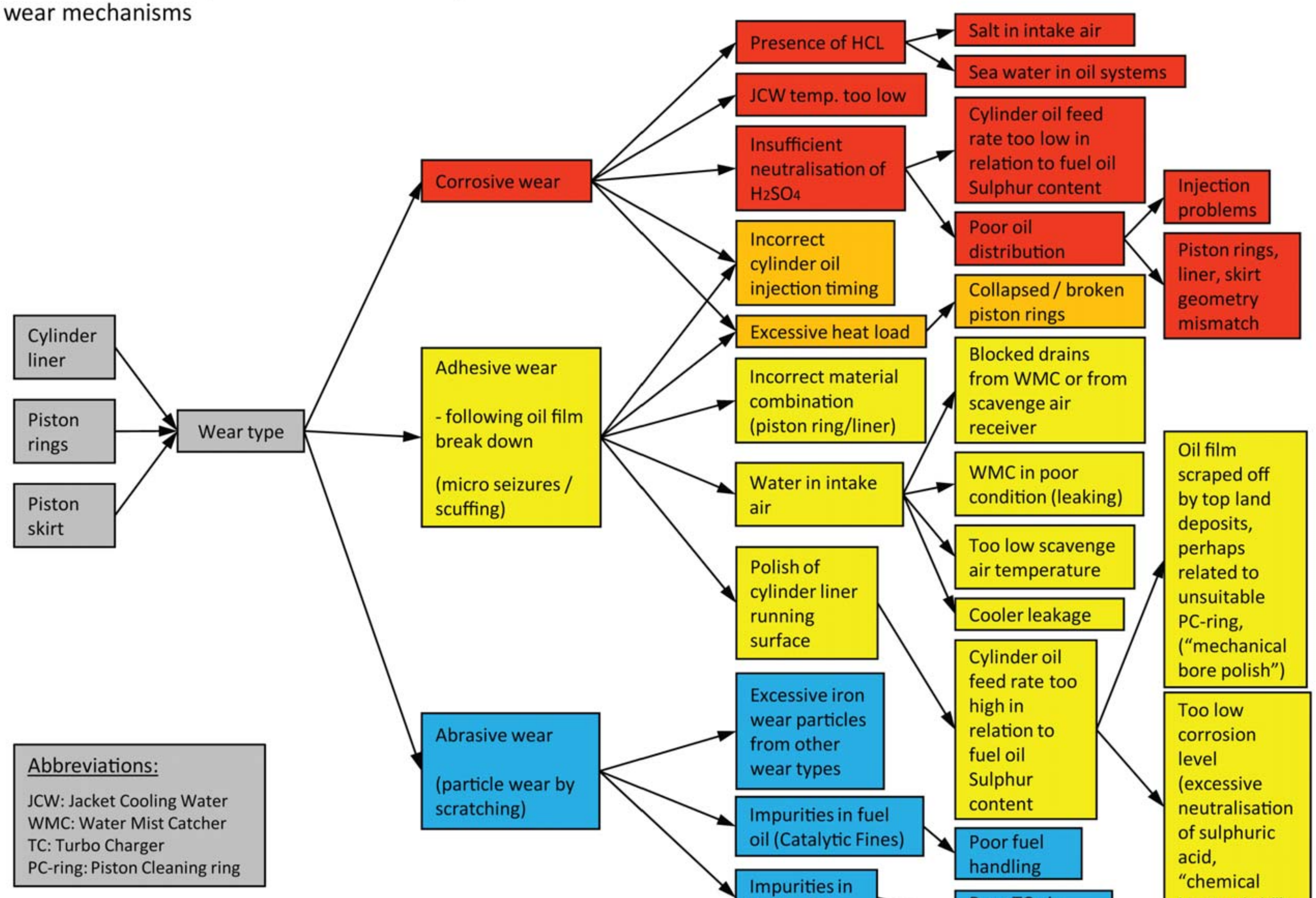
Cyl. oil consump. (l/24 hrs): at load % Cyl. oil type: Position: ☐ Exhaust ☐ Manoeuvre

			Cylinder No.											
	Condition and Symbol	**Engine Part**	1	2	3	4	5	6	7	8	9	10	11	12
	Intact - * Burning - BU Leaking oil - LO Leaking water - LW	Piston crown												
Deposits	No deposit - * Light deposit - LC Medium deposit - MC Excessive deposit - EC Polished deposit - PC	Topland												
		Ringland 1												
		Ringland 2												
		Ringland 3												
Ring breakage	Intact - * Collapsed - C Broken opposite ring gap - BO Broken near gap - BN Several pieces - SP Entirely missing - M	Ring 1												
		Ring 2												
		Ring 3												
		Ring 4												
Ring movement	Loose - * Sluggish - SL Sticking - ST	Ring 1												
		Ring 2												
		Ring 3												
		Ring 4												
Surface condition	Clean, smooth - * Running surface, Black,overall - B Running surface, Black, partly - (B) Black ring ends > 100 mm - BR Scratches (vertical) - S Micro-seizures (local) - mz Micro-seizures (all over) - MZ Micro-seizures, still active - MAZ Old MZ - OZ Machining marks still visible - ** Wear-ridges near scav. ports - WR Scuffing - SC Clover-leaf wear - CL Rings sharp-edged Top/Bot. - T/B	Ring 1												
		Ring 2												
		Ring 3												
		Ring 4												
		Piston skirt												
		Piston rod												
		Cylinder liner abv. scav. ports												
		Cylinder liner near scav. ports												
Lubrication condition	Optimal - * Too much oil - O Slightly dry - D Very dry - DO Black oil - BO	Ring 1												
		Ring 2												
		Ring 3												
		Ring 4												
		Piston skirt												
		Piston rod												
		Cylinder liner												
Deposits	No Sludge - * Sludge - S Much sludge - MS	Scavenge box												
		Scav. receiver												
	Intact - *	Flaps and nonreturn valves												
Running hours since last overhaul														

	Condition and symbol
	Intact - * Burning - BU Leakage Oil - LO Leakage Water - LW
Diposites	No deposit - * Light deposit - LC Medium deposit - MC Excessive deposit - EC Polished deposit - PC
Ring breakage	Intact - * Collapsed - C Broken opposite ring gap - BO Broken near gap - BN Several pieces - SP Entirely missing - M
Ring movement	Loose - * Sluggish - SL Sticking - ST
Surface condition	Clean, smooth - * Burning surface, Black, overall - B Burning surfase, Black, partly - (B) Black ring ends > 100 mm - BR Scratches (vertical) - S Micro-seizures (local) - mz Micro-seizures, (all over) - MZ Micro-seizures, still active - MAZ Old MZ - OZ Machining marks still visible - ** Wear-ridges near scav. ports - WR Scuffing - SC Clover-leaf wear - CL Rings sharp-edged Top/Bot. - T/B
Lubrication condition	Optimal - * Too much oil - O Slightly dry - D Very dry - DO Black oil - BO
Diposites	No Sludge - * Sludge - S Much sludge - MS
	Intact - *



Schematic summary of most common recognized wear mechanisms



Abbreviations:

JCW: Jacket Cooling Water
WMC: Water Mist Catcher
TC: Turbo Charger
PC-ring: Piston Cleaning ring

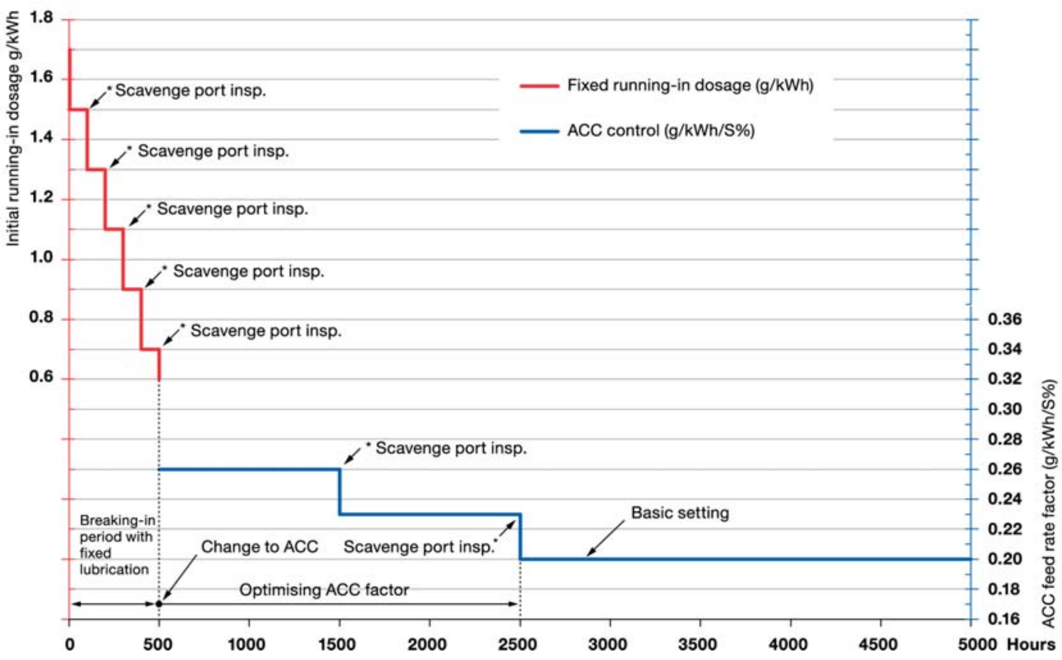
2012.06.29, JSB, LDD3

Drawing
2255-0105-0003

Factors influencing cylinder wear

MC/MC-C, ME/ME-C and ME-B engines with high topland and Alpha Lubricator or ME Lube					
		Standard BN70 cylinder oil	BN60 cylinder oil	BN50 cylinder oil	BN40 cylinder oil
Basic setting		0.20 g/kWh × S%	0.23 g/kWh × S%	0.28 g/kWh × S%	0.35 g/kWh × S%
Minimum feed rate		0.60 g/kWh			
Maximum feed rate during running-in		1.7 g/kWh			
Part-load control		100% to 25% load: proportional to indicated engine load 25% load and lower: proportional to rpm			
Running-in new or reconditioned liners and new piston rings based on standard BN70 cylinder oil	Feed rate	First 5 hours 1.7 g/kWh 5 - 500 hours: stepwise reduction from 1.5 to 0.6 g/kWh 500 - 1,500 hours: 0.26 g/kWh × S% (absolute min. 0.60 g/kWh) 1,500 - 2,500 hours: 0.23 g/kWh × S% (absolute min. 0.60 g/kWh) From 2,500 hours: 0.20 g/kWh × S% (absolute min. 0.60 g/kWh)			
	Engine load	Testbed: stepwise increase to max. load over 5 hours In service: from 50% to max. load over 16 hours			
Running-in new rings in already run-in and well running liners (standard BN70 cylinder oil)		From 50% to max. load in 5 hours Feed rate: +25% for 24 hours			
Manoeuvring and load change situations		During starting, manoeuvring and load changes, increase feed rate by means of the "LCD" by 25% of the actual figure. Keep this level for ½ hour after the load has stabilised.			
Lubrication of cylinders that show abnormal conditions		Frequent scavenge air port inspections of piston rings and cylinder liners are very important for maintaining a safe cylinder condition. If irregularities are observed, consider adjustments of the lube oil rate. In case of scuffing, sticking piston rings or high liner temperature fluctuations, raise the feed rate to 1.2 g/kWh and lower p_{max} and mep. As soon as the situation has been stabilised, set the lubrication feed rate and the pressures back to normal.			

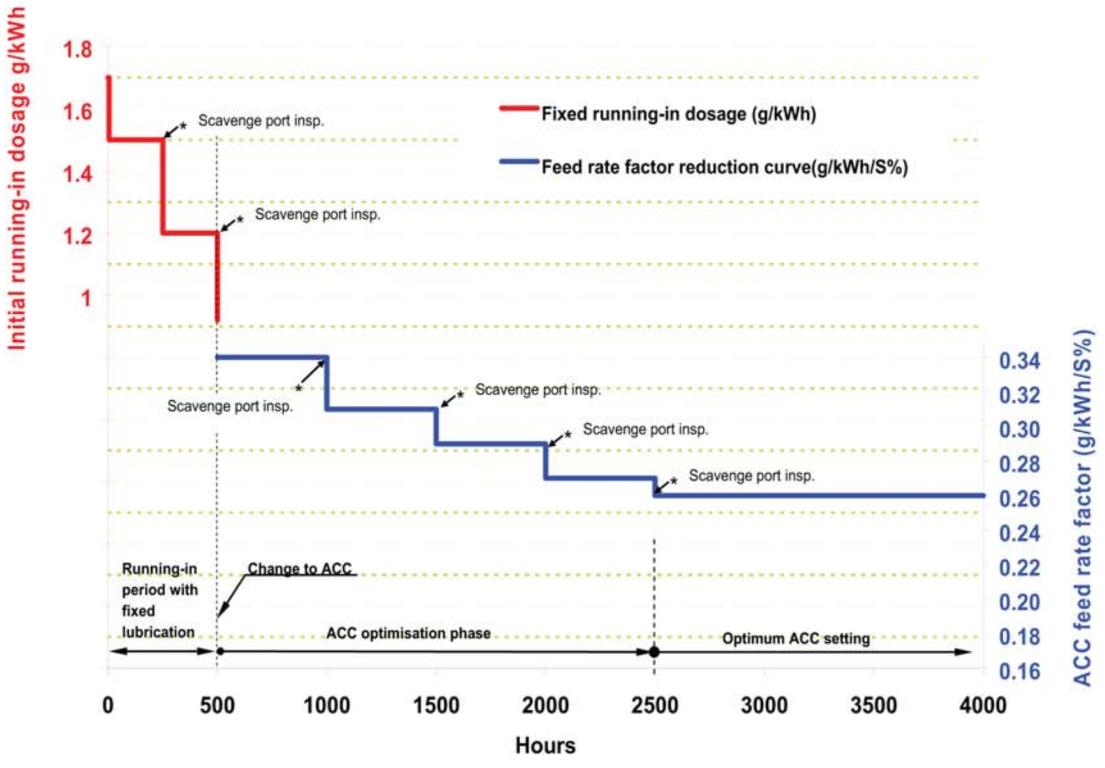
ACC Running-in Schedule



Guiding Cylinder Oil Feed Rates
S/L/K-MC/MC-C/ME/ME-C, Mk 6 and higher,
with Alpha ACC lubrication system and coated piston rings.

		Standard BN 70 cylinder oil	BN 40 cylinder oil
Basic setting		**0.26 g/kWh x S%**	**0.45 g/kWh x S%**
Minimum feed rate		0.60 g/kWh	
Maximum feed rate during normal service		1.7 g/kWh	
Part-load control		Proportional to indicated engine load	
Running-in new or reconditioned liners and new piston rings	Feed rate:	First 5 hours: 1.7 g/kWh From 5 to 250 hours: 1.5 g/kWh From 250 to 500 hours: 1.2 g/kWh From 500 to 2500 h: Stepwise reduction from 0.34 to 0.26 g/kWh x S%	
	Engine load:	Stepwise increase to max. load over 5 hours	
Running-in new rings in already run-in and well running liners:		No load restrictions	
Manoeuvring and load change situations.		During starting, manoeuvring and load changes, the feed rate should be increased by means of the "LCD" by 25% and kept at this level for ½ hour after the load has stabilised.	
Lubrication of cylinders that show abnormal conditions:		Frequent scavenge port inspections of piston rings and cylinder liners are very important for maintaining a safe cylinder condition. If irregularities are observed, adjustments of the lube oil rate should be considered. In case of scuffing, sticking piston rings or high liner temperature fluctuations, the feed rate should be raised to 1.2 g/kWh and the P-max and Mep reduced. As soon as the situation is stabilised, the lubrication and the pressures should be normalised.	

ACC Running-in Schedule



If a liner or piston crown is exchanged, two reports must be filled-in!

Cylinder Condition Report

Vessel: | I.I. no.: | Eng. builder: | Eng. no.: | Checked by:

No. of cyl.: | Eng. type: | Eng. hrs.: | Date (yymmdd): | Inspected unit no.:

Voyage info

Weeks pr. port calls: | Normal service load (% of MCR): | Lub. part load control: | Lub. type:

Cyl. oil consumption (l/24 hrs): at load %: | Cyl. oil type:

Cylinder liner

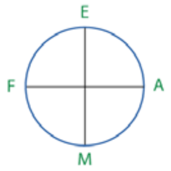
Liner hours: | Insulation pipe (Y/N): | PC ring (Y/N): | Liner material:

Drawing no.: | Frame type: | Liner cool type:

Producer/Marking: | Wear type: | Liner honed (Y/N):

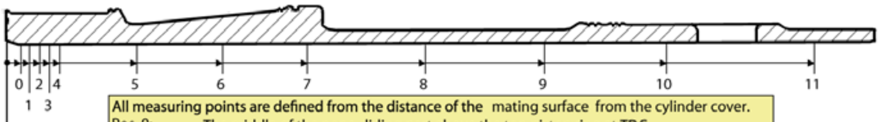
Cyl. cover tightened (Y/N): | Temp. between liner and measuring tool (°C): | Shims (mm):

Measuring point		0	1	2	3	4	5	6	7	8	9	10	11	A1 (Additional)	A2 (Additional)
Depth (mm)															
Diameter (mm)	F-A														
	E-M														



E: Exhaust M: Manoeuvre

A: Aft F: Fore



All measuring points are defined from the distance of the mating surface from the cylinder cover.

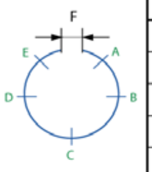
Pos. 0:	The middle of the none sliding part above the top piston ring at TDC.
Pos. 1-4:	The middle of the rings at TDC.
Pos. 5 & 6:	Equally positioned between pos. 4 and 7 (1/3 of distance).
Pos. 7:	Lubrication quill level.
Pos. 8 & 9:	Equally positioned between pos. 7 and 10 (1/3 of distance).
Pos. 10:	100 mm. above the scav. air ports.
Pos. 11:	The middle of the none sliding part below the bottom piston ring at BDC.

Liner remarks:

Piston rings

	Base material	Coating	Profile	Manufacturer	Lock type	CL grooves	Broken
Ring 1							
Ring 2							
Ring 3							
Ring 4							
Ring 5							

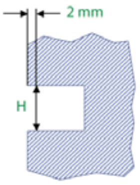
	Width of ring (mm)					Free ring gap "F" (mm)
	A	B	C	D	E	
Degrees						
Ring 1						
Ring 2						
Ring 3						
Ring 4						
Ring 5						



"F" to be measured before dismantling

Ring grooves

Height, H (mm)			
F	E	A	M



Hours since last overhaul:

Piston

Crown hours: | High topland (Y/N):

Bronze ring (Y/N): | Oros piston (Y/N):

Max burning 1 (mm)

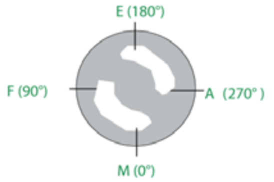
Position 1 (degree)

Max burning 2 (mm)

Position 2 (degree)

Max burning 3 (mm)

Position 3 (degree)



Reason for examination

Routine piston overhaul ☐

Test ☐

(If either of these boxes are ticked, below boxes must be kept blank)

Liner		Piston Crown		Piston Rings		Piston Skirt	
Cracks	☐	Burning	☐	Broken	☐	Leaking	☐
Scuffing	☐	Cracks	☐	Collapsed	☐	Scuffing	☐
Leak	☐	Leaking	☐	Scuffing	☐	Piston Rod	
		High Groove Wear	☐	Sticking	☐	Stuff. box	☐

Piston remarks:

Cylinder Condition Report

Drawing 2255-0130-0003

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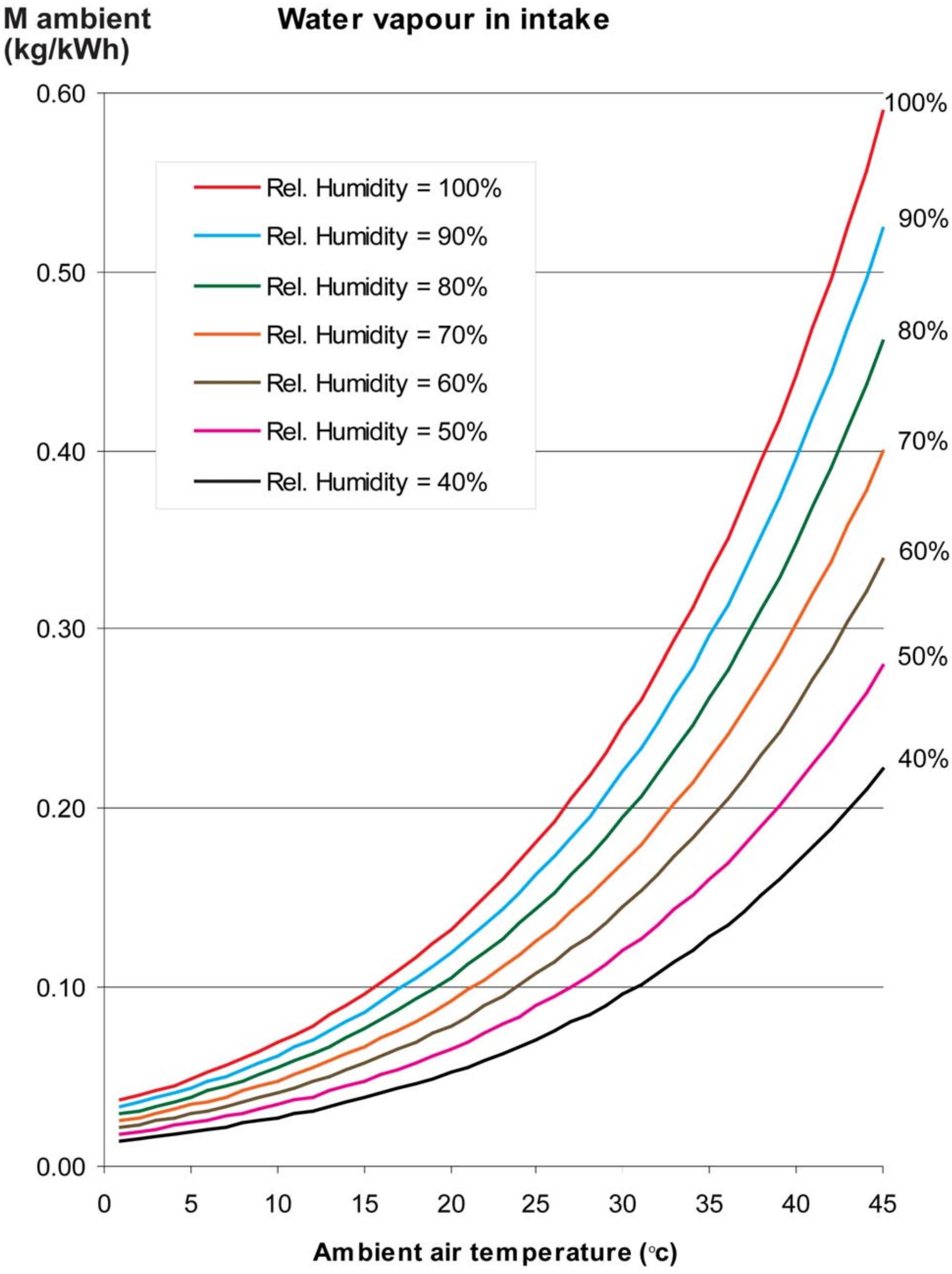
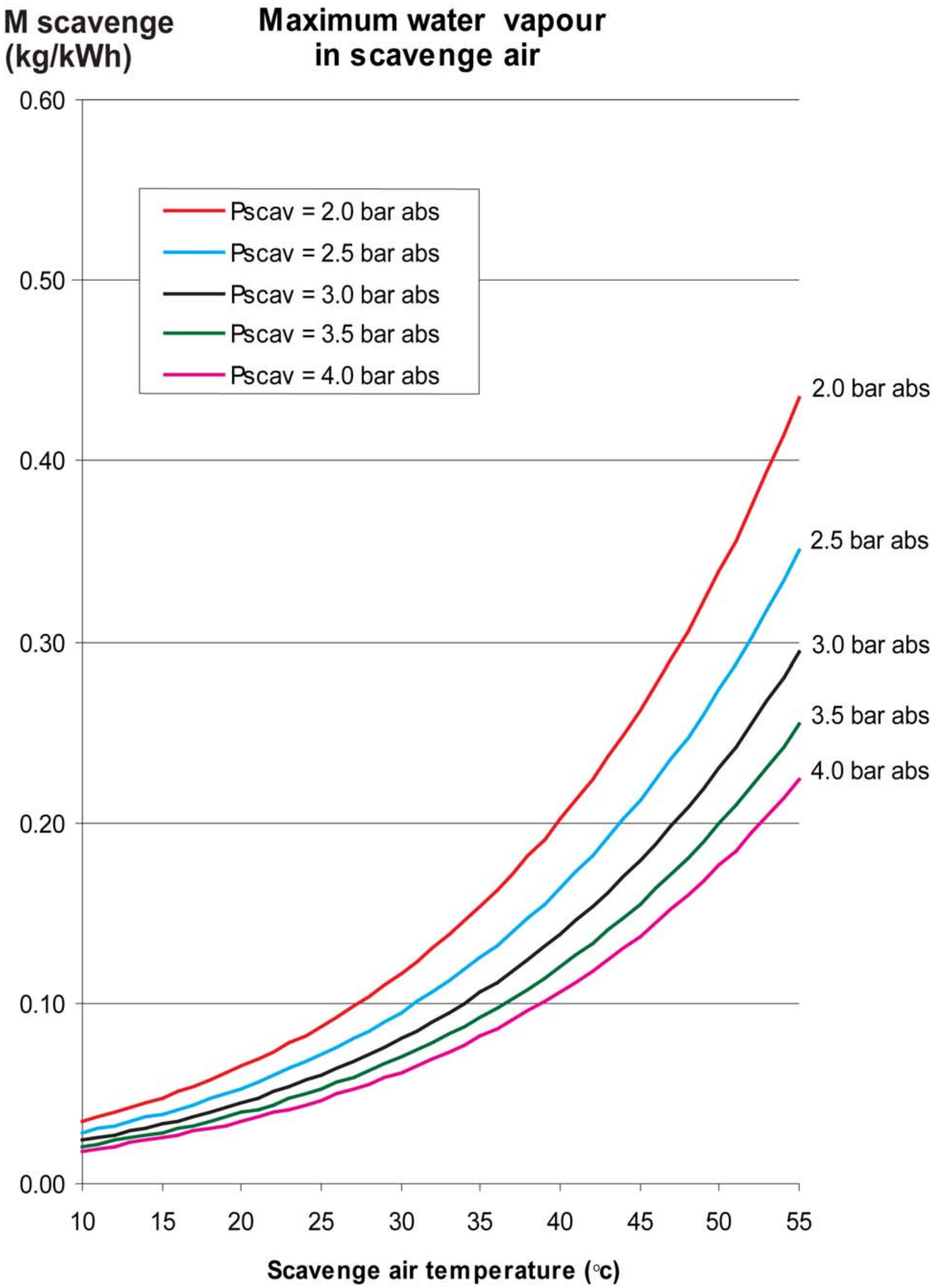
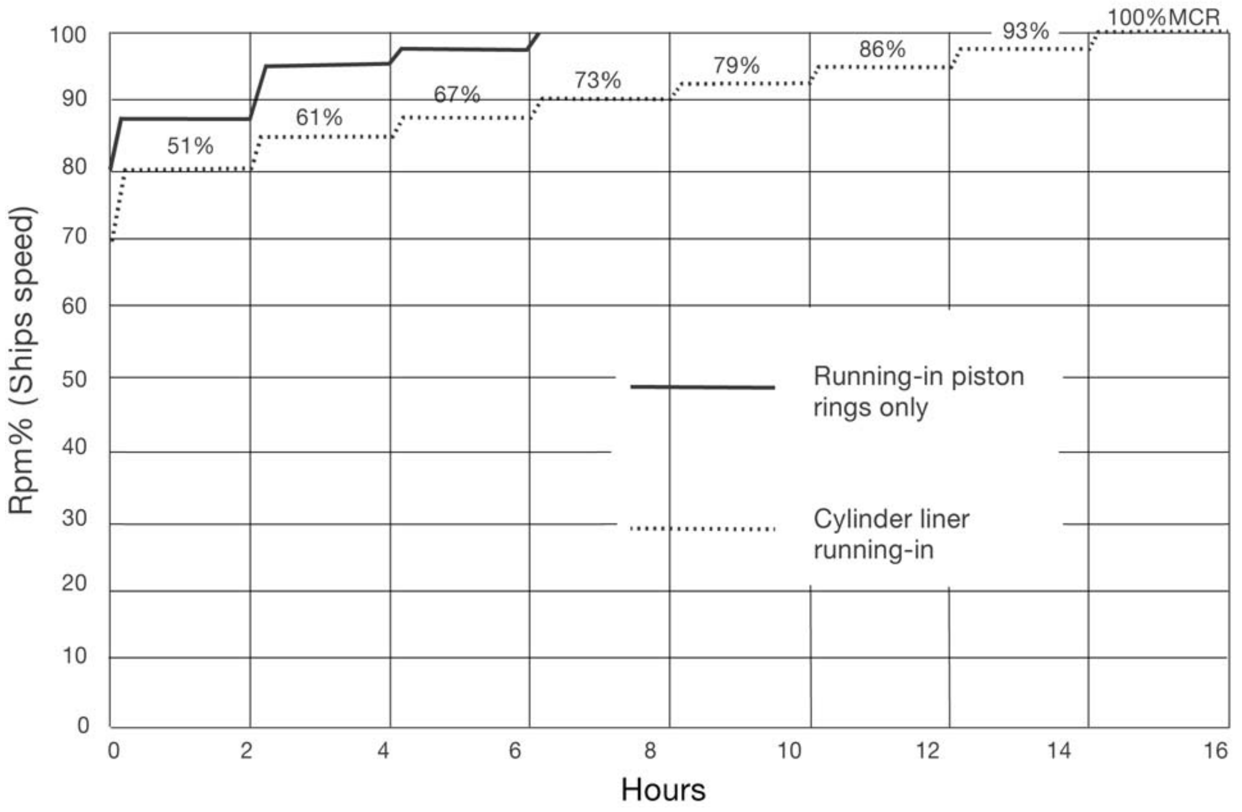

M ambient
(kg/kWh)
Water vapour in intake
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
5
10
15
20
25
30
35
40
45
Ambient air temperature (°c)
Rel. Humidity = 100%
Rel. Humidity = 90%
Rel. Humidity = 80%
Rel. Humidity = 70%
Rel. Humidity = 60%
Rel. Humidity = 50%
Rel. Humidity = 40%
100%
90%
80%
70%
60%
50%
40%

Calculation of Condensate Amount



Drawing
2255-0135-0002

Running-in Cylinder Liners and Piston Rings



Drawing

2255-0140-0003

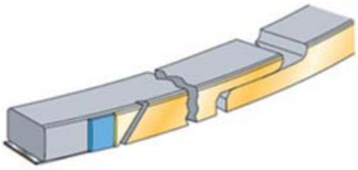
Running-in load

Large Bore Ring Configuration:

K80 Mk. 9, K90 & K98, S90 Mk. 8-9

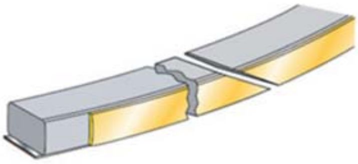
1st ring

CL-grooves:	CPR E4-180
Base material:	Vermicular cast iron, CV1
Hard coating:	Cermet coating
Run-in coating:	Alu coating
Bottom face:	Crome plating



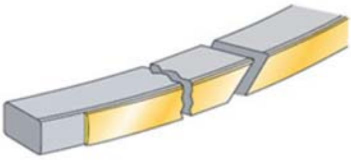
2nd ring – left cut

Base material:	Grey cast iron, CF5
Run-in coating:	Alu coating
Bottom face:	Chrome plating



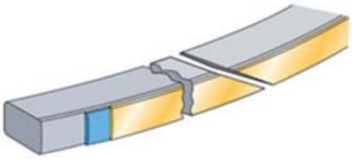
3rd ring – right cut

Base material:	Grey cast iron, CF5
Run-in coating:	Alu coating



4th ring – left cut

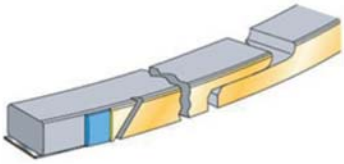
Base material:	Grey cast iron, CF5
Hard coating:	Cermet coating
Run-in coating:	Alu coating



Alternative Heavy Duty Ring Configuration:

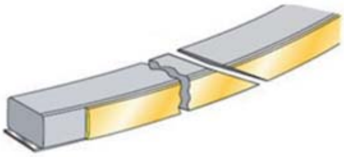
1st ring

CL-grooves:	CPR E4-180
Base material:	Vermicular cast iron, CV1
Hard coating:	Cermet coating
Running-in coating:	Alu coating
Bottom face:	Crome plating



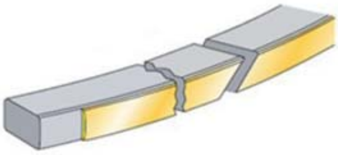
2nd ring – left cut

Base material:	Grey cast iron, CF5
Running-in coating:	Alu coating
Bottom face:	Chrome plating



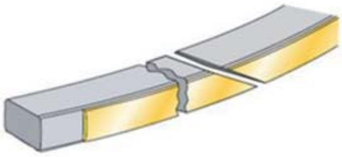
3rd ring – right cut

Base material:	Grey cast iron, CF5
Running-in coating	Alu coating

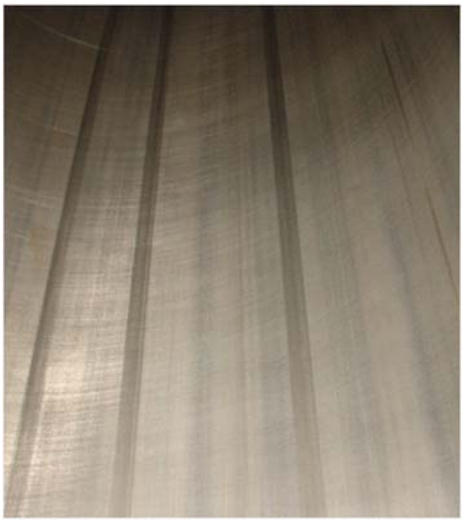


4th ring – left cut

Base material:	Grey cast iron, CF5
Running-in coating:	Alu coating



Normal Condition	Cold Corrosion
	
Normal liner condition. Light corrosive surface. Wave cut machining marks still visible on the lower part of the liner.	**Cold Corrosion**. Normal cold corrosion on the lower liner part, the corrosion facilitate good lubrication oil film, and the liner wear rates are acceptable.
Top cold Corrosion	Liner Black Deposits
	
Excessive Corrosive top part of the liner. Heavily corrosive surface, may lead to high liner wear and high ovality.	**Black Deposits** (black lacquer). The result of high humidity in the scavenging air, impacting the cylinder oil, producing alkaline material, forming a patch of deposits. Harmless to the engine and will be worn away when the air becomes dryer.

Bore Polish	Port Rib Marks
	
Liner Polish. Excessive piston top land deposits will eventually lead to liner polish and oil film break down. Possibly related to missing or malfunctioning PC-ring in combination with too high oil feed rates.	**Port Rib Marks.** Often seen in connection with exessive top land deposits due to too high cylinder oil feed rates, in combination with a cooler liner port area by cold climate and low load operation. (Not harmful).
Seizure stripe	Scuffing (Macro seizures)
	
Micro Seizures. Deriving from local oil film break down, must be treated with increased oil feed rate to make the rings run in again. May otherwise evolve into scuffing.	**Scuffing** (Macro seizures). The result of complete oil film break down is high friction and seizures leading to heavy liner wear. **The liner must be exchanged or machined.**

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T22-01	High-pressure pipe, tightening torque	75	Nm
T22-03	High-pressure pipe	120	Kg

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	**113**	Grinding tool - High-Pressure Pipe
7670-0200	**-**	Torque spanners

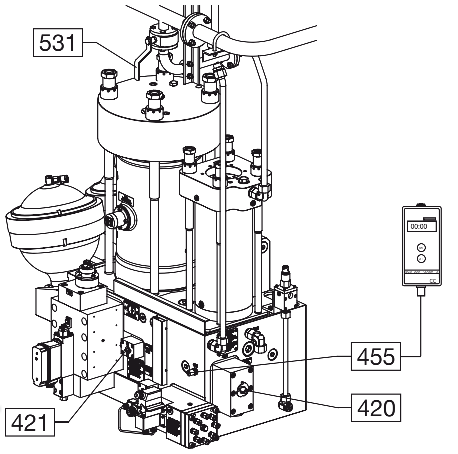
Stop the Engine

Stop the engine and shut off the oil supply.

Connect a pressure gauge at “minimess” point 455. Check the pressure.

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

Check that the system is pressure free.



2265-0101-0003D01

NOTE

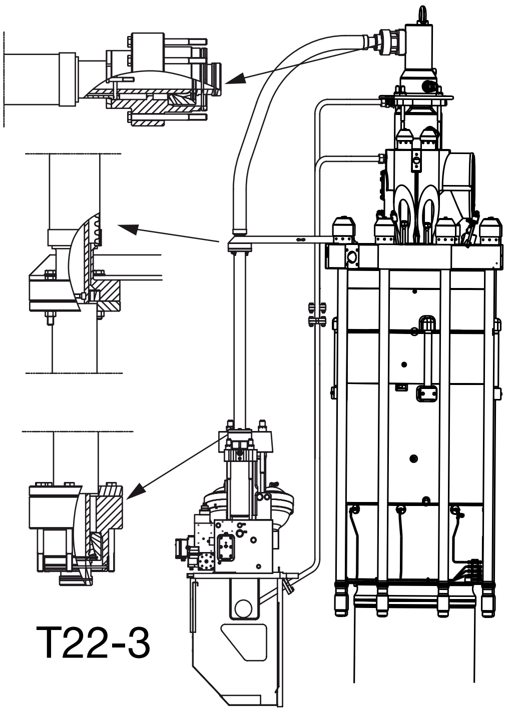
Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

Close the valve 531 for the actuator oil supply.

High-pressure pipe

When replacing the hydraulic highpres-sure pipe, the exhaust valve or the hydraulic actuator, check the high-pressure pipe sealing surfaces.

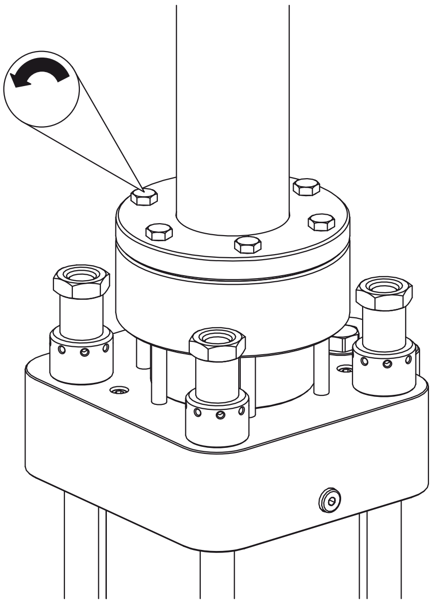
Loosen the screws for the high-pressure pipe and lift the pipe slightly away from the actuator to let the oil in the pipe drain through the drain holes in the actuator.



2265-0101-0003D02

Removing the high-pressure pipes

Remove the screws in both ends of the high-pressure pipe. Lift the high-pressure pipe away from the engine.



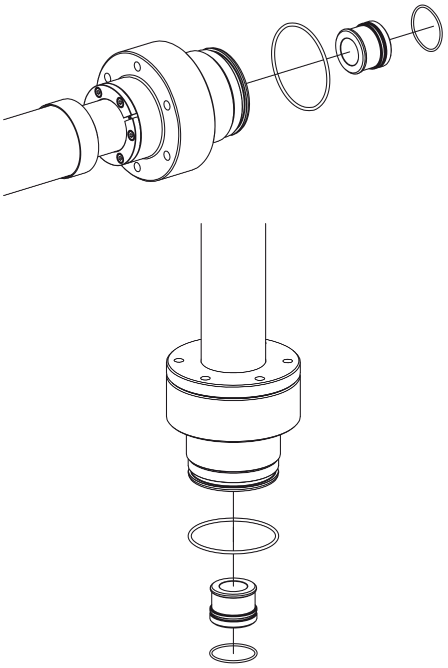
2265-0101-0003D03

Overhaul the pipe as follows:

The thrust piece

Remove the thrust piece from the actuator and exhaust valve.

Remove and discard the O-rings from the thrust piece and the thrust flange.



2265-0101-0003O01

The sleeve

Pull the thrust flange clear of the pipe end.

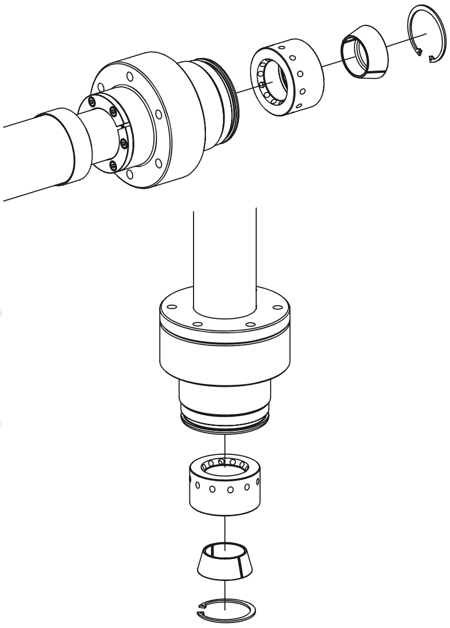
Remove the spring ring.

Push in the sleeve and remove the two-part conical locking ring.

NOTE

The two halves of the conical locking ring are matched parts. Check that the halves are marked, as a set, for refitting.

Pull the sleeve off the pipe.



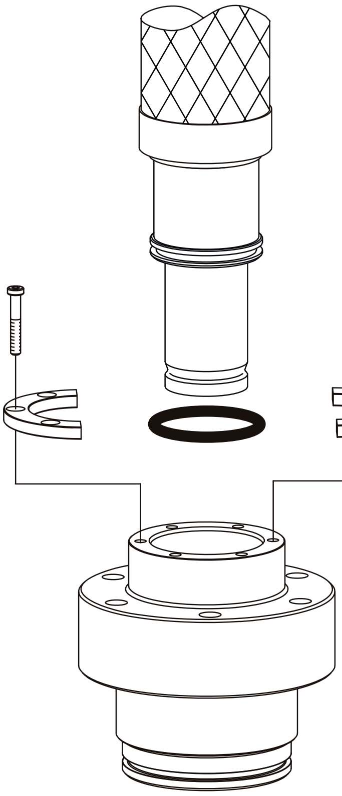
2265-0101-0003O02

The O-ring

Remove the bolts and the two-part disc from the thrust flange.

Pull the thrust flange off the pipe.

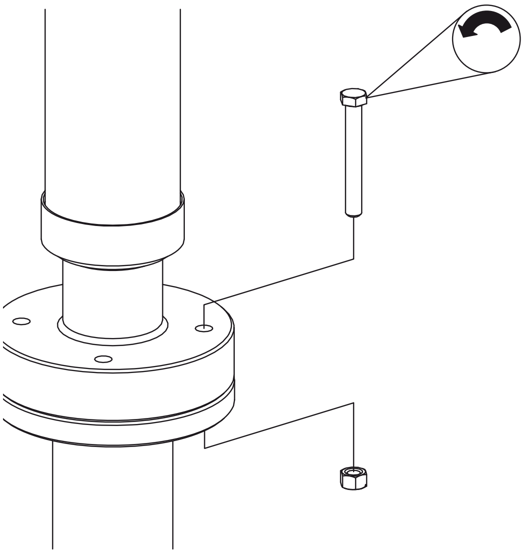
Remove and discard the O-ring.



2265-0101-0002O03

Losen and unscrew the bolts holding the flexible hose and and the lower outer pipe together.

Pull off the outer pipe from the hydraulic high-pressure pipe.



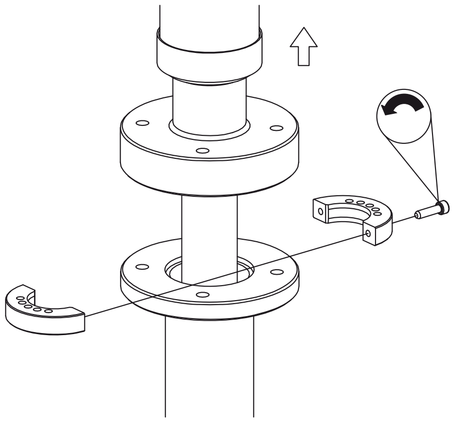
2265-0101-0003O04

Pull off the outer pipe from the hydraulic high-pressure pipe.

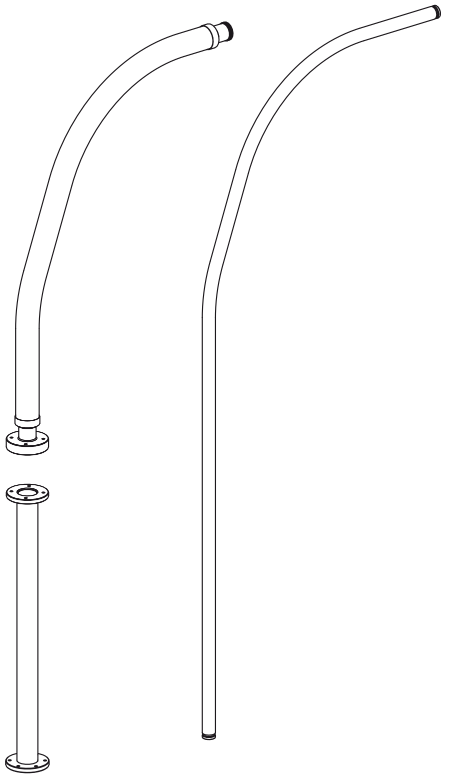
Pull up the flexible hose lower flange.

Loosen, unblot and remove the two-part disc.

Pull off the flexible hose from the hudraulic high-pressure pipe.



2265-0101-0003O05



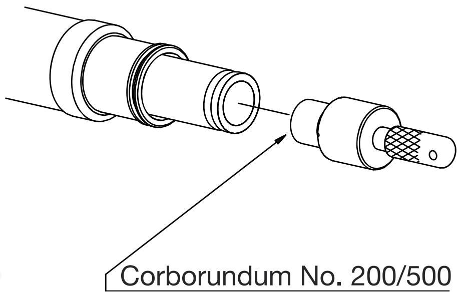
2265-0101-0003O06

The contact surfaces of the high-pressure pipes

Clean and inspect the contact surfaces of the high-pressure pipe and the thrust piece.

If necessary, grind the contact surfaces by means of the grinding mandrel.

Start grinding with a coarse grinding paste, for example Carborundum No. 200, and finish with a fine grinding paste, for example Carborundum No. 500.



2265-0101-0002O04

NOTE

After the grinding, clean the high-pressure pipe and the thrust piece.

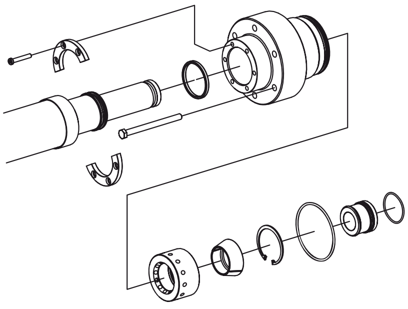
Mounting the high-pressure pipe

Fit a new O-ring on flexible hose.

Pull the flexible hose onto the hydraulic hig-pressure pipe and the lower outer pipe.

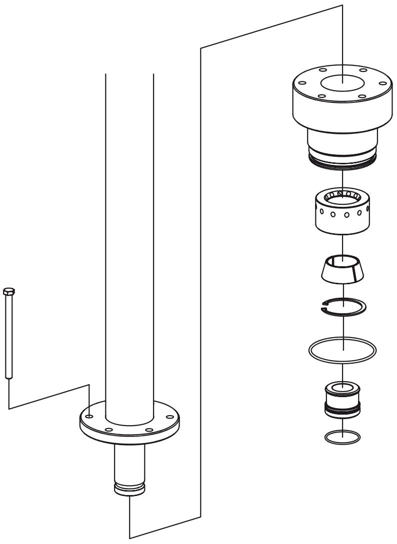
Assemble the two-part disc.

Assemble the thrust flanges and sleeves.



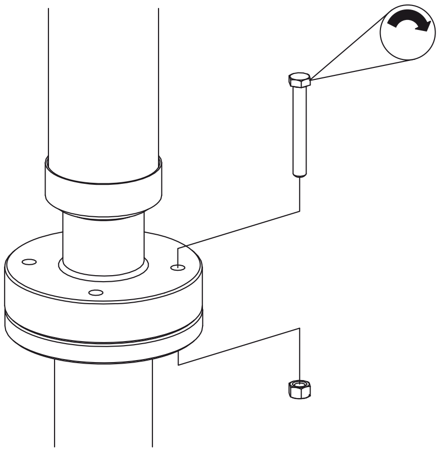
NOTE

The two halves of the conical locking ring are matched parts. Check that the halves are marked as a set, and refit.



2265-0101-0003O08

Bolt the flexible hose and the lower outer pipe together.



2265-0101-0003O09

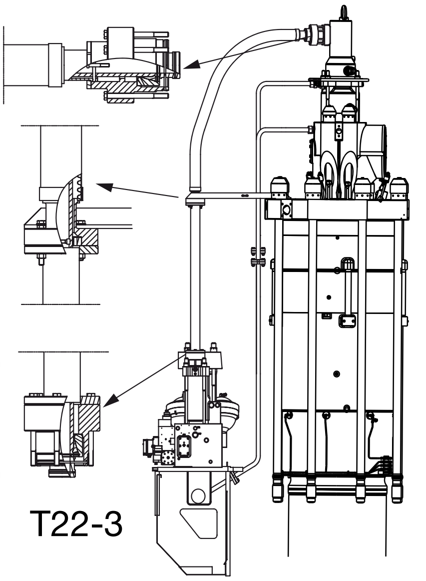
Mounting the high-pressure pipe

If not already done, mount new O-rings, lubricated with a little lubricating oil, on the thrust flanges.

Mount the high-pressure pipe on the engine.

NOTE

When mounting the high-pressure pipe, take care not to damage the sealing surfaces of the pipe/thrust pieces.



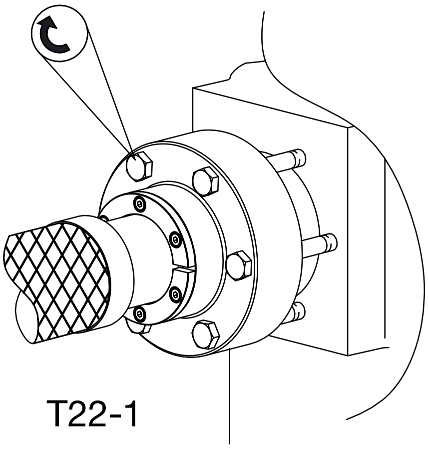
2265-0101-0003D02

Mounting the pipe to the exhaust valve and actuator

After fitting the pipe to the exhaust valve and actuator, mount and tighten the screws by hand.

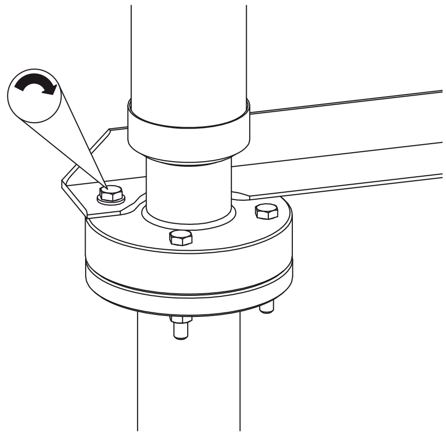
Finally, tighten the screws diagonally to the torque stated in Data, using a torque spanner.

For correct use of the torque spanner, see Data.



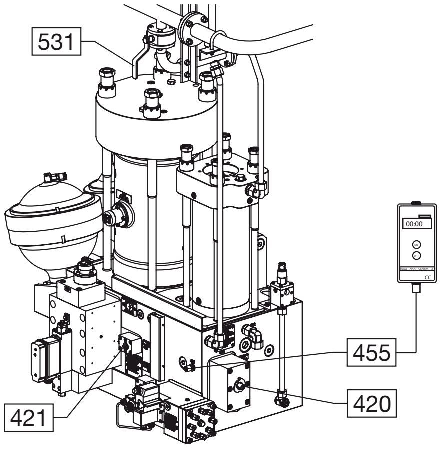
2265-0101-0002M02

Valves 531	Fasten the complete high-pressure pipe arrangement to the support bracket holding the middle section of the high-pressure pipe. Open valve 531 for actuator oil supply . For correct use of the torque spanner, see Procedure 913-5.



2265-0101-0003M03

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



2265-0101-0003M04

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T22-06	Safety valve, opening pressure	25	Bar
T22-09	Safety valve, tightening torque	70-100	Nm
T22-11	Throttle valve, tightening torque	50	Nm
T22-13	Bottom piece seat, grinding angle	29.9-30.0	°
T22-14	Valve spindle seat, grinding angle	30.4 - 30.5	°
T22-15	Check measurement G2	0 - 2.3	mm
T22-16	Gap of bottom piece seat	1.0	mm
T22-17	Spindle, max. burn-off	14.0	mm
T22-18	Spindle, max. grinding	2.0	mm
T22-19	Spindle stem, measuring area, min.	385	mm
T22-20	Spindle stem, measuring area, max.	545	mm
T22-21	Spindle stem, min. diameter	95.8	mm
T22-22	Bushing max. diameter, top	96.7	mm
T22-23	Bushing max. diameter, bottom	99.5	mm
T22-24	Oil cylinder max. inside diameter	112.2	mm
T22-25	Piston rings, min. thickness	4.2	mm
T22-26	Damper piston, min distance	48.4	mm
T22-27	Damper piston, max distance	51.4	mm
T22-28	Exhaust valve, complete	1700	kg
T22-29	Exhaust valve housing	1100	kg
T22-30	Oil cylinder	270	kg
T22-32	Spindle	200	kg
T22-33	Bottom piece	100	kg
T22-34	Air piston	15	kg

Ref.	Description	Value	Unit
T76-1	Hydraulic pressure, dismantling	2000-2400	bar
T76-1	Hydraulic pressure, mounting	2200	bar

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	**066**	Lifting tool for exhaust valve
2270-0200	**078**	Cone ring for pneumatic piston
2270-0200	**080**	Test equipment for exhaust valve
2270-0200	**091**	Gauge for exhust valve spindle
2270-0200	**150**	Gauge exhaust valve bottom piece
2270-0200	**162**	Lifting tool for exhaust valve
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**047**	Hose with unions, 1500 mm
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**106**	5-way distributor block, complete
7670-0410	**066**	Slide caliper

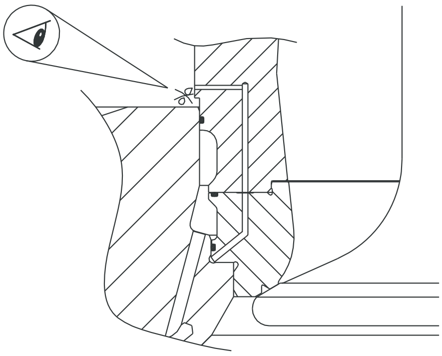
Checks during running:

Check of bottom piece sealings

With the exhaust valve mounted in the cylinder cover, check the cooling water inlet and outlet to the cylinder cover and exhaust valve is open.

Check the tightness of the sealing rings between the bottom piece and the exhaust valve housing. IF water flows from the small bore on the manoeuvring side of the exhaust valve, the lowermost sealing ring is leaking.

If water flows from the any of the rings, the exhaust valve must be dismounted and the sealing rings replaced.



2265-0201-0005C01

Check with stopped engine:

In connection with port stays, at an interval of e.g. one month, an check of all exhaust valves is recommended.

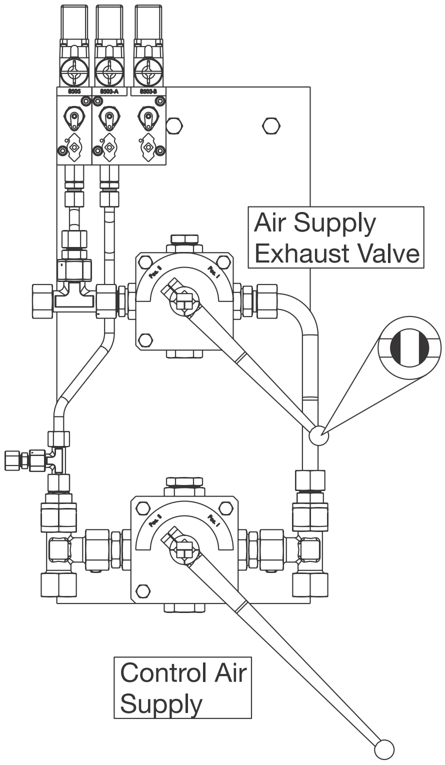
Check of spindle drop-down time

Check the position of the exhaust valve spindles on the MOP-panel.

Shut off and release the air spring on the valve next to the engine-side manoeuvring stand.

Check the drop down time for all spindles:

- drop-down within 15 minutes: check and overhaul, see next step “Check of air spring tightness”.
- drop-down between 30 minutes and 1 hour: keep under observation.
- drop-down after 1 hour: OK.



2265-0201-0005C02

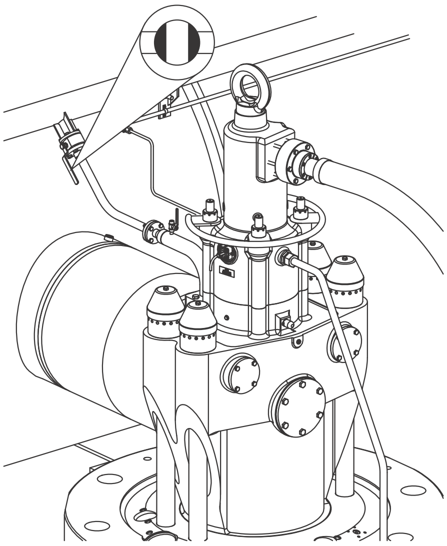
NOTE

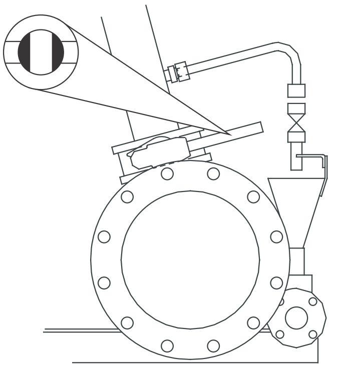
If the air piston is fitted with new sealing rings, the time at which the valve is closed may vary considerably from the above stated, especially for new exhaust valves.

Shut off cooling water

Shut the cooling water inlet and outlet connections, and drain the exhaust valve.

Shut off and relieve the air supply to the exhaust valve.





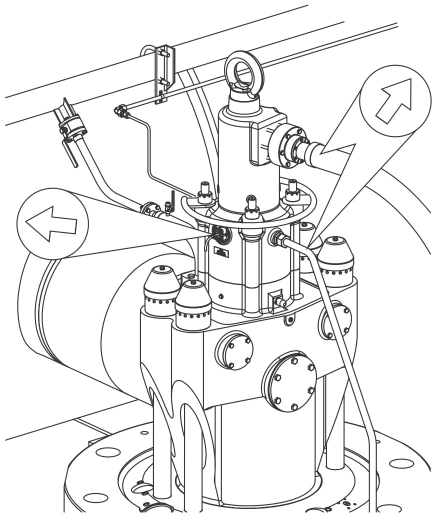
2265-0201-0006D01

Disconnect the oil pipe connections

Disconnect the high pressure pipe for the hydraulic valve actuation. *See work card 2265-0101.*

Disconnect the return oil pipe from the exhaust valve.

Disconnect the electrical plug for the valve position sensor.



2265-0201-0006D02

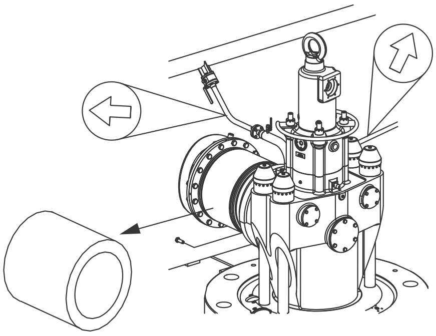
Disconnect pipe connections

Disconnect the cooling water connections from the exhaust valve and the air pipe for the air spring.

If necessary, remove the plate jacket and insulation from the intermediate pipe.

Loosen the screws which attach the intermediate pipe to the exhaust valve housing.

Support the intermediate pipe by e.g. a chain block and remove the screws.



2265-0201-0006D03

Dismantling of nuts

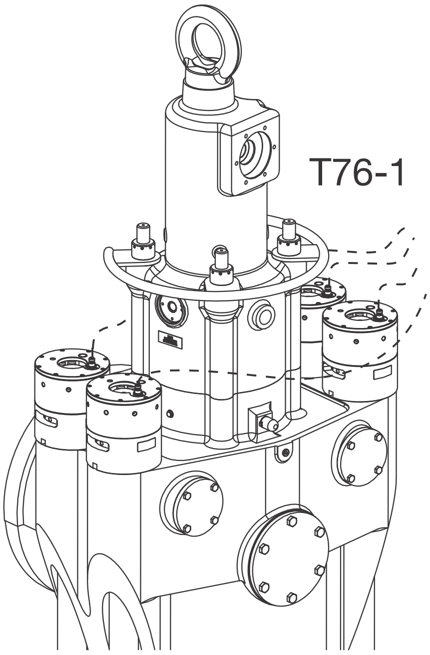
Remove the protective caps from the exhaust valve studs, and mount the four hydraulic jacks.

Connect the high-pressure pump to the jacks by means of the distributor block and four high-pressure hoses.

Bleed the hydraulic system and raise the pressure as stated in Data.

Then loosen and remove the nuts, see Data.

For use of Hydraulic tools *See work card 7665-0201.*



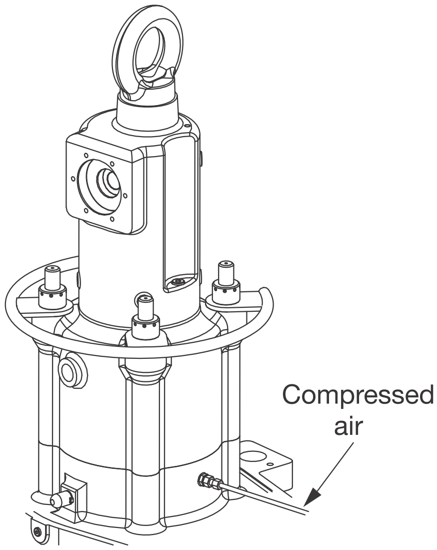
2265-0201-0006D05

Retaining bottom piece

Connect 7 bar working air to the valve air spring, thereby keeping the valve closed when it is removed from the engine.

The 7 bar working air must be connected during the entire lift of the exhaust valve.

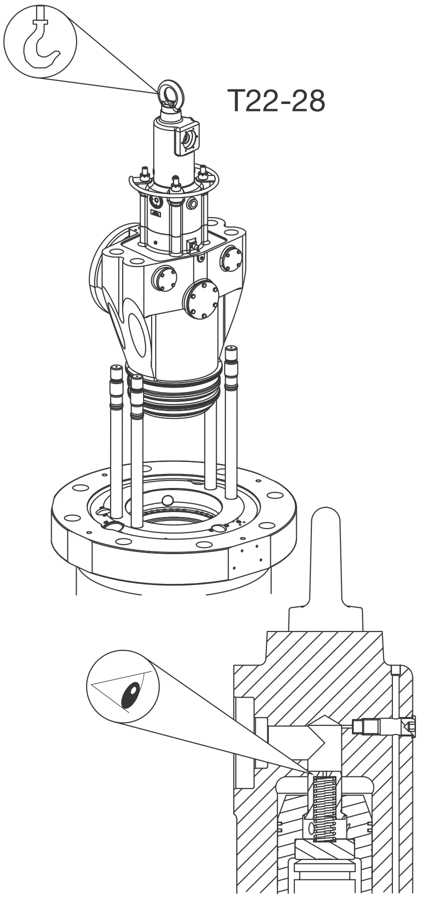
The special air coupling is found on tool panel 2270-0200.



2265-0201-0006D06

Lifting of exhaust valve

Attach the crane to the eye bolt fitted on top of the valve and start lifting the exhaust valve.



2265-0201-0006D07

CAUTION

Before attempting to lift the exhaust valve, check the position of the oil piston damper in the top of the oil cylinder.

If the bottom piece has got stuck in the cylinder cover, risky situations can occur in connection with the parts separating with the air spring force still in action. (The bottom piece is not fixed to the valve housing by other means than the force of the air spring.)

This situation can be checked with a look into the oil duct. If the oil piston moves downwards during valve lifting, the parts are not kept together and the alternative lifting procedure must be followed, see steps 8 and 9.

Land the exhaust valve on a wooden plate on the platform.

Mount the retaining tool for the bottom piece.

Disconnect the 7 bar working air hose.

Carefully clean the exhaust valve bore in the cylinder cover and recondition the seating and sealing surfaces of the bore, if required. *See work card 2265-0301.*

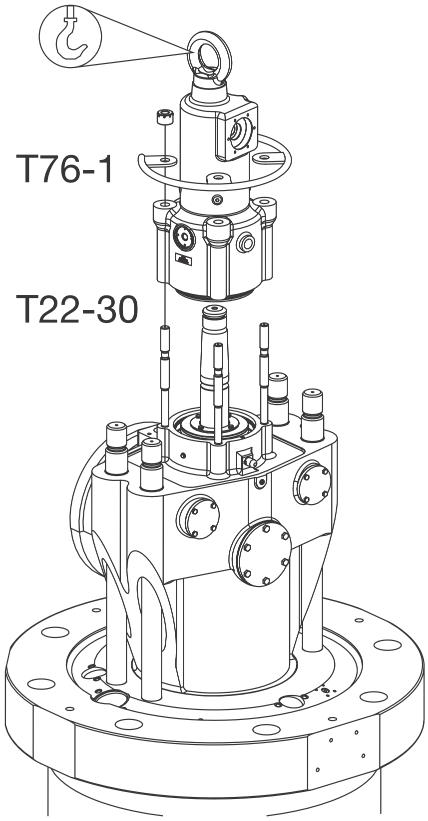
For overhaul of the exhaust valve, *see work card 2265-0201.*

Special lift:

Dismantle the oil cylinder

Remove the four hydraulic nuts and the safety strap from the oil cylinder.

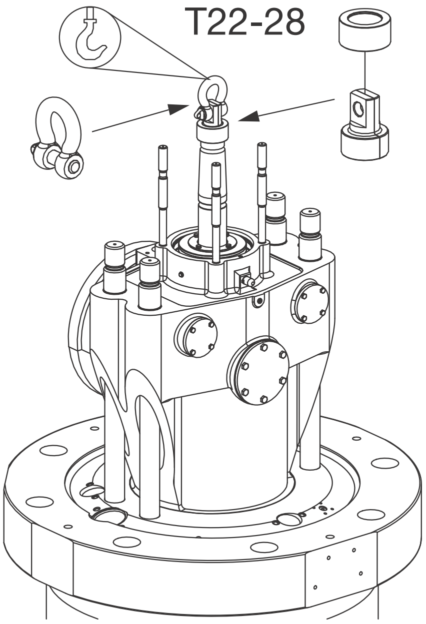
Attach the crane hook to the oil cylinder. Lift the oil cylinder away and place it on a wooden support.



2265-0201-0006D08

Spindle lift

Mount the spindle lifting tool on the exhaust valve spindle and carefully lift the exhaust valve away. The tool is found on the tool panel 2270-0200.



2265-0201-0006D09

Oil cylinder

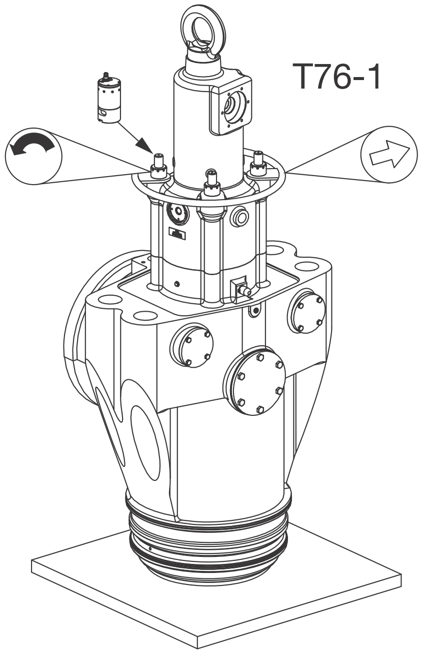
Place the exhaust valve on a wooden support on the platform.

Relieve the air pressure through the non-return valve from below the piston. Use a small screwdriver to press the ball into the non-return valve. Cover the non-return valve with a rag to catch the oil drops.

Mount 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 work card 7665-0101*.

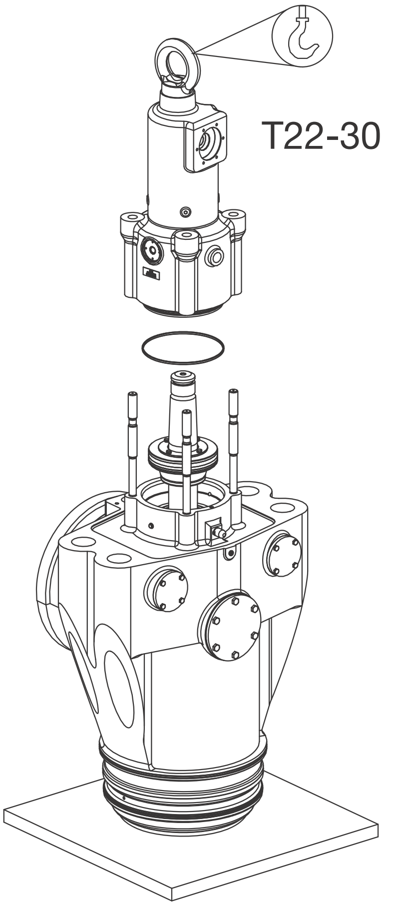
Remove the the safety strap from the oil cylinder.



2265-0201-0006O01

Lift the oil cylinder

Lift away and place the oil cylinder on a wooden support.

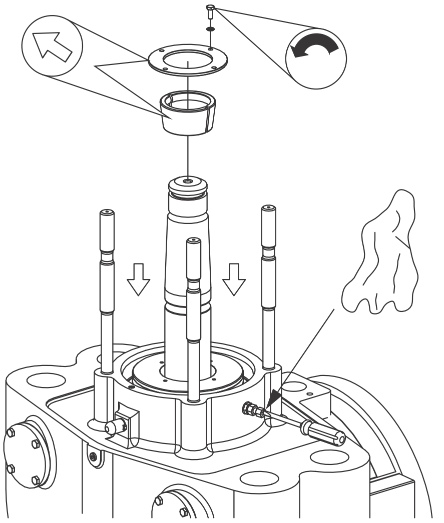


2265-0201-0006O02

Conical locking ring

Remove the four screws from the flange on top of the air piston and dismount the flange.

Loosen the air piston from the conical locking ring by means of a tin hammer, and remove the conical locking ring.

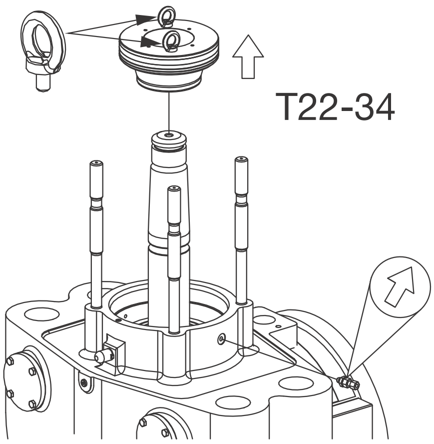


2265-0201-0006O03

Air piston

Remove the non-return valve.

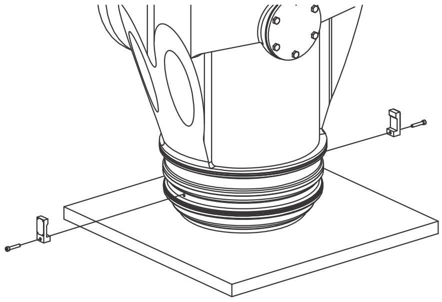
Mount two eyebolts in the top of the air piston. Remove the air piston from the air cylinder.



2265-0201-0006O04

Retaining tool

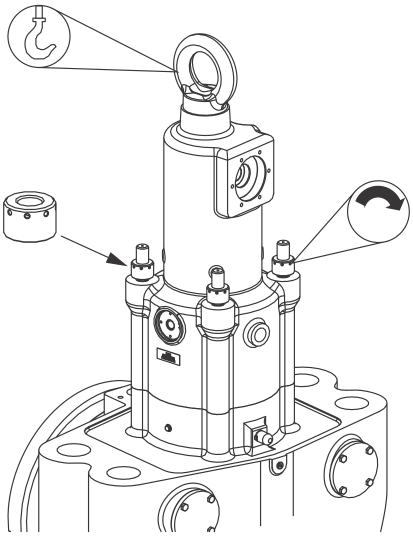
Mount the retaining tools for the bottom piece (If not already mounted).



2265-0201-0006O05

Mount oil cylinder for lifting

Use the oil cylinder as a lifting tool for the exhaust valve housing. Lift the oil cylinder with the crane, and guide it down over the studs for the oil cylinder. Mount the four nuts so that the load from the valve housing is evenly distributed.

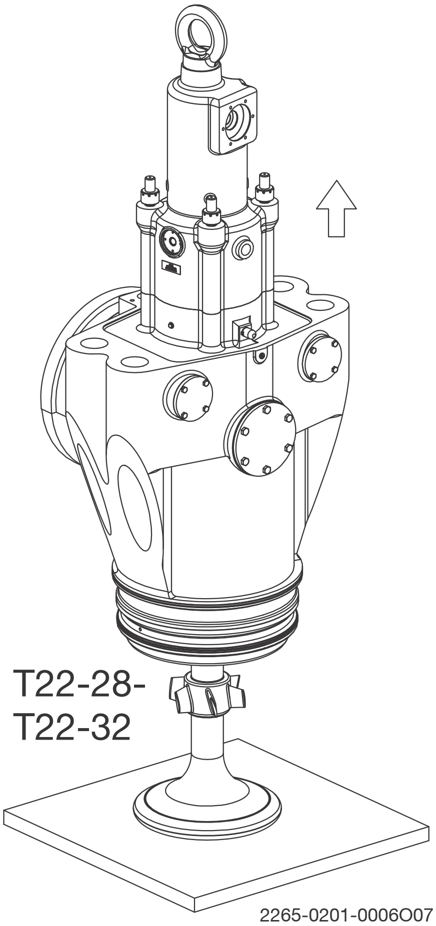


2265-0201-0006O06

Lift valve housing

Lift the oil cylinder and the valve housing clear of the exhaust valve spindle.

Land the valve housing on a wooden support and let the oil cylinder hang in the crane.



2265-0201-0006O07

Bottom piece

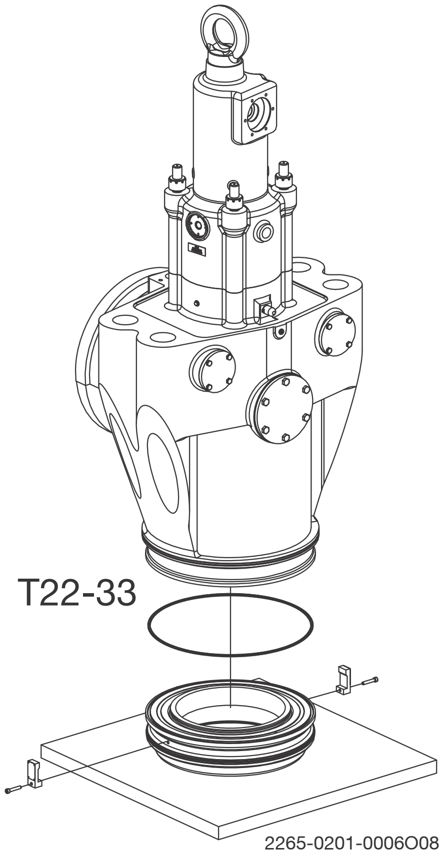
Unscrew and remove the tool which retains the bottom piece. Lift the valve housing approx. 10 mm.

If the bottom piece has become stuck, use a tin hammer to release it.

Lift the valve housing away and land it on a couple of wooden planks.

Remove and discard the O-ring from the groove in the top of the bottom piece.

Remove the oil cylinder from the exhaust valve housing.



2265-0201-0006O08

Guide Bushing:

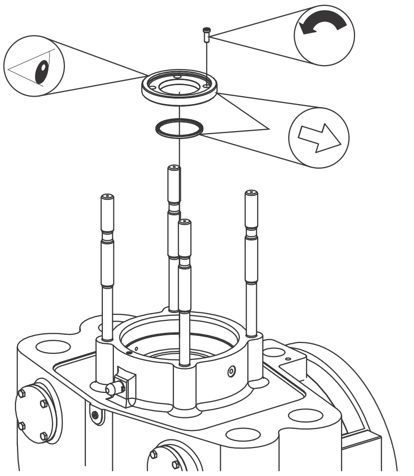
Seals

Remove the flange on top of the guide bushing.

Remove and discard the O-rings and the inside sealing ring.

Inspect the disc for knocks and burrs. If neccessary replace the flange.

Use threads in the flange to remove it.

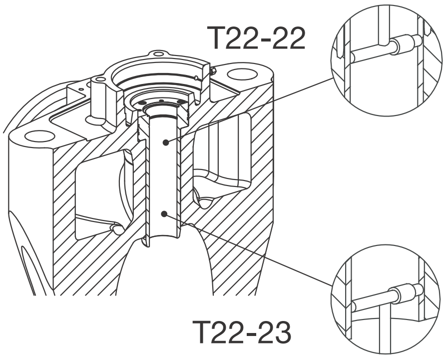


2265-0201-0006O10

Inspect guide bushing

Clean the exhaust valve housing.

Inspect the bushing in the spindle guide for wear and measure the top and bottom diameters. *See Data*.



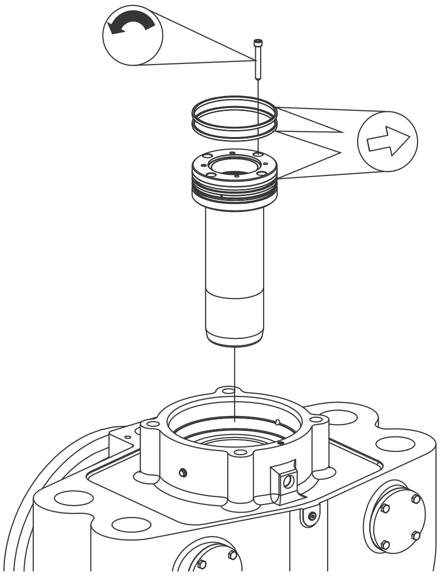
2265-0201-0006O11

Bushing renewal

If it proves necessary to replace the bushing, knock out the bushing with a hammer and a suitable mandrel.

When a new bushing is mounted, mount a new O-ring for sealing between bushing and exhaust valve housing.

Mount and tighten the screws for the bushing.

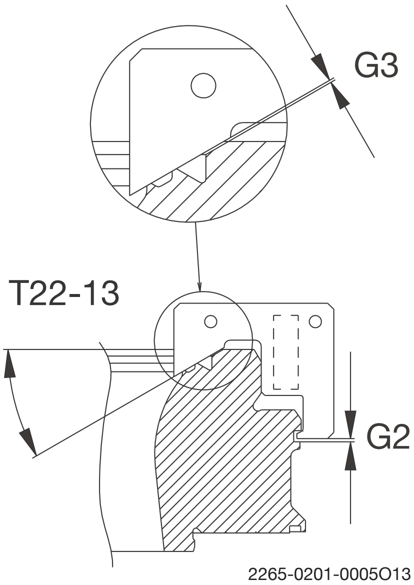


2265-0201-0006O12

Bottom piece:

Bottom piece inspection

Inspect the seating of the bottom piece **carefully** for damage and check with the bottom piece template.



2265-0201-0005O13

NOTE

Before using the bottom piece template, thoroughly clean the contact faces on the valve housing w-seat with a steel brush.

All measurements should be taken at four diametrically opposite points on the circumference of the bottom piece seating.

Small dent marks in the bottom piece seating are acceptable and need not to be ground away, provided that the dent marks do not allow blow-by of exhaust gas from the combustion chamber to the exhaust gas receiver.

For further evaluation of the bottom piece seating, see Description 2245-0200.

Take measurements **G2** and **G3**, using a feeler gauge. Compare the results with the figures stated in Data T22-15 and T22-16.

IF burn marks are visible on the bottom piece seating OR **G3** does not equal T22-16, THEN the bottom piece seat must be ground.

IF the template rests on the lower surface in the groove, i.e. **G2** = 0, THEN the bottom piece seating must be discarded and replaced with a new bottom piece. Further grinding or reconditioning is not recommended.

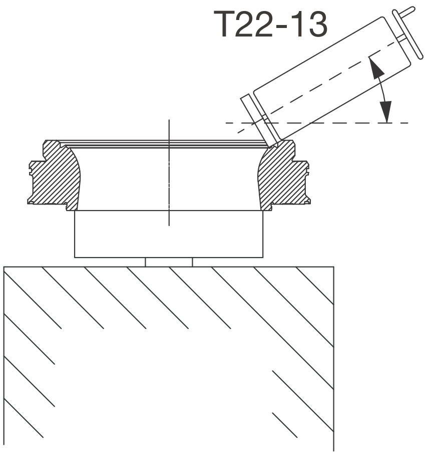
Bottom piece grinding

If it is necessary to grind the seating, proceed as follows:

Before placing the bottom piece on the grinding machine, turn the grinding head away from the grinding table.

Mount and secure the bottom piece in the grinding machine. Using a dial gauge, check that the bottom piece is correctly centered.

Adjust the grinding head to achieve the correct grinding angle as stated in Data.



2265-0201-0005O14

NOTE

As the grinding angle is very important for the correct operation of the exhaust valve, make absolutely sure that the grinding head is correctly adjusted.

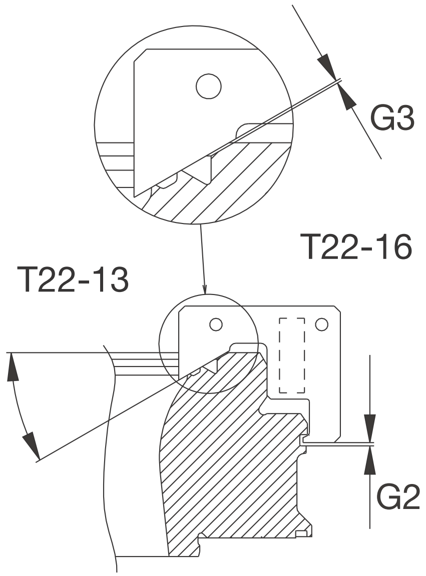
Regarding the use of the grinding machine, see separate instructions from the grinding machine manufacturer.

During grinding

During the grinding, use the bottom piece template frequently to ensure that maximum grinding is not exceeded.

After grinding, inspect the bottom piece seating again, using a feeler gauge and the bottom piece template, to measure how much material has been ground away.

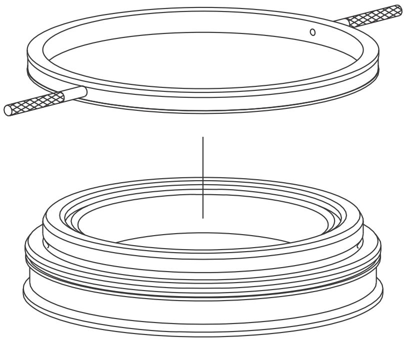
Grind the recess so that gap **G3** equals T22-16 as stated on the Data sheet.



2265-0201-0005O15

Bottom piece sealing face

After grinding the inside seating of the bottom piece, grind the outside seating using carborundum 200 and the special grinding tool.



2265-0201-0005O16

NOTE

Turn the special grinding tool by hand, alternately turning clockwise and anti-clockwise.

Grind until a smooth surface is achieved.

Clean the bottom piece.

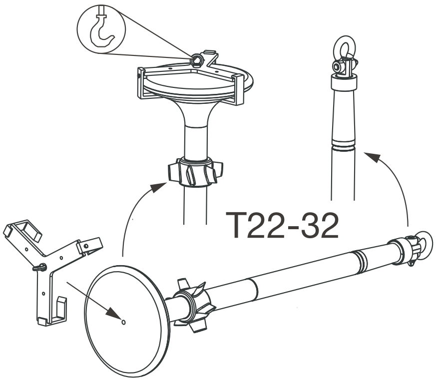
Valve spindle:

Spindle lift

When lifting or handling the exhaust valve spindle, use the special valve spindle lifting tools.

When turning the exhaust valve upside down, mount the small lifting tool in the top of the spindle. Lift the spindle with the engine room crane and land it on one side on a wooden support (e.g. a piece of plywood).

Mount the large lifting tool designed for the bottom of the spindle. Lift up the valve spindle as shown in the sketch.

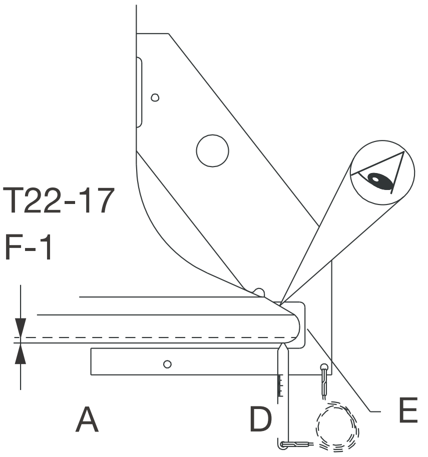


2265-0201-0005O17

Spindle inspection

Inspect the seating of the valve spindle for burn marks.

Check the burn-off F1 of the valve spindle by measuring along the spindle template from point A to point D and in point E.



2265-0201-0005O18

NOTE

Before using the spindle template, thoroughly clean the contact faces on the valve spindle with a steel brush.

All measurements should be taken at four diametrically opposite points on the circumference of the valve spindle. Make sure that the most burned-off point is measured.

Small dent marks in the valve spindle seating are acceptable and need not to be ground away, provided that the dent marks do not allow blow-by of exhaust gas from the combustion chamber to the exhaust gas receiver.

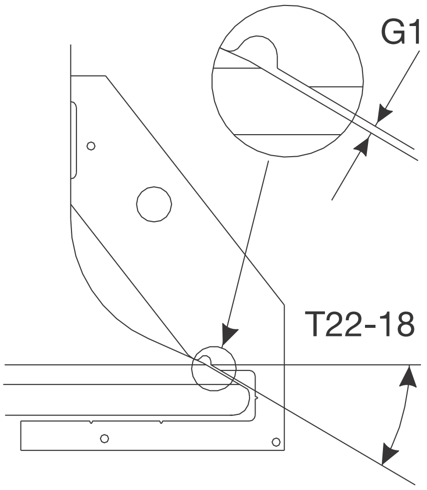
For further evaluation of the valve spindle seating, see Description 2245-0200.

Criterias for reconditioning

IF burn marks are visible on the seating, the spindle must be ground.

IF gap **G1** exceeds the maximum allowable value T22-18, see Data, OR the burn-off **F1** exceeds the maximum allowable burn-off T22-17, the spindle must not be ground. Instead the spindle must be reconditioned.

Contact MAN Diesel & Turbo for advice on reconditioning.



2265-0201-0005O19

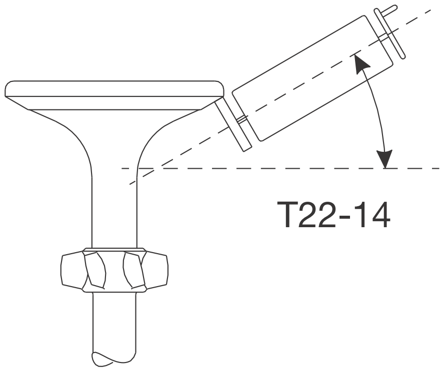
Grinding angle

Mount and secure the spindle in the grinding machine. Using a dial gauge, check that the spindle is correctly centered.

Adjust the grinding head to achieve the correct grinding angle as stated in Data.

NOTE

As the grinding angle is very important to the operation of the exhaust valve, make absolutely sure to adjust the grinding head correctly.



2265-0201-0005O20

Regarding the use of the grinding machine, see separate instructions from the grinding machine manufacturer.

During grinding, measure gap **G1** frequently. The max. grinding of the spindle, see Data, must not be exceeded.

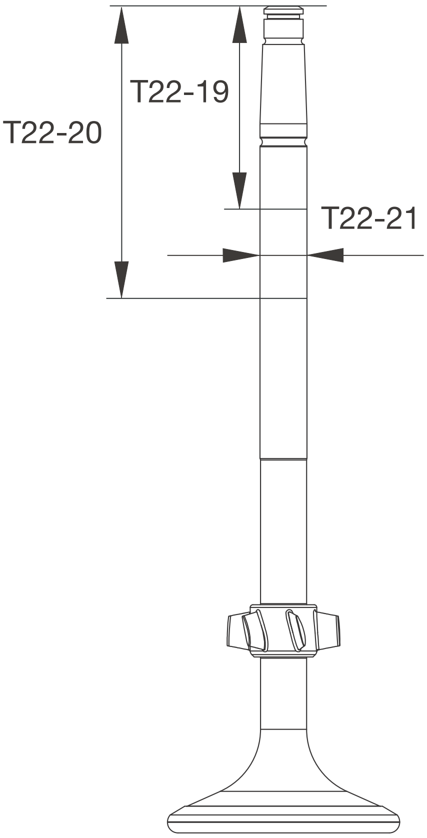
If the max. grinding limit is reached, and burn marks are still visible on the seating of the spindle, contact MAN Diesel & Turbo for advice on reconditioning.

Clean the spindle.

Spindle stem

Check the spindle stem for wear in the area T22-19 to T22-20 measured from the top of the spindle.

If the stem diameter is less than stated in Data, or the hard facing layer is worn away, contact MAN Diesel & Turbo for advice.



2265-0201-0005O21

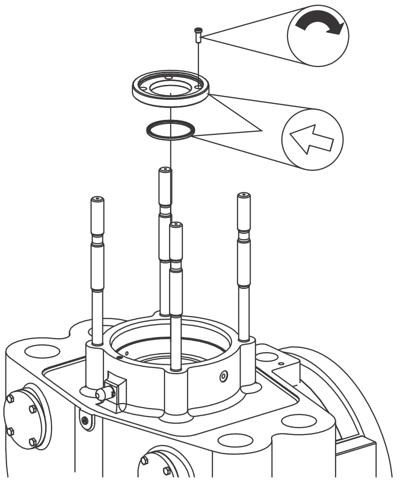
Mount seals

Mount the O-rings and sealing ring on the spindle guide.

NOTE

Make sure to mount the sealing ring correctly.

Mount the flange on top of the spindle guide.



2265-0201-0006O22

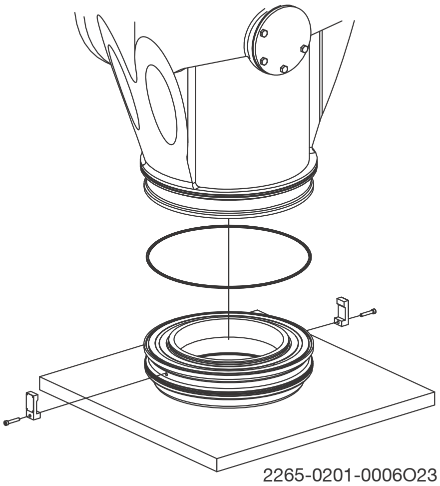
Retaining tools

Use the oil cylinder as a lifting tool for the exhaust valve housing. Lift the oil cylinder with the crane, and guide it down over the studs for the oil cylinder. Mount the four nuts so that the load from the valve housing is evenly distributed.

Mount a new O-ring in the groove in the top of the bottom piece.

Land the exhaust valve housing on the bottom piece.

Install and tighten the bottom piece retaining tools.



2265-0201-0006O23

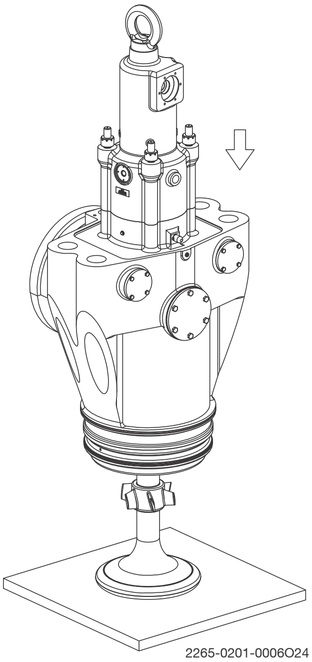
Spindle mounting

Lubricate the inside of the bushing in the spindle guide with plenty of lubricating oil.

Use the oil cylinder as a lifting tool for the exhaust valve housing.

Carefully land the exhaust valve housing with the bottom piece on the exhaust valve spindle.

Remove the oil cylinder.



2265-0201-0006O24

Exhaust Valve Housing:

Safety valve

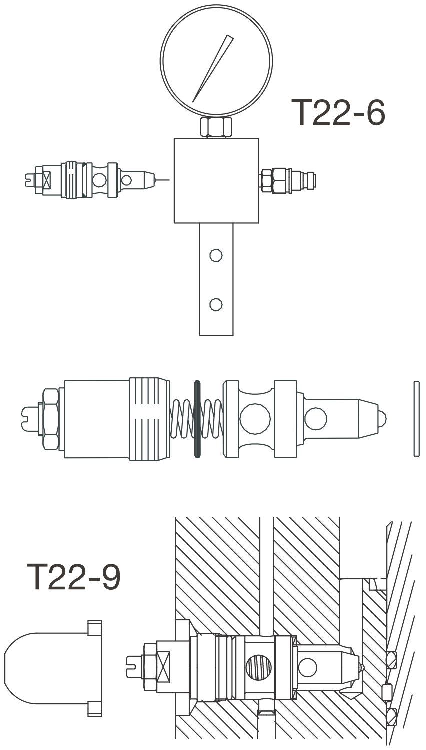
Place the safety valve in the pressure testing device. Connect the testing device with the high pressure pump by means of a hose.

Check the opening pressure, *see Data T22-6*.

If the opening pressure is not correct, loosen the lock nut and, using a screwdriver, adjust the safety valve until the correct pressure is indicated. Tighten the lock nut and test the opening pressure once more.

Mount a new gasket and a new O-ring on the safety valve. Install the safety valve in the bore near the bottom of the air cylinder. When installing the safety valve in the air cylinder, only use the machined faces on the valve housing and tighten, *see Data*.

Finally, mount the protective cap.



2265-0201-0005O26

Air Piston:

Air piston seals

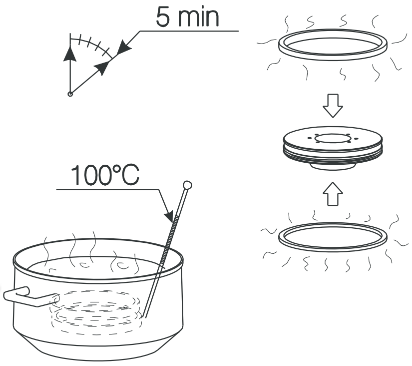
Check the teflon guide ring and teflon sealing ring for wear, if it is necessary to

replace the sealing rings on the air piston, cut them and remove them.

Be careful not to damage the edges of the ring grooves in the piston.

NOTE

Before mounting, heat the new teflon rings in 100°C hot water for at least five minutes. When mounting the teflon rings, **be careful** not to damage the running surfaces.



2265-0201-0006O28

Mount a new O-ring in the inner groove of the air piston

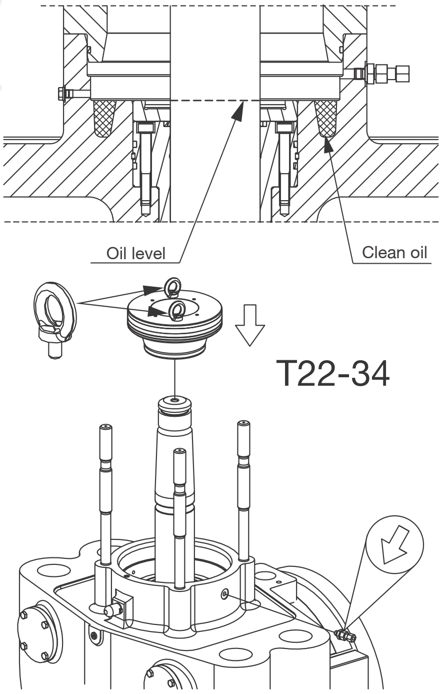
Air piston mounting

NOTE

Fill the bottom of the air cylinder up to the drain hole with clean lubricating oil.

Lower the air piston down over the valve spindle.

Mount the non return valve for compressed air



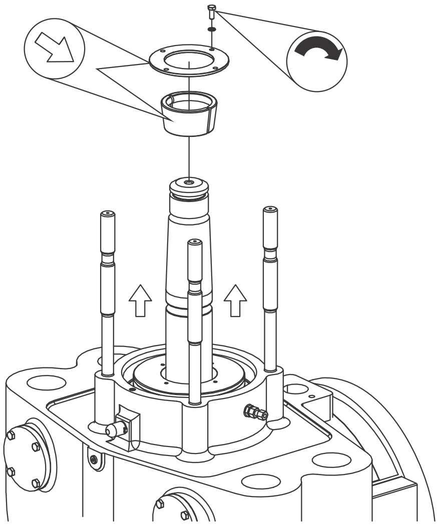
2265-0201-0006O29

Locking ring

Mount the two-part conical locking ring

Mount the flange on top of the air piston and, using four screws, tighten together the air piston and the flange.

On valves designed with securing bolts, secure the bolts. *See work card 7665-0101*.



2265-0201-0006O30

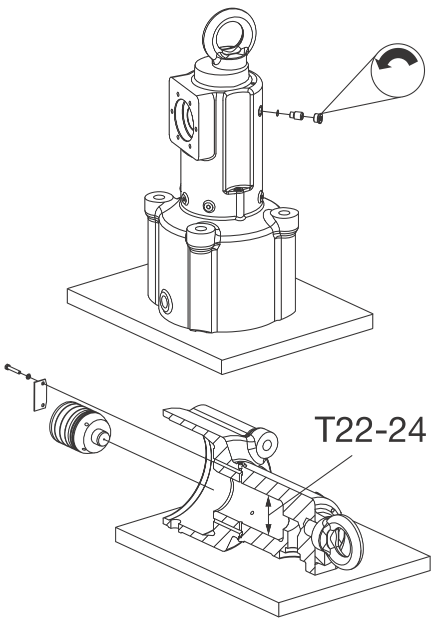
Oil Cylinder:

Oil cylinder

Place the oil cylinder in a horizontal position.

Remove the plug screw from the bore of the orifice plug. Unscrew and clean the orifice plug. Remove and discard the sealing disc. Check and clean the bore for the orifice plug in the top of the oil cylinder.

Remove the flange and take out the actuator piston. Inspect the inside of the oil cylinder for scoring. Measure the cylinder diameter. If the diameter of the oil cylinder exceeds Data T22-24, send the complete oil cylinder to an authorised MAN Diesel & Turbo workshop for reconditioning.

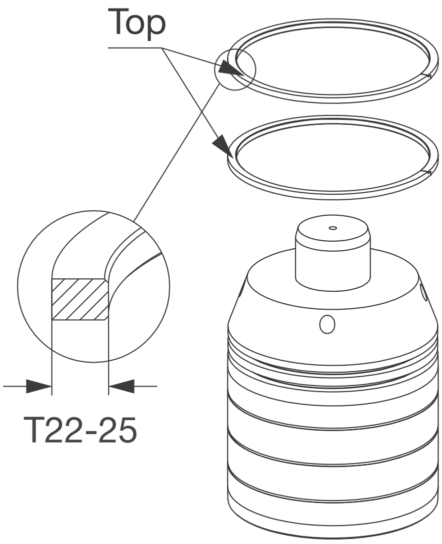


2265-0201-0005O31

Oil piston

Remove the piston rings from the oil piston and check them for wear. If the thickness of the rings has worn down to the minimum, see Data, discard the rings and mount new ones.

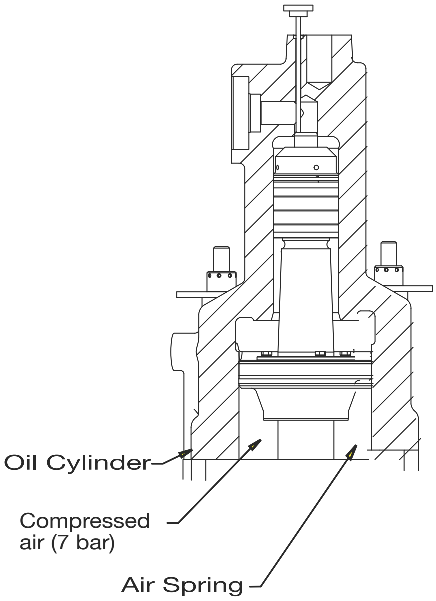
Check that the **TOP** mark on the piston rings faces upwards.



2265-0201-0005O32

Tight the air cylinder

The exhaust valve is to be assembled and compressed air (7 bar) is to be supplied to the air spring. Thereafter, the valve spindle is closed.

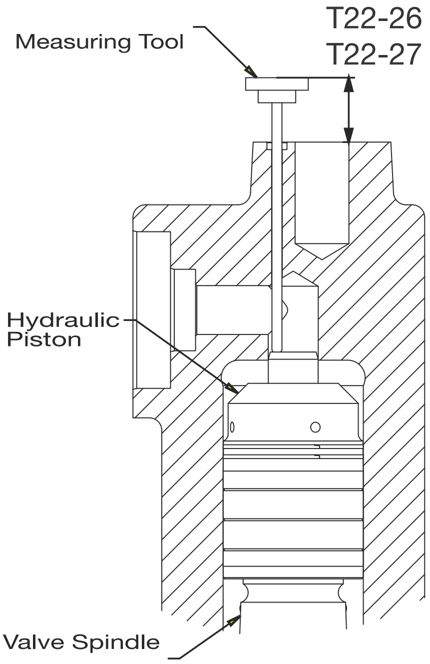


2265-0201-0009C01

Mounting the measuring tool

Remove the eyebolt and the plug.

Place the measuring tool on the damper piston and measure the distance from the top of the tool (T22-26 / T22 – 27) to the top of the oil cylinder. Measurement is to be performed with a calliper gauge.



2265-0201-0009C02

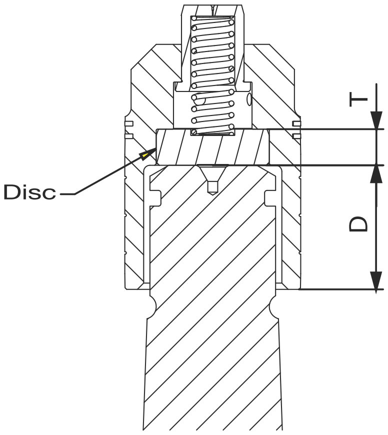
Measurement of limits

If T22-26 / T22-27 is outside the limits (See data), the disk in the hydraulic piston has to be replaced. Therefore the value should be within the specified limits.

The distance measured due to repeated grindings of bottom piece seating and the valve spindle seating may be outside the specified minimum limit. If so, a new disk (thickness reduced by 3 mm) has to replace the original one.

Evaluation and treatment of limits

Nominal thickness "**T**" of the mounted disk is marked on the bottom of the disk. Furthermore, "**T**" can be determined by the equation: **T=102 – D** .



2265-0201-0009C03

In cases where the bottom piece and valve spindle are both exchanged during overhaul, this exchange might cause the distance (T22-26 / T22-27) to move outside the specified limits. Spare disks in thickness steps of 0.5 mm within actual area can be ordered.

Oil piston damper adjustment

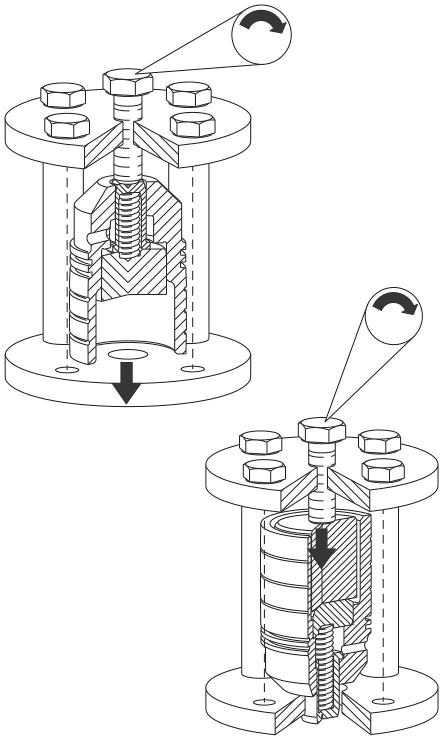
Place the piston in the special tool. Press out the damper piston and the disc using the centre screw.

Inspect the spring and the piston.

A thicker disc decreases the mesh and a thinner disc increases the mesh.

Assemble the damper piston with the new disc in the special tool. Place the piston upside down in the tool and press the disc into place in the piston.

Check the mesh once more.



2265-0201-0005O34

Oil cylinder assembly

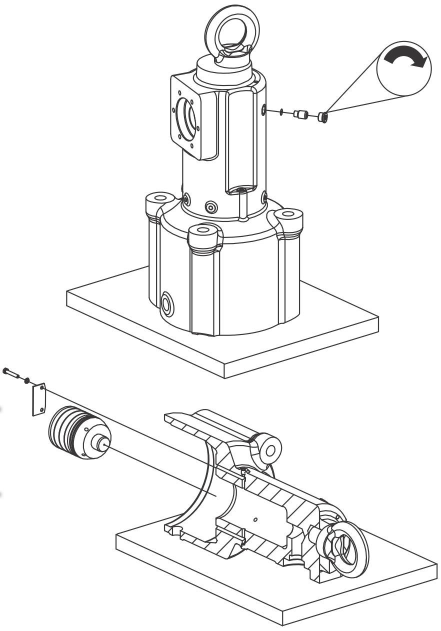
Mount the actuator piston and the flange in the oil cylinder. Tighten and lock the screws.

Mount a new sealing disc in the bore for the orifice plug. Screw the orifice plug into the bore and mount the plug screw.

Return the oil cylinder to an upright position.

NOTE

Cam lock washers, must be mounted correctly, so they lock.



2265-0201-0005O35

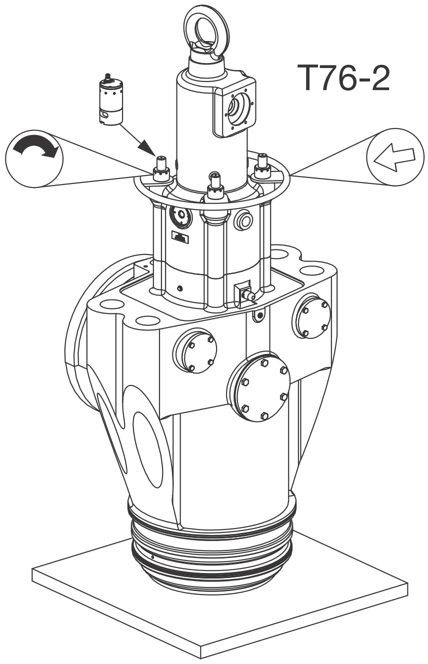
Oil cylinder mounting

Check that a new O-ring has been mounted in the outer groove of the air cylinder.

Mount the overhauled oil cylinder and the safety strap on top of the air cylinder.

Tighten two nuts at a time diagonally.

Screw the nuts onto the studs. Mount 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 the spacer rings. For the use of hydraulic tools, *See also work card 7665-0101*.



2265-0201-0006O36

Checks Before Mounting

Checks before mounting

Before mounting an overhauled exhaust valve on the engine, it is recommended that the valve is checked and prepared as follows:

Check the oil level in the bottom of the air cylinder.

Refill oil as necessary as shown.

Connect compressed air to the air cylinder to close the valve.

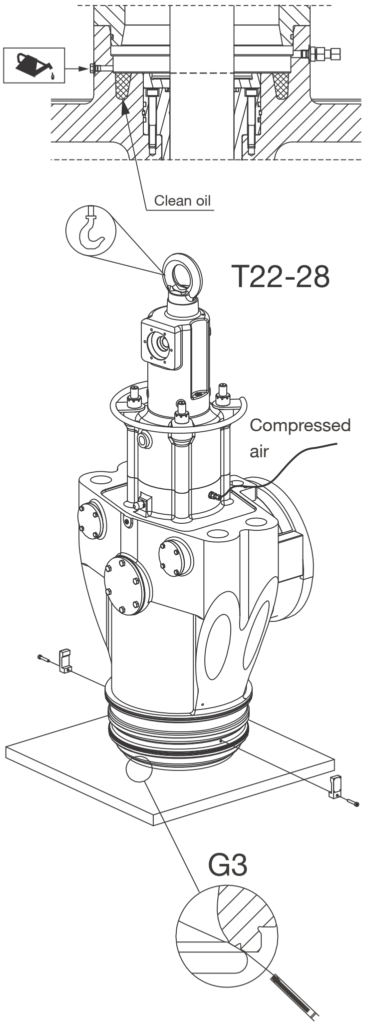
Mount the bottom piece retaining tools.

Lift up the valve with the engine room crane.

Check that a 1.0 mm feeler gauge can be inserted about 15 mm into gap **G**3, to ensure that there is a clearance between the outer parts of the seating faces of valve housing and spindle.

Remove the compressed air supply to the air cylinder.

The valve must be able to stay closed for a minimum of 15 minutes or according to the dropdown test in *work card 2265-0201*.



2265-0201-0006M01

NOTE

If the air piston is fitted with new sealing rings, the time the valve is closed may be considerably shorter than 15 minutes. The dropdown test should not be carried out until after a “running-in” period of 500 hours on valves with new sealing rings.

Check the valve is fitted with new sealing rings in the grooves on the bottom piece.

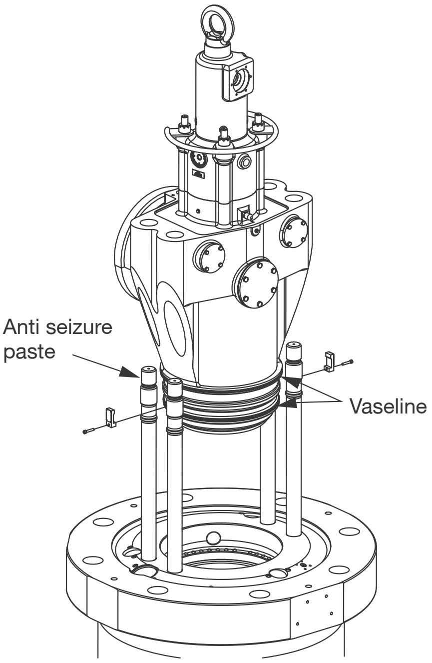
Exhaust valve landing

NOTE

Before mounting the valve on the engine, connect 7 bar working air to the oil cylinder to keep the exhaust valve closed during the mounting process. Remove the retaining tools from the bottom piece.

Lubricate the sealing rings with vaseline and the threads of the studs with anti-seizure paste.

Position the valve in the cylinder cover bore, guiding it in accordance with the exhaust flanges and the guide pin on the exhaust side of the exhaust valve.



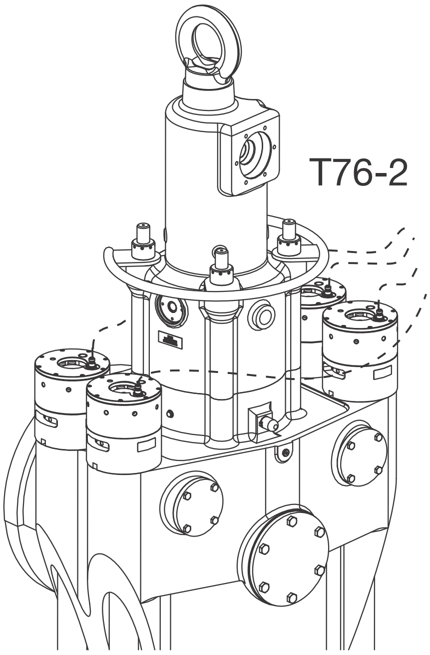
2265-0201-0006M02

Fitting of nuts

Mount and tighten the nuts hydraulically, see Data.

For use of hydraulic tools *See work card 2265-0201*.

Place the protective caps on the exhaust valve studs.



2265-0201-0006M03

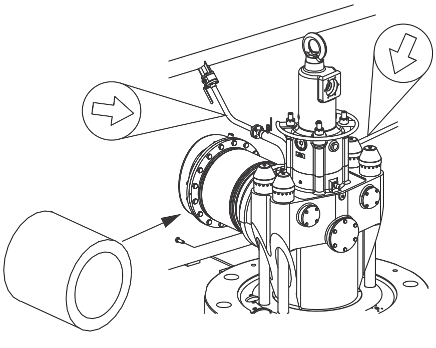
Assemble the pipe connections

Connect the intermediate pipe to the exhaust valve.

Mount and tighten the screws to the exhaust valve housing.

Assemble the insulation and plate jacket for the intermediate pipe if it has been removed.

Assemble the cooling water connections for the exhaust valve and the air pipe for the air spring.



2265-0201-0006M04

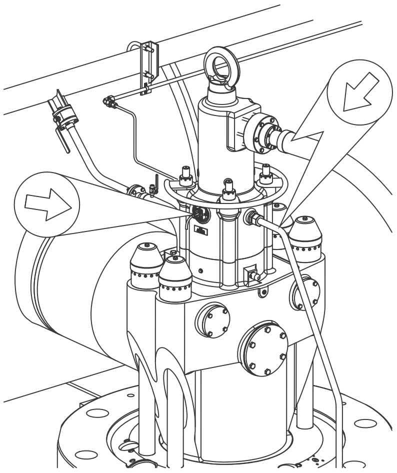
Assemble the oil pipe connections

Connect the high-pressure pipe for the hydraulic valve actuation. *See work card 2265-0201.*

Connect the return oil pipe to the exhaust valve.

Check that all pipe connections are properly tightened.

Connect the electrical plug for the position sensor.



2265-0201-0006M05

Prepare for Operation

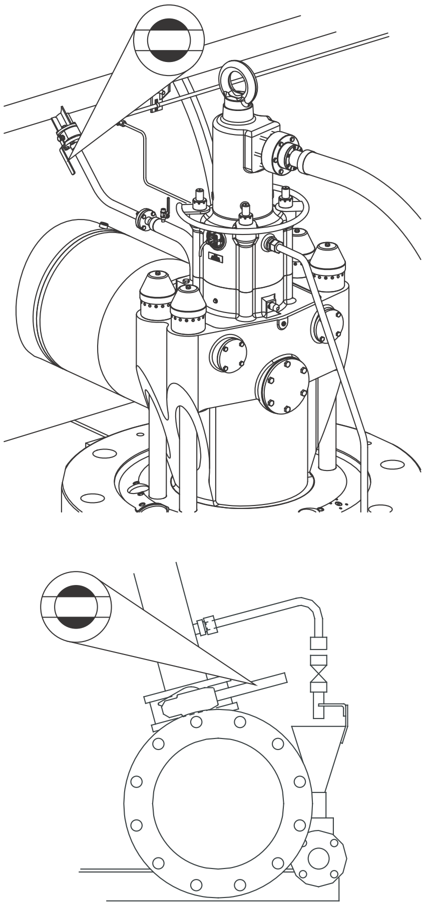
Open cooling water supplyconnections

Check that all water connections are assembled and tightened.

Open the cooling water inlet supply, and vent the exhaust valve, open the cooling water outlet valve.

Open the air supply to the exhaust valve.

Check the tightness of the sealing ring between the bottom piece and the exhaust valve housing. *See work card 2265-0201.*



2265-0201-0006M06

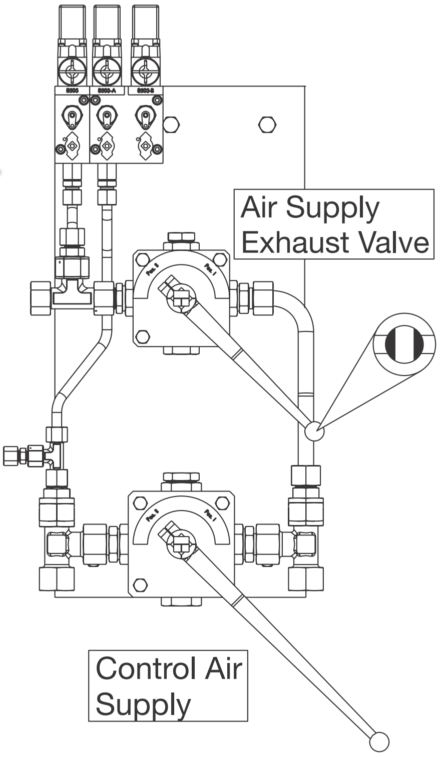
Air supply

The air supply to the exhaust valve must always be connected and pressurized before turning on the oil supply to the exhaust valve actuator.

NOTE

If the lubricating oil pumps have been started before the exhaust valve air springs are pressurized, the valves can move to open position, thus giving starting problems.

To close the exhaust valves as fast as possible, pressurize the air springs, stop the lubrication oil pumps and drain the actuators at the drain screws.



2265-0201-0005M07

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T22-39	Exhaust valve stud, screwing-in torque	550	Nm
T22-40	Starting valve stud, screwing-in torque	240	Nm
T22-41	Fuel valve stud, screwing-in torque	140	Nm
T22-44	Cylinder cover stud, check distance	206-207	mm
T22-46	Cylinder cover, complete	5800	kg
T22-47	Cylinder cover without valves	3700	kg
T22-48	Cooling jacket	140	kg
T22-49	Exhaust valve stud	120	kg
T22-50	Cylinder cover stud	80	kg
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

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
2270-0300	**046**	Grinding tool for exhaust valve seat
2270-0300	**058**	Milling and grinding wheel for fuel valve
2270-0300	**060**	Milling and grinding wheel for starting valve
2270-0300	**083**	Handle for sundry types
2270-0310	**-**	Cylinder cover hydraulic tools
2270-0350	**-**	Cylinder cover lifting tools
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**047**	Hose with unions, 1500 mm
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**131**	9-way distributor block, complete
7670-0200	**-**	Torque spanners

Shut off Oil and Water Supply

Check engine blocking

Check that the engine is stopped and blocked according to the safety precautions given on the data sheet.

Shut off the oil supply

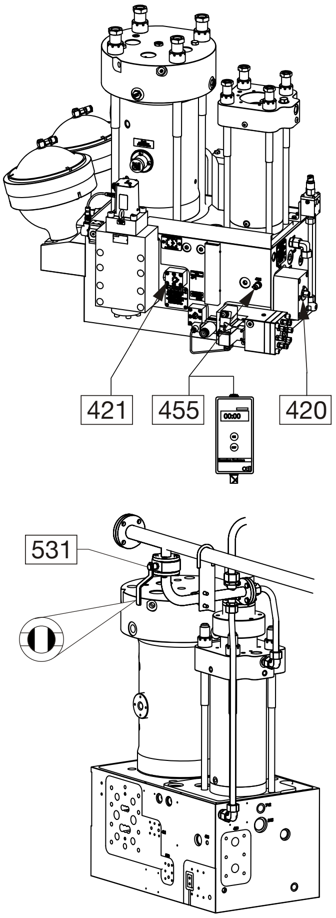
Close the fuel oil supply for the unit concerned.

Fit a pressure gauge in “minimess” point No. 455. Check the pressure.

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

Check that the hydraulic cylinder unit is pressure free.

Close valve 531 for hydraulic operation of the exhaust valve.



2265-0301-0002D02

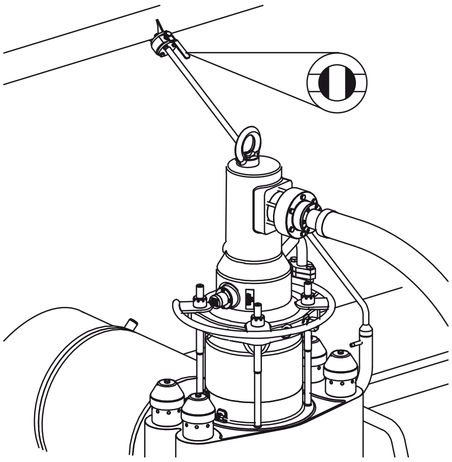
Shut off the water supply

Close the water outlet above the exhaust valve.

Shut off the water supply placed on the exhaust side below the exhaust gas receiver.

Open the drain next to the inlet valve.

Open the venting cock next to the outlet valve.



2265-0301-0011D03

Dismantling of Pipe Connections

Disconnect the oil pipes

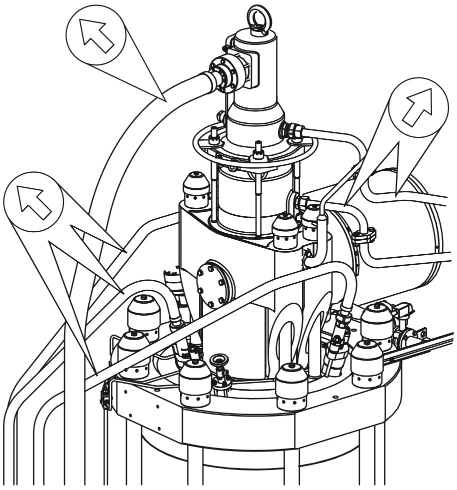
Remove the hydraulic high pressure pipe for the exhaust valve. *See work card 2265-0101.*

Unscrew the drain pipe for the exhaust valve.

Remove the fuel oil high pressure pipes. *See work card 4365-0101.*

Disconnect the pipes for return fuel oil from the fuel valves.

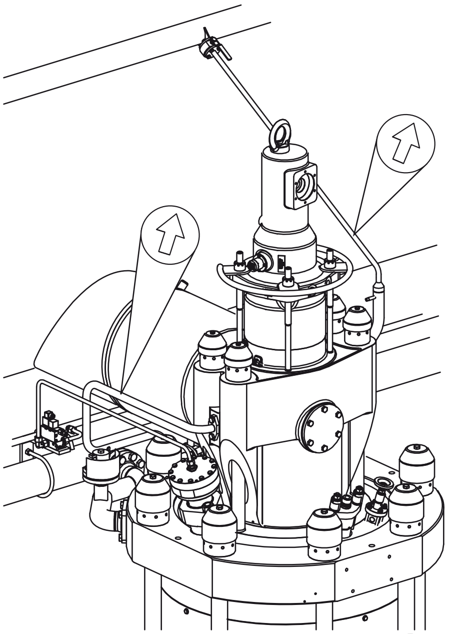
Disconnect the plug for the electrical exhaust valve sensor.



2265-0301-0002D04

Disconnect the water pipes

Unscrew and remove the water outlet pipes.



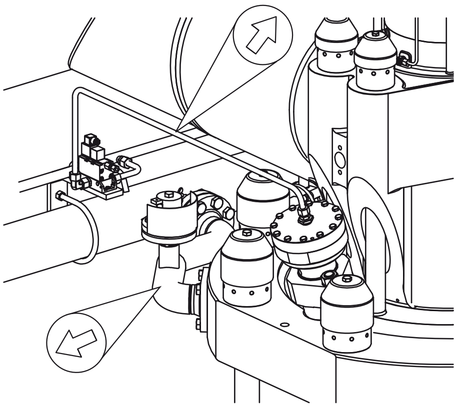
2265-0301-0011D05

Disconnect the starting air pipe

Unscrew and remove the control air pipe for the starting air valve.

Unscrew and remove the air pipe for the starting valve.

Unscrew and remove the air supply to the exhaust valve air spring.



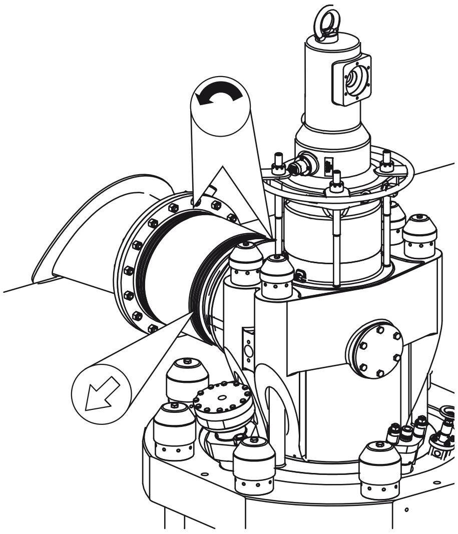
2265-0301-0002D06

Disconnect the exhaust gas compensator

Remove the protective jacket enclosing the insulation for the intermediate pipe or compensator. Remove the insulation.

Remove the bolts in the flange between the intermediate pipe and the exhaust receiver.

Remove the bolts in the flange between the intermediate pipe and the exhaust valve. Remove the intermediate pipe.



2265-0301-0011D07

Cylinder cover loosening

Remove the protective caps from the cylinder cover nuts.

Position the cylinder cover tightening tool over the cylinder cover.

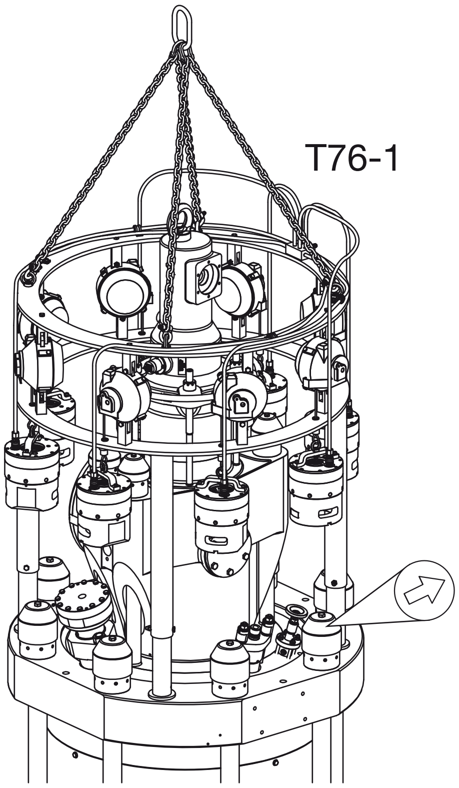
Pull down the spacer rings and the hydraulic jacks over the nuts.

Screw the jack on to the thread of the stud until the cylinder of the jack bears firmly against the spacer ring.

Continue turning until the jacks are completely compressed.

Unscrew the jack by 1 - 1¼ turn back to create a clearance between the jack and spacer ring.

The clearance between the cylinder cover and the spacer ring ensures dismantling of the jack after loosening the nut.



2265-0301-0011D08

Loosen and remove the cylinder cover nuts, *see Data*.

For use of hydraulic tools, *see work card 7665-0101.*

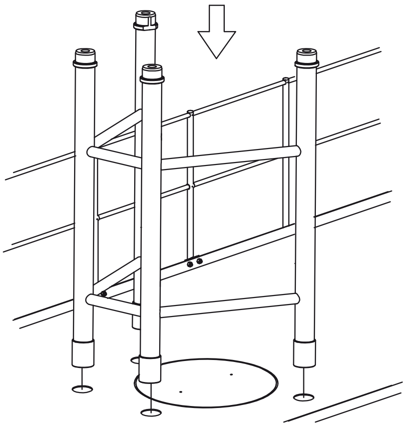
If the cylinder cover is not to be overhauled, the cylinder cover tightening tool may remain placed on the cylinder cover while the cylinder cover is removed from the engine.

If the cylinder cover is to be overhauled, remove the cylinder cover tightening tool from the cylinder cover.

Cylinder cover lifting and landing

Cylinder cover supporting tool

Fit the cylinder cover supporting tool in the purposed holes on the uppermost platform.



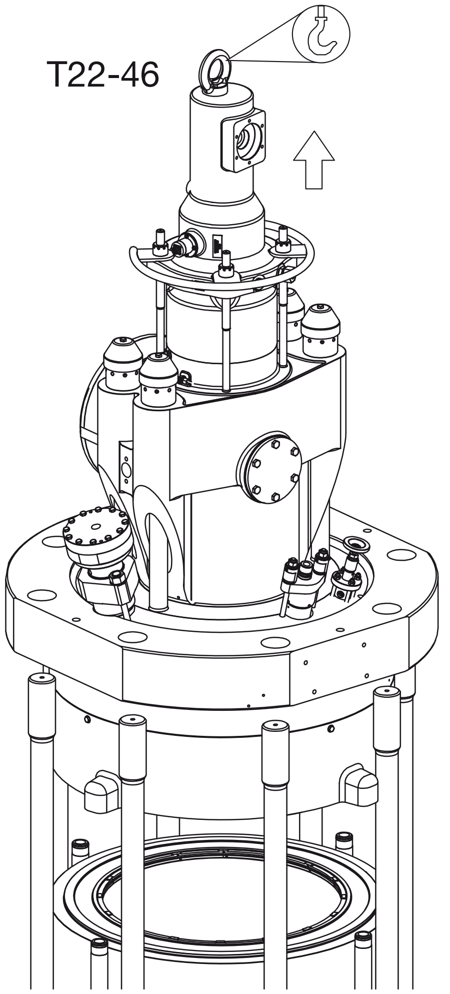
2265-0301-0002D09

Cylinder cover lifting

Hook on the engine room crane to the lifting attachment on top of the exhaust valve.

Check that all cylinder cover connections have been loosened and removed.

Lift away the cylinder cover complete.



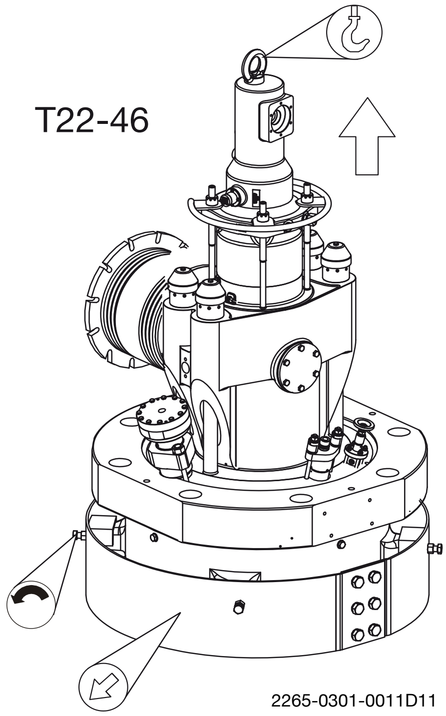
2265-0301-0011D10

Remove the protective shield

If the cylinder is equipped with a protective shield the shield must be removed before landing the cylinder cover.

To remove the shield:

- loosen the four screws
- lift up the shield approx. 100 mm
- turn the shield approx. 30 degrees relative to the cylinder cover.
- lower the shield away from the cylinder cover.
- land the cylinder cover on a couple of wooden planks



2265-0301-0011D11

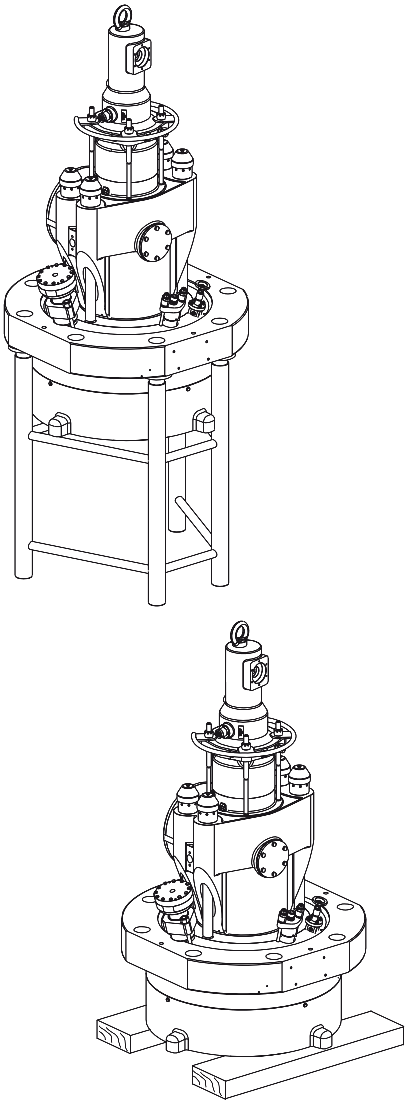
Cylinder cover landing

Land the cylinder cover on the cylinder cover support tool.

If the cylinder cover is to be overhauled it is recommended instead to land the cylinder cover on a couple of wooden planks.

NOTE

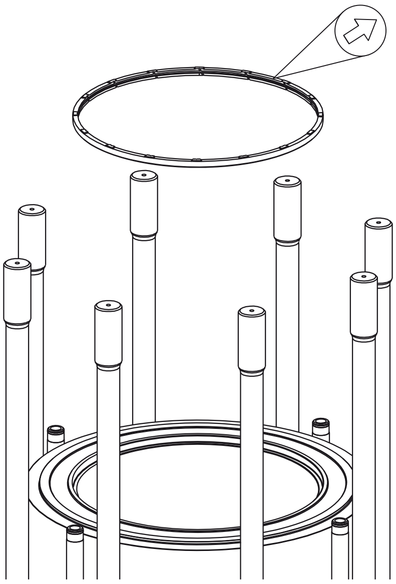
The cylinder cover supporting tool should only be used when the ship is in port.



2265-0301-0011D12

Remove sealing ring

Remove and discard the sealing ring between the cylinder cover and cylinder liner.



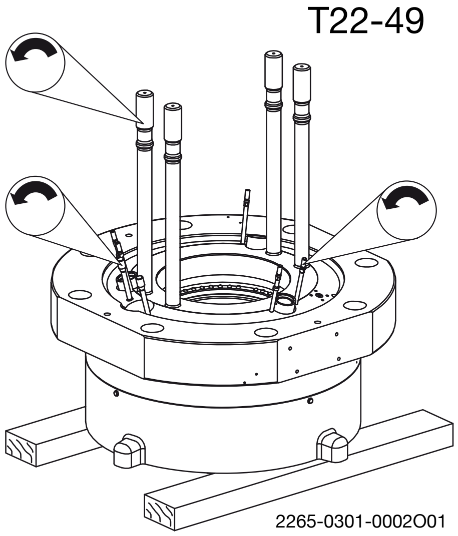
2265-0301-0002D12

Overhaul Preparations

Dismantle valves and pipes

Dismantle all valves and pipes from the cylinder cover.
See work cards 3465-0201, 2265-0101 and 4365-0101.

Remove all studs on top of the cylinder cover.



2265-0301-0002O01

Cooling Water Jacket

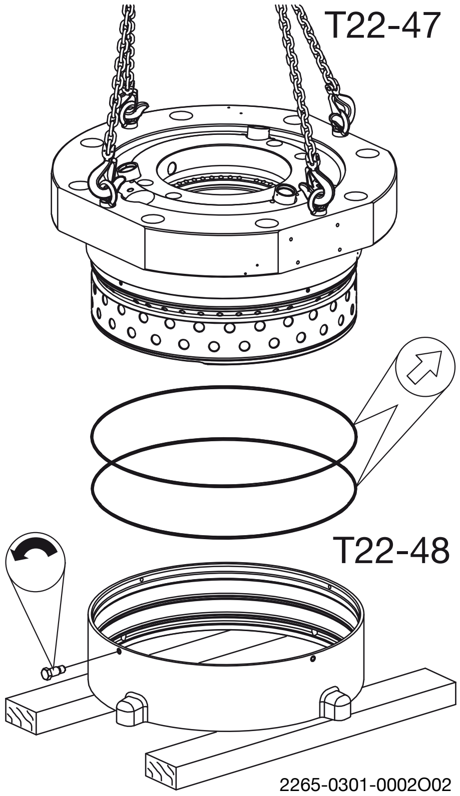
Remove the cooling water jacket

Mount four eyebolts and the lifting chains as shown in the sketch.

Remove the four screws which secure the cylinder cover.

Lift the cylinder cover free of the cooling jacket and land it on a couple of planks.

Remove and discard the O-rings from the cover, and carefully clean the cooling jacket and the cylinder cover.



2265-0301-0002O02

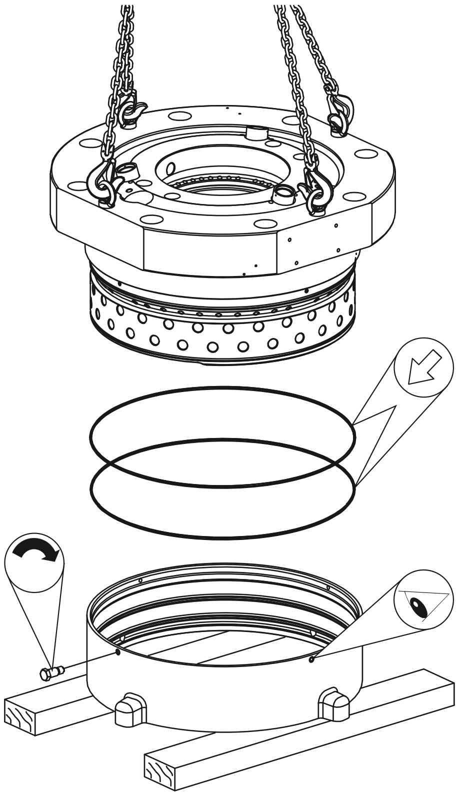
Mount the cooling water jacket

Provide the cylinder cover with new O-rings, well lubricated with vaseline.

Lift the cylinder cover and guide the jacket/ cover into position, using the guide pin as a reference (manoeuvre side).

Fit and tighten the screws for the cooling jacket.

Lubricate the threads with 'Never Seize' or molybdenum disulphide (MoS_2).

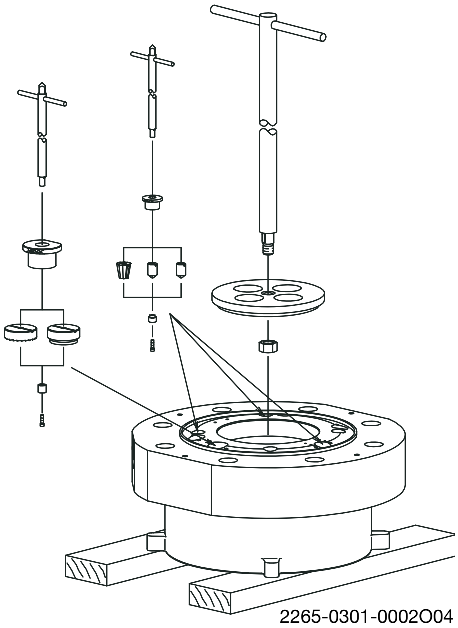


2265-0301-0002O03

Reconditioning of Bores

Seat reconditioning tools

The tools for reconditioning of the valve seats are found on tool panel 2270-0300.



2265-0301-0002O04

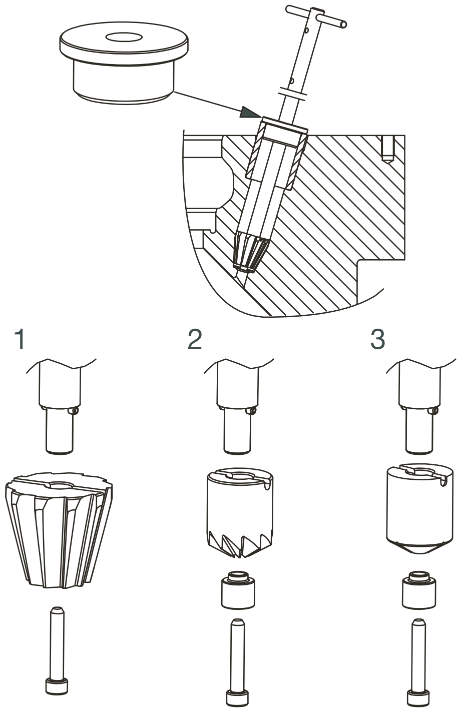
Fuel valve bore

The tool consists of a common spindle with a handle, a guide, a carbon cutter, a seating face cutter and a grinding mandrel.

Clean the fuel valve bores using the carbon cutter. If required, recondition the fuel valve seating with the appropriate cutter.

Grind the seating with the grinding mandrel and a grinding compound (e.g. Carborundum No. 200).

After the milling/grinding, clean the bore and seating carefully, and check that the seating is not damaged.



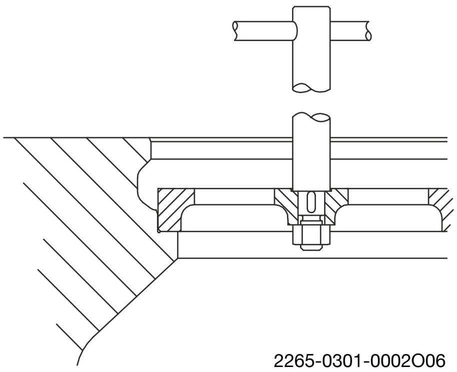
2265-0301-0002O05

Exhaust valve bore

The tool consists of a spindle with a handle and a grinding disc.

After cleaning the valve bore and seating, grind the seating with the grinding disc and a grinding compound (e.g. Carborundum No. 200).

After the grinding, clean the bore and seating carefully, and check that the seating is not damaged.



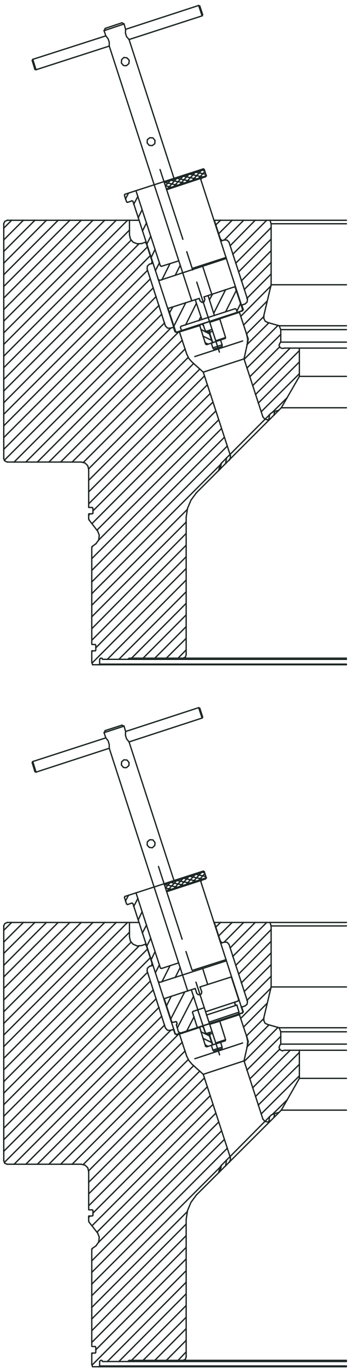
2265-0301-0002O06

Starting valve bore

The tool consists of a guide, a cutter, and a grinding disc.

Recondition the starting valve bore and seating in the same way as described for the fuel valve bore.

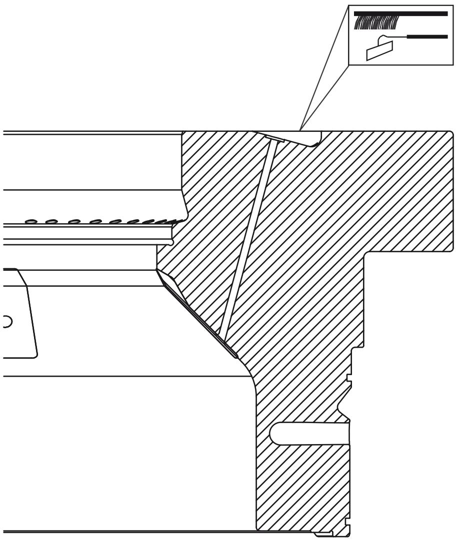
When replacing the valves on a cylinder cover while it is mounted on the engine, recondition the valve bores/seating as described here, however, without removing the studs.



2265-0301-0002O07

Indicator - safety valve bore

Clean the bores for safety valve/ indicator cock.



2265-0301-0002O08

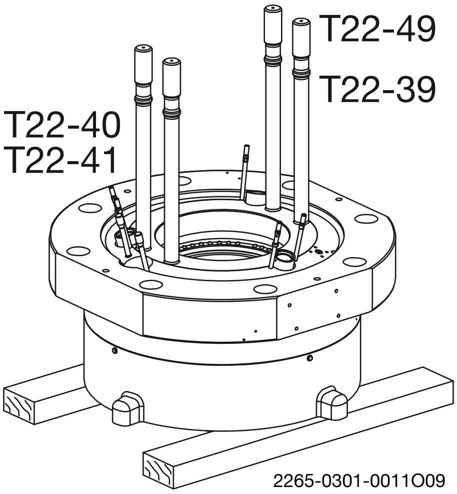
Preparations before Mounting

Fitting of studs

Lubricate the threads with ‘Never Seize’ or molybdenum disulphide (MoS_2) and fit the valve studs.

Tighten up the studs in accordance with the screwing-in torque stated on the data sheet.

Fill up the grooves between the valve studs and the bores for the valve studs with permatex to prevent water or oil from entering the bores during operation of the engine.



2265-0301-0011O09

Mounting of valves

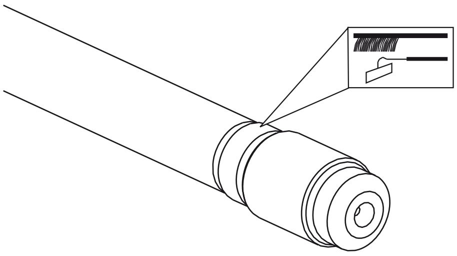
Install the valves on the cylinder cover, *see work cards 3465-0201, 2265-0101 and 4265-0101.*

Mounting of cylinder cover studs

Clean the studs

If a cylinder cover stud has been removed, it must be re-fitted before landing the cylinder cover.

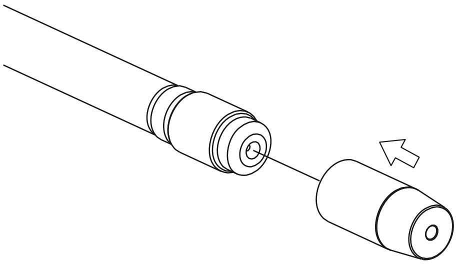
Clean the sealing face for the sealing ring.



2265-0301-0002M01

Fit the cone for sealing ring

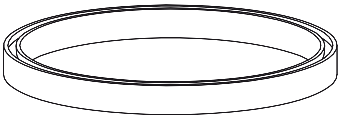
Fit the cone on the bottom end thread of the stud.



2265-0301-0002M02

Heat the sealing rings

Before mounting new sealing rings on the cylinder cover stud, **heat them to 70-100°C,** preferably in oil, for at least five minutes.



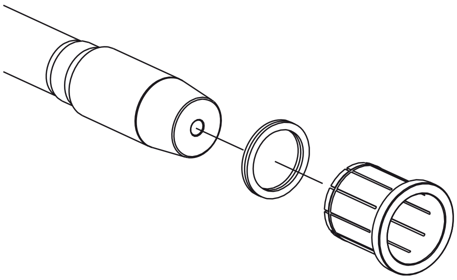
NOTE

Take care not to exceed the temperature limits.

2265-0301-0002M03

Fit the sealing ring

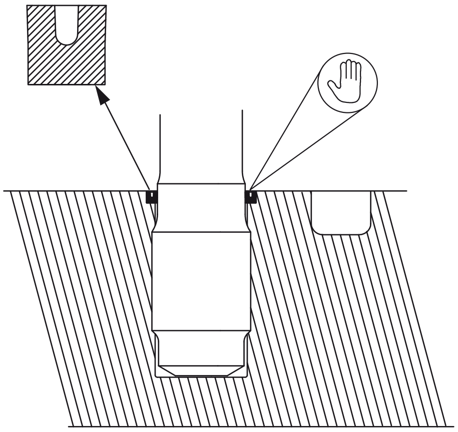
Place the sealing ring on the cone as shown in the sketch. Lubricate the cone with oil. Push on the sealing ring with the pusher. Remove the cone and pusher.



2265-0301-0002M04

Sealing ring

Screw the stud into the cylinder frame. Screw back the stud ¼ revolution. By hand push the sealing ring into the groove in the top of the cylinder frame (see the sketch).



2265-0301-0002M05

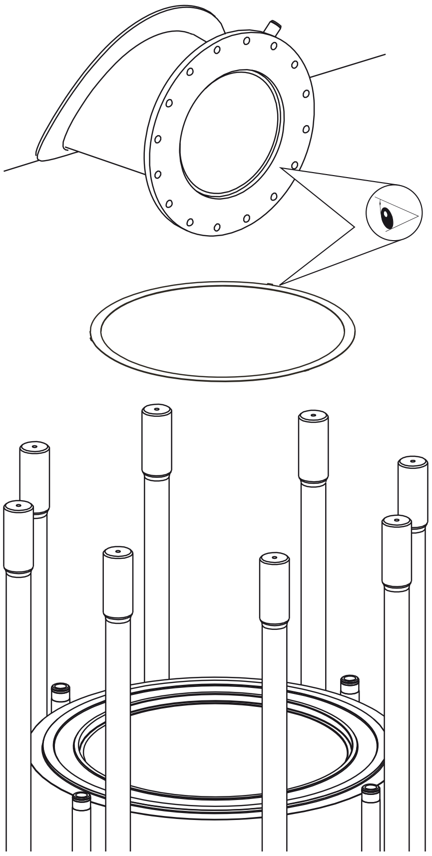
Landing Preparation

Sealing ring

Check that the liner sealing surface is clean.

Place a new sealing ring on top of the cylinder liner.

If necessary fit a new ‘klinger’ sealing ring in the groove of the flange of the intermediate pipe.

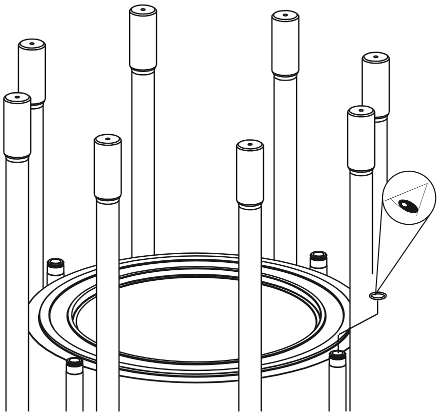


2265-0301-0002M06

Water connections

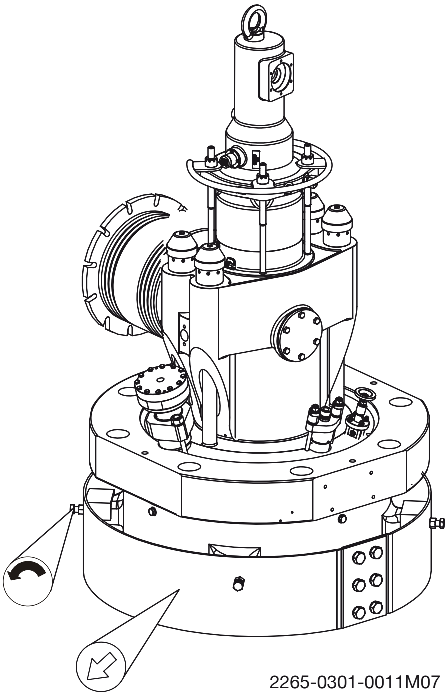
Check that the water connections are clean and provided with new O-rings.

Lubricate the O-rings with Vaseline and fit them on the cylinder liner.



Protective Shield

If the cylinder liner is equipped with a protective shield, this must be mounted on the cylinder cover before the cylinder cover is mounted on the cylinder liner.



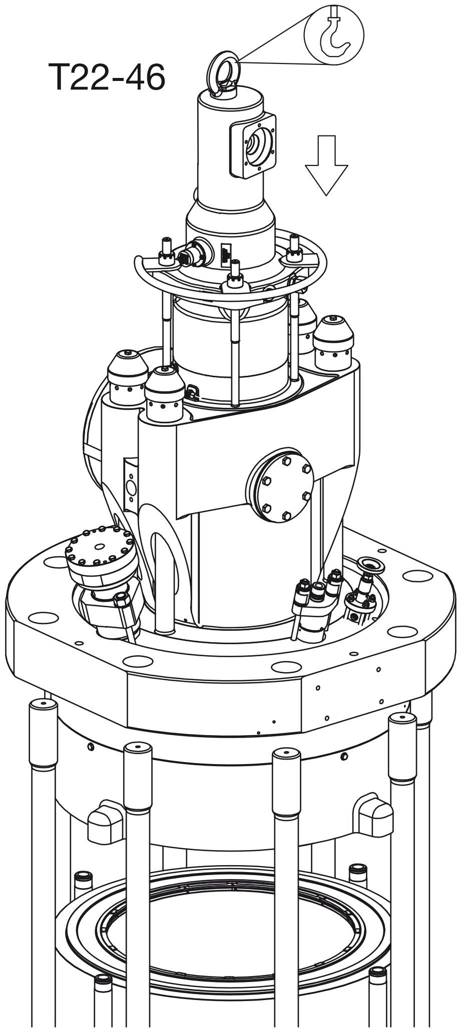
2265-0301-0011M07

Cylinder Cover Mounting

Cylinder cover landing

Carefully wipe the cylinder cover contact surface facing the cylinder liner, while the cover is resting on the support.

Lift the cylinder cover by means of the crane and lower it **carefully** into position. During the landing, **carefully** check that the cooling water connecting pipes engage correctly with the holes in the cooling jacket.

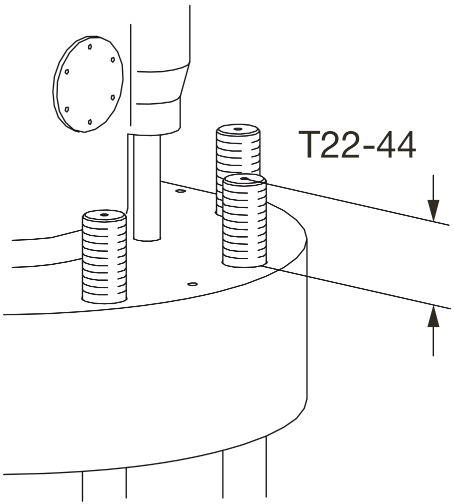


2265-0301-0011M08

Cylinder cover stud - check distance

If the cylinder cover studs have been removed and reinstalled, check the distance the stud is protruding from the cylinder cover.

If necessary, adjust to the distance T22-44 by turning the stud.



2265-0301-0002M09

Cylinder cover tightening

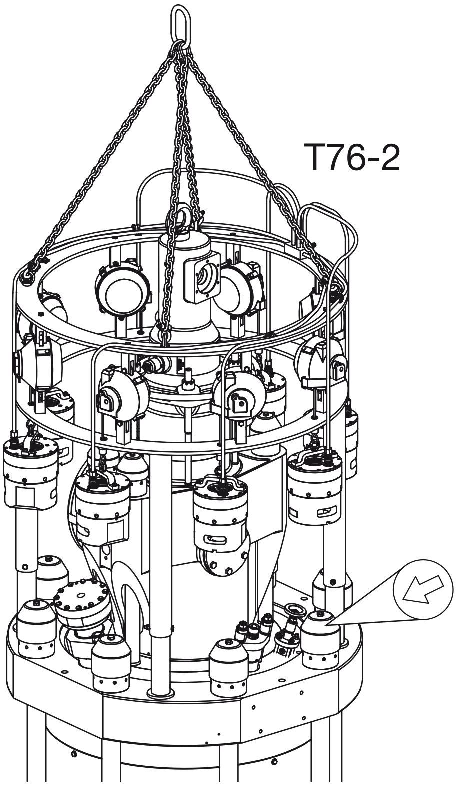
Fit and tighten the cylinder cover nuts.

Screw the jacks onto the studs. Continue turning until the jacks are completely compressed.

Unscrew the jacks 1/8 turn and tighten the nuts.

For operation of hydraulic jacks, *see work card 7665-0101.*

Fit the protective caps on the cylinder cover studs.

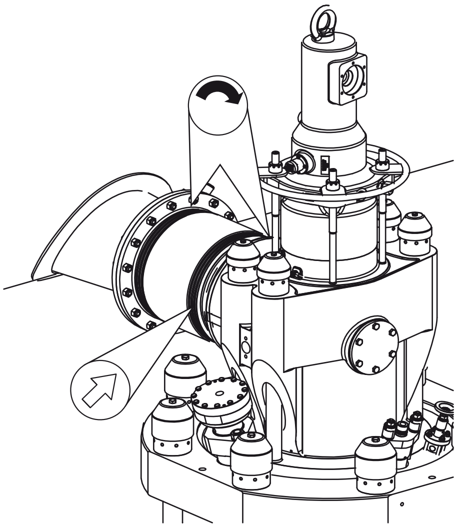


2265-0301-0011M10

Fitting Pipe Connections

Mount the exhaust gas compensator

Fit the intermediate pipe. Fit the bolts in the flange between the intermediate pipe and the exhaust valve. Fit the bolts in the flange between the intermediate pipe and the exhaust receiver.


2265-0301-0002M11

NOTE

Lubricate the bolts with “Never Seize” or molybdenum disulphide (MoS_2)

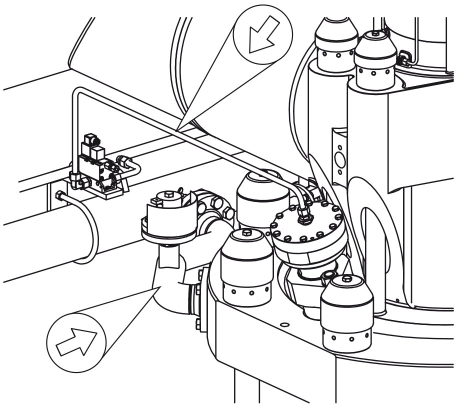
Fit the insulation. Fit the protective jacket enclosing the insulation.

Connect the starting air pipe

Connect and tighten the air pipe for the starting valve.

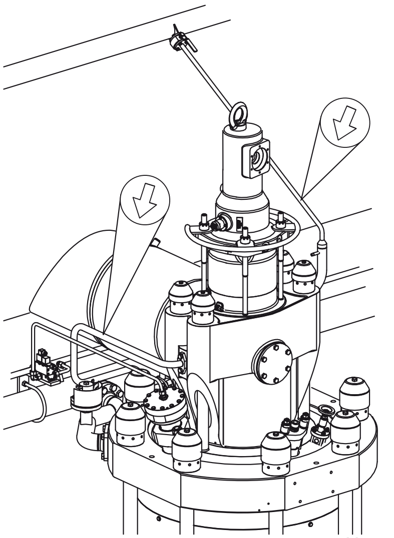
Connect and tighten the control air pipe for the starting air valve.

Connect the air supply pipe for the exhaust valve air spring.


2265-0301-0002M12

Connect the water pipes

Mount and tighten the water outlet pipes.


2265-0301-0011M13

Connect the oil pipes

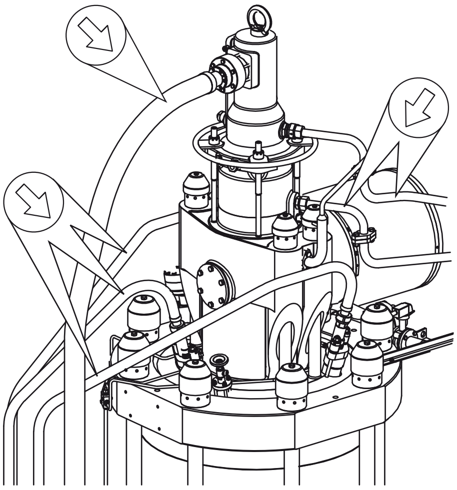
Mount the hydraulic high pressure pipe for the exhaust valve. *See work card 2265-0101.*

Connect the drain pipe for the exhaust valve.

Connect the fuel oil high pressure pipes. *See work card 4365-0101.*

Connect the pipes for return fuel oil from the fuel valves.

Connect the plug for the electrical exhaust valve sensor.



2265-0301-0002M14

Open Oil and Water Supply

Close the drain and open the water supply

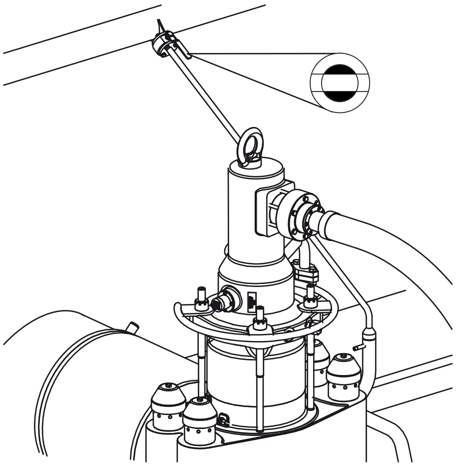
Close the venting cock next to the outlet valve.

Close the drain next to the inlet valve.

Slowly open the water supply valve, placed next to the cylinder liner cooling water jacket on the exhaust side.

Vent the unit by releasing air through the venting cock next to the outlet valve.

When the venting is finished, close the venting cock. Open the water outlet valve on the exhaust side.



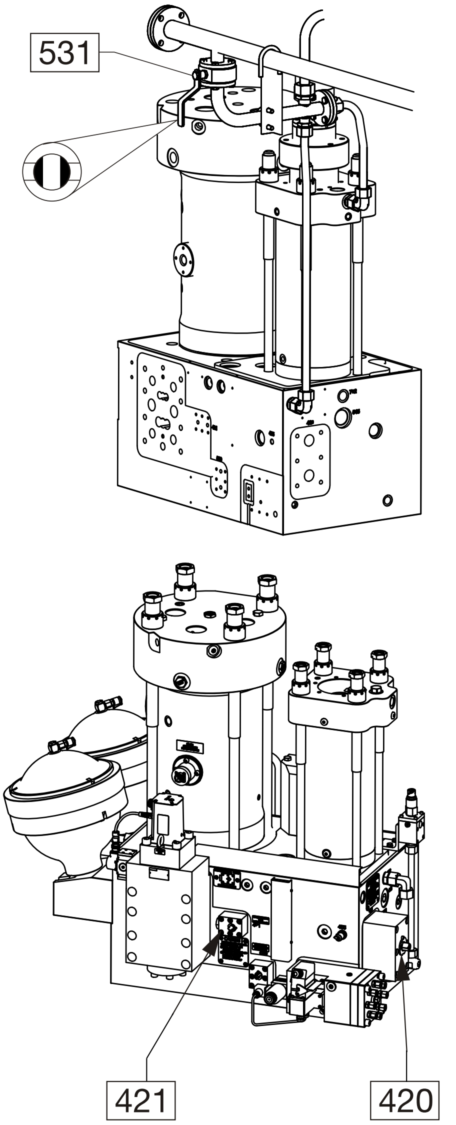
2265-0301-0011M15

Open the oil supply

Open the fuel oil supply for the unit concerned.

Open valve 531 for hydraulic operation of the exhaust valve.

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



2265-0301-0002M16

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T22-53	Test pressure	7	bar
T22-57	Piston skirt, tightening torque	380	Nm
T22-58	Cooling oil pipe, tightening torque	190	Nm
T22-59	Lifting tool, tightening torque	200	Nm
T22-62	Piston ring new, radial width	25.2	mm
T22-63	Piston ring worn, min. radial width	21.2	mm
T22-64	Groove No. 1, max. vertical height	18.8	mm
T22-65	Groove Nos. 2, 3 and 4, max. vertical height	14.8	mm
T22-66	Piston top, max. permissible burn-away	9	mm
T22-67	Piston ring new, height of ring No. 1	17.9	mm
T22-68	Piston rings new, height of ring Nos. 2, 3 and 4	13.9	mm
T22-69	CPR ring CL groove, min. depth	1.8	mm
T22-70	Minimum free ring gap (before dismantling)	44	mm
T22-71	Minimum ring gap, ring No. 1 (new ring in new liner)	5.6	mm
T22-72	Minimum ring gap, ring Nos. 2, 3 and 4 (new ring in new liner)	4	mm
T22-73	Vertical clearance, new parts	0.48	mm
T22-74	Vertical clearance, worn parts, max.	0.97	mm
T22-75	Piston top centre, max. permissible burn-away	9	mm
T22-76	Piston top centre diameter	375	mm
T22-77	Piston top outer ring area, max. permissible burn-away	6	mm
T22-78	Piston complete	3800	kg

Ref.	Description	Value	Unit
T22-079	Piston crown	1000	kg
T22-80	Piston rod	2500	kg
T22-81	Piston skirt	180	kg
T22-82	Piston cooling pipe	55	kg
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

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

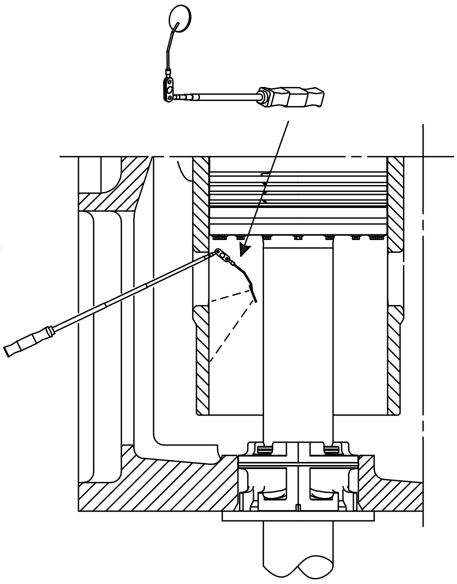
Plate	Item No.	Description
1470-0300	**124**	Rubber cover for crosshead
2270-0400	**040**	Lifting tool for piston rod foot
2270-0400	**075**	Template for piston top
2270-0400	**099**	Cover for stuffing box hole
2270-0400	**110**	Pressure test tool for piston
2270-0400	**134**	Piston ring expander
2270-0400	**158**	Guide screw for piston crown
2270-0430	**-**	Piston guide tool
2270-0470	**-**	Piston support tool
2270-0480	**-**	Piston lifting tool
7670-0200	**-**	Torque spanners
7670-0410	**066**	Slide caliper

Scavenge Port Inspection

To detect possible leakages from the piston or cylinder cover, keep the cooling water and cooling oil circulating during the scavenge port inspection.

Inspection - how to

The scavenge port inspection is carried out from the scavenge air receiver. An additional view of the rings is possible through the cleaning cover on the manoeuvring side.



2265-0401-0002C01

NOTE

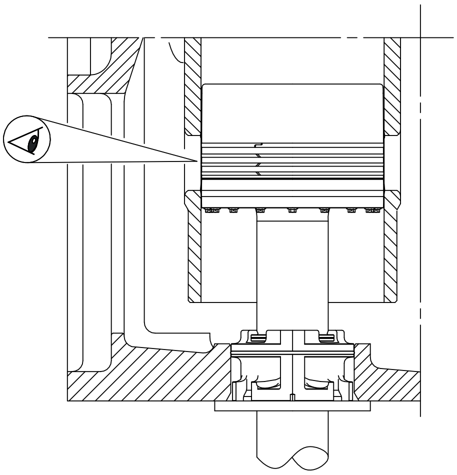
The access cover to the scavenge air receiver must be locked and secured in open position during the inspection.

Turn the engine at least ½ a revolution, and begin with a unit arriving downwards, just above the scavenge air ports. Inspect the piston rod and the lower part of the cylinder wall.

While the piston is passing downwards, inspect the piston skirt, all the piston rings, the ring lands and the piston top.

Ring inspection

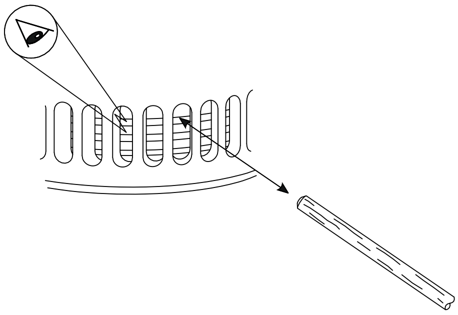
Inspect the rings, one at a time, and note down the results. *See Volume I, Operation, Chapter 707.*



2265-0401-0002C02

Ring tension

Check the tension of the piston rings, by pressing against them with a wooden stick. It is not possible to move a ring in good condition.

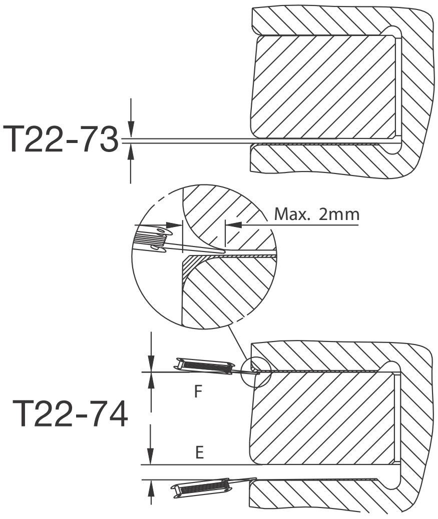


2265-0401-0002C03

Ring grooves

Measure the total clearance between the piston ring and the ring groove. The total clearance **must not** exceed the value stated in Data.

Measure the clearance at the top (E) and bottom (F) of the piston ring groove. Total clearance = E + F.

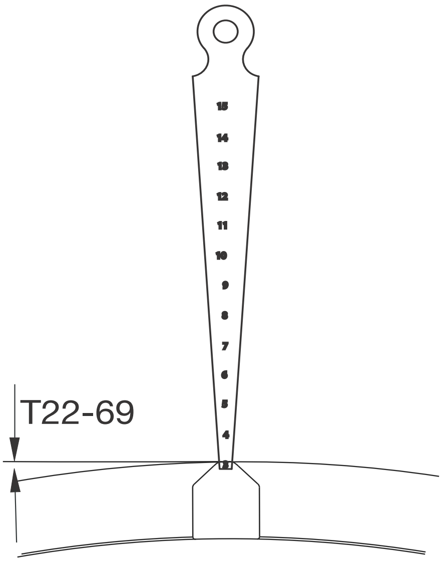


2265-0401-0008C04

For engines with CPR-POP ring (Port-On-Plan) installed:

To measure the wear of the ring, the width of the leakage passage can be measured using a feeler-gauge-type measuring tool.

The opening is 3 mm from the beginning, and the milled passage is designed in such a way that for every 1 mm the ring is worn radially, the gab opens 2 mm. For maximum allowable widt of the leakage gab see data T22-69.



2265-0401-0008C045

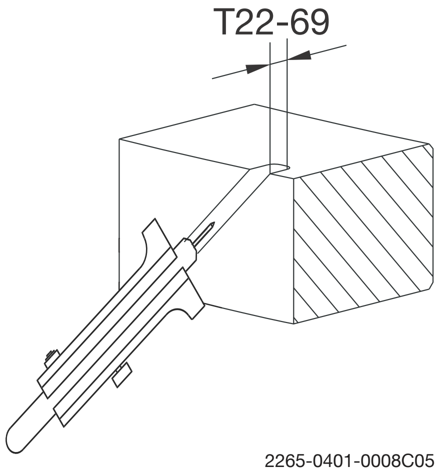
Checking, in connection with piston overhaul

NOTE

It is recommended to replace all the piston rings whenever a piston is removed from the engine.

For engines with CPR-CL ring installed:

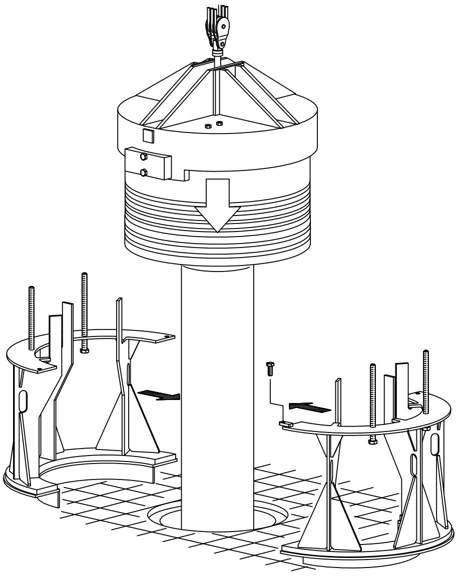
If possible, measure the depth of the pressure relief grooves with a slide calliper. The piston rings must be replaced if the radial depth of the grooves has worn down to less than stated in Data T22-69.



2265-0401-0008C05

Piston support

Remove the piston from the cylinder and place it on the piston support. *See description 2245-0100. For evaluation of the rings, see Volume I.*

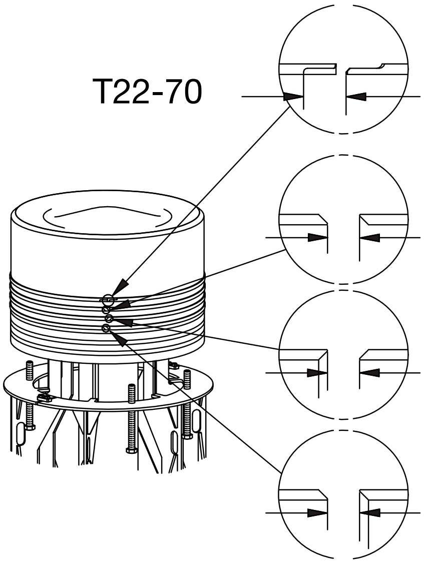


2265-0401-0002C06

Free ring gap

Before dismantling the piston rings, measure the free ring gap of all the piston rings.

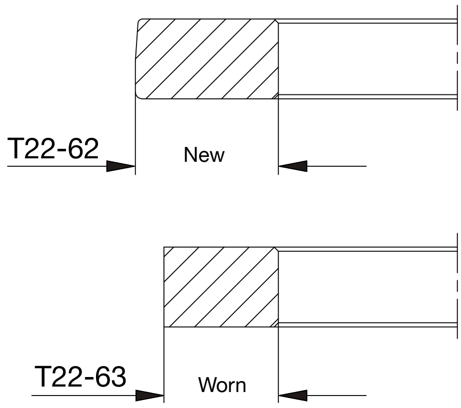
For dismantling the piston rings, see overhaul.



2265-0401-0002C07

Radial ring width

Measure the radial width of the rings. Note down the results. *See Volume I, Operation, Chapter 707.*



2265-0401-0002C08

Ring grooves

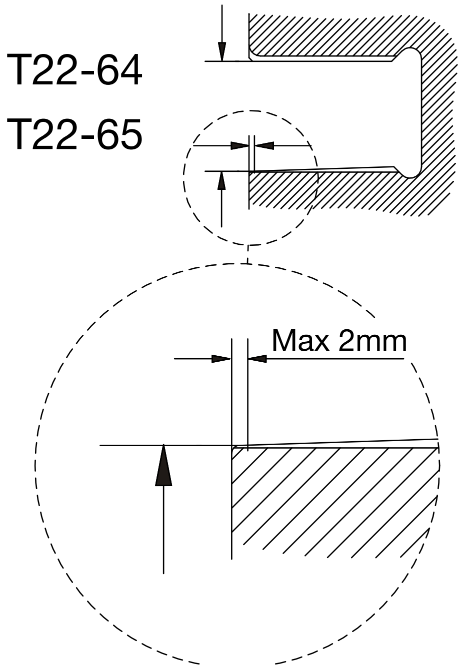
Clean the ring grooves and check them for burn marks or other deformation.

Measure the ring grooves with a calliper gauge, *see Data T22-64 and T22-65.*

Clearance in piston ring grooves:

The maximum vertical height in a worn ring groove **must not** exceed the value stated in Data. The groove is also worn out if there is no chromium layer.

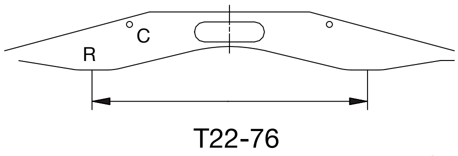
If the ring grooves are worn out, the piston crown must be reconditioned, contact MAN Diesel for advice.



2265-0401-0002C09

Piston top template

Check that the piston top template is permanently marked with the piston top centre diameter T22-76.



2265-0401-0002C10

Check that the centre area **C** has been marked off, and write the maximum permissible burn-away rate on the template. *See data T22-75.*

Mark the outer part of the template **R** for ring area, and write the maximum permissible burn-away rate for the ring shaped area. *See data T22-77.*

Piston crown top

Clean the piston crown and check the burn-away by means of the template.

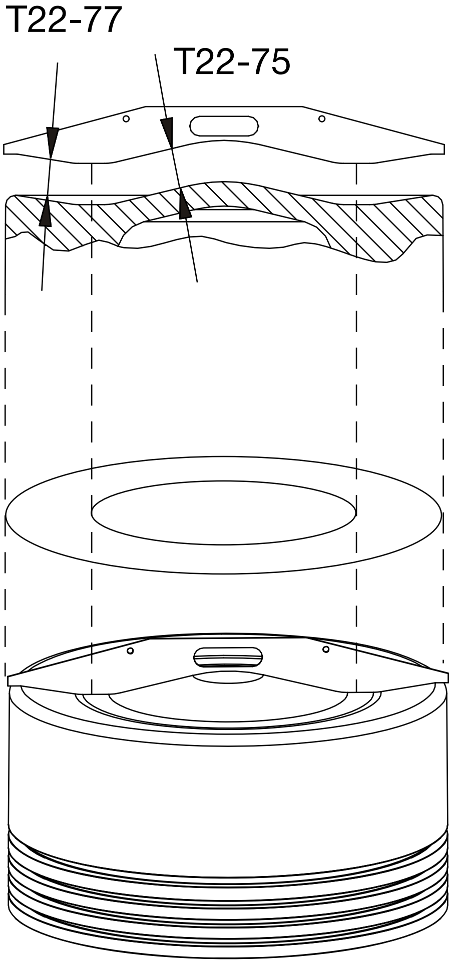
For maximum permissible burn away on the piston top centre area, see Data T22-75.

For the ring shaped area, see Data T22-77.

Check the burn-away on the whole circumference of the piston crown top.

If the burn-away exceeds the values given in Data, contact MAN Diesel for advice.

Note down the results for later reference.

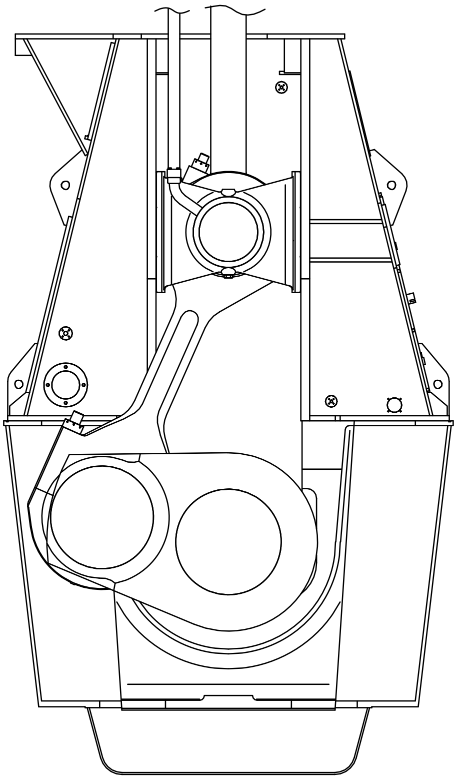


2265-0401-0002C11

Preparations in the crankcase

Open the crankcase door to the cylinder concerned.

Turn the crosshead down far enough to give access to the piston rod stuffing box and the piston rod/crosshead connection.



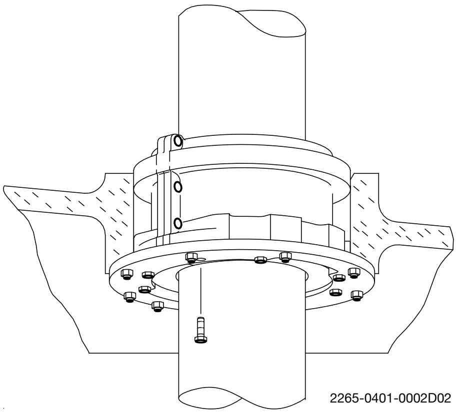
2265-0401-0002D01

Stuffing box

Release the stuffing box by removing the innermost screws from the stuffing box flange.

On engine models where the drain pipe is connected directly to the stuffing box:

- Disconnect the stuffing box drain pipe.



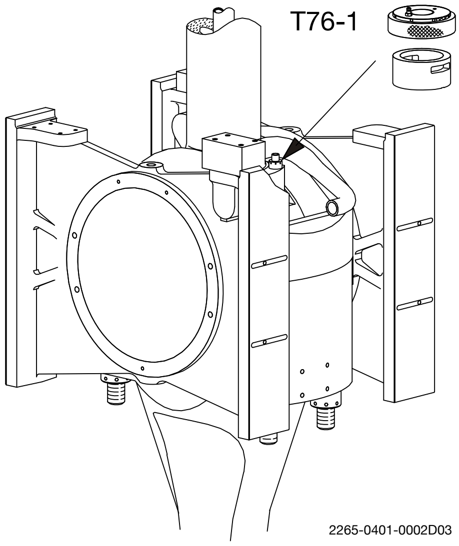
2265-0401-0002D02

NOTE

Do **NOT** remove the outermost screws from the flange.

Loosen the piston rod-crosshead connection

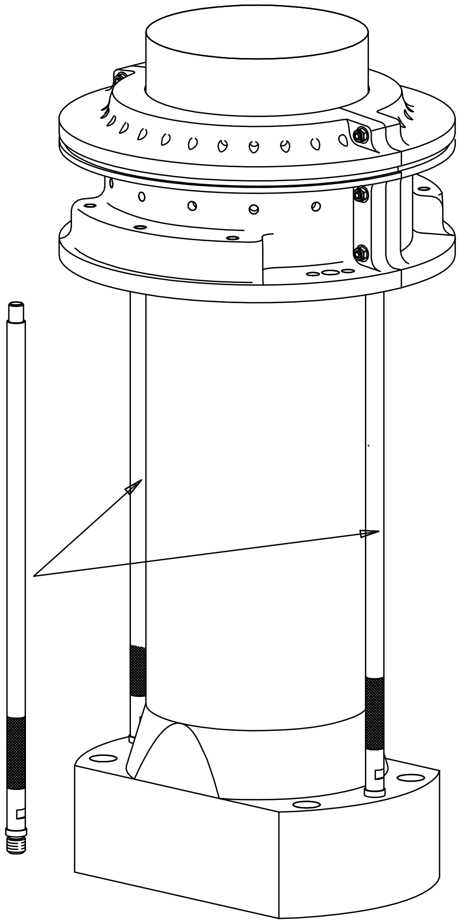
Loosen and remove the hydraulic nuts, *see Data. See work card 7665-01.*



2265-0401-0002D03

Stuffing box distance pieces

Mount the two distance pieces on the piston rod foot to protect the lower scraper ring and to guide the stuffing box.



2265-0401-0002D04

Preparations on the cylinder top

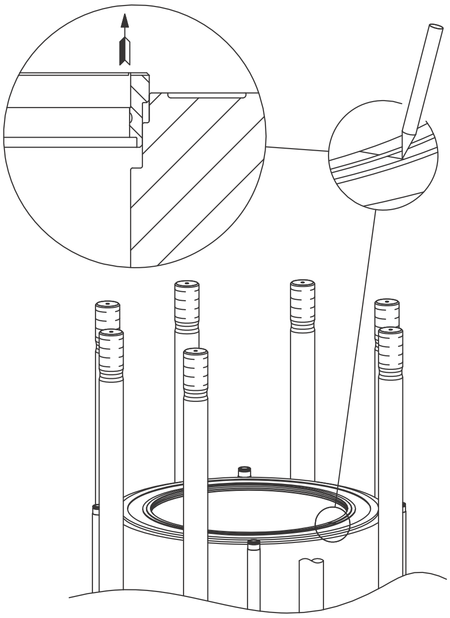
Cylinder cover

Remove the cylinder cover. *See work card 2265-0301.*

Make a scratch mark in liner and piston cleaning ring to ensure correct re-mounting. Remove the piston cleaning ring.

Carefully remove any wear ridges at the top of the cylinder liner. *See work card 2265-0601.*

If necessary, remove the aftmost access platform for the unit concerned. On some engine installations, this will be necessary to give room for the piston rod foot.



2265-0401-0016D05

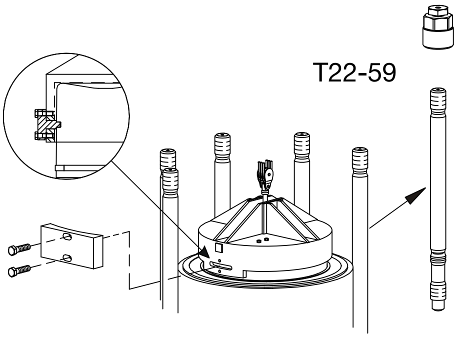
Piston lifting tool

Turn the piston to TDC. The top of the piston is now free of the cylinder liner.

Clean the lifting groove of the piston crown and mount the lifting tool.

NOTE

Make sure to mount the lifting tool correctly, so that the claws of the lifting tool enter the lifting grooves of the piston crown.



2265-0401-0002D06

If the engine is not equipped with long distance pieces, remove one or two cylinder cover studs, using a stud setter.

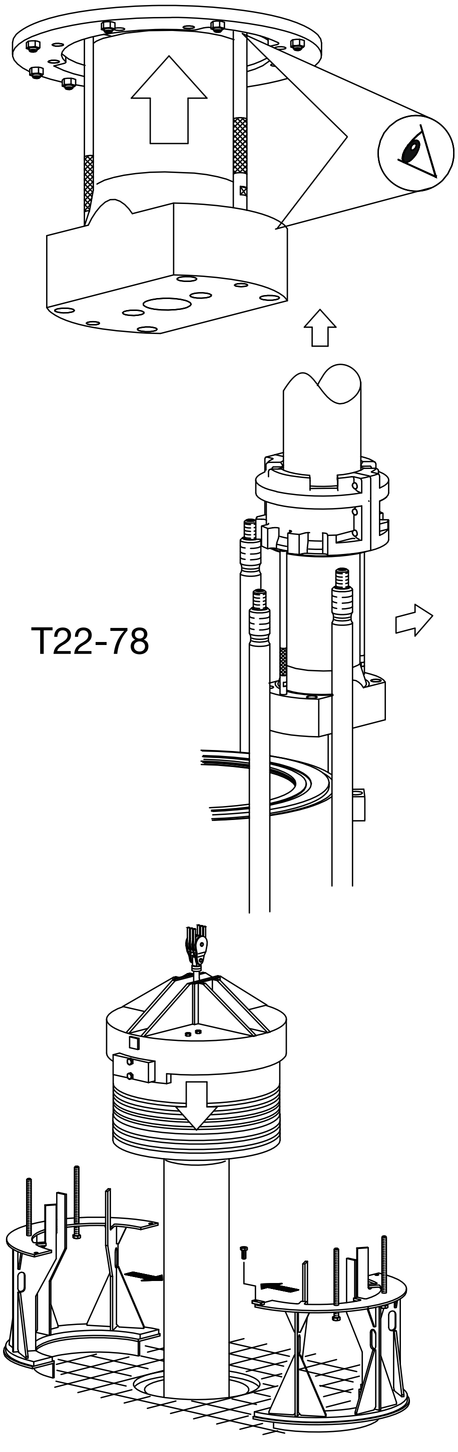
Piston lift

Lift the piston out of the cylinder liner and guide the piston rod foot through the stuffing box flange.

If the engine is equipped with long distance pieces for the stuffing box, the piston rod foot can pass between two cylinder cover studs.

Place the two halves of the support around one of the openings in the platform. Lower the piston rod foot and stuffing box through the opening in the platform. Secure the two support halves with screws and lower the piston on the support. Check the piston is resting on the piston rod flange.

Limited lifting height:
If the piston rod foot can not be lifted clear of the liner top with the standard lifting tool, contact MAN Diesel for instructions for tilted lift.



2265-0401-0002D07

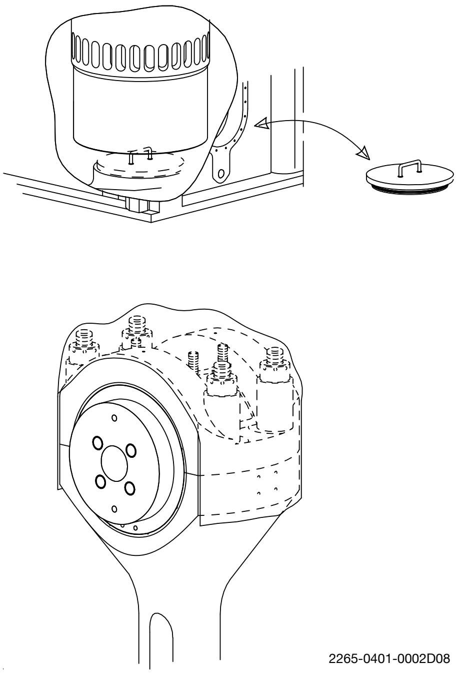
Protect the crosshead bearing

Place a cover over the opening for the piston rod stuffing box at the bottom of the cylinder unit.

Turn the crosshead down far enough to permit mounting of the protective rubber cover on the crosshead bearing cap. The protective rubber cover is found on tool panel 904.

The covers must remain in place to protect the crosshead bearing journal from impurities until the piston is remounted.

Clean, measure and recondition the cylinder liner. *See work card 7665-01.*


2265-0401-0002D08

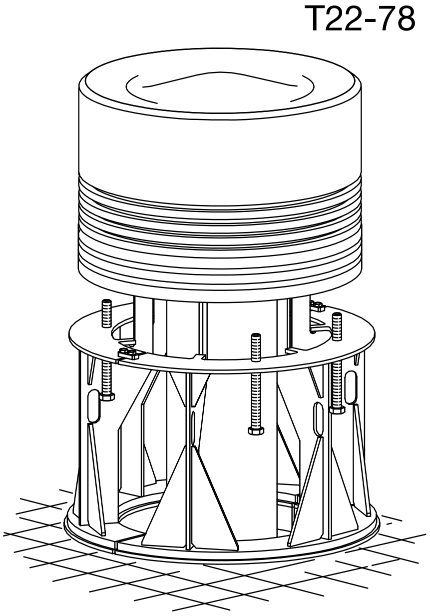
Piston support

Place the piston in the support and remove the piston lifting tool. *See Dismantling.*

Clean the piston top and the piston rings.

Check the free ring gap and the burn-off on the piston top. *See Checking.*

Remove the stuffing box. *See work card 2265-05.*



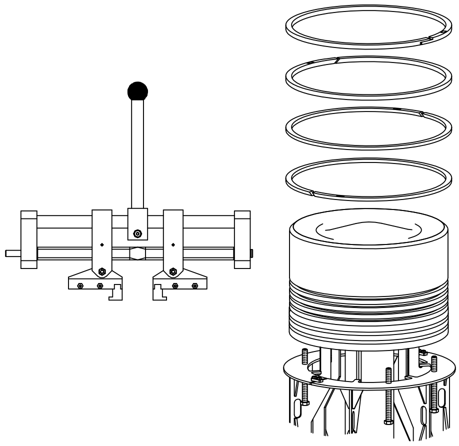
2265-0401-0002O01

Piston ring dismantling

Take off the piston rings by means of the ring expanders. If the engine is equipped with two ring expanders, the short ring expander is for the uppermost ring.

First remove the uppermost ring, then ring No. two, three and four.

Clean and inspect the rings and the ring grooves. *See Checking.*



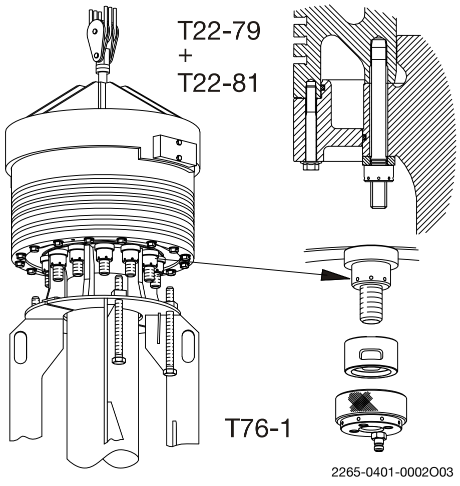
2265-0401-0002O02

Piston crown dismantling

Loosen and remove the hydraulic nuts between the rod and the piston crown. *See Data.*

For operation of hydraulic tools, see work card 7665-01.

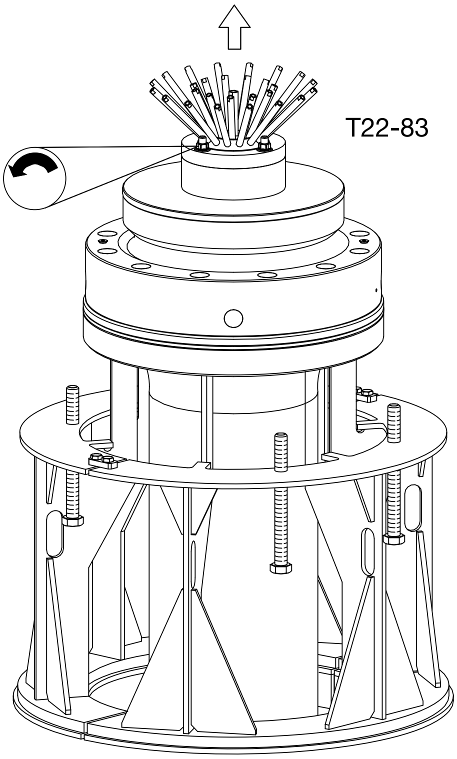
Lift the piston crown and skirt clear of the piston rod.



2265-0401-0002O03

Cooling insert

Unscrew and remove the nuts for the cooling insert. Remove the cooling insert. Clean and inspect the cooling insert.



2265-0401-0002O04

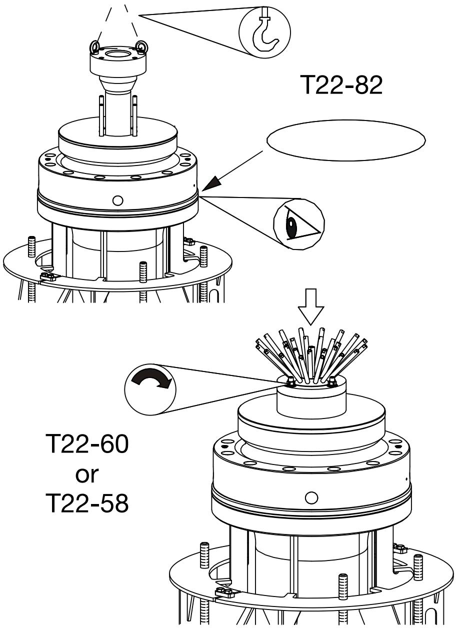
Piston rod and cooling pipe

Screw on the eyebolts and lift out the cooling oil pipe.

Clean and inspect the cooling oil pipe and the piston rod, then reinsert the cooling oil pipe. Refit the cooling insert and tighten the nuts as specified *in Data.*

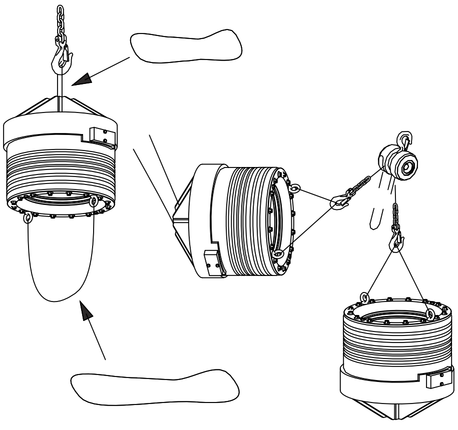
Check that the surfaces of the O-ring groove are clean and smooth.

Fit a new O-ring on the piston rod flange.



2265-0401-0002O05

Piston crown turning



2265-0401-0002O06

Unhook the crane from the piston lifting tool, and connect the lifting tool and the crane hook by means of a wire rope. Lift up the piston crown.

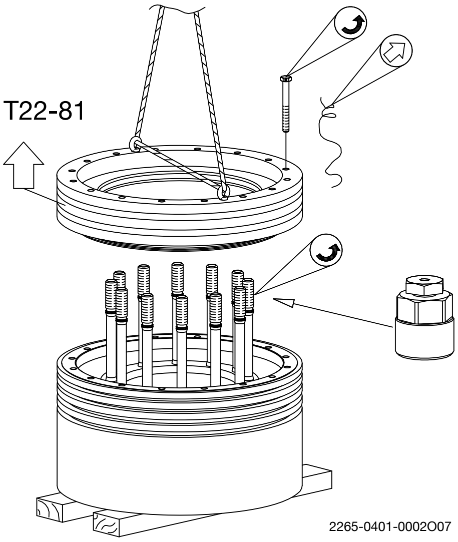
Fit two eyebolts in the piston skirt and a wire rope between the bolts as shown in the sketch.

Install a tackle in a suitable place with sufficient space below for the piston crown. Attach the tackle to the wire rope on the piston skirt and carefully turn the piston crown upside down.

Use both cranes if the engine room is equipped with two cranes.

Land the piston lifting tool and the piston crown on a sufficient support of wood pieces. Loosen the piston lifting tool and lift the piston crown clear of the tool.

Piston crown dismantling and cleaning



2265-0401-0002O07

Place the piston crown with skirt on a wooden support as shown.

Remove the locking wire and the screws in the skirt. If necessary, use two dismantling screws to pull the skirt off the piston crown. Mount two eyebolts in the skirt. Lift the skirt and land it on a couple of planks.

Discard the sealing ring on the piston skirt.

Thoroughly clean and inspect all parts of the crown and skirt. If coke deposits are found in the cooling spaces of the piston crown, the coke deposits should be washed out with Carbon Remover or a similar cleaning fluid. When all coke deposits have been dissolved, clean and inspect the piston crown again.

NOTE

Coke deposits reduce the heat transfer from the piston crown to the cooling oil. The deposits must be removed as a routine procedure when a piston is overhauled.

If the piston crown is renewed, remove the piston crown studs using a stud setter.

Piston crown assembly

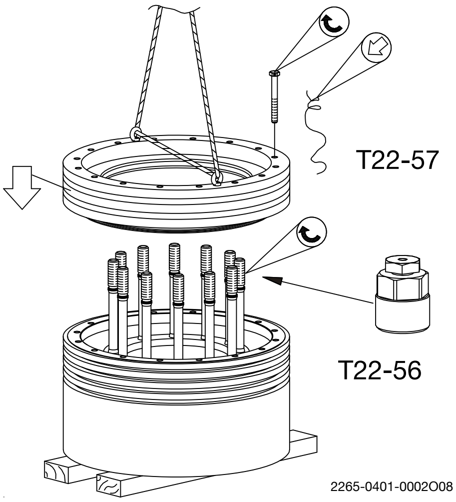
Mount the piston crown studs in a new or overhauled piston crown, lubricate the threads on the studs with molybdenum disulphide (MoS_2).

Tighten the studs to the specified torque using a stud setter, *see Data T22-56.*

Mount a new O-ring on the piston skirt, check that the surfaces of the O-ring groove is clean and smooth, coat the ring with lubricating oil before mounting.

Mount the piston skirt on the piston crown.

Tighten the screws to the specified torque, *see Data T22-57.* Lock the screws with locking wire.
See work card 7665-05.



2265-0401-0002O08

Piston crown and skirt mounting

Lubricate the O-ring on the piston rod flange with lubricating oil.

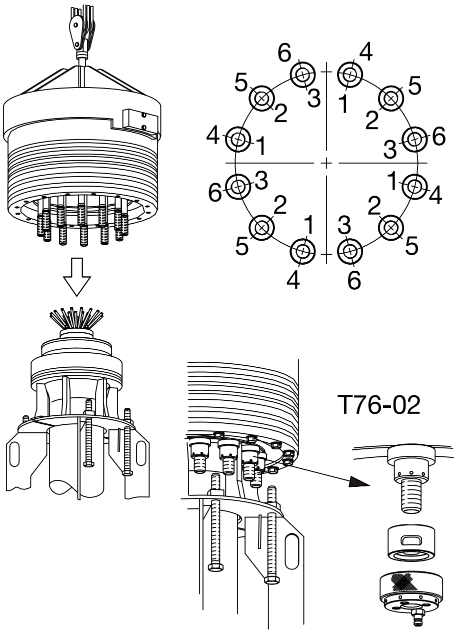
NOTE

Take care not to damage the pipes of the cooling insert when landing the piston crown on the piston rod.

Land the overhauled piston crown and skirt on the piston rod.

Mount and tighten the hydraulic nuts on the piston crown studs.

When tightening the hydraulic nuts follow the tightening sequence. All the nuts must be tightened twice to full tightening pressure, *see Data.*



2265-0401-0002O09

Sealing ring and pressure test

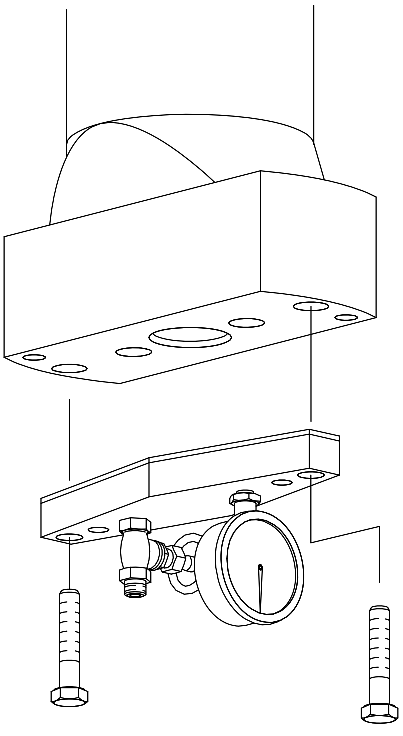
According to current class rules, the piston must be pressure tested hydraulically. It is possible to carry out a test of the sealing rings with compressed air before filling the piston with oil. The sealing ring test can also be carried out when the piston is resting in the support tool.

Sealing ring test

Mount the pressure-testing tool on the piston rod foot. Connect compressed air to the testing tool and fill the piston to 4-5 bar. Close the valve on the testing tool and remove the air connection. The piston must now hold the pressure for minimum 30 minutes.

Spray a little soap water on to the surface joints between piston rod/crown/skirt and around the hydraulic nuts to detect leaks.

Dry off all soap water.



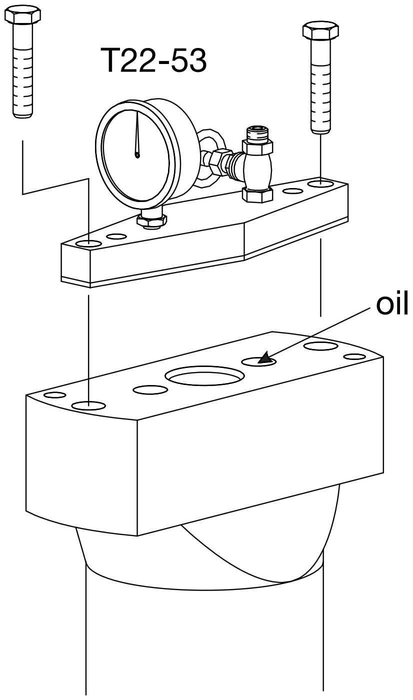
2265-0401-0002O10

Pressure test

For this test, the piston must be turned upside down *(see next step to turn a complete piston).*

Fill the piston and piston rod with lubricating oil. Mount the pressure-testing tool on the piston rod foot. Pressure-test the piston at the pressure stated on the Data Sheet. Check the contact surfaces of the piston and the sealing rings for tightness. Check that there are no cracks in the piston crown.

Turn the piston upside up and drain out the piston oil.



2265-0401-0002O11

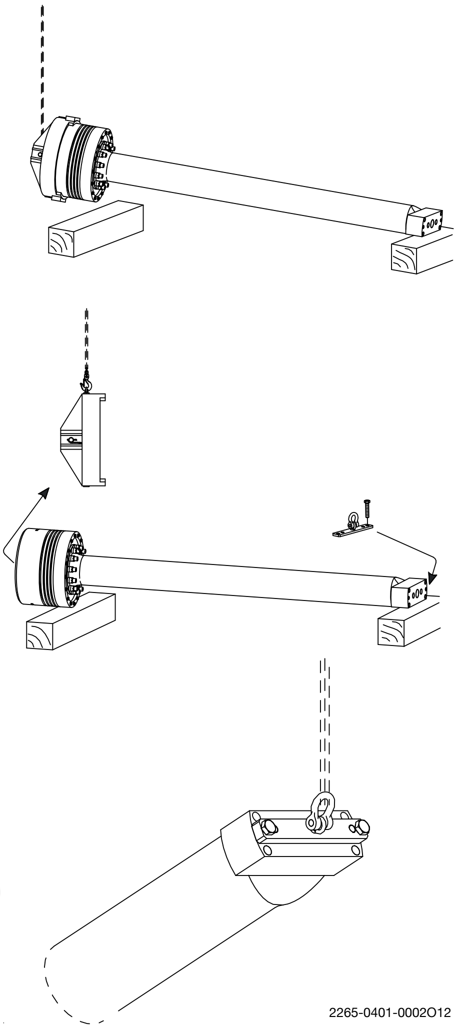
Piston turning

Lift the piston with the normal lifting tool. Lower the piston rod foot until it is close to the platform. Land the foot on a wooden block.

Lower the piston crown to the platform and land it on a wooden block in such a way that it is possible to remove the lifting tool.

Mount an eyebolt in the side of the lifting tool, hook on the crane and remove the lifting tool from the piston crown.

Attach the lifting bracket to the bottom of the piston rod foot. Hook the crane on to the lifting bracket. Lift the piston rod foot clear of the wooden block. Keep lifting until the piston rod is in a vertical position.



2265-0401-0002O12

NOTE

During the lift, follow with the crane to keep the crane positioned vertically above the lifting point. The stuffing box must be removed.

Piston completion

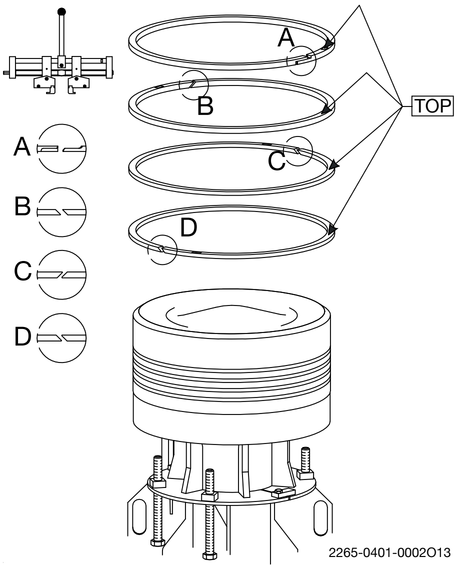
Fit the new piston rings (alternately right-hand and left-hand cuts, with the ring gaps staggered 180° and with the TOP mark upwards), using the ring expander.

When mounting the piston rings, use the ring expanders to prevent unintended deformation of the rings.

Do not expand the rings more than necessary. The uppermost ring (CPR-ring) must be mounted with the short ring expander.

Mount the piston rod stuffing box.

See work card 2265-05.

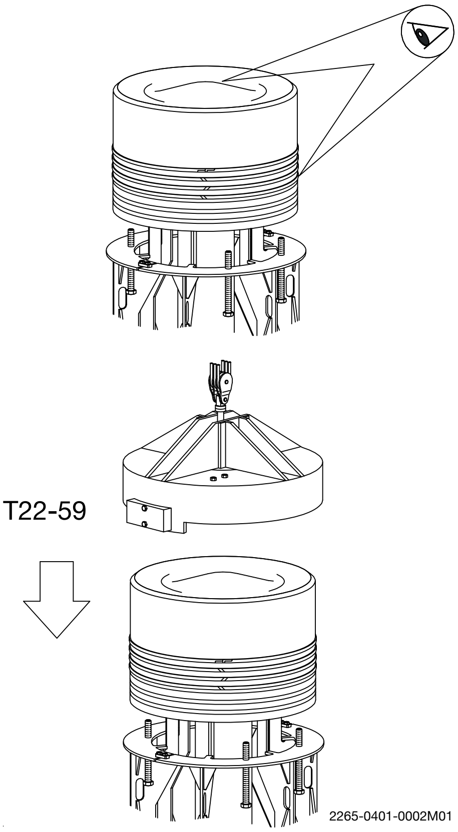


2265-0401-0002O13

Preparation of piston

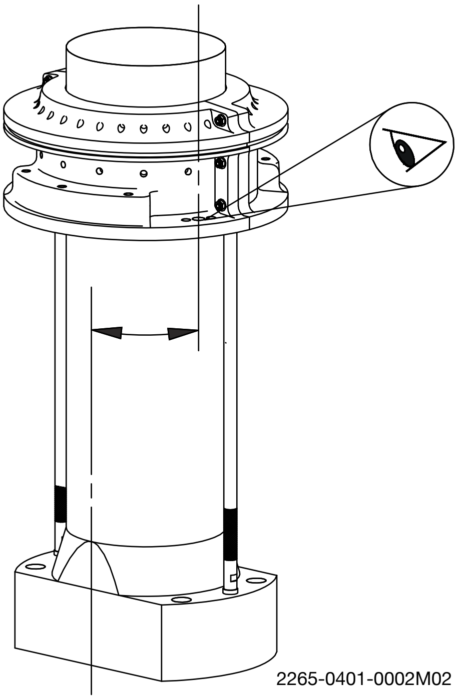
Check the piston rings and piston crown in accordance with “checking”, if not already done.

Mount the lifting tool on the piston crown. *See Data T22-59.*



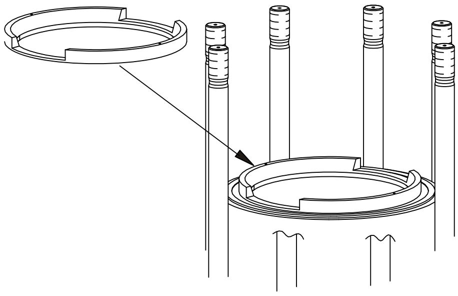
Stuffing box position

Ensure that the stuffing box is correctly positioned over the distance pieces mounted on the piston rod foot. Both the holes for the flange and the drain hole for the drain pipe must be positioned correctly.



Preparation of cylinder liner

Mount the guide ring in the top of the cylinder liner. The cut outs for the lifting tool must be turned to fore-aft position.

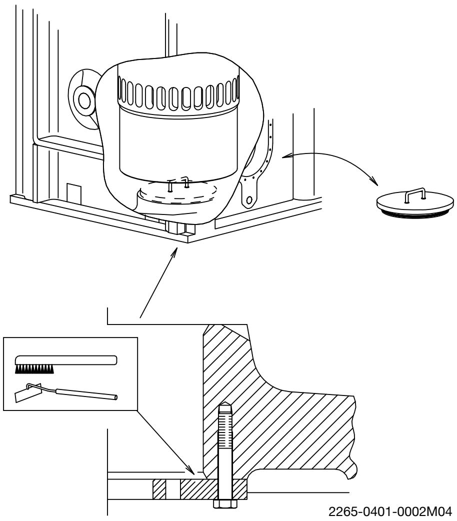


2265-0401-0002M03

Stuffing box cover

Remove the cover from the piston rod stuffing box opening in the bottom of the cylinder unit.

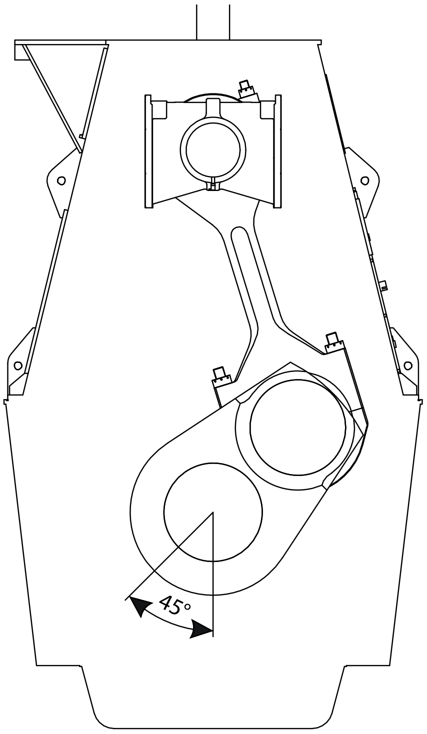
Clean the stuffing box flange.



2265-0401-0002M04

Crosshead position

Turn the crosshead to a position 45° from TDC (crank web pointing towards exhaust side).

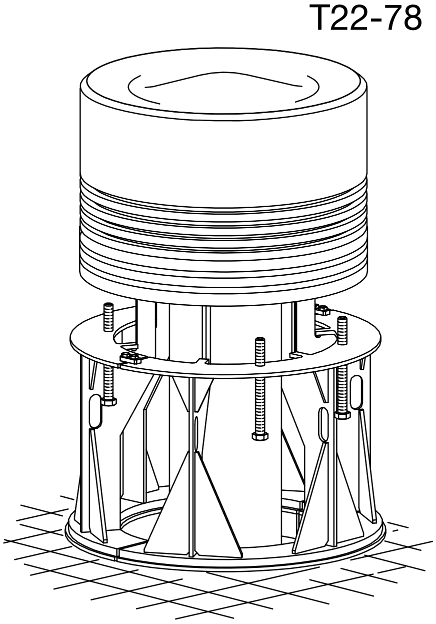


2265-0401-0002M05

Mounting of piston

Coat the O-rings of the stuffing box and the piston rod with oil. Coat the piston rings and cylinder liner with cylinder lubricating oil.

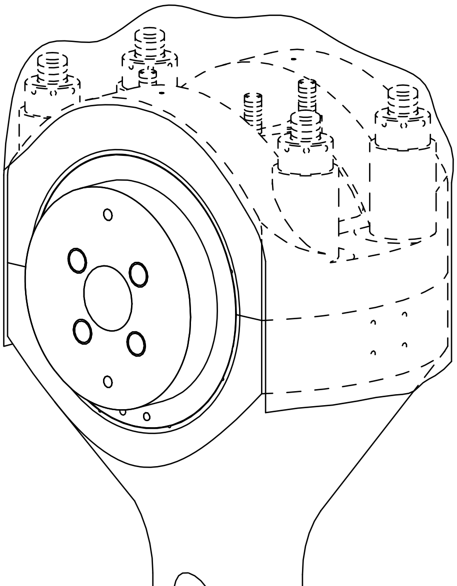
Lower the piston into the cylinder liner – while guiding the piston rod foot through the cut-out in the stuffing box flange – until the piston rings are inside the liner.



2265-0401-0002O01

Protective cover

Remove the protective rubber cover from the crosshead.



2265-0401-0002M07

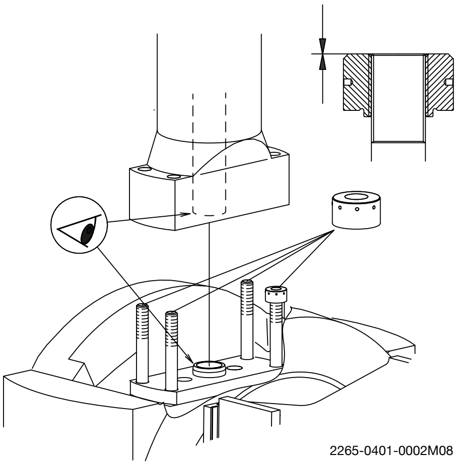
Crosshead alignment

Turn the crosshead almost to TDC.

If necessary, mount the hydraulic nuts on the studs and screw down until the nuts are flush with the top of the studs.

Turn the crosshead upwards until the piston rod foot lands on the nuts, thereby turning the crosshead until the face is parallel to the piston rod foot.

Lower the crosshead just enough to enable removal of the nuts. Turn the crosshead upwards until the piston rod lands on the crosshead. When mounting the piston on the crosshead, make sure that the piston rod foot does not damage the threads of the studs. Ensure that the guide ring in the crosshead fits correctly in the centre hole of the piston rod.


2265-0401-0002M08

Unscrew the lifting tool and remove the lifting tool and the guide ring for piston rings.

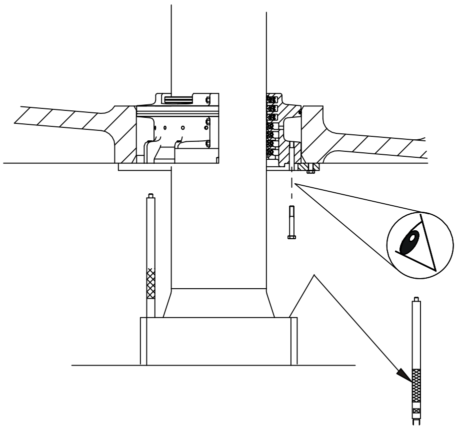
Stuffing box

Turn down and land the stuffing box on the stuffing box flange. Check that the holes in the stuffing box and stuffing box flange are correctly centered.

Tighten the piston rod stuffing box by means of the screws through the inner holes in the stuffing box flange.
For Data, see work card 2265-05.

On engine models where the drain pipe is connected directly to the stuffing box:

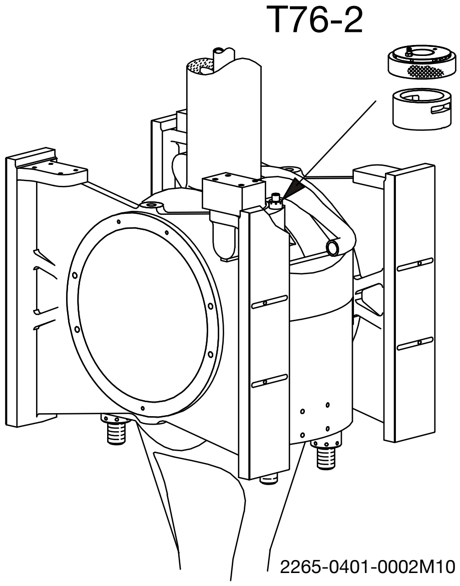
- Mount the stuffing box drain pipe.


2265-0401-0002M09

Remove the distance pieces from the piston rod foot.

Tightening of the piston rod-crosshead connection

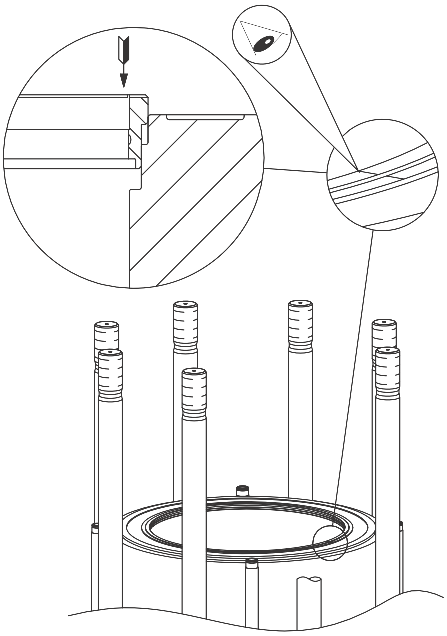
Mount and tighten the piston rod nuts with the hydraulic jacks. *See Data. See work card 7665-01.*



2265-0401-0002M10

Piston cleaning ring

Mount the piston cleaning ring in accordance with the scratch mark. If the PC-ring is damaged (broken or cracked), it must be replaced by another ring.
See work card 2265-06.

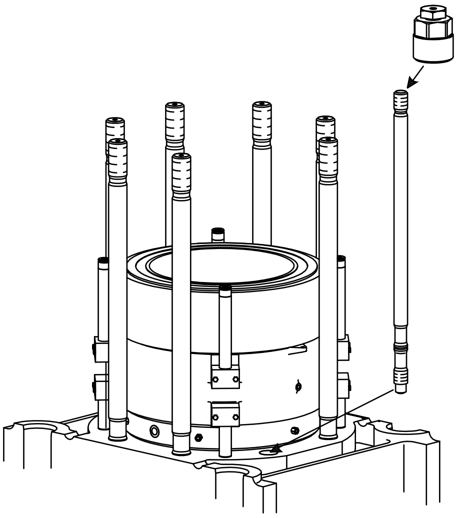


2265-0401-0016M11

Cylinder cover studs

If the cylinder cover studs have been removed, remount them. Carefully clean the surfaces around the base of the studs and check the O-rings on the studs.

Mount the cylinder cover studs with the stud setter. Screw the stud down to contact and half a revolution back.

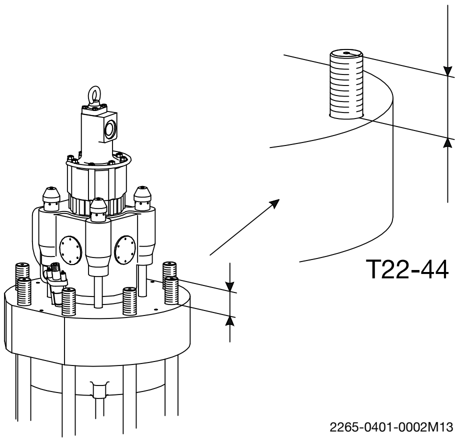


2265-0401-0002M12

Cylinder cover

Land the cylinder cover on the liner and check the distance that the stud is protruding from the cylinder cover. If necessary, adjust the distance T22-44 by turning the stud.

Tighten the cylinder cover nuts and mount the necessary pipes.
See work kard 2265-03.



2265-0401-0002M13

Running-in

Smear the piston rod with molybdenum disulphide, and turn the crankshaft a couple of revolutions.

At the first opportunity, start the engine and keep it running for about 15 minutes at a speed corresponding to “Dead Slow” Ahead.

Then stop the engine and inspect the piston rod and stuffing box.

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T22-84	Piston rod shield. Flange screws tightening torque	35	Nm
T22-85	Piston rod shield. Hexagon screw tightening torque	135	Nm
T22-86	Stuffing box flange, outer screws tightening torque	180	Nm
T22-87	Stuffing box flange, inner screws tightening torque	180	Nm
T22-88	Stuffing box halves, tightening torque	80	Nm
T22-89	Stuffing box halves fitted bolts, tightening torque	80	Nm
T22-90	Uppermost rings, ring-end clearance	4x6	mm
T22-91	Lowermost rings, ring-end clearance	3x3	mm
T22-92	Sealing ring springs new, free length	831	mm
T22-93	Scraper ring springs new, free length	782	mm
T22-102	Stuffing box complete	190	kg
T22-103	Stuffing box half	60	kg

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
1470-0300	**112**	Rubber cover for crosshead
2270-0400	**109**	Mounting tool for stuffing box spring
2270-0400	**122**	Worktable for stuffing box
7670-0200	**-**	Torque spanners
7670-0410	**066**	Slide caliper

Uppermost scraper ring and sealing rings

Dismantle the piston rod stuffing box. *See Dismantling*.

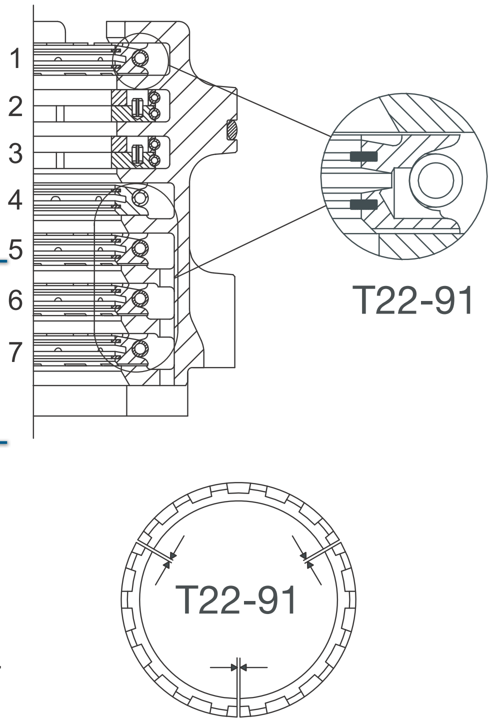
Check the end clearances of the scraper rings.

NOTE

Scraper ring no. 4 is standard type, while scraper rings no. 1, 5, 6 and 7 is Lap Joint type. The end clearances for standard type and Lap Joint type are the same.

The ring end clearance stated in Data apply to new rings.

As a general guide, it is recommended depending on the overhauling intervals and one's own experience – to replace sealing rings and scraper rings when the specified clearance value T22-91 have been halved.



2265-0501-0005C01

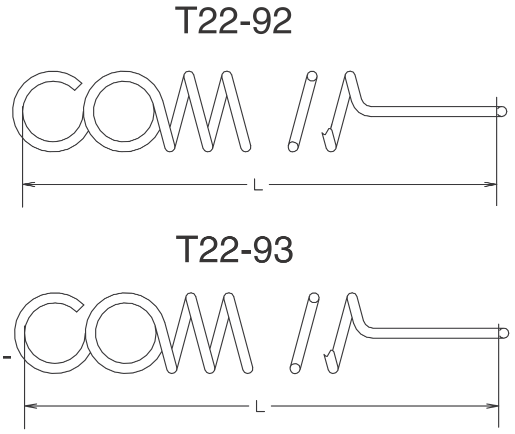
Check the length and adust the load of the springs

Garter springs:

Generally, it is recommended to renew the springs when the sealing rings and scraper rings are renewed.

The springs can be checked as follows:

Place the springs on the table, measure Lo (free length), and compare with Data. If a spring is extended more than 8% from the value given in data, it must be discarded.



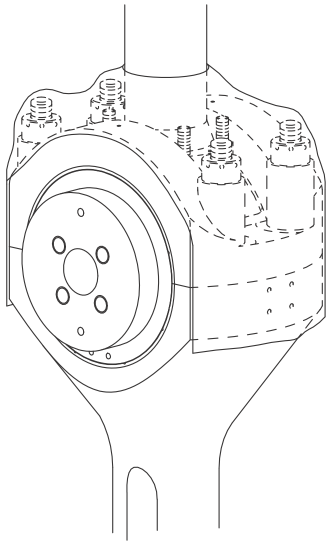
2265-0501-0001C02

If, in the period between piston overhauls, it becomes necessary to inspect the piston rod stuffing box, proceed as follows:

The crosshead

Turn the crosshead to about 90° from TDC.

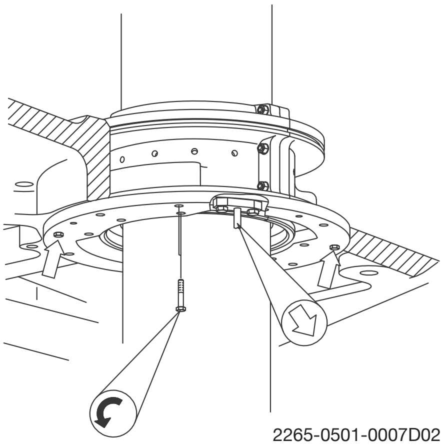
Mount the rubber cover around the piston rod to protect the crosshead bearing from impurities.



2265-0501-0007D01

Drain oil pipe

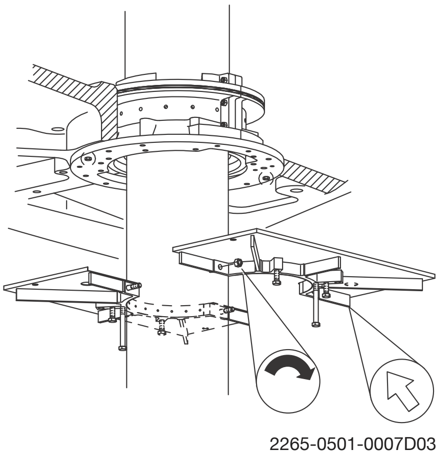
Remove the drain oil pipe and all innermost screws and all outer screws except for two screws placed diametrically opposite in the stuffing box flange, longitudinally to the engine.



2265-0501-0007D02

Mount the worktable around the piston

Mount the worktable around the piston rod so that the two remaining screws in the stuffing box flange can be loosened through the holes.



2265-0501-0007D03

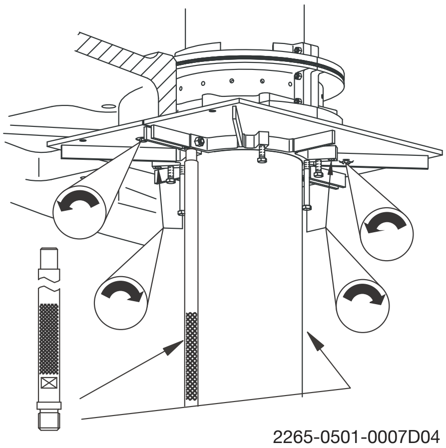
Distance pipes

Mount the two distance pieces for the stuffing box.

Remove the two long dismantling screws from the worktable.

Mount them in the stuffing box through the holes in the worktable.

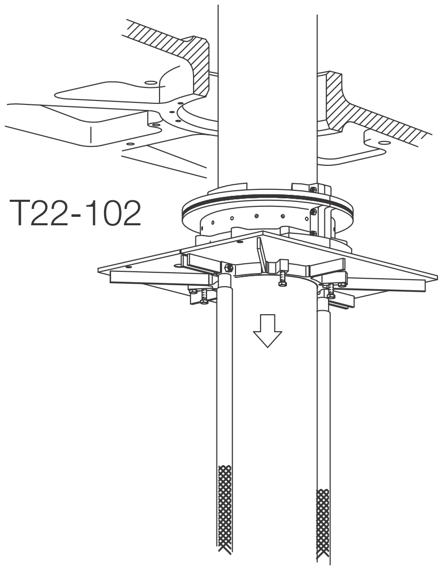
Remove the remaining two screws from the stuffing box flange.



2265-0501-0007D04

Turn the piston to BDC

Turn the piston to BDC, thereby withdrawing the stuffing box from the cylinder frame bottom.

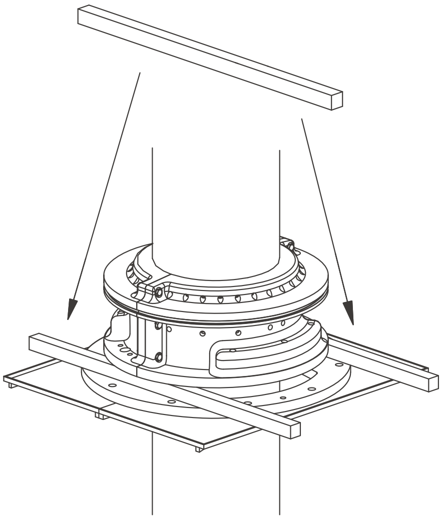


2265-0501-0007D05

Remove the distance secrews

Remove the two long dismantling screws from the stuffing box and mount them in the worktable.

By means of the four short screws in the worktable, press the stuffing box out of the flange and 30mm up.



2265-0501-0007D07

Steel bars

Place two steel bars (40 x 40 mm) between the stuffing box and the stuffing box flange, one on each side of the piston rod, see the sketch. Use the steel bars as supports when the stuffing box is disassembled. *For overhauling the stuffing box, see Overhaul.*

Normally, overhaul of the piston rod stuffing box is carried out by routine methods in connection with the dismantling (pulling) of the pistons.

During such overhauls, the piston rests on a support placed over one of the cut-outs in the top platform.

Work on the stuffing box is then carried out from the platform below.

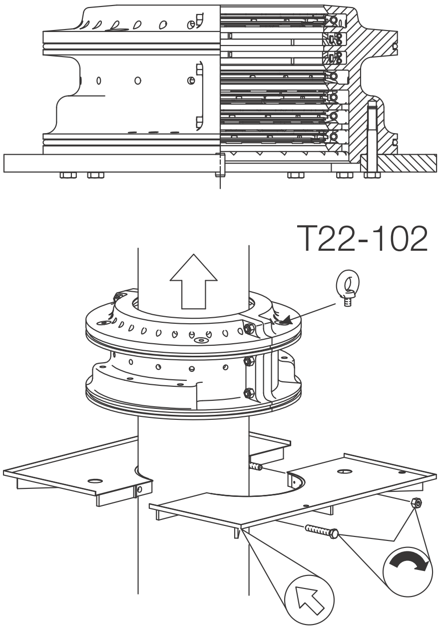
If the stuffing box is overhouled inside the engine, it is also done as described here, but the stuffing box halves are supported by the steelbars described in *Dismantling.*

Eyebolts

Mount two eyebolts in the stuffing box flange, and hook on two tackles.

Lift the stuffing box a little up the piston rod, and mount the worktable round the piston rod at a suitable working height.

Land the stuffing box on the worktable, and remove the tackles and eyebolts.

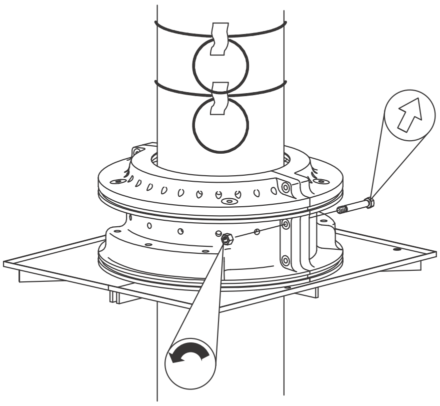


2265-0501-0007O01

O-rings

Remove the O-ring of the stuffing box. If the O-ring is intact and is to be used again, move it up the piston rod and secure it in this position, for example with tape.

Remove the nuts from the stuffing box assembling bolts.



2265-0501-0007O02

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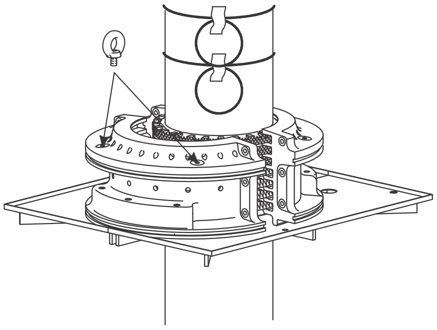
Stuffing box half Take out the six bolts, and pull away one stuffing box half.

Eyebolts Mount two eyebolts on the stuffing box half and remove it from the worktable.



2265-0501-0007O03

Remover the remaining stuffing box Remove the remaining stuffing box half and press all sealing rings and scraper rings down against the worktable.

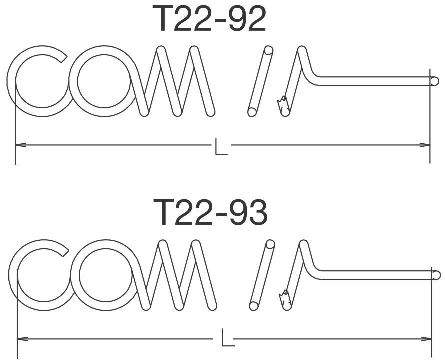
Measure the clearance Measure the clearance between the segments of the scraper rings to determine whether replacement is necessary. *See Checking.*

Dismantle and stack the rings in the same order as when fitted in the stuffing box.

Carefully clean all the ring segments.

Inspect and assess the surface quality of the sealing rings. If their sliding surfaces have scratches or marks, replace the rings.

Spring lengths Check the lengths of the springs. *See Checking.*

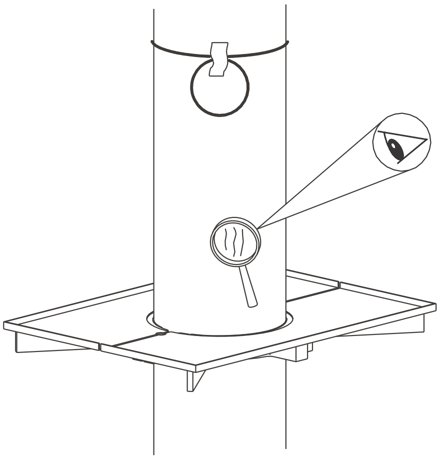


2265-0501-0007O07

Piston surface Inspect the surface of the piston rod.

If small longitudinal scratches have occurred (caused by poorly adapted stuffing box rings), smooth the piston rod surface carefully with a fine grained carborundum stone. In the case of coarse scratches, it may prove necessary to machine-grind the surface in a workshop.

Clean the valves Clean the halves of the stuffing box housing.



2265-0501-0007O08

Piston rod lubrication

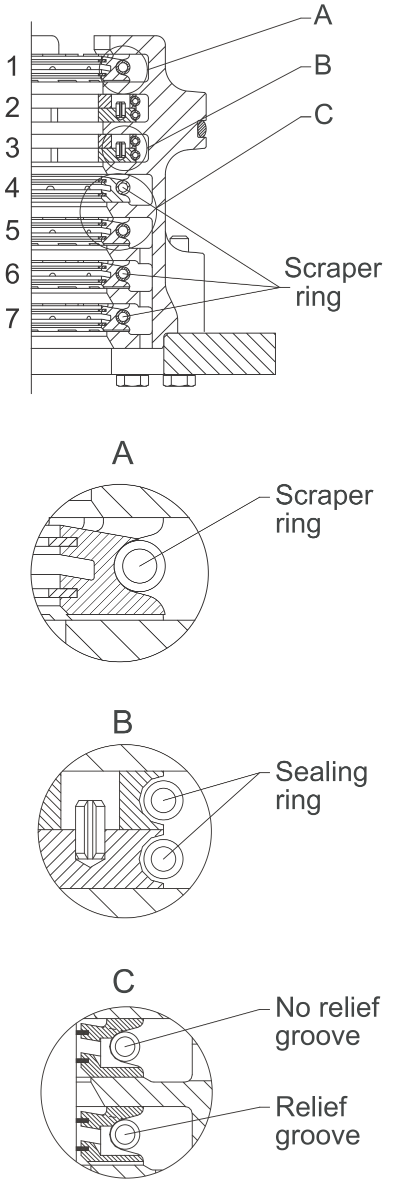
Lubricate the piston rod (in the area where all the ring units in the stuffing box will be positioned) with molybdenum disulphide (MoS2).

For correct mounting of the sealing and scraper rings see the sketch.

The scraper ring in groove no. 4 must be standard type without relief grooves on the underside.

The scraper ring in grooves no. 1, 5, 6 and 7 must be Lap Joint type with relief grooves on the underside.

Make sure that the guide pins in the sealing rings in grooves no. 2 and 3 are mounted correctly.



2265-0501-0007O10

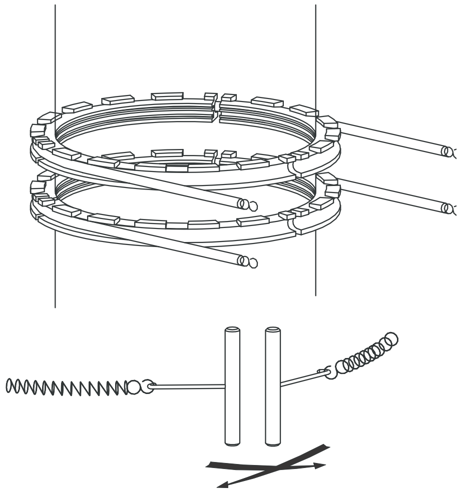
Stuffing box assembly

Assemble all the stuffing box ring units round the piston rod, on the worktable, in the following way:

- Place the lowermost scraper ring segments (Lap Joint type) on the worktable.
- Place the spring round the segments, and hook the spring ends together.

Repeat this procedure for the next two Lap Joint type scraper rings and one standard type scraper ring.

On top of the scraper rings, assemble the two sealing ring units (each consisting of a 4-part and an 8-part ring).



2265-0501-0007O1

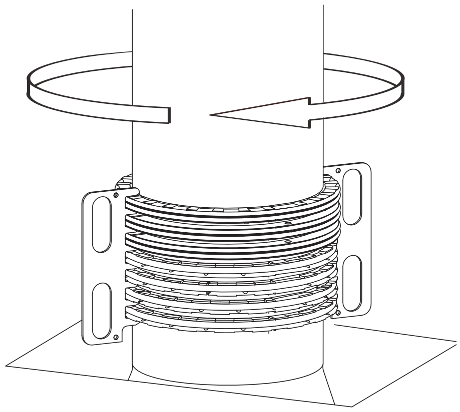
Assemble the 8-part sealing ring so that the two guide pins face upwards, place the spring round the segments and, hook the spring ends together.

Assemble the 4-part sealing ring above the 8-part sealing ring. Push the two rings together in such a manner that the guide pins in the lower sealing ring engage with the two holes in the upper sealing ring.

Finally, assemble the uppermost scraper ring (Lap Joint type).

Adjust the rings

With all rings mounted on the piston rod adjust the position of the rings to obtain an equal distance between them. Use the stuffing box gauge tool to check the spacing between the rings. This is done by carefully inserting the teeth of the gauge tool within the rings and then carefully moving the gauge along the springs.



2265-0501-0007O1

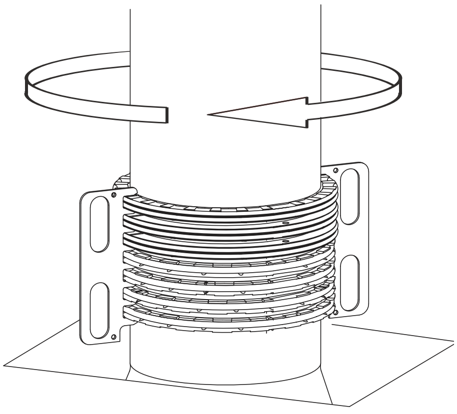
Adjust the rings

Mount the first stuffing box half. Take care not to pinch any of the rings.

Re-check and if necessary adjust the positions of the rings.

Place the other half of the stuffing box housing on the worktable, and push it into position round the rings.

In the middle holes mount and tighten up the fitted bolts to the torque specified on the Data Sheet, *See Data T22-89.*



2265-0501-0007O1

Mount and tighten the standard bolts to specified torque, *See Data T22-88.*

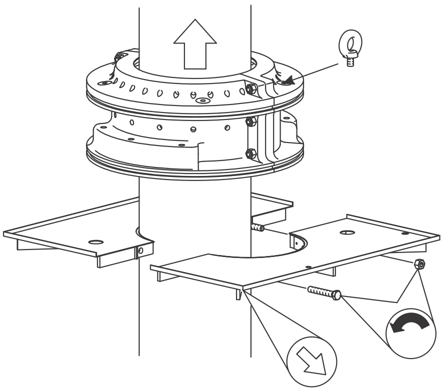
Mount the O-ring in the stuffing box groove.

Adjust the rings

Mount eyebolts and wire ropes, and lift the stuffing box a little.

Remove the worktable and lower the stuffing box until it rests against the distance pieces on the piston rod foot.

Remove wire ropes and screws.



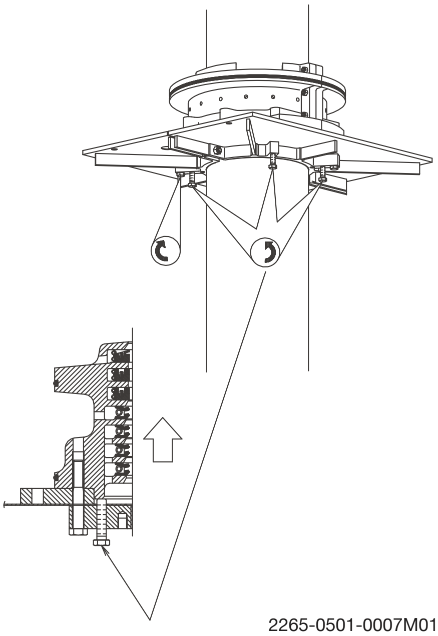
2265-0501-0007O14

Mounting the screws

After overhauling, assemble the stuffing box halves on top of four screws.

Mount the two long screws from the worktable in the stuffing box.

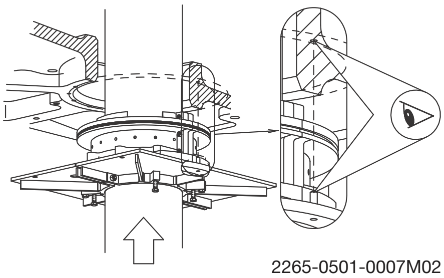
Turn down the short screws so that the stuffing box lands on the flange.



2265-0501-0007M01

Turn the piston

Turn the piston upwards until the stuffing box is in place in the cylinder frame.



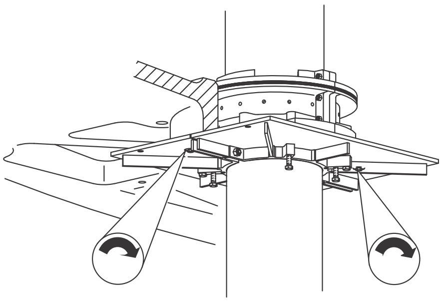
2265-0501-0007M02

NOTE

Make sure that the two guide pins in the flange enter the guide holes in the bottom of the cylinder frame.

Mount the screws

Mount two screws in the flange through the holes in the worktable.

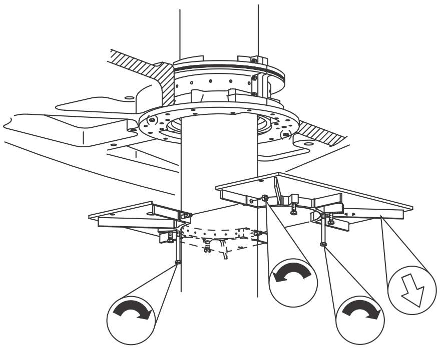


2265-0501-0007M03

Remove the worktable

Remove the long screws from the stuffing box and mount them in the worktable.

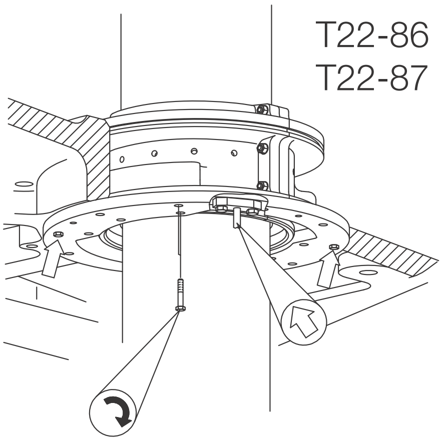
Remove the worktable from the piston rod.



2265-0501-0007M04

Mount all screws

Mount and tighten all the inner and outer screws for the stuffing box. *See Data.*



2265-0501-0007M05

Remove the protecting rubber

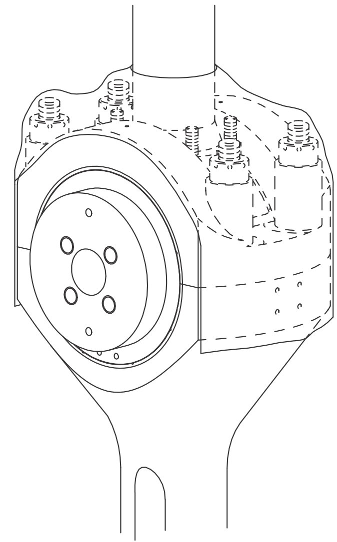
Remove the protecting rubber cover from the piston rod/crosshead.

Smear the piston rod with molybdenum disulphide.

Then turn the crankshaft a couple of revolutions.

If possible: Start up the engine and keep it running for about fifteen minutes at a number of revolutions corresponding to very slow or idle speed.

Then stop the engine and inspect the piston rod and stuffing box.



2265-0501-0007D01

2012-02-17

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T22-107	Cylinder diameter, new	800	mm
T22-108	Piston cleaning ring diameter, new	798.3±0.1	mm
T22-109	Piston cleaning ring radial width, new	15.8	mm
T22-111	Cylinder liner, complete	9700	kg
T22-112	Cooling jacket	500	kg
T22-115	PC-ring replacement criteria:	-	-
-	Liner wear * : Install New PC-ring	0 - 1.6	mm
-	Liner wear * : Install No PC-ring	>1.6	mm
-	* : At measuring point no. 5	-	-

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
2270-0610	**-**	Measuring tool for cylinder liner
2270-0640	**-**	Lifting tool for cylinder liner
7670-0200	**-**	Torque spanners
7670-0410	**066**	Slide caliper

Starting with the cylinder liner

Dismount the cylinder cover, the piston cleaning ring and the piston.
See Workcard 2265-03 and 2265-04.

Clean the cylinder liner and scavenge air ports.

Setting measuring tool

Position the cylinder liner measuring tool.

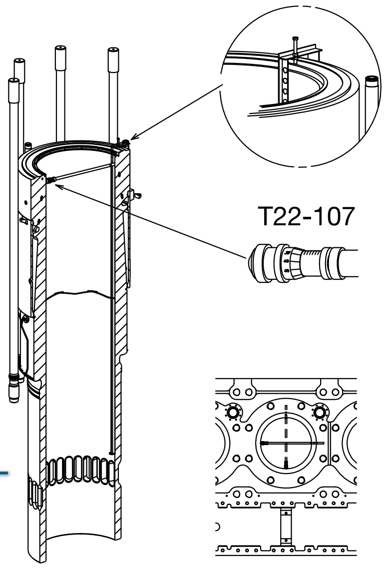
Measure the cylinder liner with an inside micrometer at the positions indicated on the measuring tool.

Take measurements in the fore-and-aft and athwartship directions.

Check and assess the condition of the cylinder liner according to the description given in chapter 2245-0100

NOTE

If the cylinder liner is to be replaced, the piston cleaning ring must also be replaced.



2265-0601-0004C02

Carefully!

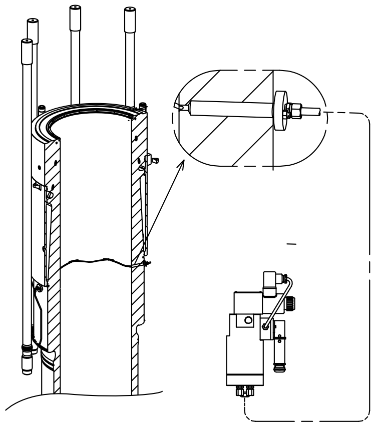
Smooth any scores or marks and grind away the wear ridges. *See Overhaul.*

Lubrication points

Check the lubricating points of the cylinder by pumping cylinder oil to each lubricating point with the cylinder lubricator.

Clean any blocked lubricating duct.

Mount the piston and cylinder cover.
See Workcard 2265-03 and 2265-04



2265-0601-0004C04

Piston cleaning (PC) ring

The PC-ring is to be regarded as an integrated part of the liner and it is intended to follow the service life of the liner.

During inspection of the piston and the liner, the PC-ring must also be inspected.

PC-ring and the wear of the liner

Compare the PC-ring diameter wear with the wear of the liner. If wear of the two components does not deviate more than T22-115 then reinstall the PC-ring.

If the PC-ring is broken or cracked, replace the ring with a new PC-ring, or no ring according to the table in T22-109 on the Data sheet.

When a new liner is installed, also a new PC-ring must be installed. When a new liner is ordered, also a new PC-ring must be ordered.

Dismantling the cylinder cover

Dismount the cylinder cover. *See Workcard 2265-02*.

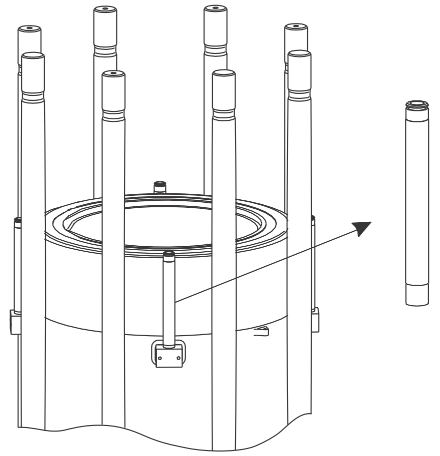
Discard the sealing ring from the top of the cylinder liner.

Turn the piston down far enough to make it possible to grind away the wear ridges at the top of the liner with a hand-grinder. *See Overhaul.*

Dismount the piston cleaning ring and the piston. *See Workcard 2265-04.*

Coling water pipes

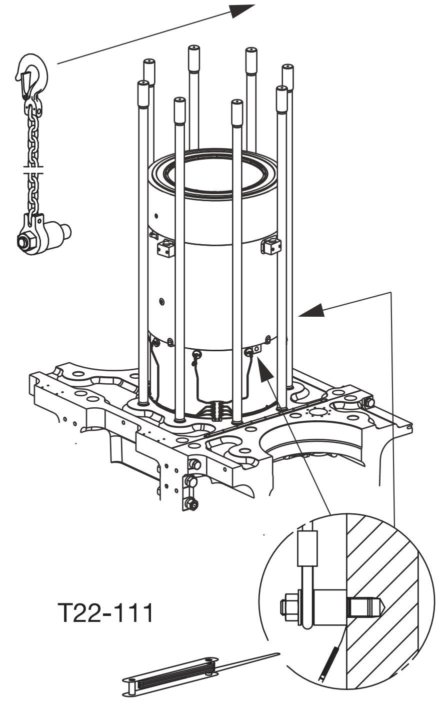
Dismount the four cooling water pipes – between the cooling jacket and cylinder cover and discard the O-rings from the pipes – and clean them carefully.



2265-0601-0010D01

Fasten the two lifting tools

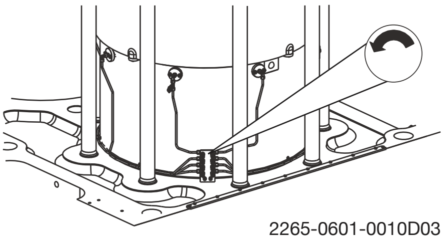
Screw the two lifting tools on to the cylinder liner. Check with a feeler gauge that there is no clearance between lifting tool and cylinder liner. For tightening torque, *see Data.*



2265-0601-0010D02

Disconnecting the oil pipes

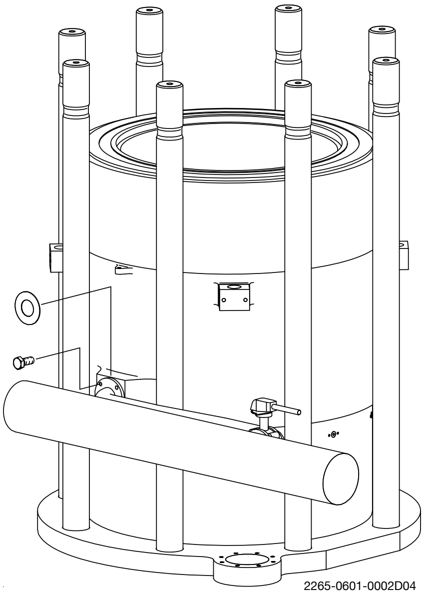
Disconnect the oil pipes leading from the cylinder lubricator to the cylinder liner.



2265-0601-0010D03

Cooling water inlet

Remove the screws of the cooling water inlet pipe.



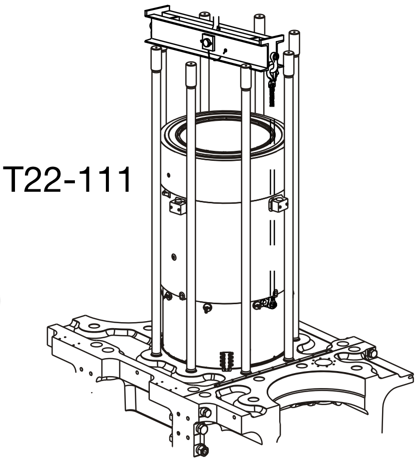
2265-0601-0002D04

Removing the liner

Attach the crane to the lifting crossbar.

Hook the lifting tools on to the crossbar on both sides of the cylinder liner.

Lift the liner with the cooling jacket out of the cylinder frame.



2265-0601-0004D05

NOTE

Low lifting height in the engine room may require the removal of one or more cylinder cover studs before dismantling the cylinder liner.

Land the cylinder liner vertically on, for instance, a couple of planks.

Back to the cylinder frame

Clean the cylinder frame internally, taking special care with the contact surfaces for the cylinder liner at the top of the cylinder frame.

The lifting tools are also used for transporting the cylinder liner.

Before removing the cooling jacket

If not already done, remove cylinder liner lubrication pipes and distributing block.

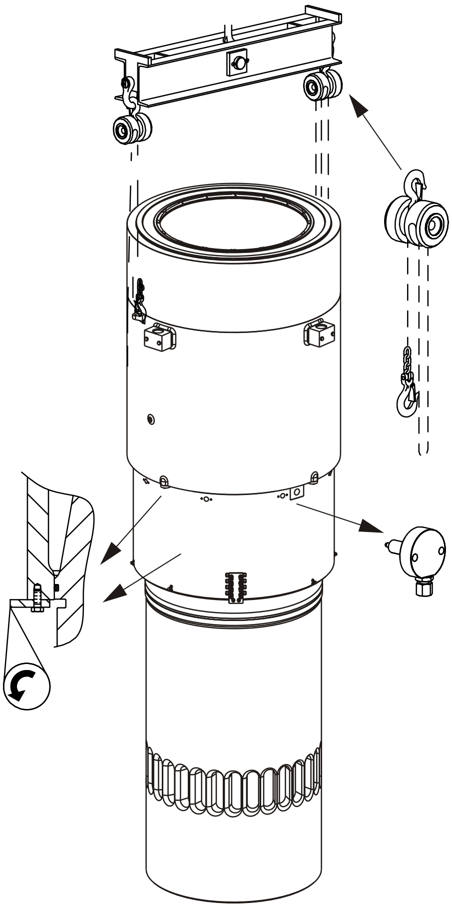
Remove the non-return valves for the cylinder liner lubrication

Attach two tackles to the crossbar, as shown.

Mount two lifting eyebolts in the cooling jacket.

Hook the tackles on to the lifting eyebolts on the cooling jacket and haul tight.

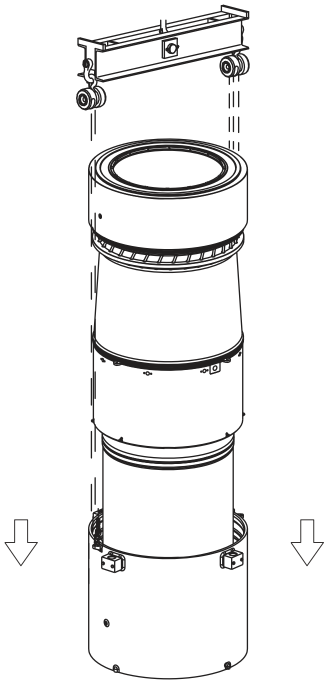
Loosen the screws on the clamps which fix the cooling jacket to the cylinder liner. Turn the clamps away from the liner.



2265-0601-0004O01

Removing the cooling jacket

Lower the cooling jacket by means of the tackles and land it on the wooden planks.



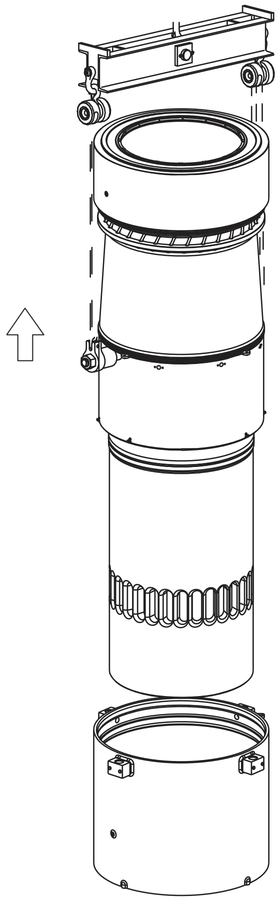
2265-0601-0010O02

Moving the cylinder liner from the cooling jacket

Mount the lifting tools on the cylinder liner. *See Data*.

Lift the cylinder liner away from the cooling jacket.

Clean the cooling jacket internally.



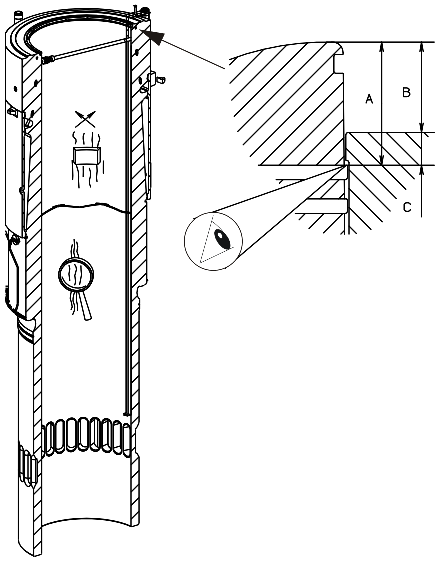
2265-0601-0010O03

Checking inside the liner body

Check and assess the condition of the cylinder liner according to the description given in chapter 2245-0100.

Carefully scratch over any scores or marks on the cylinder liner running surface, by means of a rough grindstone held in the hand.

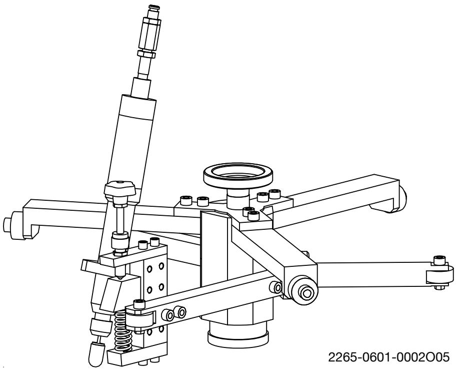
Check in the top of the liner for a wear ridge (where the piston rings reverse direction). If there is any sign of a wear ridge, it is necessary to create a groove by grinding. The groove serves to prevent the build-up of a new wear ridge.



2265-0601-0004O04

Creating the groove

It is recommended to use a wear ridge milling machine to create the groove. *For use of the milling machine, see supplier's instruction.*



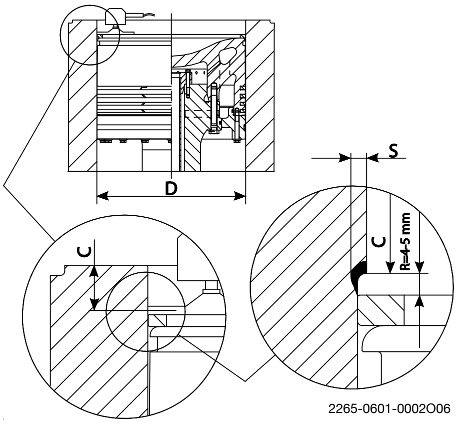
2265-0601-0002O05

Creating the groove "Alternative"

Alternatively, place an old piston ring on the top of the piston and turn to a position that enables the grinding disc to rest on the old piston ring while removing the wear ridge. Use a grinding disc with a round edge.

Check the distance **C** before grinding to ascertain that the wear ridge was caused by the top ring at TDC.

The maximum depth of the groove is calculated as $S_{max.} = D \times 0.0045$.



2265-0601-0002O06

NOTE

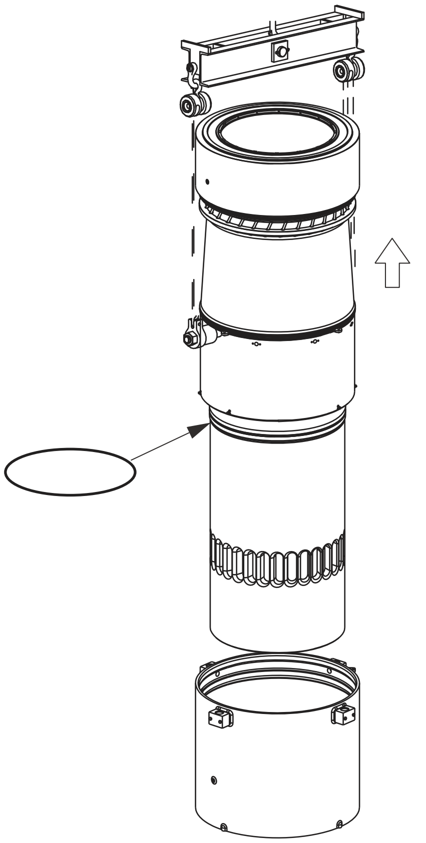
It is of the utmost importance that the groove is made with a regular rounding as shown in the sketch.

Returning the cooling jacket to liner

Apply a thin layer of grease on the contact surface for the cooling jacket on the liner.

Mount the lifting tools on the liner. Lift the liner a little and mount new O-rings for the cooling jacket. Then place the liner in the cooling jacket.

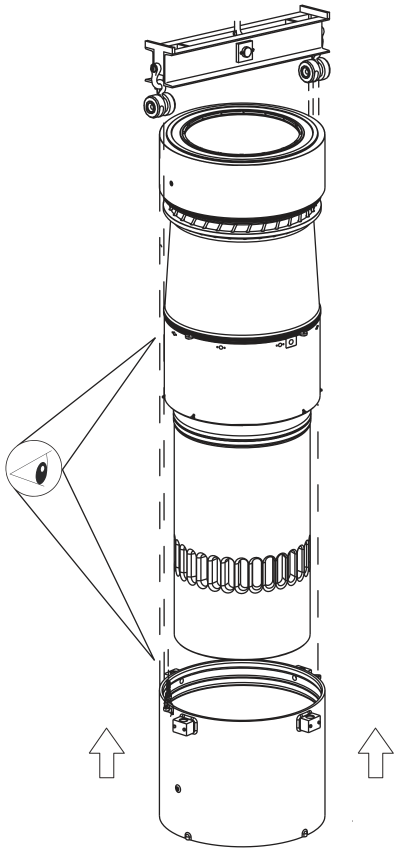
Remove the lifting tools.



2265-0601-0010O07

Positioning the cooling jacket

Lift the cooling jacket into position – marking scratches jacket/cylinder liner must coincide (manoeuvre side).



2265-0601-0010O08

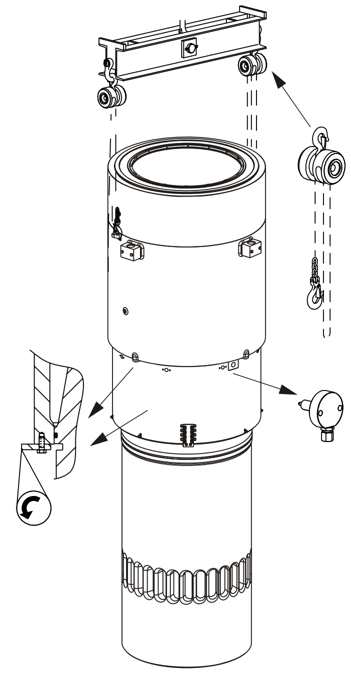
Finally

Turn the clamps until they fit in the groove of the liner, and tighten the screws.

Remove the tackles and the eyebolts from the cooling jacket.

Mount the non-return valves for the cylinder liner lubrication.

Mount the cylinder liner lubrication distributing block.



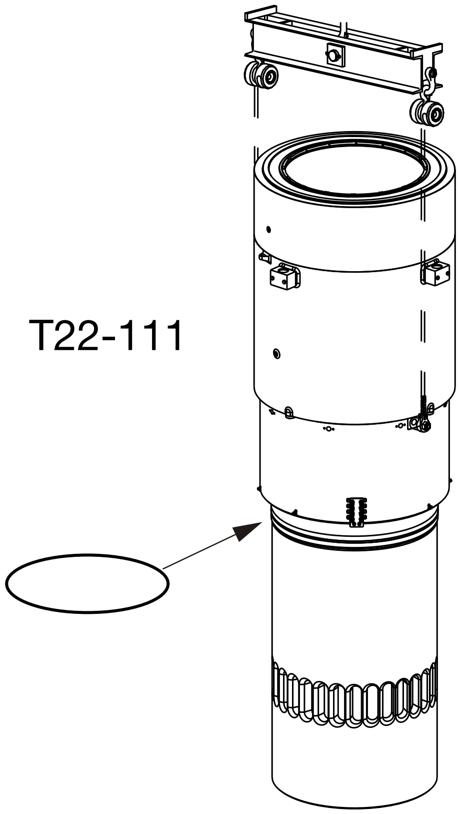
2265-0601-0004O01

Returning the cylinder liner

Mount the lifting tools on the cylinder liner and tighten to the specified torque. *See Data.*

Hook the lifting tools on to the crossbar, and lift the jacket/liner assembly.

Mount the lowermost O-ring and apply a little lubricating oil on the ring.



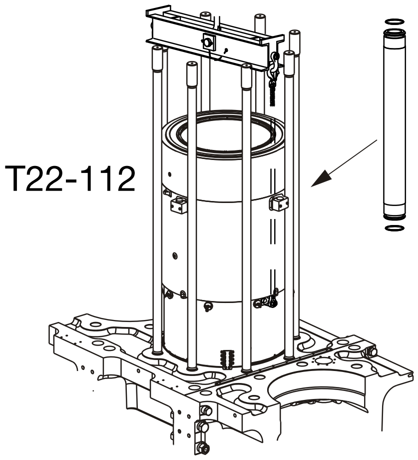
2265-0601-0004M01

Before mounting the liner

Check that the joint surfaces on the cylinder frame and cylinder liner are completely clean.

Coat the joint surfaces with permatex or a similar liquid sealing compound.

Mount the cylinder liner in the cylinder frame. Replace the O-rings on the water connections and mount the water connections on the cooling jacket.



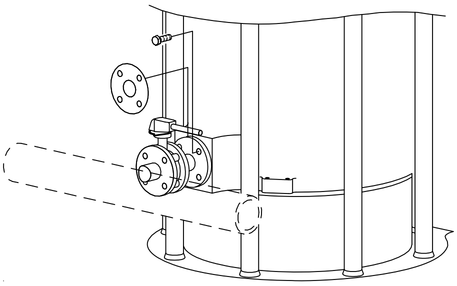
2265-0601-0004M02

Remember!

If one or more cylinder cover studs have been removed during the dismantling, mount the studs. *See Workcard 2265-04*.

New gasket for the cooling water inlet pipe

Mount a new gasket between the cooling water inlet pipe and the cooling jacket. Mount and tighten the screws.



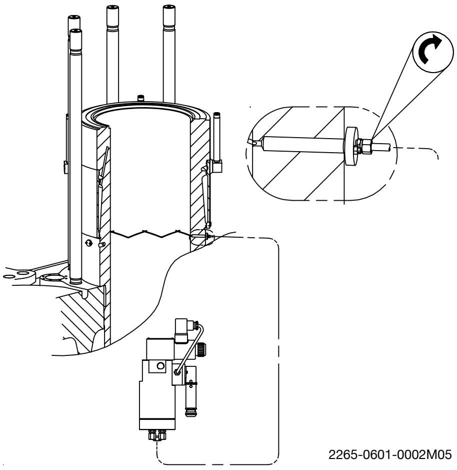
2265-0601-0002M04

Lubrication pipes

Screw the pipes from the lubricator on to the non-return valves, but do not tighten.

Vent the cylinder lubricating system by pumping all pipes through until oil, without air bubbles, comes out from the union pipe/non-return valve.

When this is in order, tighten the pipes firmly on the non-return valves and again pump until it is certain that each individual lubricating point functions correctly.



2265-0601-0002M05

Before mounting the piston

Lubricate the inside of the cylinder liner with cylinder lubricating oil and mount the piston and the piston cleaning ring. *See Workcard. 2265-04 'Mounting'*

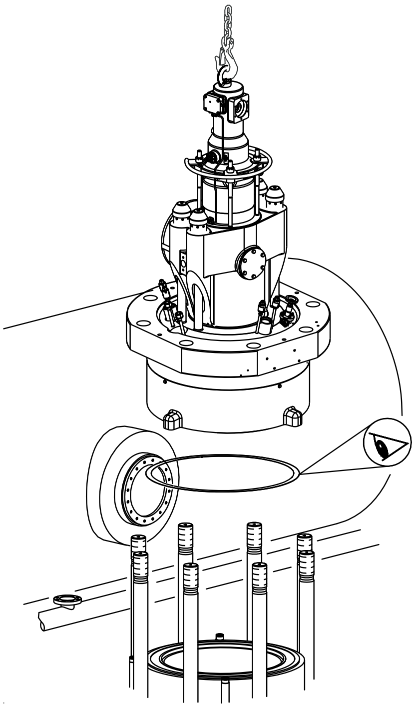
NOTE

Make sure to mount the piston cleaning ring correctly, so that the scratching marks are aligned.

Cylinder Cover

Mount the sealing ring and the cylinder cover. *See Workcard 2265-03 'Mounting'.*

Tighten the upper water connections on the cooling jacket as soon as the cylinder cover is correctly positioned.



Exhaust Valve Panel Tools

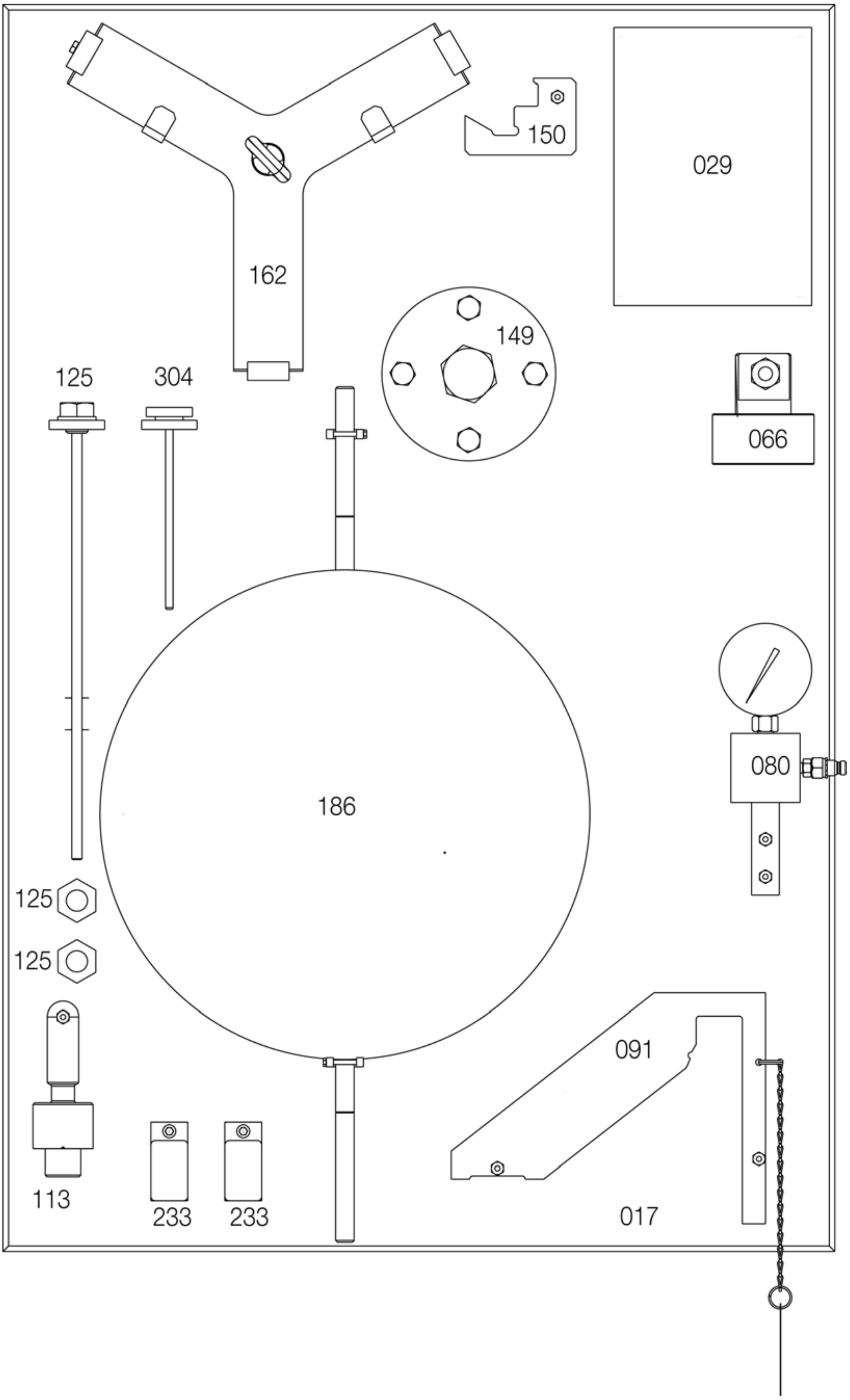
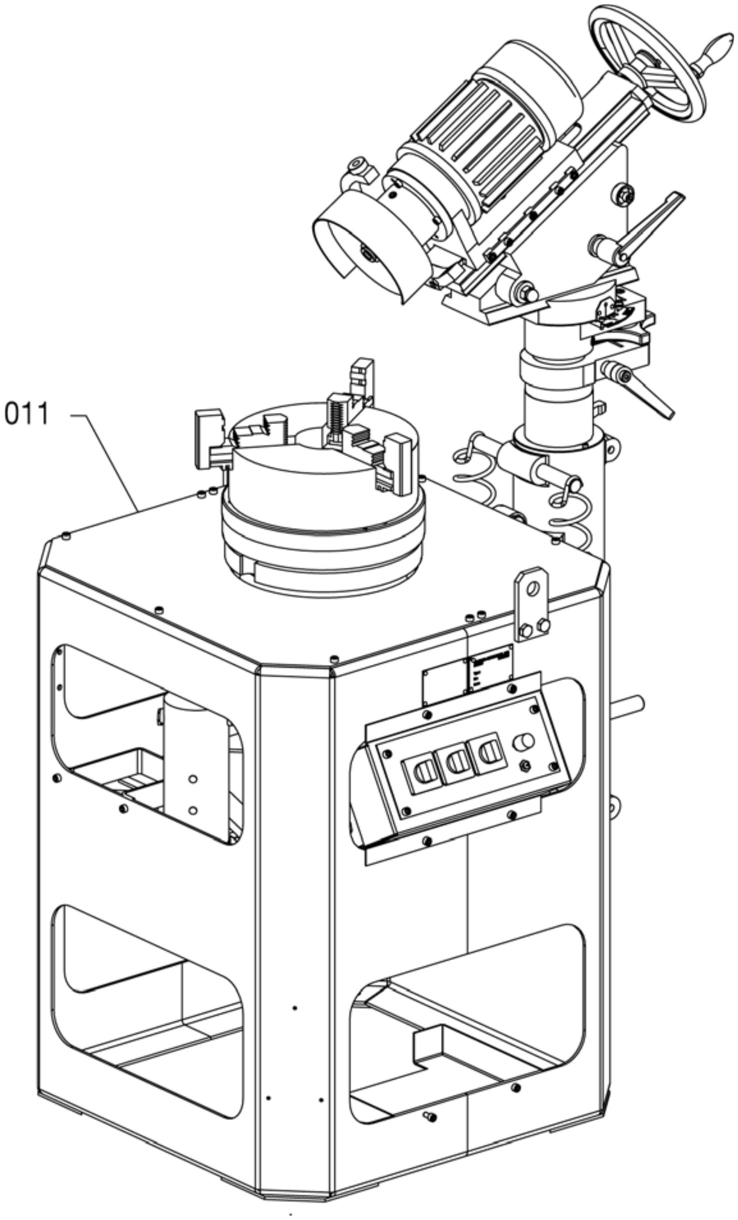


Plate
2270-0200-0010

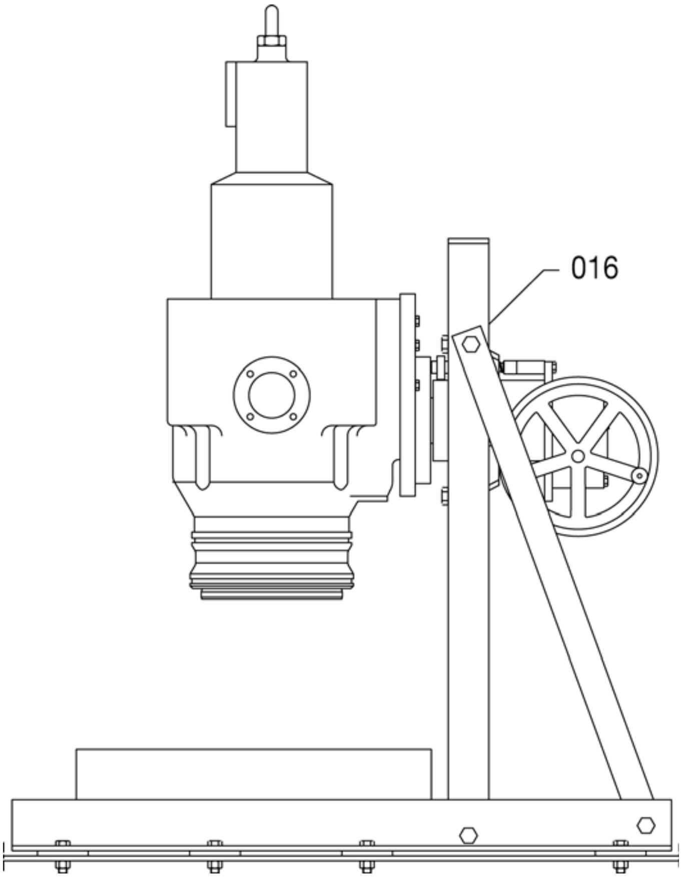
Item no	Qty	Designation
017	-	Panel for tools ms908
029	-	Name plate
066	-	Lifting tool for exhaust valve
080	-	Test equipment, exhaust valve
091	-	Gauge for exhaust valve spindle
113	-	Grinding tool for high-pressure pipe
125	-	Tool for emergency open exhaust valve
149	-	Tool for hydraulic piston
150	-	Gauge for exhaust valve bottom piece
162	-	Lifting tool for exhaust valve
186	-	Grinding ring for exhaust valve bottom piece
233	-	Retaining tool
304	-	Measuring tools



2008-07-29

Item no	Qty	Designation
011	-	Worktable for exhaust valve

2008-07-29



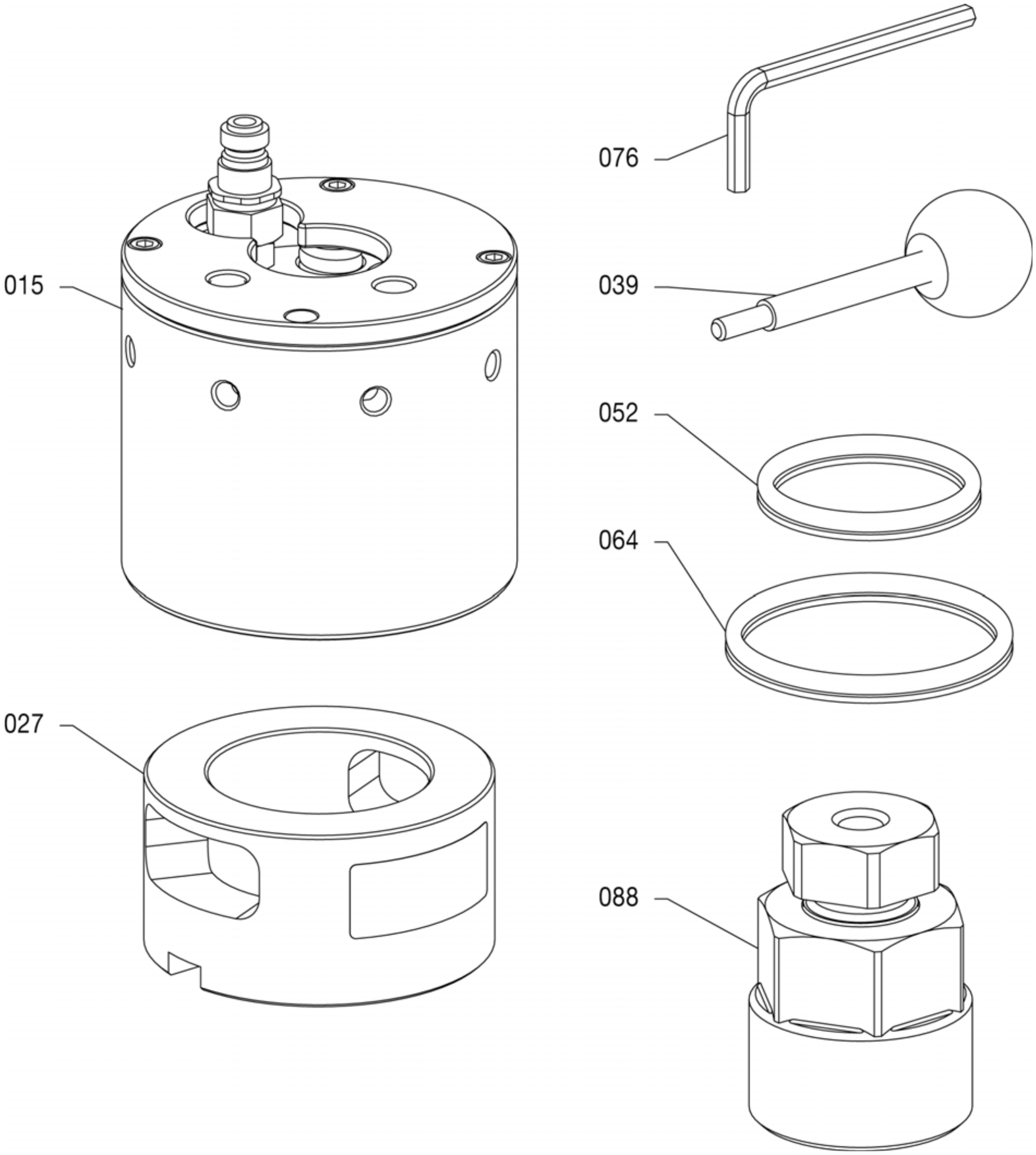
2008-07-29

Item no	Qty	Designation
016	-	Worktable for exhaust valve

2008-07-29

Exhaust Valve Hydraulic Tools

Plate 2270-0240-0001.0



Item no	Qty	Designation
015	-	Hydraulic jack
027	-	Support for hydraulic jack
039	-	Ball handle
052	-	Sealing ring with back-up ring
064	-	Sealing ring with back-up ring
076	-	Hex key
088	-	Stud setter

Exhaust Valve Actuator Hydraulic Tools

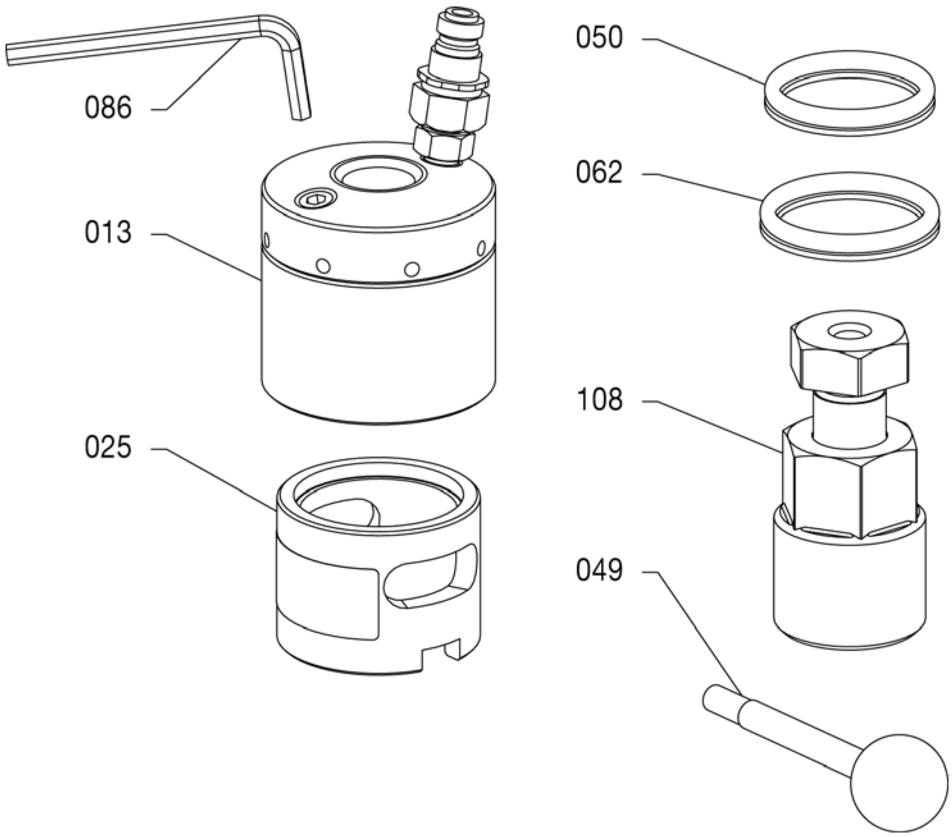


Plate
2270-0247-0001

2008-09-22

Item no	Qty	Designation
013	-	Hydraulic jack
025	-	Support for hydraulic jack
049	-	Ball handle
050	-	Sealing ring with back-up
062	-	Sealing ring with back-up
086	-	Hex key
108	-	Stud setter

Cylinder Cover Panel Tools

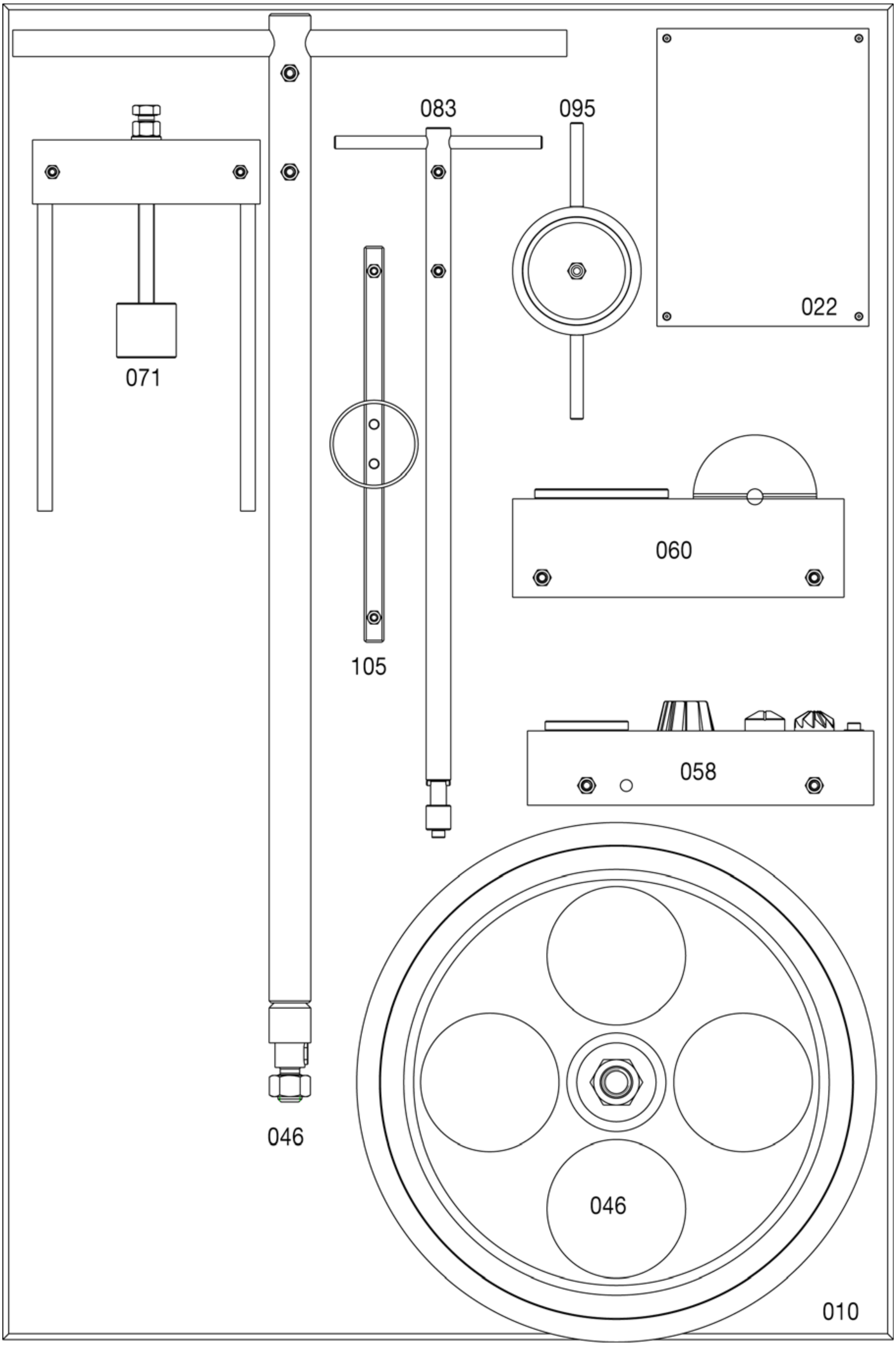
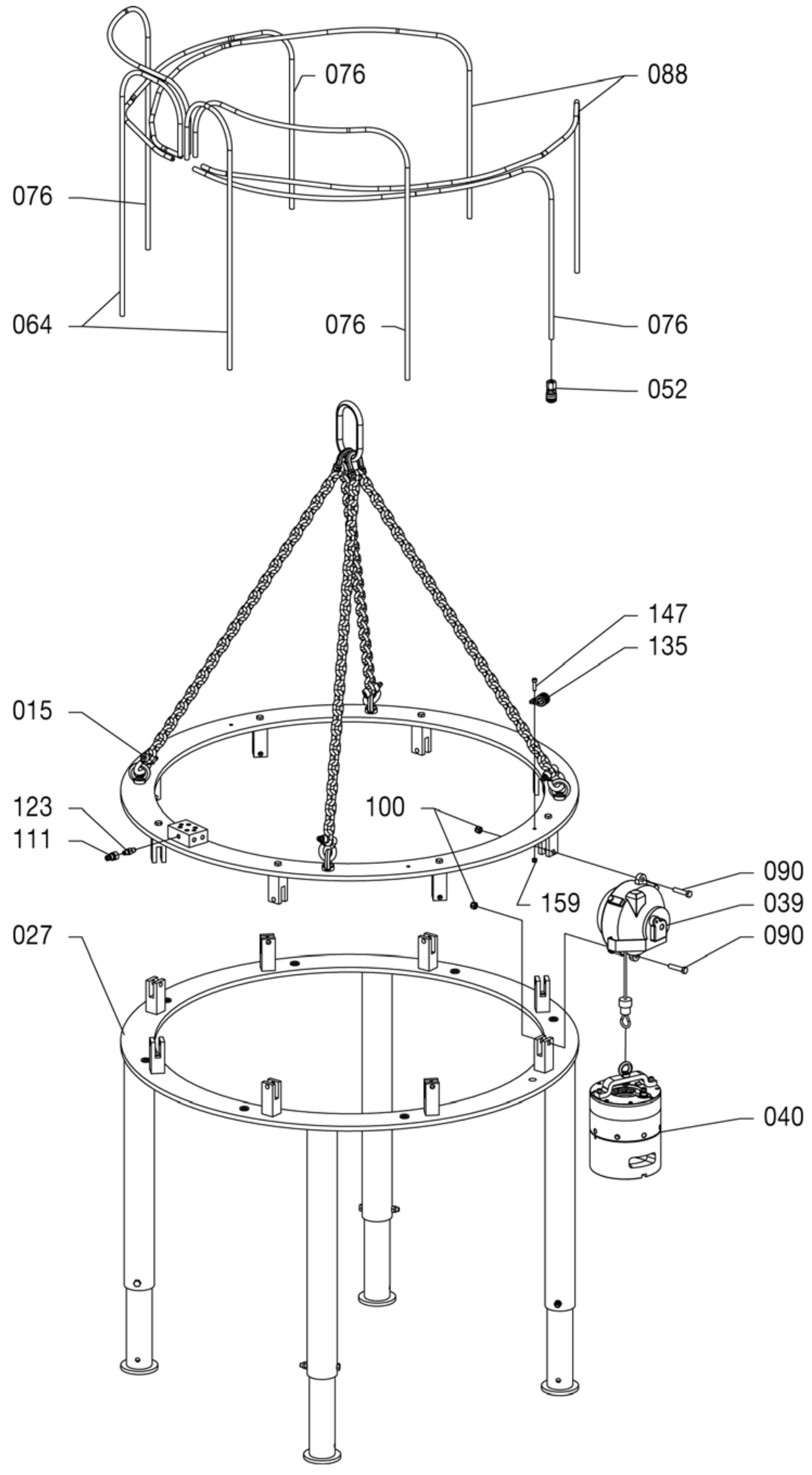


Plate 2270-0300-0004

Item no	Qty	Designation
010	-	Panel for tools
022	-	Name plate
046	-	Grinding tool for exhaust valve seat
058	-	Milling and grinding wheel for fuel valve
060	-	Milling and grinding wheel for starting valve
071	-	Dismantling lever for fuel valve
083	-	Handle, sundry types
095	-	Grinding ring for starting valve
105	-	Pin wrench for starting valve

2009-01-27

Cylinder Cover Hydraulic Tools



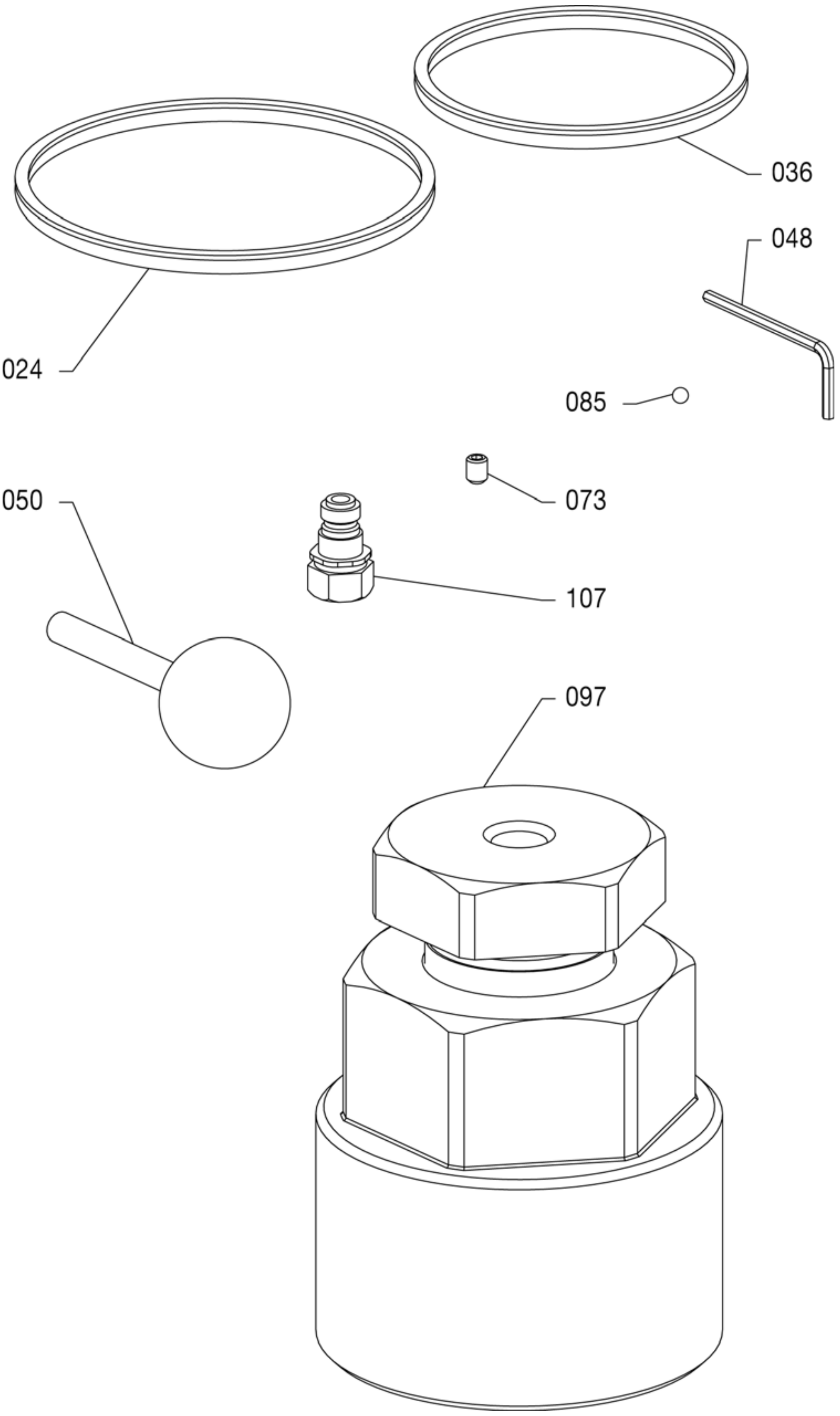
2008-07-30

Plate
2270-0310-0002

Item no	Qty	Designation
015	-	Balancing ring assembly
027	-	Balancing ring assembly
039	-	Spring balance
040	-	Hydraulic jack, complete
052	-	Quick coupling, female
064	-	Steel hose with 2 union
076	-	Steel hose with 2 union
088	-	Steel hose with 2 union
090	-	Screw
100	-	Nut, self-locking
111	-	Quick coupling, male
123	-	Hexagon nipple
135	-	Pipe clamp, 1 flap
147	-	Screw
159	-	Nut, self-locking

Cylinder Cover Hydraulic Tools Spares

Plate
2270-0315-0001



2008-07-30

Item no	Qty	Designation
024	-	Sealing ring with back-up
036	-	Sealing ring with back-up
048	-	Hex key
050	-	Ball handle
073	-	Hollow-point screw
085	-	Steel ball
097	-	Stud setter
107	-	Quick coupling, male

2008-07-30

Cylinder Cover Support Tools

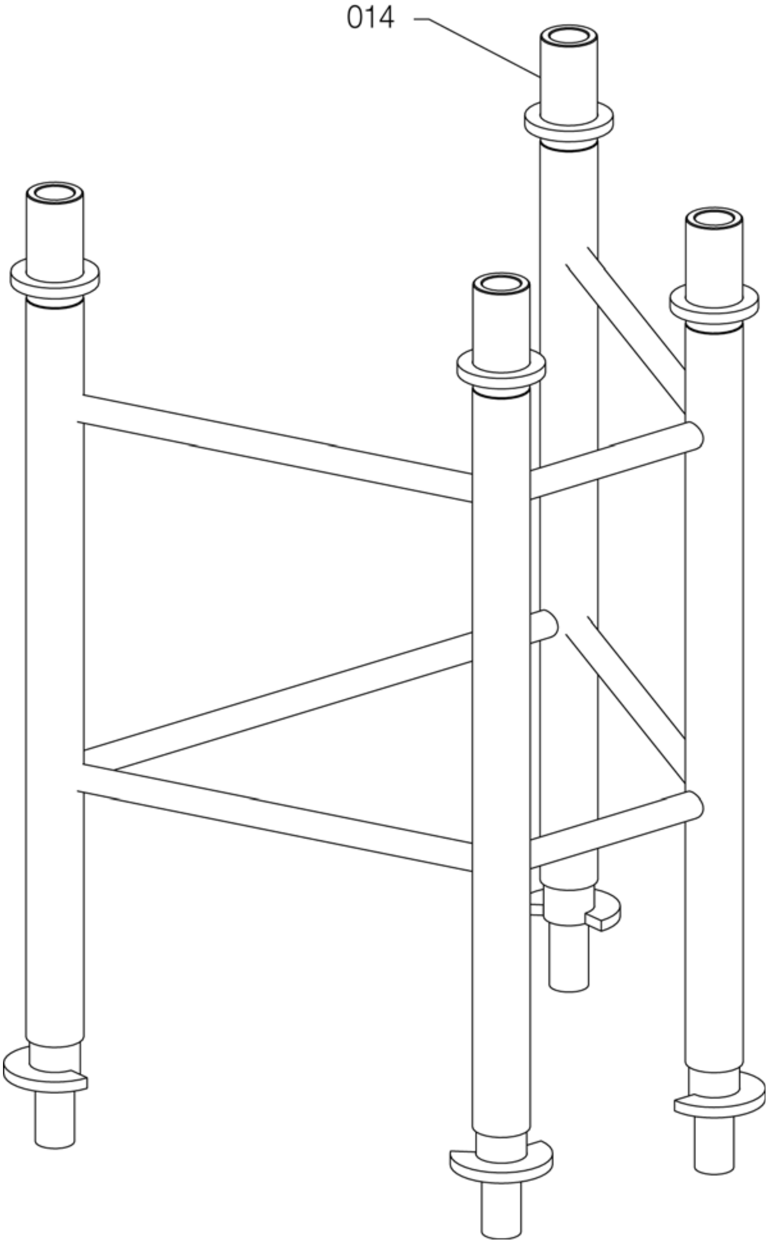
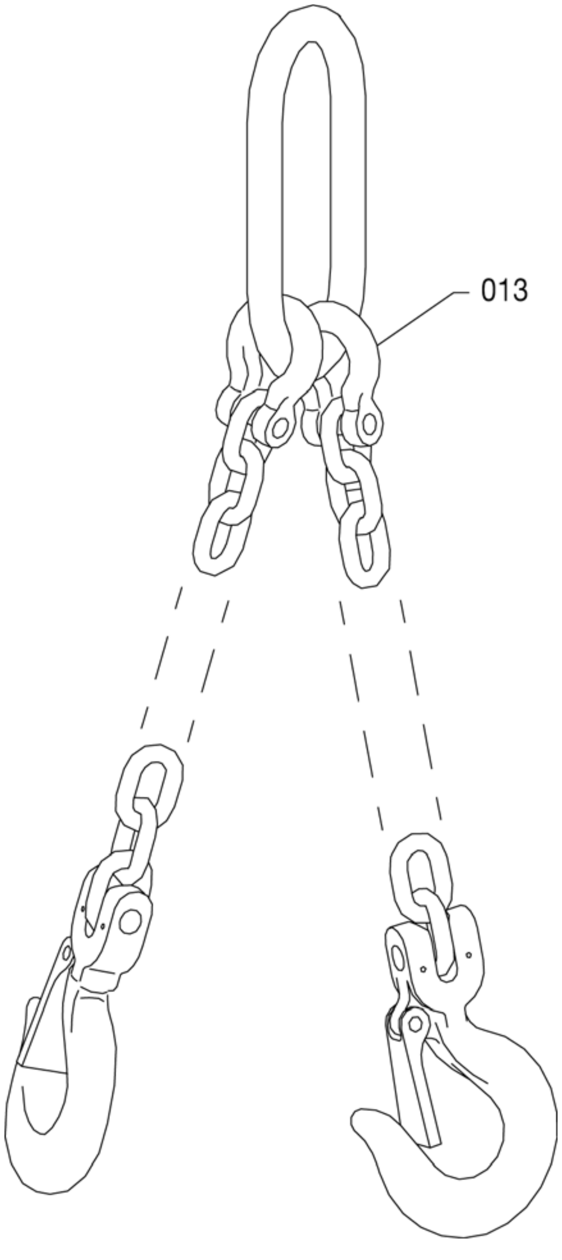


Plate
2270-0330-0003

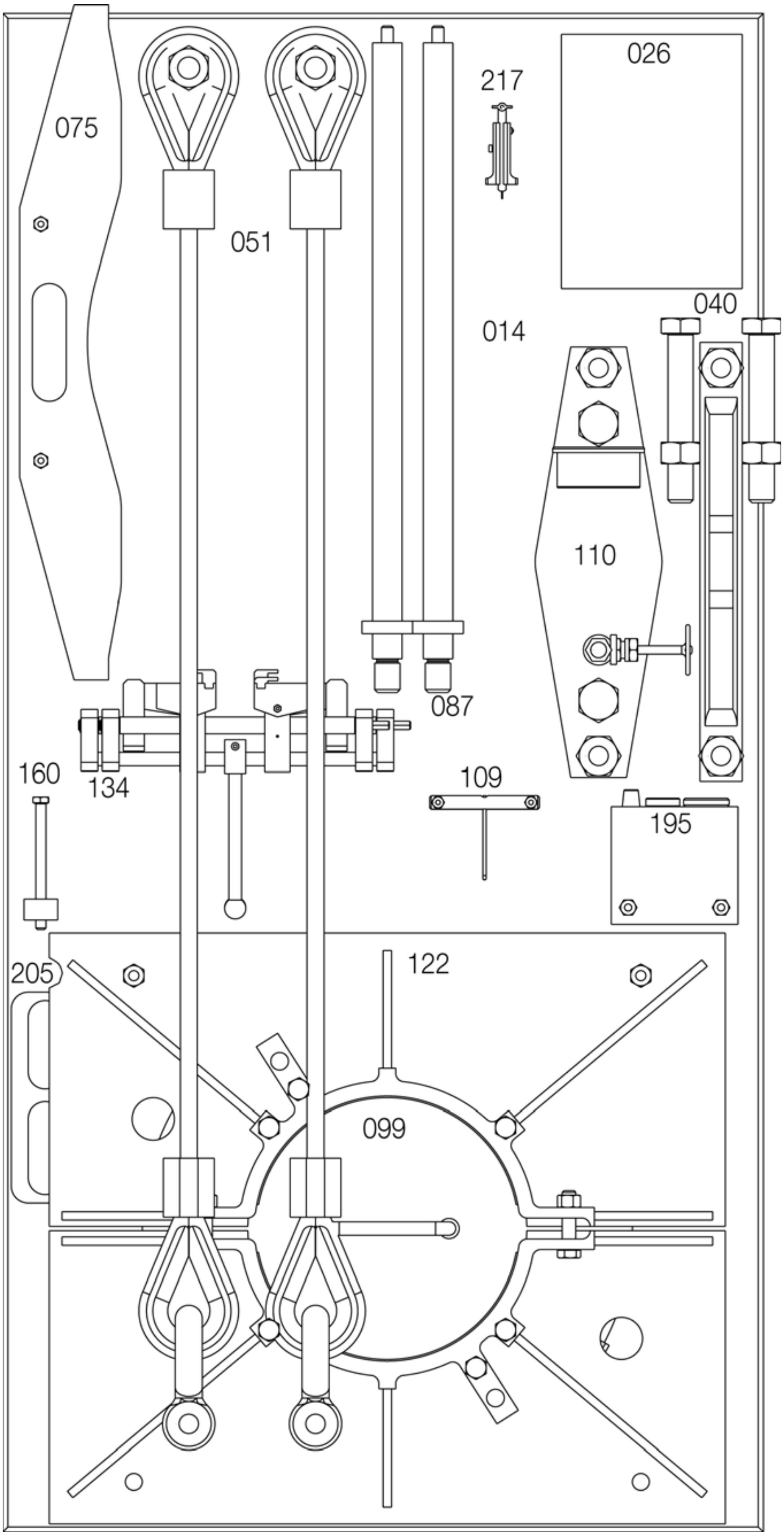
Item no	Qty	Designation
014	-	Cylinder cover rack



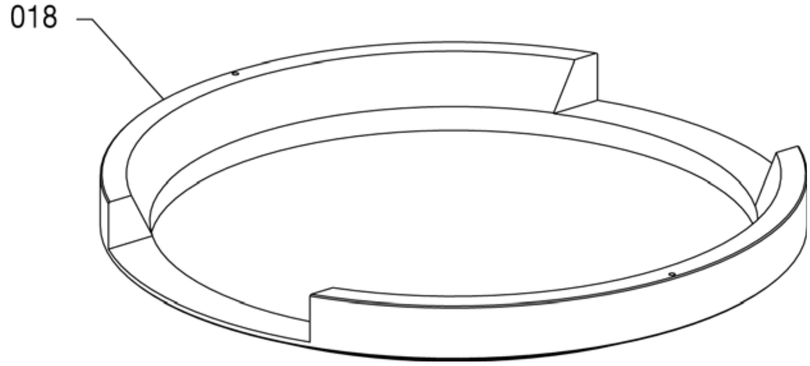
2008-05-07

Item no	Qty	Designation
013	-	Lifting chains, cylinder cover

2008-05-07


075
051
217
026
014
040
110
087
160
134
109
195
205
122
099

Item no	Qty	Designation
014	-	Panel for tools
026	-	Name plate
040	-	Lift for piston rod foot
051	-	Lift tool for cylinder liner
075	-	Template for piston top
087	-	Distance piece
099	-	Cover for stuffing box hole
109	-	Mounting tool for stuffing box spring
110	-	Pressure test tool for piston
122	-	Worktable for stuffing box
134	-	Piston ring expander
160	-	Screw
195	-	Pushing tool for seals
205	-	Gauge for stuffing box
217	-	Slide caliper



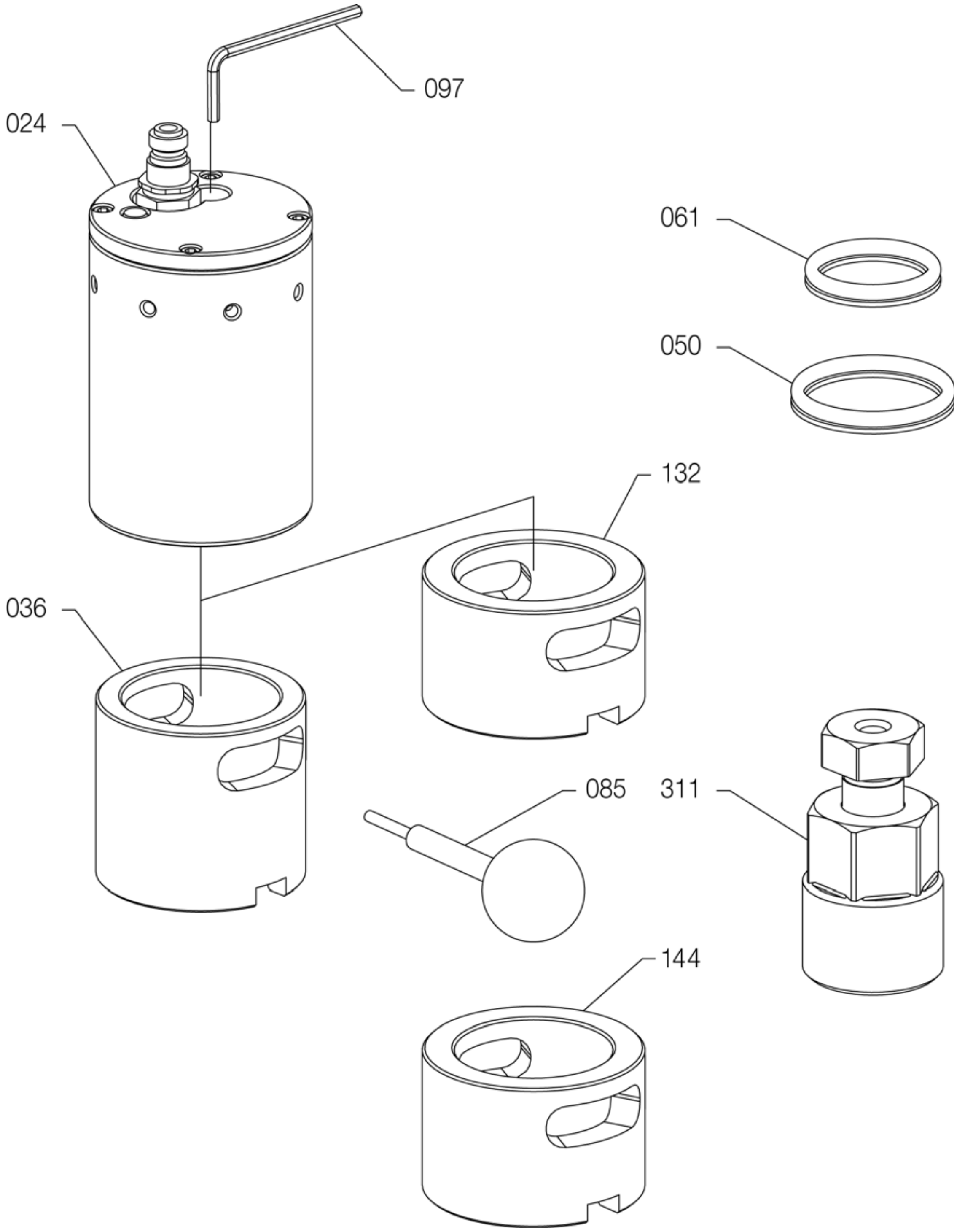
2008-07-10

Piston Guide Tool

Plate 2270-0430-0002

Item no	Qty	Designation
018	-	Guide ring for piston

2008-07-10


097
024
061
050
132
036
085
311
144

Item no	Qty	Designation
024	-	Hydraulic jack, complete
036	-	Hydraulic jack, support
050	-	Sealing ring with back-up
061	-	Sealing ring with back-up
085	-	Tommy bar
097	-	Hex key
132	-	Hydraulic jack support
144	-	Hydraulic jack support
311	-	Stud setter

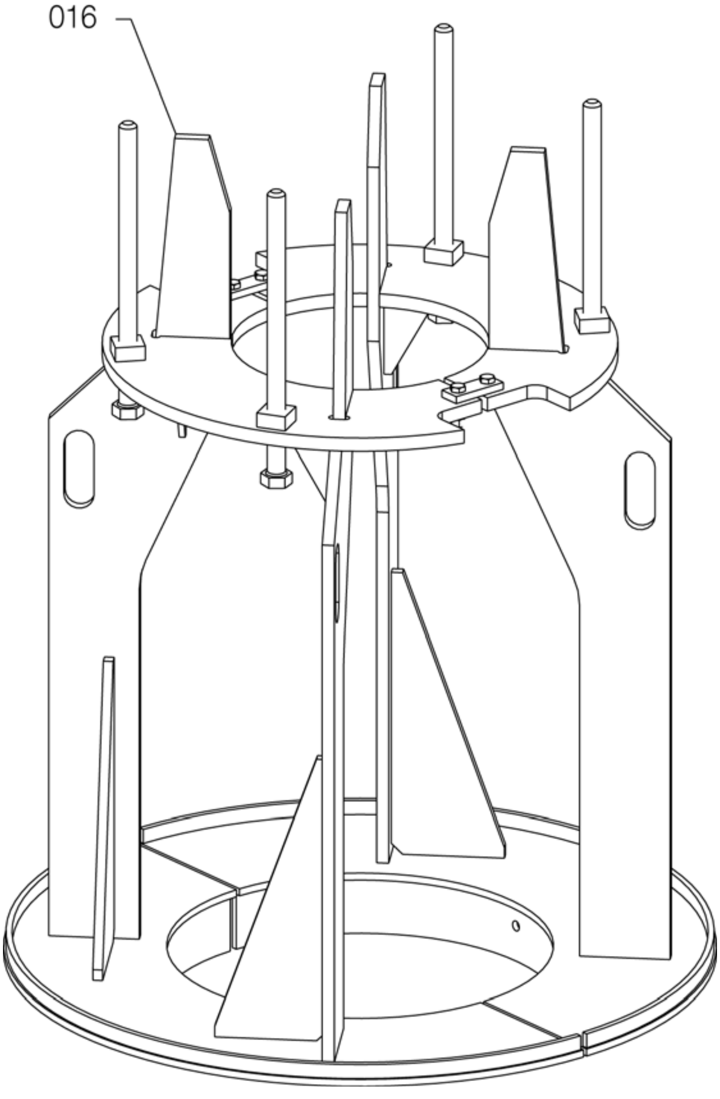
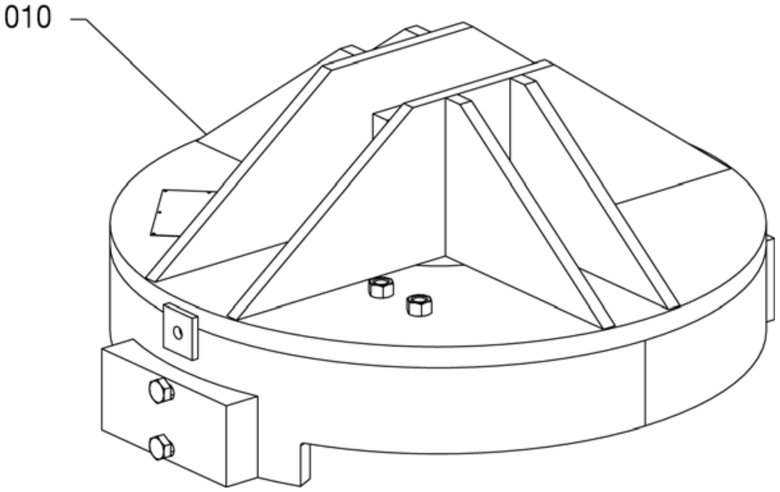


Plate 2270-0470-0009

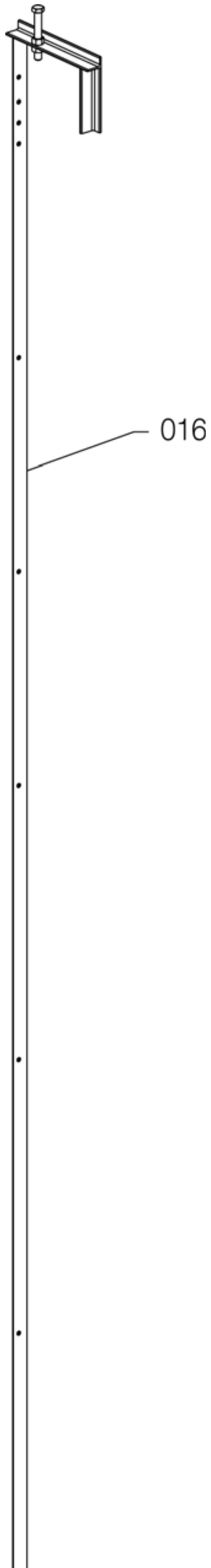
Item no	Qty	Designation
016	-	Support iron for piston



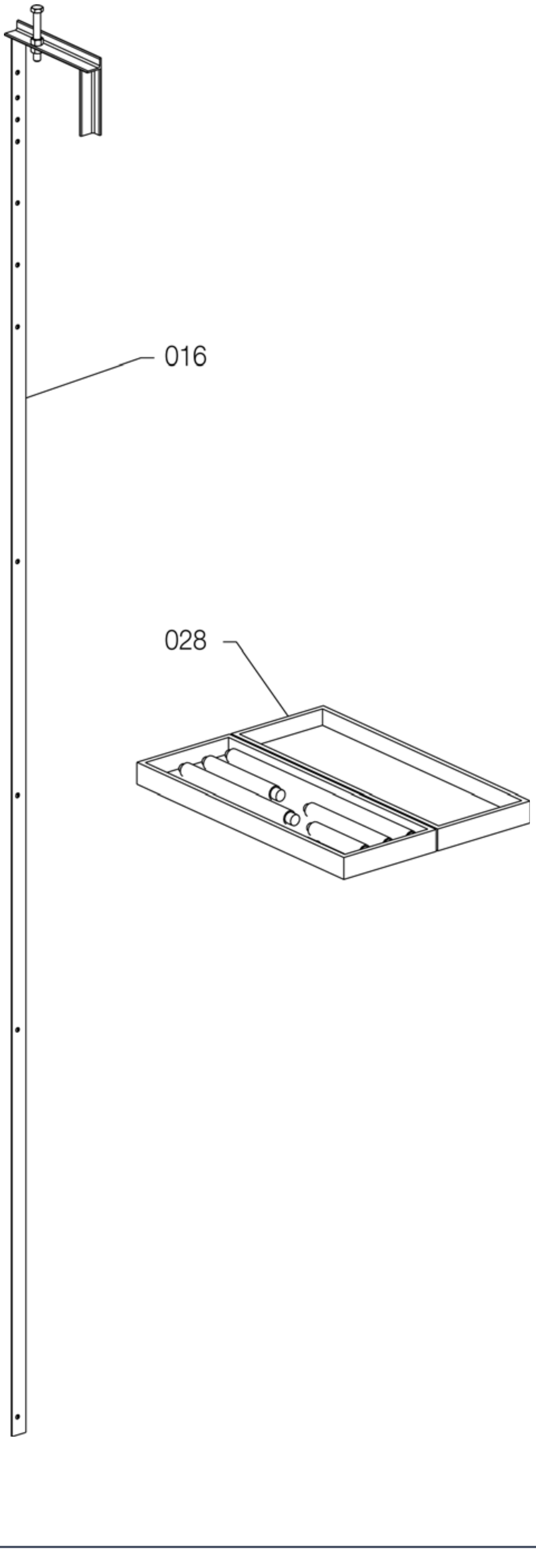
2008-07-10

Plate 2270-0480-0002

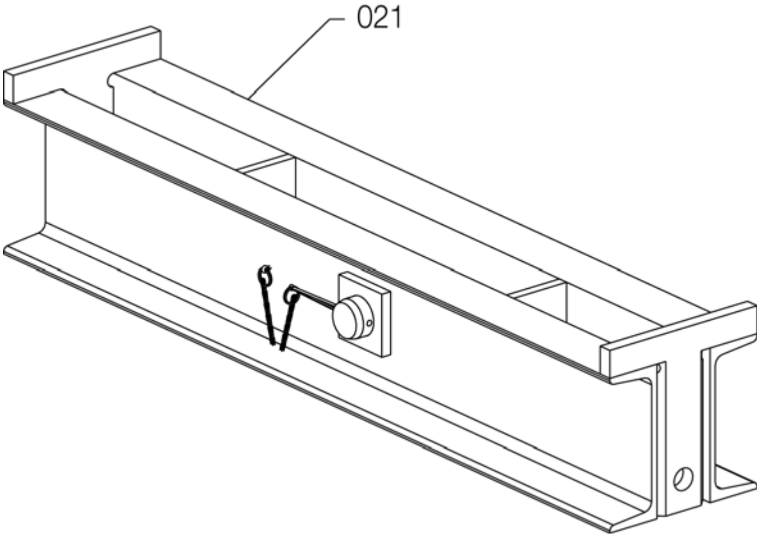
Item no	Qty	Designation
010	-	Lifting tool for piston


016

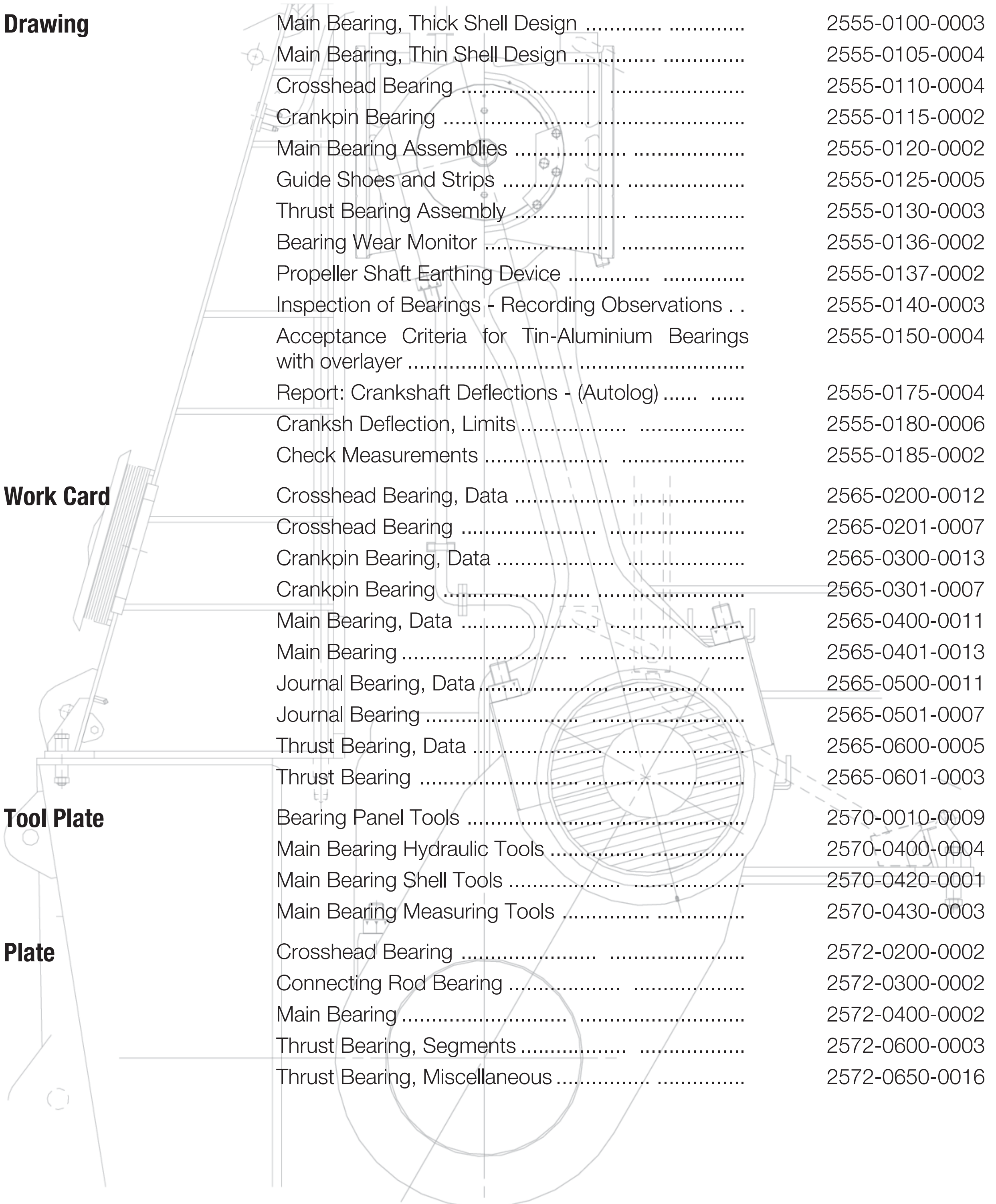
Item no	Qty	Designation
016	-	Measuring tool for cylinder liner


016
028

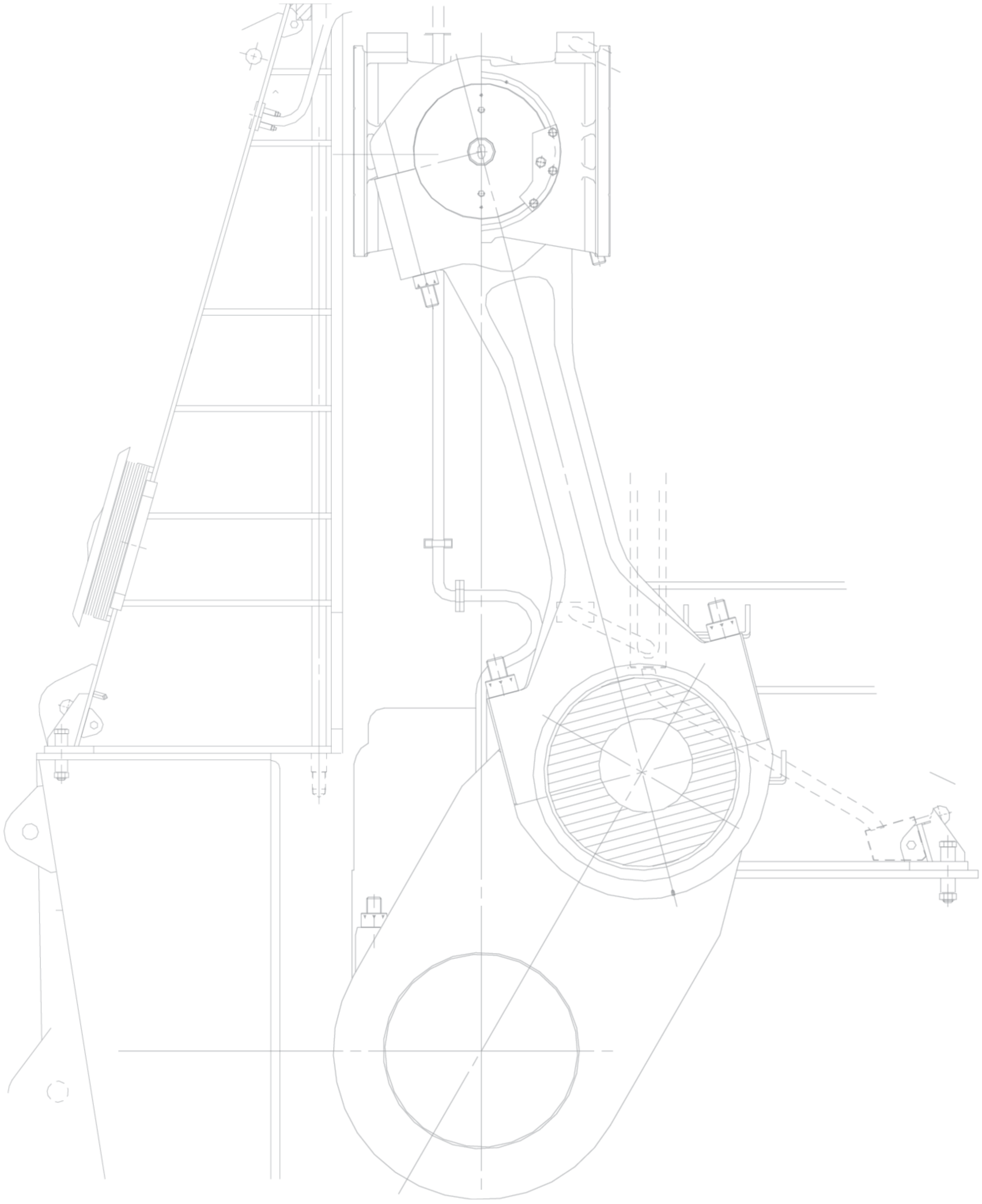
Item no	Qty	Designation
016	-	Measuring tool for cylinder liner
028	-	Measuring tool for cylinder liner


021

Item no	Qty	Designation
021	-	Cross bar for cylinder liner



Preface Chapter	Bearings	2540-0100-0002
Description	Bearings	2545-0100-0004
	Alignment of Main Bearings	2545-0110-0002
Drawing	Main Bearing, Thick Shell Design	2555-0100-0003
	Main Bearing, Thin Shell Design	2555-0105-0004
	Crosshead Bearing	2555-0110-0004
	Crankpin Bearing	2555-0115-0002
	Main Bearing Assemblies	2555-0120-0002
	Guide Shoes and Strips	2555-0125-0005
	Thrust Bearing Assembly	2555-0130-0003
	Bearing Wear Monitor	2555-0136-0002
	Propeller Shaft Earthing Device	2555-0137-0002
	Inspection of Bearings - Recording Observations . .	2555-0140-0003
	Acceptance Criteria for Tin-Aluminium Bearings with overlayer	2555-0150-0004
	Report: Crankshaft Deflections - (Autolog)	2555-0175-0004
	Cranksh Deflection, Limits	2555-0180-0006
	Check Measurements	2555-0185-0002
Work Card	Crosshead Bearing, Data	2565-0200-0012
	Crosshead Bearing	2565-0201-0007
	Crankpin Bearing, Data	2565-0300-0013
	Crankpin Bearing	2565-0301-0007
	Main Bearing, Data	2565-0400-0011
	Main Bearing	2565-0401-0013
	Journal Bearing, Data	2565-0500-0011
	Journal Bearing	2565-0501-0007
	Thrust Bearing, Data	2565-0600-0005
	Thrust Bearing	2565-0601-0003
Tool Plate	Bearing Panel Tools	2570-0010-0009
	Main Bearing Hydraulic Tools	2570-0400-0004
	Main Bearing Shell Tools	2570-0420-0001
	Main Bearing Measuring Tools	2570-0430-0003
Plate	Crosshead Bearing	2572-0200-0002
	Connecting Rod Bearing	2572-0300-0002
	Main Bearing	2572-0400-0002
	Thrust Bearing, Segments	2572-0600-0003
	Thrust Bearing, Miscellaneous	2572-0650-0016



Crosshead Bearing

The crosshead is equipped with steel shells lined with bearing metal. The lower shell is provided with an overlayer coating.

Main Bearing

The main bearings consist of steel shells, lined with bearing metal.

Thrust Bearing

The thrust bearing serves the purpose of transmitting the axial thrust of the propeller through propeller shaft and intermediate shafts to the ship’s hull.

The crankshaft is provided with a thrust collar which transmits the thrust to a number of segments mounted in a thrust shoe on either side of the thrust collar.

The thrust shoes rest on surfaces in the thrust bearing housing and are held in place by means of stoppers or cross bars. The segments have white metal cast onto the wearing faces against the thrust collar. *See also Description 2545- 0100.*

The thrust bearing is lubricated by the pressure lubrication system of the engine. The oil is supplied between the segments through spray pipes and spray nozzles.

The thrust bearing is provided with alarm, slowdown, and shutdown devices for low lube oil pressure and high segment temperature. *See also Description 7045-0100.*

Stationary engines and geared marine plants:
The crankshaft is provided with a collar for the guide bearing. The purpose of the guide bearing is to keep the crankshaft in its proper position in the axial direction.

1 General Bearing Requirements and Criteria for Evaluation

Bearings are vital engine components; therefore, bearing design and choice of bearing metal is crucial for reliable engine performance.

Bearing design criteria depend on the bearing type and, in general, on:

1. Bearing load
    - Static
    - Dynamic
2. Bearing load direction
3. Journal Orbit
4. Revolutions
5. Cooling
6. Expected lifetime
7. Overhaul aspects
8. Space aspects

The compactness of engines and the engine ratings (gas pressure, engine speed and stroke/bore) influence the magnitude of the specific load on the bearing and make the correct choice of bearing metals, construction, production quality and, in certain bearings, the application of overlayer necessary. *(See Item 3., 'Overlayers')*.

2 Bearing Metals

2.1 Tin based White Metal

Tin-based white metal is an alloy with minimum 88% tin (Sn), the rest of the alloy composition is antimony (Sb), copper (Cu), cadmium (Cd) and small amounts of other elements that are added to improve the fineness of the grain structure and homogeneity during the solidification process. This is important for the load carrying and sliding properties of the alloy. *Lead (Pb) content in this alloy composition is an impurity, as the fatigue strength deteriorates with increasing lead content, which should not exceed 0.2 % of the cast alloy composition.*

2.2 Tin Aluminium (AlSn40)

Tin aluminium is a composition of aluminium (Al) and tin (Sn) where the tin is trapped in a 3-dimensional mesh of aluminium. AlSn40 is a composition with 40% tin. The sliding properties of this composition are very similar to those of tin based white metal but the dynamic loading capacity of this material is higher than tin based white metals at similar working temperature; this is due to the ideal combination of tin and aluminium, where tin provides the good embedability and sliding properties, while the aluminium mesh functions as an effective load absorber.

3 Overlayers, Coatings and Running-in layers

An overlayer is a thin galvanic coating of mainly lead (Pb), copper (Cu) and tin (Sn), which is applied directly on to the white metal or, via a thin galvanically applied intermediate layer of either Ag or Ni, on to the tin aluminium sliding surface of the bearing. The overlayer is a soft and ductile coating, its main objective is to ensure good embedability and conformity between the bearing sliding surface and the pin surface geometry. Overlayer is mainly used in Cross Head Bearing design.

4 Flashlayer, Tin (Sn)

A flash layer is a 100% tin (Sn) layer which is applied galvanically; the thickness of this layer is only a few µm. The coating of tin flash is applied all over and functions primarily to prevent corrosion (oxidation) of the bearing. The tin flash also functions as a dry lubricant when new bearings are installed and when the crankshaft is turned.

5 Bearing Design

See Drawings 2555-0100/0105/0110/0115

Plain bearings for engines are manufactured as steel shells with a sliding surface of white metal or tin aluminium with or without overlayer/flash layer. Tin aluminium bearings are always of the thin shell design while the white metal bearings can either be of the thick shell or thin shell design.

The bearing surface is furnished with a centrally placed oil supply groove and other design features such as *smooth run-outs, oil wedges and/or bore reliefs*.

5.1 Smooth Runout of Oil Groove

(See Drawings 2555-0100/0105/0115, Fig. B-B

A smooth runout is the transition geometry between the circumferential oil supply groove and the bearing sliding surface. This special oil groove transition geometry prevents an oil scraping effect and enhances the hydrodynamic build-up of the load-carrying oil film towards the loaded area of the bearing *(Main bearing Drawings 2555-0100 and 2555-0105 and crankpin bearing Drawing 2555-0115)*.

5.2 Bore Relief

See Drawings 2555-0100/0105/0115, Fig. A-A

The bearing sliding surface is machined near the mating faces of the upper and lower shells to create bore reliefs. Their main objective is to compensate for misalignments which could result in a protruding edge (step) of the lower shell's mating face to that of the upper shell. Such a protruding edge can act as an oil scraper and cause oil starvation. *(Main bearing Drawing 2555-0100 and 2555-0105 and crankpin bearing Drawing 2555-0115)*.

5.3 Axial Oil Grooves and Oil Wedges

See Drawings 2555-0110 and 2555-0125

Oil grooves and wedges have the following functions:

1. To enhance the oil distribution over the load carrying surfaces. (The tapered areas give improved oil inlet conditions).
2. Especially in the case of crosshead bearings (Drawing 2555-0110) - to assist the formation of a hydrodynamic oil film between the load carrying surfaces.
3. To provide oil cooling (oil grooves).

In order to perform these functions, the oil must flow freely from the lubricating grooves, past the oil wedges, and into the supporting areas - where the oil film carries the load.

5.4 Thick Shell Bearings

See Drawing 2555-0100

This type of bearing has a steel back with the required stiffness

1. To ensure against distortion of the sliding surface geometry, and
2. To support the cast-on white metal in regions where the shell lacks support, for example in the area of the upper shell mating faces.

The top clearance in this bearing design is adjusted with shims, while the side clearance is a predetermined result of the summation of the housing bore, shell wall thickness, journal tolerances, and the influence of the staybolt and bearing stud tensioning force which deforms the bedplate around the bearing assembly.

Thick shell bearings are typically 30-60 mm thick and used for main bearings only.

5.5 Thin Shell Bearings

See Drawing 2555-0105

Thin shell bearings have a wall thickness between 2% and 2.5% of the journal diameter. The steel back does not have the sufficient stiffness to support the caston bearing metal alone. The bearing must therefore be supported rigidly over its full length. This type of bearing is manufactured with a circumferential overlength (crush/nip) which, when the shells are mounted and tightened up, will produce the required radial pressure between the shell and the bearing housing.

Thin shell bearings are also made as blended edge design. The blended edge design is a smooth radius that allows the main bearing shaft to incline without risking touching the bearing edge or causing high oil film pressure at the edge. The blended edge is described by two dimensions, length and depth. The actual values depend on the engine size and configuration. Drawing *2555-0105 Fig. 2* shows an example of a blended edge. With a good blended edge design, the high edge load can be reduced and distributed over a larger area, thus resulting in a decreased max. oil film pressure and increased safety against edge fatigue failure.

NOTICE

Bearings shells can be with or without blended edge and must never be switched between the bearings.

The top and side clearance in this bearing is predetermined and results from a summation of the housing bore, shell wall thickness, journal/pin diameter tolerances and, for main bearings, the deformation of the bedplate from the staybolt and bearing stud tensioning force.

5.6 Top Clearance

Correct top clearance in main bearings, crankpin bearings, and crosshead bearings is a balance between sustaining the required oil flow through the bearing, hence stabilizing the bearing temperature at a level that will ensure the fatigue strength of the bearing metal and having a geometry, which enhances a proper oil film build-up and maintenance.

Too high top clearance is often the cause of fatigue cracks.

The bearings are checked in general by measuring the top clearances.

In service, top clearance measurements can be regarded:

1. as a check of the correct re-assembly of the bearing. For new bearings the clearances should lie within the limits specified in the maintenance manual.
2. as an indicator to determine the condition of the bearing at a periodic check without opening up, *see Item 7.1, ‘Check without Opening up’*.

In both cases, it is vital that the clearance values from the previous check are available for comparison. Therefore, it is necessary to enter clearances in the engine log book with the relevant date and engine service hours *(see e.g. Drawing 2555-0140 page 5)*.

The initial clearances can be read from the testbed results

5.7 Wear

Bearing wear is negligible under normal service conditions, *see Item 7.8, ‘Bearing Wear Rate’*. Excessive wear is due to abrasive or corrosive contamination of the system oil which will affect the roughness of the journal/pin and increase the wear rate of the bearing. The so-called Spark Erosion Phenomenon (See item 6.2), will lead to highly increased Main Bearing wear rates, particularly in case of AlSn Main Bearing type.

5.8 Monitoring

The aim of monitoring engine bearings, is to avoid extensive damage to the engine. Monitoring in a wider perspective, has numerous good side-effects. One in particular is that the well known fact of possible contamination of internal engine parts, when opening up, is decreased. The systems described in the following are designed to monitor the engine bearings continiously using various techniques.

5.8.1 Bearing Wear Monitoring (BWM)

The aim of the BWM system is to detect a bearing damage before the lining (Babbitt or Tin-Aluminium) is worn away by lining scuffing (Tin-Aluminium), wiping, abrasive wear, melting out or extensive fatigue of the lining (Babbitt) and steel to steel contact occurs. However, the intended effect of the system is not to protect the bearing shells as such, but mainly to prevent consequential damage of the crankshaft and bedplate in case of severe bearing failures.

The principle of the BWM system is to measure the vertical position of the crosshead in bottom dead centre (BDC) (see Drawing 2555-0136, projection which shows the crosshead and BWM sensor on the guide plane). The BWM system monitors all three principal crank-train bearings using two proximity sensors forward/aft per cylinder unit and is placed inside the frame box.

Targeting the guide shoe bottom ends continuously, the sensors measure the distance to the crosshead in BDC. Signals are computed and digitally presented to computer hardware, from which a useable and easily interpretable interface is presented to the user. The measuring precision is more than adequate to obtain an alarm well before steel-to-steel contact in the bearings occur.

In case of wear in a main bearing, in a crankpin bearing or in a crosshead bearing, this vertical position will reflect the wear. By appropriate signal processing following a MAN Diesel & Turbo specification, the system delivers alarm or slow down relay output in the case of abnormal wear of one or more bearings. As such the system must be connected to the alarm and safety systems. *Also refer to Cheking and maintenance schedule Chapter 0760-0301*.

5.8.2 Bearing Temperature Monitoring System (BTM)

The BTM system continuously monitors the temperature of the bearings. The monitoring is performed either by measuring the temperature on the rear side of the bearing shell directly or by detecting the return oil from each bearing in the crankcase. In case of a specified temperature is recorded, either a bearing shell temperature or bearing oil outlet temperature, an alarm is raised. For shell temperature in main, crankpin and crosshead bearings two high-temperature alarm levels apply.

The first level alarm is indicated in the alarm panel while the second level activates a slow down command. For oil outlet temperature in main, crankpin and crosshead bearings two high temperature alarm levels including deviation alarm apply. The first level of the high temperature/deviation alarm is indicated in the alarm panel while the second level activates a slow down command.

5.8.3 Water in Oil Monitoring (WIOM)

Water content in the lubricating oil can be extremely damaging to engine bearings, if significantly exceeding the saturation point of a given system oil, typically max. 0.2 vol.%; for a short period up to 0.5 vol.%. This is particularly valid for Tin-Aluminium lined crosshead bearings featuring lead overlay as running layer. The higher the water content, the faster the wear rate.

The excessive water content will cause the lead overlay in crosshead bearings to corrode away rapidly. Main and crankpin bearings lined with Babbitt or Tin- Aluminium may also suffer irreparable damage from water contamination, but the damage mechanism would be different and not as acute.

The above scenario can be prevented by continiously monitoring eventual water contamination of the lubricating oil. For this purpose a Water In Oil Monitoring System is implemented in the engine lub oil system, continiously meassuring the relative humidity in the system oil. A probe in the oil piping system transmits a signal to a unit, which calculates the humidity as Water Activity (aw). This method of calculation has the advantage of being independent of oil type, temperature or age. The system is connected to the alarmsystem.

5.8.4 Propeller Shaft Earthing Device

The Propeller Shaft Earthing Device, is a system designed to avoid so called spark erosion in the engine bearings and journals. The spark erosion phenomenon is a result of difference in electrical potential between metal parts. The level of electrical potential lies generally between 200 – 600 mV on engines without protection from a Propeller Shaft Earthing Device.

In some cases, it has been found that this difference in electrical potential between the hull and the propeller shaft has caused spark erosion on the main bearings and journals of the engine. To avoid this, a continuous electrical earthing circuit between the propeller and the ships structure, must be established. This circuit usually exists when the propeller is at a rest, where a metal to metal contact is made between the shaft and the stern tube liners, or main engine bearings and journals.

However, whilst the shaft is turning the bearing oil film creates an intermittent high resistance which effectively insulates the propeller from the hull structure. Since the propeller presents a relatively large surface area of bare metal, it attracts cathodic protection currents, which tend to discharge by arcing across the bearing oil film. This can result in spark erosion which eventually leads to pitting and ‘striping’ of white metal bearing surfaces.

In order to reduce the potential between the propeller shaft (crankshaft) and the hull (engine structure), thus protecting the engine, an earthing device is installed on the intermediate shaft, *see Drawing 2555-0137*. The plate shows the principal components of a Propeller Shaft Earthing Device. As a Condition Monitor a voltmeter is installed to ensure a continuous display of the shaft/hull potential. The reading is not to exceed 50 mV. Readings in excess of this value (Alarm limit = 80 mV>) are indicative of worn bonding brushes or poorly maintained brushgear and/ or sliprings. The system is connected to the alarm system.

5.8.5 Undersize Bearings

1. **Crankpin bearings** are thin shell bearings. Due to relatively long production time, the engine builder has a ready stock of semi-produced shells *(blanks)* that covers a range from nominal diameter to 3 mm undersize, *see also Item 6.4, 'Undersize Journals/ Pins'. Semi-produced shells for journals with undersizes lower than 3 mm are not stocked as standard.* Furthermore, undersizes lower than 3 mm can also involve modification such as the bolt tension, hydraulic tool, etc.

   For advice on the application of undersize bearings, it is recommended to contact MAN Diesel & Turbo.

2. The **main bearings** for the engine series can be of the thick or thin shell type *(see Drawing 2255-0100 and 2255-0105)*; the information under point 1 is also valid here.

3. **Crosshead bearings** are only available as standard shells for engines, as the reconditioning proposal for offset grinding of the pin (refer to 6.4 2.b) facilitates the use of standard shells, but not for AlSn40 crosshead bearings.

   It is recommended to contact MAN Diesel & Turbo for advice on such reconditioning.

6 Journals/Pins

6.1 Surface Roughness

Journal/pin surface roughness is important for the bearing condition. Increased surface roughness can be caused by:

1. Abrasive damage due to contamination of the system oil.
   See also Item 7.4.2.
2. Corrosive damage due to sea water or other contamination of the system oil (acidic) or oxidation of the journals due to condensate.
   See also Item 7.4.2.
3. Spark erosion (only known in main bearings).
   See also Item 6.2, 'Spark Erosion'.
4. Scratches caused by manhandling.

With increasing journal/pin roughness, a level will be reached where the oil film thickness is no longer sufficient, causing metal contact between journal/pin and the bearing sliding surface. This will cause bearing metal to adhere to the journal/ pin, giving the surface a silvery white appearance and roughening the bearing surface at the same time. When such a condition is observed, the journal/pin must be reconditioned by polishing, and the roughness of the surface made acceptable. In extreme cases, the journal/pin must be ground to an undersize *(see Item 6.4, 'Undersize Journals/Pins')*. The bearing shell condition determines whether exchange of the shells are necessary or not.

6.2 Spark Erosion

Spark erosion is caused by a voltage discharge between the main bearing and journal surface.

The cause of the potential can be insufficient earthing of the engine and generator.

The oil film acts as a dielectric. The spark attacks in the bearing depends on the thickness of the oil film.

Since the hydrodynamic oil film thickness varies through a rotation cycle, the discharge will take place at roughly the same instant during each rotation cycle, i.e when the film thickness is at its minimum. The roughening will accordingly be concentrated in certain areas on the journal surface. However, as the bearings wear, the position of the spark attack may shift and thus other parts get damaged.

In the early stages, the roughened areas can resemble pitting erosion - but later, as the roughness increases, the small craters will scrape off and pick up bearing metal - hence the silvery white appearance.

Therefore, to ensure protection against spark erosion, the potential level must be kept at *maximum 50 mV*, which is feasible with a high efficiency earthing device. If an earthing device is installed, its effectiveness must be checked regularly. *(See also Drawing 2555-0137).*

Spark erosion has only been observed in main bearings and main bearing journals. Regarding repair of the journals, *see Item 7.11, 'Repairs of Journals/Pins'.*

The condition of the bearings must be evaluated to determine whether they can be reconditioned or if they have to be discarded. *It is recommended to contact MAN Diesel & Turbo if advice is required.*

6.3 Surface Geometry

Surface geometry defects such as lack of roundness, conicity and misalignment may give rise to operational difficulties. Such abnormal cases of journal/pin geometry and misalignment may occur after a journal grinding repair.

It is recommended to contact MAN Diesel & Turbo for advice.

6.4 Undersize Journals/Pins

In case of severe damage to the journal, it may become necessary to recondition the journal/pin by grinding to an undersize.

1. Main and crankpin journals can be ground to 3 mm undersize; undersize journals below this value require special investigations of the bearing assembly.

   It is recommended to contact MAN Diesel & Turbo for advice.

2. In service, crosshead pins can be:

   a. Polished to ($D_{nominal}$ - 0.15 mm) as the *minimum* diameter.

   b. Offset to a maximum of 0.3 mm and ground.

   c. Undersize (AlSn40) or repaired by welding.

In both cases, since standard bearings are used, the bearing top clearance will increase depending on the surface condition of the pin to be reconditioned. The offset value used for grinding must be stamped clearly on the pin.

It is recommended to contact MAN Diesel & Turbo for advice.

7 Practical Information

7.1 Check without Opening up

Follow the check list in accordance with the programme stated in *the Work Cards. Enter the results in the engine log book. See also Item 7.12, 'Inspection of Bearings'*.

1. Stop the engine and block the main starting valve and the starting air distributor and block the starting air reservoir valves.
2. Engage the turning gear.
3. Just after stopping the engine, while the oil is still circulating, check that uniform oil jets appear from all the oil outlet grooves in the crosshead bearing lower shell and the guide shoes.
4. Turn the crankthrow for the relevant cylinder unit to a suitable position and stop the lube oil circulating pump (it is recommended to turn the engine for 15 - 30 minutes with the pumps off to let the oil drip off).
5. Check the vertical clearance with a feeler gauge.

   a.
   The change in clearances must be negligible when compared with the readings from the last inspection (overhaul). If the total increase in clearance as from new is beyond the tolerance, the bearing should be inspected.

   b.
   For guide shoe and guide strip clearances and checking procedure, *see Work Card 2565*.

6. Examine the sides of the bearing shell, guide shoes and guide strips, and check for squeezed-out or loosened metal; also look for bearing metal fragments in the oil pan, *See: 2565-0401, Wire feeler Check*.
7. In the following cases, the bearings must be dismantled for inspection, *see Item 7.2, 'Open up Inspection and Overhaul'*.

   a.
   Bearing running hot.

   b.
   Oil flow and oil jets uneven, reduced or missing.

   c.
   Increase of clearance since previous reading larger than 0.10 mm.
   See also Item 7.8, 'Bearing Wear Rate'.

   d.
   Bearing metal squeezed out, dislodged or missing at the bearing, guide shoe or guide strip ends.

   e.
   The oil having been contaminated with e.g. water

If Item 7.a has been observed excessively in crosshead bearings or crankpin bearings, measure the diameter of the bearing bore in several positions. If the diameter varies by more than 0.06 mm, send the connecting rod complete to an authorised repair shop.

If Items 7.a, 7.c or 7.d are observed when inspecting main bearings, we will recommend to inspect the two adjacent bearing shells, to check for any abnormalities.

If item 7.e has been observed, check lead content in oil analysis. If high open up Cross Head Bearing.

7.2 Open up Inspection and Overhaul

See Drawing 2555-0140

NOTICE

Record the hydraulic pressure level when the nuts of the bearing cap go loose.

Carefully wipe the running surfaces of the pin/journal and the bearing shell with a clean rag. Use a powerful lamp for inspection.

Assessment of the metal condition and journal surface is made in accordance with the directions given below. *The results should be entered in the engine log book.*

See also Item 7.12, 'Inspection of Bearings'.

7.3 Types of Damage

The overlayer and bearing metal can exhibit the following types of damage.

1. Tearing of the overlayer (XH bearings) can be due to substandard bonding. The damage is not confined to specific areas of the bearing surface. The bearing metal/intermediate layer in the damaged area is seen clearly with a sharply defined overlayer border. This defect is regarded mainly as a cosmetic defect, if it is confined to small areas of the bearing surface without interconnection.

   Whether the intermediate layer is exposed can be determined, if the layer is of Ni, with a knife test, as the knife will leave only a faint or no cut mark in the intermediate layer, which is very hard.

NOTICE

For tin-aluminium bearings, the total area where the intermediate layer is exposed due to overlayer tearing, wiping or wear must not exceed the maximum limit given in the table on Drawing 2555-0150.

2. Wiping of overlayer manifests itself by parts of the overlayer being smeared out. Wiping of overlayer can take place when running-in a new bearing; however, if the wiping is excessive, the cause must be found and rectified. One of the major causes of wiping is pin/journal surface roughness and scratches.
   See also the 'Note' above.
3. Bearing metal wiping is due to metal contact between the sliding surfaces which causes increased frictional heat, resulting in plastic deformation (wiping) *(see Item 7.4, 'Causes of Wiping'). See also Item 7.10.2*.
   Moderate wiping during the running-in stage is normal, and is considered as a "cosmetic" problem. *(See item 7.7 for "dressing-up" wedges.*

7.4 Causes of Wiping

1. Hard contact spots, e.g. originating from:
   a.
   Defective pin/journal, bearing, or crosshead guide surfaces.
   b.
   Scraped bearing or guide shoe surfaces.
   c.
   Objects trapped between the housing bore and the back of the shell.
   d.
   Fretting on the back of the shell and in the housing bore.

2. Increased pin/journal surface roughness. In most cases the increase in roughness will have occurred in service, and is attributed to:

   a.
   Hard particle ingress: Hard particle ingress may be due to the malfunction of filters and/or centrifuges or loosened rust and scales from the pipings. Therefore, always pay careful attention to oil cleanliness.

   b.
   Corrosive attack:

   Water contamination of the system oil is by far the most found cause of corrosive attack of bearings.

   If the oil develops a weak acid.

   If strong acid anhydrides are added to the oil which, in combination with water, will develop acid.

   If salt water contamination of the lube oil is higher than 0.5%. The water will attack the bearing metal, and result in the formation of a very hard black tin-oxide encrustation (SnO) which may scratch and roughen the pin surface. The formation of tin oxide is intensified by rust from the storage tank. Therefore, keep the internal surface clean.

⚠ CAUTION

Special care must be taken during piston overhaul to avoid dirt entering crosshead pin oil bores.

3. Inadequate lube oil supply.
4. Misalignment.

7.5 Cracks

Crack development is a fatigue phenomenon due to high dynamic stress levels in local areas of the bearing metal, typically in combination with weakened bearing metal.

In the event of excessive local heat input, the fatigue strength of the bearing metal will decrease, and thermal cracks are likely to develop even below the normal dynamic stress level. This can typically be found in crankpin and crosshead bearing shells, exceeding 50,000 running hours.

A small cluster of hairline cracks develops into a network of cracks. At an advanced stage, increased notch effect and the influence of the hydrodynamic oil pressure will tear the white metal from the steel back and produce loose and dislodged metal fragments.

7.6 Cause of Cracks

1. Insufficient strength of the bonding between the white metal and the steel back (tinning or casting error).
2. Crack development after a short working period may be due to a misalignment (e.g. a twist between the bearing cap and housing) or geometric irregularities (e.g. a step between the contact faces of the bearing shell, or incorrect oil wedge geometry).

3. High local loading: for example, if, during running-in, the load is concentrated on a few local high spots of the white metal.

⚠ CAUTION

Bearings with cracks can only be repaired temporarily depending on the extent of the damage.

7.7 Repair of Oil Transitions

Wedges, tangential run out and bore relief.

⚠ CAUTION

It is strongly recommended to contact MAN Diesel & Turbo for advice before starting any repairs.
(See also Item 1., 'General Bearing Requirements and Criteria'.)

Formation of sharp ridges or incorrect inclination of the transition to the bearing surface will seriously disrupt the flow of oil to the bearing surface, causing oil starvation at this location.

Oil transitions are reconditioned by carefully cleaning for accumulated metal with a straight edge or another suitable tool. Oil wedges should be rebuilt to the required inclination (maximum 1/100) and length, *see Drawing 2555-0110*.

⚠ CAUTION

Check the transition geometries before installing the bearings,
see Item 13., 'Check of Bearings before Installation'.

7.8 Bearing Wear Rate

The reduction of shell thickness in the loaded area of the main, crankpin and crosshead bearing in a given time interval represents the wear rate of the bearing. Average bearing wear rate based on service experience is 0.01 mm/10,000 hrs. As long as the wear rate is in the region of this value, the bearing function can be regarded as normal. *See also Item 7.1, 'Check without Opening up', point 7.c.).*

For white metal crosshead bearings, the wear limit is confined to about 50% reduction of the oil wedge length, *see Drawing 2555-0110*. Of course, if the bearing surface is still in good shape, the shell can be used again after the oil wedges have been extended to normal length. Check also the pin surface condition, *see Items 6.1, 'Surface Roughness' and 7.9, 'Surface Roughness (journal/pin)'*.

For tin-aluminium crosshead bearings, see the 'Note' in Item 7.3.1.

For further advice, please contact MAN Diesel & Turbo A/S.

7.9 Surface Roughness (journal/pin)

Limits to surface roughness

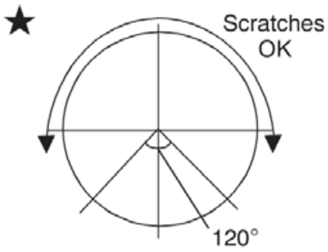
The surface roughness of the journal/pin should always be within the specified limits.

a. For main bearing and crankpin bearing journals:

• New journals:	AlSn40 HMO7	0.4 Ra 0.8 Ra
• Recondition if higher than:	AlSn40 HMO7	0.8 Ra 1.6 Ra

b. For Crosshead pins: ★

• New or repolished	0.05 Ra
• Acceptable in service:	0.05 - 0.1 Ra
• Repolishing if higher than:	0.1 Ra



Determination of the pin/journal roughness

Measure the roughness with an electronic roughness tester, or Evaluate the roughness with a RUGOTESTER®, by comparing the surface of the pin/journal with the specimens on the RUGOTESTER®. When performing this test, the pin surface and the RUGOTESTER® must be thoroughly clean and dry. Hold the tester close to the surface and compare the surfaces. If necessary, use your finger nail to run over the pin/journal surface and the RUGOTESTER ® specimens to compare and determine the roughness level.

7.10 Repairs of Bearings on Site

NOTICE

It is recommended to contact MAN Diesel & Turbo for advice before starting any repairs.
(See also Item 1., 'General Bearing Requirements and Criteria').

1. Overlayer wiping

   a. Overlayer wiping and moderate tearing in crosshead bearing lower shells is not serious, and is remedied by careful use of a scraper.
   However, see the 'Note'in Item 7.3.1.

   b. Hard contact on the edges of crosshead bearings is normally due to galvanic build-up of the overlayer. This is occasionally seen when inspecting newly installed bearings and is remedied by relieving these areas with a straight edge or another suitable scraping tool.
2. Bearing metal squeezed out or wiped:

   a. The wiped metal can accumulate in the oil grooves / wedges, run-out or bore relief where it forms ragged ridges. Such bearings can normally be used again, provided that the ridges are carefully removed with a suitable scraping tool and the original geometry is re-established *(see Item 7.7, 'Repair of Oil Transitions')*. High spots on the bearing surface must be levelled out by light cross-scraping (90 by 90 degrees).

   b. In cases of wiping where the bearing surface geometry is to be re-established, it is important:

   - to assess the condition of the damaged area and, if found necessary, to check the bearing surface for hairline cracks under a magnifying glass and with a penetrant fluid, if necessary.

   - to check the surface roughness of the journal/pin and polish if necessary.

   c. In extreme cases of wiping, the oil wedges in the crosshead bearing may disappear. In that event, the shell should be replaced.
3. For evaluation and repair of spark erosion damage, refer to Item 6.2, 'Spark Erosion'.
4. Cracked bearing metal surfaces should only be repaired temporarily. The bearing must be replaced *(see Items 7.5, 'Cracks' and 7.6, 'Cause for Cracks')*.

7.11 Repairs of Journals/Pins

Crosshead pins

Pin surface roughness should be better than 0.1 Ra *(see Item 7.9, 'Surface Roughness (journal/pin)')*. If the Ra value is higher than 0.1 μm, the pin can often be repolished on the spot, as described below. If the pin is also scratched, the position and extent of the scratched areas must be evaluated. If there are also deep scratches, these must be levelled out carefully with hardbacked polishing paper, or similar, before the polishing process is started.

NOTICE

Use a steel ruler, or similar, to support the polishing paper, as the fingertips are too flexible.

The surface roughness not counting in scratches after polishing should be better than 0.1 Ra in the 120° crown. The upper 240° can be accepted up to an average roughness of 0.2 Ra including scratches.

The following methods are recommended for repolishing on site.

1. Polishing with microfinishing film

   The polishing process is carried out with a “microfinishing film”, e.g. 3M aluminium oxide (30 micron, 15 micron and 5 micron), which can be recommended as a fairly quick and easy method, although to fully reestablish the pin surface it will often be necessary to send the crosshead to a repair shop for regrinding/polishing in an appropriate machine.

   The microfinishing film can be slung around the pin and drawn to and fro by hand and, at the same time, moved along the length of the pin, or it is drawn with the help of a hand drilling machine; in this case, the ends of the microfilm are connected together with strong adhesive tape or glued together.

2. Braided hemp rope method

   This method is executed with a braided hemp rope and jeweller’s rouge.

   Before the rope is applied all frontending scratches must be removed with fine emery cloth as per 7.11.1.

   A mixture of polishing wax and gas oil (forming an abrasive paste of a suitably soft consistency) is to be applied to the rope at regular intervals. During the polishing operation, the rope must move slowly from one end of the pin to the other.

   The polishing is continued until the roughness measurement proves that the surface is adequately smooth *(see Item 7.9)*.

   This is a very time consuming operation and, depending on the surface roughness in prior, about three to six hours may be needed to complete the polishing.

Journals (Main and crankpin journals)

1. The methods for polishing of crosshead pins can also be used here, and method a) Polishing with microfinishing film, will be the most suitable method. A 30 micron microfinishing film is recommended here or 220-270 grade emery cloth of a good quality.
2. Local damage to the journal can also be repaired. The area is to be ground carefully and the transitions to the journal sliding surface are to be rounded carefully and polished. *We recommend to contact MAN Diesel & Turbo for advice before such a repair is carried out. But as temporary repair, any ridges must be filed or ground to level.*

7.12 Inspection of Bearings

Regarding check of bearings before installation, see item 13., ‘Check of Bearings before Installation’.

For the ship’s own record and to ensure the correct evaluation of the bearings when advice is requested from MAN Diesel & Turbo, we recommend to follow the guidelines for inspection, which are stated in *Drawing 2555-0140 page 3 to 7. See the example of an Inspection Record on Drawing 2555-0140 page 6.*

8 Crosshead Bearing Assembly

8.1 Bearing Type

See also Plate 1472-0300

The type of bearing used in the crosshead assembly is a thin shell (insert) bearing *(see Item 5.5, ‘Thin Shell Bearings’)*. The lower shell is a trimetal shell, i.e. the shell is composed of a steel back with cast-on white metal and an overlayer coating.

See also Item 3, ‘Overlayers’. The upper shell is a bimetal shell, as it does not have the overlayer coating; both the upper and lower shells are protected against corrosion with tin flash *(see Item 4, ‘Flashlayer, Tin (Sn)’)*. The upper part can also be cast into the bearing cap.

8.2 Bearing Function and Configuration

Because of the oscillating movement and low sliding speed of the crosshead bearing, the hydrodynamic oil film is generated through special oil wedges *(see Item 5.3, ‘Axial Oil Grooves and Oil Wedges’)* on either side of the axial oil supply grooves situated in the loaded area of the bearing. The oil film generated in this manner can be rather thin. This makes the demands for pin surface roughness and oil wedge geometry important parameters for the assembly to function. A further requirement is effective cooling which is ensured by the transverse oil grooves. The pin surface is superfinished *(see Item 7.9 1.b)*. The lower shell is most often executed with a special surface geometry (embedded arc) which extends over a 120 degree arc, and ensures a uniform load distribution on the bearing surface in contact with the pin. The lower shell is coated with an overlayer *(see Item 3., ‘Overlayers’)*, which enables the pin sliding geometry to conform with the bearing surface in the embedded arch area.

Another geometry execution is the “Single bore” geometry, which depends on a fully positive yet small clearance. With “Single bore” the overlayer is omitted.

9 Main Bearing Assembly

The engine can be equipped with “Thick shell bearings” *(Item 5.4)* or “Thin shell bearings” *(Item 5.5)*.

The bearing type, i.e. “thick shell” or “thin shell” determines the main bearing housing assembly described below *(see table of installed bearing types, Drawing 2555-0100, and housing assemblies, Drawing 2555-0120)*.

9.1 Thick Shell Bearing Assembly

See Drawing 2555-0120, Fig. 1

The tensioning force of a thick shell bearing assembly (Fig. 1) is transferred from the bearing cap (pos. 1) to the upper shell (pos. 2) and via its mating faces to the lower shell (pos. 3).

The bearing bore is equipped with the following geometry:

1. central oil supply groove and oil inlet in the upper shell which ends in a *sloping run-out (Item 5.1)* in both sides of the lower shell, *see Drawing 2555-0100*.
2. the bearing bore is furnished with a *bore relief (Item 5.2)* at the mating faces of the upper and lower shell, *see Drawing 2555-0100*.

9.2 Thin Shell (Insert Bearing) Bearing Assembly

See Drawing 2555-0120, Fig. 2

This forms a rigid assembly (Fig. 2). The bearing cap (pos. 1) which has an inclined vertical and horizontal mating face, is wedged into a similar female geometry in the bedplate (pos. 2), which, when the assembly is pretensioned, will ensure a positive locking of the cap in the bedplate.

The lower shell can be positioned by means of screws (Pos. 3) (note: some engines do not have locking screws). During mounting of the lower shell it is very important to check that the screws are fully tightened to the stops in the bedplate. This is to prevent damage to the screws and shell during tightening of the bearing cap. *See also workcard 2565-0401.*

See also Item 5.5, 'Thin Shell Bearings' earlier in this section. For information regarding inspection and repair, see Item 7, 'Practical Information'.

10 Crankpin Bearing Assembly

See also Plate 1472-0300

This assembly is equipped with thin shells, and has two or four tensioning studs, depending on the engine type. Crankpin bearing assemblies with four studs must be tensioned in parallel, for example first the two forward studs and then the two aftmost studs; the tensioning may be executed in two or three steps. If four hydraulic jacks are available only one step is necessary plus check-step.This procedure is recommended in order to avoid a twist (angular displacement) of the bearing cap to the mating face on the connecting rod.

The oil supply groove transition to the bearing sliding surface is similar to that of the main bearing geometry. For information regarding inspection and repair, *see Item 7, 'Practical Information'*.

11 Guide Shoes and Guide Strips

See Drawing 2555-0125

(See also Plate 1472-0300)

The guide shoes, which are mounted on the fore and aft ends of the crosshead pins, slide between guides and transform the translatory movement of the piston/piston rod via the connecting rod into a rotational movement of the crankshaft.

The guide shoe is positioned relative to the crosshead pin with a positioning pin screwed into the guide shoe, the end of the positioning pin protrudes into a hole in the crosshead pin and restricts the rotational movement of the cross-head pin when the engine is turned with the piston rod disconnected.

The guide strips are bolted on to the inner side of the guide shoes and ensure the correct position of the piston rod in the fore-and-aft direction. This alignment and the clearance between the guide strips and guide is made with shims between the list and the guide shoe.

The sliding surfaces of the guide shoes and guide strips are provided with cast-in white metal and furnished with transverse oil supply grooves and wedges *(see Item 5.3, 'Axial Oil Grooves and Oil Wedges',*.

For inspection of guide shoes and guide strips, *see Item 7.1, 7.3.3 and 7.4.1 a) and b) and chapter 2565*.

12 Thrust Bearing Assembly

See Drawing 2555-0130

The thrust bearing is a tilting-pad bearing of the Michell type. There are eight pads (segments) or more placed on each of the forward and aft sides of the thrust collar. They are held in place circumferentially by stoppers. The segments can be compared to sliding blocks and are pivoted in such a manner that they can individually take up the angle of approach necessary for a hydrodynamic lubricating wedge. The lubricating/cooling oil is sprayed directly on to the forward and aft sides of the thrust collar by means of nozzles positioned in the spaces between the pads. The nozzles are mounted on a semicircular delivery pipe.

For clearances and max. acceptable wear, *see work cards.*

13 Check of Bearings before Installation

See Drawing 2255-0185

Clean the bearing shells thoroughly before inspecting.

13.1 Visual Inspection

1. Check the condition of the bearing surfaces for impact marks and burrs. Repair by scraping if necessary.
2. Check that the transition between the bore relief and the bearing sliding surface is smooth.

13.2 Check Measurements

Place the shell freely, as illustrated in *Drawing 2555-0185, Fig. 1*.

Measure the crown thickness, with a ball micrometer gauge. Measure in the centre line of the shell, 15 millimetres from the forward and aft sides.

Record the measurements as described in *Item 7.12, 'Inspection of Bearings' and Drawing 2555-0140 page 3 to 7*.

This will facilitate the evaluation of the bearing wear during later overhauls.

13.3 Cautions

As bearing shells are sensitive to deformations, care must be taken during handling, transport and storage, to avoid damaging the shell geometry and surface.

The shells should be stored resting on one side, and be adequately protected against corrosion and mechanical damage.

Preferably, keep new bearing shells in the original packing, and check that the shells are in a good condition, especially if the packing shows signs of damage.

During transport from the store to the engine, avoid any impacts which could affect the shell geometry.

1 Alignment

During installation of the engine, intermediate shaft and propeller shaft, the yard aims to carry out a common alignment, to ensure that the bearing reactions are kept within the permitted limits, with regard to the different factors which influence the vessel and engine during service.

Factors like the ship's load condition, permanent sag of the vessel, movements in sea, wear of bearings etc., makes it necessary to regularly check the alignments:

- Main bearings, see Items 2.1-2.4
- Engine bedplate, see Item 2.5
- Shafts, see Item 2.6.

2 Alignment of Main Bearings

See Drawing 2555-0175 and 2555-0180

The bearing alignment can be checked by *deflection measurements (autolog)* as described in the following section.

Example; If two adjacent main bearings at the centre of the engine are placed too high, then at this point the crankshaft centreline will be lifted to form an arc. This will cause the intermediate crank throw to deflect in such a way that it "opens" when turned into bottom position and "closes" in top position.

Since the magnitude of such axial lengthening and shortening increases in proportion to the difference in the height of the bearings, it can be used as a measure of the bearing alignment.

2.1 Deflection Measurements (autolog)

See Drawings 2555-0175

As the alignment is influenced by the temperature of the engine the deflection measurements should, for comparison, always be made under nearly the same temperature and load conditions.

It is recommended to record the actual jacket water and lub. oil temperatures in *Drawings 2555-0175*.

Procedure

Turn the crankpin for the cylinder concerned to Pos. B1, *see Fig. 2, Drawing 2555-0175*. Place a dial gauge axially in the crank throw, opposite the crankpin, and at the correct distance from the centre, as illustrated in Fig. 1. The correct mounting position is marked with punch marks on the crankthrow. Set the dial gauge to "Zero".

Make the deflection readings at the positions indicated in Fig. 2.

"*Closing*" of the crankthrow (compression of the gauge) is regarded as negative and "*Opening*" of the crankthrow (expansion of the dial gauge) is regarded as positive, *see Fig. 1*.

Since, during the turning, the dial gauge cannot pass the connecting rod at BDC, the measurement for the bottom position is calculated as the average of the two adjacent positions (one at each side of BDC).

When making deflection readings for the two rearmost cylinders, the turning gear should, at each stoppage, be turned a little backwards to ease off the tangential pressure on the turning wheel teeth. This pressure may otherwise falsify the readings.

Enter the readings in the table Fig. 3. Then calculate the BDC deflections, 1/2 (B_1+B_2), and note down the result in Fig. 4.

Enter total "vertical deflections" (opening - closing) of the throws, during the turning from bottom to top position in the table Fig. 5 (T-B).

2.2 Checking the Deflections

See Drawing 2555-0180 and Testbed Report

The results of the deflection measurements (see Drawing 2555-0175, Fig. 5) should be evaluated with the commisioning test measurements (recorded by the engine builder in the commisioning test report on site). If re-alignment has been carried out later on (e.g. following repairs), the results from these measurements should be used.

Values of permissible "*vertical deflections*" etc. are shown in *Drawing 2555-0180*.

NOTICE

The values shown on Drawing 2555-0180 are specifically attributed to the crankshaft condition, NOT the bearing wear condition.

The values represent theoretical maximum deflection, which the crankshaft material can sustain, for an unlimited time of operation, without risking to exceed the stress fatigue limits of the crankshaft.

The values are unlikely to exceed the "permissible from new" in static condition (turning of the engine).

For bearing wear measurements derived from deflection readings; always refer to commissioning test results, and judge the relative change in deflection over time.

Abnormal/deviating deflection readings should always be investigated and additional measurements performed, such as Top and Bottom clearance of adjacent main bearings.

2.3 Floating Journals

See also Item 2.2 and Drawing 2555-0180

Use a special bearing feeler gauge to investigate the contact between the main bearing journals and the lower bearing shells. Check whether the clearance between journal and lower shell is zero.

If clearance is found between journal and lower bearing shell, the condition of the shell must be checked and, if found damaged, it must be replaced.

The engine alignment should be checked and adjusted, if necessary.

To obtain correct deflection readings in case one or more journals are not in contact with the lower shell, it is recommended to contact the engine builder.

If the deflection values are within limits and there is bottom clearance found, it may be possible to install an offset bearing to get a positive bearing reaction.

2.4 Causes of Crankshaft Deflection

1. Excessive wear of main bearings
2. Displacement of bedplate *(see ‘Piano Wire Measurements’)*
3. Displacement of engine alignment and/or shafting alignment
4. Loose or broken Staybolts.
5. Loose foundation bolts.
6. Wear of shock absorber material.

2.5 Piano Wire Measurements. Bedplate Alignment

A 0.5 mm piano wire is stretched along each side of the bedplate.

The wire is loaded with 400 N horizontal force.

At the centreline of each cross girder the distance is measured between the wire and the machined faces of the bedplate top outside oil groove.

It will thus be revealed whether the latter has changed its position compared with the reference measurement from engine installation.

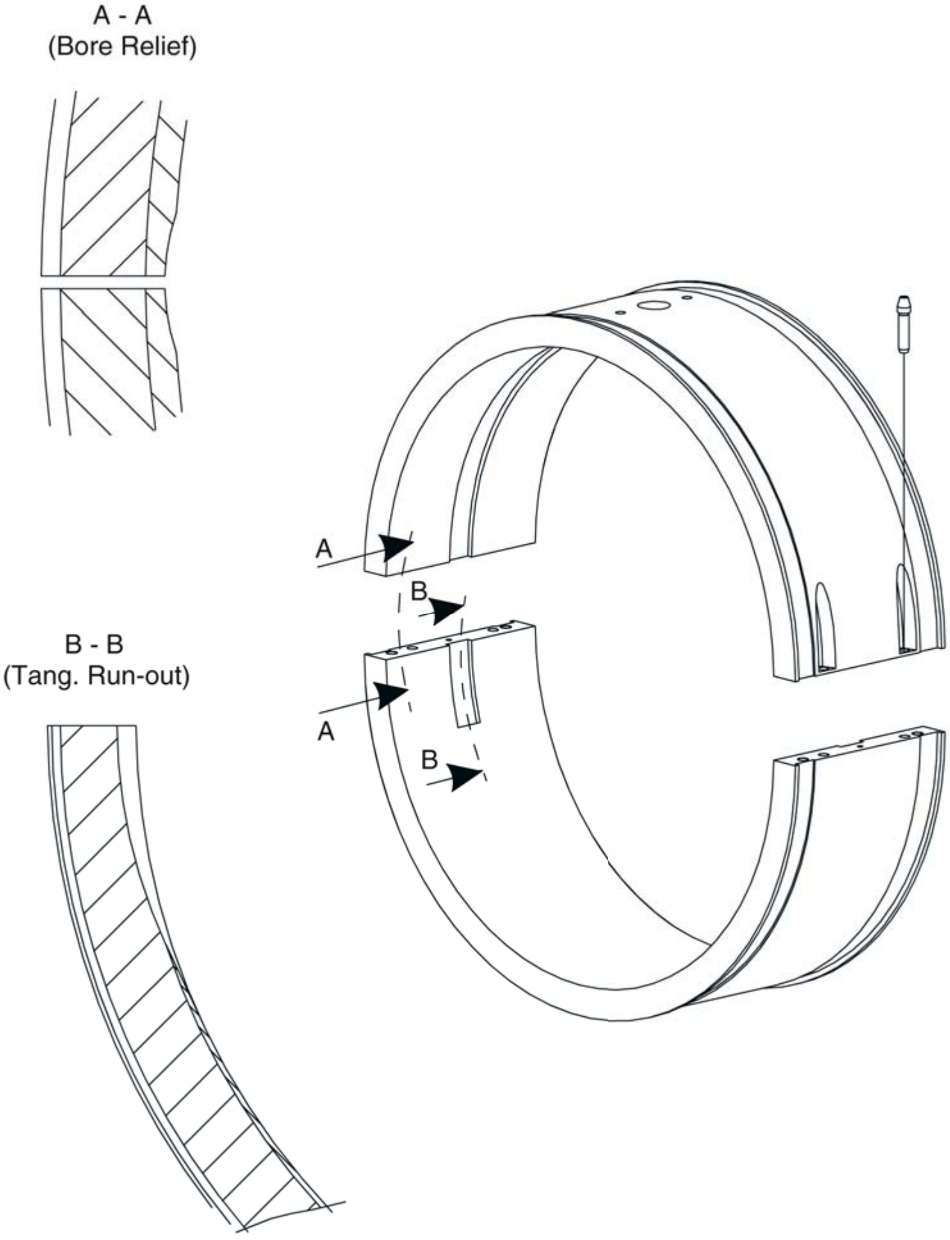
This measurement requires special equipment available from MAN Diesel & Turbo.

2.6 Shafting Alignment, Bearing Load, “Jack-up” Test

This can be checked by measuring the load at:
- the aftermost main bearing
- the intermediate shaft bearings (plummer blocks)
- in the stern tube or generator bearing.

Making these measurements normally requires specialist assistance.

As a reliable evaluation of the shafting alignment measurements requires a good basis, the best obtainable check can be made if the contractor/supplier or repair-shop has carried out the alignment based on precalculation of the bearing reactions.



Engine types with thick shell main bearing assemblies:

S/K/L50ME/MC

S/K/L60ME/MC

S/L70ME/MC

L80ME/MC

K/L90ME/MC

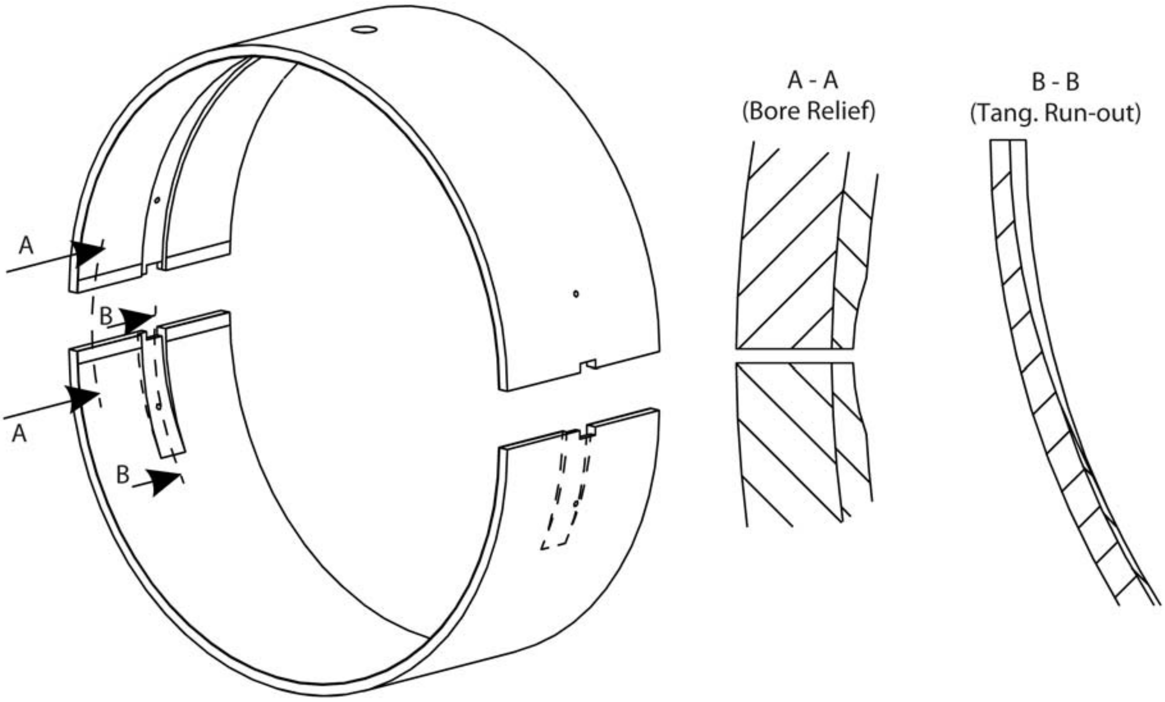


Figure 1: Thin shell bearing

Engine types with thin shell main bearing assemblies:		
S	26	MC
L / S	35	MC / MC-C / ME-B
S	40	MC / MC-C / ME-B
S	42	MC
S	46	MC-C / ME-B
G / S	50	MC-C / ME-C / ME-B
G / S	60	MC-C / ME-C
S	65	MC-C / ME-C
S	70	MC-C / ME-C
G / S / K	80	MC-C / ME-C
K / S	90	MC-C / ME-C

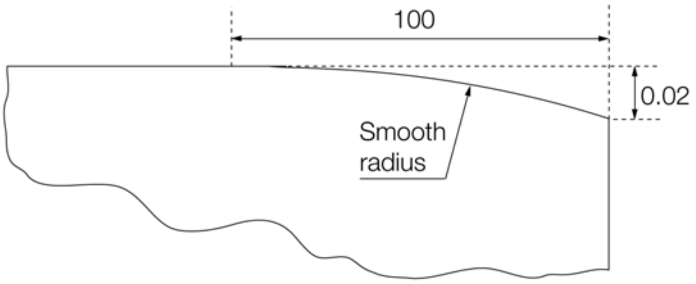
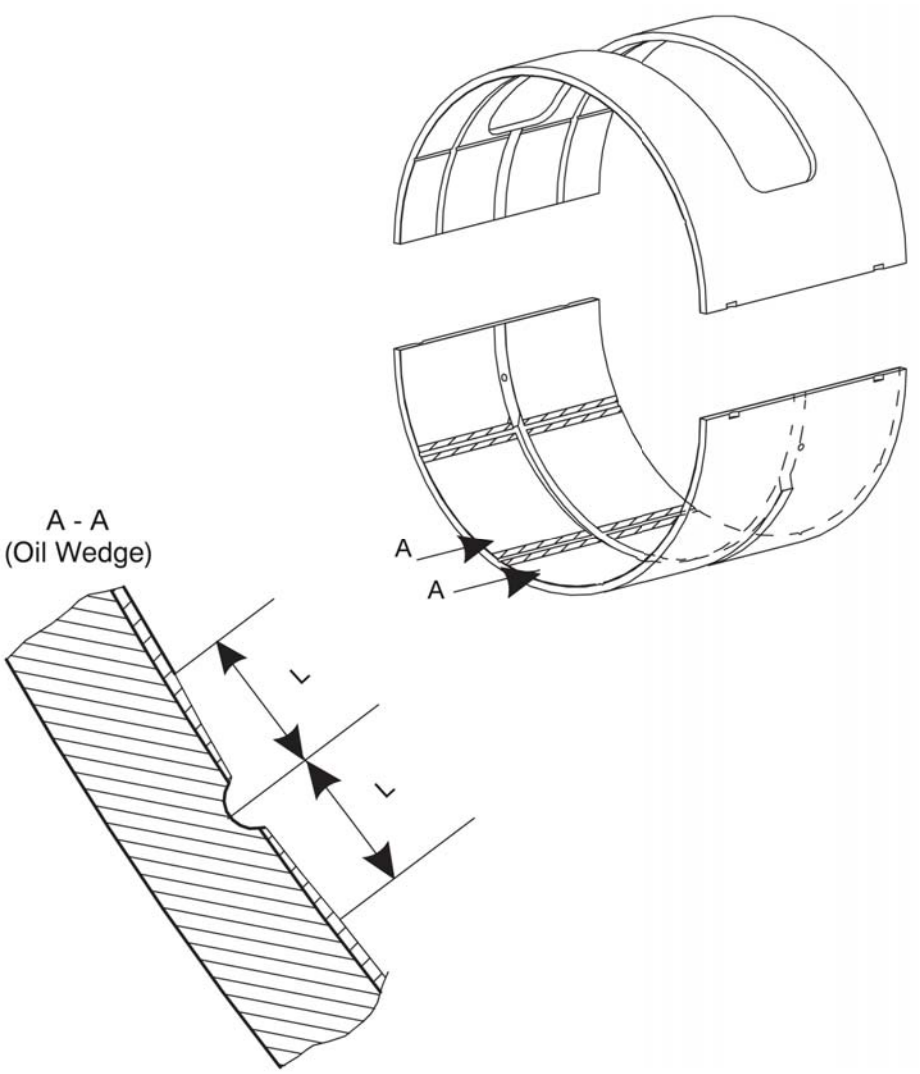


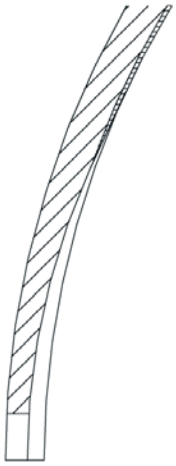
Figure 2: Blended edge



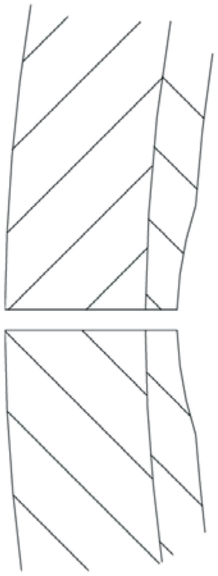
Extent of oil wedges in crosshead bearing lower shell:

Engine type:	Extent L (mm)*
S26MC	For actual values, refer to Work Card 2565-0200 *) On each side of the axial oil groove
S/L35MC/MC-C/ME-B	
S40MC-C/ME-B	
S/L42MC	
S46MC-C/ME-B	
G/S/K/L50MC/ME-C/ME-B	
G/K/L/S60MC/ME/ME-B	
S65MC-C/ME-C	
K/L/S70MC/ME	
G/K/L/S80MC/ME-C	
S/K/L90-98ME-C/MC-C	

B - B
(Tang. Run-out)



A - A
(Bore Relief)



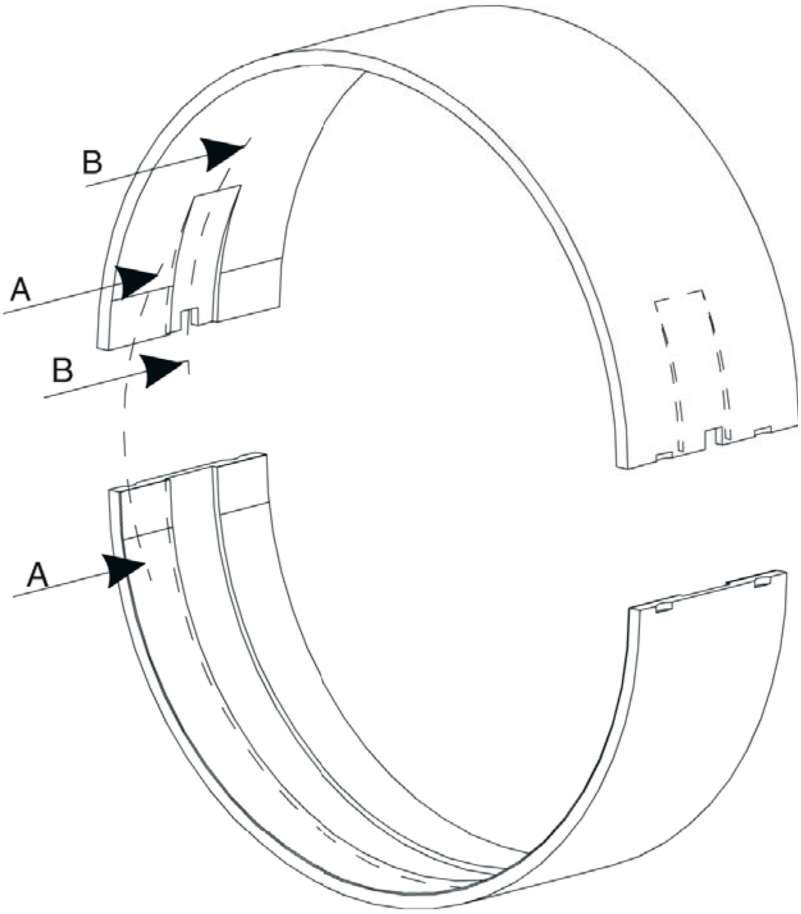
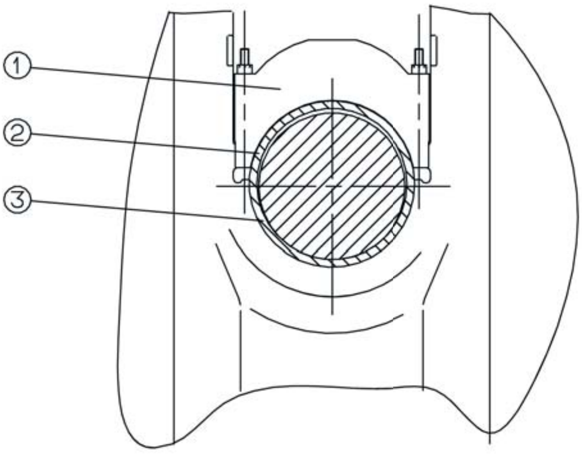


Fig. 1 Thick Shell



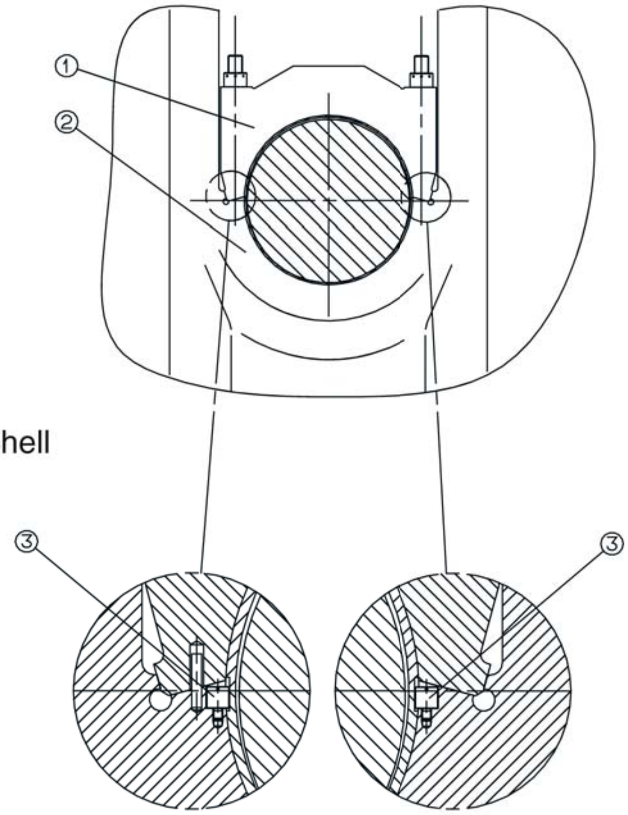
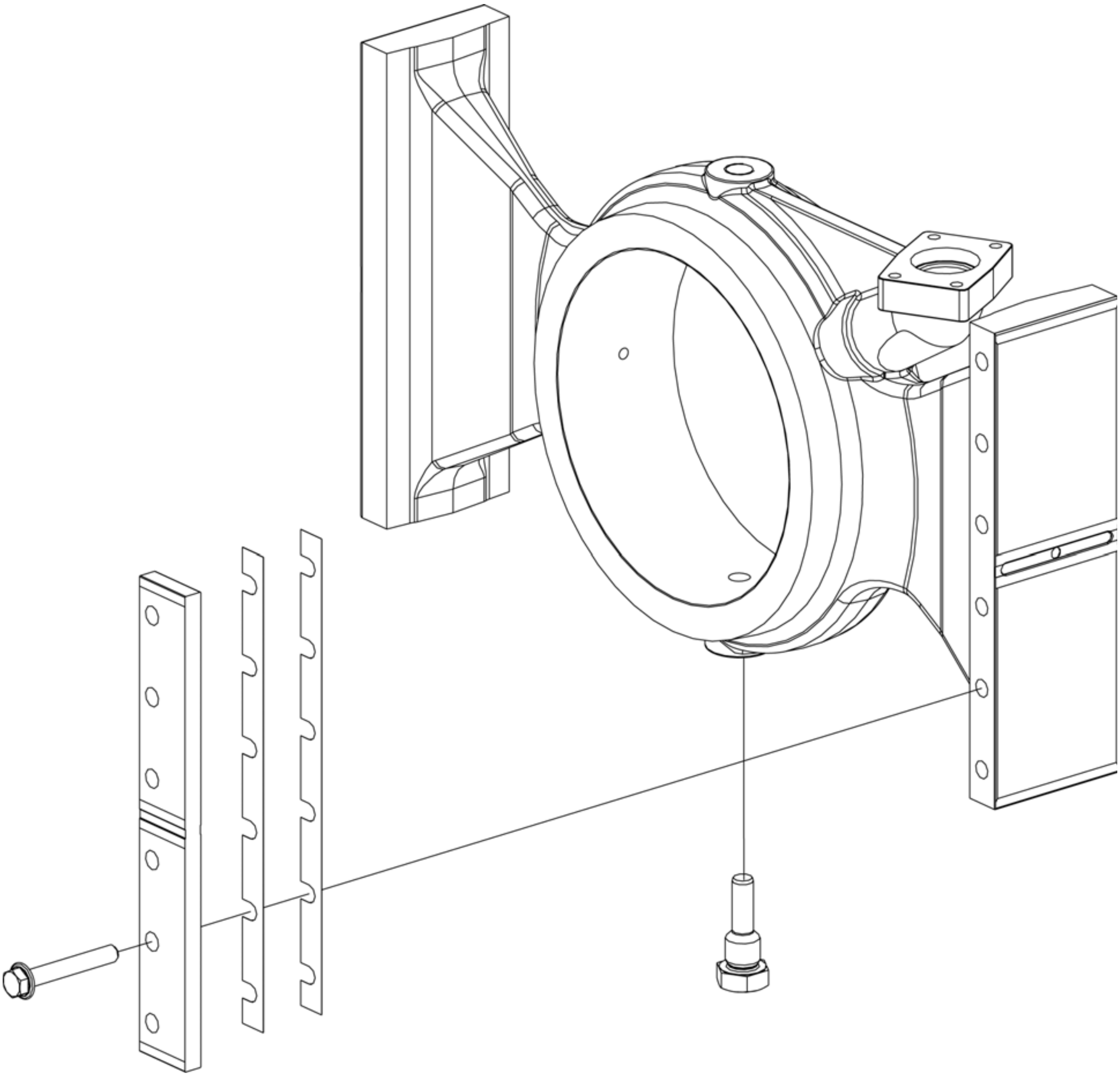


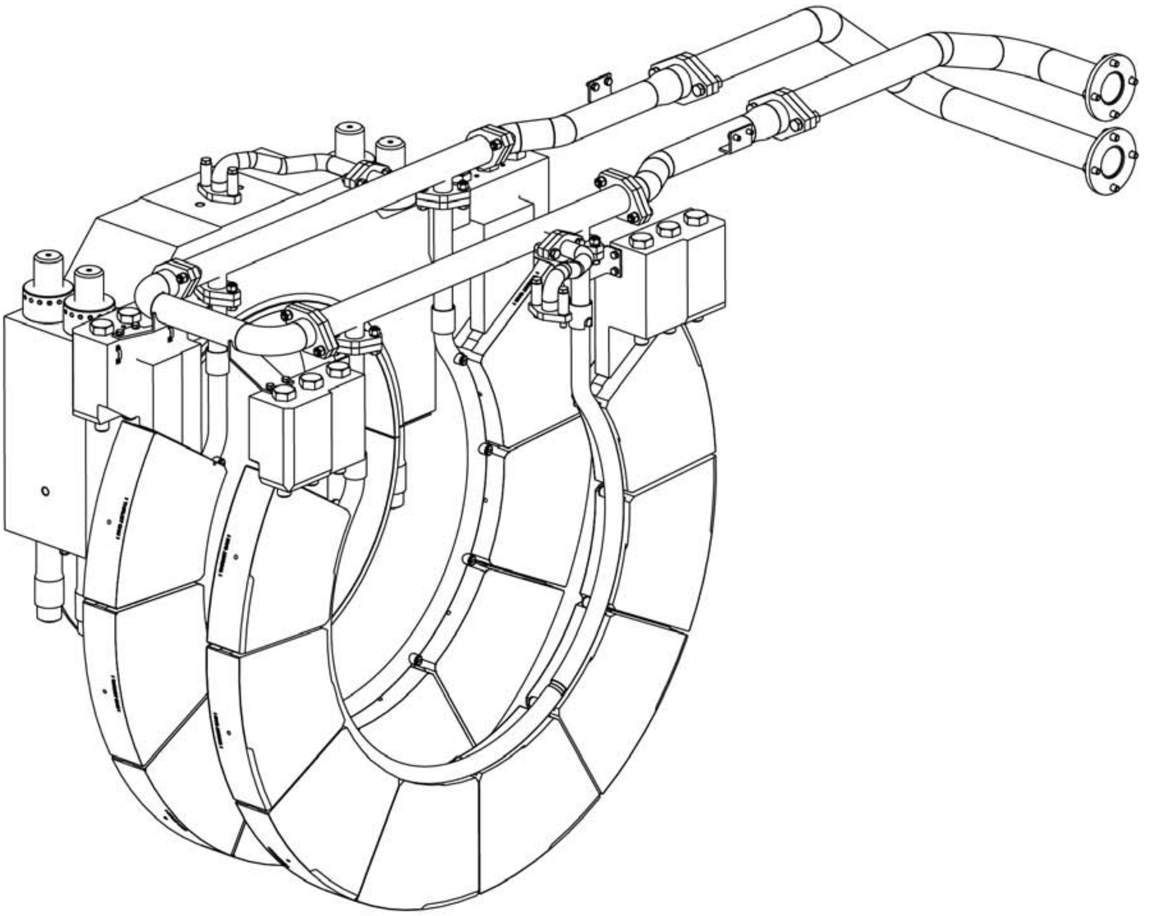
Fig. 2 Thin Shell

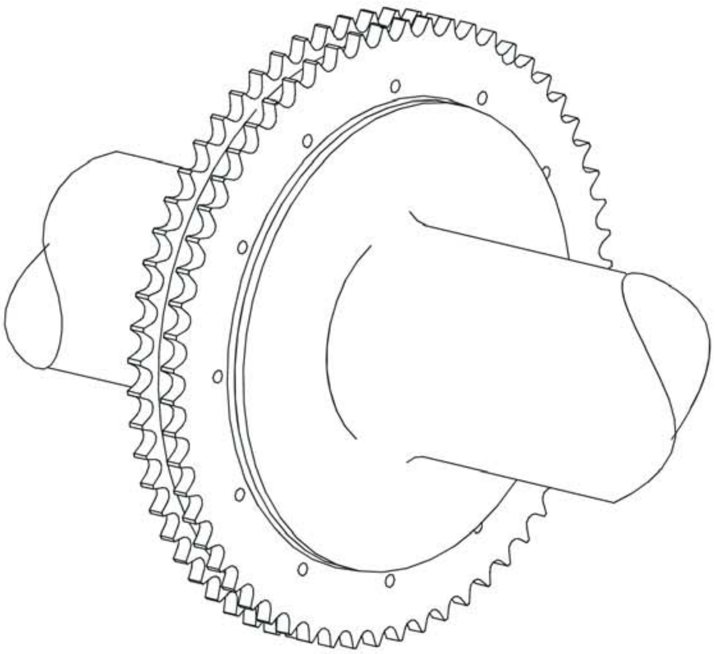


Thrust Bearing Assembly

Drawing

2555-0130-0003





Bearing Wear Monitoring System (BWM)

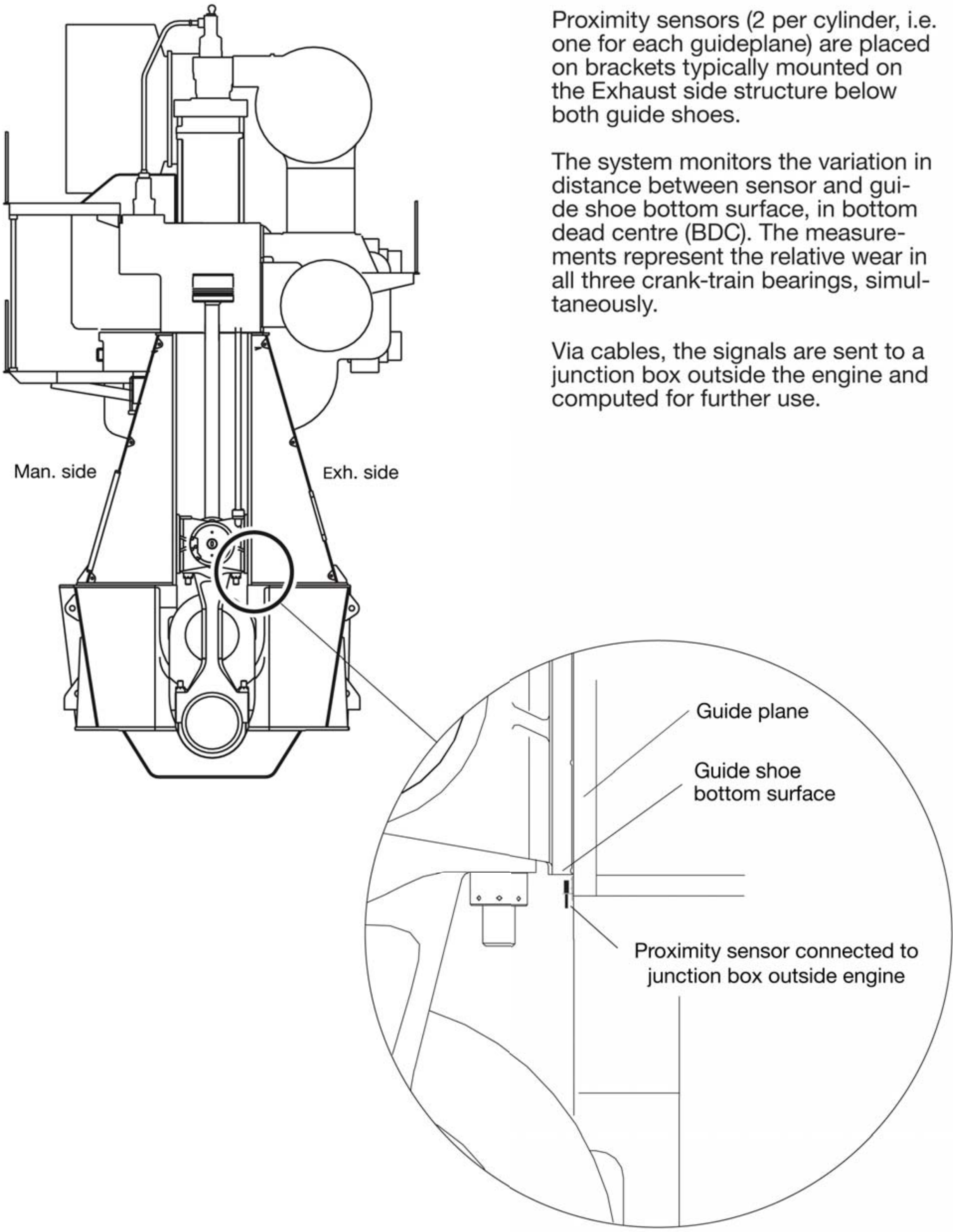
Drawing

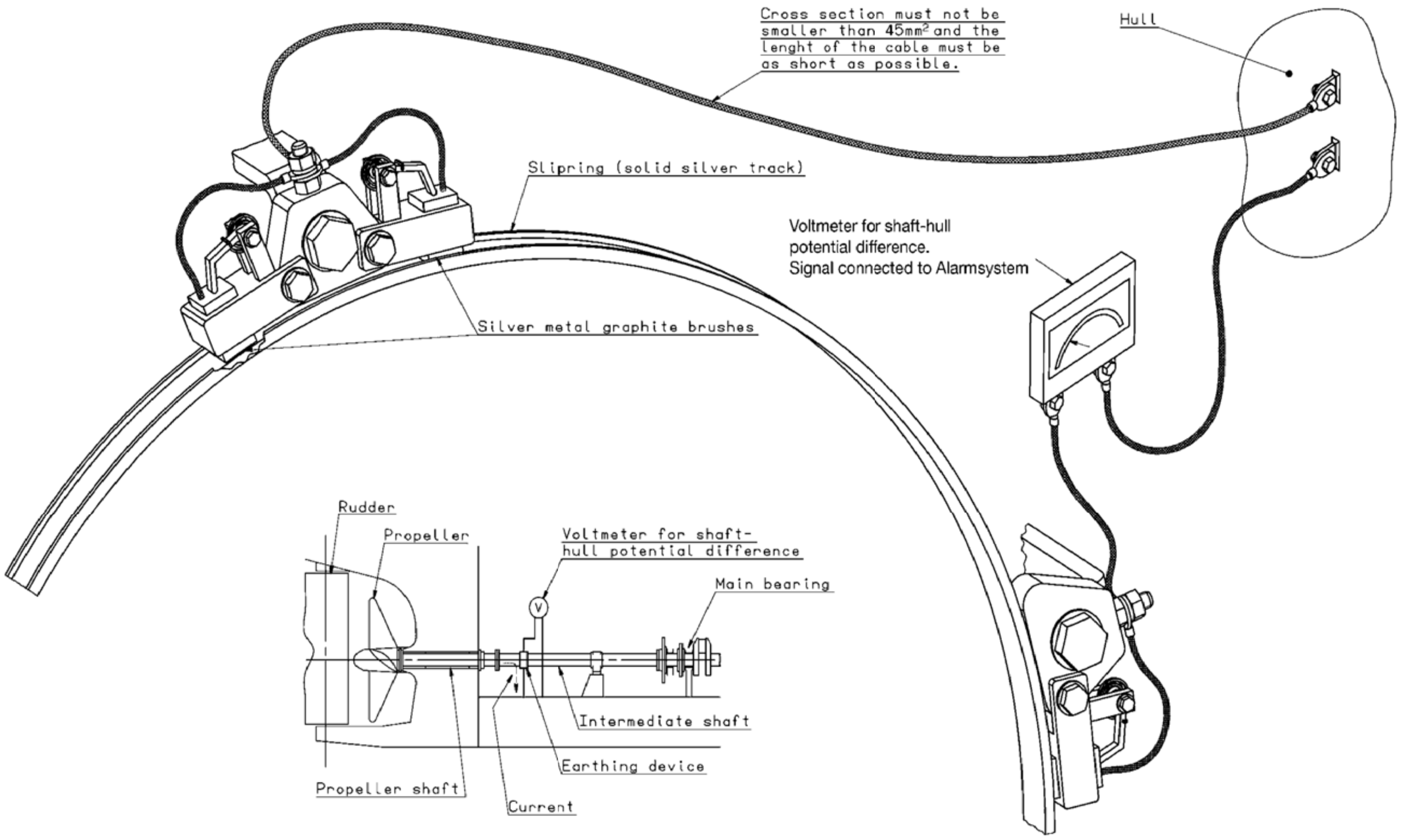
2555-0136-0002

Proximity sensors (2 per cylinder, i.e. one for each guideplane) are placed on brackets typically mounted on the Exhaust side structure below both guide shoes.

The system monitors the variation in distance between sensor and guide shoe bottom surface, in bottom dead centre (BDC). The measurements represent the relative wear in all three crank-train bearings, simultaneously.

Via cables, the signals are sent to a junction box outside the engine and computed for further use.





Drawing

2555-0137-0002

Propeller Shaft Earthing Device

Recording of Observations

References to Work Cards		
Bearing Type	**Inspection without Opening-up**	**Open-up Inspection and Overhaul**
Main bearing	2565-0401	2565-0401
Crankpin bearing	2565-0301	2565-0301
Crosshead bearing	2565-0201	2565-0201
Guide shoes	2565	–
Crosshead guides	2565	–
Thrust bearing	–	2565-0601
Camshaft bearing (MC/ME-B)	2565-0101	2565-0101

Use the Inspection Sheet, 2555-0140 page 6. For help, refer to example, 2555-0140 page 5.

A. Inspection without Opening-up

State the following information:

Date / Signature / Engine running hours / Type of inspection / Bearing type (2555-0140, table 1) / Bearing number / Observation (2555-0140 page 4, Table 3)/ Remarks / Clearances.

B. Open-up Inspection and Overhaul

State the following information:

Date / Signature / Engine running hours / Type of inspection / Bearing type (2555-0140, Table 1) / Bearing number / Manufacturer's logo / Damage to (2555-0140, Table 2) / Observation (2555-0160 page 4, Table 4) / Site and extent of damage (2555-0140 page 2 and 3) * /Remarks / Clearances / Hydraulic opening pressure / Roughness.

* The site and extent of the damage is determined by:

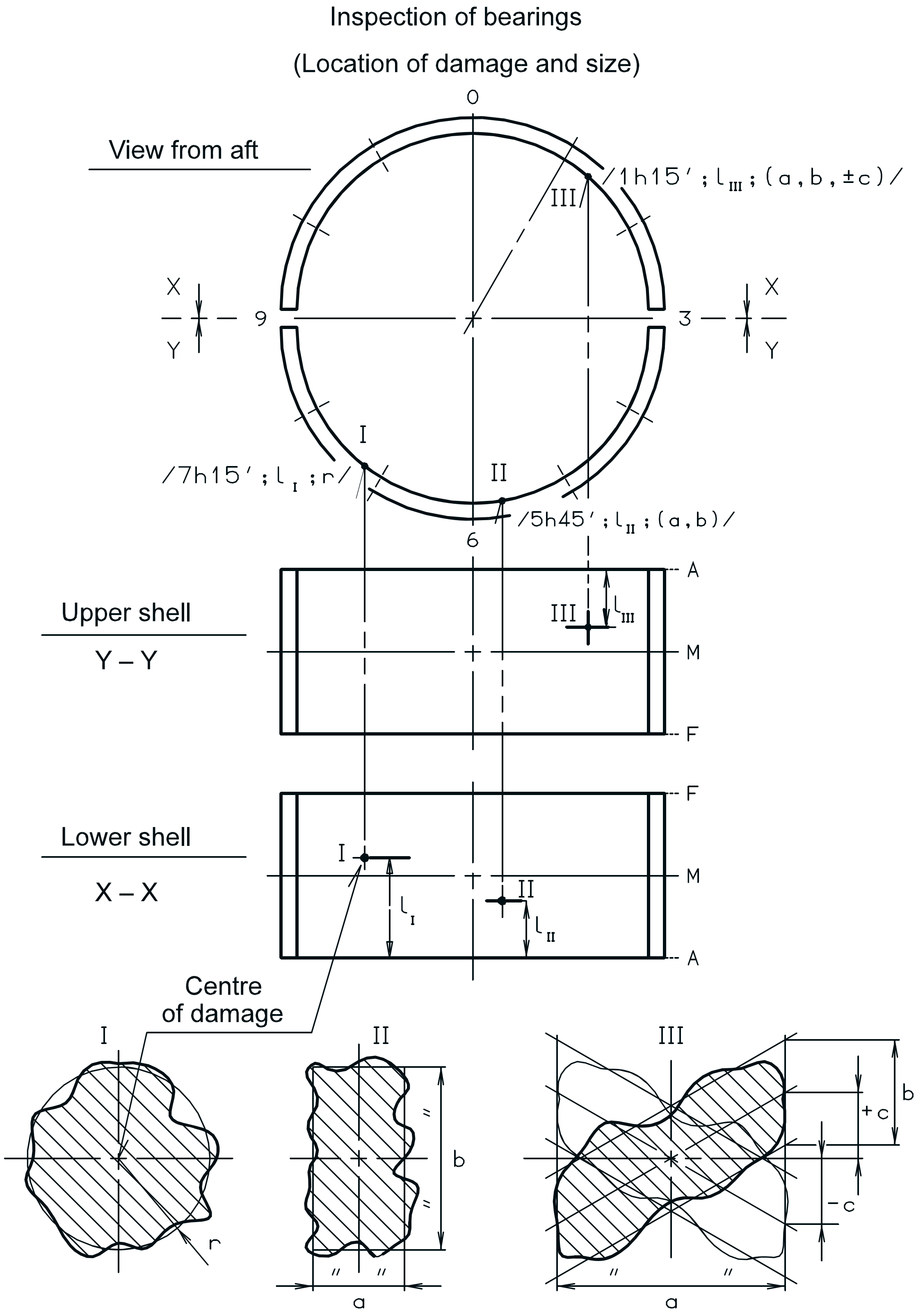
1. The approx. centre of the damaged area (see examples I, II and III). The axial location (l) of the centre should be stated in (mm) from the aft end of the bearing or the journal.
2. The extent of the damage defined by a circle with radius (r); or a rectangle (a, b) or (a, b, +/– c), (see examples I, II and III).

Note: for isolated cracks, illustration III is used, with the measurement **b** omitted.

Table 1:	
Bearing Type	
Main Bearing	MB
Crankpin Bearing	CRB
Crosshead Bearing	CHB
Guide Shoes	GS
Crosshead Guides	CG
Thrust Bearing	TB
Camshaft Bearing (MC/ME-B)	CSB

Table 2:	
Damage	
Overlayer	OL
White Metal	WM
Journal	J
Pin	P
Transitions:	
Oil Wedge	OW
Bore Relief	BR
Tang. Run-out	TR
Back of Shell	BS

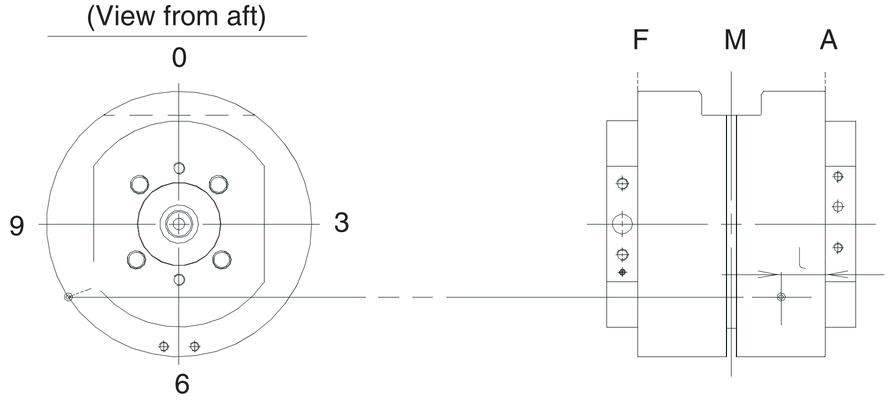
Location and size of damage in bearing shells



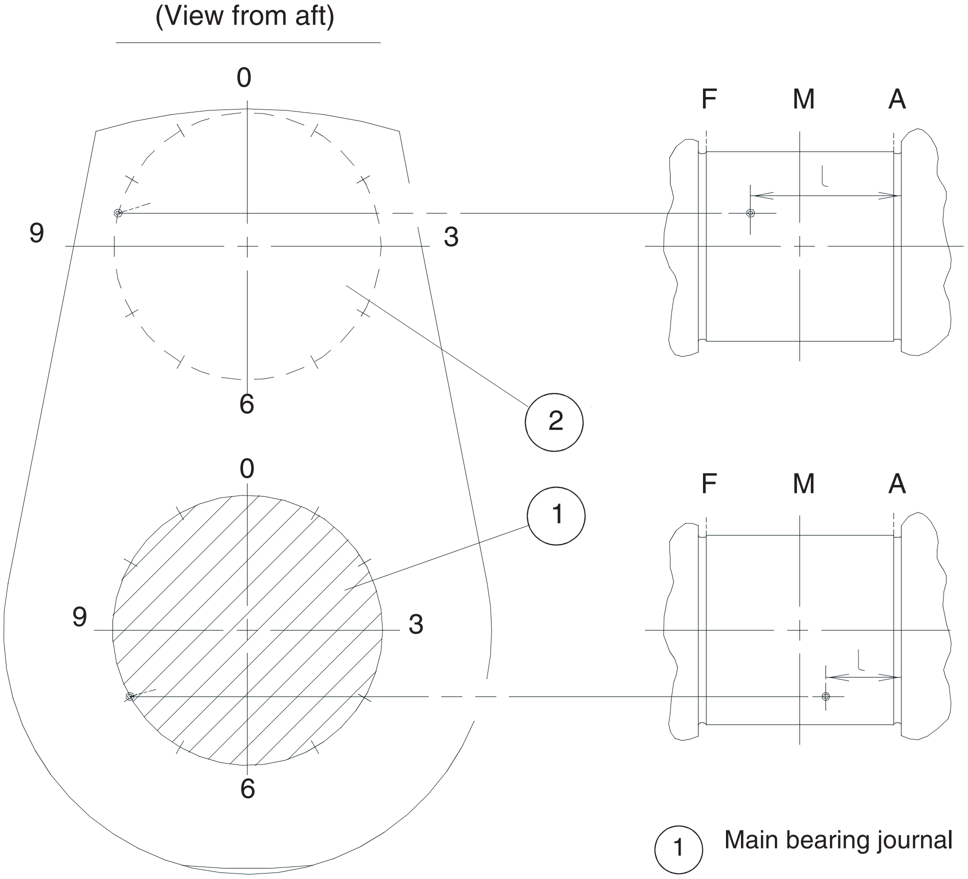
2008-10-17

Location of damage on pin/journal

Crosshead pin



Main and crank bearing journals



① Main bearing journal

② Crank pin bearing journal

Observations

Table 3

Inspection without Opening-up (7.1)		
Checks	**Symbol**	**Observations**
Oil flow OF	• U	OK, similarity Uneven
Oil Jets OJ (Crosshead, Guide strips)	• R M TW	OK, similarity Reduced Missing Twisted
White Metal WM	• SQ CR L M	OK Squeezed out Cracks Loose Missing
Crosshead Guides CG	• SC CO SW	OK Scratches Corrosion Silvery White
Oil Pan OP	• WM	OK, clean White metal fragments
Oil Condition OC	• DK WT	OK Dark Water traces

Table 4

Open-up Inspection and Overhaul (7.2)			
Checks	**Symbol**	**Observations**	**Ref.**
White Metal WM	• W HC OS CR CRC L M SSE CO	OK Wiping Hard Contact Oil Starvation Cracks Crack Cluster Loose Missing Spark Erosion Corrosion	7.3 II 7.4 7.7 7.5 7.1 7.1 6.2 7.4 B, 6.1
Overlayer OL (Crosshead only)	• TE W	OK Tearing Wiping	7.3 I 7.3 II
Transitions: Oil Wedge OW Bore Relief BR Tang. Run-out TR	• RR W D	OK Ragged Ridges Wiping Disappeared	7.7 7.7 7.10BII
Journal/Pin J/P	• SE CO SW SC	OK Spark Erosion Corrosion Silvery White Scratches	6.2 7.4B, 6.1 6.1 7.4, 7.11
Back of Shell BS	• FR TH	OK Fretting Trapped hard Particles	7.4 7.4

Inspection Records, Example

M/V	Engine type: CW / CCW 1)		Running hours Total 4)	Checked by: 4)
Yard:	Builder:	Engine No.:		
No.:	Built year:			Date: 4)

Date	Checked by	Engine running hours	Type of inspection 2)	Description of Condition	Clearance (mm) Top Fore	Clearance (mm) Top Aft	Hydr. open. pressure	Journal/pin Roughness 3)
8/3-93	N.N.	10000	7.2	MB/4 /MBD/WM /CR; L; M; HC/7h 15'; l_{I}; r//	0,5	0,5	880	N6 (M)
8/3-93	N.N.	15000	7.2	CHB/5/MBD/WM; OW/W; RR/5h 45'; l_{II}; (a,b)//	0,4	0,4	900	N3 (E)
8/3-93	N.N.	8000	7.2	CRB/3/MBD/WM/M; W/ 1h 15'; l_{III}; (a,b,+/-c)//	0,4	0,4	870	N6 (E)
8/3-93	N.N.	8000	7.1	CHB/6/OF; u/OJ; R; TW/WM; SQ//	0,45	0,45		

1) Engine direction of rotation, seen from aft, must be underllined; CW: Clockwise, CCW: Counter Clockwise
2) Inspection without opening-up: 7.1; Open-up inspection: 7.2
3) It should be stated whether the roughness is measured: M, or evaluated: E.
4) Only to be filled in, if all observations are carried out at the same running hours.

Inspection Records, Blank

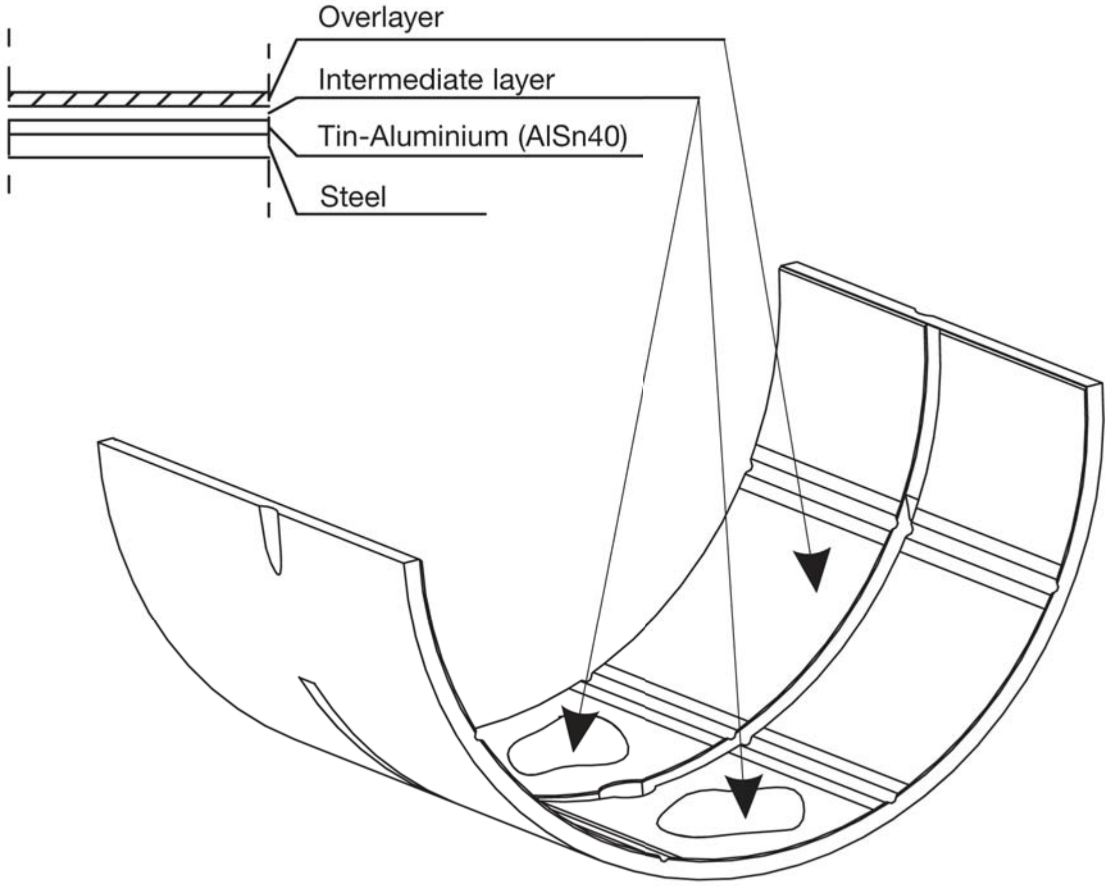
M/V	Engine type: CW / CCW 1)		Running hours Total 4)	Checked by: 4)
Yard:	Builder:	Engine No.:		
No.:	Built year:			Date: 4)

Journal/pin Roughness 3)							
Hydr. open. pressure							
Clearance (mm)	Top	Aft					
		Fore					
Description of Condition							
Type of inspection 2)							
Engine running hours							
Checked by							
Date							

1) Engine direction of rotation, seen from aft, must be underllined; CW: Clockwise, CCW: Counter Clockwise
2) Inspection without opening-up: 7.1; Open-up inspection: 7.2
3) It should be stated whether the roughness is measured: M, or evaluated: E.
4) Only to be filled in, if all observations are carried out at the same running hours.

2008-10-17

Crosshead Bearing Lower Shells



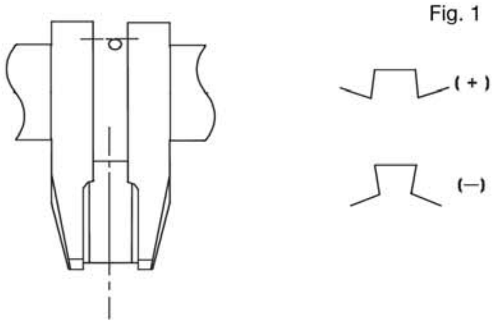
Engine Type:	Max. allowed exposure (mm^2)
26MC	2900
35MC	4300
35ME-B	5700
40ME-B	7500
42MC	6700
46MC-C/ME-B	8100
50MC-C/ME-C/ME-B	9600
60MC-C/ME-C/ME-B	13100
65MC-C/ME-C	16100
70MC-C/ME-C	17900
Maximum allowed exposure of the intermediate layer. Values are calculated according to SL05-460/NHN.	

Report: Crankshaft Deflections

Drawing 2555-0175-0004

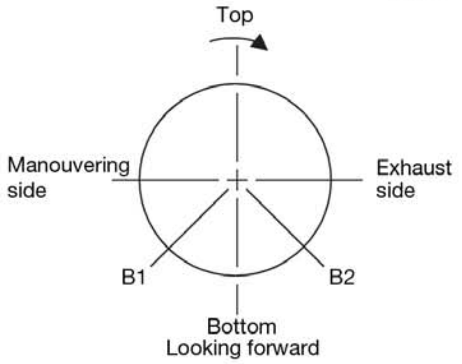
M/V	Engine type:		Total running hours	Checked by:
	Builder:	Engine No.:		Date:
Yard No.:	Built year:			
For comparison of measurements	Ships draught, aft measured (m)		Fully loaded (m)	Ballasted (m)
	Jacket cooling water temp. (°C)		Main lub. oil temp. (°C)	

Fig. 1



For deflection readings, a dial micrometer is to be placed in the punch marks.
Closing of the crankthrow is regarded as negative deflection

Fig. 2



(Unit for measuring and calculating: 1/100 mm)

Fig. 3

Crankpin position		Cyl. No. and deflections						
		1	2	3	4	5	6	7
Near bottom, manouvering side	B_1							
Manouvering side	M							
Top	T							
Exhaust side *)	E							
Near bottom, exhaust side	B_2							

*) Positions M and E are included for reference purposes.

Fig. 4

Bottom 1/2 (B_1 + B_2)	= B							

Fig. 5

Vertical Deflections								
Top-bottom or (T - B)	= V							

For permissible deflections, see Drawing 2555-0180.
See also item 2.2 'Checking the Deflections' on Description 2545-0110.

Fig. 6

Horizontal Deflections								
Exhaust - Manouvering side (E - M)	= H							

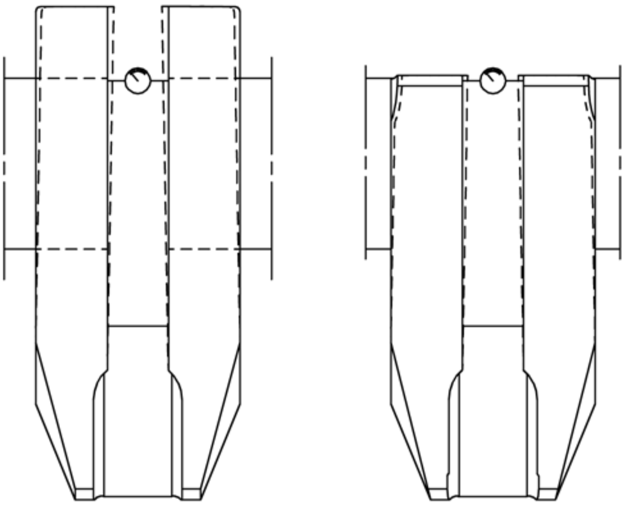
Fig. 7

Check on deflection measurements, etc	(T + B) = G							
	(E + M) = D							

If the deflection measurements (autolog) have been caried out correctly, the deflection sums G and D should not deviate more than 1/6 of the values given in Drawing 2555-0180. col. 1 (new or recently overhauled engine).

If G and D differ more, this may indicate that the dial gauge has moved, or has been read incorrectly. The deflection measurements for the cylinder(s) concerned should be repeated.

If G and D still differ, this must then be due to a floating journal or ovality/eccentricity. Check for any clearance between the journal and the lower shell in the relevant bearing(s) with a 5/100 mm feeler gauge with the crankshaft in four 90° positions.
If the feeler gauge cannot enter the clearance, the deflection measurements are acceptable.
If the feeler gauge can enter, then the journal is 'floating', and this must be remedied.



Type	Normally obtainable for a new or recently overhauled engine		Realignment recommended		Absolute maximum permissible	
	mm		mm		mm	
	1	2	1	2	1	2
S50ME-C	0.23	0.47	0.62	0.70	0.94	0.94
L60ME-C	0.22	0.45	0.59	0.67	0.89	0.89
S60ME-C	0.28	0.56	0.75	0.84	1.13	1.13
S65ME-C8	0.33	0.65	0.87	0.98	1.31	1.31
G60ME-C9	0.36	0.93	0.95	1.17	1.43	1.43
L70ME-C/ME-C8	0.26	0.53	0.70	0.79	1.05	1.05
S70ME-C/ME-C8	0.33	0.66	0.88	0.99	1.32	1.32
G70ME-C9	0.40	1.03	1.05	1.30	1.58	1.58
S80ME-C8	0.38	0.76	1.00	1.13	1.50	1.50
S80ME-C9	0.45	0.89	1.20	1.35	1.80	1.80
K80ME-C6	0.22	0.44	0.58	0.66	0.88	0.88
K80ME-C9	0.29	0.58	0.77	0.87	1.16	1.16
G80ME-C9	0.49	1.28	1.31	1.62	1.97	1.97
K90ME-C	0.20	0.41	0.54	0.61	0.82	0.82
S90ME-C/ME-C8	0.36	0.71	0.96	1.08	1.45	1.45
S90ME-C9	0.42	0.83	1.11	1.25	1.66	1.66
K98ME/ME-7	0.24	0.49	0.65	0.74	0.98	0.98
K98ME-C/ME-C7	0.20	0.41	0.54	0.61	0.81	0.81

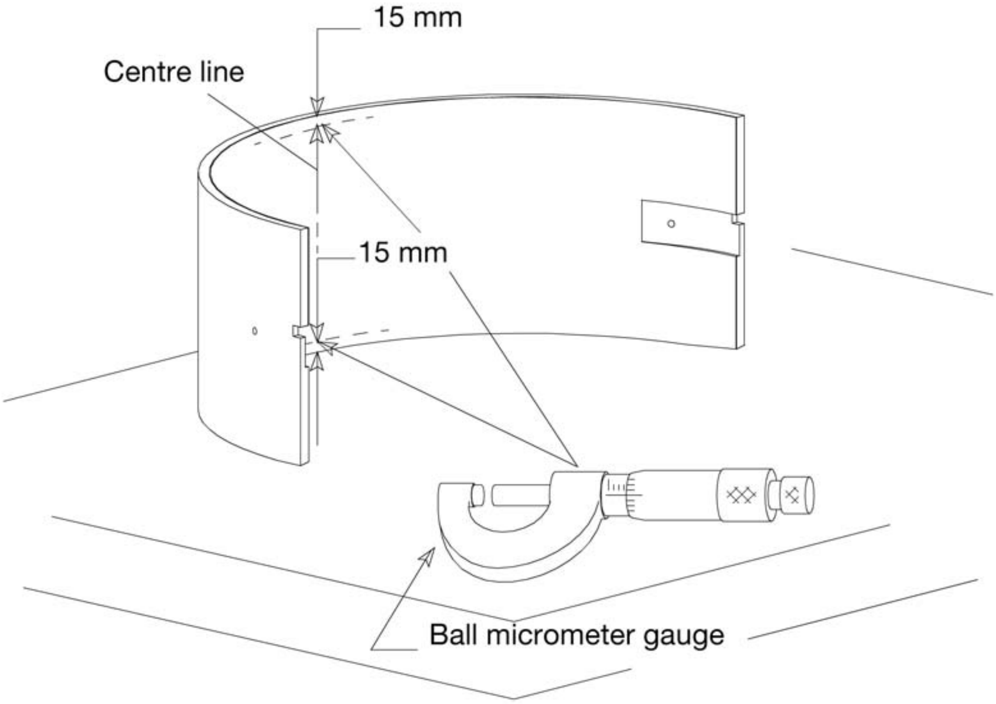
1 Normal for all crank throws

2 Permissible for the **foremost** crank throw, when the crankshaft fore end is provided with a torsional vibration damper, tuning wheel or directly coupled to a generator rotor.

Permissible for the **aftmost** crank throw, when the crankshaft generator end is provided with a flexible coupling.

When judging the alignment on the above “limiting-value”’ basis, make sure that the crankshaft is actually supported in the adjacent bearings. (See description 2545-0110 ‘Alignment of Main Bearings’ point 2.3 ‘floating journals’).

Measuring of Crown Thickness



See also Chapter 2545-0100 item 13, 'Check of Bearings before Installation'

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T14-42	Crosshead complete	3700	kg
T22-78	Piston complete	4100	kg
T25-12	Crosshead bearing, top clearance max.	0.70	mm
T25-13	Crosshead bearing, top clearance min.	0.35	mm
T25-14	Oil wedge length, L	20	mm
T25-15	Crosshead bearing cap	705	kg
T25-16	Crosshead bearing shell, upper	75	kg
T25-17	Crosshead bearing shell, lower	110	kg
T25-18	Crosshead bearing cap with bearing shell	780	kg
T25-19	Crosshead with piston and guide shoes	8700	kg
T25-20	Thrust piece, tightening torque	460	Nm
T76-01	Hydraulic pressure, dismantling	2000 - 2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

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
1470-0300	**041**	Wire guide
1470-0300	**053**	Lifting attachment for connecting rod
1470-0300	**077**	Chain for suspending piston
1470-0300	**090**	Bracket, support of crosshead
1470-0300	**112**	Rubber cover for croshead
1470-0300	**124**	Rubber cover for croshead
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**060**	Hose with unions, 5000 mm
7670-0100	**106**	5-way distributor block, complete
7670-0300	**-**	Lifting tools, etc
7670-0410	**054**	Feeler gauge set
7670-0410	**066**	Slide caliper

White Metal

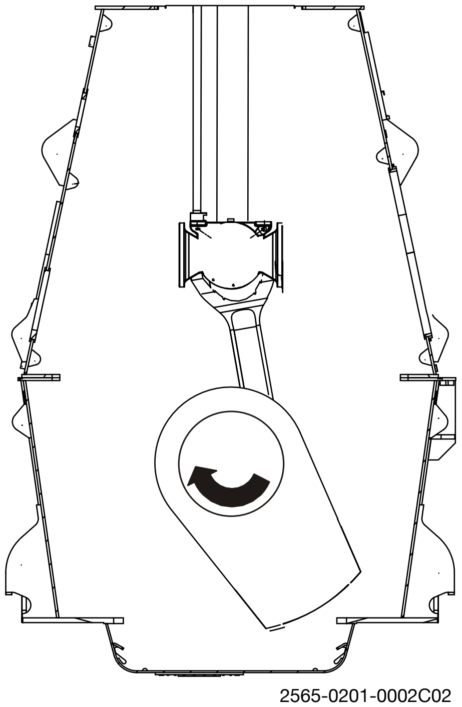
The top clearance between the journal and a new bearing shell is the result of a summation of the production tolerances of the bearing assembly components.

The top clearance for a new bearing will normally be in the range stated in Data. Note that the figures are to be used for guidance only.

For the top clearance of a specific bearing, see the measurement in the Testbed Sheet from engine builder.

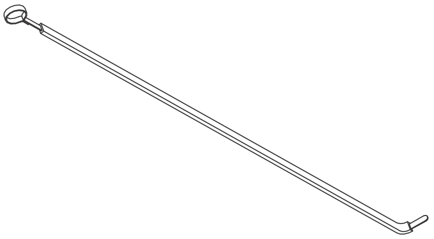
Crankcase Open the crankcase door at the relevant cylinder.

Crankthrow Turn the crankthrow concerned to BDC.



2565-0201-0002C02

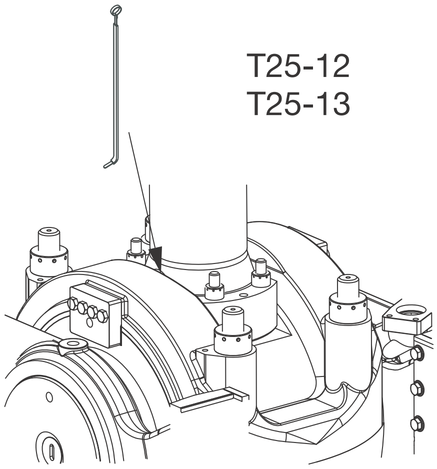
Clearance Use a selection of kjaer-feelers to measure the clearance between the top of the crosshead and bearing shell.



2565-0201-0007C03

Perform the measurement by inserting a suitable kjaer-feeler into the space between the piston rod and the crosshead bearing cap.

Proceed until the space inherent to the feeler corresponds to the actual clearance.



2565-0201-0007C04

Measuremet difference

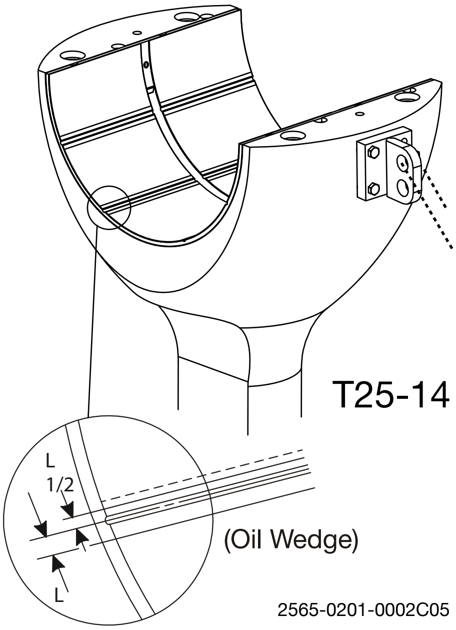
The difference between the **actual** clearance measurement and the measurement recorded in the Adjustment Sheet (or the clearance noted for a new bearing installed later) **must not** exceed 0.1 mm. If so, the crosshead bearing must be disassembled for inspection.
See Workcard 2565-0201, Dismantling.

For evaluation of the bearing shell, see Chapter 2545-0100, 'Bearings' in the instruction book.

Oil wedge

The wear limit for a crosshead bearing shell is confined to a 50% reduction of the oil wedge length **L.**

If the wear limit exceeds the 50% reduction, the bearing shell must be replaced by a new one.



2565-0201-0002C05

Alternate checking method

In case the reason for opening the crosshead bearing is a routine inspection, the following procedure is sufficient.

Measurement

Perform the clearance measurement shown in 2565-0201, Checking, section 3.

Eyebolts

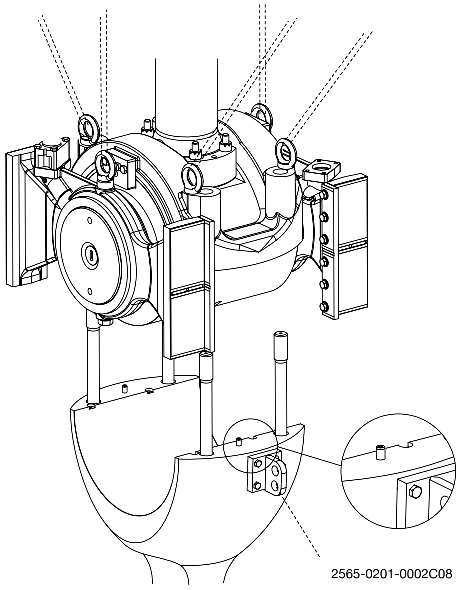
Fit the two eyebolts and tackles in the top of the crankcase in the fore and aft direction. Fit two eyebolts in the top of the guideshoes.

Turn to BDC, mount the connecting rod lifting attachments on the connecting rod. Use tackles to hold the connecting rod in the vertical position.

Unscrew the crosshead bearing cap hydraulic nuts.
For operation of the hydraulic jacks, see Section 7665.

Bearing cap

Fit two eyebolts in the bearing cap and use two small tackles in the athwartship direction to lift the bearing cap free of the guidepins and to keep the bearing cap balanced.

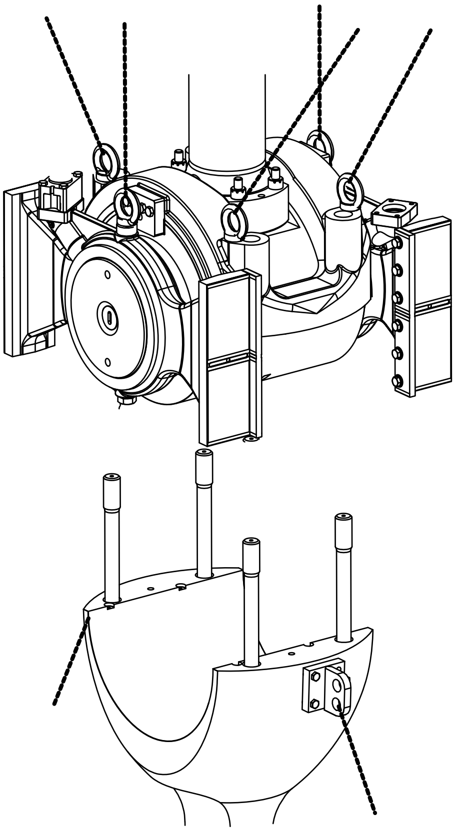


Lifting the crosshead

Use the tackles in the crankcase top to lift the crosshead and piston high enough to allow inspection of the lower crosshead bearing.

NOTE

Ensure that the crosshead is lifted simultaneously fore and aft, i.e. by placing marks on the guide planes using a felt tipped pen.



2565-0201-0002C09

If there is no anomalies

If the lower bearing shows no anomalies the piston and crosshead is lowered again and the crosshead bearing cap nuts are mounted.

Recheck

Recheck the bearing top clearance. Remove all tools.

Remember!

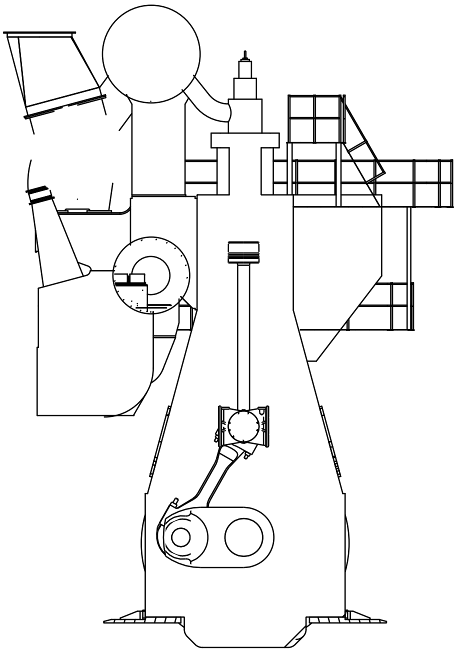
If there are any doubt concerning damage to the upper bearing, the bearing has to be dismantled and checked according to 2565-0201, Dismantling.

This procedure applies to the following two dismantling situations:
- with piston mounted
- with piston removed

With piston mounted

Crankshaft

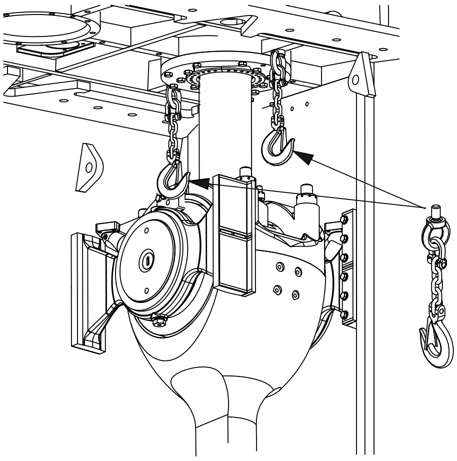
Turn the crankshaft down far enough to give access to the nuts and screws on the piston rod.



2565-0201-0002D01

Chains for the piston rod

Fit two chains in the inner screw holes in the top of the crankcase, in the athwarthship direction, for suspending the piston rod.

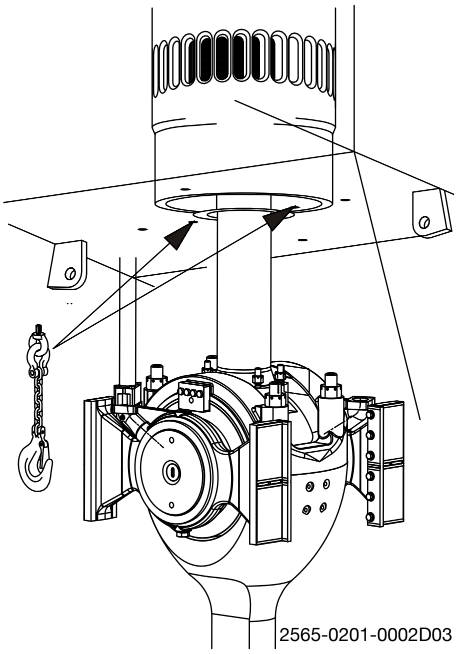


2565-0201-0002D02

Eyebolts

Mount two eyebolts in the two outer screw holes in the top of the frame box in the athwartship direction.

Remove the thrust pieces for axial guidance of the connecting rod.



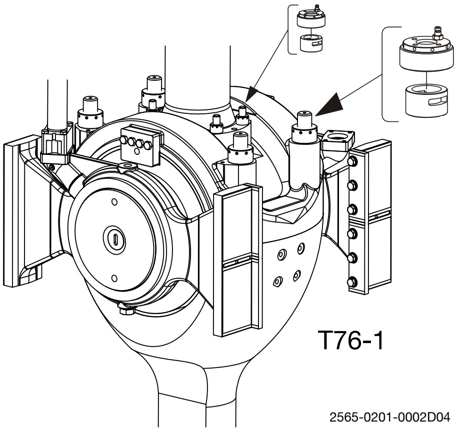
Hydraulic jacks

Mount the spacer rings and the hydraulic jacks for loosening the crosshead bearing cap nuts and the piston rod nuts.

Loosen the nuts.

For operation of the hydraulic tools, see work card 7665-0101.

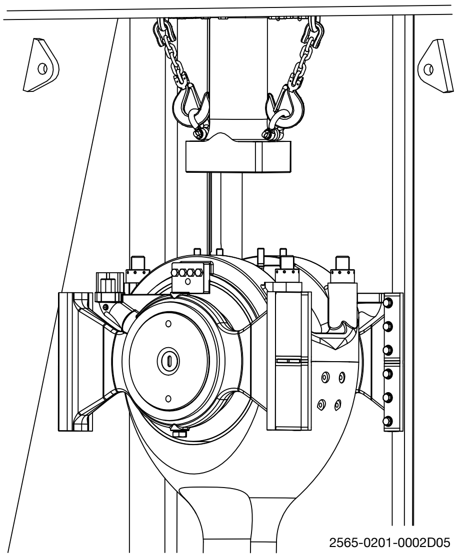
Remove the hydraulic jacks, and unscrew the nuts.



Turn the crosshead to TDC

Hook the chains to the lifting eyebolts in the piston rod.

Turn the crosshead downward, and the piston rod will then remain suspended from the two chains.



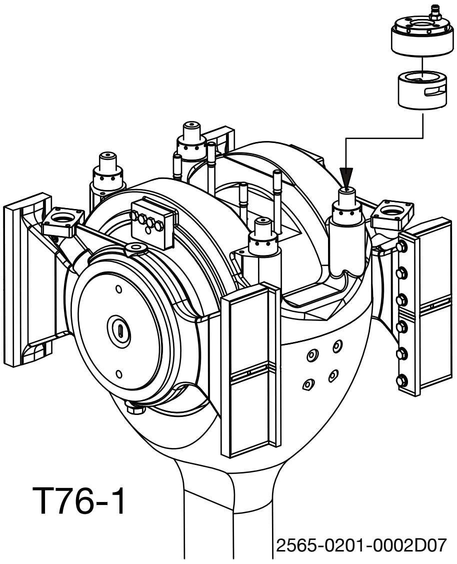
With piston removed Turn to BDC.

Hydraulic jacks

Place the spacer rings around the nuts and screw the hydraulic jacks on to the studs.

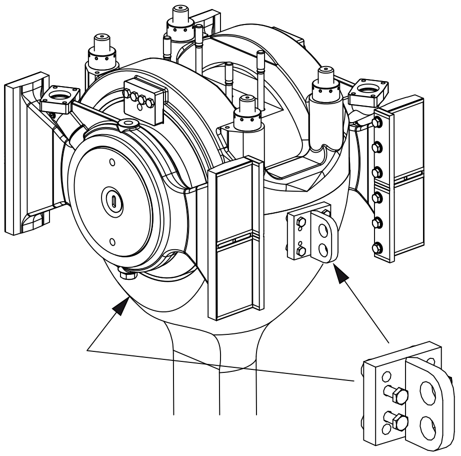
Loosen the crosshead bearing cap nuts. *For operation of the hydraulic jacks, see Workcard 7665-0101.*

Remove the hydraulic jacks and the spacer rings, and unscrew the nuts.



Lifting attachments

Mount the lifting attachments on the head of the connecting rod.

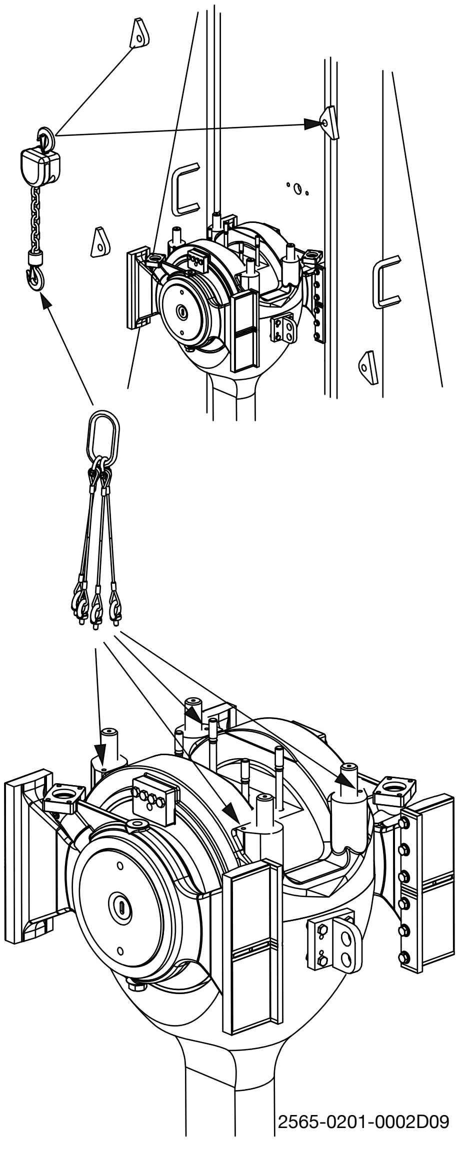


2565-0201-0002D08

Tackles

Suspend two tackles from the lifting brackets, in the athwarthship direction.

Fit the lifting tool on the top of the crosshead bearing cap.

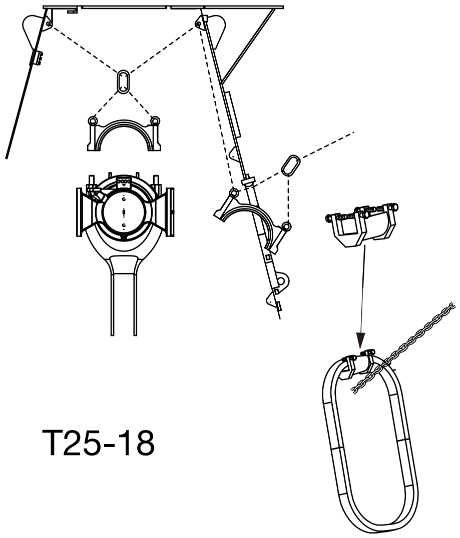


2565-0201-0002D09

Wire guide

Fit a wire guide at the top of the crankcase door frame to prevent damage.

Hook the tackles on to the eyebolts, and remove the bearing cap from the engine. Check the upper part of the journal.

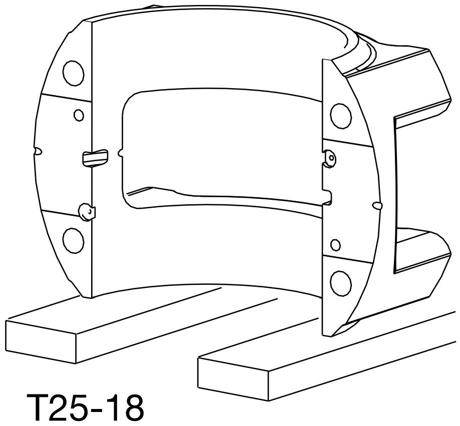


2565-0201-0002D10

Bearing cap

Place the bearing cap on one side on a couple of wooden planks.

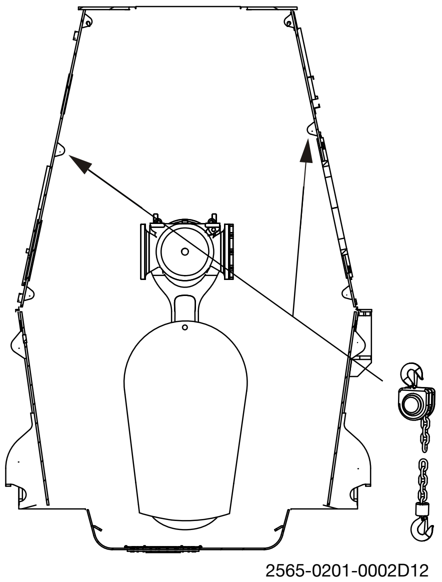
Check the bearing shell, *see work card 2565-0201, Checking.*



2565-0201-0002D11

Tackles

Fasten tackles to the fixed lifting brackets on the frame box wall.

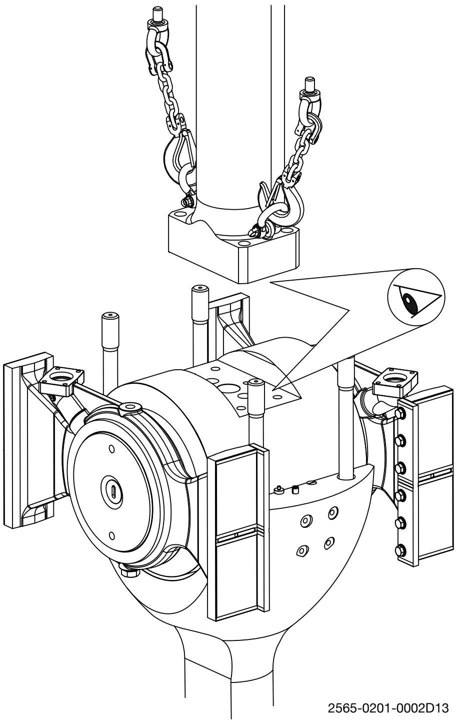


2565-0201-0002D12

If the piston is suspended

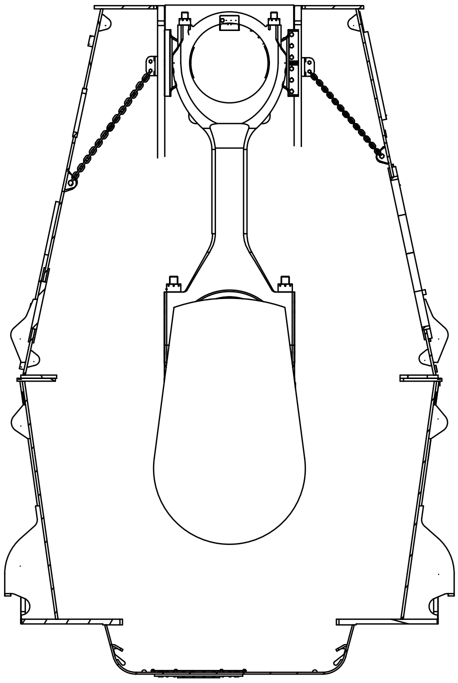
Turn the crosshead upwards until the piston rod lands on the crosshead. Ensure that the guide ring in the crosshead fits correctly in the centre hole of the piston rod.

Do not remove the chains or lifting eyebolts.


2565-0201-0002D13

The tackle hooks

Turn to TDC and attach the tackle hooks to the lifting attachments. Haul the tackles tight.


2565-0201-0002D14

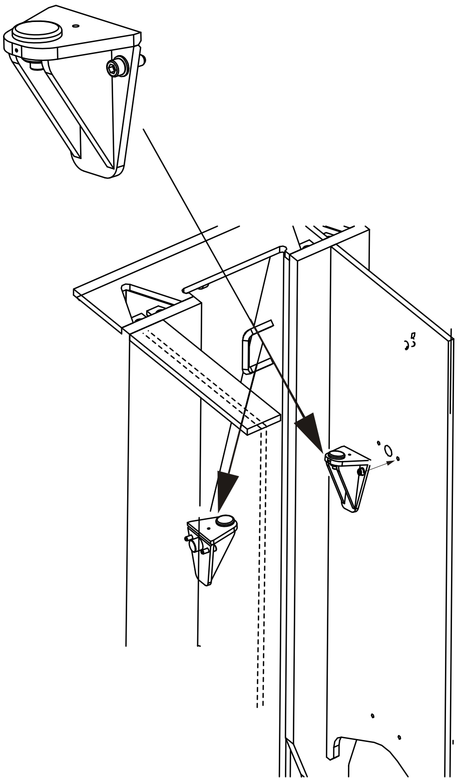
Supports for guide shoes

Fit the two supports for guide shoes on the web plate.

Carefully turn the crank down towards the exhaust side, until the guide shoes rest on the supports.

Adjust the support brackets to the guide shoes so that the weight of the crosshead is evenly distributed on the two supports.

Haul the tackles tight.



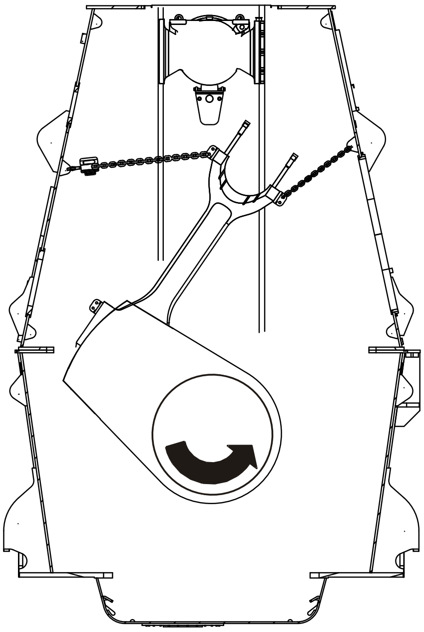
2565-0201-0002D15

CAUTION

Take care not to scratch the crosshead bearing journal or damage the threads of the crosshead bearing studs.

Turn the crankthrow

Turn the crankthrow carefully towards BDC while 'following' with the tackles, thus continuously supporting the connecting rod.



2565-0201-0002D16

Check the bearing shell and the journal

With the crosshead resting on the supports, check the lower part of the crosshead journal and the lower bearing shell.

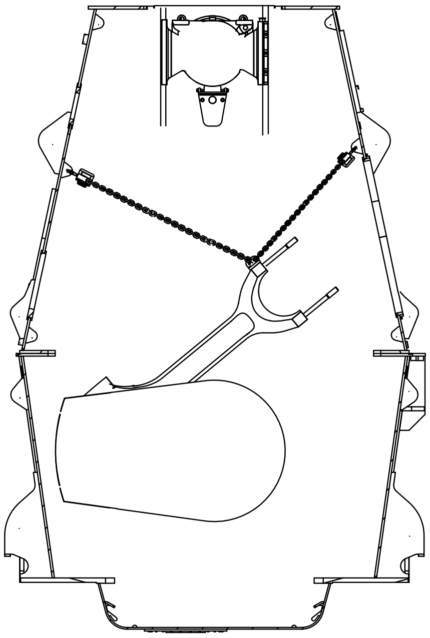
Regarding checking of journal and bearing shells, see 2545-0100, Chapter 'Bearings'.

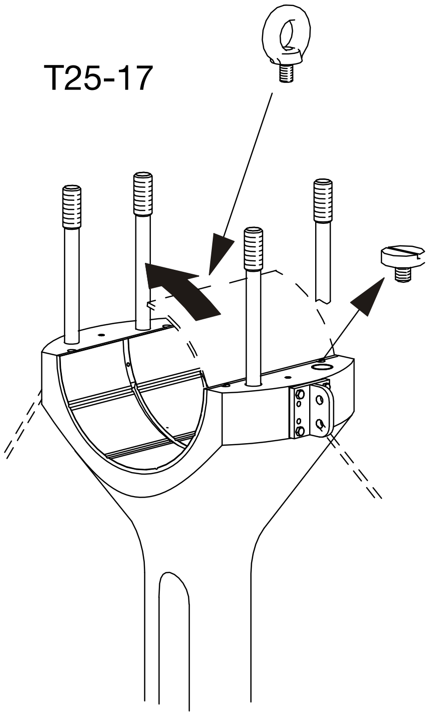
Bearing shell

In cases where it is necessary to remove the lower bearing shell, tilt the connecting rod towards the doorway on the camshaft side, using the tackles.

Dismount the locking screws, and turn the bearing shell so far out that an eyebolt can be mounted.

Lift the bearing shell out of the engine.

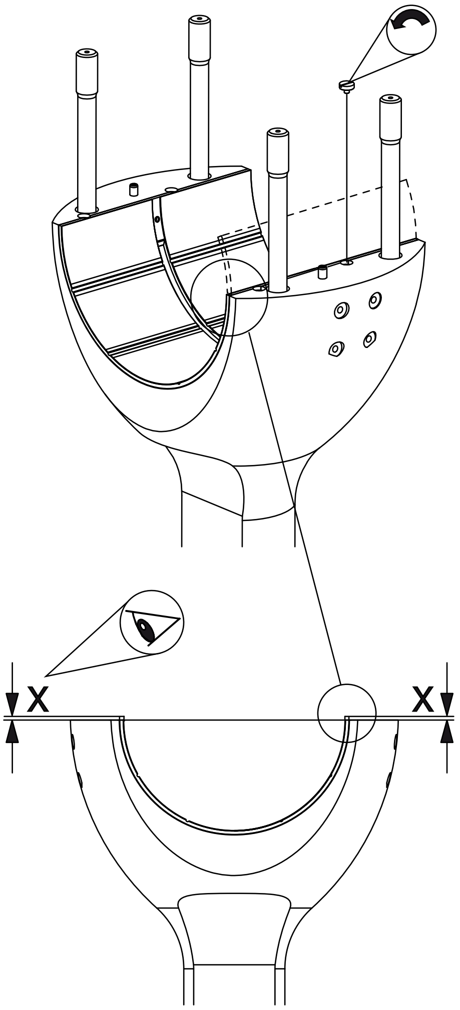




2565-0201-0002D18

With piston mounted/
With piston removed:

Mounting the bearing shell	Mount and secure the bearing shell in the bearing housing. The excess height **X** is to ensure the correct tightening-down of the bearing shell and **must not** be eliminated.

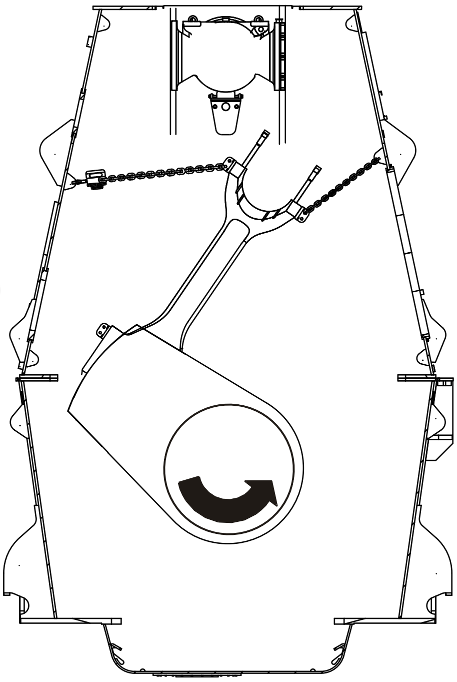


2565-0201-0002M01

The crosshead

Raise the connecting rod to an upright position.

Turn to TDC while ‘following’ with the tackles, for assembling the crosshead and the connecting rod.


2565-0201-0002M02

NOTE

Take care that the bearing studs do not damage the crosshead.

Take care that the guide shoes do not damage the bearing shell.

Lubricate the crosshead bearing with clean lube oil before “landing” the crosshead journal in the bearing.

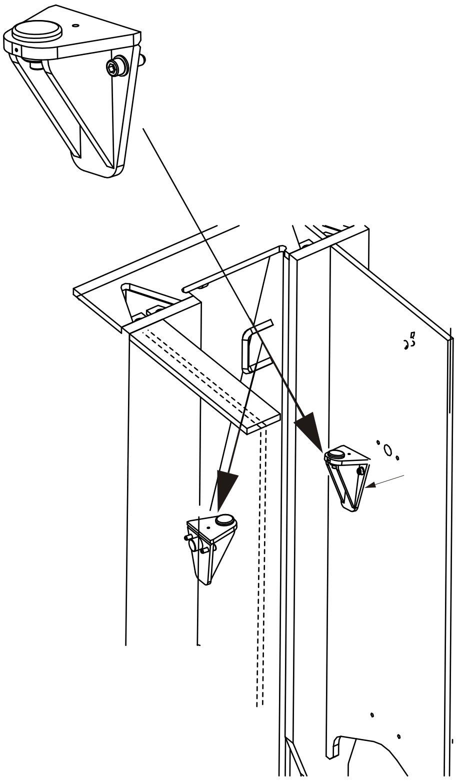
Crosshead guides

Remove the supports from the crosshead guides.

Remove the tackles from the crosshead.

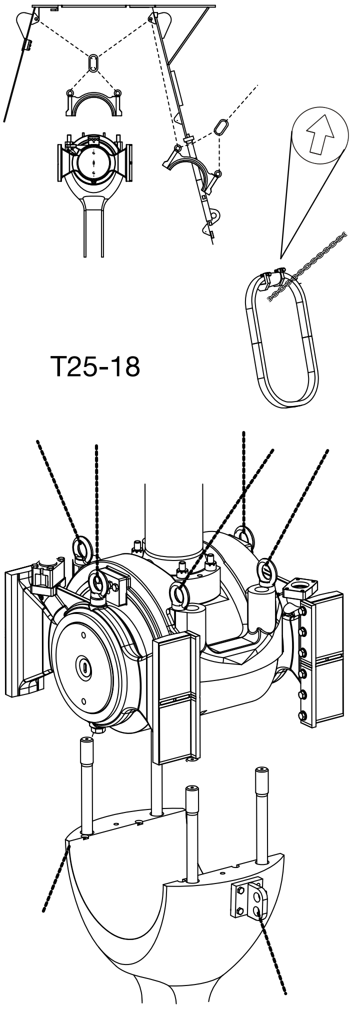
Turn the crank throw to BDC.

If the piston is mounted, slowly turn down until it is fully suspended from the chains.


2565-0201-0002M03

Bearing cap

Lift the bearing cap into the engine. Lower the bearing cap onto the crosshead and remove the tackles. Remove the lifting attachments from the connecting rod and the wire guide from the door frame.



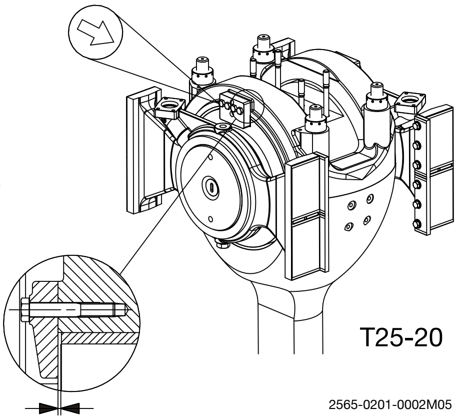
2565-0201-0002M04

Thrust pieces

Mount the thrust pieces for axial guidance of the connecting rod.
For tightening torque, see Data.

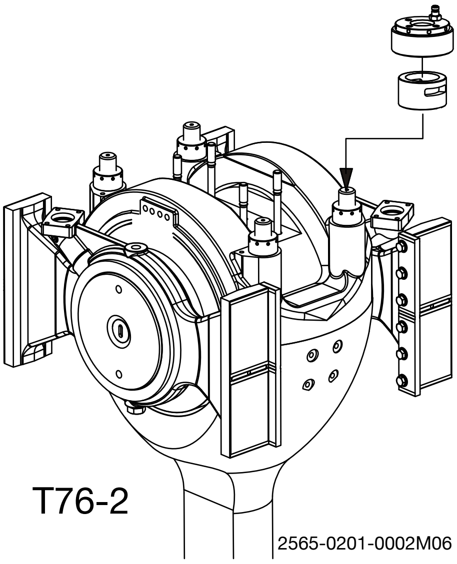
NOTE

It must be ensured that a clearance between the thrust piece and the crosshead exists fore and aft before any tightening of the trust piece.



2565-0201-0002M05

Tightening the bearing cap nuts	Tighten all four crosshead bearing cap nuts simultaneously. *See Data.* *For operation of hydraulic jacks, see Section 7665-0101.*

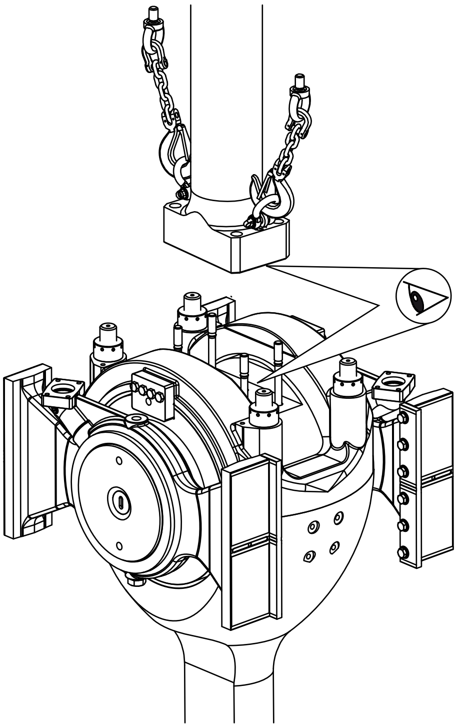


2565-0201-0002M06

Mount the piston	*See Workcard 2265-0401, Mounting.*

With piston mounted

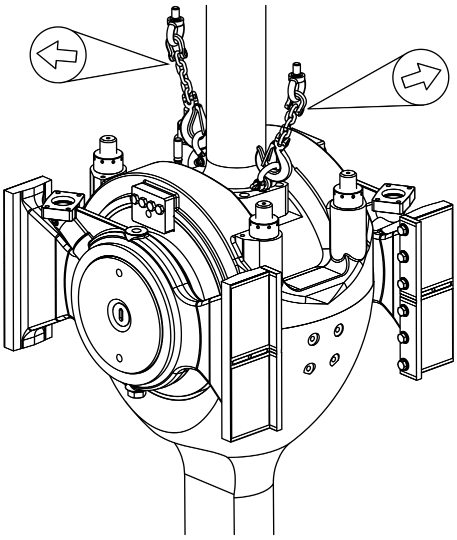
Turn the crosshead	If any shims have been removed from the crosshead, mount them again. Turn the crosshead upwards until the piston rod lands on the crosshead. Ensure that the guide ring in the crosshead fits correctly in the centre hole of the piston rod.



2565-0201-0002M08

Remove the chains and the eyebolts

Unhook the chains from the lifting eyebolts in the piston rod. Remove the chains and eyebolts from the top of the crankcase, from the piston rod and from the crosshead bearing cap.

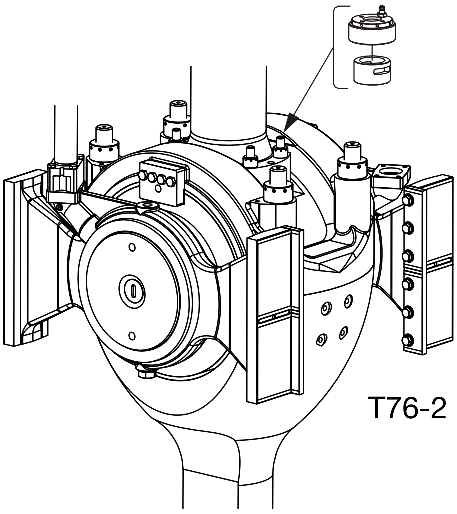


2565-0201-0002M09

Tightening the piston rod nuts and studs

Turn down to BDC and mount the hydraulic nuts on the studs.

Tighten the nuts on the piston rod foot simultanoeusly. *See Data.*



2565-0201-0002M10

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
T14-54	Connecting rod complete	10100	kg
T25-22	Crankpin bearing clearance, max.	0.75	mm
T25-23	Crankpin bearing clearance, min.	0.35	mm
T25-25	Crankpin bearing, upper shell	70	kg
T25-26	Crankpin bearing, lower shell	50	kg
T25-27	Crankpin bearing cap + shell + bearing studs	730	kg
T25-28	Piston + Crosshead + Connecting Rod	13.300	kg
T76-01	Hydraulic pressure, dismantling	2000 - 2400	bar
T76-02	Hydraulic pressure, mounting	2000	bar

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
1470-0300	**041**	Wire guide
1470-0300	**053**	Lifting attachment for connecting rod
1470-0300	**090**	Bracket, support of crosshead
1470-0310	**-**	Connecting rod, hydraulic tools
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**060**	Hose with unions, 5000 mm
7670-0100	**118**	3-way distributor block, complete
7670-0300	**-**	Lifting tools, etc
7670-0410	**054**	Feeler gauge set
7670-0410	**066**	Slide caliper

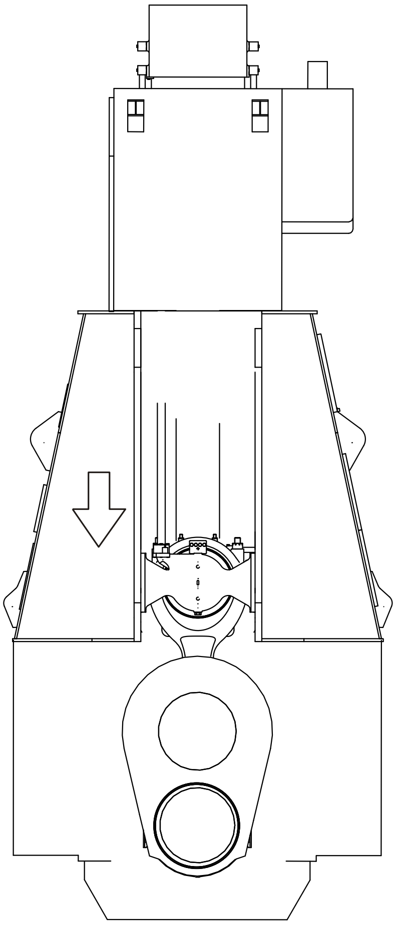
Crankpin Bearing

The bottom clearance between the journal and a new bearing shell is the result of a summation of the production tolerances of the bearing assembly components.

For the bottom clearance of a specific bearing, see the measurement in the 'Test-bed Sheet', from the engine builder.

Crankcase door Open the crankcase door at the relevant cylinder.

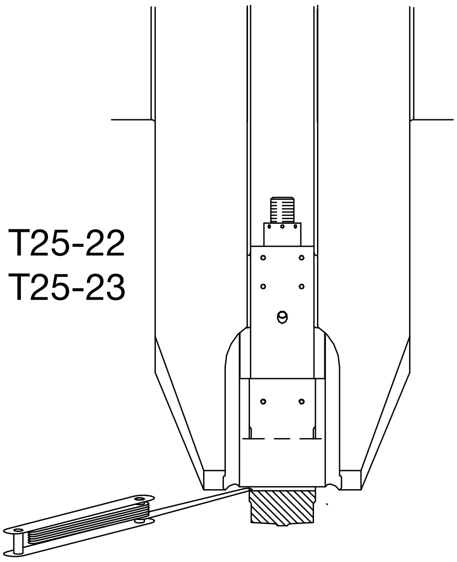
Turn the crank Turn the crank concerned to BDC.



2565-0301-0002C02

Clearance

Measure the clearance in the crankpin bearing by inserting a feeler gauge at the bottom of the bearing shell in both sides. *See Data for bottom clearance.*



2565-0301-0002C03

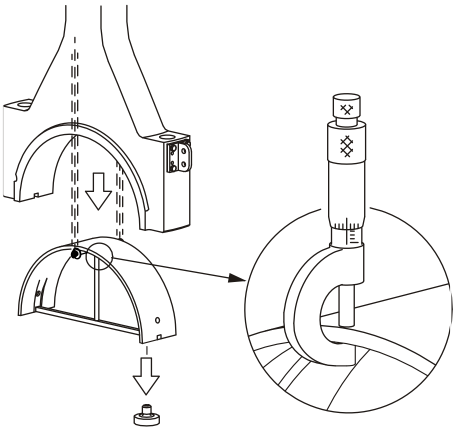
Remember!

The difference between the **actual** clearance measurement and the measurement recorded in the Adjustment Sheet (or the clearance noted for a new bearing installed later) **must not** exceed 0.1 mm. If so, the crankpin bearing must be disassembled for inspection.
See 'Dismantling'.

Wear limit

The wear limit for the crankpin bearing shells is based on an evaluation of the bearing condition at the time of inspection.

An average wear rate of 0.01 mm per 10,000 hours is regarded as normal.



2565-0301-0006C05

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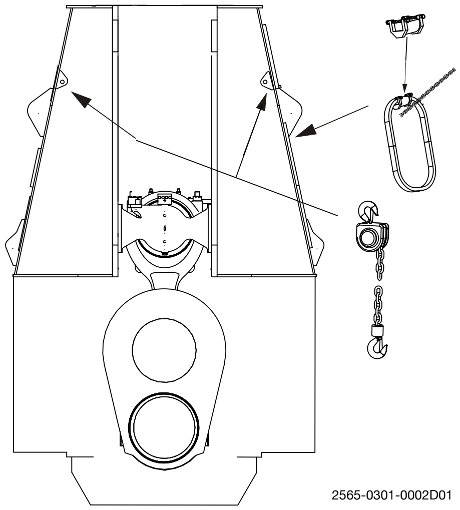
External inspection

For further external inspection of the crankpin bearing, see description 2545-0100.

Wire guide

Suspend two tackles from the lifting brackets, in the athwartship direction.

Mount the wire guide in the top of the crankcase door opening.



2565-0301-0002D01

Turn the crank to TDC

Mount the lifting tool in each side of the crankpin bearing cap.

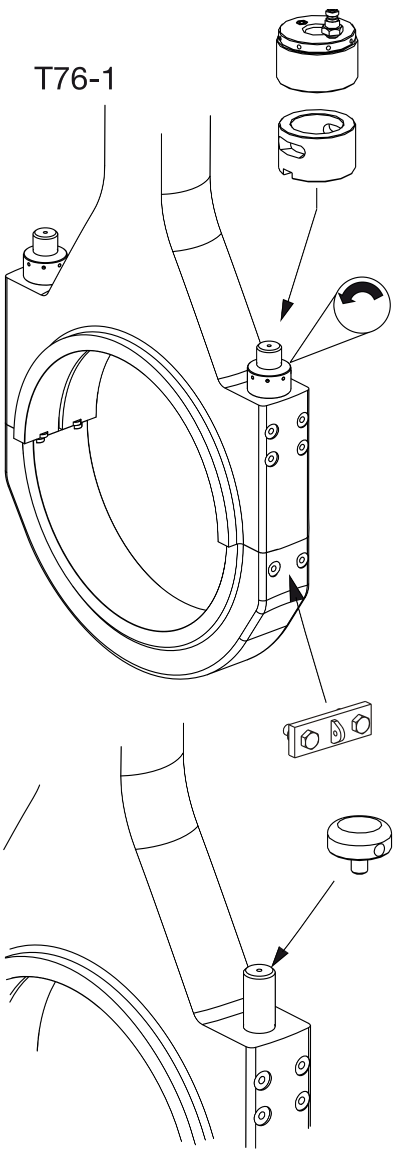
Using shackles and wire ropes, hook on the tackles and haul tight.

Loosen the crankpin bearing stud nuts, using the hydraulic jacks.

For operation of the hydraulic jacks, see work card 7665-0101.

Remove the hydraulic jacks and the nuts.

Mount the protective screws on top of the studs. The protective screws are found on the tool panel.



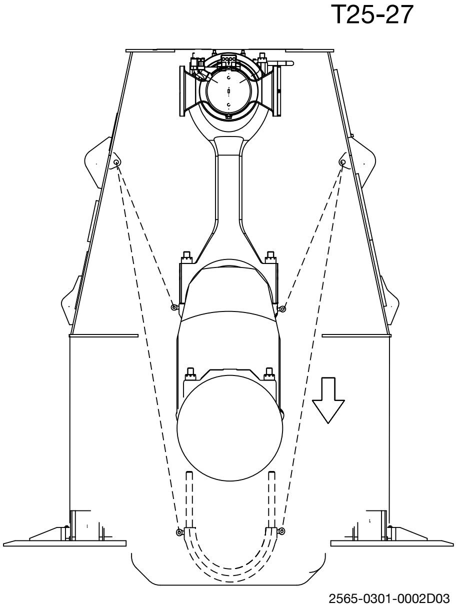
2565-0301-0007D02

Bearing cap

Lower the bearing cap while seeing **carefully** that the studs do not damage the crankpin journal.

Land the bearing cap on a couple of planks placed in the oil pan.

Inspect the bearing shell.



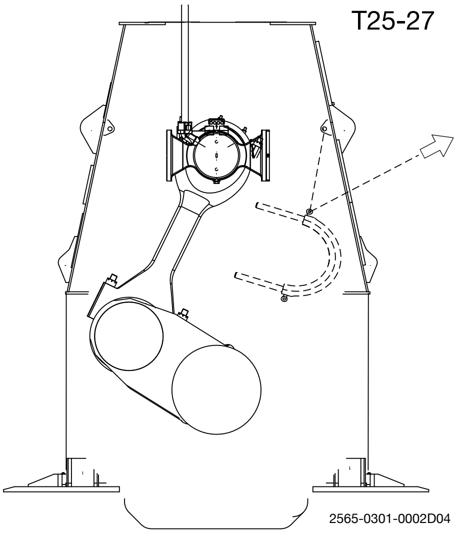
Bearing shell

If the bearing shell needs to be replaced, remove the whole bearing cap from the crankcase.

Suspend a tackle outside the engine above the crankcase door opening.

Turn the crankthrow to the exhaust side to give space for lifting out the crankpin bearing cap.

Using the tackle from the frame box inside wall, together with the tackle suspended outside the engine, lift the bearing cap out of the crankcase.

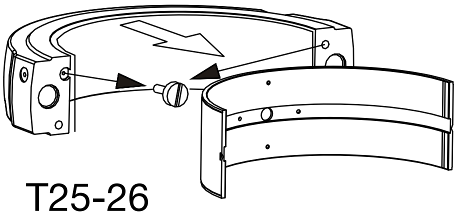


Replacing the bearing shell

Place the bearing cap on one side on a couple of planks.

Dismount the bearing shell lock screws and replace the bearing shell by a new one.

The bearing shells **must** be replaced in pairs.



2565-0301-0002D05

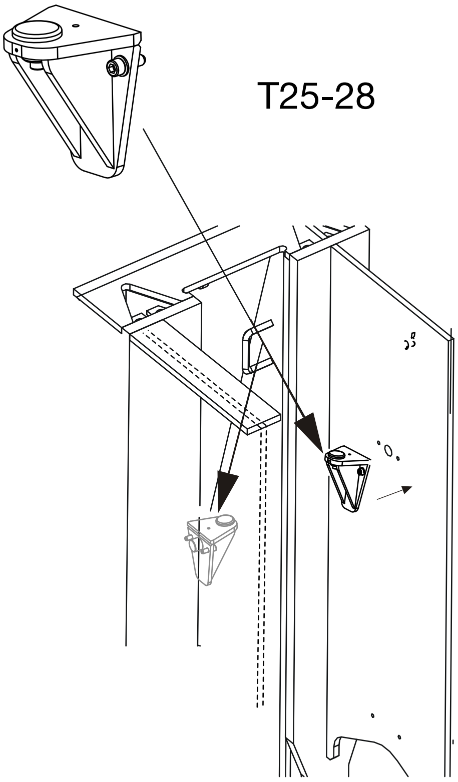
Crosshead supports

Turn to TDC.

Mount the two supports for crosshead on the web plates.

Carefully turn the crank to the camshaft side and down until the guide shoes rest on the supports.

Adjust the support brackets to the guide shoes so that the weight of the crosshead is evenly distributed on the four supports.

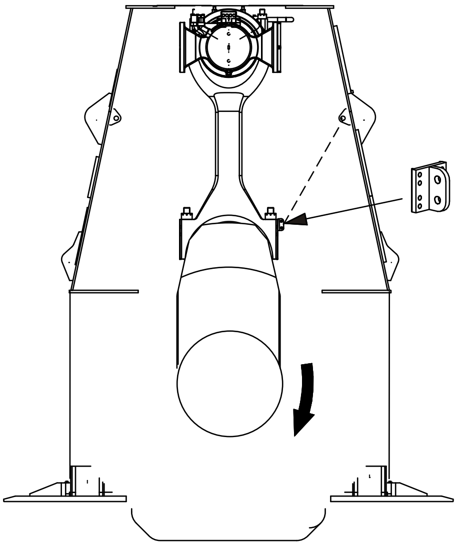


2565-0301-0002D06

Lifting attachments

Mount a lifting attachment for securing the connecting rod at the lower end, on the camshaft side.

Hook the tackle on to the lifting attachment.



2565-0301-0002D07

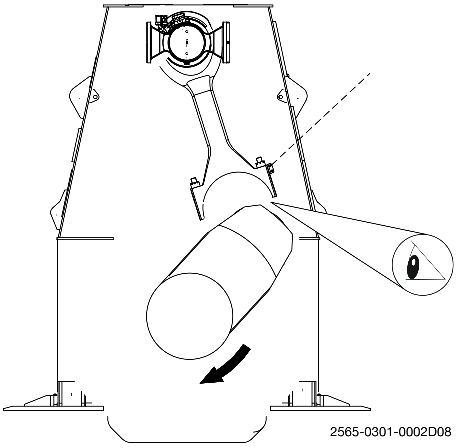
Bearing shell surface

Carefully turn the crankshaft downwards, while ‘following’ with the tackle, making sure that the upper part of the bearing comes completely clear of the recess in the crankshaft when the parts begin to ‘separate’.

If necessary suspend a second tackle from the bracket below the doorway.

Continue turning the crankshaft until the bearing surface can be freely inspected.

Inspect the bearing shell surface and the crankpin journal.



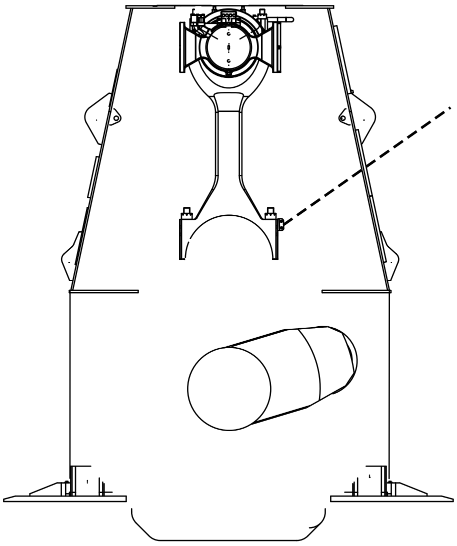
2565-0301-0002D08

Replacing bearing shell

If it is necessary to replace the bearing shell, proceed as follows:

Turn the crankshaft approx. 80° to a horizontal position.

Release the tackle so that the connecting rod is hanging freely.

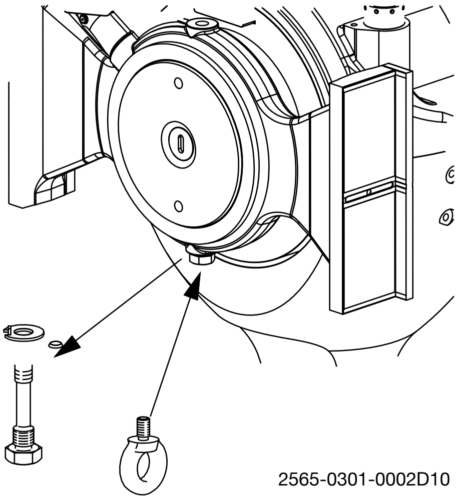


2565-0301-0002D09

Eyebolt

Mount an eyebolt in the bottom of each guide shoe.

Suspend two tackles from the eyebolts.

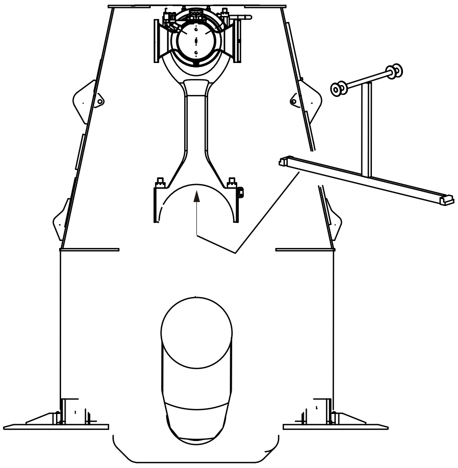


2565-0301-0002D10

Lifting tool

Place the lifting tool for the crankpin upper shell on the crank webs and hook the tackles on to the lifting tool.

Mount the tool on the bearing shell in the connecting rod, using the tackles, and haul tight.

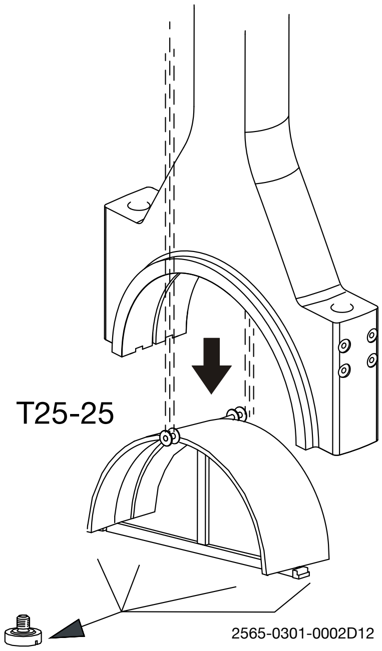


2565-0301-0002D11

Dismounting the bearing shell

Dismount the bearing shell lock screws.

Lower the lifting tool with the bearing shell, using the tackles.



2565-0301-0002D12

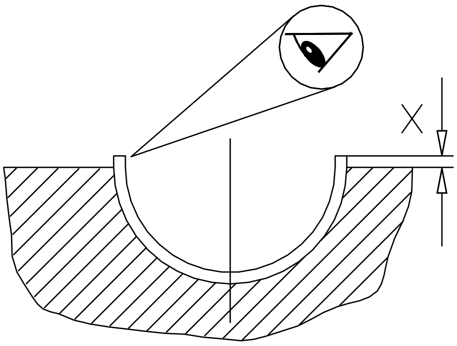
Replacing the bearing shells

If necessary, replace the bearing shells with new ones. The bearing shells **must** be replaced in pairs.

Bearing shells of three mm undersize are available as spares in case of journal rectification.

Coat the bearing shell surfaces and the journal with clean oil.

The excess height **X** is to ensure the correct tightening-down of the bearing shell, and **must no**t be eliminated.

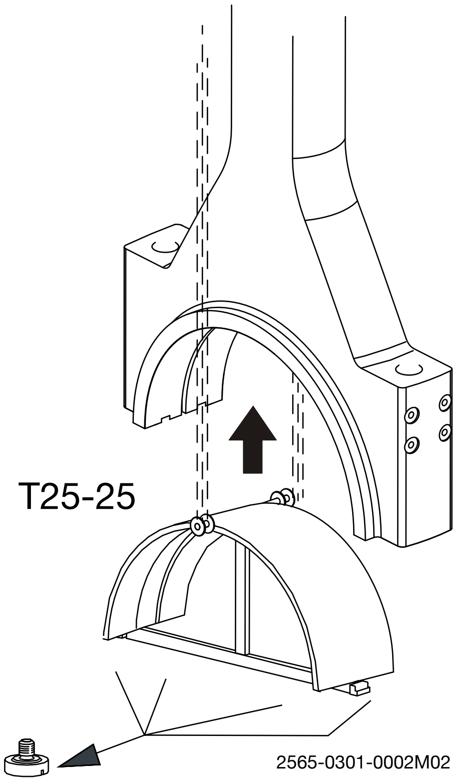


2565-0301-0002M01

Upper bearing shell

Lift the upper bearing shell for the crankpin concerned into the crankcase.

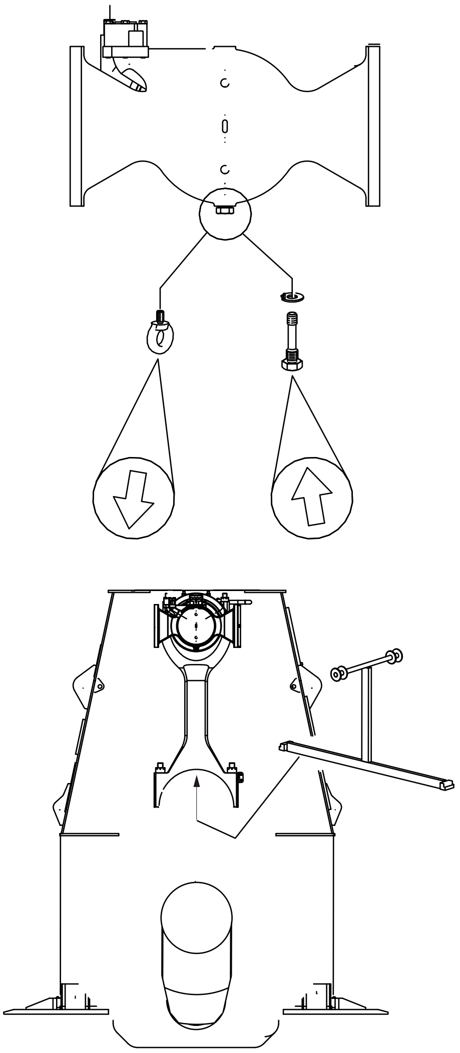
Carefully lift the bearing shell into position in the connecting rod, and mount the lock screws.



2565-0301-0002M02

Remove the tools

Remove the lifting tool, the tackles and the eyebolts from the guide shoes.



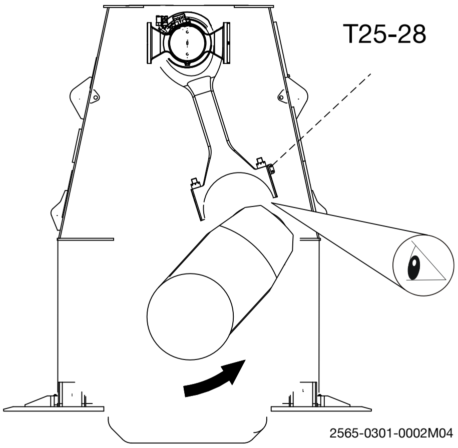
2565-0301-0002M03

The tackle

Hook the tackle on to a lifting pipe under the gallery platform and on to the lifting attachment on the connecting rod, and haul tight.

Carefully turn the crankshaft upwards, while following up with the tackle, making sure that the upper part of the bearing enters the recess in the crankshaft when the parts turn together.

Remove the tackle and the lifting attachment from the connecting rod.

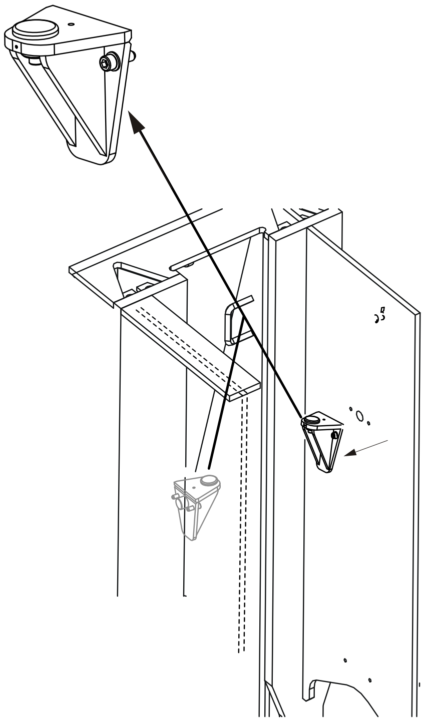


2565-0301-0002M04

The crosshead

Turn the crosshead to TDC.

Remove the two crosshead support brackets from the crosshead guides.



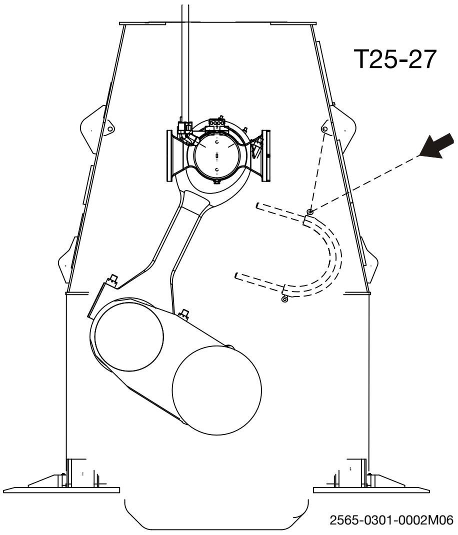
2565-0301-0002M05

Lifting brackets

Suspend the tackles from the lifting brackets in the side of the frame box.

Lift the bearing cap assembly into the crankcase and land it on a couple of planks placed in the oil pan.

Remove the wire guide tool from the engine.

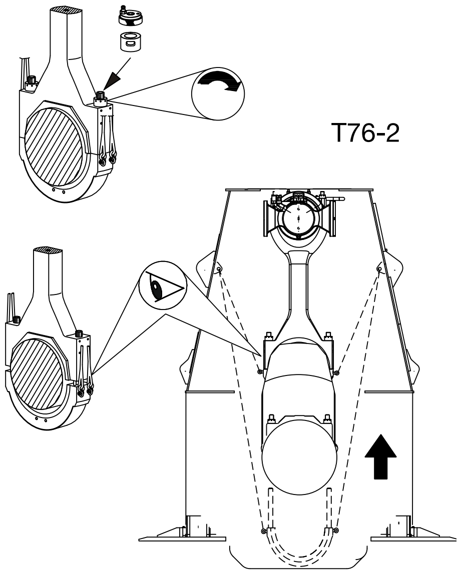


2565-0301-0002M06

Hook the tackles

Check that the protective screws are still fitted on the studs.

Hook the tackles on to the wire ropes and lift the bearing cap into position against the connecting rod.



2565-0301-0002M07

NOTE

During mounting, take care that the studs do not damage the crankpin journal, and check that the guide pins mounted in the bearing cap enter the holes in the connecting rod.

Remove the protective screws.

Mount the nuts and, by means of spacer rings and hydraulic jacks, tighten the crankpin bearing cap. *See Data.*

For operation of hydraulic jacks, *see work card 7665-0101.*.

Remove the crankpin lifting tools from the bearing cap.

Remove the tackles from the side of the frame box.

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T25-30	Main bearing, top clearance max.	0.60	mm
T25-31	Main bearing, top clearance min.	0.25	mm
T25-32	Main bearing cap	1080	kg
T25-33	Main bearing shell, upper	68	kg
T25-34	Main bearing shell, lower	74	kg
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

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
1070-1030	**-**	Crankshaft tools
1470-0300	**041**	Wire guide
2570-0010	**045**	Pulley for wire for main bearing
2570-0010	**070**	Lifting tool for main bearing cap
2570-0010	**082**	Dismantling tool for main bearing shell
2570-0010	**094**	Mounting tool for thin bearing shell
2570-0010	**128**	Retaining tool for main bearing shell
2570-0400	**-**	Main bearing hydraulic tools
2570-0420	**019**	Lifting tool for main bearing shell
2570-0430	**-**	Main bearing measuring tools

Plate	Item No.	Description
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**023**	Hydraulic pump, hand operated
7670-0100	**047**	Hose with unions, 1500 mm
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**106**	5-way distributor block, complete
7670-0300	**-**	Lifting tools, etc
7670-0410	**054**	Feeler gauge set
7670-0410	**078**	Dial gauge and stand tool

General

The condition of the main bearings can be checked by:

- Deflection readings
- Visual checking
- Edge checking and
- Measuring of top clearance.

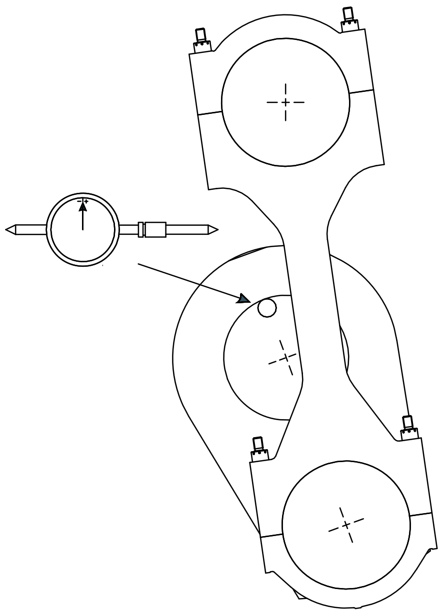
Crankshaft deflection readings

Crankshaft deflection readings should be taken while the ship is afloat (i.e. not while in dry dock).

As the alignment is influenced by the engine temperature as well as the loading conditions, deflection measurements should, for comparison purposes, always be made under nearly the same temperature and load conditions.

Dial gauge

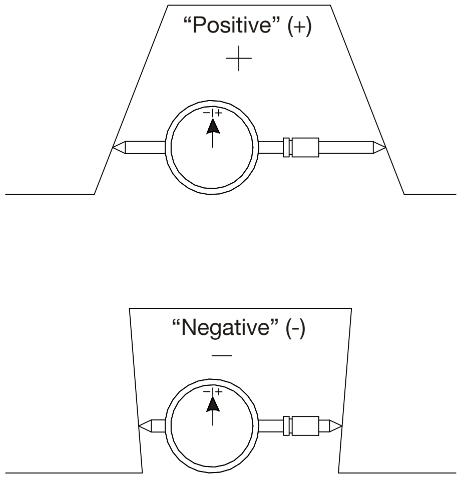
Place a dial gauge axially in the crank throw opposite the crankpin, as illustrated on the sketch. The correct mounting position is marked with punch marks on the crank throw. *See also Description 2545-0101.*



2565-0401-0004C01

The compression of the gauge

“Closing” of the crank throw (compression of the gauge) is regarded as negative (–) and “opening” as positive (+).



2565-0401-0004C02

Readings to be taken

Set the dial gauge to zero at the **B1** side near BDC. Whilst turning clockwise, take the readings when the throw passes the positions:

B1 (near bottom)

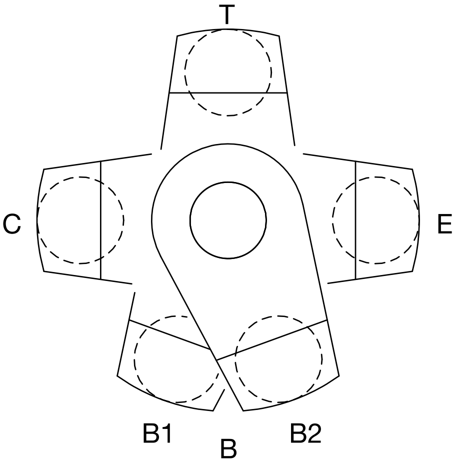
C (camshaft side)

T (top)

E (exhaust side)

B2 (near bottom)

B = 1/2 (B2+B1)



Looking forward

B1
C
T
E
B2
½ (B1+B2)=B

2565-0401-0004C03

Deflection readings

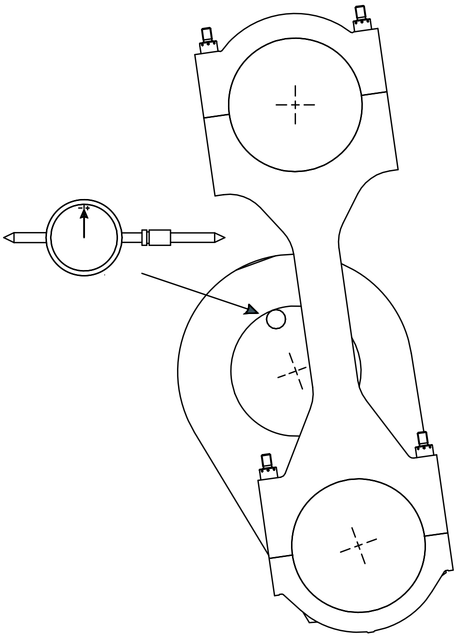
When taking deflection readings for the three aftmost cylinders, the turning gear should, at each stoppage, be turned a little backwards to ease off the tangential pressure on the turning wheel teeth. Otherwise, this pressure may falsify the readings.

For evaluation of the crankshaft deflection readings, *see Description 2545-0100.*

If the crankshaft deflection (alignment indicator) is approaching the tolerance limits *(see Description 2545-0100)*, the two adjacent main bearings must be checked for wear. See next page for checking of main bearing.

If the bearings are found to be in good order, please contact MAN Diesel & Turbo or the engine manufacturer for checking of the bedplate alignment.

As reference, use the “after seatrial” deflection table.



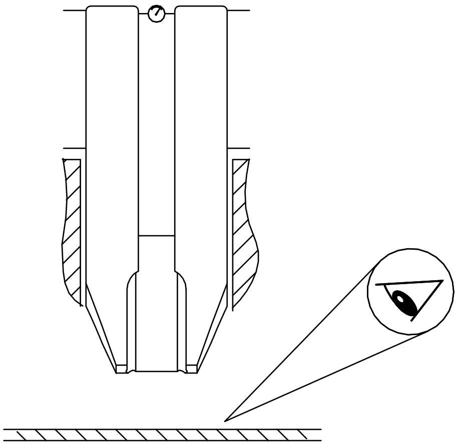
2565-0401-0004C01

Visual check

The condition of the bearing can be checked as follows:

Visually look for bearing metal fragments in the oil pan, and check the filters for metal fragments.

Such fragments can be from crosshead, guide shoe or crankpin bearings. If fragments are found, the damaged bearing can be found by edge checking with a feeler.



2565-0401-0004C05

General

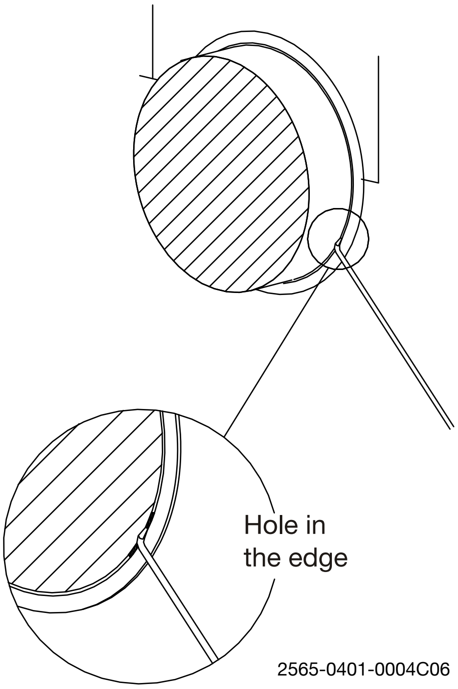
Bearing damage usually propagates rather quickly towards the edge of the bearing where, eventually, it causes chips to be broken off, which means that loose pieces of white metal can fall down into the crankcase beneath the bearing support.

Large, thick pieces will normally be found during a crankcase inspection, and small, thin pieces can enter the filter. A check of the bearing edges together with inspection of the crankcase and the filter normally provides a good indication of the bearing condition.

Checking the bearing edges

Bearing edges can be checked with a "feeler" that is able to follow the bearing edge against the journal the whole way round on each side. If white metal is missing at the edge, the tip of the "feeler" will enter the hole, thus locating the damage. In most cases this hole can be seen by the naked eye as a dark spot when using a strong flashlight.

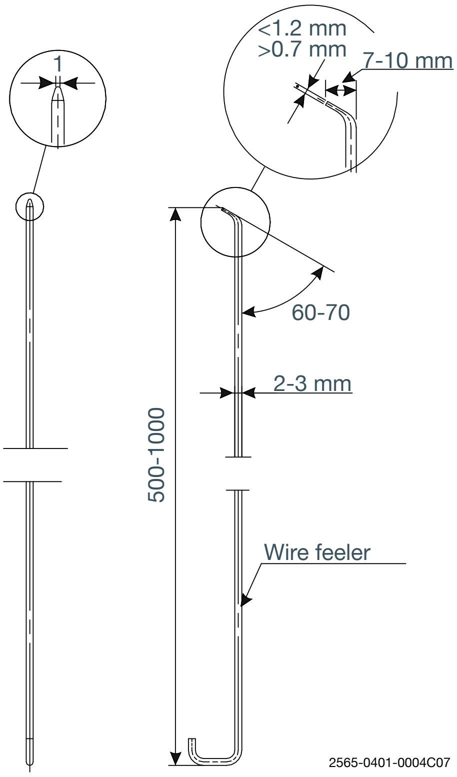
The No. 1 and the two aftmost main bearings are more difficult to access on the whole circumference on each side, but it is often possible to bend the "feeler" to suit the situation and thus reach as far round as possible.



2565-0401-0004C06

Wire-feeler

It is rather easy to make a feeler (see sketch). The “feeler” should be made from a piece of steel wire (e.g. a welding rod) approx. 0.6 - 1 m long depending on the engine type, and 2 to 3 mm thick. Approx. 7 to 10 mm of the wire should be bent to an angle of approx. 65° to form a “feeler tip”. Grind the tip smooth to obtain the shape and dimension shown on the sketch. Note that the thickness of the white metal is approx. 1.5 mm, which is why the tip should be less than 1.2 mm thick, and bigger than the max. top clearance. At the other end of the tip, a “handle” should be made by bending a hook or similar in the same direction as the tip.



2565-0401-0004C07

NOTE

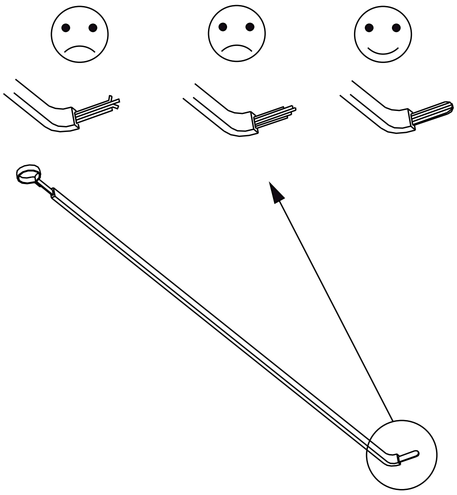
The above dimensions of the “wire-feeler” are guideline values and may depend on the engine type as well as individual, personal designs.

The clearance in the bearings

If there is too large a difference in the crankshaft deflection readings (autolog) check the clearance in the individual bearings.

Bearing clearance checks should also be carried out during time-based overhauls, surveys and during crankcase inspections.

If there is a suspicion of a damaged bearing, it is recommended to edge check the bearing, without opening up.



2565-0401-0004C08

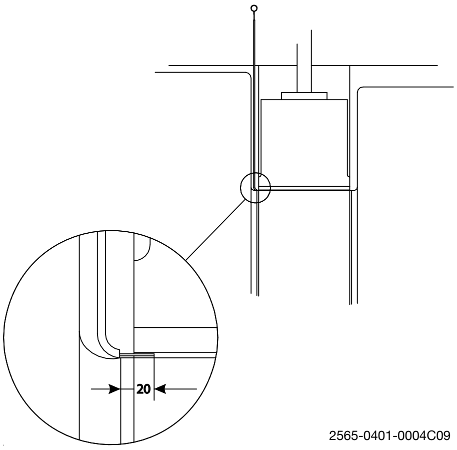
Feeler blades

Before measuring, check that the feeler blades are in good condition.

The feeler is inserted along the crank throw. When the feeler hits the journal, gently attempt to enter the feeler gauge into the bearing. Do not use force.

Measure until a Go/No go difference of 0.05 mm has been found, e.g. Go = 0.75 mm / No go = 0.8 mm.

Check the feeler blades after measuring.



2565-0401-0004C09

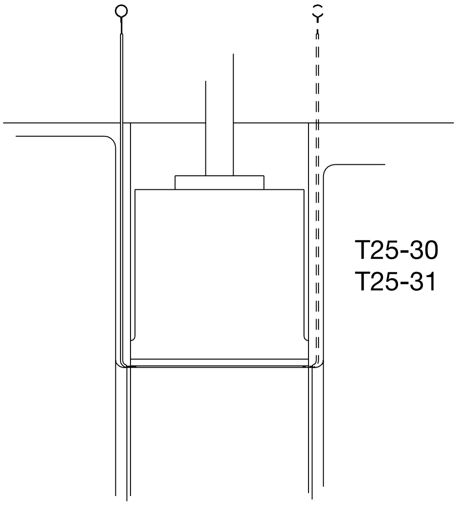
Remember !

The clearance is measured at both the fore and the aft part of the bearing.

NOTE

The bearing clearances for a new bearing stated in Data (*see Data*) are for guidance purposes only.

Also note that bearings shells can be with or without blended edge and must never be switched between the bearings. When ordering spare parts, always specify the bearing no. See also note on 2572-0400 page 2.



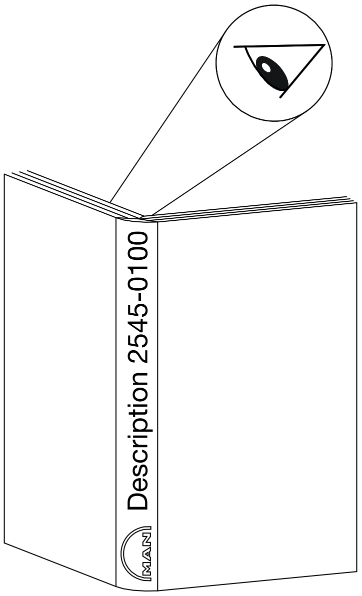
2565-0401-0004C10

Evaluation of the bearing

The difference between the actual clearance measurement and the measurement recorded in the adjustment sheet (or the clearance noted for a new bearing installed later) must not exceed 0.10 mm. If it does, *see Description 2545-0100.*

For evaluation of the bearing, see Description 2545-0100.

If the bearing needs to be disassembled for inspection, see "Dismantling".



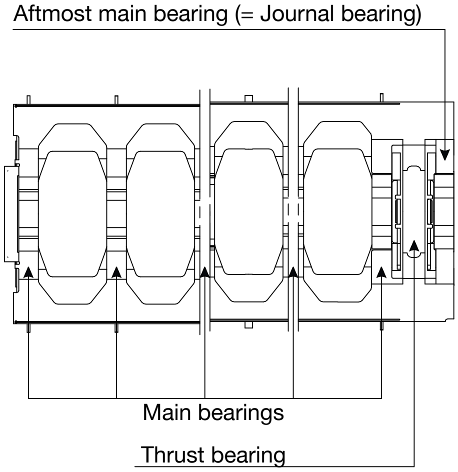
2565-0401-0004C11

Positioning the crankshaft

Dismantling of main bearing

The bearings are divided into two categories:

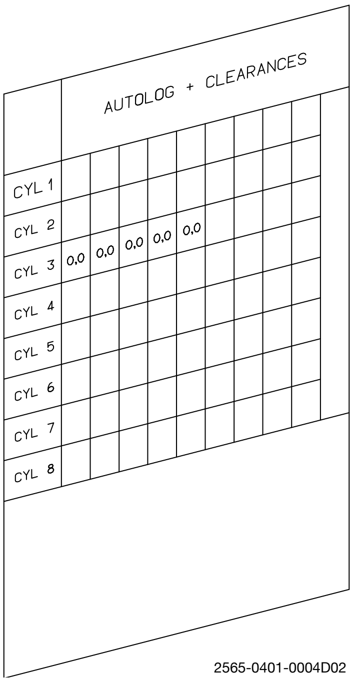
- The main bearings
- The aftmost main bearing often referred to as “Journal bearing” *(See work card 2565-05).*



2565-0401-0004D01

Before any dismantling

Check and write down the main bearing top clearances and crankshaft deflection readings for the cylinder unit concerned.



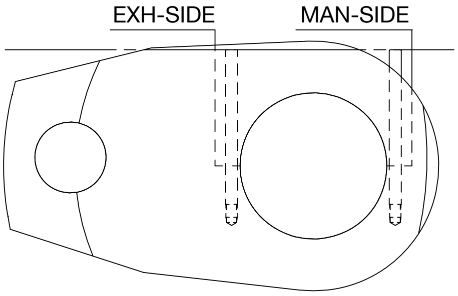
AUTOLOG + CLEARANCES

CYL 1										
CYL 2										
CYL 3	0,0	0,0	0,0	0,0	0,0					
CYL 4										
CYL 5										
CYL 6										
CYL 7										
CYL 8										

2565-0401-0004D02

Turn the crank throw

Turn the crank throw to the position shown on the sketch and in such a way that the top of the studs is flush with or slightly above the crank throw.



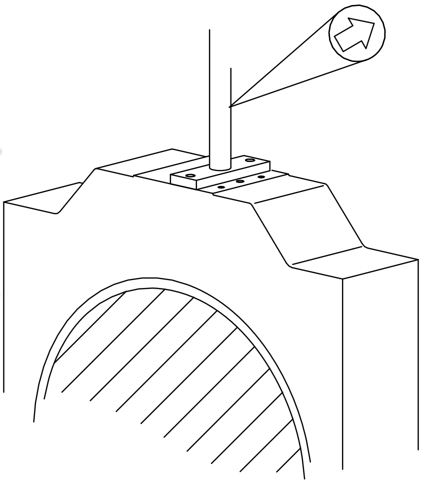
2565-0401-0004D03

NOTE

Be sure that the crosshead for the neighbouring cylinder is in a higher position than for the cylinder you are working on, otherwise it will be impossible to lift the cap.

Oil pipes

Disconnect the lubricating oil pipe from the main pipe.



2565-0401-0004D04

NOTE

On some engines, the oil pipes for the Axial Vibration Damper (AVD) have to be removed together with the oil pipe on main bearing No. 1.

NOTE

Some engines have temperature sensors fitted to the main, crosshead, and crankpin bearings. These sensors must be carefully handled to avoid damaging the equipment.

Mounting of tools and tackles

Mount pulley **E** above the bearing cap and an eyebolt in the stop screw fitted in the bottom of the opposite guide-shoe.

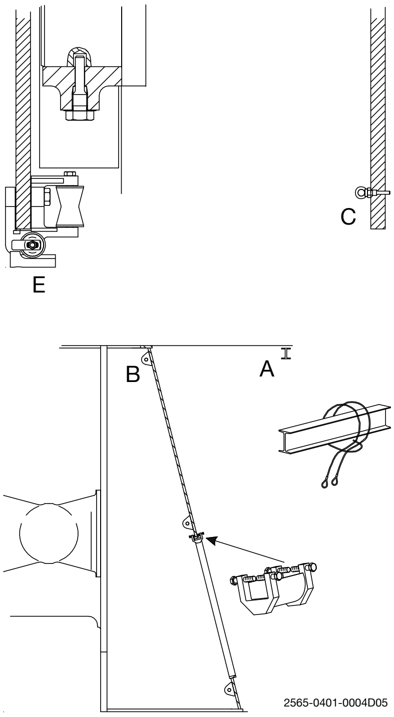
Be sure that the eyebolt is tightened to full contact.

Mount the wire guide as shown. Mount tackles in the following positions:

A: a 3 tonne chain tackle, in a wire strap around the beam

B: a 3 tonne chain tackle

C: a 3 tonne pull lift

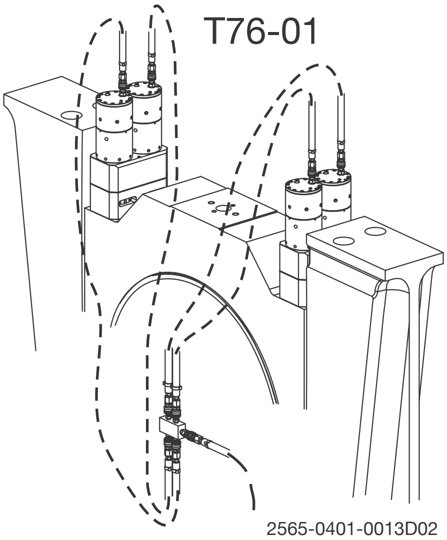


2565-0401-0004D05

Hydraulic jacks

Assemble the main bearing hydraulic tools on the bearing studs. Connect the hydraulic pump.

Loosen the nuts.



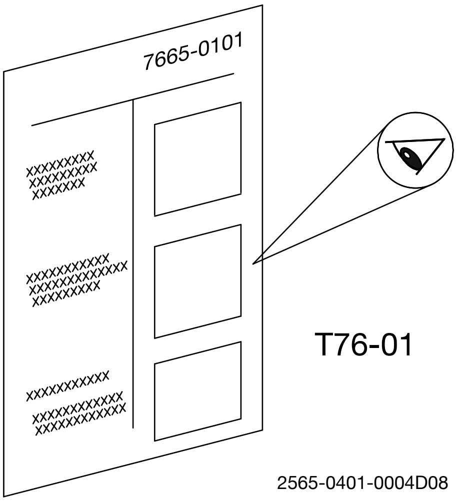
2565-0401-0013D02

Hydraulic tools

For operation of the hydraulic tools, see work card 7665-0101.

Remove the hydraulic main bearing tools from the engine.

Unscrew and remove the nuts from the main bearing studs.



2565-0401-0004D08

Removal of main bearing cap

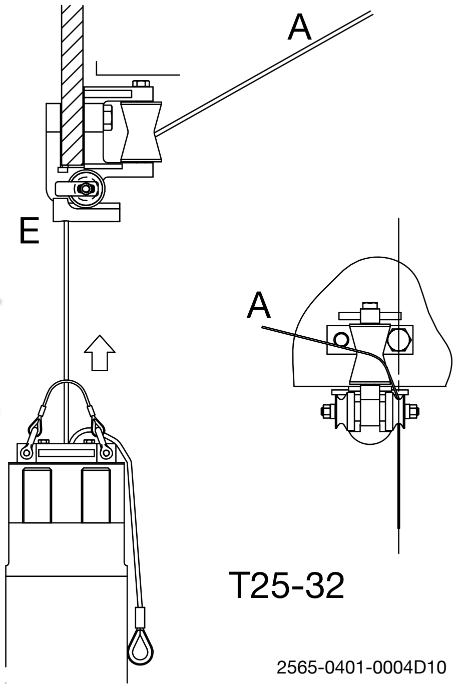
Mount the main bearing lifting tool on the main bearing cap

Wind the longest of the free wire ropes around pulley **E** as shown, and attach it to tackle **A** from outside the door.

NOTE

When tightening up the tackle, be sure that the wire guide is positioned correctly to protect the doorframe.

Carefully lift the main bearing cap clear of the studs.

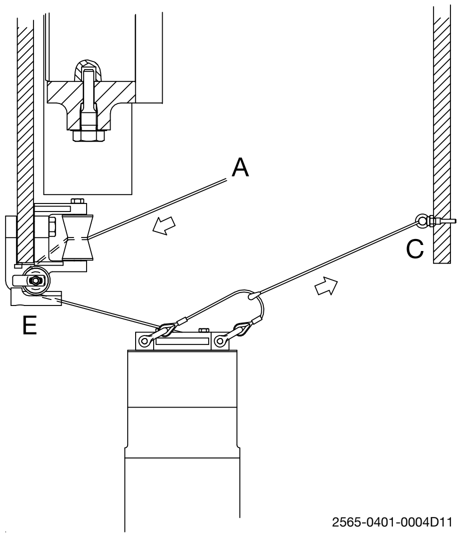


2565-0401-0004D10

Moving the bearing cap in for or aft direction

Attach pull lift **C** to the short wire rope across the lifting attachment.

By tightening pull lift **C**, and loosening tackle **A**, pull the bearing cap clear of the crosshead guides.



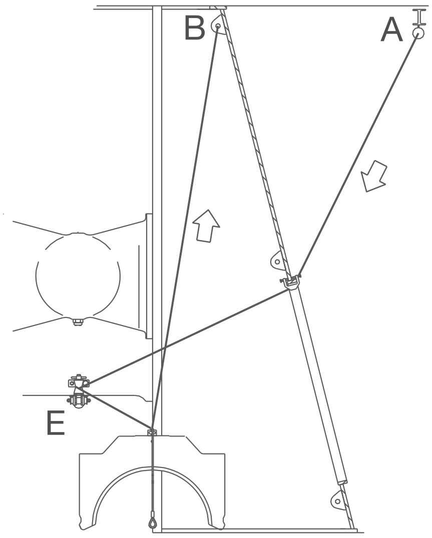
2565-0401-0004D11

Moving the bearing cap towards the manoevering side

Attach tackle **B** to the shortest of the free wire ropes.

By loosening tackle **A** and pull lift **B**, move the bearing cap until it is hanging freely below tackle **B**.

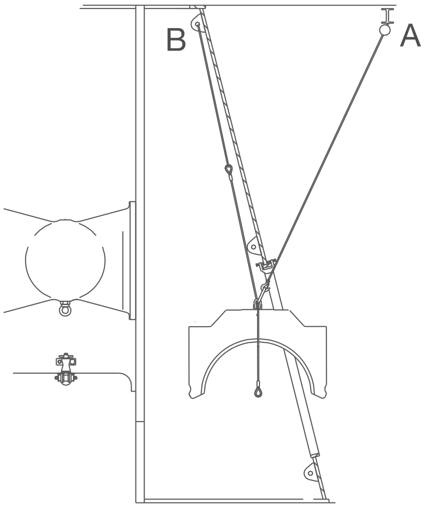
Release tackle **A** and wind the long wire rope off pulley **E**.



2565-0401-0013D12

Moving the bearing cap out of the engine

Attach tackle **A** to the short wire rope across the lifting tool, and lift the bearing cap out of the engine.



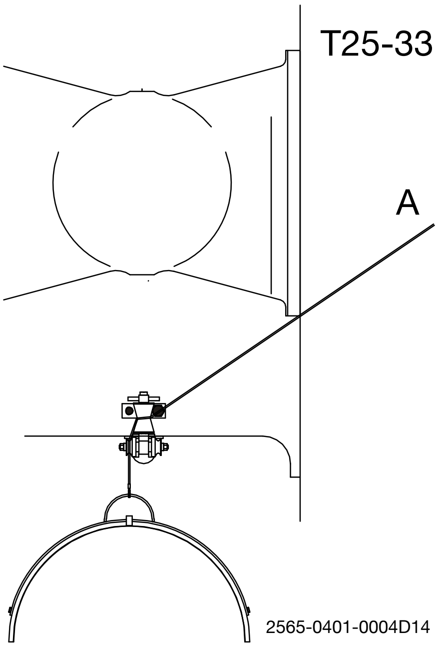
2565-0401-0013D13

Removal of upper bearing shell

Mount the bearing shell lifting tool on the upper main bearing shell, pull the wire around pulley **E**, as shown, and attach it to tackle **A** outside the engine.

Carefully lift the bearing shell until it is hanging freely below the guideshoe.

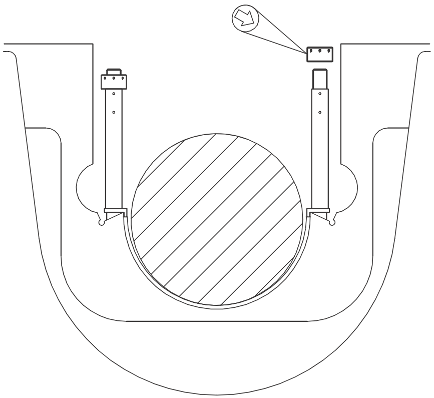
Lift the bearing shell out of the engine in the same way as the bearing cap.



2565-0401-0004D14

Remember!

If the crankshaft is turned with the bearing cap dismounted, use the two stops to prevent the lower shell from being rolled out.



2565-0401-0013D15

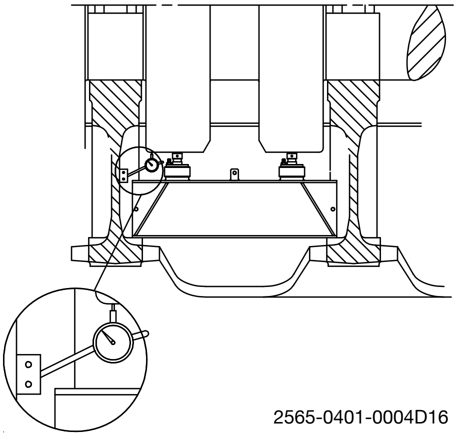
Lifting the crankshaft

Place the crosspiece in the bedplate with the ends resting on the cross girders, and position the hydraulic jacks beneath the crank webs as shown.

Tighten the screws against the crank webs and compress the jacks.

Connect the hydraulic jacks to the high pressure pump, and raise the pressure until the crankshaft has been lifted 0.2-0.5 mm, but max. the clearance in the two adjacent bearings.

Note down the pressure for later reference.



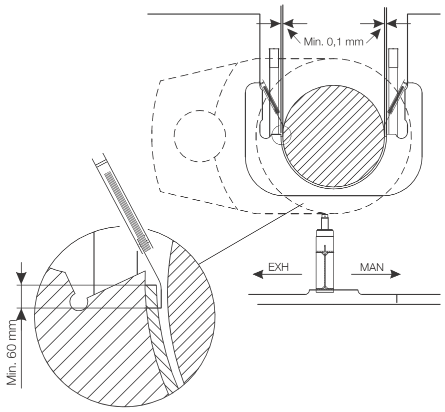
2565-0401-0004D16

Check the clearance between the journal and the bearing shell

Check that there is min. 0.1 mm clearance between journal and bearing shell, or between bearing shell and main bearing support, on both sides of the journal.

NOTE

The feeler blade must be inserted minimum 60 mm into the gap to pass the bore relief in the bearing shell.



2565-0401-0013D17

If the clearance is less than 0.1 mm, move the crosspiece sideways until clearance is obtained. Normally, adjustment needs to be 50-150 mm to the exhaust side (the side where the clearance is missing).

NOTE

The lower shell must be lifted out to the side with the most clearance, which is normally the manoeuvre side.

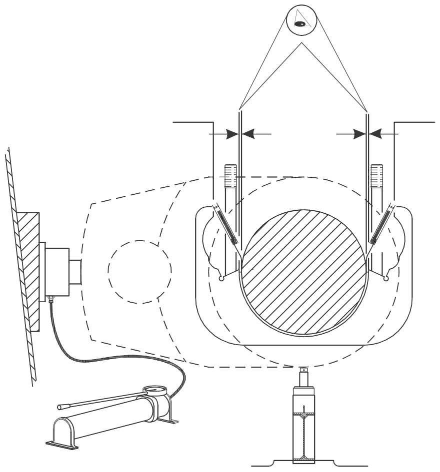
Correcting the journal position

If re-positioning of the crosspiece does not ensure a vertical lift, place a 5-tonne jack between the side wall and the crank throw, to correct the journal position in this way.

If it is available, note down the pressure applied to the jack. This data is used to ensure that the crankshaft is in the same position when the new bearing is installed.

NOTE

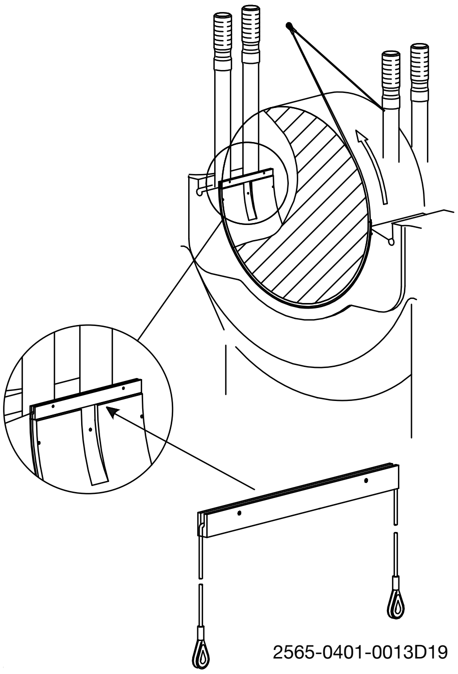
It is recommended that the crankshaft lifting tool is only removed if it is urgently necessary and then only after the main bearing shell has been reinstalled.



2565-0401-0013D18

Dismanteling tool.

Place the dismantling tool on top of the lower bearing shell.



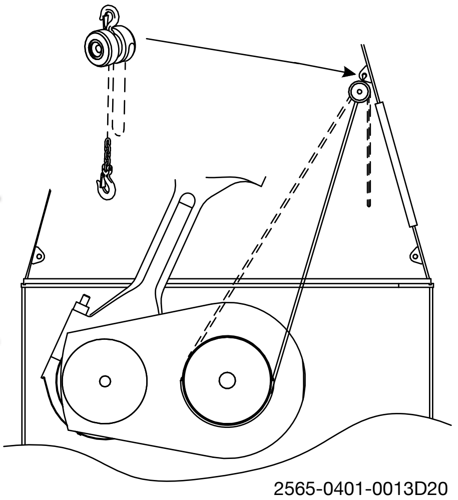
2565-0401-0013D19

Removing the lower shell

Pull the lower shell around and up until it lies over the main bearing journal. Never use a tackle larger than 0.5 tonne.

NOTE

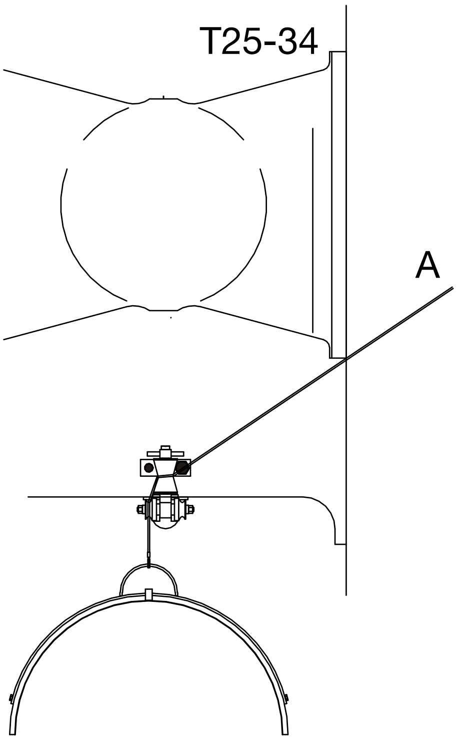
While pulling out the shell, it is recommended to hold a foot or hand on the wire rope, to tighten it up and to observe whether the shell is sticking.



2565-0401-0013D20

Lifting tool

Take the lower shell out of the engine in the same way as the upper shell, using the lifting tool.



2565-0401-0004D21

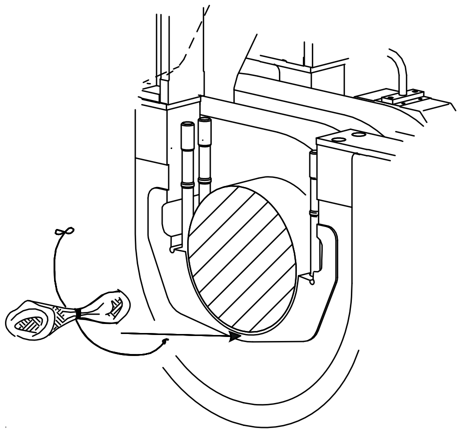
Cleaning and inspection

Clean and inspect the bearing shells. It is recommended that the main bearing shells be replaced in pairs.

If it is nevertheless desired to replace only one shell, this requires a careful evaluation of the condition of the shell that is to be reinstalled.

See Description 2545-0100.

For advice on replacing individual bearing shells, it is recommended to contact MAN Diesel & Turbo or the engine builder.



2565-0501-0003O01

Before remounting

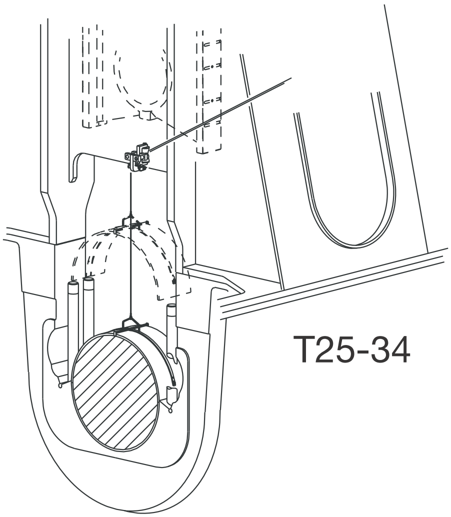
Check the bearing support for damage and burrs. If damage is found, contact MAN Diesel & Turbo for advice.

Make sure that all parts are clean, use non-fluffy cloth to clean between journal and main bearing support.

Lubricate the bearing journal, the main bearing support and the back of the shell, with main engine lubricating oil.

Bearing shell lifting tool

Using the bearing shell lifting tool, the pulleys and tackles, lift the lower bearing shell into the crankcase until it is hanging above the crankshaft journal.



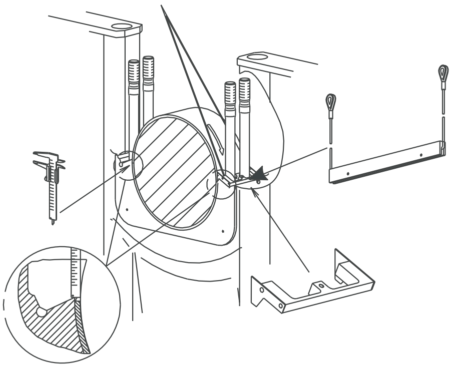
2565-0401-0013M01

Mounting of bearing shells

Place the dismantling tools for the bearing shell in the same side as when the shell was dismantled and attach them to the 0.5 tonne tackle.

Position the guide tool for the lower bearing shell on the main bearing support.

Lubricate the journal, the lower bearing shell and the bearing support with clean oil.



2565-0401-0013M02

Land the bearing shell on the journal, and remove the lifting tool from the bearing shell.

Push down, by hand, the bearing shell, while following with the dismantling tool, in order to prevent the bearing shell from falling.

NOTE

The bearing shell should always be mounted in the same side as it was dismounted.

To ensure that the shell is correctly mounted, check that the distance from the main bearing support to the shell is equal in both sides.

After placing the bearing shell

Remove the guide tool when the lower bearing shell has been mounted.

Lower the crankshaft and remove the hydraulic jacks and the crosspiece from below the crankshaft.

Wipe the contact surfaces between the upper and the lower bearing shells clean with a non-fluffy piece of cloth.

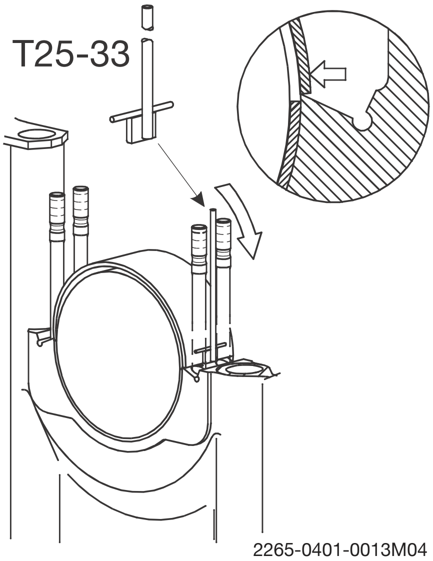
Mounting the upper bearing shell

Land the upper bearing shell on the main journal in the same way as the lower bearing shell.

Make sure that none of the edges of the upper bearing shell are resting on the edge of the bearing support.

If available, place the special tool, or similar, between the studs and press the shell into place.

Clean the contact surfaces between the bearing support and the bearing cap. Make sure that no oil is left on the contact surfaces.

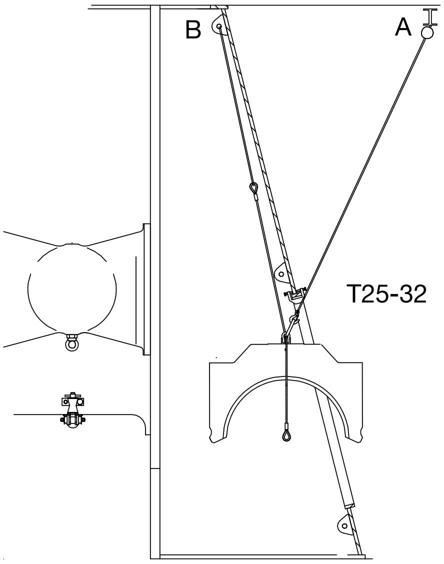


2265-0401-0013M04

Returning the bearing cap

Mount the lifting tool on the bearing cap. Using the tackles and wire ropes on the main bearing cap lifting tool, lift the bearing cap into the crankcase in reverse order to dismantling.

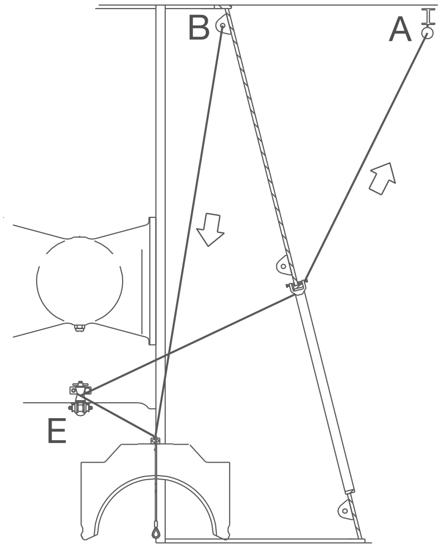
See “Dismantling - Moving the bearing cap”.



2565-0401-0004M05

Moving the bearing cap into the engine

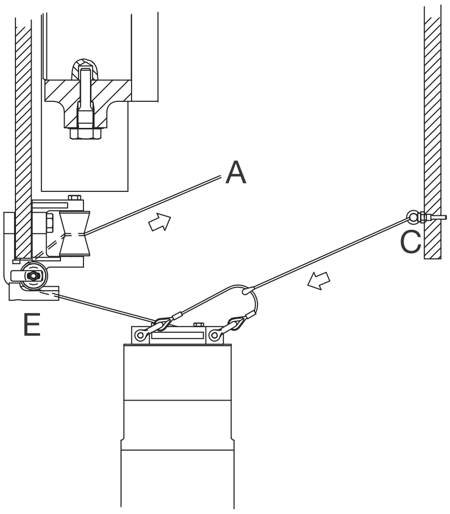
Using pulley **E** mounted above the bearing and the pull lift mounted below the opposite guideshoe, move the bearing cap into position vertically above the bearing journal in the reverse order to dismantling. *See "Dismantling - Removal of the main bearing cap".*



2565-0401-0013M06

NOTE

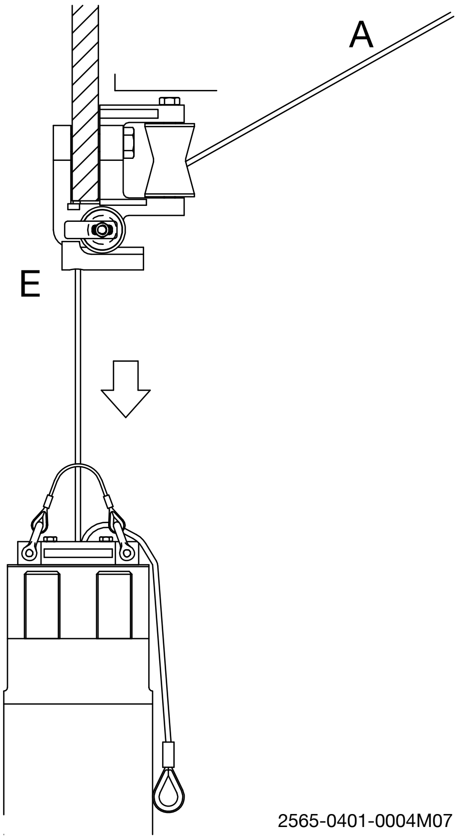
Be sure that it is the longest wire rope that is pulled around pulley **E** below the webplate.



2565-0401-0013M07

Landing the bearing cap

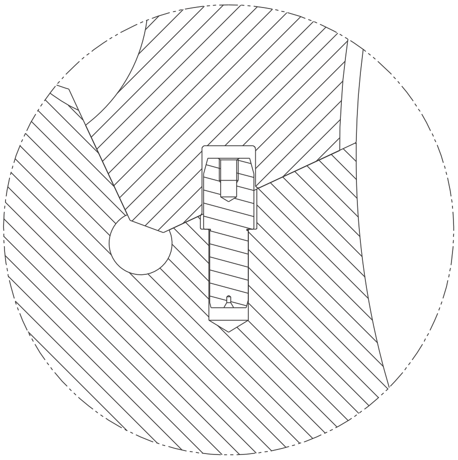
Carefully lower the main bearing cap on to the upper bearing shell. Keep a hand on the wire rope while lowering, so that sticking of the bearing cap is immediately felt.



2565-0401-0004M07

NOTE

Be sure that the cap lands correctly and that the guide pin in the assembly surface enters the hole in the bearing cap.

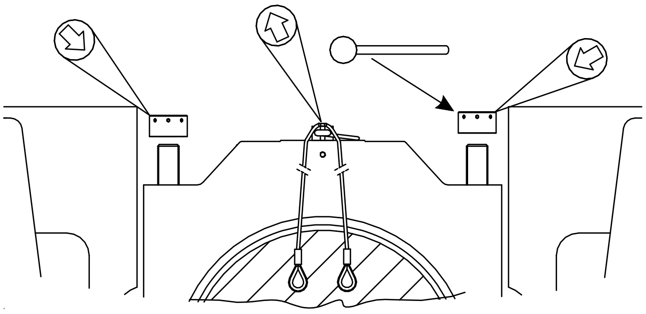


2565-0401-0013M08

Remove the bearing cap lifting tool

Screw the nuts on to the main bearing studs.

Using a tommy bar, tighten the nuts on both sides of the bearing cap.

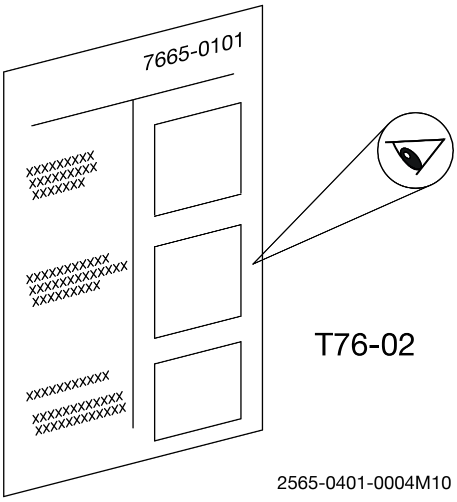


2565-0401-0004M09

Tightening of hydraulic nuts

Mount the hydraulic jack nuts on the studs. *See "Dismantling".*

For operation of the hydraulic tools, see work card 7665-0101.

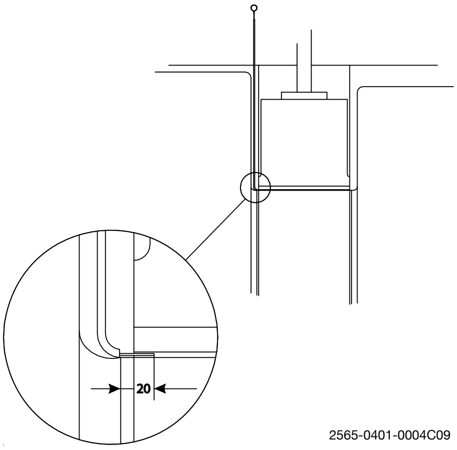


2565-0401-0004M10

NOTE

Before removing the hydraulic jacks, check the top clearance between the upper bearing shell and the journal.

See "Checking".

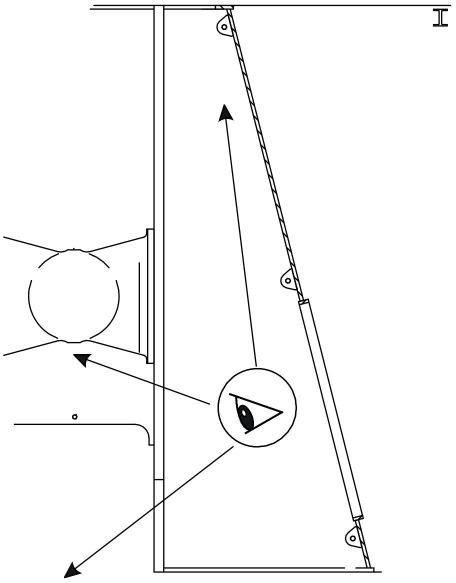


2565-0401-0004C09

Remove all tools from the engine

NOTE

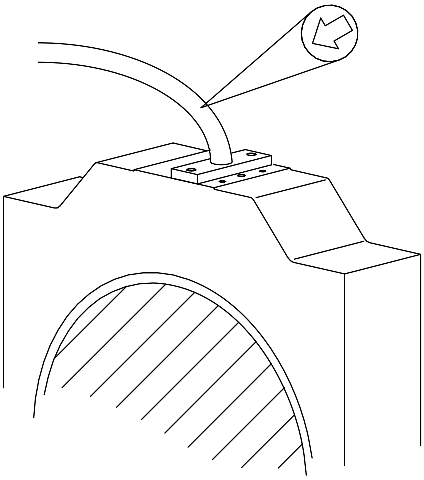
Search the crankcase to ensure that there are no tools, shackles or rags left behind.



2565-0401-0001312

Oil pipe

Mount the lubricating oil pipe on the main bearing cap,


2565-0401-0004M13

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
T25-40	Journal bearing, top clearance max.	0.55	mm
T25-41	Journal bearing, top clearance min.	0.25	mm
T25-42	Journal bearing cap	1080	kg
T25-43	Upper bearing shell	68	kg
T25-44	Lower bearing shell	74	kg
T25-45	End cover	320	kg
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

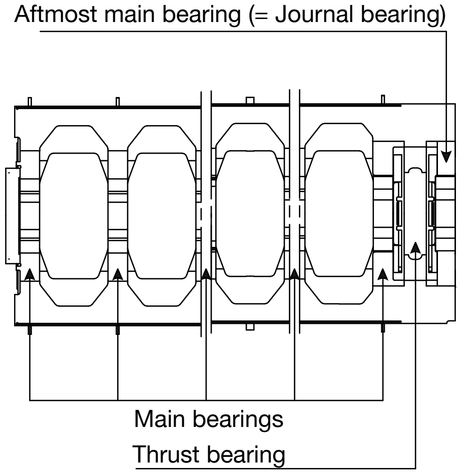
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first two digits in the plate number, e.g. **2570-0010** refers to chapter 25, Bearings.

Tools

Plate	Item No.	Description
1070-1040	**-**	Thrust shaft tools
1470-0300	**041**	Wire guide
2570-0010	**045**	Pulley for wire for main bearing
2570-0010	**070**	Lifting tool for main bearing cap
2570-0010	**082**	Dismantling tool for main bearing shell
2570-0010	**094**	Mounting tool for thin bearing shell
2570-0010	**128**	Retaining tool for main bearing shell
2570-0400	**-**	Main bearing hydraulic tools
2570-0420	**019**	Lifting tool for main bearing shell
2570-0430	**-**	Main bearing measuring tools
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**023**	Hydraulic pump, hand operated
7670-0100	**047**	Hose with unions, 1500 mm
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**060**	Hose with unions, 5000 mm
7670-0100	**106**	5-way distributor block, complete
7670-0300	**-**	Lifting tools, etc
7670-0410	**054**	Feeler gauge set
7670-0410	**078**	Dial gauge and stand tool

Journal Bearing

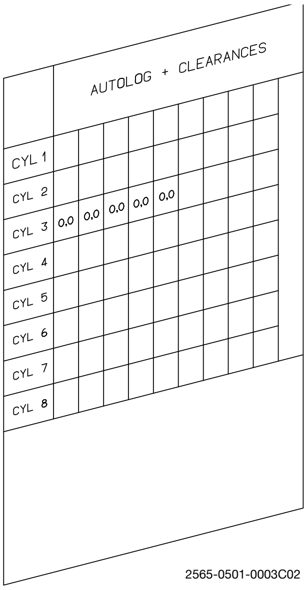
Check the journal bearing in the same way as the remaining main bearings, *see work card 2565-0401.*



2565-0501-0003C01

Bearing clearances

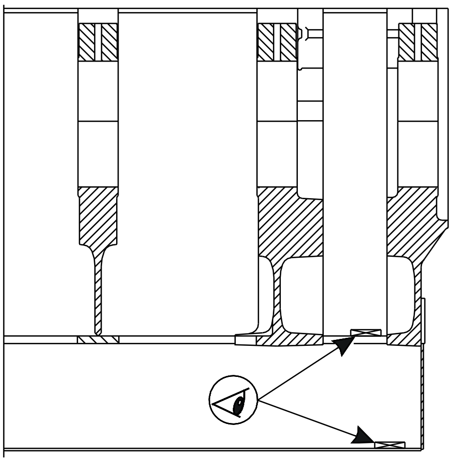
Write down the journal bearing clearances.



2565-0501-0003C02

Visual check

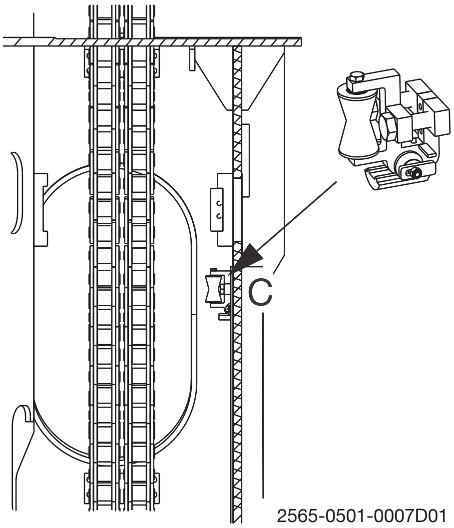
Also check the journal bearing by visually searching the area underneath the bearing support for bearing material.



2565-0501-0003C03

Lifting tool

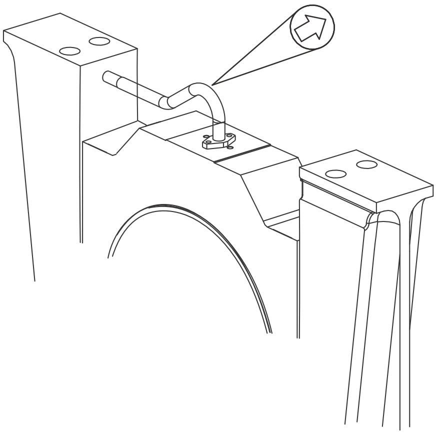
Mount the pulley for wire for the main bearing on the welded lifting bracket on the aftermost part of the framebox C.



2565-0501-0007D01

Oil pipes

Remove the oil pipes necessary to dismantle the journal bearing cap.



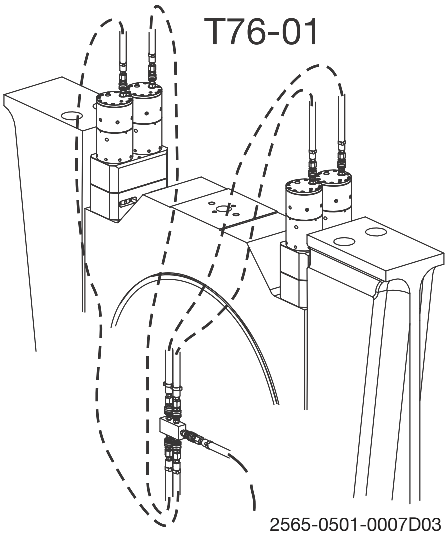
2565-0501-0007D02

Hydraulic jacks

Assemble the main bearing hydraulic tools on the bearing studs. Connect the hydraulic pump.

Loosen the nuts.

For operation of the hydraulic tools, see work card 7665-0101.

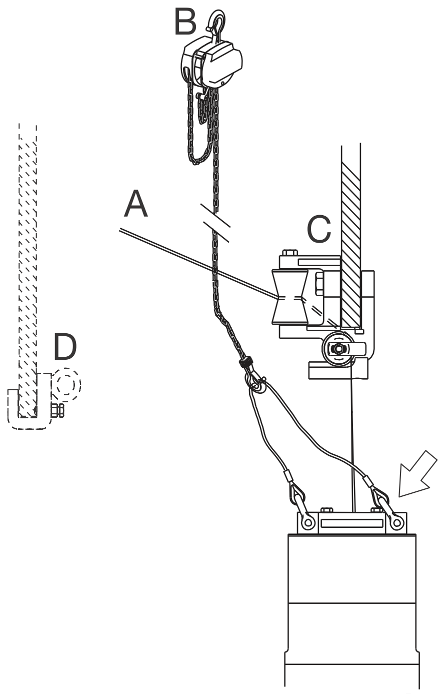


2565-0501-0007D03

Main bearing lifting tool

Mount the main bearing lifting tool (with wire and shackles) on the journal bearing cap.

Mount the lifting bracket on the web-plate D.



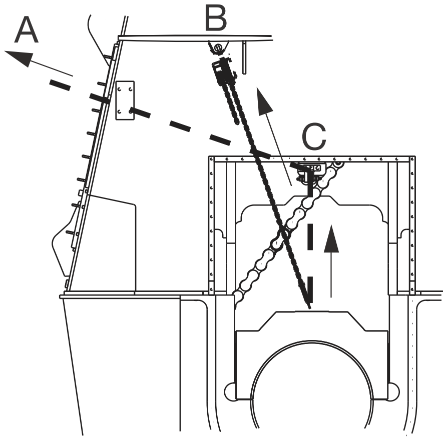
2565-0501-0007D05

Lifting procedure

Vertical lift

Lift the bearing cap vertically free from the studs using the pulley C and a chain tackle mounted outside the engine (under the gallery A).

Mount another chain tackle between the lifting bracket in the top of the framebox B (manoeuvring side) and the wire between the shackles on the lifting tool for the main bearing cap.

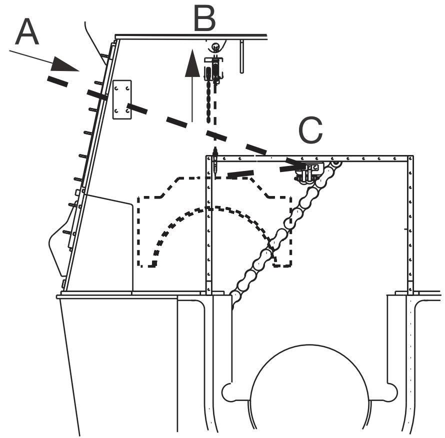


2565-0501-0007D06

Moving the bearing cap

Pull the bearing cap towards the chain by hand. If necessary use a chain tackle mounted on the lifting bracket on the web plate D (see above).

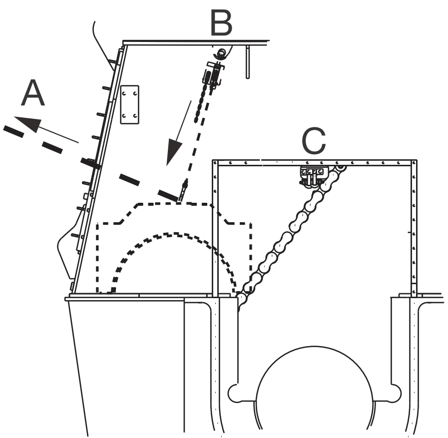
Pull the bearing cap towards the manoeuvring side with chain tackle B, while slacking chain tackle A.



2565-0501-0007D07

»Parking« the bearing cap

Place the bearing cap so that half of the bearing cap is resting on the bulk head inside the engine (manoeuvring side) and the other half is suspended in chain tackle B.



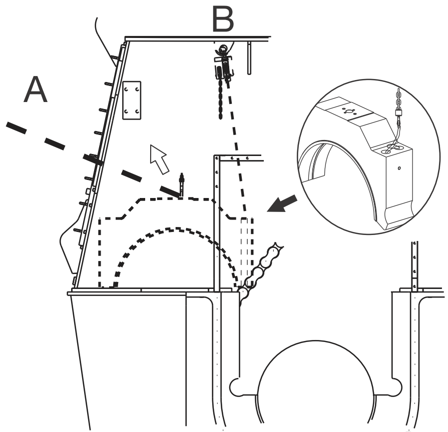
2565-0501-0007D08

Bearing cap

Secure the freely hanging bearing cap end by pulling a strap through the holes for the bearing cap studs and mount a chain tackle between the strap and a lifting bracket in the top of the framebox (manoeuvring side) I.E. bracket B.

Chain tackle

Remove the chain tackle A from the lifting tool for main bearing cap.



2565-0501-0007D09

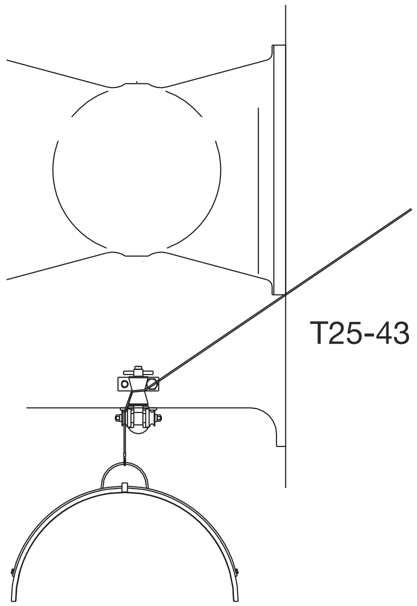
Removal of the Bearing Shells

Removal of the upper bearing shell

Mount the bearing shell lifting tool on the upper main bearing shell, pull the wire around the pulley as shown and attach it to a tackle outside the engine on the exhaust side.

Carefully lift the bearing free below the pulley.

Lift the bearing shell out of the engine to the exhaust side.



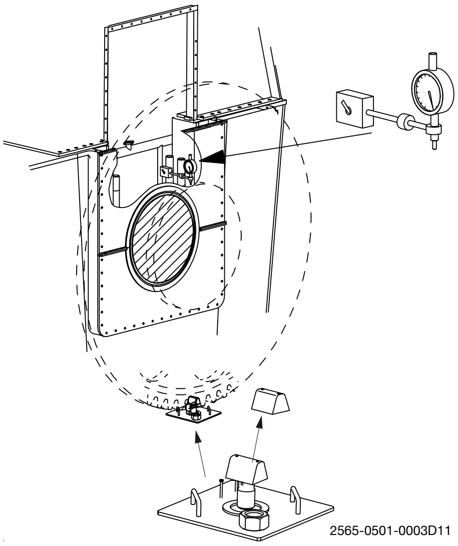
2565-0501-0004D10

Removal of the lower bearing shell

Place the lifting tool for thrust shaft under the turning wheel as shown. Mount a dial gauge to measure the lift of the crankshaft.

Tighten the screw against the turning wheel and compress the jack.

Connect the hydraulic jack to the high-pressure pump, and raise the pressure until the crankshaft has been lifted 0.2-0.5 mm, but max. the clearance in the adjacent bearing.

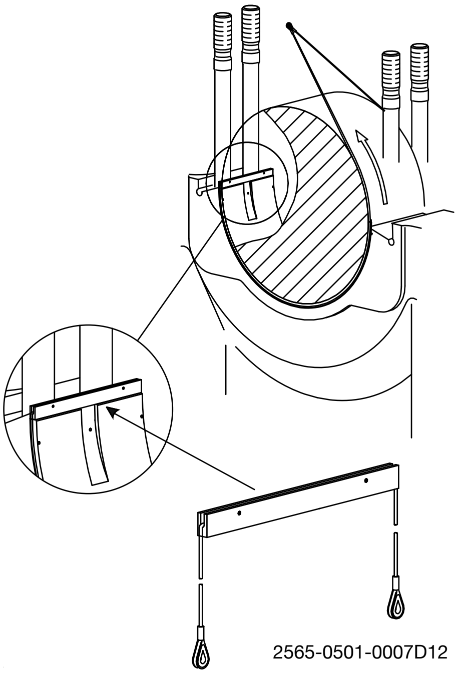


2565-0501-0003D11

Dismantling tool

Place the dismantling tool on top of the lower bearing shell.

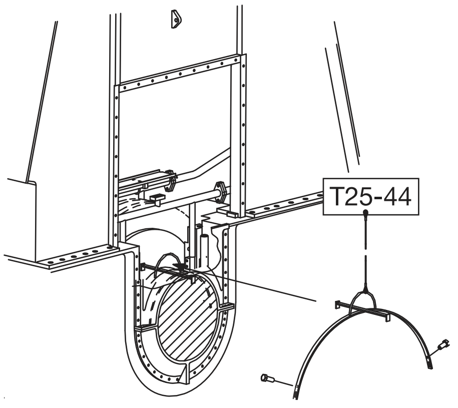
Pull the lower bearing shell round and upwards until it lies over the bearing journal. Never use a tackle larger than <u>0.5-ton.</u>



2565-0501-0007D12

Lower shell

Remove the lower shell from the engine in the same way as the upper shell, i.e. using the lifting tool.



2565-0501-0007D13

Bearing shell

Clean and inspect the bearing shells. It is recommended that the main bearing shells are replaced in pairs.

If it is nevertheless desired to replace only one shell, this requires a careful evaluation of the condition of the shell that is to be reinstalled.

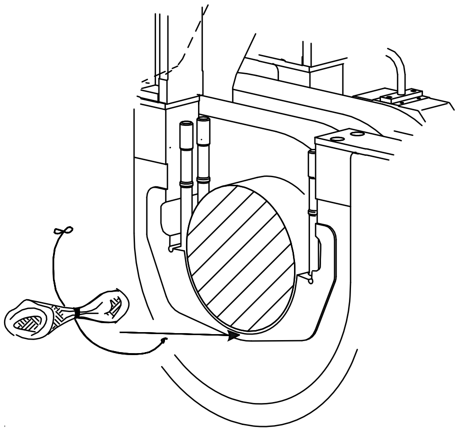
See Description 2545-0100.

For advice on replacing individual bearing shells, it is recommended to contact MAN Diesel & Turbo or the engine builder.

Before reinstalling

Before reinstalling:

- Check the bearing support for damage and burrs. If damage is found, contact MAN Diesel & Turbo for advice.
- Make sure that all parts are clean, use non-fluffy cloth to clean between journal and bearing support.
- Lubricate the bearing journal, the bearing support and the back of the shell, with main engine lubricating oil.

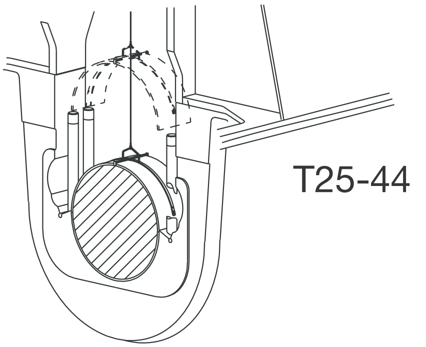


2565-0501-0003O01

Lower bearing shell

Lubricate the journal, the lower bearing shell and the bearing support with clean oil.

Using the bearing shell lifting tool, the pulleys and tackles, lift the lower bearing shell into the crankcase and land it on the crankshaft journal.



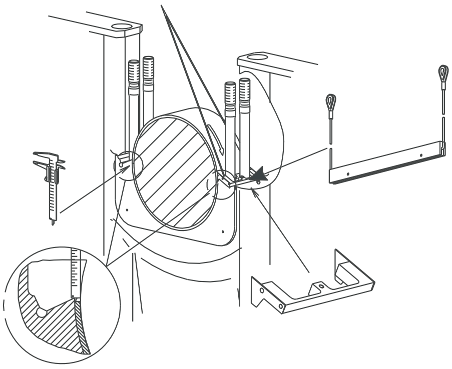
2565-0501-0007M01

Mounting of bearing shells

Place the dismantling tools for the bearing shell in the same side as when the shell was dismantled and attach them to the 0.5 tonne tackle.

Position the guide tool for the lower bearing shell on the bearing support.

Lubricate the journal, the lower bearing shell and the bearing support with clean oil.



2565-0501-0007M02

Land the lower bearing shell on the journal and remove the lifting tool from the bearing shell.

Push down, by hand, the bearing shell, while following with the dismantling tool, in order to prevent the bearing shell from falling.

NOTE

The bearing shell should always be mounted in the same side as it was dismounted.

To ensure that the shell is correctly mounted, check that the distance from the bearing support to the shell is equal in both sides.

After placing the bearing shell

Remove the guide tool when the lower bearing shell has been installed.

Lower the crankshaft and remove the lifting tool for thrustshaft under the turning wheel.

Wipe the contact surfaces between the upper and the lower bearing shells clean with a non-fluffy piece of cloth.

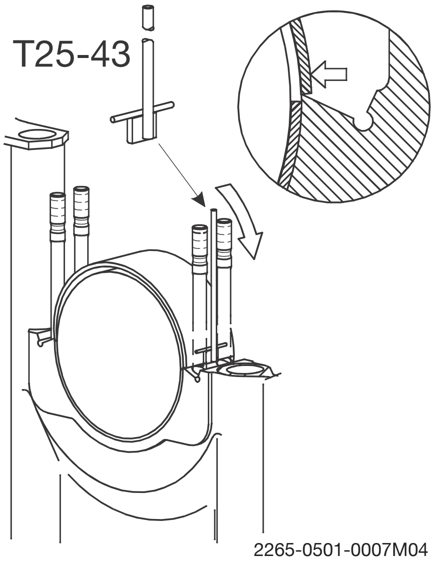
Mounting the upper bearing shell

Land the upper bearing shell on the main journal in the same way as the lower bearing shell.

Make sure that none of the edges of the upper bearing shell are resting on the edge of the bearing support.

If available, place the special tool, or similar, between the studs and press the shell into place.

Clean the contact surfaces between the bearing support and the bearing cap. Make sure that no oil is left on the contact surfaces.



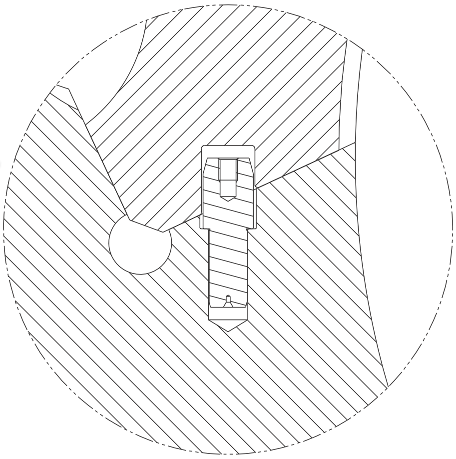
2265-0501-0007M04

Bearing cap

Using the lifting tool and the tackles, lift the bearing cap in place in reverse order to dismantling.

NOTE

Be sure that the cap lands correctly and that the guide pin in the assembly surface enters the hole in the bearing cap.

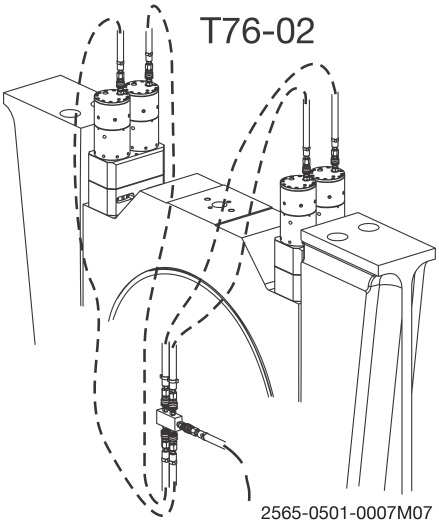


2565-0401-0007M05

Nuts and spacer rings

Install the nuts, the spacer rings, the hydraulic jacks, and tighten the nuts.
See Data.

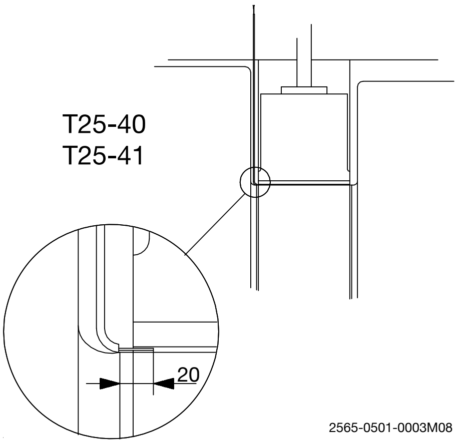
For operation of the hydraulic tools, see work card 7665-0101.



2565-0501-0007M07

NOTE

Before removing the hydraulic jacks, check the top clearance between the upper bearing shell and the journal.

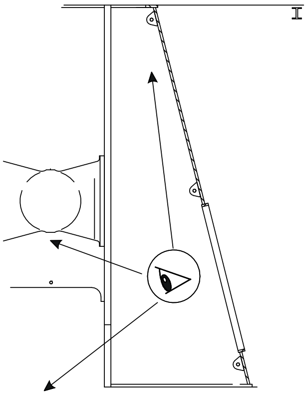


2565-0501-0003M08

Tools Remove all tools from the engine.

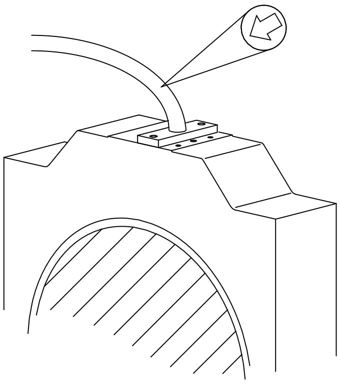
NOTE

Search the crankcase to ensure that there are no tools, shackles or rags left behind.



2565-0501-0007M09

Finally Reconnect all disassembled piping, and mount the cover for the chain housing.



2565-0501-0003M10

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T25-45	End cover	1000	kg
T25-48	Thrust bearing segment	130	kg
T25-49	Segment stopper	100	kg
T25-54	Segment stopper tightening torque	1650	Nm
T25-60	Segment stopper tightening torque + angle	150+45	Nm+°

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
2570-0010	**104**	Tool for turning out segments
2570-0020	**-**	Segment stopper hydraulic tools
7670-0100	**011**	Hydraulic pump, pneumatically operated
7670-0100	**047**	Hose with unions, 1500 mm
7670-0100	**059**	Hose with unions, 3000 mm
7670-0100	**106**	5-way distributor block, complete
7670-0300	**-**	Lifting tools, etc
7670-0410	**054**	Feeler gauge set

Thrust Bearing

The clearance in the thrust bearing was measured during testbed trials of the engine and noted down in the 'Adjustment Sheet'. *See description 6345-0100.*

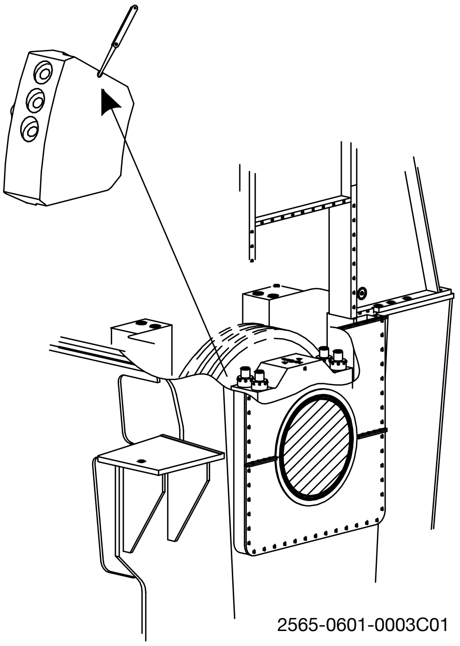
For a new engine the clearance is 0.5-1.0 mm, and for an engine in service it must not exceed 2.0 mm.

In service it is only necessary to measure the wear of the thrust bearing pads, and to inspect for white metal particles below the thrust bearing.

Wear groove

A wear groove of 1 mm is positioned in the uppermost thrust segment. (The segment with thermometers).

For measuring the wear, it is necessary to dismantle the foremost segment stopper. *See 'Dismantling'.*

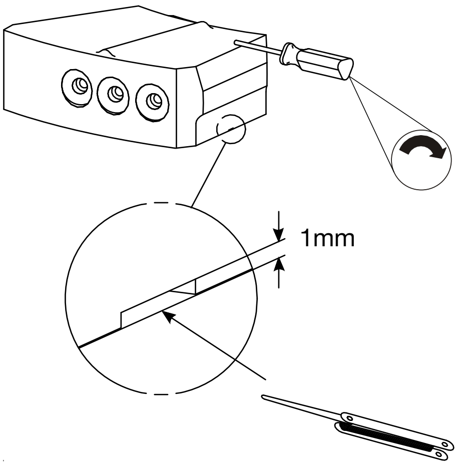


2565-0601-0003C01

To measure the wear

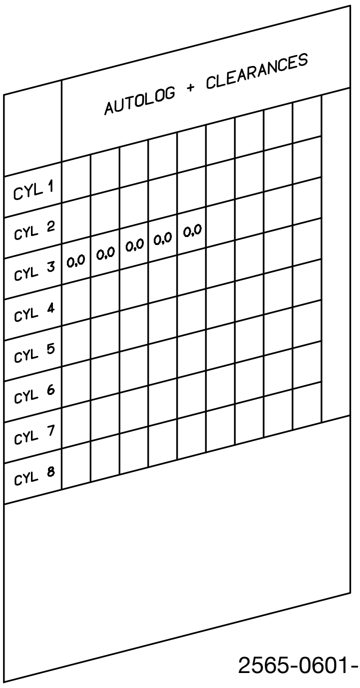
To measure the wear, the thrust segment has to be pressed against the thrust cam, to eliminate any gap, i.e. by using a suitable crowbar on the back of the segment.

If a feeler gauge of 0.1 mm is **not** able to enter the groove (the wear is more than 0.9 mm), the thrust bearing must be overhauled.



2565-0601-0003C02

Remember! Note down the wear for later reference.



2565-0601-0003C03

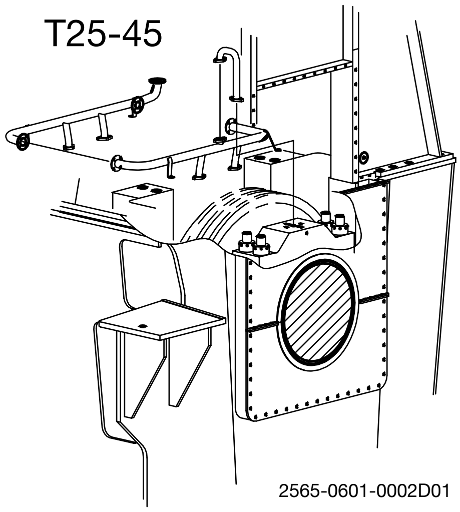
End cover

Remove the end cover of the engine.

Remove the lub. oil pipe from the aftmost main bearing shell.

Remove the lub. oil pipe above the thrust segments.

T25-45



2565-0601-0002D01

Segment stopper

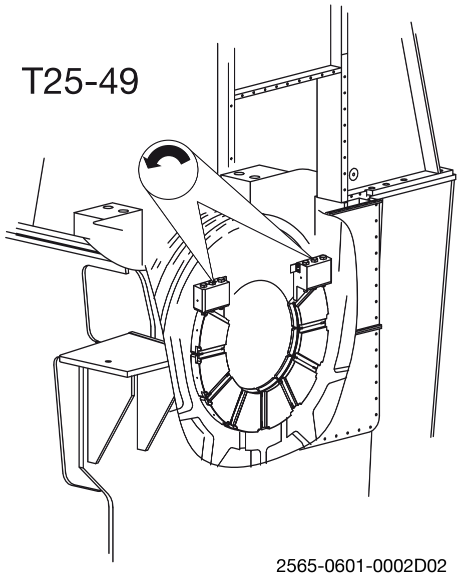
Loosen and remove the screws from the segment stoppers.

Screw an eyebolt into the stoppers that are to be removed.

Suspend a tackle above each stopper and hook the tackle on to the eyebolt.

Remove the stoppers from the chain drive above the thrust segments (AHEAD or ASTERN) that are to be taken out.

T25-49

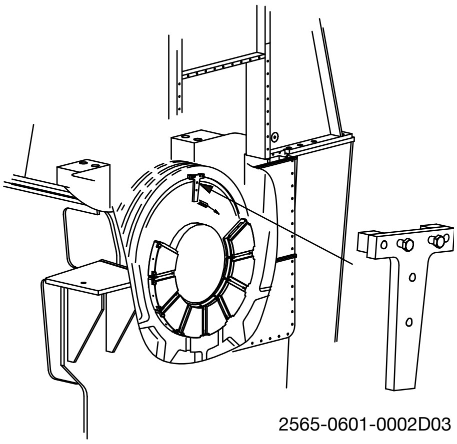


2565-0601-0002D02

Segment tool

Suspend a tackle from the chain tightener
bracket above the segments which are to be removed.

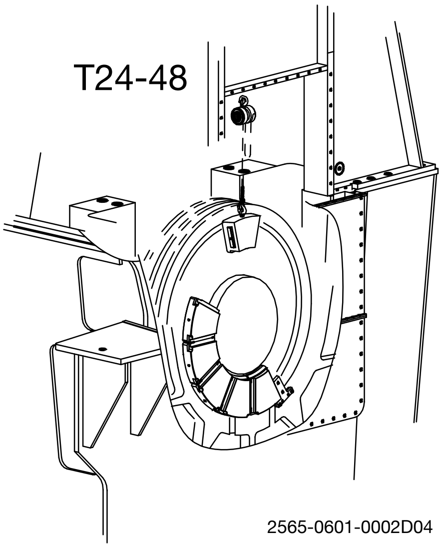
For turning-up the thrust segments, mount the segment tool on the chain-wheel.



2565-0601-0002D03

Inspect the segment

Turn up the segments, one at a time, by turning the engine, and remove the segment from the chain casing. Inspect the segment and remount it before turning up the next segment. *See 'Mounting'.*



2565-0601-0002D04

NOTE

Never remove more than one segment at a time.

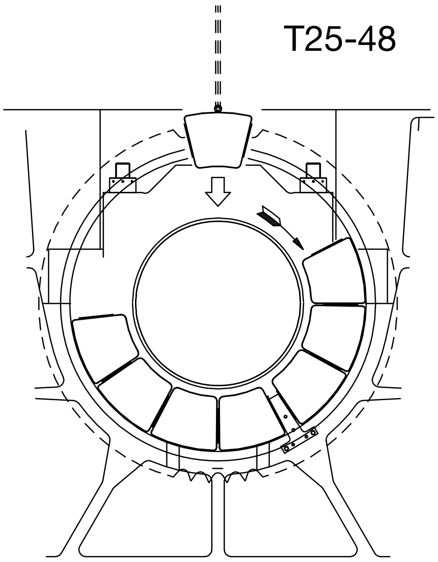
Mounting the segment

Suspend a tackle from the crossbar above the segments which are to be mounted.

Mount the segment tool on the chain-wheel.

Land the segment on the journal and remove the eyebolt from the segment.

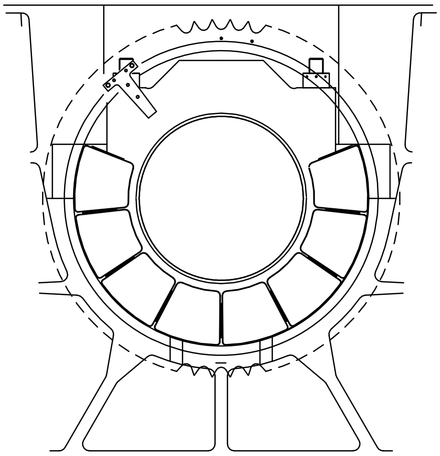
Carefully slide the segment on to the segment tool. Turn the engine to dismantle the next segment.
See 'Dismantling'.



2565-0601-0002M01

Removing the segment tool

After the last segment has been mounted, turn the segment tool up and dismount it.

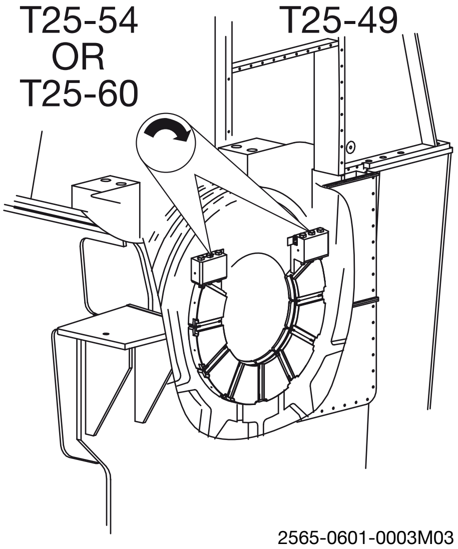


2565-0601-0002M02

Segment stoppers

Mount the segment stoppers.

Tighten the segment stopper screws as stated in data.



2565-0601-0003M03

Protective shield

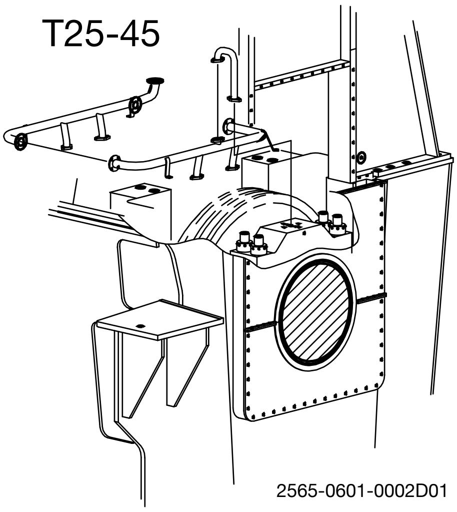
Mount the protective shield.

Mount the lub. oil pipe for the thrust segments.

Mount the lub. oil pipe for the aftmost main bearing.

Mount the end cover.

T25-45



2565-0601-0002D01

Bearing Panel Tools

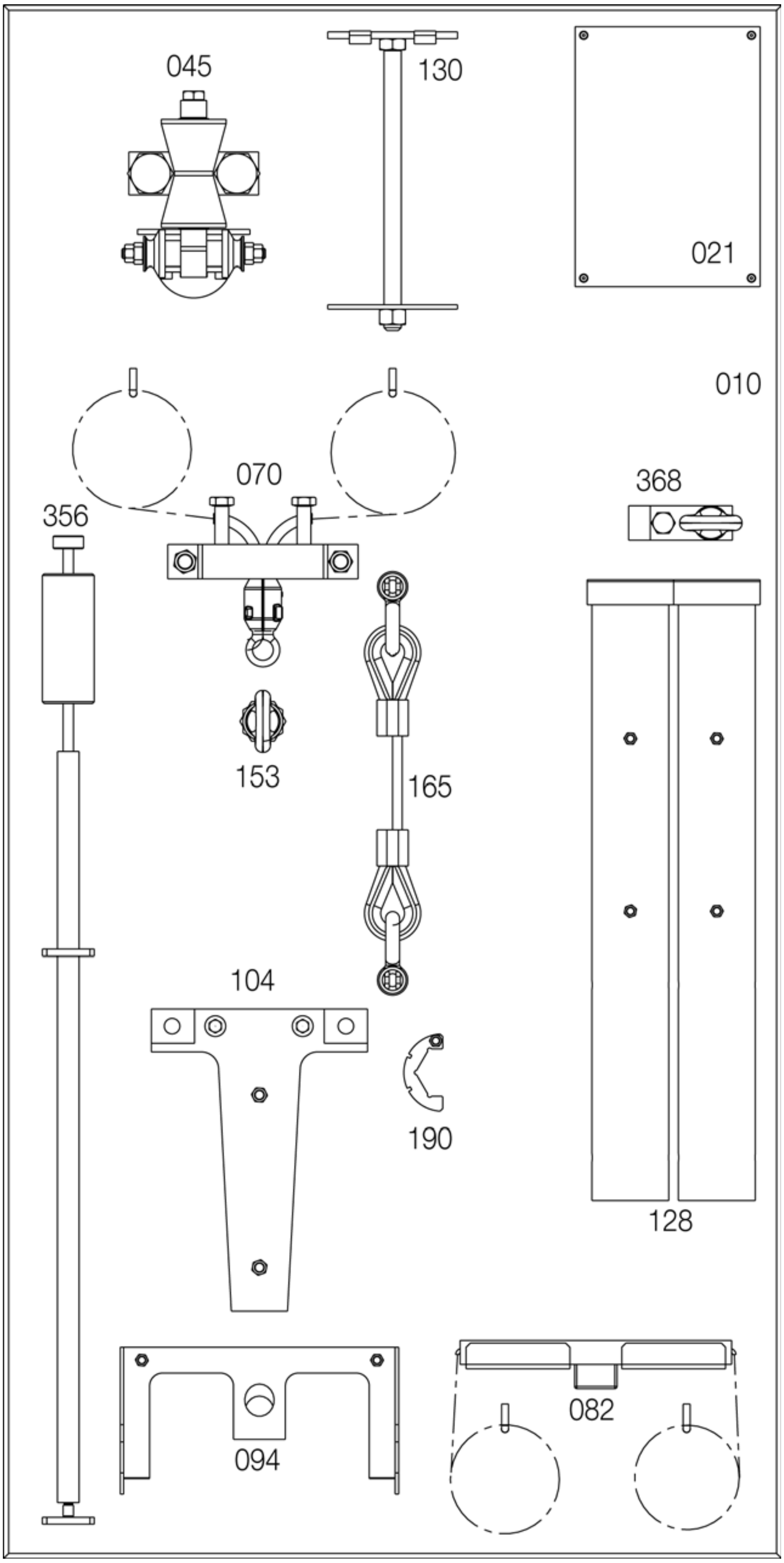
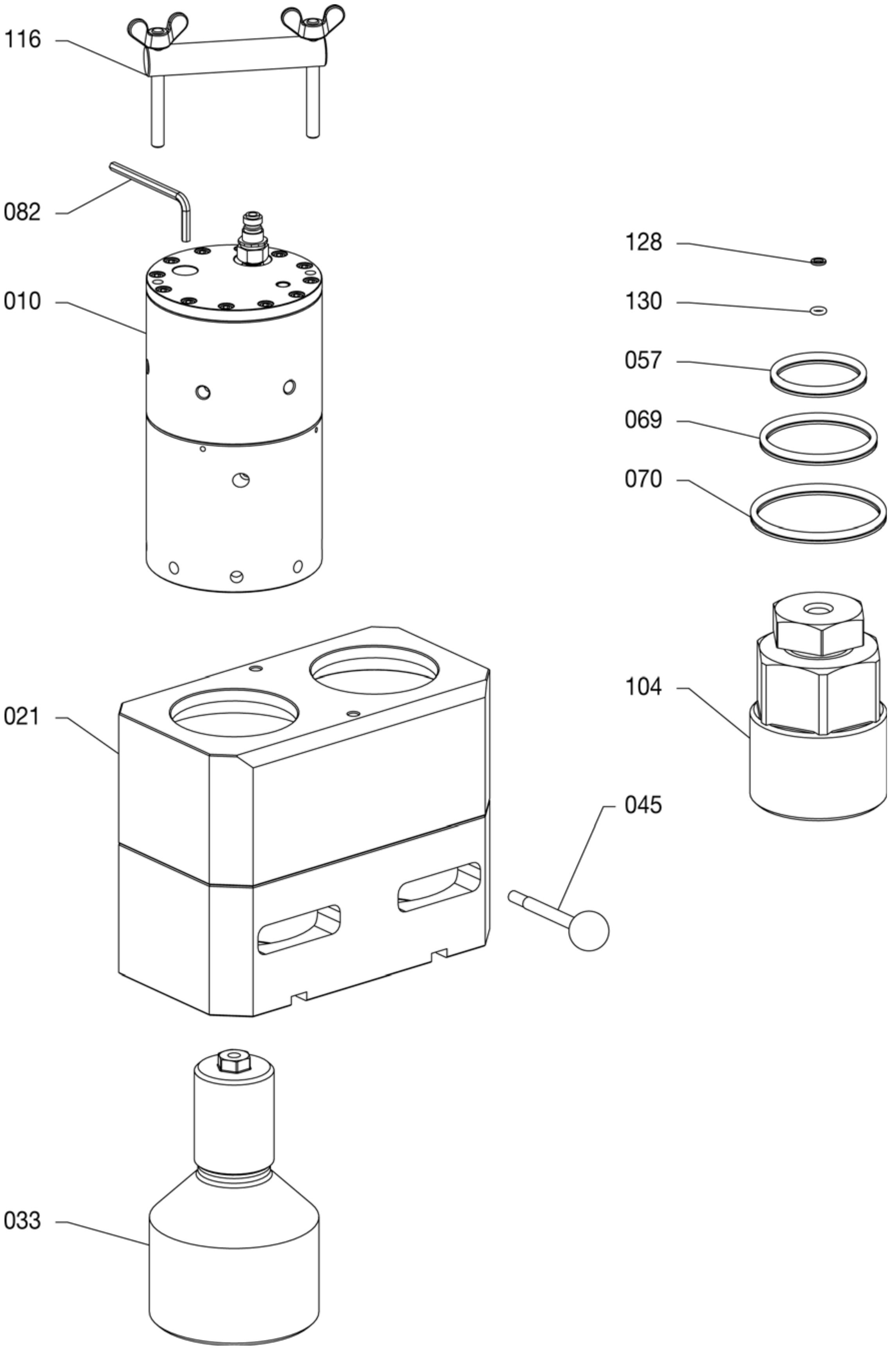


Plate 2570-0010-0009

Item no	Qty	Designation
010	-	Panel for tools
021	-	Name plate
045	-	Pulley for wire for main bearing
070	-	Lifting tool for main bearing cap
082	-	Dismantling tool for main bearing shell
094	-	Mounting tool for thin bearing shell
104	-	Tool for turning out segments
128	-	Retaining tool for main bearing shell
130	-	Lifting tool for relief valve
153	-	Eye bolt
165	-	Wire
190	-	Tightning template A.V.D.
356	-	Extractor for guide pin
368	-	Lifting bracket

Main Bearing Hydraulic Tools

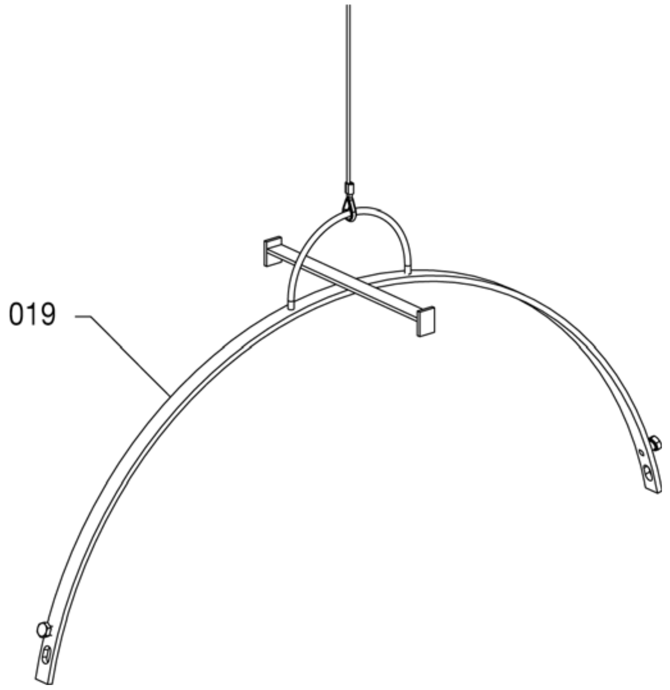
Plate
2570-0400-0004



2008-12-15

Item no	Qty	Designation
010	-	Hydraulic jack, complete
021	-	Support for hydraulic jack
033	-	Extension stud for hydraul
045	-	Ball handle
057	-	Sealing ring with back-up
069	-	Sealing ring with back-up
070	-	Sealing ring with back-up
082	-	Hex key
104	-	Stud setter
116	-	Handle
128	-	Back-up ring
130	-	O-ring

2008-12-15

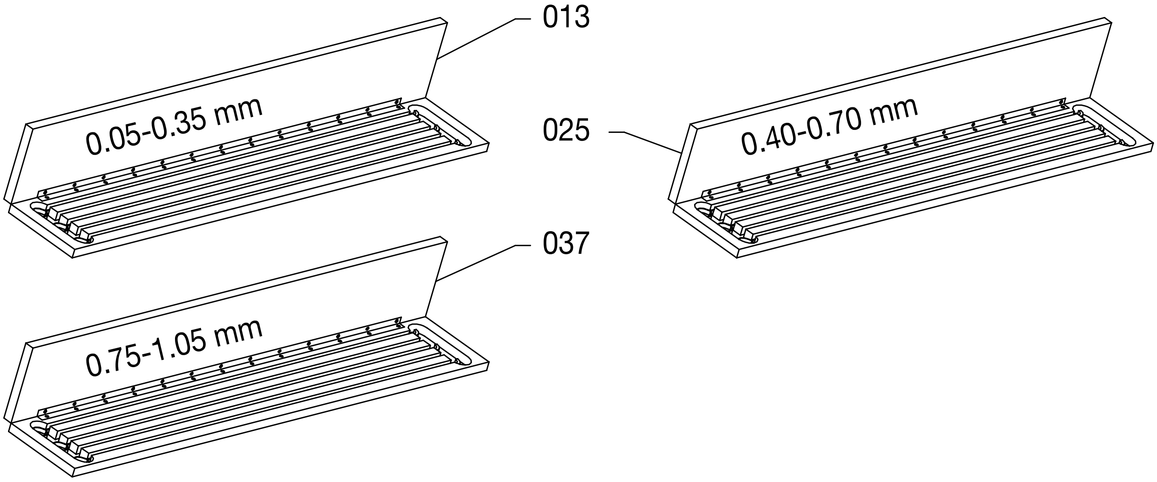


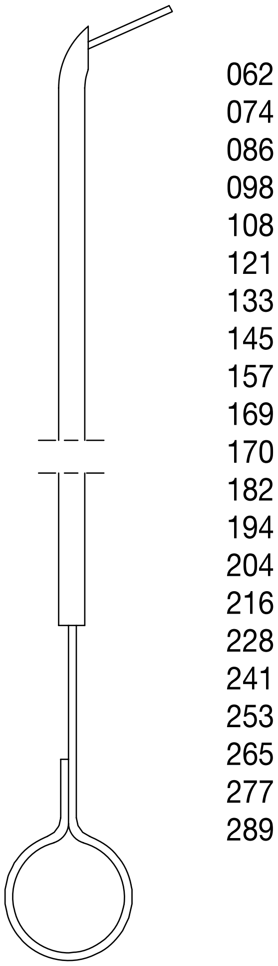
2008-07-14

Item no	Qty	Designation
019	-	Lifting tool for main bearing shell

2008-07-14

Main Bearing Measuring Tools





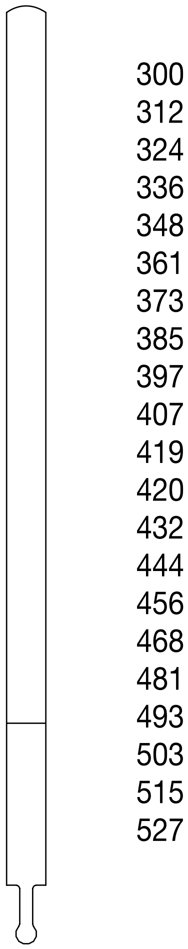


Plate 2570-0430-0003

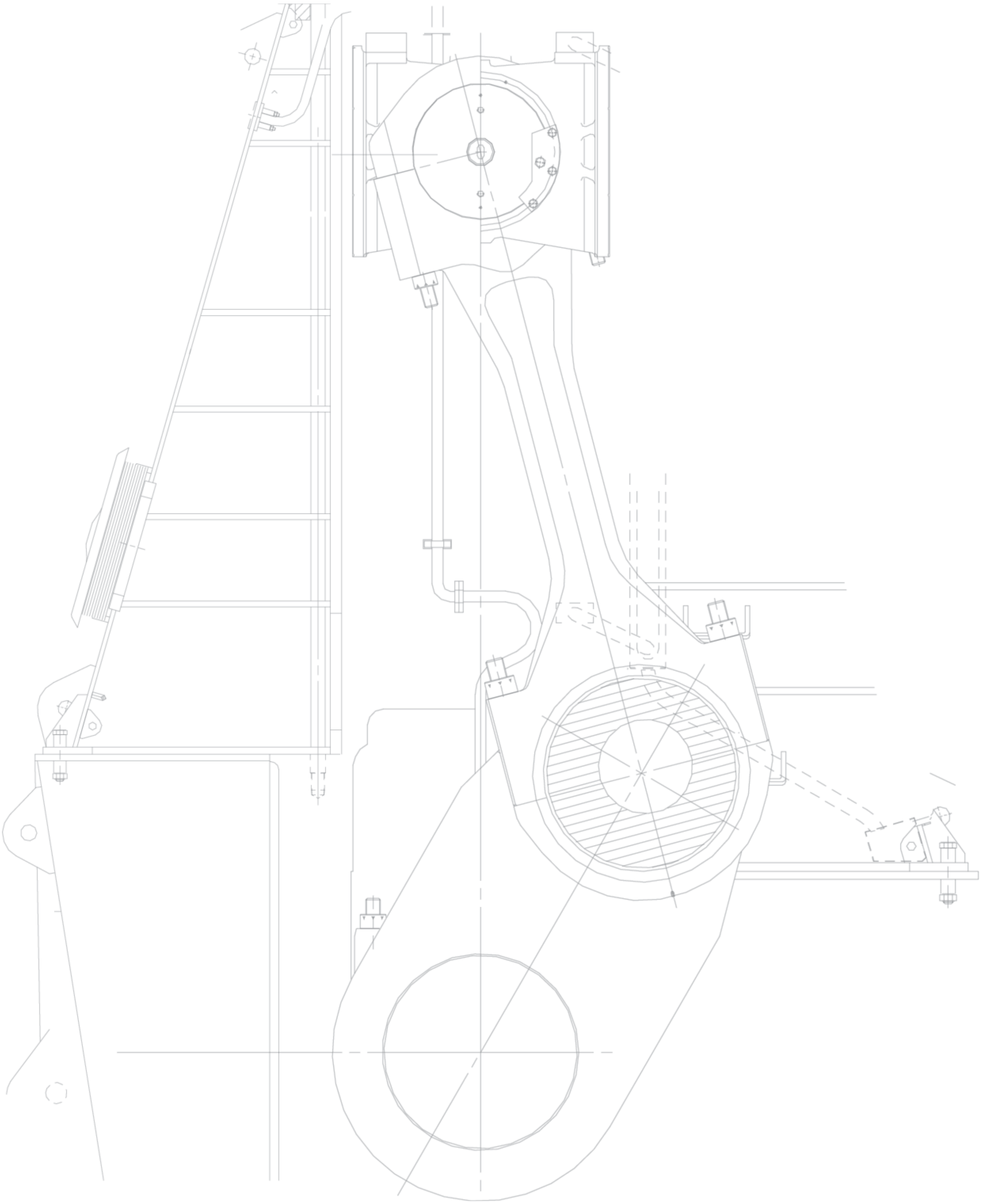
2008-07-14 - en

Item no	Qty	Designation
013	-	Feeler gauge set
025	-	Feeler gauge set
037	-	Feeler gauge set
062	-	Feeler gauge, 0.05mm
074	-	Feeler gauge, 0.10mm
086	-	Feeler gauge, 0.15mm
098	-	Feeler gauge, 0.20mm
108	-	Feeler gauge, 0.25mm
121	-	Feeler gauge, 0.30mm
133	-	Feeler gauge, 0.35mm
145	-	Feeler gauge, 0.40mm
157	-	Feeler gauge, 0.45mm
169	-	Feeler gauge, 0.50mm
170	-	Feeler gauge, 0.55mm
182	-	Feeler gauge, 0.60mm
194	-	Feeler gauge, 0.65mm
204	-	Feeler gauge, 0.70mm
216	-	Feeler gauge, 0.75mm
228	-	Feeler gauge, 0.80mm
241	-	Feeler gauge, 0.85mm
253	-	Feeler gauge, 0.90mm
265	-	Feeler gauge, 0.95mm
277	-	Feeler gauge, 1.00mm
289	-	Feeler gauge, 1.05mm
300	-	Spare tip for feeler gauge, 0.05mm
312	-	Spare tip for feeler gauge, 0.10mm
324	-	Spare tip for feeler gauge, 0.15mm
336	-	Spare tip for feeler gauge, 0.20mm
348	-	Spare tip for feeler gauge, 0.25mm
361	-	Spare tip for feeler gauge, 0.30mm
373	-	Spare tip for feeler gauge, 0.35mm
385	-	Spare tip for feeler gauge, 0.40mm
397	-	Spare tip for feeler gauge, 0.45mm
407	-	Spare tip for feeler gauge, 0.50mm
419	-	Spare tip for feeler gauge, 0.55mm
420	-	Spare tip for feeler gauge, 0.60mm
432	-	Spare tip for feeler gauge, 0.65mm
444	-	Spare tip for feeler gauge, 0.70mm
456	-	Spare tip for feeler gauge, 0.75mm
468	-	Spare tip for feeler gauge, 0.80mm
481	-	Spare tip for feeler gauge, 0.85mm
493	-	Spare tip for feeler gauge, 0.90mm
503	-	Spare tip for feeler gauge, 0.95mm
515	-	Spare tip for feeler gauge, 1.00mm
527	-	Spare tip for feeler gauge, 1.05mm

Lubricating Oil System

Table of contents

Preface Chapter	Lubricating Oil System	3040-0100-0001
Description	Cylinder Lubrication	3045-0110-0009
	Circulating Oil and Oil System	3045-0120-0002
	Maintenance of Circulating Oil System	3045-0130-0005
	Turbocharger Lubrication	3045-0140-0002
Drawing	Cylinder Lubricating Oil Pipes	3055-0110-0002
	Circulatiing Oil System - Outside Engine (Engines with Uni-Lube System)	3055-0115-0002
	Circulatiing Oil System - Inside Engine	3055-0125-0003
	Flushing of Main Lubricating Oil System - Location of Chackbag and Blank Flanges	3055-0130-0003
	Cleaning System - Stuffing Box Drain Oil (Option) .	3055-0135-0002
	Turbocharger Lubrating Oil Pipes	3055-0155-0002
Work Card	Cylinder Lubricator, Data	3065-0600-0001
	Cylinder Lubricator	3065-0601-0006
Plate	Cylinder Lubricator	3072-0600-0002
	Chain Drive Lubrication	3072-0700-0004



Cylinder Lubricators

The engine is equipped with electronically controlled cylinder lubricators for lubrication of the running surface of liners and rings.

See chapter 3045-0110.

1 Lubricators

Each cylinder liner has a number of lubricating quills, through which oil is introduced from the Lubricators.

There are three different types of lubricators available for B&W engines:

- ME-lubricators (integrated with the ME engine ECS system).
- Alpha lubricators for MC engines.
- Mechanical lubricators for MC engines.

For the specific lubricator system installed, please see individual instruction book. The oil is pumped into the cylinder (via non-return valves) when the piston rings pass the lubricating orifices, during the upward stroke.

2 Cylinder Oil Film

The purpose of cylinder lubrication is as follows:

1. To create a hydrodynamic oil film separating the piston rings from the liner. The oil amount needed to create an oil film is more or less independent of the fuel being used. Measurements of the oil film have also revealed that when the feed rate for optimum oil film is reached no further increase of the oil film is obtained from an increase of the feed rate, the optimum is kept safely down to a feed rate of 0.60 g/kWh.

2. To clean the piston rings, ring lands and ring grooves. Cleaning of piston rings, ring lands and grooves is essential, and relies on the detergency properties of the cylinder oil. All approved cylinder oils fulfil the requirements, even at a feed rate as low as 0.60 g/kWh.

3. Control of cylinder liner corrosion, i.e. neutralisation of sulphuric acid. The combustion process creates highly corrosive sulphuric acids depending on the sulphur content in the fuel. To obtain an optimal corrosive level of the cylinder liner, the ACC factor for the cylinder oil feed rate must be set according to instructions. The ACC (Adaptive Cylinder oil Control) concept ensures a correct cylinder oil feed rate level in relation to the fuel oil Sulphur content.

If a satisfactory cylinder condition is to be achieved, it is of vital importance that the oil film is intact. Therefore, the following conditions must be fulfilled:

1. The cylinder lubricators must be correctly timed.

2. The cylinder oil type and BN must be selected in accordance with the fuel being burned.

3. New liners and piston rings must be carefully run-in, see drawing 2255-0125.

4. The oil feed-rate (dosage) under normal service must be in accordance with the engine builder’s recommendations. Furthermore, the dosage feed rate must be adjusted in accordance with the service experience for the actual trade (obtained from the scavenge port inspections).

3 Cylinder Oils

The tables below indicates international brands of cylinder oils that have been tested in service with acceptable results, and some of the oils have also given long term satisfactory serivce during heavy fuel operation in MAN B&W engines.

Do not consider the list complete, as oils from other companies can be equally suitable. Further information can be obtained by contacting the engine builder or MAN Diesel & Turbo, Copenhagen.

Man Diesel & Turbo recommend the use of cylinder oils with the following main properties:

- SAE 50 viscisity
- High detergency
- Alkalinity (BN) must be chosen according to the applied fuel sulpher content

Cylinder oils			
Oil company	Oil name	Specified BN level	Viscosity level,SAE
BP	CL-DX 405	40	50
	CL 505*	50	50
	CL 605*	60	50
	CLO-50M	70	50
	Energol CL 805	80	50
Castrol	Cyltech 40SX	40	50
	Cyltech 50S*	50	50
	Cyltech 70	70	50
	Cyltech 80 AW	80	50
Chevron	Taro Special HT LS 40	40	50
	Taro Special HT 55*	55	50
	Taro Special HT 70	70	50
ExxonMobil	Mobilgard L540	40	50
	Mobilgard 560 VS*	60	50
	Mobilgard 570	70	50
Shell	Alexia S4*	60	40
	Alexia 50	70	50
Total	Talusia LS 40	40	50
	Talusia Universal*	57	50
	Talusia HR 70	70	50

* Not recommended for Mark 9 and G- type engines

For Mark 9 and G- type engines: the following is recommended:

- For high sulphur fuel: Cylinder lube oil with 70BN or higher
- For low sulpher fuel: Cylinder lube oil with 40BN
- Cylinder lube oil viscosity: SAE50

1 Circulating Oil

Lubricating and cooling oil

Rust and oxidation inhibited engine oils, of the SAE 30 viscosity grade, should be chosen.

In order to keep the crankcase and piston cooling space clean of deposits, the oils should have adequate dispersancy/detergency properties.

Alkaline circulating oils are generally superior in this respect.

The international brands of oils listed below have all given satisfactory service in one or more MAN diesel engine installation(s).

Company	Circulating oil SAE 30, BN 5-10
BP	Energol OE-HT30
Castrol	Marine CDX 30
Chevron	Veritas 800 Marine 30
Exxon Mobil	Mobilgard 300
Shell	Melina S 30
Total	Atlanta Marine D3005

The list must not be considered complete, and oils from other companies may be equally suitable.

Further information can be obtained by contacting the engine builder or MAN Diesel & Turbo.

2 Circulating Oil System

(See Drawing 3055-0115)

One of the pumps (1) draws the oil from the bottom tank and forces it through the lub. oil cooler (2), the filter (3) with an absolute fineness of minimum 50 µm (0.05 mm) (40 µm, 0.04 mm for AlSn40 bearings) corresponding to a nominal fineness of approx. 30 µm at a retaining rate of 90%) and thereafter delivers it to the engine via the flange RU.

RU The main part of the oil is, via the telescopic pipe, sent to the piston cooling manifold, where it is distributed between piston cooling and bearing lubrication. From the crosshead bearings, the oil flows through bores in the connecting rods, to the crankpin bearings.

The remaining oil goes to lubrication of the main bearings, thrust bearing, camshaft (not ME/ME-C engines) and turbocharger.

The relative amounts of oil flowing to the piston cooling manifold, and to the main bearings, are regulated by a butterfly valve, or an orifice plate. The oil distribution inside the engine is shown on *Drawing 3055-0125*.

Circulating Oil Pressure: *See 7045-0100*.

3 Circulating Oil Failure

3.1 Cooling Oil Failure

The piston cooling oil is supplied via the telescopic pipe fixed to a bracket on the crosshead. From here it is distributed to the crosshead bearing, guide shoes, crankpin, bearing and to the piston crown.

Failing supply of piston cooling oil, to one or more pistons, can cause heavy oil coke deposits in the cooling chambers. This will result in reduced cooling, thus increasing the material temperature above the design level.

In such cases, to avoid damage to the piston crowns, the cylinder loads should be reduced immediately (see slow-down below), and the respective pistons pulled at the first opportunity, for cleaning of the cooling chambers.

Cooling oil failure will cause alarm and slow-down of the engine. *See 7045-0100*.

For CPP-plants with a shaft generator coupled to the grid, an auxiliary engine will be started automatically and coupled to the grid before the shaft generator is disconnected and the engine speed reduced. *See Drawing 6655-0120, 'Sequence Diagram'.*

After remedying a cooling oil failure, it must be checked (with the circulating oil pump running) that the cooling oil connections in the crankcase do not leak, and that the oil outlets from the crosshead, crankpin bearings, and piston cooling, are in order.

3.2 Lubricating Oil Failure

If the lub. oil pressure falls below the pressures stated in 7045-0100, the engine's safety equipment shall reduce the speed to slow down level, respectively stop the engine when the SHUT DOWN oil pressure level has been reached.

For CPP-plants with a shaft generator coupled to the grid, an auxiliary engine will be started automatically and coupled to the grid before the shaft generator is disconnected and the engine speed reduced. *See 6655-0120, 'Sequence Diagram'*.

Find and remedy the cause of the pressure drop.

NOTICE

A likely cause of pressure drop, is worn-out bearings, causing the filters to clog.

Check for traces of melted white metal in the crankcase and oil pan. *See also Section 6645-0100*.

“Feel over” 15-30 minutes after starting, again one hour later, and finally also after reaching full load *(see also Section 6645-0120)*.

1 Oil System Cleanliness

In a new oil system, as well as in a system which has been drained owing to repair or oil change, the utmost care must be taken to avoid the ingress and presence of abrasive particles, because filters and centrifuges will only remove these slowly, and some are therefore bound to find their way into bearings etc.

For this reason - prior to filling-up the system - careful cleaning of pipes, coolers and storage tank is strongly recommended.

2 Cleaning the Circulating Oil System

The recommendations below are based on our experience, and laid out in order to give the contractor/supplier and operators the best possible advice regarding the avoidance of mishaps to a new engine, or after a major repair.

The instruction given in this book is an abbreviated version of our flushing procedure used prior to shoptrial. A copy of the complete flushing procedure is available through MAN Diesel & Turbo or the engine builder.

2.1 Cleaning before filling-up

In order to reduce the risk of bearing damage, the normal careful manual cleaning of the crankcase, oil pan, pipes and storage tank, is naturally very important.

However, it is equally important that the system pipes and components, *between the filter(s)* and the bearings, are also carefully cleaned for removal of "welding spray" and oxide scales.

If the pipes have been sand blasted, and thereafter thoroughly cleaned or "acid-washed", then this ought to be followed by "washing-out" with an alkaline liquid, and immediately afterwards the surfaces should be protected against corrosion.

In addition, particles may also appear in the circulating oil coolers, and therefore we recommend that these are also thoroughly cleaned.

2.2 Flushing Procedure, Main Lub. Oil System

Regarding flushing of the camshaft lub. oil pipes:

Engines with Uni-lube system, see *Section 3045-0160.*

Experience has shown that both during and after such general cleaning, airborne abrasive particles can still enter the circulating oil system. For this reason it is necessary to flush the whole system by continuously circulating the oil - while bypassing the engine bearings, etc.

This is done to remove any remaining abrasive particles, and, before the oil is again led through the bearings, it is important to definitely ascertain that the system and the oil have been cleaned adequately.

During flushing (as well as during the preceding manual cleaning) the bearings must be effectively protected against the entry of dirt.

The methods employed to obtain effective particle removal during the oil circulation depend upon the actual plant installations, especially upon the filter(s) type, lub. oil centrifuges and the bottom tank layout.

Cleaning is carried out by using the lub. oil centrifuges and by pumping the oil through the filter. A special flushing filter, with fineness down to 10 µm, is often used as a supplement to or replacement of the system filter.

The following items are by-passed by blanking off with special blanks:

a. The main bearings
b. The crossheads
c. The thrust bearing
d. The turbocharger(s)
e. The axial vibration damper.
f. The torsional vibration damper (if installed)
g. The moment compensators (if installed)
h. The chain drive

See also Drawing 3055-0130 page 1.

It is possible for dirt to enter the crosshead bearings due to the design of the open bearing cap. It is therefore essential to cover the bearing cap with rubber shielding throughout the flushing sequence.

As the circulating oil cannot by-pass the bottom tank, the whole oil content should partake in the flushing.

During the flushing, the oil should be heated to 60-65°C and circulated using the full capacity of the pump to ensure that all protective agents inside the pipes and components are removed.

It is essential to obtain an oil velocity which causes a turbulent flow in the pipes that are being flushed.

Turbulent flow is obtained with a Reynold number of 3000 and above.

$$R_e = \frac{V \times D}{v} \times 1000, \text{ where}$$

R_e = Reynold number
V = Average flow velocity (m/s)
v = Kinematic viscosity (cSt)
D = Pipe inner diameter (mm)

The preheating can be carried out, for instance, by filling the waterside of the circulating oil cooler (between the valves before and after the cooler) with fresh water and then leading steam into this space. During the process the deaerating pipe must be open, and the amount of steam held at such a level that the pressure in the cooler is kept low.

In order to obtain a representative control of the cleanliness of the oil system during flushing, "control bags" are used (e.g. 100 mm wide by 400 mm long, but with an area of not less than 1000 cm^2, and made from 0.050 mm filter gauze). Proposals for checkbag housings are shown on *Drawing 3055-0130 page 2.*.

To ensure cleanliness of the oil system after the filter, two bags are placed in the system, one at the end of the main lub. oil line for the telescopic pipes, and one at the end of the main lub. oil line for the bearings.

To ensure cleanliness of the oil itself, another bag is fed with circulating oil from a connection stub on the underside of a horizontal part of the main pipe between circulating oil pump and main filter. This bag should be fitted to the end of a 25 mm plastic hose and hung in the crankcase.

At intervals of approx. two hours, the bags are examined for retained particles, whereafter they are cleaned and suspended again, without disturbing the oil circulation in the main system.

The oil flow through the "control bags" should be sufficient to ensure that they are continuously filled with oil. The correct flow is obtained by restrictions on the bag supply pipes.

The max. recommended pressure differential across the check bag is 1 bar, or in accordance with information from the check bag supplier.

On condition that the oil has been circulated with the full capacity of the main pump, the oil and system cleanliness is judged sufficient when, *for two hours, no abrasive particles have been collected*.

As a supplement, and for reference during later inspections, we recommend that in parallel to using the checkbag, the cleanliness of the lub. oil is checked by particle counting, in order to find particle concentration, size and type of impurities. When using particle counting, flushing should not be accepted as being complete until the cleanliness is found to be within the range in ISO 4406 level ≤19/15 (corresponding to NAS 1638, Class 10).

In order to improve the cleanliness, it is recommended that the circulating oil centrifuges are in operation during the flushing procedure. The centrifuge preheaters ought to be used to keep the oil heated to the proper level.

NOTICE

If the centrifuges are used without the circulating oil pumps running, then they will only draw relatively clean oil, because, on account of low oil velocity, the particles will be able to settle at different places within the system.

A portable vibrator or hammer should be used on the outside of the lub. oil pipes during flushing in order to loosen any impurities in the piping system. The vibrator is to be moved one metre at least every 10 minutes in order not to risk fatigue failures in piping and welds.

A flushing log, *see Drawing 3055-0130 page 3*, is to be used during flushing and for later reference.

As a large amount of foreign particles and dirt will normally settle in the bottom tank during and after the flushing (low flow velocity), it is recommended that the oil in the bottom tank is pumped to a separate tank via a 10 µm filter, and then the storage tank is again cleaned manually. The oil should be returned to the tank via the 10 µm filter.

If this storage tank cleaning is not carried out, blocking up of the filters can frequently occur during the first service period, because settled particles can be dispersed again:

a. due to the oil temperature being higher than that during flushing,

b. due to actual engine vibrations.

Important: When only a visual inspection of the lub. oil is carried out, it is important to realise that the smallest particle size which is detectable by the human eye is approx. 0.04 mm.

During running of the engine, the lub. oil film thickness in the bearings becomes as low as 0.005 mm or even lower. Consequently, visual inspection of the oil *cannot* protect the bearings from ingress of harmful particles. It is recommended to inspect the lub. oil in accordance with ISO 4406.

3 Circulating Oil Treatment

3.1 General

Circulating oil cleaning, during engine operation, is carried out by means of an inline oil filter, the centrifuges, and possibly by-pass filter, if installed, as illustrated on *Drawing 3055-0115*.

The engine as such consumes about 0.1 g/kWh of circulating lub. oil, which must be compensated for by adding new lub. oil.

It is this continuous and necessary refreshing of the oil that will control the BN and viscosity on an acceptable equilibrium level as a result of the fact that the oil consumed is with elevated figures and the new oil supplied has standard data.

In order to obtain effective separation in the centrifuges, it is important that the flow rate and the temperature are adjusted to their optimum, as described in the following.

3.2 The Centrifuging Process

Efficient oil cleaning relies on the principle that - provided the through-put is adequate and the treatment is effective - an equilibrium condition can be reached, where the engine contamination rate is balanced by the centrifuge separation rate i.e.:

Contaminant quantity added to the oil per hour = contaminant quantity removed by the centrifuge per hour.

It is the purpose of the centrifuging process to ensure that this equilibrium condition is reached, with the oil insolubles content being as low as possible.

Since the cleaning efficiency of the centrifuge is largely dependent upon the flow-rate, it is very important that this is optimised.

The above considerations are further explained in the following.

3.3 The System Volume, in Relation to the Centrifuging Process

As mentioned above, a centrifuge working on a charge of oil will, in principle, after a certain time, remove an amount of contamination material per hour which is equal to the amount of contamination material produced by the engine in the same span of time.

This means that the system (engine, oil and centrifuges) is in equilibrium at a certain level of oil contamination (Peq) which is usually measured as pentane insolubles %.

In a small oil system (small volume), the equilibrium level will be reached sooner than in a large system (Fig. 1) - but the final contamination level will be the same for both systems - because in this respect the system oil acts only as a carrier of contamination material.

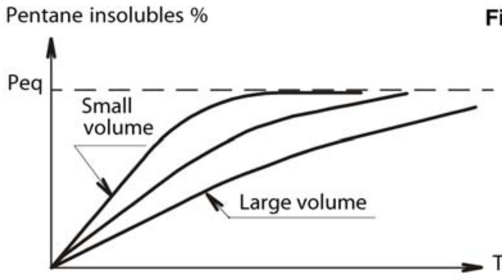


Fig. 1

A centrifuge can be operated at greatly varying flow rates (Q).

Practical experience has revealed that the content of pentane insolubles, before and after the centrifuge, is related to the flow rate as shown in Fig. 2.

Fig. 2 illustrates that the amount of pentane insolubles removed will decrease with rising Q.

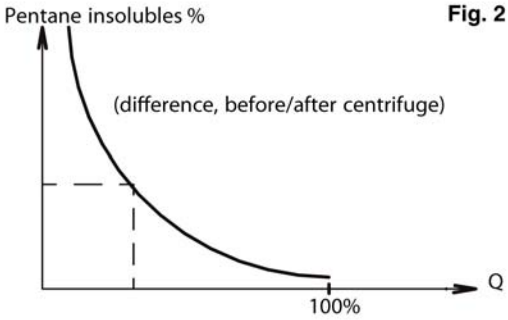


Fig. 2

It can be seen that:

a. At low Q, only a small portion of the oil is passing the centrifuge/hour, but is being cleaned effectively.

b. At high Q, a large quantity of oil is passing the centrifuge/hour, but the cleaning is less effective.

Thus, by correctly adjusting the flow rate, an optimal equilibrium cleaning level can be obtained (Fig. 3).

This minimum contamination level is obtained by employing a suitable flow rate that is only a fraction of the stated maximum capacity of the centrifuge *(see the centrifuge manual)*.

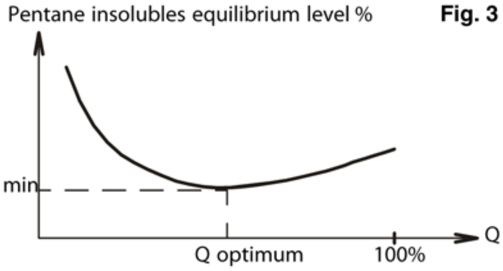


Fig. 3

3.4 Guidance Flow Rates

The ability of the system oil to “carry” contamination products is expressed by its detergency/dispersancy level.

This means that a given content of contamination - for instance 1 % pentane insolubles - will, in a detergent oil, be present as smaller, but more numerous particles than in a straight oil.

Furthermore, the particles in the detergent oil will be surrounded by additives, which results in a specific gravity very close to that of the oil itself, thereby hampering particle settling in the centrifuge.

This influences the position of the minimum in Fig. 3, as illustrated in Fig. 4.

As can be seen, the equilibrium level in a detergent oil will be higher than in a straight oil, and the optimum flow rate will be lower.

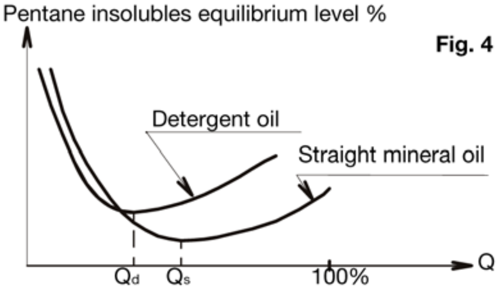


Fig. 4

However, since the most important factor is the particle size (risk of scratching and wear of the bearing journals), the above-mentioned difference in equilibrium levels is of relatively minor importance, and the following guidance figures can be used:

In general,

a. the optimum centrifuge flow rate for a detergent oil is about 20-25% of the maximum centrifuge capacity,

b. whereas, for a *straight oil*, it is about 50-60%.

c. This means that for most system oils of today, which incorporate a certain detergency, the optimum will be at about 30-40% of the maximum centrifuge capacity.

The *preheating* temperature should be about 80°C.

4 Oil Deterioration

4.1 General

Oil seldom loses its ability to lubricate, i.e. to form an oil film which reduces friction, but it can become corrosive.

If this happens, the bearing journals can be attacked, such that their surfaces become too rough, and thereby cause wiping of the white metal.

In such cases, not only must the bearing metal be renewed, but also the journals (silvery white from adhering white metal) will have to be re-polished.

Lubricating oil corrosiveness is either due to advanced oxidation of the oil itself (Total Acid Number, TAN) or to the presence of inorganic acids (Strong Acid Number, SAN). *See further on in this Section*.

In both cases the presence of water will multiply the effect, especially an influx of salt water.

4.2 Oxidation of Oils

At normal service temperature the rate of oxidation is insignificant, but the following three factors will accelerate the process:

4.2.1 High Temperature

The temperature level will generally increase if the coolers are not effective.

Local high-temperature areas will arise in pistons, if circulation is not continued for about 15 minutes after stopping the engine.

The same will occur in electrical preheaters, if circulation is not continued for 5 minutes after the heating has been stopped, or if the heater is only partly filled with oil (insufficient venting).

4.2.2 Air Admixture

Good venting of the bottom tank should be arranged.

The total oil quantity should be such that it is not circulated more than about 15-18 times per hour. This ensures that sufficient time exists for deaeration during the period of “rest” in the bottom tanks.

It is important that the whole oil content takes part in the circulation, i.e. stagnant oil should be avoided.

4.2.3 Catalytic Action

Oxidation will be considerably accelerated if oxidation catalysts are present in the oil.

In this respect, wear particles of copper are especially bad, but also ferrous wear particles and rust are active.

In addition, lacquer and varnish-like oxidation products of the oil itself have an accelerating effect. Therefore, continuous cleaning is important to keep the “sludge” content low.

As water will evaporate from the warm oil in the bottom tank, and condense on the tank ceiling, rust is apt to develop here and fall into the oil, thereby tending to accelerate oxidation. This is the reason for advocating the measures mention in *Section 6645-0100*, concerning cleaning and rust prevention.

4.3 Signs of Deterioration

If oxidation becomes grave, prompt action is necessary because the final stages of deterioration can develop and accelerate very quickly, i.e. within one or two weeks.

Even if this seldom happens, it is prudent to be acquainted with the following signs of deterioration, which may occur singly or in combinations.

- The sludge precipitation in the centrifuge multiplies.
- The smell of the oil becomes bad (acrid or pungent).
- Machined surfaces in crankcase become coffee-brown (thin layer of lacquer).
- Paint in crankcase peels off, or blisters.
- Excessive carbon deposits (coke) are formed in piston cooling chambers.

In serious cases of oil deterioration, the system should be cleaned and flushed thoroughly, before fresh oil is filled into it.

4.4 Water in the Oil

Water contamination of the circulating oil should always be avoided.

The presence of water, especially salt water, will:

- accelerate oil oxidation (tend to form organic and inorganic acids)
- tend to corrode machined surfaces and thereby increase the roughness of bearing journals and piston rods, etc. *(see e.g. Section 2545-0100)*
- tend to form tin-oxide on white metal *(see Section 2545-0100)*.

In addition, freshwater contamination can enhance the conditions for bacteriological attack.

For alkaline oils, a minor increase in the freshwater content is not immediately detrimental, as long as the engine is running, although it should, as quickly as possible, be reduced again to *below* 0.2% water content.

If the engine is stopped with excess water in the oil, then once every hour, it should be turned a little more than 1/2 revolution (to stop in different positions), while the oil circulation and centrifuging (at preheating temperature) continue to remove the water. This is particularly important in the case of salt water ingress.

Water in the oil may be noted by “dew” formation on the sight glasses, or by a *milky* appearance of the oil.

Its presence can also be ascertained by heating a piece of glass, or a soldering iron, to 200-300°C and immersing it in an oil sample. If there is a hissing sound, water is present.

If a large quantity of (sea) water has entered the oil system, it may be profitable to suck up sedimented water from the bottom of the tank. Taste the water for salt.

In extreme cases it may be necessary to remove the oil/water mixture, and clean and/or flush the system, before filling up again with the cleaned oil, or the new oil.

4.5 Check of Oil Condition

As described in items 4.3 and 4.4, the on site surveillance of oil condition involves keeping a check of:

- alterations in separated sludge amount
- appearance and smell of the oil
- “dew” on sight glasses
- lacquer formation on machined surfaces
- paint peeling and/or blistering
- “hissing” test
- carbon deposits in piston crown.

In addition to the above, oil samples should be sent ashore for analysis at least every three months. The samples should be taken while the engine is running, and from a test cock on a main pipe through which the oil is circulating.

Kits for rapid on-board analyses are available from the oil suppliers. However, such kits can only be considered as supplementary and should not replace laboratory analyses.

5 Circulating Oil: Analyses and Characteristic Properties

Used-oil analysis is most often carried out at oil company laboratories. It is normal service for these to remark upon the oil condition, based upon the analysis results. The report usually covers the following characteristics:

Property	Remarks	Guiding Limits for used oils
Oil Type	Alkaline detergent (for 2-stroke engines)	
Specific Gravity	Usually 0.90-0.98. Mainly used for identification of the oil.	±5% (of initial value)
Viscosity	The viscosity increases with oil oxidation, and also by contamination with cylinder oil, heavy fuel, or water. A decrease in the viscosity may be due to dilution with diesel oil.	max. + 40% min.-15% (of initial value)
Flash Point (open cup)	Lowest temperature at which the oil gives off a combustible vapour. Gives an indication of possible fuel oil contamination.	min. 180°C
TAN (Total Acid Number)	This expresses the total content of organic and inorganic acids in the oil. Organic (or weak) acids are due to oxidation. TAN = SAN + Weak acid number.	max. 2
SAN (Strong Acid Number)	This expresses the amount of inorganic (or strong) acids in the oil. These are usually sulphuric acid from the combustion chamber, or hydrochloric acid arising from salt water (ought to be stated in the analysis). SAN makes the oil corrosive (especially if water is present) and should be zero.	0
Alkalinity/BN (Base Number)	Gives the alkalinity level in oils containing acid neutralizing additives. *See also Service Letter SL02-408/KEA*.	max.+ 100% min.-30% (of initial values)
Water	Risky if TAN and SAN are high. Salt water has a higher corrosive effect than freshwater. *See previous point 4.4. Also refer to SL05-460/NHN*	fresh: 0.2% (0.5% for short periods) Saline: trace
Conradsen Carbon	Residue from incomplete combustion, or cracked lubricating and cylinder oil.	max. + 3%
Ash	Some additives leave ash, which may thereby be used to indicate the amount of additives in the oil. The ash can also consist of wear particles, sand and rust. The ash content of a used oil can only be evaluated by comparison with the ash content of the unused oil.	max. + 2%

Property	Remarks	Guiding Limits for used oils
Insolubles	Usually stated as pentane/heptane and benzene insolubles. The amount of insoluble ingredients in the oil is checked as follows: Equal parts of the oil sample are diluted with benzene (C_6H_6) and normal pentane (C_5H_{12}) or heptane (C_7H_{14}). As oxidized oil (lacquer and varnish-like components) is only soluble in benzene, and not in pentane or heptane, the difference in the amount of insolubles is indicative of the degree of oil oxidation. The benzene insolubles are the solid contaminants.	Non-coagulated pentane insolubles max. 2% Non-coagulated benzene insolubles max. 1%

The above limiting values are given for reference/guidance purposes only.

The assessment of oil condition can seldom be based on the value of a single parameter, i.e. it is usually important, and necessary, to base the evaluation on the overall analysis specification.

For qualified advice, we recommend consultation with the oil company or engine builder.

6 Cleaning of Drain Oil from Piston Rod Stuffing Boxes

See Drawing 3055-0135

The oil which is drained off from the piston rod stuffing boxes is mainly circulating oil with an admixture of partly-used cylinder oil and, as such, it contains sludge from the scavenge air space. In general, this oil can be re-used if thoroughly cleaned.

Drawing 3055-0135 shows the cleaning installations. (Option)

The drain oil is collected in tank No. 1. When the tank is nearly full, the oil is transferred, via the centrifuge, to tank No. 2, and thereafter, via the centrifuge, recirculated a number of times.

When centrifuging the stuffing box drain oil, the flow-rate should be decreased to about 50% of what is normally used for the circulating oil, and the preheating temperature raised to about 90°C. This is because, in general, the drain oil is a little more viscous than the circulating oil, and also because part of the contamination products consist of oxidized cylinder oil, with a specific gravity which does not differ much from that of the circulating oil itself.

Water-washing should only be carried out if recommended by the oil supplier. Finally, the centrifuged oil, in tank No. 2, should be filtered a number of times through the cellulose fine filter, at a temperature of 60-80°C.

This will remove any very fine soot and oxidation products not taken out by the centrifuging, and thus make the oil suitable for returning to the circulating system.

Provided that the *circulating oil is an alkaline detergent type*, it is not necessary to analyse each charge of cleaned drain oil before it is returned to the system. Regular sampling and analysis of the circulating oil and drain oil will be sufficient.

If, however, the *circulating oil is not alkaline*, all the cleaned drain oil should be checked for acidity, for instance by means of an analysis kit, before it is returned to the system.

The “total acid number” (TAN) should not exceed 2. *See also Item 5, ‘Circulating Oil: Analyses & Characteristic Properties’*. If the TAN exceeds 2, the particular charge of drain oil should be disposed of.

1 MAN Diesel & Turbo T/C, System Details

The lub. oil system for the MAN Diesel & Turbo type of turbocharger is shown separately on *Drawing 3055-0155*.

The system is supplied from the main lub. oil system.
See also Drawing 3055-0125.

The oil is discharged to the main lub. oil system. The discharge line is connected to the venting pipe, E, which leads to open air.
See also Drawing 3055-0115.

In case of failing lub. oil supply from the main lub. oil system, e.g. due to a power black-out or defects in the system, the engine will stop due to shut-down. Lubrication of the turbocharger bearings is ensured by a separate tank.

The tank is mounted on top of the turbocharger, and is able to supply lub. oil until the rotor is at a standstill, or until the lub.oil supply is re-established.

2 MET T/C, System Details

The MET turborchargers are also lubricated via the main lub. oil system. *See description of turbocharger lub. oil system in Item 1 'MAN Diesel & Turbo T/C, System Details'*.

3 ABB TPL T/C, System Details

The ABB TPL turbochargers are designed either with an integrated lub. oil system or with a similar system as MDT TC. Please refer to the relevant ABB TPL-instruction manual.

Cylinder Lubricating Oil Pipes

Fig. 1

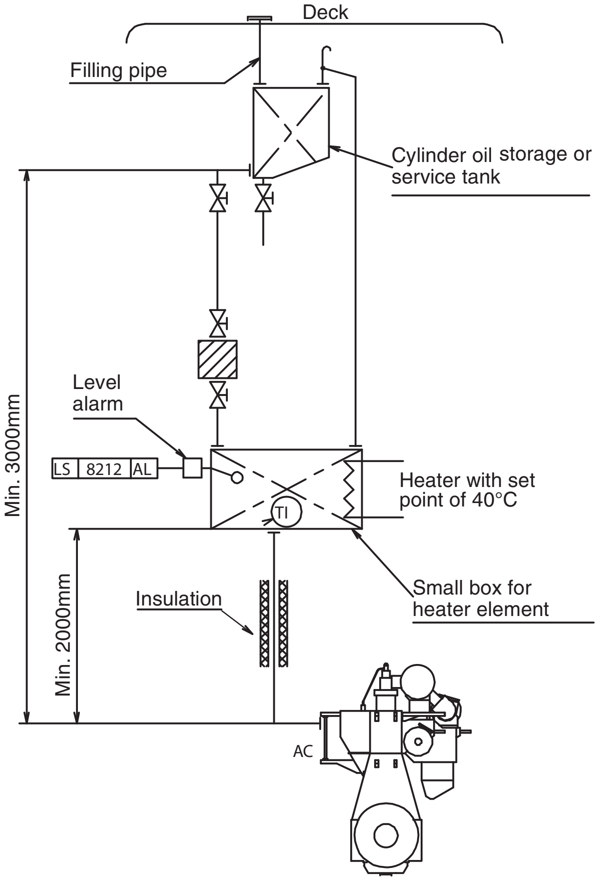
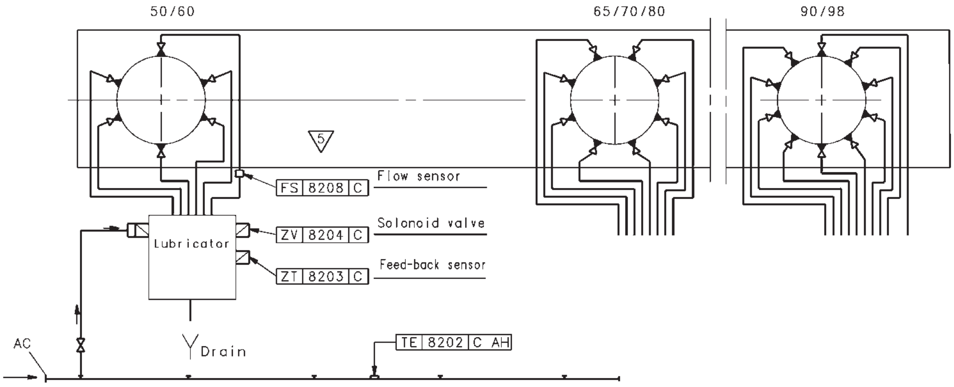


Fig. 2

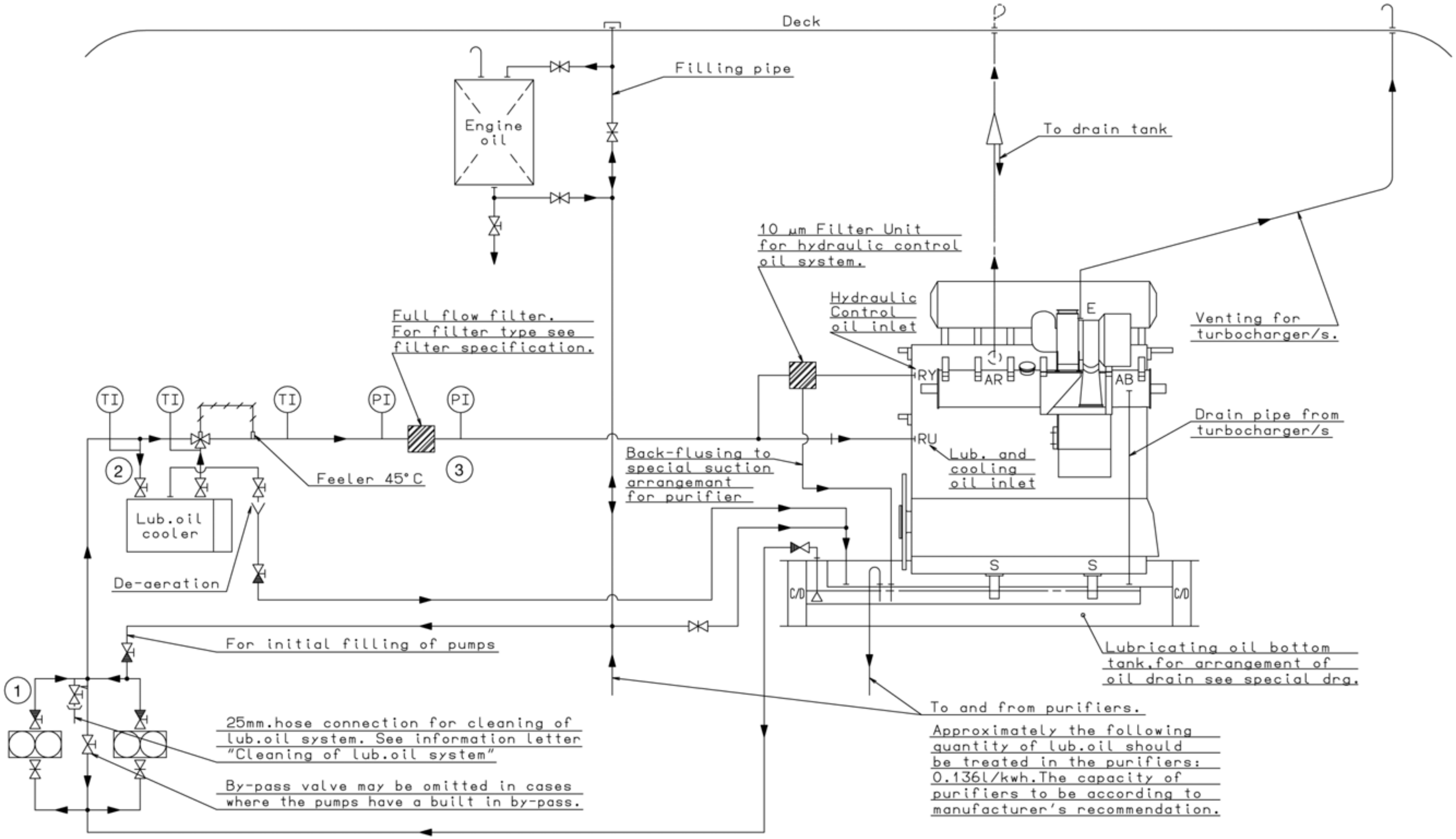


Drawing 3055-0110-0002

Circulating Oil System (Outside Engine)

Drawing

3055-0115-0002



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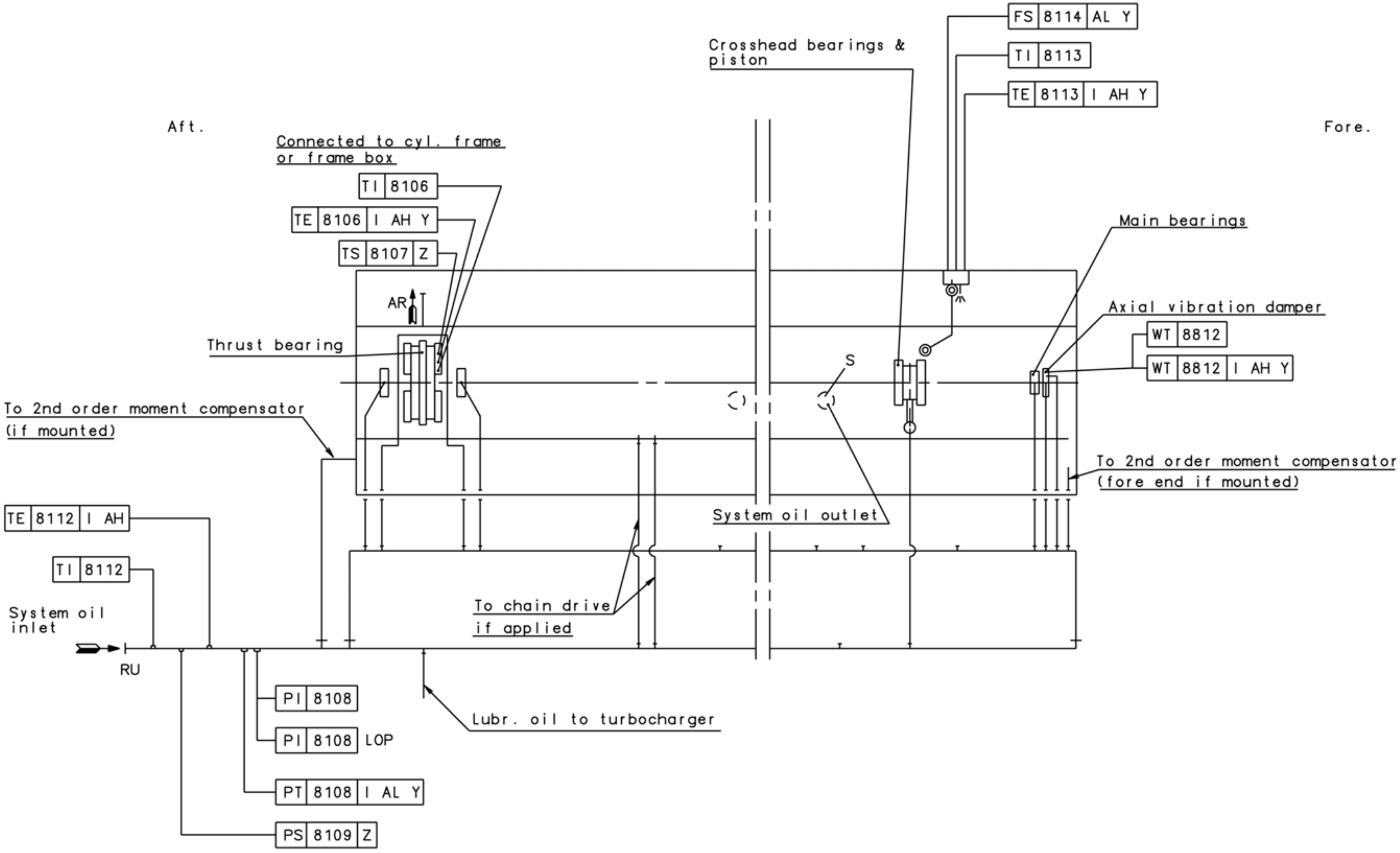
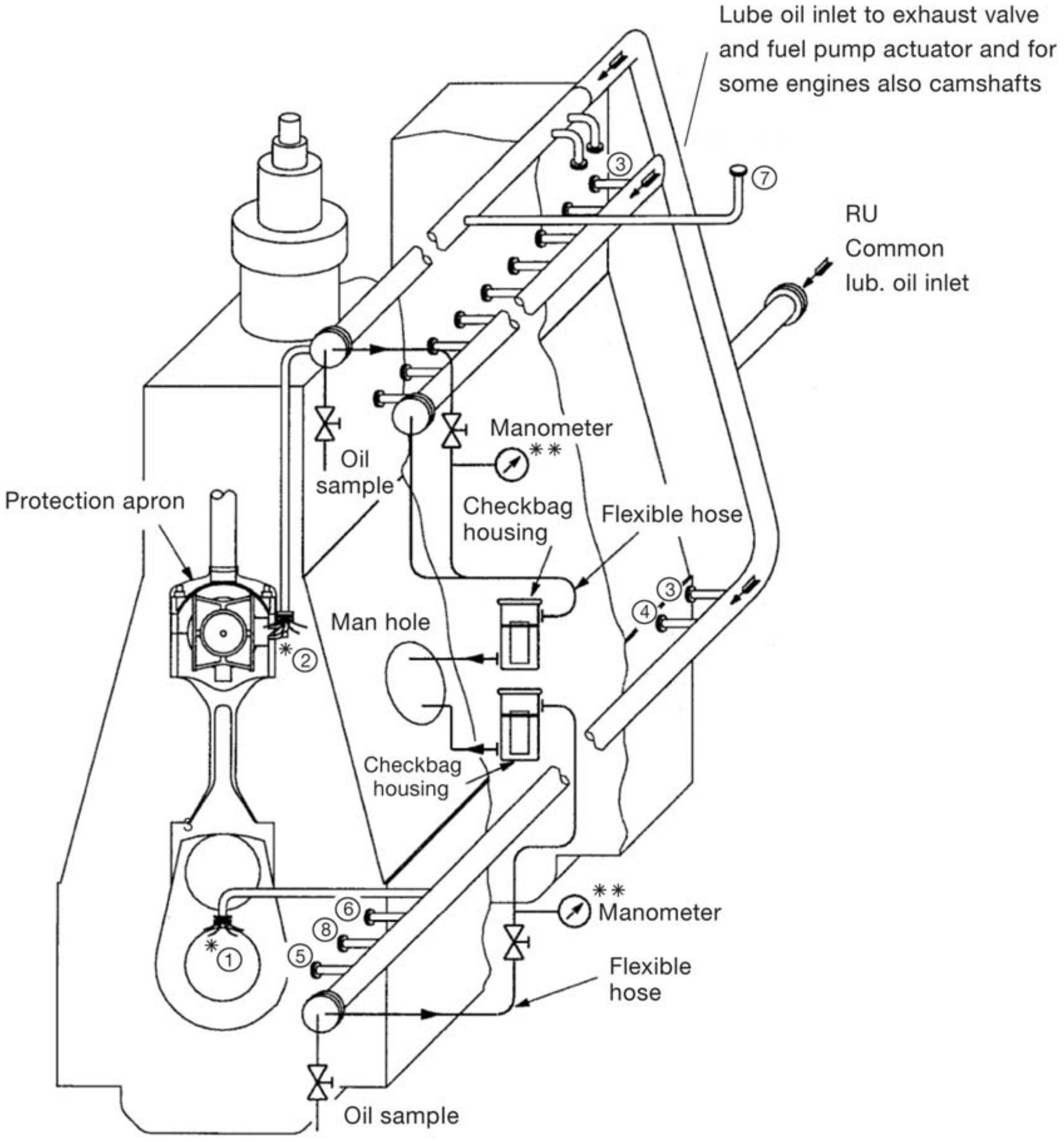


Drawing

3055-0125-0003

Circulating Oil System (Inside Engine)

Location of Checkbag and Blank Flanges



Blanking off pipes:

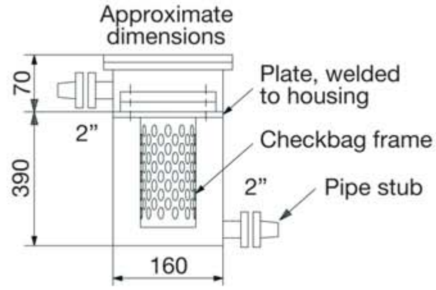
1. Main bearing by-pass blanks
2. Crosshead bearings by-pass blanks
3. Blank-off Thrust bearing
4. Blank-off or by-pass axial vibration damper
5. Blank-off torsional vibration damper
6. Blank-off forward moment compensator chain drive
7. Blank-off or by-pass turbocharger
8. Blank-off PTO-PTI power gear

✱ See Page 2.

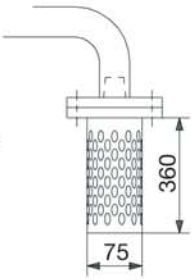
✱✱ Manometer, max. recommended pressure before checkbag: 1 bar o. or in accordance with information from the checkbag supplier.

Dimension of Checkbag and Blank Flanges

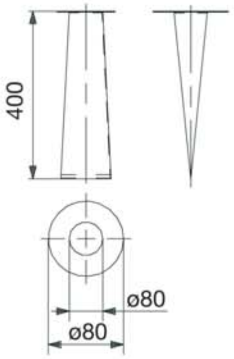
Sketch of check-bag housing:



Alternative check-bag (Inside engine):



Checkbag monofil filter cloth: 50 µm.

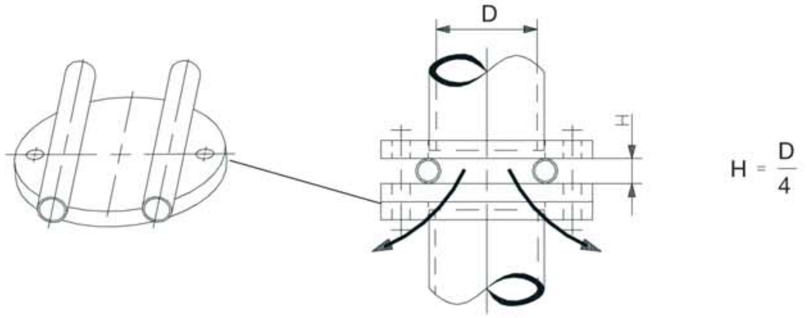


The holes in the checkbag frame are, in our experience to be approx 5 mm. in diameter, to avoid damage to the checkbag and too high pressure drop.

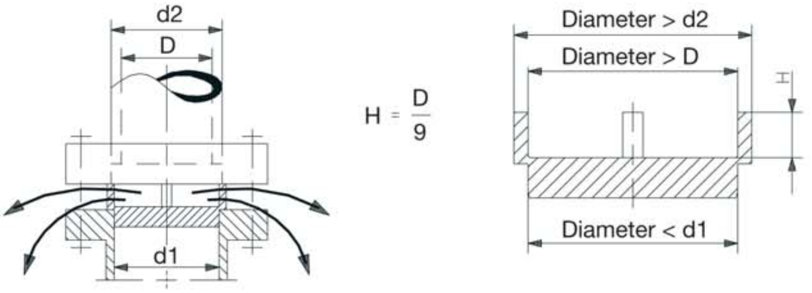
The above filter components can be delivered from MAN Diesel & Turbo

Blank flanges for flushing:

A) Blank at main bearings



B) Blank between telescopic pipes and crossheads



Flushing Log

M/V:	Engine Type:		System:	Checked by:
	Builder:	Engine No.:	M.E. Lub. Oil	
Yard: No.:	Built year:			Date:

Info	Pumps Centrifugal ☐ Screw ☐ Maker: Type: Capacity:	Filters Absolute/fineness Maker : Main : µm Type : By-pass : µm Type :	Centrifuge Maker: Type: Capacity:	Magnet Filter Maker: Type: Other Filters Maker: Type:

Filter Unit (if used) µm Type: Maker:		
Inspection of	Checked by	Date
Pipes:		
Tanks:		

		L.O. System							
		Temp. [C]	Press. [bar] at pump & M.E.	Pump 1-2			Purifier	Filter Unit	Check No. & ISO Code
				Time start & stop	Running hours per day	Running hours total	Start/ stop running hours	Start/ stop running hours	
Date:	Remarks								

Sign.	Inspector:	Yard/Engine builder Total flushing hrs.:	Final cleanliness: Check bags________ ISO 4406 Code_______

Recording of pump running hrs. with ½hr.
Cleaning and replacement of filters to be recorded under remarks.
Accepted flushing cleanliness level: Clean check bags after 2 hrs. (ISO 4406 Code ≤ 19/15)

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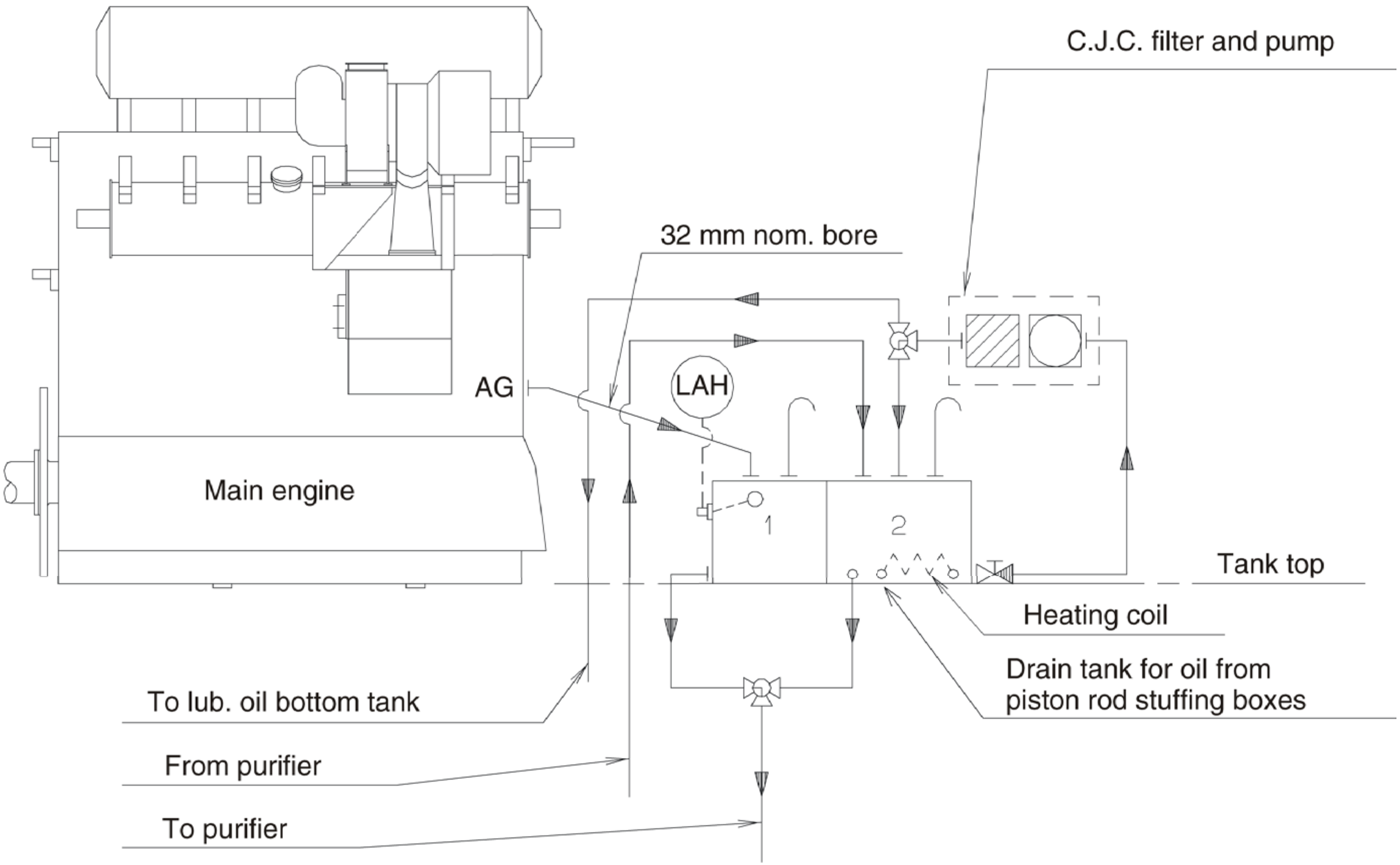
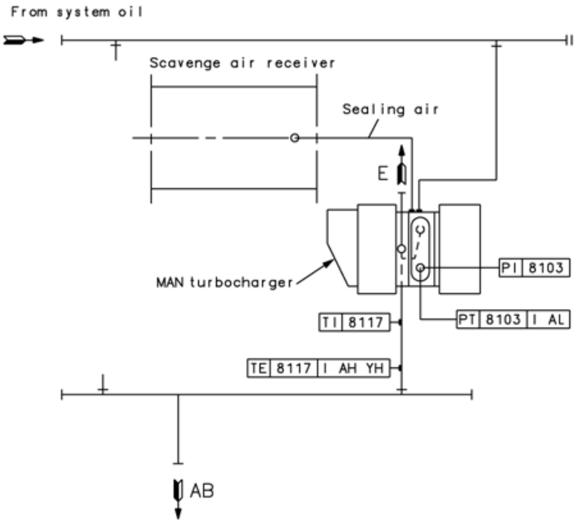


Drawing

3055-0135-0002

Cleaning System, Stuffiing Box Drain Oil (Option)

MAN Turbocharger



MET Turbocharger

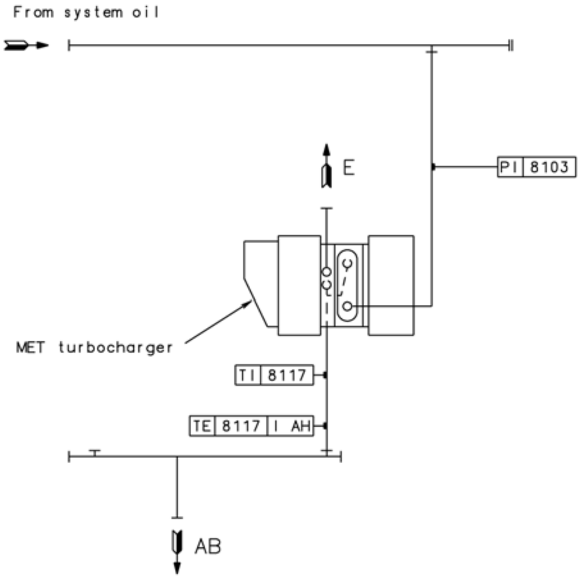
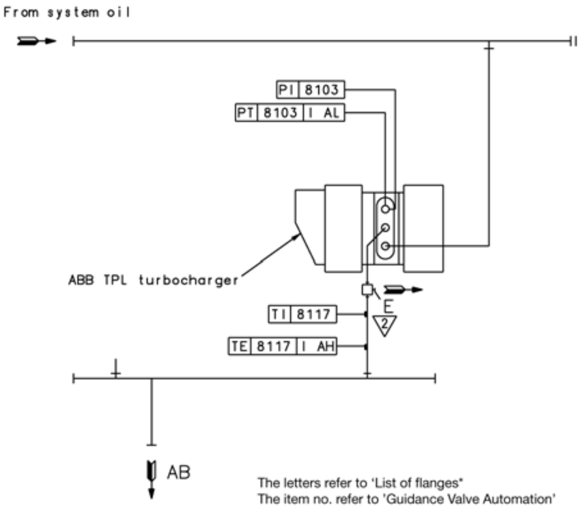


ABB TPL Turbocharger



The letters refer to 'List of flanges'
The item no. refer to 'Guidance Valve Automation'

Safety Precautions

for detailed sketch see 0545-0100

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

Check of Oil Injection

With stopped engine With stopped engine and normally when the system has been disassembled:

The MOP control panel

Activate the prelub.-function on the MOP control panel, and check that all lubricators are operating correctly.

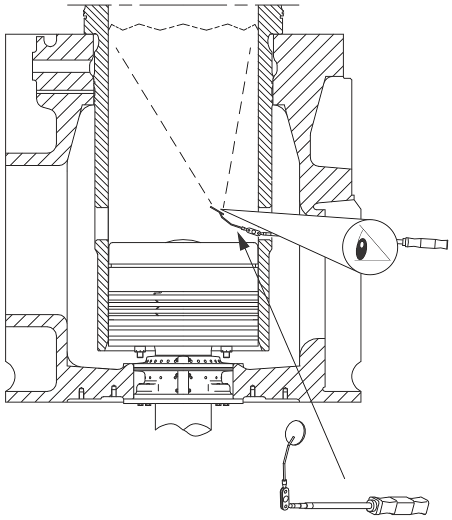
For use of the MOP Panel, see Volume I Chapter 703.

Inspection

If the cylinder cover or the exhaust valve is removed, check inside the liner that all lubricating points are working properly.

Otherwise, remove the covers for scavenge port inspection.

Turn the piston to BDC and check inside the liner with a mirror and a powerful light source that all lubrication points are working properly.



3065-0601-0001C01

With running engine

Check all lubricators on LEDs

Check that all lubricators are operating correctly by watching the LEDs on the intermediate boxes for each lubricator.

The LEDs give signal when oil is injected.

Check the pressure shocks from the injection of the lubricators on each lubricator pipe by feeling with a hand.

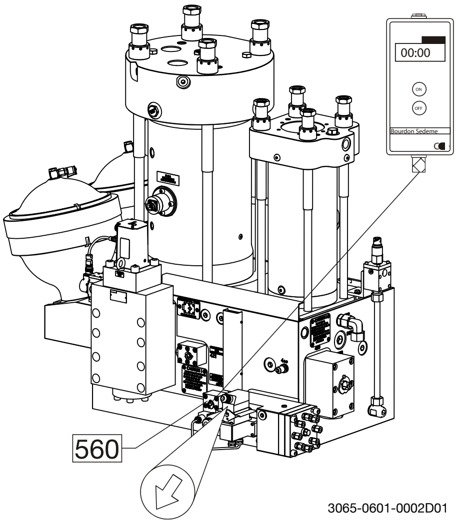
If in doubt, disconnect the pipe at the cylinder liner to observe the oil flow.

Dismantling of lubricators

Normally, the engine must be stopped and blocked before dismounting a lubricator.

The supply valve

Close the supply valve for cylinder lubricating oil.



3065-0601-0002D01

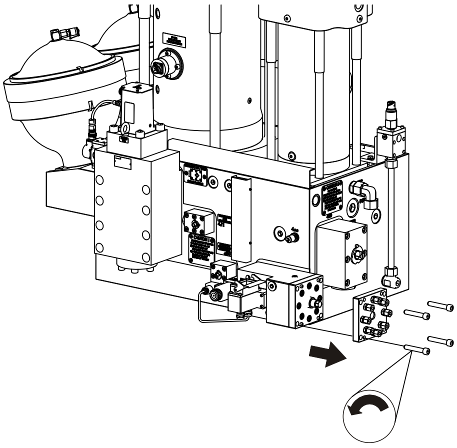
Pressure check

Mount a pressure gauge at “minimess” point 565.

Check the pressure.

Close valve 560. Check that the cylinder lubricator is pressure free. If pressure is still present, activate the “prelub” function on the MOP panel to remove the pressure.

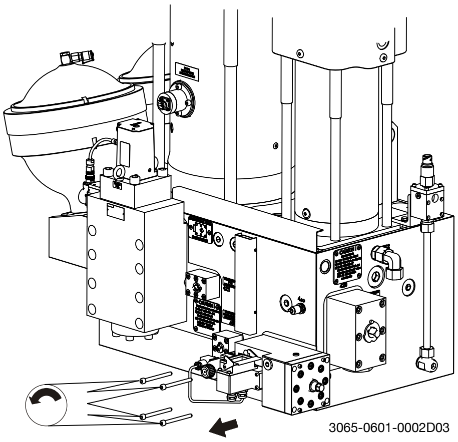
Disconnect the electrical plug on the side of the lubricator.



3065-0601-0002D02

Remove the cover of the lubricator

Unscrew the four screws in the aft side of the lubricator and disconnect the cover with pertaining pipes.



Remove the lubricator

Unscrew the four screws on the side that secure the lubricator to the hydraulic cylinder unit.

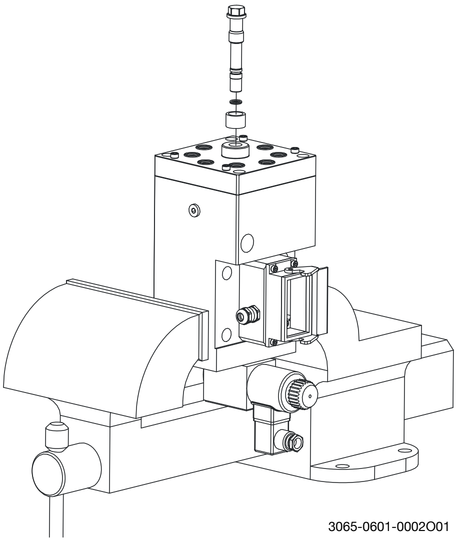
Pull the pipe flange to one side and pull the lubricator out and clear of the guide pins.

Special running

It is possible to change a lubricator while the engine is running if a spare lubricator with O-rings and the necessary tools is available. The change should be done in a maximum of 15 minutes.

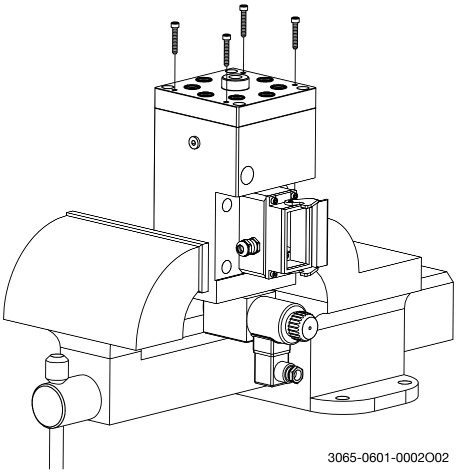
- Reduce the engine rpm to below 40% of MCR-rpm
- Dismount the lubricator as described in steps 1-3
- Mount a spare lubricator as described in work card 2265-06.

Remove the O-ring	Place the lubricator in a bench vice with soft “jaws”. Remove the adjusting screw with bushings. Discard the O-ring from the adjusting screw.



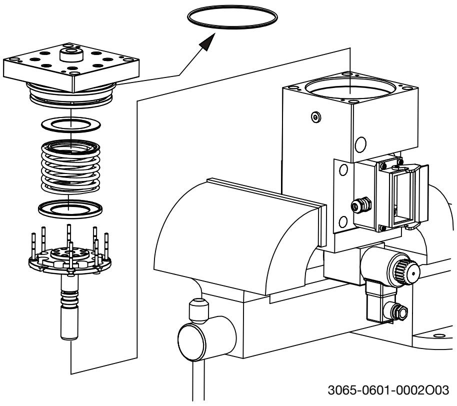
3065-0601-0002O01

The cylinder block	Push down the cylinder block and remove the four screws from the cylinder block.



3065-0601-0002O02

Overhaul dismantling	Pull up the cylinder block. Remove the springs, spring disc and actuator piston with plungers. Remove and discard the O-ring from the cylinder block.

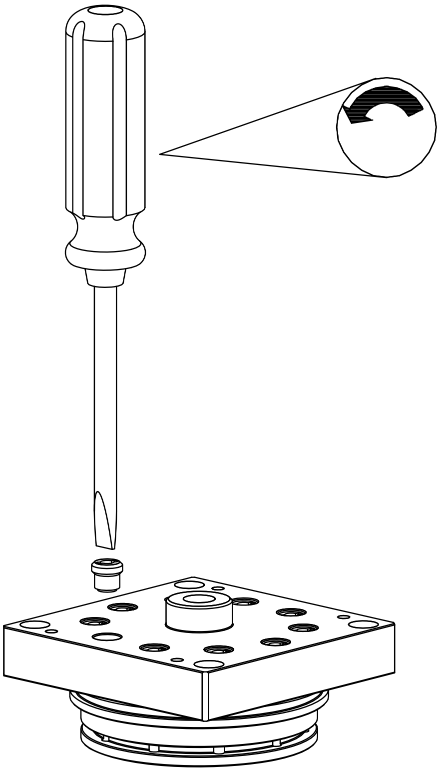


3065-0601-0002O03

Non-return valves

Screw out the non-return valves and remove and discard the O-rings.

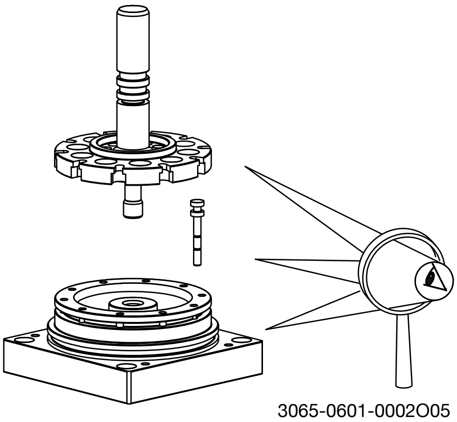
Clean the valves and check them with compressed air.



3065-0601-0002O04

General inspections

Inspect the plungers, actuator piston and cylinder block for wear, using a magnifying glass.

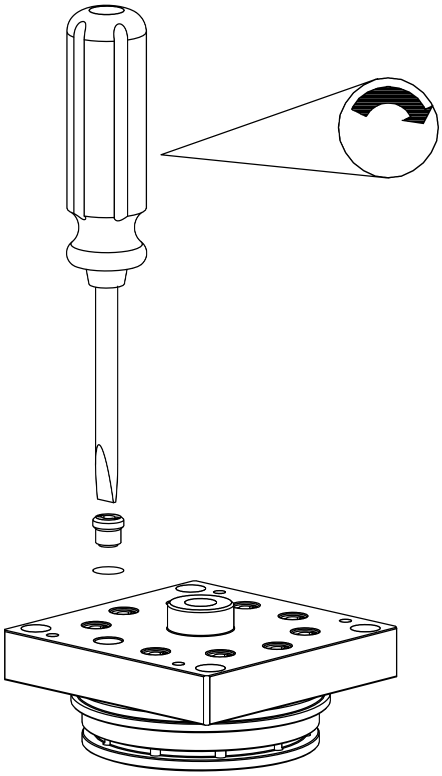


3065-0601-0002O05

Mount the non-return valve

Fit the non-return valve with new O-rings.

Mount the non-return valves in the cylinder block.

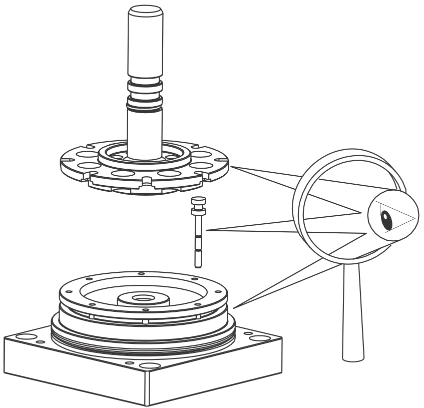


3065-0601-0002O06

Inspection

Inspect the plungers, actuator piston sealing ring and cylinder block for wear, using a magnifying glass.

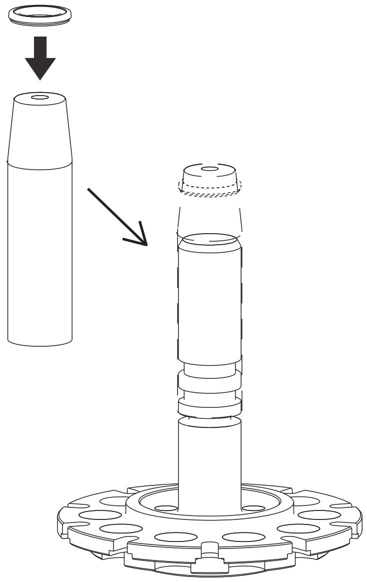
If the sealing ring needs to be replaced, proceed as follows:



3065-0601-0006C15

Place new sealing ring on the cone

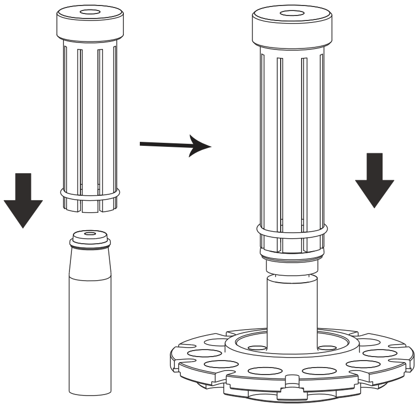
Slide the cone for the sealing ring onto the actuator piston so that only the lowermost groove is exposed. place a new sealing ring on the uppermost part of the cone.



3065-0601-0006C16

Use the pushing tool

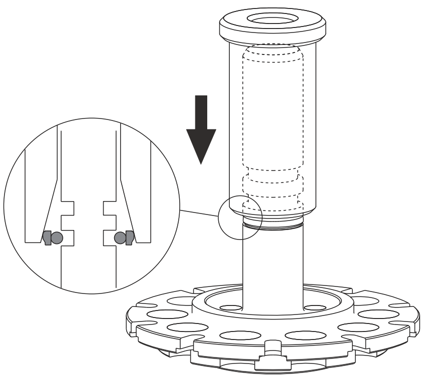
Push the pushing tool over the cone thus pushing the sealing ring down to the lowest groove, then remove both tools.



3065-0601-0006C17

Mount the non-return valve

Push the compressor over the ring so that the sealing ring goes back to its original form and into the groove.

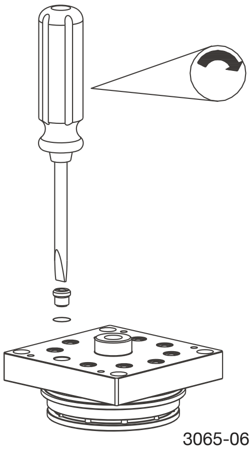


3065-0601-0006C18

Non-return valve

Fit the non-return valve with new O-rings.

Mount the non-return valves in the cylinder block.

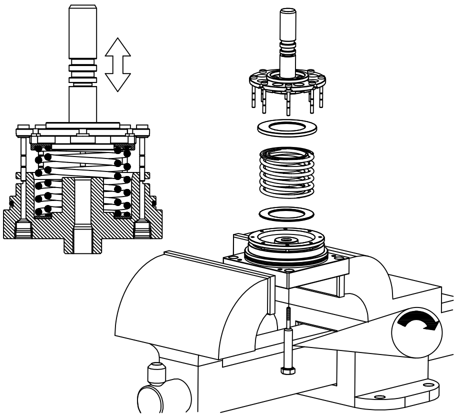


3065-0601-0006C19

The cylinder block

Fit the cylinder block with a new O-ring. Pre-assemble the cylinder block with the actuator piston and plungers to ensure correct guidance of the plungers, before finally assembling the cylinder block unit.

Mount the springs and spring disc and press down the actuator piston with plungers. Mount the special screw, supplied with the test equipment for accumulators to keep the spring compressed.



3065-0601-0002O07

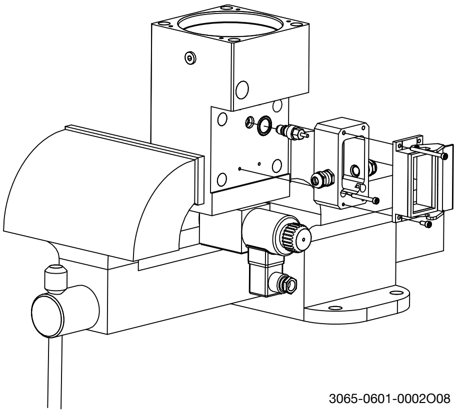
The terminal box

Remove the cover from the terminal box, and disconnect the wires for the feedback (pick-up) sensor.

Remove the terminal box.

Carefully unscrew the feedback sensor and remove and discard the O-ring.

Clean the housing with diesel oil or kerosene and dry with a non-fluffy cloth.



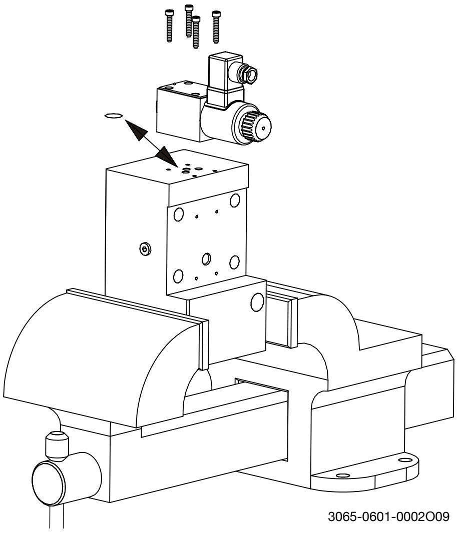
3065-0601-0002O08

Solenoid valve

Turn the lubricator upside down in the vice.

Unscrew the solenoid valve.

Discard the O-rings.

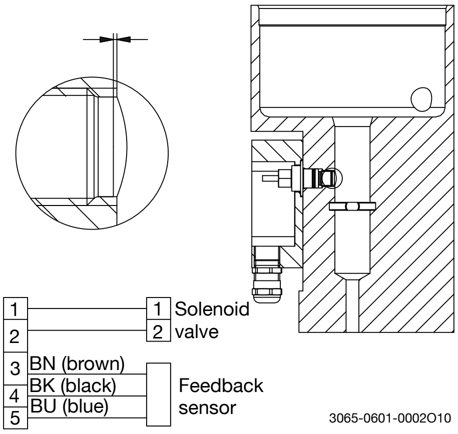


Remember !

Before mounting the feedback sensor, check that the sensor is flush with the sensor housing.

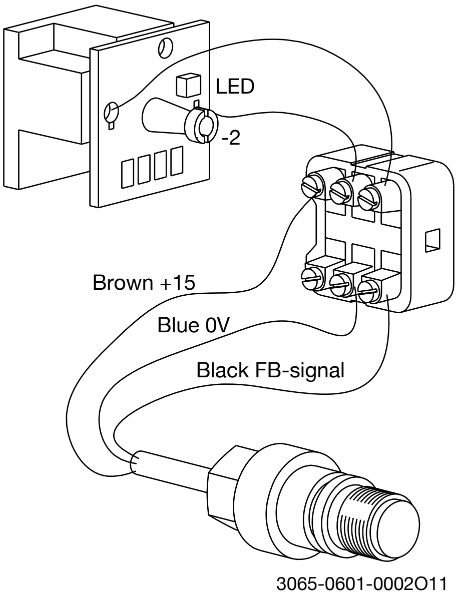
Mount the feedback sensor or a new one, if necessary, with a new O-ring.

Check with an object with a straight edge (e.g. the end of a calliper) that the end of the feedback sensor does not protrude into the actuator piston cylinder.



Mount the terminal box

Connect the wires and mount the cover on the terminal box.



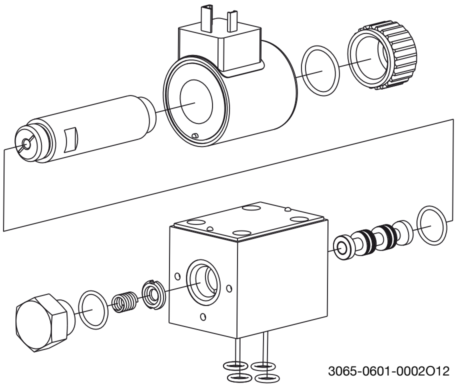
Solenoid Valve

Disassemble and clean the valve.

Check the slide for wear. If the slide is scratched or scuffed, the valve must be replaced by a new one.

Lubricate the slide with oil and check that the slide can move lightly with a good fit in the housing.

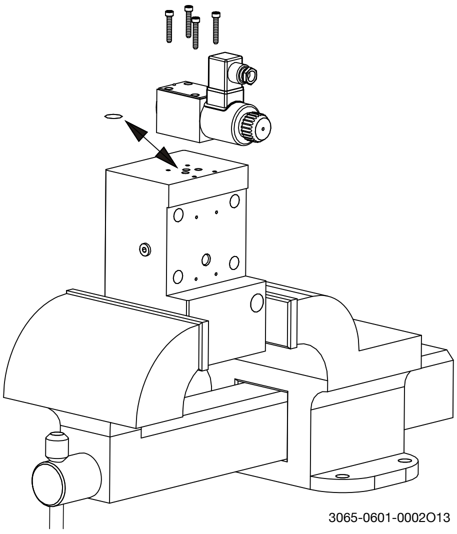
Assemble the valve.



3065-0601-0002O12

Mounting the solenoid valve

Mount the solenoid valve fitted with new O-rings. Coat the O-rings with a little grease to keep the rings in place during mounting.



3065-0601-0002O13

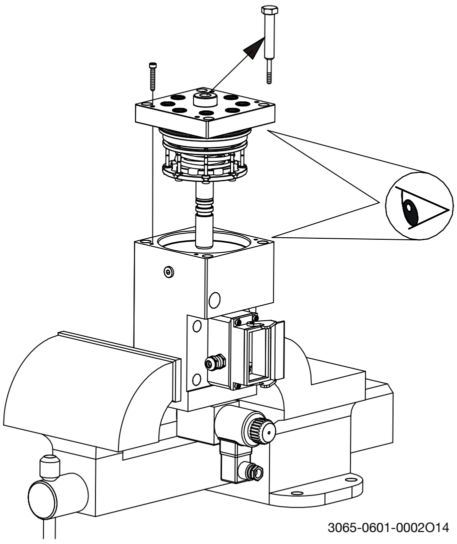
Cylinder block assembly and cylinder housing

Mount the cylinder block assembly in the cylinder housing.

Check that the spring pin engages correctly with the cylinder block assembly.

Mount the screws and tighten the block to the housing.

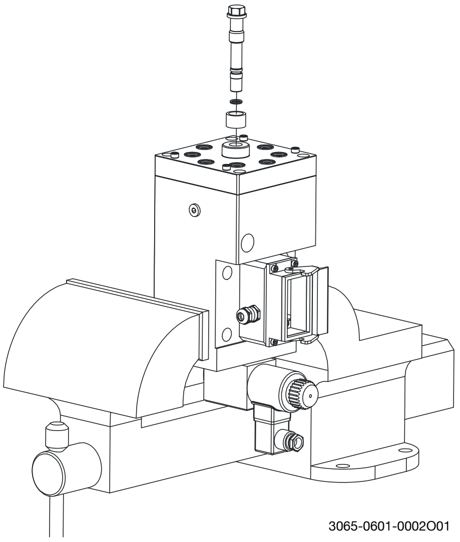
Remove the special screw.



3065-0601-0002O14

New O-ring and distance bushing

Mount the adjusting screw fitted with a new O-ring and the distance bushing.



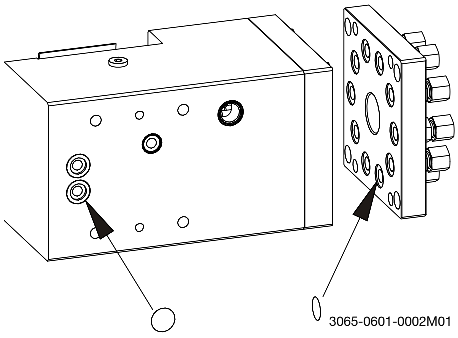
Remember !

If the lubricator is not to be mounted on the engine immediately after overhauling, cover all openings with plastic to prevent dirt from entering the lubricator during storage.

Cover all surfaces with a thin layer of oil.

New O-ring on the lubricator

Mount new O-rings on the lubricator and on the cover with pipes.



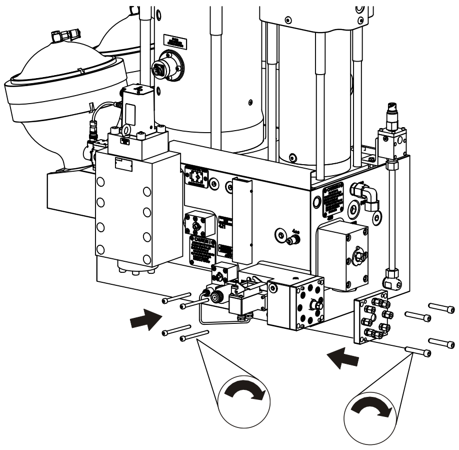
3065-0601-0002M01

Mounting the lubricator and cylinder oil supply pipe

Mount the lubricator and tighten the screws on the hydraulic cylinder unit.

Tighten the screws in the aft end of the lubricator to the pipe connection.

Mount the cylinder oil supply pipe.



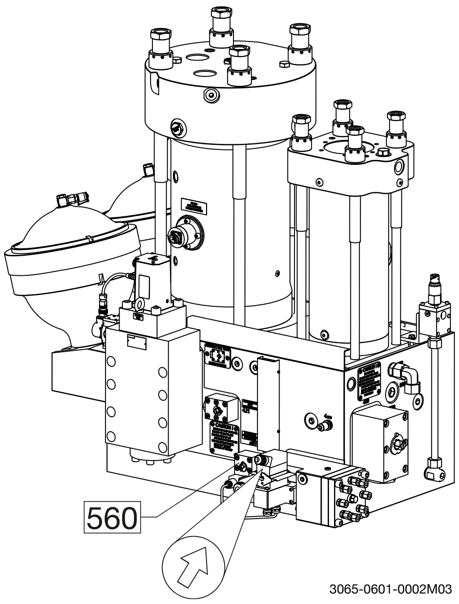
3065-0601-0002M02

Finally

Mount the electrical plug. Check the injection of cylinder oil on the feedback LED on the terminal box for the specific lubricator.

Open valve 560 for hydraulic oil supply.

Open the valve for cylinder lubricating oil supply.



3065-0601-0002M03

Preface Chapter Compressed Air System 3440-0100-0002

Drawing Starting Air System 3455-0100-0002

Work Card Starting Air Valve, Data 3465-0200-0002
Starting Air Valve 3465-0201-0002

Plate Starting Air System, Air Reciever 3472-0150-0002
Starting Air Valve 3472-0200-0003
Main Starting Air Valve 3472-0300-0004
Starting Air Safety Cap 3472-0900-0005
Control Air System 3472-0250-0001

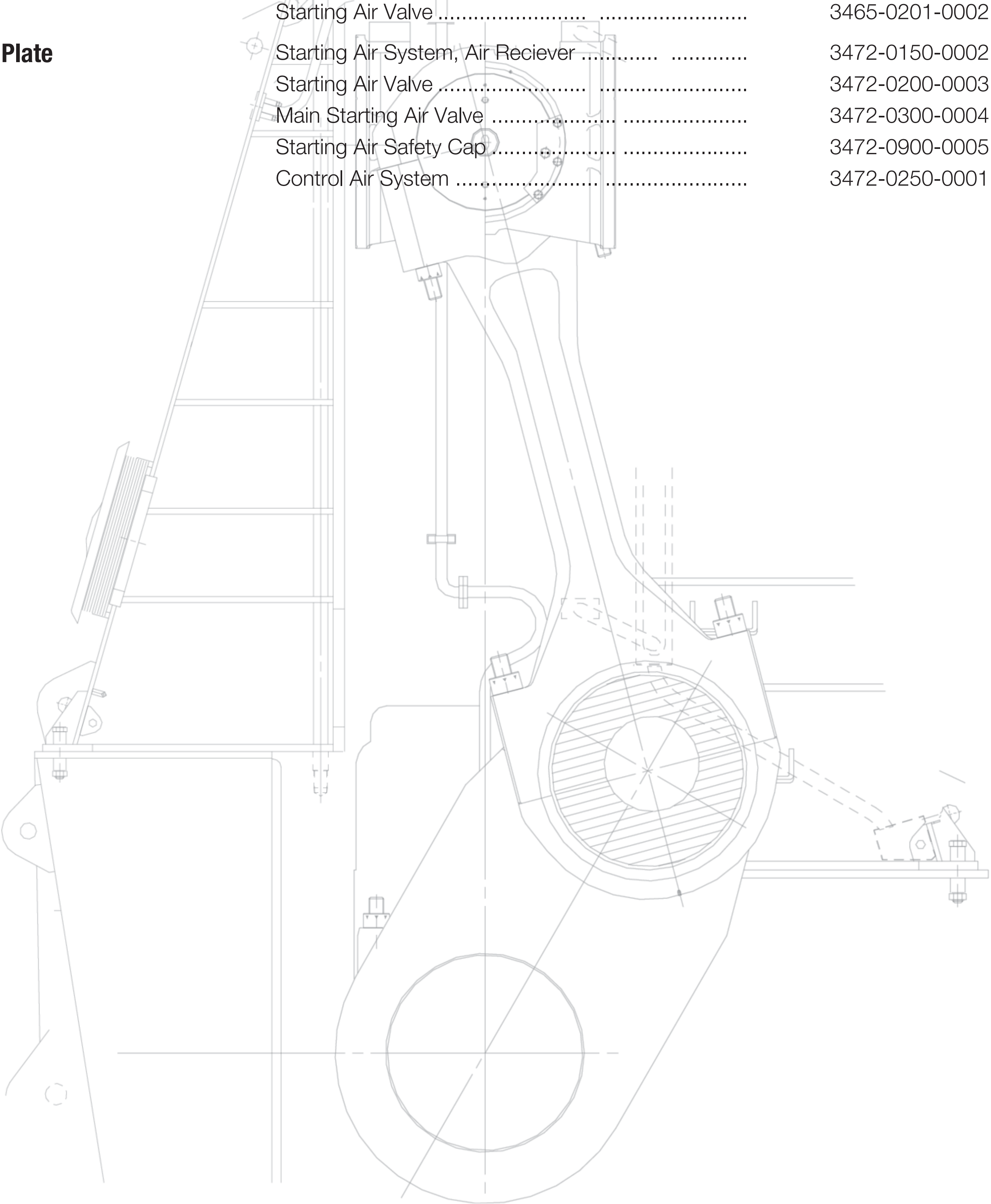
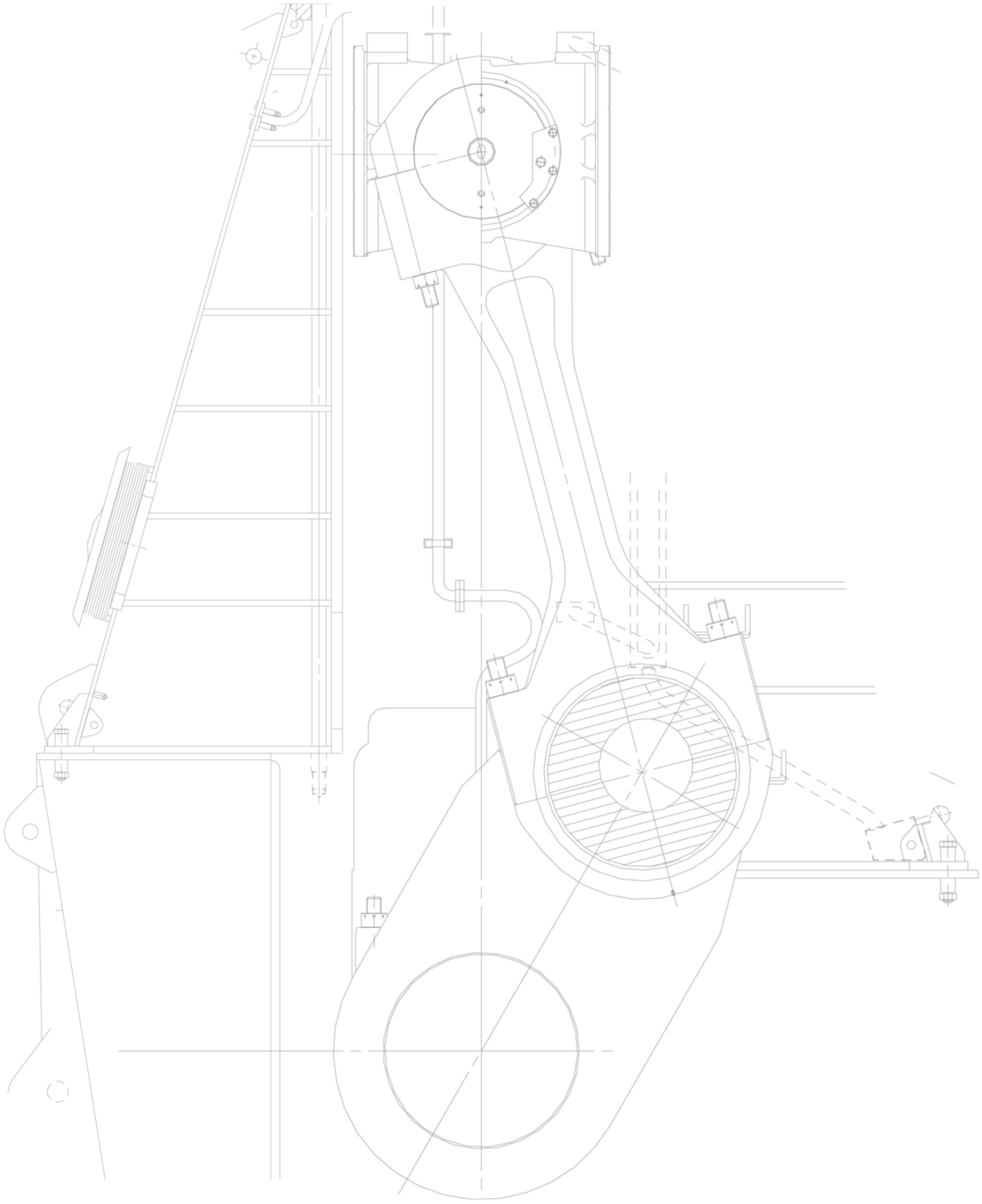


Table of contents



Starting Air System

The starting air system consists of the manoeuvring system and the starting air components, which comprise:

- Main Starting Valve
- Solenoid Valves
- Starting Valves

The manoeuvring system is of electric/pneumatic design. See also *Drawing 7055-0150*.

Main Starting Valve

The main starting valve is interposed in the starting air main pipe. The main starting valve consists of a large ball valve and, optionally, a smaller ball valve for slow-turning prior to starting the engine, which is fitted as a by pass for the large valve. Both valves are operated by pneumatic actuators.

If the smaller ball valve is installed, an adjusting screw will be mounted for setting the slow-turning speed.

Furthermore, a non-return valve is incorporated to prevent blowback in the event of excessive pressure in the starting air line.

The main starting valve is equipped with a blocking device consisting of a plate which by means of a hand-wheel, can be made to block the actuators.

The ball valves and their actuators are, together with the non-return valve and blocking device, built together to form a unit.

⚠ WARNING

During all inspections of the engine, the blocking device of the main starting valve must be in the BLOCKED position.

The only exception is when the starting valves are being tested for tightness, in which case the blocking device of the main starting valve must be in the WORKING position and the shutoff valve for the starting air distributor must be in the CLOSED position. *See Drawing 7055-0150.*

Solenoid Valve

The Engine Control System controls the opening and closing of the starting valves, via one solenoid pilot valve fitted for each cylinder. When actuated by the ECS, the solenoid valve leads control air from the control air system to the starting valve on the individual cylinder cover.

Starting Valves

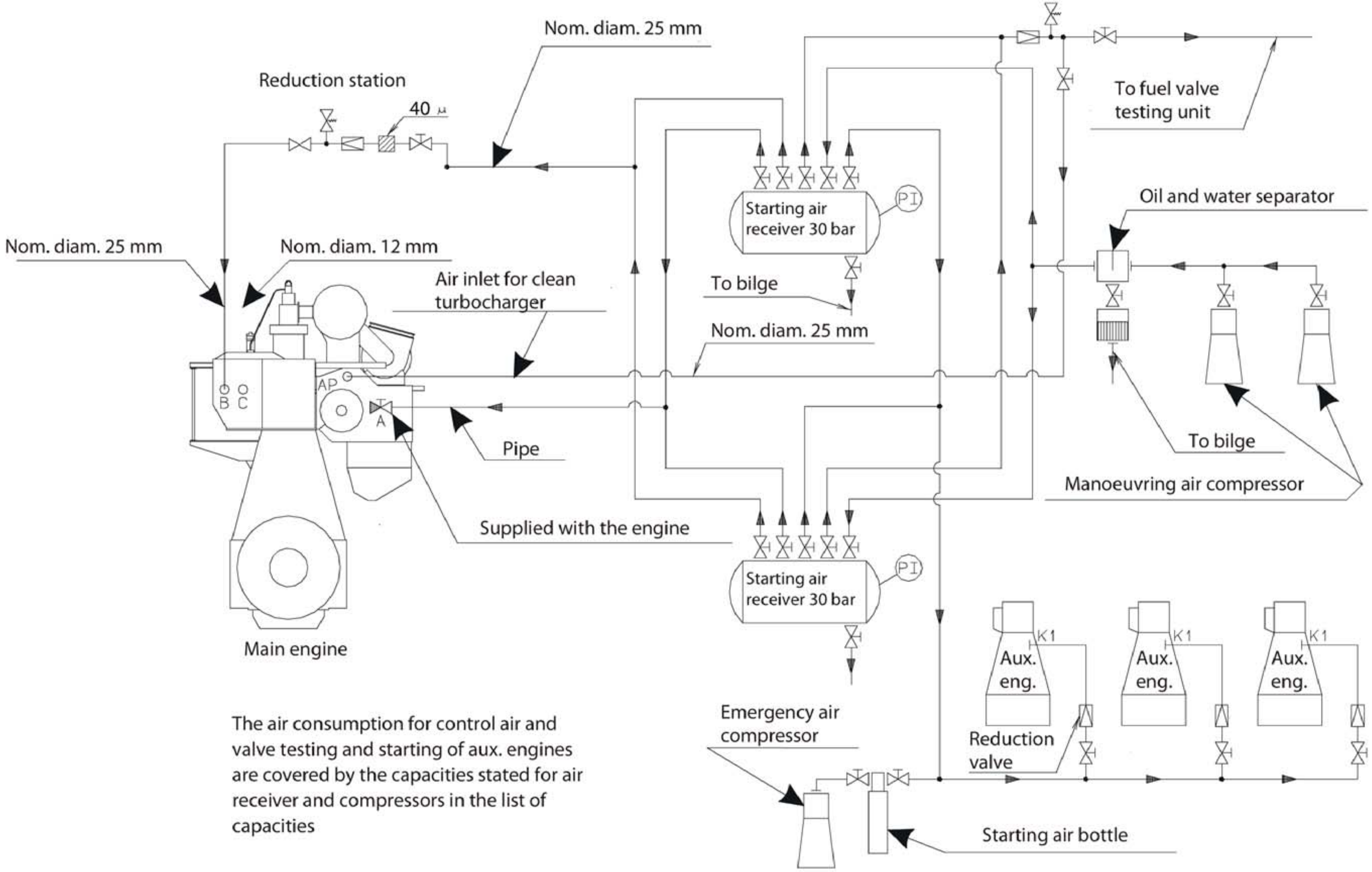
One starting valve (spring-loaded) is fitted on each cylinder cover. They are controlled by control air from the control air system.

When the main starting valve is open, the chamber below the piston of the starting valve is pressurised through the starting air pipe.

The starting valve is kept closed by the spring. When the chamber above the starting valve piston is pressurised with control air from the control air system, the starting valve opens, and starting air now flows from the starting air pipe to the cylinder.

When the starting period is finished, the chamber above the piston is vented through the vent pipe of the solenoid valve, and the starting valve will close.

The starting air in the chamber below the piston and the starting air pipe is vented slowly through small holes in the starting air pipe.



The air consumption for control air and valve testing and starting of aux. engines are covered by the capacities stated for air receiver and compressors in the list of capacities

Drawing
3455-0100-0002

Starting Air System

Starting Air Valve, Data

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T34-01	Piston tightening torque	135	Nm
T34-02	Valve tightening angle	60	°
T34-04	Starting air valve	64	kg

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.

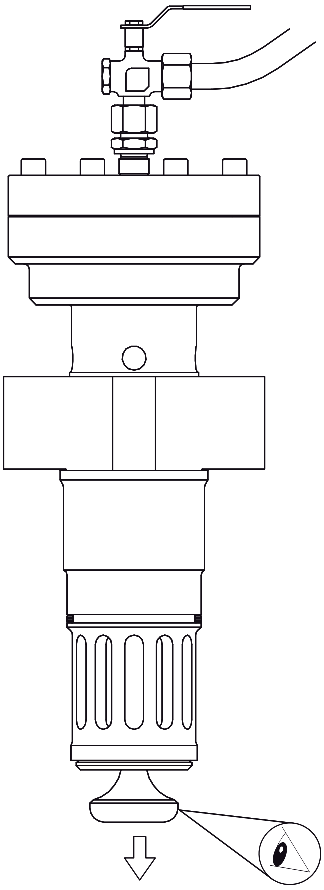
Tools

Plate	Item No.	Description
2270-0300	**083**	Handle for sundry types
2270-0300	**095**	Grinding ring for starting valve
7670-0200	**-**	Torque spanners

Air Valve

When the starting air valve has been overhauled, connect a supply of working air to the control air inlet at the top of the valve.

Check that the valve opens approx. 15-20 mm.

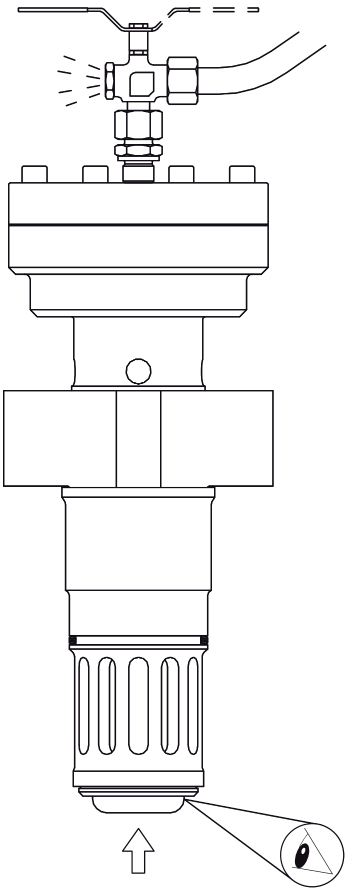


3465-0201-0002C01

Air supply

Shut off the air supply

Check that the valve closes fully.



3465-0201-0002C02

Repeat

Repeat steps 1 and 2 a couple of times.

Air pipes

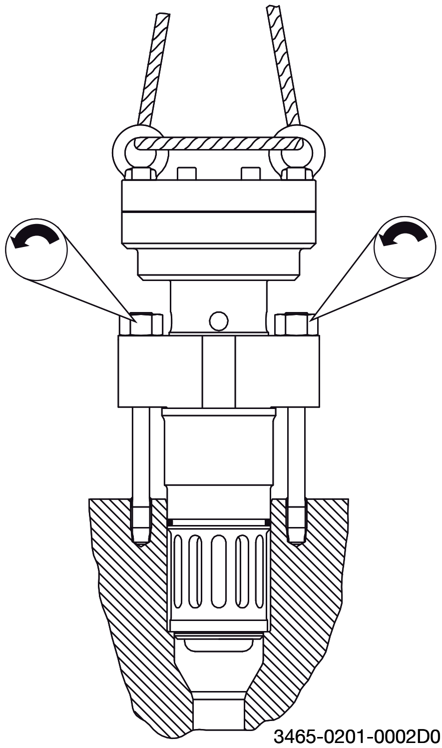
Shut off the starting air and control air inlet.

Dismount the control air pipes

Mount two eyebolts in the top cover of the valve.

Hook a lifting wire on to the eyebolts.

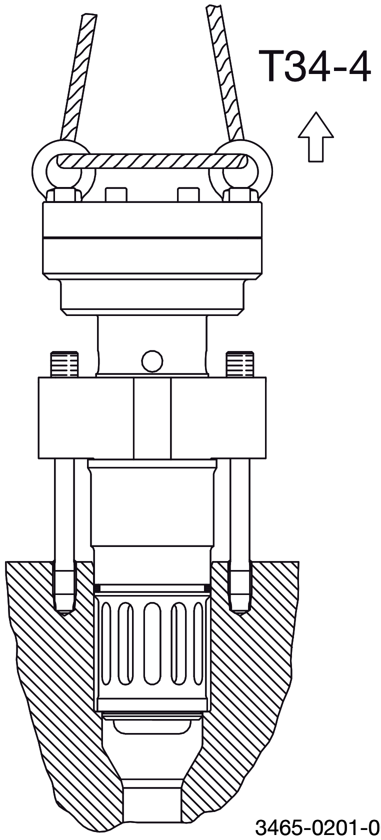
Unscrew the fixing nuts of the starting valve flange.



3465-0201-0002D01

Starting valve

Lift away the starting valve.

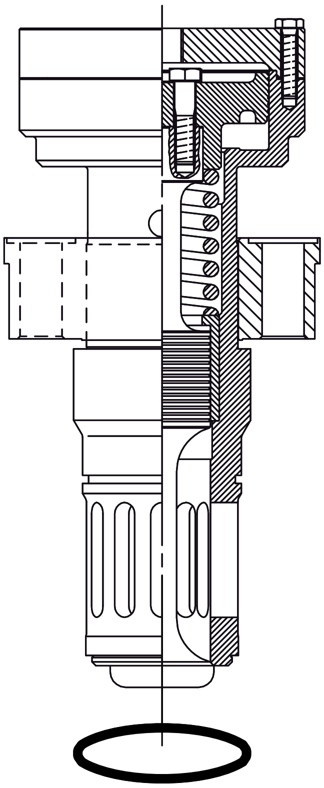


3465-0201-0002D02

O-ring

Place the starting air valve horizontally in a bench vice provided with “soft” jaws.

Remove and discard the O-ring from the valve housing.

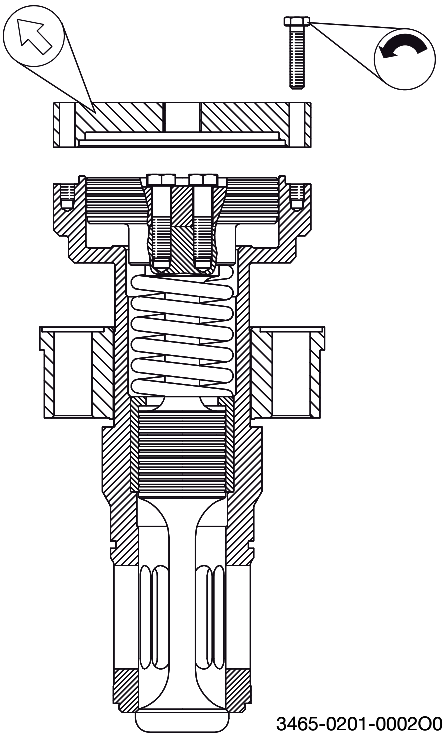


3465-0201-0002O01

Top cover

Loosen and remove the screws from the top cover.

Dismount the top cover.



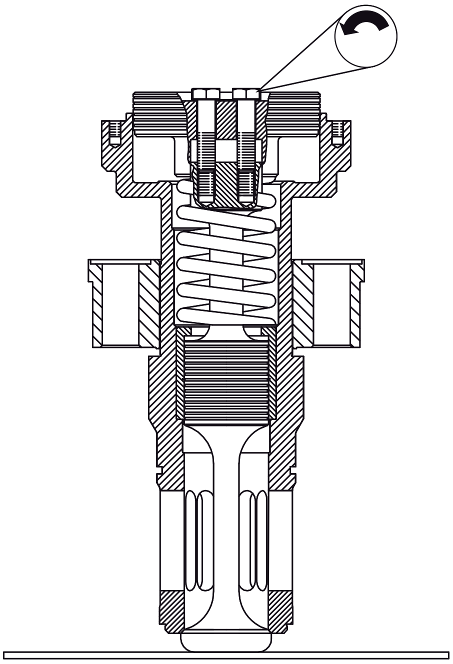
3465-0201-0002O02

Piston and spindle

Use the face wrench for the spindle as a back-stop when loosening the two screws which tighten the piston to the spindle.

Remove the screws and discard the locking device.

When unscrewing, the piston will partially be pressed out of the valve housing due to the spring force.



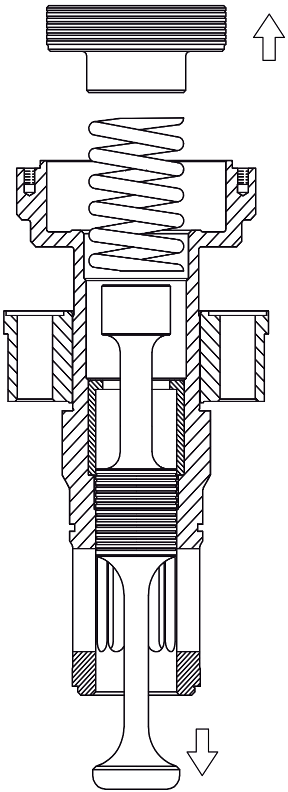
3465-0201-0002O03

Remove the spring from the top of the housing

Remove the piston from the top end of the valve housing.

Take out the spindle from the bottom end of the valve housing.

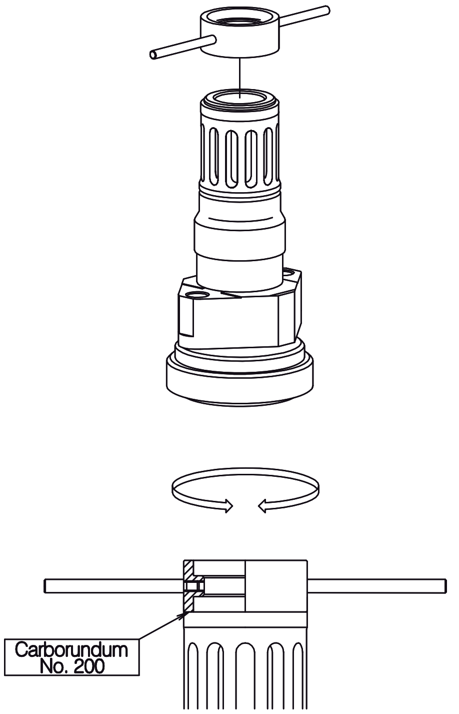
Remove the spring from the top end of the housing.



3465-0201-0002O04

Grind the valve housing seating

Apply grinding paste, e.g. carborundum No. 200. Grind the valve housing seating with the grinding ring.

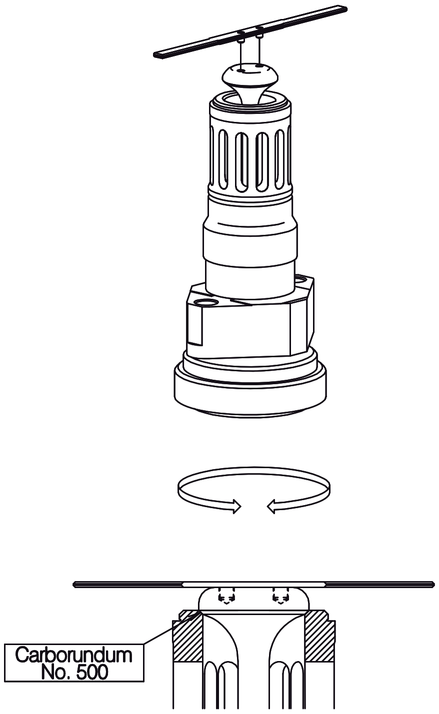


3465-0201-0002O05

Match the seatings

When lapping the seatings of the spindle and valve housing to match, use the face wrench to rotate the spindle.

As grinding paste, use e.g. carborundum No. 500.



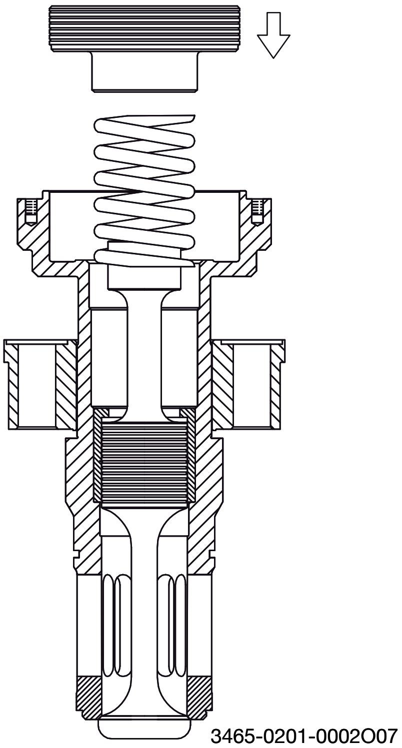
3465-0201-0002O06

Assemble the valve housing parts

Thoroughly clean the valve housing and all the parts in diesel oil or kerosene.

Lubricate all internal parts and sliding surfaces with, e.g., Molybdenum Disulphide, MoS_2.

Insert the spindle in the valve housing. Then mount the spring in the housing around the spindle and, finally, place the piston on top of the spindle.



Tighten and lock the screws

Fit the discs and the two screws.

When tightening the screws, the piston will compress the spring.

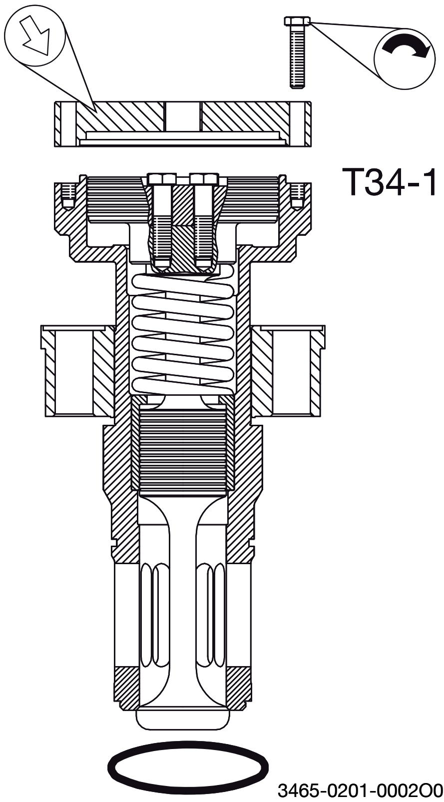
Tighten the screws continuously until the piston faces tightly against the spindle. Use the face wrench as a back-stop. *See Data.*

Lock the screws with locking device.
For correct use of locking device, see work card 7665-0501.

Top cover

Mount and tighten the top cover.

Fit a new O-ring on the valve housing.



3465-0201-0002O09

Starting air valve

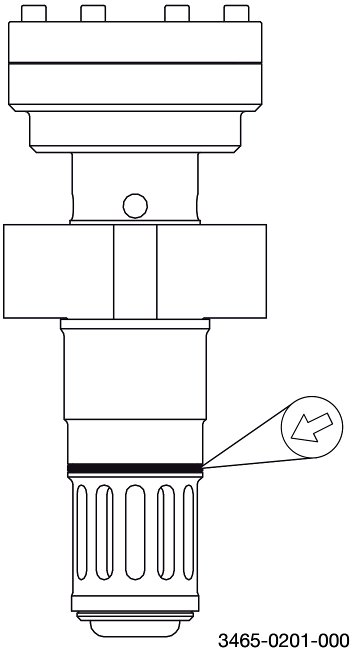
Check the starting air valve.

If the valve is not to be mounted in the engine immediately, cover all openings with plastic to prevent dirt from entering the valve during storage.

Starting valve bore

Carefully clean the starting valve bore in the cylinder cover and, if necessary, recondition the seat for the starting valve in the bore.
See work card 2265-0301.

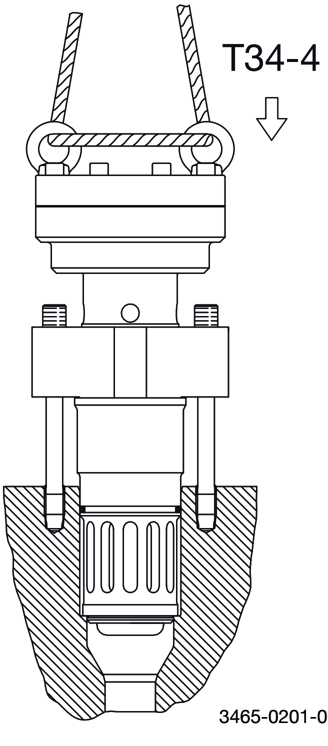
If not already done, fit a new O-ring on the overhauled valve and lubricate with 'Never Seize' or Molybdenum Disulphide, MoS_2.



3465-0201-0002M01

Mount the valve

Mount the valve in the cylinder cover.

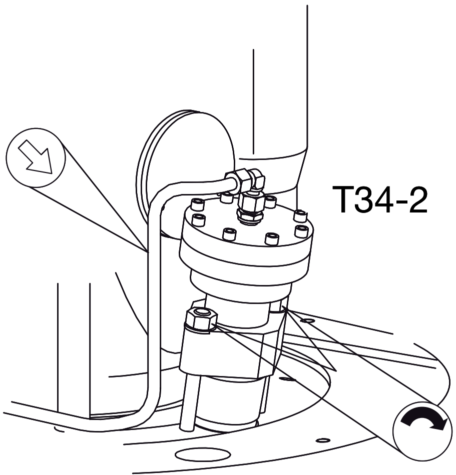


3465-0201-0002M02

Control air pipe

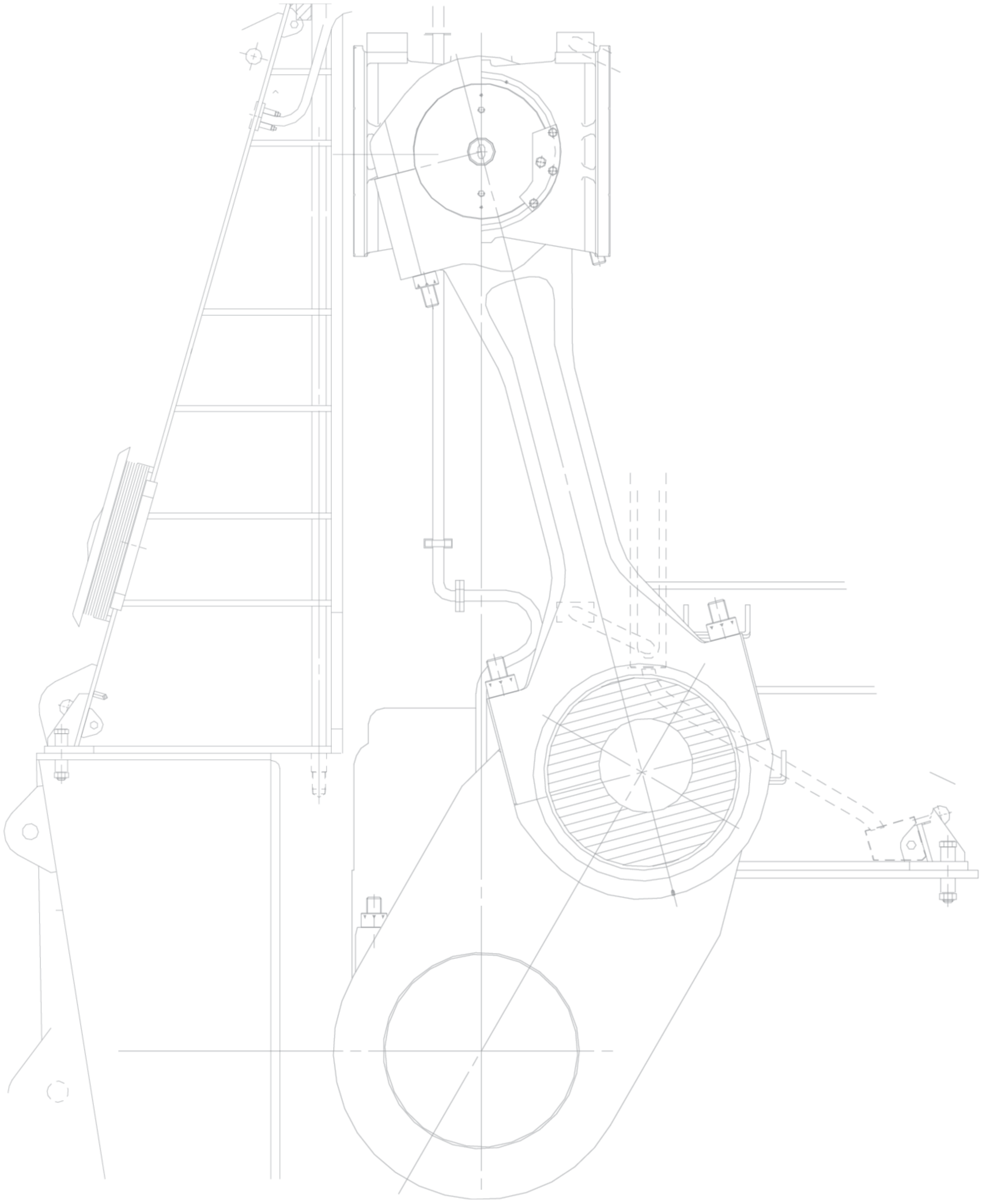
Mount the nuts and tighten-up in at least three steps, to reach the full tightening angle, *see Data.*

Mount the control air pipe and turn on starting air and control air.



3465-0201-0002M03

Preface Chapter	Fuel System	4240-0100-0002
Description	Fuel Oil	4245-0100-0003
	Pressurised Fuel Oil System	4245-0110-0003
	Fuel Treatment	4245-0120-0003
Drawing	Residual Fuel Standards	4255-0100-0003
	Fuel Oil System	4255-0105-0003
	Fuel Pipes on Engine	4255-0110-0002
	Fuel Oil Centrifuges - Mode of Operation	4255-0115-0003
	Centrifuge Flow Rate and Separation Temperature - Preheating	4255-0120-0002
	Preheating of Heavy Fuel Oil (Prior to Injection)	4255-0125-0002
Work Card	Fuel Oil High-Pressure Pipe, Data	4265-0100-0013
	Fuel Oil High-Pressure Pipe	4265-0101-0016
	Fuel Valve, Data	4265-0200-0003
	Fuel Valve	4265-0201-0002
	Fuel Valve Spindle Guide, Data	4265-0300-0001
	Fuel Valve Spindle Guide	4265-0301-0001
	Fuel Valve Non-return valve, Data	4265-0400-0001
	Fuel Valve Non-return valve	4265-0401-0003
	Fuel Oil Pressure Booster, Data	4265-0500-0009
	Fuel Oil Pressure Booster	4265-0501-0014
	Fuel Oil Pressure Booster Top Cover, Data	4265-0600-0009
	Fuel Oil Pressure Booster Top Cover	4265-0601-0013
	Fuel Oil Pressure Booster Suction Valve, Data	4265-0700-0002
	Fuel Oil Pressure Booster Suction Valve	4265-0701-0010
Tool Plate	Fuel System Panel Tools	4270-0010-0013
	Fuel Valve Nozzle Tools	4270-0210-0002
	Fuel Valve Nozzle Tools	4270-0210-0003
	Fuel Valve Testing Tools	4270-0220-0001
	Fuel Valve inspection Tools	4270-0230-0001
	Fuel Pump Top Cover Tools	4270-0900-0001
Plate	Fuel Oil System	4272-0010-0009
	Fuel Oil System By-pass Valve	4272-0030-0003
	Fuel Oil System Drain Box	4272-0040-0002
	Fuel Oil System Drain Box	4272-0040-0004
	Fuel Oil High-pressure Pipe	4272-0100-0013
	Fuel valve	4272-0200-0005
	Fuel Oil Pressure Booster	4272-0500-0015



Fuel Injection Valve Actuator

The electronically controlled fuel injection system consists of the hydraulically controlled Fuel Oil Pressure Booster, its controlling valve, i.e. FIVA (Fuel Injection Valve Actuator) valve and the fuel injection valves. The FIVA valve (controlled by the ECS) ensures fast and precise control of the oil flow to the Fuel Oil Pressure Booster. The oil flow pushes the hydraulic piston and fuel injection plunger, thus generating the injection pressure and hence the injection.

After the injection has finished, the plunger and piston are returned to their starting positions by the piston being connected to a drain and letting the pressure in the fuel supply drive the plunger back. The Fuel Oil Pressure Booster is then filled and ready for the next injection sequence. The fuel system permits continuous circulating of heated heavy fuel oil through the fuel oil pressure booster and fuel valves to keep the system heated during engine standstill.

Fuel Oil High Pressure Pipes

All high-pressure pipes in the system are provided with a protective outer pipe. The space between the pipe and the protective outer pipe communicates, through bores in the union nipples, with a drain bore in the fuel oil pressure pump top cover.

Fuel Valve

The fuel valve consists of a valve head and a valve housing. Fitted within the valve housing are a non-return valve combined with a spindle and spindle guide with a pressure spring, and a nozzle.

The spindle is provided with a cut-off slide. When the fuel valve is fitted in the cylinder cover, the valve parts are tightened together by the pressure from the securing nuts.

Functioning

The functioning of the fuel valve is as follows:

The electrical fuel oil primary pump circulates preheated oil through the fuel oil pressure booster and fuel valve. The fuel oil passes through the fuel valve, leaving through a circulation bore and the return oil pipe on the valve head.

When the pressure at the beginning of the fuel oil pressure booster's delivery stroke has reached the predetermined pressure, the circulating bores are closed.

When the pressure has reached the predetermined opening value for the fuel valve, the spindle will be lifted and oil injected through the nozzle into the engine cylinder.

On completion of the fuel oil pressure booster's delivery stroke, the valve spindle is pressed against its seat and injection now ceases. Then the circulating bore is uncovered, and oil starts to re-circulate through the valve.

1 Diesel Oil

Diesel oil fulfilling:

ISO 8217, CIMAC no. 21, British Standard MA 100 Class M2, ASTM Classification of Diesel fuel oil D975 grade No. 4-D, or similar; may be used. If deviating qualities are applied, the engine must be prepared for this.

2 Heavy Oil

Most commercially available fuel oils with a viscosity below 700 cSt. at 50°C (7000 sec. Redwood I at 100°F) can be used.

For guidance on purchase, reference is made to ISO 8217, BS6843 and to CIMAC recommendations no. 21 regarding requirements for heavy fuel for diesel engines, edition 2003. From these, the maximum accepted grades are RMG 700 and RMK 700. The mentioned ISO and BS standards supersede BS MA 100 in which the limit is M9.

For reference purposes, an extract from relevant standards and specifications is shown in *Drawing 4255-0100*.

The data in the above fuel standards and specifications refer to fuel as delivered to the plant, i.e. before cleaning.

In order to ensure effective and sufficient cleaning of the fuel oil – i.e. removal of water and solid contaminants – the fuel oil specific gravity at 15°C (60°F) should be below 1.010 for e.g. ALCAP.

Higher densities can be allowed if special treatment systems are installed. *See Chapter 4245-0120*.

Current analysis information is not sufficient for estimating the combustion properties of the oil.

This means that service results depend on oil properties which cannot be known beforehand. This especially applies to the tendency of the oil to form deposits in combustion chambers, gas passages and turbines. It may therefore be necessary to rule out some oils that cause difficulties.

If the plant has been out of service for a long time without circulation of fuel oil in the tanks (service and settling), the fuel must be circulated before start of the engine.

Before starting the pump(s) for circulation, the tanks are to be drained for possible water settled during the stop.

The risk of concentration of dirt and water in the fuel to the engines caused by long time settling is consequently considerably reduced. For treatment of fuel oil, *see further on in this Chapter.*

3 Fuel Sampling

3.1 Sampling

To be able to check whether the specification indicated and/or the stipulated delivery conditions have been complied with, we recommend that a minimum of one sample of each received fuel lot be retained. In order to ensure that the sample is representative for the oil received, a sample should be drawn from the transfer pipe at the start, in the middle, and at the end of the receiving period.

3.2 Analysis of Samples

The samples received from the oil supply company are frequently not identical with the heavy fuel oil actually received. It is also appropriate to verify the heavy fuel oil properties stated in the delivery note documents, such as density, viscosity, and pour point. If these values deviate from those of the heavy fuel oil received, there is a risk that the heavy fuel oil separator and the preheating temperature are not set correctly for the given injection viscosity.

3.3 Sampling Equipment

Several suppliers of sampling and fuel test equipment are available on the market, but for more detailed and accurate analyses, a fuel analysing institute should be contacted.

4 Guiding Fuel Oil Specification

4.1 Heavy Fuel Specifications

Based on our general service experience we have, as a supplement to the above-mentioned standards, drawn up the guiding fuel oil specification shown in the table below.

Fuel oils limited by this specification have, to the extent of the commercial availability, been used with satisfactory results on MAN Diesel & Turbo two-stroke low speed diesel engines, as well as MAN Diesel & Turbo auxiliary engines.

Guiding specification (maximum values)	Unit	Fuel Oil
Density at 15°C	kg/m^3	1010[1]
Kinematic viscosity at 100°C	cSt	55
Kinematic viscosity at 50°C	cSt	700
Flash point	°C	≥60
Pour point	°C	30
Carbon residue	%(m/m)	20
Ash	%(m/m)	0.15
Total sediment after ageing	%(m/m)	0.10
Water	%(v/v)	0.5

Guiding specification (maximum values)	Unit	Fuel Oil
Sulphur	%(m/m)	Statutory requirements
Vanadium	mg/kg	450
Aluminium + Silicon	mg/kg	60
Equal to ISO 8217 RMK 700/CIMAC H700		

1) 991 if older centrifuges are installed.

NOTICE

The Heavy Fuel data refers to the fuel as supplied, i.e. before any onboard cleaning.
If fuel oils with analysis data exceeding the above figures are to be used, especially with regard to viscosity and specific gravity, the engine builder should be contacted for advice regarding possible fuel oil system changes.

On account of the relatively low commercial availability, only limited service experience has been accumulated on fuels with data exceeding the following:

Conradson Carbon	18 %
Sulphur	4 %
Vanadium	400 mg/kg

Therefore, in the case of fuels with analysis data exceeding these figures, a close watch should be kept on engine performance.

1 System Layout

The system is normally arranged such that both diesel oil and heavy fuel oil can be used as fuel. *See Drawings 4255-0105 and -0110*

Drawing 4255-0105 shows the fuel system.

From the storage tanks, the oil is pumped to an intermediate tank, from which the centrifuges can deliver it to the respective service tanks (“day-tank”).

To obtain the most efficient cleaning, the centrifuges are equipped with preheaters, so that the oil can be preheated to 98°C (regarding the cleaning, *see Chapter 4245-0120). Also refer to SL 05-452/KEA.*

From the particular service tank in operation, the oil is led to one of the two electrically driven supply pumps.

These pumps deliver the oil, under a pressure of about 4 bar, through an automatic filter and a flow-meter.

Thereupon the oil continues to the low pressure side of the fuel oil system.

The filter mesh shall correspond to an absolute fineness of 10 µm. The absolute finess corresponds to a nominal finess of approximatly 5 µm, at a retaining rate of 90 %.

The oil is thereafter drawn to one of two electrically driven circulating pumps, which passes it through the preheater, the viscosity regulator, the filter, and on to the fuel injection pumps.

The filter mesh shall correspond to an absolute fineness of maximum 150 µm.

The return oil from the fuel valves and pumps is led back, via the venting pipe, to the suction side of the circulating pump.

In order to maintain a constant pressure in the main line at the inlet to the fuel pumps, the capacity and delivery rate of the circulating pump exceeds the amount of fuel consumed by the engine.

In addition, a spring-loaded overflow valve is fitted, which functions as a by-pass between the fuel oil inlet to the fuel injection pumps and the fuel oil return, thus ensuring a constant pressure in the fuel oil inlet line.

The fuel oil drain pipes are equipped with heat tracing, through which hot jacket cooling water flows. The drain pipe heat tracing must be in operation during running on heavy fuel. *See also Drawing 5055-0110.*

To ensure an adequate flow of heated oil through the fuel pumps, housings and fuel valves at all loads (including stopped engine), the fuel valves are equipped with a slide and circulating bore.

By means of the “built-in” circulation of preheated fuel oil, the fuel pumps and fuel valves can be maintained at service temperature, also while the engine is stopped.

Consequently, it is not necessary to change to diesel oil when the engine is stopped, provided that the circulating pump is kept running and preheating of the circulated fuel oil is maintained, *see Chapter 4245-0120.*

If, during long standstill periods, it is necessary to stop the circulating pump or the preheating, the fuel oil system must first be emptied of the heavy oil.

This is carried out by:

- Changing to diesel oil in due time before the engine is stopped, *see Chapter 4245-0120*, or
- Stopping the preheating, and pumping the heavy oil back to the service tank, through the change-over valve mounted at the top of the venting pipe. *See Chapter 4245-0120*.

2 Fuel Oil Pressure

Carry out adjustment of the fuel oil pressure, during engine standstill, in the following way:

1. Adjust the valves in the system as for normal running, thus permitting fuel oil circulation.
2. Start the supply and circulating pumps, and check that the fuel oil is circulating.
3. Supply Pumps:
   Adjust the spring-loaded safety valve at supply pump No. 1 to open at the maximum working pressure of the pump.
   The pressure must not be set below 4 bar, due to the required pressure level in the supply line, see point 4.
   Make the adjustment gradually, while slowly closing and opening the valve in the discharge line, until the pressure, with closed valve, has the above-mentioned value.

Carry out the same adjustment with supply pump No. 2.

4. Regulate the fuel oil pressure, by means of the over-flow valve between the supply pump’s discharge and suction lines. Adjust so that the pressure in the low pressure part of the fuel system is 4 bar.
5. Circulating Pumps:
   With the supply pumps running at 4 bar outlet pressure, secure that the spring-loaded relief by-pass valves for each circulating pump (the valve is preset from the valve manufacturer) open at the maximum working pressure of the circulation pumps involved, about 10 bar.
   If adjustments have to be made, regulate the spring tension in the relief bypass valve(s), see valve maker’s instruction.
6. Fuel Line: Regulate the fuel oil pressure by means of the spring-loaded overflow valve installed between the main inlet pipe to the fuel injection pumps and the outlet pipe on the engine. Adjust the overflow valve so that the pressure in the main inlet pipe is 7-8 bar, *See also Chapter 7045-0100.*
7. With the engine running, the pressure will fall a little. Re-adjust to the desired value at MCR.

1 Cleaning

1.1 General

Fuel oils are always contaminated and must therefore, before use, be thoroughly cleaned for solid as well as liquid contaminants.

The solid contaminants are mainly rust, sand and refinery catalytic fines ("cat fines"); the main liquid contaminant is water, – i.e. either fresh or salt water.

These impurities can:

- cause damage to fuel pumps and fuel valves.
- result in increased cylinder liner wear.
- be detrimental to exhaust valve seatings.
- give increased fouling of gasways and turbocharger blades.

1.2 Centrifuging

Effective cleaning can only be ensured by means of centrifuges.

The ability to separate water depends largely on the specific gravity of the fuel oil relative to the water – at the separation temperature. In addition, the fuel oil viscosity (at separation temp.) and flow rate, are also influencing factors.

The ability to separate abrasive particles depends upon the size and specific weight of the smallest impurities that are to be removed; and in particular on the fuel oil viscosity (at separation temp.) and flow rate through the centrifuge.

To obtain optimum cleaning, it is of the utmost importance to:

a. operate the centrifuge with as low a fuel oil viscosity as possible.
b. allow the fuel oil to remain in the centrifuge bowl for as long as possible.

Re a.

The optimum (low) viscosity, is obtained by running the centrifuge preheater at the maximum temperature recommended for the fuel concerned.

NOTICE

It is especially important that, in the case of fuels above 1500 Sec. RW/ 100°F (i.e. 180 cSt/50°C), the highest possible preheating temperature – 98°C – should be maintained in the centrifuge preheater. *See Drawing 4255-0120.* Also refer to SL 05-452/KEA.

The centrifuge should operate for 24 hours a day except during necessary cleaning.

Re 2.

The fuel is kept in the centrifuge as long as possible, by adjusting the flow rate so that it corresponds to the amount of fuel required by the engine, without excessive re-circulation.

The ideal output should thus correspond to the normal amount of fuel required by the engine, plus the amount of fuel consumed during periods when the centrifuge is stopped for cleaning.

The nominal capacity of the installed centrifuges must be according to the maker's instructions.

For efficient removal of water by means of a conventional purifier, the correct choice of gravity disc is of special importance. The centrifuge manual states the disc which should be chosen, corresponding to the specific gravity of the fuel in question.

Centrifuge Capacity: Series or Parallel Operation

It is normal practice to have at least two centrifuges available for fuel cleaning. *See Drawing 4255-0115*

Regarding centrifuge treatment of today's residual fuel qualities, the latest experimental work has shown that, the best mode of operating modern centrifuges with no gravity disc, is when the centrifuges are operated in parallel.

Experiments have shown, that when running the centrifuges i series, particles which are not removed during treatment in the first centrifuge are not removed during treatment in the second centrifuge either. Therefore, running the centrifuges i parallel, provides the oportunity of decreasing the flow through the centrifuges, as the amount of fuel that need be treated per hour, is shared by two centrifuges, thus increasing the cleaning quality.

However, it is recommended to follow the maker's specific instructions, *see item 1.3.*

Regarding the determination/checking of the centrifuging capacity, we generally advise that the recommendations of the centrifuge maker are followed, but the curves shown on *Drawing 4255-0120* can be used as a guidance.

1.3 High Density Fuels

To cope with the trend towards fuels with density exceeding 991 kg/m^3 at 15°C, the centrifuging technology has been further developed.

Improved centrifuges, with automatic de-sludging provides adequate separation of water and particles from the fuel, up to a density of 1010 kg/m^3 at 15°C.

The centrifuges should be operated in parallel or in series according to the maker's instructions and recommendations.

1.4 Homogenisers

As a supplement only (to the centrifuges), a homogeniser may be installed in the fuel oil system, to homogenise possible water and sludge still present in the fuel after centrifuging. A homogenizer should always be installed AFTER the centrifuges.

1.5 Fine Filter

As a supplement only (to the centrifuges), a fine filter with very fine mesh may be installed, to remove possible contaminants present in the fuel after centrifuging.

A homogeniser should be inserted before a possible fine filter in order to minimise the risk of blocking by agglomeration of asphaltenes.

1.6 Super Decanters

As a supplement only, a super decanter may be installed. This is, in principle, a “horizontal” clarifier. The aim is to remove sludge before normal centrifuging and thus minimize the risk of blocking of the centrifuges.

2 Fuel oil stability

Fuel oils of today are produced on the basis of widely varying crude oils and refinery processes. Practical experience has shown that, due to incompatibility, certain fuel types may occasionally tend to be unstable when mixed.

As a consequence, fuel mixing should be avoided to the widest possible extent.

A mixture of incompatible fuels, in the storage tanks and the settling tanks, may lead to stratification, and also result in rather large amounts of sludge being taken out by the centrifuges, in some cases even causing centrifuge blocking.

Stratification can also take place in the service tank, leading to a fluctuating preheating temperature, when this is controlled by a viscorator.

Service tank stratification can be counteracted by recirculating the contents of the tank through the centrifuge. This will have to be carried out at the expense of the previously mentioned benefits of low centrifuge flow rate.

3 Preheating before Injection

In order to ensure correct atomization, the fuel oil has to be preheated before injection.

The necessary preheating temperature is dependent upon the specific viscosity of the oil in question.

Inadequate preheating (i.e. too high viscosity):

- will influence combustion,
- may cause increased cylinder wear (liners and rings),
- may be detrimental to exhaust valve seatings,
- may result in too high injection pressures, leading to excessive mechanical stresses in the fuel oil system.

In most installations, preheating is carried out by means of steam, and the resultant viscosity is measured by a viscosity regulator (viscorator), which also controls the steam supply.

Depending upon the viscosity/temperature relationship, and the viscosity index of the fuel oil, an outlet temperature of up to 150°C will be necessary. This is illustrated in the diagram on *Drawing 4255-0125,* which indicates the expected preheating temperature as a function of the fuel oil viscosity.

Recommended viscosity meter setting is 10-15 cSt.

As opposed to a too high viscosity, experience from service has shown that a higher viscosity of the fuel oil than the above recommended, before the fuel oil pump, is not a too strict parameter, for which reason we allow a viscosity of up to 20 cSt after the preheater.

In order to avoid too rapid fouling of the preheater, a temperature of 150°C should not be exceeded.

3.1 Precaution

Caution must be taken to avoid heating the fuel oil pipes by means of the heat tracing when changing from heavy fuel to diesel oil, and during running on diesel oil.

Under these circumstances excessive heating of the pipes may reduce the viscosity too much, which will involve the risk of the fuel pumps running hot, thereby increasing the risk of sticking of the fuel pump plunger and damage to the fuel oil sealings. *(See item 4.2).*

3.2 Fuel Preheating during engine standstill

During engine standstill, the circulation of preheated heavy fuel oil (HFO) does not require the viscosity to be as low as is recommended for injection. Thus, in order to save energy, the preheating temperature may be lowered some 20°C, giving a viscosity of about 30 cSt.

3.3 Starting after engine standstill

If the engine has been stopped on HFO, and the HFO has been circulated at a reduced temperature during standstill, the preheating and viscosity regulation should be made operative about one hour before starting the engine, so as to obtain the required viscosity, *see Item 3., ‘Preheating before Injection’.*

4 Other Operational Aspects

4.1 Circulating Pump Pressure

The fuel oil pressure measured on the engine (at fuel pump level) should be 7-8 bar, equivalent to a circulating pump pressure of up to 10 bar. This maintains a pressure margin against gasification and cavitation in the fuel system, even at 150°C.

The supply pump may be stopped when the engine is not in operation.
See Drawing 4255-0105.

4.2 Fuel change-over

The engine is equipped with uncooled, “all-symmetrical”, light weight fuel valves – with built-in fuel circulation. This automatic circulation of the preheated fuel (through the high-pressure pipes and the fuel valves) during engine standstill, is the background for MAN Diesel & Turbo recommending *constant operation on heavy fuel.*

However, change-over to diesel oil can become necessary if, for instance:

- the vessel is expected to have a prolonged inactive period with cold engine, e.g. due to:
  - a major repair of the fuel oil system etc.
  - a docking
  - more than 5 days’ stop (incl. laying-up)
- environmental legislation requiring the use of low-sulphur fuels.

Change-over can be performed at any time:

- during engine running
- during engine standstill

In order to prevent:

- fuel pump and injector sticking/scuffing
- poor combustion
- fouling of the gasways

it is very important to carefully follow the temperature / load requirements of the change-over procedures.

4.3 Change-over between heavy fuel oil (HFO) and distillate fuel (DFO) during running

Before the intended change-over from HFO to DFO and vice versa, we recommend checking the compatibility of the two fuels – preferably at the bunkering stage. The compatibility can be checked either by an independent laboratory or by using test kits onboard.

As incompatible fuels may lead to filter blockage, there should be extra focus on filter operation in case of incompatibility.

Change-over of fuel can be somewhat harmful for the fuel equipment, because hot HFO is mixed with relatively cold DFO. The mixture is not expected to be immediately homogeneous, and some temperature/viscosity fluctuations are to be expected. The process therefore needs careful monitoring of temperature and viscosity.

In general, only the viscosity controller should control the steam valve for the fuel oil heater. However observations of the temperature/viscosity must be the factor for manually taking over the control of the steam valve to protect the fuel components.

During change-over two factors are to be kept under observation:

- The viscosity must not drop below 2 cSt and not exceed 20 cSt.
- The rate of temperature change of the fuel inlet to the fuel pumps must not exceed 2°C/min to protect the fuel equipment from thermal shock (expansion problems) resulting in sticking.

It should be noticed that when operating on low-viscosity fuel internal leakages in the fuel equipment will increase. With worn pump elements this can result in starting difficulties, and an increased start index might be necessary. The wear in the fuel pumps should be monitored by comparing the fuel index for the new engine and during service. At a 10% increase of the fuel index for the same load the plunger/barrels can be considered as worn out and should be replaced.

A change-over of the main engine’s fuel will result in a dilution of the fuel already in the booster circuit. The fuel feed to the system will mix with fuel in the system, and the main engine’s consumption from the system will be a mixture of the fuels. A complete change of fuel (only DFO in the system) can therefore take several hours, depending on engine load, system layout and volume of fuel in the booster-circuit.

Before manoeuvring in port, it should be tested that the engine is able to start on DFO.

We do not recommend reducing the temperature difference between the HFO and the DFO by preheating the DFO in the service tank. This will reduce the cooling capacity of the oil and might result in a too low viscosity during change-over.

4.3.1 Manual change-over

4.3.1.1 Distillate fuel oil to heavy fuel oil

- Ensure that the HFO in the service tank is at normal service temperature (80- 100°C)
- Reduce the engine load.
  The load should be 25-40% MCR during this process to ensure a slow heatup to normal HFO service temperature at engine inlet (up to 150°C), maximum change gradient 2°C/min.
- Carry out change-over by turning the three-way valve.
  The load can, based on experience with the individual system, be changed to a higher level – up to 75% MCR, as long as the change gradient is kept below 2°C/min.

- Slowly stop the cooler (if installed) when the viscosity exceeds 5 cSt .
  A slow stop of the cooler can be done by controlling the oil flow through the cooler, the cooling medium flow or a combination of both.
  The temperature change gradient at engine inlet is still to be kept below 2°C/min.
- Open for steam to pre-heater and check that the set point is at normal level (10-15 cSt).
  Manual control of the heater might be necessary if it is observed that the viscosity control exceeds the maximum temperature change gradient of 2°C/min at engine inlet.
- Open for steam tracing when the pre-heater is operating normally.

4.3.1.2 Heavy fuel oil to distillate fuel oil

- Ensure that the temperature of the DFO in the service tank is at an acceptable level. The following must be taken into consideration:

  - Viscosity at engine inlet must not drop below 2 cSt.
  - Heat transmission from metal parts in the system to the fuel will occur.
  - Cooling capacity in the system, if any
- Reduce the pre-heating of the fuel, by increasing the set point of the viscosity controller to 18 cSt.
  - Manual control of the heater might be necessary if it is observed that the viscosity control exceeds the maximum temperature change gradient 2°C/ min. at engine inlet
- Reduce the engine load when the fuel reaches a temperature corresponding to 18 cSt.
  - During this change-over the load should be 25-40% MCR to ensure a slow reduction of the temperature at engine inlet, max. change gradient 2°C/min.
- Stop steam tracing.
  Carry out change-over by turning the three-way valve.
  - The load can, based on experience with the individual system, be changed to a higher level – up to 75% MCR, as long as the change gradient is kept below 2°C/min.
- Stop steam to pre-heater when the regulating valve has closed completely.
  Depending on system layout and condition, it might be necessary to open the heater bypass.
- Slowly start the cooler (if installed) when viscosity is below 10 cSt.
  - To obtain slow start of the cooler control the oil flow through the cooler, the cooling medium flow or a combination of both.
  - Keep the temperature change gradient at engine inlet below 2°C/min.

4.4 Change-over during standstill

When change-over is to be carried out during standstill of the engine there is no consumption from the fuel system and thus, no replacement of the oil. It is therefore necessary to return the oil to the HFO service tank. This will cause some DFO to be returned to the HFO service tank. However this is better than contaminating the DFO service tank with HFO.

When change-over is performed at standstill the engine should not be started until all the components in the fuel oil system have had sufficient time to adapt to the new temperature.

4.4.1 Heavy fuel oil to distillate fuel oil

- Stop the preheating and heat tracing.
- Start the supply and circulating pumps (if they are not already running).
- Change position of the change-over valve at the venting pipe, so that the fuel oil is pumped to the HFO service tank.
- Temperature in the system should now drop to the same level as the HFO service tank temperature.
- Change position of the change-over valve at the fuel tanks, so that DFO is led to the supply pumps.
- When the HFO is replaced with DFO, turn the change-over valve at the venting pipe back to its normal position. The HFO in the venting pipe is now mixed with DFO.
- Stop the circulating pumps.
- Stop the supply pumps.

4.4.2 Distillate fuel oil to heavy fuel oil

- Start the supply pumps.
- Start the circulating pumps (if they are not already running).
- Change position of the change-over valve at the fuel tanks so that HFO is led to the supply pumps.
- Change position of the change-over valve at the venting pipe, so that the fuel oil is pumped to the HFO service tank.
- Temperature in the system should now rise to the same level as the HFO service tank temperature.
- When the DFO is replaced with HFO turn the change-over valve at the venting pipe back to its normal position. The DFO in the venting pipe is now mixed with HFO.
- Stop the supply pumps.
- Start the preheating and heat tracing.

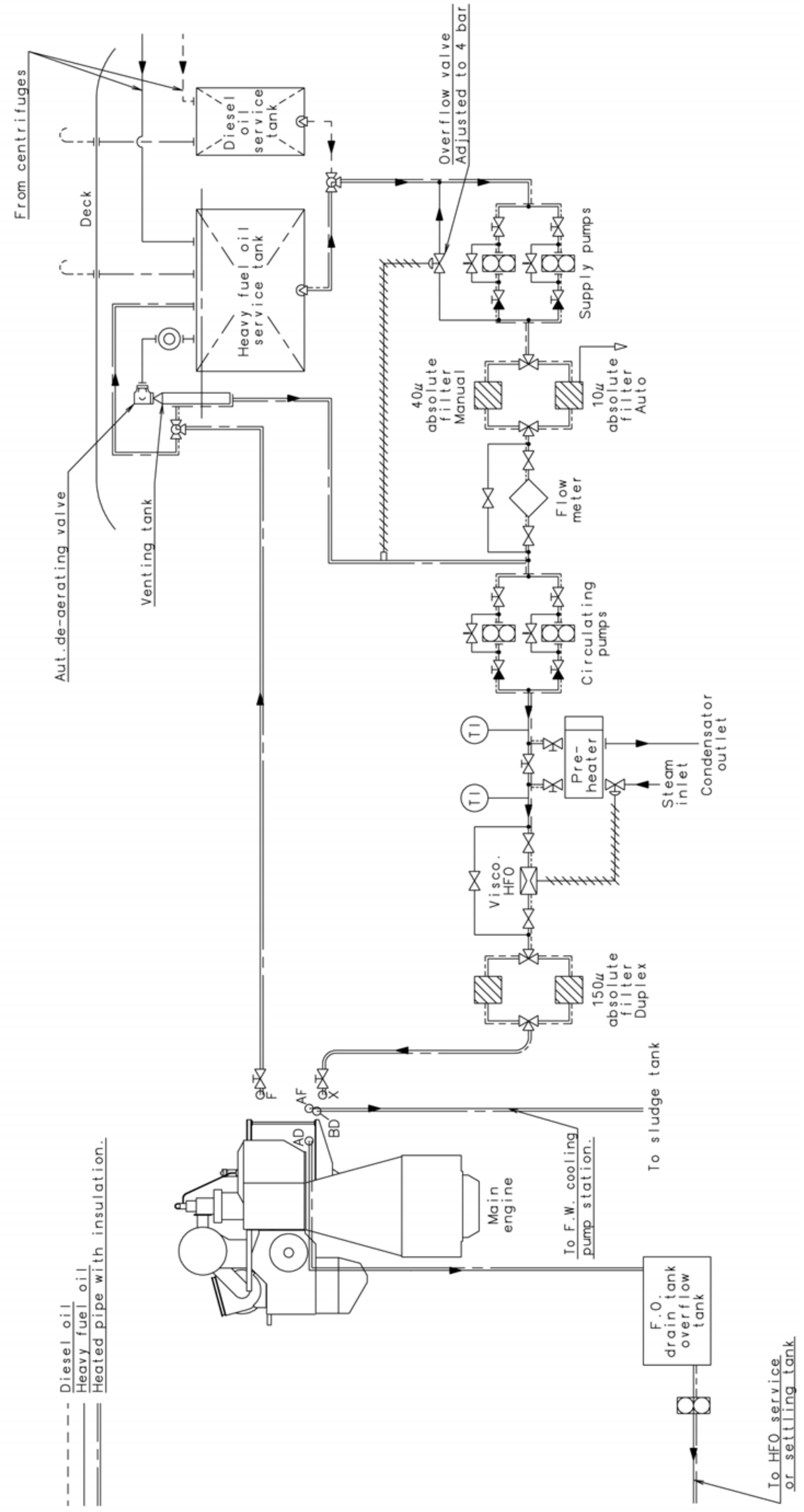
Recommendations for residual fuels for diesel engines (as received)

Note: This table is derived from CIMAC official document no. 21

Characteristics [1]	Unit	Limit	CIMAC A30	CIMAC B30	CIMAC D80	CIMAC E180	CIMAC F180	CIMAC G380	CIMAC H380	CIMAC K380	CIMAC H700	CIMAC K700	Test method reference
Density at 15 °C	Kg/m^3	Max.	960.0	975.0	980.0	991.0		991.0		1010.0	991.0	1010.0	ISO 3675 or ISO 12185 (see also 6.1)
Kinematic viscosity at 50 °C	mm^2/s [2]	Max.	30.0		80.0	180.0		380.0			700.0		ISO 3104
		Min. [3]	22.0	-	-	-		-			-		ISO 3104
Flash point	°C	Min.	60		60	60		60			60		ISO 2719 (see also 6.2)
Pour point (upper)	°C												
1. Winter quality		Max.	0	24	30	30		30			30		ISO 3016
2. Summer quality		Max.	6	24	30	30		30			30		ISO 3016
Carbon residue	% (m/m)	Max.	10		14	15	20	18	22		22		ISO 10370
Ash	% (m/m)	Max.	0.10		0.10	0.10	0.15	0.15			0.15		ISO 6245
Water	% (V/V)	Max.	0.5		0.5	0.5		0.5			0.5		ISO 3733
Sulphur [4]	% (m/m)	Max.	3.50		4.00	4.50		4.50			4.50		ISO 14596 or ISO 8754 (see also 6.3)
Vanadium	mg/kg	Max.	150		350	200	500	300	600		600		ISO 14597 or IP 501 (see also 6.8)
Total sediment potential	% (m/m)	Max.	0.10		0.10	0.10		0.10			0.10		ISO 10307-2 (see also 6.6)
Aluminium plus silicon [5]	mg/kg	Max.	80		80	80		80			80		ISO 10478
Used lubricating oil (ULO)			The fuel must be free of ULO. A fuel shall be considered free of ULO. if one or more of the elements Zinc. Phosphorus and Calcium is below or at the specified limit. <u>All</u> three elements must exceed the same limits before a fuel is to be deemed to contain ULO.										
Zinc	mg/kg	-	15										IP 501 or IP 470
Phosphorus	mg/kg	-	15										IP 501 or IP 500
Calcium	mg/kg	-	30										IP 501 or IP 470 (see also 6.7)

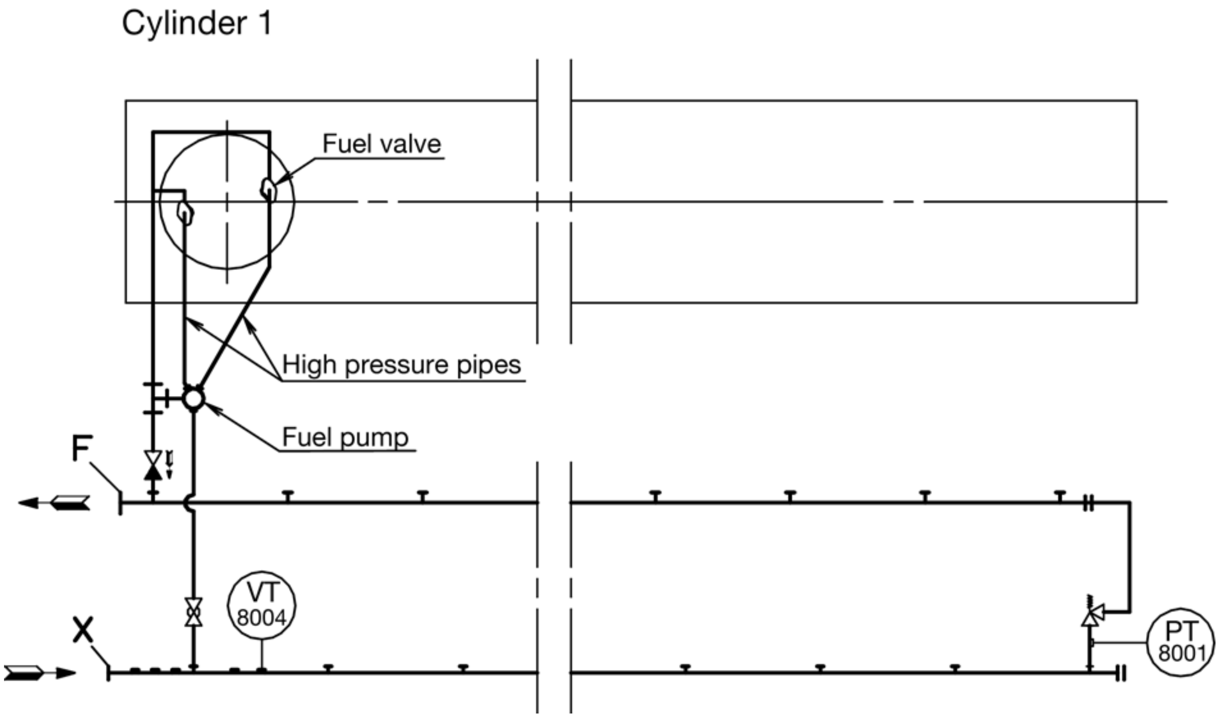
1) See General Recommendations paragraph 3 for additional characteristics not included in this table.
2) 1 mm^2/s = 1 cSt.
3) Fuels with density close to the *maximum*, but with very low viscosity, may exhibit poor ignition quality, see Annex 6.
4) A sulphur limit of 1.5% m/m, will apply to SOx Emission Control Areas designated by the IMO, when its relevant protocol comes into force. There may be local variations.
5) See Annex 3.

Fuel Oil System

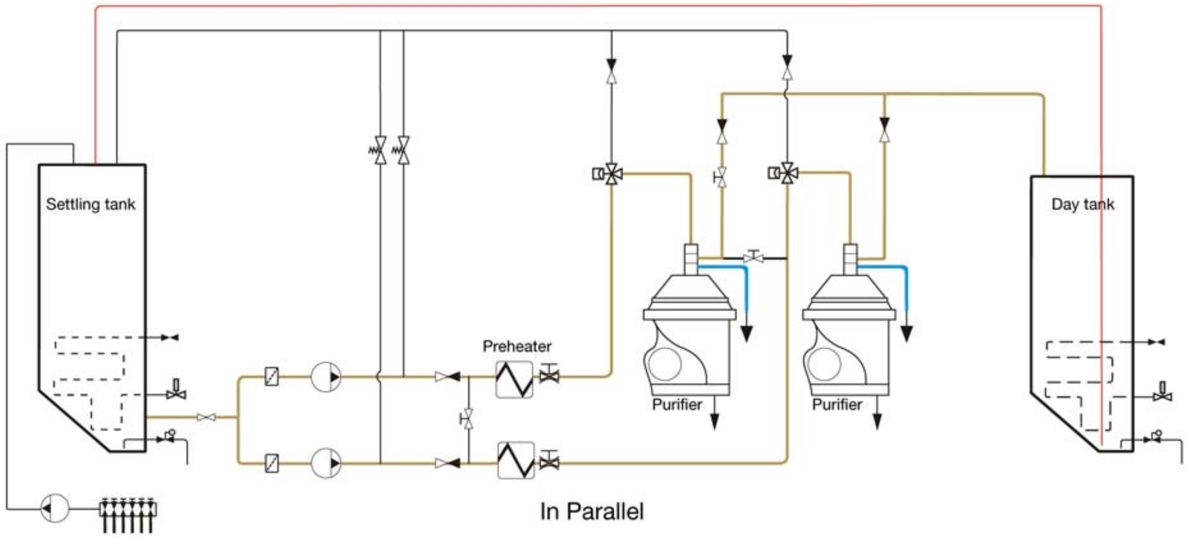


Drawing

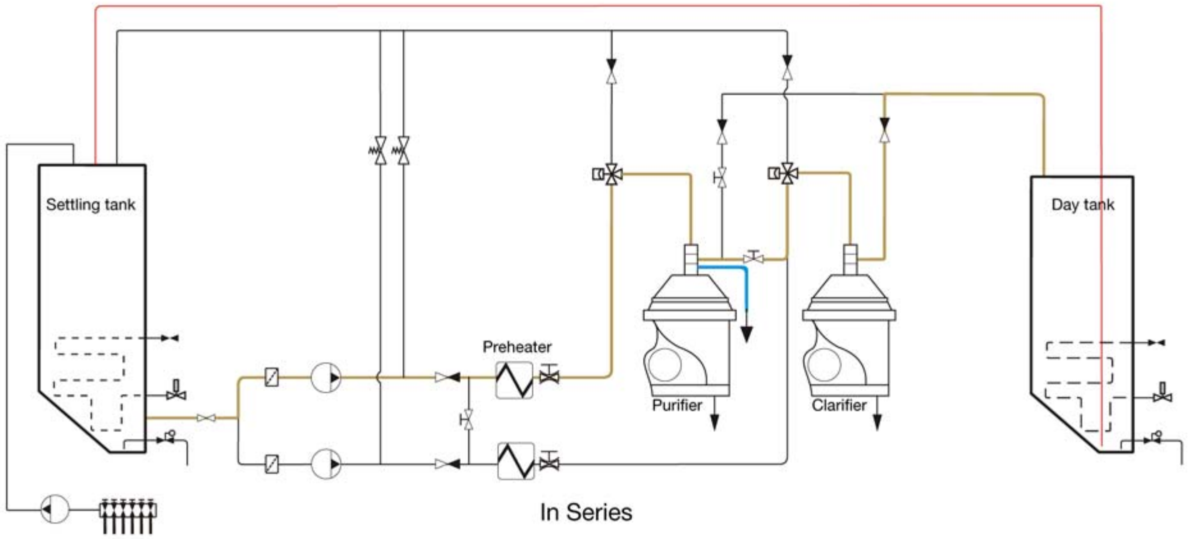
4255-0105-0003


Cylinder 1
Fuel valve
High pressure pipes
Fuel pump
F
X
VT 8004
PT 8001

Fuel Oil Centrifuges (Modes of Operation)



In Parallel



In Series

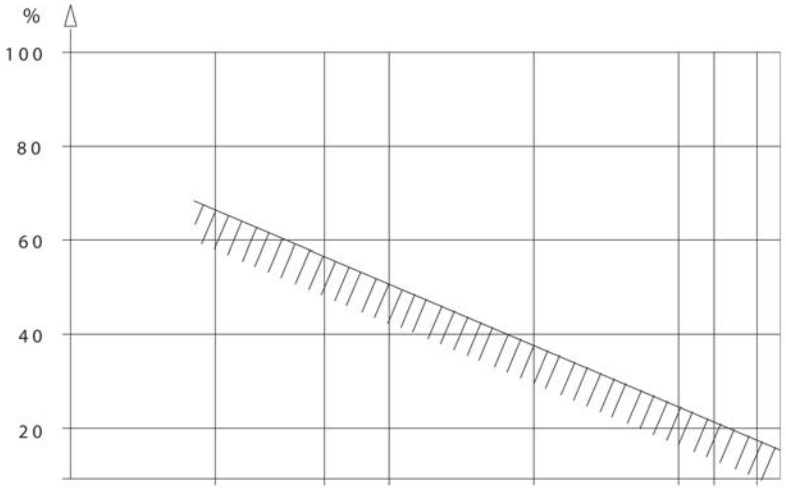
By courtesy of Alfa-Laval

Drawing
4255-0115-0003

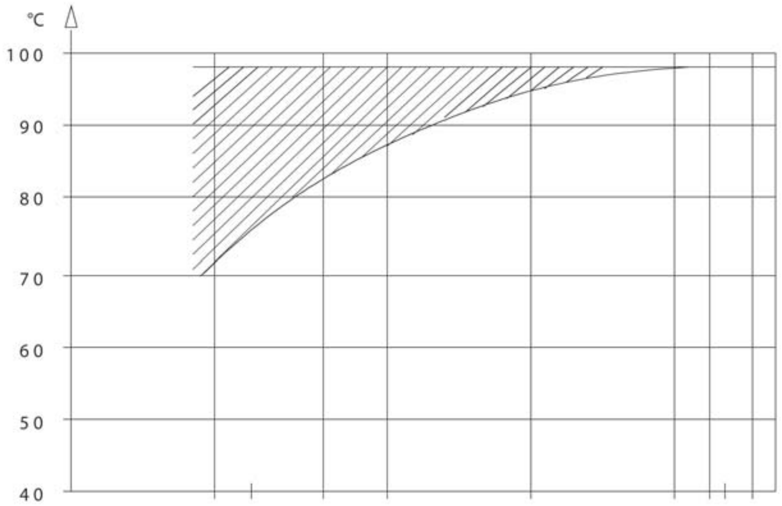
Centrifuge Flow Rate and Separation Temperature (Preheating)

Rate of Flow

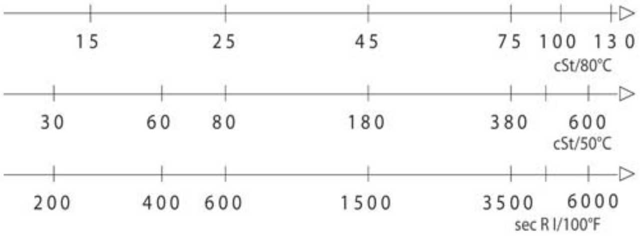
Related to rated capacity of centrifuge



Separation Temperature



Log Scales



Drawing

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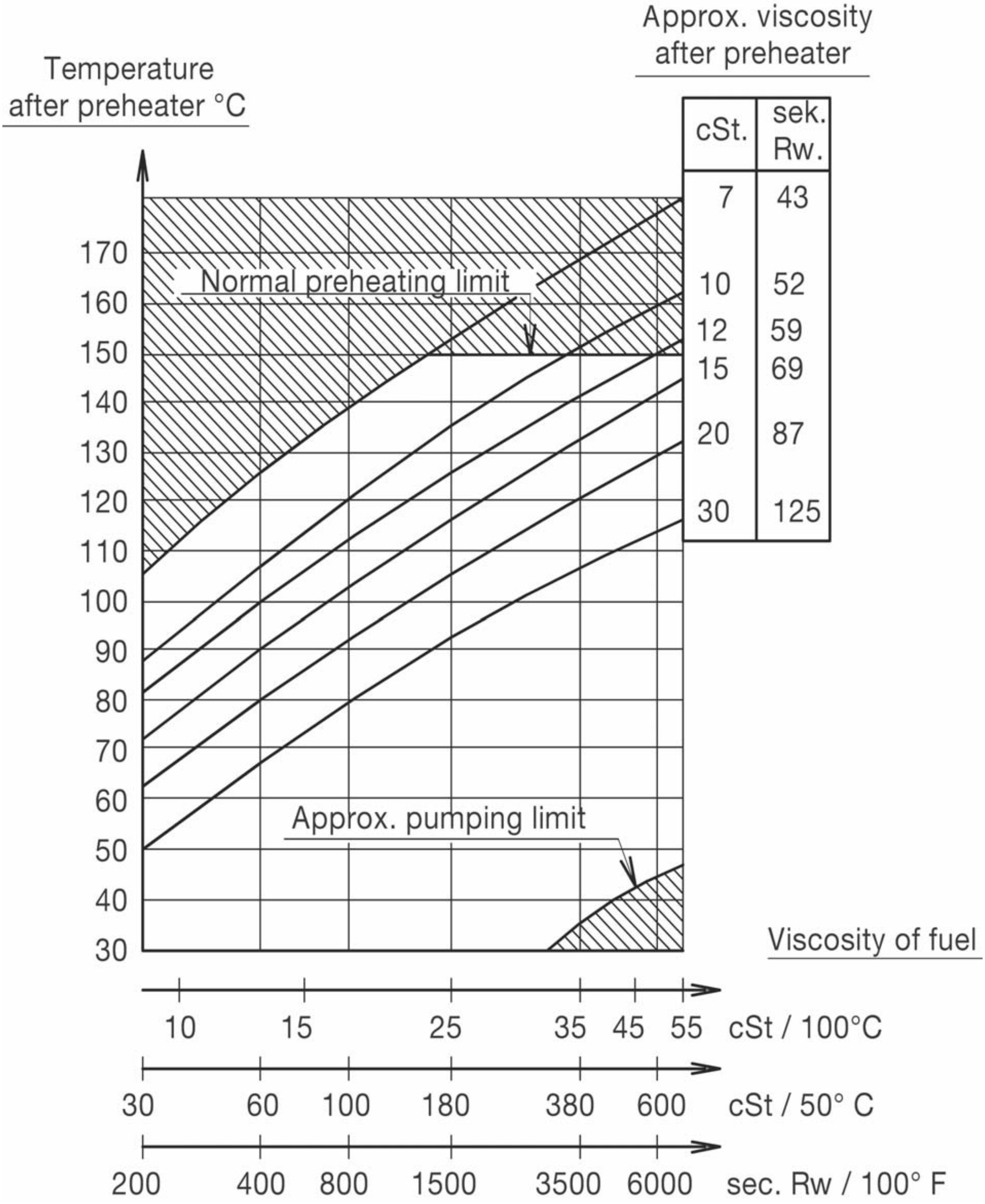


This cart is based on information from oil suppliers regarding typical marine fuels with viscosity index 70-80. Since the viscosity after the preheater is the controlled parameter, the preheating temperature may vary, dependent on the viscosity and the viscosity index of the fuel.

Recommended viscosity meter setting is 10-15 cSt.

Fuel Oil High-Pressure Pipe, Data

Work Card
4265-0100-0013

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T42-04	Union nuts, tightening torque	300	Nm
T42-07	Fuel oil high-pressure pipe, tightening torque (fuel oil pressure booster - fuel oil distributor block)	550	Nm
T42-08	Fuel oil high-pressure pipe, tightening torque (fuel oil distributor block - fuel valves)	300	Nm
T42-80	Mounting screws, tightening torque	190	Nm
T42-81	Fuel oil inlet seat, max. grinding diameter	40	mm
T42-82	Fuel oil outlet seat, max. grinding diameter	26	mm
T42-83	Fuel oil distributor block	100	kg
T42-86	Fuel oil pipe, pressure booster - distributor block	35	kg
T42-87	Fuel oil pipe, distributor block - fuel valves	20	kg
T42-88	Distance from pipe end to thrust bushing lower edge (fuel oil pressure booster - fuel oil distributor block)	20	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
4270-0010	**095**	Milling tool for fuel oil pipe seat (outlet)
4270-0010	**105**	Milling tool for fuel oil pipe (Dist. block - F.O. valves)
4270-0010	**310**	Hook wrench
4270-0010	**453**	Milling tool for fuel oil pipe seat (inlet)
4270-0010	**465**	Milling tool for fuel oil pipe (FOPB - Dist. block)
4270-0010	**-**	Crowfoot wrench head - sundry types

Engine with protective hose pipe between pressure booster - distributor block and double-walled pipes between distributor block - fuel valves

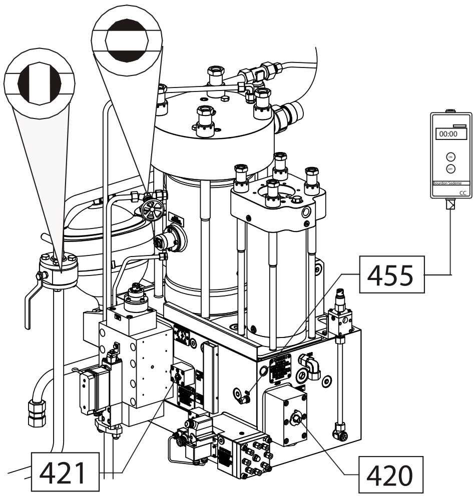
Relieve and check the pressure

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

Close valve 420 and open valve 421 on the hydraulic block. Check that the hydraulic cylinder unit is pressure free.

Close the fuel oil inlet valve.

Open the fuel oil drain.



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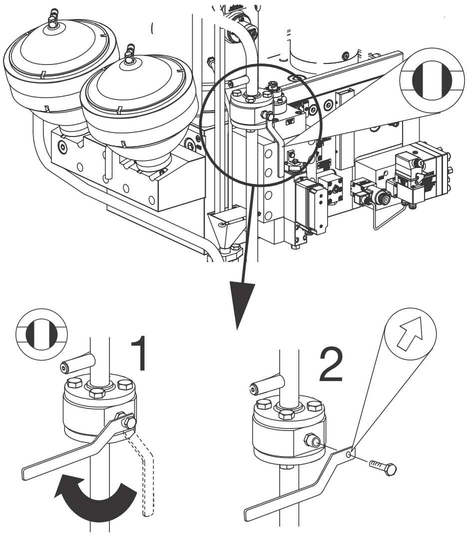
Remove the fuel oil inlet valve handle

NOTE

For safety reasons, remove the valve handle



4265-0501-0005D02

NOTE

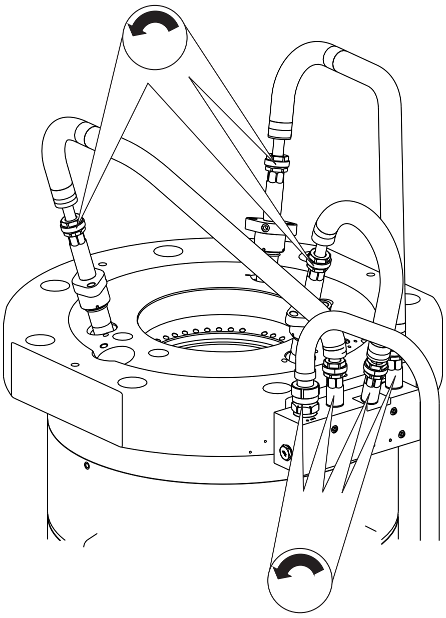
Make sure that the pressure is fully relieved from the fuel oil high-pressure pipes.

Remove the Union nuts and outer cones

Unscrew the outermost union nuts at the fuel valve end and at the distributor block end of the small high-pressure pipes.

Pull the union nuts clear of the unions.

Lift the outermost cone rings clear of the unions.



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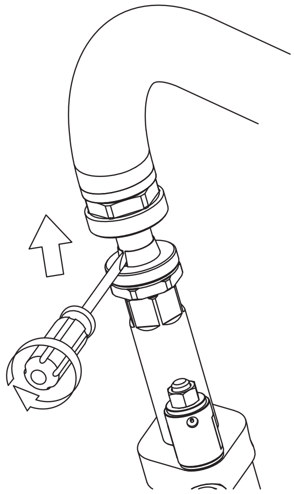
Remove the inner cones

By means of a screwdriver, carefully increase the gap (and hereby the diameter) of the innermost cones.

Lift the cones clear of the innermost union nuts.

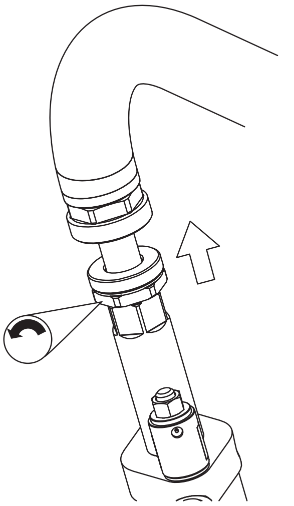


4265-0101-0012D03

Remove the Inner union nuts and sea-ling ring housings

Unscrew the innermost union nuts from the union nipples and lift them away from the union nipples.

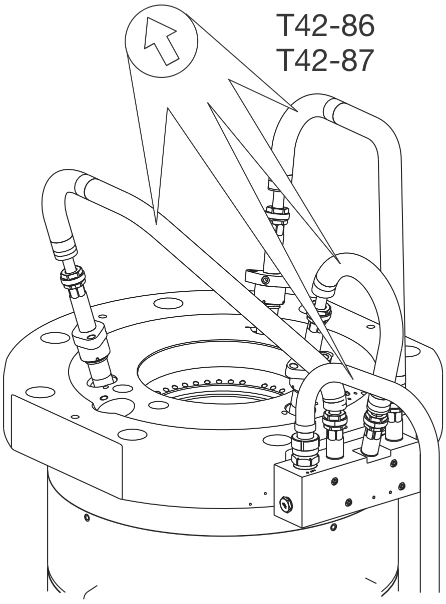
Lift the sealing ring housings with sealing rings clear of the union nipples and unscrew the union nipples from the fuel valves and distributor block.



4265-0101-0012D04

Remove the small pipes (Dist. block - F.O. valves)

Lift the pipe ends clear of the fuel valves/distributor block and remove the high-pressure pipes from the egine.



4265-0101-0016D05

Remove the large pipe (FOPB - Dist. block)

Using a hool spanner, unscrew the union nuts at the fuel oil pressure booster end and at the distributor end.

Remove the high-pressure pipe clear from the engine.

NOTE

It is recommended always to overhaul the high-pressure pipes before remounting them on the engine.
See Procedure for Overhaul.

The overhaul should prefeably take place immediately after the high-pressure pipe has been dismantled.

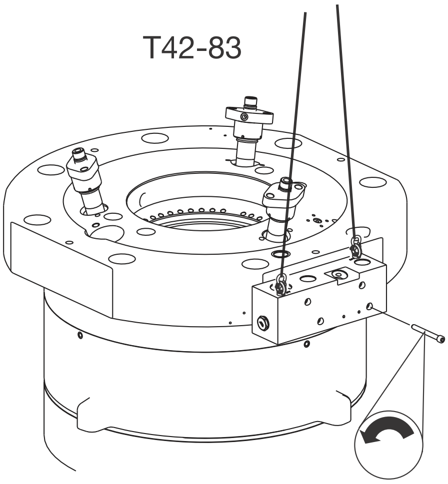
Loosen the distributor block

Mount two eyebolts, shackles and round sling in the distributor block.

Hook the round sling on to the engine room crane.

Tighten up the round sling / engine room crane slightly.

Loosen and remove the four screws securing the distributor block to the cylinder cover

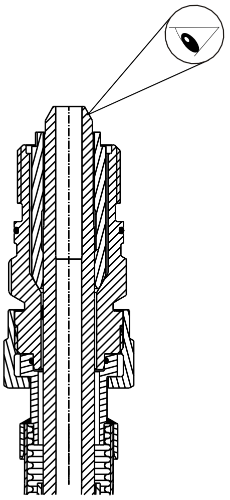


4265-0101-0016D08

Check the thrust bushings

Whenever the fuel oil high-pressure system has been dismantled, it is necessary, before remounting the high-pressure pipes, to carefully inspect the tapered contact surfaces of the pipe ends, together with their seats in fuel valves, fuel pump top cover, and distributor block.

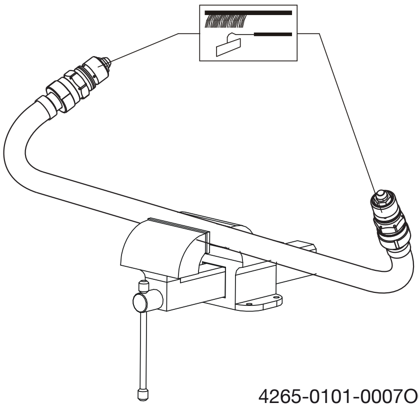
Furthermore, the position of the thrust bushings on the pipe ends must be checked. If the distance is incorrect, compared with the measurement stated in Data T42-88, it should be adjusted by screwing the thrust bushing up or down the pressure pipe.



4265-0101-0007O01

Clean pipe ends

Carefully clean both ends of the high-pressure pipe in clean diesel oil. If any of the pipe ends require reconditioning, carefully mount the high-pressure pipe in a bench vice.



4265-0101-0007O02

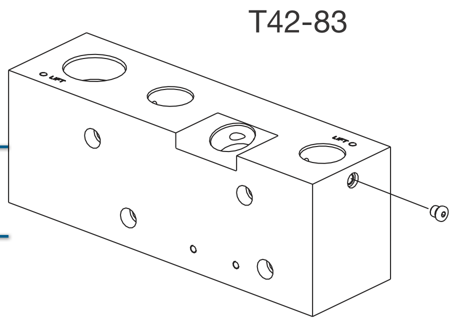
Fuel oil Distributor block

Whenever the fuel oil high-pressure pipes are dismantled, it is strongly recommended to carefully inspect the seating surfaces of the distributor block.

NOTE

For removal of the fuel oil high-pressure pipes, see dismantling.

If scores or marks are found on the seating surfaces, the distributor block must be reconditioned as follows.

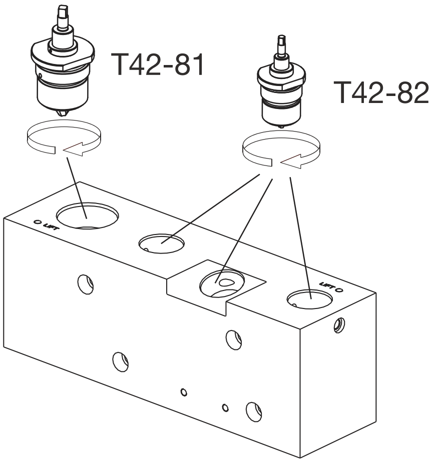


4265-0101-0016O03

Dismantle the distributor block from the cylinder cover. Unscrew and remove the plug screws from the block.

For major scores or marks, use the milling tool and plenty of drilling oil emulsion to mill the seating surfaces.

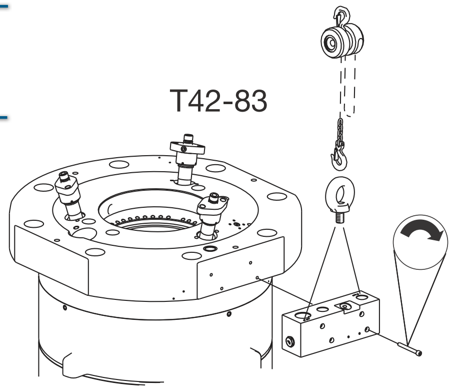
For minor scores or marks, use the grinding tool and a suitable grinding compound (e.g. Carborundum) to grind the seating surfaces.



4265-0101-0016O04

NOTE

When milling or grinding, take care not to exceed the max. grinding limits given in the datasheet..



4265-0101-0016O06

If the max. grinding limits are exceeded, the distributor block must be renewed..

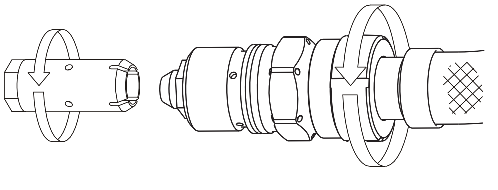
After reconditioning of the seating surfaces carefully clean the distributor block and blow through with compressed air.

Reinsert the plug screws and mount the distributor block on the cylinder cover.

Mount the four screws securing the distributor block lightly. Do not tighten the mounting screwes yet.

Remove hose

Pull down the union nut with flexible protective hose, together with the coupling nut, on to the high-pressure pipe and screw off the thrust bushing (left-hand thread).



4265-0101-0007O04

Remove the coupling nut and, when the thrust bushings at both ends of the pipe have been dismounted, pull the flexible protective hose with union nuts off the high-pressure pipe.

Grind pipe ends

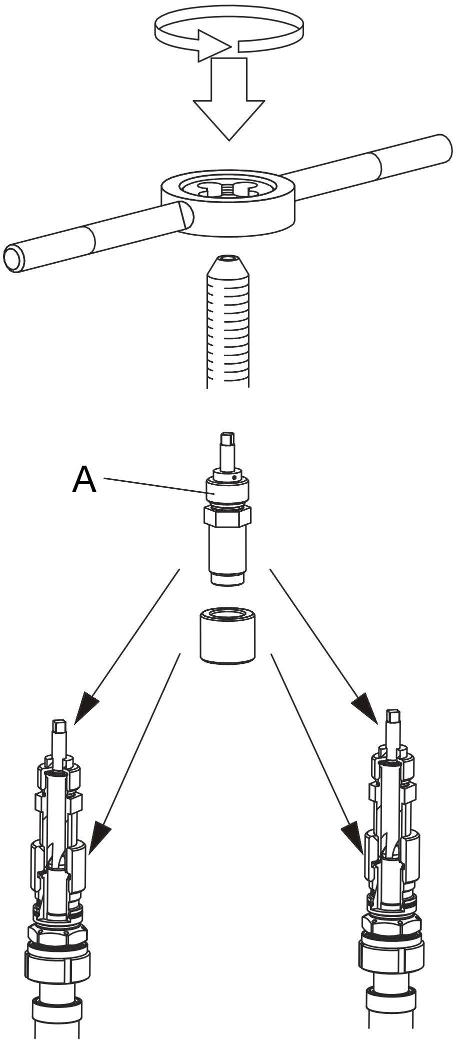
Shape-up the threads on the pipe ends with the nut die.

Add drilling oil emulsion before mounting the cutting tool.

Turn the miller clockwise with, for instance, a tap wrench while lightly tightening the upper tightening ring A to provide a suitable pressure between the miller and the pipe end.

During the milling process, remove the cutting tool at intervals, clean the pipe end and add drilling oil emulsion.

After completing the reconditioning, clean the high-pressure pipe with diesel oil and wipe dry with a clean cloth.



4265-0101-0007O05

Assemble pipes

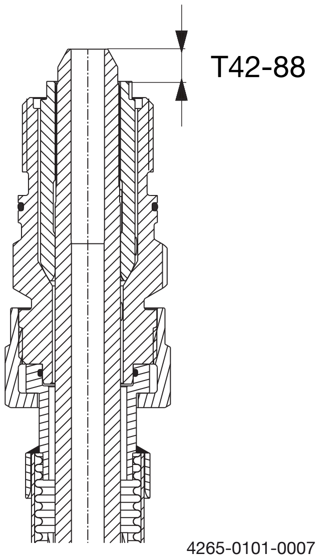
When assembling the high-pressure pipe, screw the thrust bushings so high up on the thread of the pressure pipe that the distance between the pipe end and the bottom edge of the thrust bushing is as stated in Data.

Replace the O-rings.

Before mounting a high-pressure pipe, check the centre distances between pipe ends and seats, and lubricate the threads of the union nuts with molybdenum disulphide (MoS_2).

For reconditioning of the seat in the fuel valve, see Procedure 4265-0201.

For reconditioning of the seat in the fuel oil pressure booster top cover, see Procedure 4265-0601.



4265-0101-0007O06

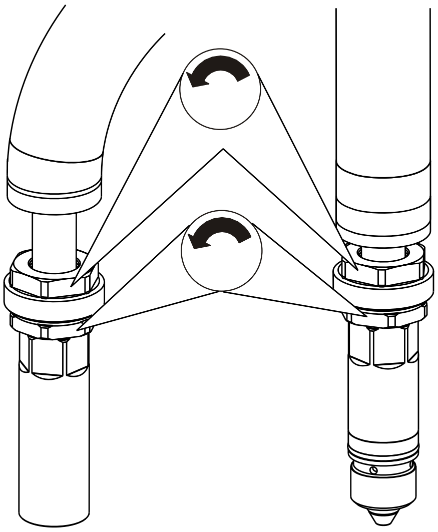
Check pipe ends on the small pipes

Whenever the fuel oil high-pressure system has been dismantled, it is necessary, before reconnecting the high-pressure pipes, to carefully inspect the tapered contact surfaces of the pipe ends, together with their seats in fuel valves, fuel pump top cover and distributor block.

If the pipe ends require reconditioning, proceed as follows:

Union nuts

If not already done, unscrew the upper and the lower union nuts from the union nipples.



4265-0101-0004O01

Milling

Fasten the pipe in a vice with soft jaws. Mount the miller on the pipe end.

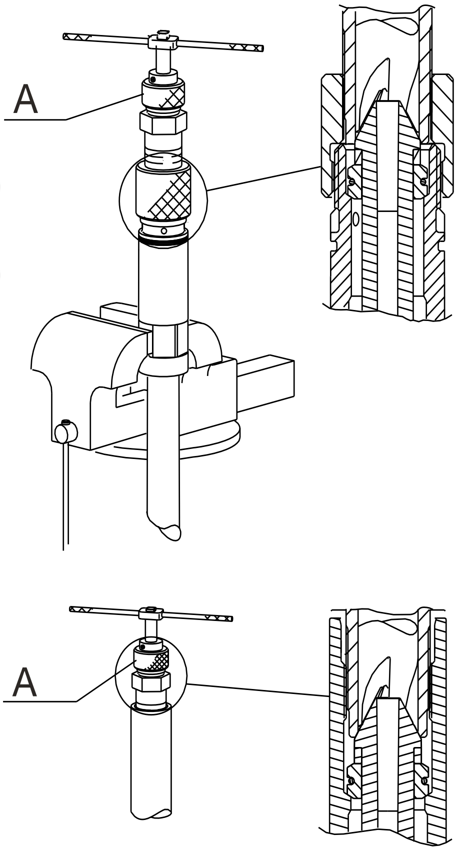
The two pipe ends are of different designs - *see scetch.*

NOTE

Turn the upper tightening ring (A) until the miller presses against the pipe end.

Turn the miller with, for instance, a tap wrench while lightly tighening the upper tightening ring (A) to provide a suitable pressure between the miller and the pipe end.

During the millingprocess, add drilling oil emulsion liberally.



4265-0101-0004O02

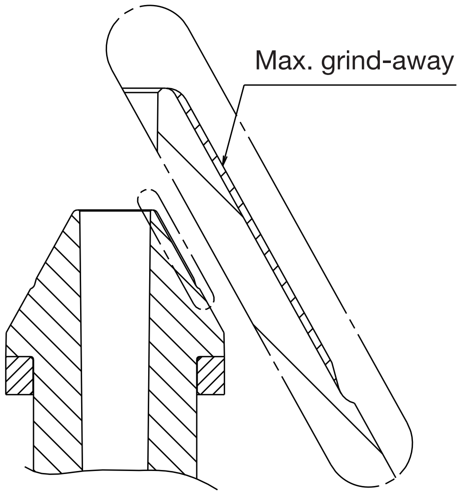
Maximum milling

On both pipe ends a small groove has been ground to indicate the maximum allowable milling of the pipe ends.

The pipe ends is flush with the bottom of the groove.

If the pipe ends are still not in order, the pipe must be discarded.

After completing the milling, carefully clean the high-pressure pipe, and blow through the bore with compressed air.

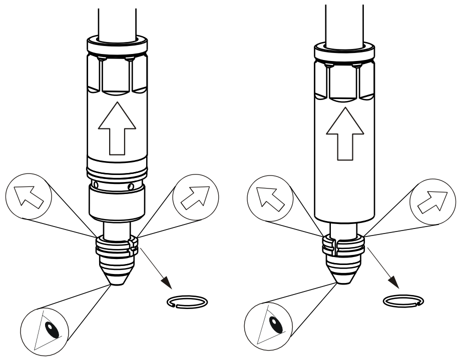


4265-0101-0004O03

Remove the sleeves

Lift up the union nuts and the union nipples.

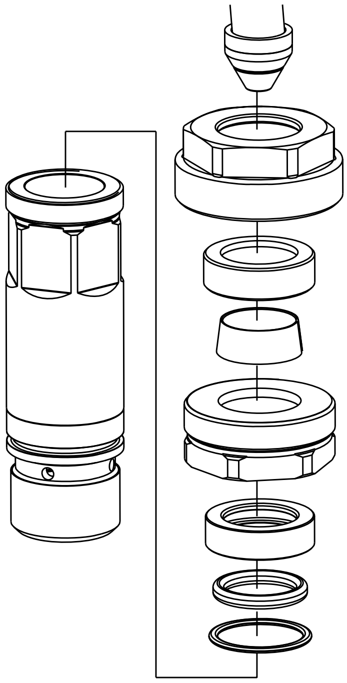
Remove the spring rings from the two-part sleeves. Remove the sleeves.



4265-0101-0004O04

Clean all parts

Remove the union nipple and union nuts from the pipe ends. Clean all parts and replace the O-rings. Remount the union nipple and union nuts on both pipe ends.

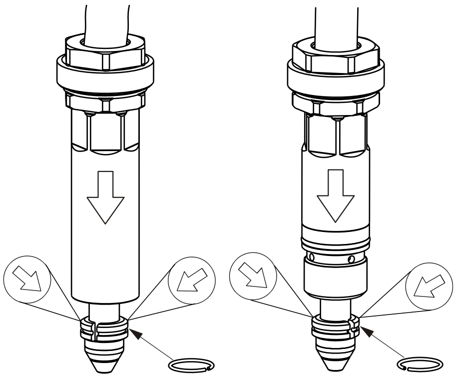


4265-0101-0004O05

Re-assemble the pipe ends

Mount the two-part sleeves and lock the sleeves with the spring rings.

Screw the union nuts losely (approx. 2 revolutions) on to the union nipples.



4265-0101-0004O06

For reconditioning of the seat in the fuel valve, see Procedure 4265-0201.

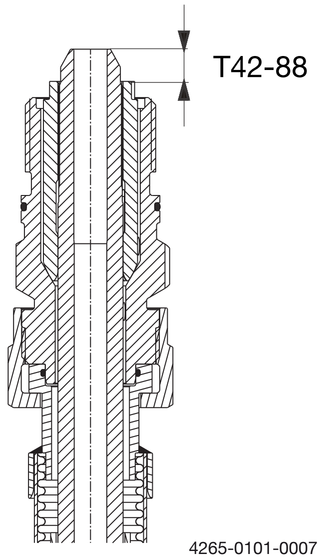
For reconditioning of the seat in the fuel oil pressure booster top cover, see Procedure 4265-0601.

Prepare the high-pressure pipes

Check that the distance between the thrust bushing and the pipe end is correct at both ends of the large pipe. See overhaul.

Ensure that the fuel valves are fitted with new O-rings. Lubricate the thread of the fuel valves with a heat resistant grease.

Ensure that the union nipples at the fuel oil pressure booster end, and at the distributor block end of the high-pressure pipes are fitted with new O-rings. Lubricate the thread on the union nipples with a heat resistant grease.



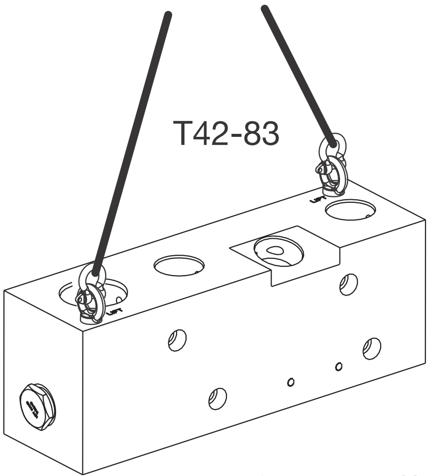
4265-0101-0007O06

Prepare the distributor block

If not already done, mount the eye bolts, shackles and round sling on the distributor block.

Using the engine room crane suspend the distributor block in position next to the cylinder cover.

Mount the four screws securing the distributor block lightly. Do not tighten yet.



4265-0101-0016M01

Mount large pipe (FOPB - Dist. block)

Mount the large high-pressure pipe between the fuel oil pressure booster and the distributor block.

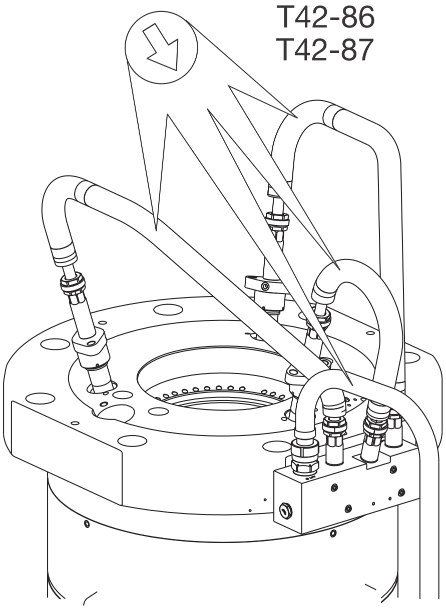
Mount small pipes (Dist. block - valves)

Mount the double-walled fuel oil high-pressure pipes between the distributor block and the fuel valves.

NOTE

The nipples must be screwed by hand, as the threads of the union nipples, fuel valves, distributor block or fuel oil distributor, might otherwise be damaged.

Tightening with a fork spanner should only be done after the union nipples at both ends of the pipes have been screwed into position

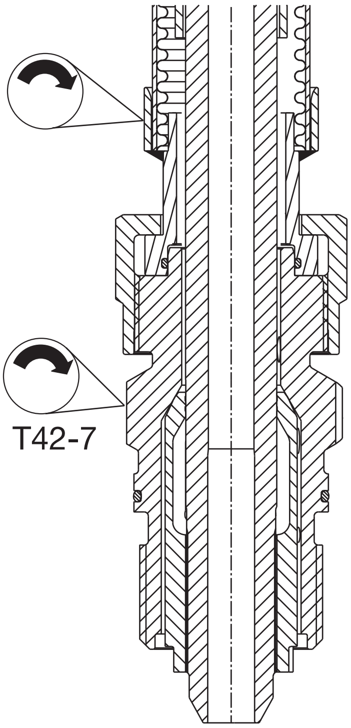


4265-0101-0016M06

Tighten large pipe (FOPB - Dist block)

Using af crowfoot wrench and a torque spanner tighten the union nipples of the large pipe to the torque stated in Data T42-07.

Screw the union nuts onto the union nipples by hand and tighten lightly with a hook spanner.



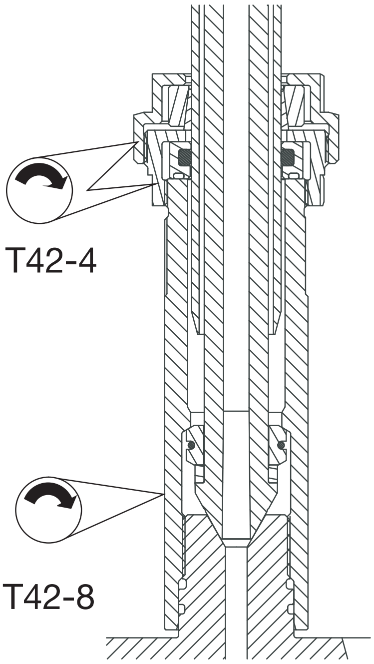
4265-0101-0016M07

Tighten small pipes (Dist. block - valves)

Tighten the union nipples to the torque stated on the Data sheet T42-08 using a crowfoot wrench and a torque spanner.

Using a crowfoot wrench, screw the innermost union nut loosely (approx. two revolutions) onto the union nipple. Screw the outermost union nut onto the innermost union nut in the same manner. Using a torque wrench, tighten the two union nuts to the torque stated on the data sheet T42-04, starting with the innermost union nut and finishing with the outermost union nut. If the union nipple has to be retightened, the two union nuts must be loosened.

Repeat this tightening procedure on all three high pressure pipes connectig the distributor block and the fuel valves.

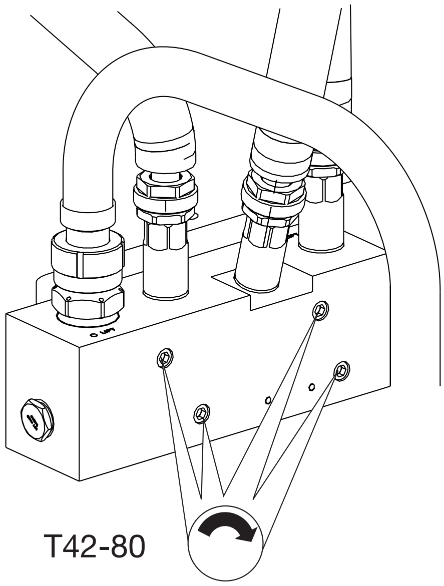


4265-0101-0016M08

Secure distributor block

Tighten all four mounting screws on the fuel oil distributor block.

See data T42-80



4265-0101-0016M09

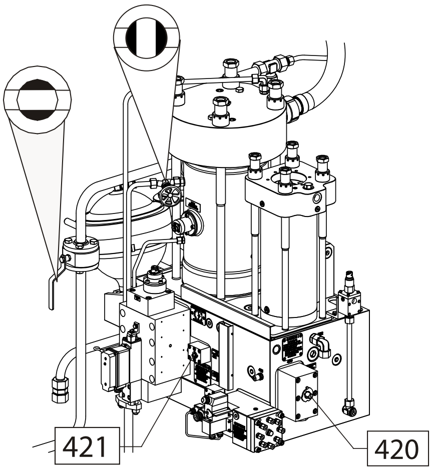
Open fuel inlet

If dismantled, re-mount the return oil pipe on the fuel valve.

Close the fuel oil drain.

Open the fuel oil inlet valve.

Open valve 420 and close valve 421 on the hydraulic block.



4265-0101-0006M04

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T42-09	Fuel valve opening pressure	300-380	bar
T42-11	Inlet seat, max. diameter	25	mm
T42-12	Fuel valve	14	kg

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
2270-0300	**071**	Dismantling lever for fuel valve
4270-0010	**095**	Milling tool for fuel oil pipe seat
4270-0010	**166**	Grinding mandrel for valve head
4270-0010	**178**	Grinding mandrel for thread spindel
4270-0010	**180**	Grinding mandrel for holder, outside
4270-0010	**191**	Grinding mandrel for holder, inside
4270-0220	**-**	Fuel valve testing tools
7670-0200	**-**	Torque spanners
7670-0410	**066**	Slide caliper

Fuel Valve

The fuel valves must be given the utmost attention and care, as the greater part of irregularities that may occur during the running of the engine can be attributed to defects in these valves.

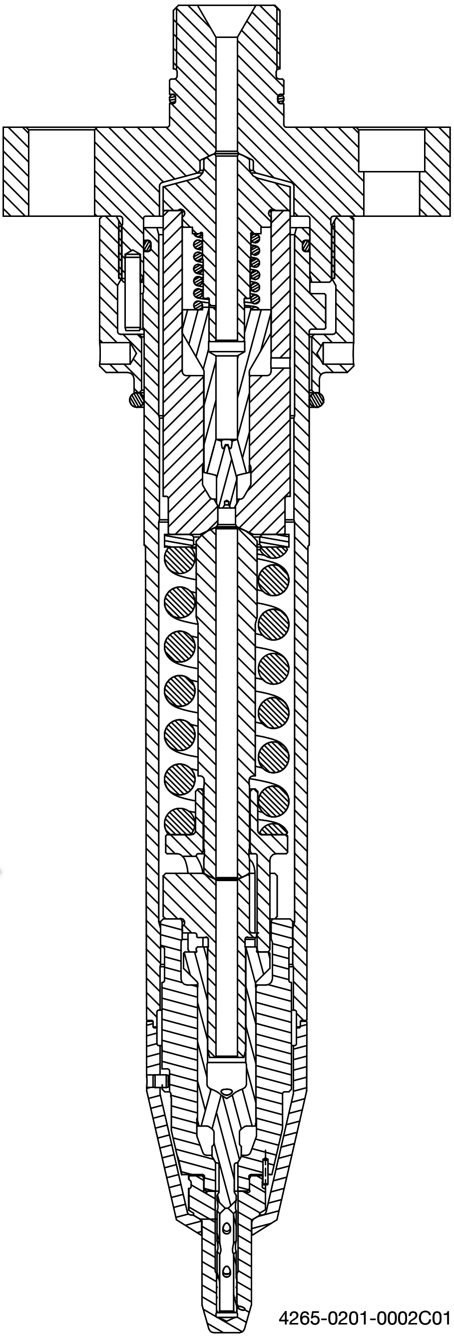
If the engine gives normal performance in accordance with diagrams and exhaust temperatures, it is only necessary to inspect the fuel valves after the service period stated in the Checking and Maintenance Programme.
See General Description.

In order to obtain reliable results during testing of the fuel valves, all fuel valves that are dismantled from the engine must be disassembled, cleaned, inspected and re-assembled before testing. *See work card 4265-0301.*

NOTE

In the event that the slide-type fuel valve is pressure tested without being cleaned between the fuel nozzle and the cut-off slide, the opening pressure value measured might be considerably lower than specified.

All fuel valves **must** be function-tested before being mounted in the cylinder cover.



4265-0201-0002C01

Pressure testing pump Use only hydraulic oil (rust-preventing) with a viscosity of between 7 and 10 cSt at 50°C.

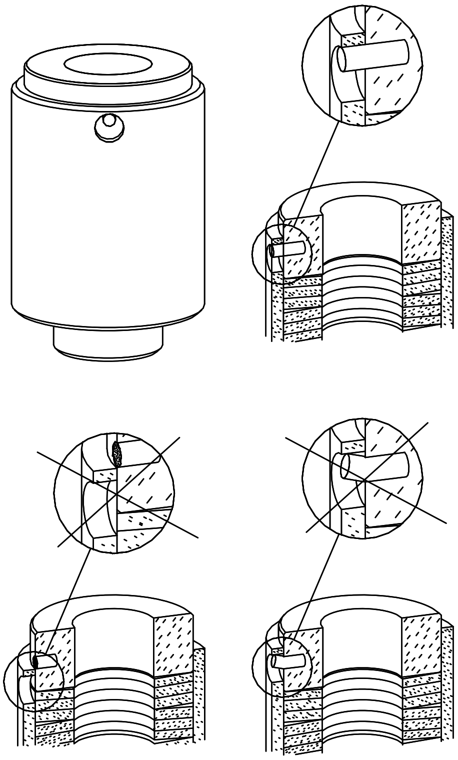
For operation of the pressure testing pump, see the supplier’s instructions.

Note that the high-pressure pump should be periodically checked in accordance with the supplier’s instructions.

Spring housing

To ensure that over tightening has not taken place, check that the locking/indicating pin has not been bent or broken off.

In the event of over tightening, replace the spring housing by a new one.

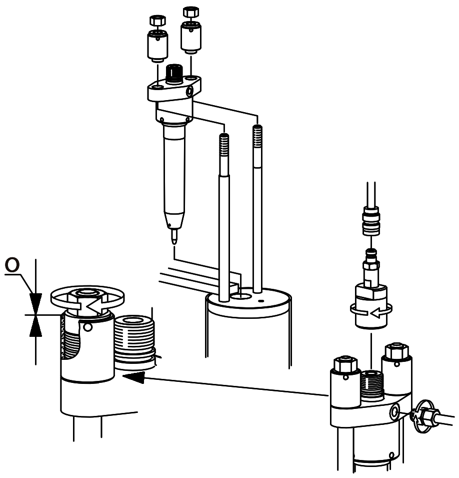


4265-0201-0002C02

Setting-up the fuel valve

Place the fuel valve in the test rig and secure it with the spring housings and nuts.

Tighten the nuts until the top face of the pressure disc is flush with the top face of the spring housings. Mount the oil pipe between the pressure testing pump and the fuel valve.



4265-0201-0002C03

Pressure testing procedure

The following functions of the fuel valve must be checked:

- Flushing and jet control
- Opening pressure
- Sealing test and sliding function
- Pressure test, O-ring sealing

Flushing and jet control

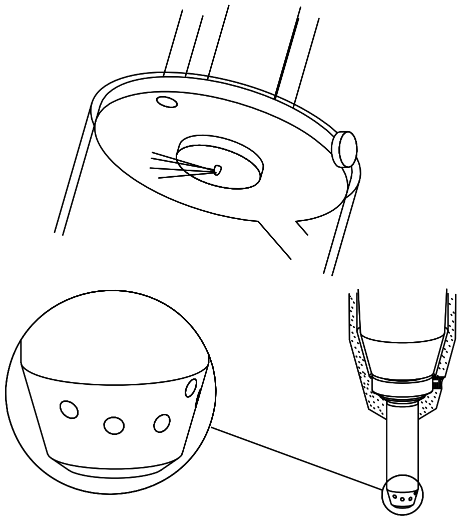
Remove air in the system and check the fuel jet in the following way.

Slowly increase the oil pressure until straight jets of oil are ejected from the nozzle holes (no atomization).

Acceptance criteria:

There is to be a continuous jet of oil through at least one of the nozzle holes.

Owing to the geometry of the internal part of the nozzle - and because of the height to which the spindle is lifted during pressure testing is lower than the height it is lifted during normal engine operation - the fuel oil will not necessarily flow from all of the nozzle holes.



4265-0201-0002C04

Cause of fault:

If the jets do not fulfil the above point, the cause may be:

- Dirt in the nozzle holes
- The nozzle is not mounted correctly

Opening pressure

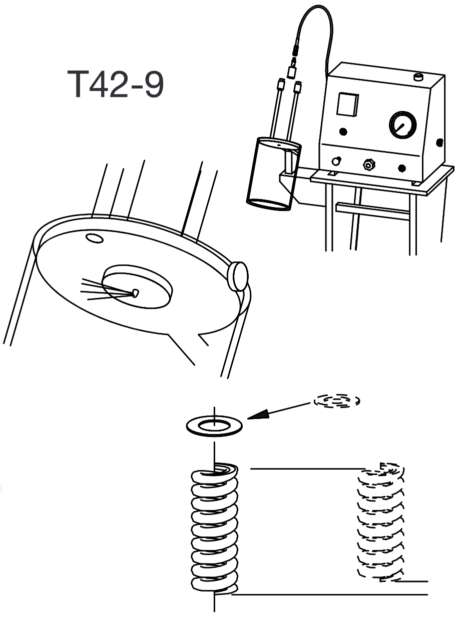
To check the opening pressure, increase the oil pressure until oil is admitted through the nozzle holes.

Acceptance criteria:

Check the opening pressure on the pressure gauge and compare with Data T42-9 on the datasheet.

NOTE

Do NOT attempt to carry out an atomization test on the slide type fuel valvs, as this may damage the cut-off slide and nozzle.



4265-0201-0002C05

Cause of fault:

If the opening pressure is higher than specified in T42-9, the cause may be that a wrong type of spring is used - replace the spring on the thrust spindle, if necessary, replace the complete thrust spindle.

If the opening pressure is lower than specified in T42-9, the cause may be that the spring has sagged - replace the spring, or add a special thin disc.

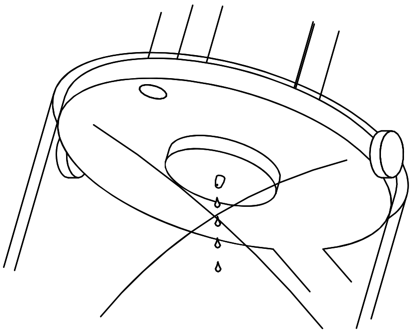
NOTE

Special thin discs are available as spares.

If a spring or a disc has been changed, the pressure testing procedure of the fuel valve must be repeated.

Sealing test and sliding function

To check the needle valve seat for tightness and the slide for correct closing.



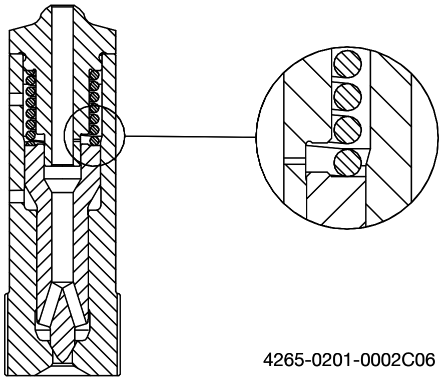
Slowly increase the oil pressure to about 50 bar below the opening pressure. Maintain the built-up pressure by closing for the oil supply.

Acceptance criteria:
Oil must not flow from the nozzle holes.

The pressure drops relatively slowly to about 15 bar, after which it drops quickly to 0 (the slide is pressed against the conical seat and opens for circulation oil).

NOTE

Oil flows out of the leak oil outlet when the fuel valve is full of oil.



4265-0201-0002C06

Cause of fault:

If oil flows out of the nozzle holes, the cause is either:

- Defective spindle guide at needle seat, or a sticking spindle. Examine and/or replace the spindle guide.
  See work card 4265-0301.
- Too quick pressure drop:

- the clearances of the movable parts, both of the spindle guide and of the non-return valve, are too large, or the seats between the thrust piece/ spindle in the spindle guide or thrust piece/valve slide in the non-return valve are damaged.

Examine and/or replace both the spindle guide and non-return valve.
See work card 4265-0301.

If a quick pressure drop from 15 to 0 bar cannot be registered:

- The valve slide is sticking; or
- The vent hole in the thrust piece is blocked.

If so, disassemble and examine the spindle guide, replace if necessary.
See work card 4265-0301.

Pressure test, O-ring sealing

To ensure that the leak oil (circulation oil) remains in the closed system, build up a working pressure of about max. 10 bar until oil flows out of the leak oil outlet.

Close the leak oil outlet with a gasket and plug screw.

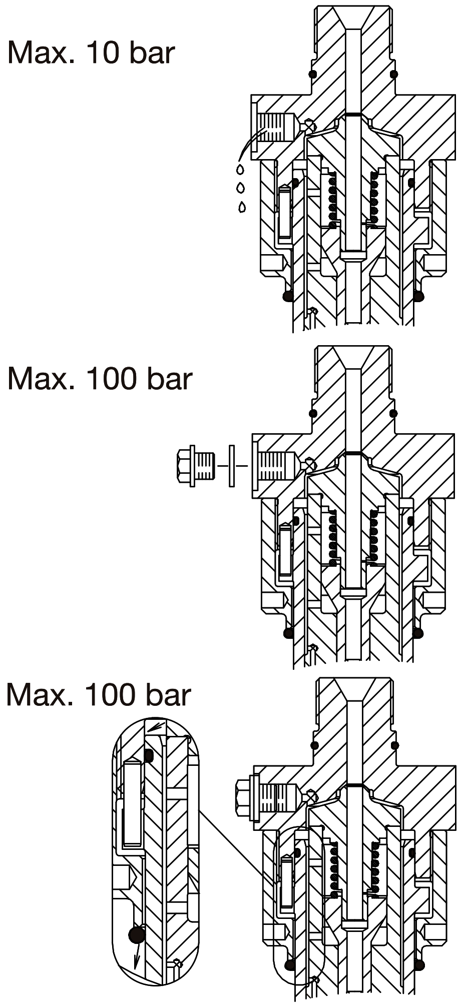
Increase the working pressure to about 100 bar.

Acceptance criteria:

The built-up pressure of about 100 bar should be maintained.

Cause of fault:

If oil leaks out at the union nut, the O-ring inside the fuel valve head is defective, and must be replaced.

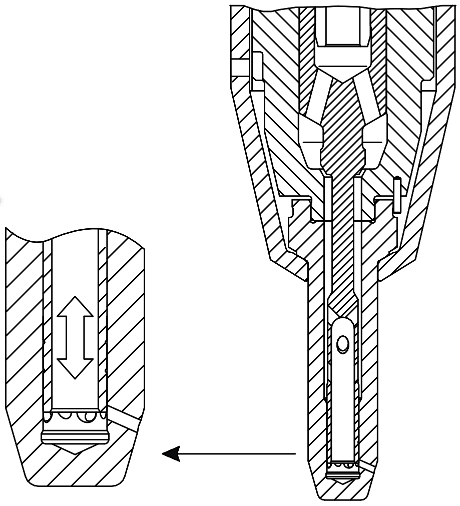


4265-0201-0002C07

Atomization test

NOTE

Do **NOT** attempt to carry out an atomization test on slide type fuel valves, as this may damage the cut-off slide and nozzle.



4265-0201-0002C08

The atomization test may damage the valve because it makes the needle oscillate, with a small lift at a very high frequency. The high pressure drop across the cut-off edge and the high contact pressure between slide and fuel nozzle, in combination with the poor lubricity of the test oil, increase the risk of seizures between cut-off slide and nozzle.

All of these conditions involve the risk of seizure between the cut-off slide and the nozzle.

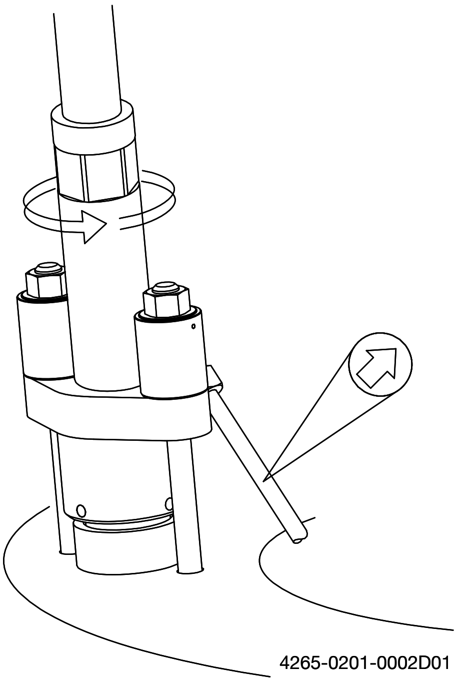
Removing the return oil pipe

Close the fuel oil inlet and outlet valves, and drain the high-pressure pipe and the fuel valve.

Dismantle and remove the fuel oil high-pressure pipe.

See work card 4272-0101.

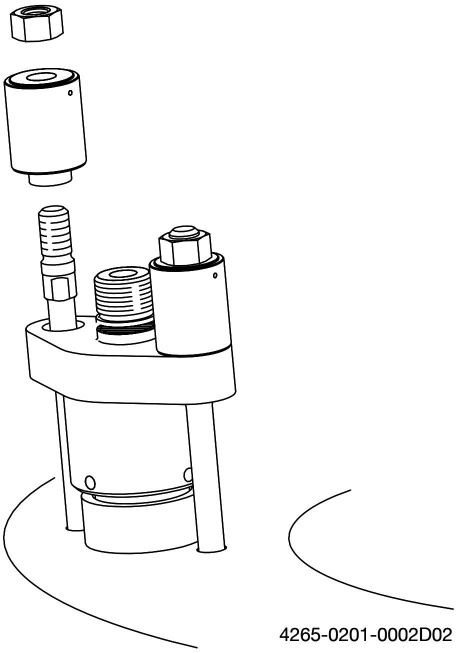
Disconnect the return oil pipe from the fuel valve.



4265-0201-0002D01

First

Remove the nuts and the spring housings.

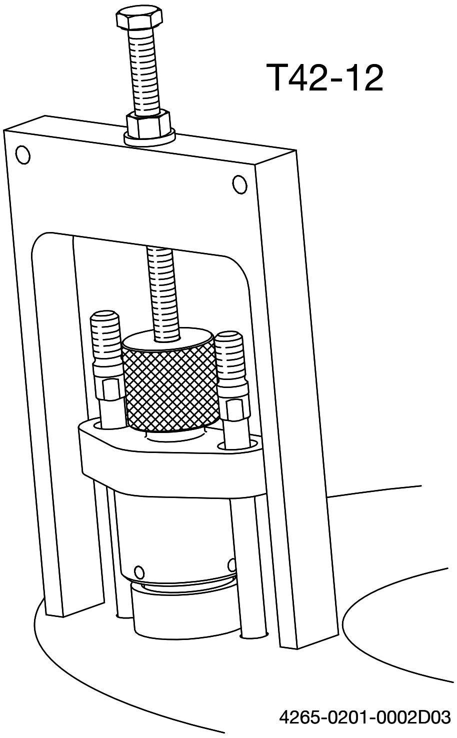


4265-0201-0002D02

Removing the valve

Take out the valve. If the valve is sticking, use the fuel valve dismantling tool to pull the fuel valve clear of the top cover.

If the valve is not to be overhauled immediately, the valve should be placed immersed in diesel oil until overhauling.



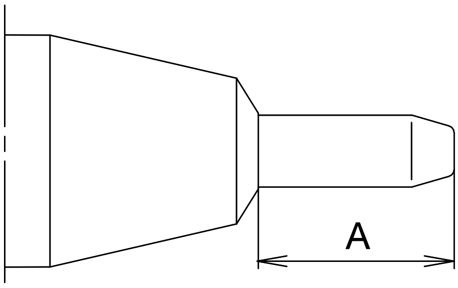
4265-0201-0002D03

When fuel valves are overhauled, all parts should be handled carefully and be kept clean.

Use only clean, non-fluffy rags for wiping purposes. Make sure to remove all liquid or solid impurities. Whenever fuel valves are overhauled, all sealing rings should be discarded and replaced by new, faultless sealing rings before reassembly.

First

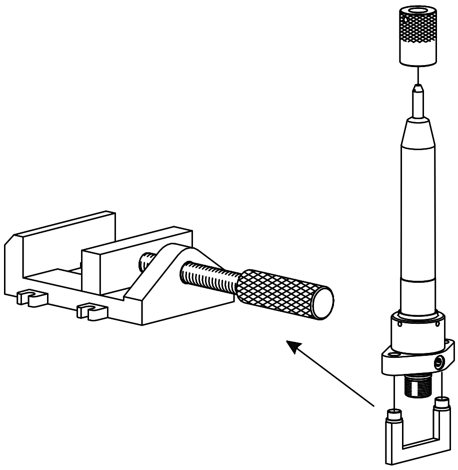
Measure the length A of the protruding part of the nozzle, and write down the result for correct re-assembling of the valve.



4265-0201-0002O01

Valve holder

Place the valve holder in a machine vice, mount the fuel valve in the holder and fit the valve with the guide disc from the grinding tool.

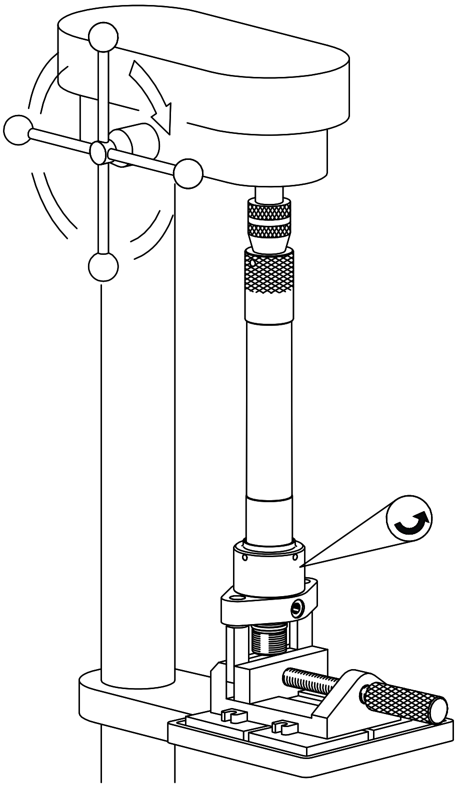


4265-0201-0002O02

Compress the fuel valve

Compress the fuel valve and the spring inside, by means of a drilling machine, to avoid seizures in the union thread. Hold the fuel valve compressed and unscrew the union nut with a hook spanner.

Remove the valve from the valve holder.



4265-0201-0002O03

Dismantling the fuel valve

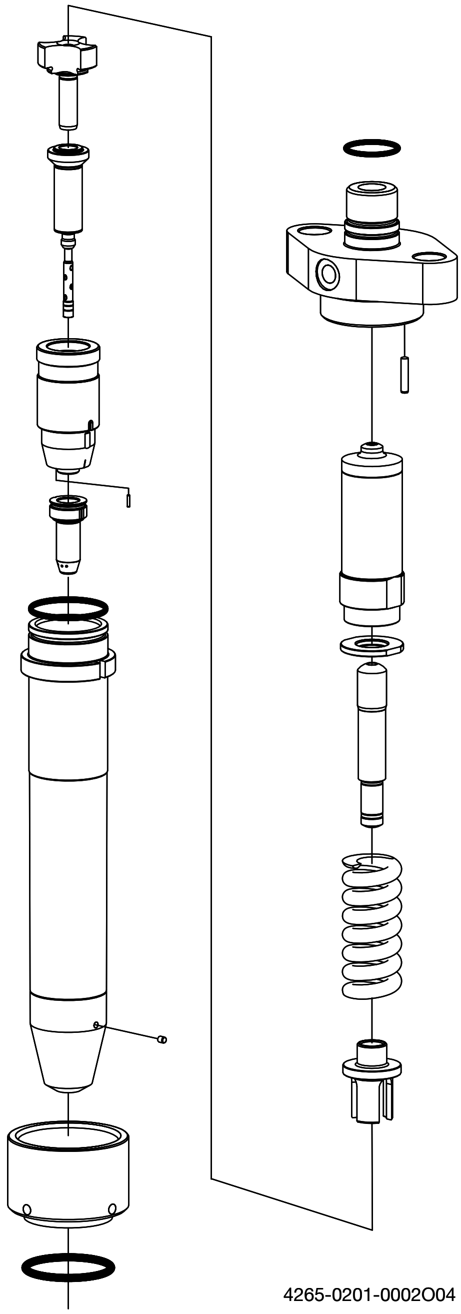
Pull the valve head clear of the valve housing.

Remove the:

- Non return valve
- Thrust spindle parts
- Thrust foot
- Spindle guide and fuel nozzle

from the valve housing.

Remove and discard all the O-rings.



4265-0201-0002O04

Test and examine fuel valve parts

Carefully clean and examine all surfaces of the:

- Fuel valve housing
- Fuel valve head
- Thrust spindle

If necessary, grind the seating surfaces by means of a fine-grain abrasive (such as Carborundum No. 500).

The grinding mandrels supplied are only purposed for:

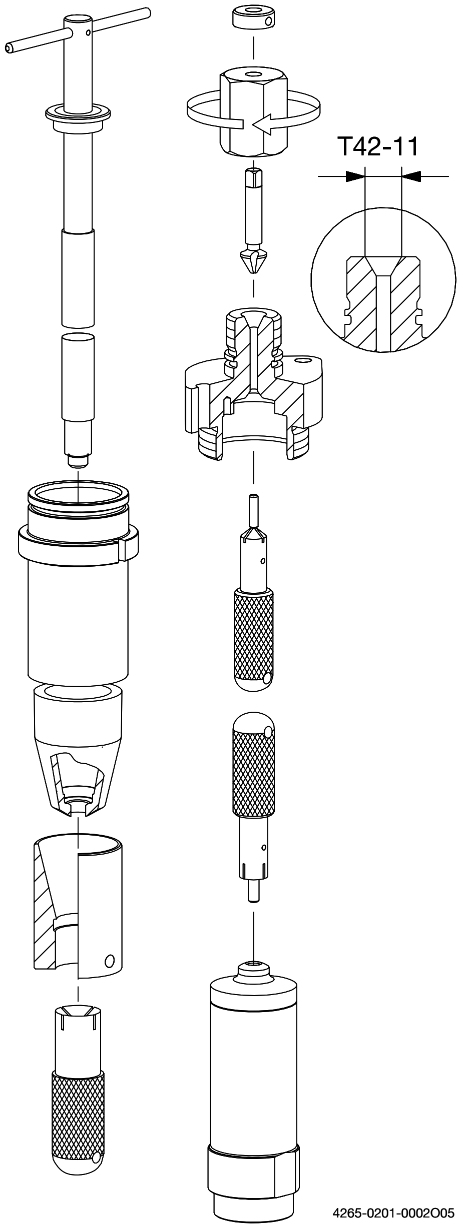
- The fuel valve housing bottom.
- The underside of the fuel valve lead.
- The top of the non-return valve.

This grinding must only be carried out manually.

After the grinding, wash the parts in gas oil and blow clean by means of compressed air to remove any remains of the grinding compound.

In the event of more serious damage to the seating surface for the high-pressure pipe in the valve head, the milling tool can be used.

Normally, the milling tool is turned by hand, but it may be fitted in the chuck of a column-type drilling machine provided that the number of revolutions is kept at a minimum (not exceeding approx. 100 r/min). An ample supply of cutting emulsion must be used.



NOTE

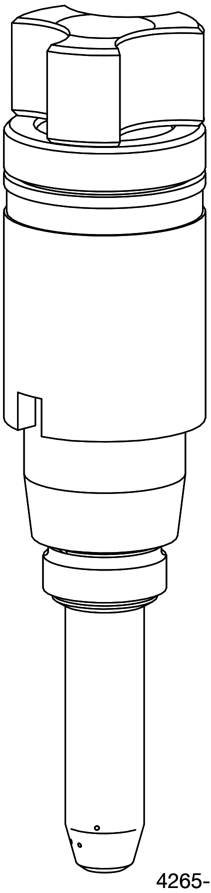
Take care not to exceed the maximum diameter of the seat, *see Data.*

Spindle guide

The complete spindle guide, including the fuel nozzle, should be sent to an authorised MAN repair shop for overhaul. If this is not possible, the spindle guide may be overhauled on board.
See work card 4265-03.

NOTE

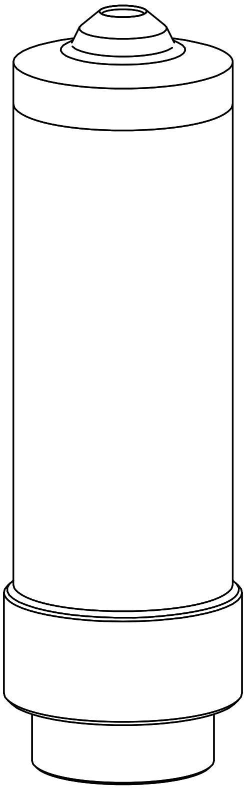
Do not attempt to remove the fuel nozzle from the spindle guide unless the spindle guide has been dismantled. Otherwise the cut-off slide on the spindle may be damaged.



4265-0201-0002O06

Non-return valve

The non-return valve should be sent to an authorised MAN repair shop for overhaul. If this is not possible, the non-return valve may be overhauled on board.
See work card 4265-04.



4265-0201-0002O07

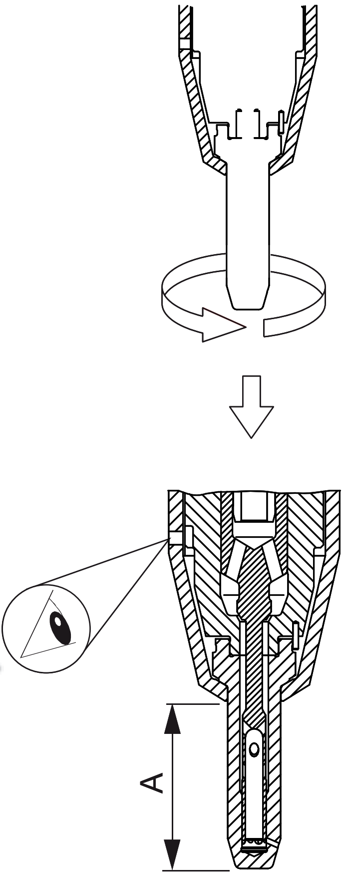
Spindle guide into the fuel valve housing

Mount the complete spindle guide, including the fuel nozzle, in the fuel valve housing.

Carefully slide the spindle guide down into the valve holder, and turn the nozzle until the spindle guide engages correctly with the guide pin. Check that distance A corresponds to the measurement taken before the valve was disassembled.

NOTE

Make sure that the fuel nozzle and spindle guide engage correctly with the guide pin in the fuel valve housing. This can be ascertained by attempting to turn the nozzle after mounting. It must not be possible to turn the nozzle.



4265-0201-0002O08

Mount

- the thrust foot
- the parts of the thrust spindle
- the non-return valve

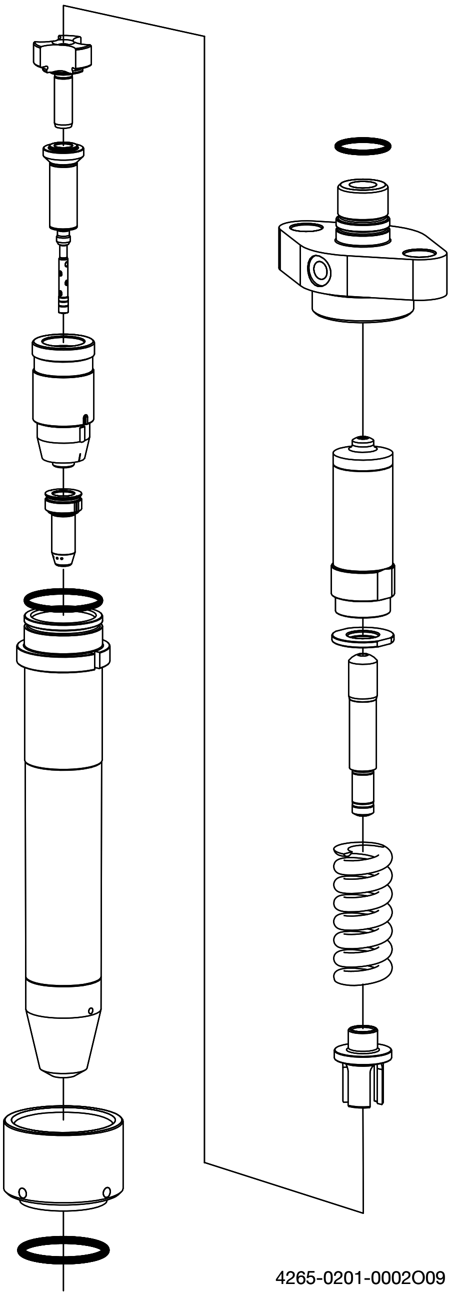
in the fuel valve housing.

Mount a new O-ring in the uppermost groove of the fuel valve housing.

Lubricate the thread of the valve head with molybdenum disulphide (MoS_2).

For the correct use of this lubricant, *see work card 3045-0150.*

Fit the valve head with new O-rings.

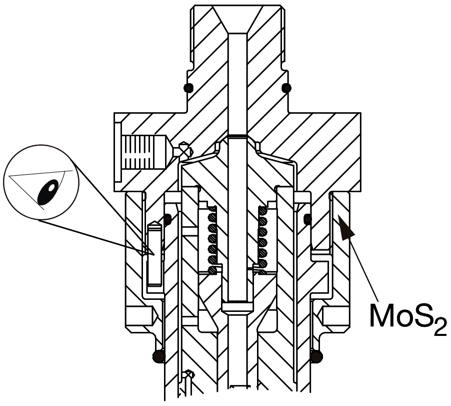


4265-0201-0002O09

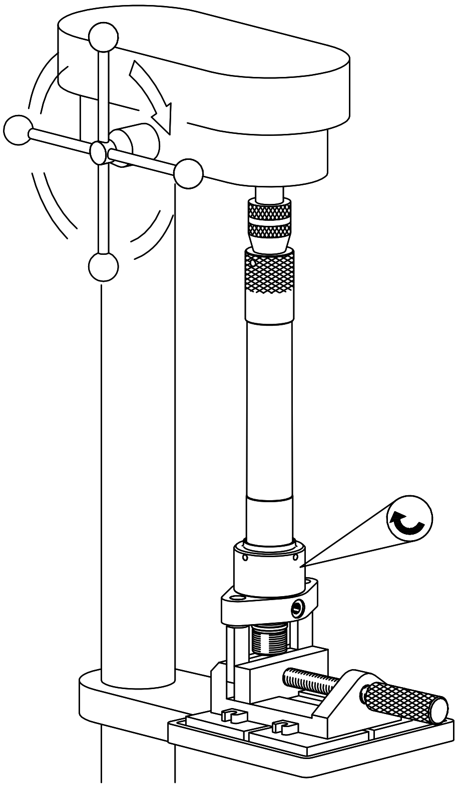
Make sure

Make sure that the guide pin between valve housing and valve head is intact, and press the valve head down into the valve housing.

See that the guide pin between valve housing and valve head engages correctly so as to prevent relative turning of the parts.



4265-0201-0002O10



4265-0201-0002O11

Tightening the union nut

Assemble the valve by means of the union nut.

Place the valve in the valve holder in a drilling machine.

Compress the fuel valve and the spring inside. Keep the valve compressed and tighten the union nut with a hook spanner.

After overhaul, the fuel valve must be tested in the test rig.

See work card 4265-0201.

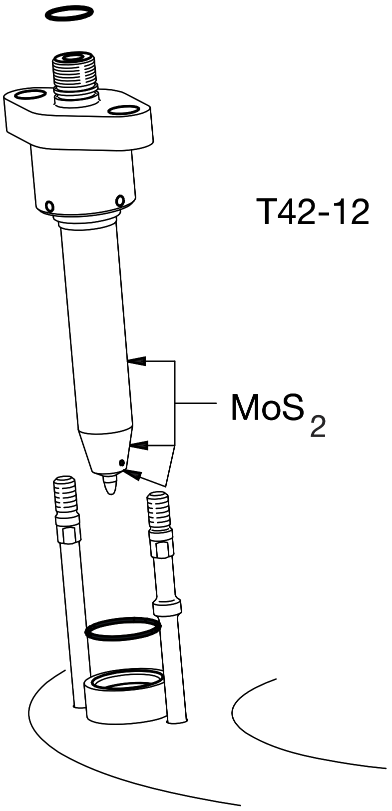
Remember

If the fuel valve is not to be mounted in the engine immediately after the overhaul, cover all openings of the valve with plastic to prevent dirt from entering the valve during storage.

First

Before mounting the fuel valve, thoroughly clean the valve bore in the cylinder cover and check the seating in the bore for marks which, if any, must be eliminated. (For reconditioning of the valve bores in the cylinder cover, *see work card 2265-03.*

If not already done, mount new O-rings on the fuel valve. Lubricate the valve with molybdenum Disulphide (MoS_2).

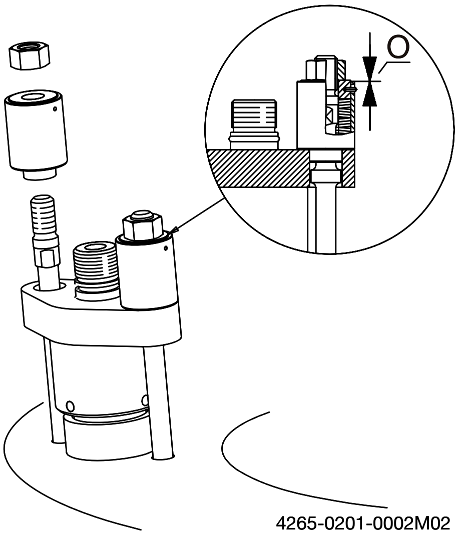


4265-0201-0002M01

Mount the valve

Mount the valve in position in the cylinder cover.

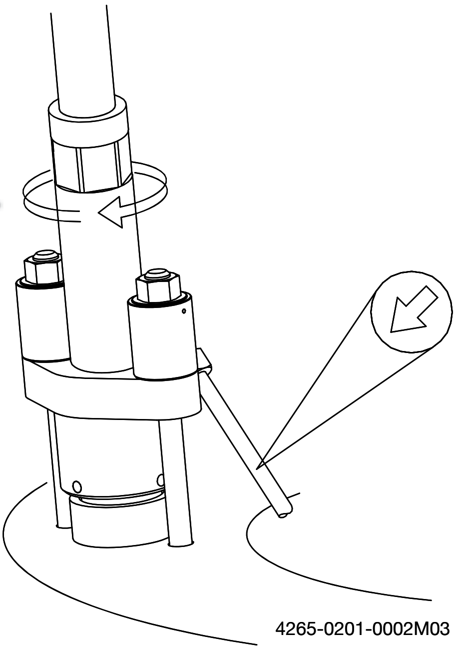
Mount the spring housings and the nuts. Tighten the nuts until the top face of the pressure disc is flush with the top face of the spring housing. This must be done with great care, as the spring tension in the housing determines the correct tightening of the fuel valve to the cylinder cover as well as the correct compression of the fuel valve.



4265-0201-0002M02

Lubricate the thread on the union nipple

Lubricate the thread on the union nipple of the fuel oil pipe with a heat resistant anti seize grease before mounting.



4265-0201-0002M03

NOTE

It is recommended to overhaul the fuel oil high-pressure pipe before mounting. *See work card 4265-0101*.

As a minimum, the distance between the fuel oil pipe ends and the thrust bushings must be checked and, if necessary, adjusted.

Mount the overhauled fuel oil high-pressure pipe and the return oil pipe.
See work card 4265-0101.

NOTE

All fuel valves must be function-tested before being mounted in the cylinder cover, *see work card 4265-0201.*

Safety Precautions

Data

Ref.	Description	Value	Unit
T42-15	Nozzle spray hole cleaning tool table		
-	A: Nozzle spray hole - B: Cleaning drill - C: Test pin	-	-
-	A: 0.45 - B: 0.40 - C: 0.49	-	-
-	A: 0.50 - B: 0.45 - C: 0.54	-	-
-	A: 0.55 - B: 0.50 - C: 0.59	-	-
-	A: 0.60 - B: 0.55 - C: 0.64	-	-
-	A: 0.65 - B: 0.60 - C: 0.69	-	-
-	A: 0.70 - B: 0.65 - C: 0.74	-	-
-	A: 0.75 - B: 0.70- C: 0.79	-	-
-	A: 0.80 - B: 0.75 - C: 0.84	-	-
-	A: 0.85 - B: 0.80 - C: 0.89	-	-
-	A: 0.90 - B: 0.85 - C: 0.94	-	-
-	A: 0.95 - B: 0.90 - C: 0.99	-	-
-	A: 1.00 - B: 0.95 - C: 1.04	-	-
-	A: 1.05 - B: 1.00 - C: 1.09	-	-
-	A: 1.10 - B: 1.05 - C: 1.14	-	-
-	A: 1.15 - B: 1.10 - C: 1.20	-	-
-	A: 1.20 - B: 1.15 - C: 1.24	-	-
-	A: 1.25 - B: 1.20 - C: 1.30	-	-
-	A: 1.30 - B: 1.25 - C: 1.34	-	-
-	A: 1.35 - B: 1.30 - C: 1.39	-	-
-	A: 1.40 - B: 1.35 - C: 1.44	-	-
-	A: 1.45 - B: 1.40 - C: 1.49	-	-
-	A: 1.50 - B: 1.45 - C: 1.54	-	-
-	A: 1.55 - B: 1.50 - C: 1.59	-	-
-	A: 1.60 - B: 1.55 - C: 1.65	-	-
-	A: 1.65 - B: 1.60 - C: 1.70	-	-
-	A: 1.70 - B: 1.65 - C: 1.74	-	-
-	A: 1.75 - B: 1.70 - C: 1.80	-	-
-	A: 1.80 - B: 1.75 - C: 1.85	-	-
-	A: 1.85 - B: 1.80 - C: 1.89	-	-
-	A: 1.90 - B: 1.85 - C: 1.94	-	-
-	A: 1.95 - B: 1.90 - C: 1.99	-	-
-	A: 2.00 - B: 1.95 - C: 2.05	-	-
-	A: 2.05 - B: 2.00 - C: 2.09	-	-
-	A: 2.10 - B: 2.05 - C: 2.14	-	-
-	A: 2.15 - B: 2.10 - C: 2.19	-	-
-	A: 2.20 - B: 2.15 - C: 2.24	-	-
-	A: 2.25 - B: 2.20 - C: 2.29	-	-

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
4270-0210	-	Fuel valve nozzle tools

Cleaning “Outside”

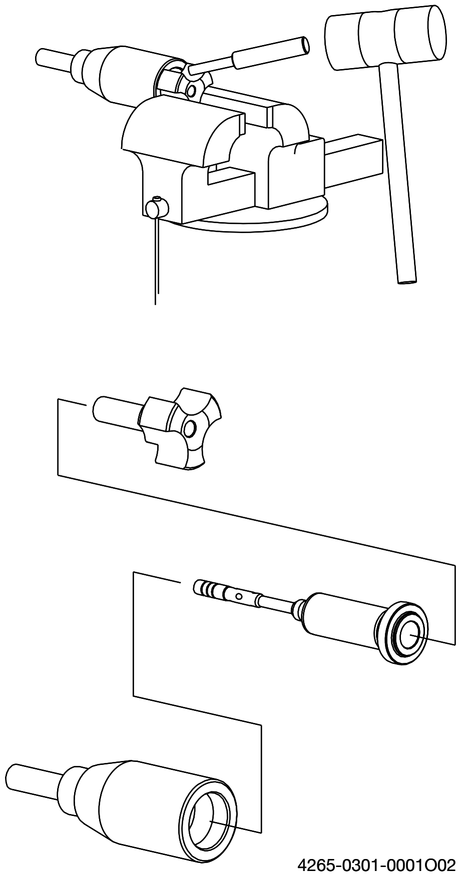
Clean the outside of the spindle guide in pure gas oil or similar. The individual parts of the spindle guide are not interchangeable, therefore only one guide is to be disassembled at a time.

NOTE

The spindle guide, thrust piece and spindle are matched parts and may not be replaced individually.

Disassemble the spindle guide

Place the spindle guide in a bench vice provided with “soft” jaws, and use the brass mandrel as shown to disassemble the spindle guide.



4265-0301-0001O02

Pull the fuel nozzle off the spindle guide

Mount the pulling tool around the fuel nozzle on the spindle guide. Turn the nut to pull the fuel nozzle off the spindle guide.

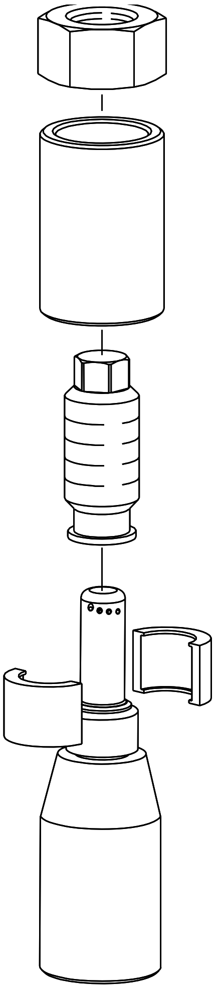
NOTE

The pulling tool is not standard for all engines, but may be delivered as an optional extra.

Alternative

If no pulling tool is available, the fuel nozzle can be dismantled from the spindle guide using two screwdrivers.

Place the screwdrivers opposite each other in the small gap between the fuel nozzle and the spindle guide and very carefully force the fuel nozzle off the spindle guide.



4265-0301-0001O04

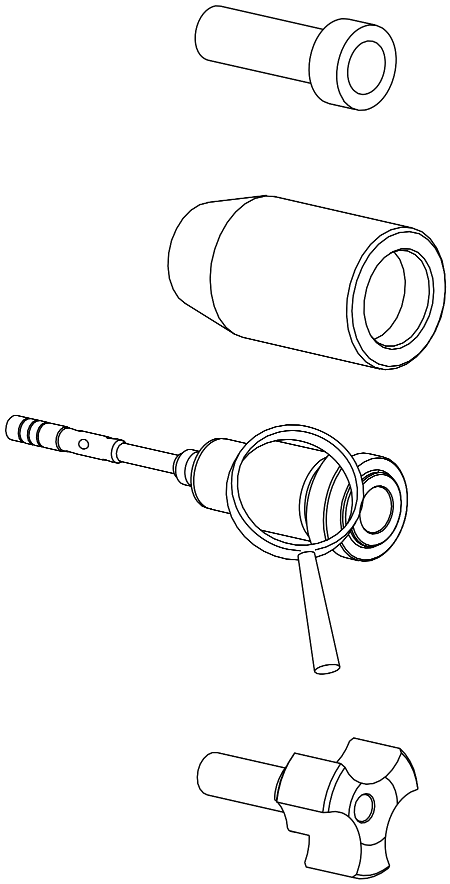
Check and examine all parts

Clean all the parts of the spindle guide in gas oil and wipe dry with a clean piece of cloth.

Clean all parts again in gas oil or 'Electrocleaner' and wipe dry with a clean piece of cloth.

Place all the parts on a clean, soft, lint-free cloth and examine them through an 8-10 times magnification magnifying glass and an inspection lamp.

During the examination, pay special attention to the seating surfaces and sliding surfaces of the parts.



4265-0301-0001O05

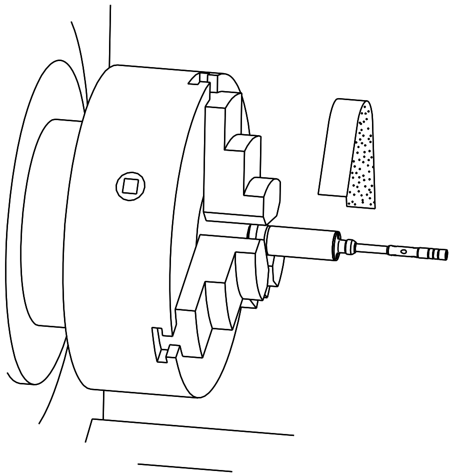
Preparation for polishing

Remove any deposits or very fine scratches by placing the spindle, thrust piece or spindle guide respectively in a lathe, as shown, and polishing with a very fine conventional polishing linen 'grade 360'.

Use also a little oil for the polishing (a coarser polishing linen must **absolutely not** be used).

NOTE

The sliding surface of the cut-off slide may only be polished **VERY** carefully. The sliding surface must not be damaged.



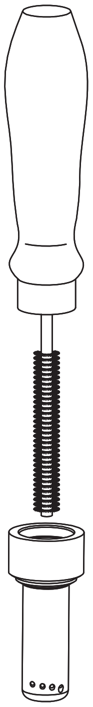
4265-0301-0001O06

After polishing, clean the parts again and re-check the seat on thrust piece/spindle, the seat on slide valve/spindle, and the seat on spindle/guide. Use an inspection lamp and an 8-10 times enlargement magnifying glass.

If the seats are not in order, i.e. if there are pressing-in marks or similar on the seats, the complete spindle guide must be discarded.

Fuel nozzle cleaning

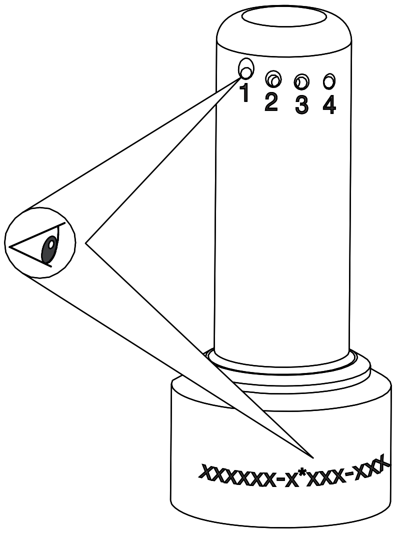
Clean any carbon deposits from the central bore of the fuel nozzle by means of the special brass brush. Clean the fuel nozzle with gas oil and wipe dry with a clean cloth.



4265-0301-0001O07

Find the correct matching test pin in the data sheet table

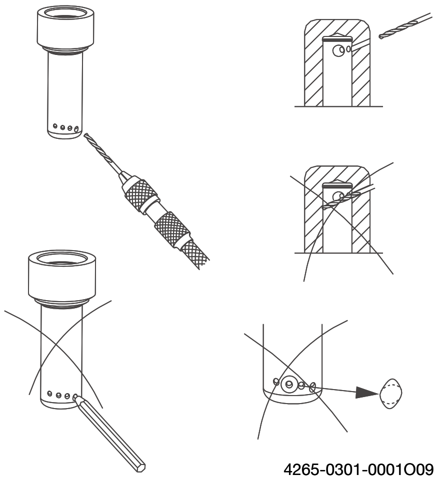
Read the nominal hole size on the cylindrical part of the nozzle, as shown in the figure. The hole size is given in 1/100 mm. Depending on the engine model, there can be one or more different sizes of the holes. Find the correct drill size and matching test pin in the table, *T42-15, on the data sheet,* via the nominal hole size.



4265-0301-0001O08

Spray holes

Clean the spray holes, using gas oil and the special drills supplied.



4265-0301-0001O09

NOTE

During this operation be very careful not to push the drill too far to avoid scratching the snug-fit surface on the inside of the fuel nozzle.

Then test the spray holes with the test pin. If the test pin is able to enter just one of the holes, the fuel nozzle must be discarded.

This also applies to nozzles with oval holes (can be ascertained with a magnifying glass).

Check the fuel nozzle before mounting on the spindle guide, the cut-off slide must be able to move freely inside the nozzle.

NOTE

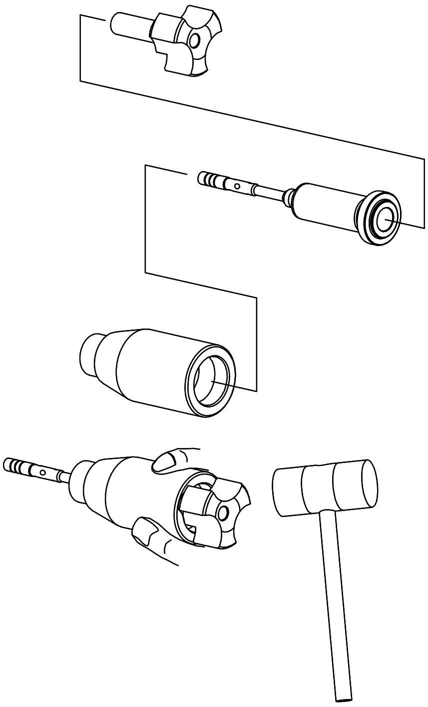
It is recommended that the fuel nozzle is changed whenever the spindle guide is being overhauled or at the maximum running hours given in the maintenance and checking schedule 0760-0301.

Spindle and the thrust piece

Lubricate the spindle and the thrust piece with the cut-off slide with a little Molybdenum Disulphide (MoS_2).

Thrust piece, spindle and the spindle guide

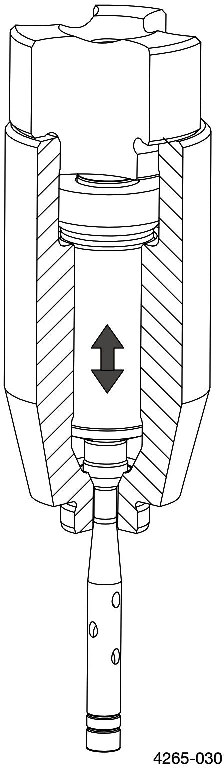
Assemble the thrust piece, the spindle and the spindle guide and carefully knock the parts together using a soft hammer.



4265-0301-0001O11

Free spindle movement

Shake the spindle guide back and forth. The spindle with the cut-off slide must be able to slide freely back and forth inside the spindle guide, with a ‘clicking’ sound.



4265-0301-0001O12

Mounting of nozzle

Lubricate the sliding surfaces of the nozzle and the spindle with a little Molybdenum Disulphide (MoS_2).

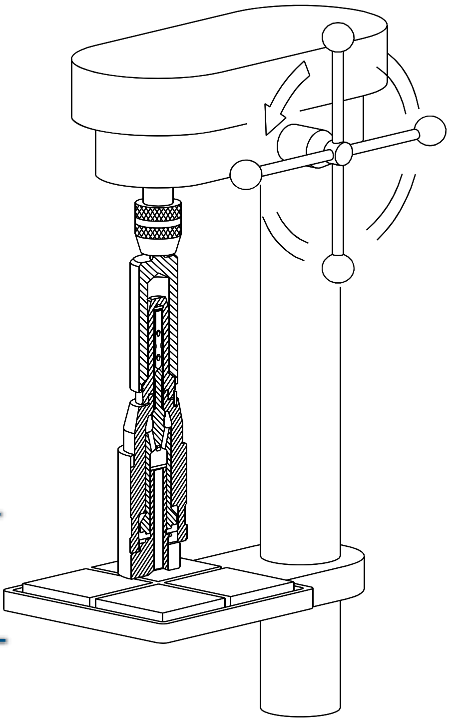
Mount the nozzle on the spindle guide.

Place the parts on the plane of a drilling machine or hydraulic press and position the mounting tool over the parts. Make sure that all the parts are perfectly aligned.

Press the nozzle on to the spindle guide.

NOTE

The mounting tools are not standard for all engines but may be delivered as optional extras.



4265-0301-0001O13

If no mounting tools are available, the nozzle can be mounted on the spindle guide using a short piece of pipe.

Place the pipe around the nozzle, so that the lower end of the pipe rests on the ‘foot’ of the fuel nozzle. Then press the parts together the same way as when using the mounting tools.

Check that the spindle inside the spindle guide is able to move freely as in step 10.

Remember!

If the spindle guide is not to be mounted in a fuel valve immediately after the overhaul, cover all openings of the spindle guide with plastic to prevent dirt from entering the spindle guide during storage.

Non-Return Valve for Fuel Valve, Data

Work Card
4265-0400-0001

Safety Precautions

for detailed sketch see 0545-0100

○	Stop the Engine
○	Shut off starting air supply - At starting air receiver
○	Block the main starting valve
○	Shut off starting air distributor/distributing system supply
○	Shut off safety air supply - Not ME Engines
○	Shut off control air supply
○	Shut off air supply to exhaust valve - Only when stopped lubricating oil pumps
○	Engage turning gear
○	Shut off cooling water
○	Shut off fuel oil
○	Stop lubricating oil supply
○	Lock the turbocharger rotors
○	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
4270-0010	**154**	Flange for dismantling non-return valve
4270-0230	**-**	Fuel valve inspection tool

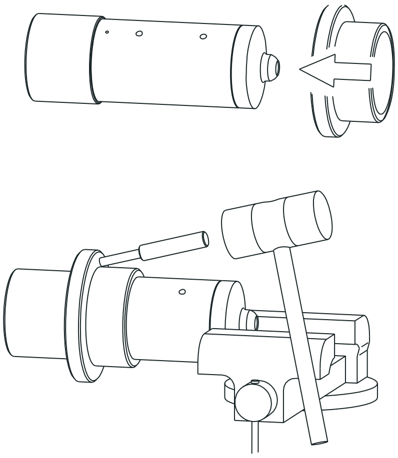
NOTE Extreme care and accuracy should be exercised when carrying out this operation.

Cleaning "outside"

Clean the outside of the non-return valve with pure gas oil. The individual parts are not interchangeable, therefore only one guide is to be disassembled at a time.

NOTE Except for the slide valve spring, defective parts cannot be replaced individually by new ones.

Place the non-return valve as shown in cleaning "outside" in a bench vice provided with "soft" jaws, and disassemble the non-return valve, using the disassembling tool and a hammer as shown.

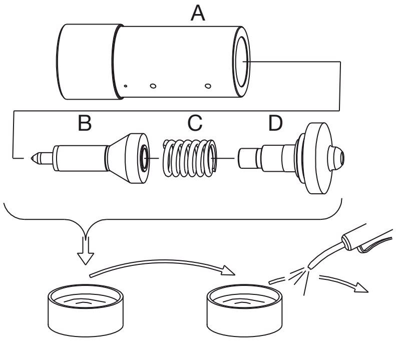


4265-0401-0003O01

Cleaning "inside"

Clean all the parts for the spindle guide in gas oil and wipe them dry with a clean piece of cloth.

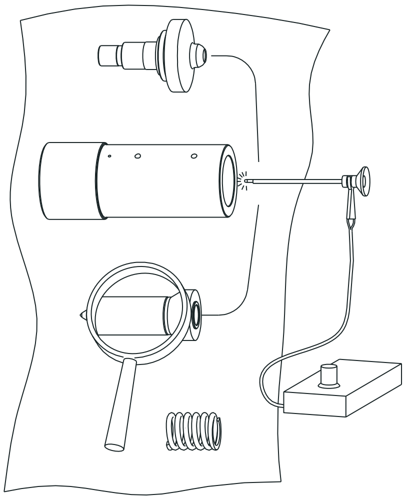
Finally, clean in either gas oil, kerosene or 'Electrocleaner', and wipe the parts dry with a clean piece of cloth.



4265-0104-0003O02

Inspection after cleaning

Now place the parts on clean, lint-free rags and examine with an 8-10 times enlargement magnifying glass, and an inspection lamp with magnifying glass as shown in the drawing.



4265-0104-0003O03

Examine the slide faces of movable parts for coating. The fit between the vent slide and the housing will be too tight if there is a coating.

Fix the vent slide and, subsequently, the housing in a lathe as shown in the drawing and remove the coating by means of very fine conventional polishing linen 'grade 360'.

Also a little oil should be used (a coarser polishing linen must **absolutely not** be used).

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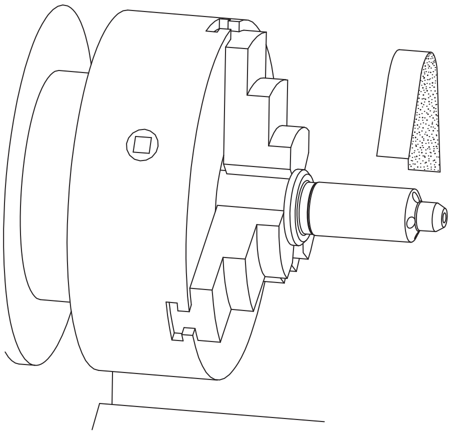
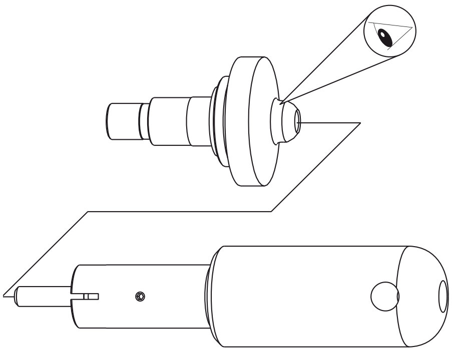


4265-0401-0001O04

Sealing surface grinding.

Check the outside sealing face on the thrust piece **.**

If necessary, grind the seating surfaces by means of the grinding mandrel, found on tool panel 909, and a fine-grain abrasive (such as Carborundum No. 500).



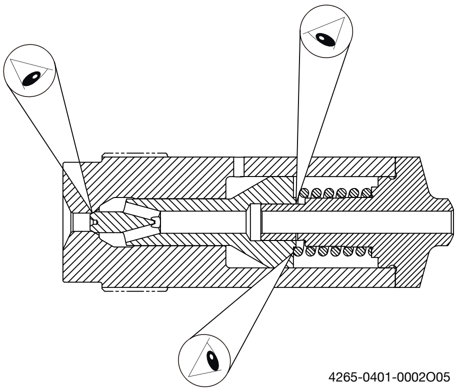
4265-0104-0003O06

Inside checking

Check the spring for the thrust piece for outside wear marks. If defective, it should be exchanged.

Check the seat on the thrust piece and the vent slide, and the seat on vent slide/housing. Use an inspection lamp and an 8-10 times enlargement magnifying glass.

Check that the circulation oil hole is clean.

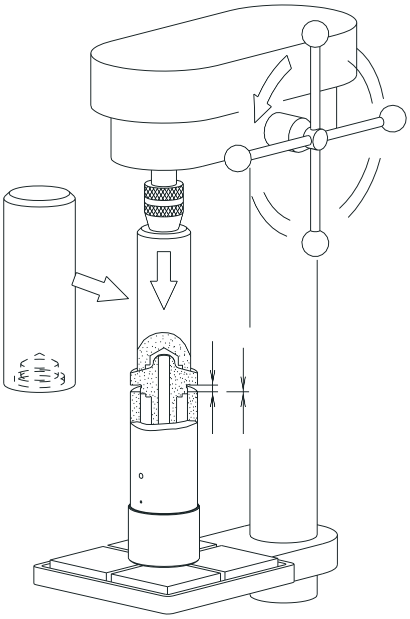

4265-0401-0002O05

If the seats are not in order, i.e. if there are pressing-in marks or similar on the seats, the complete spindle guide must be discarded.

Assembly

Mount the non-return valve as follow:

- Lubricate all movable parts with molybdenum disulphide (MoS_2).
- Place the loosely-assembled non-return valve on the plane of a drilling machine, with the tool positioned as shown in the drawing. Use a short piece of pipe to place the valve in.
- Make sure that the thrust piece and the other parts are perfectly aligned and that the thrust piece is guided in the vent slide.
- Press the handle until the housing and thrust piece meet.


4265-0104-0003O07

NOTE

If the non-return valve is not to be mounted in a fuel valve immediately after the overhaul, cover all openings of the non-return valve with plastic to prevent dirt from entering the valve during storage.

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T42-21	Booster complete	430	kg
T42-22	Booster housing	140	kg
T42-23	Hydraulic plunger	31	kg
T76-01	Hydraulic pressure, dismantling	2000-2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

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	**369**	Lifting tool for hydraulic plunger
7670-0200	**-**	Torque spanners

Shut Off the Oil Supply

Close the fuel oil inlet valve.

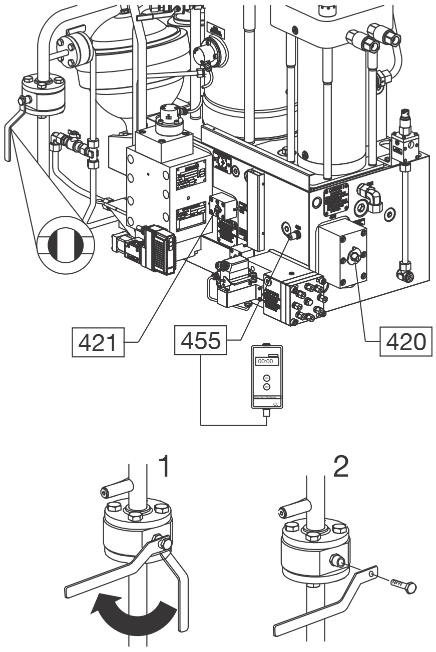
Open fuel oil drain

NOTE

For Safety reasons, remove the valve handle.

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

Close valve 420 and open valve 421 on the hydraulic block. Check that the hydraulic cylinder unit is pressure free.



4265-0501-0014D01

Remove pipes

Remove the fuel oil high pressure pipes, *see word card 4265-0101.*

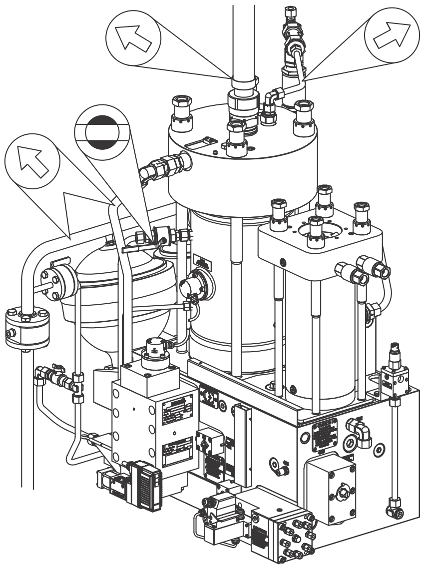
Disconnect the electrical sensor connection.

Remove the fuel oil inlet pipe.

Remove all drain pipes connected to the fuel oil pressure booster.

NOTE

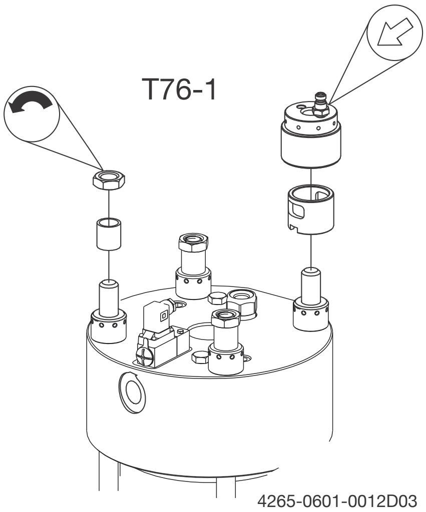
Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.



4265-0501-0014D02

Loosen the nuts

For use of hydraulic tools, see also work card 7665-0101.



4265-0601-0012D03

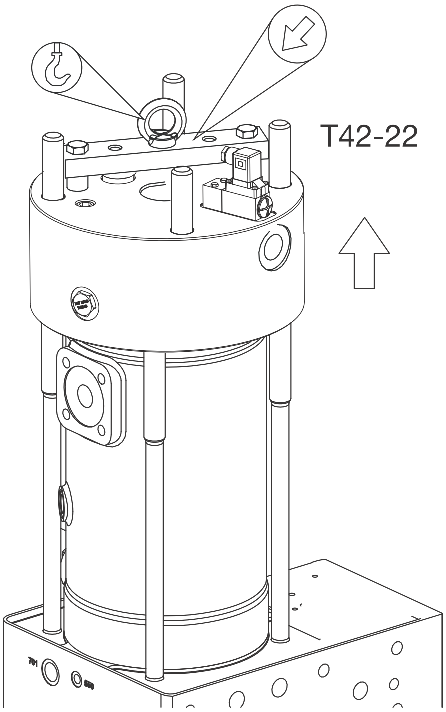
Remove the fuel oil pressure booster

Mount the lifting tool on top of the fuel oil pressure booster.

See work card 4265-0601.

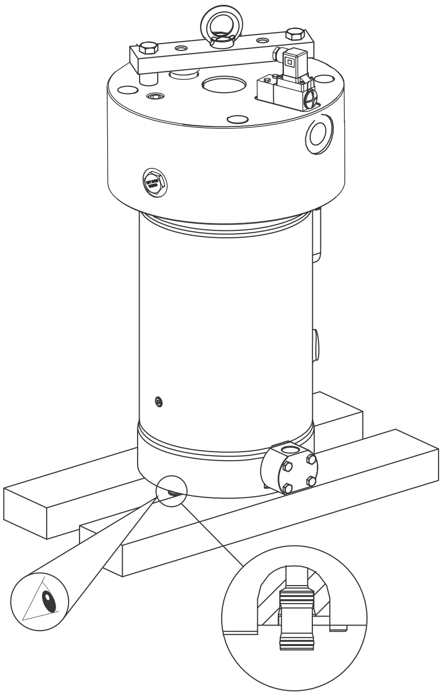
Carefully lift the fuel oil pressure booster clear of the hydraulic block and the fuel oil pressure booster studs.

Cover the hole in the hydraulic block, to keep the hydraulic high pressure system clean.

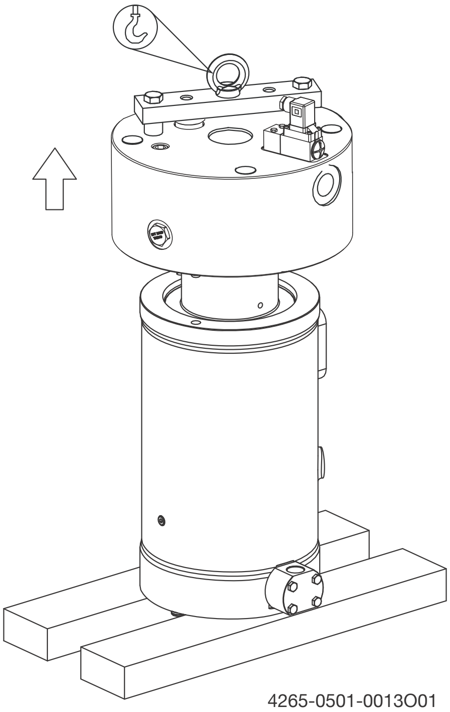


4265-0501-0013D04

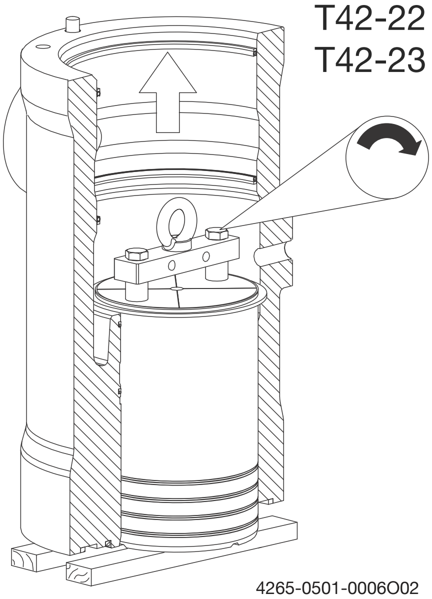
Remember! Land the fuel oil pressure booster on a wooden support and take care not to damage the drain oil bushing.



4265-0501-0013D05

Place the fuel oil pressure booster on a wooden support	Remove the booster top cover, *see work card 4265-0601.*	

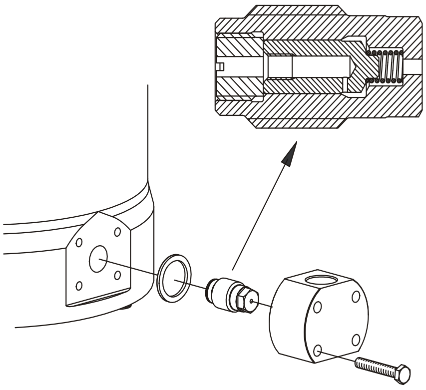
4265-0501-0013O01

Lift up the plunger	Mount the lifting tool on top of the hydraulic plunger.	

4265-0501-0006O02

Throttle valve

Unscrew the flange for the throttle valve. Screw out the throttle valve, clean the valve in gas oil and blow through with compressed air.



4265-0501-0003O03

Booster housing

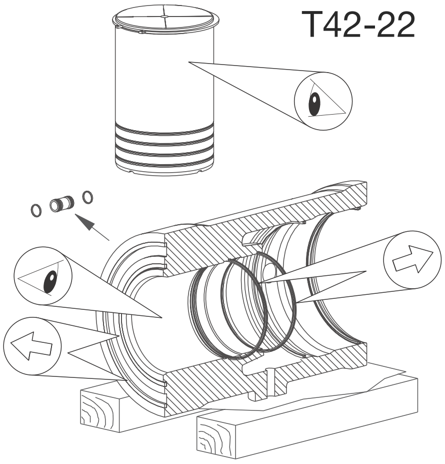
Clean the booster housing and the hydraulic plunger with kerosene or gas oil.

Place the booster housing on one side.

Remove the two sealing rings from the cylindrical part of the booster housing and the sealing ring from the bottom. Discard the sealing rings.

Carefully clean the bottom of the booster housing.

Inspect the hydraulic cylinder surface and the hydraulic piston for wear and seizures.



4265-0501-0006O04

Check the position sensor tip for damage. The position sensor should only be renewed if it is not working properly.

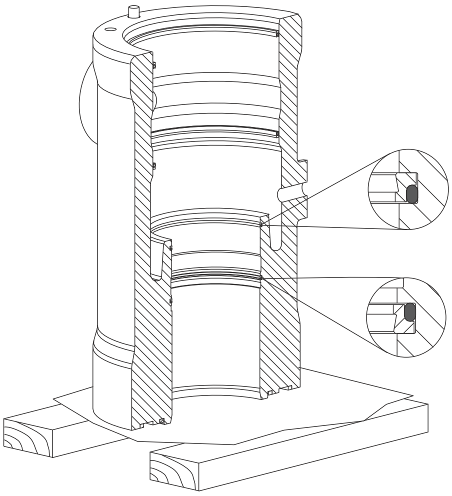
Pull out the drain oil bushing and discard the two sealing rings. Clean the hole and the bushing.

Fit the bushing with new sealing rings.

Sealing rings

Mount new sealing rings in the hydraulic cylinder.

Turn the booster housing to an upright position and place it on a clean piece of oil paper.

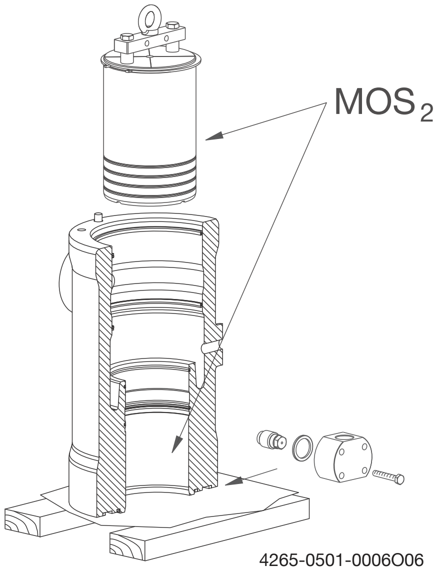


4265-0501-0006O05

Lubricate the cylinder

Lubricate the cylinder (lower part) and the hydraulic piston with proactive oil.

Install the hydraulic piston.



4265-0501-0006O06

NOTE

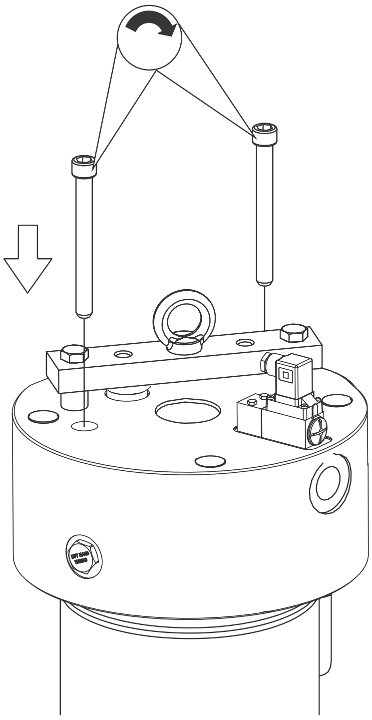
All parts of the hydraulic high pressure system must be kept absolutely clean and free of impurities.

In this case, pay particular attention to the hydraulic piston and the lower part of the booster housing.

Assemble the throttle valve and the flange.

Booster cover

Mount the booster top cover and tighten the top cover screws. *See work card 4265-0601.*



4265-0501-0013O07

Remember !

If the booster is stored before use, cover all openings with plastic and apply preservation oil to all machined surfaces to prevent corrosion.

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

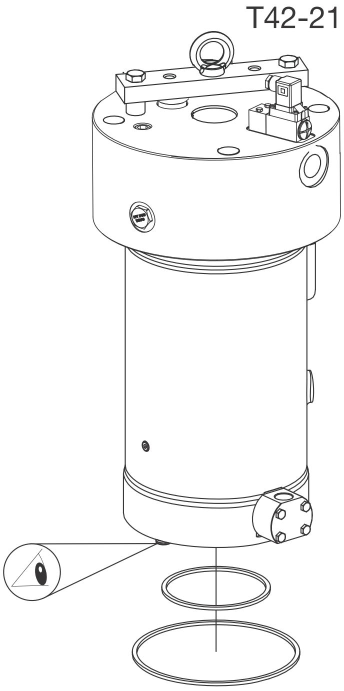
First

If the fuel oil pressure booster has been preserved for storage, remove all preservation and plastic covers.

Mount the lifting tool on top of the fuel oil pressure booster.

Lift up the fuel oil pressure booster, and check if the bottom surface is clean and free of impurities.

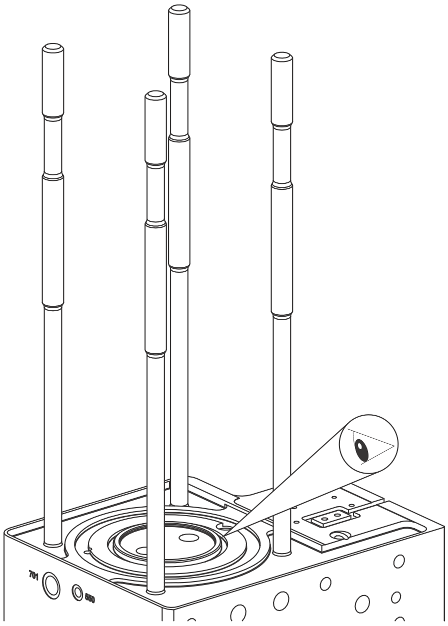
Fit new sealing rings if not already done.



4265-0501-0013M01

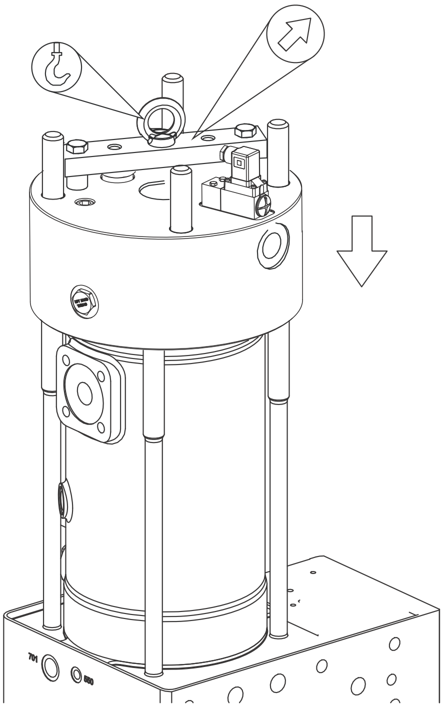
Check the hydraulic block face

Check that the face on the hydraulic block is completely clean.



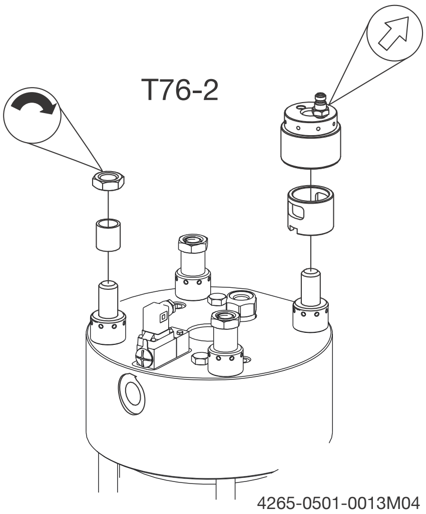
4265-0501-0012M02

Carefully	Land the fuel oil pressure booster on the hydraulic block. Remove the lifting tool.



4265-0501-0013M03

Tighten the nuts	Tighten the nuts hydraulically. For use of hydraulic tools, *see work card 7665-0101.*



4265-0501-0013M04

Connect drain pipes

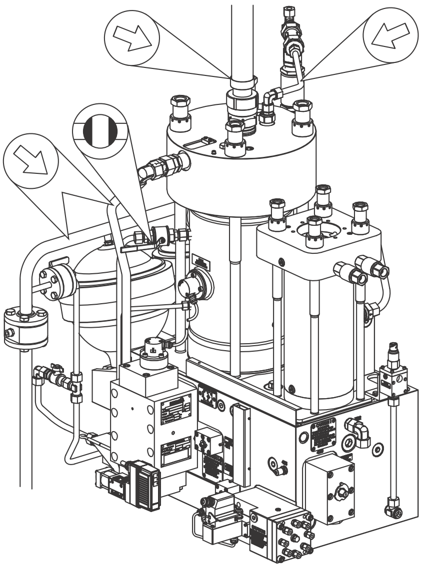
Connect and tighten all drain pipes to the fuel oil pressure booster.

Connect the fuel oil inlet pipe.

Connect the fuel oil high pressure pipes, *see work card 4265-0101.*

Close the fuel oil drain valve.

Connect the electrical sensor plug.



4265-0501-0014M05

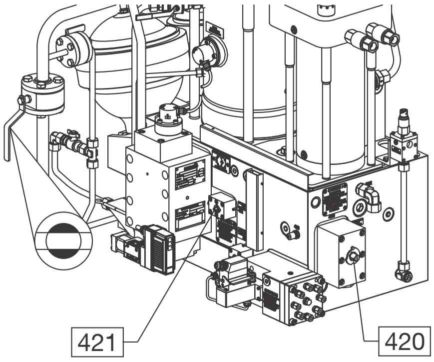
Close drain & open fuel suppply

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

Close the oil drain.

Remount the fuel valve handle

Open the fuel oil inlet valve.



4265-0501-0014M06

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T42-28	Fuel outlet seat, max.grinding diameter	26	mm
T42-29	Booster top cover	250	kg
T42-30	Fuel plunger	30	kg
T76-01	Hydraulic pressure, dismantling	2000 - 2400	bar
T76-02	Hydraulic pressure, mounting	2200	bar

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	**071**	Lifting tool for fuel pump housing
4270-0010	**095**	Milling tool for fuel oil pipe seat
4270-0010	**321**	Locking device
4270-0900	**-**	Mounting tools - top cover seals
7670-0200	**-**	Torque spanners
7670-0410	**066**	Slide caliper

Close the Fuel Oil Inlet Valve

Close the fuel oil inlet valve.

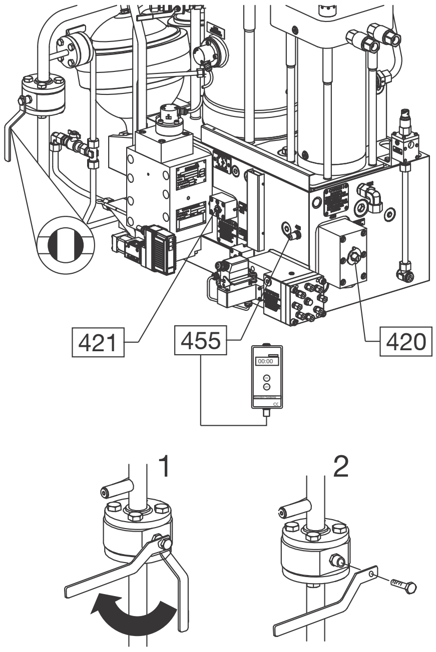
Open fuel oil drain

NOTE

For safety reasons, remove the valve handle.

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

Close valve 420 and open valve 421 on the hydraulic block. Check that the hydraulic cylinder unit is pressure free.



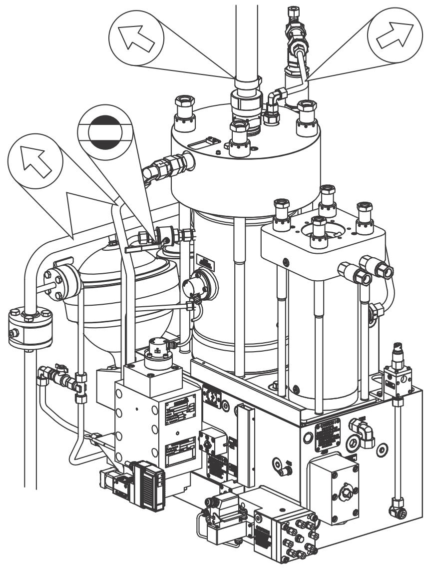
4265-0501-0014D01

Drain oil pipe

Remove the fuel oil high pressure pipes, *See work card 4265-0101.*

Drain the fuel oil pressure booster for oil.

Remove the drain oil pipe from the top cover.

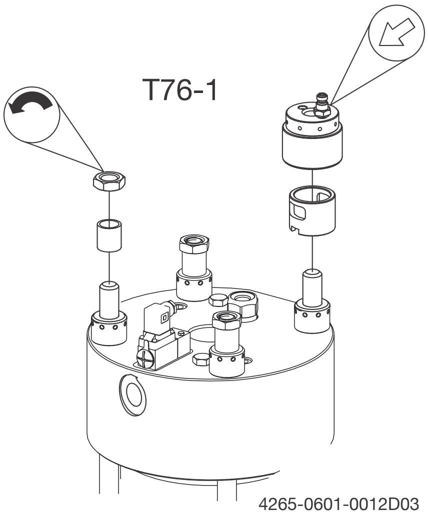


4265-0501-0014D02

Loosen the nuts hydraulically

Mount 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 operation of the hydraulic tools, see work card 7665-0101.

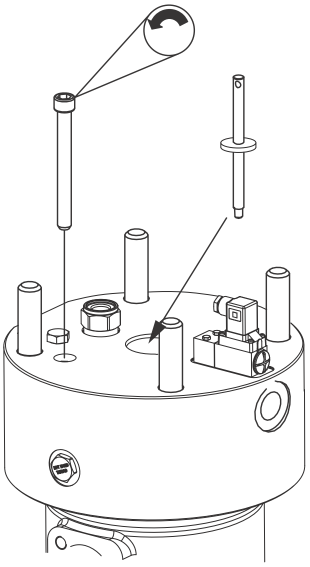


4265-0601-0012D03

Centre plug screw

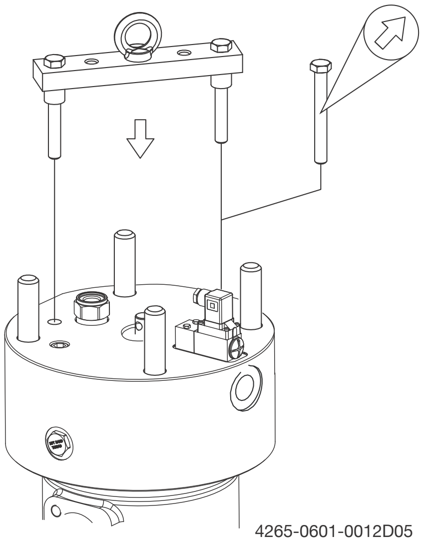
Mount the retaining tool for the fuel plunger.

Remove the two Allen screws.



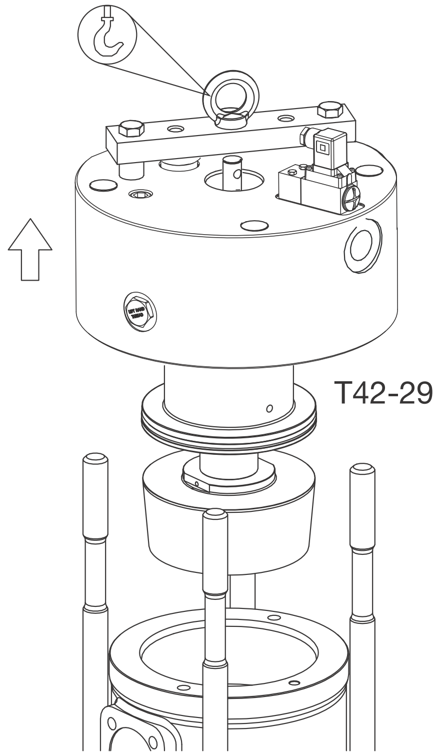
4265-0601-0012D04

Mount the lifting tool Remove the two hexagon head screws and mount the lifting tool in the holes.



4265-0601-0012D05

Lift the top cover Carefully lift up the top cover assembly, and land it on a wooden support.



4265-0601-0012D06

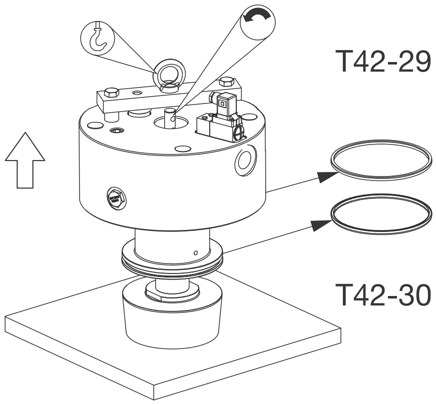
Discard the sealing rings

Land the top cover assembly on a wooden support.

Unscrew the retaining tool for the fuel plunger.

Carefully lift the booster top cover clear of the plunger.

Remove and discard the sealing rings.



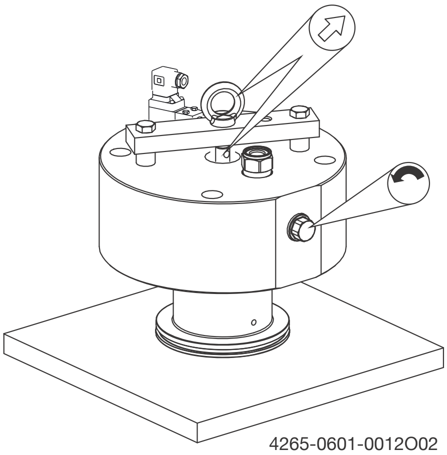
4265-0601-0012O01

Remove the suction valve

Remove the lifting tool and the retaining tool from the top cover.

Unscrew and remove the suction valve from the top cover.

See work card 4265-0701.



4265-0601-0012O02

Milling / grinding

Carefully clean and examine the top cover.

Reconditioning of the seatings for the high-pressure pipes is carried out by milling according to the following procedure:

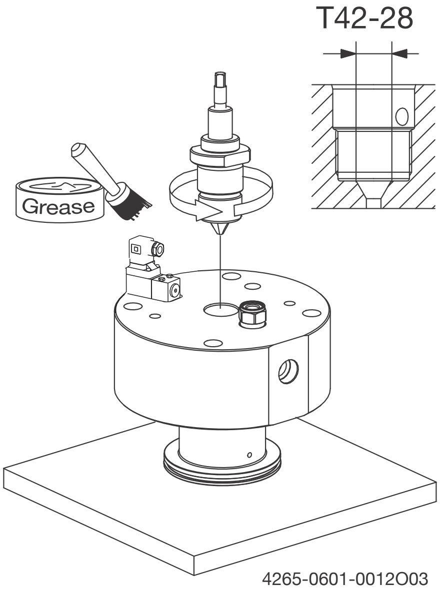
Fill the oil ducts in the top cover with Vaseline or heavy grease.

During the work the miller is guided by the guide screwed into the thread for the high-pressure pipe.

Turn the miller by means of, e.g. a tap wrench, while tightening the guide screw lightly to provide a suitable pressure between miller and seat.

During the milling, add drilling oil emulsion liberally.

For the max. milling/grinding diameter of the seat, *see Data T42-28*.



4265-0601-0012O03

After completing the milling

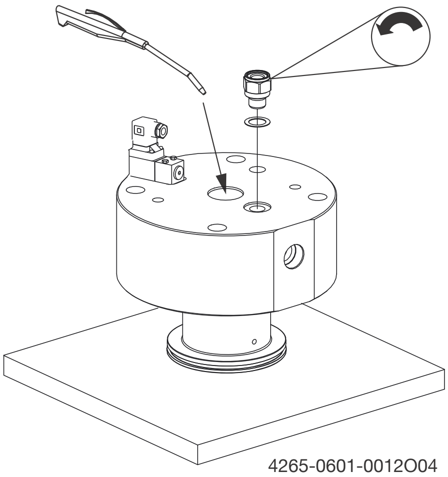
Blow out the Vaseline/grease from the oil ducts by means of compressed air.

WARNING

Always use eye protection when working with compressed air.

Clean the top cover with gas oil, and blow dry with compressed air.

Unscrew the orifice plug for return oil. Clean the plug and remount it.



4265-0601-0012O04

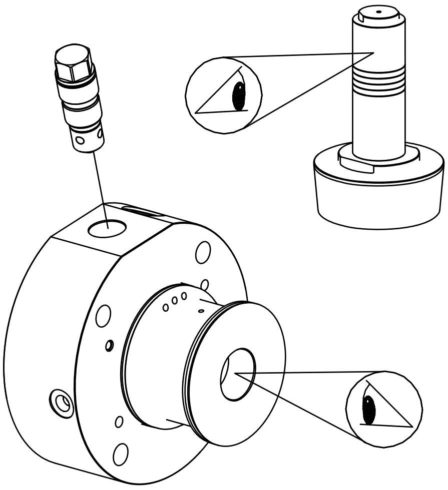
Top cover and fuel plunger

Place the top cover on one side and clean the bore for the fuel plunger in clean kerosene. Inspect the bore and plunger.

For evaluation of the fuel plunger/ top cover assembly, *see Description 6345-0320*.

Mount the suction valve, *see work card 4265-0701*.

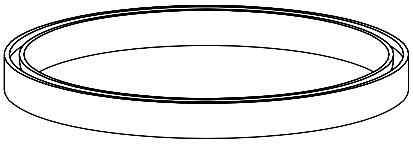
The top cover and fuel plunger are matched parts and must only be renewed as a set.



4265-0601-0002O05

Before fitting new sealing rings

Before fitting new sealing rings on the top cover, **heat them to 160-220°C** for at least five minutes.



NOTE

Take care not to exceed the temperature limit.

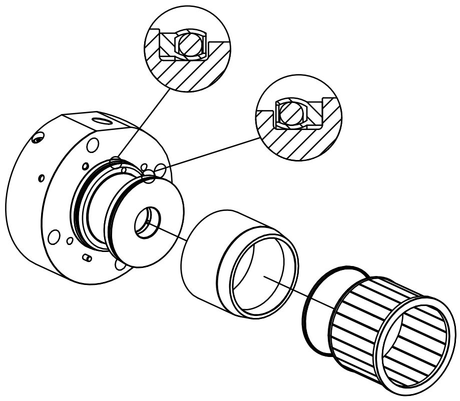
4265-0601-0002O06

Sealing rings

Mount the sealing rings as shown.

Place the cone on the top cover and fit the uppermost ring first.

Push the sealing ring in place with the pushing tool.



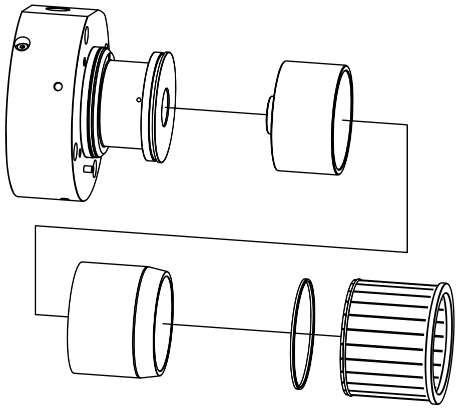
4265-0601-0002O07

How to mount the sealing ring

Remove the cone from the top cover and place the spacer ring tap in the hole for the plunger.

Place the cone on the top cover and on the spacer ring.

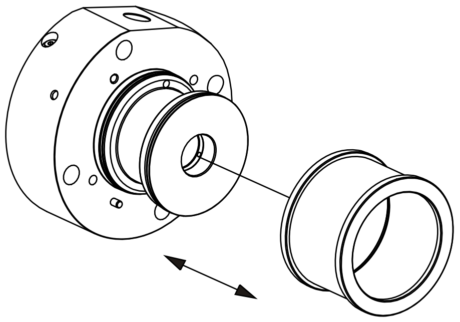
Fit the sealing ring in the lowermost groove by use of the pushing tool. Remove the cone and the spacer ring.



4265-0601-0002O08

Compress the sealing rings

Compress the sealing rings with the compression tool.



4265-0601-0002O09

Plunger

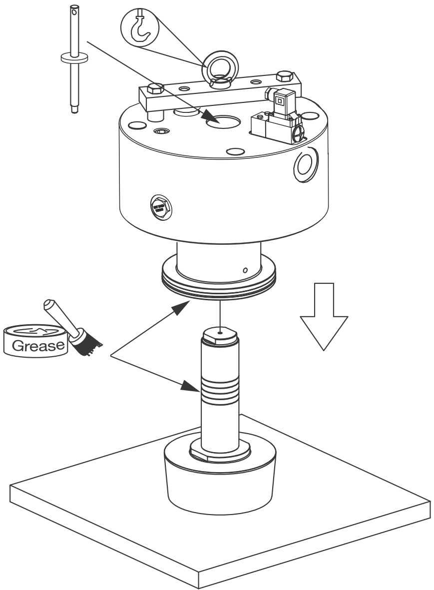
Turn the top cover to an upright position.
Place the retaining tool for the fuel plunger in the centre hole and mount the lifting tool.

Place the plunger on a plane surface.

Apply a little clean grease to the inner hole in the top cover and a thin layer to the plunger.

Carefully lower the top cover onto the fuel plunger, until the top cover rests on the plunger.

Screw the retaining tool into the fuel plunger, to lock the plunger in position.



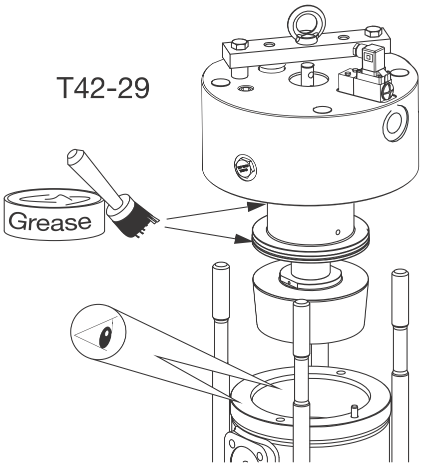
4265-0601-0012O10

Mounting the top cover

Mount the lifting tool on the new or overhauled top cover assembly.

Lift the top cover assembly and apply grease to the new sealing rings.

Check that the face on the fuel oil pressure booster housing and the inside cylindrical part are clean and free of fuel oil.

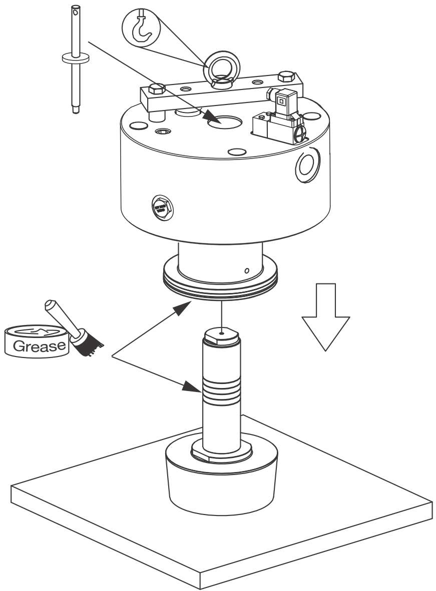


4265-0601-0012M01

Check for a correct positioning

Carefully land the top cover on the fuel oil pressure booster.

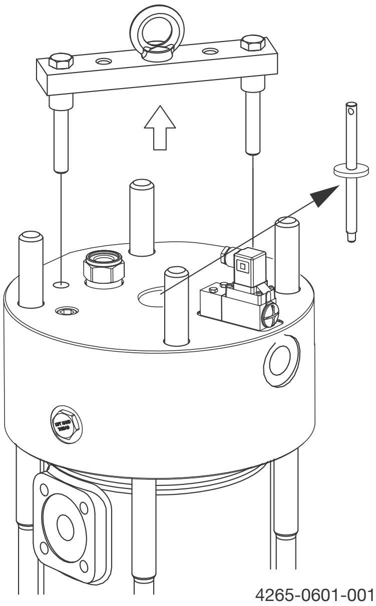
Check that the guide pin in the top cover is entering the hole in the fuel oil pressure booster housing for correct positioning.



4265-0601-0012O10

Remove the lifting tool from the top cover

Unscrew and remove the retaining tool for the fuel plunger.

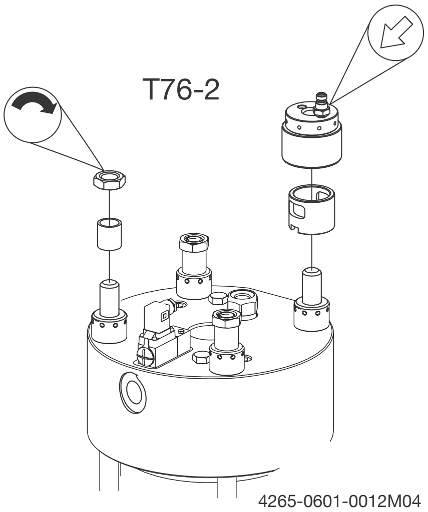


4265-0601-0012M03

Tighten the nuts

Screw the nuts on to the studs. Mount 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 the spacer rings.

For use of hydraulic tools, see also work card 7665-0101.

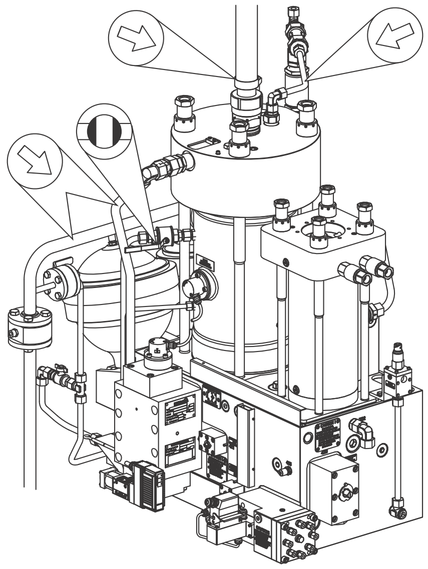


4265-0601-0012M04

Connect the return oil pipe

Connect the fuel oil high-pressure pipes, *see work card 4265-0101.*

Connect the return oil pipe.



4265-0501-0014M05

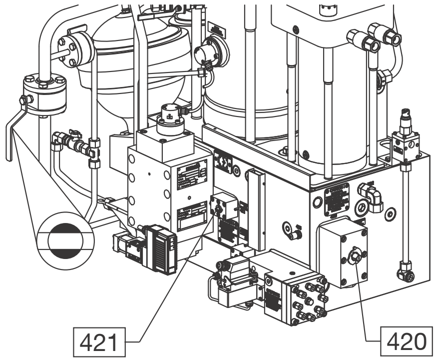
Close drain & open fuel suppply

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

Close the oil drain.

Remount the fuel valve handle

Open the fuel oil inlet valve.



4265-0501-0014M06

Fuel Oil Pressure Booster Suction Valve, Data

Work Card
4265-0700-0002

Safety Precautions

for detailed sketch see 0545-0100

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

Data

Ref.	Description	Value	Unit
T42-33	Fuel suction valve, tightening torque	1165	Nm

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

Shut Off the Oil Supply

Close the fuel oil inlet valve.

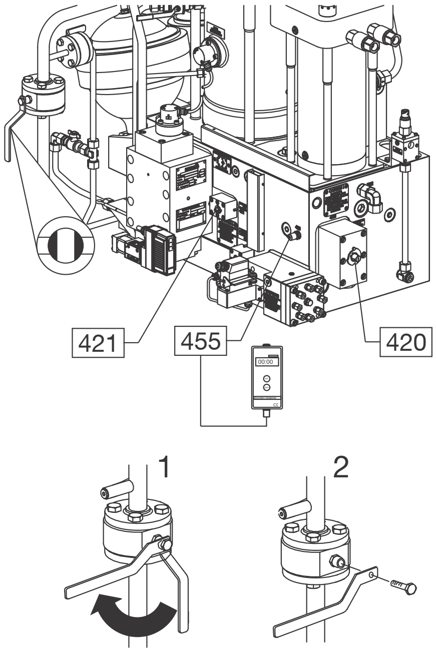
Open fuel oil drain

NOTE

For Safety reasons, remove the valve handle.

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

Close valve 420 and open valve 421 on the hydraulic block. Check that the hydraulic cylinder unit is pressure free.

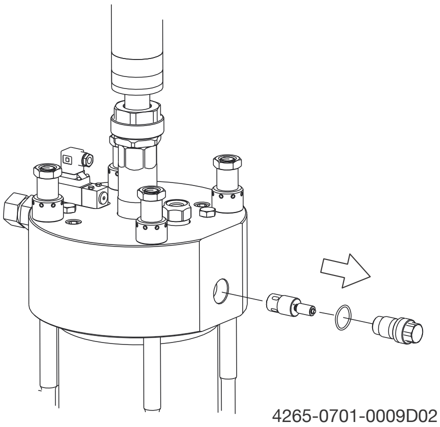


4265-0501-0014D01

Unscrew the union nut

Unscrew the union nut for the suction valve, remove and discard the O-ring.

Pull out the suction valve.

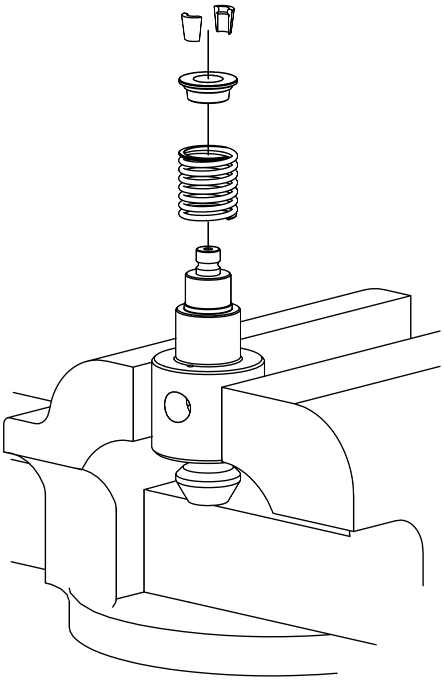


4265-0701-0009D02

Clean the fuel suction valve

Set up the fuel suction valve in a bench vice with “soft” jaws and press down the spring by means of the cone to release the valve spindle from the two-part conical ring.

Clean the parts thoroughly in clean diesel oil and carefully dry.



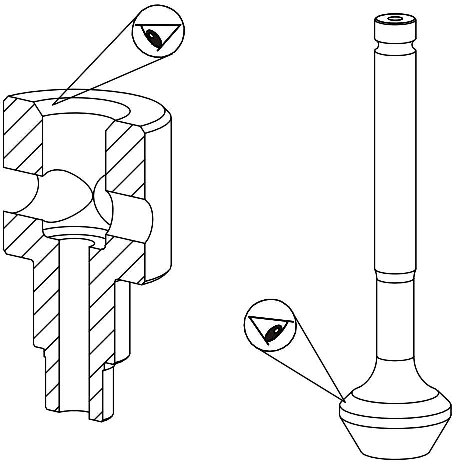
4265-0701-0002O01

The valve spindle

Inspect the seat on the valve spindle and the seat on the valve housing for damage.

If the seats are worn or damaged, a new suction valve must be fitted.

It is not recommended to recondition the valve by lapping. Lapping will damage the seat geometry and lead to very limited running time for the valve.

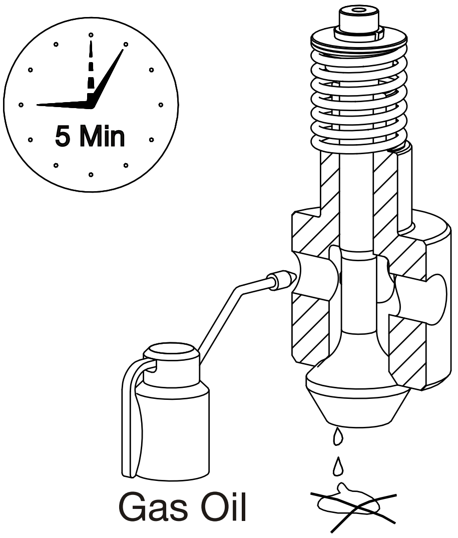


4265-0701-0002O02

After cleaning the valve spindle

After cleaning and inspecting all the parts, lubricate these with molybdenum disulphide (MoS2) and assemble the suction valve.

Check the seats for tightness by filling the inlet hole with diesel oil and waiting 5 minutes. No oil may pass through the seats.



4265-0701-0002O03

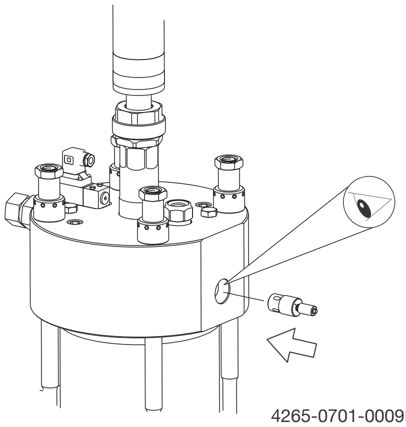
Remember

If the suction valve is not to be mounted on the engine immediately after the overhaul, cover all openings of the valve with plastic to prevent dirt from entering the valve during storage.

Mount new suction valve

Check that the face for the suction valve is clean.

Mount the overhauled or new suction valve.

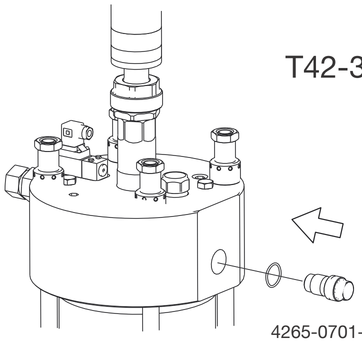


4265-0701-0009M01

Mount a new O-ring on the union nut

Lubricate the O-ring and the thread on the union nut with molybdenum disulphide (MoS_2) grease.

Mount and tighten the nut to the specified torque. *See Data*.



4265-0701-0009M02

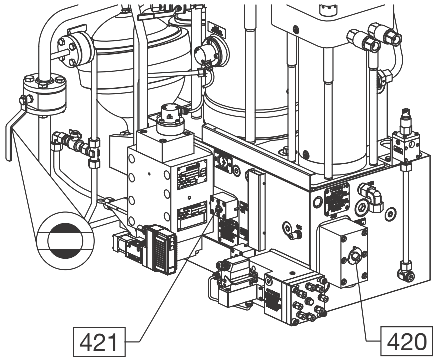
Close drain & open fuel supply

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

Close the oil drain.

Remount the fuel valve handle

Open the fuel oil inlet valve.



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