

# **L28/32H**

## **Instruction Manual - Marine**

Four-stroke GenSet

compliant with IMO Tier II

Engineering the Future – since 1758.

**MAN Diesel & Turbo**



|  |               |              |
|--|---------------|--------------|
|  | <b>GenSet</b> | <b>Index</b> |
|--|---------------|--------------|

**L28-2**

| Text  | Index        | Drawing No.     |
|---|--------------|-----------------|
| <b>Engine data</b> <b>500/600</b>   |              |                 |
| Preface   | Description  | A6000           |
| Warning   | Description  | A6001           |
| Questionnaire   | Description  | A6002           |
| Main particulars  | Description  | 600.00 (07H)    |
| Introduction  | Description  | 600.01 (08H)    |
| Safety  | Description  | 600.02 (06H)    |
| Cross section   | Description  | 600.05 (07H)    |
| Key for engine designation  | Description  | 600.10 (02H)    |
| Designation of cylinders  | Description  | 600.11 (01H)    |
| Engine rotation clockwise   | Description  | 600.12 (02H)    |
| Code identification for instruments   | Description  | 600.20 (03H)    |
| Introduction to planned maintenance programme                               | Description  | 600.24 (02H)    |
| Planned maintenance programme   | Description  | 600.25 (33H)    |
| Operation data & set points   | Description  | 600.30 (50H)    |
| Green Passport  | Description  | 600.33 (02H)    |
| Data for pressure and tolerance   | Description  | 600.35 (16H)    |
| Data for tightening torque  | Description  | 600.40 (18H)    |
| Declaration of weight   | Description  | 600.45 (01H)    |
| Ordering of spare parts   | Description  | 600.50 (06H)    |
| How to return spare parts   | Description  | 600.51 (05H)    |
| Service letters   | Description  | 600.55 (01H)    |
| Conversion table  | Description  | 600.60 (01)     |
| Basic symbol for piping   | Description  | 600.65 (01H)    |
| <b>Operation of engine</b> <b>501/601</b>                                   |              |                 |
| Operating   | Description  | 601.01 (21H)    |
| Out of service  | Description  | 601.05 (17H)    |
| Starting-up after out of service periods                                    | Description  | 601.10 (17H)    |
| Guidelines for longterm low-load operation on HFO                           | Description  | 601.15 (03H)    |
| Guidelines regarding MAN Diesel GenSets operating on low sulphur fuel oil   | Description  | 601.16 (02H)    |
| <b>Performance and condition</b> <b>502/602</b>                             |              |                 |
| Engine performance and condition  | Description  | 602.01 (12H)    |
| Evaluation of readings regarding combustion condition                       | Description  | 602.02 (11H)    |
| Condensate amount   | Description  | 602.05 (08H)    |
| Engine performance data   | Working card | 602-01.00 (03H) |
| <b>Trouble shooting</b> <b>503/603</b>                                      |              |                 |
| Starting failure  | Description  | 603.01 (08H)    |
| Faults in fuel oil system   | Description  | 603.02 (09H)    |
| Disturbances during running   | Description  | 603.03 (08H)    |
| Ignition in crankcase   | Description  | 603.04 (09H)    |
| Trouble shooting guide for centrifugal by-pass filter                       | Description  | 603.05 (08H)    |
| Trouble shooting guide for turbine starter                                  | Description  | 603.06 (09H)    |
| Trouble shooting guide for cooling water system                             | Description  | 603.09 (08H)    |
| Trouble shooting guide for lubricating oil cooler                           | Description  | 603.10 (01H)    |
| <b>Media specification</b> <b>504/604</b>                                   |              |                 |
| Quality requirement for lube oil (SAE30) for heavy fuel oil operation (HFO) | Description  | 604.01 (27H)    |

| Index | GenSet |  |
|-------|--------|--|
|-------|--------|--|

**L28-2**

| Text  | Index          | Drawing No.     |
|---|----------------|-----------------|
| Quality requirem. for lube oil (SAE30) for operation with gas oil, diesel oil (MGO/MDO) and biofuel | Description    | 604.01 (26H)    |
| Treatment and maintenance of lubricating oil  | Description    | 604.03 (11H)    |
| Criteria for cleaning/exchange of lubricating oil   | Description    | 604.04 (17H)    |
| Lubricating points  | Description    | 604.05 (01H)    |
| Lubricating points  | Description    | 604.05 (02H)    |
| Lubricating oil in base frame   | Description    | 604.06 (16H)    |
| Specific lube oil consumption - SLOC  | Description    | 604.07 (02H)    |
| Heavy fuel oil (HFO) specification  | Description    | 3.3.3-01        |
| Diesel oil (MDO) specification  | Description    | 3.3.2-01        |
| Gas oil / diesel oil (MGO) specification  | Description    | 3.3.1-01        |
| Bio fuel specification  | Description    | 3.3.1-02        |
| Viscosity-temperature diagram (VT diagram)  | Description    | 3.3.4-01        |
| Fuel oil cleaning   | Description    | 604.30 (01H)    |
| Engine cooling water specifications   | Description    | 3.3.7-01        |
| Cooling water inspecting  | Description    | 000.07-01       |
| Cooling water system cleaning   | Description    | 000.08-01       |
| Water specification for fuel-water emulsions  | Description    | 3.3.10-01       |
| Specifications for intake air (combustion air)  | Description    | 3.3.11-01       |
| <b>Cylinder head</b>  | <b>505/605</b> |                 |
| Cylinder head   | Description    | 605.01 (14H)    |
| Dismantling of cylinder head  | Working card   | 605-01.00 (01H) |
| Inspection of inlet valve, exhaust valve and valve guide  | Working card   | 605-01.05 (06H) |
| Reconditioning of valve spindle seat and valve seat ring  | Working card   | 605-01.10 (01H) |
| Valve rotator   | Working card   | 605-01.15 (01H) |
| Replacement of valve guide  | Working card   | 605-01.20 (05H) |
| Safety valve  | Working card   | 605-01.25 (04H) |
| Indicator valve   | Working card   | 605-01.26 (02H) |
| Replacement of sleeve for fuel injector   | Working card   | 605-01.30 (04H) |
| Replacement of valve seat ring  | Working card   | 605-01.35 (06H) |
| Mounting of cylinder head   | Working card   | 605-01.40 (06H) |
| Inspection of cylinder head cooling water space   | Working card   | 605-01.45 (01H) |
| Cylinder head   | Plate          | 60501-19H       |
| Valve spindles and valve gear   | Plate          | 60502-31H       |
| Safety valve and indicator valve  | Plate          | 60508-11H       |
| Cylinder head, top cover  | Plate          | 60510-12H       |
| <b>Piston/connecting rod</b>  | <b>506/606</b> |                 |
| Piston, connecting rod and cylinder liner   | Description    | 606.01 (10H)    |
| Dismounting of piston and connecting rod  | Working card   | 606-01.00 (01H) |
| Separation of piston and connecting rod   | Working card   | 606-01.05 (03H) |
| Piston  | Working card   | 606-01.10 (09H) |
| Connecting rod  | Working card   | 606-01.15 (04H) |
| Criteria for replacement of connecting rod big-end and main bearing shells                          | Working card   | 606-01.16 (02H) |
| Mounting of piston and connecting rod   | Working card   | 606-01.20 (01H) |
| Hydraulic tightening of connecting rod screws   | Working card   | 606-01.25 (04H) |
| In-situ inspection of connecting rod big-end bearing  | Working card   | 606-01.30 (01H) |
| Inspection and honing of cylinder liner   | Working card   | 606-01.35 (08H) |
| Replacement of cylinder liner   | Working card   | 606-01.40 (01H) |
| Grinding of seal face on cylinder liner and cylinder head   | Working card   | 606-01.45 (01H) |
| Dismounting of piston and cylinder liner at low overhaul heights                                    | Working card   | 606-01.50 (01H) |
| Piston and connecting rod (hydraulic tightened)   | Plate          | 60601-34H       |
| Cylinder liner  | Plate          | 60610-09H       |

|  | GenSet | Index |
|--|--------|-------|
|--|--------|-------|

**L28-2**

| Text   | Index        | Drawing No.     |
|--|--------------|-----------------|
| <b>Camshaft</b> <b>507/607</b>   |              |                 |
| Camshaft and camshaft drive  | Description  | 607.01 (05H)    |
| Camshaft and camshaft drive  | Working card | 607-01.00 (01H) |
| Inspection and replacement of camshaft bearing                                       | Working card | 607-01.05 (01H) |
| Adjustment of camshaft for valve and injection timing                                | Working card | 607-01.20 (04H) |
| Intermediate wheel   | Plate        | 60701-06H       |
| Camshaft and camshaft bearing  | Plate        | 60705-22H       |
| <b>Operating gear</b> <b>508/608</b>   |              |                 |
| Operating gear for valves and fuel injection pumps                                   | Description  | 608.01 (12H)    |
| Inspection of valve roller guides  | Working card | 608-01.00 (01H) |
| Inspection of fuel injection pump roller guide                                       | Working card | 608-01.05 (01H) |
| Control and adjustment of valve clearance  | Working card | 608-01.10 (01H) |
| Roller guide and push rods   | Plate        | 60801-17H       |
| <b>Control/safety</b> <b>509/609</b>   |              |                 |
| Control and safety system  | Description  | 609.01 (20H)    |
| Instruments and automatics   | Description  | 609.05 (11H)    |
| Lambda controller  | Description  | 609.10 (15H)    |
| Starting box   | Description  | 609.35 (06H)    |
| Converter for engine- and turbocharger RPM signal                                    | Description  | 609.40 (01H)    |
| Functional test and adjustment of safety, alarm and monitoring equipment             | Working card | 609-01.00 (01H) |
| Functional test and adjustment of overspeed trip                                     | Working card | 609-01.05 (01H) |
| Adjustment and test of ON/OFF pressostate  | Working card | 609-05.00 (02H) |
| Adjustment and test of ON/OFF thermostate  | Working card | 609-05.01 (02H) |
| Function and test of level switch (LAL 25)   | Working card | 609-05.02 (02H) |
| Adjustment and test of analogous transmitter   | Working card | 609-05.03 (02H) |
| Adjustment and test of analogous temperature transmitter                             | Working card | 609-05.04 (02H) |
| Adjustment of lambda controller  | Working card | 609-10.00 (16H) |
| Governor and governor drive  | Plate        | 60901-13H       |
| Governor and governor drive  | Plate        | 60901-14H       |
| Governor and governor drive  | Plate        | 60901-15H       |
| Regulating mechanism   | Plate        | 60902-18H       |
| Overspeed device   | Plate        | 60903-38H       |
| Instrument panel   | Plate        | 60905-20H       |
| Instrument panel   | Plate        | 60905-27H       |
| Instrument panel   | Plate        | 60905-32H       |
| Thermometer  | Plate        | 60907-19H       |
| Pressostate, thermostate, diff. pressostate and pressure transmitter                 | Plate        | 60907-02H       |
| Prelubricating oil alarm (LAL 25)  | Plate        | 60919-01H       |
| Level switch in oil sump (LAL/LAH 28)  | Plate        | 60920-01H       |
| Local starting box - No 1  | Plate        | 60935-13H       |
| Local starting box - No 1  | Plate        | 60935-16H       |
| Local starting box - No 2  | Plate        | 60935-14H       |
| Local starting box - No 2 (incl. high lub. oil temp.)                                | Plate        | 60935-15H       |
| Engine control box   | Plate        | 60936-08H       |
| Terminal box   | Plate        | 60936-07H       |
| Converter  | Plate        | 60956-01        |
| <b>Crankshaft</b> <b>510/610</b>   |              |                 |
| Crankshaft and main bearings   | Description  | 610.01 (12H)    |
| Checking of main bearings alignment (deflection), hydraulic tightened connecting rod | Working card | 610-01.00 (10H) |



| Index | GenSet |  |
|-------|--------|--|
|-------|--------|--|

**L28-2**

| Text  | Index          | Drawing No.     |
|---|----------------|-----------------|
| Inspection of main bearing shells   | Working card   | 610-01.05 (05H) |
| Inspection of guide bearing shells  | Working card   | 610-01.10 (08H) |
| Vibration damper  | Working card   | 610-04.00 (01H) |
| Crankshaft  | Plate          | 61001-15H       |
| Crankshaft  | Plate          | 61001-21H       |
| Resilient gear wheel  | Plate          | 61002-07H       |
| Coupling for central drive lub. oil pump  | Plate          | 61002-11H       |
| Coupling for central drive lub. oil pump  | Plate          | 61002-12H       |
| Coupling for central drive lub. oil pump  | Plate          | 61002-13H       |
| Coupling for central drive lub. oil pump  | Plate          | 61002-14H       |
| Resilient gear wheel  | Plate          | 61002-15H       |
| Resilient gear wheel  | Plate          | 61002-16H       |
| Resilient gear wheel  | Plate          | 61002-17H       |
| Flywheel with gear rim  | Plate          | 61003-02H       |
| Flywheel with gear rim  | Plate          | 61003-05H       |
| Flywheel with gear rim  | Plate          | 61003-06H       |
| Torsional vibration damper  | Plate          | 61004-05H       |
| Torsional vibration damper  | Plate          | 61004-12H       |
| Torsional vibration damper  | Plate          | 61004-13H       |
| Torsional vibration damper  | Plate          | 61004-14H       |
| Torsional vibration damper  | Plate          | 61004-15H       |
| Torsional vibration damper  | Plate          | 61004-16H       |
| Tuning wheel  | Plate          | 61004-06H       |
| <b>Engine frame/Oil pan</b>   | <b>511/611</b> |                 |
| Engine frame and base frame   | Description    | 611.01 (07H)    |
| Functional test of crankcase safety relief valves                                     | Working card   | 611-01.00 (04H) |
| Frame with main bearings  | Plate          | 61101-11H       |
| Front cover for lubricating oil pump  | Plate          | 61102-09H       |
| Front cover for lubricating oil pump and cooling water pump                           | Plate          | 61102-07H       |
| Front cover for lubricating oil pump and cooling water pumps                          | Plate          | 61102-10H       |
| Covers on frame   | Plate          | 61106-20H       |
| Cover on frame  | Plate          | 61106-14H       |
| <b>Turbocharger</b>   | <b>512/612</b> |                 |
| Turbocharger system   | Description    | 612.01 (28H)    |
| Cleaning the turbocharger in service, water washing of compressor                     | Description    | 612.05 (07H)    |
| Cleaning the turbocharger in service, dry cleaning - turbine                          | Description    | 612.10 (09H)    |
| Cleaning the turbocharger in service, water washing - turbine side                    | Description    | 612.15 (02H)    |
| Overhaul of charging air cooler   | Working card   | 612-01.00 (02H) |
| Charge air cooler housing - draining  | Working card   | 612-01.05 (02H) |
| Water washing of compressor side - turbochager type NR15/R - NR20/R - NR24/R - NR26/R | Working card   | 612-05.00 (03H) |
| Dry cleaning of turbocharger - turbine side   | Working card   | 612-10.00 (02H) |
| Water washing of turbine side   | Working card   | 612-15.00 (01H) |
| Charging air cooler - freshwater  | Plate          | 61201-12H       |
| Charging air cooler - freshwater  | Plate          | 61201-13H       |
| Charging air cooler - freshwater  | Plate          | 61201-14H       |
| Charging air cooler - freshwater  | Plate          | 61201-15H       |
| Charging air cooler - seawater  | Plate          | 61201-16H       |
| Charging air cooler - seawater  | Plate          | 61201-17H       |
| Charging air cooler   | Plate          | 61201-29H       |
| Exhaust pipe arrangement  | Plate          | 61202-23H       |
| Exhaust pipe arrangement with welded compensator                                      | Plate          | 61202-32H       |
| Exhaust pipe arrangement  | Plate          | 61202-26H       |

|  | GenSet | Index |
|--|--------|-------|
|--|--------|-------|

**L28-2**

| Text  | Index          | Drawing No.     |
|---|----------------|-----------------|
| Exhaust pipe arrangement with welded compensator                      | Plate          | 61202-28H       |
| Exhaust pipe arrangement  | Plate          | 61202-27H       |
| Exhaust pipe arrangement with welded compensator                      | Plate          | 61202-42H       |
| Water washing of compressor side                                      | Plate          | 61205-02H       |
| Steam trap  | Plate          | 61208-01H       |
| Blowgun for dry cleaning of turbocharger                              | Plate          | 61210-02H       |
| <b>Compressed air system</b>  | <b>513/613</b> |                 |
| Compressed air system   | Description    | 613.01 (20H)    |
| Air filter  | Working card   | 613-01.21 (02H) |
| Overhaul, test and inspection of turbine starter                      | Working card   | 613-01.30 (02H) |
| Main starting valve   | Working card   | 613-01.40 (01H) |
| Check of compressed air piping system                                 | Working card   | 613-01.90 (02H) |
| Turbine starter   | Plate          | 61309-05H       |
| Main starting valve   | Plate          | 61310-03H       |
| Muffler   | Plate          | 61312-02H       |
| Emergency starting valve  | Plate          | 61313-03H       |
| Starting valve  | Plate          | 61314-03H       |
| Main stop valve   | Plate          | 61315-03H       |
| Air strainer  | Plate          | 61316-03H       |
| Safety valve  | Plate          | 61319-01H       |
| ON-OFF valve for jet system   | Plate          | 61320-05H       |
| ON-OFF valve for jet system   | Plate          | 61320-06H       |
| Air filter  | Plate          | 61321-03H       |
| Pressure reduction valve  | Plate          | 61322-04H       |
| Turning gear  | Plate          | 61325-07H       |
| Pneumatic turning gear (motor power unit)                             | Plate          | 61325-08H       |
| Pneumatic turning gear (spindle, gear case and gearing)               | Plate          | 61325-09H       |
| <b>Fuel oil system</b>  | <b>514/614</b> |                 |
| Internal fuel oil system  | Description    | 614.01 (25H)    |
| Fuel injection pump and fuel injection pipe                           | Working card   | 614-01.05 (02H) |
| Fuel injection pump and fuel injection pipe                           | Working card   | 614-01.05 (05H) |
| Fuel injection valve  | Working card   | 614-01.10 (03H) |
| Fuel oil split filter   | Working card   | 614-01.15 (01H) |
| Check of fuel oil piping system                                       | Working card   | 614-01.90 (01H) |
| Adjustment of the maximum combustion pressure                         | Working card   | 614-05.01 (02H) |
| Fuel injection pump   | Plate          | 61401-03H       |
| Fuel injection pump   | Plate          | 61401-09H       |
| Fuel injection valve  | Plate          | 61402-04H       |
| Fuel injection valve, cooled  | Plate          | 61402-07H       |
| Fuel oil filter duplex  | Plate          | 61403-15H       |
| Fuel injection pipe   | Plate          | 61404-06H       |
| Pipes on cylinder section - forced lubrication with cooling oil pipes | Plate          | 61430-03H       |
| Nozzle cooling pump   | Plate          | 61440-05H       |
| <b>Lubricating oil system</b>   | <b>515/615</b> |                 |
| Internal lubricating oil system                                       | Description    | 615.01 (29H)    |
| Lubricating oil cooler  | Description    | 615.06 (02H)    |
| Centrifugal by-pass filter  | Description    | 615.15 (05H)    |
| Crankcase ventilation   | Description    | 615.31 (03H)    |
| Lubricating oil pump, engine driven                                   | Working card   | 615-01.00 (01H) |
| Prelubricating pump   | Working card   | 615-01.05 (02H) |
| Lubricating oil filter  | Working card   | 615-01.10 (01H) |

| Index | GenSet |  |
|-------|--------|--|
|-------|--------|--|

**L28-2**

| Text  | Index          | Drawing No.     |
|---|----------------|-----------------|
| Lubricating oil, thermostatic valve                     | Working card   | 615-01.20 (01H) |
| Check of lubricating oil piping system                  | Working card   | 615-01.90 (01H) |
| Lubricating oil cooler                                  | Working card   | 615-06.00 (02H) |
| Centrifugal by-pass filter                              | Working card   | 615-15.00 (01H) |
| Lubricating oil pump (central driven)                   | Plate          | 61501-12H       |
| Lubricating oil pump (gear driven)                      | Plate          | 61501-22H       |
| Lubricating oil filter (Type A)                         | Plate          | 61502-11H       |
| Lubricating oil filter (Type B)                         | Plate          | 61502-12H       |
| Lubricating oil filter (suppl. for plate 61502-11H/12H) | Plate          | 61502-15H       |
| Lubricating oil thermostatic valve                      | Plate          | 61503-08H       |
| Prelubricating pump with el-motor                       | Plate          | 61504-04H       |
| Lubricating oil cooler                                  | Plate          | 61506-10H       |
| Centrifugal by-pass filter                              | Plate          | 61515-09H       |
| Hand wing pump  | Plate          | 61525-02H       |
| Lubricating oil separator                               | Plate          | 61530-07H       |
| Lubricating oil pipes on engine                         | Plate          | 61530-02H       |
| <b>Cooling water system</b>                             | <b>516/616</b> |                 |
| Cooling water system                                    | Description    | 616.01 (17H)    |
| Cooling water thermostatic valve                        | Description    | 616.04 (15H)    |
| Check of cooling water system                           | Working card   | 616-01.90 (01H) |
| Cooling water thermostatic valve                        | Working card   | 616-04.00 (01H) |
| Cooling water thermostatic valve                        | Plate          | 61604-07H       |
| High temperature fresh water pump                       | Plate          | 61610-05H       |
| Low temperature fresh water pump                        | Plate          | 61610-07H       |
| Low temperature fresh water pump                        | Plate          | 61610-10H       |
| Sea water pump  | Plate          | 61615-04H       |
| Pipes on cylinder head                                  | Plate          | 61625-04H       |
| Cooling water pipes on engine                           | Plate          | 61630-01H       |
| Preheater - fresh water                                 | Plate          | 61635-06H       |
| <b>Special equipment</b>                                | <b>517/617</b> |                 |
| Kit for cylinder unit                                   | Kit            | 61704-02H       |
| Kit for overspeed device                                | Kit            | 61743-01H       |
| Kit for covers on frame                                 | Kit            | 61751-01H       |
| <b>Specific plant information</b>                       | <b>519/619</b> |                 |
| Resilient mounting of generating sets                   | Description    | 619.03 (10H)    |
| Fitting instructions for resilient mountings of gensets | Working card   | 619-03.00 (21H) |
| Fitting instructions for resilient mountings of gensets | Working card   | 619-03.00 (22H) |
| Fitting instructions for resilient mountings of gensets | Working card   | 619-03.00 (23H) |
| Replacement of conicals                                 | Working card   | 619-03.05 (01H) |
| Maintenance of conicals                                 | Working card   | 619-03.10 (01H) |
| Flexible external connections                           | Plate          | 61902-03H       |
| Conical element   | Plate          | 61903-04H       |
| <b>Tools</b>  | <b>520/620</b> |                 |
| Introduction to spare part plates for tools             | Description    | 620.01 (01H)    |
| Function of the hydraulic tools                         | Working card   | 620-01.05 (03H) |
| Application of hydraulic tools                          | Working card   | 620-01.06 (01H) |
| Hand lever pump   | Working card   | 620-01.07 (01H) |
| Maintenance of hydraulic tools                          | Working card   | 620-01.10 (01H) |
| Tightening with torque spanner                          | Working card   | 620-01.15 (01H) |

|  |               |              |
|--|---------------|--------------|
|  | <b>GenSet</b> | <b>Index</b> |
|--|---------------|--------------|

**L28-2**

| Text   | Index        | Drawing No.     |
|--|--------------|-----------------|
| Tool combinations for tightening of connecting rod screws                          | Working card | 620-01.20 (01H) |
| Max. pressure indicator  | Working card | 620-01.25 (02H) |
| Tools for cylinder head  | Plate        | 62005-03H       |
| Tools for piston, connecting rod and cylinder liner                                | Plate        | 62006-11H       |
| Tools for operating gear for inlet valves, exhaust valves and fuel injection pumps | Plate        | 62008-03H       |
| Tools for control and safety systems, automatics and instruments                   | Plate        | 62009-02H       |
| Tools for crankshaft and main bearing  | Plate        | 62010-07H       |
| Tools for crankshaft and main bearing  | Plate        | 62010-10H       |
| Tools for crankshaft and main bearing  | Plate        | 62010-11H       |
| Tools for fuel oil system and injection equipment                                  | Plate        | 62014-02H       |
| Tools for lubricating oil system   | Plate        | 62015-02H       |
| Hydraulic tools  | Plate        | 62021-08H       |
| Tools for low overhaul height, piston, cylinder liner and connecting rod           | Plate        | 62050-01H       |
| Operating manual for testing tool (Fuel injection valve)                           | Description  | GXO-D001        |

**Engine data**

**500/600**



## Instruction Manual for:

### MAN Diesel & Turbo Identification No. for Instruction Manual.

Identification No. for Description:

**000 . 00**

Function  
Section No.

Identification No. for Working Card:

**000 - 00 . 00**

Sub-function  
Function  
Section No.

Identification No. for Plates:

**00000 - 00 H**

H for Holeby  
Edition  
Section No. and Function

For ordering of spare parts, see page 500.50 / 600.50

*All data provided in this document/manual is non-binding. This data serves informational purposes only and is especially not guaranteed in any way.*

*Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.*

*If this document/manual is delivered in another language than English and doubts arise concerning the translation, the English text shall prevail.*

Original instructions

## **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 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>

Copyright 2011 © MAN Diesel & Turbo, branch of MAN Diesel & Turbo SE, Germany, registered with the Danish Commerce and Companies Agency under CVR Nr.: 31611792, (herein referred to as "MAN Diesel & Turbo").

This document/manual must not, either wholly or partly, be copied, reproduced, made public or in any other way made available to any third party without the written to this effect from MAN Diesel & Turbo.

### **MAN Diesel & Turbo**

H. Christoffersensvej 6  
4960 Holeby  
Denmark

Phone: +45 54 69 31 00

Fax: +45 54 69 30 30

[mandieselturbo-hol@mandieselturbo.com](mailto:mandieselturbo-hol@mandieselturbo.com)

[www.mandieselturbo.com](http://www.mandieselturbo.com)

### **PrimeServ Holeby**

#### **GenSet & Powerplant**

Service & Spare Parts

Fax : +45 54 69 30 31

After office hours : +45 40 14 40 45

[PrimeServ-hol@mandieselturbo.com](mailto:PrimeServ-hol@mandieselturbo.com)

### **MAN Diesel & Turbo**

Branch of MAN Diesel & Turbo SE,  
Germany

CVR No.: 31611792

Head office: Teglholmegade 41

2450 Copenhagen SV, Denmark

German Reg.No.: HRB 22056

Amtsgericht Augsburg

|                           |         |  |
|---------------------------|---------|--|
| Description<br>Page 1 (1) | Warning |  |
|---------------------------|---------|--|

General

Warning !

*(Marine engines only)*

It is important that all MAN Diesel & Turbo engines are operated within the given specifications and performance tolerances specified in the engines' Technical Files and are maintained according to the MAN Diesel & Turbo maintenance instructions in order to comply with given emissions 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 engine shall be performed as specified in MAN Diesel & Turbo instructions including, but not limited to, the instructions to that effect included in the Technical File.

## Your opinion counts!

Your opinion is valuable to us as it helps us to evaluate our services and to continuously improve the quality of our Technical Documentation.

May we ask you for a few minutes of your time to complete and then return this questionnaire to [TechDoc@mandieselturbo.com](mailto:TechDoc@mandieselturbo.com):

|  |                          |                          |                          |                          |                          |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Your company:  |                          | Very satisfied           | Rather Satisfied         | Rather dissatisfied      | Very dissatisfied        |
| Your position:   |                          |                          |                          |                          |                          |
| How do you rate the overall level of satisfaction with the manuals supplied? | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Which improvements would you suggest to be made in the future?               |                          |                          |                          |                          |                          |
|  |                          |                          |                          |                          |                          |
| Ring binders and organisation  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Comments/suggestions:  |                          |                          |                          |                          |                          |
|  |                          |                          |                          |                          |                          |
| Labelling of ring binders  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Comments/suggestions:  |                          |                          |                          |                          |                          |
|  |                          |                          |                          |                          |                          |
| Structuring of information and documents                                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Comments/suggestions:  |                          |                          |                          |                          |                          |
|  |                          |                          |                          |                          |                          |
| Access aids (contents page, index, register, etc.)                           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Comments/suggestions:  |                          |                          |                          |                          |                          |
|  |                          |                          |                          |                          |                          |
| Preparation of CDs/DVDs (navigation, etc.)                                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Comments/suggestions:  |                          |                          |                          |                          |                          |
|  |                          |                          |                          |                          |                          |
| Readability of texts and drawings (paper, CD/DVD)                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Comments/suggestions:  |                          |                          |                          |                          |                          |
|  |                          |                          |                          |                          |                          |
| Comprehensibility of contents  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Comments/suggestions:  |                          |                          |                          |                          |                          |
|  |                          |                          |                          |                          |                          |
| Scope of information provided  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Comments/suggestions:  |                          |                          |                          |                          |                          |
|  |                          |                          |                          |                          |                          |



Your opinion counts!

Customer satisfaction

|                           |                         |                              |
|---------------------------|-------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Main Particulars</b> | <b>600.00</b><br>Edition 07H |
|---------------------------|-------------------------|------------------------------|

**L28/32H**

|                                 |   |  |
|---------------------------------|---|--|
| <b>Cycle</b>                    | : | <b>4-stroke</b>  |
| <b>Configuration</b>            | : | <b>In-line</b>   |
| <b>Cyl. Nos. available</b>      | : | <b>5-6-7-8-9</b>   |
| <b>Power range</b>              | : | <b>1050-1980 kW</b>  |
| <b>Speed</b>                    | : | <b>720/750 rpm</b>   |
| <b>Bore</b>                     | : | <b>280 mm</b>  |
| <b>Stroke</b>                   | : | <b>320 mm</b>  |
| <b>Stroke/bore ratio</b>        | : | <b>1.14:1</b>  |
| <b>Piston area per cyl.</b>     | : | <b>616 cm<sup>2</sup></b>  |
| <b>Swept volume per cyl.</b>    | : | <b>19.7 ltr.</b>   |
| <b>Compression ratio</b>        | : | <b>13.9:1</b>  |
| <b>Max. combustion pressure</b> | : | <b>130 bar</b>   |
| <b>Turbocharging principle</b>  | : | <b>Constant pressure system and intercooling</b>   |
| <b>Fuel quality acceptance</b>  | : | <b>HFO (up to 700 cSt/50° C, RMK700)<br/>MDO (DMB) - MGO (DMA, DMZ)<br/>according ISO8217-2010</b> |

| Power lay-out            |         | MCR version |      |
|--------------------------|---------|-------------|------|
| Speed                    | rpm     | 720         | 750  |
| Mean piston speed        | m/sec.  | 7.7         | 8.0  |
| Mean effective pressure  | bar     | 17.8        | 17.9 |
| Max. combustion pressure | bar     | 130         | 130  |
| Power per cylinder       | kW/cyl. | 210         | 220  |

|  |         |     |     |
|--|---------|-----|-----|
| Overload rating (up to 10%) allowable in 1 hour for every 12 hours |         |     |     |
| Power per cylinder   | kW/cyl. | 230 | 240 |



|                           |              |                       |
|---------------------------|--------------|-----------------------|
| Description<br>Page 1 (1) | Introduction | 600.01<br>Edition 08H |
|---------------------------|--------------|-----------------------|

General

Introduction

This instruction book provides general information on the engine design, operation and maintenance. It can also be used as a reference when ordering spare parts. Reliable and economical operation of the plant is conditional upon its correct operation and maintenance in accordance with MAN Diesel & Turbo's instructions. Emissions-related maintenance of the diesel engine shall be performed as specified in MAN Diesel & Turbo's instructions and any additional instructions to that effect included in the Technical File. Consequently, it is essential that the engine room personnel are fully acquainted with the contents of this book and the Technical File.

Every care is taken to ensure that all information in this instruction book is present and correct.

This book must not, either wholly or partly, be copied, reproduced, made public or in any other way made available to any third party without the written consent to this effect from MAN Diesel & Turbo.

If an instruction book is delivered in another language than English and doubts arise concerning the translation, the English text shall prevail.

Description

The book is a basic instruction manual for the particular engine supplied, with plant-adapted information such as basic media-system drawings, electrical wiring diagrams and test bed reports.

The first five sections (500-504) of the book serve as a guide to engine operation, and the next fifteen sections (505-519) contain technical descriptions, spare parts illustrations with appurtenant parts lists, as well as working cards.

The last section (520) comprises tools.

The engine is divided into a number of main components/assemblies, each of which is described in a section of this book (section 505-519).

Each of these sections starts with technical descriptions of the systems/components, followed by working cards and the spare parts illustration plates and parts lists.

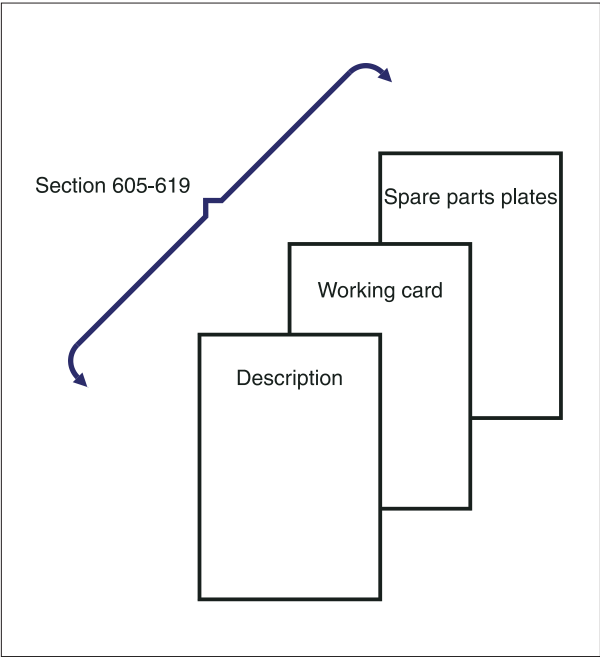


Fig. 1. Structuring of instruction book.

|                           |               |                              |
|---------------------------|---------------|------------------------------|
| Description<br>Page 1 (2) | <b>Safety</b> | <b>600.02</b><br>Edition 06H |
|---------------------------|---------------|------------------------------|

**General****General**

Proper maintenance, which is the aim of this book, constitutes the crucial point in obtaining optimum safety in the engine room. The general measures mentioned here should therefore be a natural routine to the entire engine room staff.

**Cleanliness**

The engine room should be kept clean above and below the floor plates. If grit or sand blows into the engine room when the ship is in port, the ventilation should be stopped and ventilating ducts, skylights, and doors in the engine room should be closed.

In particular, welding or work which causes spreading of grit and chips must be avoided near the engine, unless this is closed or covered, 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 easily be detected.

**Fire**

If the crankcase is opened before the engine is cold, welding and the use of naked light will involve the risk of explosions and fire. The same applies to inspection of oil tanks and the space below the fooler. Attention is furthermore drawn to the danger of fire when using paint and solvents with a low flash point. Porous insulating material drenched with oil from leakages is easily inflammable and should be renewed. See also: "Ignition in crankcase" in section 603.

**Order**

Hand tools should be placed easily accessible on tool boards. Special tools should be fastened to tool panels (if supplied) in the engine room close to the area of application. No major objects must be left unfastened, and the floor and passages should be kept clear.

**Spares**

Large spare parts should, as far as possible, be placed well strapped near the area of application and accessible by crane. The spare parts should be well preserved against corrosion and protected against mechanical damage. The stock should be checked at intervals and replenished in time.

**Light**

Ample working light should be permanently installed at appropriate places in the engine room, and portable working light, in explosion-proof fittings, should be obtainable everywhere.

**Freezing**

If there is a risk of damage due to freezing when the plant is out of service, engines, pumps, coolers, and pipe systems should be emptied of cooling water.

**Warning**

The opening of cocks may cause discharge of hot liquids or gases. The dismantling of parts may cause springs to be released.

The removal of fuel valves (or other valves in the cylinder head) may cause oil to run down to the piston crown, and if the piston is hot, an explosion may then blow out the valve.

When testing fuel valves with the hand pump, do not touch the spray holes, as the jet may pierce the skin. Think out beforehand which way the liquids, gases or flames will move, and keep clear.

**Crankcase work**

Check beforehand that the starting air supply to the engine is shut off.

|                              |               |                           |
|------------------------------|---------------|---------------------------|
| <b>600.02</b><br>Edition 06H | <b>Safety</b> | Description<br>Page 2 (2) |
|------------------------------|---------------|---------------------------|

## General

### Feeling over

Whenever repairs or alterations have been made to the running gear, apply the "Feel-over sequence" until ensured that there is no undue heating, oil-mist formation, blow-by, or failure of cooling water or lubricating oil systems.

### Feel-over sequence

Feel-over after 5-15 and 30 minutes' idle running and finally when the engine is running at full load. See also "Starting-up sequence" in the section 602.

### Turning with air

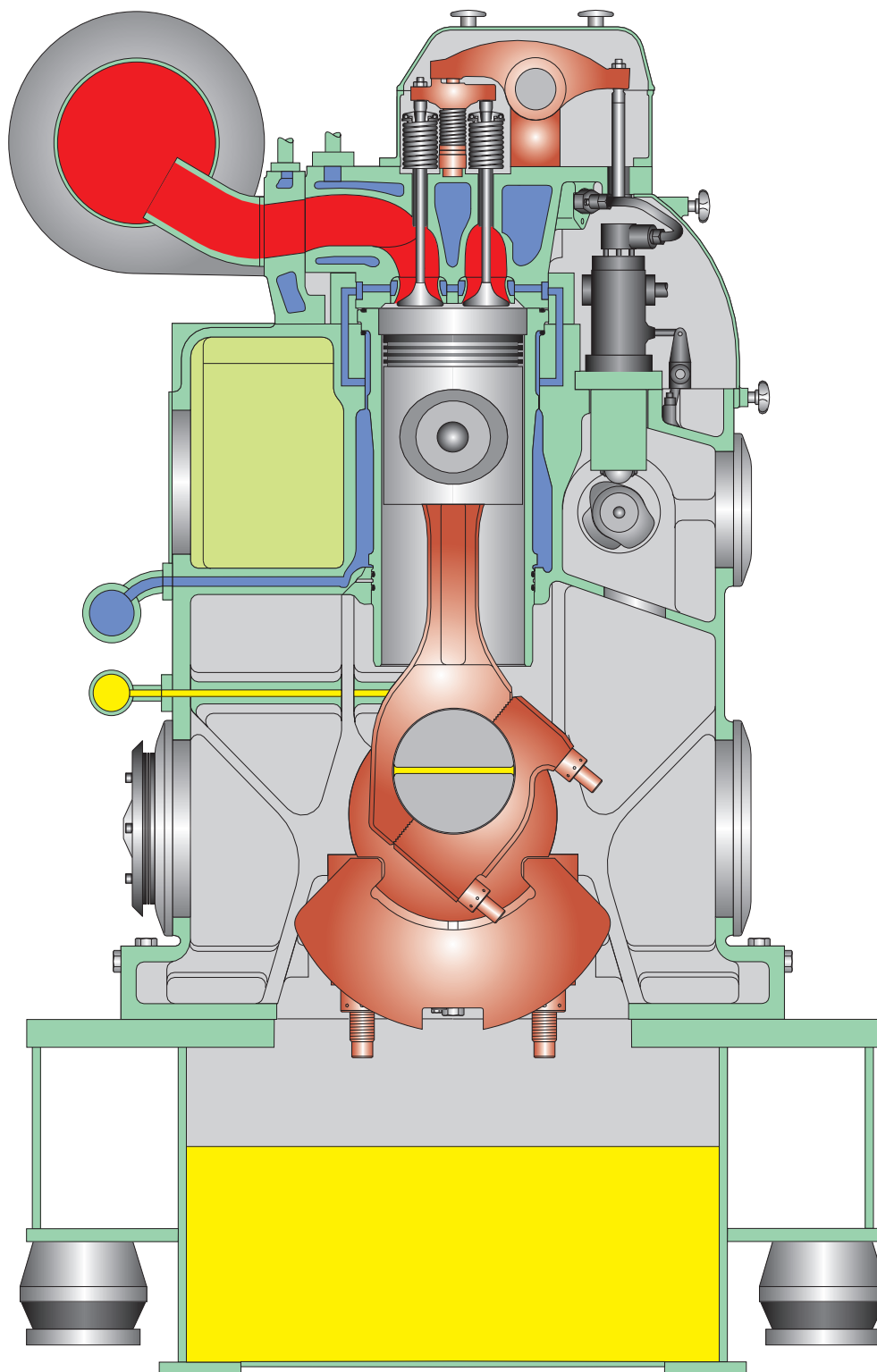
After prolonged out-of-service periods or overhaul work which may involve a risk of accumulation of liquid in the combustion spaces, turning with open indicator cocks should always be effected, through at least two complete revolutions.

### Check and maintain

Lubricating oil condition, filter elements and measuring equipment.

|                           |               |                       |
|---------------------------|---------------|-----------------------|
| Description<br>Page 1 (1) | Cross Section | 600.05<br>Edition 07H |
|---------------------------|---------------|-----------------------|

L28/32H

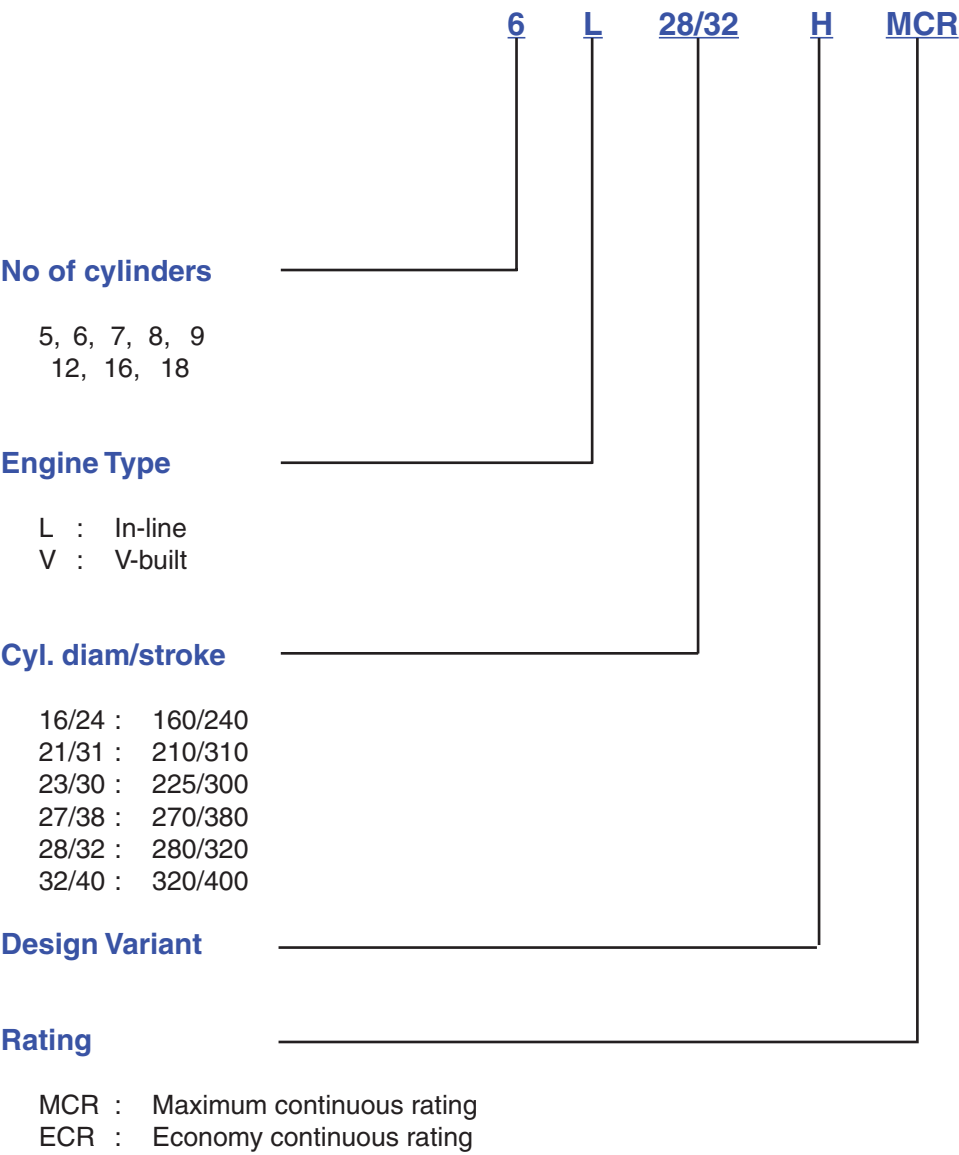


|                           |                            |                       |
|---------------------------|----------------------------|-----------------------|
| Description<br>Page 1 (1) | Key for Engine Designation | 600.10<br>Edition 02H |
|---------------------------|----------------------------|-----------------------|

General

Engine Type Identification

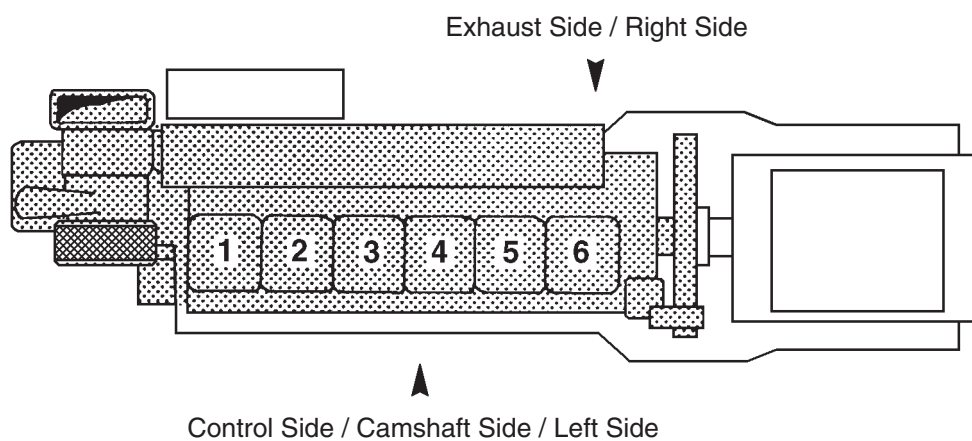
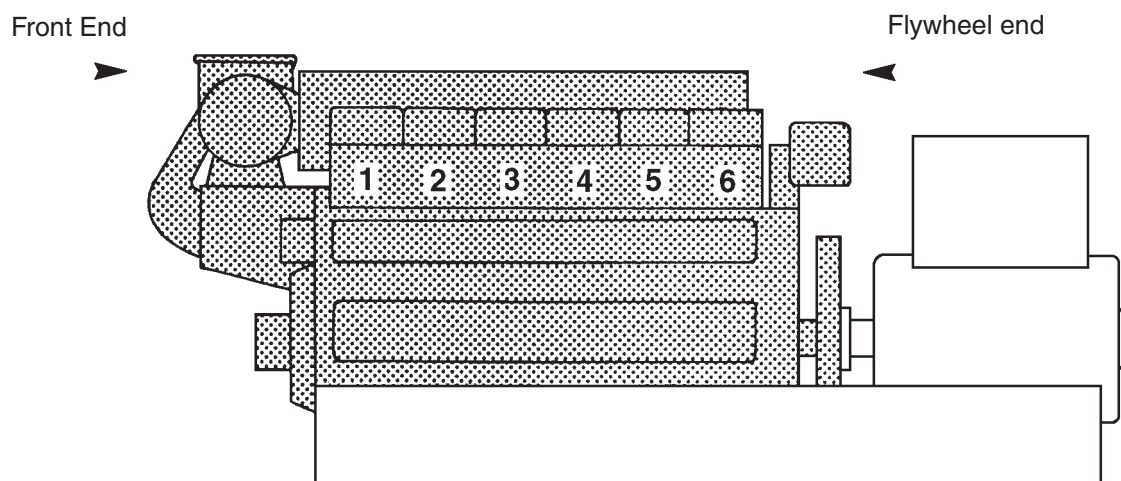
The engine types of the MAN B&W programme are identified by the following figures:



08028-0D/H5250/94.08.12

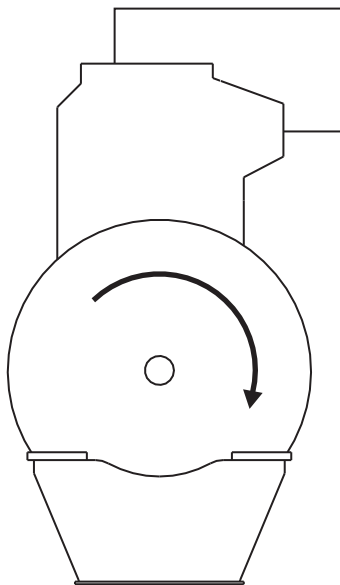


|                           |                                 |                              |
|---------------------------|---------------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Designation of Cylinders</b> | <b>600.11</b><br>Edition 01H |
|---------------------------|---------------------------------|------------------------------|

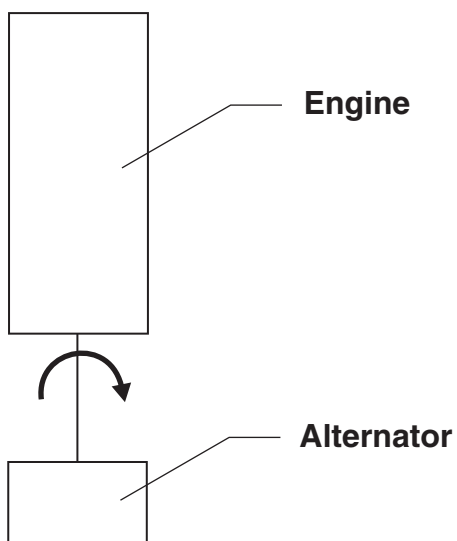
**L28/32H**

|                           |                                  |                              |
|---------------------------|----------------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Engine Rotation Clockwise</b> | <b>600.12</b><br>Edition 02H |
|---------------------------|----------------------------------|------------------------------|

## General



Direction of rotation seen from flywheel end “Clockwise”



|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (2) | <b>Code Identification for Instruments</b> | <b>600.20</b><br>Edition 03H |
|---------------------------|--|------------------------------|

**General****Explanation of Symbols**

Measuring device  
Local reading

**T**emperature **I**ndicator  
No. 40 \*



Measuring device  
Sensor mounted on engine/unit  
Reading/identification mounted in a panel on the engine/unit

**P**ressure **I**ndicator  
No. 22 \*



Measuring device  
Sensor mounted on engine/unit  
Reading/identification outside the engine/unit

**T**emperature **A**larm **H**igh  
No. 12 \*



Measuring device  
Sensor mounted on engine/unit  
Reading/identification in a panel on the engine/unit and reading/indication outside the engine/unit

**P**ressure **T**ransmitting  
No. 22 \*

\* Refer to standard location and text for instruments on the following pages.

| Specification of letter code for measuring devices |               |                   |                 |
|--|---------------|-------------------|-----------------|
| 1st letter   |               | Following letters |                 |
| F  | Flow          | A                 | Alarm           |
| L  | Level         | D                 | Differential    |
| P  | Pressure      | E                 | Element         |
| S  | Speed, System | H                 | High            |
| T  | Temperature   | I                 | Indicating      |
| U  | Voltage       | L                 | Low             |
| V  | Viscosity     | S                 | Switching, Stop |
| X  | Sound         | T                 | Transmitting    |
| Z  | Position      | X                 | Failure         |
|  |               | V                 | Valve, Atuator  |

**600.20**

Edition 03H

**Code Identification for Instruments**

Description

Page 2 (2)

**General****Standard Text for Instruments****Diesel Engine/Alternator****LT Water System**

|                                |  |                                     |
|--------------------------------|--|-------------------------------------|
| 01 inlet to air cooler         | 04 inlet to alternator                 | 07 inlet to lub. oil cooler         |
| 02 outlet from air cooler      | 05 outlet from alternator              | 08 inlet to fresh water cooler (SW) |
| 03 outlet from lub. oil cooler | 06 outlet from fresh water cooler (SW) | 09                                  |

**HT Water System**

|                              |                               |                                   |
|------------------------------|-------------------------------|-----------------------------------|
| 10 inlet to engine           | 14 inlet to HT air cooler     | 17 outlet from fresh water cooler |
| 10A FW inlet to engine       | 14A FW inlet to air cooler    | 18 inlet to fresh water cooler    |
| 11 outlet from each cylinder | 14B FW outlet from air cooler | 19 preheater                      |
| 12 outlet from engine        | 15 outlet from HT system      | 19A inlet to prechamber           |
| 13 inlet to HT pump          | 16 outlet from turbocharger   | 19B outlet from prechamber        |

**Lubricating Oil System**

|   |  |                        |
|---|--|------------------------|
| 20 inlet to cooler                      | 24 sealing oil - inlet engine                | 28 level in base frame |
| 21 outlet from cooler / inlet to filter | 25 prelubricating                            | 29 main bearings       |
| 22 outlet from filter / inlet to engine | 26 inlet rocker arms and roller guides       |                        |
| 23 inlet to turbocharger                | 27 intermediate bearing / alternator bearing |                        |

**Charging Air System**

|   |                            |    |
|---|----------------------------|----|
| 30 inlet to cooler                            | 34 charge air conditioning | 38 |
| 31 outlet from cooler                         | 35 surplus air inlet       | 39 |
| 32 jet assist system                          | 36 inlet to turbocharger   |    |
| 33 outlet from TC filter / inlet to TC compr. | 37 charge air from mixer   |    |

**Fuel Oil System**

|                       |                                 |    |
|-----------------------|---------------------------------|----|
| 40 inlet to engine    | 44 outlet from sealing oil pump | 48 |
| 41 outlet from engine | 45 fuel-rack position           | 49 |
| 42 leakage            | 46 inlet to prechamber          |    |
| 43 inlet to filter    | 47                              |    |

**Nozzle Cooling System**

|                            |                           |                    |
|----------------------------|---------------------------|--------------------|
| 50 inlet to fuel valves    | 54                        | 58 oil splash      |
| 51 outlet from fuel valves | 55 valve timing           | 59 alternator load |
| 52                         | 56 injection timing       |                    |
| 53                         | 57 earth/diff. protection |                    |

**Exhaust Gas System**

|                             |    |    |
|-----------------------------|----|----|
| 60 outlet from cylinder     | 64 | 68 |
| 61 outlet from turbocharger | 65 | 69 |
| 62 inlet to turbocharger    | 66 |    |
| 63 combustion chamber       | 67 |    |

**Compressed Air System**

|                              |                                 |                                |
|------------------------------|---------------------------------|--------------------------------|
| 70 inlet to engine           | 74 inlet to reduction valve     | 78 inlet to sealing oil system |
| 71 inlet to stop cylinder    | 75 microswitch for turning gear | 79                             |
| 72 inlet to balance arm unit | 76 inlet to turning gear        |                                |
| 73 control air               | 77 waste gate pressure          |                                |

**Load Speed**

|                   |                             |                                |
|-------------------|-----------------------------|--------------------------------|
| 80 overspeed air  | 84 engine stop              | 88 index - fuel injection pump |
| 81 overspeed      | 85 microswitch for overload | 89 turbocharger speed          |
| 82 emergency stop | 86 shutdown                 | 90 engine speed                |
| 83 engine start   | 87 ready to start           |                                |

**Miscellaneous**

|                                  |                                  |                            |
|----------------------------------|----------------------------------|----------------------------|
| 91 natural gas - inlet to engine | 94 cylinder lubricating          | 97 remote                  |
| 92 oil mist detector             | 95 voltage                       | 98 alternator winding      |
| 93 knocking sensor               | 96 switch for operating location | 99 common alarm            |
| 100 inlet to MDO cooler          | 101 outlet to MDO Cooler         | 102 alternator cooling air |

General

General

The overhaul intervals are based on operation on a specified fuel oil quality at normal service output, which means 70-100% of MCR.

In the long run it is not possible to obtain a secure and optimal economic running without an effective maintenance system.

With the structure and amount of information in the maintenance programme, it can be integrated in the entire ship's/power station's maintenance system or it can be used separately.

The crux of the maintenance system is the key diagram, see page 600.25, indicating the inspection intervals for the components/systems, so that the crew can make the necessary overhauls, based on the engines' condition and/or the time criteria.

The stated, recommended intervals are only for guidance as different service conditions, the quality of the fuel oil and the lubricating oil, treatment of the cooling water, etc, will decisively influence on the actual service results and thus the intervals between necessary overhauls.

Experience with the specific plant/crew is to be used for adjustment of time between overhaul. Further it is to be used for adjusting the timetable stated for guidance in the working cards.

Working cards

Each of the working cards can be divided into two: a front page and one or several pages, describing and illustrating the maintenance work.

The front page indicates the following:

1.

Safety regulations, which MUST be carried through before the maintenance work can start.
2.

A brief description of the work.
3.

Reference to work, which must be carried out, if any, before the maintenance work can start.

4. Related procedures - indicates other works, depending on this work - or works which would be expedient to carry out.

5. Indicates x number of men in x number of hours for accomplishing the work.

The stated consumption of hours is only intended as guide.

Experience with the specific station/crew may lead to a bringing up-to-date.

6. Refers to data, which are required for carrying out the work.

7. Special tools, which must be used. Please note that not all tools are standard equipment.

8. Various requisite hand tools.

9. Indicates the components/parts, which it is advisable to replace during the maintenance work. Please note, that this is a condition for the intervals stated.

Working Card  
S/N: 12

Dismantling of Cylinder Head

605-01.00  
Edition 01H

LV28/32H

1

Safety precautions:  
■ Stopped engine  
■ Shut-off starting air  
■ Shut-off cooling water  
■ Shut-off fuel oil  
■ Shut-off cooling oil  
■ Stopped lub. oil circuit.

2

Description:  
Dismantling of cylinder head for inspection and/or overhaul.

3

Starting position:  
Cooling water has been drained from engine.

4

Related procedure:  
Control of the surface on the cylinder liner.

5

Main power:  
Working time :   xxx  Hours  
Capacity       :   xxx  man

6

Data:  
Data for pressure and tolerance (Page 600.35)  
Oil for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

7

Special tools:  
Plate no.   Item no.   Note  
82079-07H   2086  
82079-09H   1178  
82071-11H   0321  
82081-04H   0728  
82081-04H   2235  
82081-04H   2237  
82081-04H   2142   6 Piece  
82081-04H   2240   1 Piece  
82081-04H   0817

8

Hand tools:  
Ring and open end spanner 14 mm.  
Ring and open end spanner 17 mm.  
Ring and open end spanner 24 mm.

9

Replacement and wearing parts:  
Plate no.   Item no.   Qty. pr. cyl.  
60501-11H   4579       1  
61202-15H   3462       1  
60510-06H   1988       1  
60510-06H   0681       2  
60505-05H   1050       2

94.35 - ES0S

HOLBERT

Fig 1. Guidance instruction for working cards.

94.35 - ES0S

08028-0D/H5250/94.08.12



|                           |                                    |                              |
|---------------------------|------------------------------------|------------------------------|
| Description<br>Page 1 (4) | <b>Planned Maintenance Program</b> | <b>600.25</b><br>Edition 33H |
|---------------------------|------------------------------------|------------------------------|

**L28/32H**

| Description   | ● = Overhaul to be carried out<br>■ = Check the condition | Check new/<br>Overhauled parts<br>after -hours | Time Between Overhaul |     |      |                            |       |       |       |        |         |           | Working<br>Card<br>No.   |
|---|---|--|-----------------------|-----|------|----------------------------|-------|-------|-------|--------|---------|-----------|--|
|   |   |  | 50                    | 200 | 2000 | 8000                       | 16000 | 32000 | Daily | Weekly | Monthly | 3th month |  |
| <b>Operating of Engine:</b><br><br>Readings of data for Engine and Generator, with reference to "Engine Performance Data", section 602-1 .....  |   |  |                       |     |      |                            |       |       | ■     |        |         |           | 602-01.00  |
| <b>Cylinder Head:</b><br><br>Inlet and exhaust valve - Overhaul and regrinding of spindel and valve seat .....<br>Inspection of inlet, exhaust valves and valve guide .....<br>Check of valve rotators rotation during engine rotation ...<br>Sleeve for fuel injector .....<br>Safety valve - Overhaul and adjustment of opening pressure .....<br>Indicator valve .....<br><br>Cylinder head cooling water space - Inspection .....<br>Cylinder head nut - Retightening .....         |   | 200  |                       |     | ■    | ●<br>■<br>■<br>■<br>■<br>■ |       |       |       |        |         | ■         | 605-01.10<br>605-01.05<br>605-01.05<br>605-01.30<br>605-01.25<br>605-01.26<br><br>605-01.45<br>605-01.40     |
| <b>Piston, Connecting Rod and Cylinder Liner:</b><br><br>Inspection of piston .....<br>Piston ring and scraper ring .....<br><br>Piston pin and bush for connecting rod - Check of clearance .....<br>Connecting rod - Measuring of big-end bore .....<br>Inspection of big-end bearings shells .....<br><br>Connecting rod - Retightening.....<br>Cylinder liner - Cleaning, honing and measuring .....<br>Cylinder liner removed - Check the water space and guide ring in frame..... |   | 200  |                       |     |      | ■<br>●<br>■<br>■<br>■      | ■     |       |       |        |         |           | 606-01.10<br>606-01.10<br><br>606-01.15<br>606-01.15<br>606-01.16<br><br>606-01.25<br>606-01.35<br>606-01.40 |
| <b>Camshaft and Camshaft Drive:</b><br><br>Camshaft - Inspection of gear wheels, bolt, connections etc.....<br>Camshaft bearing - Inspection of clearance .....<br>Camshaft adjustment - Check the condition.....<br><br>Lubrication of camshaft bearing - Check.....   |   | 200  |                       |     |      | ■<br>■<br>■<br>■           |       |       |       |        |         |           | 607-01.00<br>607-01.05<br>607-01.20<br><br>607-01.00   |

**600.25**

Edition 33H

**Planned Maintenance Program**Description  
Page 2 (4)**L28/32H**

| Description  | ● = Overhaul to be carried out<br>■ = Check the condition | Check new/<br>Overhauled parts<br>after -hours | Time Between Overhaul |     |      |      |       |       |       |        |         |           | Working<br>Card<br>No. |                        |
|--|---|--|-----------------------|-----|------|------|-------|-------|-------|--------|---------|-----------|------------------------|------------------------|
|  |   |  | 50                    | 200 | 2000 | 8000 | 16000 | 32000 | Daily | Weekly | Monthly | 3th month |                        | Observations           |
|  |   |  |                       |     |      |      |       |       |       |        |         |           |                        |                        |
| <b>Operating Gear for Inlet Valves, Exhaust Valves and Fuel Injection Pumps:</b> |   |  |                       |     |      |      |       |       |       |        |         |           |                        |                        |
| Roller guide for valve gear.....   |   |  |                       |     |      | ■    |       |       |       |        |         |           |                        | 608-01.00              |
| Valve gear - Valve bridge, spring, push rod, etc .....                           |   |  |                       |     |      | ■    |       |       |       |        |         |           |                        | 608-01.10              |
| Roller guide for fuel injection pump .....                                       |   |  |                       |     |      | ■    |       |       |       |        |         |           |                        | 608-01.05              |
| Roller guide housing.....  |   |  |                       |     |      | ■    |       |       |       |        |         |           |                        | 608-01.10              |
| Inlet and exhaust valve - Check and adjustment of valve clearance .....          |   |  |                       | ■   |      |      |       |       |       |        |         |           |                        | 608-01.10              |
| Lubricating of operating gear - Check .....                                      |   |  |                       |     |      | ■    |       |       |       |        |         |           |                        | 608-01.00<br>608-01.05 |
| <b>Control and Safety System, Automatics and Instruments:</b>                    |   |  |                       |     |      |      |       |       |       |        |         |           |                        |                        |
| Safety, alarm and monitoring equipment .....                                     |   |  |                       |     |      |      |       |       |       |        | ■       |           |                        | 609-01.00              |
| Jet system - Adjustment .....  |   |  |                       |     |      |      |       |       |       |        | ■       |           |                        | 609-01.00              |
| Pick-up - Adjustment .....   |   |  |                       |     |      |      |       |       |       |        | ■       |           |                        | 609-10.00              |
| Governor - Check oil level, see governor instruction book, section 609 .....     |   |  |                       |     |      |      |       |       |       |        | ■       |           |                        |                        |
| <b>Crankshaft and Main Bearing:</b>  |   |  |                       |     |      |      |       |       |       |        |         |           |                        |                        |
| Checking of main bearings aligment, (autolog) .....                              |   |  |                       |     | ■    |      |       |       |       |        |         |           |                        | 610-01.00              |
| Inspection af main bearing .....   |   |  |                       |     |      | ■    |       |       |       |        |         |           |                        | 610-01.05              |
| Inspection of guide bearing .....  |   |  |                       |     |      | ■    |       |       |       |        |         |           |                        | 610-01.10              |
| Vibration damper - Check the condition .....                                     |   |  |                       |     |      | ■    |       |       |       |        |         |           |                        | 610-04.00              |
| Lubricating of gear wheel for lub. oil pump and cooling water pump etc.....      |   |  |                       |     |      |      | ■     |       |       |        |         |           |                        |                        |
| Counter weight - Retightening, see page 600.40 .....                             |   | 200  |                       |     | ■    |      |       |       |       |        |         |           |                        |                        |
| Main- and guide bearing cap - Retightening .....                                 |   | 200  |                       |     | ■    |      |       |       |       |        |         |           |                        | 610-01.05<br>610-01.10 |

08028-0D/H5250/94.08.12

|                           |                                    |                              |
|---------------------------|------------------------------------|------------------------------|
| Description<br>Page 3 (4) | <b>Planned Maintenance Program</b> | <b>600.25</b><br>Edition 33H |
|---------------------------|------------------------------------|------------------------------|

**L28/32H**

| Description  | ● = Overhaul to be carried out<br>■ = Check the condition | Check new/<br>Overhauled parts<br>after -hours | Time Between Overhaul |     |      |      |       |       |       |        |        |           | Working<br>Card<br>No. |
|--|---|--|-----------------------|-----|------|------|-------|-------|-------|--------|--------|-----------|------------------------|
|  |   |  | 50                    | 200 | 2000 | 8000 | 16000 | 32000 | Daily | Weekly | Montly | 3th month |                        |
| <b>Engine Frame and Bedplate:</b>  |   |  |                       |     |      |      |       |       |       |        |        |           |                        |
| Holding down bolts - Retightening, see page 600.40 .....   |   | 200  |                       |     | ■    |      |       |       |       |        |        |           |                        |
| Bolts between engine frame and base frame - Retightening, see page 600.40 .....                          |   | 200  |                       |     | ■    |      |       |       |       |        |        |           |                        |
| For flexible mounted engines - Check anti-vibration mountings .....                                      |   | 200  |                       |     | ■    |      |       |       |       |        |        |           | 619-03.00              |
| Safety cover - Function test .....   |   |  |                       |     | ■    |      |       |       |       |        |        |           | 611-01.00              |
| <b>Turbocharger System:</b>  |   |  |                       |     |      |      |       |       |       |        |        |           |                        |
| Dry cleaning of turbine side .....   |   | ●  |                       |     |      |      |       |       |       |        |        |           | 612-10.00              |
| Wet cleaning of turbine side .....   |   |  |                       |     |      |      |       |       | ●     |        |        |           | 612-15.00              |
| Water washing of compressor side .....   |   | ●  |                       |     |      |      |       |       |       |        |        |           | 612-05.00              |
| Cleaning of air filter - Compressor side (see turbo-charger instruction book) .....                      |   |  |                       |     |      |      |       |       |       |        |        |           |                        |
| Turbocharger complete - Dismantling, cleaning, inspection etc. (see turbocharger instruction book) ..... |   |  |                       |     |      |      |       |       |       |        |        |           |                        |
| Charging air cooler - Cleaning and inspection .....  |   |  |                       |     |      |      |       |       |       |        |        | ■         | 612-01.00              |
| Charging air cooler housing - Draining .....   |   |  |                       |     |      |      |       |       |       |        |        | ●         |                        |
| Exhaust pipe - Compensator .....   |   |  |                       |     |      |      |       |       |       |        |        | ■         |                        |
| <b>Compressed Air System:</b>  |   |  |                       |     |      |      |       |       |       |        |        |           |                        |
| Air starter motor - Dismantling and inspection .....   |   |  |                       |     |      |      |       |       |       |        |        | ■         | 613-01.30              |
| Function test - Main starting valve, starting valve, main valves and emergency start valve .....         |   |  |                       |     |      |      |       |       |       |        |        | ■         | 613-01.40              |
| Dirt separator - Dismantling and cleaning .....  |   |  |                       |     |      |      |       |       |       |        |        | ●         |                        |
| Muffler - Dismantling and cleaning .....   |   |  |                       |     |      |      |       |       |       |        |        | ●         |                        |
| Compressed air system - Draining .....   |   |  |                       |     |      |      |       |       |       |        |        | ●         | 613-01.90              |
| Compressed air system - Check of the system .....  |   |  |                       |     |      |      |       |       |       |        |        | ■         | 613-01.90              |
| Drain of bowl.....<br>(filter element to be replaced when pressure drop exceeds 0.7 bar)                 |   |  |                       |     |      |      |       | ●     |       |        |        |           | 613-01.21              |

**600.25**

Edition 33H

**Planned Maintenance Program**Description  
Page 4 (4)**L28/32H**

| Description  | ● = Overhaul to be carried out<br>■ = Check the condition | Check new/<br>Overhauled parts<br>after -hours | Time Between Overhaul |     |      |      |       |       |       |        |         |  |  | Working<br>Card<br>No. |
|--|---|--|-----------------------|-----|------|------|-------|-------|-------|--------|---------|--|--|------------------------|
|  |   |  | 50                    | 200 | 2000 | 8000 | 16000 | 32000 | Daily | Weekly | Monthly | 3th month                                      | Observations   |                        |
| <b>Fuel Oil System and Injection Equipment:</b><br><br>Fuel oil filter - Dismantling and cleaning.....<br>Fuel oil feed pump .....<br>Fuel oil injection pump - Dismantling and cleaning .....<br><br>Fuel injection valve - Adjustment of opening pressure ....<br>Fuel oil high-pressure pipe - Dismantling and check.....<br>Adjustment of the maximum combustion pressure.....<br><br>Fuel oil system - Check the system.....<br>Nozzle cooling system - Check the system .....<br><br>Fuel oil - Oil samples after every bunkering, see sec.604 |   | 200  |                       | ■   | ■    |      |       |       |       |        |         | ●<br>●<br>●<br><br><br><br><br>●<br><br>■<br>■ | 614-01.15<br>614-10.00<br>614-01.05<br><br>614-01.10<br>614-01.05<br>614-05.01<br><br>614-01.90<br>614-01.90 |                        |
| <b>Lubricating Oil System:</b><br><br>Lubricating oil pump - Engine driven .....<br>Lubricating oil filter - Cleaning and exchange .....<br>Lubricating oil cooler .....<br><br>Prelubricating pump - El. driven .....<br>Thermostatic valve .....<br>Centrifugal filter - Cleaning and exchange of paper .....<br><br>Lubricating oil - Oil samples, see section 604 .....<br>Lubricating oil system - Check the system .....   |   |  |                       |     | ■    | ■    |       |       |       |        |         | ●<br>●<br><br><br>■<br>●<br><br>■<br>■         | 615-01.00<br>615-01.10<br>615-06.00<br><br>615-01.05<br>615-01.20<br>615-15.00<br><br>615-01.90              |                        |
| <b>Cooling Water System:</b><br><br>Cooling water pump - Engine driven (sea water and fresh water).....<br>Thermostatic valve .....<br>Cooling water system - Check the system .....<br><br>Cooling water system - Water samples, see sec. 604 .....   |   |  |                       |     | ■    |      |       |       |       |        | ■<br>■  |  | 616-01.90  |                        |

08028-0D/H5250/94.08.12

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (2) | <b>Operation Data &amp; Set Points</b> | <b>600.30</b><br>Edition 50H |
|---------------------------|--|------------------------------|

**L28/32H**

|  |                  | Normal Value at Full load<br>at ISO conditions |                           | Acceptable<br>value at shop<br>test or after<br>repair | Alarm Set point    |                                 | Autostop of engine |                |
|--|------------------|--|---------------------------|--|--------------------|---------------------------------|--------------------|----------------|
| <b>Lubricating Oil System</b>  |                  |  |                           |  |                    |                                 |                    |                |
| Temp. before cooler<br>(outlet engine)                                   | SAE 30<br>SAE 40 | TI 20<br>TI 20                                 | 60-75° C<br>65-82° C      | <75° C<br><82° C                                       | TAH 20<br>TAH 20   | 90° C<br>100° C                 |                    |                |
| Temp. after cooler<br>(inlet engine)                                     | SAE 30<br>SAE 40 | TI 22<br>TI 22                                 | 45-65° C<br>50-72° C      | <65° C<br><72° C                                       | TAH 22<br>TAH 22   | 75° C<br>85° C                  | TSH 22<br>TSH 22   | 85° C<br>95° C |
| Pressure after filter (inlet eng)  |                  | PI 22  | 3.5-4 bar                 | >4.0 bar   | PAL 22             | 3 bar                           | PSL 22             | 2.5 bar        |
| Elevated pressure i.g. when<br>centrifugal filter installed              |                  | PI 22  | 4-5 bar                   | >4.5 bar   | PAL 22             | 3.5 bar                         | PSL 22             | 3.0 bar        |
| Pressure drop across filter  |                  | PDAH 21-22                                     | 0.5-1 bar                 | <0.5 bar   | PDAH 21-22         | 1.5 bar                         |                    |                |
| Prelubricating pressure  |                  |  |                           |  | LAL 25             | level switch                    |                    |                |
| Pressure inlet turbocharger  |                  | PI 23  | 1.5 ±0.2 bar              | >1.5 bar   |                    |                                 |                    |                |
| Lub. oil, level in base frame  |                  |  |                           |  | LAL 28/<br>LAH 28  | low/high level                  |                    |                |
| Temp. main bearings  |                  | TE 29  | 75-85° C                  | <85° C   | TAH 29             | 95° C                           |                    |                |
| <b>Fuel Oil System</b>   |                  |  |                           |  |                    |                                 |                    |                |
| Pressure after filter  | MDO<br>HFO       | PI 40<br>PI 40                                 | 2.5-5 bar<br>5-16 bar (A) |  | PAL 40<br>PAL 40   | 1.5 bar<br>4 bar                |                    |                |
| Leaking oil  |                  |  |                           |  | LAH 42             | leakage                         |                    |                |
| Press. nozz. cool. oil, inlet eng.<br>Temp. nozz. cool. oil, outlet eng. |                  | PI 50<br>TI 51                                 | 2-3 bar<br>80-90° C       |  | PAL 50             | 1.5 bar (B)<br>95° C (B)        |                    |                |
| <b>Cooling Water System</b>  |                  |  |                           |  |                    |                                 |                    |                |
| Press. LT-system, inlet engine   |                  | PI 01  | 1-2.5 bar (D)             | >1.3 bar   | PAL 01             | 0.4 bar + (C)                   |                    |                |
| Press. HT-system, inlet engine   |                  | PI 10  | 1.5-4.6 bar               | >1.8-<6 bar  | PAL 10             | 0.4 bar + (C)                   |                    |                |
| Temp. HT-system, inlet engine  |                  | TI 10  | 60-75° C                  |  |                    |                                 |                    |                |
| Temp. HT-system, outl. cyl.units   |                  | TI 11  | 70-85° C                  | <85° C   |                    |                                 |                    |                |
| Temp. HT-system, outlet engine   |                  |  |                           |  | TAH 12<br>TAH 12-2 | 90° C<br>93° C                  | TSH 12             | 95° C          |
| Temp. raise across cyl. units  |                  |  | max. 10° C                |  |                    |                                 |                    |                |
| <b>Exhaust Gas and Charge Air</b>  |                  |  |                           |  |                    |                                 |                    |                |
| Exh. gas temp. before TC   |                  | TI 62  | 425-475° C                |  | TAH 62<br>TAH 62-2 | 550° C<br>600° C                |                    |                |
| Exh. gas temp. outlet cyl.<br>Diff. between individual cyl.              |                  | TI 60  | 270-380° C                | average<br>±25° C                                      | TAH 60<br>TAD 60   | 410° C<br>average (F)<br>±50° C |                    |                |
| Exh. gas temp. after TC  |                  | TI 61  | 275-350° C                |  | TAH 61             | 500° C                          |                    |                |
| Ch. air press. after cooler<br>Ch. air temp. after cooler                |                  | PI 31<br>TI 31                                 | 2-2.5 bar<br>35-55° C     | <55° C   | TAH 31             | 65° C                           |                    |                |
| <b>Compressed Air System</b>   |                  |  |                           |  |                    |                                 |                    |                |
| Press. inlet engine  |                  | PI 70  | 7-9 bar                   | >7.5-<9 bar  | PAL 70             | 7 bar                           |                    |                |

Specific plants will not comprise alarm equipment and autostop for all parameters listed above. For specific plants additional parameters can be included. For remarks to some parameters, see overleaf.

10° C change in ambient temperature correspond to approx. 15° C exhaust gas temperature change

**600.30**  
Edition 50H

## Operation Data & Set Points

Descriptoin  
Page 2 (2)

### L28/32H

|   | Normal Value at Full load<br>at ISO conditions |         | Acceptable<br>value at shop<br>test or after<br>repair | Alarm Set point |         | Autostop of engine |                    |
|---|--|---------|--|-----------------|---------|--------------------|--------------------|
| <b>Speed Control System</b><br>Engine speed<br>GenSets for 60 Hz<br>Mechanical<br>Elec.<br>GenSets for 50 Hz<br>Mechanical<br>Elec. | SI 90  | 720 rpm | 820 rpm  | SAH 81          | 815 rpm | SSH 81<br>SSH 81   | 825 rpm<br>815 rpm |
|   | SI 90  | 750 rpm | 855 rpm  | SAH 81          | 850 rpm | SSH 81<br>SSH 81   | 860 rpm<br>850 rpm |
|   | SI 89  | (G)     |  | SAH 89          | (E)     |                    |                    |
| Turbocharger speed  | SI 89  | (G)     |  | SAH 89          | (E)     |                    |                    |

#### Remarks to individual Parameters

##### A. Fuel Oil Pressure, HFO-operation.

When operating on HFO, the system pressure must be sufficient to depress any tendency to gasification of the hot fuel.

The system pressure has to be adjusted according to the fuel oil preheating temperature.

##### B. Nozzle Cooling Oil System

The nozzle cooling oil system is only applied for Tier II marine and stationary engines.

##### C. Cooling Water Pressure, Alarm Set Points.

As the system pressure in case of pump failure will depend on the height of the expansion tank above the engine, the alarm set point has to be adjusted to 0.4 bar plus the static pressure.

##### D. Press. LT -system, inlet engine (PI 01)

With two-string cooling water system the normal value can be higher, max. 4.0 bar.

#### E. Limits for Turbocharger Overspeed Alarm (SAH 89)

| Engine type | 720 rpm | 750 rpm |
|-------------|---------|---------|
| 5L28/32H    | 42,680  | 42,680  |
| 6L28/32H    | 42,680  | 42,680  |
| 7L28/32H    | 34,900  | 34,900  |
| 8L28/32H    | 34,900  | 34,900  |
| 9L28/32H    | 36,180  | 36,180  |

#### F. Exhaust Gas Temperatures

The exhaust gas temperature deviation alarm is normally  $\pm 50^{\circ}\text{C}$  with a delay of 1 min., but at start-up the delay is 5 min. Furthermore the deviation limit is  $\pm 100^{\circ}\text{C}$  if the average temperature is below  $200^{\circ}\text{C}$ .

#### G. Turbocharger Speed

Normal value at full load of the turbocharger is dependent on engine type (cyl. no) and engine rpm. The value given is just a guide line. Actual values can be found in the acceptance test protocol.

|                           |                         |                              |
|---------------------------|-------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>"Green Passport"</b> | <b>600.33</b><br>Edition 02H |
|---------------------------|-------------------------|------------------------------|

### General

In 2009 IMO adopted the „Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009“

Until this convention enters into force the recommendatory guidelines “Resolution A.962(23)” (adopted 2003) apply. This resolution has been implemented by some classification societies as “Green Passport”.

MAN Diesel & Turbo is able to provide a list of hazardous materials complying with the requirements of the IMO Convention. This list is accepted by classification societies as a material declaration for “Green Passport”.

This material declaration can be provided on request.

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (2) | <b>Data for Pressure and Tolerance</b> | <b>600.35</b><br>Edition 16H |
|---------------------------|--|------------------------------|

**L28/32H**

| Section    | Description  | mm. / bar  |
|------------|--|--|
| <b>605</b> | Safety valve to be adjusted to<br>Maximum inner diameter, valve guide<br>For grinding of valve spindle and valve seat ring<br>(see also working card 605-01.10)<br>Minimum height of valve head, inlet valve and exhaust valve, "H" 1<br>Maximum height of spindle above cylinder head, "H" 2  | 170 bar<br>18.35 mm.<br><br>6.5 mm.<br>108.0 mm  |
| <b>606</b> | Piston and piston ring grooves (see working card 606-01.10)<br>Clearance between connecting rod bush and piston pin<br>Maximum ovalness in big-end bore (without bearing)<br>New cylinder liner, inside diameter<br>Maximum inside diameter cylinder liner   | 0.15 - 0.25 mm.<br>0.10 mm.<br>280.03 - 280.08 mm.<br>280.60 mm.   |
| <b>607</b> | Clearance between camshaft and camshaft bearing<br>Maximum clearance between camshaft and camshaft bearing<br>Clearance between teeth on intermediate wheel<br>Plunger lift at TDC, injection timing:<br>IMO Tier II - D2, 720 rpm<br>IMO Tier II - D2, 750 rpm<br><i>*) for information on max settings check the engine's IMO Technical file.</i><br>Plunger Lift, World Bank II**<br><i>** Standard injection timing value is based on ISO condition.</i><br><i>Special injection timing of engines can be necessary due to</i><br><i>Power plant size and/or Ambient conditions.</i> | 0.13 - 0.22 mm.<br>0.35 mm.<br>0.20 - 0.30 mm<br><br>8.30 <sup>+0.05</sup> mm*<br>8.27 <sup>+0.05</sup> mm*            |
| <b>608</b> | Valve clearance, Inlet valve (cold engine 15 - 55°C)<br>Valve clearance, Exhaust valve (cold engine 15 - 55°C)<br>Maximum clearance between rocker arm bush and rocker arm shaft   | 0.40 mm.<br>0.90 mm.<br>0.30 mm.   |
| <b>609</b> | Clearance between pick-up and impulse wheel<br>Adjustment of Lambda controller.<br>(see working card 609-10.00)  | 1 ±0.3 mm  |
| <b>610</b> | Clearance (equal on both sides) between main bearing cap and frame,<br>before tightening of bracing screw (side screw)<br>Deflection of crankshaft (autolog) (see working card 510-01.00)<br>Clearance between crankshaft and sealing ring, (upper and lower part)<br>Clearance in main bearing<br>Clearance in guide bearing (axial)<br>Maximum clearance in guide bearing (axial)<br>Clearance between bearing and gearwheel shaft:<br>Clearance when new bearings are mounted<br>Maximum clearance<br>Clearance axial   | 0.06 ± 0.02 mm<br><br>0.3 - 0.4 mm.<br>0,2-0,344 mm<br>0.15 - 0.46 mm<br>0.8 mm<br><br>0.125-0.200<br>0.250<br>0.2-0.3 |
| <b>611</b> | Opening pressure of safety relief valves (on crankcase), max:  | 0.20 bar   |



|                              |  |                           |
|------------------------------|--|---------------------------|
| <b>600.35</b><br>Edition 16H | <b>Data for Pressure and Tolerance</b> | Description<br>Page 1 (2) |
|------------------------------|--|---------------------------|

L28/32H

| Section | Description  | mm. / bar   |
|---------|--|---|
| 614     | Maximum combustion pressure at full load<br>Individual cylinders; admissible deviation from average<br>A change of the height of the thrust piece spacer ring of 0.10 mm.<br>will change the maximum pressure by<br>1° turning of camshaft gear wheel changes max. pressure by approx<br>Measurement "X" between thrust piece and roller guide housing<br>Opening pressure of fuel valve<br>Pressure testing, cooling oil sealing, on fuel valve | Max 133 bar<br>± 3 bar<br><br>1 bar<br>6 bar<br>11 ± 0.2 mm<br>320 bar<br>100 bar |

|                           |                                   |                              |
|---------------------------|-----------------------------------|------------------------------|
| Description<br>Page 1 (2) | <b>Data for Tightening Torque</b> | <b>600.40</b><br>Edition 18H |
|---------------------------|-----------------------------------|------------------------------|

**L+V28/32H**

| Section | Description   |  | Thread  | Tightening   |   | Lubricant   |
|---------|---|--|---|--|---|---|
|         |   |  |   | Torque<br>Nm   | Pressure<br>bar                           |   |
| 605     | Cylinder head stud (in frame)<br>Nut for cylinder head stud   | Stud<br>Nut  | M 39<br>M 39 x 3  | 200  | 700                                       | Loctite 243<br>Oil / Molykote<br>(Unimol gl 82)                                     |
| 606     | Connecting rod screw<br>(see working card 606-01.25)<br>Connecting rod screw (hydraulic<br>tightening)  | Stud<br>Nut  | M 39 x 3<br>M 39 x 3  |  | 700                                       | Molykote<br>(Unimol gl 82)<br>—   |
| 607     | Camshaft assembling<br>Gear wheel on camshaft<br>Intermediate wheel shaft<br>Intermediate wheel assembling<br>Gear wheel on crankshaft  | Nut<br>Screw<br>Nut<br>Nut<br>Nut  | M 12<br>M 12<br>M 22 x 1.5<br>M 12<br>M 12  | 85<br>70<br>250<br>50<br>50                                      |   | Molykote<br>(Unimol gl 82)<br>—<br>—<br>—<br>—                                      |
| 608     | Housing for valve gear<br>Rocker arm bracket  | Screw<br>Nut   | M 16<br>M 12  | 160<br>40  |   | —<br>—  |
| 610     | Main bearing stud (in frame)<br><br>Nut for main bearing stud<br>Main bearing side screw - L28/32H<br>Main bearing side screw - V28/32H<br>Counterweight on crankshaft<br>Vibration damper on crankshaft<br>Flywheel mounting (without fitted bolt)<br>Flywheel mounting (with fitted bolt)<br>- L28/32H<br>- V28/32H<br>Gear rim on flywheel | Stud<br><br>Nut<br>Screw<br>Screw<br>Screw<br>Nut<br>Nut<br>Nut<br>Nut<br>Nut<br>Screw | M 56<br><br>M 52 x 3<br>M 24<br>M 30<br>M 26 x 1.5<br>M 30<br>M30<br>M 30<br>M 30<br>M 16 | 200<br><br>350<br>600<br>300<br>500<br>1350<br>1350<br>480<br>75 | 900                                       | Loctite 243<br>Molykote<br>(Unimol gl 82)<br>—<br>—<br>—<br>—<br>oil<br>—<br>—<br>— |
| 611     | Frame / baseframe   | Nut  | M 24  | 500  |   | —   |
| 614     | Fuel-pump connecting piece<br>Fuel-pump top flange (barrel)<br>Fuel-pump cavitation plugs<br>Fuel-pump mounting<br>Fuel-valve (nozzle nut)<br>Fuel-valve mounting<br>Fuel-valve (lock nut)<br>High pressure pipe  | Screw<br>Screw<br>Plug<br>Screw<br>Nut<br>Nut<br>Nut<br>Nut                            | M 10<br>M 12<br>M 20 x 1.5<br>M16<br>M 26 x 1.5<br>M 16<br>M 16 x 1.5<br>M 22 x 1.5       | 60<br>100<br>100 - 120<br>150<br>100 - 120<br>30<br>100<br>60    | (3 x cross-tightening<br>20 - 40 - 60 Nm) | —<br>—<br>—<br>—<br>—<br>—<br>—<br>—  |

|                              |                                   |                           |
|------------------------------|-----------------------------------|---------------------------|
| <b>600.40</b><br>Edition 18H | <b>Data for Tightening Torque</b> | Description<br>Page 2 (2) |
|------------------------------|-----------------------------------|---------------------------|

**L+V28/32H**

| Section | Description   |               | Thread     | Tightening   |                 | Lubricant                  |
|---------|---|---------------|------------|--------------|-----------------|----------------------------|
|         |   |               |            | Torque<br>Nm | Pressure<br>bar |                            |
| 615     | Gear wheel on lub. oil pump                                   | Nut           | M 30 x 2   | 400          |                 | Molykote<br>(Unimol gl 82) |
| 616     | Impeller and gear wheel on fresh-water cooling pump - L28/32H | Nut           | M 24 x 1.5 | 250          |                 | —                          |
|         | Impeller and gear wheel on fresh-water cooling pump - V28/32H | Nut           | M 33 x 2   | 400          |                 | —                          |
| 619     | Conical elements mounting - L28/32H                           |               |            |              |                 |                            |
|         | Upper mounting  | Screw         | M 20       | 150          |                 | —                          |
|         | Lower mounting  | Screw/<br>Nut | M 20       | 320          |                 | —                          |
|         | Sandwich elements mounting - V28/32H                          |               |            |              |                 |                            |
|         | Upper mounting  | Screw         | M 16       | 165          |                 | —                          |
|         | Lower mounting  | Screw         | M 16       | 165          |                 | —                          |

|                           |                              |                              |
|---------------------------|------------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Declaration of Weight</b> | <b>600.45</b><br>Edition 01H |
|---------------------------|------------------------------|------------------------------|

**L28/32H**

| Section | Component                               | Plate No.                  | Item No.   | Weight in Kg.           |
|---------|---|----------------------------|------------|-------------------------|
| 605     | Cylinder Head, incl. rocker arms        | 60501-60502<br>60508-60510 |            | 255                     |
| 606     | Piston, complete                        | 60601                      | 08         | 40                      |
|         | Piston Pin                              | 60601                      | 01         | 19                      |
|         | Connecting Rod, complete                | 60601                      | 06         | 81                      |
|         | Cylinder Liner, complete                | 60610                      | 10         | 119                     |
|         | Cooling Water Jacket                    | 60610                      | 15         | 33                      |
| 607     | Camshaft, section                       | 60705                      | 02, 16, 20 | 29                      |
| 608     | Housing for Roller Guide                | 60801                      | 20         | 17                      |
| 609     | Governor, complete                      | 60901                      | 01-09-10   | 28                      |
| 611     | Main Bearing Cap                        | 61101                      | 26         | 75                      |
|         | Guide Bearing Cap                       | 61101                      | 19         | 85                      |
|         | Front cover                             | 61102                      | 01         | 164                     |
|         | End cover, complete                     | 61106                      | 11         | 179                     |
| 612     | Turbocharger, complete                  |                            |            | See special instruction |
|         | Intermediate piece                      | 61202                      | 26         | 9                       |
|         | Air Cooler                              | 61203                      | 38         | 450                     |
|         | Inlet Bend                              | 61203                      | 33         | 93                      |
|         | Charging Air Cooler Housing             | 61203                      | 34         | 350                     |
| 613     | Air Starter                             | 61309                      | 63         | 40                      |
| 614     | Fuel Injection Pump                     | 61401                      | 01-02      | 15                      |
|         | Fuel Injection Valve                    | 61402                      | 02         | 5                       |
|         | Fuel Oil Feed Pump                      | 61410                      | 22         | 22                      |
| 615     | Lubricating Oil Pump                    | 61501                      | 35         | 45                      |
|         | Thermostatic Valve                      | 61503                      | 11         | 29                      |
|         | Prelubricating Oil Pump, incl. el-motor | 61504                      | 25         | 20                      |
|         | Centrifugal Filter                      | 61515                      | 33         | 24                      |
| 616     | Thermostatic Valve                      | 61604                      | 11         | 29                      |
|         | Cooling Water Pump                      | 61610                      | 19         | 30                      |

|                           |                                |                              |
|---------------------------|--------------------------------|------------------------------|
| Description<br>Page 1 (2) | <b>Ordering of Spare Parts</b> | <b>600.50</b><br>Edition 06H |
|---------------------------|--------------------------------|------------------------------|

**General**

Spare parts can be ordered from MAN Diesel & Turbo, PrimeServ.

When spare parts are ordered or inquired, the following data must be indicated, in order to ensure correct identification of the required parts:

- Name of customer
- Name of plant /vessel
- Vessel IMO No
- Engine type
- Engine serial No
- Engine builder
- Plate No and edition No
- Item No
- Quantity
- Designation of the item No

Note:

- Components from different engine builders cannot be considered as interchangeable.
- A wide number of spare parts can be orders as spare part kits.
- Selected components may be available in both original and upgraded version.

These data are necessary to ensure supply of the correct spare parts for a particular engine, even though the spare part illustrations contained in this book may not always be in complete accordance with the individual components of a specific engine.

For ordering of spare parts for governor, turbocharger and alternator, please see the special chapter in the instruction book for these components.

**Information found on the nameplate of the engine(s)**

*Example:*

| Name of customer | Name of Plant/Vessel | IMO No   | Engine type | Engine serial No | Engine builder                 |
|------------------|----------------------|----------|-------------|------------------|--------------------------------|
| Mercy Ship       | Africa Mercy         | L7803188 | 5L21/31     | SB5L21-10799     | MAN Diesel & Turbo or Licensee |

Information found on each plate at the instruction manual:

Plate No 51435    Edition No 13    Item No 440    Qty. 1    Description Leak oil pipe

**MAN Diesel & Turbo**

Plate Page 1 (2)    **Fuel Injection Pump Connections**    51435-13

**L21/31**

**MAN Diesel & Turbo**

51435-13    **Fuel Injection Pump Connections**    Plate Page 2 (2)

**L21/31**

| Item no | Qty  | Designation       | Benævneelse      | Item no | Qty | Designation   | Benævneelse |
|---------|------|-------------------|------------------|---------|-----|---------------|-------------|
| 025     | 3/E  | Cylindrical screw | Cylindrisk skrue | 440     | 1/E | Leak oil pipe | Lækagerør   |
| 037     | 1/E  | Connection socket | Forbindelsesblok | 452     | 1/E | Plate         | Plade       |
| 049     | 22/E | Seal ring         | Tætningsring     | 464     | 2/E | Screw         | Skrue       |
|         | 26/E | 5 cyl. engine     | 5 cyl. motor     | 476     | 3/E | Screw         | Skrue       |
|         | 28/E | 6 cyl. engine     | 6 cyl. motor     |         |     |               |             |
|         | 30/E | 7 cyl. engine     | 7 cyl. motor     |         |     |               |             |

|                           |                         |                      |
|---------------------------|-------------------------|----------------------|
| Description<br>Page 2 (2) | Ordering of Spare Parts | 600.50<br>Edition 03 |
|---------------------------|-------------------------|----------------------|

General

|                  |            |                      |                            |                |      |
|------------------|------------|----------------------|----------------------------|----------------|------|
| Name of customer |            | Name of Plant/Vessel |                            | IMO No         |      |
| Engine type      |            | Engine No            |                            | Engine Builder |      |
| Plate No         | Edition No | Item No              | Designation of the Item No |                | Qty. |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |
|                  |            |                      |                            |                |      |

For ordering or inquiry for items in free text, kindly contact MAN PrimeServ Holeby  
at: +45 54 69 31 00 or via e-mail [primeserv-hol@mandieselturbo.com](mailto:primeserv-hol@mandieselturbo.com)

|                           |   |                              |
|---------------------------|---|------------------------------|
| Description<br>Page 1 (1) | <b>How to Return Spare Parts and/or Tools</b> | <b>600.51</b><br>Edition 05H |
|---------------------------|---|------------------------------|

**General****How to return spare parts and/or tools**

If the unfortunate situation occurs that your spare parts do not fit or is damaged in any way, you need to return your spare parts to us.

The return procedure is as follows:

Send an email to our office via  
Holeby: primeserv-hol@mandieselturbo.com or  
Frederikshavn: primeserv-frh@mandieselturbo.com

Clearly stating:

- Our order number
- Item numbers
- Reason for return
- Your reference
- Pictures of damaged parts – if any.

Please be noted that your parts are not to be returned unless there is an agreement with our Sales Coordinators and/or Superintendents.

When parts are received in good condition, we will issue a credit-note. Please mark the box with our order number or attach a copy of our packing list.

For return of tools please mark the box with our project name and number on the box (P-xxxxx)

**Remarks:**

Please note that spare parts and/or tools are not to be returned unless there is a written agreement with MAN Diesel & Turbo, PrimeServ in Holeby or Frederikshavn.

- If you return your spare parts and/or tools without a written agreement you will be charged a fee for unauthorised returns.

- If you return to Holeby instead of Frederikshavn, you will have to pay freight charges of minimum EUR 70,-

Please return by cheapest mean to the below address:

- **Spare Parts:**  
MAN Diesel & Turbo  
Niels Juels Vej 15  
9900 Frederikshavn  
Denmark  
Att: Dept.: Store (WLS-FRH)
- **Tools:**  
MAN Diesel & Turbo  
Langerak 74  
9900 Frederikshavn  
Denmark  
Att: Dept.: Service Center (DC5)

For returns to Singapore warehouse please use the following address:

MAN Diesel & Turbo Singapore Pte. Ltd.  
14 Tuas Avenue 1  
Singapore 639499  
Att.: Logistic Centre, Asia

**Note:** Please be aware that it is only spare parts that have been purchased in Singapore that can be returned to Singapore warehouse.

|                           |                        |                              |
|---------------------------|------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Service Letters</b> | <b>600.55</b><br>Edition 01H |
|---------------------------|------------------------|------------------------------|

**General**

**Description**

In order to ensure the most efficient, economical and up-to-date operation of our engines, we regularly send out "Service Letters" containing first-hand information regarding accumulated service experience.

The service letters can either deal with specific engine types, or contain general instructions and recommendations for all engine types, and are used as a reference when we prepare up-dated editions of instruction books.

Since new service letters might be of great importance to the operation of the plant, we recommend that engine staff file them as supplements to the relevant chapters of this instruction book.



|                           |                         |                             |
|---------------------------|-------------------------|-----------------------------|
| Description<br>Page 1 (3) | <b>Conversion Table</b> | <b>600.60</b><br>Edition 01 |
|---------------------------|-------------------------|-----------------------------|

**General****Basic SI Units**

| Quantity              | Name     | Symbol |
|-----------------------|----------|--------|
| length                | metre    | m      |
| mass                  | kilogram | kg     |
| time                  | second   | s      |
| electric current      | ampere   | A      |
| absolute temperature* | kelvin   | K      |
| amount of substance   | mole     | mol    |
| luminous intensity    | candela  | cd     |

\* Also named "thermodynamic temperature"

**Supplementary SI Units**

| Quantity    | Name      | Symbol |
|-------------|-----------|--------|
| plane angle | radian    | rad    |
| solid angle | steradian | sr     |

**Additional SI Units**

| Quantity    | Name   | Symbol | Definition                 |
|-------------|--------|--------|----------------------------|
| time        | minute | min    | 1 min = 60 s               |
| time        | hour   | h      | 1 h = 60 min               |
| plane angle | degree | °      | 1° = (π/180) rad           |
| volume      | litre  | l      | 1 l = 1 dm <sup>3</sup>    |
| pressure    | bar    | bar    | 1 bar = 10 <sup>5</sup> Pa |

**Length (m)**

|  |                     |
|--|---------------------|
| 1 in (inch)                            | 25.40 mm = 0.0254 m |
| 1 ft (foot) = 12 inches                | 0.3048 m            |
| 1 yd (yard) = 3 ft = 36 inches         | 0.9144 m            |
| 1 statute mile = 1760 yds              | 1609 m              |
| 1 n mile (international nautical mile) | 1852 m              |

**SI Prefixes**

| Factor           | Prefix | Symbol | Factor            | Prefix | Symbol |
|------------------|--------|--------|-------------------|--------|--------|
| 10 <sup>18</sup> | exa    | E      | 10 <sup>-1</sup>  | deci   | d      |
| 10 <sup>15</sup> | peta   | P      | 10 <sup>-2</sup>  | centi  | c      |
| 10 <sup>12</sup> | tera   | T      | 10 <sup>-3</sup>  | milli  | m      |
| 10 <sup>9</sup>  | giga   | G      | 10 <sup>-6</sup>  | micro  | μ      |
| 10 <sup>6</sup>  | mega   | M      | 10 <sup>-9</sup>  | nano   | n      |
| 10 <sup>3</sup>  | kilo   | k      | 10 <sup>-12</sup> | pico   | p      |
| 10 <sup>2</sup>  | hecto  | h      | 10 <sup>-15</sup> | femto  | f      |
| 10               | deca   | da     | 10 <sup>-18</sup> | atto   | a      |

**Area (m<sup>2</sup>)**

|                        |  |
|------------------------|--|
| 1 sq. in (square inch) | 0.6452 x 10 <sup>-3</sup> m <sup>2</sup> |
| 1 sq. ft (square foot) | 92.90 x 10 <sup>-3</sup> m <sup>2</sup>  |

**Velocity, Speed (m/s) (3.6 km/h = 1 m/s)**

1 kn (knot) = 1 nautical mile/h 1.852 km/h = 0.5144 m/s  
Concerning other conversions, see table for length

**Density**

1 lb/cub. ft 16.02 kg/m<sup>3</sup>

**Force (1 kg m/s<sup>2</sup> = 1 N)**

1 kp (kilopound)\* 9.807 N  
1 poundal\*\* 138.3 x 10<sup>-3</sup> N  
1 lbf (pound force) 4.448 N

\* Can occasionally be found stated as kgf (kilogram force).

Standard acceleration of free fall g<sub>n</sub> = 9.80665 m/s<sup>2</sup>

\*\* Unit of force in the ft-lb-s system

**Stress (1 N/m<sup>2</sup> = 10<sup>-6</sup> N/mm<sup>2</sup>)**

1 kp/mm<sup>2</sup> = 100 kp/cm<sup>2</sup> 9.807 N/mm<sup>2</sup>  
1 lbf/sq. in (psi) = 0.07031 at 6.895 x 10<sup>-3</sup> N/mm<sup>2</sup>

**Dynamic viscosity (N s/m<sup>2</sup>)**

1 kp s/m<sup>2</sup> 9.807 N s/m<sup>2</sup> = 98.07 P (poise)  
1 poundal s/sq.ft 1.488 N s/m<sup>2</sup>  
1 lbf/sq.ft 47.88 N s/m<sup>2</sup>

poise is a special name taken from the CGS system. 1 P = 0.1 Pa s

1 cP = 1 mPa s = 10<sup>-3</sup> Pa s

**Kinematic viscosity (m<sup>2</sup>/s)**

1 sq.ft/s 92.90 x 10<sup>-3</sup> m<sup>2</sup>/s = 92.90 x 10<sup>-3</sup> cSt \*

\* 1 cSt (centi stokes) = 10<sup>-6</sup> m<sup>2</sup>/s. Stokes is a special name taken from the CGS system. 1 St = 10<sup>-4</sup> m<sup>2</sup>/s

**Energy, Work (1 Nm = 1 J, Wh)**

1 cal<sub>I.T.</sub>\* 4.187 J\*  
1 kpm 9.807 J  
1 hph (metric) 2.648 x 10<sup>6</sup> J = 0.7355 kWh  
1 ft. lbf 1.356 J  
1 hph (UK, US) 2.685 x 10<sup>6</sup> J = 0.7457 kWh  
1 BTU (UK, US) 1.055 x 10<sup>3</sup> J = 1.055 kJ

\* Exact value: 4.1868 J  
I.T. = International Steam Table

600.60  
Edition 01

## Conversion Table

Description  
Page 2 (3)

## General

Power ( $1 \text{ kg m}^2/\text{s}^3 = 1 \text{ N m/s} = 1 \text{ J/s} = 1 \text{ W}$ )

|                              |        |               |
|------------------------------|--------|---------------|
| 1 kpm/s                      | 9.807  | W             |
| 1 hp (metric) = 75 kpm/s     | 735.5  | W = 0.7355 kW |
| 1 kcal <sub>l.T.</sub> /h    | 1.163  | W             |
| 1 ft lbf/s                   | 1.356  | W             |
| 1 hp (UK, US) = 550 ft.lbf/s | 745.7  | W             |
| 1 BTU/h                      | 0.2931 | W             |

Moment of Force, Torque ( $\text{kg m}^2/\text{s}^2 = \text{Nm}$ )

Can easily be derived from the above tables.

Moment of Inertia ( $\text{kg m}^2$ )

|                                   |                            |
|-----------------------------------|----------------------------|
| 1 GD <sup>2</sup> (old notation)  | = 4 x I* kg m <sup>2</sup> |
| 1 WR <sup>2</sup> (old notation)* | = 1 x I* kg m <sup>2</sup> |

\*I =  $\int dm_r \times r^2$        $m_r$  = mass at the radius r  
 G = W = mass in kg      D = Diameter of gyration  
 R = Radius of gyration

## Specific fuel consumption\* (g/kWh)

|                  |             |
|------------------|-------------|
| 1 g/hph (metric) | 1.360 g/kWh |
|------------------|-------------|

\* See also table for specific fuel oil consumption values

## Temperature difference (K)

|                   |       |
|-------------------|-------|
| 1 °C (Celsius)    | 1 K   |
| 1 °F (Fahrenheit) | 5/9 K |

Temperature levels (K)  
(see "Derived SI Units with special Names")

|                          |                              |
|--------------------------|------------------------------|
| t °C (Celsius)           | $t_c + 273.15 = K$           |
| t °F (Fahrenheit)        | $5/9(t_f - 32) + 273.15 = K$ |
| Celsius from Fahrenheit: | $t_c = 5/9(t_f - 32)$        |
| Fahrenheit from Celsius: | $t_f = 9/5 \times t_c + 32$  |

## Derived SI Units with Special Names

| Quantity                         | Name    | Symbol | Expressed in basic, supplementary or derived SI units |
|----------------------------------|---------|--------|---|
| frequency                        | hertz   | Hz     | 1 Hz = 1 s <sup>-1</sup>                              |
| force                            | newton  | N      | 1 N = 1 kg m/s <sup>2</sup>                           |
| pressure, stress                 | pascal  | Pa     | 1 Pa = 1 N/m <sup>2</sup> *                           |
| energy, working quantity of heat | joule   | J      | 1 J = 1 Nm  |
| power                            | watt    | W      | 1 W = 1 J/s   |
| electric potential (DC)          | volt    | V      | 1 V = 1 W/A   |
| temperature                      | Celsius | °C     | 1°C = 1 K**   |

\* For mechanical stresses N/mm<sup>2</sup> is widely used. 1 N/mm<sup>2</sup> = 10<sup>6</sup> N/m<sup>2</sup>\*\* t (°C) = T(K) - T<sub>0</sub>(K), where T<sub>0</sub> = 273.15 K

## Specific heat capacity (J/(kg K))

|  |                                  |
|--|----------------------------------|
| 1 kcal <sub>l.T.</sub> /(kg x °C)                    | 4.187 x 10 <sup>3</sup> J/(kg K) |
| 1 BTU*/(lb x °F) = 1 kcal <sub>l.T.</sub> /(kg x °C) | 4.187 x 10 <sup>3</sup> J/(kg K) |

\* British Thermal Unit (see table for energy conversions)

## Heat conductance (W/(m K))

|                                      |       |         |
|--------------------------------------|-------|---------|
| 1 cal <sub>l.T.</sub> /(cm x s x °C) | 418.7 | W/(m K) |
| 1 kcal <sub>l.T.</sub> /(m x h x °C) | 1.163 | W/(m K) |
| 1 BTU*/(ft x h x °F)                 | 1.731 | W/(m K) |

\* British Thermal Unit (see table for energy conversions)

Heat transmission (W/(m<sup>2</sup> K))

|   |  |
|---|--|
| 1 cal <sub>l.T.</sub> /(cm x s x °C)              | 41.87 x 10 <sup>3</sup> W/(m <sup>2</sup> K) |
| 1 kcal <sub>l.T.</sub> /(m <sup>2</sup> x h x °C) | 1.163 W/(m <sup>2</sup> K)                   |
| 1 BTU*/(ft <sup>2</sup> x h x °F)                 | 5.678 W/(m <sup>2</sup> K)                   |

## Specific fuel oil consumption (SFOC)

## Reference conditions

Specific fuel oil consumption values refer to brake power, and the following reference conditions:

Reference conditions (ISO)

|  |              |
|--|--------------|
| Blower inlet temperature 25°C                  | 298 K        |
| Blower inlet pressure                          | 1000 mbar    |
| Charge air coolant temperature 25°C            | 298 K        |
| Fuel oil lower calorific value (10200 kcal/kg) | 42707 kJ/kgk |

|                           |                         |                             |
|---------------------------|-------------------------|-----------------------------|
| Description<br>Page 3 (3) | <b>Conversion Table</b> | <b>600.60</b><br>Edition 01 |
|---------------------------|-------------------------|-----------------------------|

**General****Volume (1 m<sup>3</sup> = 1000 l)**

|   |   |
|---|---|
| 1 cub. in (cubic inch)                          | 16.39 x 10 <sup>-6</sup> m <sup>3</sup>           |
| 1 cub. ft (cubic foot)                          | 28.32 x 10 <sup>-3</sup> m <sup>3</sup> = 28.32 l |
| 1 gallon* (imperial, UK)                        | 4.546 x 10 <sup>-3</sup> m <sup>3</sup> = 4.546 l |
| 1 gallon* (US)                                  | 3.785 x 10 <sup>-3</sup> m <sup>3</sup> = 3.785 l |
| 1 barrel (US petroleum barrel) = 42 gallon (US) | 0.1590 m <sup>3</sup>                             |
| 1 bbl (dry barrel, US)                          | 0.1156 m <sup>3</sup>                             |
| 1 register ton = 100 cub. ft                    | 2.832 m <sup>3</sup>                              |

\* 1 gallon = 4 quarts = 8 pints

**Mass (kg)**

|                                      |                             |
|--------------------------------------|-----------------------------|
| 1 lb (pound mass) = 16 ozs (ounces)  | 0.4536 kg                   |
| 1 cwt (UK) (hundredweight) = 112 lbs | 50.80 kg                    |
| 1 long ton (UK) = 20 cwt = 2240 lbs  | 1.016 metric tons = 1016 kg |
| 1 short ton (UK) = 2000 lbs          | 0.907 metric tons = 907 kg  |
| 1 slug*                              | 14.59 kg                    |

\* Unit and mass in the ft-lb-s system

**Pressure**

**(1 N/m<sup>2</sup> = 1 Pa, 1 bar = 10<sup>5</sup> Pa, 1 mbar = 10<sup>-3</sup> bar)**

|                         |   |  |
|-------------------------|---|--|
| 1 kp/cm <sup>2</sup>    | = 1 at = 0.9678 atm   | 98.07 x 10 <sup>3</sup> Pa = 0.9807 bar                        |
| 1 at                    | = 735.5 mm Hg* = 10 m H <sub>2</sub> O**                    | (T = 277 K)  |
| 750 mm Hg*              | 10 <sup>5</sup> Pa = 1 bar                                  |  |
| 1 mm Hg*                | (T = 273 K)   | 133.3 Pa = 1.333 mbar  |
| 1 mm H <sub>2</sub> O** | (T = 277 K)   | 10 <sup>-4</sup> at = 9.807 Pa = 98.07 x 10 <sup>-3</sup> mbar |
| 1 in Hg*                | (T = 273 K)   | 3386 Pa = 33.86 mbar   |
| 1 in H <sub>2</sub> O** | (T = 277 K)   | 249.1 Pa = 2.491 mbar  |
| 1 atm                   | (standard atmosphere) 760 mm Hg, 1.013 x 10 <sup>5</sup> Pa | = 1013 mbar  |
| 1 atm                   | = 1.033 at  |  |
| 1 lbf/sq.in (psi)       | 6895 Pa = 68.95 mbar  |  |

\* Mercury. 1 mm Hg = 1 Torr

Values in table provided gn = 9.80665 m/s<sup>2</sup>

\*\* Water column (WC)

**Some physical data in SI units**

Nomenclature

t = temp. in °C

r = density in kg/m<sup>3</sup>

ΔK = temperature difference

C<sub>p</sub> = heat capacity in J/(kg DK)

|   | t  | ρ         | C <sub>p</sub>         | t range | C <sub>p</sub>               |
|---|----|-----------|------------------------|---------|------------------------------|
| Water                                   | 18 | 999       | 4.18 x 10 <sup>3</sup> |         |                              |
| Lubricating oil (approx.)*              | 15 | 900       | 1.96 x 10 <sup>3</sup> |         |                              |
| Atmospheric air (dry) (p=1 bar)         | 0  | 1.276     | 998                    | 0-150   | 1005                         |
| Exhaust gas                             |    |           |                        | 200-400 | 1080                         |
| * Viscosity: 100-140 cSt at 40°C        |    |           |                        |         |                              |
| 750 mm Hg = 1 bar = 10 <sup>5</sup> Pa  |    |           |                        |         |                              |
| 1 atm (standard pressure at sea level)  |    |           |                        |         |                              |
| Gas constant for air and exhaust gas    |    |           |                        |         |                              |
| Water, heat of evaporation 100°C        |    | 1.013 bar |                        |         | 2.256 x 10 <sup>6</sup> J/kg |
| Fuel oil. Lower calorific value         |    |           |                        |         | 41-43 x 10 <sup>6</sup> J/kg |
| ISO 3046/1-1986 standard reference fuel |    |           |                        |         | 43 x 10 <sup>6</sup> J/kg    |
| Diesel engine reference fuel            |    |           |                        |         | (see below)                  |

|                           |                                 |                              |
|---------------------------|---------------------------------|------------------------------|
| Description<br>Page 1 (3) | <b>Basic Symbols for Piping</b> | <b>600.65</b><br>Edition 01H |
|---------------------------|---------------------------------|------------------------------|

**General**

| No                                     | Symbol | Symbol designation                                     | No   | Symbol | Symbol designation                           |
|--|--------|--|--|--------|--|
| <b>1. GENERAL CONVENTIONAL SYMBOLS</b> |        |  | 2.14   |        | Spectacle flange                             |
| 1.1                                    |        | Pipe   | 2.15   |        | Orifice                                      |
| 1.2                                    |        | Pipe with indication of direction of flow              | 2.16   |        | Orifice                                      |
| 1.3                                    |        | Valves, gate valves, cocks and flaps                   | 2.17   |        | Loop expansion joint                         |
| 1.4                                    |        | Appliances   | 2.18   |        | Snap coupling                                |
| 1.5                                    |        | Indicating and measuring instruments                   | 2.19   |        | Pneumatic flow or exhaust to atmosphere      |
| 1.6                                    |        | High-pressure pipe                                     | <b>3. VALVES, GATE VALVES, COCKS AND FLAPS</b> |        |  |
| 1.7                                    |        | Tracing  |  |        | Valve, straight through                      |
| 1.8                                    |        | Enclosure for several components assembled in one unit |  |        | Valve, angle                                 |
| <b>2. PIPES AND PIPE JOINTS</b>        |        |  |  |        | Valve, three-way                             |
| 2.1                                    |        | Crossing pipes, not connected                          |  |        | Non-return valve (flap), straight            |
| 2.2                                    |        | Crossing pipes, connected                              |  |        | Non-return valve (flap), angle               |
| 2.3                                    |        | Tee pipe   |  |        | Non-return valve (flap), straight screw down |
| 2.4                                    |        | Flexible pipe  |  |        | Non-return valve (flap), angle, screw down   |
| 2.5                                    |        | Expansion pipe (corrugated) general                    |  |        | Safety valve                                 |
| 2.6                                    |        | Joint, screwed   |  |        | Angle safety valve                           |
| 2.7                                    |        | Joint, flanged   |  |        | Self-closing valve                           |
| 2.8                                    |        | Joint, sleeve  |  |        | Quick-opening valve                          |
| 2.9                                    |        | Joint, quick-releasing                                 |  |        | Quick-closing valve                          |
| 2.10                                   |        | Expansion joint with gland                             |  |        | Regulating valve                             |
| 2.11                                   |        | Expansion pipe   |  |        | Ball valve (cock)                            |
| 2.12                                   |        | Cap nut  |  |        | Butterfly valve                              |
| 2.13                                   |        | Blank flange   |  |        | Gate valve                                   |

**600.65**

Edition 01H

**Basic Symbols for Piping**Description  
Page 2 (3)**General**

| No   | Symbol | Symbol designation   | No                                     | Symbol | Symbol designation                   |
|------|--------|--|--|--------|--------------------------------------|
| 3.17 |        | Double-seated changeover valve   | <b>4. CONTROL AND REGULATION PARTS</b> |        |                                      |
| 3.18 |        | Suction valve chest  | 4.1                                    |        | Fan-operated                         |
| 3.19 |        | Suction valve chest with non-return valves   | 4.2                                    |        | Remote control                       |
| 3.20 |        | Double-seated changeover valve, straight   | 4.3                                    |        | Spring                               |
| 3.21 |        | Double-seated changeover valve, angle  | 4.4                                    |        | Mass                                 |
| 3.22 |        | Cock, straight through   | 4.5                                    |        | Float                                |
| 3.23 |        | Cock, angle  | 4.6                                    |        | Piston                               |
| 3.24 |        | Cock, three-way, L-port in plug  | 4.7                                    |        | Membrane                             |
| 3.25 |        | Cock, three-way, T-port in plug  | 4.8                                    |        | Electric motor                       |
| 3.26 |        | Cock, four-way, straight through in plug   | 4.9                                    |        | Electromagnetic                      |
| 3.27 |        | Cock with bottom connection  | 4.10                                   |        | Manual (at pneumatic valves)         |
| 3.28 |        | Cock, straight through, with bottom conn.  | 4.11                                   |        | Push button                          |
| 3.29 |        | Cock, angle, with bottom connection  | 4.12                                   |        | Spring                               |
| 3.30 |        | Cock, three-way, with bottom connection  | 4.13                                   |        | Solenoid                             |
| 3.31 |        | Thermostatic valve   | 4.14                                   |        | Solenoid and pilot directional valve |
| 3.32 |        | Valve with test flange   | 4.15                                   |        | By plunger or tracer                 |
| 3.33 |        | 3-way valve with remote control (actuator)   | <b>5. APPLIANCES</b>                   |        |                                      |
| 3.34 |        | Non-return valve (air)   | 5.1                                    |        | Mudbox                               |
| 3.35 |        | 3/2 spring return valve, normally closed   | 5.2                                    |        | Filter or strainer                   |
| 3.36 |        | 2/2 spring return valve, normally closed   | 5.3                                    |        | Magnetic filter                      |
| 3.37 |        | 3/2 spring return valve contr. by solenoid   | 5.4                                    |        | Separator                            |
| 3.38 |        | Reducing valve (adjustable)  | 5.5                                    |        | Steam trap                           |
| 3.39 |        | On/off valve controlled by solenoid and pilot directional valve and with spring return | 5.6                                    |        | Centrifugal pump                     |

|                           |                                 |                              |
|---------------------------|---------------------------------|------------------------------|
| Description<br>Page 3 (3) | <b>Basic Symbols for Piping</b> | <b>600.65</b><br>Edition 01H |
|---------------------------|---------------------------------|------------------------------|

**General**

| No.  | Symbol | Symbol designation                                    | No.   | Symbol | Symbol designation       |
|------|--------|---|---|--------|--------------------------|
| 5.7  |        | Gear or screw pump                                    | <b>6. FITTINGS</b>                                  |        |                          |
| 5.8  |        | Hand pump (bucket)                                    | 6.1   |        | Funnel / waste tray      |
| 5.9  |        | Ejector   | 6.2   |        | Drain                    |
| 5.10 |        | Various accessories (text to be added)                | 6.3   |        | Waste tray               |
| 5.11 |        | Piston pump   | 6.4   |        | Waste tray with plug     |
| 5.12 |        | Heat exchanger  | 6.5   |        | Turbocharger             |
| 5.13 |        | Electric preheater                                    | 6.6   |        | Fuel oil pump            |
| 5.14 |        | Air filter  | 6.7   |        | Bearing                  |
| 5.15 |        | Air filter with manual control                        | 6.8   |        | Water jacket             |
| 5.16 |        | Air filter with automatic drain                       | 6.9   |        | Overspeed device         |
| 5.17 |        | Water trap with manual control                        | <b>7. READING INSTR. WITH ORDINARY DESIGNATIONS</b> |        |                          |
| 5.18 |        | Air lubricator  | 7.1   |        | Sight flow indicator     |
| 5.19 |        | Silencer  | 7.2   |        | Observation glass        |
| 5.20 |        | Fixed capacity pneumatic motor with direction of flow | 7.3   |        | Level indicator          |
| 5.21 |        | Single acting cylinder with spring returned           | 7.4   |        | Distance level indicator |
| 5.22 |        | Double acting cylinder with spring returned           | 7.5   |        | Recorder                 |
| 5.23 |        | Steam trap  |   |        |                          |

**Operation of engine**

**501/601**

|                           |                  |                              |
|---------------------------|------------------|------------------------------|
| Description<br>Page 1 (3) | <b>Operating</b> | <b>601.01</b><br>Edition 21H |
|---------------------------|------------------|------------------------------|

**L+V28/32H****Preparations for Starting**

The following describes what to do before starting, when the engine has been out of service for a longer period of time, or if major overhauls has been made.

1. Check the oil level in the base frame (or in the lub. oil tank if the engine is with dry sump), air lubricator and in the governor.

Start-up the prelubricating pump.

The engine shall be prelubricated at least 2 minutes prior to start.

Check oil pressures before and after the filter.

2. Open the cooling water supply, start separate cooling water pumps where installed, and check the cooling water pressure.

**Note:** To avoid shock effects owing to large temperature fluctuations just after the start, it is recommended:

- a) to preheat the engine, cooling water of at least 60 °C should be circulated through the frame and cylinder head for at least 2 hours before start.
  - either by means of cooling water from engines which are running or by means of a built-in preheater (if installed).

or

- b) When starting without preheated cooling water, the engine must only be started on MDO (Ma-rine Diesel Oil).

The engine should not be run up to more than 50% load to begin with, and the increase to 100% should take place gradually over 5 to 10 minutes.

**Note:** When starting on HFO (Heavy Fuel Oil), only item "a" should be used.

3. Open the nozzle cooling oil supply (only when started on HFO), circulate preheated oil through the nozzles for at least 15 minutes.

4. Open the fuel oil supply to the feed pump.

Starting on HFO: circulate preheated fuel through the pumps until correct working temperatures has been obtained. Takes normally 30-60 minutes.

5. Check the pressure in the starting air receiver(s) and open the starting air supply (blow-off water, if any, drain the starting air system before opening).

6. Check that the sealing oil system for the injection pumps are working correct.

7. Check in the regulating gear:

- That all fuel pumps are at index "0" when the regulating shaft is in the STOP position.
- That each fuel pump can be pressed by hand to full index when the regulating shaft is in the STOP position, and that the pumps return automatically to the "0" index when the hand is removed.
- That the spring-loaded pull rod is working correctly.
- That the stop cylinder for regulating shaft works properly, both when stopping normally and at overspeed and shut down.
- Testing is made by simulating these situations.

8. Open the indicator valves and turn the engine some few revolutions, check that no liquid is flowing out from any of the indicator valves during the turning.

Slow-turning must always be carried out, before the engine is started after prolonged out of-service periods and after overhauls, which may involve a risk of liquid having collected in the cylinders.

9. Close the indicator valves.

10. Disengage the turning gear, if fitted. Check that it is locked in the "OUT" position.



|                              |                  |                           |
|------------------------------|------------------|---------------------------|
| <b>601.01</b><br>Edition 21H | <b>Operating</b> | Description<br>Page 2 (3) |
|------------------------------|------------------|---------------------------|

## L+V28/32H

### Starting

1. Start the engine, by activating the start button.
2. Check the lubricating oil pressure, cooling water pressure, fuel oil feed pressure. Check that the prelubricating oil pump is stopped.
3. Check that all alarms are connected.

See also "checks after starting-up".

### Tending during running

When the engine is running, the planned maintenance program and the following should be checked:

1. The lubricating oil pressure must be within the stated limits and must not fall below the stated minimum pressure. The paper filtering cartridges must be replaced before the pressure drop across the filter reaches the stated maximum value, or the pressure after the filter has fallen below the stated minimum value. Dirty filter cartridges cannot be cleaned for re-use.
2. The lubricating oil temperature must be kept within the stated limits indicated on the data sheet.
3. The fuel oil pressure must be kept at the stated value, and the filter must be cleaned before the pressure drop across the filter reaches the stated maximum value.
4. The cylinder cooling water temperature must be kept within the limits indicated and the temperature rise across the engine should not exceed 10°C.
5. The cooling water temperature at the charging air cooler inlet should be kept as low as possible; however, not as low as to produce condensation water in the charging air space.

Adjustment takes place in the external system outside the engine, and the amount of cooling water must be so adjusted that the temperature rise across the charging air cooler is 3 - 5 °C.

6. The exhaust gases should be free from smoke at all loads. For normal exhaust temperatures, see the test sheet from shop and sea trials.

7. Keep the charging air pressure and temperature under control. For normal values, see the test sheet from shop and sea trials.

8. Recharge the starting air receivers when the pressure has dropped to about 20 bar. Stop recharging at 30 bar.

9. To ensure the greatest possible operational liability, condition of the engine should be continuously observed in order that preventive maintenance work can be carried out before serious breakdowns occur.

### Stopping

1. Before stopping, it is recommended to run the engine at reduced load, or to idle for about 5 minutes for cooling-down purposes.
2. The engine is stopped by keeping the fuel pump delivery rate at "0", by turning the "load-limit" knob on the governor to "0", or by activating the remote stopping device.

### Start and Stop on HFO

Start and stop of the engine should take place on HFO in order to prevent any incompatibility problems by change-over to MDO.

MDO should only be used in connection with maintenance work on the engine or longer periods of engine standstill.

Before starting on HFO the engine must be properly preheated, as described in "Preparations for starting" and as below.

Stopping the engine on HFO is no problem, but it should be ensured that the temperature of fuel pipes not are reduced to a level below the pour point of the fuel, otherwise reestablishing of the circulation might cause problems.

|                           |                  |                              |
|---------------------------|------------------|------------------------------|
| Description<br>Page 3 (3) | <b>Operating</b> | <b>601.01</b><br>Edition 21H |
|---------------------------|------------------|------------------------------|

**L+V28/32H****Starting on MDO**

For starting on MDO there are no restrictions except lubricating oil viscosity may not be higher than 1500 cSt (5° C SAE 30, or 10° C SAE 40).

Initial ignition may be difficult if the engine and ambient temperature are lower than 5° C, and 15° C cooling water temperature.

|                           |                       |                              |
|---------------------------|-----------------------|------------------------------|
| Description<br>Page 1 (2) | <b>Out-of Service</b> | <b>601.05</b><br>Edition 17H |
|---------------------------|-----------------------|------------------------------|

## General

### 1. Stand-by Engines

During engine standstill in stand-by position, the media cooling water, fuel oil and nozzle oil should be continuously circulated at temperatures similar to the operation conditions.

The engine shall be prelubricated 2 minutes prior to start, if there is not intermittent or continuous pre-lubricating installed. intermittent prelub. is 2 min every 10 minutes.

### 2. Maintenance during Standstil

in periods, duringe stand-still of the engine (not in stand-by position) it is recommended, that the pre-lubricating oil pump is startet minimum 10 minutes once every week and that the engine during the prelubricating period is turnd 2-3 revolutions..

### 3. Laid-up Vessels

During the lay-up period (and also when laying-up the vessel), we recommend that our special instructions for preservation of the engines, are followed.

### 4. Works before Major Repairs

**4.1** After stopping the engine, while the oil is still warm, start the electrically driven prelubrication pump, open up the crancase and camshaft housing and check that the oil is flowing freely from all bearings. Also take off the top covers on the cylinder heads and make sure that oil is not supplied for lubrication of rocker arms, as non-return valves are fitted which do not open until the oil pressure at the inlet to the rocker arms exceeds 1 bar.

After overhaul of pistons, bearings, etc. this check should be repeated before starting the engine.

**4.2.** After stopping the prelubricating pump, check the bottom of the oil sump for fragments of babbitt from bearings, and check crankpin and main bearings clearances with a feeler gauge. Measure the bearing clerance at the top, at the bottom, and 10 degrees above and below the joints at both sides.

**4.3.** Open up all filters to check that filter elements are intact. Filter cartridges in the lub. oil filter is to be replaced before start after repair or due to excessive differential pressure. After eremoval, dirty elements can be examined for particles of bearing metal at the bottom of the paper lamellae. (The elements can not be used again).

**4.4.** Check the cylinder walls.

**4.5.** Take deflection measurements of the crankshaft.

**4.6.** A lubricating oil sample should be send to a laboratory for immediate analysis.

**4.7.** Drain plugs are unscrewed from the bottom of turbochargers, or the drain cock is opened, if there is installed drain facilities in the exhaust gas system this should be opened.

### 5. Works during Repairs

The following should be made during the major repairs.

**5.1.** Retighten all bolts and nuts in the crankcase and check their locking devices. Also retighten foundation bolts.

**5.2.** Check the various gear wheel drives for the camshaft(s).

**5.3.** Remedy leakages of water and oil in the engine, and blow through blocked-up drain pipes.

**5.4.** Drain starting air pipes of water.

**5.5.** Empty the oil sump of lubricating oil and remove the sludge, if not done within a period of one year. Very thoroughly clean the sump and subsequently coat with clean lubricating oil.

### 6. Works after Repairs

**6.1.** If an opening-up of engine or lubricating oil system may have caused ingress of impurities, cleaning should be carried out very carefully before starting the engine.

|                              |                       |                           |
|------------------------------|-----------------------|---------------------------|
| <b>601.05</b><br>Edition 17H | <b>Out-of Service</b> | Description<br>Page 2 (2) |
|------------------------------|-----------------------|---------------------------|

## General

The differential pressure across the lub. oil filter must be watched very carefully after cleaning and starting-up the engine. Be sure to replace filter cartridges in due time.

**6.2.** After restoring normal lubricating oil circulation, turn the engine at least two revolutions by means of the turning rod to check the movability of the relevant parts of the engine.

**6.3.** Close drain cocks in the turbocharger (or in the exhaust gas system if mounted).

**6.4.** Lubricate bearings and rod connections in the manoeuvring gear. Disconnect the governor and move the rod connections by hand to check that the friction in bearings and fuel pumps is sufficiently low. If repair of bearings or alignment of engine has been made, checks 1, 2, and 5 should be repeated.

**6.5.** Checks to be made just before starting of the engine are mentioned under 601.01.

**6.6.** Add cooling water and check with pressure on the system for leakage at the upper and lower cylinder liner sealings and at cooling water connections.

**6.7.** Check the governor as follows:  
Start up the engine and run it at the synchronous number of revolutions.

**6.7 a)** Speed setting: Check before switching-in generator on the switchboard that the servomotor adjusts the r.p.m. with a suitable quickness after actuation of the synchronizer knob on the switchboard. The range from - 5% to + 5% from the synchronous r.p.m. should be tested.

**6.7 b)** Adjustment speed: Switch-in generator on the switchboard and set the load to about 40%. On reaching normal oil temperatures in governor and engine, increase the load instantaneously to about 80% ( by starting major pump or compressor). This must not cause the frequency to fall by more than some 8%, and the engine must return to a constant r.p.m. about 3 seconds (although this r.p.m. will be a little lower than before owing to the speed drop of the governor). If the engine is operated in parallel with other engines, an even sharing of load shall be established within about 3 seconds. If the governor reacts too slowly, compensating adjustment is effected as indicated in Woodward's instruction manual (Compensating adjustment).

**Note:** It is a condition for this test that the engine and turbocharger are in perfect operating condition, so that they can be eliminated as possible sources of error.

**6.7 c)** Hunting: Run the engine at synchronous r.p.m., and without load. Provided the governor oil is warm, the regulating lever must not perform any major periodical movements, and neither must there be any variation up and down in the engine speed. If that is the case, repeat the compensating adjustment according to Woodward's instruction manual.

**6.7 d)** Speed Drop: in case of unsatisfactory load sharing between two or more engines this can be rectified by increasing the speed drop of the engine that is subject to the greatest load (or by reducing the setting of the other engines).

The setting should not normally be increased beyond 70 on the scale, and satisfactory parallel operation can generally be obtained at settings between 40 and 60.

|                           |   |                              |
|---------------------------|---|------------------------------|
| Description<br>Page 1 (1) | <b>Starting-up after Out of Service Periods</b> | <b>601.10</b><br>Edition 17H |
|---------------------------|---|------------------------------|

**L+V28/32H**

The following enumerates checks are to be made immediately after starting, during load increase, and during normal running. The sequence has been accordingly.

*In the following it is assumed that the engine has been out of service for some time, for instance due to repairs and*

- checks during out of service periods have been carried out as described in the previous chapter.

When starting after such an out-of-service period, the following checks must be made in the stated order in addition to normal surveillance and recording.

### 1. To be made immediately after starting:

- 1.1. See that the turbocharger is running.
- 1.2. See that the lubricating oil pressure is in order.
- 1.3. See that all cylinders are firing (see exhaust temperatures).
- 1.4. See that everything is normal for the engine speed, fuel oil, cooling water and system oil.
- 1.5. Check by simulation of the overspeed shutdown device that the engine stops. The overspeed setting should be according to "Set Points and Operation Data" section 600.

### 2. To be made during the starting-up, but only if required after repairs or alterations made:

- 2.1. If the condition of the machinery is not well-known, especially after repairs or alterations, the "feel-over sequence" should always be followed. that is:

After 5-15 and 30 minutes' idle running, open the crankcase and the camshaft housing and feel-over on the surfaces of all moving parts where friction may arise and cause undue heating.

Feel: Main bearings, big-end bearings, (alternator), and camshaft bearings, piston pins, cylinder liners, roller guides and gear wheels.

After the last feel-over, repeat check 4 page 601.05, see also **Ignition in Crankcase** page 603.04 in section 603.

After repair or renewal of cylinder liners, piston rings or bearings, allowance must be made for a running-in period, i.e. the engine load should be increased gradually as indicated in the tables below. The engine output is determined on the basis of the fuel index and the load on the electric switchboard. The turbocharger speed gives some indication of the engine output, but is not directly proportional to the output throughout the service period.

Begin the starting-up sequence at a reduced engine speed, e.g. 400 rpm, until it can be known for certain that there are no hot spots in the engine. Then increase the speed to the normal rpm and connect to the switchboard and put on load.

The load increase during the starting-up sequence may, for instance, be:

25 % load for 2 hours  
50 % load for 2 hours  
75 % load for 2 hours  
100 % load may be put on.

The pump index indicated in the tables has been given as a percentage of the index at full load. To enable the index to be read directly off the fuel pumps the following formula can be employed:

$$I = \frac{I\%}{100} \times I_F$$

$I_F$  = Index at full load (from testbed table)

$I\%$  = Index expressed as % of full load index (stated in the preceding starting-up sequence).

Following the alteration of the pump index of the one or two cylinders concerned it must be checked that when in the STOP position the governor is able to move all the fuel pumps to an average pump index not exceeding 2 or 3, thus excluding the possibility of racing of the engine when the propeller is declutched.

After completing the starting-up sequence, make sure that all fuel pumps are set at the same index and that the governor can cause all fuel pumps to move to "0" index.

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (1) | <b>Guidelines for Longterm Low-Load Operation on HFO</b> | <b>601.15</b><br>Edition 03H |
|---------------------------|--|------------------------------|

## General

### Part load/low load operation

In certain ship and power station operation modes the diesel generating sets are exposed to part load/low load operation.

During manoeuvring of the ship all diesel generating sets are often started up for safety reasons, resulting in low load operation of all the engines. During harbour stay one diesel generator could be low-loaded when only hotel purposes are consuming electricity.

Island mode operation of diesel generating sets in power stations is frequently exposed to low load operation like on a ship.

At part load/low load it is important to maintain constant media temperatures, i.e. for cooling water, lubricating oil and fuel oil in order to ensure adequate combustion chamber temperature and thus complete combustion.

At loads lower than 20% MCR there is a risk of time dependant retardation of the engine performance condition due to fouling of the exhaust gas channels and combustion air channels, combustion chambers

and turbocharger. HFO-operation at loads lower than 20% MCR should therefore only take place within certain time limitations according to the curves.

After a certain period of HFO-operation at loads lower than 20% MCR, a change to MDO should take place in order to prevent further retardation of the engine performance condition. Alternatively, the engine load should be raised to 70% MCR over a period of 15 minutes and maintained here for some time in order to burn off the carbon deposits, thus re-establishing adequate performance condition. After such a "clean burning period" low load operation on HFO can be continued.

However, the operator must be aware of the fact that fouling in the combustion air inlet channels, if any, will not be cleaned at high load operation. Extensive low load running can therefore result in the need for manual cleaning of the combustion air inlet channels.

If special application conditions require continuous HFO-operation at loads lower than 20% MCR and occasionally performed "clean-burning" periods are inconvenient or impossible, special equipment and arrangements must be established.

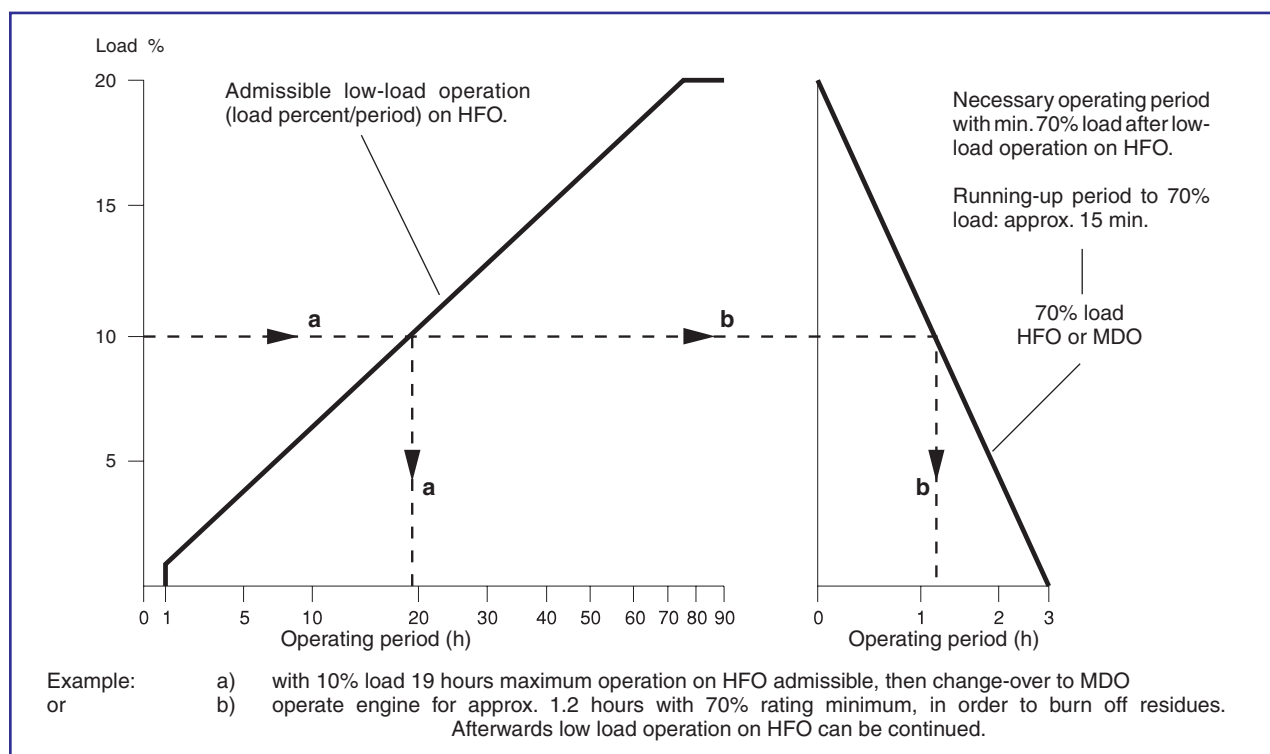


Fig 1 Low-load operation.

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (1) | <b>Guidelines Regarding MAN Diesel &amp; Turbo GenSets<br/>Operating on Low Sulphur Fuel Oil</b> | <b>601.16</b><br>Edition 02H |
|---------------------------|--|------------------------------|

## General

Exhaust emissions from marine diesel engines have been the focus of recent legislation. Apart from nitrous oxides (NOx), sulphur oxides (SOx) are considered to be the most important pollution factor. A range of new regulations have been implemented and others will follow (IMO, EU Directive, and CARB). These regulations demand reduction of SOx emissions by restricting the sulphur content of the fuel. That is to say sulphur limits for HFO as well as mandatory use of low sulphur distillate fuels for particular applications. This guideline covers the engine related aspects of the use of such fuels.

### Low sulphur HFO

From an engine manufacturer's point of view there is no lower limit for the sulphur content of HFO. We have not experienced any trouble with the currently available low sulphur HFO, that are related to the sulphur content or specific to low sulphur HFO. This may change in the future if new methods are applied for the production of low sulphur HFO (desulphurization, uncommon blending components). MAN Diesel & Turbo will monitor developments and inform our customers if necessary.

If the engine is not operated permanently on low sulphur HFO, then the lubricating oil should be selected according to the highest sulphur content of the fuels in operation.

### Low sulphur distillates

In general our GenSet is developed for continuous operation on HFO as well as on MDO/MGO. Occasionally changes in operation mode between HFO and MDO/MGO are considered to be within normal operation procedures for our engine types and do thus not require special precautions.

Running on low sulphur fuel (< 0.1% S) will not cause problems, but please notice the following restrictions:

In order to avoid seizure of the fuel oil injection pump components the viscosity at engine fuel oil inlet must be > 2.0 cSt. In order to achieve this it may be necessary to install a fuel oil cooler, when the engine is running on MGO. This is both to ensure correct viscosity and avoid heating up the service tank, which is important as the fuel oil injection pumps are cooled by the fuel.

When operating on MDO/MGO a larger leak oil amount from fuel oil injection pumps and fuel oil injection valves can be expected compared to operation on HFO.

In order to carry out a quick change between HFO and MDO/MGO the change over should be carried out by means of the valve V1-V2 installed in front of the engine.

For the selection of the lubricating oil the same applies as for HFO. For temporary operation on distillate fuels including low sulphur distillates nothing has to be considered. A lubricating oil suitable for operation on diesel fuel should only be selected if a distillate fuel is used continuously.

**Performance and  
condition**

**502/602**



|                           |   |                              |
|---------------------------|---|------------------------------|
| Description<br>Page 1 (3) | <b>Engine Performance and Condition</b> | <b>602.01</b><br>Edition 12H |
|---------------------------|---|------------------------------|

## L+V28/32H

### Performance Data and Engine Condition

During operation small changes in the engine condition take place continuously as a result of combustion, including fouling of airways and gasways, formation of deposits, wear, corrosion, etc. If continuously recorded, these changes in the condition can give valuable information about the operational and maintenance condition of the engine. Continuous observation can contribute to forming a precise and valuable basis for evaluation of the optimum operation and maintenance programmes for the individual plant.

### Engine Performance Data

If abnormal or incomprehensible deviations in operation are recorded, expert assistance in the evaluation thereof should be obtained.

We recommend taking weekly records of the most important performance data of the engine plant. During recording (working card 502-01.00 can be used) the observations are to be compared continuously in order to ascertain alterations at an early stage and before these exert any appreciable influence on the operation of the plant.

As a reference condition for the performance data, the testbed measurements of the engine or possibly the measurements taken during the sea trial on the delivery of the ship can be used. If considerable deviations from the normal conditions are observed, it will be possible, in a majority of cases, to diagnose the cause of such deviations by means of a total evaluation and a set of measurements, after which possible adjustment/overhauls can be decided on and planned.

### Evaluation of Performance Data

#### Air Cooler

Fouling of the air side of the air cooler will manifest itself as an increasing pressure drop, lower charge air pressure and an increased exhaust/charge air temperature level (with consequential influence on the overhaul intervals for the exhaust valves).

An increase in charge air temperature involves a corresponding increase in the exhaust gas temperature level by a ratio of about 1:1.5, i.e. 1°C higher charge air temperature causes about 1.5°C higher exhaust gas temperature.

Reduction of the charge air pressure results in a corresponding reduction of the compression pressure and max. combustion pressure.

When checking the max. pressure adjustment of the engine, it is therefore to be ensured that the existing charge air pressure is correct.

### Fuel Injection Pump

The amount of fuel injected is equivalent to the supplied energy and is thus an expression of the load and mean effective pressure of the engine. The fuel pump index can therefore be assumed to be proportional to the mean pressure. Consequently, it can be assumed that the connected values of the pump index are proportional to the load.

The specific fuel consumption, SFOC (measured by weight) will, on the whole, remain unchanged whether the engine is operating on HFO or on MDO, when considering the difference in calorimetric heat value. However, when operating on HFO, the combination of density and calorific value may result in a change of up to 6% in the volumetric consumption at a given load. This will result in a corresponding change in the fuel pump index, and attention should be paid to this when adjusting the overload preventive device of the engine.

To avoid overloading of the engine the charge air pressure and turbine speed recorded at the shop test should not be exceeded.

At the Power Control Synchronizing (PCS) panel in the engine control room it is possible to reduce the load by adjusting the setting for maximum MCR load limit

Abrasive particles in the fuel oil result in wear of fuel injection pumps and fuel valve nozzles. Effective treatment of the fuel oil in the purifier can keep the content of abrasive particles to a minimum. Worn fuel injection pumps will result in an increase of the index on account of an increased loss in the pumps due to leakage.

## L+V28/32H

When evaluating operational results, a distinction is to be made between changes which affect the whole engine (all cylinder units) and changes which occur in only one or a few cylinders.

Deviations occurring for a few cylinders are, as a rule, caused by malfunctioning of individual components, for example a fuel valve with a too low opening pressure, blocked nozzle holes, wear or other defects, an inlet or exhaust valve with wrongly adjusted clearance, burned valve seat, etc.

### Turbochargers

Fouling of the turbine side of the turbocharger will, in its first phase, manifest itself in increasing turbocharger revolutions on account of increased gas velocity through the narrowed nozzle ring area. In the long run, the charging air quantity will decrease on account of the greater flow resistance through the nozzle ring, resulting in higher wall temperatures in the combustion chambers.

Service experience has shown that the turbine side is exposed to increased fouling when operating on HFO.

The rate of fouling and thereby the influence on the operation of the engine is greatest for small turbochargers where the flow openings between the guide vanes of the nozzle ring are relatively small. Deposits occur especially on the guide vanes of the nozzle ring and on the rotor blades. In the long run, fouling will reduce the efficiency of the turbocharger and thereby also the quantity of air supplied for the combustion of the engine. A reduced quantity of air will result in higher wall temperatures in the combustion spaces of the engine.

Detailed information and instructions regarding water washing of the turbocharger are given in the instruction manual.

### Fuel Valves

Assuming that the fuel oil is purified effectively and that the engine is well-maintained, the operational conditions for the fuel valves and the overhaul intervals will not normally be altered essentially when operating on HFO.

If, for any reason, the surface temperature of the fuel valve nozzle is lower than the condensation temperature of sulphuric acid, sulphuric acid condensate can form and corrosion take place (cold corrosion). The formation of sulphuric acid also depends on the sulphur content in the fuel oil.

Normally, the fuel nozzle temperature will be higher than the approx. 180°C at which cold corrosion starts to occur.

Abrasive particles in the fuel oil involve heavier wear of the fuel valve needle, seat, and fuel nozzle holes. Therefore, abrasive particles are to the greatest possible extent to be removed at the purification.

### Exhaust Valves

The overhaul intervals for exhaust valves is one of the key parameters when the reliability of the entire engine is to be judged. The performance of the exhaust valves is therefore extremely informative.

Especially under unfavourable conditions, fuel qualities with a high vanadium and sodium content will promote burning of the valve seats. Combinations of vanadium and sodium oxides with a corrosive effect will be formed during combustion. This adhesive ash may, especially in the event of increased valve temperatures, form deposits on the seats. An increasing sodium content will reduce the melting point and thereby the adhesive temperature of the ash, which will involve a greater risk of deposits. This condition will be especially unfavourable when the  $\frac{Na}{Va}$  weight ratio increases beyond 1:3.

The exhaust valve temperature depends on the actual maintenance condition and the load of the engine. With correct maintenance, the valve temperature is kept at a satisfactory low level at all loads. The air supply to the engine (turbocharger/air cooler) and the maximum pressure adjustment are key parameters in this connection.

It is important for the functioning of the valves that the valve seats are overhauled correctly in accordance with our instructions.

The use of rotocaps ensures a uniform distribution of temperature on the valves.

|                           |   |                              |
|---------------------------|---|------------------------------|
| Description<br>Page 3 (3) | <b>Engine Performance and Condition</b> | <b>602.01</b><br>Edition 12H |
|---------------------------|---|------------------------------|

**L+V28/32H****Air Inlet Valves**

The operational conditions of the air inlet valves are not altered substantially when using residual fuel.

**Fuel Injection Pumps**

Assuming effective purification of the fuel oil, the operation of the fuel injection pumps will not be very much affected.

The occurrence of increasing abrasive wear of plunger and barrel can be a consequence of insufficient purification of the fuel oil, especially if a fuel which contains residues from catalytic cracking is used. Water in the fuel oil increases the risk of cavitation in connection with pressure impulses occurring at the fuel injection pump cut-off. A fuel with a high asphalt content has deteriorating lubricating properties and can, in extreme cases, result in sticking of the fuel injection pump plungers.

**Engine Room Ventilation, Exhaust System**

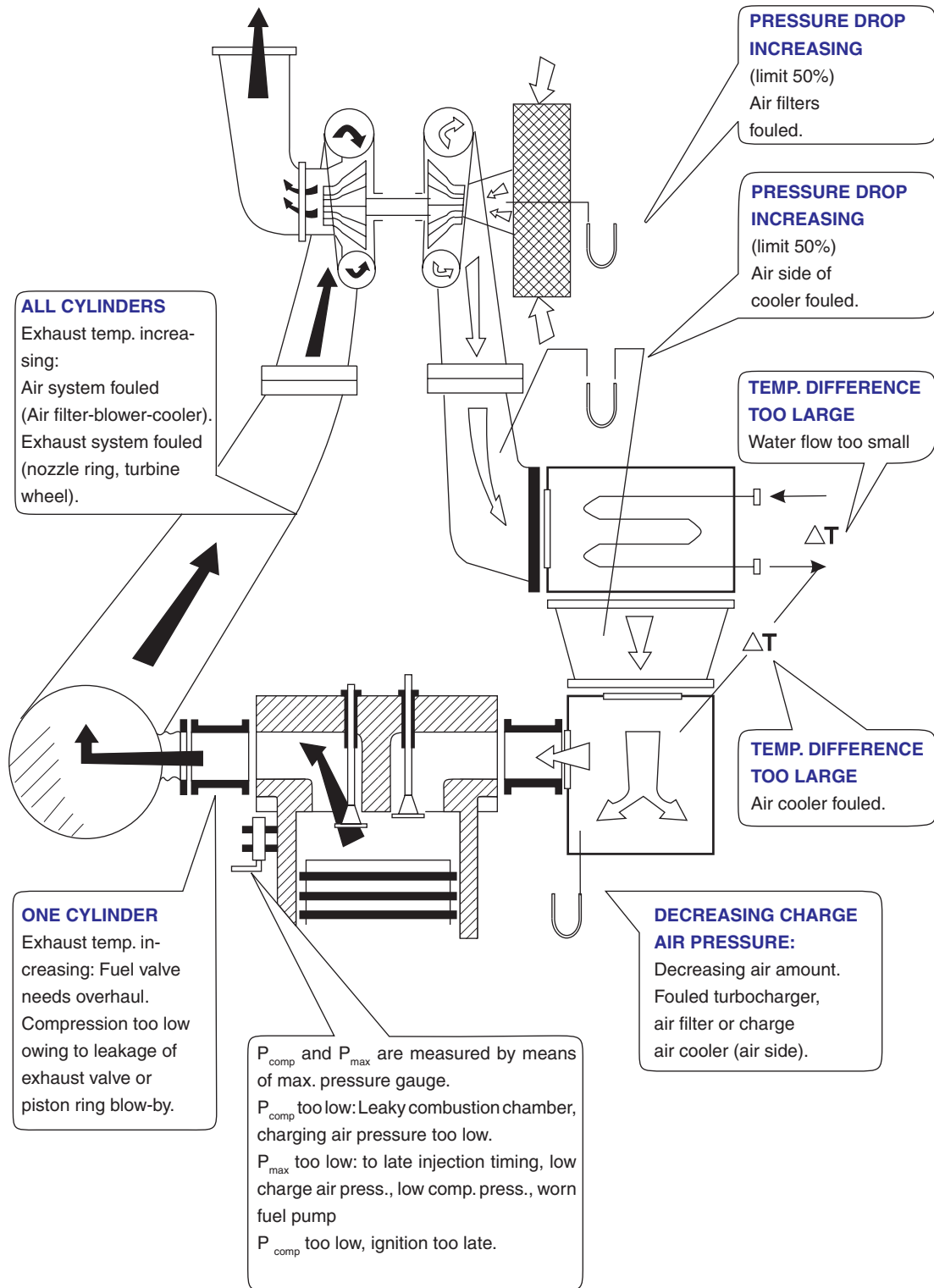
Good ventilation of the engine room and suitable location of the fresh air intake on the deck are important. Sea water in the intake air might involve corrosive attack and influence the overhaul intervals for the exhaust valves.

The fresh air supply (ventilation) to the engine room should correspond to approximately 1.5 times the air consumption of the engines and possible boilers in operation. Under-pressure in the engine room will involve an increased exhaust temperature level.

The exhaust back-pressure measured after the turbochargers at full load must not exceed 300 mm water column. An increase in the exhaust back-pressure will also cause an increased exhaust valve temperature level, and increased fuel consumption.

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (1) | <b>Evaluation of Readings Regarding<br/>Combustion Condition</b> | <b>602.02</b><br>Edition 11H |
|---------------------------|--|------------------------------|

General



*Please also see Description 602.01,  
Engine Performance and Condition*

## General

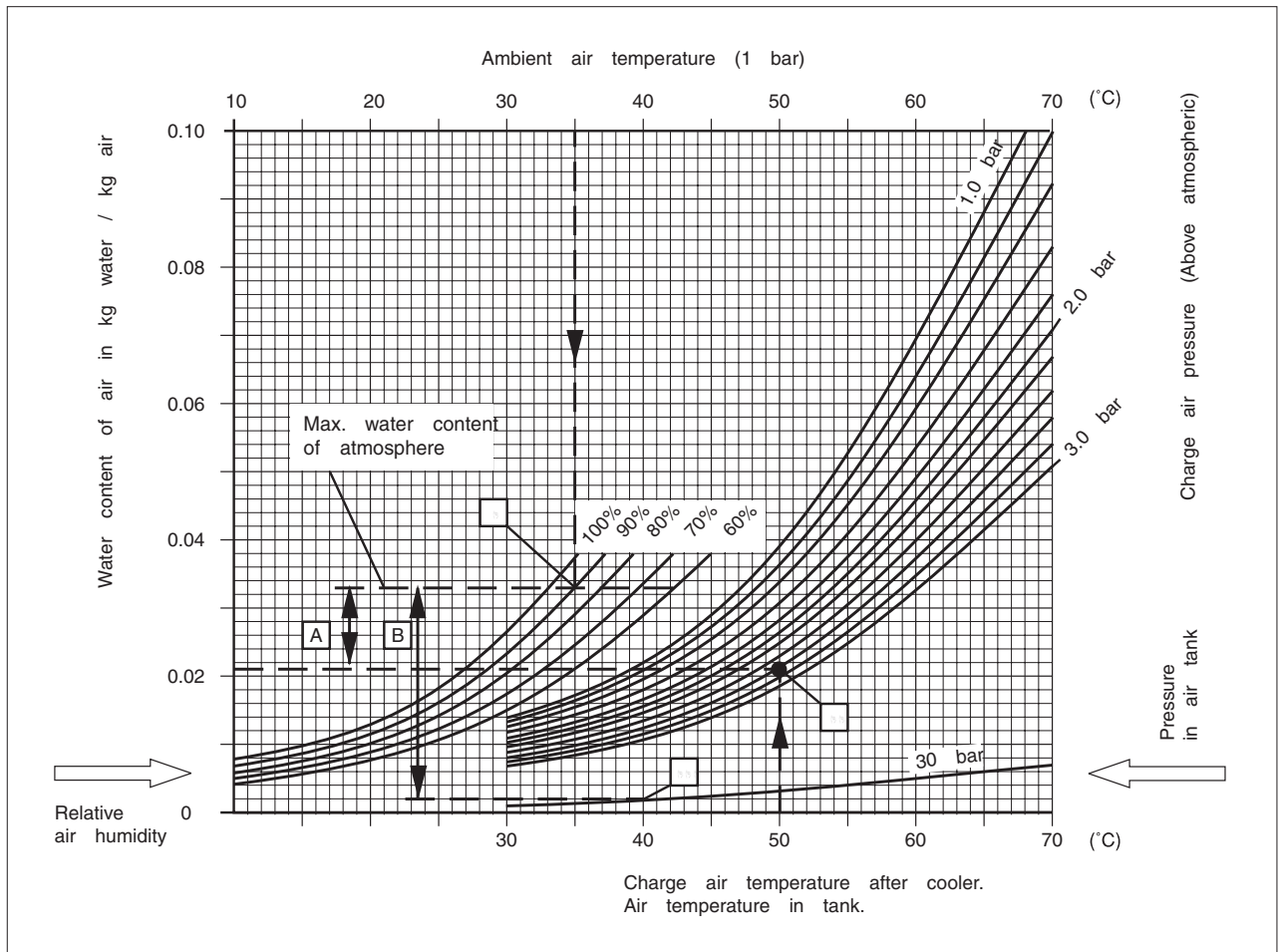


Fig. 1. Nomogram for calculation of condensate amount.

## General

There is always a certain amount of water in air. When the air is saturated with aqueous vapour, the humidity is said to be 100% and there is as much water in the air as it can absorb without condensing. The amount of water in kg/kg air can be found from the diagram. The ability to absorb the water depends on the pressure and temperature of the air.

## Amount of Condensation Water in The Charge Air Receiver

Both higher pressure and lower temperature reduce the ability to absorb water. A turbocharged diesel engine takes air from outside, compresses and cools the air. Then, normally, the air cannot absorb the same amount of water as before.

Condensation of water in the engine's charge air receiver is consequently dependent on the humidity and the temperature of the ambient air. To find out if condensation in the charge air receiver will occur the diagram can be used.

## Example:

|                        |         |
|------------------------|---------|
| 6L28/32H, 720 rpm (P)  | 1260 kW |
| Ambient air condition: |         |
| air temperature        | 35 °C   |
| relative air humidity  | 90 %    |
| Charge air temperature | 50 °C   |
| Charge air pressure    | 2.6 bar |

As a guidance, an air consumption of 8.2 kg/kWh (Le) at full load can be used for MAN Diesel A/S, Holey engines.

## General

Solution according to diagram:

|                              |             |
|------------------------------|-------------|
| Water content of air (I)     | 0.033 kg/kg |
| Max. water cont. of air (II) | 0.021 kg/kg |

Amount of condensate in charge air receiver.

$$= (I - II) \times l_e \times P$$

$$= (0.033 - 0.021) \times 8.2 \times 1260 = \underline{123 \text{ kg/h}}$$

### Draining of Condensation Water.

This phenomenon will occur on all turbocharged engines. For MAN B&W Holeby 4-stroke engine, there is no risk with a small amount of water in the charge air receiver. But if the charge air receiver is filled with water, there is a risk of getting water into the cylinder. This water have to be drained away. As standard a valve is mounted on the charge air receiver/cooler on the engine. This valve is to be used for draining of the water. If there is a great amount, the valve can be left half-open. If the amount is small, the charge air receiver can be drained periodically.

### Amount of Condensate Water in Air Tanks.

The volume of condensate in the air tank is determined by means of the curve at the bottom to the right of the diagram, representing an operating pressure of 30 bar.

#### Example:

Amount of condensate in air tank.

|                                 |   |
|---------------------------------|---|
| Volumetric capacity of tank (V) | 4000 dm <sup>3</sup>                          |
| Temperature in tank (T)         | 40 °C=313K                                    |
| Internal press. of tank (p)     | 30 bar  |
|                                 | $= 31 \times 10^5 \text{ N/m}^2(\text{abs.})$ |
| Gas constant for air (R)        | 287 Nm/kg.K                                   |
| Ambient air temperature         | 35 °C   |
| Relative air humidity           | 90 %  |
| Weight of air in tank           |   |

$$m = \frac{p \times V}{R \times T} = \frac{31 \times 10^5 \times 4}{287 \times 313} = 138 \text{ kg}$$

Solution acc. to above diagram:

|                               |              |
|-------------------------------|--------------|
| Water content of air (I)      | 0.033 kg/kg  |
| Max. water cont. of air (III) | 0.0015 kg/kg |

Amount of condensate in air tank

$$= (I - III) \times m.$$

$$= (0.033 - 0.0015) \times 138 = \underline{4.35 \text{ kg.}}$$

|                            |                                |                                 |
|----------------------------|--------------------------------|---------------------------------|
| Working Card<br>Page 1 (4) | <b>Engine Performance Data</b> | <b>602-01.00</b><br>Edition 03H |
|----------------------------|--------------------------------|---------------------------------|

**L28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Measurements of engine performance data.

**Starting position:**

Engine is running.

**Related procedure:****Man power:**

Working time : ½ hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.                   |
|-----------|----------|-------------------------|
| 62005     | 10       | Max. pressure indicator |

**Hand tools:****Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|-----------|----------|--------|

**602-01.00**  
Edition 03H

## Engine Performance Data

Working Card  
Page 2 (4)

### L28/32H

#### Engine Performance Data

|   |            |   |             |           |            |   |           |              |            |    |                            |
|---|------------|---|-------------|-----------|------------|---|-----------|--------------|------------|----|----------------------------|
| 1 | M/V        | 2 | Engine Type | 3         | Engine No. | 4 | Date/Year | 5            | Hour       | 6  | Total Engine running Hours |
| 7 | Engine RPM | 8 | Visc.       | Fuel Type | Density    | 9 | Type      | Turbocharger | Serial No. | 10 | Turbocharger RPM           |

#### Switchboard

|    |             |    |             |    |             |    |                  |
|----|-------------|----|-------------|----|-------------|----|------------------|
| 11 | Effect (kW) | 12 | Voltage (V) | 13 | Current (A) | 14 | cos $\phi$ /kVAr |
|----|-------------|----|-------------|----|-------------|----|------------------|

#### Cylinder Data

|    |                          |   |   |   |   |   |   |   |   |   |    |         |
|----|--------------------------|---|---|---|---|---|---|---|---|---|----|---------|
| 15 | Cylinder No.             | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 16 | Average |
| 17 | Fuel Pump Index          |   |   |   |   |   |   |   |   |   |    |         |
| 18 | Maximum Pressure (bar)   |   |   |   |   |   |   |   |   |   |    |         |
| 19 | Compress. Pressure (bar) |   |   |   |   |   |   |   |   |   |    |         |
| 20 | Exhaust Temp. (° C)      |   |   |   |   |   |   |   |   |   |    |         |
| 21 | Cooling Water (°C)       |   |   |   |   |   |   |   |   |   |    |         |

#### Turbocharger

|    |                                   |    |                                  |    |                                    |
|----|-----------------------------------|----|----------------------------------|----|------------------------------------|
| 22 | Temp. inlet blower (° C)          | 23 | Pressure before blower (mmWC)    | 24 | Temp. after blower (° C)           |
| 25 | $\Delta$ Press. air cooler (mmWC) | 26 | Temp. charge air (° C)           | 27 | Press. charge air (bar)            |
| 28 | Temp. exhaust gas before TC (° C) | 29 | Temp. exhaust gas after TC (° C) | 30 | Press. exhaust gas after TC (mmWC) |

#### Lubricating Oil System

|    |                          |    |                            |    |                           |
|----|--------------------------|----|----------------------------|----|---------------------------|
| 31 | Temp. after engine (° C) | 32 | Press. before filter (bar) | 33 | Press. after filter (bar) |
| 34 | Temp. inlet engine (° C) | 35 | Press. before TC (bar)     | 36 |                           |

#### Cooling Water System

|    |                                      |    |                                       |    |                                  |
|----|--------------------------------------|----|---------------------------------------|----|----------------------------------|
| 37 | LT temp. inlet air cooler (° C)      | 38 | LT temp. outlet air cooler (° C)      | 39 | LT press. inlet air cooler (bar) |
| 40 | LT temp. inlet lub. oil cooler (° C) | 41 | LT temp. outlet lub. oil cooler (° C) | 42 | LT temp. inlet alternator (° C)  |
| 43 | LT temp. outlet alternator (° C)     | 44 | HT FW temp. inlet engine (° C)        | 45 | HT FW press. inlet engine (bar)  |

#### Fuel Oil System

|    |   |    |   |
|----|---|----|---|
| 46 | Fuel oil temp. inlet engine (° C)         | 47 | Fuel oil press. before engine (bar)       |
| 48 | Nozz. cool. oil press. inlet engine (bar) | 49 | Nozz. cool. oil temp. outlet engine (° C) |

|    |       |
|----|-------|
| 50 | Sign. |
|----|-------|



|                            |                                |                                 |
|----------------------------|--------------------------------|---------------------------------|
| Working Card<br>Page 3 (4) | <b>Engine Performance Data</b> | <b>602-01.00</b><br>Edition 03H |
|----------------------------|--------------------------------|---------------------------------|

## L28/32H

### The Instruction for Filling in the Diagram "Engine Performance Data".

The numbers in the instruction are commensurate with the numbers on the diagram.

The automatic symbols mentioned in the instruction TI 01, TI 03, PI 01 etc, refer to the diagrams printed in the instruction books for specified plants.

### Engine Performance Data.

1. Name of ship, if stationary name of plant.
2. Engine type.
3. Engine no.
4. Date/year of observations.
5. Hour, time of observations.
6. Total engine running hours - engineer's log-book.
7. Engine revolutions per minute (RPM) - can be read on tachometer SI 90.
8. Fuel oil type: The viscosity must be stated (in cSt) and the temperature by which the viscosity has been measured f.inst. 180 cSt/50°C. Density must be stated: g/cm<sup>3</sup>.
9. Turbocharger: Type and serial number are stated on the rating plate of turbocharger.
10. Turbocharger revolutions per minute (RPM) - can be read on the tachometer SI 89.

### Switchboard.

11. Effect alternator (kW) - can be read on the main switchboard.
12. Voltage (V) - can be read on the switchboard.
13. Current (A) - can be read on the switchboard.
14. Cos  $\varphi$ /kVAr - can be read on the switchboard.

### Cylinder Data.

15. Cylinder no. - can be read on engine plate. A/B is used for V-engines.
16. Average for all engine cylinders for point: 17-18-19-20-21.
17. Fuel pump index - can be read on each of the high pressure fuel oil injection pumps.
18. Max pressure (bar) can be read for each cylinder by means of indicator or  $P_{\max}$  gauge.
19. Compression pressure (bar) - can be read for each cylinder by means of the indicator measurement, which is carried out during idling by nominal RPM.
20. Exhaust temperature (°C)  
- Thermometer TI 60.
21. Water outlet cylinder (°C) (jacket cooling)  
- Thermometer TI 11.

### Turbocharger.

22. Thermometer inlet blower (°C) can be read by means of a thermometer placed in the engine room near the air filter of the TC.
23. Pressure before blower (mmWC) - can be read by means of a mmWC instrument placed in the engine room near the TC.
24. Temperature after blower (°C) - can be read by means of a thermometer TI 30.
25.  $\Delta$  Pressure air cooler (mm/WC).
26. Charge air temperature (°C). Temperature of the charge air in the charge air receiver.  
- Thermometer TI 31.
27. Pressure charge air (bar). Pressure of the charge air in the charge air receiver.  
- Pressure gauge PI 31.
28. Temperature of the exhaust gas before TC (°C) - Thermometer TI 62.

**L28/32H**

**29.** Temperature of the exhaust gas after TC (°C)  
- Thermometer TI 61.

**30.** Pressure of the exhaust gas after the TC (bar)  
- Pressure gauge PI 61.

**Lubricating Oil System.**

**31.** Temperature of the lub. oil inlet cooler (°C)  
- Thermometer TI 20.

**32.** Pressure of the lub. oil before the filter (bar)  
- Pressure gauge PI 21.

**33.** Pressure of the lub. oil after the filter (bar)  
- Pressure gauge PI 22.

*The filter element should be replaced with a pressure drop across the filter of 1.5 bar.*

**34.** Temperature of the lub. oil inlet engine (°C)  
- Thermometer TI 22.

**35.** Pressure of the lub. oil before the turbocharger (bar).  
- Pressure gauge PI 23.

**Cooling Water System.**

**37.** Temperature of low temperature (LT) cooling water (sea, raw or fresh) at inlet charge air cooler (°C)  
- Thermometer TI 01.

**38.** Temperature of low temperature (LT) cooling water (sea, raw or fresh) at outlet charge air cooler (°C)  
- Thermometer TI 02.

**39.** Pressure of the low temperature (LT) cooling water (sea, raw or fresh) at inlet charge air cooler (bar)  
- Pressure gauge PI 01.

**40.** Temperature of the low temperature (LT) cooling water (sea, raw or fresh) at inlet lub. oil cooler (°C)  
- Thermometer TI 07.

**41.** Temperature of the low temperature (LT) cooling water (sea, raw or fresh) at outlet lub. oil cooler (°C)  
- Thermometer TI 03.

**42.** Temperature of the low temperature (LT) cooling water (sea, raw or fresh) at inlet alternator (°C)  
- Thermometer TI 04.

**43.** Temperature of the low temperature (LT) cooling water (sea, raw or fresh) at outlet alternator (°C)  
- Thermometer TI 05.

**44.** Temperature of the high temperature (HT) fresh water (FW) at inlet engine (°C)  
- Thermometer TI 10.

**45.** Pressure of the high temperature (HT) fresh water (FW) of outlet engine (°C)  
- Thermometer TI 10.

**Fuel Oil System.**

**46.** Temperature of the fuel oil at inlet engine (°C)  
- Thermometer TI 40.

**47.** Pressure of the fuel oil before engine (bar)  
- Pressure gauge PI 40.

**48.** Nozzle cooling oil pressure at inlet engine (bar)  
- Pressure gauge PI 50.

**49.** Nozzle cooling oil pressure at outlet engine (bar)  
- Pressure gauge PI 51.

**50.** Signature.

**Trouble shooting**

**503/603**

|                           |                          |                              |
|---------------------------|--------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Starting Failures</b> | <b>603.01</b><br>Edition 08H |
|---------------------------|--------------------------|------------------------------|

**General**

| Trouble   | Possible cause   | Trouble shooting   |
|---|--|--|
| Engine turns as soon as shut-off valve is opened, without start but-ton being activated | Faults in electrical system  | Check electrical parts   |
| Engine does not turn when start button is activated                                     | Air pressure in starting air receiver too low<br><br>Main valve(s) closed<br><br>Pinion does not engage the fly wheel<br><br>Air motor runs, pinion engages but does not rotate<br><br>Faults in electrical system | Start compressors, re-charge air receiver<br><br>Open valve at receiver and stop valve interposed in line between receiver and engine<br><br>Check the air starter for broken clutch jaws or other broken parts<br><br>Check the air motor for broken shafting, bearing or clutch jaws<br><br>Check electrical parts |
| Engine turns too slowly or irregularly when start but-ton is depressed                  | Worn air motor parts<br><br>Start valve is sticking in close position  | Remove and disassemble the air motor. Examine all parts and re-place any that are worn or damaged. Use the guidelines for determining unserviceable parts<br><br>Check start valve   |

|                           |                                  |                              |
|---------------------------|----------------------------------|------------------------------|
| Description<br>Page 1 (3) | <b>Faults in Fuel Oil System</b> | <b>603.02</b><br>Edition 09H |
|---------------------------|----------------------------------|------------------------------|

**L+V28/32H**

| Trouble  | Possible cause  | Trouble shooting  |
|--|---|---|
| Engine turns on starting air, but ignition fails. Fuel pumps are not actuated          | <p>Sluggish movement of manoeuvring gear</p> <p>Governor setting incorrect</p> <p>Overspeed or another shutdown function is activated</p> <p>Piston in Lambda controller is actuated</p> <p>Piston in Lambda controller is actuated owing to uncanceled shutdown function (1)</p> <p>Failures in governor</p> <p>Incorrect adjustment of manoeuvring gear</p> | <p>Lubricate and mobilize rod connections in manoeuvring gear</p> <p>Adjust governor, see special instruction manual</p> <p>Cancel shutdown function</p> <p>Check that piston is not sticking. Check that pressure in cylinder is relieved. Check that the overspeed trip is not actuated.</p> <p>Check pressures and temperatures. Check for faults in shut-down devices</p> <p>Check that governor is working properly. For further fault location, see special instr. manual</p> <p>Check rod connec. Check that fuel pump index is corresponding to "Adjustments after trials" in testbed chart</p> |
| Engine turns on starting air, but no fuel is injected owing to failures in fuel system | <p>Incorrect adjustment of limiter cylinder</p> <p>Fuel oil service tank empty</p> <p>Air in fuel pumps and fuel injection valves (2)</p> <p>Worn-out fuel pump</p> <p>Defective fuel injection valves or valve nozzles (4)</p> <p>Too low pressure before fuel injection pumps (3)</p>   | <p>Adjust setting of limiter cylinder</p> <p>Pump oil into the tank</p> <p>Vent the fuel pumps until fuel without air bubbles appears. If ignition fails in just one cyl., vent the re-spective fuel injection valve. If ignition still fails, install a spare valve before attempting to start the engine again.</p> <p>Change fuel pumps</p> <p>Change defective fuel valves</p> <p>Increase the fuel oil feed pump pressure</p>  |
| Engine turns on starting air, fuel is injected, but ignition fails                     | <p>Water in the fuel</p> <p>Fuel valves or nozzles defective (4)</p>  | <p>Drain off water and repeat venting of fuel pumps</p> <p>Change defective fuel valves, see Working Card 614-01.10.</p>  |

Cont.

|                              |                                  |                           |
|------------------------------|----------------------------------|---------------------------|
| <b>603.02</b><br>Edition 09H | <b>Faults in Fuel Oil System</b> | Description<br>Page 2 (3) |
|------------------------------|----------------------------------|---------------------------|

**L+V28/32H**

| Trouble  | Possible cause                        | Trouble shooting  |
|--|---------------------------------------|---|
|  | Compression during start too low (5)  | Check intake and exhaust valve for tight closing. Check cyl. wear and piston rings                                  |
|  | Incorrect timing of camshaft (6)      | Check fuel pump timing advance, and fuel valve opening pressure as well as camshaft adjustment                      |
| First ignitions are too violent (safety valves are opening). Engine runs erratically | Oil has collected on piston crown (7) | Slow turning with open indicator valves, to locate defective fuel valve, remove oil                                 |
|  | Sluggish movement of manoeuvring gear | Lubricate and mobilize rod connections and bearings in manoeuvring gear   |
|  | Fuel pump index too high              | Check rod connection in manoeuvring gear. Check that governor is working properly. Limiter cylinder to be set lower |

**Remarks**

- 1) If the shut-down function is due to overspeed, the shut-down activation is cancelled by resetting the overspeed device and thus venting the Lambda controller/air cylinder.
- 2) Whether air is present in the fuel oil system is seen by repeating the venting of fuel pumps. The cause may be that a fuel valve is kept in open position (spindle sticking or spring broken). Heating of fuel to a too high temperature may have a similar effect owing to formation of gas in the fuel. If a sticking valve is found, it should be changed and overhauled. It should be checked that no oil has collected on the piston crown. Air in the fuel oil system may also be the result of the fuel oil feed pump sucking-in air through a defective stuffing box or a leaky seal.
- 3) If the fuel oil pressure drops, the filter may be clogged up, or the by-pass at the feed pump may have opened.
- 4) If the fuel is forced into the cylinder through a defective fuel valve or through worn-out atomizer holes, no or too sluggish atomization may prevent ignition, possibly followed by too violent ignition.
- 5) To obtain ignition temperature in the cylinders, the compression pressure during starting should be normal, see the testbed chart. This can be checked by measuring the compression pressure during starting. Cylinders having too low compression should be inspected.
- 6) Major alterations of the combustion characteristics of the fuel may demand adjustment of the timing of the fuel pumps. One or more camshaft sections may be incorrectly fitted (after dismantling). Too high opening pressure of the fuel valves will also delay the injection.

|                           |                                  |                              |
|---------------------------|----------------------------------|------------------------------|
| Description<br>Page 3 (3) | <b>Faults in Fuel Oil System</b> | <b>603.02</b><br>Edition 09H |
|---------------------------|----------------------------------|------------------------------|

**L+V28/32H**

- 7) Oil on the piston crown will in most cases have leaked down from a defective fuel valve. As these oil accumulations are dangerous, the leakage should be found and remedied before the engine is started again.

|                           |                                    |                              |
|---------------------------|------------------------------------|------------------------------|
| Description<br>Page 1 (3) | <b>Disturbances during Running</b> | <b>603.03</b><br>Edition 08H |
|---------------------------|------------------------------------|------------------------------|

**L+V28/32H**

| Trouble                            | Possible cause  | Trouble shooting  |
|------------------------------------|---|---|
| Exhaust temperature(s) increase(s) | <p>(All cyls.) Increased charging air temperature due to ineffective air coolers</p> <p>(All cyls.) Fouling or air and gas passages</p> <p>(All cyls.) Insufficient cleaning of fuel oil or changed combustion characteristics</p> <p>(All cyls.) Wrong position of camshaft (Maladjustment)</p> <p>(Single cyls.) Fuel valve or valve nozzle defective</p> <p>(Single cyls.) Leaky exhaust valves (1)</p> <p>(Single cyls.) Blow-by-leaky combustion chamber (2)</p> <p>(Single cyls.) Damaged fuel pump cam</p> | <p>See Working Card 612-01.00.</p> <p>Reduce load and water-wash turbine. Clean air filters and coolers</p> <p>See Description 604.25.</p> <p>Check <math>P_{max}</math>. Check camshaft adjustment</p> <p>See Working Card 614-01.10.</p> <p>Check the valve clearance. Replace cyl. head with defective valve</p> <p>See Working Card 606-01.00.</p> <p>Check timing advance of fuel pump</p> |
| Exhaust temperature(s) decrease(s) | <p>(All cyls.) Decreased charging air temperature</p> <p>(Single cyls.) Air in fuel pump(s) and fuel injection valve(s)</p> <p>(Single cyls.) Spindle in fuel valve sticking (3)</p> <p>(Single cyls.) Fuel pump plunger sticking or leaking</p>  | <p>Check that thermostatic valve (bypass valve) in cold water system is working properly and correctly set</p> <p>Venting of fuel pump(s) until fuel without air bubbles appears. Check feed pump pressure</p> <p>Change and overhaul defective fuel valve</p> <p>Change fuel pump plunger/barrel assembly</p>  |
| Engine RPM decreases               | <p>Pressure before fuel pumps too low</p> <p>Fuel valve or fuel pump defective</p> <p>Water in the fuel</p> <p>Governor defective (4)</p> <p>Increased internal friction in engine (5)</p>  | <p>Raise fuel oil feed pump pressure to normal. Check filter</p> <p>Change defective valve or pump</p> <p>Drain off water and vent the fuel pumps</p> <p>Replace defective governor</p> <p>See "Ignition in Crankcase"</p>  |

Cont.



|                              |                                    |                           |
|------------------------------|------------------------------------|---------------------------|
| <b>603.03</b><br>Edition 08H | <b>Disturbances during Running</b> | Description<br>Page 2 (3) |
|------------------------------|------------------------------------|---------------------------|

**L+V28/32H**

| Trouble                          | Possible cause  | Trouble shooting  |
|----------------------------------|---|---|
| Engine stops                     | Shut-down   | Check pressure and temperatures. If OK, check for faults in shut-down devices. See also Starting Failures   |
| Smoky exhaust                    | Turbine RPM lagging behind engine RPM<br><br>Air supply too low<br><br>Fuel valves or nozzles defective<br><br>"Trumpets" at nozzle holes. Failure of cooling (especially during heavy-oil operation) (6) | Reasonably smoke is normal when RPM increases; no measures called for. If smoky exhaust during normal running, clean turbine(s) and check valves<br><br>Fouling of air and gas passages, see section 612.<br><br>See Working Card 614-01.10.<br><br>Overhaul fuel valves. Re-establish nozzle-cooling |
| Exhaust valve knocking           | Adjusting screw for valve setting loose. Push rod thrust disc damaged   | Inspect and replace defective parts as necessary  |
| Rising cooling water temperature | Pump stopped. Increased friction (7)  | Stop the engine. Check the cooling water. Find cause of increased friction and remedy fault   |
| Lubricating oil pressure fails   | Lubricating oil pump defective. (8)<br>Filters/cooler fouled  | Stop the engine. For further details, see "Ignition in crankcase"   |
| Alternator                       | Short circuit   | Flywheel must be dismantled and guide pin replaced  |

**Remarks**

- 1) This manifests itself by rise of the exhaust temperature and falling of the compression and maximum combustion pressure of the respective cylinder.

To limit the damage to the valves, these should be changed immediately, if possible, or the fuel pump of the cylinder concerned should be put out of operation by moving the index to stop and locking it in this position.

- 2) Blow-by means a serious danger of piston seizure, and the engine must if possible be stopped and the piston in question pulled. If this is not possible, the fuel pump index must, as described above, be moved to stop. Leaky piston rings will normally result in a heavy excess pressure in the crankcase.

|                           |                                    |                              |
|---------------------------|------------------------------------|------------------------------|
| Description<br>Page 3 (3) | <b>Disturbances during Running</b> | <b>603.03</b><br>Edition 08H |
|---------------------------|------------------------------------|------------------------------|

**L+V28/32H**

- 3) If this happens the fuel pump barrel and plunger must be changed, and if, to obtain full load of the respective cylinder, it is necessary to increase the fuel pump index by more than 10 index degrees, the fuel pump is in most cases worn out. Usually this is confirmed by inspection of the fuel pump plunger on which the helical cut-off edge will show a pitted and corroded area where material is plucked out. In that case the pump can be provided with a new barrel and plunger.
- 4) The governor will not reduce the fuel pump delivery to zero in case of, for instance, failure of the governor oil pump, but the engine speed will start fluctuating.  
  
When the governor is defective the engine is protected against racing by the overspeed trip, i.e. the engine is stopped automatically in case of excessive speed. It is essential, therefore, that the overspeed trip is kept in perfect order. Regarding governor failure, see special instruction book.
- 5) Usually a bearing failure will not slow down the engine appreciably, but the seizure of a piston in the cylinder liner might do so. If a PG-governor is employed, the index will increase and exhaust temperatures rise. If such cases occur, repair is necessary before starting the engine again. Feel over and look out for oil mist.
- 6) If the cooling of the atomizers fails (if arranged for oil cooling) while running, carbon deposits will build up round the nozzle holes, sometimes in the shape of small cones or trumpets which causes the engine to smoke, or it will cause sticking of the valve spindle. For this reason the nozzle cooling should be well maintained.
- 7) If the cooling water temperature for the entire engine has risen to 90-100° C, it should be checked - by opening the test cocks, if fitted on the discharge from cylinders - whether steam has developed. If this is the case, there is no water on the cooling surfaces, which may therefore be heated unduly. To avoid heat stresses arising in cylinder liners and cylinder heads, if the water returns too early, the engine should be stopped and left to cool, while the discharge valve is closed. After 15 minutes it is opened a little to allow the water to rise slowly in the cooling jackets. Check filling at test cocks. Make crankcase inspection to ascertain that internal water leakage has not arisen. Remember slow turning with open indicator valves at subsequent starting-up.
- 8) If the lubricating oil pressure drops below the minimum mentioned in Data; Find the cause of the pressure drop and remedy the defect before re-starting the engine. Feel over 5-15-30 minutes after starting, and again when full load is obtained. See section 602.

|                           |                              |                              |
|---------------------------|------------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Ignition in Crankcase</b> | <b>603.04</b><br>Edition 09H |
|---------------------------|------------------------------|------------------------------|

**L+V28/32H****Cause**

During running, the atmosphere in the crankcase contains the same gases (N<sub>2</sub>-O<sub>2</sub>-CO<sub>2</sub>) in the same proportions as in the ambient air, but an intense spray of coarse oil drops is flung around everywhere. If undue friction and thus heating arises between sliding surfaces, or heat is transmitted otherwise to the crankcase, the heated surface will cause evaporation of the lubricating oil splashed on to it. When the oil vapours condense they form a multitude of minute drops suspended in the atmosphere, i.e. a milky white oil mist is formed, able to nourish and spread a flame if ignited. Such ignition may be caused by the same "hot spot" which produced the oil mist. If a large quantity of oil mist has developed before ignition, the burning may cause considerable pressure rise in the crankcase, forcing the relief valves to open. In a few cases, when presumably the whole crankcase has been filled with oil mist, the consequential explosion has thrown off crankcase doors and caused fire in the engine room.

Every precaution should therefore be taken to (A) avoid "hot spots" and (B) discover oil mist in time.

**A. "Hot spots" in crankcase.**

Overheating of bearings is a result of too bad or failing lubrication possibly caused by pullution of the lubricating oil.

It is therefore important that the lubricating oil filtration equipment is in perfect condition. Filter cartridges must not be used again, if they have been removed from the filter. Check of the oil condition by analysis is recommended.

**B. Oil mist in crankcase.**

Presence of oil mist may be noted at the vent pipe, which is usually fitted to the top of the engine frame.

Measures (in case of white oil mist).

**Warning:** Keep away from doors and relief valves on crankcase. Do not stay unnecessarily in doorways near doors of the engine room casing.

**1. Stop the engine**

**2. Leave the engine room.** Shut doors and keep away from them. Make ready fire-fighting equipment.

**Warning:** Do not open crankcase until 10 minutes after stopping of the engine. When opening up, keep clear of possible flames. Do not use naked light and do not smoke.

**3. Take off all doors on one side of the crankcase.** Cut off starting air. Engage turning gear, if fitted.

**4. Locate the hot spot.** Powerful lamps should be employed at once (in explosion-proof fittings). Feel over all sliding surfaces (bearings, liners, pistons, roller guides, etc.).

Look for squeezed-out bearing metal and discoloration by heat (blistered paint, burned oil, heated steel).

**5. Prevent further heating,** preferably by making a permanent repair. Special attention should be given to ensure lubricating oil supply and satisfactory condition of the frictional surfaces involved. It is equally important to replace filter elements in time.

**6. Start electrically driven lubricating oil pump** and check oil flow from all bearings and splash pipes in crankcase while turning the engine through at least two revolutions. See Description 601.05, Point 4.1.

**7. Stop and feel over. Look out for oil mist.**

Especially the frictional surfaces that caused the heating should be felt over (5-15-30 minutes after starting, and again when full load is obtained). See Description 601.10, Point 2.

**8. In case it has not been possible to locate the hot spot,** point 7 should be intensified and repeated until the cause of the oil mist has been found and remedied. In very rare cases oil mist could be due to "atomization" of lubricating oil by the action of an air jet (for instance blow-by, or blow-by through cracked piston).

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (1) | <b>Trouble Shooting Guide for Centrifugal By-pass Filter</b> | <b>603.05</b><br>Edition 08H |
|---------------------------|--|------------------------------|

**L+V28/32H**

Tabulated below are the corresponding remedial actions to be taken if the following faults are observed:

| Trouble                       | Possible cause  | Trouble shooting  |
|-------------------------------|---|---|
| Oil leakage through cover nut | Missing or damaged O-ring (see Item 29, Plate 61515)                                    | Replace O-ring  |
|                               | Seal face damaged   | Replace O-ring  |
| Excessive vibrations          | Rotor out of balance owing to uneven build-up of deposit on rotor walls resulting from: |   |
|                               | Missing or damaged O-ring, allowing leakage (see Item 23, Plate 61515)                  | Replace O-ring  |
|                               | O-ring seat on rotor joint faces damaged  | Replace rotor assembly                                    |
|                               | Rotor assembly inadequately tightened   | Tighten and bring to notice of maintenance staff          |
|                               | Standtube incorrectly seated or damaged   | Re-fit or replace if damaged                              |
|                               | Dirt deposit not completely removed   | Clean and bring to notice of maintenance staff            |
|                               | Rotor castings distorted through maltreatment   | Replace rotor assembly                                    |
|                               | Rotor assembly components fitted in wrong sequence                                      | Follow sequence in Working Card 615-15.00 in section 615. |
|                               | Bushes loose or worn in tube assembly   | Fit new bearing tube assembly                             |

|                           |   |                              |
|---------------------------|---|------------------------------|
| Description<br>Page 1 (2) | <b>Trouble Shooting Guide for Turbine Starter</b> | <b>603.06</b><br>Edition 09H |
|---------------------------|---|------------------------------|

**L+V28/32H**

| Trouble   | Possible cause   | Trouble shooting  |
|---|--|---|
| Motor will not run.                                       | <p>No air supply.</p> <p>Damaged motor assembly (12).</p> <p>Foreign material in motor and/or piping.</p> <p>Blocked exhaust system.</p> <p>Defective control or relay valve.</p>  | <p>Check for blockage or damage to air supply lines or tank.</p> <p>Inspect motor assembly and power train and repair power train or replace motor assembly if necessary.</p> <p>Remove motor assembly and piping and remove the blockage.</p> <p>Remove housing exhaust cover (1) and check for blockage.</p> <p>Replace control valve or relay valve.</p>                           |
| Loss of power   | <p>Low air pressure to starter.</p> <p>Restricted air supply line.</p> <p>Relay valve malfunctioning.</p> <p>Exhaust flow restricted.</p> <p>Damaged motor assembly.</p>   | <p>Check air supply.</p> <p>Check for blockage or damage to air lines.</p> <p>Clean or replace lines or relay valve. Lubricate relay valve.</p> <p>Check for blocked or damaged piping. Clean or replace piping. Check for dirt or foreign material and clean or remove. Check for ice build-up. Melt ice and reduce moisture build-up to starter.</p> <p>Replace motor assembly.</p> |
| Drive (36) of (57) will not engage.                       | <p>No pressure to drive housing port.</p> <p>Internal drive housing ports blocked.</p> <p>Fluid in drive unit components.</p> <p>Damaged or worn piston assembly (54), o-rings or seals.</p> <p>O-rings and seals dry.</p> | <p>Check air supply.</p> <p>Remove blockage.</p> <p>Remove fluid.</p> <p>Replace damaged or worn parts.</p> <p>Relubricate o-rings and seals.</p>   |
| Motor runs, pinion engages, but does not rotate flywheel. | Damaged or broken drive train.   | Disassemble drive train and replace worn or damaged parts.  |
| Excessive butt engagement.                                | <p>Damaged drive pinion (36) or (63) or flywheel.</p> <p>Damaged starter drive (36) or (57) components.</p>  | <p>Inspect drive pinion and flywheel and replace if necessary.</p> <p>Inspect drive components and replace worn or damaged parts.</p>   |
| Cont. ....  |  |   |

|                              |   |                           |
|------------------------------|---|---------------------------|
| <b>603.06</b><br>Edition 09H | <b>Trouble Shooting Guide for Turbine Starter</b> | Description<br>Page 2 (2) |
|------------------------------|---|---------------------------|

**L+V28/32H**

| Trouble                          | Possible cause   | Trouble shooting   |
|----------------------------------|--|--|
|                                  | Low air pressure.  | Check air supply.  |
|                                  | Wrong drive pinion.  | Replace with proper drive pinion.  |
| Oil blowing out of exhaust.      | Oil in air supply line.                                      | Inspect air line and remove source of oil.   |
|                                  | Splash deflector retaining screw (5) or pipe plug missing.   | Install splash deflector retaining screw or pipe plug.   |
|                                  | Worn or damaged rotor seals or static o-rings.               | Replace static seals on outside of motor or send motor to Inger-soll-Rand to be rebuilt.   |
| Oil leaking from gear case (28). | Worn or damaged o-rings.                                     | Replace o-rings.   |
|                                  | Loose joints.  | Make sure that joints fit properly and starter assembly cap screws are tightened to 60 ft-lb (81 Nm) torque. Make sure all seals and o-rings fit and seal properly at their perimeters. If they do not replace with new seals and o-rings. |
|                                  | Excessive high-speed operation.                              | Operate according to recommendations.  |
|                                  | High number of start cycles.                                 | Replace worn components.   |
|                                  | Loose or leaking pipe plugs (10) or (11).                    | Tighten or replace pipe plugs using Ingersoll-Rand No SMB-441 pipe sealant.  |
|                                  | Splash deflector retaining screw loose or pipe plug missing. | Tighten splash deflector retaining screw or replace pipe plug.   |
| Air or gas leakage.              | Loose joints.  | Make sure that joints fit properly and starter assembly cap screws are tightened to 60 ft-lb (81 Nm) torque. Make sure all seals and o-rings fit and seal properly at their perimeters. If they do not replace with new seals and o-rings. |
|                                  | Excessive high-speed operation.                              | Operate according to recommendations.  |
|                                  | High number of start cycles.                                 | Replace worn components.   |
|                                  | Loose or leaking pipe plugs.                                 | Tighten or replace pipe plugs.   |
|                                  | Splash deflector retaining screw loose or pipe plug missing. | Tighten splash deflector retaining screw or replace pipe plug.   |

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (1) | <b>Trouble Shooting for Cooling Water System</b> | <b>603.09</b><br>Edition 08H |
|---------------------------|--|------------------------------|

**General****Description**

The built-on fresh water pump in the high temperature (HT) circuit is of the centrifugal type and is mounted on the front cover of the engine and is driven through a gearing.

The pump bearings are lubricated automatically with oil from the lubricating oil system of the engine.

If the pump leaks and the shaft sealing rings are worn, it is recommended to replace the shaft seal, see work card 616-02.00.

| Trouble                                    | Possible cause   | Trouble shooting   |
|--|--|--|
| The pump does not work after start         | Pump draws in air at suction side<br><br>The system is not filled-up<br><br>Air cannot escape on delivery side<br><br>Leaking shaft seal | Check packings and pipes for tightness<br><br>Check the level in the expansion tank<br><br>Vent the system<br><br>Check the shaft seal |
| Pump capacity drops after normal operation | Air leakages of shaft seal<br><br>Fouled impeller  | Overhaul the shaft seal<br><br>Clean the impeller  |
| Pump does not give maximum delivery        | Suction valve not fully open<br><br>Defective seals<br><br>Worn impeller and worn wear rings   | Open the suction valve<br><br>Replace the seals<br><br>Overhaul the pump   |

Note! Running troubles with the pump, apart from mechanical faults, are most often due to leaks in the suction line. It is essential, therefore, that all packings and gaskets are in order and that they are renewed when necessary. Even a thiny hole in the suction line will reduce the pump capacity.

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (2) | <b>Trouble Shooting for Lubricating Oil Cooler</b> | <b>603.10</b><br>Edition 01H |
|---------------------------|--|------------------------------|

**General****Trouble Shooting.**

In case of damage to plates or gaskets, it will often be necessary to replace them.

First examine very carefully the external conditions around the plate heat exchanger in order to localize the cause of the damage!

In case of fatigue fracture, this will normally necessitate a replacement of all plates and gaskets - as there may be a risk of fatigue fracture in all the material.

In case of corrosion, all plates must be examined carefully!

For work to be carried out see working card 615-05.00.

| <b>Visible Leakage</b>   |  |  |
|--|--|--|
| Trouble  | Possible cause   | Trouble shooting   |
| Leakage.   | Too high pressure.   | Reduce the pressure to the correct working pressure, see page 600.30 "Operating Data & Set Points".  |
| Leakage.<br>(Phase 1)  | Insufficient tightening                                      | Tighten up the plate heat exchanger - however, not under the minimum dimension and never, when the plate heat exchanger is under pressure or over 40°C.<br><br>If the plate heat exchanger is still leaky, proceed with phase 2.   |
| Leakage.<br>(Phase 2)  | Fouled or deformed plates.<br>Inelastic or deformed gaskets. | Separate the plate heat exchanger and check if the plates are deformed or fouled.<br>Check that the gaskets are elastic and non-deformed, and that the faces of the joints are clean.<br>Replace deformed plates and gaskets, if any.<br>Before assembling, clean very carefully all plates and gaskets.<br>Assemble the plate heat exchanger and start it up again.<br><b>Note!</b> Even tiny impurities such as sand grains may cause leakage. |
| Leakage.<br>(Even after tightening of the plate heat exchanger to minimum dimension) | Gaskets.   | Separate the plate heat exchanger.<br>Clean the plates very carefully.<br>Replace the gaskets.<br>Assemble the plate heat exchanger and start it up again.   |
| Leakage.<br>(Through the drain holes of the gaskets)                                 | Defective gasket or badly corroded plate.                    | Separate the plate heat exchanger.<br>Replace defective plates and gaskets, if any.<br>Assemble the plate heat exchanger and start it up again.  |



|                              |  |                           |
|------------------------------|--|---------------------------|
| <b>603.10</b><br>Edition 01H | <b>Trouble Shooting for Lubricating Oil Cooler</b> | Description<br>Page 2 (2) |
|------------------------------|--|---------------------------|

## General

| Non-Visible Leakage  |  |   |
|--|--|---|
| Trouble  | Possible cause                                     | Trouble shooting  |
| Reduced heat transmission and/or increasing pressure drop. | Fouled plates or choked plate channels.            | Separate the plate heat exchanger and check if the plates are fouled.<br>Clean the plates very carefully.<br>Assemble the plate heat exchanger and start it up again.   |
| Leakage.<br>(The fluids get mixed)<br>(Phase 1)            | Holes in plates.<br>Corrosion or fatigue fracture. | A suspected leakage can be localized in the following way:<br>Remove one of the lower pipe connections.<br>Then put the opposite side under pressure.<br>If the medium continues to run out of the lower pipe connections- after the pressure has stabilized - one or several plates are leaking.<br>Close down the plate heat exchanger.<br>Separate the plate heat exchanger and check the plates very carefully.<br>Check suspected plates with a dye penetrant.<br>Check defective plates and gaskets.<br>Before assembling, clean all plates and gaskets.<br>Assemble the plate heat exchanger and check to find more defective plates, if any, by putting one side under pressure.<br>Start up again.   |
| Leakage.<br>(The fluids get mixed)<br>(Phase 2)            | Holes in plates.<br>Corrosion or fatigue fracture. | Close down the plate heat exchanger.<br>Separate the plate heat exchanger.<br>Put all plates to dry. Suspend the plates in the plate heat exchanger again and tighten it.<br>Circulate medium at full capacity on one plate side (every second plate channel). Keep the other plate channels unpressurised and free from liquid!<br>Stop the circulation after a few minutes of operation and open the plate heat exchanger again. Take care to avoid water spraying onto the dry plate side!<br>By a careful study of the plates it will be possible to find moist areas, if any, on the otherwise dry plate sides.<br>Check these areas with a dye penetrant!<br>Replace defective plates and gaskets.<br>Before assembling, clean all plates and gaskets.<br>Assemble the plate heat exchanger and check to find more defective plates, if any, by putting one side under pressure.<br>Start up again.<br>If the unit is still leaking, check all plates with a dye penetrant! |

**Media specification**

**504/604**

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (5) | <b>Specification for lubricating oils (SAE30) for<br/>heavy fuel oil operation (HFO)</b> | <b>604.01</b><br>Edition 27H |
|---------------------------|--|------------------------------|

**L28/32H**  
**V28/32H**

The specific output achieved by modern diesel engines combined with the use of fuels that satisfy the quality requirements more and more frequently increase the demands on the performance of the lubricating oil which must therefore be carefully selected.

Medium alkalinity lubricating oils have a proven track record as lubricants for the moving parts and turbocharger cylinder and for cooling the pistons. Lubricating oils of medium alkalinity contain additives that, in addition to other properties, ensure a higher neutralisation reserve than with fully doped engine oils (HD oils).

International specifications do not exist for medium alkalinity lubricating oils. A test operation is therefore necessary for a corresponding period in accordance with the manufacturer's instructions.

Only lubricating oils that have been approved by MAN Diesel & Turbo may be used. These are listed in the table entitled "*Lubricating oils approved for use in heavy fuel oil-operated MAN Diesel & Turbo four-stroke engines*".

## Specifications

### Base oil

The base oil (doped lubricating oil = base oil + additives) must have a narrow distillation range and be refined using modern methods. If it contains paraffins, they must not impair the thermal stability or oxidation stability.

The base oil must comply with the limit values in the table below, particularly in terms of its resistance to ageing:

| Properties/characteristics                                  | Unit     | Test method              | Limit values  |
|---|----------|--------------------------|---|
| Make-up   | -        | -                        | Ideally paraffin based  |
| Low temperature behaviour, still flowable                   | °C       | ASTM D 2500              | - 15  |
| Flash point (Cleveland)                                     | °C       | ASTM D 92                | > 200   |
| Ash content (oxidised ash)                                  | Weight % | ASTM D 482               | < 0.02  |
| Coke residue (according to Conradson)                       | Weight % | ASTM D 189               | < 0.50  |
| Ageing tendency following 100 hours of heating up to 135 °C | -        | MAN ageing oven *        | -   |
| insoluble n-heptane   | Weight % | ASTM D 4055 or DIN 51592 | < 0.2   |
| Evaporation loss  | Weight % | -                        | < 2   |
| Spot test (filter paper)                                    | -        | MAN Diesel & Turbo test  | Precipitation of resins or asphalt-like ageing products must not be identifiable. |

Table 1 Base oils - target values

\* Works' own method

**604.01**

Edition 27H

**Specification for lubricating oils (SAE30) for  
heavy fuel oil operation (HFO)**Description  
Page 2 (5)**L28/32H  
V28/32H****Medium-alkaline lubricating oil**

The prepared oil (base oil with additives) must have the following properties:

**Additives**

The additives must be dissolved in the oil and their composition must ensure that as little ash as possible is left over, even if the engine is provisionally operated with distillate oil.

The ash must be soft. If this prerequisite is not met, it is likely the rate of deposition in the combustion chamber will be higher, particularly at the exhaust valves and at the turbocharger inlet casing. Hard additive ash promotes pitting of the valve seats and causes the valves to burn out, it also increases mechanical wear of the cylinder liners.

Additives must not increase the rate at which the filter elements in the active or used condition are blocked.

**Washing ability**

The washing ability must be high enough to prevent the accumulation of tar and coke residue as a result of fuel combustion. The lubricating oil must not absorb the deposits produced by the fuel.

**Dispersibility**

The selected dispersibility must be such that commercially-available lubricating oil cleaning systems can remove harmful contaminants from the oil used, i.e. the oil must possess good filtering properties and separability.

**Neutralisation capability**

The neutralisation capability (ASTM D2896) must be high enough to neutralise the acidic products produced during combustion. The reaction time of the additive must be harmonised with the process in the combustion chamber.

For tips on selecting the base number, refer to the table entitled "*Base number to be used for various operating conditions*".

**Evaporation tendency**

The evaporation tendency must be as low as possible as otherwise the oil consumption will be adversely affected.

**Additional requirements**

The lubricating oil must not contain viscosity index improver. Fresh oil must not contain water or other contaminants.

**Lubricating Oil Selection**

| Engine   | SAE-Class |
|--|-----------|
| 23/30H, 28/32H, 23/30A, 28/32A<br>At cooling water temperatures > 32° C a SAE40 oil can be used.<br>In this case please contact MAN Diesel | 30        |

Table 2 Viscosity (SAE class) of lube oils

**Neutralisation properties (BN)**

Lubricating oils with medium alkalinity and a range of neutralisation capabilities (BN) are available on the market. According to current knowledge, a relationship can be established between the anticipated operating conditions and the BN number as shown in the table entitled "*Base number to be used for various operating conditions*". However, the operating results are still the overriding factor in determining which BN number produces the most efficient engine operation.

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 3 (5) | <b>Specification for lubricating oils (SAE30) for<br/>heavy fuel oil operation (HFO)</b> | <b>604.01</b><br>Edition 27H |
|---------------------------|--|------------------------------|

**L28/32H**  
**V28/32H**

| approx. BN of fresh oil (mg KOH/g oil) | Engines / Operating conditions  |
|--|---|
| 20                                     | Marine diesel oil (MDO) with a lower quality (ISO-F-DMC) or heavy fuel oil with a sulphur content of less than 0.5 %  |
| 30                                     | generally 23/30H and 28/32H. 23/30A, 28/32A and 28/32S under normal operating conditions. For engines 16/24, 21/31, 27/38, 32/40, 32/44CR, 40/54, 48/60 as well as 58/64 and 51/60DF with exclusive HFO operation only with sulphur content < 1.5 %.  |
| 40                                     | With unfavourable operating conditions 23/30A, 28/32A and 28/32S and also where corresponding requirements in relation to the oil service life and washing ability exist. In general 16/24, 21/31, 27/38, 32/40, 32/44CR, 40/54, 48/60 as well as 58/64 and 51/60DF with exclusive HFO operation providing the sulphur content is greater than 1.5 %. |
| 50                                     | 32/40, 32/44CR, 40/54, 48/60 and 58/64, if the oil service life or engine cleanliness is insufficient with a BN number of 40 (high sulphur content of fuel, extremely low lubricating oil consumption).   |

Table 3 Base number to be used for various operating conditions

### Operation with low sulphur fuel

To comply with the emissions regulations, the sulphur content of fuels used nowadays varies. Fuels with a low-sulphur content must be used in environmentally-sensitive areas (SECA). Fuels with a high sulphur content may be used outside SECA zones. In this case, the BN number of the lubricating oil selected must satisfy the requirements for operation using fuel with a high-sulphur content. A lubricating oil with low BN number may only be selected if fuel with a low-sulphur content is used exclusively during operation.

However, the results obtained in practise that demonstrate the most efficient engine operation are the factor that ultimately decides which additive fraction is permitted.

### Cylinder lubricating oil

In engines with separate cylinder lubrication, the pistons and cylinder liners are supplied with lubricating oil via a separate lubricating oil pump. The quantity of lubricating oil is set at the factory according to the quality of the fuel to be used and the anticipated operating conditions.

Use a lubricating oil for the cylinder and lubricating circuit as specified above.

### Speed controller

Multigrade oil 5W40 should ideally be used in mechanical-hydraulic controllers with a separate oil sump. If this oil is not available when filling, 15W40 oil can be used instead in exceptional cases. In this case, it makes no difference whether synthetic or mineral-based oils are used.

The military specification for these oils is O-236.

### Lubricating oil additives

The use of other additives with the lubricating oil, or the mixing of different brands (oils by different manufacturers), is not permitted as this may impair the performance of the existing additives which have been carefully harmonised with each another and also specifically tailored to the base oil.

### Selection of lubricating oils / warranty

The majority of mineral oil companies are in close regular contact with engine manufacturers and can therefore provide information on which oil in their specific product range has been approved by the engine manufacturer for the particular application. Irrespective of the above, lubricating oil manufacturers are liable in any case for the quality and characteristics of their products. If you have any questions, we will be happy to provide you with further information.

**L28/32H**  
**V28/32H****Oil during operation**

There are no prescribed oil change intervals for MAN Diesel & Turbo medium speed engines. The oil properties must be regularly analysed. The oil can be used for as long as the oil properties remain within the defined limit values (see table entitled "Limit values for used lubricating oil"). An oil sample must be analysed every 1-3 months (see maintenance schedule). The quality of the oil can only be maintained if it is cleaned using suitable equipment (e.g. a separator or filter).

**Temporary operation with gas oil**

Due to current and future emission regulations, heavy fuel oil cannot be used in designated regions. Low-sulphur diesel fuel must be used in these regions instead.

If the engine is operated with low-sulphur diesel fuel for less than 1000 h, a lubricating oil which is suitable for HFO operation (BN 30 – 40 mg KOH/g) can be used during this period.

If the engine is operated provisionally with low-sulphur diesel fuel for more than 1000 h and is subsequently operated once again with HFO, a lubricating oil with a BN of 20 must be used. If the BN 20 lubricating oil by the same manufacturer as the lubricating oil used for HFO operation with higher BN (30 or 40), an oil change will not be required when effecting the changeover. It will be sufficient to use BN 20 oil when replenishing the used lubricating oil.

If you wish to operate the engine with HFO once again, it will be necessary to change over in good time to a lubricating oil with a higher BN (30 – 40). If the lubricating oil with higher BN is by the same manufacturer as the BN 20 lubricating oil, the changeover can also be effected without an oil change. In doing so, the lubricating oil with higher BN (30 – 40) must be used to replenish the used lubricating oil roughly 2 weeks prior to resuming HFO operation.

|                    | Limit value                                     | Procedure               |
|--------------------|---|-------------------------|
| Viscosity at 40 °C | 75-160 mm <sup>2</sup> /s                       | ISO 3104 or ASTM D 445  |
| Base Number (BN)   | at least 50% of fresh oil                       | ISO 3771                |
| Flash Point (PM)   | at least 185 °C                                 | ISO 2719                |
| Water Content      | max. 0.2% (max. 0.5% for brief periods)         | ISO 3733 or ASTM D 1744 |
| n-Heptan Insoluble | max. 1.5%                                       | DIN 51592 or IP 316     |
| Metal Content      | depends on engine type and operating conditions |                         |
| Guide value only   |   |                         |
| Fe                 | max. 50 ppm                                     |                         |
| Cr                 | max. 10 ppm                                     |                         |
| Cu                 | max. 15 ppm                                     |                         |
| Pb                 | max. 20 ppm                                     |                         |
| Sn                 | max. 10 ppm                                     |                         |
| Al                 | max. 20 ppm                                     |                         |

Table 4 Limit values for used lubricating oil

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 5 (5) | <b>Specification for lubricating oils (SAE30) for<br/>heavy fuel oil operation (HFO)</b> | <b>604.01</b><br>Edition 27H |
|---------------------------|--|------------------------------|

**L28/32H**  
**V28/32H**

### Examinations

We can analyse heavy fuel oil for customers at our laboratory. A 0.5 l sample is required for the test.

### Note!

**No liability when using these oils**

MAN Diesel & Turbo does not assume liability for problems that occur when using these oils.

| Manufacturer                | Base Number [mg KOH/g]      |                                    |                                    |
|-----------------------------|-----------------------------|------------------------------------|------------------------------------|
|                             | 20                          | 30                                 | 40                                 |
| AGIP                        | -                           | Cladium 300 - SAE30                | Cladium 400 - SAE30                |
| BP                          | Energol IC-HFX 203          | Energol IC-HFX 303                 | Energol IC-HFX 403                 |
| CASTROL                     | TLX Plus 203                | TLX Plus 303                       | TLX Plus 403                       |
| CEPSA                       | -                           | Troncoil 3030 Plus                 | Troncoil 4030 Plus                 |
| CHEVRON<br>(TEXACO, CALTEX) | Taro 20DP30<br>Taro 20DP30X | Taro 30DP30<br>Taro 30DP30X        | Taro 40XL 30<br>Taro 40XL30X       |
| EXXON MOBIL                 | -                           | Mobilgard M330<br>EXXMAR 30 TP 30  | Mobilgard M340<br>EXXMAR 40 TP 30  |
| PETROBRAS                   | Marbrax CCD-320             | Marbrax CCD-330                    | Marbrax CCD-340                    |
| REPSOL                      | Neptuno NT 2030             | Neptuno NT 3030                    | Neptuno NT 4030                    |
| SHELL                       | Argina S 30                 | Argina T 30                        | Argina X 30                        |
| TOTAL Lubmarine             | -                           | Aurelia XL 3030<br>Aurelia TI 3030 | Aurelia XL 3040<br>Aurelia TI 3040 |

Table 5 Approved lubricating oils for heavy fuel oil-operated MAN Diesel & Turbo four-stroke engines.

|                           |   |                              |
|---------------------------|---|------------------------------|
| Description<br>Page 1 (5) | <b>Quality Requirements for Lube Oil (SAE30) for Operation with Gas Oil, Diesel Oil (MGO/MDO) and Biofuel</b> | <b>604.01</b><br>Edition 26H |
|---------------------------|---|------------------------------|

**L28/32H**  
**V28/32H**

The specific output achieved by modern diesel engines combined with the use of fuels that satisfy the quality requirements more and more frequently increase the demands on the performance of the lubricating oil which must therefore be carefully selected.

Doped lubricating oils (HD oils) have a proven track record as lubricants for the drive, cylinder, turbo-charger and also for cooling the piston. Doped lubricating oils contain additives that, amongst other things, ensure dirt absorption capability, cleaning of the engine and the neutralisation of acidic combustion products.

Only lubricating oils approved by MAN Diesel may be used. These are listed in the tables below.

## Specifications

### Base oil

The base oil (doped lubricating oil = base oil + additives) must have a narrow distillation range and be refined using modern methods. If it contains paraffins, they must not impair the thermal stability or oxidation stability.

The base oil must comply with the following limit values, particularly in terms of its resistance to ageing.

| Properties/characteristics                                  | Unit     | Test method              | Limit values  |
|---|----------|--------------------------|---|
| Make-up   | -        | -                        | Ideally paraffin based  |
| Low temperature behaviour, still flowable                   | °C       | ASTM D 2500              | - 15  |
| Flash point (Cleveland)                                     | °C       | ASTM D 92                | > 200   |
| Ash content (oxidised ash)                                  | Weight % | ASTM D 482               | < 0.02  |
| Coke residue (according to Conradson)                       | Weight % | ASTM D 189               | < 0.50  |
| Ageing tendency following 100 hours of heating up to 135 °C | -        | MAN ageing oven *        | -   |
| insoluble n-heptane   | Weight % | ASTM D 4055 or DIN 51592 | < 0.2   |
| Evaporation loss  | Weight % | -                        | < 2   |
| Spot test (filter paper)                                    | -        | MAN Diesel test          | Precipitation of resins or asphalt-like ageing products must not be identifiable. |

Table 1 Base oils - target values

\* Works' own method



|                       |  |                           |
|-----------------------|--|---------------------------|
| 604.01<br>Edition 26H | Quality Requirements for Lube Oil (SAE30) for Operation with Gas Oil, Diesel Oil (MGO/MDO) and Biofuel | Description<br>Page 2 (5) |
|-----------------------|--|---------------------------|

L28/32H  
V28/32H

Doped lubricating oils (HD-oils)

The base oil to which the additives have been added (doped lubricating oil) must have the following properties:

Additives

The additives must be dissolved in the oil and their composition must ensure that as little ash as possible remains following combustion.

The ash must be soft. If this prerequisite is not met, it is likely the rate of deposition in the combustion chamber will be higher, particularly at the exhaust valves and at the turbocharger inlet casing. Hard additive ash promotes pitting of the valve seats and causes the valves to burn out, it also increases mechanical wear of the cylinder liners.

Additives must not increase the rate at which the filter elements in the active or used condition are blocked.

Washing ability

The washing ability must be high enough to prevent the accumulation of tar and coke residue as a result of fuel combustion.

Dispersibility

The selected dispersibility must be such that commercially-available lubricating oil cleaning systems can remove harmful contaminants from the oil used, i.e. the oil must possess good filtering properties and separability.

Neutralisation capability

The neutralisation capability (ASTM D2896) must be high enough to neutralise the acidic products produced during combustion. The reaction time of the additive must be harmonised with the process in the combustion chamber.

Evaporation tendency

The evaporation tendency must be as low as possible as otherwise the oil consumption will be adversely affected.

Additional requirements

The lubricating oil must not contain viscosity index improver. Fresh oil must not contain water or other contaminants.

Lubricating Oil Selection

| Engine   | SAE-Class |
|--|-----------|
| 23/30H, 28/32H, 23/30A, 28/32A<br>At cooling water temperatures > 32° C a SAE40 oil can be used.<br>In this case please contact MAN Diesel | 30        |

Table 2 Viscosity (SAE class) of lube oils

Doped oil quality

We recommend doped lubricating oils (HD oils) according to international specifications MIL-L 2104 or API-CD with a base number of BN 10 – 16 mgKOH/g. Military specification O-278 lubricating oils can be used.

The operating conditions of the engine and the quality of the fuel determine which additive fractions the lubricating oil contains. If marine diesel oil with a sulphur content of up to 2.0 % by weight according to ISO-F-DMC and coke residues of up to 2.5 % by weight is used, you should choose a base number of roughly 20. However, the operating results that ensure the most efficient engine operation ultimately decide the additive content.

Cylinder lubricating oil

In engines with separate cylinder lubrication, the pistons and cylinder liners are supplied with lubricating oil via a separate lubricating oil pump. The quantity of lubricating oil is set at the factory according to the quality of the fuel to be used and the anticipated operating conditions.

Use a lubricating oil for the cylinder and lubricating circuit as specified above.

08028-0D/H5250/94.08.12

|                           |   |                              |
|---------------------------|---|------------------------------|
| Description<br>Page 3 (5) | <b>Quality Requirements for Lube Oil (SAE30) for Operation with Gas Oil, Diesel Oil (MGO/MDO) and Biofuel</b> | <b>604.01</b><br>Edition 26H |
|---------------------------|---|------------------------------|

**L28/32H**  
**V28/32H**

### Speed controller

Multigrade oil 5W40 should ideally be used in mechanical-hydraulic controllers with a separate oil sump. If this oil is not available when filling, 15W40 oil can be used instead in exceptional cases. In this case, it makes no difference whether synthetic or mineral-based oils are used.

The military specification for these oils is O-236.

### Lubricating oil additives

The use of other additives with the lubricating oil, or the mixing of different brands (oils by different manufacturers), is not permitted as this may impair the performance of the existing additives which have been carefully harmonised with each another and also specifically tailored to the base oil.

### Selection of lubricating oils / warranty

The majority of mineral oil companies are in close regular contact with engine manufacturers and can therefore provide information on which oil in their specific product range has been approved by the engine manufacturer for the particular application. Irrespective of the above, lubricating oil manufacturers are liable in any case for the quality and characteristics of their products. If you have any questions, we will be happy to provide you with further information.

### Oil during Operation

There are no prescribed oil change intervals for MAN Diesel medium speed engines. The oil properties must be regularly analysed. The oil can be used for as long as the oil properties remain within the defined limit values (see table entitled "Limit values for used lubricating oil"). An oil sample must be analysed every 1-3 months (see maintenance schedule). The quality of the oil can only be maintained if it is cleaned using suitable equipment (e.g. a separator or filter).

### Temporary operation with gas oil

Due to current and future emission regulations, heavy fuel oil cannot be used in designated regions. Low-sulphur diesel fuel must be used in these regions instead.

If the engine is operated with low-sulphur diesel fuel for less than 1000 h, a lubricating oil which is suitable for HFO operation (BN 30 – 40 mg KOH/g) can be used during this period.

If the engine is operated provisionally with low-sulphur diesel fuel for more than 1000 h and is subsequently operated once again with HFO, a lubricating oil with a BN of 20 must be used. If the BN 20 lubricating oil by the same manufacturer as the lubricating oil used for HFO operation with higher BN (30 or 40), an oil change will not be required when effecting the changeover. It will be sufficient to use BN 20 oil when replenishing the used lubricating oil.

If you wish to operate the engine with HFO once again, it will be necessary to change over in good time to a lubricating oil with a higher BN (30 – 40). If the lubricating oil with higher BN is by the same manufacturer as the BN20 lubricating oil, the changeover can also be effected without an oil change. In doing so, the lubricating oil with higher BN (30 – 40) must be used to replenish the used lubricating oil roughly 2 weeks prior to resuming HFO operation.

**604.01**

Edition 26H

**Quality Requirements for Lube Oil (SAE30) for Operation with Gas Oil, Diesel Oil (MGO/MDO) and Biofuel**Description  
Page 4 (5)**L28/32H  
V28/32H****Tests**

We can analyse heavy fuel oil for customers at our laboratory. A 0.5 l sample is required for the test.

**Danger!****Improper handling of fuels**

If fuels are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the fuel supplier must be observed.

**Note!****No liability assumed if these oils are used**

MAN Diesel SE will not assume liability for any problems associated with using these oils.

**Approved lubricating oils SAE 30**

| Manufacturer                | Base Number<br>10-16 <sup>1)</sup> [mgKOH/g]   |
|-----------------------------|--|
| AGIP                        | Cladium 120 - SAE 30<br>Sigma S SAE 30 <sup>2)</sup>                                       |
| BP                          | Energol DS 3-153   |
| CASTROL                     | Castrol MLC 30<br>Castrol MHP 153<br>Seamax Extra 30                                       |
| CHEVRON<br>(Texaco, Caltex) | Taro 12 XD 30<br>Delo 1000 Marine SAE 30<br>Delo SHP30                                     |
| EXXON MOBIL                 | Exxmar 12 TP 30<br>Mobilgard 312<br>Mobilgard ADL 30 <sup>2)</sup><br>Delvac 1630          |
| PETROBRAS                   | Marbrax CCD-310  |
| Q8                          | Mozart DP30  |
| REPSOL                      | Neptuno NT 1530  |
| SHELL                       | Gadinia 30<br>Gadinia AL30<br>Sirius FB30 <sup>2)</sup><br>Sirius/Rimula X30 <sup>2)</sup> |
| STATOIL                     | MarWay 1530<br>MarWay 1030   |
| TOTAL Lubmarine             | Disola M3015   |

Table 3 Lubricating oils (SAE30) which have been approved for the use in MAN Diesel four-stroke engines running on gas oil and Diesel oil

<sup>1)</sup> If marine diesel oil with a low quality (ISO-F-DMC) is used, a base number (BN) of roughly 20 should be used.

<sup>2)</sup> with a sulphur content of less than 1%

|                           |   |                              |
|---------------------------|---|------------------------------|
| Description<br>Page 5 (5) | <b>Quality Requirements for Lube Oil (SAE30) for Operation with Gas Oil, Diesel Oil (MGO/MDO) and Biofuel</b> | <b>604.01</b><br>Edition 26H |
|---------------------------|---|------------------------------|

**L28/32H**  
**V28/32H**

|  | Limit value  | Procedure               |
|--|--|-------------------------|
| Viscosity at 40 °C                                   | 75-160 mm <sup>2</sup> /s  | ISO 3104 or ASTM D445   |
| Base Number (BN)                                     | at least 50% of fresh oil  | ISO 3771                |
| Flash Point (PM)                                     | at least 185 °C  | ISO 2719                |
| Water Content  | max. 0.2% (max. 0.5% for brief periods)  | ISO 3733 or ASTM D 1744 |
| n-Heptan Insoluble                                   | max. 1.5%  | DIN 51592 or IP 316     |
| Metal Content  | depends on engine type and operating conditions  |                         |
| Guide value only<br>Fe<br>Cr<br>Cu<br>Pb<br>Sn<br>Al | max. 50 ppm<br>max. 10 ppm<br>max. 15 ppm<br>max. 20 ppm<br>max. 10 ppm<br>max. 20 ppm |                         |
| When operating with biofuels:<br>biofuel fraction    | max 12%  | FT-IR                   |

Table 4 Limit values for used lubricating oil

|                           |   |                                     |
|---------------------------|---|-------------------------------------|
| Description<br>Page 1 (4) | <b>Treatment and maintenance of lubricating oil</b> | <b>604.03</b><br><b>Edition 11H</b> |
|---------------------------|---|-------------------------------------|

## L32/40, L28/32H, V28/32H

### General

During operation of trunk engines the lubricating oil will gradually be contaminated by small particles originating from the combustion.

Engines operated on heavy fuels will normally increase the contamination due to the increased content of carbon residues and other contaminants.

Contamination of lubricating oil with either freshwater or seawater can also occur.

A certain amount of contaminants can be kept suspended in the lubricating oil without affecting the lubricating properties.

The condition of the lubricating oil must be kept under observation (on a regular basis) by analyzing oil samples. *See Section 504.04 "Criteria for Cleaning/Exchange of Lubricating Oil".*

The moving parts in the engine are protected by the built-on duplex full-flow lubricating oil filter. The replaceable paper filter cartridges in each filter chamber have a fineness of 10-15 microns. The safety filter, at the centre of each filter chamber, is a basket filter element, with a fineness of 60 microns (sphere passing mesh).

The pressure drop across the replaceable paper filter cartridges is one parameter indicating the contamination level. The higher the dirt content in the oil, the shorter the periods between filter cartridge replacement and cleaning.

The condition of the lubricating oil can be maintained / re-established by exchanging the lubricating oil at fixed intervals or based on analyzing oil samples.

### Operation on Marine Diesel Oil (MDO) & Marine Gas Oil (MGO)

For engines exclusively operated on MDO/MGO we recommend to install a built-on centrifugal bypass filter as an additional filter to the built-on full flow depth filter.

It is advisable to run bypass separators continuously for engines operated on MDO/MGO as separators present the best cleaning solution. Mesh filters have the disadvantage that they cannot remove water and their elements clog quickly.

### Operation on Heavy Fuel Oil (HFO)

HFO-operated engines require effective lubricating oil cleaning. In order to ensure a safe operation it is necessary to use supplementary cleaning equipment together with the built-on full flow depth filter.

It is mandatory to run bypass separators continuously for engines operated on HFO, as an optimal lubricating oil treatment is fundamental for a reliable working condition. Therefore it is mandatory to clean the lubricating oil with a bypass separator, so that the wear rates are reduced and the lifetime of the engine is extended.

### Bypass equipment

As a result of normal operation, the lubricating oil contains abraded particles and combustion residues which have to be removed by the bypass cleaning system and to a certain extent by the duplex full-flow lubricating oil filter as well.

With automatic mesh filters this can result in an undesirable and hazardous continuous flushing. In view of the high cost of cleaning equipment for removing micro impurities, this equipment is only rated for a certain proportion of the oil flowing through the engine since it is installed in a bypass.

The bypass cleaning equipment is operated

- continuously when the engine is in operation or at standstill

For cleaning of lubricating oil the following bypass cleaning equipment can be used:

- Separator unit
- Decanter unit
- Self cleaning automatic bypass mesh filter
- Centrifugal bypass filter (Holeby Gensets can be delivered with this built-on filter)
- Bypass depth filter

The separator unit, decanter unit, the self-cleaning automatic bypass mesh filter and the bypass depth filter capacity must be adjusted according to maker's recommendations.

In case full flow filtration equipment is chosen, this must only be installed as in-line cleaning upstream to the duplex full-flow lubricating oil filter, built onto the engine.

|                       |  |                           |
|-----------------------|--|---------------------------|
| 604.03<br>Edition 11H | Treatment and maintenance of lubricating oil | Description<br>Page 2 (4) |
|-----------------------|--|---------------------------|

## L32/40, L28/32H, V28/32H

The most appropriate type of equipment for a particular application depends on the engine output, the type and amount of combustion residues, the annual operating time and the operating mode of the plant. Even with a relatively low number of operating hours there can be a great deal of combustion residues if, for instance, the engine is inadequately preheated and quickly accelerated and loaded.

### Separator

Continuous lubricating oil cleaning during engine operation is mandatory. An optimal lubricating oil treatment is fundamental for a reliable working condition of the engine.

If the lubricating oil is circulating without a separator in operation, the lubricating oil will gradually be contaminated by products of combustion, water and/or acid. In some instances cat-fines may also be present.

In order to prolong the lubricating oil lifetime and remove wear elements, water and contaminants from the lubricating oil, it is mandatory to use a bypass separator.

The separator will reduce the carbon residue content and other contaminants from combustion on engines operated on HFO, and keep the amount within MDT's recommendation, on condition that the separator unit is operated according to maker's recommendations.

When operating a cleaning device, the following recommendations must be followed:

- The optimum cleaning effect is achieved by keeping the lubricating oil in a state of low viscosity for a long period in the separator bowl.
- Sufficiently low viscosity is obtained by preheating the lubricating oil to a temperature of 95°C - 98°C, when entering the separator bowl.
- The separator unit capacity must be adjusted according to maker's recommendations.

Slow passage of the lubricating oil through the separator is obtained by using a reduced flow rate and by operating the separator 24 hours a day, stopping only for maintenance, according to maker's recommendation.

### Lubricating oil preheating

The installed heater on the separator unit ensures correct lubricating oil temperature during separation. When the engine is at standstill, the heater can be used for two functions:

- The oil in the sump can be preheated to 95 – 98 °C by the heater and cleaned continuously by the separator.
- The heater can also be used to maintain an oil temperature of at least 40 °C, depending on installation of the lubricating oil system.

### Cleaning capacity

Normally, it is recommended to use a self-cleaning filtration unit in order to optimize the cleaning period and thus also optimize the size of the filtration unit. Separators for manual cleaning can be used when the reduced effective cleaning time is taken into consideration by dimensioning the separator capacity.

### The required flow

In order to calculate the required lubricating oil flow through the separator, the separator maker's recommendation must be followed.

As a guidance, the following formula should form the basis for choosing the required flow for the separator capacity:

$$Q = \frac{P \times 1.36 \times n}{T}$$

Q = required flow (l/h)

P = engine output kW)

t = actual effective separator operating time per day (hour)

n = number of turnovers per day of the theoretical oil volume corresponding to 1.36 l/kW or 1 l/HP

The following values for "n" are recommended:

- n = 5 for HFO operation (residual)
- n = 4 for MDO operation
- n = 3 for distillate fuel

|                           |   |                                     |
|---------------------------|---|-------------------------------------|
| Description<br>Page 3 (4) | <b>Treatment and maintenance of lubricating oil</b> | <b>604.03</b><br><b>Edition 11H</b> |
|---------------------------|---|-------------------------------------|

## L32/40, L28/32H, V28/32H

### Example 1

For multi-engine plants, one separator per engine in operation is recommended.

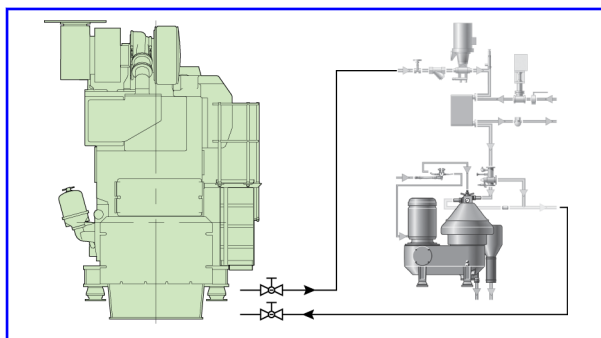


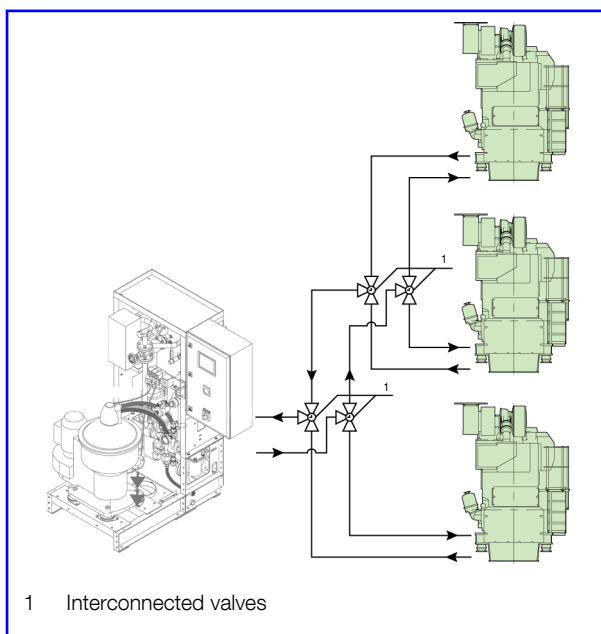
Figure 1: Example 1

One 1000 kW engine operating on HFO connected to a self-cleaning separator with a daily effective separating period of 23 hours:

$$Q = \frac{1000 \times 1.36 \times 5}{23} = 296 \text{ l/h}$$

### Example 2

As alternative one common separator can be installed, with one in reserve if possible, for multi-engine plants.



1 Interconnected valves

Figure 2: Example 2

Three 1000 kW engines operating on HFO connected to a common self-cleaning separator with a daily effective separating period of 23 hours:

$$Q = \frac{3000 \times 1.36 \times 5}{23} = 887 \text{ l/h}$$

### Separator installation

With multi-engine plants, one separator per engine in operation is recommended, but if only one separator is in operation, the following layout can be used:

- A common separator can be installed, with one in reserve if possible for operation of all engines through a pipe system, which can be carried out in various ways. The aim is to ensure that the separator is only connected to one engine at a time. This to ensure that there is no suction and discharging from one engine to another.

It is recommended that inlet and outlet valves are connected, so that they can only be changed over simultaneously.

With only one engine in operation there are no problems with separating, but if several engines are in operation for some time it is recommended to split up the time so that there is separation on all engines, which are operating in turns.

The capacity of the separator has to correspond with the separating of oil on the single engine  $n$  times during the available time, every 24 hours. See section regarding required flow.

### Check of lubricating oil system

For cleaning of the lubricating oil system after overhauls and inspection of the lubricating oil piping system the following checks must be carried out:

1. Examine the piping system for leaks.
2. Retighten all bolts and nuts in the piping system.
3. Move all valves and cocks in the piping system. Lubricate valve spindles with graphite or similar.
4. Blow through drain pipes.
5. Check flexible connections for leaks and damages.
6. Check manometers and thermometers for possible damages.



|                       |  |                           |
|-----------------------|--|---------------------------|
| 604.03<br>Edition 11H | Treatment and maintenance of lubricating oil | Description<br>Page 4 (4) |
|-----------------------|--|---------------------------|

## L32/40, L28/32H, V28/32H

### Deterioration of oil

Oil seldomly loses its ability to lubricate, i.e. to form a friction-decreasing oil film, but it may become corrosive to the steel journals of the bearings in such a way that the surface of these journals becomes too rough and wipes the bearing surface.

In that case the bearings must be renewed, and the journals must also be polished. The corrosiveness of the lubricating oil is either due to far advanced oxidation of the oil itself (TAN) or to the presence of inorganic acids (SAN). In both cases the presence of water will multiply the effect, especially sea water as the chloride ions act as an inorganic acid.

### Signs of deterioration

If circulating oil of inferior quality is used and the oxidative influence becomes grave, prompt action is necessary as the last stages in the deterioration will develop surprisingly quickly, within one or two weeks. Even if this seldomly happens, it is wise to be acquainted with the signs of deterioration.

These may be some or all of the following:

- Sludge precipitation in the separator multiplies
- Smell of oil becomes acid or pungent
- Machined surfaces in the crankcase become coffee-brown with a thin layer of lacquer
- Paint in the crankcase peels off or blisters
- Excessive carbon is formed in the piston cooling chamber

In a grave case of oil deterioration the system must be cleaned thoroughly and refilled with new oil.

### Oxidation of oils

At normal service temperature the rate of oxidation is insignificant, but the following factors will accelerate the process:

#### High temperature

If the coolers are ineffective, the temperature level will generally rise. A high temperature will also arise in electrical pre-heaters if the circulation is not continued for 5 minutes after the heating has been stopped, or if the heater is only partly filled with oil.

#### Catalytic action

Oxidation of the oil will be accelerated considerably if catalytic particles are present in the oil. Wear particles of copper are especially harmful, but also fer-

rous particles and rust are active. Furthermore, the lacquer and varnish oxidation products of the oil itself have an accelerating effect. Continuous cleaning of the oil is therefore important to keep the sludge content low.

### Water washing

Water washing of HD oils (heavy duty) must not be carried out.

### Water in the oil

If the TAN is low, a minor increase in the fresh water content of the oil is not immediately detrimental while the engine is in operation. Naturally, it should be brought down again as quickly as possible (below 0.2% water content, which is permissible, *see description "B 12 15 0/504.04 criteria for exchange of lube oil"*). If the engine is stopped while corrosion conditions are unsatisfactory, the crankshaft must be turned  $\frac{1}{2}$  -  $\frac{3}{4}$  revolution once every hour. Please make sure that the crankshaft stops in different positions, to prevent major damage to bearings and journals. The lubricating oil must be circulated and separated continuously to remove water.

Water in the oil may be noted by steam formation on the sight glasses, by appearance, or ascertained by immersing a piece of glass or a soldering iron heated to 200-300°C in an oil sample. If there is a hissing sound, water is present. If a large quantity of water has entered the lubricating oil system, it has to be removed. Either to suck up sediment water from the bottom, or replace the oil in the sump. An oil sample must be analysed immediately for chloride ions.



|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (2) | <b>Criteria for Cleaning/Exchange of Lubricating Oil</b> | <b>604.04</b><br>Edition 17H |
|---------------------------|--|------------------------------|

## General

### Replacement of Lubricating Oil

The expected lubricating oil lifetime in operation is difficult to determine. The lubricating oil lifetime is depending on the fuel oil quality, the lubricating oil quality, the lubricating oil consumption, the lubricating oil cleaning equipment efficiency and the engine operational conditions.

In order to evaluate the lubricating oil condition a sample should be drawn on regular basis at least once every three month or depending on the latest analysis result. The lubricating oil sample must be drawn before the filter at engine in operation. The sample bottle must be clean and dry, supplied with sufficient identification and should be closed immediately after filling. The lubricating oil sample must be examined in an approved laboratory or in the lubricating oil suppliers own laboratory.

A lubricating oil replacement or an extensive lubricating oil cleaning is required when the MAN Diesel exchange criteria's have been reached.

### Evaluation of the Lubricating Oil Condition

Based on the analysis results, the following guidance are normally sufficient for evaluating the lubricating oil condition. The parameters themselves can not be judged alonstanding, but must be evaluated together in order to conclude the lubricating oil condition.

#### 1. Viscosity

Limit value :

|                     | Normal value | min. value | max. value |
|---------------------|--------------|------------|------------|
| SAE 30 [cSt@40° C]  | 95 - 125     | 75         | 160        |
| SAE 30 [cSt@100° C] | 11 - 13      | 9          | 15         |
| SAE 40 [cSt@40° C]  | 135 - 165    | 100        | 220        |
| SAE 40 [cSt@100° C] | 13.5 - 15.0  | 11         | 19         |

Unit : cSt (mm<sup>2</sup>/s)

Possible test

methods : ASTM D-445, DIN 51562/53018, ISO 3104

Increasing viscosity indicates problems with insolubles, HFO contamination, water contamination, oxidation, nitration and low load operation. Decreasing viscosity is generally due to dilution with lighter viscosity oil.

#### 2. Flash Point

Min. value : 185° C

Possible test

method : ASTM D-92, ISO 2719

Normally used to indicate fuel dilution.

#### 3. Water Content

Max. value : 0.2 %

Unit : Weight %

Possible test

method : ASTM D4928, ISO 3733

Water can originate from contaminated fuel oil, an engine cooling water leak or formed as part of the combustion process. If water is detected also Sodium, Glycol or Boron content should be checked in order to confirm engine coolant leaks.

#### 4. Base Number (BN)

Min. value : The BN value should not be lower than 50% of fresh lubricating oil value, but minimum BN level never to be lower than 10-12 at operating on HFO!

Unit : mg KOH/g

Possible test

method : ASTM D-2896, ISO 3771

## General

The neutralization capacity must secure that the acidic combustion products, mainly sulphur originate from the fuel oil, are neutralized at the lube oil consumption level for the specific engine type. Gradually the BN will be reduced, but should reach an equilibrium.

Unit : Weight %

Possible test method : ASTM D-893 procedure B in n-Heptane, DIN 51592

### 5. Total Acid Number (TAN)

Max. value : 3.0 acc. to fresh oil value

Unit : mg KOH/g

Possible test method : ASTM D-664

TAN is used to monitor oil degradation and is a measure of the total acids present in the lubricating oil derived from oil oxidation (weak acids) and acidic products of fuel combustion (strong acids).

Additionally test : If the level in n-Heptane insolubles is considered high for the type of oil and application, the test could be followed by a supplementary determination in Toluene.

Total insolubles is mainly derived from products of combustion blown by the piston rings into the crank-case. It also includes burnt lubricating oil, additive ash, rust, salt, wear debris and abrasive matter.

### 6. Insolubles Content

Max. value : 1.5 % generally, depending upon actual dispersant value and the increase in viscosity.

### 7. Metal Content

| Metal content | Remarks  | Attention limits |
|---------------|--|------------------|
| Iron          | Depend upon engine type and operating conditions | max. 50 ppm      |
| Chromium      |  | max. 10 ppm      |
| Copper        |  | max. 15 ppm      |
| Lead          |  | max. 20 ppm      |
| Tin           |  | max. 10 ppm      |
| Aluminium     |  | max. 20 ppm      |
| Silicon       |  | max. 20 ppm      |

|                           |                           |                              |
|---------------------------|---------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Lubricating Points</b> | <b>604.05</b><br>Edition 01H |
|---------------------------|---------------------------|------------------------------|

**General****Lubricating Oil Types used in the Engine.**

| Description                    | Lub. Oil Type   |
|--------------------------------|---|
| Engine system lubricating oil. | SAE 30 oil according to lubricating oil specification on page 604.01. |
| Turbocharger                   | Engine system lubricating oil.  |
| Governor                       | See Governor instruction in section 609.                              |
| Air lubricator                 | SAE 10W non-detergent oil.  |
| Alternator                     | See special instructions in section 618 or separate instruction.      |
| Hydraulic tools                | Hydraulic oil or turbine oil. (with a viscosity of about SAE 20).     |

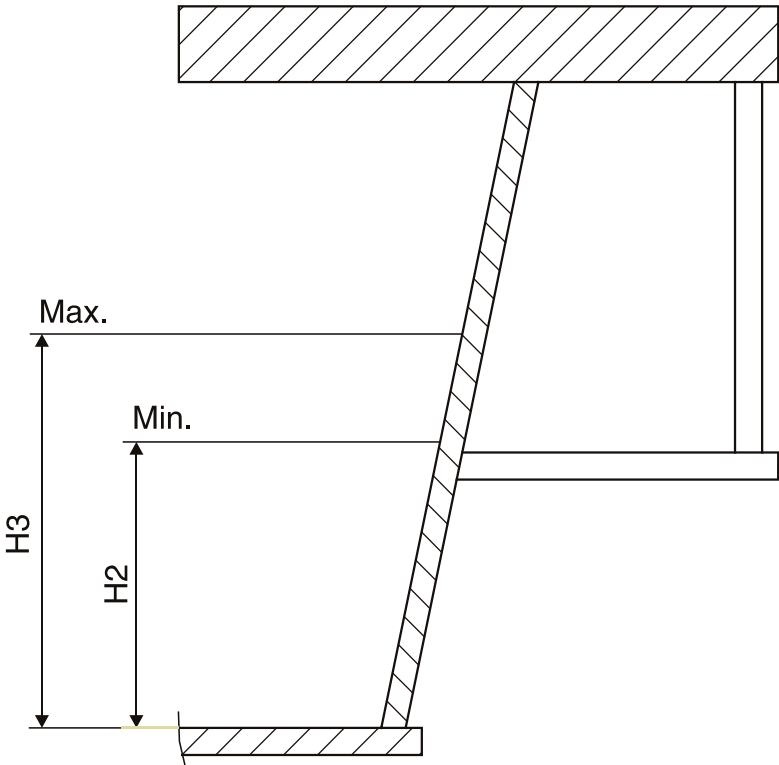
|                           |                           |                              |
|---------------------------|---------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Lubricating Points</b> | <b>604.05</b><br>Edition 02H |
|---------------------------|---------------------------|------------------------------|

**General****Lubricating Oil Types used in the Engine.**

| Description                    | Lub. Oil Type   |
|--------------------------------|---|
| Engine system lubricating oil. | SAE 40 oil according to lubricating oil specification on page 604.01. |
| Turbocharger                   | Engine system lubricating oil.  |
| Governor                       | See Governor instruction in section 609.                              |
| Air lubricator                 | SAE 10W non-detergent oil.  |
| Alternator                     | See special instructions in section 618 or separate instruction.      |
| Hydraulic tools                | Hydraulic oil or turbine oil. (with a viscosity of about SAE 20).     |

|                           |                               |                       |
|---------------------------|-------------------------------|-----------------------|
| Description<br>Page 1 (1) | Lubricating Oil in Base Frame | 604.06<br>Edition 16H |
|---------------------------|-------------------------------|-----------------------|

L28/32H



| Type L28/32H       | 5 cyl. | 6 cyl. | 7 cyl. | 8 cyl. | 9 cyl. |
|--------------------|--------|--------|--------|--------|--------|
| Min. level H2 (mm) | 265    | 265    | 265    | 265    | 265    |
| Max. level H3 (mm) | 365    | 365    | 365    | 365    | 365    |
| Min. litre H2      | 792    | 935    | 1078   | 1220   | 1362   |
| Max. litre H3      | 1111   | 1311   | 1511   | 1710   | 1910   |

08028-0D/H5250/94.08.12

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (2) | <b>Specific Lubricating Oil Consumption - SLOC</b> | <b>604.07</b><br>Edition 02H |
|---------------------------|--|------------------------------|

**General**

| Engine type | RPM         | SLOC [g/kWh] |
|-------------|-------------|--------------|
| L16/24      | 1000/1200   | 0.4 - 0.8    |
| L21/31      | 900/1000    | 0.4 - 0.8    |
| L23/30H     | 720/750/900 | 0.6 - 1.0    |
| L27/38      | 720/750     | 0.4 - 0.8    |
| L28/32H     | 720/750     | 0.6 - 1.0    |
| V28/32H     | 720/750     | 0.6 - 1.0    |
| V28/32S     | 720/750     | 0.4 - 0.8    |
| L32/40      | 720/750     | 0.7 - 1.1    |

Please note that only maximum continuous rating ( $P_{MCR}$  (kW)) should be used in order to evaluate the SLOC, see the description 504.07.

Please note, during engine running-in the SLOC may exceed the values stated.

The following formula is used to calculate the SLOC:

SLOC [g/kWh] =

$$\frac{(\text{lubricating oil added [dm}^3]) \cdot \rho_{\text{lubricating oil [kg/m}^3]}}{\text{run.hrs period} \cdot P_{MCR} [\text{kW}]}$$

The lubricating oil density,  $\rho$  @ 15°C must be known in order to convert  $\rho$  to the present lubricating oil temperature in the base frame. The following formula is used to calculate  $\rho$ :

$$\rho_{\text{lubricating oil [kg/m}^3]} =$$

$$\rho_{\text{lubricating oil @ 15}^\circ\text{C [kg/m}^3]} - 0,64 \cdot (t_{\text{lubricating oil [}^\circ\text{C]} - 15)$$

The engine maximum continuous design rating ( $P_{MCR}$ ) must always be used in order to be able to compare the individual measurements, and the running hours since the last lubricating oil adding must be used in the calculation. Due to inaccuracy \*) at adding lubricating oil, the SLOC can only be evaluated after 1,000 running hours or more, where only the average values of a number of lubricating oil additions are representative.

Note \*)

A deviation of  $\pm 1$  mm with the dipstick measurement must be expected, which corresponds up to  $\pm 0.1$  g/kWh, depending on the engine type.

## General

[illegible]

## Heavy fuel oil (HFO) specification

### Prerequisites

MAN four-stroke diesel engines can be operated with any heavy fuel oil obtained from crude oil that also satisfies the requirements in Table 1, providing the engine and fuel processing system have been designed accordingly. To ensure that the relationship between the fuel, spare parts and repair / maintenance costs remains favorable at all times, the following points should be observed.

### Heavy fuel oil (HFO)

#### Origin/Refinery process

The quality of the heavy fuel oil largely depends on the quality of crude oil and on the refining process used. This is why the properties of heavy fuel oils with the same viscosity may vary considerably depending on the bunker positions. Heavy fuel oil is normally a mixture of residual oil and distillates. The components of the mixture are normally obtained from modern refinery processes, such as Catcracker or Visbreaker. These processes can adversely affect the stability of the fuel as well as its ignition and combustion properties. The processing of the heavy fuel oil and the operating result of the engine also depend heavily on these factors.

Bunker positions with standardised heavy fuel oil qualities should preferably be used. If oils need to be purchased from independent dealers, also ensure that these also comply with the international specifications. The engine operator is responsible for ensuring that suitable heavy fuel oils are chosen.

#### Specifications

Fuels intended for use in an engine must satisfy the specifications to ensure sufficient quality. The limit values for heavy fuel oils are specified in Table 1. The entries in the last column of Table 1 provide important background information and must therefore be observed.

Different international specifications exist for heavy fuel oils. The most important specifications are ISO 8217-2010 and CIMAC-2003, which are more or less identical. The ISO 8217 specification is shown in Fig. 1. All qualities in these specifications up to K700 can be used, providing the fuel preparation system has been designed accordingly. To use any fuels, which do not comply with these specifications (e.g. crude oil), consultation with Technical Service of MAN Diesel & Turbo SE in Augsburg is required. Heavy fuel oils with a maximum density of 1,010 kg/m<sup>3</sup> may only be used if up-to-date separators are installed.

#### Important

Even though the fuel properties specified in the table entitled "The fuel specification and corresponding properties for heavy fuel oil" satisfy the above requirements, they probably do not adequately define the ignition and combustion properties and the stability of the fuel. This means that the operating behaviour of the engine can depend on properties that are not defined in the specification. This particularly applies to the oil property that causes formation of deposits in the combustion chamber, injection system, gas ducts and exhaust gas system. A number of fuels have a tendency towards incompatibility with lubricating oil which leads to deposits being formed in the fuel delivery pump that can block the pumps. It may therefore be necessary to exclude specific fuels that could cause problems.

#### Blends

The addition of engine oils (old lubricating oil, ULO –used lubricating oil) and additives that are not manufactured from mineral oils, (coal-tar oil, for example), and residual products of chemical or other processes such as solvents



(polymers or chemical waste) is not permitted. Some of the reasons for this are as follows: abrasive and corrosive effects, unfavourable combustion characteristics, poor compatibility with mineral oils and, last but not least, adverse effects on the environment. The order for the fuel must expressly state what is not permitted as the fuel specifications that generally apply do not include this limitation.

If engine oils (old lubricating oil, ULO – used lubricating oil) are added to fuel, this poses a particular danger as the additives in the lubricating oil act as emulsifiers that cause dirt, water and catfines to be transported as fine suspension. They therefore prevent the necessary cleaning of the fuel. In our experience (and this has also been the experience of other manufacturers), this can severely damage the engine and turbocharger components.

The addition of chemical waste products (solvents, for example) to the fuel is prohibited for environmental protection reasons according to the resolution of the IMO Marine Environment Protection Committee passed on 1st January 1992.

#### Leak oil collector

Leak oil collectors that act as receptacles for leak oil, and also return and overflow pipes in the lube oil system, must not be connected to the fuel tank. Leak oil lines should be emptied into sludge tanks.

|                                       |                          |      |                         |  |
|---------------------------------------|--------------------------|------|-------------------------|--|
| Viscosity (at 50 °C)                  | mm <sup>2</sup> /s (cSt) | max. | 700                     | Viscosity/injection viscosity  |
| Viscosity (at 100 °C)                 |                          | max. | 55                      | Viscosity/injection viscosity  |
| Density (at 15 °C)                    | g/ml                     | max. | 1.010                   | Heavy fuel oil processing  |
| Flash point                           | °C                       | min. | 60                      | Flash point (ASTM D 93)  |
| Pour point (summer)                   |                          | max. | 30                      | Low-temperature behaviour (ASTM D 97)  |
| Pour point (winter)                   |                          | max. | 30                      | Low-temperature behaviour (ASTM D 97)  |
| Coke residue (Conradson)              | Weight %                 | max. | 20                      | Combustion properties  |
| Sulphur content                       |                          |      | 5 or legal requirements | Sulphuric acid corrosion   |
| Ash content                           |                          |      | 0.15                    | Heavy fuel oil processing  |
| Vanadium content                      | mg/kg                    |      | 450                     | Heavy fuel oil processing  |
| Water content                         | Vol. %                   |      | 0.5                     | Heavy fuel oil processing  |
| Sediment (potential)                  | Weight %                 |      | 0.1                     |  |
| Aluminium and silicon content (total) | mg/kg                    | max. | 60                      | Heavy fuel oil processing  |
| Acid number                           | mg KOH/g                 |      | 2.5                     |  |
| Hydrogen sulphide                     | mg/kg                    |      | 2                       |  |
| Used lubricating oil (ULO)            | mg/kg                    |      |                         | The fuel must be free of lubricating oil (ULO = used lubricating oil, old oil). Fuel is considered as contaminated with lubricating oil when the following concentrations occur:<br>Ca > 30 ppm and Zn > 15 ppm or Ca > 30 ppm and P > 15 ppm. |

|  |          |  |   |                           |
|--|----------|--|---|---------------------------|
| Asphaltene content   | Weight % |  | 2/3 of coke residue<br>(according to Conradson) | Combustion properties     |
| Sodium content   | mg/kg    |  | Sodium < 1/3 Vanadium,<br>Sodium<100            | Heavy fuel oil processing |
| The fuel must be free of admixtures that cannot be obtained from mineral oils, such as vegetable or coal-tar oils. It must also be free of tar oil and lubricating oil (old oil), and also chemical waste products such as solvents or polymers. |          |  |   |                           |

Table 1: Table\_The fuel specification and corresponding characteristics for heavy fuel oil

6680 3.3.3-01

Heavy fuel oil (HFO) specification

General

ISO 8217:2010(E)

© ISO 2010 – All rights reserved

| Characteristic               | Unit               | Limit | Category ISO-F-        |           |           |            |       |       |       |       |        |       |       |          | Test method reference                        |
|------------------------------|--------------------|-------|------------------------|-----------|-----------|------------|-------|-------|-------|-------|--------|-------|-------|----------|--|
|                              |                    |       | RMA<br>10              | RMB<br>30 | RMD<br>80 | RME<br>180 | RMG   |       |       |       | RMK    |       |       |          |  |
|                              |                    |       |                        |           |           |            | 180   | 380   | 500   | 700   | 380,0  | 500,0 | 700,0 | 700      |  |
| Kinematic viscosity at 50 °C | mm <sup>2</sup> /s | max.  | 10,00                  | 30,00     | 80,00     | 180,0      | 180,0 | 380,0 | 500,0 | 700,0 | 380,0  | 500,0 | 700,0 | ISO 3104 |  |
| Density at 15 °C             | kg/m <sup>3</sup>  | max.  | 920,0                  | 960,0     | 975,0     | 991,0      | 991,0 |       |       |       | 1010,0 |       |       |          | see 7.1<br>ISO 3675 or<br>ISO 12185          |
| CCAI                         | —                  | max.  | 850                    | 860       | 860       | 860        | 870   |       |       |       | 870    |       |       |          | see 6.3 a)                                   |
| Sulfur                       | mass %             | max.  | Statutory requirements |           |           |            |       |       |       |       |        |       |       |          | see 7.2<br>ISO 8754<br>ISO 14596             |
| Flash point                  | °C                 | min.  | 60,0                   | 60,0      | 60,0      | 60,0       | 60,0  |       |       |       | 60,0   |       |       |          | see 7.3<br>ISO 2719                          |
| Hydrogen sulfide             | mg/kg              | max.  | 2,00                   | 2,00      | 2,00      | 2,00       | 2,00  |       |       |       | 2,00   |       |       |          | IP 570                                       |
| Acid number                  | mg KOH/g           | max.  | 2,5                    | 2,5       | 2,5       | 2,5        | 2,5   |       |       |       | 2,5    |       |       |          | ASTM D664                                    |
| Total sediment aged          | mass %             | max.  | 0,10                   | 0,10      | 0,10      | 0,10       | 0,10  |       |       |       | 0,10   |       |       |          | see 7.5<br>ISO 10307-2                       |
| Carbon residue: micro method | mass %             | max.  | 2,50                   | 10,00     | 14,00     | 15,00      | 18,00 |       |       |       | 20,00  |       |       |          | ISO 10370                                    |
| Pour point (winter quality)  | °C                 | max.  | 0                      | 0         | 30        | 30         | 30    |       |       |       | 30     |       |       |          | ISO 3016                                     |
| summer quality               | °C                 | max.  | 6                      | 6         | 30        | 30         | 30    |       |       |       | 30     |       |       |          | ISO 3016                                     |
| Water                        | volume %           | max.  | 0,30                   | 0,50      | 0,50      | 0,50       | 0,50  |       |       |       | 0,50   |       |       |          | ISO 3733                                     |
| Ash                          | mass %             | max.  | 0,040                  | 0,070     | 0,070     | 0,070      | 0,100 |       |       |       | 0,150  |       |       |          | ISO 6245                                     |
| Vanadium                     | mg/kg              | max.  | 50                     | 150       | 150       | 150        | 350   |       |       |       | 450    |       |       |          | see 7.7<br>IP 501,<br>IP 470 or<br>ISO 14597 |
| Sodium                       | mg/kg              | max.  | 50                     | 100       | 100       | 100        | 100   |       |       |       | 100    |       |       |          | see 7.8<br>IP 501<br>IP 470                  |

Figure 1: ISO 8217-2010 specification for heavy fuel oil

ISO 8217:2010(E)

| Characteristic   | Unit  | Limit | Category ISO-F-  |     |     |     |     |     |     |     |     |     | Test method reference                     |  |
|--|-------|-------|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|---|--|
|  |       |       | RMA  | RMB | RMD | RME | RMG |     |     |     | RMK |     |   |  |
|  |       |       | 10 <sup>a</sup>  | 30  | 80  | 180 | 380 | 500 | 700 | 380 | 500 | 700 |   |  |
| Aluminium plus silicon   | mg/kg | max.  | 25   | 40  | 40  | 50  | 60  |     |     |     | 60  |     |   | see 7.9<br>IP 501,<br>IP 470 or<br>ISO 10478 |
| Used lubricating oils (ULO);<br><br>calcium and zinc; or<br>calcium and phosphorus | mg/kg | —     | The fuel shall be free from ULO. A fuel shall be considered to contain ULO when either one of the following conditions is met.<br><br>calcium > 30 and zinc > 15; or<br>calcium > 30 and phosphorus > 15 |     |     |     |     |     |     |     |     |     | see 7.10<br>IP 501 or<br>IP 470<br>IP 500 |  |

© ISO 2010 – All rights reserved

6680 3.3.3-01

Heavy fuel oil (HFO) specification

General

Figure 2: ISO 8217-2010 specification for heavy fuel oil (continued)

## Additional information

### Selection of heavy fuel oil

The purpose of the following information is to show the relationship between the quality of heavy fuel oil, heavy fuel oil processing, the engine operation and operating results more clearly.

Economic operation with heavy fuel oil within the limit values specified in the table entitled "*The fuel specification and corresponding properties for heavy fuel oil*" is possible under normal operating conditions, provided the system is working properly and regular maintenance is carried out. If these requirements are not satisfied, shorter maintenance intervals, higher wear and a greater need for spare parts is to be expected. The required maintenance intervals and operating results determine, which quality of heavy fuel oil should be used.

### Viscosity/injection viscosity

It is an established fact that the price advantage decreases as viscosity increases. It is therefore not always economical to use the fuel with the highest viscosity as in many cases the quality of this fuel will not be the best.

Heavy fuel oils with a high viscosity may be of an inferior quality. The maximum permissible viscosity depends on the preheating system installed and the capacity (flow rate) of the separator.

The prescribed injection viscosity of 12 - 14 mm<sup>2</sup>/s (for GenSets, 23/30H and 28/32H: 12 - 18 cSt) and corresponding fuel temperature upstream of the engine must be observed. This is the only way to ensure efficient atomisation and mixture formation and therefore low-residue combustion. This also prevents mechanical overloading of the injection system. For the prescribed injection viscosity and/or the required fuel oil temperature upstream of the engine, refer to the viscosity temperature diagram.

### Heavy fuel oil processing

Whether or not problems occur with the engine in operation depends on how carefully the heavy fuel oil has been processed. Particular care should be taken to ensure that highly-abrasive inorganic foreign matter (catalyst particles, rust, sand) are effectively removed. It has been shown in practice that wear as a result of abrasion in the engine increases considerably if the aluminum and silicon content is higher than 15 mg/kg.

Viscosity and density influence the cleaning effect. This must be taken into account when designing and making adjustments to the cleaning system.

### Settling tank

Heavy fuel oil is precleaned in the settling tank. The longer the fuel remains in the tank and the lower the viscosity of heavy fuel oil is, the more effective the precleaning process will be (maximum preheating temperature of 75 °C to prevent the formation of asphalt in heavy fuel oil). A settling tank is sufficient for heavy fuel oils with a viscosity of less than 380<sup>2</sup>/s at 50 °C. If the heavy fuel oil has a high concentration of foreign matter, or if fuels in accordance with ISO-F-RM, G/H/K380 or H/K700 are to be used, two settling tanks will be required one of which must be sized for 24-hour operation. Before the content is moved to the service tank, water and sludge must be drained from the settling tank.

### Separators

A separator is particularly suitable for separating material with a higher specific density – water, foreign matter and sludge, for example. The separators must be self-cleaning (i.e. the cleaning intervals must be triggered automatically).

Only new generation separators should be used. They are extremely effective throughout a wide density range with no changeover required, and can separate water from heavy fuel oils with a density of up to 1.01 g/ml at 15 °C.

Table "Achievable proportion of foreign matter and water (following separation)" shows the prerequisites that must be met by the separator. These limit values are used by manufacturers as the basis for dimensioning the separator and ensure compliance.

The manufacturer's specifications must be complied with to maximize the cleaning effect.

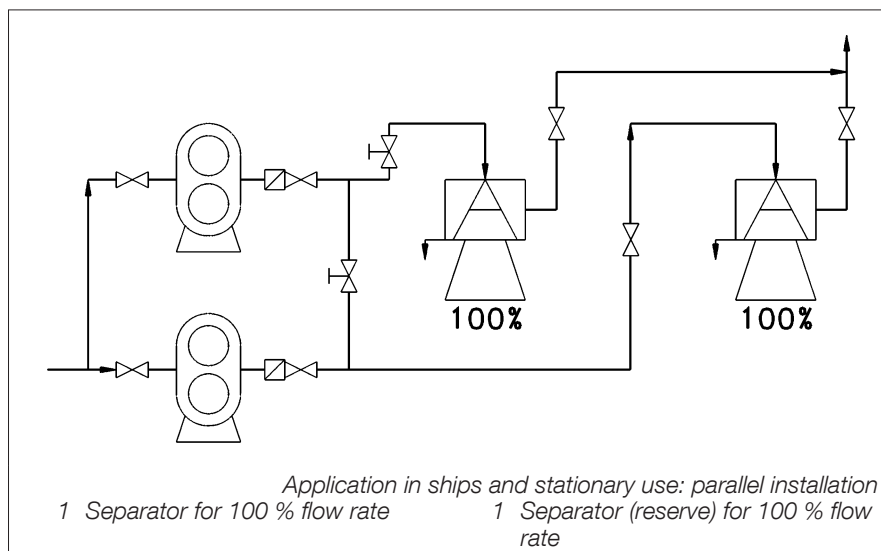


Figure 3: Location of heavy fuel oil cleaning equipment and/or separator

The separators must be arranged according to the manufacturers' current recommendations (Alpha Laval and Westfalia). The density and viscosity of the heavy fuel oil in particular must be taken into account. If separators by other manufacturers are used, MAN Diesel should be consulted.

If processing is carried out in accordance with the MAN Diesel specifications and the correct separators are chosen, it may be assumed that the results stated in the table entitled "Achievable proportion of foreign matter and water" for inorganic foreign matter and water in the heavy fuel oil will be achieved at the engine inlet.

Results obtained during operation in practice show that the wear occurs as a result of abrasion in the injection system and the engine will remain within acceptable limits if these values are complied with. In addition, an optimum lubricating oil treatment process must be ensured.

| Definition  | Particle size | Quantity          |
|---|---------------|-------------------|
| Inorganic foreign matter including catalyst particles | < 5 µm        | < 20 mg/kg        |
| Al+Si content   | --            | < 15 mg/kg        |
| Water content   | --            | < 0.2 % by vol. % |

Table 2: Achievable proportion of foreign matter and water (after separation)

It is particularly important to ensure that the water separation process is as thorough as possible as the water takes the form of large droplets, and not a finely distributed emulsion. In this form, water also promotes corrosion and sludge formation in the fuel system and therefore impairs the supply, atomisation and combustion of the heavy fuel oil. If the water absorbed in the fuel is seawater, harmful sodium chloride and other salts dissolved in this water will enter the engine.

Vanadium/Sodium

Water-containing sludge must be removed from the settling tank before the separation process starts, and must also be removed from the service tank at regular intervals. The tank's ventilation system must be designed in such a way that condensate cannot flow back into the tank.

If the vanadium/sodium ratio is unfavorable, the melting point of the heavy fuel oil ash may fall in the operating area of the exhaust-gas valve which can lead to high-temperature corrosion. Most of the water and water-soluble sodium compounds it contains can be removed by pretreating the heavy fuel oil in the settling tank and in the separators.

The risk of high-temperature corrosion is low if the sodium content is one third of the vanadium content or less. It must also be ensured that sodium does not enter the engine in the form of seawater in the intake air.

If the sodium content is higher than 100 mg/kg, this is likely to result in a higher quantity of salt deposits in the combustion chamber and exhaust-gas system. This will impair the function of the engine (including the suction function of the turbocharger).

Under certain conditions, high-temperature corrosion can be prevented by using a fuel additive that increases the melting point of the heavy fuel oil ash (also see "Additives for heavy fuel oils").

Ash

Fuel ash consists for the greater part of vanadium oxide and nickel sulphate (see above chapter for more information). Heavy fuel oils containing a high proportion of ash in the form of foreign matter, e.g. sand, corrosion compounds and catalyst particles, accelerate the mechanical wear in the engine. Catalyst particles produced as a result of the catalytic cracking process may be present in the heavy fuel oils. In most cases, these are aluminium silicate particles that cause a high degree of wear in the injection system and the engine. The aluminium content determined, multiplied by a factor of between 5 and 8 (depending on the catalytic bond), is roughly the same as the proportion of catalyst remnants in the heavy fuel oil.

Homogeniser

If a homogeniser is used, it must never be installed between the settling tank and separator as otherwise it will not be possible to ensure satisfactory separation of harmful contaminants, particularly seawater.

Flash point (ASTM D 93)

National and international transportation and storage regulations governing the use of fuels must be complied with in relation to the flash point. In general, a flash point of above 60 °C is prescribed for diesel engine fuels.

Low-temperature behaviour (ASTM D 97)

The pour point is the temperature at which the fuel is no longer flowable (pumpable). As the pour point of many low-viscosity heavy fuel oils is higher than 0 °C, the bunker facility must be preheated, unless fuel in accordance with RMA or RMB is used. The entire bunker facility must be designed in such a way that the heavy fuel oil can be preheated to around 10 °C above the pour point.

Pump characteristics

If the viscosity of the fuel is higher than 1000 mm<sup>2</sup>/s (cST), or the temperature is not at least 10 °C above the pour point, pump problems will occur. For more information, also refer to "Low-temperature behaviour (ASTM D 97)".

Combustion properties

If the proportion of asphalt is more than two thirds of the coke residue (Conradson), combustion may be delayed which in turn may increase the formation of combustion residues, leading to such as deposits on and in the injection nozzles, large amounts of smoke, low output, increased fuel consumption and a rapid rise in ignition pressure as well as combustion close to the cylinder wall (thermal overloading of lubricating oil film). If the ratio of asphalt to coke residues reaches the limit 0.66, and if the asphalt content exceeds 8%, the risk of deposits forming in the combustion chamber and injection

## Ignition quality

system is higher. These problems can also occur when using unstable heavy fuel oils, or if incompatible heavy fuel oils are mixed. This would lead to an increased deposition of asphalt (see "Compatibility").

Nowadays, to achieve the prescribed reference viscosity, cracking-process products are used as the low viscosity ingredients of heavy fuel oils although the ignition characteristics of these oils may also be poor. The cetane number of these compounds should be  $> 35$ . If the proportion of aromatic hydrocarbons is high (more than 35 %), this also adversely affects the ignition quality.

The ignition delay in heavy fuel oils with poor ignition characteristics is longer; the combustion is also delayed which can lead to thermal overloading of the oil film at the cylinder liner and also high cylinder pressures. The ignition delay and accompanying increase in pressure in the cylinder are also influenced by the end temperature and compression pressure, i.e. by the compression ratio, the charge-air pressure and charge-air temperature.

The disadvantages of using fuels with poor ignition characteristics can be limited by preheating the charge air in partial load operation and reducing the output for a limited period. However, a more effective solution is a high compression ratio and operational adjustment of the injection system to the ignition characteristics of the fuel used, as is the case with MAN Diesel piston engines.

The ignition quality is one of the most important properties of the fuel. This value does not appear in the international specifications because a standardised testing method has only recently become available and not enough experience has been gathered at this point in order to determine limit values. The parameters, such as the calculated carbon aromaticity index (CCAI), are therefore aids that are derived from quantifiable fuel properties. We have established that this method is suitable for determining the approximate ignition quality of the heavy fuel oil used.

A testing instrument has been developed based on the constant volume combustion method (fuel combustion analyser FCA) and is currently being tested by a series of testing laboratories.

The instrument measures the ignition delay to determine the ignition quality of a fuel and this measurement is converted into an instrument-specific cetane number (FIA-CN or EC). It has been established that in some cases, heavy fuel oils with a low FIA cetane number or ECN number can cause operating problems.

As the liquid components of the heavy fuel oil decisively influence the ignition quality, flow properties and combustion quality, the bunker operator is responsible for ensuring that the quality of heavy fuel oil delivered is suitable for the diesel engine. (Also see illustration entitled "*Nomogram for determining the CCAI – assigning the CCAI ranges to engine types*").

6680 3.3.3-01

Heavy fuel oil (HFO) specification

General



## Sulphuric acid corrosion

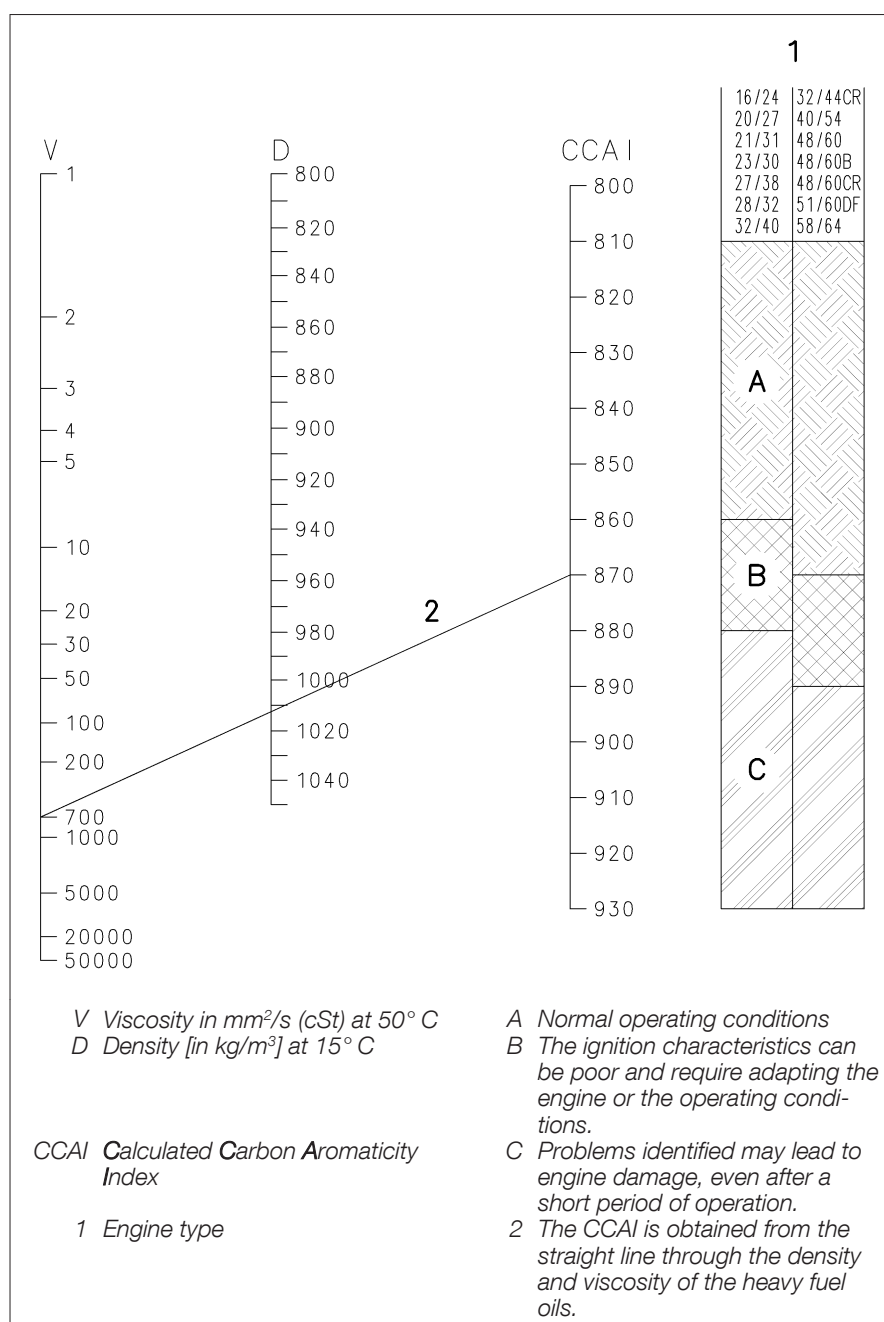


Figure 4: Nomogram for determining the CCAI – assigning the CCAI ranges to engine types

The CCAI can be calculated using the following formula:

$$\text{CCAI} = D - 141 \log \log (V + 0.85) - 81$$

The engine should be operated at the cooling water temperatures prescribed in the operating handbook for the relevant load. If the temperature of the components that are exposed to acidic combustion products is below the acid dew point, acid corrosion can no longer be effectively prevented, even if alkaline lubricating oil is used.

The BN values specified in Section 3.3.6 are sufficient, providing the quality of lubricating oil and the engine's cooling system satisfy the requirements.

**Compatibility**

The supplier must guarantee that the heavy fuel oil is homogeneous and remains stable, even after the standard storage period. If different bunker oils are mixed, this can lead to separation and the associated sludge formation in the fuel system during which large quantities of sludge accumulate in the separator that block filters, prevent atomisation and a large amount of residue as a result of combustion.

This is due to incompatibility or instability of the oils. Therefore heavy fuel oil as much as possible should be removed in the storage tank before bunkering again to prevent incompatibility.

**Blending the heavy fuel oil**

If heavy fuel oil for the main engine is blended with gas oil (MGO) to obtain the required quality or viscosity of heavy fuel oil, it is extremely important that the components are compatible (see "Compatibility").

**Additives for heavy fuel oils**

MAN Diesel & Turbo SE engines can be operated economically without additives. It is up to the customer to decide whether or not the use of additives is beneficial. The supplier of the additive must guarantee that the engine operation will not be impaired by using the product.

The use of heavy fuel oil additives during the warranty period must be avoided as a basic principle.

Additives that are currently used for diesel engines, as well as their probable effects on the engine's operation, are summarised in the table below *"Additives for heavy fuel oils – classification/effects"*.

|                           |  |
|---------------------------|--|
| Precombustion additives   | <ul style="list-style-type: none"> <li>▪ Dispersing agents/stabilisers</li> <li>▪ Emulsion breakers</li> <li>▪ Biocides</li> </ul> |
| Combustion additives      | <ul style="list-style-type: none"> <li>▪ Combustion catalysts (fuel savings, emissions)</li> </ul>                                 |
| Post-combustion additives | <ul style="list-style-type: none"> <li>▪ Ash modifiers (hot corrosion)</li> <li>▪ Soot removers (exhaust-gas system)</li> </ul>    |

Table 3: Additives for heavy fuel oils – Classification/effects

**Heavy fuel oils with low sulphur content**

From the point of view of an engine manufacturer, a lower limit for the sulphur content of heavy fuel oils does not exist. We have not identified any problems with the low-sulphur heavy fuel oils currently available on the market that can be traced back to their sulphur content. This situation may change in future if new methods are used for the production of low-sulphur heavy fuel oil (desulphurisation, new blending components). MAN Diesel & Turbo will monitor developments and inform its customers if required.

If the engine is not always operated with low-sulphur heavy fuel oil, corresponding lubricating oil for the fuel with the highest sulphur content must be selected.

**Improper handling of operating fluids**

If operating fluids are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the supplier of operating fluids must be observed.

**Tests****Sampling**

To check whether the specification provided and/or the necessary delivery conditions are complied with, we recommend you retain at least one sample of every bunker oil (at least for the duration of the engine's warranty period). To ensure that the samples taken are representative of the bunker oil, a sample should be taken from the transfer line when starting up, halfway through the operating period and at the end of the bunker period. "Sample Tec" by Mar-Tec in Hamburg is a suitable testing instrument which can be used to take samples on a regular basis during bunkering.

**Analysis of samples**

Our department for fuels and lubricating oils (Augsburg factory, department EQC) will be pleased to provide further information on request.

We can analyse fuel for customers at our laboratory. A 0.5 l sample is required for the test.

## Diesel oil (MDO) specification

### Marine diesel oil

Other designations

Marine diesel oil, marine diesel fuel.

Origin

Marine diesel oil (MDO) is supplied as heavy distillate (designation ISO-F-DMB) exclusively for marine applications. MDO is manufactured from crude oil and must be free of organic acids and non-mineral oil products.

### Specification

The suitability of fuel depends on the design of the engine and the available cleaning options, as well as compliance with the properties in the following table that refer to the as-delivered condition of the fuel.

The properties are essentially defined using the ISO 8217-2010 standard as the basis. The properties have been specified using the stated test procedures.

| Properties                        | Unit                            | Testing method | Designation     |
|-----------------------------------|---------------------------------|----------------|-----------------|
| ISO-F specification               |                                 |                | DMB             |
| Density at 15 °C                  | kg/m <sup>3</sup>               | ISO 3675       | 900             |
| Kinematic viscosity at 40 °C      | mm <sup>2</sup> /s $\Delta$ cSt | ISO 3104       | > 2,0<br>< 11 * |
| Pour point (winter quality)       | °C                              | ISO 3016       | < 0             |
| Pour point (summer quality)       | °C                              |                | < 6             |
| Flash point (Pensky Martens)      | °C                              | ISO 2719       | > 60            |
| Total sediment content            | % by weight                     | ISO CD 10307   | 0.10            |
| Water content                     | % by vol.                       | ISO 3733       | < 0.3           |
| Sulphur content                   | % by weight                     | ISO 8754       | < 2.0           |
| Ash content                       | % by weight                     | ISO 6245       | < 0.01          |
| Carbon residue (MCR)              | % by weight                     | ISO CD 10370   | < 0.30          |
| Cetane number or cetane index     | -                               | ISO 5165       | > 35            |
| Hydrogen sulphide                 | mg/kg                           | IP 570         | < 2             |
| Acid value                        | mg KOH/g                        | ASTM D664      | < 0.5           |
| Oxidation resistance              | g/m <sup>3</sup>                | ISO 12205      | < 25            |
| Lubricity<br>(wear scar diameter) | $\mu$ m                         | ISO 12156-1    | < 520           |
| Copper strip test                 | -                               | ISO 2160       | < 1             |
| Other specifications:             |                                 |                |                 |
| British Standard BS MA 100-1987   |                                 |                | Class M2        |
| ASTM D 975                        |                                 |                | 2D              |
| ASTM D 396                        |                                 |                | Nr. 2           |

Table 1: Marine diesel oil (MDO) – characteristic values to be adhered to

\* For engines 27/38 with 350 resp. 365 kW/cyl the viscosity must not exceed 6 mm<sup>2</sup>/s @ 40 °C, as this would reduce the lifetime of the injection system.

6680 3.3.2-01

Diesel oil (MDO) specification

General

**Additional information****Lubricity**

During transshipment and transfer, MDO is handled in the same manner as residual oil. This means that it is possible for the oil to be mixed with high-viscosity fuel or heavy fuel oil – with the remnants of these types of fuels in the bunker ship, for example – that could significantly impair the properties of the oil.

Normally, the lubricating ability of diesel oil is sufficient to operate the fuel injection pump. Desulphurisation of diesel fuels can reduce their lubricity. If the sulphur content is extremely low (< 500 ppm or 0.05%), the lubricity may no longer be sufficient. Before using diesel fuels with low sulphur content, you should therefore ensure that their lubricity is sufficient. This is the case if the lubricity as specified in ISO 12156-1 does not exceed 520 µm.

The fuel must be free of lubricating oil (ULO – used lubricating oil, old oil). Fuel is considered as contaminated with lubricating oil when the following concentrations occur:

Ca > 30 ppm and Zn > 15 ppm or Ca > 30 ppm and P > 15 ppm.

The pour point specifies the temperature at which the oil no longer flows. The lowest temperature of the fuel in the system should be roughly 10 °C above the pour point to ensure that the required pumping characteristics are maintained.

A minimum viscosity must be observed to ensure sufficient lubrication in the fuel injection pumps. The temperature of the fuel must therefore not exceed 45 °C.

Seawater causes the fuel system to corrode and also leads to hot corrosion of the exhaust valves and turbocharger. Seawater also causes insufficient atomisation and therefore poor mixture formation accompanied by a high proportion of combustion residues.

Solid foreign matter increase mechanical wear and formation of ash in the cylinder space.

We recommend the installation of a separator upstream of the fuel filter. Separation temperature: 40 – 50°C. Most solid particles (sand, rust and catalyst particles) and water can be removed, and the cleaning intervals of the filter elements can be extended considerably.

**Improper handling of operating fluids**

If operating fluids are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the supplier of operating fluids must be observed.

**Analyses**

We can analyse fuel for customers at our laboratory. A 0.5 l sample is required for the test.

## Gas oil / diesel oil (MGO) specification

### Diesel oil

#### Other designations

Gas oil, marine gas oil (MGO), diesel oil

Gas oil is a crude oil medium distillate and therefore must not contain any residual materials.

### Military specification

Diesel oils that satisfy specification F-75 or F-76 may be used.

### Specification

The suitability of fuel depends on whether it has the properties defined in this specification (based on its composition in the as-delivered state).

The DIN EN 590 and ISO 8217-2010 (Class DMA or Class DMZ) standards have been extensively used as the basis when defining these properties. The properties correspond to the test procedures stated.

| Properties                                   | Unit                     | Test procedure           | Typical value      |
|--|--------------------------|--------------------------|--------------------|
| Density at 15 °C                             | kg/m <sup>3</sup>        | ISO 3675                 | ≥ 820.0<br>≤ 890.0 |
| Kinematic viscosity at 40 °C                 | mm <sup>2</sup> /s (cSt) | ISO 3104                 | ≥ 2<br>≤ 6.0       |
| Filterability*<br>in summer and<br>in winter | °C<br>°C                 | DIN EN 116<br>DIN EN 116 | ≤ 0<br>≤ -12       |
| Flash point in closed cup                    | °C                       | ISO 2719                 | ≥ 60               |
| Sediment content (extraction method)         | weight %                 | ISO 3735                 | ≤ 0.01             |
| Water content                                | Vol. %                   | ISO 3733                 | ≤ 0.05             |
| Sulphur content                              | weight %                 | ISO 8754                 | ≤ 1.5              |
| Ash  |                          | ISO 6245                 | ≤ 0.01             |
| Coke residue (MCR)                           |                          | ISO CD 10370             | ≤ 0.10             |
| Hydrogen sulphide                            | mg/kg                    | IP 570                   | < 2                |
| Acid number                                  | mg KOH/g                 | ASTM D664                | < 0.5              |
| Oxidation stability                          | g/m <sup>3</sup>         | ISO 12205                | < 25               |
| Lubricity<br>(wear scar diameter)            | µm                       | ISO 12156-1              | < 520              |
| Cetane number or cetane index                | -                        | ISO 5165                 | ≥ 40               |
| Copper strip test                            | -                        | ISO 2160                 | ≤ 1                |
| Other specifications:                        |                          |                          |                    |
| British Standard BS MA 100-1987              |                          |                          | M1                 |
| ASTM D 975                                   |                          |                          | 1D/2D              |

Table 1: Diesel fuel (MGO) – properties that must be complied with.

\* The process for determining the filterability in accordance with DIN EN 116 is similar to the process for determining the cloud point in accordance with ISO 3015

### Additional information

#### Use of diesel oil

If distillate intended for use as heating oil is used with stationary engines instead of diesel oil (EL heating oil according to DIN 51603 or Fuel No. 1 or no. 2 according to ASTM D 396), the ignition behaviour, stability and behaviour at low temperatures must be ensured; in other words the requirements for the filterability and cetane number must be satisfied.

#### Viscosity

To ensure sufficient lubrication, a minimum viscosity must be ensured at the fuel pump. The maximum temperature required to ensure that a viscosity of more than 1.9 mm<sup>2</sup>/s is maintained upstream of the fuel pump, depends on the fuel viscosity. In any case, the fuel temperature upstream of the injection pump must not exceed 45 °C.

#### Lubricity

Normally, the lubricating ability of diesel oil is sufficient to operate the fuel injection pump. Desulphurisation of diesel fuels can reduce their lubricity. If the sulphur content is extremely low (< 500 ppm or 0.05%), the lubricity may no longer be sufficient. Before using diesel fuels with low sulphur content, you should therefore ensure that their lubricity is sufficient. This is the case if the lubricity as specified in ISO 12156-1 does not exceed 520 µm.

You can ensure that these conditions will be met by using motor vehicle diesel fuel in accordance with EN 590 as this characteristic value is an integral part of the specification.



### Improper handling of operating fluids

If operating fluids are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the supplier of operating fluids must be observed.

### Analyses

We can analyse fuel for customers at our laboratory. A 0.5 l sample is required for the test.

## Bio fuel specification

### Biofuel

Other designations Biodiesel, FAME, vegetable oil, rapeseed oil, palm oil, frying fat

Origin Biofuel is derived from oil plants or old cooking oil.

### Provision

Transesterified and non-transesterified vegetable oils can be used.

Transesterified biofuels (biodiesel, FAME) must comply with the standard EN 14214.

Non-transesterified biofuels must comply with the specifications listed in Table 1.

These specifications are based on experience to date. As this experience is limited, these must be regarded as recommended specifications that can be adapted if necessary. If future experience shows that these specifications are too strict, or not strict enough, they can be modified accordingly to ensure safe and reliable operation.

When operating with bio-fuels, lubricating oil that would also be suitable for operation with diesel oil (see Sheet 3.3.5) must be used.

| Properties/Characteristics   | Unit  | Test method                      |
|------------------------------|---|----------------------------------|
| Density at 15 °C             | 900 - 930 kg/m <sup>3</sup>                             | DIN EN ISO 3675,<br>EN ISO 12185 |
| Flash point                  | > 60 °C   | DIN EN 22719                     |
| lower calorific value        | > 35 MJ/kg<br>(typical: 37 MJ/kg)                       | DIN 51900-3                      |
| Viscosity/50 °C              | < 40 cSt (corresponds to a viscosity/40 °C of < 60 cSt) | DIN EN ISO 3104                  |
| Cetane number                | > 40  | FIA                              |
| Coke residue                 | < 0.4%  | DIN EN ISO 10370                 |
| Sediment content             | < 200 ppm   | DIN EN 12662                     |
| Oxidation stability (110 °C) | > 5 h   | ISO 6886                         |
| Phosphorous content          | < 15 ppm  | ASTM D3231                       |
| Na and K content             | < 15 ppm  | DIN 51797-3                      |
| Ash content                  | < 0.01%   | DIN EN ISO 6245                  |
| Water content                | < 0.5%  | EN ISO 12537                     |
| Iodine number                | < 125g/100g   | DIN EN 14111                     |
| TAN (total acid number)      | < 5 mg KOH/g  | DIN EN ISO 660                   |
| Filterability                | < 10 °C below the lowest temperature in the fuel system | EN 116                           |

Table 1: Non-transesterified bio-fuel - Specifications



**DANGER****Improper handling of operating fluids**

If operating fluids are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the supplier of operating fluids must be observed.

**Analyses**

We can analyse fuel for customers at our laboratory. A 0.5 l sample is required for the test.

## Viscosity-temperature diagram (VT diagram)

### Explanations of viscosity-temperature diagram

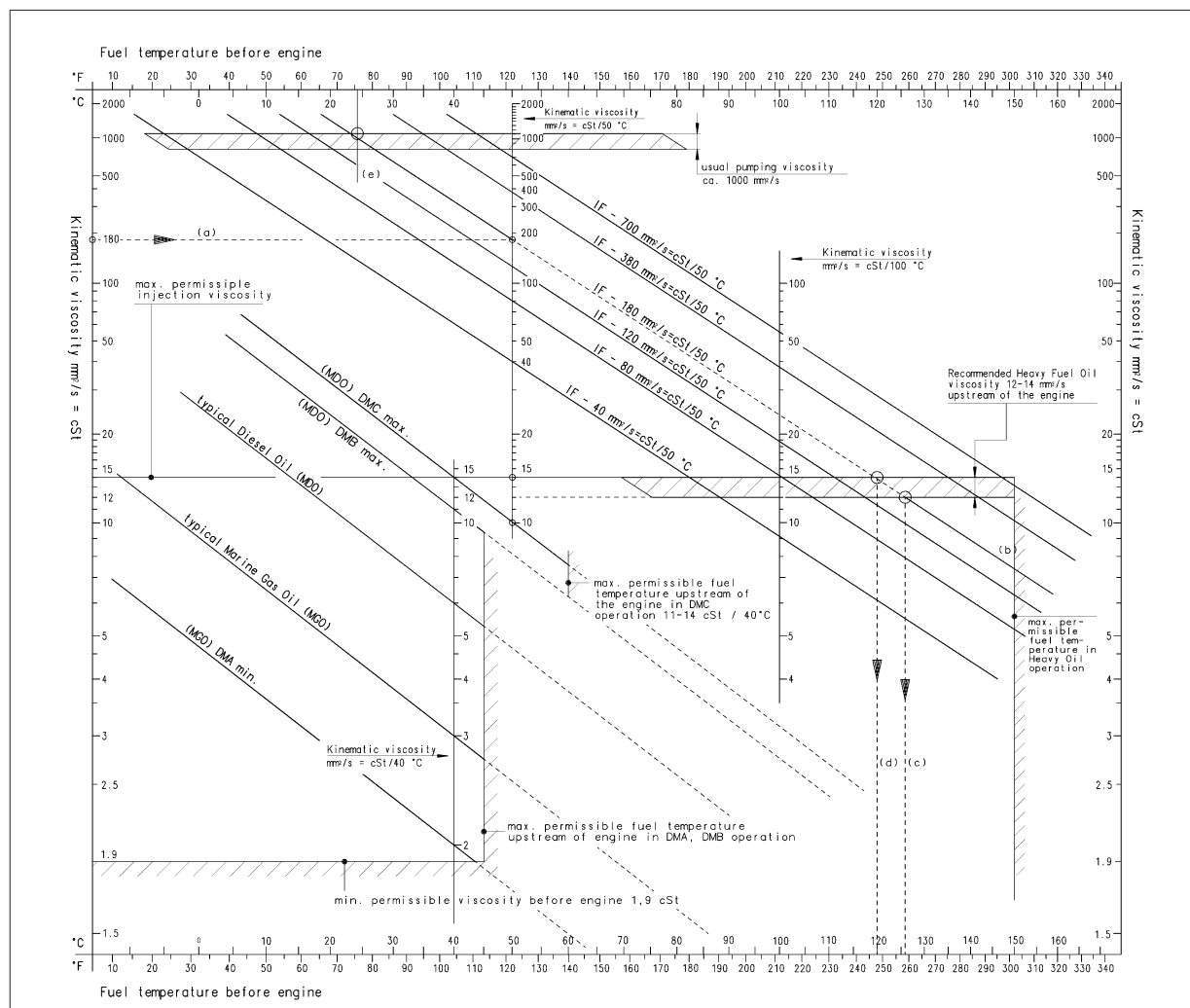


Figure 1: Viscosity-temperature diagram (VT diagram)

In the diagram, the fuel temperatures are shown on the horizontal axis and the viscosity is shown on the vertical axis.

The diagonal lines correspond to viscosity-temperature curves of fuels with different reference viscosities. The vertical viscosity axis in  $\text{mm}^2/\text{s}$  (cSt) applies for 40, 50 or 100 °C.

### Determining the viscosity-temperature curve and the required preheating temperature

Example: Heavy fuel oil with  $180 \text{ mm}^2/\text{s}$  at  $50 \text{ °C}$

| Prescribed injection viscosity in $\text{mm}^2/\text{s}$ | Required temperature of heavy fuel oil at engine inlet* in °C |
|--|---|
| $\geq 12$  | 126 (line c)  |
| $\leq 14$  | 119 (line d)  |

Table 1: Determining the viscosity-temperature curve and the required preheating temperature

Viscosity-temperature diagram (VT diagram)

Viscosity-temperature diagram (VT diagram)

General

\* With these figures, the temperature drop between the last preheating device and the fuel injection pump is not taken into account.

A heavy fuel oil with a viscosity of 180 mm<sup>2</sup>/s at 50 °C can reach a viscosity of 1000 mm<sup>2</sup>/s at 24 °C (line e) – this is the maximum permissible viscosity of fuel that the pump can deliver.

A heavy fuel oil discharge temperature of 152 °C is reached when using a recent state-of-the-art preheating device with 8 bar saturated steam. At higher temperatures there is a risk of residues forming in the preheating system – this leads to a reduction in heating output and thermal overloading of the heavy fuel oil. Asphalt is also formed in this case, i.e. quality deterioration.

The heavy fuel oil lines between the outlet of the last preheating system and the injection valve must be suitably insulated to limit the maximum drop in temperature to 4 °C. This is the only way to achieve the necessary injection viscosity of 14 mm<sup>2</sup>/s for heavy fuel oils with a reference viscosity of 700 mm<sup>2</sup>/s at 50 °C (the maximum viscosity as defined in the international specifications such as ISO CIMAC or British Standard). If heavy fuel oil with a low reference viscosity is used, the injection viscosity should ideally be 12 mm<sup>2</sup>/s in order to achieve more effective atomisation to reduce the combustion residue.

The delivery pump must be designed for heavy fuel oil with a viscosity of up to 1 000 mm<sup>2</sup>/s. The pour point also determines whether the pump is capable of transporting the heavy fuel oil. The bunker facility must be designed so as to allow the heavy fuel oil to be heated to roughly 10 °C above the pour point.

## NOTICE

### Viscosity

The viscosity of gas oil or diesel oil (marine diesel oil) upstream of the engine must be at least 1.9 mm<sup>2</sup>/s. If the viscosity is too low, this may cause seizing of the pump plunger or nozzle needle valves as a result of insufficient lubrication.

This can be avoided by monitoring the temperature of the fuel. Although the maximum permissible temperature depends on the viscosity of the fuel, it must never exceed the following values:

- 45 °C at the most with MGO (DMA) and MDO (DMB) and
- 60 °C at the most with MDO (DMC).

A fuel cooler must therefore be installed.

If the viscosity of the fuel is < 2 cSt at 40 °C, consult the technical service of MAN Diesel & Turbo SE in Augsburg.

|                           |                          |                              |
|---------------------------|--------------------------|------------------------------|
| Description<br>Page 1 (2) | <b>Fuel Oil Cleaning</b> | <b>604.30</b><br>Edition 01H |
|---------------------------|--------------------------|------------------------------|

## General

### Purification Recommendations.

Fuel oils are always contaminated and should therefore be thoroughly cleaned for solid as well as liquid contaminants before use. The solid contaminants in the fuel are mainly rust, sand, dust and re-finery catalysts. Liquid contaminants are mainly water, i.e. either fresh water or salt water.

The impurities can cause damage to fuel pumps and fuel valves, can result in increased cylinder liner wear and deteriorate the exhaust valve seats. Also increased fouling of gas ways and turbocharger blends may result from the use of inadequately cleaned fuel oils.

Effective cleaning can only be ensured by means of a centrifuge. We recommend the capacity of the installed centrifuges to be at least according to the centrifuging maker's recommendations. To obtain optimum cleaning it is of the utmost importance to operate the centrifuge with as low a viscosity of the fuel oil as possible and allow the fuel oil to remain in the centrifuge bowl as long time as possible.

Especially for fuels above 180 cST/50°C (1500 sec. RW/100°F) the highest possible temperature 98°C (208°F) should be maintained in the centrifuge oil preheater.

The fuel is kept in the centrifuge as long as possible by adjusting the flow rate through the centrifuge so that it corresponds to the amount of fuel required by the engine without excessive re-circulating. Consequently, the centrifuge should operate for 24 hours a day except during necessary cleaning.

Taking today's fuel qualities into consideration the need for cleaning centrifuges ("shooting frequency") should not be underestimated. Correct choice and adjustment of the regulating screws and/or the gravity discs are of special importance for efficient water removal. The centrifuge manual states the disc or screw adjustment which should be chosen on the basis of the specific gravity of the fuel.

Normal practice is to have at least two centrifuges available for fuel cleaning. Results from experimental work on centrifuges, treating today's qualities of residual fuel, have shown that the best cleaning effect, especially as regards removal of catalyst fines is achieved when the centrifuges are operated in series, in purifier/clarifier mode.

Therefore - series operation of centrifuges ensuring a maximum of safety is a fully accepted alternative to the previously recommended parallel operation, provided the operating capacity of each individual centrifuge can handle the total amount of fuel required by the engine, without exceeding the flow rate recommended by the centrifuge maker for the operating mode in question.

If the installed centrifuge capacity is on the low side corresponding to the specific viscosity of the used fuel oil and if more than one centrifuge is available, parallel operation in order to obtain an even lower flow rate may be considered. However, in view of the above results and recommendations serious considerations should be given to installing new equipment in correspondance with today's fuel qualities and flow recommendation.

| Cleaning of H.F.O. by Centrifuging |  |   |
|------------------------------------|--|---|
| Operating options                  | Single centrifuge as purifier.<br>Two centrifuges in parallel.<br>Two centrifuges in series. |   |
| Optimum operating configurations   |  |   |
| Normal conditions                  | Water content<br>below 1 %   | Parallel operation<br>Purifier / Purifier<br>or |
|                                    | Density at 15°C<br>below 0.991   | Series operation<br>Purifier + Clarifier        |
| Extreme conditions                 | Water content<br>below 1 %   | Parallel operation                              |
|                                    | Density at 15°C<br>below 0.991   | Purifier / Purifier                             |
|                                    | High content<br>of catalyst fines  | Series operation<br>Purifier + Clarifier        |

Table 1. Cleaning of HFO.

## General

For the determination of centrifuging capacity, we generally advise to follow the recommendations of the centrifuge maker, but the curves on fig. 1, can be used as a guidance.

A Homogenizer may be installed in the fuel oil system as a supplement to the centrifuges to homogenize possible water and sludge still present in the fuel after centrifuging.

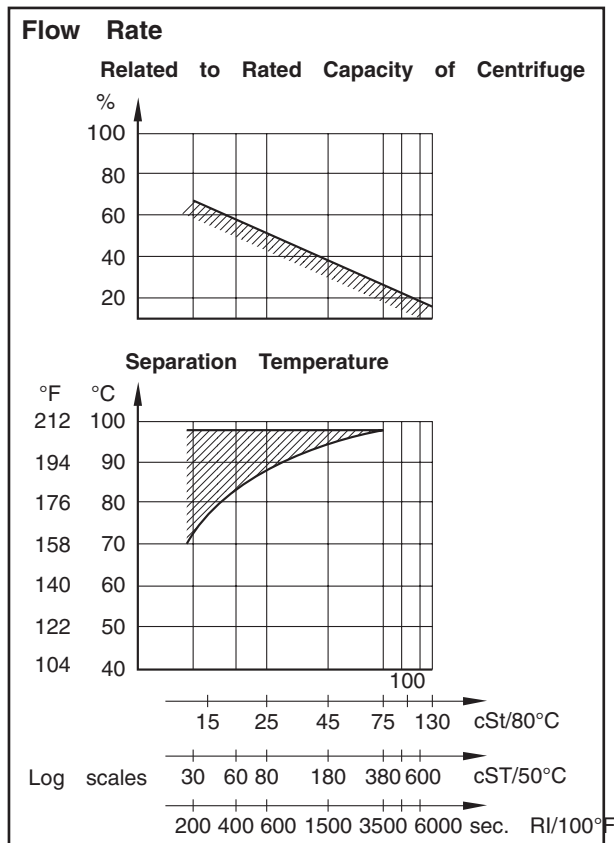


Fig. 1. Flowrate through centrifuge related to nominal capacity of centrifuge.

## Engine cooling water specifications

### Preliminary remarks

As is also the case with the fuel and lubricating oil, the engine cooling water must be carefully selected, handled and checked. If this is not the case, corrosion, erosion and cavitation may occur at the walls of the cooling system in contact with water and deposits may form. Deposits obstruct the transfer of heat and can cause thermal overloading of the cooled parts. The system must be treated with an anticorrosive agent before bringing it into operation for the first time. The concentrations prescribed by the engine manufacturer must always be observed during subsequent operation. The above especially applies if a chemical additive is added.

### Requirements

#### Limit values

The properties of untreated cooling water must correspond to the following limit values:

| Properties/Characteristic | Properties  | Unit   |
|---------------------------|---|--------|
| Water type                | Distillate or fresh water, free of foreign matter. The following are prohibited: Seawater, brackish water, river water, brines, industrial waste water and rainwater. | -      |
| Total hardness            | max. 10   | °dH*   |
| pH value                  | 6.5 - 8   | -      |
| Chloride ion content      | Max. 50   | mg/l** |

Table 1: Cooling water - properties to be observed

\*) 1°dH (German hardness)  $\triangleq$  10 mg CaO in 1 litre of water  $\triangleq$  17.9 mg CaCO<sub>3</sub>/l

$\triangleq$  0.357 mval/l  $\triangleq$  0.179 mmol/l

\*\*) 1 mg/l  $\triangleq$  1 ppm

#### Testing equipment

The MAN Diesel water testing equipment incorporates devices that determine the water properties referred to above in a straightforward manner. The manufacturers of anticorrosive agents also supply user-friendly testing equipment. For information on monitoring cooling water, refer to Work Card 000.07.

### Additional information

#### Distillate

If distilled water (from a fresh water generator, for example) or fully desalinated water (from ion exchange or reverse osmosis) is available, this should ideally be used as the engine cooling water. These waters are free of lime and salts which means that deposits that could interfere with the transfer of heat to the cooling water, and therefore also reduce the cooling effect, cannot form. However, these waters are more corrosive than normal hard water as the thin film of lime scale that would otherwise provide temporary corrosion protection does not form on the walls. This is why distilled water must be handled particularly carefully and the concentration of the additive must be regularly checked.

**Hardness**

The total hardness of the water is the combined effect of the temporary and permanent hardness. The proportion of calcium and magnesium salts is of overriding importance. The temporary hardness is determined by the carbonate content of the calcium and magnesium salts. The permanent hardness is determined by the amount of remaining calcium and magnesium salts (sulphates). The temporary (carbonate) hardness is the critical factor that determines the extent of limescale deposit in the cooling system.

Water with a total hardness of  $> 10^{\circ}\text{dGH}$  must be mixed with distilled water or softened. Subsequent hardening of extremely soft water is only necessary to prevent foaming if emulsifiable slushing oils are used.

**Damage to the cooling water system****Corrosion**

Corrosion is an electrochemical process that can widely be avoided by selecting the correct water quality and by carefully handling the water in the engine cooling system.

**Flow cavitation**

Flow cavitation can occur in areas in which high flow velocities and high turbulence is present. If the steam pressure is reached, steam bubbles form and subsequently collapse in high pressure zones which causes the destruction of materials in constricted areas.

**Erosion**

Erosion is a mechanical process accompanied by material abrasion and the destruction of protective films by solids that have been drawn in, particularly in areas with high flow velocities or strong turbulence.

**Stress corrosion cracking**

Stress corrosion cracking is a failure mechanism that occurs as a result of simultaneous dynamic and corrosive stress. This may lead to cracking and rapid crack propagation in water-cooled, mechanically-loaded components if the cooling water has not been treated correctly.

**Processing of engine cooling water****Formation of a protective film**

The purpose of treating the engine cooling water using anticorrosive agents is to produce a continuous protective film on the walls of cooling surfaces and therefore prevent the damage referred to above. In order for an anticorrosive agent to be 100 % effective, it is extremely important that untreated water satisfies the requirements in the Section *Requirements*.

Protective films can be formed by treating the cooling water with an anticorrosive chemical or an emulsifiable slushing oil.

Emulsifiable slushing oils are used less and less frequently as their use has been considerably restricted by environmental protection regulations, and because they are rarely available from suppliers for this and other reasons.

**Treatment prior to initial commissioning of engine**

Treatment with an anticorrosive agent should be carried out before the engine is brought into operation for the first time to prevent irreparable initial damage.

**Treatment of the cooling water**

The engine must not be brought into operation without treating the cooling water first.

## Additives for cooling water

### Required approval

Only the additives approved by MAN Diesel and listed in the tables under the section entitled *"Approved cooling water additives"* may be used.

A cooling water additive may only be permitted for use if tested and approved as per the latest directives of the ICE Research Association (FVV) "Suitability test of internal combustion engine cooling fluid additives." The test report must be obtainable on request. The relevant tests can be carried out on request in Germany at the staatliche Materialprüfanstalt (Federal Institute for Materials Research and Testing), Abteilung Oberflächentechnik (Surface Technology Division), Grafenstraße 2 in D-64283 Darmstadt.

Once the cooling water additive has been tested by the FVV, the engine must be tested in the second step before the final approval is granted.

### Only in closed circuits

Additives may only be used in closed circuits where no significant consumption occurs, apart from leaks or evaporation losses.

### Chemical additives

Sodium nitrite and sodium borate based additives etc. have a proven track record. Galvanised iron pipes or zinc sacrificial anodes must not be used in cooling systems. This corrosion protection is not required due to the prescribed cooling water treatment and electrochemical potential reversal can occur due to the cooling water temperatures which are normally present in engines nowadays. If necessary, the pipes must be deplated.

### Slushing oil

This additive is an emulsifiable mineral oil with added slushing ingredients. A thin film of oil forms on the walls of the cooling system. This prevents corrosion without interfering with the transfer of heat and also prevents limescale deposits on the walls of the cooling system.

The significance of emulsifiable corrosion-slushing oils is fading. Oil-based emulsions are rarely used nowadays for environmental protection reasons and also because stability problems are known to occur in emulsions.

### Anti-freeze agents

If temperatures below the freezing point of water in the engine cannot be excluded, an anti-freeze solution that also prevents corrosion must be added to the cooling system or corresponding parts. Otherwise, the entire system must be heated. (Military specification: Sy-7025).

Sufficient corrosion protection can be provided by adding the products listed in the table entitled *"Anti-freeze solutions with slushing properties"* while observing the prescribed concentration. This concentration prevents freezing at temperatures down to -22 °C. However, the quantity of anti-freeze solution actually required always depends on the lowest temperatures that are to be expected at the place of use.

Anti-freezes are generally based on ethylene glycol. A suitable chemical anti-corrosive agent must be added if the concentration of the anti-freeze solution prescribed by the user for a specific application does not provide an appropriate level of corrosion protection, or if the concentration of anti-freeze solution used is lower due to less stringent frost protection requirements and does not provide an appropriate level of corrosion protection. For information on the compatibility of the anti-freeze solution with the anticorrosive agent



and the required concentrations, contact the manufacturer. As regards the chemical additives indicated in the table „*Nitrite-Containing Chemical Additives*“, their compatibility with ethylene glycol-based antifreezes has been proved. Anti-freeze solutions may only be mixed with one another with the consent of the manufacturer, even if these solutions have the same composition.

Before an anti-freeze solution is used, the cooling system must be thoroughly cleaned.

If the cooling water contains an emulsifiable slushing oil, anti-freeze solution must not be added as otherwise the emulsion would break up and oil sludge would form in the cooling system.

Observe the applicable environmental protection regulations when disposing of cooling water containing additives. For more information, consult the additive supplier.

### Biocides

If you cannot avoid using a biocide because the cooling water has been contaminated by bacteria, observe the following steps:

- You must ensure that the biocide to be used is suitable for the specific application.
- The biocide must be compatible with the sealing materials used in the cooling water system and must not react with these.
- The biocide and its decomposition products must not contain corrosion-promoting components. Biocides whose decomposition products contain chloride or sulphate ions are not permitted.
- Biocides that cause foaming of cooling water are not permitted.

## Prerequisite for effective use of an anticorrosive agent

### Clean cooling system

As contamination significantly reduces the effectiveness of the additive, the tanks, pipes, coolers and other parts outside the engine must be free of rust and other deposits before the engine is started up for the first time and after repairs are carried out on the pipe system. The entire system must therefore be cleaned with the engine switched off using a suitable cleaning agent (see Work Cards 000.03 and 000.08 by MAN Diesel).

Loose solid matter in particular must be removed by flushing the system thoroughly as otherwise erosion may occur in locations where the flow velocity is high.

The cleaning agents must not corrode the seals and materials of the cooling system. In most cases, the supplier of the cooling water additive will be able to carry out this work and, if this is not possible, will at least be able to provide suitable products to do this. If this work is carried out by the engine operator, he should use the services of a specialist supplier of cleaning agents. The cooling system must be flushed thoroughly following cleaning. Once this has been done, the engine cooling water must be treated immediately with anticorrosive agent. Once the engine has been brought back into operation, the cleaned system must be checked for leaks.

### Regular checks of the cooling water condition and cooling water system

Treated cooling water may become contaminated when the engine is in operation, which causes the additive to lose some of its effectiveness. It is therefore advisable to regularly check the cooling system and the cooling water condition. To determine leakages in the lube oil system, it is advisable to carry out regular checks of water in the compensating tank. Indications of oil content in water are, e.g. discoloration or a visible oil film on the surface of the water sample.

The additive concentration must be checked at least once a week using the test kits specified by the manufacturer. The results must be documented.

#### NOTICE

### Concentrations of chemical additives

The chemical additive concentrations shall not be less than the minimum concentrations indicated in the table „*Nitrite-containing chemical additives*“.

Excessively low concentrations can promote corrosion and must be avoided. If the concentration is slightly above the recommended concentration this will not result in damage. Concentrations that are more than twice the recommended concentration should be avoided.

Every 2 to 6 months send a cooling water sample to an independent laboratory or to the engine manufacturer for integrated analysis.

Emulsifiable anticorrosive agents must generally be replaced after abt. 12 months according to the supplier's instructions. When carrying this out, the entire cooling system must be flushed and, if necessary, cleaned. Once filled into the system, fresh water must be treated immediately.

If chemical additives or anti-freeze solutions are used, cooling water should be replaced after 3 years at the latest.

If there is a high concentration of solids (rust) in the system, the water must be completely replaced and entire system carefully cleaned.

Deposits in the cooling system may be caused by fluids that enter the cooling water, or the break up of emulsion, corrosion in the system and limescale deposits if the water is very hard. If the concentration of chloride ions has increased, this generally indicates that seawater has entered the system. The maximum specified concentration of 50 mg chloride ions per kg must not be exceeded as otherwise the risk of corrosion is too high. If exhaust gas enters the cooling water, this may lead to a sudden drop in the pH value or to an increase in the sulphate content.

Water losses must be compensated for by filling with untreated water that meets the quality requirements specified in the section **Requirements**. The concentration of the anticorrosive agent must subsequently be checked and adjusted if necessary.

Subsequent checks of cooling water are especially required if the cooling water had to be drained off in order to carry out repairs or maintenance.

## Protective measures

Anticorrosive agents contain chemical compounds that can pose a risk to health or the environment if incorrectly used. Comply with the directions in the manufacturer's material safety data sheets.

Avoid prolonged direct contact with the skin. Wash hands thoroughly after use. If larger quantities spray and/or soak into clothing, remove and wash clothing before wearing it again.

If chemicals come into contact with your eyes, rinse them immediately with plenty of water and seek medical advice.

Anticorrosive agents are generally harmful to the water cycle. Observe the relevant statutory requirements for disposal.

## Auxiliary engines

If the same cooling water system used in a MAN Diesel & Turbo two-stroke main engine is used in a marine engine of type 16/24, 21/31, 23/30H, 27/38 or 28/32H, the cooling water recommendations for the main engine must be observed.

## Analysis

We analyse cooling water for our customers in our chemical laboratory. A 0.5 l sample is required for the test.

## Permissible cooling water additives

### Nitrite-containing chemical additives

| Manufacturer   | Product designation   | Initial dosing for 1,000 litres | Minimum concentration ppm |                            |                                 |
|--|---|---------------------------------|---------------------------|----------------------------|---------------------------------|
|  |   |                                 | Product                   | Nitrite (NO <sub>2</sub> ) | Na-Nitrite (NaNO <sub>2</sub> ) |
| Drew Marine<br>One Drew Plaza<br>Boonton<br>New Jersey 07005<br>USA              | Liquidewt<br>Maxigard   | 15 l                            | 15,000                    | 700                        | 1,050                           |
|  |   | 40 l                            | 40,000                    | 1,330                      | 2,000                           |
| Wilhelmsen (Unitor)<br>KJEMI-Service A.S.<br>P.O.Box 49/Norway<br>3140 Borgheim  | Rocor NB Liquid<br>Dieselguard                                      | 21.5 l                          | 21,500                    | 2,400                      | 3,600                           |
|  |   | 4.8 kg                          | 4,800                     | 2,400                      | 3,600                           |
| Nal fleet Marine<br>Chemicals<br>P.O.Box 11<br>Northwich<br>Cheshire CW8DX, U.K. | Nal fleet EWT Liq<br>(9-108)<br>Nal fleet EWT 9-111<br>Nalcool 2000 | 3 l                             | 3,000                     | 1,000                      | 1,500                           |
|  |   | 10 l                            | 10,000                    | 1,000                      | 1,500                           |
|  |   | 30 l                            | 30,000                    | 1,000                      | 1,500                           |
| Nalco  | Nalcool 2000<br>TRAC 102<br>TRAC 118                                | 30 l                            | 30,000                    | 1,000                      | 1,500                           |
|  |   | 30 l                            | 30,000                    | 1,000                      | 1,500                           |
|  |   | 3 l                             | 3,000                     | 1,000                      | 1,500                           |
| Maritech AB<br>P.O.Box 143<br>S-29122 Kristianstad                               | Marisol CW  | 12 l                            | 12,000                    | 2,000                      | 3,000                           |

| Manufacturer  | Product designation     | Initial dosing for 1,000 litres | Minimum concentration ppm |                            |                                 |
|---|-------------------------|---------------------------------|---------------------------|----------------------------|---------------------------------|
|   |                         |                                 | Product                   | Nitrite (NO <sub>2</sub> ) | Na-Nitrite (NaNO <sub>2</sub> ) |
| Uniservice<br>Via al Santuario di N.S.<br>della Guardia 58/A<br>16162 Genova, Italy | N.C.L.T.                | 12 l                            | 12,000                    | 2,000                      | 3,000                           |
|   | Colorcooling            | 24 l                            | 24,000                    | 2,000                      | 3,000                           |
| Marichem – Marigases<br>64 Sfaktirias Street<br>18545 Piraeus, Griechenland         | D.C.W.T. - Non-Chromate | 48 l                            | 48,000                    | 2,400                      | -                               |
| Marine Care<br>3144 NA Maasluis<br>The Netherlands                                  | Caretreat 2             | 16 l                            | 16,000                    | 4,000                      | 6,000                           |
| Vecom<br>Schlenzigstraße 7<br>21107 Hamburg<br>Deutschland                          | Cool Treat NCLT         | 16 l                            | 16,000                    | 4,000                      | 6,000                           |

Table 2: Nitrite-containing chemical additives

**Nitrite-free additives (chemical additives)**

| Manufacturer  | Product designation              | Initial dosing for 1 000 litres | Minimum concentration |
|---|----------------------------------|---------------------------------|-----------------------|
| Arteco<br>Technologiepark<br>Zwijnaarde 2<br>B-9052 Gent, Belgium | Havoline XLI                     | 75 l                            | 7.5 %                 |
| Total Lubricants<br>Paris, France                                 | WT Supra                         | 75 l                            | 7.5 %                 |
| Q8 Oils   | Q8 Corrosion Inhibitor Long-Life | 75 l                            | 7.5 %                 |

Table 3: Chemical additives - nitrite free

**Emulsifiable slushing oils**

| Manufacturer  | Product (designation) |
|---|-----------------------|
| BP Marine, Breakspear Way, Hemel Hempstead, Herts HP2 4UL | Diatsol M<br>Fedaro M |
| Castrol Int., Pipers Way, Swindon SN3 1RE, UK             | Solvex WT 3           |
| Deutsche Shell AG, Überseering 35, 22284 Hamburg, Germany | Oil 9156              |

Table 4: Emulsifiable slushing oils

**Anti-freeze solutions with slushing properties**

| Manufacturer   | Product designation                                | Minimum concentration |
|--|--|-----------------------|
| BASF<br>Carl-Bosch-Str.<br>67063 Ludwigshafen,<br>Rhein<br>Deutschland | Glysantin G 48<br>Glysantin 9313<br>Glysantin G 05 | 35%                   |
| Castrol Int.<br>Pipers Way<br>Swindon SN3 1RE, UK                      | Antifreeze NF, SF                                  |                       |
| BP, Britannic Tower<br>Moor Lane,<br>London EC2Y 9B, UK                | Anti-frost X2270A                                  |                       |
| Deutsche Shell AG<br>Überseering 35<br>22284 Hamburg<br>Deutschland    | Glycoshell   |                       |
| Mobil Oil AG<br>Steinstraße 5<br>20095 Hamburg<br>Deutschland          | Frostschutz 500                                    |                       |
| Arteco, Technologiepark<br>Zwijnaarde 2<br>B-9052 Gent, Belgium        | Havoline XLC                                       |                       |
| Total Lubricants<br>Paris, France                                      | Glacelf Auto Supra<br>Total Organifreeze           |                       |

Table 5: Anti-freeze solutions with slushing properties

## Cooling water inspecting

### Summary

Acquire and check typical values of the operating media to prevent or limit damage.

The fresh water used to fill the cooling water circuits must satisfy the specifications. The cooling water in the system must be checked regularly in accordance with the maintenance schedule.

The following work/steps is/are necessary:

Acquisition of typical values for the operating fluid,  
evaluation of the operating fluid and checking the concentration of the anti-corrosive agent.

### Tools/equipment required

Equipment for checking the fresh water quality

The following equipment can be used:

- The MAN Diesel & Turbo water testing kit, or similar testing kit, with all necessary instruments and chemicals that determine the water hardness, pH value and chloride content (obtainable from MAN Diesel & Turbo or Mar-Tec Marine, Hamburg)

Equipment for testing the concentration of additives

When using chemical additives:

- Testing equipment in accordance with the supplier's recommendations. Testing kits from the supplier also include equipment that can be used to determine the fresh water quality.

### Testing the typical values of water

Short specification

| Typical value/property | Water for filling and refilling (without additive) | Circulating water (with additive) |
|------------------------|--|-----------------------------------|
| Water type             | Fresh water, free of foreign matter                | Treated cooling water             |
| Total hardness         | $\leq 10^\circ\text{dGH}^{1)}$                     | $\leq 10^\circ\text{dGH}^{1)}$    |
| pH value               | 6.5 - 8 at 20 °C                                   | $\geq 7.5$ at 20 °C               |
| Chloride ion content   | $\leq 50 \text{ mg/l}$                             | $\leq 50 \text{ mg/l}^{2)}$       |

Table 1: Quality specifications for cooling water (abbreviated version)

<sup>1)</sup> dGH German hardness

$1^\circ\text{dGh}$  = 10 mg/l CaO  
= 17.9 mg/l  $\text{CaCO}_3$   
= 0.179 mmol/L

<sup>2)</sup> 1mg/l = 1 ppm

## Testing the concentration of anticorrosive agents

### Short specification

| Anticorrosive agent | Concentration  |
|---------------------|--|
| Chemical additives  | according to the quality specification in Volume 010.005 Engine - Operating Instructions, Chapter 3, Sheet 3.3.7 |
| Anti-freeze agents  | according to the quality specification in Volume 010.005 Engine - Operating Instructions, Chapter 3, Sheet 3.3.7 |

Table 2: Concentration of the cooling water additive

### Testing the concentration of chemical additives

The concentration should be tested every week, and/or according to the maintenance schedule, using the testing instruments, reagents and instructions of the relevant supplier.

Chemical slushing oils can only provide effective protection if the right concentration is precisely maintained. This is why the concentrations recommended by MAN Diesel & Turbo (quality specifications in Volume 010.005 Engine – Operating Instructions, Chapter 3, Page 3.3.7) must be complied with in all cases. These recommended concentrations may be other than those specified by the manufacturer.

### Testing the concentration of anti-freeze agents

The concentration must be checked in accordance with the manufacturer's instructions or the test can be outsourced to a suitable laboratory. If in doubt, consult MAN Diesel & Turbo.

### Regular water samplings

Small quantities of lubricating oil in cooling water can be found by visual check during regular water sampling from the expansion tank.

### Testing

We test cooling water for customers in our laboratory. To carry out the test, we will need a representative sample of abt. 0.5 l.

## Cooling water system Cleaning

### Summary

Remove contamination/residue from operating fluid systems, ensure/re-establish operating reliability.

Cooling water systems containing deposits or contamination prevent effective cooling of parts. Contamination and deposits must be regularly eliminated.

This comprises the following:  
Cleaning the system and, if required,  
removal of limescale deposits,  
flushing the system.

### Cleaning

The cooling water system must be checked for contamination at regular intervals. Cleaning is required if the degree of contamination is high. This work should ideally be carried out by a specialist who can provide the right cleaning agents for the type of deposits and materials in the cooling circuit. The cleaning should only be carried out by the engine operator if this cannot be done by a specialist.

### Oil sludge

Oil sludge from lubricating oil that has entered the cooling system or a high concentration of anticorrosive agents can be removed by flushing the system with fresh water to which some cleaning agent has been added. Suitable cleaning agents are listed alphabetically in the table entitled "*Cleaning agents for removing oil sludge*". Products by other manufacturers can be used providing they have similar properties. The manufacturer's instructions for use must be strictly observed.

| Manufacturer | Product                  | Concentration | Duration of cleaning procedure/temperature |
|--------------|--------------------------|---------------|--|
| Drew         | HDE - 777                | 4 - 5%        | 4 h at 50 – 60 °C                          |
| Nalfleet     | MaxiClean 2              | 2 - 5%        | 4 h at 60 °C                               |
| Unitor       | Aquabreak                | 0.05 – 0.5%   | 4 h at ambient temperature                 |
| Vecom        | Ultrasonic Multi Cleaner | 4%            | 12 h at 50 – 60 °C                         |

Table 1: Cleaning agents for removing oil sludge

### Lime and rust deposits

Lime and rust deposits can form if the water is especially hard or if the concentration of the anticorrosive agent is too low. A thin lime scale layer can be left on the surface as experience has shown that this protects against corrosion. However, limescale deposits with a thickness of more than 0.5 mm obstruct the transfer of heat and cause thermal overloading of the components being cooled.

Rust that has been flushed out may have an abrasive effect on other parts of the system, such as the sealing elements of the water pumps. Together with the elements that are responsible for water hardness, this forms what is known as ferrous sludge which tends to gather in areas where the flow velocity is low.

Products that remove limescale deposits are generally suitable for removing rust. Suitable cleaning agents are listed alphabetically in the table entitled "*Cleaning agents for removing lime scale and rust deposits*". Products by



other manufacturers can be used providing they have similar properties. The manufacturer's instructions for use must be strictly observed. Prior to cleaning, check whether the cleaning agent is suitable for the materials to be cleaned. The products listed in the table entitled "*Cleaning agents for removing lime scale and rust deposits*" are also suitable for stainless steel.

| Manufacturer | Product          | Concentration | Duration of cleaning procedure/temperature |
|--------------|------------------|---------------|--|
| Drew         | SAF-Acid         | 5 - 10%       | 4 h at 60 - 70 °C                          |
|              | Descale-IT       | 5 - 10%       | 4 h at 60 - 70 °C                          |
|              | Ferroclean       | 10%           | 4 - 24 h at 60 - 70 °C                     |
| Nalfleet     | Nalfleet 9 - 068 | 5%            | 4 h at 60 - 75 °C                          |
| Unitor       | Descalex         | 5 - 10%       | 4 - 6 h at approx. 60 °C                   |
| Vecom        | Descalant F      | 3 - 10%       | Approx. 4 h at 50 - 60 °C                  |

Table 2: Cleaning agents for removing limescale and rust deposits

#### In emergencies only

Hydrochloric acid diluted in water or aminosulphonic acid may only be used in exceptional cases if a special cleaning agent that removes limescale deposits without causing problems is not available. Observe the following during application:

- Stainless steel heat exchangers must never be treated using diluted hydrochloric acid.
- Cooling systems containing non-ferrous metals (aluminium, red bronze, brass, etc.) must be treated with deactivated aminosulphonic acid. This acid should be added to water in a concentration of 3 - 5 %. The temperature of the solution should be 40 - 50 °C.
- Diluted hydrochloric acid may only be used to clean steel pipes. If hydrochloric acid is used as the cleaning agent, there is always a danger that acid will remain in the system, even when the system has been neutralised and flushed. This residual acid promotes pitting. We therefore recommend you have the cleaning carried out by a specialist.

The carbon dioxide bubbles that form when limescale deposits are dissolved can prevent the cleaning agent from reaching boiler scale. It is therefore absolutely necessary to circulate the water with the cleaning agent to flush away the gas bubbles and allow them to escape. The length of the cleaning process depends on the thickness and composition of the deposits. Values are provided for orientation in the table entitled "*Detergents for removing lime scale and rust deposits*".

#### Following cleaning

The cooling system must be flushed several times once it has been cleaned using cleaning agents. Replace the water during this process. If acids are used to carry out the cleaning, neutralise the cooling system afterwards with suitable chemicals then flush. The system can then be refilled with water that has been prepared accordingly.



#### Only carry out the cleaning operation once the engine has cooled down

Start the cleaning operation only when the engine has cooled down. Hot engine components must not come into contact with cold water. Open the venting pipes before refilling the cooling water system. Blocked venting pipes prevent air from escaping which can lead to thermal overloading of the engine.

**Cleaning products can cause damage**

The products to be used can endanger health and may be harmful to the environment.

Follow the manufacturer's handling instructions without fail.

The applicable regulations governing the disposal of cleaning agents or acids must be observed.

6682 000.08-01

Cooling water system  
General

## Water specification for fuel-water emulsions

### Prerequisites

The water used for the fuel-water emulsion is an operating fluid that must be carefully selected, processed (if necessary) and monitored. If this is not done, deposits, corrosion, erosion and cavitation may occur on the fuel system components that come into contact with the fuel-water emulsion.

### Specifications

#### Limit values

The characteristic values of the water used must be within the following limit values:

| Properties/<br>Characteristic | Characteristic value  | Unit |
|-------------------------------|---|------|
| Water type                    | Seawater, brackish water, river water, brines, industrial waste water and rainwater, distilled or fresh water | -    |
| Total hardness                | max. 10   | °dH* |
| pH value                      | 6.5 - 8   | -    |
| Chloride ion content          | max. 50   | mg/l |

Table 1: Fuel-water emulsion - characteristic values to be observed

\*) 1° dH (German hardness)  $\triangleq$  10 mg CaO in 1l water  $\triangleq$  17.9 mg CaCO<sub>3</sub>/l  
 $\triangleq$  0.357 mval/l  $\triangleq$  0.179 mmol/l

#### Testing instruments

The MAN Diesel water testing kit contains instruments that allow the water characteristics referred to above (and others) to be easily determined.

### Additional information

#### Distillate

If distillate (e.g. from the fresh water generator) or fully desalinated water (ion exchanger) is available, this should ideally be used for the fuel-water emulsion. These types of water are free of lime and salts.

#### Hardness

The total hardness of the water is the combined effect of the temporary and permanent hardness. It is largely determined by the calcium and magnesium salts. The temporary hardness depends on the hydrocarbonate content in the calcium and magnesium salts. The lasting (permanent) hardness is determined by the remaining calcium and magnesium salts (sulphates).

Water with hardness greater than 10°dH (German total hardness) must be blended or softened with distillate. It is not necessary to increase the hardness of extremely soft water.



#### Treatment with anticorrosive agents not required

Treatment with anticorrosive agents is not required and must be omitted.

## Specifications for intake air (combustion air)

### General

The quality and condition of intake air (combustion air) have a significant effect on the power output, wear and emissions of the engine. In this regard, not only are the atmospheric conditions extremely important, but also contamination by solid and gaseous foreign matter.

Mineral dust in the intake air increases wear. Chemicals and gases promote corrosion.

This is why effective cleaning of intake air (combustion air) and regular maintenance/cleaning of the air filter are required.

When designing the intake air system, the maximum permissible overall pressure drop (filter, silencer, pipe line) of 20 mbar must be taken into consideration.

### Requirements

Gas engines or dual-fuel engines may only be equipped with a dry filter. An oil filter should not be installed, because they enrich air with oil mist, which is not permissible for gas operated engines. Filters of efficiency class G4 according to EN 779 must be used. The concentrations downstream of the air filter and/or upstream of the turbocharger inlet must not exceed the following limit values:

| Properties  | Typical value | Unit *             |
|---|---------------|--------------------|
| Dust (sand, cement, CaO, Al <sub>2</sub> O <sub>3</sub> etc.)                       | max. 5        | mg/Nm <sup>3</sup> |
| Chlorine  | max. 1.5      |                    |
| Sulphur dioxide (SO <sub>2</sub> )  | max. 1.25     |                    |
| Hydrogen sulphide (H <sub>2</sub> S)  | max. 5        |                    |
| Salt (NaCl)   | max. 1        |                    |
| * One Nm <sup>3</sup> corresponds to one cubic meter of gas at 0 °C and 101.32 kPa. |               |                    |

Table 1: Intake air (combustion air) - typical values to be observed



**WARNING**

### Intake air shall not contain any flammable gases

Intake air shall not contain any flammable gases. Make sure that the combustion air is not explosive.

**Cylinder head**

**505/605**

|                           |                      |                                     |
|---------------------------|----------------------|-------------------------------------|
| Description<br>Page 1 (1) | <b>Cylinder head</b> | <b>605.01</b><br><b>Edition 14H</b> |
|---------------------------|----------------------|-------------------------------------|

## L28/32H, V28/32H

### General

The cylinder head is made of cast iron and is tightened to form a gas-tight seal against a sealing ring on the cylinder liner by means of 6 nuts and 6 studs, which are screwed into the engine frame. The nuts are tightened by means of hydraulic jacks.

Each cylinder head is equipped with two air inlet and two exhaust valves which are actuated by rocker arms running in bearings on a shaft supported in a bracket on top of the cylinder head.

The fuel injection valve (see section 614) is located in a interchangeable sleeve in the center of the cylinder head.

Furthermore the cylinder head is equipped with an indicator valve and a safety valve.

The cylinder head has a screwed-on coaming which encloses the valves. The coaming is closed with a top cover and thus provides an oil tight enclosure for the valve gear. The coaming is equipped with an inspection cover for the rotators.

### Air inlet and exhaust valves

The inlet valve spindles are identical to the exhaust spindles.

The valves are made of heat-resistant material. Hard metal is welded on to the valve spindle seats to avoid depressions by combustion particles.

The valve spindles are fitted with valve rotators which turn the spindles a little each time the valves open.

The cylinder head is equipped with interchangeable seat rings and valve guides for inlet and exhaust valves. The valve seat rings and valve guides for inlet and exhaust valves are identical.

The seat rings are made of heat-resistant steel, directly hardened on the seating surface and the seat rings are directly water cooled in order to assure low valve temperature.

### Valve rotator

The retainer body of the valve rotator (1) has a number of pockets, arranged in circumferential direction, with balls that are forced against the upper end of an inclined race by coil springs acting in tangential direction. The ball race (3) serves as ball track in the opposite direction. The spring washer (4) seats against the inner rim of the retainer body

and is encased by the seating collar (5) which overlaps it. The assembled valve rotator is held together, when removed, by the retaining ring (6).

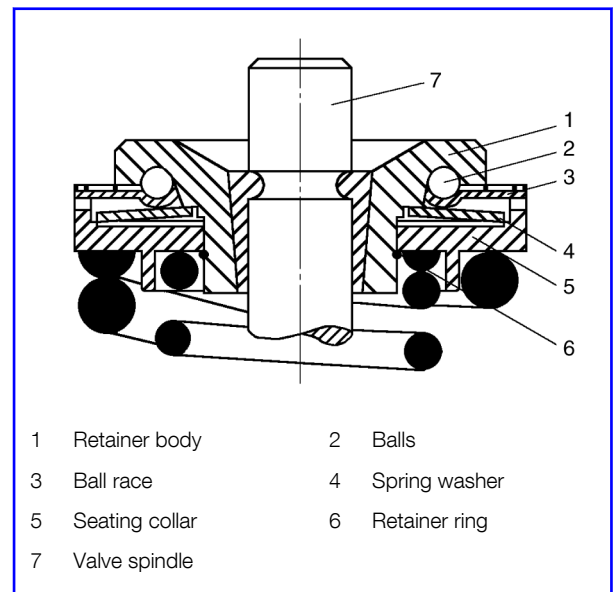


Figure 1: Valve rotator

As the valve starts to open, the increasing valve spring-load causes the spring washer to flatten, and the load applied to the balls in the pockets of the retainer body forces the balls in the ball race to roll down the inclined races. The transfer of the reaction load of the ball race to the spring washer reduces the reaction load of the spring washer on the inner rim of the retainer body. Ball race, spring washer, seating collar and valve springs are, however, force-locked by friction grip. The reaction load of the balls on the inclined races induces rotation to the retainer body and valve with relation to the seating collar and the valve springs. As the valve closes, load is released from the spring washer and thus from the balls, allowing them to be returned to their original positions without rolling by the tangential force of the coil springs.

L/V28/32H

**Safety precautions:**

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Shut-off cooling oil
- Stopped lub. oil circul.

**Description:**

Dismantling of cylinder head for inspection and/or overhaul.

**Starting position:**

Cooling water has been drained from engine.

**Related procedure:**

Dismounting of piston and connecting rod, 606-01.00  
 Dismounting and inspection of inlet valve, exhaust valve and valve guide, 605-01.05  
 Safety valve, 605-01.25  
 Dismantling, overhaul and test pressure of fuel oil valve, 614-01.10

**Man power:**

Working time : 1 Hour  
 Capacity : 2 men

**Data:**

Data for pressure and tolerance (Page 600.35)  
 Data for torque moment (Page 600.40)  
 Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.                    |
|-----------|----------|--------------------------|
| 62021     | 10       |                          |
| 62021     | 01       | Oil injector, (complete) |
| 62021     | 50       | 6 Piece                  |
| 62021     | 51       | 1 Piece                  |
| 62021     | 15       |                          |
| 62005     | 01       |                          |
| 62021     | 25       | Hydraulic tools          |
| 62014     | 15       |                          |

**Hand tools:**

Ring and open end spanner 14 mm.  
 Ring and open end spanner 17 mm.  
 Ring and open end spanner 24 mm.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|

## L/V28/32H

- 1) Open the drain cock and vent cock for cooling water.
- 2) Take off the rocker arm top cover.
- 3) Take off the cover which gives access to the injection pump.
- 4) Disconnect the fuel oil high-pressure pipe.
- 5) Disconnect the cooling oil pipes, (inlet and outlet).
- 6) Disconnect the rocker arm lubricating oil pipe.
- 7) Remove the thermometer attachment branch (cooling water outlet pipe).
- 8) Remove the exhaust pipe flange screws.
- 9) Remove the cylinder head nuts, as shown, by means of hydraulic jacks, see working card 620-01.05.
- 10) Mount the lifting tool on the cylinder head.
- 11) Attach the hook to the lifting tool and lift the cylinder head away.

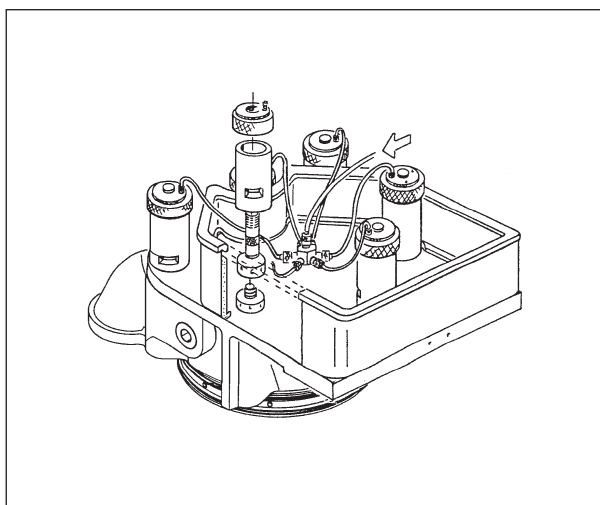


Fig. 1

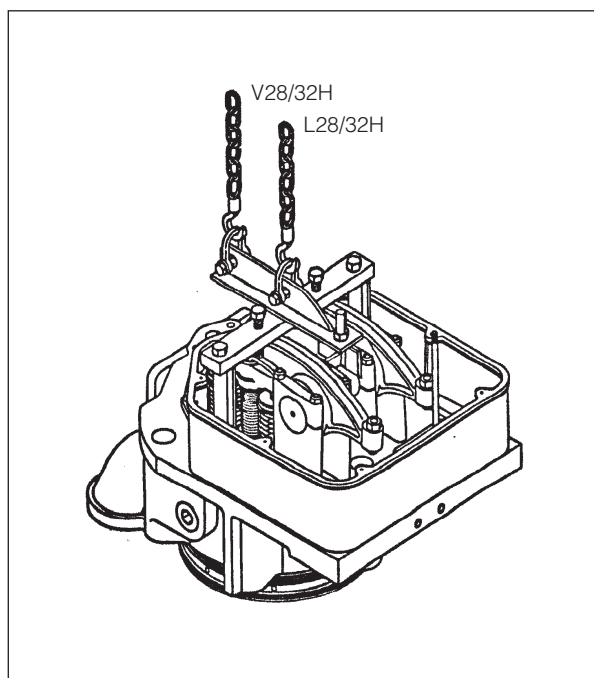


Fig. 2



|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (3) | <b>Inspection of Inlet Valve, Exhaust Valve and<br/>Valve Guide</b> | <b>605-01.05</b><br>Edition 06H |
|----------------------------|---|---------------------------------|

**L+V28/32H****Safety precautions**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description**

Dismounting of inlet and exhaust valve, inspection of valve guide and mounting of inlet and exhaust valve.

**Starting position**

Cylinder head, dismantled from engine 605-01.00

**Related procedure**

Reconditioning of valve spindle seat and valve seat ring, 605-01.10  
 Valve rotator, 605-01.15  
 Replacement of valve guide, 605-01.20  
 Replacement of valve seat ring, 605-01.35  
 Mounting of cylinder head, 605-01.45

**Man power**

Working time : 1 hour  
 Capacity : 1 man

**Data**

Data for pressure and tolerance (Page 600.35)  
 Data for torque moment (Page 600.40)  
 Declaration of weight (Page 600.45)

**Special tools**

| Plate no | Item no | Note        |
|----------|---------|-------------|
| 62005    | 01      |             |
| 62005    | 05      |             |
| 62005    | 25/30   | Extra tools |
| 62005    | 55      |             |

**Hand tools**

Ring and open end spanner, 19 mm.  
 Ring and open end spanner, 24 mm.  
 Small screw driver.  
 Measuring tools.

**Replacement and wearing parts**

| Plate no | Item no | Qty. / |
|----------|---------|--------|
| 60501    | 017     | 4/cyl. |

**L+V28/32H****Dismantling of Inlet and Exhaust Valve Spindles**

- 1) Land and fasten the cylinder head upon the special work table and remove the lifting tool.

**Or as an Alternative:**

Land the cylinder head on the floor upon wooden supports and remove the lifting tool.

- 2) Mount the supporting devices for the valve spindle heads on the work table.

**Or as an Alternative:**

Place wooden blocks under the valve spindle heads.

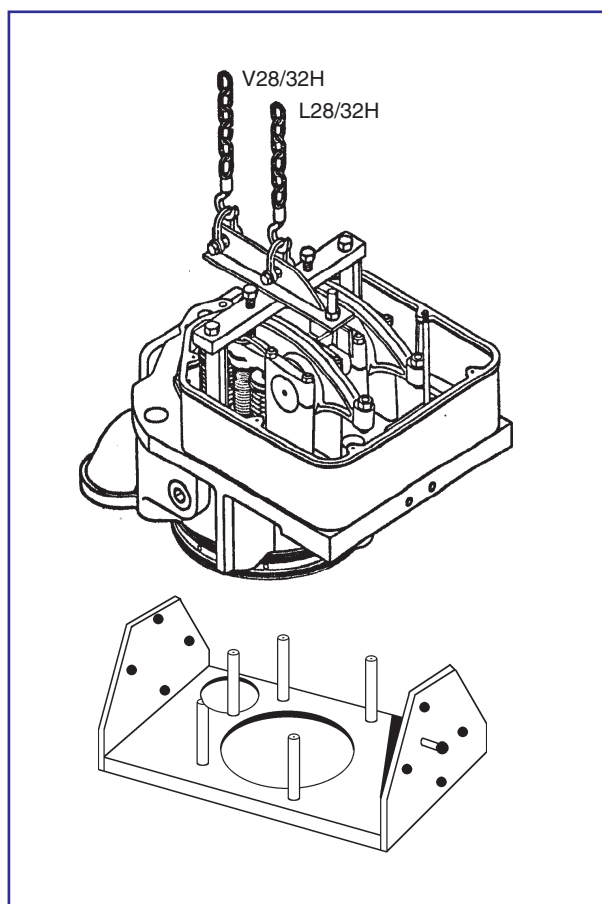


Fig 1

- 3) Turn back the rocker arm and remove the spring-loaded valve bridge over the valve spindles.
- 4) After having removed the valve bridge and turned the rocker arm back, the tool should be fitted by means of the screws (A), see fig 2 tightened in the threaded holes in the cylinder head.

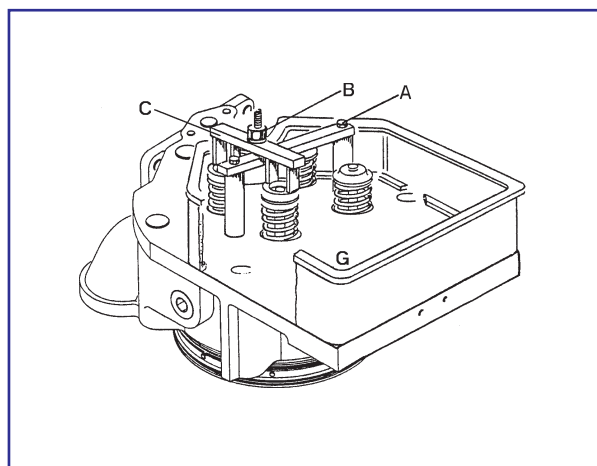


Fig 2

- 5) Now compress the valve springs by tightening the nut (B), after which the cone rings can be re-moved, see fig 3.

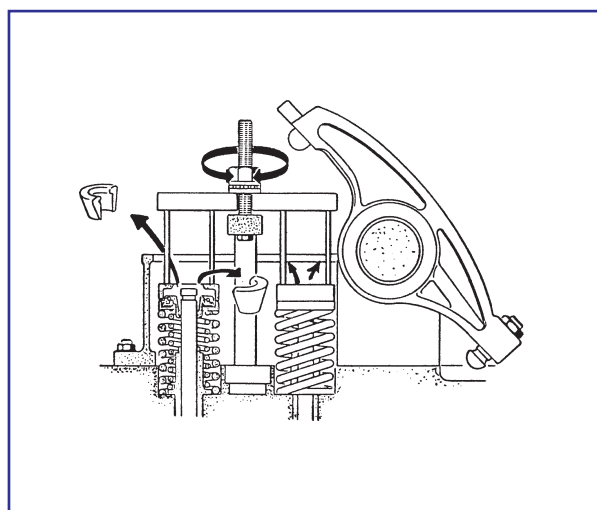


Fig 3

- 6) Release the springs again. Remove the nut (B) and the traverse (C). Now valve rotator and springs can be removed.
- 7) Remove the supporting devices under the work table and take out the valve spindle.
- 8) Repeat point 4 - 7 to remove the two other valve spindles.

### Inspection of Valves/Valve Seats

- 9) A slight grinding of valve/valve seat can be carried out by means of the handle as shown, see fig 4.

If the valve seat is heavily burnt or scarred, it should be ground using the valve seat grinder according to working card 605-01.10.

### Inspection of valve guide

- 10) Too much clearance between valve spindle and spindle guide may cause increased lub. oil consumption, fouling up of the spindle guide and thus give the risk of a sticking valve spindle.

Too much clearance also means insufficient guidance of the valve spindle, and thus bad alignment between spindle head and valve seat ring. In connection with overhaul of the cylinder head, the valve spindle guides should be cleaned, inspected and measured for wear. If the inner diameter of the valve spindle guide exceeds the tolerance, see page 600.35 the valve spindle guide must be replaced. See working card 605-01.20.

- 11) For mounting of valve spindle follow the instructions in point 4 - 7 in reversed order.

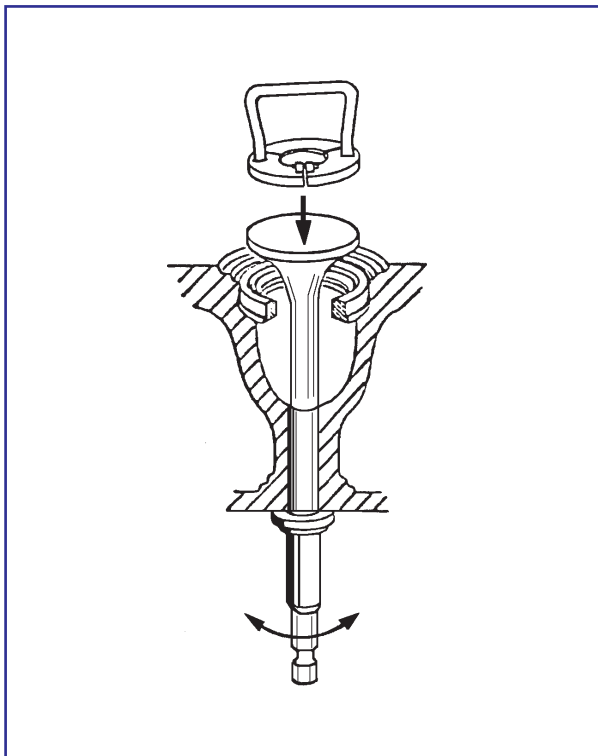


Fig 4

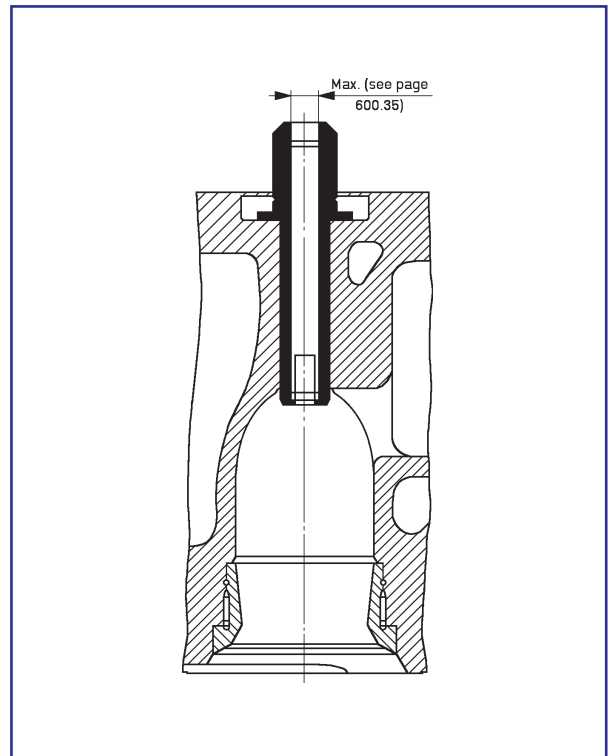


Fig 5

|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (3) | <b>Reconditioning of Valve Spindle Seat<br/>and Valve Seat Ring</b> | <b>605-01.10</b><br>Edition 01H |
|----------------------------|---|---------------------------------|

L/V28/32H

**Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Reconditioning of valve spindle seat and valve seat ring, with special grinding machine.

**Starting position:**

Valve spindle has been removed, 605-01.05

**Related procedure:**

Mounting of valve spindle, 605-01.05

**Man power:**

Working time : 6 Hours  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.  |
|-----------|----------|--|
| 62005     | 40       | Grinding machine for valve spindle.                  |
| 62005     | 35       | Grinding machine for valve seat ring. (Extra tools). |

**Hand tools:**

All the hand tools and new stones, are included in the tools box for grinding machine.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|

## L/V28/32H

**Reconditioning of Valve Seat Ring.**

Reconditioning of valve seat rings by machining is carried out by means of a grinding machine, the pilot spindle of which is to be mounted in the valve spindle guide. For operation of the grinding machine, see separate instructions.

The grinding of the valve seat ring should be carried out according to the following sequence:

- 1) The seating surface itself is ground with a feed at an angle "A" of  $30^\circ \pm \begin{smallmatrix} 0,10^\circ \\ 0 \end{smallmatrix}$ .

The grinding should be continued until a clean and uniform surface condition has been obtained.

Carry out the final grinding with a feed in direction from inside to outwards, as normally the best surface quality is obtained in this way.

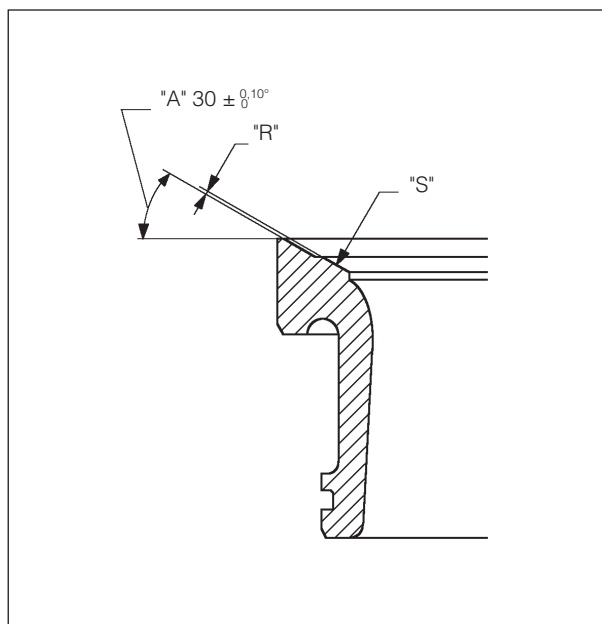


Fig. 1.

- 2) Normally the valve seat ring can be reconditioned several times.

However when the seat "S" has been ground to such an extent, that the recess "R" disappears, the valve seat ring has to be scrapped and a new one must be installed, see working card 605-01.35

**Reconditioning of Valve Spindle.**

Reconditioning by machining is carried out with the valve spindle being rotated in a turning lathe and a special grinding machine mounted on the tool post of the turning lathe.

For operation of the grinding machine, see separated instructions.

- 1) The seating surface itself is ground with a feed at an angle "A" of  $30^\circ \pm \begin{smallmatrix} 0 \\ 0,25^\circ \end{smallmatrix}$ .
- 2) The grinding should be continued until a clean and uniform surface condition has been obtained.
- 3) After completing the grinding, the height "H"1 of the valve head should be checked.

"H"1 has to be at least, see page 600.35.

If measured to be less, the spindle has to be scrapped.

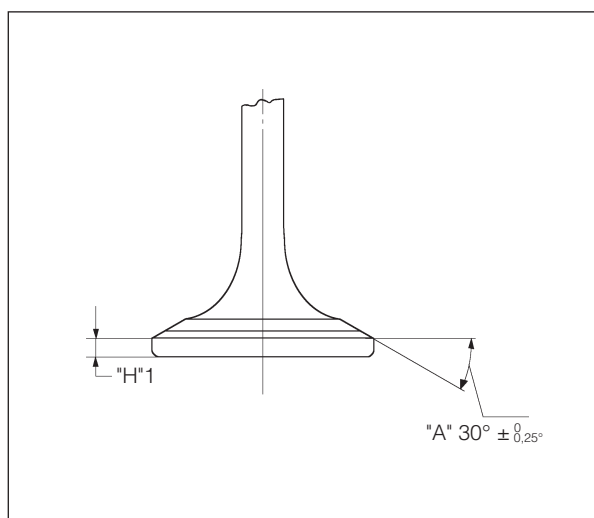
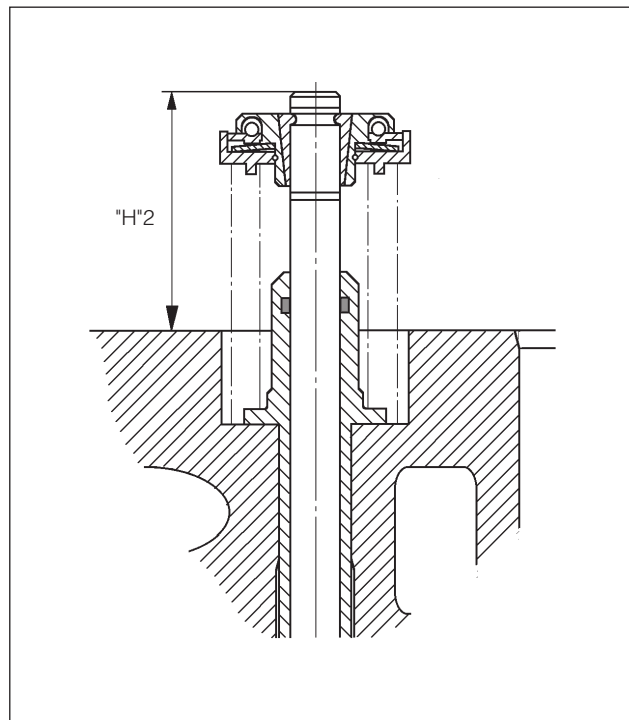


Fig. 2.

**L/V28/32H**

After assembling the valves, check - on account of the valve motion - that distance "H"2 between the upper edge of the cylinder head and the upper edge of the valve spindle does not exceed the maximum value, see page 600.35.

*Fig. 3.*

|                            |                      |                                 |
|----------------------------|----------------------|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Valve Rotator</b> | <b>605-01.15</b><br>Edition 01H |
|----------------------------|----------------------|---------------------------------|

**L/V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Dismantling, inspection and mounting of valve rotator.

**Starting position:**

Valve spindles has been removed, 605-01.05

**Related procedure:**

Mounting of valve spindles, 605-01.05

**Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
| 62005     | 05       |       |

**Hand tools:**

Small screw driver.  
Ring and open end spanner 24 mm.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|

605-01.15

Edition 01H

## Valve Rotator

Working Card  
Page 2 (2)

## L/V28/32H

**Inspection of Rotocap.**

Dirt especially in the ball pockets due to residues in the oil (abrasives, combustion products), can cause the individual parts to become stuck, and hinder the movement of the balls.

Rotocap valve rotators need no servicing under normal operating conditions.

Unusual operating conditions may lead to disturbances. Rotation of the valve should be checked at the intervals specified in the "Maintenance program". Rotator performance is satisfactory when the valve rotates visibly and evenly.

**Dismantling of Rotocap.**

See working card 605-01.05, point 3 to 6.

**Overhauls**

Valve rotators should be cleaned and inspected for wear and ball impressions whenever the valves are removed. The individual parts can be disassembled after removal of the retaining ring, by means of which the seating collar is fastened to the retainer body.

Parts showing wear grooves or depressions formed by the balls should be replaced.

When inserting the balls and the tangential springs, note that all balls on the inclined races of the ball pockets point in the same direction, see fig. 1.

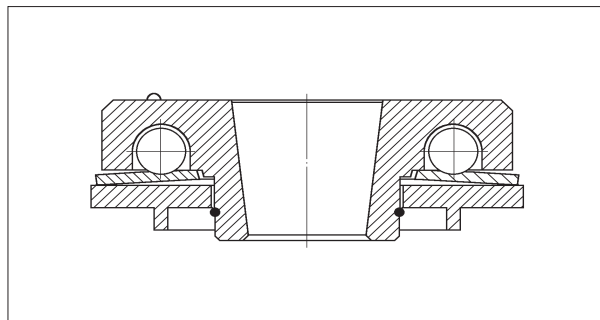


Fig. 1.

The inner ring of the spring washer should rest on the retainer body.

**Note !** Having assembled the valve rotator in dry condition it should be placed in clean lubricating oil for a short period of time.

**Mounting of Rotocap**

See working card 605-01.05, point 3 to 6, opposite direction.



|                           |                                   |                                 |
|---------------------------|-----------------------------------|---------------------------------|
| Working Card<br>Page1 (2) | <b>Replacement of Valve Guide</b> | <b>605-01.20</b><br>Edition 05H |
|---------------------------|-----------------------------------|---------------------------------|

**L+V28/32H****Safety precautions**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description**

Dismantling and mounting of valve guide, for inlet and exhaust valve.

**Starting position**

Valve spindle has been removed, 605-01.05

**Related procedure**

Mounting of valve spindles, 605-01.05

**Man power**

Working time : 3/4 Hour  
Capacity : 1 man

**Data**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools**

| Plate no. | Item no. | Note.       |
|-----------|----------|-------------|
| 62005     | 60       | Lytra tools |

**Hand tools**

Hammer.  
Nitrogen (N<sub>2</sub>), or similar.

**Replacement and wearing parts**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
| 60501     | 017      | 4/cyl. |
| 60501     | 029      | 4/cyl. |

**L+V28/32H**

If the clearance exceeds the shown max. limit, (see page 600.35), the valve guide must be replaced.

**Dismounting of valve guide**

- 1) The valve guide is knocked out from the bottom of the cylinder head, by means of a mandrel, which has a shoulder turning that fits into the valve guide, see fig. 1.

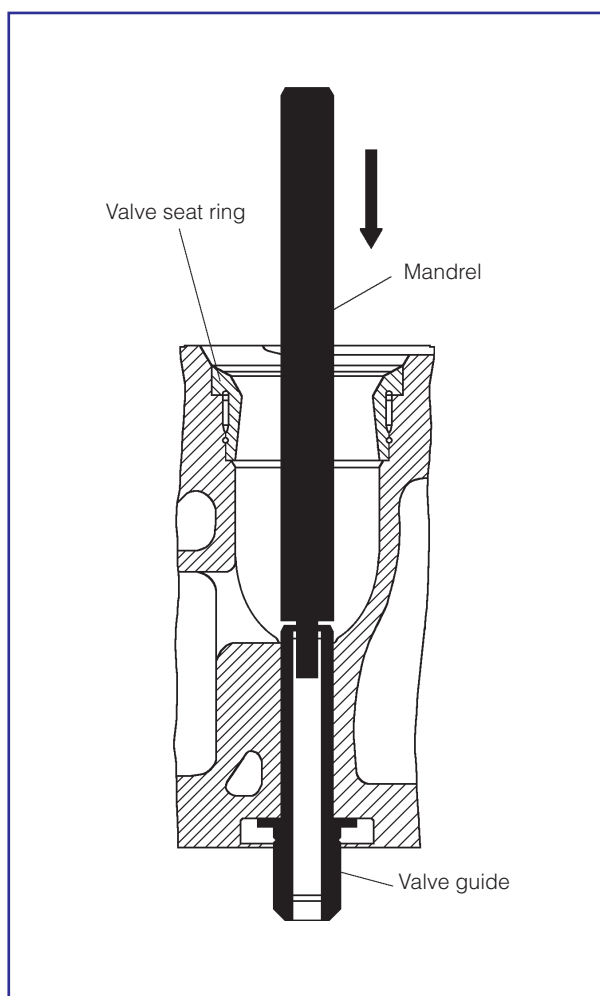


Fig 1

- 2) After having knocked out the valve guide, carefully clean the bore of the cylinder head and inspect for marks that can prevent mounting of a new valve guide.

- 3) Before mounting the new valve guide, it has to be cooled down to approx. -70°C with nitrogen or similar.

When the new valve guide has been inserted into the bore be sure that the shoulder bears against the cylinder head, by knocking slightly with the mandrel and a hammer.

- 4) Before mounting of the valve spindle insert a new o-ring in the valve guide.

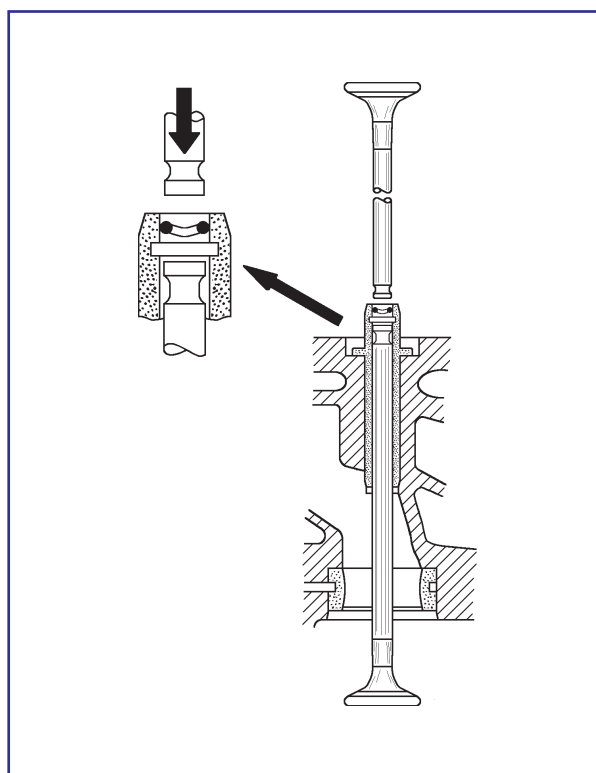


Fig 2.

Correct mounting can easily be done by the use of two valve spindles as mounting tool, one spindle to be used as support and the other spindle to be used for pushing the o-ring downwards.

Screw drivers or other sharp tools should never be used for this purpose.

- 5) For mounting of valve spindle, see working card 605-01.05.

## L+V28/32H

**Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description:**

Dismantling, inspection, reassembling and pressure testing of safety valve.

**Starting position:****Related procedure:**

Indicator valve 605-01.26

**Man power:**

Working time : 1 hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no | Item no | Note                   |
|----------|---------|------------------------|
| 62014    | 01      | Pressure test pump.    |
| 62014    | 04      | Pipe for fuel injector |

**Hand tools:**

Open end spanner, 32 mm.  
Small hammer.  
Copaslip.

**Replacement and wearing parts:**

| Plate no | Item no | Qty. / |
|----------|---------|--------|
| 60508    | 14      | 1/cyl. |

L+V28/32H

Maintenance and Checking.

During extended periods of standstill and at general engine overhauls, the safety valves should be thoroughly cleaned.

**Note:** Do not attempt to stop a safety valve from leaking by increasing the spring load.

The setting of the opening pressure is stamped onto the cap nut (1), see fig 1.

1. Dismantling.

1.1 Screw the safety valve out of the cylinder head.

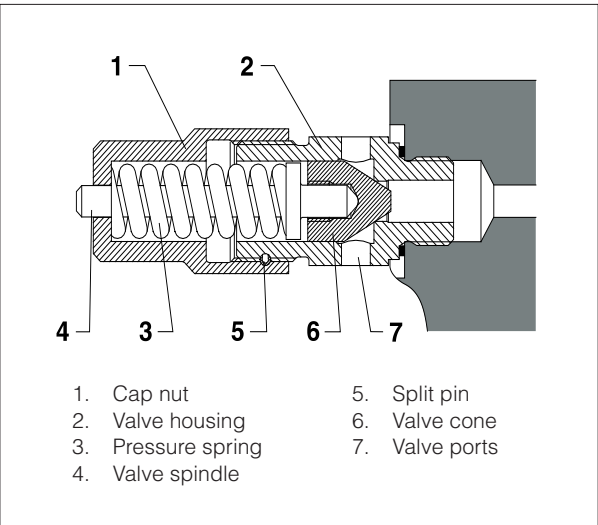


Fig 1. Safety valve

- 1.2 Clamp valve in vice.
- 1.3 Unscrew cap nut (1).
- 1.4 Remove pressure spring (3), valve spindle (4) and valve cone (6).
- 1.5 Inspect and carefully clean all parts and condition valve, if necessary.

2. Reassembling.

- 2.1 Lubricate the threads on valve housing (2) with copaslip or similar.
- 2.2 Reassemble the safety valve, reverse sequence of operations outlined above, point 1.1 to 1.5.

3. Test of Safety Valve.

The valve is to be tested after each overhaul by making a leakage test and testing the opening pressure.

- 3.1 Mount the safety valve in the fuel injection test pump by using the test pipe for fuel injections.
- 3.2 Vent the system by pumping until the oil flows free of air bubbles through the valve ports (7) in the valve housing (2).

Leakage Test

- 3.3 Increase the pressure to 135 bar.
- 3.4 Check that the pressure do not sink below 135 bar within 1 minute.

| If the pressure is | Then   |
|--------------------|--|
| OK                 | Continue with point 3.5.                                       |
| below 135 bar      | Scrap the valve.<br><br>or<br><br>Lap the valve cone and seat. |

|                            |                     |                                 |
|----------------------------|---------------------|---------------------------------|
| Working Card<br>Page 3 (3) | <b>Safety Valve</b> | <b>605-01.25</b><br>Edition 04H |
|----------------------------|---------------------|---------------------------------|

**L+V28/32H****Test of Opening Pressure**

3.5 Increase the pressure to the opening pressure.

| If the opening pressure is | Then                                     |
|----------------------------|--|
| OK                         | The procedure is ended.                  |
| Not OK                     | The valve must be adjusted, see point 4. |

**4. Adjustment of Opening Pressure**

4.1 Increase the pressure to the opening pressure.

4.2 Turn the cap nut (1) to the correct opening pressure.

4.3 Drill a new hole for mounting of split pin (5).

**5. Mounting of Safety Valve**

5.1 Lubricate the threads on the valve housing (2) with copaslip or similar.

5.2 Mount the safety valve on the cylinder head.

|                            |                        |                                 |
|----------------------------|------------------------|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Indicator Valve</b> | <b>605-01.26</b><br>Edition 02H |
|----------------------------|------------------------|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Dismounting, inspection and mounting of indicator valve.

**Starting position:****Related procedure:**

Safety valve 605-01.25

**Man power:**

Working time : 1/2 hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque momen (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate No | Item No | Note |
|----------|---------|------|
|----------|---------|------|

**Hand tools:**

|                           |       |
|---------------------------|-------|
| Ring and open end spanner | 10 mm |
| Ring and open end spanner | 27 mm |
| Steel brush               |       |
| Copaslip                  |       |

**Replacement and wearing parts:**

| Plate No | Item No | Qty./  |
|----------|---------|--------|
| 60508    | 16      | 1/Cyl. |

605-01.26

Edition 02H

## Indicator Valve

Working Card  
Page 2 (2)

## L+V28/32H

## Maintenance

By normal working conditions the indicator valve require very little maintenance except an inspection in connection with the normal cylinder cover overhaul.

## Inspection of the Indicator Valve:

1. Disassemble the indicator valve.
2. Check the valve seat and the cone for "burning through".

*If the valve seat in the housing is "burned", the entire valve is to be replaced.*

3. Clean and lubricate all components before remounting.

4. Ensure that the spindle is in "OPEN" position when assembling the valve.

**NOTE:** Otherwise cone and seat may be damaged.

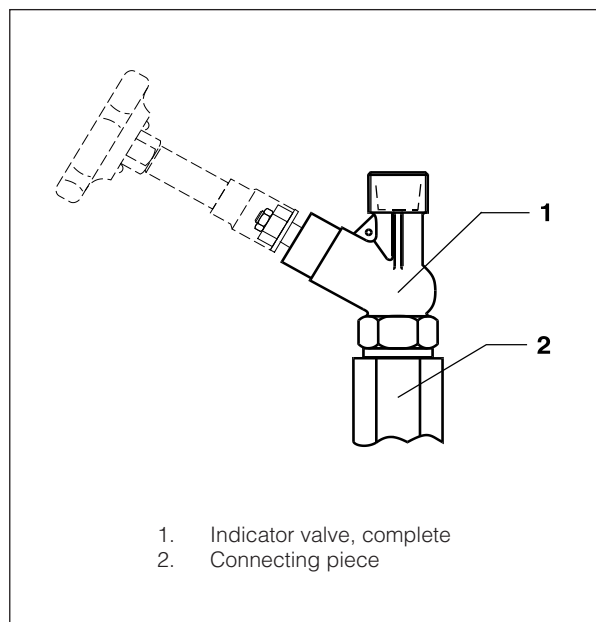


Fig 1 Indicator valve.

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Replacement of Sleeve for Fuel Injector</b> | <b>605-01.30</b><br>Edition 04H |
|----------------------------|--|---------------------------------|

**L+V28/32H****Safety precautions**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description**

Dismounting, inspection and mounting of sleeve for fuel injector.

**Starting position**

The cylinder head has been dis-mounted from engine, 605-01.00  
The fuel injector has been removed, 614-01.10

**Related procedure**

Mounting of fuel valve, 614-01.10

**Man power**

Working time : 1 Hour  
Capacity : 1 man

**Data**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|-----------|----------|-------|

**Hand tools**

Brass mandrel.  
Hammer.  
Lub. oil.  
Two small screw driver.  
Loctite 572.

**Replacement and wearing parts**

| Plate no. | Item no. | Qty./  |
|-----------|----------|--------|
| 60501     | 125      | 1/cyl. |
| 60501     | 137      | 1/cyl. |
| 60501     | 149      | 1/cyl. |



**L+V28/32H****Dismounting of Sleeve for Fuel Injector**

- 1) Remove the snap ring by means of two screw drivers.
- 2) The sleeve can now be driven out of the bore by use of a brass mandrel and a hammer.

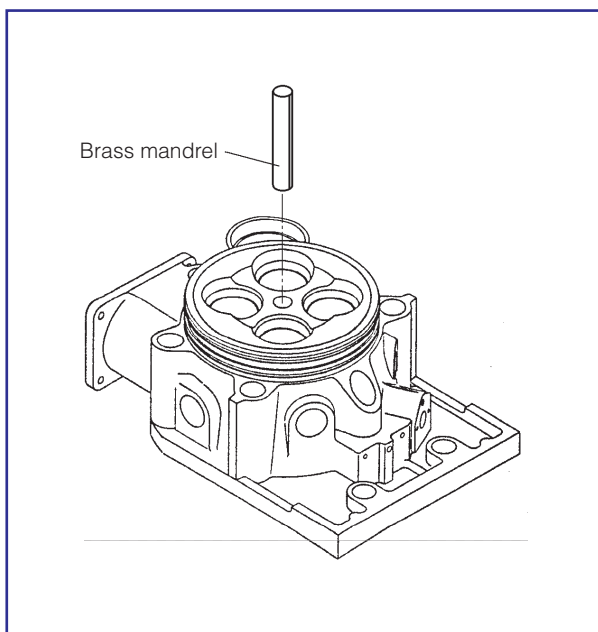


Fig 1

**Inspection of Bore in Cylinder Head and mounting of the Sleeve:**

- 3) Clean and inspect the bore in the cylinder head. Any marks which could prevent mounting of the sleeve, should be gently smoothed.

- 4) Coat the sealing ring zone in the bore with grease or lub. oil.

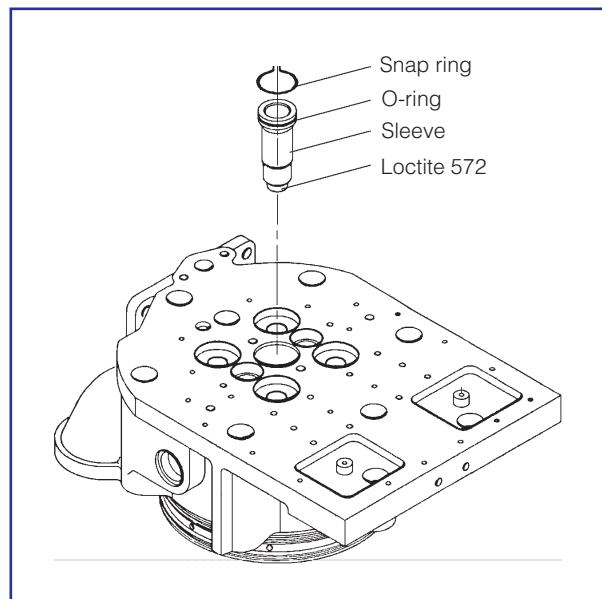


Fig 2

- 5) Install new sealing rings on the sleeve.
- 6) Coat the sealing surfaces on the sleeve with loctite 572.
- 7) Insert the sleeve in the bore.
- 8) Mount the snap ring.

## L+V28/32H

**Safety precautions**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description**

Replacement of valve seat ring, for inlet and exhaust valve.

**Starting position**

Inlet and exhaust valves have been removed, 605-01.05

**Related procedure**

Mounting of valve spindles, 605-01.05

**Man power**

Working time : 1 1/2 Hours  
Capacity : 1 man

**Data**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools**

| Plate no. | Item no. | Note.       |
|-----------|----------|-------------|
| 62021     | 01       |             |
| 62021     | 50       | 1 piece     |
| 62005     | 45       | Extra tools |
| 62005     | 50       | Extra tools |
| 62021     | 46       | 1 piece     |

**Hand tools**

Ring and open end spanner 36 mm  
Hammer.  
Loctite, 648.  
Lub. oil.

**Replacement and wearing parts**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
| 60501     | 245      | 4/cyl. |
| 60501     | 257      | 4/cyl. |

## L+V28/32H

## Dismounting of Valve Seat Rings

When reconditioning of a valve seat ring no longer is possible due to dimensions exceeding the scrapping criteria, the seat ring has to be replaced.

Dismounting of a valve seat ring is carried out by means of a special extractor tool set comprising following components, see fig 1.

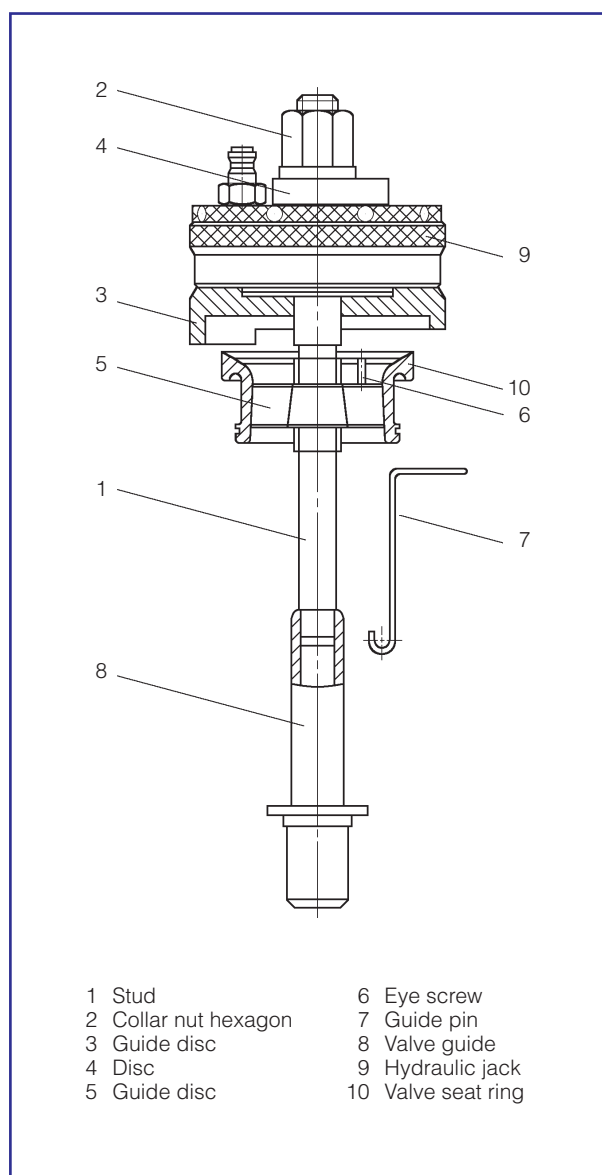


Fig 1

## Procedure for Dismounting a Valve Seat Ring

- 1) By means of the guide pin (7) the guide disc (5) is led vertically through the valve seat ring. Then the guide disc (5) is lifted with the guide pin (7) until the latter is guided by the valve seat ring. The stud (1) is then screwed in until it rests in the valve guide.

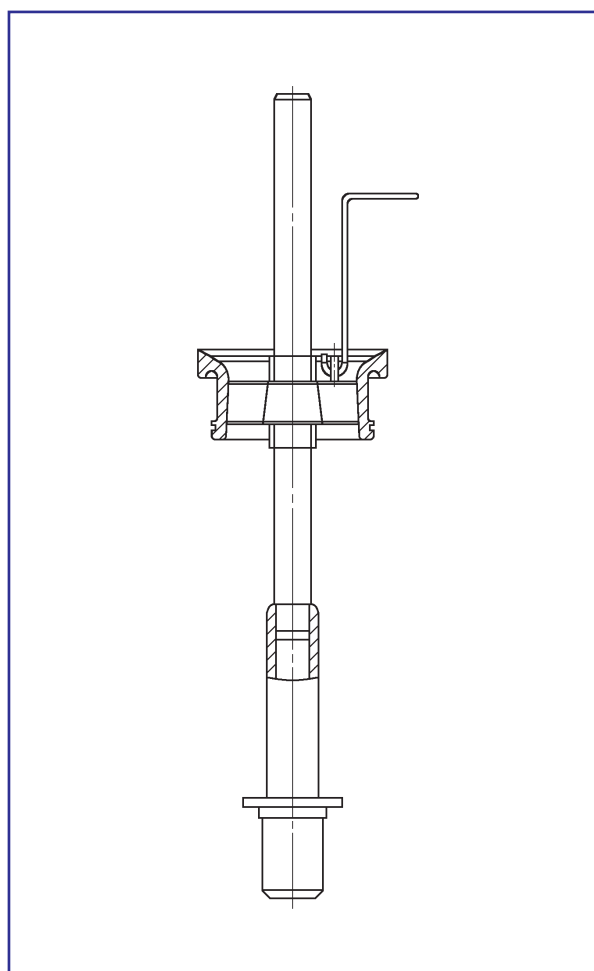


Fig 2

- 2) The guide disc (3) is positioned so that it bears against the bottom of the cylinder head, and the hydraulic jack is clamped with the disc (4) and collar nut hexagon (2), see fig 1. The hydraulic jack is the one used for main bearing caps.

## L+V28/32H

- 3) By pumping up the pack, see working card 620-01.05 for the use of hydraulic tools, the valve seat is pressed out max. 6 mm, and the pressure is released again. The collar nut hexagon is tightened and the operation is continued until the valve seat ring can be removed.

- 3) To facilitate mounting of the valve seat ring it is cooled down, however to no more than -25°C or the O-ring can be damaged.
- 4) Place the O-ring on the valve seat ring and coat with oil/loctite as shown in fig 4, just before positioning it in the bore.

### Mounting of Valve Seat Rings

- 1) Prior to mounting of a new valve seat ring, the bore must be cleaned thoroughly and inspected for marks. Marks that can hinder mounting of the valve seat ring must be removed.
- 2) Tools for mounting of valve seat rings are shown in fig 3.

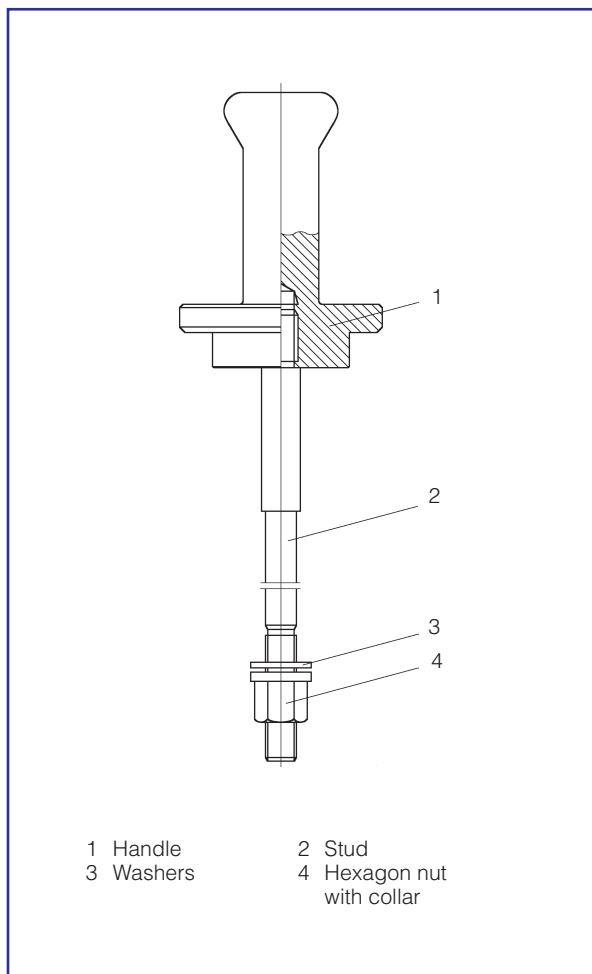


Fig 3

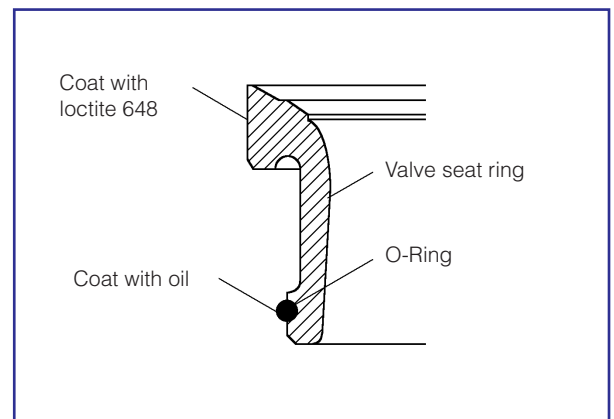


Fig 4

- 5) The valve seat ring is positioned in the bore, handle with stud inserted as shown in fig 5, and washer with screw is screwed tight.

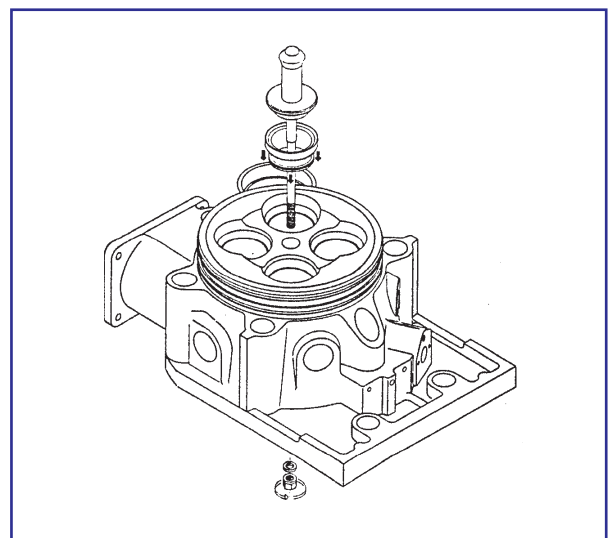


Fig 5

**L+V28/32H**

- 6) By knocking on the handle and at the same time tightening the nut (4), the valve seat ring slides in place in the bore and it is felt on the knocks when it bears in the bore.
- 7) Prior to mounting of the valve spindle the valve seat ring must be ground to ensure correct centering of valve guide and valve seat ring. This can be done according to working card 605-01.05 or 605-01.10.

## L+V28/32H

**Safety precautions**

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Shut-off cooling oil
- Stopped lub. oil circul.

**Description**

Mounting of cylinder head after inspection and/or overhaul.

**Starting position**

Cylinder head is completely assembled, 605-01.05 to 605-01.35  
Valve gear of respective cylinder is in right position (valve closed).  
Control of the surface on the cylinder liner, 606-01.45

**Related procedure**

Adjustment of valve clearance 608-01.10

**Man power**

Working time : 1 1/2 Hour  
Capacity : 2 men

**Data**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools**

| Plate no. | Item no. | Note.    |
|-----------|----------|----------|
| 62021     | 10       |          |
| 62021     | 01       |          |
| 62021     | 50       | 6 Pieces |
| 62021     | 51       | 1 Piece  |
| 62021     | 15       |          |
| 62005     | 01       |          |
| 62010     | 01       |          |
| 62021     | 25       |          |
| 62014     | 15       |          |

**Hand tools**

Ring and open end spanner, 14 mm.  
Ring and open end spanner, 17 mm.  
Ring and open end spanner, 24 mm.  
Lub. oil and copaslip.

**Replacement and wearing parts**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
| 60501     | 269      | 2/cyl. |
| 60510     | 08       | 1/cyl. |
| 60610     | 01       | 2/cyl. |
| 61202     | 31       | 1/cyl. |
| 61625     | 01       | 2/cyl. |

**L+V28/32H**

- 1) Check the jointing surfaces of the cylinder head/cylinder liner to see that they are clean and without damage marks, see working card 606-01.45, Fit new o-rings on the water passage, lubricate the o-rings with a little oil.
- 2) Check all contact faces on the cylinder head and nuts, including threads, and make sure that these are plane and smooth and absolutely free from foreign particles.
- 3) Attach the lifting tool to the cylinder head that has been made ready for installation, and position it carefully on the cylinder liner.

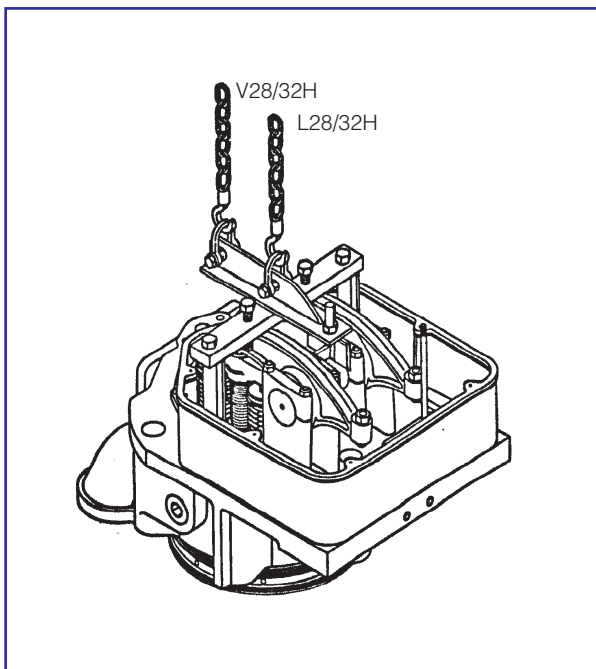


Fig 1

- 4) Make sure that the nuts run easily on the threads and that they bear on their entire contact surfaces.
- 5) Coat threads and contact faces with copaslip before fitting the nuts.
- 6) Screw nuts onto the studs and tighten lightly with the tommy bar.

Place the spacer ring around the nuts with the slot in such a position that the tommy bar can be used.

Tighten the hydraulic jacks and make sure that the cylinder of the jacks bears firmly against the spacer ring. Tighten up all the nuts, see page 600.40. For using the hydraulic tools, see working card 620-01.05.

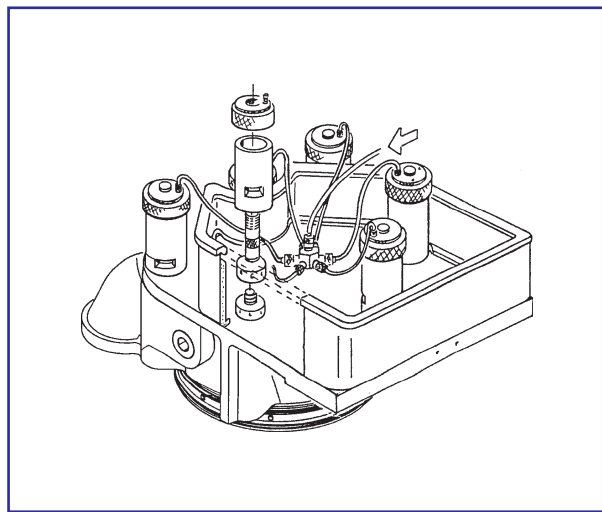


Fig 2

- 7) If new studs or nuts have been fitted, the nuts must be tightened and loosened three times, in order to compensate for deformation of the thread and in order to ensure a safe minimum load of the studs through the tightening.
- 8) Adjust the valve clearance, see working card 608-01.10.
- 9) Fit the pipes for fuel oil, lub. oil, cooling oil, cooling water and the flange for exhaust pipe.
- 10) Prior to start up check for leakages, and after start up check for leakages and oil flow.
- 11) Mount the cover for rocker arm and the front cover for fuel pump.

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Inspection of Cylinder Head Cooling Water Space</b> | <b>605-01.45</b><br>Edition 01H |
|----------------------------|--|---------------------------------|

L/V28/32H

**Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Inspection of cylinder head cooling water space.

**Starting position:**

The cylinder head dismantled from engine, 605-01.00

**Related procedure:****Man power:**

Working time : ¼ Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|-----------|----------|-------|

**Hand tools:**

Steel brush

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|



## L/V28/32H

**Inspection of Cylinder Head Cool. Water Space.**

- 1) Inspect the cooling water inlet at the bottom and the cooling water outlet in the top of the cylinder head, see fig. 1.
- 2) Remove all possible deposits.
- 3) Pour water into the cooling water outlet and make sure, that water is coming out of all the cooling water inlet bores at the bottom of the cylinder head.
- 4) Clean if necessary the cooling water inlet and outlet by means of a steel brush. Flush the cooling water space after cleaning.
- 5) Should the cylinder head cooling water space contrary to expectation be blocked with deposits, contact MAN B&W Diesel, Høleby for further instructions.

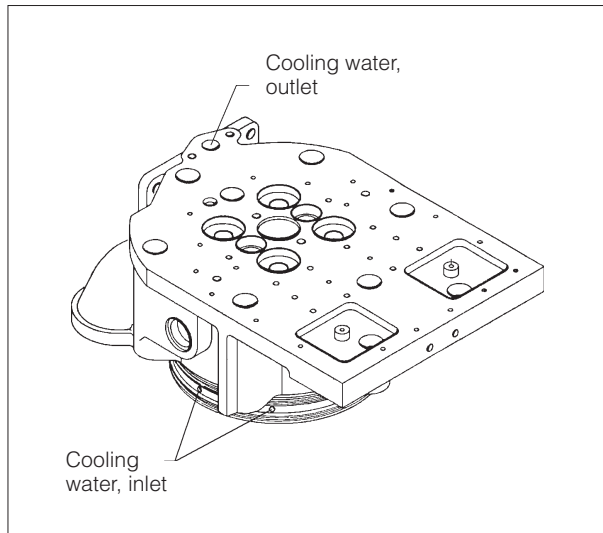
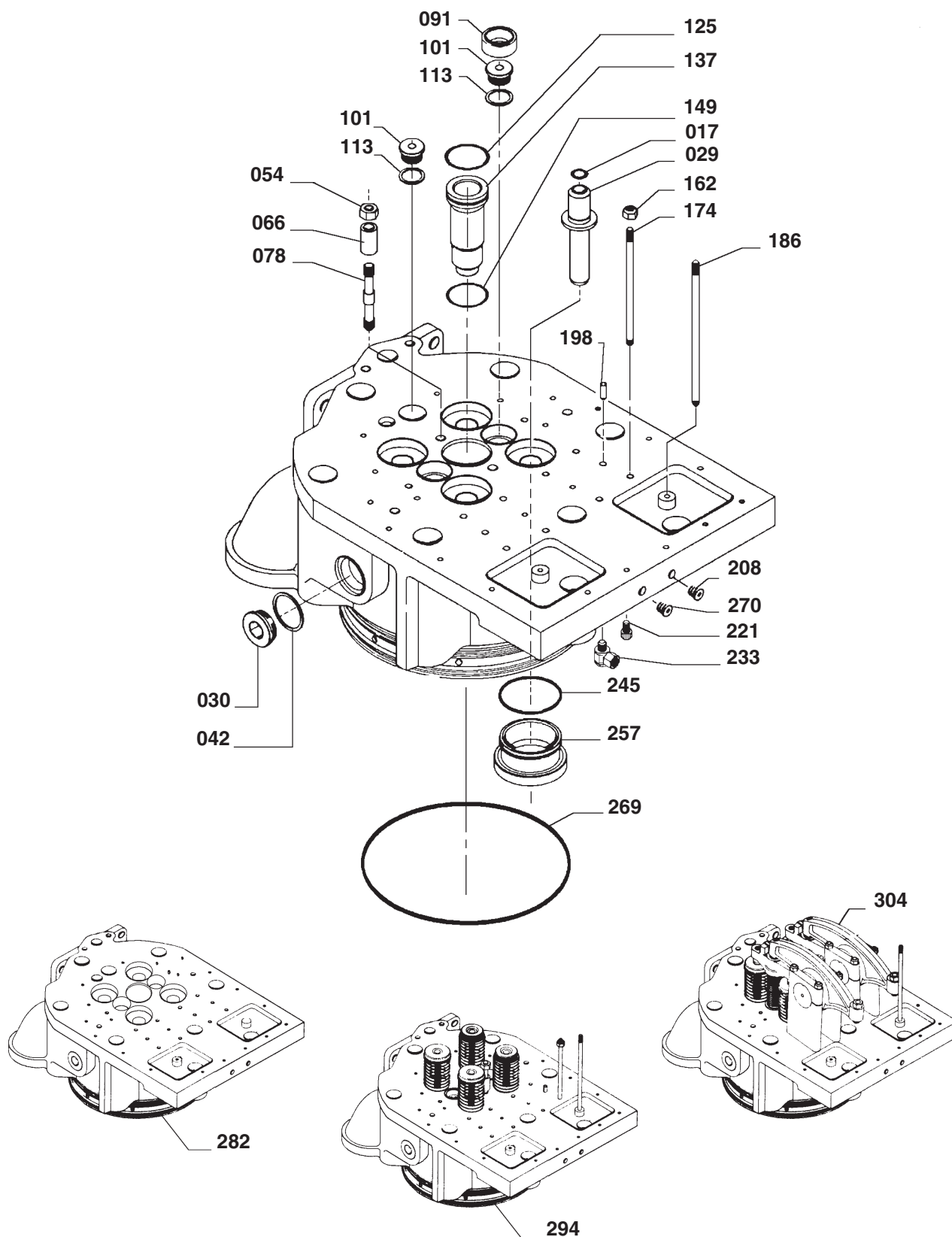


Fig. 1. Cylinder Head

|                     |                      |                  |
|---------------------|----------------------|------------------|
| Plate<br>Page 1 (2) | <b>Cylinder Head</b> | <b>60501-19H</b> |
|---------------------|----------------------|------------------|

**L+V28/32H**



60501-19H

## Cylinder Head

Plate  
Page 2 (2)

## L+V28/32H

| Item No. | Qty. | Designation   | Benævnelse  | Item No. | Qty. | Designation   | Benævnelse  |
|----------|------|---|---|----------|------|---|---|
| 017      | 4/C  | O-ring  | O-ring  | 304      |      | Cylinder head (as 294) with brackets and rockerarms installed | Cylinderdæksel (som 294) monteret med bukke og vippearne. |
| 029      | 4/C  | Valve guide, inlet and exhaust  | Ventilstyr, indstr. og udstr.   |          |      |   |   |
| 030      | 6/C  | Plug screw  | Propskrue   |          |      |   |   |
| 042      | 6/C  | Gasket  | Pakning   |          |      |   |   |
| 054      | 2/C  | Nut   | Møtrik  |          |      |   |   |
| 066      | 2/C  | Distance pipe   | Afstandsrør   |          |      |   |   |
| 078      | 2/C  | Stud  | Tap   |          |      |   |   |
| 091      | 2/C  | Thrust collar   | Trykflange  |          |      |   |   |
| 101      | 4/C  | Plug screw  | Propskrue   |          |      |   |   |
| 113      | 4/C  | Gasket  | Pakning   |          |      |   |   |
| 125      | 1/C  | Snap ring   | Låsering  |          |      |   |   |
| 137      | 1/C  | Sleeve for fuel valve   | Foring for br. ventil   |          |      |   |   |
| 149      | 1/C  | O-ring  | O-ring  |          |      |   |   |
| 162      | 8/C  | Nut   | Møtrik  |          |      |   |   |
| 174      | 8/C  | Stud  | Tap   |          |      |   |   |
| 186      | 4/C  | Stud  | Tap   |          |      |   |   |
| 198      | 4/C  | Spring pin  | Fjederstift   |          |      |   |   |
| 208      | 2/C  | Plug screw  | Propskrue   |          |      |   |   |
| 221      | 2/C  | Screw   | Skrue   |          |      |   |   |
| 233      | 2/C  | Coupling  | Kobling   |          |      |   |   |
| 245      | 4/C  | O-ring  | O-ring  |          |      |   |   |
| 257      | 4/C  | Valve seat ring, (inlet and exhaust)                                      | Ventilsædering, (indstr. og udstødning)   |          |      |   |   |
| 269      | 2/C  | O-ring  | O-ring  |          |      |   |   |
| 270      | 2/C  | Plug screw  | Propskrue   |          |      |   |   |
| 282      |      | Cylinder head with valve guide sleeve for fuel valve and valve seat rings | Cylinderdæksel monteret med spindelstyr, foring for br. ventil og ventilsæderinge |          |      |   |   |
| 294      |      | Cylinder head (as 282) with valve spindles installed                      | Cylinderdæksel (som 282), monteret med ventilspindler                             |          |      |   |   |

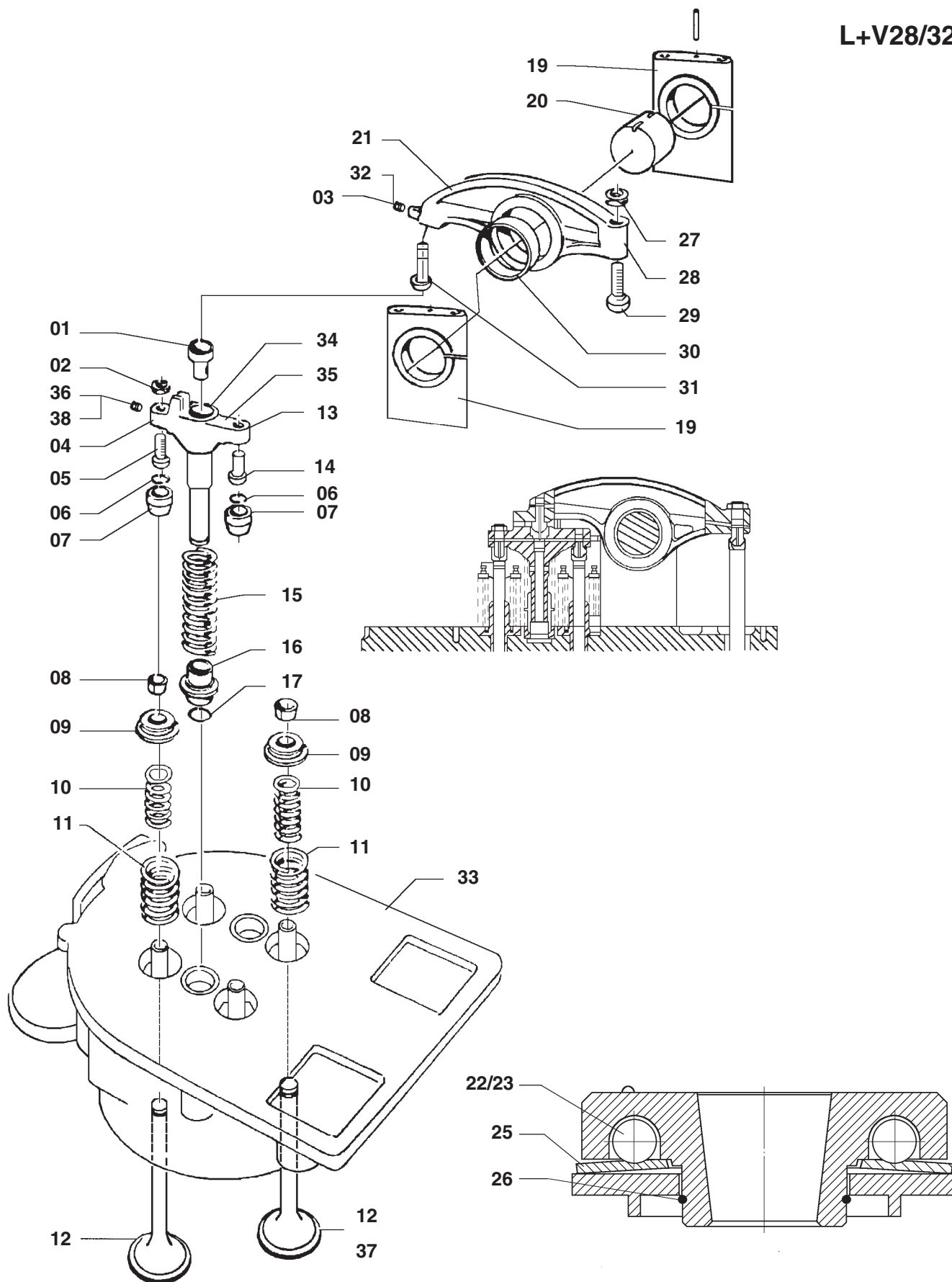
When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/C = Antal/Cylinder

L+V28/32H



60502-31H

## Valve Spindles and Valve Gear

Plate  
Page 2 (2)

## L+V28/32H

| Item No. | Qty. | Designation   | Benævnelse   | Item No. | Qty. | Designation   | Benævnelse  |
|----------|------|---|--|----------|------|---|---|
| 01       | 2/C  | Thrust piece  | Trykstykke   | 28       | 2/C  | Rocker arm  | Vippearm  |
| 02       | 2/C  | Nut   | Møtrik   | 29       | 2/C  | Thrust screw  | Trykskrue   |
| 03       | 4/C  | Plug screw  | Propskrue  | 30       | 2/C  | Bearing bush  | Lejebøsning   |
| 04       | 1/C  | Valve bridge, inlet   | Ventilbro, indstrømning  | 31       | 2/C  | Thrust pin  | Trykskrue   |
| 05       | 2/C  | Thrust screw  | Trykskrue  | 32       | /I   | Loctite 572   | Loctite 572   |
| 06       | 4/C  | Circlip   | Fjederring   | 33       | 1/C  | Cylinder head as Plate 60501 + Plate 60502  | Cylinderdæksel som Plate 60501 + Plate 60502  |
| 07       | 4/C  | Thrust piece  | Trykstykke   | 34       | 1/C  | Valve bridge, inlet complete incl. item 01, 02, 04, 05, 06, 07, 14, 15, 16 and 17   | Ventilbro, indstrømning komplet inkl. item 01, 02, 04, 05, 06, 07, 14, 15, 16 og 17 |
| 08       | 4/C  | Conical ring in 2/2   | Konisk ring 2/2  | 35       | 1/C  | Valve bridge, exhaust complete incl. item 01, 02, 05, 06, 07, 13, 14, 15, 16 and 17 | Ventilbro, udstødning komplet inkl. item 01, 02, 05, 06, 07, 13, 14, 15, 16 og 17   |
| 09       | 4/C  | Rotocap, complete incl. item 22, 23, 25, 26                                   | Rotationsgiver, komplet inkl. item 22, 23, 25, 26                        | 36       | 4/C  | Screw   | Skrue   |
| 10       | 4/C  | Inner spring  | Indvendig fjeder   | 37       | 2/C  | Valve spindle, exhaust (only for stationary engines)                                | Ventilspindel, uds. (kun for stationære motorer)                                    |
| 11       | 4/C  | Outer spring  | Udvendig fjeder  | 38       | /I   | Loctite 243   | Loctite 243   |
| 12       | 4/C  | Valve spindle, inlet and exhaust (valve spindle exh. only for marine engines) | Ventilspindel, inds. og uds. (ventilspindel uds. kun for marine motorer) |          |      |   |   |
| 13       | 1/C  | Valve bridge,exhaust  | Ventilbro, udstødning  |          |      |   |   |
| 14       | 2/C  | Thrust piece  | Trykstykke   |          |      |   |   |
| 15       | 2/C  | Spring  | Fjeder   |          |      |   |   |
| 16       | 2/C  | Ball guide  | Kuglestyr  |          |      |   |   |
| 17       | 2/C  | Securing ring   | Sikring  |          |      |   |   |
| 19       | 4/C  | Rocker arm bracket incl spring pin  | Buk for vippearms inkl spændstift  |          |      |   |   |
| 20       | 2/C  | Rocker arm shaft  | Aksel for vippearms  |          |      |   |   |
| 21       | 2/C  | Rocker arm, compl. (Item 03, 27, 28, 29, 30, 31)                              | Vippearm, komplet (Item 03, 27, 28, 29, 30, 31)                          |          |      |   |   |
| 22       | 24/C | Spring  | Fjeder   |          |      |   |   |
| 23       | 24/C | Ball  | Kugle  |          |      |   |   |
| 25       | 4/C  | Spring washer   | Fjederskive  |          |      |   |   |
| 26       | 4/C  | Retainer ring   | Låserring  |          |      |   |   |
| 27       | 2/C  | Nut   | Møtrik   |          |      |   |   |

When ordering spare parts, see also page 600.50.

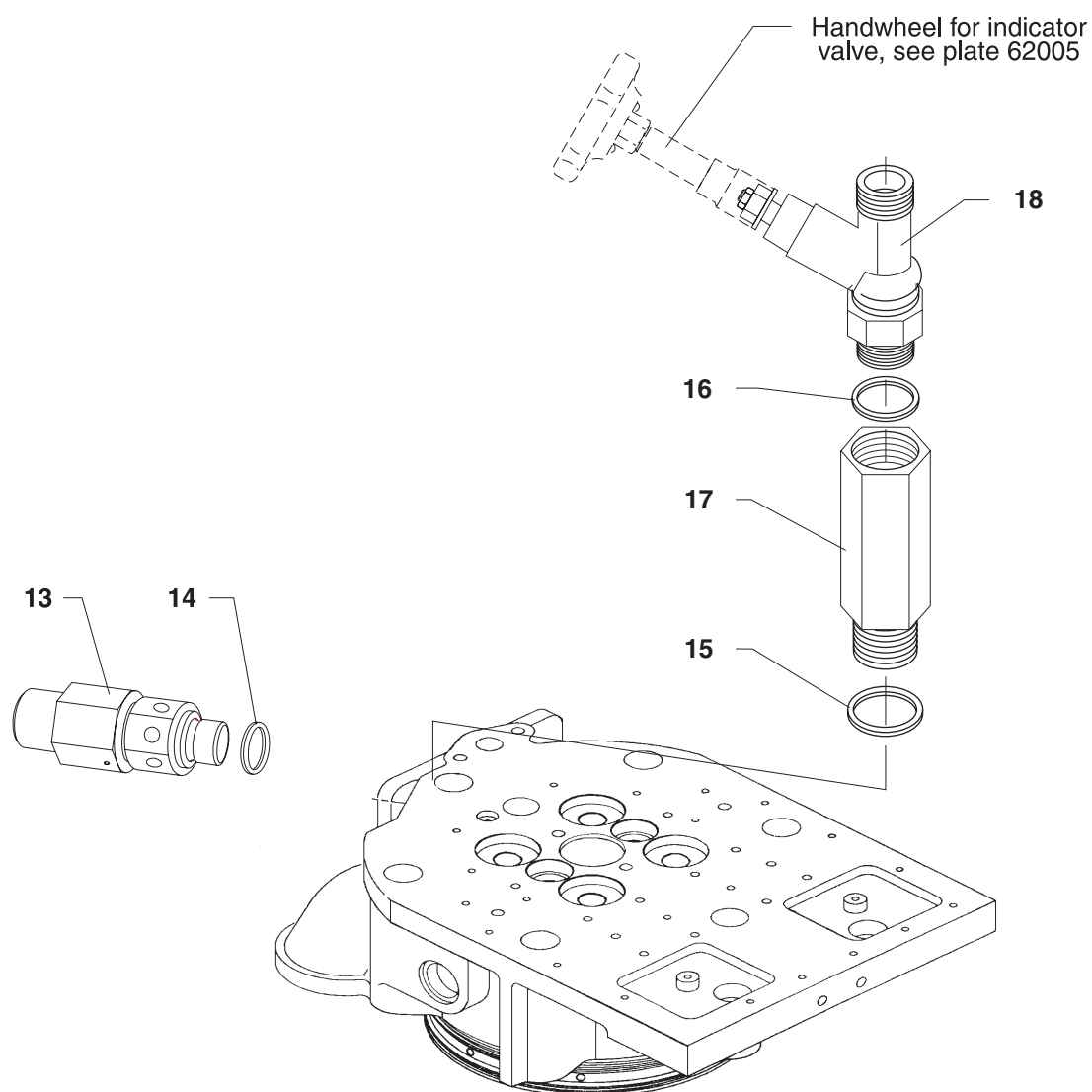
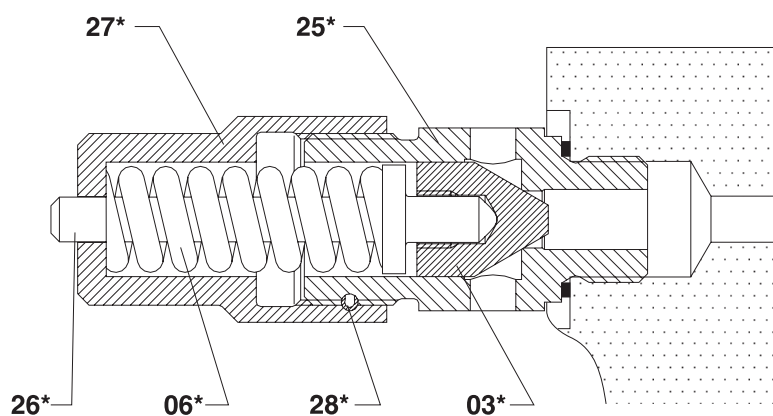
\* = Only available as part of a spare parts kit.  
Qty./C = Qty./Cylinder  
Qty./I = Qty./Individual

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/C = Antal/Cylinder  
Antal/I = Antal/Individuelt

|                     |   |                  |
|---------------------|---|------------------|
| Plate<br>Page 1 (2) | <b>Safety Valve and Indicator Valve</b> | <b>60508-11H</b> |
|---------------------|---|------------------|

**L+V28/32H**



|           |                                  |                     |
|-----------|----------------------------------|---------------------|
| 60508-11H | Safety Valve and Indicator Valve | Plate<br>Page 2 (2) |
|-----------|----------------------------------|---------------------|

L+V28/32H

| Item No. | Qty. | Designation  | Benævnelse  | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|---|----------|------|-------------|------------|
| 03*      | 1/C  | Valve cone   | Ventilkugle   |          |      |             |            |
| 06*      | 1/C  | Pressure spring  | Trykfjeder  |          |      |             |            |
| 13       | 1/C  | Safety valve, complete incl. item 03, 06, 25, 26, 27, 28 | Sikkerhedsventil, komplet inkl. item 03, 06, 25, 26, 27, 28 |          |      |             |            |
| 14       | 1/C  | Gasket   | Pakning   |          |      |             |            |
| 15       | 1/C  | Gasket   | Pakning   |          |      |             |            |
| 16       | 1/C  | Gasket   | Pakning   |          |      |             |            |
| 17       | 1/C  | Connecting piece   | Forbindelsesstykke  |          |      |             |            |
| 18       | 1/C  | Indicator valve, complete                                | Indikatorventil, komplet                                    |          |      |             |            |
| 25*      | 1/C  | Valve housing  | Ventilhus   |          |      |             |            |
| 26*      | 1/C  | Valve spindle  | Ventilspindel   |          |      |             |            |
| 27*      | 1/C  | Cap nut  | Dækselmøtrik  |          |      |             |            |
| 28*      | 1/C  | Split pin  | Fjedernot   |          |      |             |            |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.

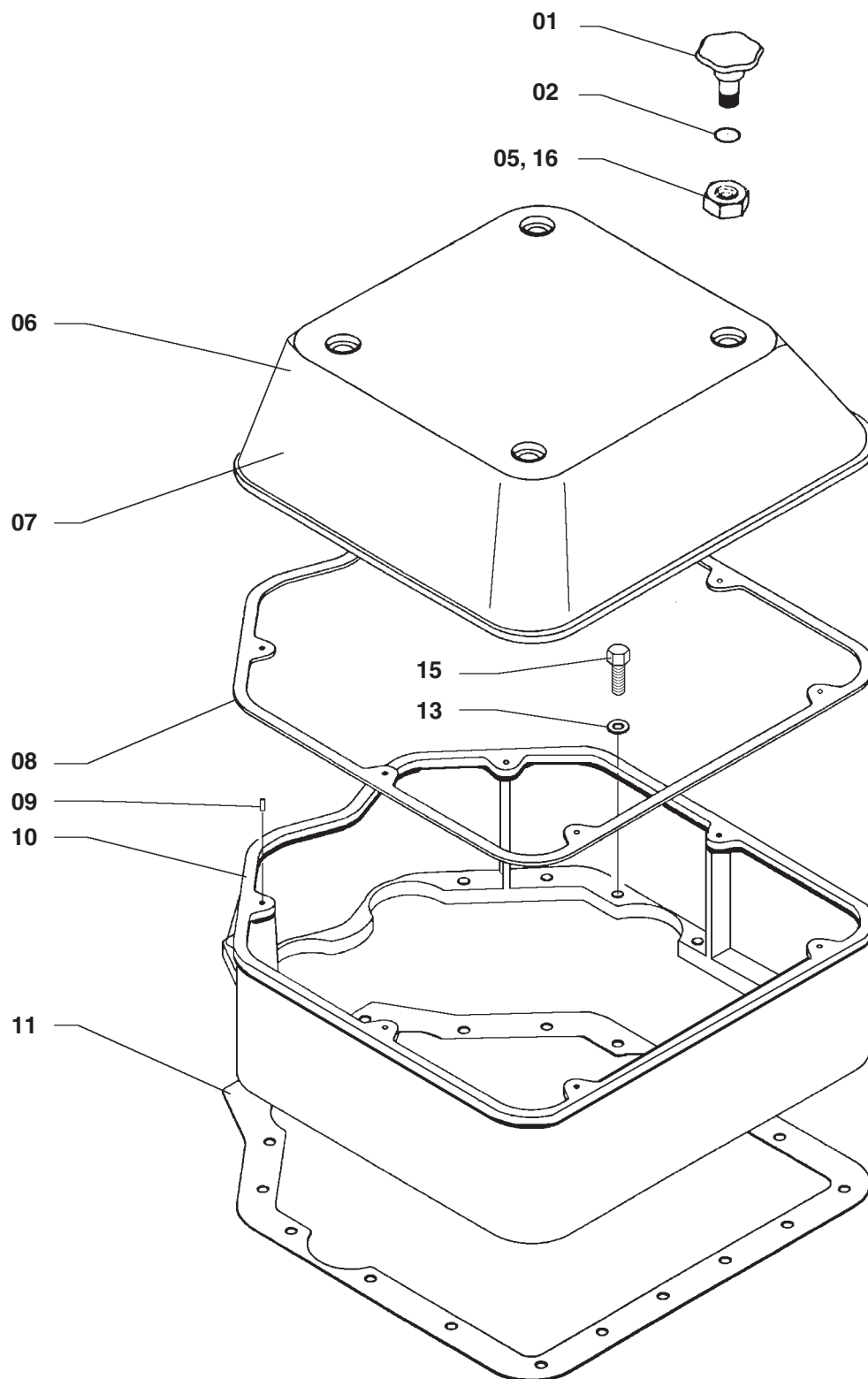
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.

Antal/C = Antal/Cylinder

L+V28/32H





**60510-12H****Cylinder Head, Top Cover**Plate  
Page 2 (2)**L+V28/32H**

| Item No. | Qty. | Designation  | Benævnelse  | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|---|----------|------|-------------|------------|
| 01       | 4/C  | Handle   | Håndtag   |          |      |             |            |
| 02       | 4/C  | O-ring   | O-ring  |          |      |             |            |
| 05       | 4/C  | Nut  | Møtrik  |          |      |             |            |
| 06       | 1/C  | Top cover  | Topdæksel   |          |      |             |            |
| 07       | 1/C  | Top cover, compl.<br>incl. item Nos.<br>01, 02, 05, 06 | Topdæksel, kompl.<br>inkl. pos. nr.<br>01, 02, 05, 06 |          |      |             |            |
| 08       | 1/C  | Gasket   | Pakning   |          |      |             |            |
| 09       | 6/C  | Spring pin   | Fjederstift   |          |      |             |            |
| 10       | 1/C  | Coaming  | Karm  |          |      |             |            |
| 11       | 1/C  | Gasket   | Pakning   |          |      |             |            |
| 13       | 18/C | Washer   | Skive   |          |      |             |            |
| 15       | 18/C | Screw  | Skrue   |          |      |             |            |
| 16       | /l   | Loctite 638  | Loctite 638   |          |      |             |            |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/C = Antal/Cylinder

**Piston/connecting rod**

**506/606**

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (1) | <b>Piston, Connecting Rod and Cylinder Liner</b> | <b>606.01</b><br>Edition 10H |
|---------------------------|--|------------------------------|

**L/V28/32H****Piston**

The piston, which is oil-cooled and of the monobloc type made of nodular cast iron, is equipped with 3 compression rings and 1 scraper ring.

By the use of a combination of compression rings with different barrel-shaped profiles and chrome-plated running surface on all rings, the piston ring pack is optimized for maximum sealing effect and minimum wear rate.

The piston has a cooling oil space close to the piston crown and the piston ring zone. The heat transport and thus the cooling effect is based on the shaker effect arising during the piston movement. As cooling oil is used oil from the engine's lubricating oil system.

**Piston Pin**

The piston pin is fully floating which means that it can turn freely in the pin bosses of the piston as well as in the connecting rod bush. The piston pin is upwords in place in axial direction by two circlips (seeger rings).

**Connecting Rod**

The connecting rod is die-forged. The big-end has an inclined joint in order to facilitate the piston and connecting rod assembly to be withdrawn up through the cylinder liner. The joint faces on connecting rod and bearing cap are serrated to ensure precise location and to prevent relative movement of the parts.

The big-end bearing is of trimetal type, i.e. steel shells lined with tin-aluminium or lead-bronze coated with a running layer. Design as plain type or rillentype. The bearing shells are of the precision type and are therefore to be fitted without scraping or any other kind of adaption.

The small-end bearing is of trimetal type and is pressed into the connecting rod.

**Cylinder Liner**

The cylinder liner is made of fine-grained, pearlite cast iron and is fitted in a bore in the engine frame. Between the liner and the cylinder head and between the liner and the frame there are fitted replaceable cast iron sealing rings. The liner is clamped by the cylinder head and is guided by a bore at the bottom of the cooling water space of the engine frame. The liner can thus expand freely downwards, when heated during the running of the engine. Sealing for the cooling water is obtained by means of silicone rubber rings which are fitted in grooves machined in the liner.

Tell-tale borings in the frame, starting from a level between the sealing rings and leading to the exterior will reveal any sealing malfunction by sign of leaking water or lubricating oil mist.

|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (3) | <b>Dismounting of Piston and Connecting Rod</b> | <b>606-01.00</b><br>Edition 01H |
|----------------------------|---|---------------------------------|

**L28/32H****Safety precautions:**

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Shut-off cooling oil
- Stopped lub. oil circul.

**Description:**

Dismounting of piston and connecting rod assembly, for inspection and/or overhaul.

**Starting position:**

Cylinder head has been dismounted from engine, 605-01.00  
Crank case open.

**Related procedure:**

Separation of piston and connecting rod, 606-01.05  
Inspection and honing of cylinder liner, 606-01.35

**Man power:**

Working time : 1 Hour  
Capacity : 2 men

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.        |
|-----------|----------|--------------|
| 62006     | 01       |              |
| 62006     | 03       |              |
| 62006     | 09       | 2 pieces     |
| 62006     | 22       |              |
| 62006     | 28       | 140 - 760 Nm |
| 62010     | 01       |              |

Tool combination for dismounting of connecting rod screw, see working card 620-01.20.

**Hand tools:**

Threaded pin M16.  
Open end spanner 32 mm.  
Wire.  
Scraper or similar.  
Small adjustable spanner.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|

**L28/32H**

1) Clean the upper part of the cylinder, if not, the piston may get stuck during removal in the carbon deposited in this area.

If the liner is mounted with a flame ring then start with item No a to e.

If the liner is not mounted with a flame ring then continue with item No 2.

- a) Turn the piston to the bottom.
- b) Mount the tool for dismounting of the flame ring in the cylinder at the top of the piston.
- c) Place a used piston ring on top of the flame ring tool.
- d) Mount the tube (for holding down the cylinder liner during the piston withdrawal) on one of the cylinder head studs, screw on the nut and tighten it slightly.

e) Turn the piston in top, in order to push the flame ring out of the cylinder by means of the tool.

Info: It is the used piston ring which pushes the flame ring out of the cylinder, while the flame ring tool guides the piston ring out against the cylinder liner.

2) Remove the gangway, if any installed, in order to improve the access conditions.

3) Turn the crankshaft to bring the crank throw concerned into a position approx. 50 degrees before TDC.

This position is identifiable by the connecting rod shaft being very close to cylinder liner skirt, see fig. 1.

4) Clean the threaded hole in the piston top, and mount the eye screw.

Mount the tube (for holding down the cylinder liner during the piston withdrawal) on one of the cylinder head studs, screw on the nut and tighten it slightly.

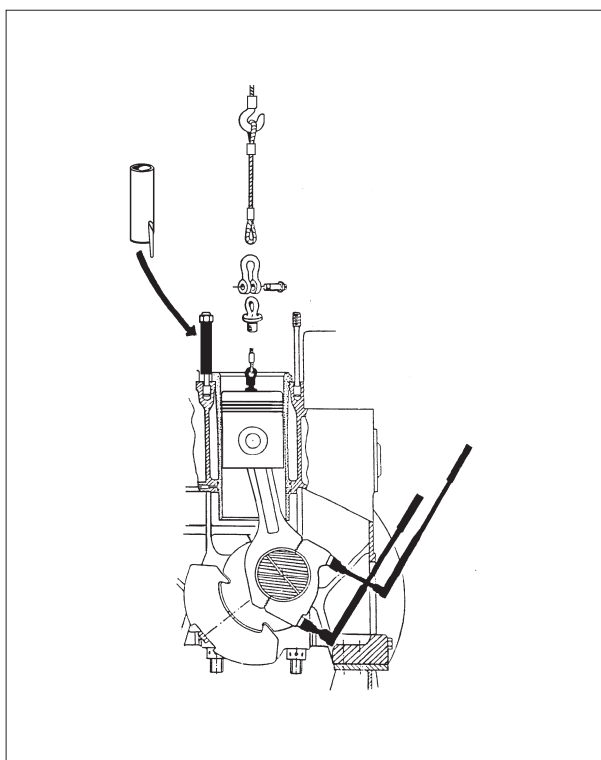


Fig. 1. Mounting of tools. (placing).

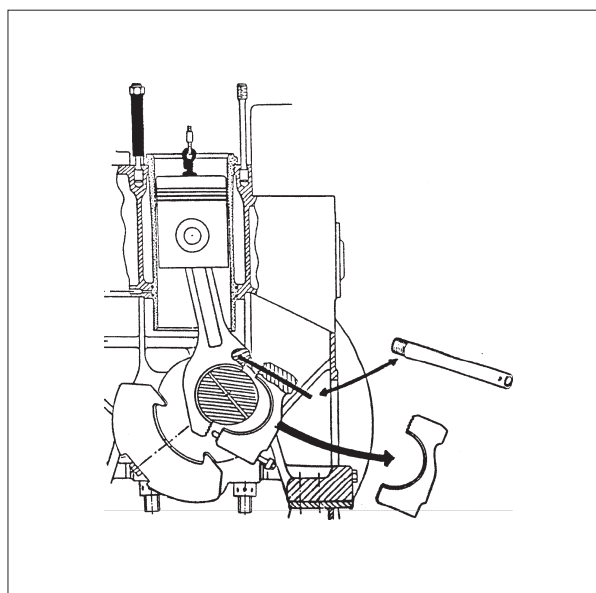
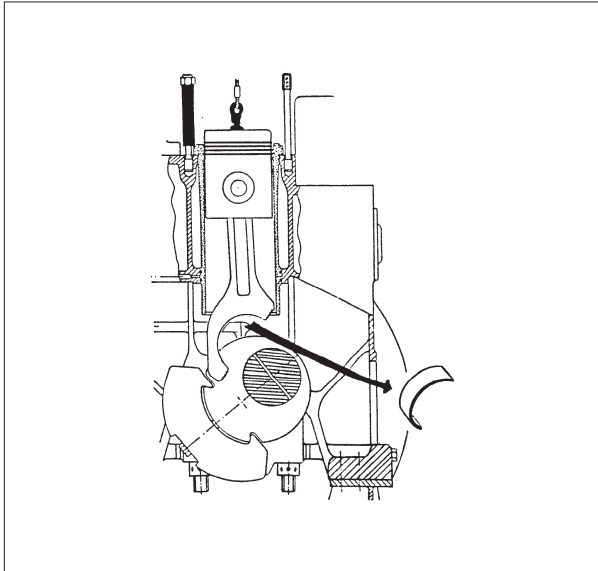


Fig. 2. Removal of bearing cap.

5) Attach a wire rope to the eye bolt by means of a shackle, hook the wire on to a tackle and pull the wire rope tight.

**L28/32H**

*Fig. 3. Removal of upper big-end bearing shell.*

If minor adjustment of the crank throw position appears necessary for access to the connecting rod screws, the wire rope must be slackened before turning of the crankshaft and tightened up again in the new crank throw position.

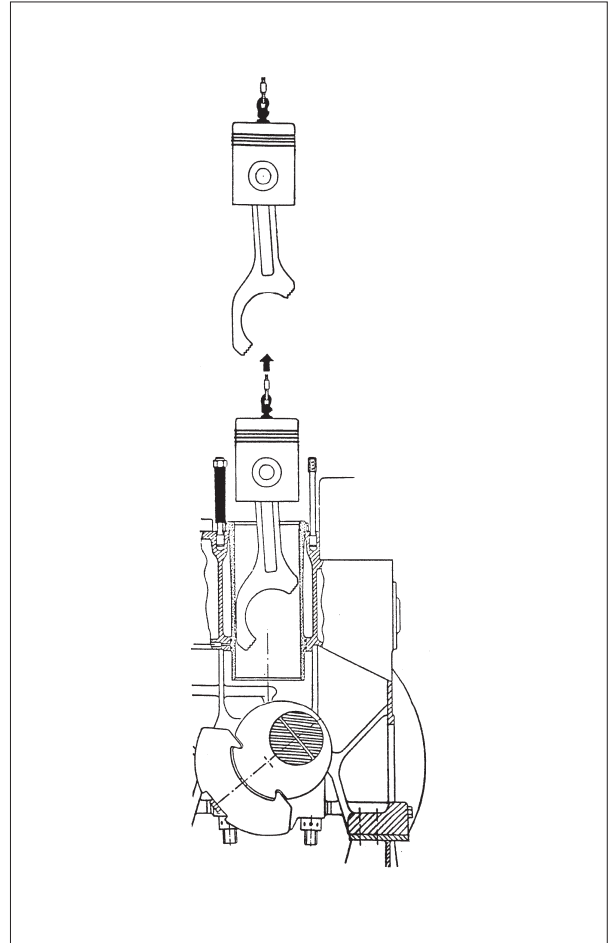
**6)** Unload the connecting rod screws and unscrew one of the upper screws.

**7)** Mount the guide pin for the bearing cap in one of the threaded holes and fit a screwdriver or similar in the hole in the guide pin, and unscrew the screws.

**8)** Remove the screwdriver from the guide pin, and dismount the bearing cap by sliding it along the guide pin, see fig. 2.

**9)** Remove the guide pin from the connecting rod.

**10)** Pull the piston and connecting rod assembly upwards and remove the upper big-end bearing shell, see fig. 3.



*Fig. 4. Lift of piston and connecting rod assembly.*

**11)** Lift the piston and connecting rod assembly up through the cylinder liner and out of the engine, see fig. 4.

**NOTE:** The purpose of the guide pin is to prevent any damage of crank journal, joint faces or bearing surface to occur during dismounting of the bearing cap, and to facilitate easy handling when removing the bearing cap from the crankcase.

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Separation of Piston and Connecting Rod</b> | <b>606-01.05</b><br>Edition 03H |
|----------------------------|--|---------------------------------|

**L/V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Separation of piston and connecting rod for inspection or/and overhaul.  
 Assembly of the piston and connecting rod after inspection or/and overhaul.

**Starting position:**

Piston and connecting rod are dismantled from engine, 606-01.00

**Related procedure:**

Inspection or/and overhaul of piston, 606-01.10  
 Inspection or/and overhaul of connecting rod, 606-01.15  
 Inspection of connecting rod big-end bearing, 606-01.16

**Man power:**

Working time : 1/4 hour  
 Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
 Data for torque moment (Page 600.40)  
 Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.   |
|-----------|----------|---------|
| 62006     | 01       | L28/32H |
| 62006     | 03       | L28/32H |
| 62006     | 05       | V28/32H |
| 62006     | 20       |         |

**Hand tools:**

Open end spanner, 32 mm.  
 Wooden wedge, 2 pieces.  
 Wooden support.  
 Wire.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|

## L/V28/32H

**Separation of the Piston and Connecting Rod:**

1) Land the piston and connecting rod carefully on wooden support to prevent damage of piston and scraper ring, see fig. 1 or 2.

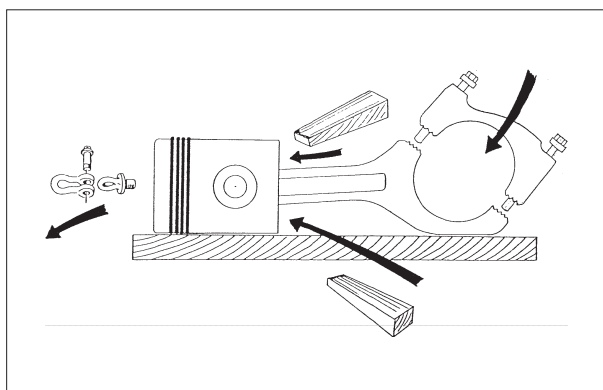


Fig. 1. L28/32H

2) The bearing cap should be mounted with the screws tightened only by hand, in order to protect the serrated joint faces during handling of the assembly, see fig. 1 or 2.

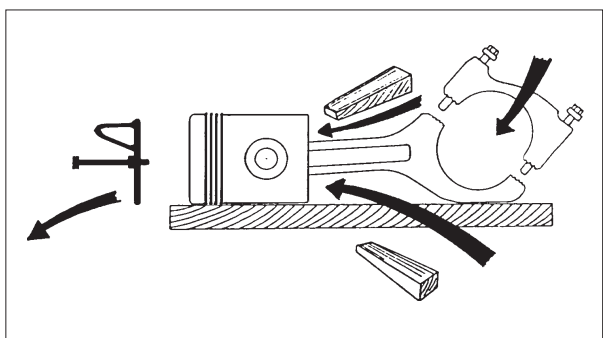


Fig. 2. V28/32H

3) Remove the shackle and eye screw/lifting tool from the piston crown, see fig. 1 or 2.

4) Place the piston and connecting rod assembly in upright position resting on the top face of the piston crown, see fig. 3.

Wooden wedges should be used to prevent the connecting rod from swinging out and thus impact the piston skirt during the lifting into upright position.

5) Place a wire around the big-end of the connecting rod, attach a tackle and tighten the wire rope, see fig. 3

6) Take out the securing ring, (seeger circlips), push out the piston pin and lift the connecting rod away.

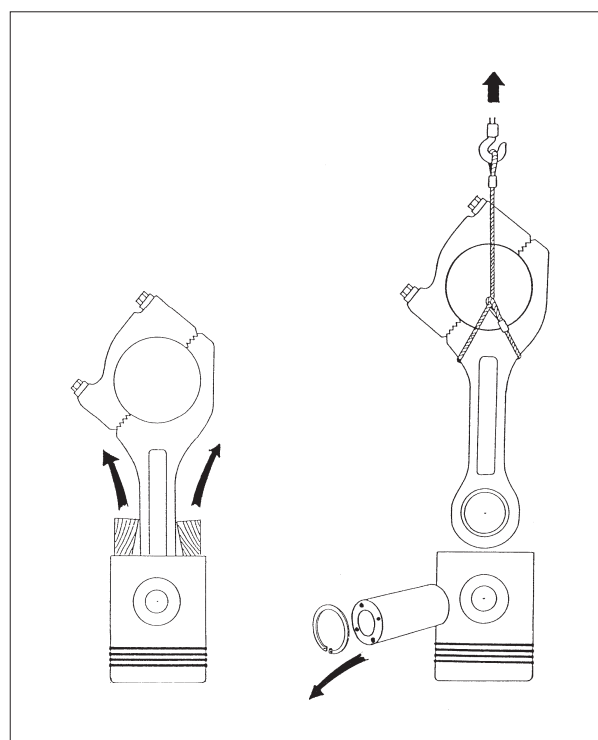


Fig. 3.

**Assembly of the Piston and Connecting Rod.**

7) For assembly of the piston and connecting rod, see point 1-6 in opposite direction.

8) Lubricate the piston pin before assembling.



|                            |                                 |                                 |
|----------------------------|---------------------------------|---------------------------------|
| Working Card<br>Page 1 (4) | <b>Piston (with flame ring)</b> | <b>606-01.10</b><br>Edition 09H |
|----------------------------|---------------------------------|---------------------------------|

**L+V28/32H****Safety precautions**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description**

Cleaning and inspection of piston. Control of piston ring, scraper ring and ring grooves.

**Starting position**

Piston has been dismantled from connecting rod 606-01.05

**Related procedure**

Mounting of piston and connecting rod 606-01.20

**Man power**

Working time : 1/2 Hour  
Capacity : 1 man

**Data**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools**

| Plate no | Item no | Note. |
|----------|---------|-------|
| 62006    | 13      |       |
| 62006    | 15      |       |
| 62006    | 16      |       |

**Hand tools**

Tools for cleaning of piston, steel brush, scraper etc.

**Replacement and wearing parts**

| Plate no | Item no | Qty. / |
|----------|---------|--------|
|----------|---------|--------|

|                                 |                                 |                            |
|---------------------------------|---------------------------------|----------------------------|
| <b>606-01.10</b><br>Edition 09H | <b>Piston (with flame ring)</b> | Working Card<br>Page 2 (4) |
|---------------------------------|---------------------------------|----------------------------|

## L+V28/32H

### Removal of Piston Ring

For removal of piston rings, which are to be used again, and for all mounting of rings, only the special ring opener which prevents local over stressing of the rings should be used.

Straps to expand the ring gap or tools working on the same principle must not be used, as this would result in permanent deformation which might cause blow-by or broken rings.

### Inspection of Piston

- 1) Remove the piston and scraper rings.
- 2) Clean and examine the piston rings to determine if reuse is acceptable, see page 3.
- 3) Clean the piston outside and inside.
- 4) Inspect the piston ring and scraper ring grooves for wear, see page 3.

|                            |                                 |                                 |
|----------------------------|---------------------------------|---------------------------------|
| Working Card<br>Page 3 (4) | <b>Piston (with flame ring)</b> | <b>606-01.10</b><br>Edition 09H |
|----------------------------|---------------------------------|---------------------------------|

**L+V28/32H**

The piston has to be scrapped if:

- A) The wear limit on the testing mandrel is exceeded, see fig 1A

or

- B) The clearance between the new piston/scrapper ring and ring groove is exceeded, see fig 1B.

**Note: At each piston overhaul:**

- **The piston and scraper ring must be exchanged.**
- **The cylinder liner must be honed according to the instructions.**

|                  | Piston and oil scraper ring.<br><i>Nominal size.</i> | New ring grooves.<br>Tolerances. | Ring grooves.<br>Max. wear limit. |
|------------------|--|----------------------------------|-----------------------------------|
| Piston ring no 1 | New<br>5.0 mm  | 5.0 mm $+0.18$<br>$+0.16$        | 5.43 mm                           |
| Piston ring no 2 | New<br>5.0 mm  | 5.0 mm $+0.14$<br>$+0.12$        | 5.43 mm                           |
| Piston ring no 3 | New<br>4.95 mm                                       | 5.0 mm $+0.14$<br>$+0.12$        | 5.43 mm                           |
| Scraper ring     | New<br>8.0 mm  | 8.0 mm $+0.12$<br>$+0.10$        | 8.43 mm                           |

Table 1 Nominal size, new ring groove tolerance and wear limit for ring grooves

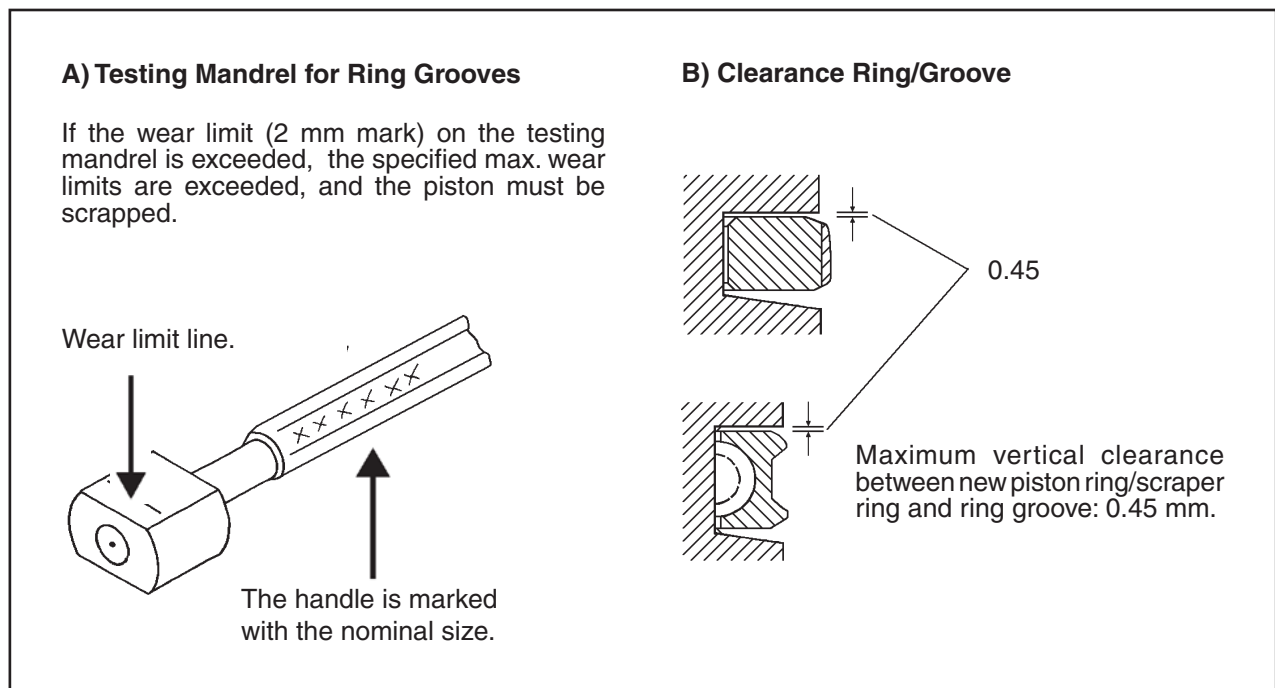


Fig 1 Wear limits for ring grooves

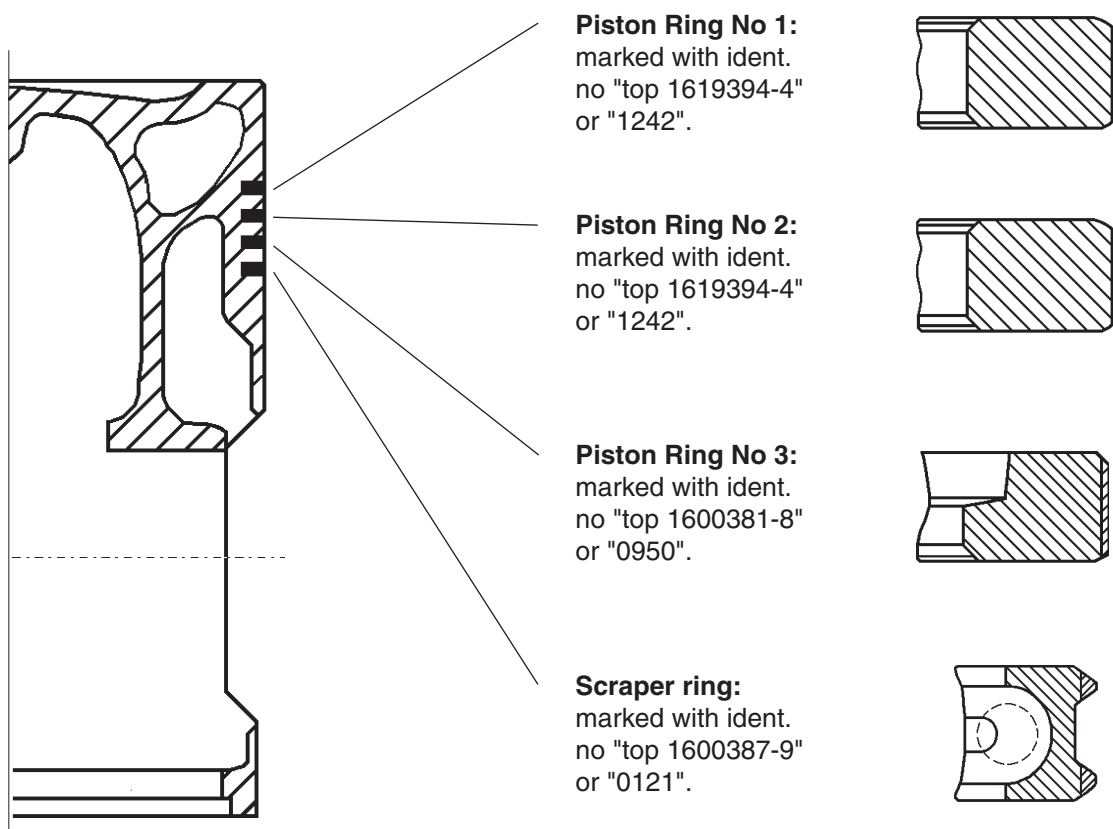
**606-01.10**  
Edition 09H

## Piston (with flame ring)

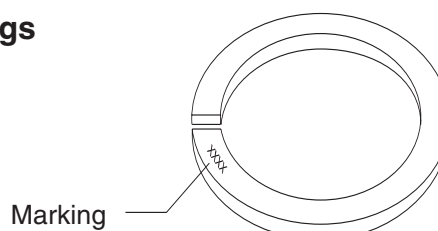
Working Card  
Page 4 (4)

**L+V28/32H**

### Position of Piston and Scraper Rings



### Marking of Piston and Scraper Rings



Identification marks to face upwards against the piston crown when mounted.

**Note:** The marking may include other figures than mentioned above, for instance trade mark and production codes.

08028-0D/H5250/94.08.12

|                            |                       |                                 |
|----------------------------|-----------------------|---------------------------------|
| Working Card<br>Page 1 (4) | <b>Connecting Rod</b> | <b>606-01.15</b><br>Edition 04H |
|----------------------------|-----------------------|---------------------------------|

**L/V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Cleaning, inspection and test measurement of connecting rod.

**Starting position:**

Connecting rod has been dismantled from piston, 606-01.05

**Related procedure:**

Mounting of piston and connecting rod, 606-01.20

**Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.      |
|-----------|----------|------------|
| 62006     | 28       | 140-760 Nm |

**Hand tools:**

Inside micrometer (242 mm).  
Feeler gauge 0,15 - 0,20 mm.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|-----------|----------|--------|

## L/V28/32H

**Cleaning and Inspection of Big-end Bore.**

The connecting rod is cleaned on all machined surfaces.

The serrated joint faces and threaded screw holes are to be degreased with a volatile solvent and blown dry with working air.

The serrated joint faces are inspected.

The serration on the connecting rod may, due to relative movements between the mating surfaces, show damages in form of wear marks and pittings or even cracks in highly loaded zones.

Observed damages should be registered in the schem "Connecting Rod Inspection". See page 4.

Wear marks are visible but not appreciable at a fingernail. Pittings are not only visible but also noticeable at a fingernail.

Single distinctly raised spots caused by pitting should be gently smoothed by careful, local treatment with a file.

The serration on the connecting rod and on the bearing cap can be damaged by improper handling during dismounting, transport and overhaul work.

**Note !** The connecting rod and bearing cap must therefore be handled with care.

Single dent marks caused by impact can be rectified by gentle and careful local treatment with a file.

In case of damage of the serration, reuse must be rejected, and a new connecting rod assembly including new bearing shells must be mounted in the engine.

The connecting rod screws are to be carefully cleaned.

The threads are inspected for seizures and tested in the threaded holes in the connecting rod. The test must confirm, that the screws can be turned into bottom position by hand. The contact surface of the screw heads is inspected for seizure and pittings.

Screws, which are damaged as mentioned above or cannot be turned into the threaded holes by hand, must be renewed.

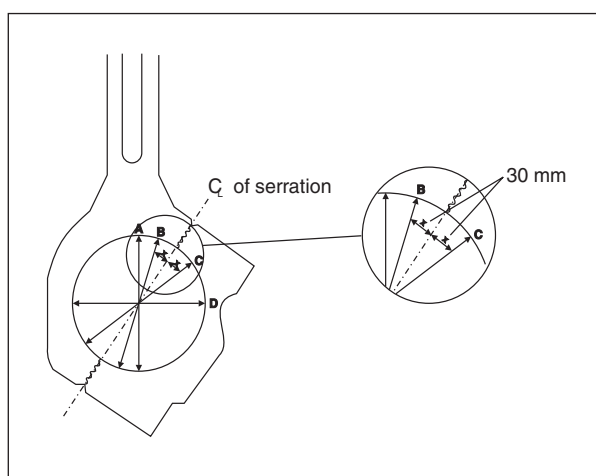
**Measurement of Big-end Bore.**

Fig. 1. Point of measurement

For check of roundness the big-end bore has to be measured in a condition, where the connecting rod is mounted with the bearing cap but without bearing shells, and the connecting rod screws are tightened up with the prescribed torque, see working card 606-01.25.

**Note !** The ident no. on the connecting rod and the bearing cap, **must** always be the same, see fig. 3.

Measurements **must** be taken 30 mm from serration centerline. See fig. 1.

The measuring is executed with an inside micrometer.

Five different diameters are measured in the middle of the boring, see fig. 1 and registered in the scheme "Connecting Rod Inspection". See page 4.

The maximum ovalness is calculated as the difference between biggest and smallest diameter measured. For maximum allowable ovalness see page 600.35.

L/V28/32H

If the ovalness exceeds this value, reuse must be rejected and a new complete connecting rod, including new screws and new bearing shells has to be mounted in the engine.

Please note that squares for statement of information and identification, should also be properly filled in.

Connecting Rod Bush.

Inspect the surface of the piston pin and the connecting rod bush. Measure the clearance between the piston pin and bush, max. clearance between pin and bush, see page 600.35.

In case the specified clearance is exceeded, contact MAN B&W Diesel A/S, Holeby for replacement.

Bearing Shells for Big-end.

Criteria for replacement of connecting rod big-end bearing, see working card 606-01.16.

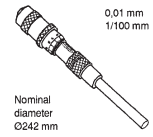
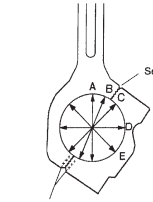
| Connecting Rod Inspection for L+V28/32H (SI)  |   |   |   | Plant/Ship: |
|---|---|---|---|-------------|
|   |   |   |   | Engine No.: |
|   |   |   |   | Sign.:      |
| Cylinder no.  | 1   | 2   | 3   |             |
| Connecting rod ident no.  |   |   |   |             |
| Running hours for connecting rod  |   |   |   |             |
|    | A   | - 0,5                                       | - 3,0                                       |             |
|   | B   | - 2,0                                       | - 7,0                                       |             |
|   | C   | - 1,5                                       | - 5,0                                       |             |
|   | D   | + 5,0                                       | + 5,5                                       |             |
|   | E   | + 3,0                                       | + 3,5                                       |             |
| Ovalness: Difference between minimum and maximum.                                   | 7,0   | 12,5  |   |             |
| Condition of serration  | <input type="checkbox"/> Serration OK       | <input type="checkbox"/> Serration OK       | <input type="checkbox"/> Serration OK       |             |
| Tightening for measurement see instruction.   | <input type="checkbox"/> Wear               | <input type="checkbox"/> Wear               | <input type="checkbox"/> Wear               |             |
|   | <input type="checkbox"/> Cracks             | <input type="checkbox"/> Cracks             | <input type="checkbox"/> Cracks             |             |
|   | <input type="checkbox"/> Corrosion/ Pitting | <input type="checkbox"/> Corrosion/ Pitting | <input type="checkbox"/> Corrosion/ Pitting |             |
|   | <input type="checkbox"/> Impact mark        | <input type="checkbox"/> Impact mark        | <input type="checkbox"/> Impact mark        |             |
|  | Remarks:<br>to be reused                    | Remarks:<br>to be rejected                  | Remarks:                                    |             |

Fig. 2. "Connecting rod inspection".

The example, see fig. 2 shows measurements and damage observations for two connecting rods, on the scheme "Connecting Rod Inspection", (In case the specified maximum ovalness is exceeded, contact MAN B&W Diesel A/S, Holeby for overhaul).

For connecting rod no. 1 the maximum ovalness is 0,07 mm and reuse thus acceptable.

For connecting rod no. 2 the maximum ovalness is 0,125 mm and therefore the connecting rod is being rejected.

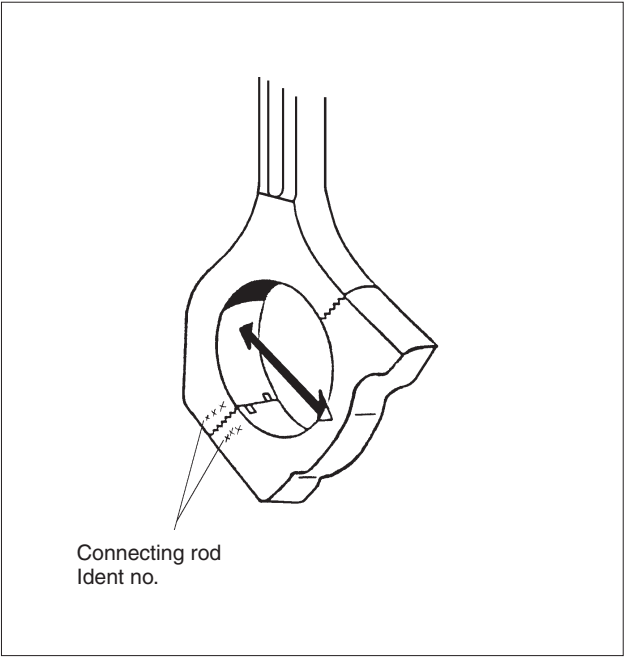


Fig. 3.

**606-01.15**  
Edition 04H

## Connecting Rod

Working Card  
Page 4 (4)

**L/V28/32H**

| Connecting Rod Inspection for L/V28/32H(SI) |  |  |  |  | Plant/Ship:                                    |  | Engine Type:                                   |  |  |
|---|--|--|--|--|--|--|--|--|--|
|   |  |  |  |  | Engine No.:                                    |  | Running Hours:                                 |  |  |
|   |  |  |  |  | Sign.:   |  | Insp. Date:                                    |  |  |
| Cylinder no.                                | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
| Connecting rod ident no.                    |  |  |  |  |  |  |  |  |  |
| Running hours for connecting rod            |  |  |  |  |  |  |  |  |  |
| A<br>0,01 mm                                |  |  |  |  |  |  |  |  |  |
| B<br>1/100 mm                               |  |  |  |  |  |  |  |  |  |
| C   |  |  |  |  |  |  |  |  |  |
| D   |  |  |  |  |  |  |  |  |  |
| E   |  |  |  |  |  |  |  |  |  |
| Nominal diameter<br>Ø242 mm                 |  |  |  |  |  |  |  |  |  |
| Ovalness: Diff. between min./max.           |  |  |  |  |  |  |  |  |  |
| Condition of serration                      | <input type="checkbox"/> Serration OK          | <input type="checkbox"/> Serration OK          | <input type="checkbox"/> Serration OK          | <input type="checkbox"/> Serration OK          | <input type="checkbox"/> Serration OK          | <input type="checkbox"/> Serration OK          | <input type="checkbox"/> Serration OK          | <input type="checkbox"/> Serration OK          | <input type="checkbox"/> Serration OK          |
| Tightening for measurement see instruction. | <input type="checkbox"/> Wear                  | <input type="checkbox"/> Wear                  | <input type="checkbox"/> Wear                  | <input type="checkbox"/> Wear                  | <input type="checkbox"/> Wear                  | <input type="checkbox"/> Wear                  | <input type="checkbox"/> Wear                  | <input type="checkbox"/> Wear                  | <input type="checkbox"/> Wear                  |
|   | <input type="checkbox"/> Cracks                | <input type="checkbox"/> Cracks                | <input type="checkbox"/> Cracks                | <input type="checkbox"/> Cracks                | <input type="checkbox"/> Cracks                | <input type="checkbox"/> Cracks                | <input type="checkbox"/> Cracks                | <input type="checkbox"/> Cracks                | <input type="checkbox"/> Cracks                |
|   | <input type="checkbox"/> Corrosion/<br>Pitting | <input type="checkbox"/> Corrosion/<br>Pitting | <input type="checkbox"/> Corrosion/<br>Pitting | <input type="checkbox"/> Corrosion/<br>Pitting | <input type="checkbox"/> Corrosion/<br>Pitting | <input type="checkbox"/> Corrosion/<br>Pitting | <input type="checkbox"/> Corrosion/<br>Pitting | <input type="checkbox"/> Corrosion/<br>Pitting | <input type="checkbox"/> Corrosion/<br>Pitting |
|   | <input type="checkbox"/> Impact mark           | <input type="checkbox"/> Impact mark           | <input type="checkbox"/> Impact mark           | <input type="checkbox"/> Impact mark           | <input type="checkbox"/> Impact mark           | <input type="checkbox"/> Impact mark           | <input type="checkbox"/> Impact mark           | <input type="checkbox"/> Impact mark           | <input type="checkbox"/> Impact mark           |
| Connecting rod<br>Ident no.                 | Remarks:                                       | Remarks:                                       | Remarks:                                       | Remarks:                                       | Remarks:                                       | Remarks:                                       | Remarks:                                       | Remarks:                                       | Remarks:                                       |

The diagram shows a cross-section of a connecting rod. Points A, B, C, D, and E are marked on the circular surface. A serration is shown on the left side of the rod. Arrows point from the labels to their respective locations on the diagram.

**Note !** The ident no. on the connecting rod and on the bearing cap, must always be the same.



|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (8) | <b>Criteria for Replacement of<br/>Connecting Rod Big-end and Main Bearing Shells</b> | <b>606-01.16</b><br>Edition 02H |
|----------------------------|---|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Inspection of bearing shells.

**Starting position:**

Bearing shells removed from engine:  
 Big-end bearing, 606-01.00 and 606-01.30  
 or  
 Main bearing, 610-01.05  
 Guide bearing, 610-01.10

**Related procedure:**

Mounting of bearing shells:  
 Big-end bearing, 606-01.20 and 606-01.30  
 Main bearing, 610-01.05  
 Guide bearing, 610-01.10

**Man power:**

Working time : 1/4 Hour  
 Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
 Data for torque moment (Page 600.40)  
 Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
| 62006     | 55       |       |

**Hand tools:**

Magnifier (x30).

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|-----------|----------|--------|

**L+V28/32H**

This paper gives information about the evaluation of the connecting rod big-end and main bearing shells when wear appears on the running surface under normal operating conditions.

Bearing damages caused by incorrect running conditions, like

- Scoring of the running surface due to foreign particles in the lubricating oil.
- Cavitation.
- Corrosion
- Overloading, overheating a.s.o.

are not described in this paper.

In these cases, the bearing shells must be exchanged, of course, and in order to avoid further bearing failures, the cause of the failure must be found and eliminated.

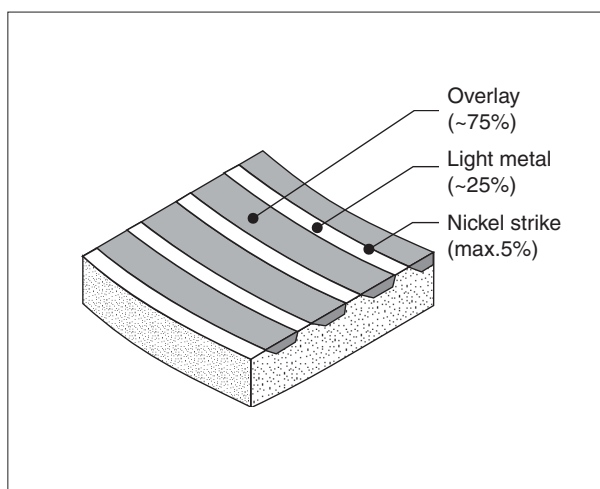


Fig. 1. Running surface of the bearing shell.

A new bearing shell has a running surface with approx. 75 % galvanic overlay and approx. 25 % light-alloy metal, see fig. 1.

Wear of the bearings running surface starts primarily in the soft overlay, where the overlay in the slots is reduced approx. 0.001 mm. The difference between the light-alloy metal and the overlay is by further wear almost constant, i.e. approx. 0.005 mm.

The gravity of the running surface's wear must be determined with a magnifier (x30), hereby the overlay can be seen as the dark area and the light-alloy metal as the light area.

The ratio between the width of the light-alloy metal and the width of the slot as well as the dimension of the worn area are important for determining the wear of the bearing.

The bearing can also operate although part of the overlay is missing in the slots. Practice has shown, that bearings with partly empty slots can run without any negative influence on the operation of the bearing.

By determining the condition of the bearing shell, the overlay at a minor stressed area must be used as comparison.

The valuation of the bearing shell condition is divided into 5 groups:

1. Re-use
2. Limiting case - wear
3. Limiting case - local levelling
4. Limiting case - permanent breakage on the overlay
5. Empty slots.

In case of a combination of the above mentioned conditions, the lowest possible limits are valid.

**Criteria for Replacement of  
Connecting Rod Big-end and Main Bearing Shells****606-01.16**  
Edition 02H**L+V28/32H****1.1. Bearing Shells for Re-use.**

**Condition:** The slot geometry corresponds to a new bearing shell. The overlay in the slots is fully preserved, see fig. 2.

Dark spots are mainly oil coke remains.

**Valuation:** The ratio between light-alloy metal and overlay is 75 % to 25 %. Re-use!

**1.2. Bearing Shells for Re-use.**

**Condition:** The overlay is equally worn, approx. 0.005 mm in the slots. The light-alloy strips show no wear, see fig. 3.

Dark spots are mainly oil coke remains.

**Valuation:** Due to worn running surface the light-alloy strips are slightly widened. Re-use!

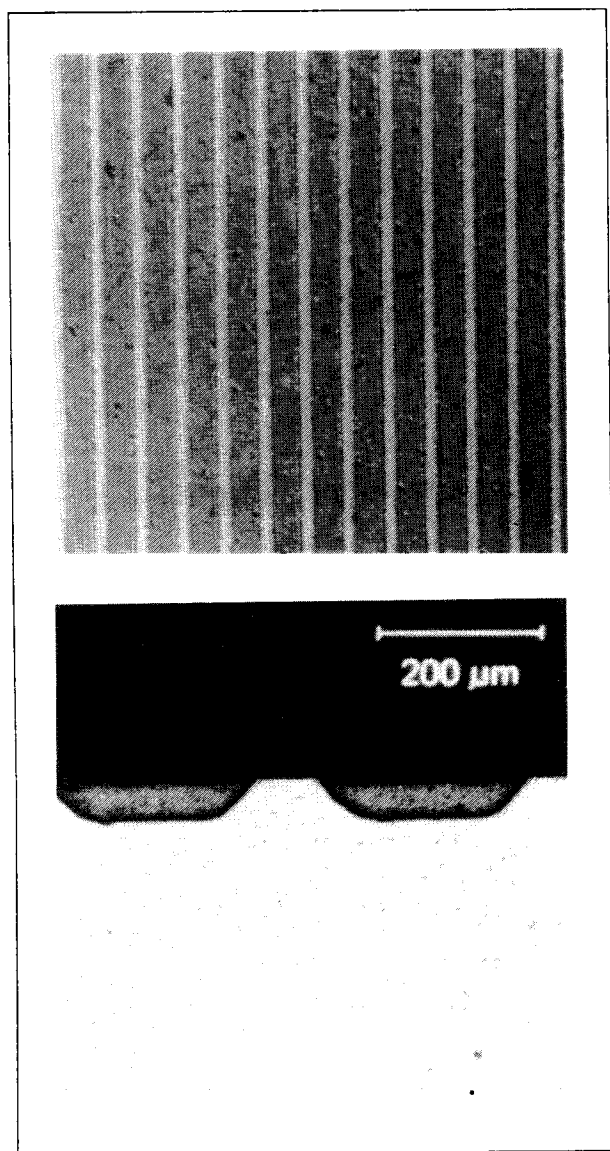


Fig. 2.

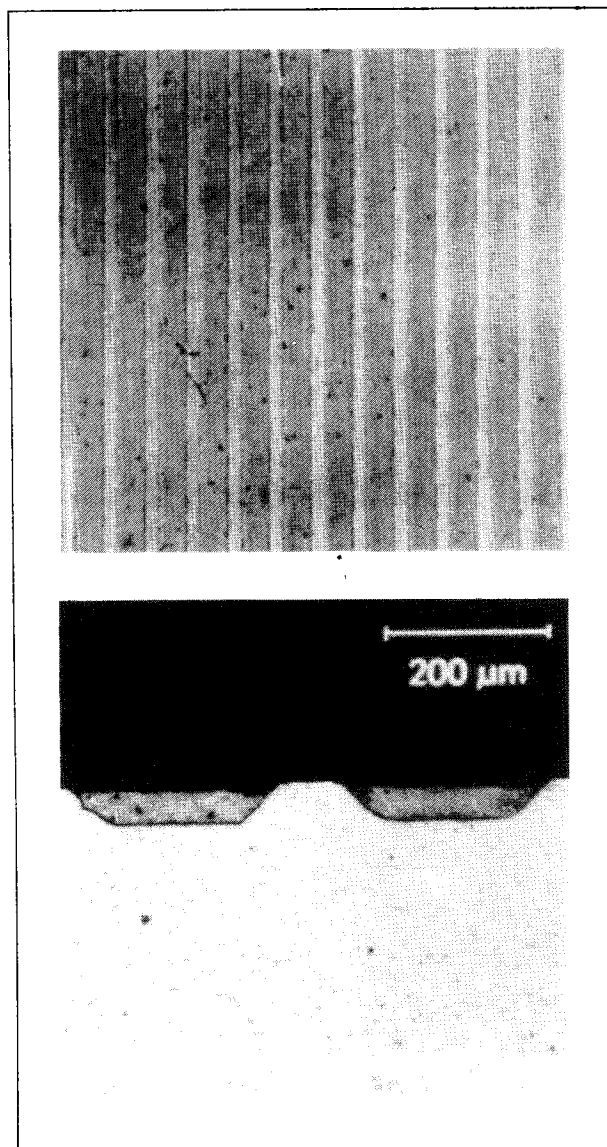


Fig. 3.



606-01.16

Edition 02H

## Criteria for Replacement of Connecting Rod Big-end and Main Bearing Shells

Working Card  
Page 4 (8)

### L+V28/32H

#### 1.3. Bearing Shells for Re-use.

**Condition:** Small particles all over the overlay. The light-alloy metal shows no changes of importance, see fig. 4.

**Valuation:** Re-use of the shell, as the particles are wedged in the slots.

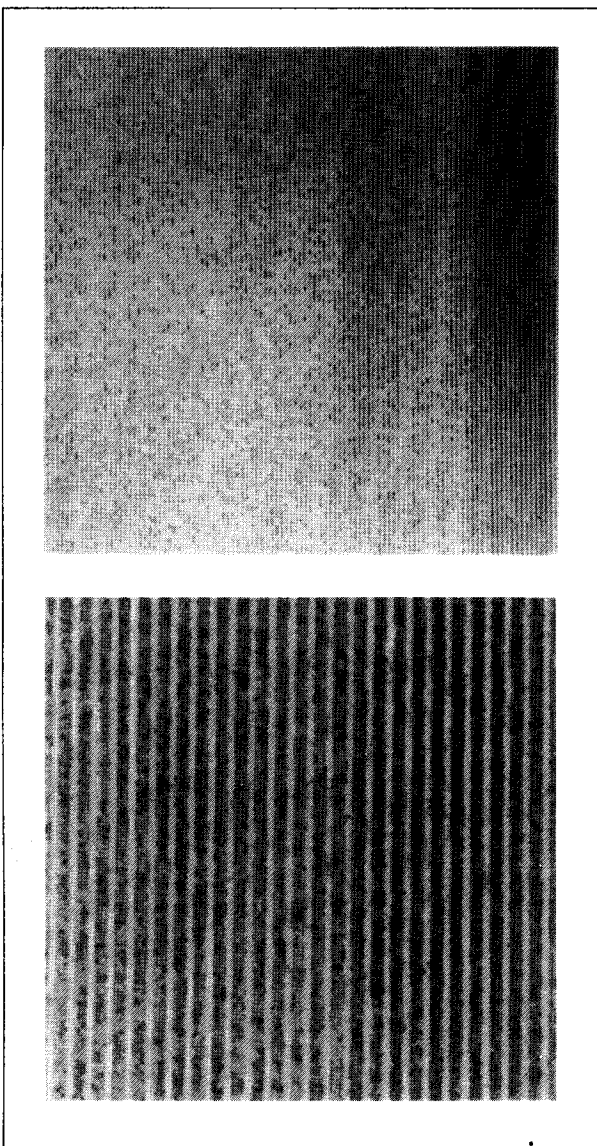


Fig. 4.

#### 1.4. Bearing Shells for Re-use.

**Condition:** The overlay has been dragged and smudged over the light-alloy metal. These are only partly visible, see fig. 5.

**Valuation:** Re-use of the shell.

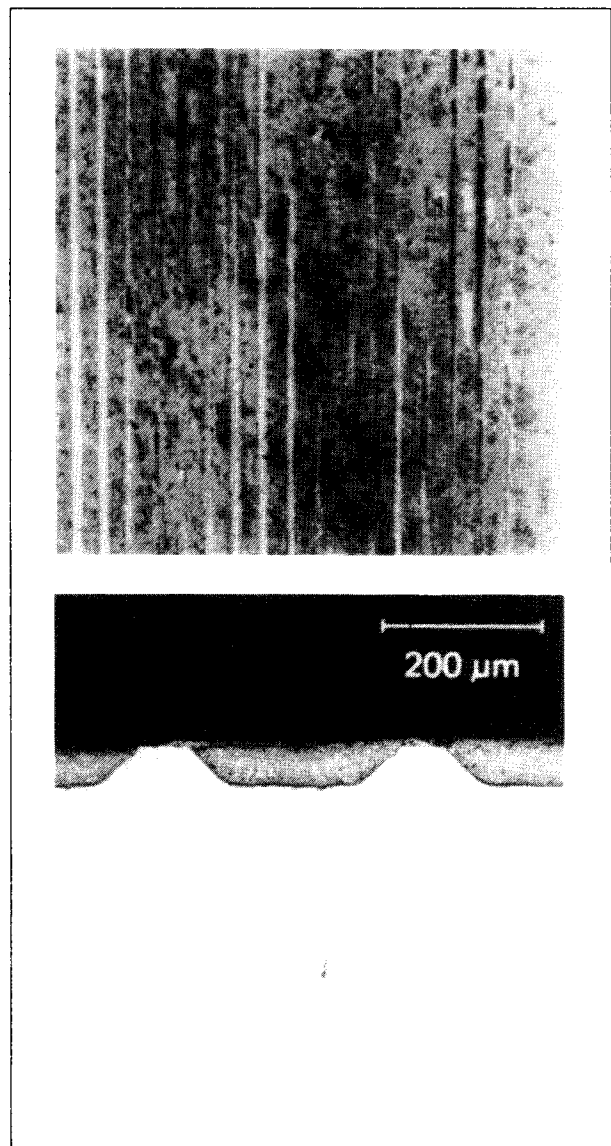


Fig. 5.

08028-0D/H5250/94.08.12

L+V28/32H

## 2. Limiting Case - Wear

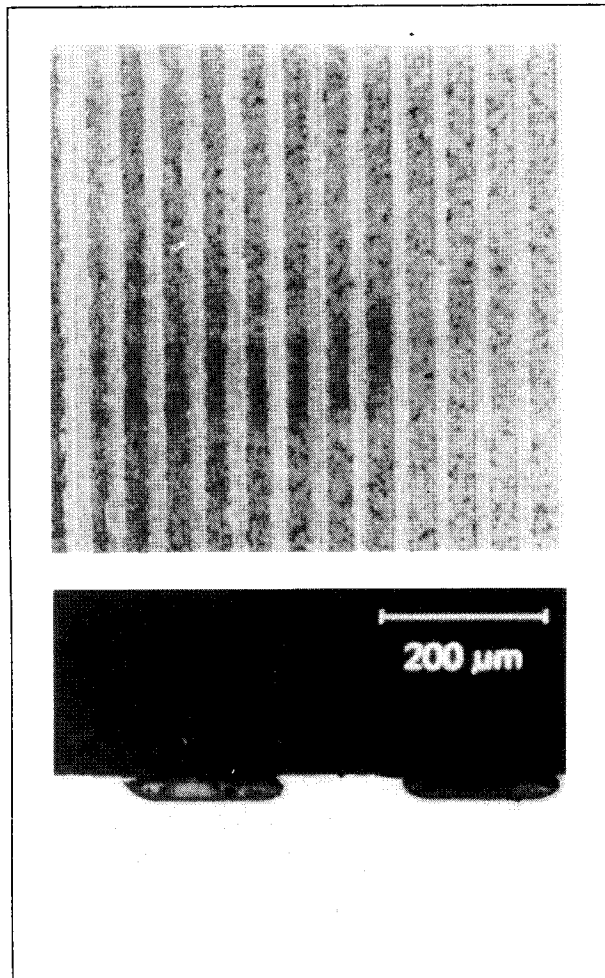


Fig. 6.

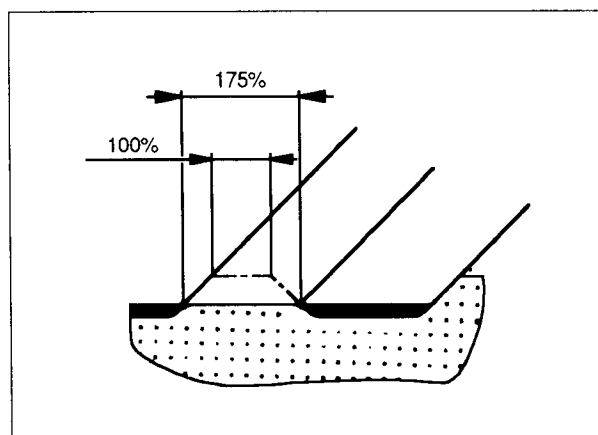


Fig. 7.

**Condition:** The bearing shell is locally so worn, that the ratio between the light-alloy metal and the overlay is 1:1, see fig. 6. The width of the light-alloy metal has increased from 100 % (new bearing shell) up to 175 %. In the slots some overlay is still left, see fig. 7.

**Valuation:** The bearing can operate with wear of the below listed size, see fig. 8 og 9. If the wear limits are exceeded the bearing shells must be exchanged due to safety precautions.

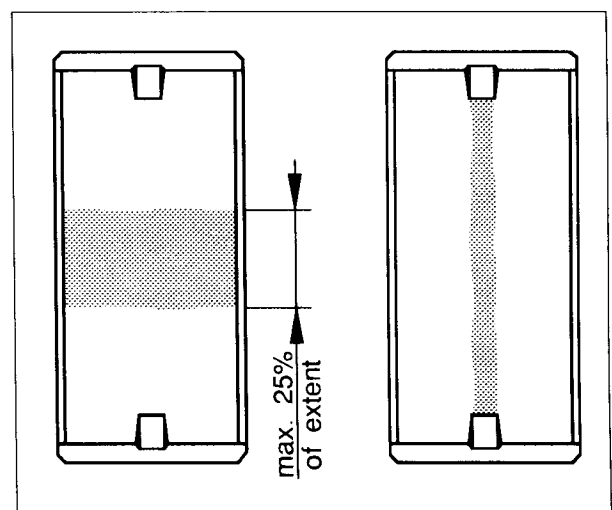


Fig. 8.

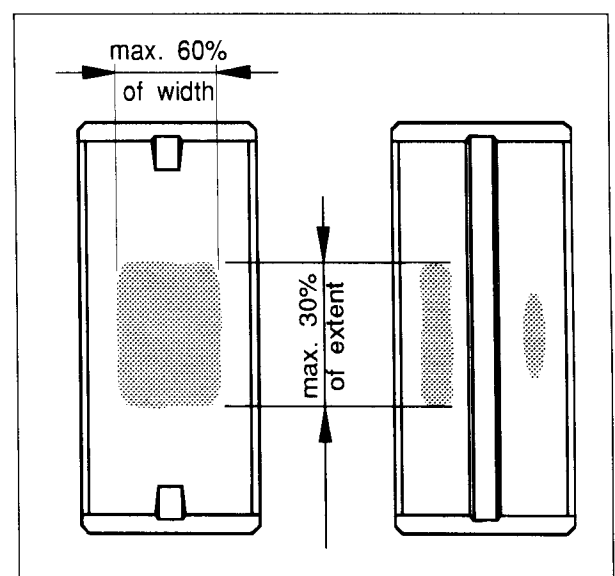


Fig. 9.

## L+V28/32H

## 3. Limit Case - Levelling

**Condition:** The slots are locally totally levelled as shown in fig. 10.

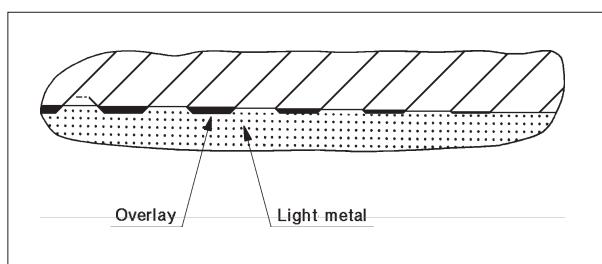


Fig. 10.

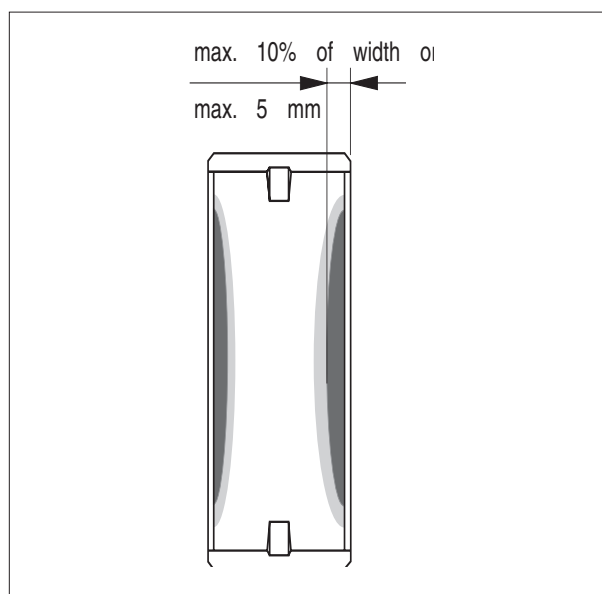


Fig. 11.

**Valuation:** If the limits shown in fig. 11 and 12 are exceeded the bearing shells must be exchanged.

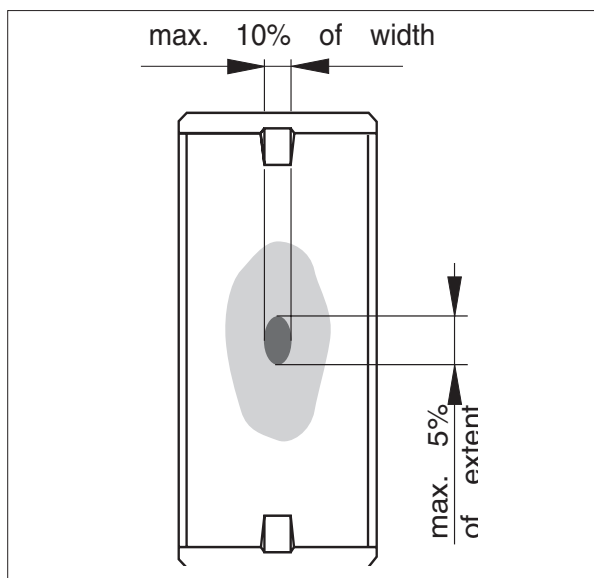


Fig. 12.



L+V28/32H

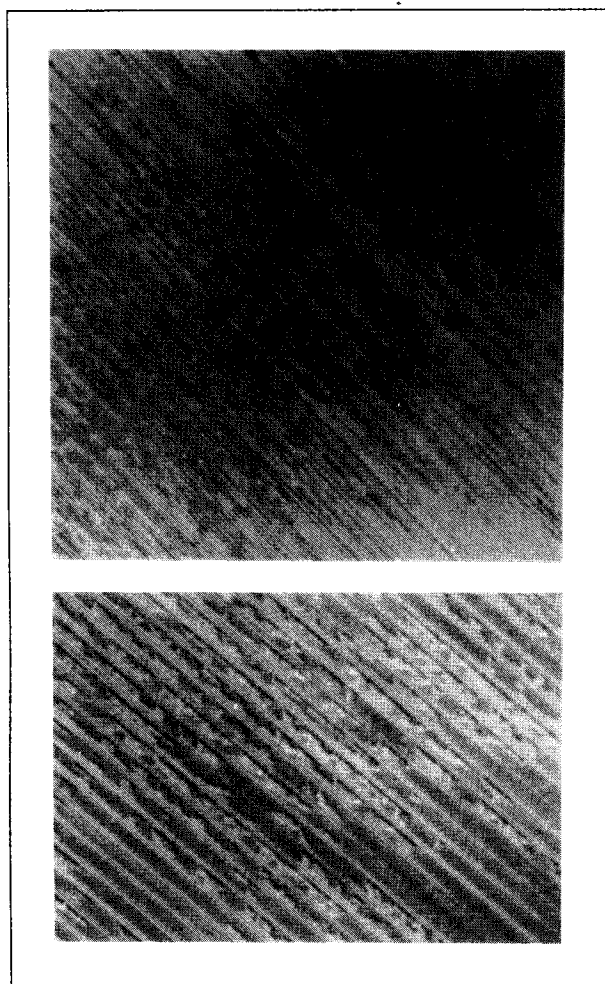
**4. Limit Case - Permanent Breakage of the Running Surface**

Fig. 13.

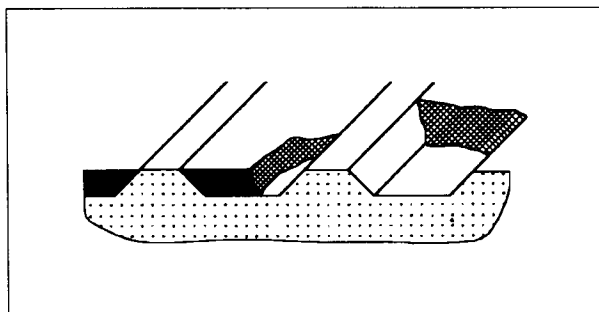


Fig. 14.

**Condition:** Breakage in the overlay due to local overload, as shown in fig. 13 and 14.

**Valuation:** If the limits as shown below in fig. 15 and 16 below are exceeded with totally or partially empty slots, the bearing shells must be exchanged.

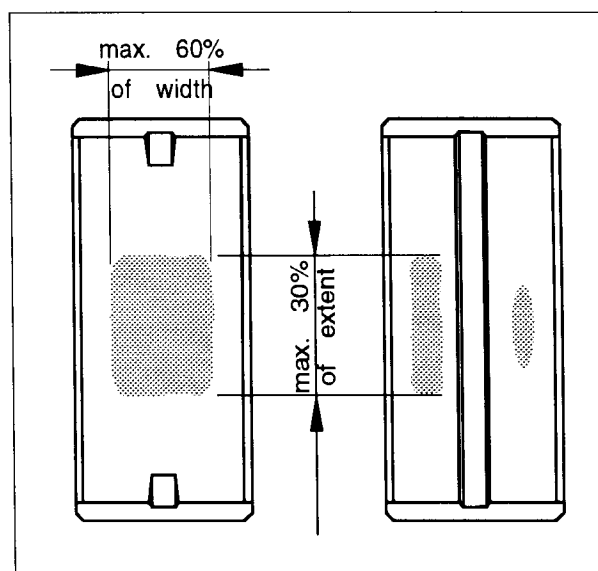


Fig. 15.

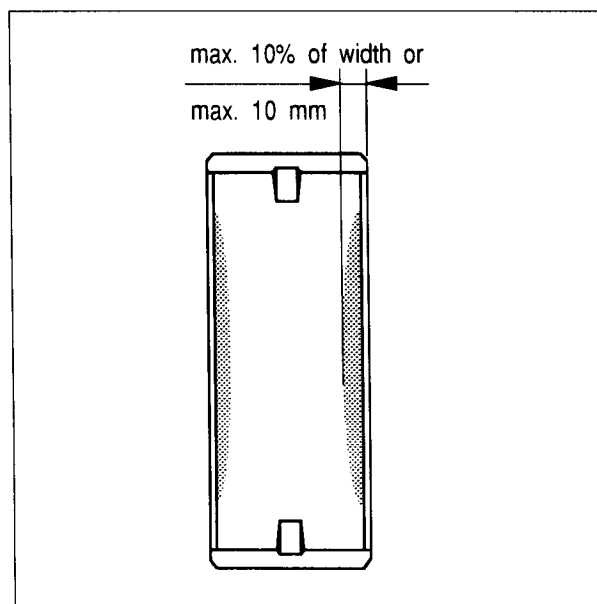


Fig. 16.

## L+V28/32H

## 5. Limit Case - Empty Slots

**Condition:** In some areas there is no overlay in the slots, see fig. 17.

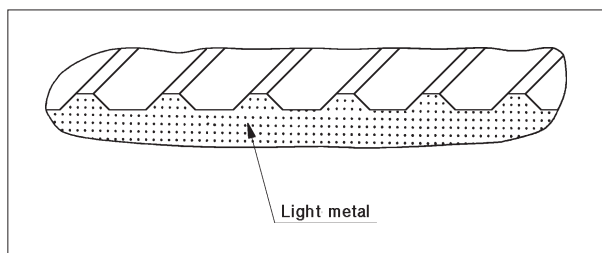


Fig. 17.

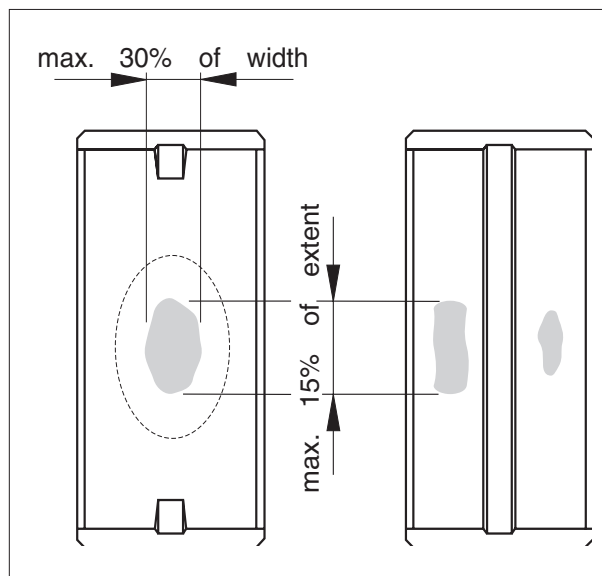


Fig. 18.

**Valuation:** If the limits shown in the below fig. 18 and 19, are exceeded, the bearing shells must be exchanged.

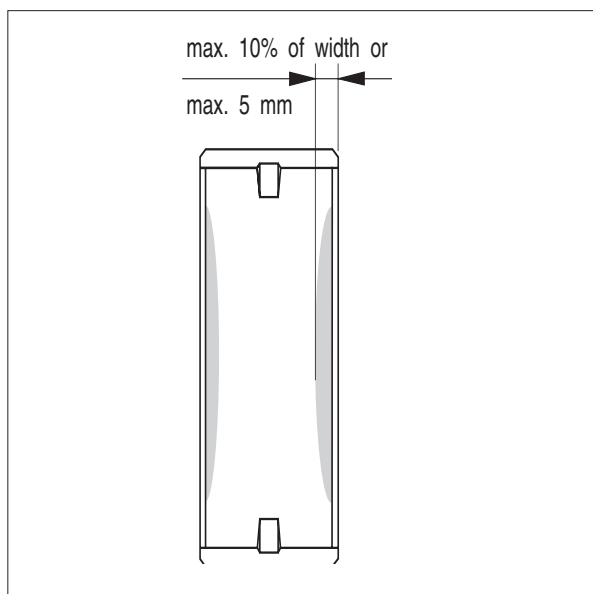


Fig. 19.



**Assembling of Piston and Connecting Rod****606-01.20**  
Edition 01H**L28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Mounting of piston and connecting rod assembly,  
after overhaul and/or inspection.

**Starting position:**

Piston mounted on the connecting rod, crank-shaft  
turned in the right position and the cylinder liner  
is OK, see working card 606-01.35.

**Related procedure:**

Tightening of connecting rod screws, 606-01.25  
Mounting of cylinder head, 605-01.40

**Man power:**

Working time : 1 1/2 Hours  
Capacity : 2 men

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
| 62006     | 01       |       |
| 62006     | 03       |       |
| 62006     | 11       |       |
| 62006     | 13       |       |
| 62006     | 22       |       |

**Hand tools:**

Open end spanner 32 mm.  
Clean lubricating oil.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./  |
|-----------|----------|--------|
| 60601     | 09       | 1/cyl. |
| 60601     | 10       | 1/cyl. |
| 60601     | 11       | 1/cyl. |
| 60601     | 12       | 1/cyl. |

**L28/32H**

1) Mount the lifting device comprising eye screw, shackle and wire rope on the piston.

2) Lift up the piston and connecting rod and mount the piston and scraper rings, see point 14, and working card 606-01.10.

3) Remove the backstop for cylinder liner and place the piston guide ring on top of the cylinder liner, see fig. 1.

4) When the piston approaches the guide ring, stop the lowering, coat guide ring, piston, piston rings and scraper ring, with clean lubricating oil in order to minimize friction during the subsequent lowering of the assembly.

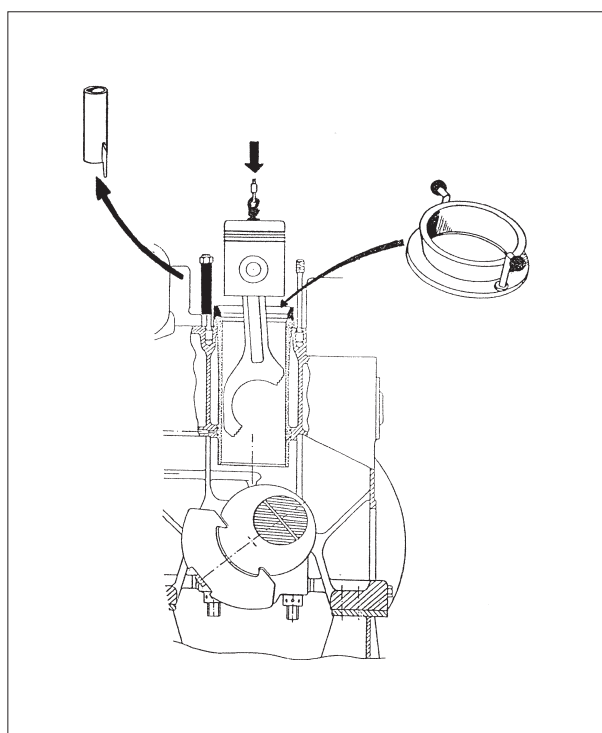


Fig. 1.

5) Make sure that the crank throw is in a position allowing the connecting rod to go clear of both crank journal and cylinder liner skirt during further lowering.

A crank throw position of approx 50 degrees before TDC will ensure this and also be suitable for the further mounting procedure.

6) Lower the piston further down, lubricate the ends of the bearing shells (a in fig. 2) with copaslip, molycote pasta or similar and mount the upper shell of the big-end bearing.

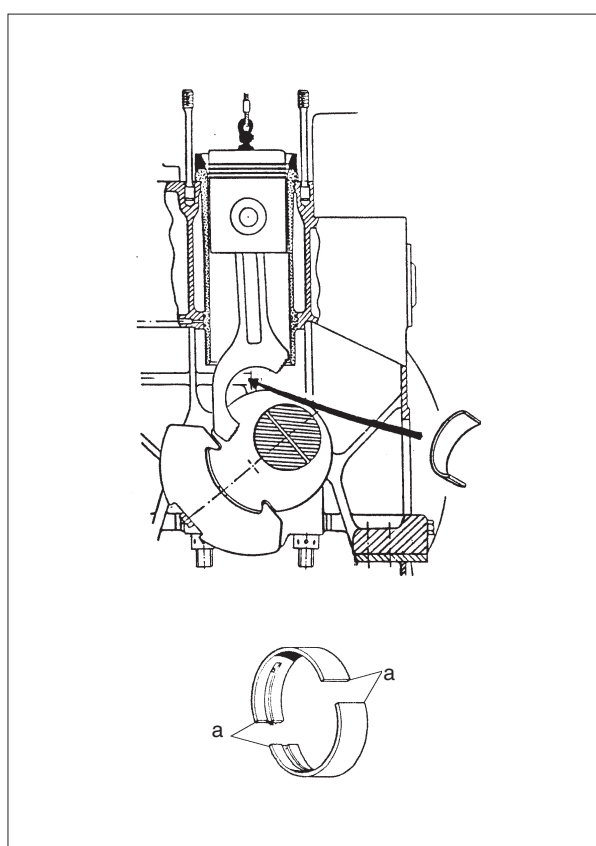


Fig. 2.

7) Coat the crank journal with clean lubricating oil.

8) Now lower the piston and connecting rod slowly into correct landing on the journal.

During this the connecting rod must be guided by hand to ensure correct approach and landing on the journal, see fig. 3.

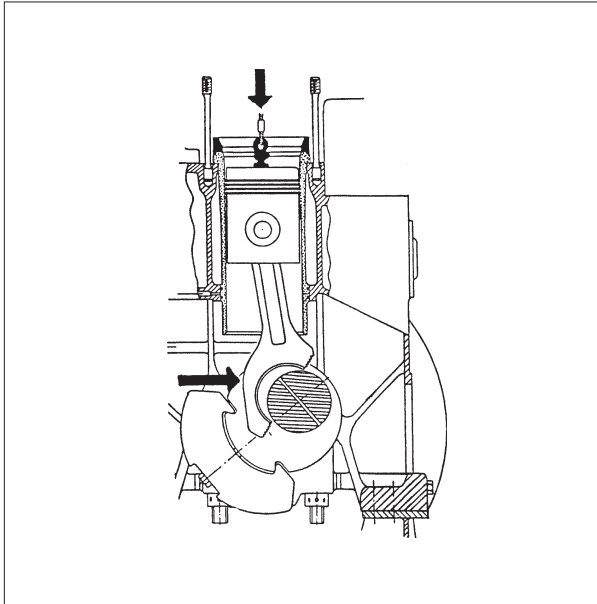
**L28/32H**

Fig. 3.

**Note !** The ident no. on the connecting rod and on the bearing cap, must always be the same, see fig. 4.

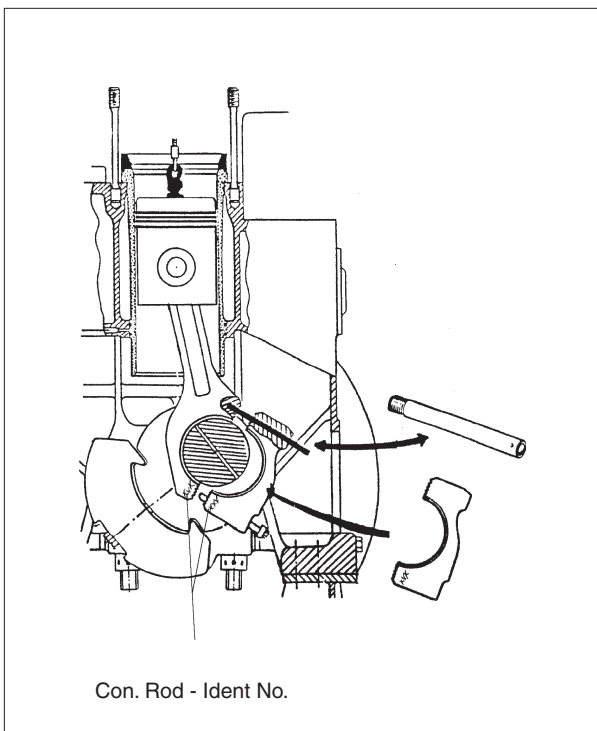


Fig. 4.

**9)** Mount the bearing cap with inserted lower shell of the big-end bearing, using the guide pin, see fig. 4.

**10)** Lubricate threads and contact face of the connecting rod screws with copaslip, molycote pasta or similar.

**11)** Mount the screws and tighten them slightly using an open end spanner.

**12)** Slacken the tackle and dismount the eye screw/shackle from the piston.

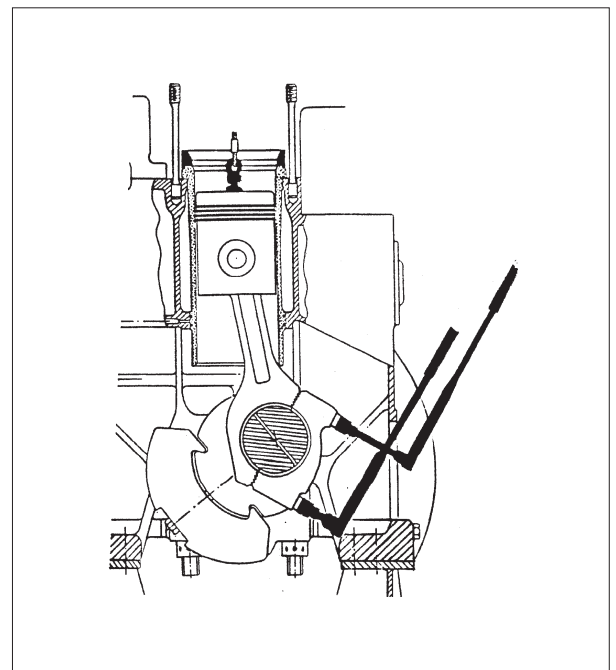


Fig. 5.

**13)** Tighten the screws according to "Tightening Procedure for Connecting Rod Screws", see working card 606-01.25.

**Fitting of Piston and Scraper Rings.**

**14)** Piston rings should only be removed from and fitted to the piston by the use of a special tool, the so-called piston ring opener.

**L28/32H**

If the rings are opened further than necessary there is a risk of overstressing, which means that rings will become permanently distorted and will not conform to the cylinder inner running surface.

The piston rings should be installed with the identification mark, which is stamped into the ring close to the ring joints, facing upwards.

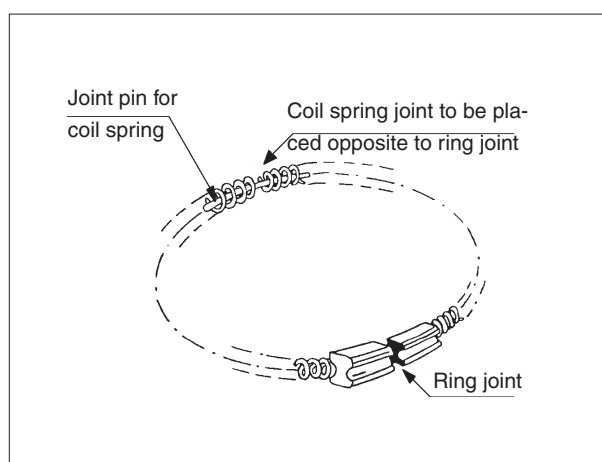


Fig. 6.

Before fitting the coil spring loaded scraper ring, the coil spring is dismantled from the ring by removal of the joint pin. The coil spring is placed and assembled in the ring groove then the scraper ring is fitted in the groove in such a way that the ring joint is approximately 180° offset to the spring joint.

Ascertain correct assembling by checking the back clearance. The back clearance is sufficient when the face of the ring is below the groove edge, when the ring is pressed against the bottom of the groove.

When installed on the piston, the rings should be pushed back and forth in the grooves to make sure that they can move freely. It is also advisable to insert a feeler gauge of adequate thickness between ring and groove.

Adequate clearance is present if the feeler gauge can be moved all the way round.

To prevent gas leakage through coinciding ring joints the piston rings should be turned into positions offsetting the ring joint 180° to each other.

**L+V28/32H****Safety Precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description:**

Tightening procedure for connecting rod screws.

Check of connecting rod screws, tightening condition.

**Starting Position:**

Piston, connecting rod, bearing shells and bearing cap preassembled. 606-01.20

**Related Procedure:****Man Power:**

Working time : 1/2 Hour  
Capacity : 2 men

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special Tools:**

| Plate No | Item No | Note |
|----------|---------|------|
| 62021    |         |      |

**Hand Tools:****Replacement and Wearing Parts:**

| Plate No | Item No | Qty./ |
|----------|---------|-------|
|----------|---------|-------|

## L+V28/32H

- 1) Tighten the screw pos. 3 home to the connecting rod by hand.
- 2) Mount the lower part pos. 2 and fasten the lower part with the nuts, pos. 4.
- 3) Tighten the nuts by hand.
- 4) Mount the hydraulic tool, pos. 5.

Be aware of the max. lifting height of the tool and adjust the distance between the piston and the cylinder before adding pressure to the tool. Please see *Working Card 620-01.05*

- 5) Connect the tool to the hydraulic tool.
- 6) Add the prescribed hydraulic pressure, (to both screws simultaneously). Please see *Description 600.40*, and tighten the screws by using a handle, pos 6.
- 7) Relieve the hydraulic pressure on the tool.
- 8) Add the hydraulic pressure to the tool.
- 9) Tighten the nuts again.

**Note:** The Points 7 to 9 are to be followed in order to remove tensions in the screws, if any.

- 10) If there still is a distance and the nuts still can be tightened then repeat the points 7, 8 and 9.

- 11) Relieve the pressure on the tool and remove it from the screws.

**Note:** General instruction about hydraulic tightening. Please see *Working Card 620-01.10*

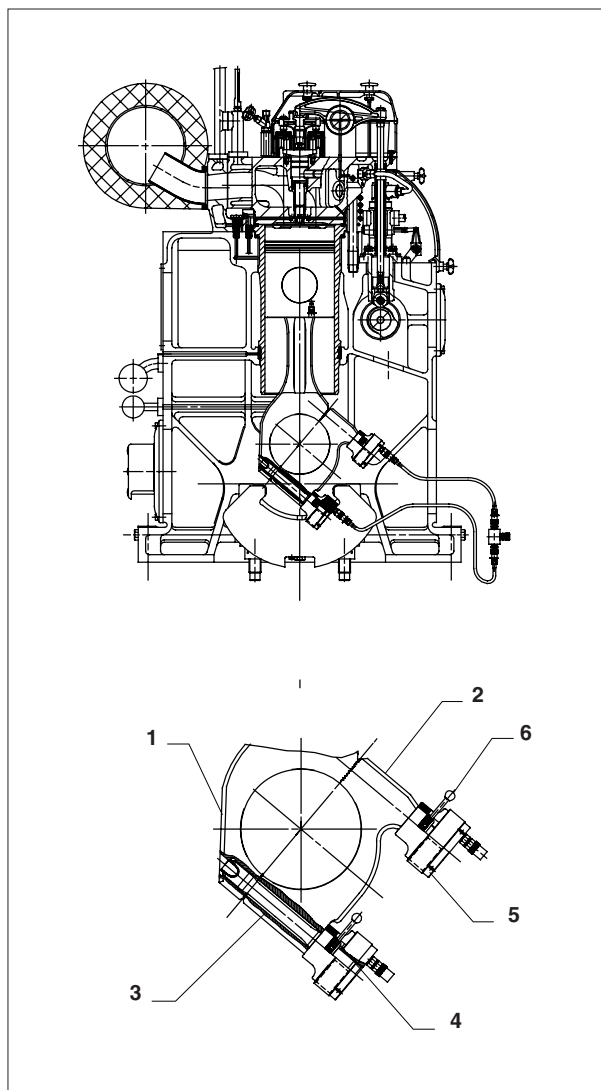


Fig. 1

**L28/32H****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☒ Shut-off fuel oil
- ☒ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description:**

In-situ inspection and/or replacement of connecting rod big-end bearing, dismantling and mounting.

**Starting position:**

Fuel injector dismantled, 614-01.00  
Crankcase open.  
Top cover for cylinder head removed.

**Related procedure:**

Inspection of connecting rod  
big-end bearing 606-01.16  
Tightening and check of connecting  
rod screws, 606-01.25

**Man power:**

Working time : 1 1/2 Hours  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.        |
|-----------|----------|--------------|
| 62006     | 07       |              |
| 62006     | 22       |              |
| 62006     | 28       | 140 - 760 Nm |

Tool combination for tightening of connecting rod screw, see working card 620-01.20.

**Hand tools:**

Open end spanner 32 mm.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|-----------|----------|--------|

**L28/32H**

The big-end bearing shells can be inspected and/or replaced in-situ i.e. without dismantling the piston and connecting rod assembly from the engine.

**Dismounting.**

1) The crankshaft of the engine is turned into a position allowing the connecting rod screws to be loosened. Having loosened the connecting rod screws, the crankshaft is turned until the piston is in a position thus allowing the connecting rod bearing cap to be dismantled, see fig. 1.

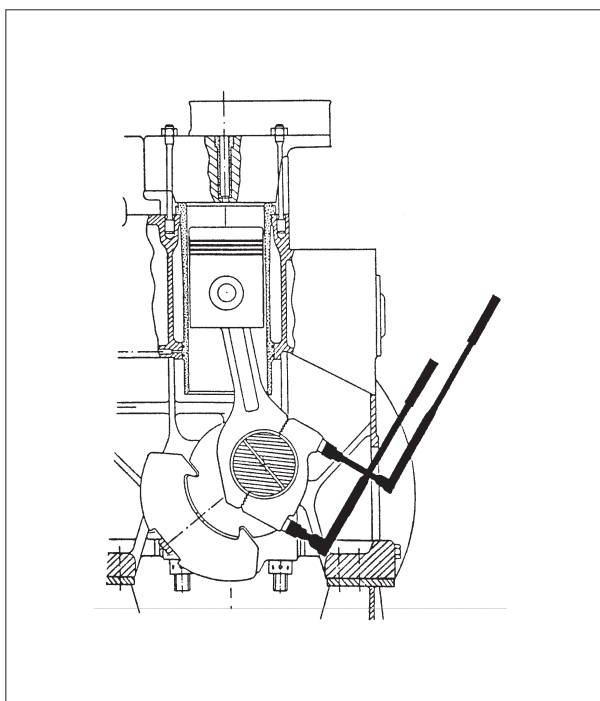


Fig. 1.

2) Before removing connecting rod bearing cap, the especially long eye bolt is mounted. It is inserted through the fuel injector sleeve and is screwed into the thread hole in the piston, see fig. 2. Then by means of a tackle it is slightly tightened.

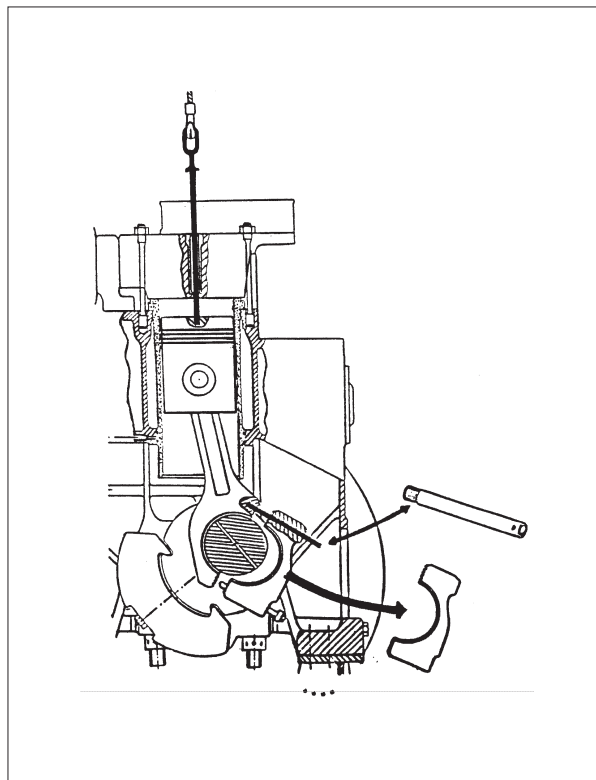


Fig. 2.

3) Having tightened the tackle slightly, the connecting rod bearing cap and bearing shell are dismantled, see working card 606-01.00, for use of guide pin.

4) When connecting rod bearing cap and bearing shell have been dismantled, the piston/connecting rod is lifted from the bearing journal. Piston/connecting rod should not be lifted further than just to allow dismantling of the upper bearing shell, see fig. 3.



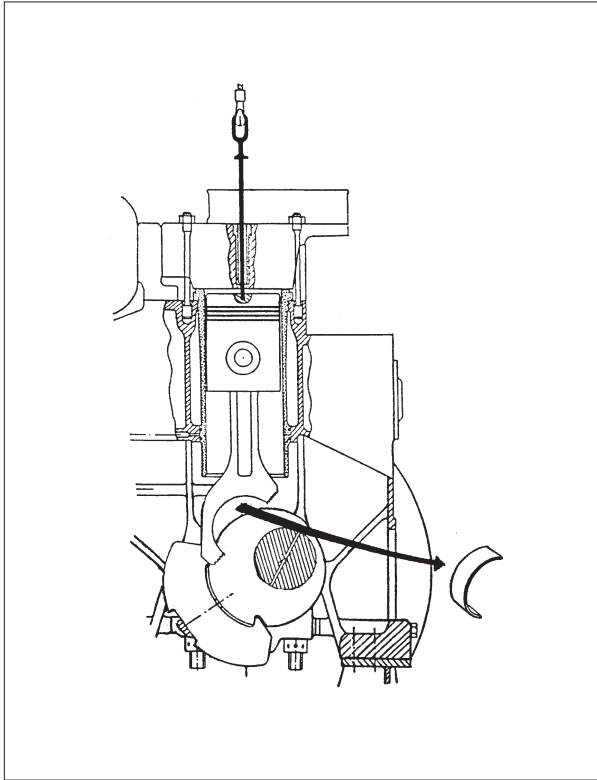
**L28/32H**

Fig. 3.

5) For inspection of bearing shell, see working card 606-01.16

**Mounting.**

Before remounting of inspected or new bearing, all components must be cleaned.

**Note:** See also working card 606-01.20.

1) The bearing shell is placed in the bore, the contact surfaces of the shells to be in parallel to the contact surface of the connecting rod, the bearing cap respectively.

2) Ascertain that the crank throw concerned is in a position of approx 50 degrees before TDC.

3) Coat the journal with clean lubricating oil and lower the piston and connecting rod assembly slowly into correct landing on the journal.

While lowering the connecting rod, it must be guided by hand to ensure correct approach and landing on the journal, see fig. 4.

4) Mount the bearing cap with inserted lower big-end bearing shell, using the guide pin.

5) Lubricate threads and contact face of the connecting rod screws with copaslip or similar.

6) Mount the screws and tighten them slightly using an open-end spanner.

7) Slacken the tackle and dismount the eye screw from the piston crown.

8) Tighten the screws according to "Tightening Procedure for Connecting Rod Screw", see working card 606-01.25.

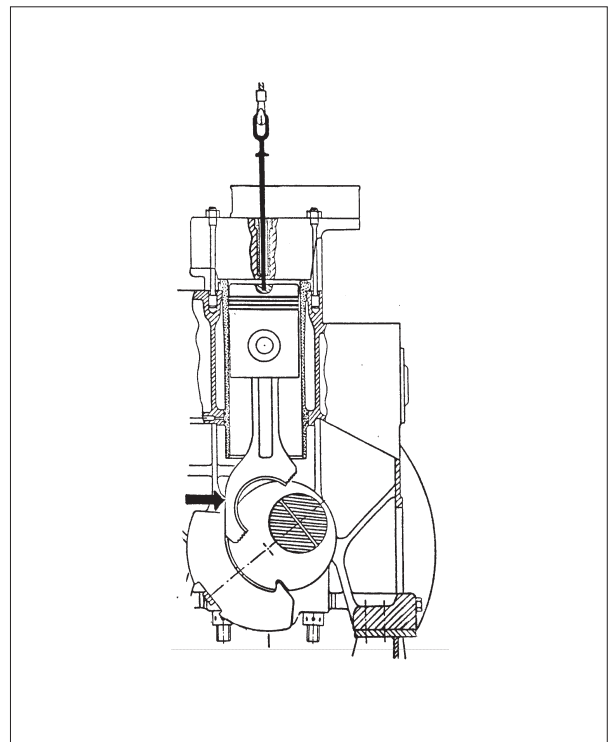


Fig. 4.

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (4) | <b>Inspection and Honing of Cylinder Liner</b> | <b>606-01.35</b><br>Edition 08H |
|----------------------------|--|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Inspection and honing of cylinder liner with honing brush.

**Starting position:**

Piston and connecting rod is removed, 606-01.00

**Related procedure:**

Mounting of piston and connecting rod, 606-01.20  
 Replacement of cylinder liner, 606-01.40  
 Grinding of seal face on cylinder head and cylinder liner, 606-01.45

**Man power:**

Working time : 1/2 Hour  
 Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
 Data for torque moment (Page 600.40)  
 Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.       |
|-----------|----------|-------------|
| 62006     | 50       | Extra tools |
| 62006     | 51       | Extra tools |
| 62006     | 60       | Extra tools |

**Hand tools:**

Drilling machine 60-180 rpm.  
 Honing oil.  
 Gas oil.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|

**L+V28/32H****Measurement of Cylinder Diameter.**

While the piston is removed from the cylinder, the latter is measured to record the wear. The measurements are taken by means of an inside micrometer, with measuring points at TDC-position for uppermost piston ring, halfway down and at the bottom of the cylinder liner, see fig. 1.

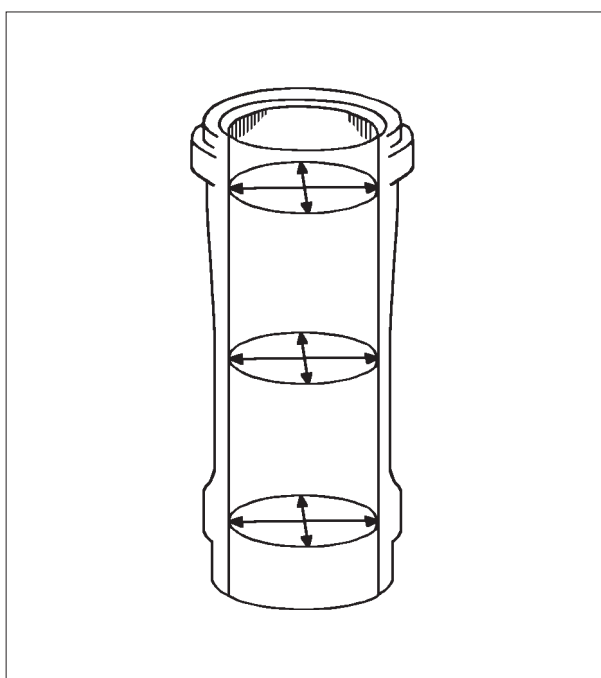


Fig. 1.

The measurements should normally be taken in transverse as well as in longitudinal direction.

When measuring, take care that the measuring tool has the approximately same temperature as the liner. When the wear of a cylinder liner exceeds the value indicated on page 600.35, i.e. when it becomes too troublesome to maintain satisfactory service conditions, the cylinder liner in question should be ex-changed.

**Honing the Cylinder Liner.**

The renovation can be made either with dismantled liner in the workshop or with liner mounted in the engine frame and by the use of the belonging funnel.

Prior to the honing, deposits of coke and possible wear edges in the top of the liner must be removed by scraping.

If the cylinder is of the flame ring type, the used flame ring has to be cleaned in water. Subsequently, the flame ring is remounted in the cylinder before carrying out the honing process.

Note: After the honing process has taken place the used flame ring is discarded. A new flame ring is always mounted in the cylinder when replacing a piston ring.

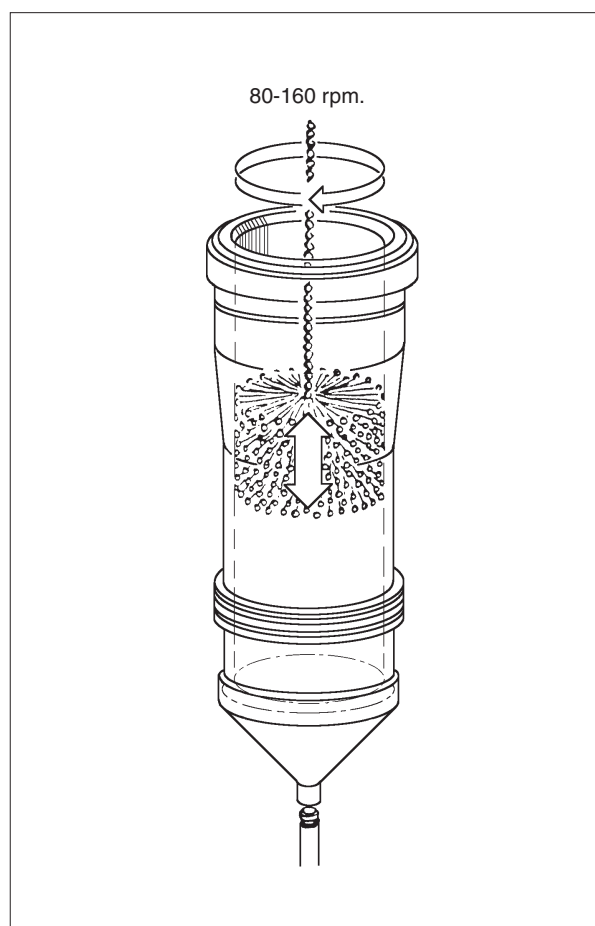


Fig. 2.

The honing is made by means of a flex-honer with finess grains 80-120. A revolution speed between 80 and 160 rpm is chosen.

**L+V28/32H**

In order to achieve the required angle between the honing grooves, see fig. 2, the vertical speed is adjusted to about 1 m/sec. which corresponds to about 2 sec. for one double movement (the flex honer is lead from below up and down in 2 sec.)

The procedure is to be continued until the cylinder wall is covered by honing grooves and the surface has a slight matt appearance and without any signs of glaze .

During the honing it is important to lubricate freely with honing oil or cutting oil.

After the honing, the liner is carefully cleaned with gas oil, and make sure that all abrasive particles have been removed.

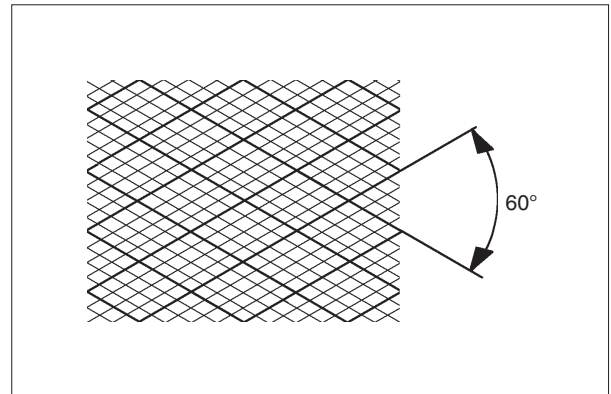


Fig. 3.

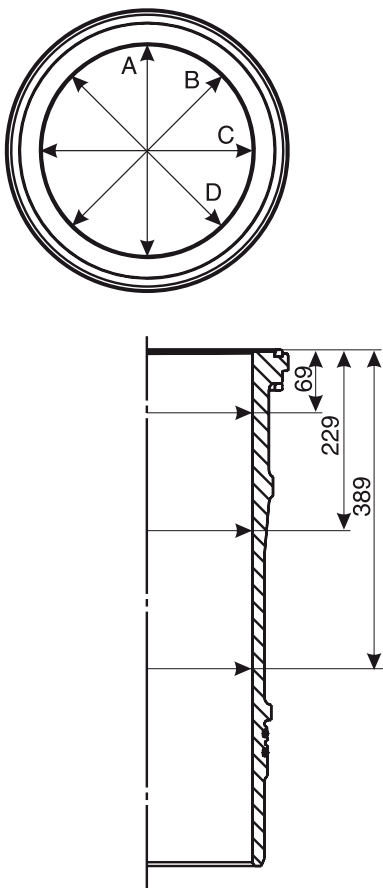
**606-01.35**  
Edition 08H

## Inspection and Honing of Cylinder Liner

Working Card  
Page 4 (4)

### L+V28/32H

#### Measurements of Cylinder Liner

|  |        |                    |              |                                 |                                 |   |   |  |  |
|--|--------|--------------------|--------------|---------------------------------|---------------------------------|---|---|--|--|
| Plant/ship:  |        |                    | Engine Type: |                                 | Engine No.:                     |   |   |  |  |
| Date:  | Sign.: | Cyl. no.           | Pos.         | <input type="checkbox"/> A-side | <input type="checkbox"/> B-side |   |   |  |  |
|  |        |                    |              | A                               | B                               | C | D |  |  |
| Running hours:   |        | 1                  | 1            |                                 |                                 |   |   |  |  |
| Fuel: cSt  |        |                    | 2            |                                 |                                 |   |   |  |  |
| Separator: Yes   |        |                    | 3            |                                 |                                 |   |   |  |  |
|  |        | 2                  | 1            |                                 |                                 |   |   |  |  |
|  |        |                    | 2            |                                 |                                 |   |   |  |  |
|  |        |                    | 3            |                                 |                                 |   |   |  |  |
|  |        | 3                  | 1            |                                 |                                 |   |   |  |  |
|  |        |                    | 2            |                                 |                                 |   |   |  |  |
|  |        |                    | 3            |                                 |                                 |   |   |  |  |
|  |        | 4                  | 1            |                                 |                                 |   |   |  |  |
|  |        |                    | 2            |                                 |                                 |   |   |  |  |
|  |        |                    | 3            |                                 |                                 |   |   |  |  |
|  |        | 5                  | 1            |                                 |                                 |   |   |  |  |
|  |        |                    | 2            |                                 |                                 |   |   |  |  |
|  |        |                    | 3            |                                 |                                 |   |   |  |  |
|  |        | 6                  | 1            |                                 |                                 |   |   |  |  |
|  |        |                    | 2            |                                 |                                 |   |   |  |  |
|  |        |                    | 3            |                                 |                                 |   |   |  |  |
|  |        | 7                  | 1            |                                 |                                 |   |   |  |  |
|  |        |                    | 2            |                                 |                                 |   |   |  |  |
|  |        |                    | 3            |                                 |                                 |   |   |  |  |
|  |        | 8                  | 1            |                                 |                                 |   |   |  |  |
|  |        |                    | 2            |                                 |                                 |   |   |  |  |
|  |        |                    | 3            |                                 |                                 |   |   |  |  |
|  |        | Tem. of cyl. liner | 25°C         | 9                               | 1                               |   |   |  |  |
|  |        | Nom. diameter      | 280H8        |                                 | 2                               |   |   |  |  |
|  |        | Minimum            | 280.0        |                                 | 3                               |   |   |  |  |
| Maximum  | 280.60 |                    |              |                                 |                                 |   |   |  |  |

08028-0D/H5250/94.08.12

|                            |                                      |                                 |
|----------------------------|--------------------------------------|---------------------------------|
| Working Card<br>Page 1 (3) | <b>Replacement of Cylinder Liner</b> | <b>606-01.40</b><br>Edition 01H |
|----------------------------|--------------------------------------|---------------------------------|

**L/V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Replacement of cylinder liner.  
Dismounting and mounting of cooling water guide jacket.

**Starting position:**

Cylinder head and piston/connecting rod dismantled, working card 605-01.00 and 606-01.00.

**Related procedure:**

|  |           |
|--|-----------|
| Mounting of piston and connecting rod,                     | 606-01.20 |
| Grinding of seal face on cylinder head and cylinder liner, | 606-01.45 |

**Man power:**

|              |   |   |       |
|--------------|---|---|-------|
| Working time | : | 2 | Hours |
| Capacity     | : | 2 | men   |

**Data:**

|                                 |               |
|---------------------------------|---------------|
| Data for pressure and tolerance | (Page 600.35) |
| Data for torque moment          | (Page 600.40) |
| Declaration of weight           | (Page 600.45) |

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
| 62006     | 45       |       |

**Hand tools:**

Allen key, 8 mm.  
Adjustable spanner.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. /  |
|-----------|----------|---------|
| 60610     | 04       | 1/cyl.  |
| 60610     | 07       | 12/cyl. |
| 60610     | 08       | 2/cyl.  |
| 60610     | 11       | 2/cyl.  |

See also plate 60610.

## L/V28/32H

**Dismounting of Cylinder Liner.**

- 1) Dismount the cooling water guide jacket.
- 2) Prior to mounting of the lifting tool and dismounting from the frame, it must be ensured that the liner and frame have been marked to match, for the sake of a possible remounting of the liner, see fig. 1.

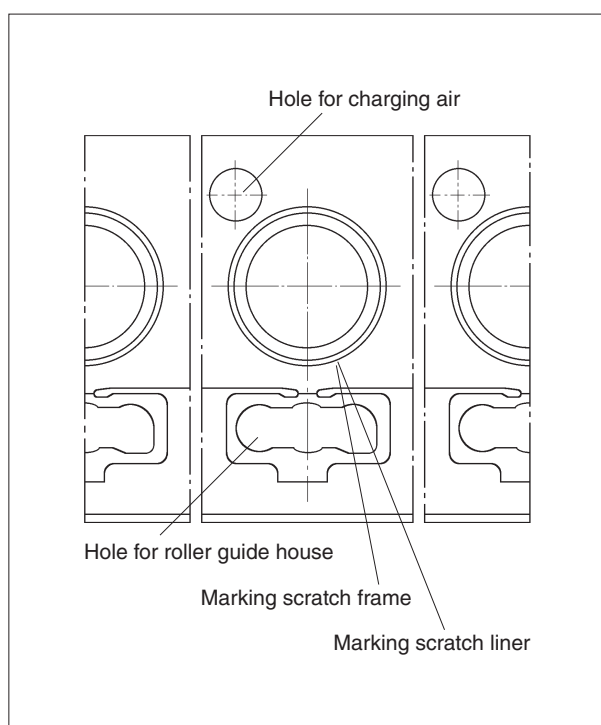


Fig. 1.

- 3) Mount the lifting tool as shown, see fig. 2.
- 4) Turn the lifting eye nut to pull out the liner, until the upper edge of the liner lie aligned against the copper protecting pieces of the cross bar.

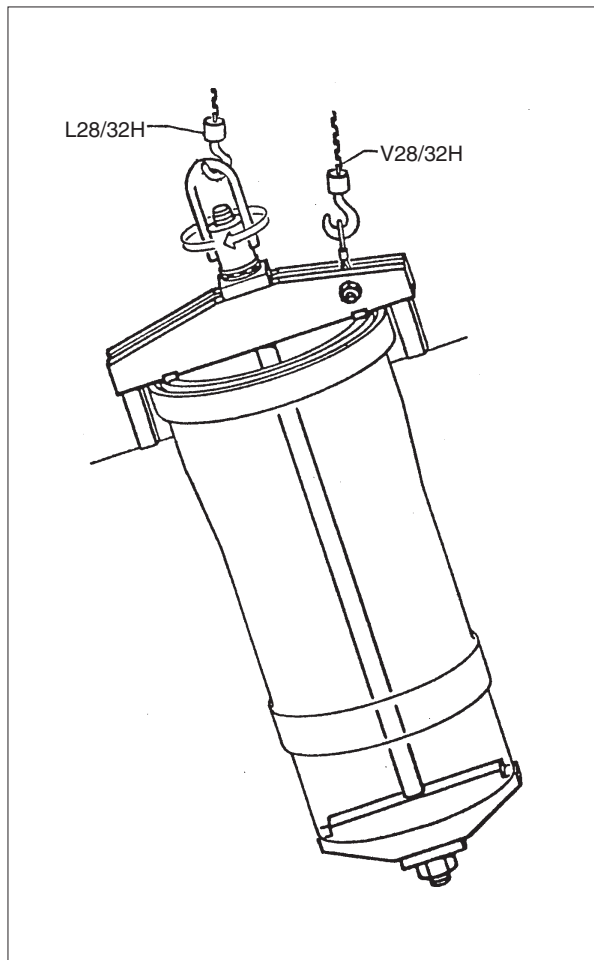


Fig. 2.

- 5) Attach a tackle hook to the eye nut or the wire and the cross bar, and lift the liner out from the engine frame and stand it careful onto wooden supports.
- 6) Clean all parts and inspect for damage and wear, according to the description. For measurement of cylinder liner, see working card 606-02.00.

## LV28/32H

**Mounting of Cylinder Liner.**

7) Check that the sealing surfaces on engine, cylinder liner, and sealing rings are perfectly clean.

8) Mount the lifting tool, attach a tackle hook to the eye nut or to the wire in the cross bar and lift the liner.

9) Check that the o-ring grooves are clean. Mount the o-rings and lubricate with a little oil. Place a new sealing on top of the frame.

10) Lower the cylinder liner carefully into the engine frame.

When the first o-ring touches the sealing face, align the liner so that the scratch mark on the liner flange points to the scratch mark on the frame as illustrated, or align the liner so that the milling groove in the liner flange coincides with the fixing piece on the engine frame control side (if mounted).

11) After having cleaned and inspected the cooling water jacket, mount new o-rings on the cooling water connections and change air connections.

Fit a new sealing ring and mount the jacket.

12) Mount the cooling water jacket, (for torque moment see page 600.40), piston/connecting rod and cylinder head according to working card 606-01.20 and 605-01.40.

13) When preparing the start-up, check for possible leakages of water and oil, including the inspection hole in the frame, see fig. 3.

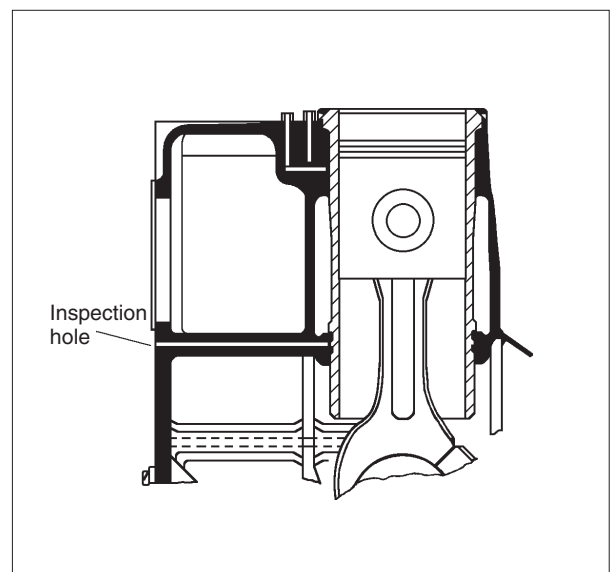


Fig. 3.



|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Grinding of Seal Face on<br/>Cylinder Liner and Cylinder Head.</b> | <b>606-01.45</b><br>Edition 01H |
|----------------------------|---|---------------------------------|

**L/V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Grinding of seal face on cylinder liner and cylinder head by hand, with grinding tools and grinding pasta.

**Starting position:**

Cylinder head has been removed  
from the engine, 605-01.00  
Cooling water guide jacket, removed.

**Related procedure:**

Mounting of cylinder head, 605-01.40

**Man power:**

Working time : 1 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
| 62005     | 20       |       |

**Hand tools:**

Grinding pasta.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
| 60610     | 08       | 1/cyl. |

## L/V28/32H

**Note:** The grinding tool is used for both grinding the groove in the liner flange (1) and the seating surface on the cylinder head (2), see fig. 1.

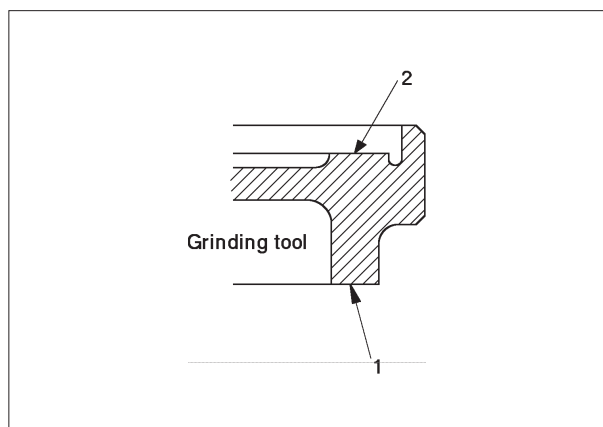


Fig. 1.

**Grinding.**

**1)** Loosen the sealing ring in liner flange and take it out.

**2)** Face-grind sealing groove in cylinder liner flange, see fig. 2 and seating surface on the cylinder head, see fig. 3. With the use of grinding pasta and the grinding tool.

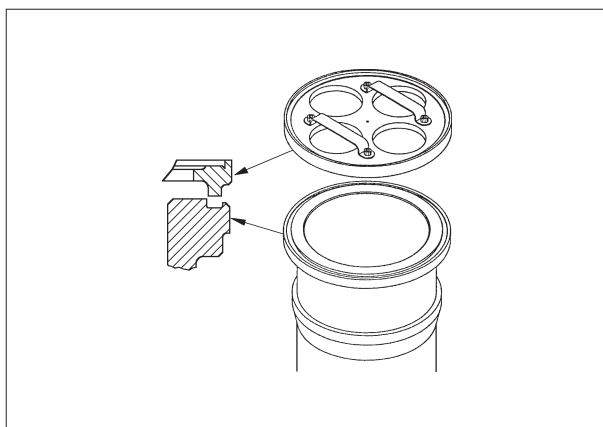


Fig. 2.

To do so, move the tool back and forth and lift it out from time to time, to allow the grinding compound to distribute evenly.

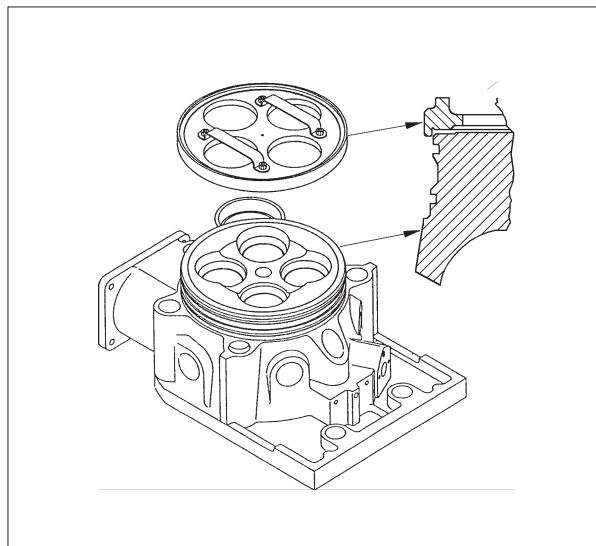


Fig. 3.

**3)** After grinding, remove all traces of abrasive and grinding compound.

**4)** When having ground the contact faces, it must be observed that the gap between cylinder head and liner is no less than 0,5 mm, that is, the difference between measurements y and z must not be less than 0,5 mm, see fig. 4.

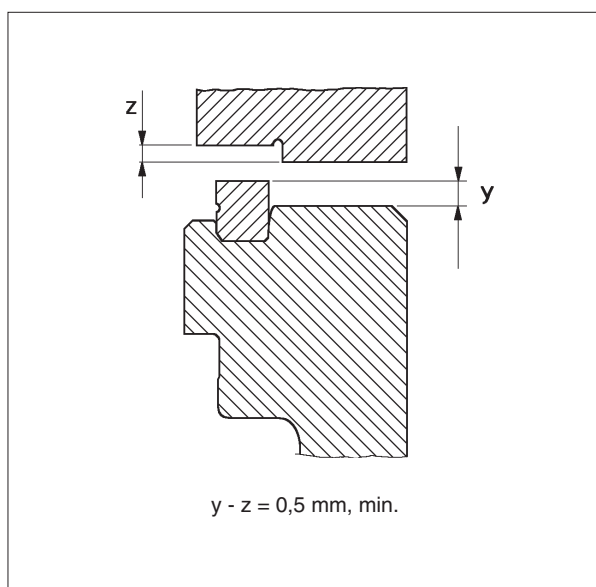


Fig. 4.

|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Dismounting of Piston and Cylinder Liner<br/>at Low Overhaul Heights</b> | <b>606-01.50</b><br>Edition 01H |
|----------------------------|---|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Dismounting of piston, connecting rod and cylinder liner for inspection and/or overhaul.

**Starting position:**

Cylinder head has been dismounting from the engine.  
Crankcase open.

**Related procedure:**

Separation of piston and connecting rod.  
Inspection and honing of cylinder liner.

**Manpower:**

Working time : 2 ½ Hours  
Capacity : 2 men

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no | Item no | Note         |
|----------|---------|--------------|
| 62050    |         |              |
| 62006    | 05      |              |
| 62006    | 09      | 2 pieces     |
| 62006    | 22      |              |
| 62006    | 24      |              |
| 62006    | 28      |              |
| 62006    | 65      |              |
| 62010    | 01      | If necessary |

Tool combination for dismounting of connecting rod screw, 620-01.20

**Hand tools:**

Inside micrometer (195 mm).  
Feeler gauge 0,15 - 0,20 mm.

**Replacement and wearing parts:**

| Plate no | Item no | Qty/ |
|----------|---------|------|
|----------|---------|------|

**L+V28/32H****Dismantling of Piston at Low Overhaul Heights.**

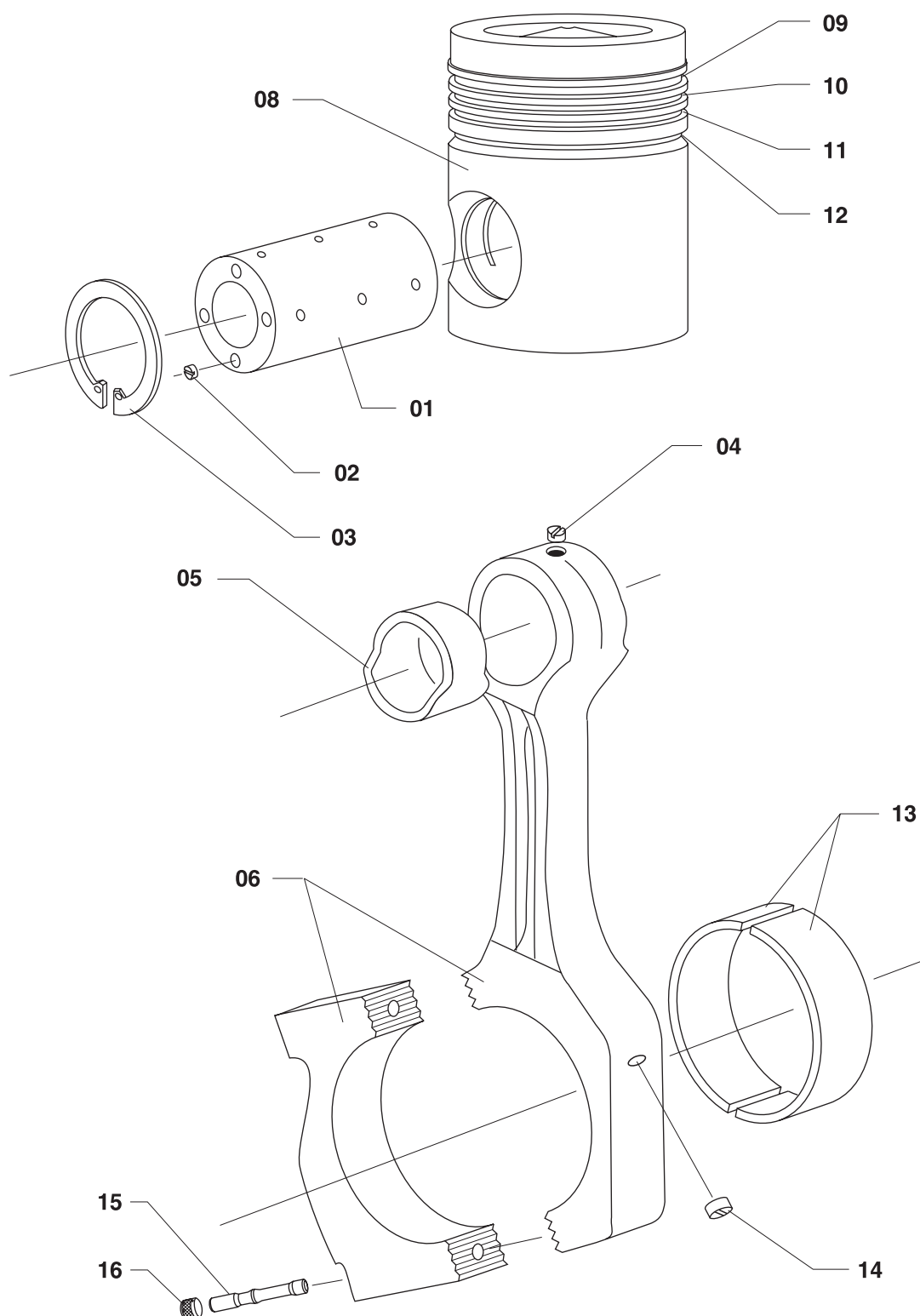
- 1) Lift up the piston and the connecting rod through the cylinder liner until the piston is clear of the liner.
- 2) Mount collar on the connecting rod, see plate 62050, item 1896.
- 3) Place the piston with the collar on the cylinder liner.
- 4) Mount pull-lifts on the collar.

| If  | Then  |
|---|---|
| The overhaul height is too low to pull out piston and connecting rod in one piece.            | Dismount the piston from the connecting rod, remove the piston and pull out the connecting rod by the pull-lifts. |
| The overhaul height is sufficient to pull out the piston and the connecting rod in one piece. | Remove the piston and connecting rod by means of the pull-lifts.  |

**Dismantling of Cylinder Liner at Low Overhaul Heights.**

- 1) Mount normal lifting tool for cylinder liners.
- 2) Carefully pull the cylinder liner half-way out of the frame.
- 3) Mount special lifting tool for cylinder liners at low overhaul heights, see plate 62050, item 1895.
- 4) Attach pull-lifts on the lifting tool for the cylinder liner, see plate 62050, item 1895
- 5) Take out the liner over the camshaft side.

**L28/32H**



**60601-34H****Piston and Connecting Rod (Hydraulic Tightened)**Plate  
Page 2 (2)**L28/32H**

| Item No | Qty. | Designation   | Benævnelse                                   | Item No | Qty. | Designation | Benævnelse |
|---------|------|---|--|---------|------|-------------|------------|
| 01      | 1/C  | <b>Piston pin incl. item No 02</b>                      | Stempelpind inkl. pos. nr. 02                |         |      |             |            |
| 02      | 4/C  | <b>Socket screw</b>                                     | Kraterskrue                                  |         |      |             |            |
| 03      | 2/C  | <b>Retaining ring</b>                                   | Sikringsring                                 |         |      |             |            |
| 04      | 1/C  | <b>Plug screw</b>                                       | Propskrue                                    |         |      |             |            |
| 05      | 1/C  | <b>Bush for connecting rod</b>                          | Plejlstangs-bøsning                          |         |      |             |            |
| 06      | 1/C  | <b>Connecting rod incl. item Nos 04, 05, 14, 15, 16</b> | Plejlstang inkl. pos. nr. 04, 05, 14, 15, 16 |         |      |             |            |
| 08      | 1/C  | <b>Piston</b>   | Stempel                                      |         |      |             |            |
| 09      | 1/C  | <b>Piston ring</b>                                      | Stempelring                                  |         |      |             |            |
| 10      | 1/C  | <b>Piston ring</b>                                      | Stempelring                                  |         |      |             |            |
| 11      | 1/C  | <b>Piston ring</b>                                      | Stempelring                                  |         |      |             |            |
| 12      | 1/C  | <b>Oil scraper ring</b>                                 | Olieskrabering                               |         |      |             |            |
| 13      | 1/C  | <b>Connecting rod bearing 2/2</b>                       | Plejlstangs-leje 2/2                         |         |      |             |            |
| 14      | 1/C  | <b>Plug screw</b>                                       | Propskrue                                    |         |      |             |            |
| 15      | 2/C  | <b>Connecting rod stud</b>                              | Plejlstangsbolt                              |         |      |             |            |
| 16      | 2/C  | <b>Nut</b>  | Møtrik                                       |         |      |             |            |

When ordering spare parts, see also page 600.50.

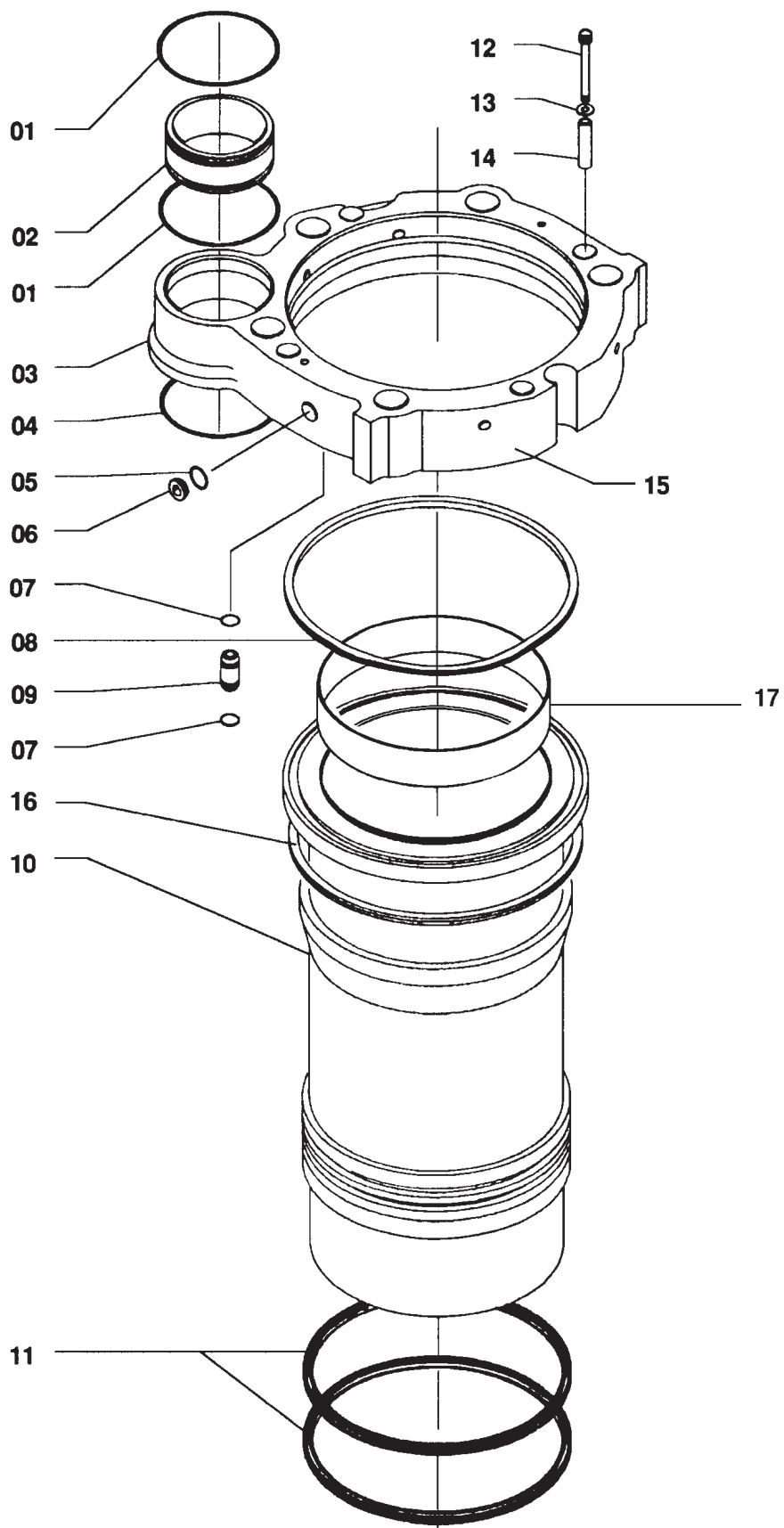
\* = Only available as part of a spare parts kit.  
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/C = Antal/Cylinder

|                     |                                       |           |
|---------------------|---------------------------------------|-----------|
| Plate<br>Page 1 (2) | Cylinder Liner and Water Guide Jacket | 60610-09H |
|---------------------|---------------------------------------|-----------|

L28/32H



60610-09H

## Cylinder Liner and Water Guide Jacket

Plate  
Page 2 (2)

## L28/32H

| Item No | Qty. | Designation  | Beskrivelse                          | Item No | Qty | Designation | Beskrivelse |
|---------|------|--|--------------------------------------|---------|-----|-------------|-------------|
| 01      | 2/C  | O-ring   | O-ring                               |         |     |             |             |
| 02      | 1/C  | Sleeve   | Muffe                                |         |     |             |             |
| 03      | 1/C  | Water guide jacket                                 | Kølekappe                            |         |     |             |             |
| 04      | 1/C  | O-ring   | O-ring                               |         |     |             |             |
| 05      | 6/C  | Sealing ring                                       | Tætningsring                         |         |     |             |             |
| 06      | 6/C  | Plug screw   | Propskrue                            |         |     |             |             |
| 07      | 12/C | O-ring   | O-ring                               |         |     |             |             |
| 08      | 1/C  | Sealing ring                                       | Tætningsring                         |         |     |             |             |
| 09      | 6/C  | Cooling water connection                           | Kølevands-<br>overgang               |         |     |             |             |
| 10      | 1/C  | Cylinder liner                                     | Cylinderforing                       |         |     |             |             |
| 11      | 2/C  | O-ring   | O-ring                               |         |     |             |             |
| 12      | 4/C  | Hexagon screw                                      | Unbracoskrue                         |         |     |             |             |
| 13      | 4/C  | Washer   | Skive                                |         |     |             |             |
| 14      | 4/C  | Sleeve   | Foring                               |         |     |             |             |
| 15      | 1/C  | Water guide jacket<br>incl. item no. 05 and<br>06. | Kølekappe inkl. item nr.<br>05 og 06 |         |     |             |             |
| 16      | 1/C  | Sealing ring                                       | Tætningsring                         |         |     |             |             |
| 17      | 1/C  | Flame ring   | Flammering                           |         |     |             |             |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50

\* = Kun tilgængelig som en del af et reservedelssæt  
Antal/C = Antal/Cylinder



**Camshaft**

**507/607**

**L28/32H****General**

The camshaft which controls the actuation of inlet valves, exhaust valves and fuel injection pumps is driven by a gear wheel on the crankshaft through an intermediate wheel, and rotated by a speed which is half of that of the crankshaft, see fig. 1.

The camshaft is placed in the engine frame at the control side, (left side, seen from the flywheel end) and is carried in bearing bushes which are fitted in bores in the engine frame, each bearing is replaceable and locked in position in the engine frame by means of lock screws.

The camshaft is built-up of sections, one for each cylinder unit. Each section is equipped with fixed cams for operation of fuel injection pump, air inlet valve and exhaust valve. The sections are assembled by bolting of the ample dimensioned and precision made flange connections, which also act as bearing journals.

Except for the foremost and the aftmost ones, the sections are identical and therefore interchangeable. The foremost section is equipped with a clutch for driving the fuel oil feed pump (if mounted). The gear wheel for driving the camshaft as well as a gear wheel connection of governor are screwed on the aftmost section.

The lubricating oil pipes for the gear wheels are equipped with nozzles which are adjusted to apply the oil at the points where the gear wheels are in mesh. The position of the nozzles is determined by direction of rotation of the engine.

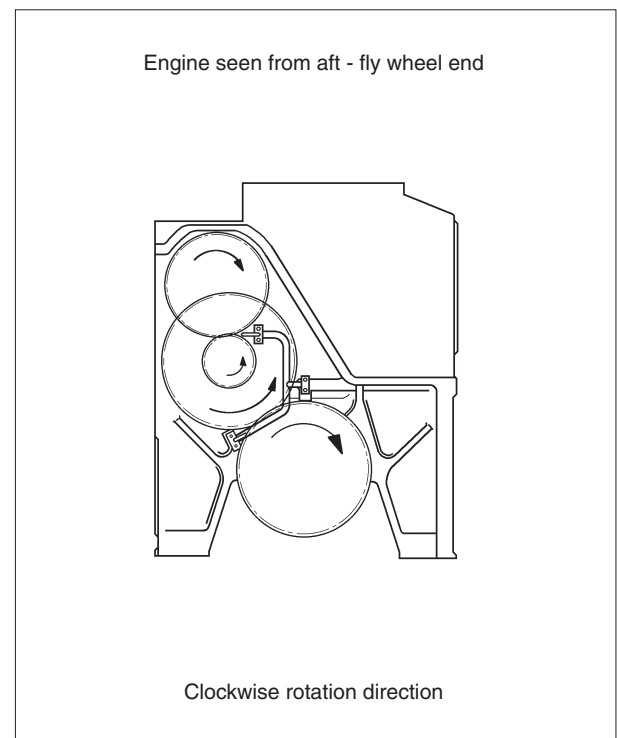


Fig. 1. Intermediate wheel

|                            |                                    |                                 |
|----------------------------|------------------------------------|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Camshaft and Camshaft Drive</b> | <b>607-01.00</b><br>Edition 01H |
|----------------------------|------------------------------------|---------------------------------|

**L/V28/32H****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description:**

Checking of gear wheels, bolted connections and lubricating system.

**Starting position:****Related procedure:****Man power:**

Working time : 3 Hours  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.        |
|-----------|----------|--------------|
| 62006     | 26       | 20 - 120 Nm. |

**Hand tools:**

Allen key, 12 mm.  
Ring and open end spanner, 19 mm.  
Socket spanner, 19 mm.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./  |
|-----------|----------|--------|
| 60705     | 12       | 6/eng. |
| 60705     | 24       | 3/eng. |
| 61106     | 11       | 1/cyl. |
| 61106     | 13       | 1/cyl. |
| 61106     | 14       | 1/eng. |

**L/V28/32H**

**1)** Dismount the covers which give access to the gear wheels, camshaft and crankcase.

Examine all gear wheels for cracks, wear and deformations. While turning the engine to enable inspection all over the circumference of the gear wheels.

**2)** Check all screws, nuts and bolted connections, including locking devices everywhere in the gear wheel housing, camshaft housing and crankcase to check that they have not worked loose. Tightening torques, see page 600.40.

**3)** Examine all lubricating oil spray pipe nozzles.

**4)** Start the electrical lubricating oil pump and check the oil flow everywhere. Be particularly careful to check that the oil jet hits the gear wheels correctly at the points where the wheels mesh.

**L+V28/32H****Safety precautions**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☒ Shut-off fuel oil
- ☒ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description**

Check of roller path of cams and check of camshaft bearing.  
Replacement of camshaft bearing.

**Starting position**

Cover for camshaft and gear wheel has been removed.

**Related procedure**

Camshaft and camshaft drive, 607-01.00

**Man power**

Working time : 2 Hours  
Capacity : 2 men

**Data**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools**

| Plate No | Item No | Note         |
|----------|---------|--------------|
| 62006    | 26      | 20 - 120 Nm. |

**Hand tools**

Ring and open end spanner, 19 mm.  
Socket spanner, 19 mm.  
Feeler gauge.  
Big screw driver.

**Replacement and wearing parts**

| Plate No | Item No | Qty. / |
|----------|---------|--------|
| 60705    | 01      | 1/eng. |
| 60705    | 03      | 1/cyl. |
| 60705    | 21      | 1/cyl. |

**L+V28/32H****To Check Roller Path of Cams.**

**1)** While turning the engine, examine the cam discs and in particular, check the roller path of all cams for cracks, crackles and ruffle. Also examine the rollers of the roller guides.

**Note:** if there are flat spots on the roller and if some of the rollers may be blocked, if so, the roller must be replaced by a new one, see working card 608-01.00.

**To Check Camshaft Bearings.**

**2)** The wearing surface of the camshaft bearings cannot be checked without dismantling the camshaft. However, ab-normal wear of one or more bearings will become apparent in the form of burrs of white metal at the circumference of the camshaft journal, and in that case the bearing will in no doubt be discoloured, as well.

The bearing clearance is measured with a feeler gauge, see data sheet 600.35.

**To Replace Camshaft Bearing.**

**3)** If one or several of the camshaft bearings should be replaced the camshaft must be wholly or partly dismantled.

Dismount the fuel oil feed pump, if mounted and check that the camshaft sections are marked in relation to each other. Disassemble the camshaft aft (toward flywheel) of the bearing that is to be replaced. Dismount all roller guides that are located forward of the disassembling position, see working card 608-01.00 and 608-01.05.

Pull the disconnected sections of the camshaft so far a head that the bearing which is to be replaced is free.

Take out the locating screw of the camshaft bearing concerned and push the bearing out of the bore in the engine frame, see fig. 1.

Check the lubricating oil ducts to the bearing for free flow.

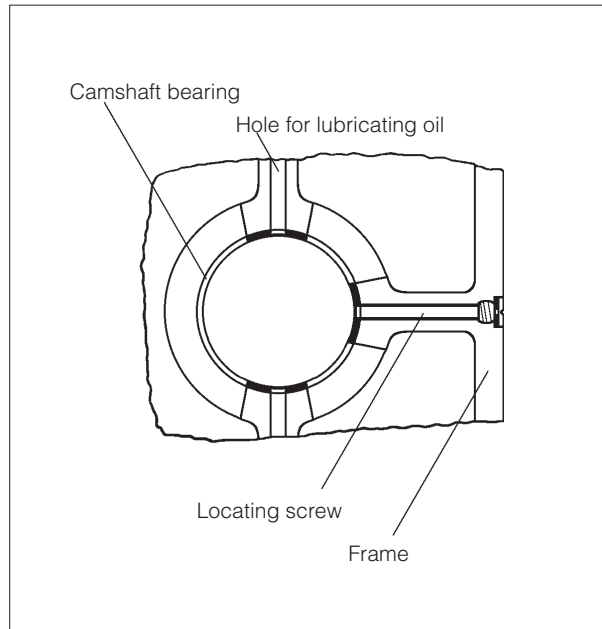


Fig. 1.

Mount a new camshaft bearing in the bore and make sure that the hole for insertion of the locating screw in the bearing is in a correct position. Lock the bearing by means of the locating screw, which is to be provided with a new gasket. To facilitate the fitting of the bearing it can be cooled down with  $\text{CO}_2$ .

Inspect the camshaft journal for seizures.

If necessary, the camshaft section must be entirely removed from the engine, and the journal concerned must be polished.

Coat all the journals of the camshaft section with clean lubricating oil and push the camshaft into position, making sure that the marks on the flanges coincide.

Assemble the sections and fit the bolts (coated with Molycote or similar).

Tighten the nuts with a torque spanner, see data sheet 600.40.

Mount all roller guides as well as the fuel oil feed pump.

**L28/32H****Safety precautions**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description**

Adjustment of the injection timing.

**Starting position****Related procedure****Manpower**

Working time : 2-5 hours  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 500.35)  
Data for torque moment (Page 500.40)  
Declaration of weight (Page 500.45)

**Special tools**

| Plate no | Item no | Note         |
|----------|---------|--------------|
| 62006    | 26      | 20 - 120 Nm. |
| 62010    | 01      |              |
| 62008    | 05      |              |

**Hand tools**

Ring and open end spanner, 19 mm.  
Socket spanner, 19 mm.  
Depth gauge.  
Plastic hammer.

**Replacement and wearing parts**

| Plate no | Item no | Qty /     |
|----------|---------|-----------|
| 60801    | 23      | 1 set/cyl |

## L28/32H

## Measure of fuel pump lead

- 1) Dismantle covers for fuel camshaft and fuel pump and covers for gear wheel
- 2) Check the mobility of the regulating device. Turn engine to pos. cylinder No. 1 until the cambase circle is reached (approx. 40° BTDC).
- 3) Position the support of the measuring tool on the two bolts of the camshaft covering. Slip on the distance sleeves and fasten to the cylinder crankcase by means of hexagon nuts.
- 4) Insert the dial gauge into the support.
- 5) Set the dial gauge to "Zero".
- 6) Turn the engine until the TDC mark (ignition DC) for the actual cylinder is reached. Read the dial gauge and note down the gauge value.
- 7) Determine the values for the other cylinders in the same way.

Calculate the average value of all measurements.

**Note:** During attaching, pay attention to the correct fitting position of the contact point, see fig 1.

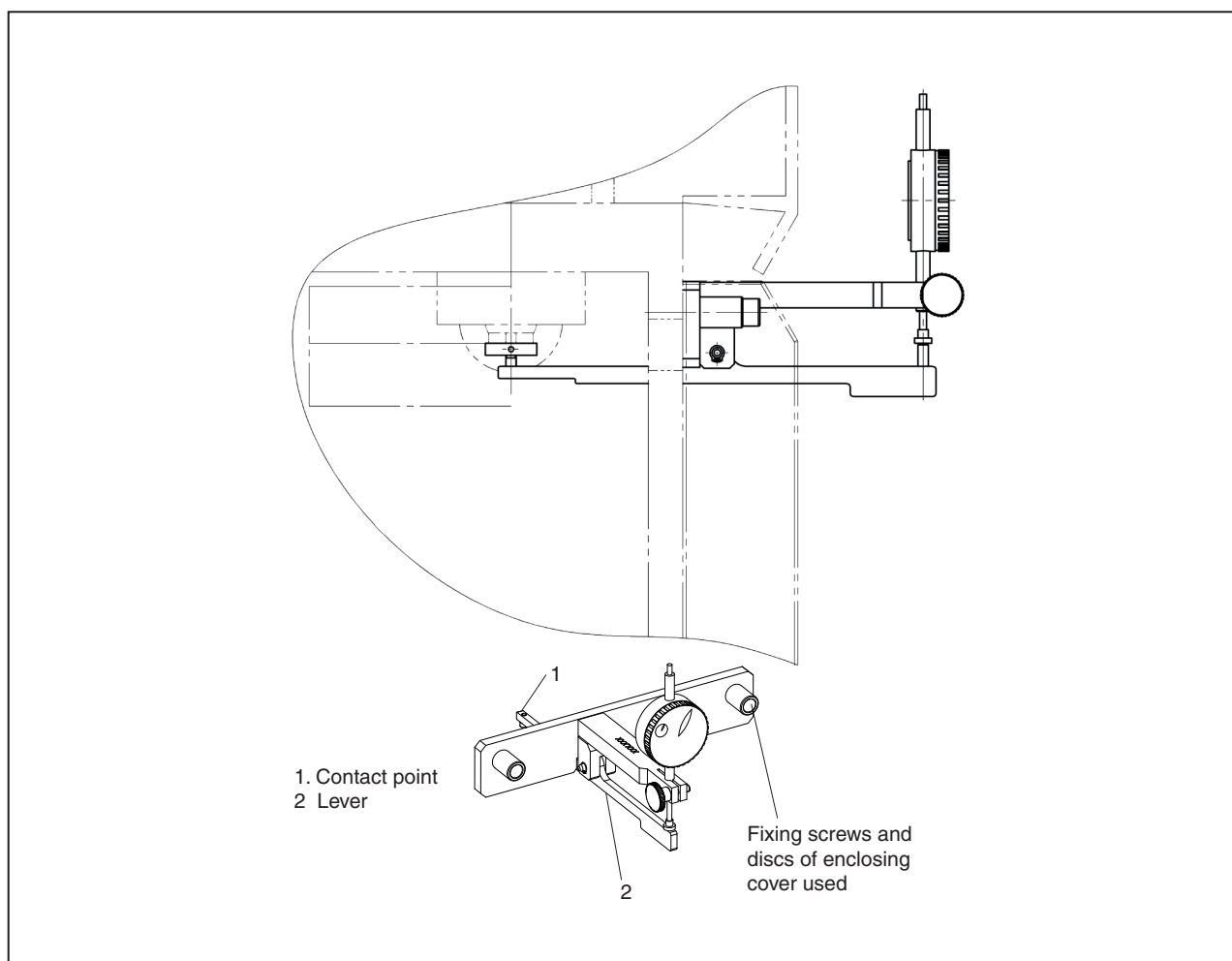


Fig 1 Fitting position of the contact point.



**L28/32H**

- 8) Compare the calculated value determined with the value mentioned below.
- 9) If the values exceeds the limits, an adjustment must be done in order to correct the errors, on the X-measure or reset the gear wheel, see following text for changing "X"-measuring.

| Cyl.      | kW/Cyl. | rpm | Average value    |
|-----------|---------|-----|------------------|
| 5-6-7-8-9 | 210     | 720 | See section 600, |
| 5-6-7-8-9 | 220     | 750 | Description      |
|           |         |     | 600.35           |

Fig 2 Plunger lift (average value)

To get a consistent lifting values on the plunger/ combustion pressure on the different cylinders the "X"-measure can be changed.

When changing "X" it must be ensured that the distance between the upper edge of the roller guide housing and the thrust piece on the roller guide is not exceeded, when the roller is resting on the circular part of the fuel cam, *please see description 500.35*.

In all cases "X" must be checked and adjusted, if necessary, when fuel oil pump, roller guide, roller guide housing and/or camshaft section have been replaced/dismantled.

**Note:** If several fuel oil pumps, roller guides, roller guide housings and/or camshaft sections are dismantled at the same time it is advisable to number the parts in order to facilitate remounting and adjustment.

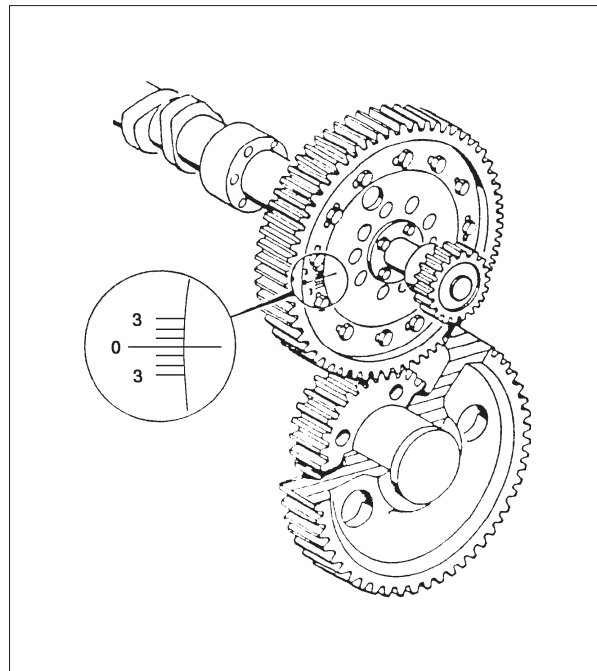


Fig 3 Gear wheel with engraved scale.

The gear wheel is provided with an engraved scale, *see fig 3*, and the hub of the cam shaft is provided with a mark.

When the screws, which fasten the gear wheel, are loosened the gear wheel is turned (by turning the crankshaft) in relation to the camshaft.

If the crankshaft is turned in the engines normal direction of rotation the injection timin is retarded (closer to TDC).

If the crankshaft is turned against the engines normal direction of rotation the injection timing is advanced (away from TDC).

After the adjustment the screws are fastened with a torque wrench, *please see description 500.40*, and secured.

L28/32H

The injection timing can be altered on each cylinders by inserting or removing shims under the thrust piece on the roller guide, thus changing the measure “X”, see Fig 4.

Thinner and/or fewer shims (increase of the distance “X”) results in a retarded injection timing.

Thicker and/or more shims (reduction of the distance “X”) results in an advanced injection.

If the distance “X” is to be changed the trigger (1) is used for dismantling of the thrust piece (2), whereafter the thickness and/or the number of shims (3) can be changed.

After replacement of shims the thrust piece is re-mounted, see fig 5, in the roller guide (4) with a soft hammer (5).

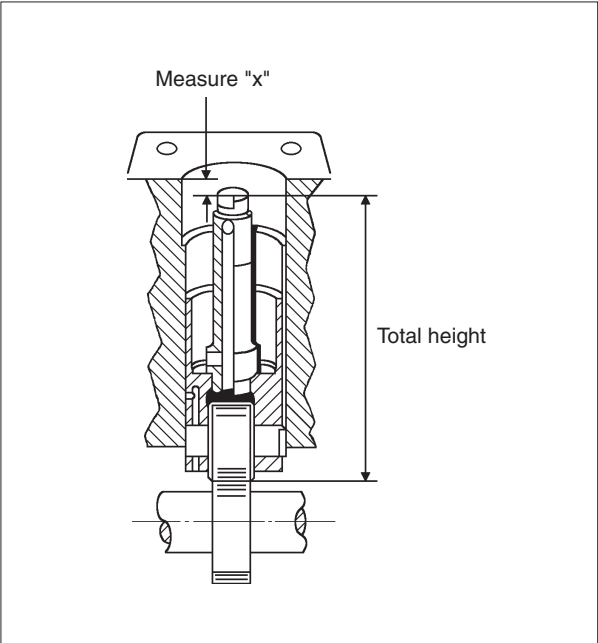


Fig 4 Measure “X”

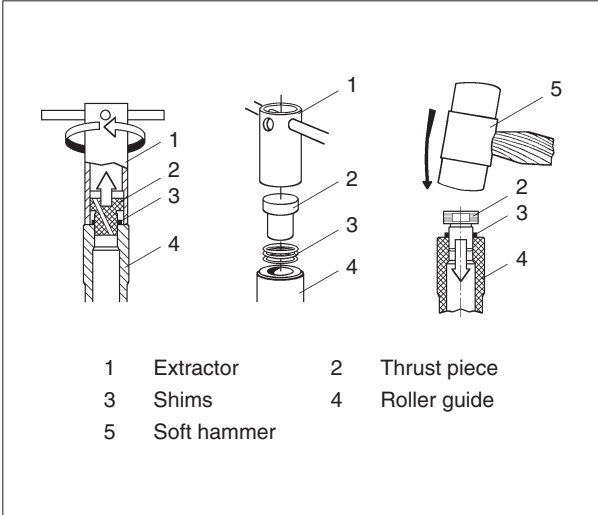


Fig 5 Remounting of thrust piece.

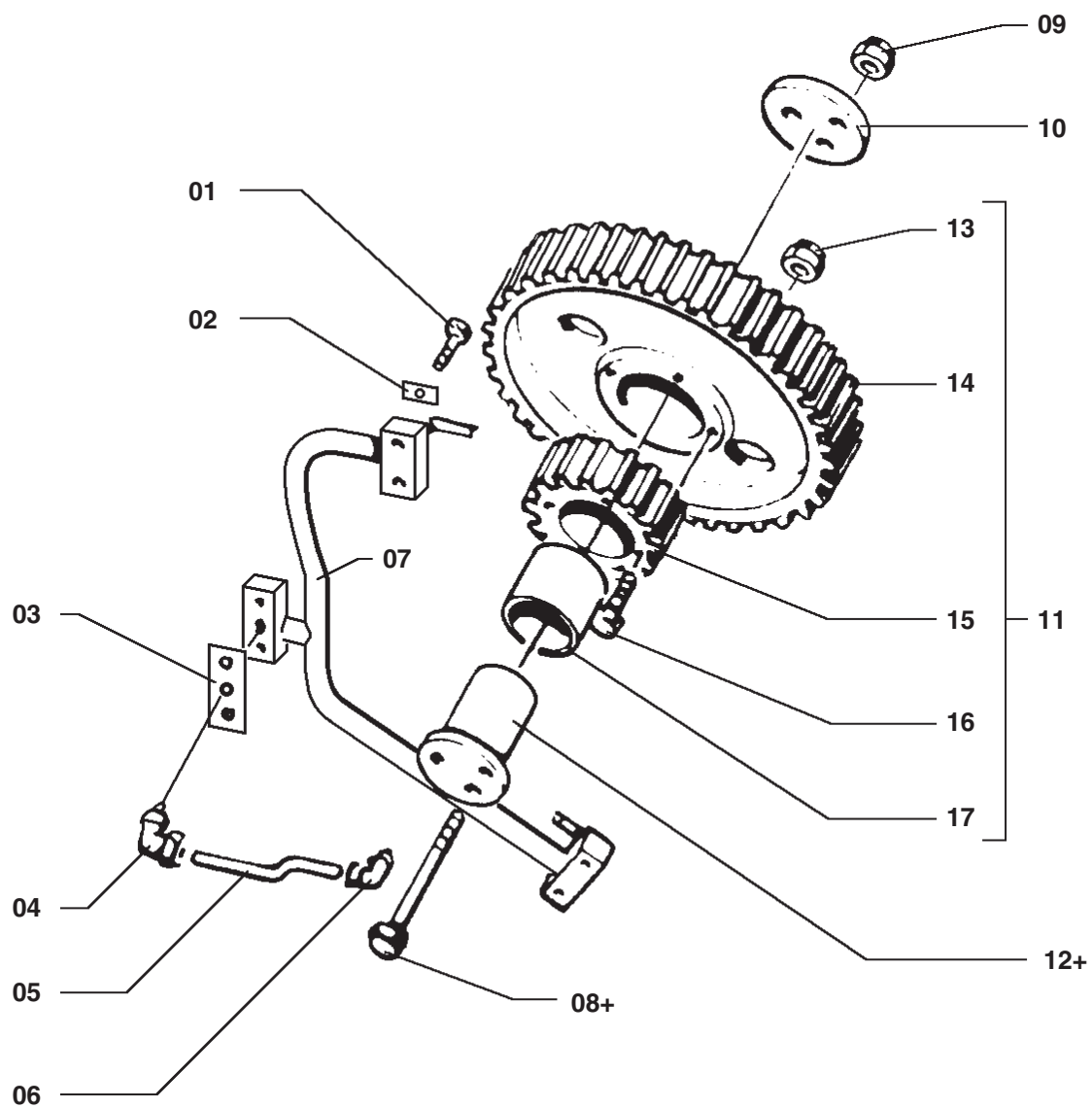
| Action                       |   | Results      |   |                  |                          |
|------------------------------|---|--------------|---|------------------|--------------------------|
| Total height on roller guide |   | Distance "x" |   | Injection timing | Max. combustion pressure |
| increased                    | ↑ | Reduced      | ↓ | Advanced         | ↑                        |
| Reduced                      | ↓ | increased    | ↑ | Delayed          | ↓                        |

Fig 6

- 10) Remove the complete measuring tool.
- 11) Mount all camshaft covers.
- 12) Plunger lift value, please see description 500.35.

|                     |                    |           |
|---------------------|--------------------|-----------|
| Plate<br>Page 1 (2) | Intermediate Wheel | 60701-06H |
|---------------------|--------------------|-----------|

L28/32H



60701-06H

## Intermediate Wheel

Plate  
Page 2 (2)

## L28/32H

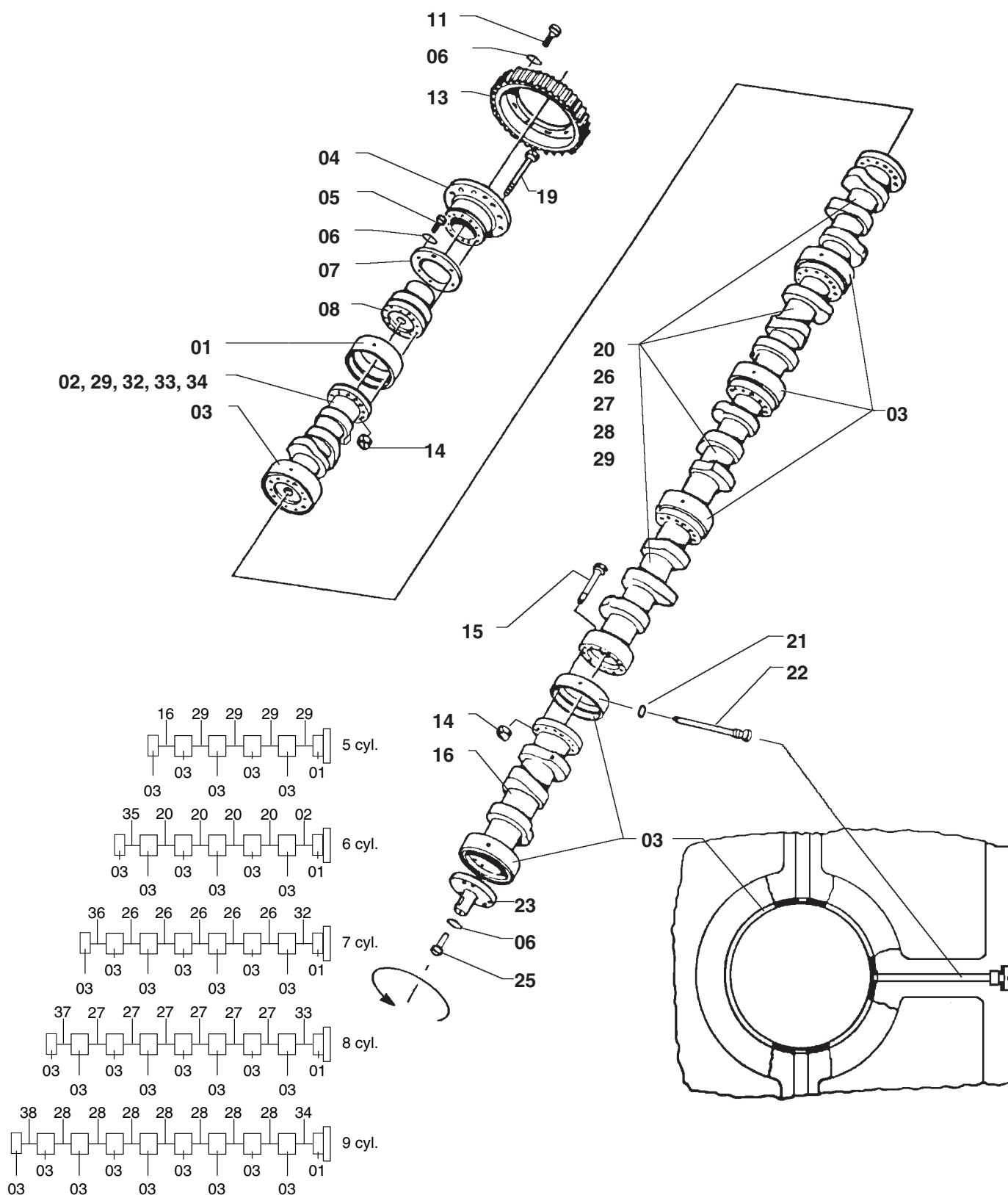
| Item No. | Qty. | Designation   | Benævnelse         | Item No. | Qty. | Designation | Benævnelse |
|----------|------|---|--------------------|----------|------|-------------|------------|
| 01       | 6/E  | Screw   | Skrue              |          |      |             |            |
| 02       | 6/E  | Lock plate  | Sikringsplade      |          |      |             |            |
| 03       | 3/E  | Gasket  | Pakning            |          |      |             |            |
| 04       | 1/E  | Union   | Vinkelforskruning  |          |      |             |            |
| 05       | 1/E  | Pipe  | Rør                |          |      |             |            |
| 06       | 1/E  | Union   | Vinkelforskruning  |          |      |             |            |
| 07       | 1/E  | Spray pipe  | Sprøjterør         |          |      |             |            |
| 08+      | 3/E  | Fitted bolt   | Pasbolt            |          |      |             |            |
| 09       | 3/E  | Self locking nut  | Selvlåsende møtrik |          |      |             |            |
| 10       | 1/E  | Cover   | Dæksel             |          |      |             |            |
| 11       | 1/E  | Gear wheel, complete  | Tandhjul, kompl.   |          |      |             |            |
| 12+      | 1/E  | Axle journal  | Lejetap            |          |      |             |            |
| 13       | 4/E  | Self locking nut  | Selvlåsende møtrik |          |      |             |            |
| 14       | 1/E  | Spur gear   | Tandhjul           |          |      |             |            |
| 15       | 1/E  | Spur gear   | Tandhjul           |          |      |             |            |
| 16       | 4/E  | Bolt  | Bolt               |          |      |             |            |
| 17       | 1/E  | Bearing bush  | Lejebøsning        |          |      |             |            |
|          |      | + Item No. 08 and 12 require an individual matching, before mounting, contact MAN B&W, Holeby |                    |          |      |             |            |
|          |      | + Item nr. 08 og 12 kræver en individuel tilpasning, før monteringen kontakt MAN B&W, Holeby  |                    |          |      |             |            |

When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

**L28/32H**

**60705-22H****Camshaft and Camshaft Bearing**Plate  
Page 2 (2)**L28/32H**

| Item No. | Qty.                         | Designation   | Benævnelse  | Item No. | Qty. | Designation                                  | Benævnelse                               |
|----------|------------------------------|---|---|----------|------|--|--|
| 01       | 1/E                          | <b>Camshaft bearing</b>   | Styreakselleje  | 26       | 5/E  | <b>Camshaft, intermediate, 7 cyl. engine</b> | Styreaksel, mellem 7 cyl. motor          |
| 02       | 1/E                          | <b>Camshaft section "aft", 6 cyl. engine</b>  | Styreakselssektion "agter", 6 cyl. motor  | 27       | 6/E  | <b>Camshaft, intermediate, 8 cyl. engine</b> | Styreaksel, mellem 8 cyl. motor          |
| 03       | 1/C                          | <b>Camshaft bearing</b>   | Styreakselleje  | 28       | 7/E  | <b>Camshaft, intermediate, 9 cyl. engine</b> | Styreaksel, mellem 9 cyl. motor          |
| 04       | 1/E                          | <b>Hub</b>  | Nav   | 29       | 4/E  | <b>Camshaft section "aft", 5 cyl. engine</b> | Styreakselssektion "agter", 5 cyl. motor |
| 05       | 6/E                          | <b>Screw</b>  | Skrue   | 32       | 1/E  | <b>Camshaft section "aft", 7 cyl. engine</b> | Styreakselssektion "agter", 7 cyl. motor |
| 06       | 24/E                         | <b>Disc spring</b>  | Skivefjeder   | 33       | 1/E  | <b>Camshaft section "aft", 8 cyl. engine</b> | Styreakselssektion "agter", 8 cyl. motor |
| 07       | 1/E                          | <b>Guide ring</b>   | Styrering   | 34       | 1/E  | <b>Camshaft section "aft", 9 cyl. engine</b> | Styreakselssektion "agter", 9 cyl. motor |
| 08       | 1/E                          | <b>Shaft pin</b>  | Akseltap  | 35       | 1/E  | <b>Camshaft "Fore" 6 cyl. engine</b>         | Styreaksel "For" 6 cyl. motor            |
| 11       | 12/E                         | <b>Screw</b>  | Skrue   | 36       | 1/E  | <b>Camshaft "Fore" 7 cyl. engine</b>         | Styreaksel "For" 7 cyl. motor            |
| 13       | 1/E                          | <b>Gear wheel</b>   | Tandhjul  | 37       | 1/E  | <b>Camshaft "Fore" 8 cyl. engine</b>         | Styreaksel "For" 8 cyl. motor            |
| 14       | 70/E<br>52/E<br>66/E<br>92/E | <b>Self locking nut 6 cyl. engine<br/>7 cyl. engine<br/>8 cyl. engine<br/>9 cyl. engine</b> | Selvlåsende møtrik 6 cyl. motor<br>7 cyl. motor<br>8 cyl. motor<br>9 cyl. motor | 38       | 1/E  | <b>Camshaft "Fore" 9 cyl. engine</b>         | Styreaksel "For" 9 cyl. motor            |
| 15       | 60/E<br>42/E<br>56/E<br>82/E | <b>Screw 6 cyl. engine<br/>7 cyl. engine<br/>8 cyl. engine<br/>9 cyl. engine</b>            | Skrue 6 cyl. motor<br>7 cyl. motor<br>8 cyl. motor<br>9 cyl. motor              |          |      |  |  |
| 16       | 1/E                          | <b>Camshaft "Fore" 5 cyl. engine</b>  | Styreaksel "For" 5 cyl. motor   |          |      |  |  |
| 19       | 10/E                         | <b>Screw</b>  | Skrue   |          |      |  |  |
| 20       | 4/E                          | <b>Camshaft, intermediate, 6 cyl. engine</b>  | Styreaksel, mellem, 6 cyl. motor  |          |      |  |  |
| 21       | 7/E<br>8/E<br>9/E<br>10/E    | <b>Gasket 6 cyl. engine<br/>7 cyl. engine<br/>8 cyl. engine<br/>9 cyl. engine</b>           | Pakning 6 cyl. motor<br>7 cyl. motor<br>8 cyl. motor<br>9 cyl. motor            |          |      |  |  |
| 22       | 7/E<br>8/E<br>9/E<br>10/E    | <b>Guide screw 6 cyl. engine<br/>7 cyl. engine<br/>8 cyl. engine<br/>9 cyl. engine</b>      | Styreskrue 6 cyl. motor<br>7 cyl. motor<br>8 cyl. motor<br>9 cyl. motor         |          |      |  |  |
| 23       | 1/E                          | <b>Coupling flange</b>  | Koblingssflange   |          |      |  |  |
| 25       | 6/E                          | <b>Screw</b>  | Skrue   |          |      |  |  |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./C = Qty./Cylinder  
 Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/C = Antal/Cylinder  
 Antal/E = Antal/Motor

**Operating gear**

**508/608**

**L/V28/32H****Roller Guides**

The fuel injection pumps and the rocker arms for inlet and exhaust valves are operated by the cams, on the camshaft through roller guides. The roller guides for fuel pump, inlet and exhaust valves are located in bores in a common housing for each cylinder, this housing is bolted to the engine frame.

The roller runs on a bush fitted on a pin that is pressed into the roller guide and secured by means of a lock screw.

**Operating Gear for Fuel Injection Pumps**

The injection pumps which is mounted directly on the roller guide housing is activated via thrust pieces from the roller guide.

The roller is pressed down on to the cam by a spring, which is fixed between the roller guide and the foot plate of the fuel injection pump.

**Operating Gear for Inlet and Exhaust Valves**

The movement from the roller guides for inlet and exhaust is transmitted via the push rods the rocker arms and spring-loaded valve bridges to each of the two valve sets. The bridge is placed between the valve spindles and in the one end it is provided with a pressed-on thrust shoe and in the other end it is fitted with a thrust screw for adjustment of the valve clearance.

On its top the bridge is controlled by a spherical thrust shoe on the rocker arm and at the bottom by a guide which rests in a spherical socket in the cylinder head.

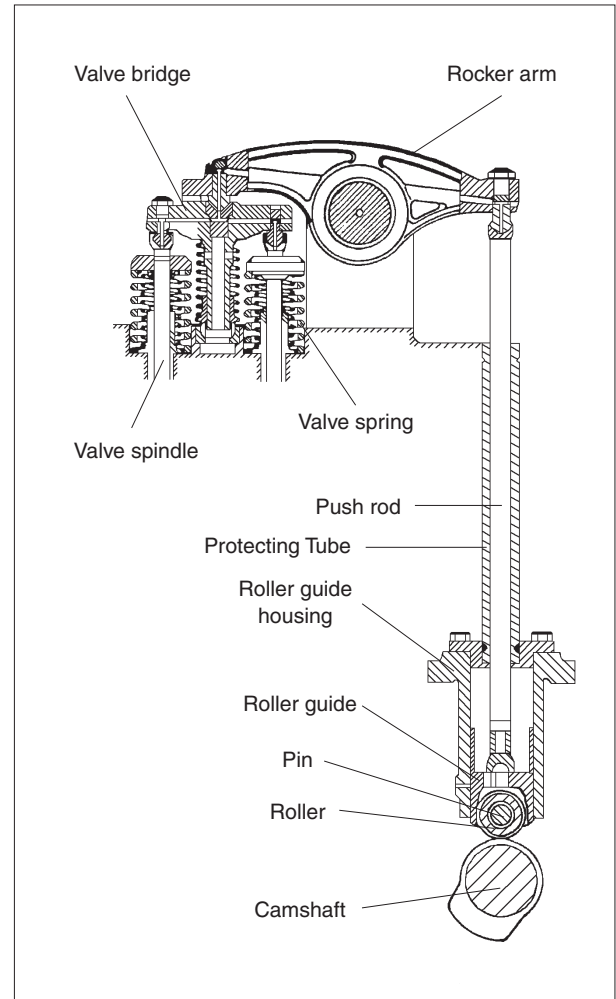


Fig. 1. Valve Operating Gear.



|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Inspection of Valve Roller Guides</b> | <b>608-01.00</b><br>Edition 01H |
|----------------------------|--|---------------------------------|

**L/V28/32H**

|   |   |             |          |        |       |    |             |       |    |        |       |    |        |
|---|---|-------------|----------|--------|-------|----|-------------|-------|----|--------|-------|----|--------|
| <b>Safety precautions:</b><br><br><div><div><input checked="" type="checkbox"/></div> Stopped engine</div> <div><div><input checked="" type="checkbox"/></div> Shut-off starting air</div> <div><div><input type="checkbox"/></div> Shut-off cooling water</div> <div><div><input checked="" type="checkbox"/></div> Shut-off fuel oil</div> <div><div><input type="checkbox"/></div> Shut-off cooling oil</div> <div><div><input checked="" type="checkbox"/></div> Stopped lub. oil circul.</div> | <b>Special tools:</b><br><br><table><tr><td>Plate no.</td><td>Item no.</td><td>Note.</td></tr><tr><td>62006</td><td>26</td><td>20 - 120 Nm</td></tr></table>  | Plate no.   | Item no. | Note.  | 62006 | 26 | 20 - 120 Nm |       |    |        |       |    |        |
| Plate no.   | Item no.  | Note.       |          |        |       |    |             |       |    |        |       |    |        |
| 62006   | 26  | 20 - 120 Nm |          |        |       |    |             |       |    |        |       |    |        |
| <b>Description:</b><br><br>Dismounting, inspection and/or overhaul, and mounting of valve roller guides.<br>Inspection of roller guide housing.   | <b>Hand tools:</b><br><br>Ring and open end spanner, 19 mm.<br>Socket spanner, 19 mm.<br>Socket spanner, 24 mm.<br>Allen key, 3 mm.<br>Ratchet spanner.<br>Hammer.<br>Drift.  |             |          |        |       |    |             |       |    |        |       |    |        |
| <b>Starting position:</b><br><br>Top cover for cylinder head and cover for fuel injection pump removed.   |   |             |          |        |       |    |             |       |    |        |       |    |        |
| <b>Related procedure:</b><br><br>Inspection of fuel injection pump roller guide, 608-01.05<br>Control and adjusting of valve clearance, 608-01.10   |   |             |          |        |       |    |             |       |    |        |       |    |        |
| <b>Man power:</b><br><br>Working time : 2 Hours<br>Capacity : 1 man   |   |             |          |        |       |    |             |       |    |        |       |    |        |
| <b>Data:</b><br><br>Data for pressure and tolerance (Page 600.35)<br>Data for torque moment (Page 600.40)<br>Declaration of weight (Page 600.45)  | <b>Replacement and wearing parts:</b><br><br><table><tr><td>Plate no.</td><td>Item no.</td><td>Qty. /</td></tr><tr><td>60801</td><td>04</td><td>4/cyl.</td></tr><tr><td>60801</td><td>08</td><td>2/cyl.</td></tr><tr><td>60801</td><td>09</td><td>1/cyl.</td></tr></table><br>See also plate 60801. | Plate no.   | Item no. | Qty. / | 60801 | 04 | 4/cyl.      | 60801 | 08 | 2/cyl. | 60801 | 09 | 1/cyl. |
| Plate no.   | Item no.  | Qty. /      |          |        |       |    |             |       |    |        |       |    |        |
| 60801   | 04  | 4/cyl.      |          |        |       |    |             |       |    |        |       |    |        |
| 60801   | 08  | 2/cyl.      |          |        |       |    |             |       |    |        |       |    |        |
| 60801   | 09  | 1/cyl.      |          |        |       |    |             |       |    |        |       |    |        |

## L/V28/32H

**Dismounting of Roller Guide.**

- 1) Turn the engine so that the roller, rests on the circular part of the cam.
- 2) Unscrew the nuts which secure the rocker arm brackets, and lift off the rocker arm with brackets.
- 3) Remove the push rods (1), see fig. 1.

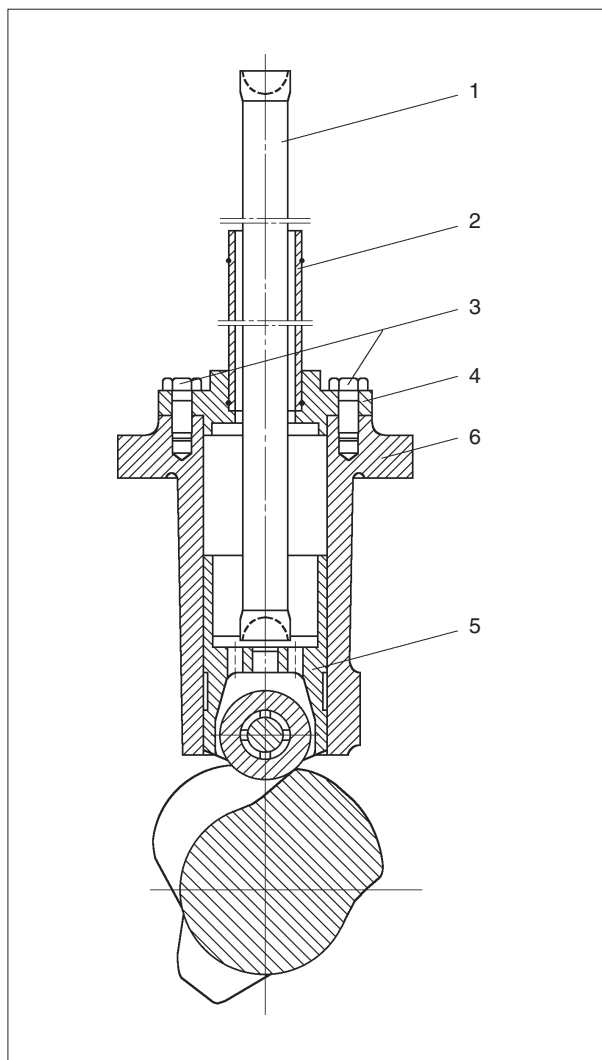


Fig. 1.

- 4) Loosen the lock screw for the push rod protecting tube, see plate 60801, item 07, on the roller guide top cover and lift up and remove the protecting tube (2).

- 5) Dismount the screws (3) which secure the roller guide top cover, take off the cover, and lift out the roller guide (5).

Disconnect any pipes that may be in the way (lub. oil and fuel oil pipes).

- 6) If the roller guide housing is to be dismantled, the fuel injection pump and the fuel injection pump roller guide are to be dismantled, see working card 614-01.05 and a number of lubricating oil and fuel oil pipes are also to be disconnected.

The roller guide housing (6) cannot be dismantled with the roller guides fitted.

- 7) If the event of any marks or scores from seizures, these must be polished away.

- 8) Inspect the spherical stud for deformations (replace as necessary).

Examine the surface of the roller for marks and other deformations.

Make sure that there is free rotation between the roller and the bush and the shaft pin, and replace the bush, if necessary.

**Replacement of Roller, Bush and Shaft Pin.**

- 9) Remove the lock screw which secures the roller guide shaft pin and push out the shaft pin.

The roller, shaft pin, and bush can now be replaced as required.

- 10) Blow through the lubricating ducts in roller guide and roller guide housing, and clean the lubricating grooves.

**Mounting of Roller Guide.**

- 11) When assembling the parts, which is carried out in the reverse order to the above care must be exercised not to damage the o-rings when mounting the protecting tube.

- 12) Adjusting of valve clearance, see working card 608-01.10.

|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Inspection of Fuel Injection Pump Roller Guide</b> | <b>608-01.05</b><br>Edition 01H |
|----------------------------|---|---------------------------------|

L/V28/32H

**Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☒ Shut-off fuel oil
- ☒ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description:**

Dismounting, inspection and/or overhaul, and mounting af roller guide for fuel injection pump.

**Starting position:**

Cover for fuel injection pump removed.  
Fuel injection pump has been removed, 614-01.05

**Related procedure:**

Adjustment and/or check of max. combustion pressure, 614-01.20

**Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|-----------|----------|-------|

**Hand tools:**

Allen key, 3mm.  
Hammer.  
Drift.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|

**L/V28/32H****Dismounting of Roller Guide.**

1) Remove the support ring (1) and spring (2) and take up the roller guide (3), see fig. 1.

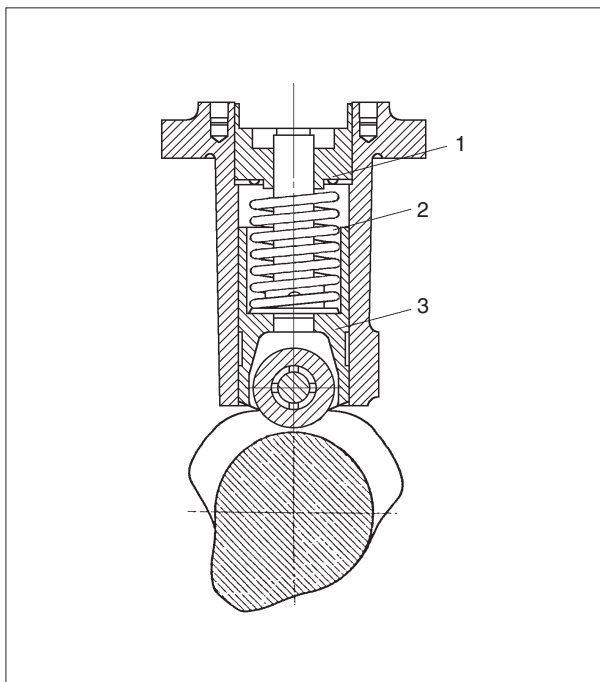


Fig. 1.

**Inspection of Roller Guide.**

2) If the event of any marks or scores from seizures, these must be polished away.

3) Inspect the spherical stud for deformations (replace as necessary).

Examine the surface of the roller for marks and other deformations.

Make sure that there is free rotation between the roller and the bush and the shaft pin, and replace the bush if necessary.

**Replacement of Roller, Bush and Shaft Pin.**

4) Remove the lock screw which secures the roller guide shaft pin and push out the shaft pin.

The roller, shaft pin, and bush can now be replaced as required.

5) Blow through the lubricating ducts in roller guide and roller guide housing, and clean the lubricating grooves.

**Mounting of Roller Guide.**

6) When assembling the parts which is carried out in the reverse order.

7) For adaption of the thrust piece of the roller guide, see working card 614-01.20.

L/V28/32H

**Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description:**

Control and/or adjusting of valve clearance.

**Starting position:**

Cover for rocker arm are removed.  
All indicator valves open.

**Related procedure:****Man power:**

Working time : 1/4 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.   |
|-----------|----------|---------|
| 62008     | 02       | Exhaust |
| 62008     | 01       | Inlet   |
| 62010     | 01       |         |

**Hand tools:**

Ring and open end spanner, 30 mm.  
Big screw driver.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|

See also plate 60502.

## L/V28/32H

**Adjusting of Inlet Valve Clearance.**

- 1) Turn the engine so that the roller, rests on the circular part of the cam, i.e. the inlet valves and the exhaust valves are closed.
- 2) Loosen the adjustment screws on valve bridge and rocker arm, see fig. 1.

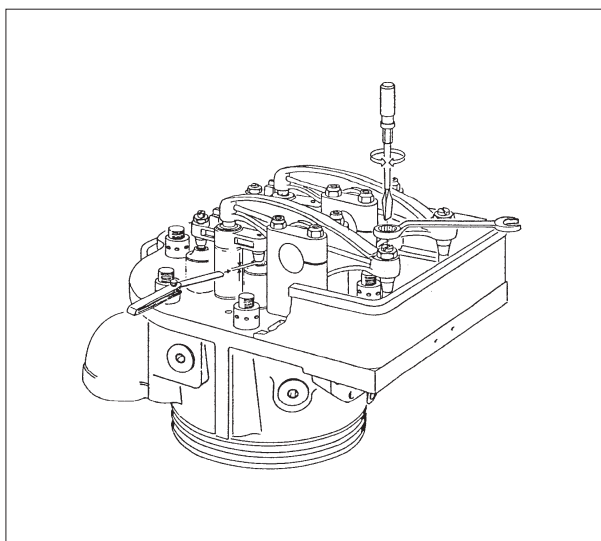


Fig. 1.

- 3) Clearance between valve bridge and valve spindle, see page 600.40.

- 4) Place the feeler gauge marked with "correct" 0,4 mm above the valve spindle nearest to the rocker arm bracket, see fig. 1.

- 5) Adjust the clearance between valve bridge and valve spindle by means of the adjustment screw on the rocker arm (above the push rod) and tighten the lock nut.

The feeler gauge is to remain in this position when adjusting the clearance of the other valve.

- 6) Place another feeler gauge, at the same size 0,40 mm above the other valve spindle, see fig. 2.

- 7) Adjust the clearance between valve bridge and valve spindle by means of the adjustment screw on the valve bridge, and tighten the lock nut, see fig. 2.

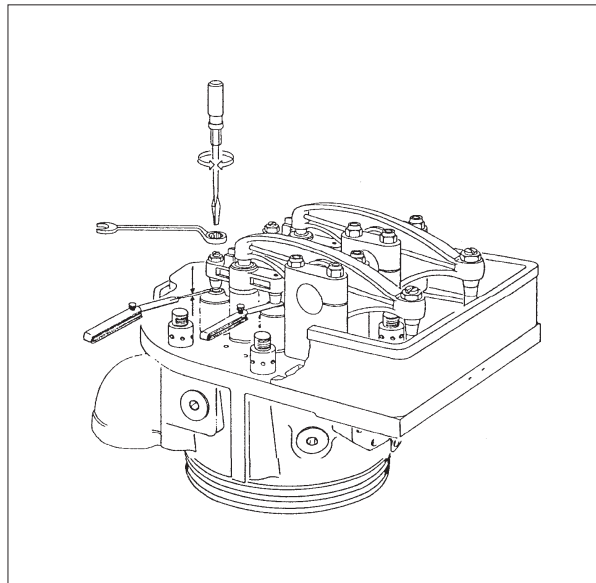


Fig. 2.

- 8) Check that the clearance is correct simultaneously at both valve spindles.

**Adjusting of Exhaust Valve Clearance.**

- 9) Carry out adjustment in the same way as described for the inlet valves, but using the feeler gauge for exhaust valve clearance 0,90 mm.

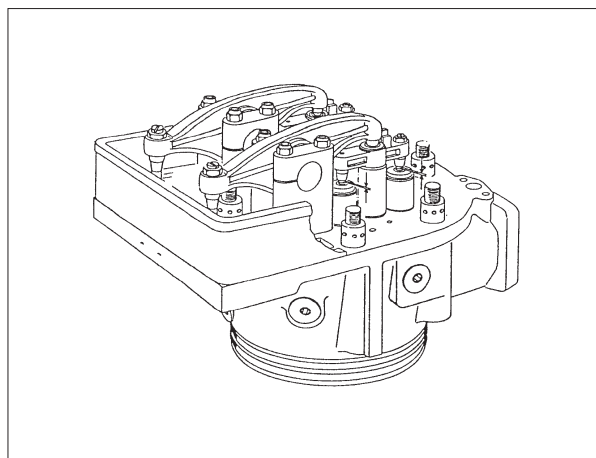


Fig. 3.

L/V28/32H

**10)** The feeler gauges for checking the clearance have two gauges which are marked "incorrect" and "correct", the latter to be used when adjusting the valve clearance, see fig. 4.

After tightening up the counter nuts on rocker arms and valves bridge, be sure that the feeler gaugs marked "correct" can be inserted into the two clearances simultaneously as where it must not be possible to insert the gauges marked "incorrect".

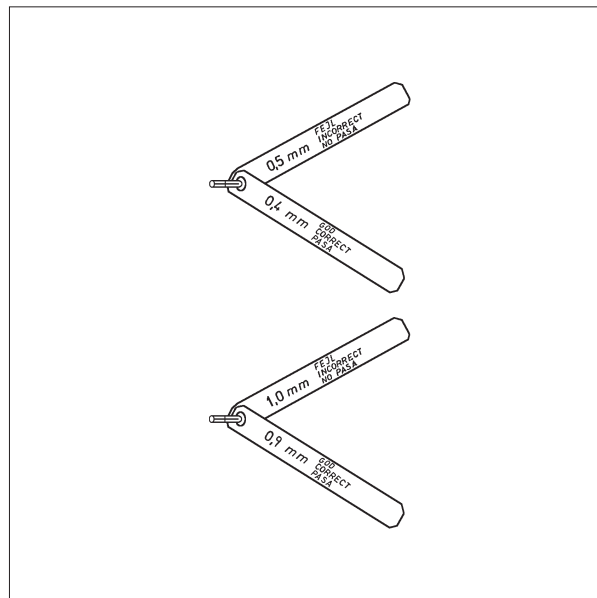
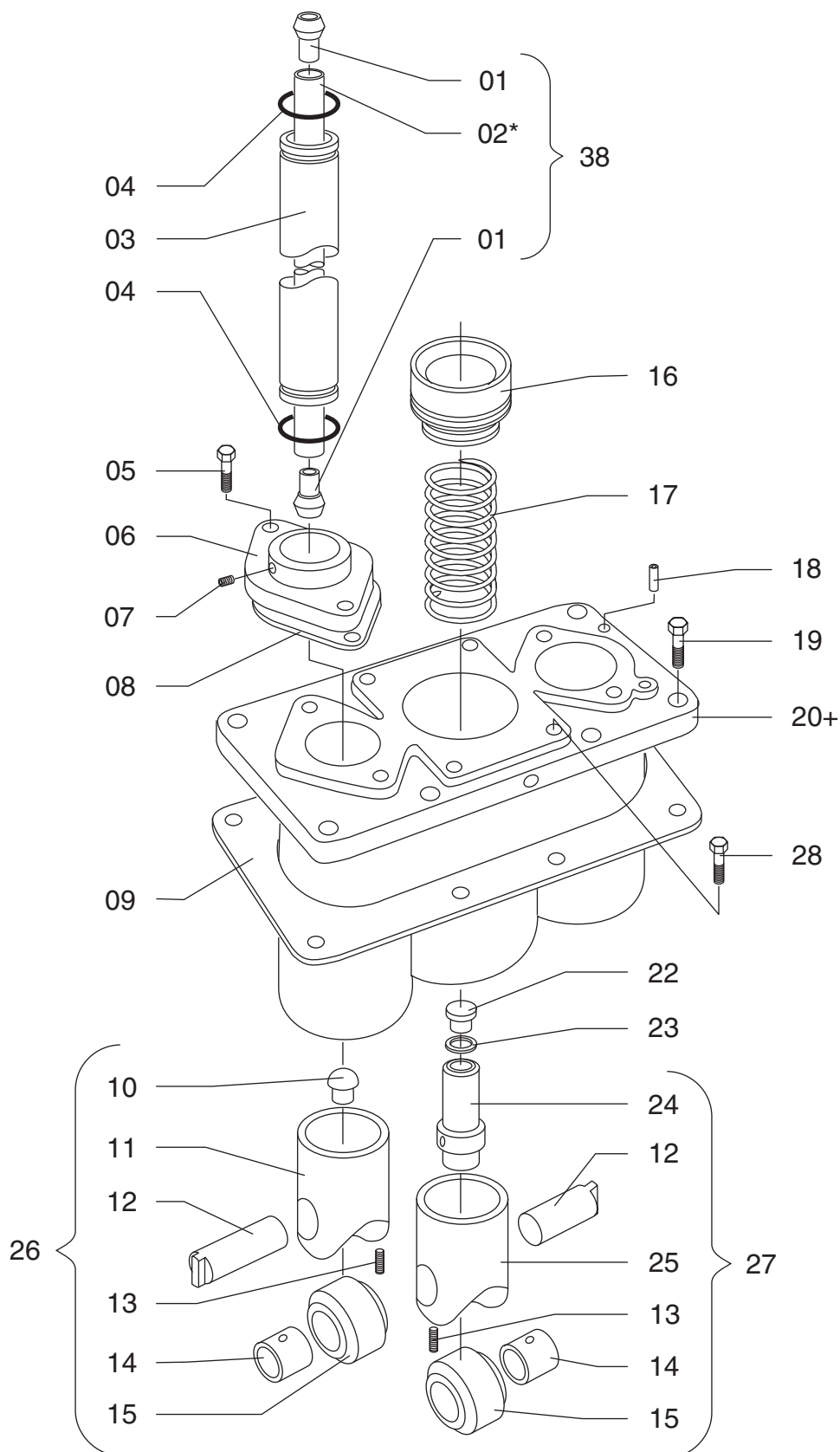


Fig. 4.

|                     |                            |           |
|---------------------|----------------------------|-----------|
| Plate<br>Page 1 (2) | Roller Guide and Push Rods | 60801-17H |
|---------------------|----------------------------|-----------|

L28/32H





60801-17H

## Roller Guide and Push Rods

Plate  
Page 2 (2)

## L28/32H

| Item no | Qty. | Designation   | Benævnelse   | Item no | Qty. | Designation   | Benævnelse  |
|---------|------|---|--|---------|------|---|---|
| 01      | 4/C  | Thrust piece  | Trykstykke   | 27      | 1/C  | Roller guide for fuel injection pump, complete incl. item 12, 13, 14, 15, 24, 25                | Rullestyr for brændselspumpe, komplet inkl. item 12, 13, 14, 15, 24, 25                         |
| 02*     | 2/C  | Pipe  | Rør  | 28      | 4/C  | Screw   | Skrue   |
| 03      | 2/C  | Protecting tube   | Skærmrør   | 38      | 2/C  | Push rod, complete incl. item 01, 02  | Stødstang, komplet inkl. item 01, 02  |
| 04      | 4/C  | Sealing ring  | Tætningsring   |         |      |   |   |
| 05      | 4/C  | Screw   | Skrue  |         |      |   |   |
| 06      | 2/C  | Cover   | Dæksel   |         |      |   |   |
| 07      | 2/C  | Screw   | Skrue  |         |      |   |   |
| 08      | 2/C  | Gasket  | Pakning  |         |      |   |   |
| 09      | 1/C  | Gasket  | Pakning  |         |      |   |   |
| 10      | 2/C  | Ball pin  | Kugletap   |         |      |   |   |
| 11      | 2/C  | Roller guide  | Rullestyr  |         |      |   |   |
| 12      | 3/C  | Pin   | Tap  |         |      |   |   |
| 13      | 3/C  | Stop screw  | Stopskrue  |         |      |   |   |
| 14      | 3/C  | Bush  | Foring   |         |      |   |   |
| 15      | 3/C  | Roller  | Rulle  |         |      |   |   |
| 16      | 1/C  | Washer for spring   | Skive for fjeder   |         |      |   |   |
| 17      | 1/C  | Spring  | Fjeder   |         |      |   |   |
| 18      | 2/C  | Guide pin   | Styrestift   |         |      |   |   |
| 19      | 8/C  | Screw   | Skrue  |         |      |   |   |
| 20+     | 1/C  | Housing for roller guides   | Hus for rullestyr  |         |      |   |   |
| 22      | 1/C  | Thrust piece  | Tryktap  |         |      |   |   |
| 23      | 1/C  | 1 set shims (0.1, 0.3, 0.5 and 1.0 mm)                                  | 1 sæt shims (0,1, 0,3, 0,5 og 1,0 mm)                                    |         |      |   |   |
| 24      | 1/C  | Thrust piece  | Tryktap  |         |      |   |   |
| 25      | 1/C  | Roller guide  | Rullestyr  |         |      |   |   |
| 26      | 2/C  | Roller guide for valve gear, complete incl. item 10, 11, 12, 13, 14, 15 | Rullestyr for ventilbevægelse, komplet inkl. item 10, 11, 12, 13, 14, 15 |         |      |   |   |
|         |      |   |  |         |      | + Item no 20 require an individual matching before mounting, contact MAN Diesel & Turbo, Holeby | + Item nr. 20 kræver en individuel tilpasning før montering, kontakt MAN Diesel & Turbo, Holeby |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/C = Antal/Cylinder

**Control/safety**

**509/609**

|                           |                                   |                              |
|---------------------------|-----------------------------------|------------------------------|
| Description<br>Page 1 (2) | <b>Control and Safety Systems</b> | <b>609.01</b><br>Edition 20H |
|---------------------------|-----------------------------------|------------------------------|

**L+V28/32H****Governor**

The engine speed is controlled by a hydraulic governor. The purpose of the governor is to regulate the rate of delivery from the fuel pumps, so that the engine speed is kept within certain limits, independent on the load.

Information about the design, function and operation of the governor is found in the special governor instruction book.

The governor is mounted on the fly wheel end of the engine and is driven from the camshaft via a cylindrical gear wheel and a set of bevel gears.

**Pick-up for Engine RPM**

The pick-up for transfer of signal to the tachometer instrument for engine RPM is mounted on the fly wheel end cover of the engine.

A signal varying proportionally to engine RPM is created in the pick-up by the rotating toothed impulse wheel mounted on the camshaft end.

**Pick-up for Turbocharger RPM**

See turbocharger instruction book, section 612.

**Regulating Shaft**

The governor movements are transmitted through a spring-loaded pull rod to the fuel pump regulating shaft which is fitted along the engine.

The spring-loaded pull rod permits the governor to give full deflection even if the stop cylinder of the manoeuvring system keep the fuel pump regulating shaft at "no fuel" position.

Each fuel pump is connected to the common, longitudinal regulating shaft by means of a two-piece, spring-loaded arm.

Should a fuel pump plunger seize in its barrel, thus blocking the regulating guide, governing of the remaining fuel pumps may continue unimpaired owing to the spring-loaded linkage between the blocked pump and the regulating shaft.

**Stop Screw for Max. Delivery Rate**

The bracket for stop cylinder/limiting cylinder is fitted with a stop screw which prevents the fuel pumps from being set to a higher delivery rate than what corresponds to the permissible overload rating.

This is effected by the arm on the regulating shaft being stopped by the stop screw, *see fig. 1*.

**Mechanical Overspeed (SSH 81)**

The engine is protected against overspeeding in the event of, for instance, governor failure by means of an overspeed trip.

The engine is equipped with a stopping device which starts to operate if the maximum permissible revolution number is exceeded.

The overspeed tripping device is fitted to the end cover of the lubricating oil pump and is driven through this pump.

If the pre-set tripping speed is exceeded, the spring-loaded fly weight (1), *see fig. 1*, will move outwards and press down the arm (2).

The arm is locked in its bottom position by the lock pin (3) which is pressed in by the spring (4).

At the same time the arm (2) presses down the spindle (5), and the pneumatic valve (6) opens, whereby compressed air will be led to the Lambda cylinder, *see Description 609.10*, in which the piston is pressed forward and turns the fuel pump regulating rod to STOP position, thereby the engine stops, the spring-loaded pull rod connection to the governor being compressed.

**609.01**

Edition 20H

**Control and Safety Systems**Description  
Page 2 (2)**L+V28/32H**

The engine can be stopped manually by pressing down the button (7), see fig. 1, which will activate the spring-loaded fly weight (1) through the lever (8).

If the overspeed has been activated the overspeed must be reset before the engine can be started. Reset is done by means of the button (10).

The overspeed alarm (SAH 81) is activated by means of the micro switch (9).

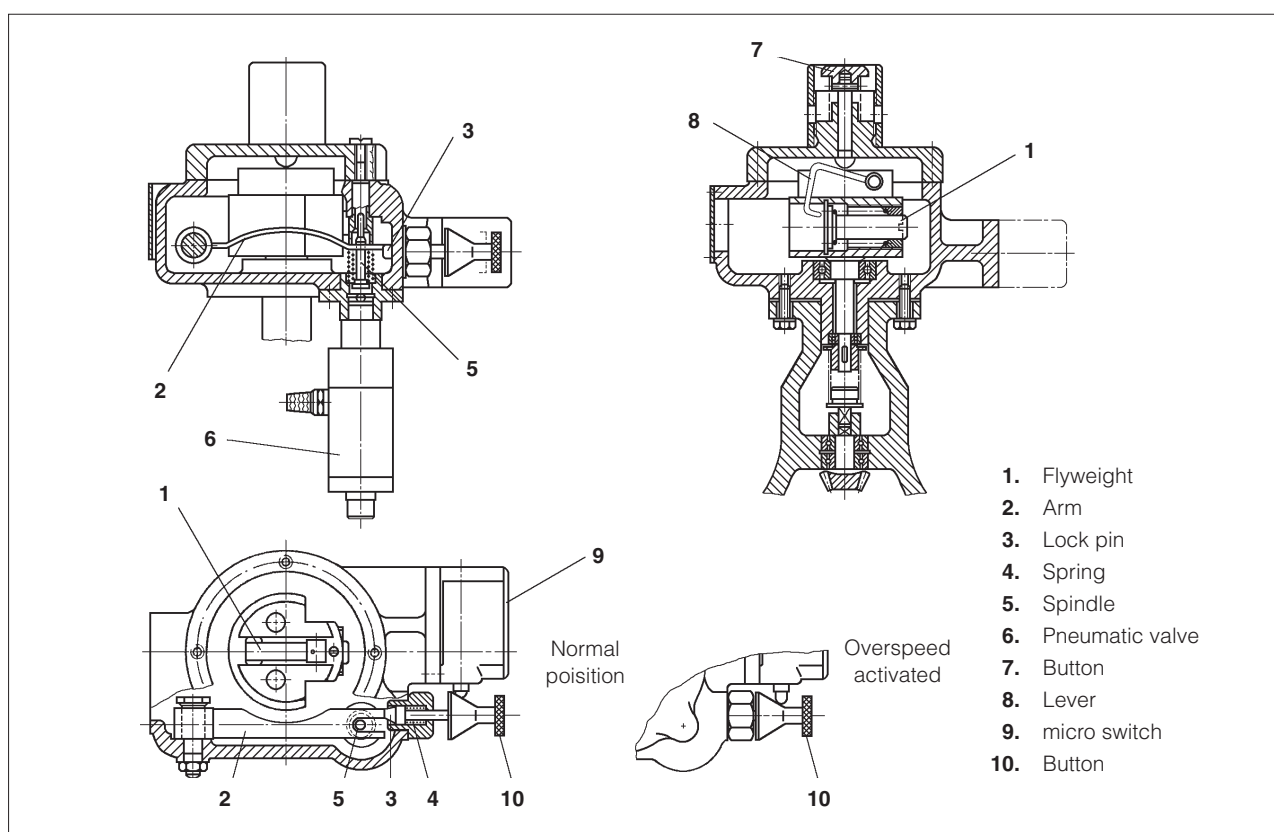


Fig 1 Mechanical overspeed (SSH 81).

**L28/32H****Main instrument panel**

As standard the engine is equipped with an instrument panel, comprising instruments for visual indication of the most essential pressures. Illustrated on fig. 1.

The instrument panel is mounted flexibly on rubber elements and all manometer connections are connected to the panel by means of flexible hoses, as shown on fig. 2.

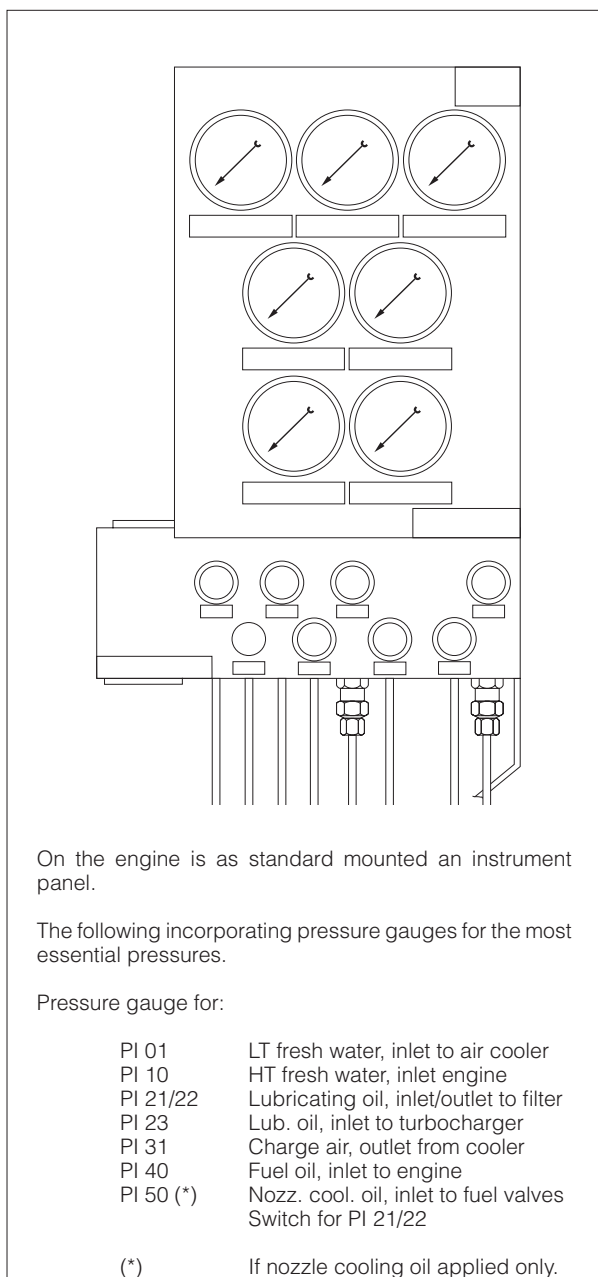


Fig. 1. Lay-out of instrument panel

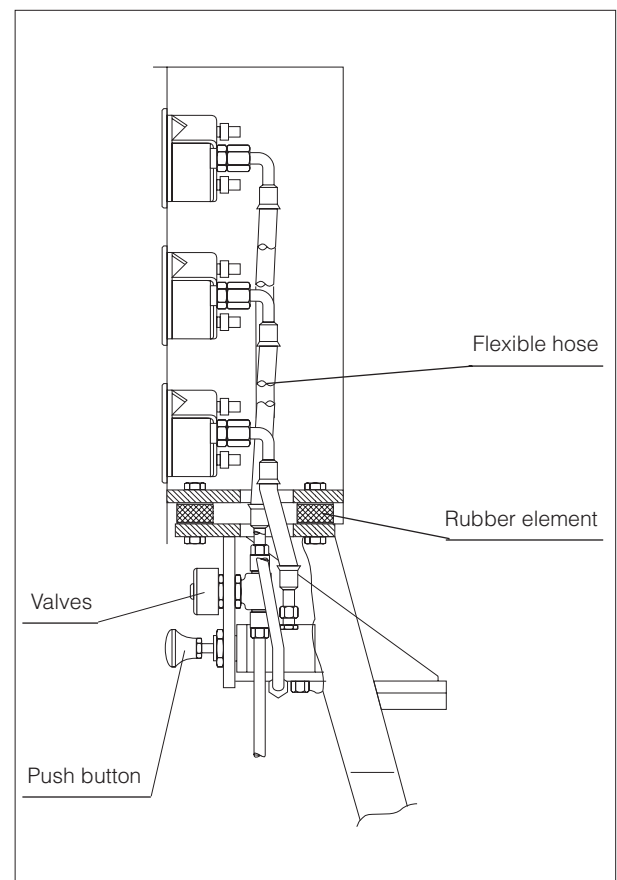


Fig. 2. Cross section of instrument panel

The connecting pipes to the manometers are equipped with valves which make it possible to replace the manometers during operation.

In the charging air and nozzle oil piping damping filters are inserted for levelling out pressure fluctuations.

**L28/32H****Instrumentation**

As standard the engine is supplied with the following instrumentation mounted local on the engine:

|               |       |   |
|---------------|-------|---|
| Thermometer   | TI 01 | LT water - inlet air cooler               |
| Thermometer   | TI 02 | LT water - outlet from air cooler         |
| Thermometer   | TI 03 | LT water - outlet from lub. oil cooler    |
| Thermometer   | TI 10 | HT fresh water - inlet to engine          |
| Thermometer   | TI 11 | HT fresh water - outlet each cylinder     |
| Thermometer   | TI 20 | Lubricating oil - inlet to cooler         |
| Thermometer   | TI 22 | Lubricating oil - outlet from filter      |
| Thermometer   | TI 30 | Charge air - inlet to cooler              |
| Thermometer   | TI 31 | Charge air - outlet from cooler           |
| Thermometer   | TI 40 | Fuel oil - inlet to engine                |
| Thermometer*) | TI 51 | Nozz. cool. oil - outlet from fuel valves |
| Thermometer   | TI 60 | Exhaust gas - outlet each cylinder        |
| Thermometer   | TI 61 | Exhaust gas - outlet turbocharger         |

\*) If nozzle cooling oil applied only.

The actual number of the instrumentation for the plant can be seen on the diagrams for the specific plant in the sections 612-613-614-615-616.  
For code identification see 600.20.

**Pressostates and Thermostates**

The engine is supplied with a number of alarm- and shut-down functions. The alarms shall via the alarm panel warn against an abnormal working condition, which can lead to break down and the shut-down functions shall stop the engine before a break down. I.e. a shut-down is "worse" than an alarm because a shut-down is given if the engine could be severe damage by running on these conditions.

As standard the engine is equipped with:

**Shut-down Switches for**

- too low lubricating oil pressure - inlet engine
- too high HT FW temperature - outlet engine
- too high engine speed (over speed)

**Alarm Switches for**

- leaking fuel oil
- too low lubricating oil pressure - inlet engine
- too low prelubricating oil pressure (level alarm)

- too high press. drop across lub. oil filter
- too high HT FW temperature - outlet engine
- too low starting air pressure - inlet engine
- too high engine speed (overspeed)

The actual number and type of the alarm- and shut-down switches for the plant can be seen in the list "Engine Automatic part list" in this section.

**Leakage Alarm (LAH 42)**

Waste and leak oil from the comparement, for the injection equipment, fuel valves, high-pressure pipes and engine feed pump (if mounted) is led to a fuel leakage alarm unit.

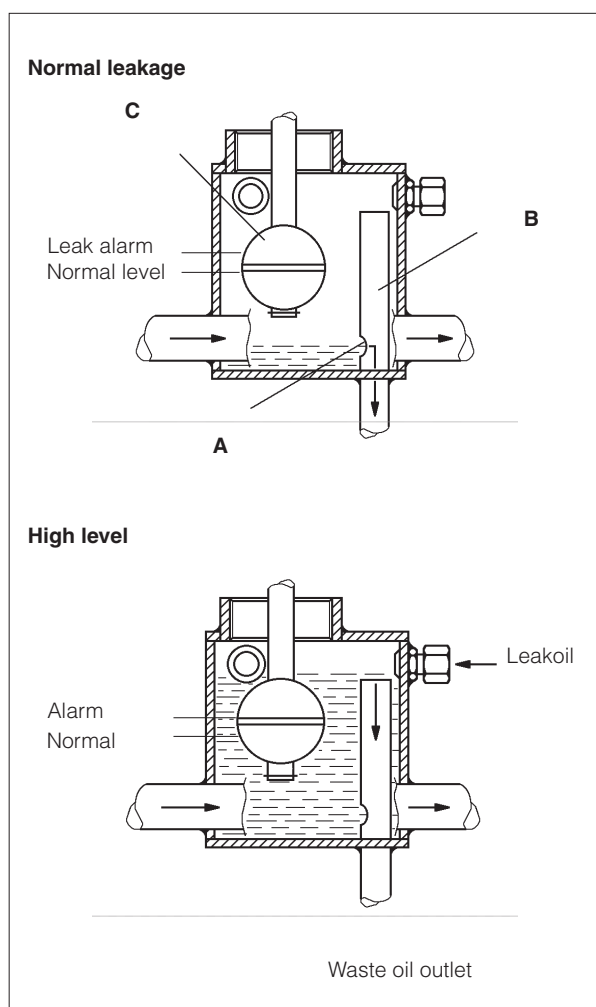


Fig. 4. Fuel oil leakage alarm.

|                           |                                   |                              |
|---------------------------|-----------------------------------|------------------------------|
| Description<br>Page 3 (3) | <b>Instruments and Automatics</b> | <b>609.05</b><br>Edition 11H |
|---------------------------|-----------------------------------|------------------------------|

**L28/32H**

The alarm unit consist of a box with a float switch for level monitoring, see fig. 4.

The supply fuel oil to the engine is led through the unit in order to keep heated up, thereby ensuring free drainage passage even for high-viscous waste/leak oil.

Under normal conditions there will always be a smaller amount of waste/leak oil from the comparement, this will be led out through the bore "A" in the pipe "B" as illustrated.

In case of a larger then normal leakage, the level in the box will rise and the level switch "C" will be activated. The larger amount of leak oil will be lead out through the top of the pipe "B".

**Alarm for Prelubricating (LAL 25)**

Alarm for missing prelubricating, when the engine is stopped is given by means of a level switch (LAL 25) mounted in the main lubricating oil pipe.

**Alarm and Shut-down for Overspeed**

When the mechanical overspeed is activated, see 609.01 fig. 2, a micro-switch will release the alarm for overspeed (SAH 81) and activate the shut-down solenoid in the governor.

The latter function is a back-up for the mechanical overspeed.

|                           |                          |                              |
|---------------------------|--------------------------|------------------------------|
| Description<br>Page 1 (2) | <b>Lambda Controller</b> | <b>609.10</b><br>Edition 15H |
|---------------------------|--------------------------|------------------------------|

**L28/32H****Purpose**

The purpose with the lambda controller is to prevent injection of more fuel in the combustion chamber than can be burned during a momentary load increase. This is carried out by controlling the relation between the fuel index and the charge air pressure.

The Lambda controller is also used as stop cylinder.

**Advantages**

The lambda controller has the following advantages:

- Reduction of visible smoke in case of sudden momentary load increases.
- Improved load ability.
- Less fouling of the engine's exhaust gas ways.
- Limitation of fuel oil index during starting procedure.

**Principles for functioning**

Figure 1 illustrates the controller's operation mode. In case of a momentary load increase, the regulating device will increase the index on the injection pumps and hereby the regulator arm (1) is turned, the switch (2) will touch the piston arm (3) and be pushed downwards, whereby the electrical circuit will be closed.

Thus the solenoid valve (4) opens. The jet system is activated, the turbocharger accelerates and increases the charge air pressure, thereby pressing the piston (3) backwards in the lambda cylinder (5). When the lambda ratio is satisfactory, the jet system will be de-activated.

At a 50% load change the system will be activated for about 3-8 seconds.

If the system is activated more than 10 seconds, the solenoid valve will be shut off and there will be a remote signal for "jet system failure".

**Fuel oil limiting during start procedure**

During the start procedure the lambda controller is used as an index limiter.

Hereby heavy smoke formation is prevented during start procedure and further the regulating device cannot over-react.

**Air Consumption**

At 50% step load the air consumption will be as follows:

| Cyl. no.        | 5    | 6    | 7    | 8    | 9    |
|-----------------|------|------|------|------|------|
| Nm <sup>3</sup> | 1.12 | 1.35 | 1.57 | 1.80 | 2.02 |



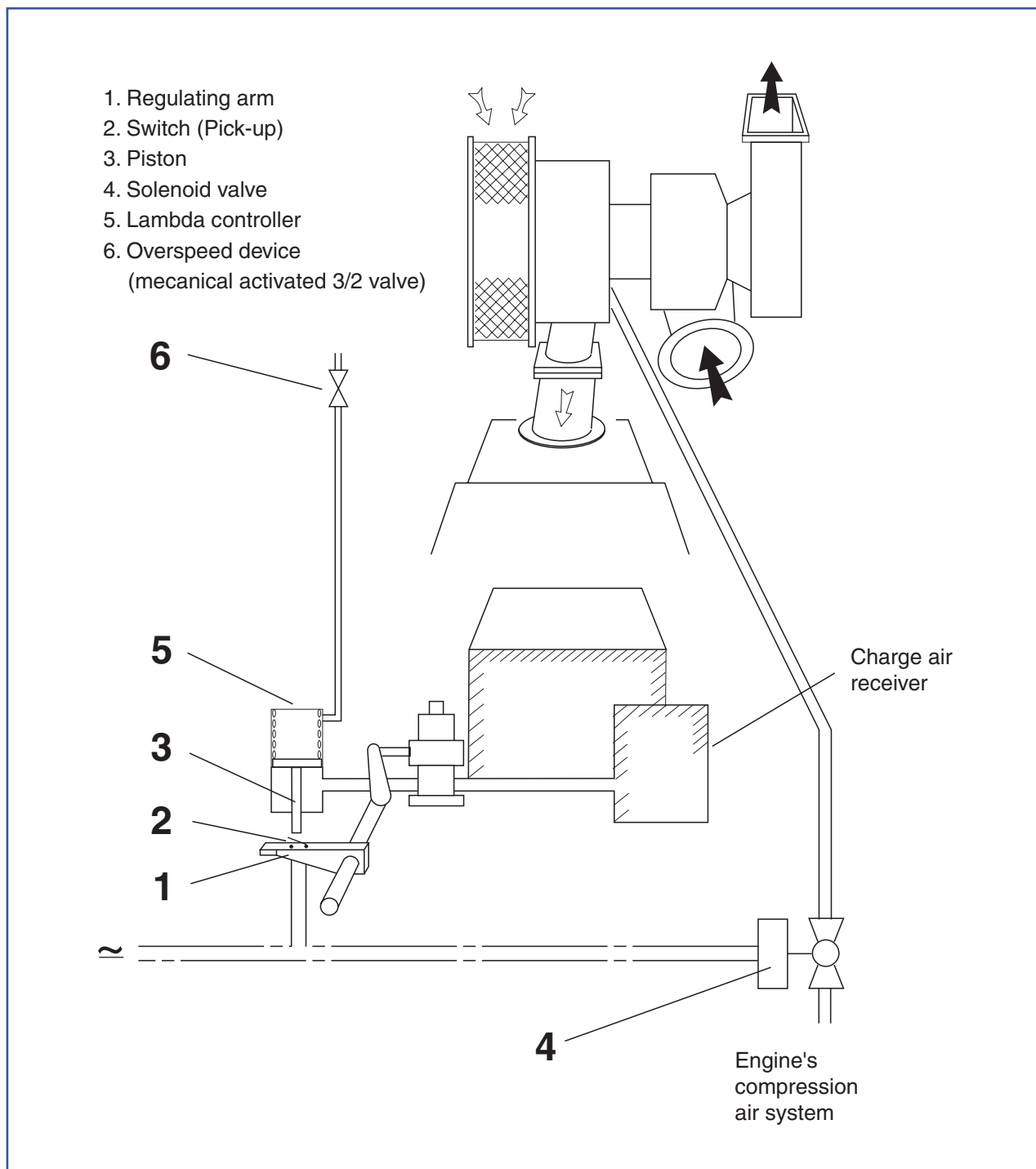
**L28/32H**

Fig 1      *Lambda controller incl. start limitation*

|                           |                     |                              |
|---------------------------|---------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Starting Box</b> | <b>609.35</b><br>Edition 06H |
|---------------------------|---------------------|------------------------------|

## L28/32H

### Description

The starting box is mounted on the engine's control side. On front of the box there are the following indications/pushbuttons:

- Indication of engine or turbocharger RPM
- Indication of electronic overspeed
- Pushbutton for "Manual Start"
- Pushbutton for "Manual Stop"
- Pushbutton for "Remote" \*
- Pushbutton for "Local" \*
- Pushbutton for "Blocking" \*
- Pushbutton for change-over between engine and turbocharger RPM

\* The function chosen is indicated in the pushbutton. See fig. 1.

### Manual Start

The engine can be started by means of the start button, but only if the button "Local" is activated.

The manual, local start is an electrical, pneumatic start, i.e. when activating the start button a solenoid valve opens for air to the air starter, thereby engaging the starter and starting the diesel engine. Throughout the starting cycle the start button must be activated.

The air starter is automatically disengaged when the diesel engine exceeds 110 RPM. If the start button is disengaged before the diesel engine has exceeded 110 RPM, further starting cycles are blocked, until 5 sec. after the engine is at standstill.

### Remote Start

Remote start can only take place if the pushbutton for "Remote" is activated.

### Manual Stop

The "Manual Stop" button is connected to the stop coil on the governor.

### Blocking

If "Blocking" is activated, it is not possible to start the diesel engine.

### Engine / Turbocharger RPM

By activating the "Engine RPM/TC RPM" button, the indication is changed.

Engine RPM indication is green light-emitting diodes and turbocharger RPM indication is red light-emitting diodes.

### External Indications

There are output signals for engine RPM and turbocharger RPM.

Engine: 0 - 1200 RPM ~ 4-20 mA

TC: 0 - 60000 RPM ~ 4-20 mA

The pushbuttons for "Remote", "Local" and "Blocking" have potential free switches for external indication.

All components in the starting box are wired to the built-on terminal box.

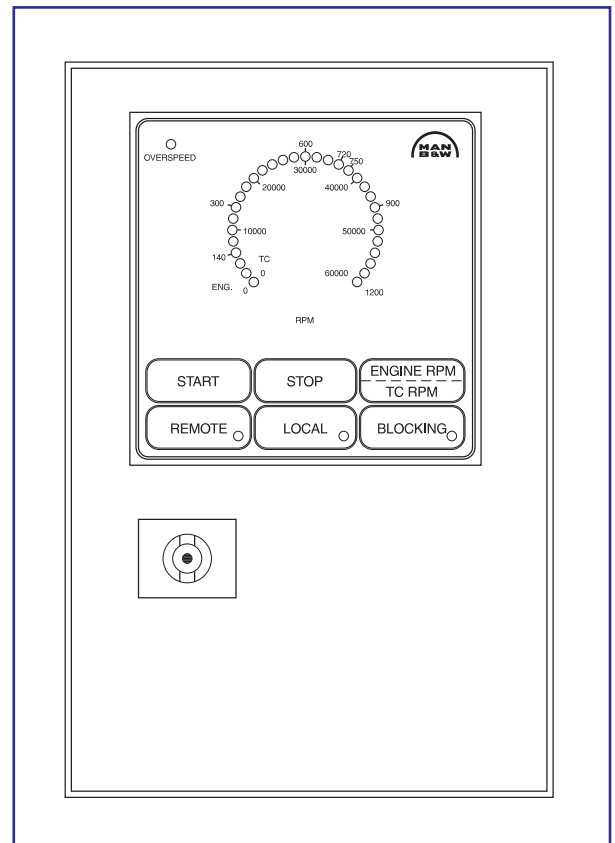


Fig 1 Starting box.

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (1) | <b>Converter for Engine- and Turbocharger RPM Signal</b> | <b>609.40</b><br>Edition 01H |
|---------------------------|--|------------------------------|

L+V28/32H

Engine RPM signal

For measuring the engine's RPM, a pick-up mounted on the engine is used giving a frequency depending on the RPM. To be able to show the engine's RPM on an analogue tachometer, the frequency signal is sent through an f/I converter (frequency/current converter), where the signal is transformed into a proportional 4-20 mA ~ 0-1200 RPM signal.

Further, the converter has following signals:

- overspeed
- engine run
- safe start
- tacho fail

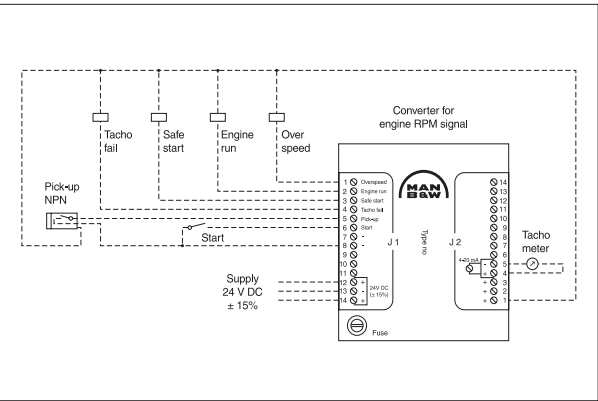


Fig 1. Converter for engine RPM.

Overspeed

When the engine speed reach the setpoint for electronic overspeed the converter gives a shutdown signal and a alarm signal through a relay.

Engine run

When the engine speed reach 710 RPM or 200 RPM + 10 seconds, the converter gives a "engine run" signal.

The engine run signal will be deactivated when the speed is 640 RPM. If the engine speed haven't been over 710 RPM the signal will be deactivated at 200 RPM.

The "engine run" signals will be given through a relay. One for synchronizing and one for start/stop of pre. lub. oil pump or alarm blocking at start/stop.

Safe start

When the safe start signal is activated the engine can start. When the engine reach 140 RPM the air starter will be shut-off.

Further, the safe start signal is a blocking function for the air starter during rotation.

Tacho fail

The tacho fail signal will be on when everything is normal. If the pick-up or the converter failes the signal will be deactivated. E.g. if there is power supply failure.

The converter for engine RPM signal is mounted in the terminal box on the engine.

Turbocharger RPM signal

For measuring the turbocharger RPM, a pick-up mounted on the engine is used giving a frequency depending on the RPM. To be able to show the turbocharger's RPM on an analogue tachometer, the frequency signal is sent through a f/I converter (frequency/current converter), where the signal is transferred into a proportional 4-20 mA ~ 0-60000 RPM.

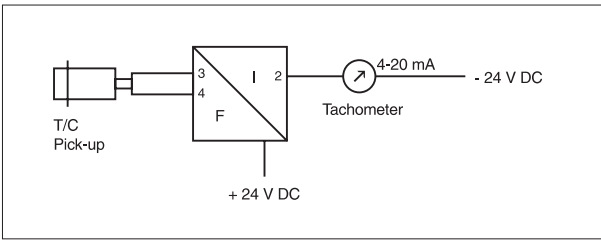


Fig 2. Converter for TC RPM.

The converter is mounted in the terminal box on the engine.

|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Functional Test and Adjustment of Safety,<br/>Alarm and Monitoring Equipment</b> | <b>609-01.00</b><br>Edition 01H |
|----------------------------|---|---------------------------------|

**General****Safety precautions**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description**

Function test and adjustment of safety, alarm and monitoring equipment.

**Starting position****Related procedure**

|                                |           |
|--------------------------------|-----------|
| Overspeed trip                 | 609-01.05 |
| Pressostate                    | 609-05.00 |
| Thermostate                    | 609-05.01 |
| Level switch (LAL 25)          | 609-05.02 |
| Analog pressure transmitter    | 609-05.03 |
| Analog temperature transmitter | 609-05.04 |

**Man power**

Working time :        hours  
Capacity :        man

**Data**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools**

Plate No      Item No      Note.

See Related Procedure

**Hand tools**

See Related Procedure

**Replacement and wearing parts**

Plate No      Item No      Qty. /

## General

### Maintenance of monitoring and safety systems

One of the most important parameters in the preventive work is that the alarm system as well as the shutdown and overspeed devices are functioning 100%.

If some of these functions are out of operation, they have to be repaired immediately. If this is not possible because of the present working situation, the engine has to be under constant observation until it can be stopped.

It is recommended that all functions are tested every three months according to the mentioned working cards.

The extent of the alarm and safety functions is variable from plant to plant.

For check of these functions use the working cards mentioned under related procedure on page 1.

### Alarm System

It is important that all alarms lead to prompt investigation and remedy of the error.

No alarm is insignificant. It is therefore important that all engine crew members are familiar with and well trained in the use and importance of the alarm system.

The most serious alarms are equipped with slowdown and/or shutdown functions.

**General****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Functional test and adjustment of overspeed trip.

**Starting position:**

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

**Related procedure:****Man power:**

Working time : 1 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
| 62009     | 01       |       |

**Hand tools:**

Allen key, 4 mm.  
Allen key, 2 mm.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|           |          |        |

## General

**1)** The engine is run up manually, (on governor "synchronizer") and at no load, while watching the tachometer.

On reaching the revolution number indicated on page 600.30 or in "Test Report", the overspeed tripping device must function, thus actuating the stop cylinders. The fuel injection pump control rods are now moved to zero index, and the engine stops.

**2)** If the overspeed device trip at a revolution number different from that stated on page 600.30 or in the "Test Report" the overspeed device must be adjusted.

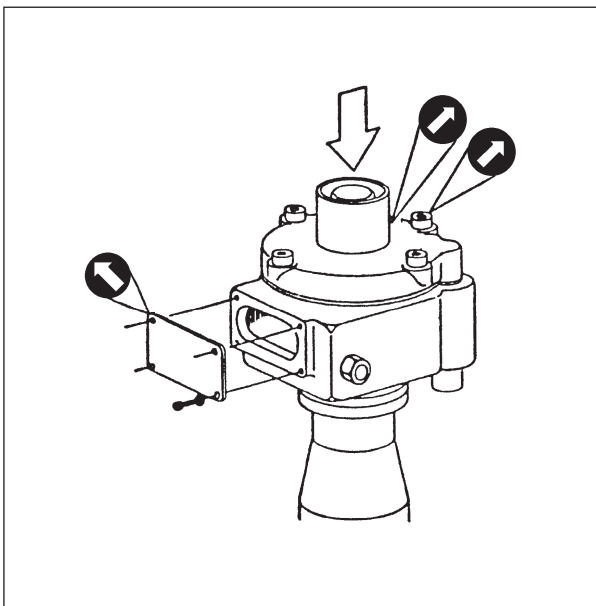


Fig. 1.

### Adjustment of Overspeed Trip.

**3)** Remove both covers on the housing of the overspeed tripping device, see fig. 1.

Turn the engine until the adjusting screw is opposite the opening on the side of the housing. Now loosen the lock screw and turn the adjusting screw, using the tubular pin spanner supplied, see fig. 2.

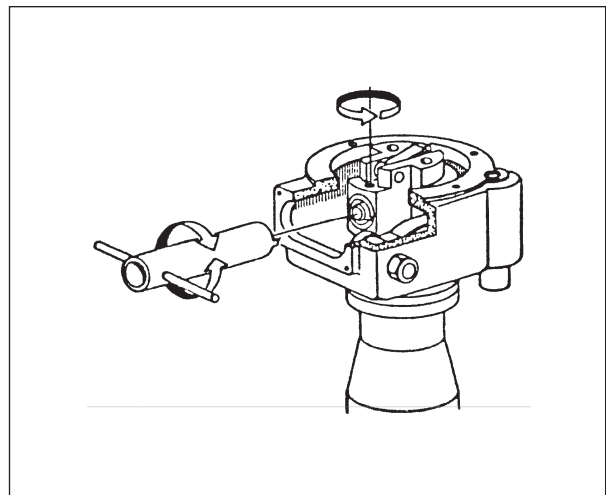


Fig. 2.

Turn the adjusting screw outwards (slacken flyweight spring) to reduce the revolution number. Be careful not to screw the adjusting screw so far out that it may touch the release arm. Tighten the lock screw and test the overspeed device again.

**4)** Refit the covers when the overspeed device functions at correct revolution number.

**5)** The overspeed device can be tested manually by depressing the button on top of the housing, see fig. 1. This will activate the flyweight and the arm for release of the air valve for the stop cylinders and the engine should thus stop. (This test must also be carried out without load).

**6)** It is recommended now and then, while the engine is at a standstill, to move the flyweight by means of the push button to ensure that the flyweight can always move with sufficient ease.

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Adjustment and Test of On/Off Pressostate</b> | <b>609-05.00</b><br>Edition 02H |
|----------------------------|--|---------------------------------|

**General****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Adjustment and test of on/off pressostate. (lub. oil, fuel oil, water etc.).

**Starting position:**

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

**Related procedure:****Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|           |          |       |

**Hand tools:**

Screw driver.  
Testing pump.  
Ring and open end spanner, 10 mm.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|           |          |       |



## General

### Adjustment:

1) When the pressostate cover is removed and locking screw pos. 5, fig. 1 is loosened, the range can be set with the spindle pos. 1 while at the same time the scale pos. 2 is read.

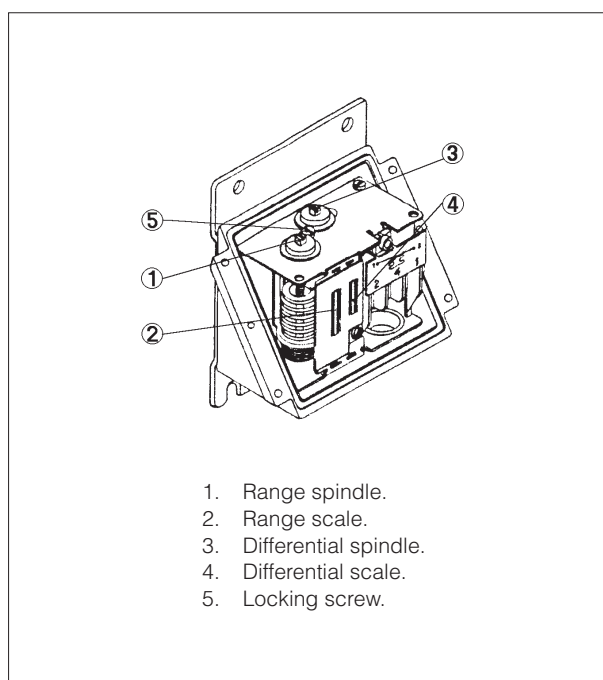


Fig. 1.

2) In pressostates having an adjustable differential, the spindle pos. 3 must be used to make the adjustment. The differential obtained can be read directly on the scale pos. 4.

Set points, see page 600.30.

### Test:

It is possible to make a functional test of the pressure switch. This is to be carried out according to the following procedure.

3) Shut off system pressure with the valve pos. 3, fig. 2.

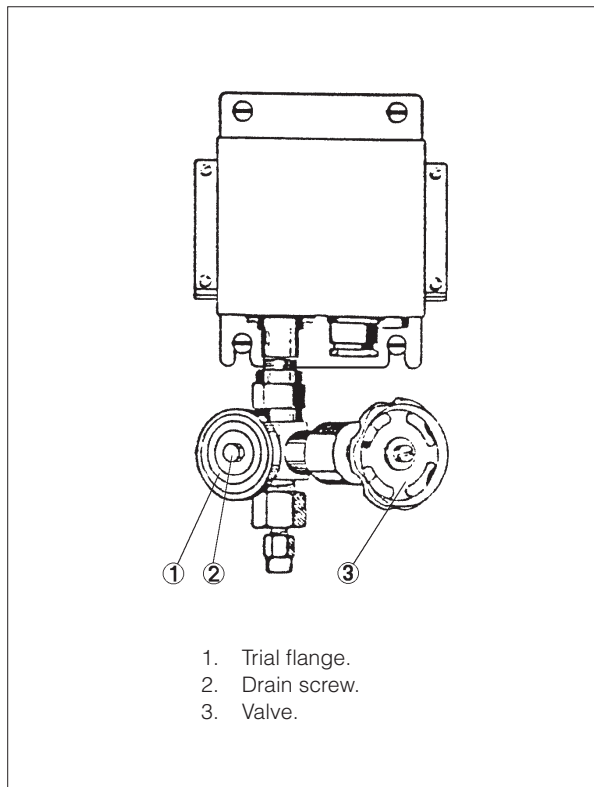


Fig. 2.

4) Remove the screw pos. 2.

5) Mount the testing pump on the trial flange pos. 1.

### Alarm for Falling Pressure:

6) Pump up the pressure until the switch has changed. The pressure will slowly be relieved and it must be checked that the switch change back to the pressure stated as the alarm point.

### Alarm for Rising Pressure:

7) Pump up the pressure until the switch changes, and check that it happens at the stated alarm point.

8) After the final check and adjustment, remove the testing pump, mount the screw pos. 2 and open the valve pos. 3.

**Adjustment and Test of On/Off Thermostate****609-05.01**  
Edition 02H**L+V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Adjustment and test of on/off thermostate. (lub. oil, fuel oil, water etc.).

**Starting position:**

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

**Related procedure:****Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|           |          |       |

**Hand tools:**

Screw driver.  
Special testing devices.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|           |          |        |

**L+V28/32H****Adjustment:**

1) When the thermostat cover is removed and locking screw pos. 5, fig. 1 is loosened, the range can be set with the spindle pos. 1 while at the same time the scale pos. 2 is read.

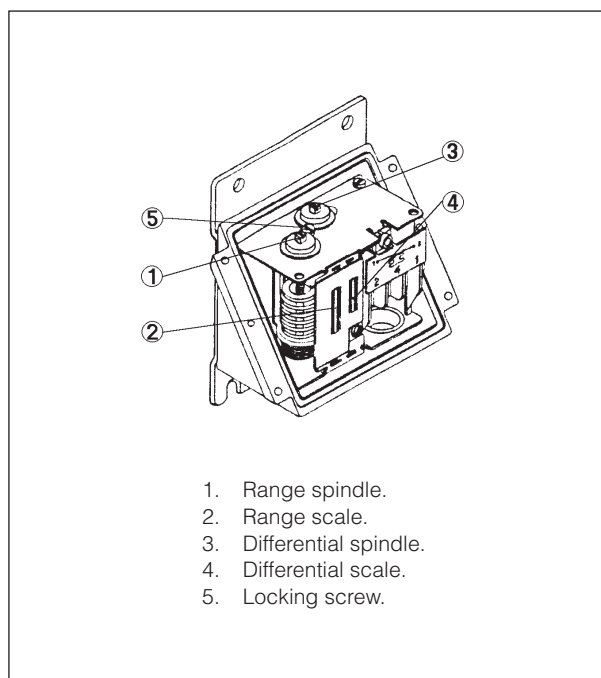


Fig. 1.

2) Thermostates having an adjustable differential, the spindle pos. 3 can be used while the scale pos. 4 is read.

Set points, see page 600.30.

**Test:**

3) The functional test of the thermostat is to be carried out according to the following procedure.

4) Take out the sensor of the pocket.

5) Test the sensor in a water bath, where the temperature can be controlled.

**Alarm for Falling temperature:**

6) Raise the temperature until the switch has changed.

Then the temperature must slowly be reduced, and check that the switch changes back at the temperature stated in the list page 600.30.

**Alarm for Rising temperature:**

7) Raise the temperature until the switch changes and check that it happens at the stated alarm points.

8) Adjust if necessary.

9) The sensor is mounted again.

**General****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Function and test of level switch, LAL 25, in lubricating oil system.

**Starting position:**

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

**Related procedure:****Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|           |          |       |

**Hand tools:****Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|           |          |        |

## General

The level switch LAL 25, which is mounted on the main lubricating oil pipe of the engine, gives alarm for missing prelubricating oil.

### Function.

- 1) By starting the prelubricating oil pump the main lubricating oil pipe will be filled with lubricating oil, which means that the level switch is lifted and the alarm is disconnected.
- 2) When the prelubricating is interrupted, the lub. oil will run out of the system through the bearings, which means that level switch is lowered and the alarm starts.

### Test:

The test is carried out when the engine is stopped.

- 3) Start the lubricating oil pump, and let the pump run about 5 min.
- 4) Stop the prelubricating oil pump. The alarm must be released after 0 - 5 min., depending of the oil viscosity.

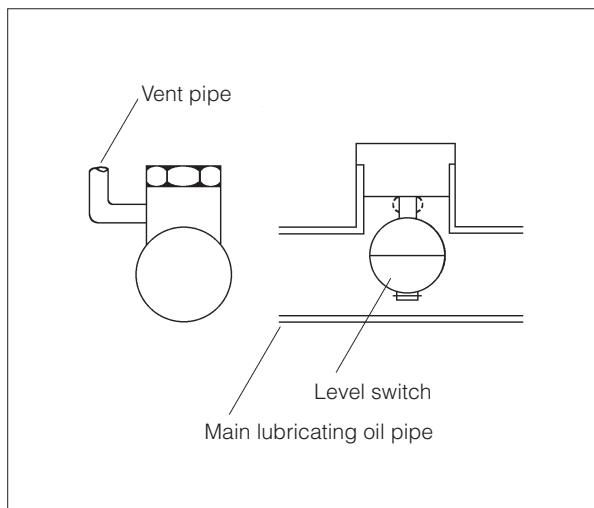


Fig. 1.

**General****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Adjustment and test of analogous pressure transmitter.

**Starting position:**

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

**Related procedure:****Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|           |          |       |

**Hand tools:**

Ring and open end spanner, 10 mm.  
Testing pump.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|           |          |       |

## General

The pressure transmitter registers the actual pressure and marks the change to an electrical signal, which adjusts the pressure.

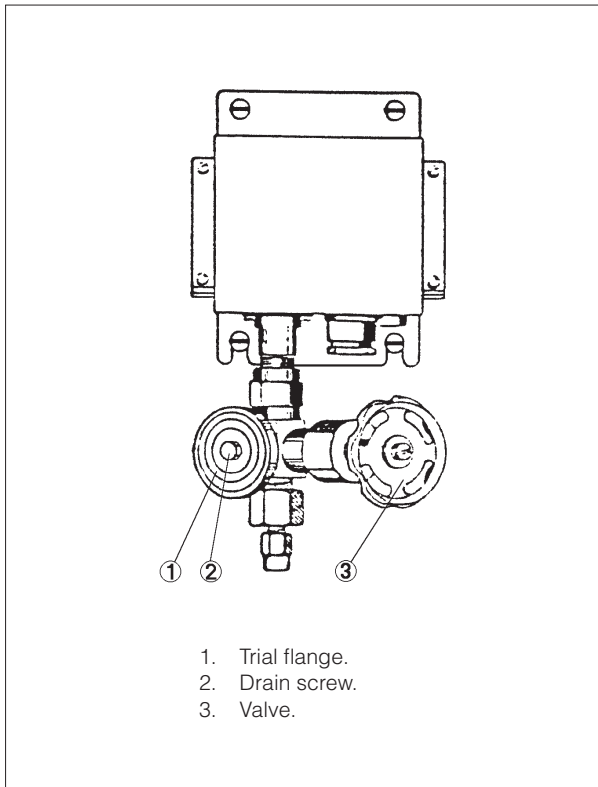


Fig. 1.

### Adjustment:

**1)** The pressure transmitter shall not be adjusted, but the alarm limit must be set on the alarm plant. Kindly see the instruction book for the alarm plant.

Set points, see page 600.30.

### Test:

**2)** It is possible to make a functional test of the pressure transmitter. This is carried out according to the following procedure:

**3)** Shut off system pressure with the valve pos. 3.

**4)** Remove the screw pos. 2.

**5)** Mount the testing apparatus on the trial flange pos. 1. and pump on a pressure within the working area of the transmitter.

If the alarm plant has an instrument unit, the pressure can be read on this. Other wise the test can be carried out by watching if the alarm plant gives any alarm, when the alarm limit which is stated on page 600.30 is exceeded (if the alarm plant is adjusted).

**6)** The screw pos. 2 is mounted, and the valve pos. 3. is opened after the test is finished.

|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Adjustment and Test of<br/>Analogous Temperature Transmitter</b> | <b>609-05.04</b><br>Edition 02H |
|----------------------------|---|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Adjustment and test of analogous temperature transmitter, (PT 100 sensor).

**Starting position:**

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

**Related procedure:****Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|-----------|----------|-------|

**Hand tools:**

Special testing devices.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty./ |
|-----------|----------|-------|
|-----------|----------|-------|



**L+V28/32H**

The PT 100 sensor consist of a resistance wire which changes resistance depending on the temperature.

Look and design varify depending on the place of measurement and manufacture.

**Adjustment:**

**1)** The PT 100 sensor cannot be adjusted, but the alarm limit must be set on the alarm plant.

Set point, see page 600.30.

**Test:**

**2)** The functional trial of the PT 100 sensor can be carried out according to the following procedure.

**3)** Take out the sensor of the pocket.

**4)** Test the sensor by diving the sensor in the water. Compare the signal from the sensor with the water temperature.

If the alarm plant has an instrument unit, the temperature can be read on this.

Otherwise the test can be carried out by watching if the alarm plant gives any alarm, when the alarm limit which is stated on page 600.30 is exceeded (if the alarm plant is adjusted).

**5)** The sensor is mounted again.

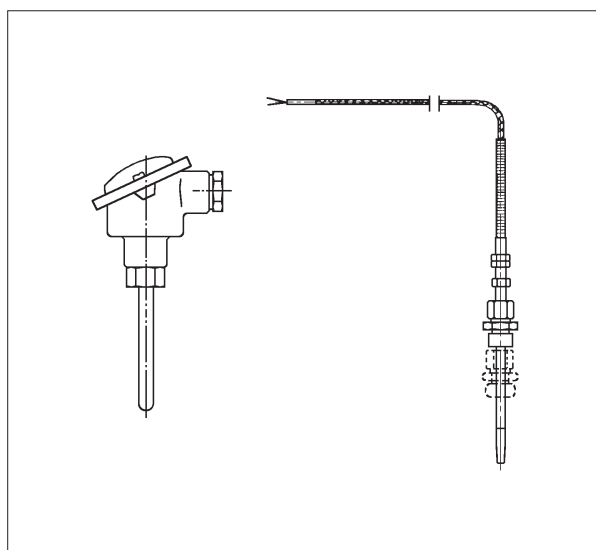


Fig. 1.

|                            |                          |                                 |
|----------------------------|--------------------------|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Lambda Controller</b> | <b>609-10.00</b><br>Edition 16H |
|----------------------------|--------------------------|---------------------------------|

**L28/32H**

|  |
|--|
| <p><b>Safety precautions:</b></p> <div><div><input checked="" type="checkbox"/></div>Stopped engine</div> <div><div><input type="checkbox"/></div>Shut off starting air</div> <div><div><input type="checkbox"/></div>Shut off cooling water</div> <div><div><input type="checkbox"/></div>Shut off fuel oil</div> <div><div><input type="checkbox"/></div>Shut off cooling oil</div> <div><div><input type="checkbox"/></div>Stopped lub. oil circul.</div> |
|--|

Working time

:

1

hour

Capacity

:

1

man

Data for pressure and tolerance

(Page 600.35)

Data for torque moment

(Page 600.40)

Declaration of weight

(Page 600.45)

## L28/32H

## Adjustment of the Lambda Controller

All adjustments are made when the engine is in standstill position.

1. Check that the free space between the pick-up and the band steel on the regulating arm is min. 1 mm, see fig 1.

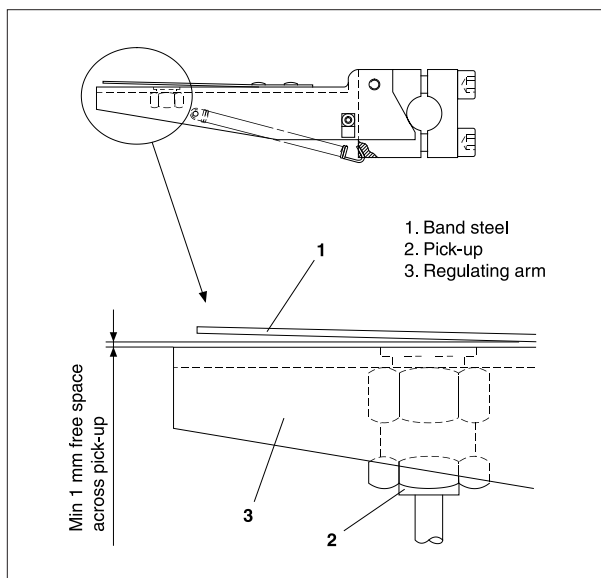


Fig 1.

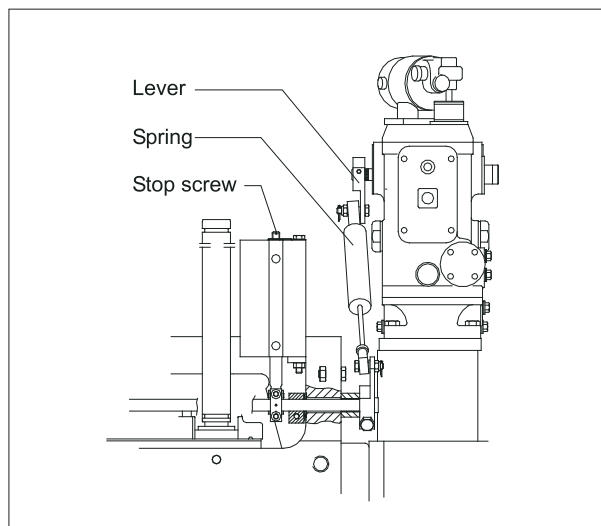


Fig 2.

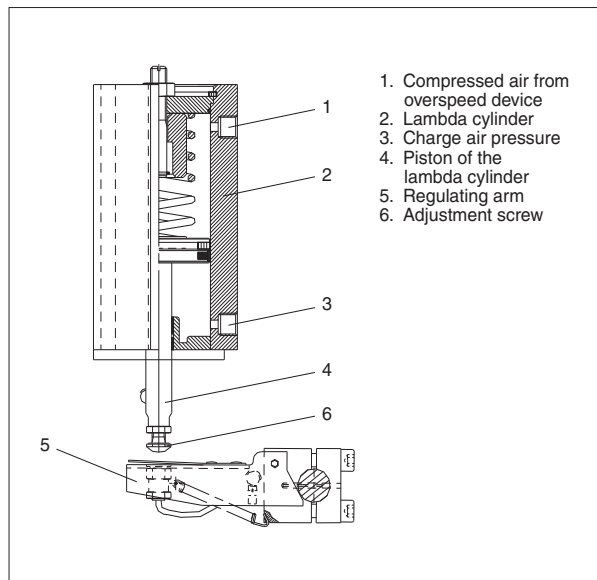


Fig 3.

2. Turn the lever (fig 2) of the governor a few times to full load with an adjustable spanner (spring between governor and fuel rack full compressed). Check that the fuel index is 24 mm at the fuel pump.

**Note:** Be sure that the fuel index is 24 mm at the fuel pump when the engine is started.

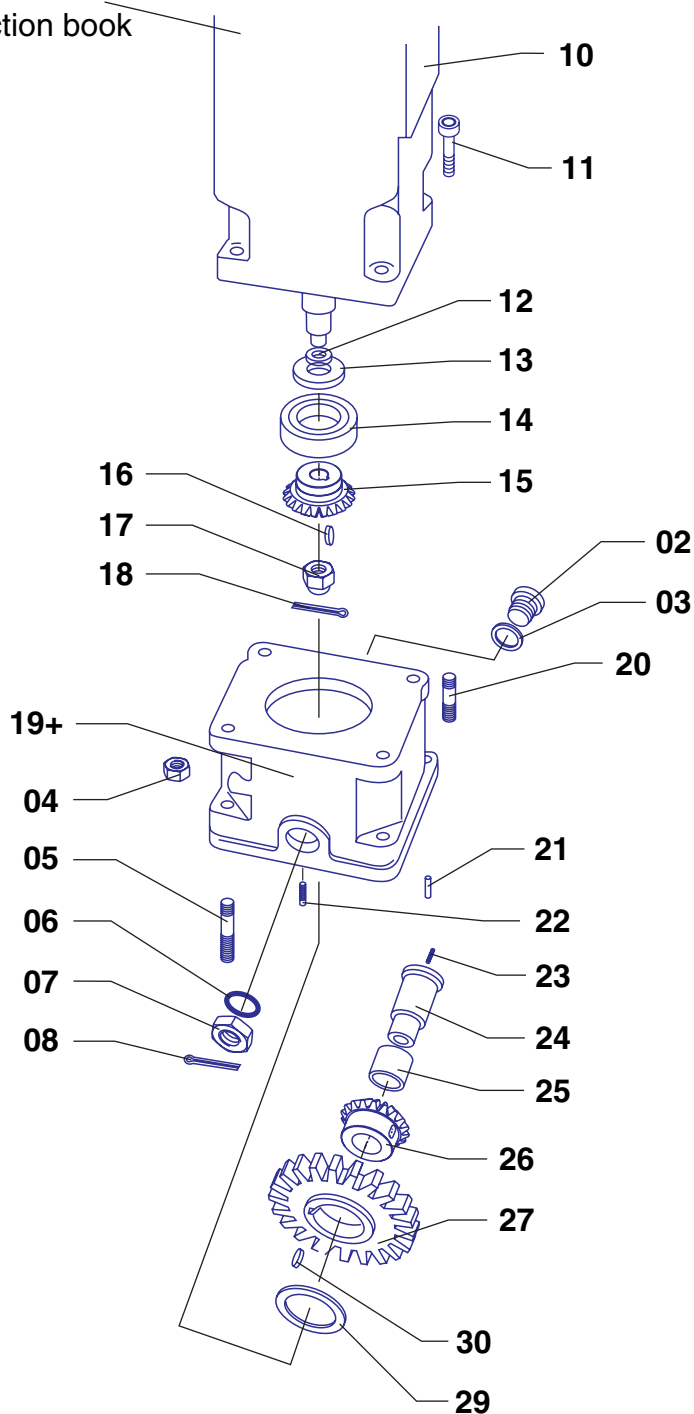
3. In case of large deviation from index 24 adjustment is done by turning the regulating arm (5), fig 3. Finally adjustment is done at the adjustment screw (6), fig 3.
4. Adjustment completed.

## Adjustment of the stop screw

5. Remove pipe for charge air pressure, see fig 3.
6. Supply air pressure until the piston rod reaches its upper position.
7. Adjust the stop screw, see fig 2, to 110% load according to the test bed, plus 1.5 index. Use the index arm on the fuel pump nearest to the lambda controller as control for the index.
8. Adjustment finished.

L28/32H

For actuator,  
see special  
instruction book



**60901-13H****Governor and Governor Drive**Plate  
Page 2 (2)**L28/32H**

| Item No. | Qty. | Designation                                | Benævnelse                               | Item No.   | Qty. | Designation      | Benævnelse |
|----------|------|--|--|--|------|------------------|------------|
| 02       | 1/E  | <b>Plug screw</b>                          | Propskrue                                | 29   | 1/E  | <b>Wear disc</b> | Slidskive  |
| 03       | 1/E  | <b>Gasket</b>                              | Pakning                                  | 30   | 1/E  | <b>Key</b>       | Feder      |
| 04       | 4/E  | <b>Nut</b>                                 | Møtrik                                   | <b>+ Item No. 19 require an individual matching (by shims) before mounting, contact, MAN B&amp;W, Holeby</b> |      |                  |            |
| 05       | 2/E  | <b>Stud</b>                                | Tap                                      |  |      |                  |            |
| 06       | 1/E  | <b>O-ring</b>                              | O-ring                                   |  |      |                  |            |
| 07       | 1/E  | <b>Castle nut</b>                          | Kronemøtrik                              |  |      |                  |            |
| 08       | 1/E  | <b>Split pin</b>                           | Split                                    |  |      |                  |            |
| 10       | 1/E  | <b>Actuator</b>                            | Aktuator                                 |  |      |                  |            |
| 11       | 4/E  | <b>Screw</b>                               | Skrue                                    |  |      |                  |            |
| 12       | 1/E  | <b>Shim (set 0,1 - 0,3 - 0,5 - 1,0 mm)</b> | Mellemlæg (sæt 0,1 - 0,3 - 0,5 - 1,0 mm) |  |      |                  |            |
| 13       | 1/E  | <b>Disc</b>                                | Skive                                    |  |      |                  |            |
| 14       | 1/E  | <b>Ball bearing</b>                        | Kugleleje                                |  |      |                  |            |
| 15       | 1/E  | <b>Bevel gear wheel</b>                    | Konisk tandhjul                          |  |      |                  |            |
| 16       | 1/E  | <b>Key</b>                                 | Feder                                    |  |      |                  |            |
| 17       | 1/E  | <b>Castle nut</b>                          | Kronemøtrik                              |  |      |                  |            |
| 18       | 1/E  | <b>Split pin</b>                           | Split                                    |  |      |                  |            |
| 19+      | 1/E  | <b>Housing</b>                             | Hus                                      |  |      |                  |            |
| 20       | 2/E  | <b>Stud</b>                                | Tap                                      |  |      |                  |            |
| 21       | 2/E  | <b>Pin</b>                                 | Stift                                    |  |      |                  |            |
| 22       | 1/E  | <b>Plug</b>                                | Prop                                     |  |      |                  |            |
| 23       | 1/E  | <b>Plug</b>                                | Prop                                     |  |      |                  |            |
| 24       | 1/E  | <b>Axle journal</b>                        | Akseltap                                 |  |      |                  |            |
| 25       | 1/E  | <b>Bush</b>                                | Bøsning                                  |  |      |                  |            |
| 26       | 1/E  | <b>Bevel gear wheel</b>                    | Konisk tandhjul                          |  |      |                  |            |
| 27       | 1/E  | <b>Gear wheel</b>                          | Tandhjul                                 |  |      |                  |            |

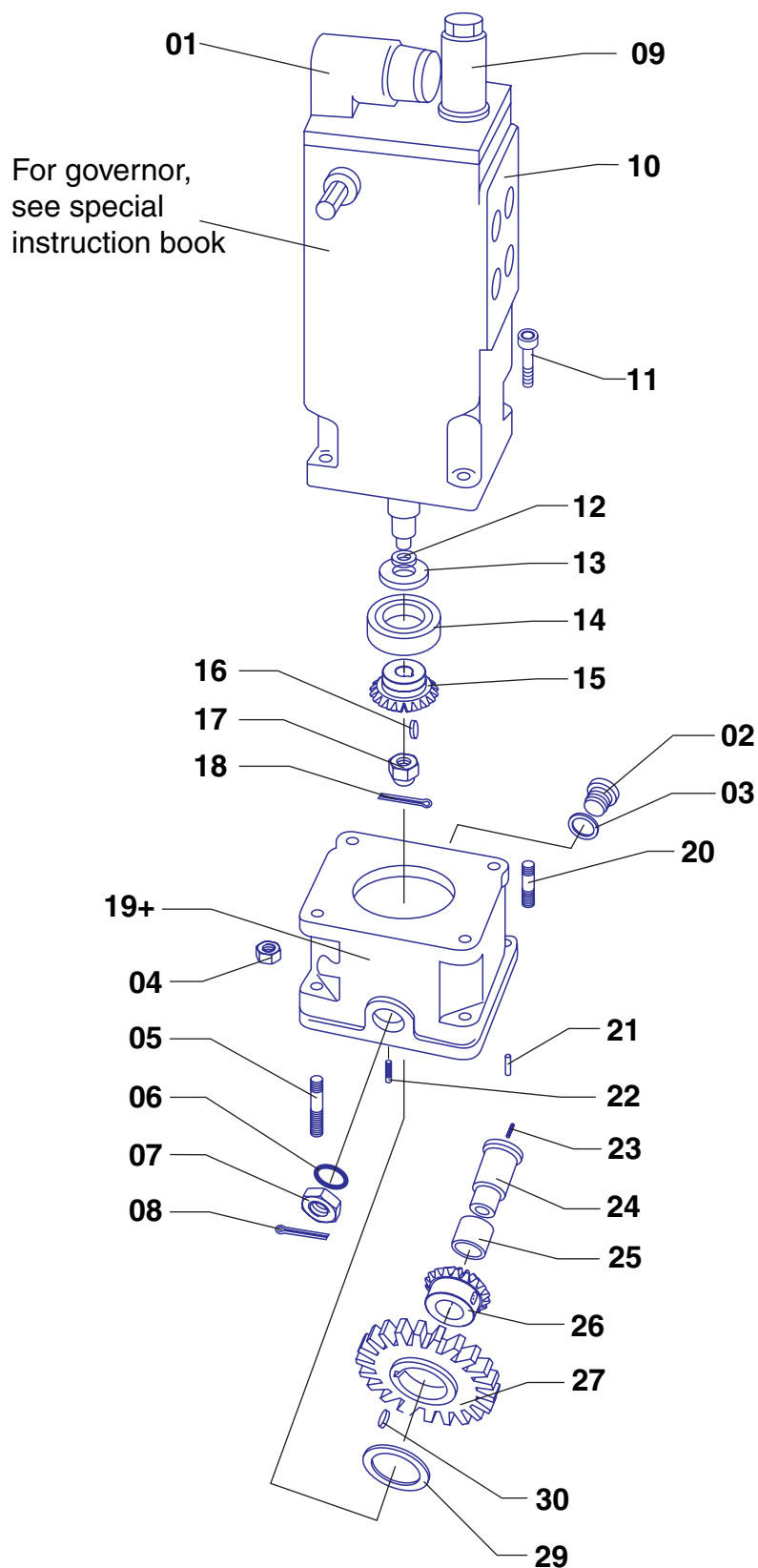
When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

L28/32H



**60901-14H****Governor and Governor Drive**Plate  
Page 2 (2)**L28/32H**

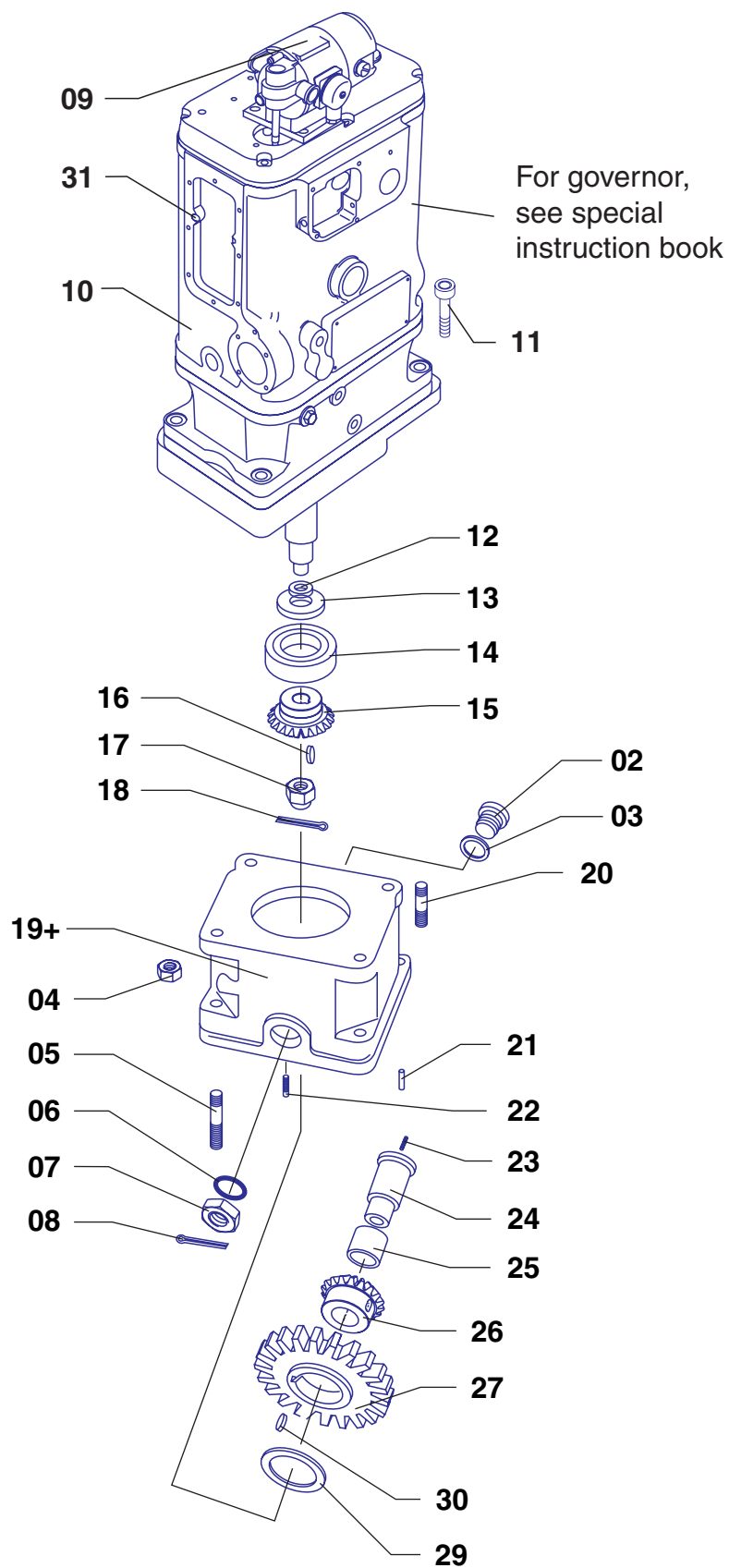
| Item No. | Qty. | Designation                                | Benævnelse                               | Item No. | Qty. | Designation  | Benævnelse   |
|----------|------|--|--|----------|------|--|--|
| 01       | 1/E  | <b>Synchronizing motor</b>                 | Synchroniserings-motor                   | 29       | 1/E  | <b>Wear disc</b>   | Slidskive  |
| 02       | 1/E  | <b>Plug screw</b>                          | Propskrue                                | 30       | 1/E  | <b>Key</b>   | Feder  |
| 03       | 1/E  | <b>Gasket</b>                              | Pakning                                  |          |      | <b>+ Item No. 19 require an individual matching (by shims) before mounting, contact, MAN B&amp;W, Holeby</b> | <b>+ Item nr. 19 kræver en individual tilpasning (med shims) før monter-<br/>ing, kontakt MAN B&amp;W, Holeby.</b> |
| 04       | 4/E  | <b>Nut</b>                                 | Møtrik                                   |          |      |  |  |
| 05       | 2/E  | <b>Stud</b>                                | Tap                                      |          |      |  |  |
| 06       | 1/E  | <b>O-ring</b>                              | O-ring                                   |          |      |  |  |
| 07       | 1/E  | <b>Castle nut</b>                          | Kronemøtrik                              |          |      |  |  |
| 08       | 1/E  | <b>Split pin</b>                           | Split                                    |          |      |  |  |
| 09       | 1/E  | <b>Shut down solenoid</b>                  | Shut-down spole                          |          |      |  |  |
| 10       | 1/E  | <b>Governor - incl. item 01, 09 and 12</b> | Regulator - inkl. item 01, 09 og 12      |          |      |  |  |
| 11       | 4/E  | <b>Screw</b>                               | Skrue                                    |          |      |  |  |
| 12       | 1/E  | <b>Shim (set 0,1 - 0,3 - 0,5 - 1,0 mm)</b> | Mellemlæg (sæt 0,1 - 0,3 - 0,5 - 1,0 mm) |          |      |  |  |
| 13       | 1/E  | <b>Disc</b>                                | Skive                                    |          |      |  |  |
| 14       | 1/E  | <b>Ball bearing</b>                        | Kugleleje                                |          |      |  |  |
| 15       | 1/E  | <b>Bevel gear wheel</b>                    | Konisk tandhjul                          |          |      |  |  |
| 16       | 1/E  | <b>Key</b>                                 | Feder                                    |          |      |  |  |
| 17       | 1/E  | <b>Castle nut</b>                          | Kronemøtrik                              |          |      |  |  |
| 18       | 1/E  | <b>Split pin</b>                           | Split                                    |          |      |  |  |
| 19+      | 1/E  | <b>Housing</b>                             | Hus                                      |          |      |  |  |
| 20       | 2/E  | <b>Stud</b>                                | Tap                                      |          |      |  |  |
| 21       | 2/E  | <b>Pin</b>                                 | Stift                                    |          |      |  |  |
| 22       | 1/E  | <b>Plug</b>                                | Prop                                     |          |      |  |  |
| 23       | 1/E  | <b>Plug</b>                                | Prop                                     |          |      |  |  |
| 24       | 1/E  | <b>Axle journal</b>                        | Akseltap                                 |          |      |  |  |
| 25       | 1/E  | <b>Bush</b>                                | Bøsning                                  |          |      |  |  |
| 26       | 1/E  | <b>Bevel gear wheel</b>                    | Konisk tandhjul                          |          |      |  |  |
| 27       | 1/E  | <b>Gear wheel</b>                          | Tandhjul                                 |          |      |  |  |

When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

**L28/32H**



**60901-15H****Governor and Governor Drive**Plate  
Page 2 (2)**L28/32H**

| Item No. | Qty. | Designation                         | Benævnelse                               | Item No.  | Qty. | Designation       | Benævnelse     |
|----------|------|-------------------------------------|--|---|------|-------------------|----------------|
| 02       | 1/E  | Plug screw                          | Propskrue                                | 30  | 1/E  | Key               | Feder          |
| 03       | 1/E  | Gasket                              | Pakning                                  | 31  | 1/E  | Shutdown solenoid | Shutdown spole |
| 04       | 4/E  | Nut                                 | Møtrik                                   | + Item No. 19 require an individual matching (by shims) before mounting, contact, MAN Diesel A/S. |      |                   |                |
| 05       | 2/E  | Stud                                | Tap                                      |   |      |                   |                |
| 06       | 1/E  | O-ring                              | O-ring                                   |   |      |                   |                |
| 07       | 1/E  | Castle nut                          | Kronemøtrik                              |   |      |                   |                |
| 08       | 1/E  | Split pin                           | Split                                    |   |      |                   |                |
| 09       | 1/E  | Synchronizing motor                 | Synkroniseringsmotor                     |   |      |                   |                |
| 10       | 1/E  | Governor, Europa (720/750 rpm)      | Regulator, Europa (720/750 rpm)          |   |      |                   |                |
| 11       | 4/E  | Screw                               | Skrue                                    |   |      |                   |                |
| 12       | 1/E  | Shim (set 0,1 - 0,3 - 0,5 - 1,0 mm) | Mellemlæg (sæt 0,1 - 0,3 - 0,5 - 1,0 mm) |   |      |                   |                |
| 13       | 1/E  | Disc                                | Skive                                    |   |      |                   |                |
| 14       | 1/E  | Ball bearing                        | Kugleleje                                |   |      |                   |                |
| 15       | 1/E  | Bevel gear wheel                    | Konisk tandhjul                          |   |      |                   |                |
| 16       | 1/E  | Key                                 | Feder                                    |   |      |                   |                |
| 17       | 1/E  | Castle nut                          | Kronemøtrik                              |   |      |                   |                |
| 18       | 1/E  | Split pin                           | Split                                    |   |      |                   |                |
| 19+      | 1/E  | Housing                             | Hus                                      |   |      |                   |                |
| 20       | 2/E  | Stud                                | Tap                                      |   |      |                   |                |
| 21       | 2/E  | Pin                                 | Stift                                    |   |      |                   |                |
| 22       | 1/E  | Plug                                | Prop                                     |   |      |                   |                |
| 23       | 1/E  | Plug                                | Prop                                     |   |      |                   |                |
| 24       | 1/E  | Axle journal                        | Akseltap                                 |   |      |                   |                |
| 25       | 1/E  | Bush                                | Bøsning                                  |   |      |                   |                |
| 26       | 1/E  | Bevel gear wheel                    | Konisk tandhjul                          |   |      |                   |                |
| 27       | 1/E  | Gear wheel                          | Tandhjul                                 |   |      |                   |                |
| 29       | 1/E  | Wear disc                           | Slidskive                                |   |      |                   |                |

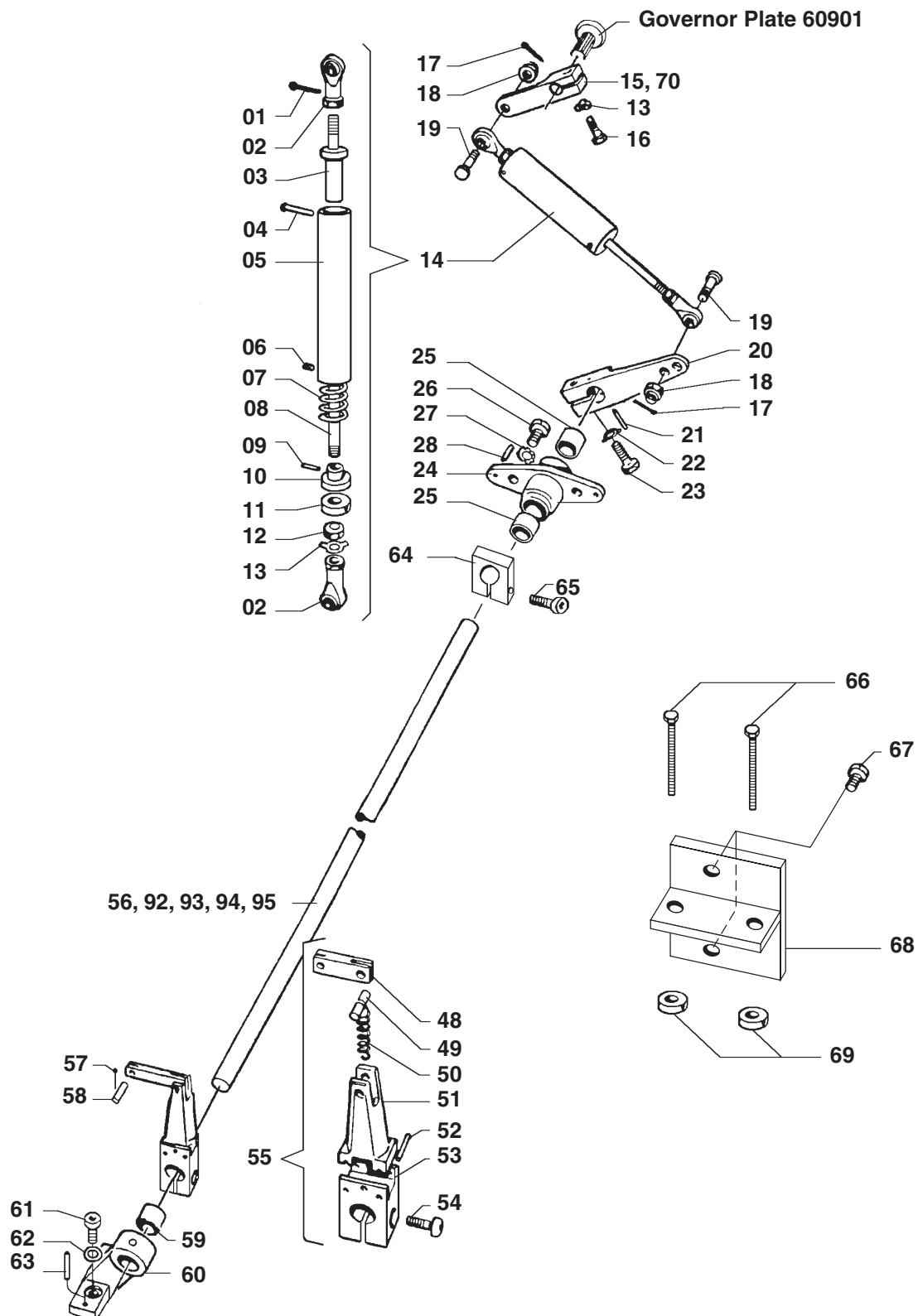
When ordering spare parts, see also page 500.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 500.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

|                     |                             |                  |
|---------------------|-----------------------------|------------------|
| Plate<br>Page 1 (3) | <b>Regulation Mechanism</b> | <b>60902-18H</b> |
|---------------------|-----------------------------|------------------|

**L28/32H**

**60902-18H****Regulation Mechanism**Plate  
Page 2 (3)**L28/32H**

| Item No. | Qty. | Designation                      | Benævnelse                        | Item No. | Qty. | Designation                    | Benævnelse                    |
|----------|------|----------------------------------|-----------------------------------|----------|------|--------------------------------|-------------------------------|
| 01       | 1/R  | Split pin                        | Split                             | 28       | 2/R  | Spring pin                     | Fjederstift                   |
| 02       | 2/R  | Pull rod head                    | Trækstangshoved                   | 48       | 1/C  | Linkage                        | Lænkeled                      |
| 03       | 1/R  | Pull rod end                     | Trækstangsende                    | 49       | 1/C  | Pin                            | Stift                         |
| 04       | 1/R  | Cylindrical pin                  | Cylindrisk stift                  | 50       | 1/C  | Spring                         | Fjeder                        |
| 05       | 1/R  | Spring housing                   | Fjederhus                         | 51       | 1/C  | Spring arm                     | Fjederarm                     |
| 06       | 1/R  | Pointed screw                    | Pinolskrue                        | 52       | 3/C  | Spring pin                     | Fjederstift                   |
| 07       | 1/R  | Spring                           | Fjeder                            | 53       | 1/C  | Arm holder                     | Armholder                     |
| 08       | 1/R  | Pull rod                         | Trækstang                         | 54       | 1/C  | Screw                          | Skrue                         |
| 09       | 1/R  | Cylindrical pin                  | Cylindrisk stift                  | 55       | 1/C  | Spring loaded lever, complete  | Fjederbelastet arm, komplet   |
| 10       | 1/R  | Guide ring                       | Styrering                         | 56       | 1/E  | Regulating shaft 5 cyl. engine | Reguleringsaksel 5 cyl. motor |
| 11       | 1/R  | Guide ring                       | Styrering                         | 57       | 1/C  | Split pin                      | Split                         |
| 12       | 1/R  | Nut                              | Møtrik                            | 58       | 1/C  | Pin                            | Stift                         |
| 13       | 2/R  | Locking plate                    | Låseblik                          | 59       | 1/C  | Bush                           | Bøsning                       |
| 14       | 1/R  | Spring loaded pull rod, complete | Fjederbelastet trækstang, komplet | 60       | 1/C  | Bearing bracket incl. item 59  | Lejeblik inkl. item 59        |
| 15       | 1/R  | Governor arm, Woodward           | Regulator arm, Woodward           | 61       | 2/C  | Screw                          | Skrue                         |
| 16       | 1/R  | Screw                            | Skrue                             | 62       | 2/C  | Washer                         | Skive                         |
| 17       | 2/R  | Split pin                        | Split                             | 63       | 2/C  | Spring pin                     | Fjederstift                   |
| 18       | 2/R  | Self locking nut                 | Selvlåsende møtrik                | 64       | 1/E  | Stop ring                      | Stopring                      |
| 19       | 2/R  | Screw for ball head              | Skrue for kuglehoved              | 65       | 1/E  | Screw                          | Skrue                         |
| 20       | 1/R  | Arm                              | Arm                               | 66       | 2/E  | Screw                          | Skrue                         |
| 21       | 1/R  | Spring pin                       | Fjederstift                       | 67       | 2/E  | Screw                          | Skrue                         |
| 22       | 1/R  | Locking plate                    | Låseblik                          | 68       | 1/E  | Bracket                        | Konsol                        |
| 23       | 1/R  | Screw                            | Skrue                             | 69       | 2/E  | Nut                            | Møtrik                        |
| 24       | 1/R  | Bearing housing incl. item 25    | Lejehus inkl. item 25             | 70       | 1/E  | Governor arm, Europa           | Regulator arm, Europa         |
| 25       | 2/R  | Bush                             | Bøsning                           | 92       | 1/E  | Regulating shaft 6 cyl. engine | Reguleringsaksel 6 cyl. motor |
| 26       | 2/R  | Screw                            | Skrue                             | 93       | 1/E  | Regulating shaft 7 cyl. engine | Reguleringsaksel 7 cyl. motor |
| 27       | 2/R  | Washer                           | Skive                             |          |      |                                |                               |

When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder  
 Qty./R = Qty./Regulation mechanism

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/Cylinder  
 Antal/R = Antal/Reguleringsmekanisme

|                     |                             |                  |
|---------------------|-----------------------------|------------------|
| Plate<br>Page 3 (3) | <b>Regulation Mechanism</b> | <b>60902-18H</b> |
|---------------------|-----------------------------|------------------|

**L28/32H**

| Item No. | Qty. | Designation                       | Benævnelse                       | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-----------------------------------|----------------------------------|----------|------|-------------|------------|
| 94       | 1/E  | Regulating shaft<br>8 cyl. engine | Reguleringsaksel<br>8 cyl. motor |          |      |             |            |
| 95       | 1/E  | Regulating shaft<br>9 cyl. engine | Reguleringsaksel<br>9 cyl. motor |          |      |             |            |

When ordering spare parts, see also page 600.50.

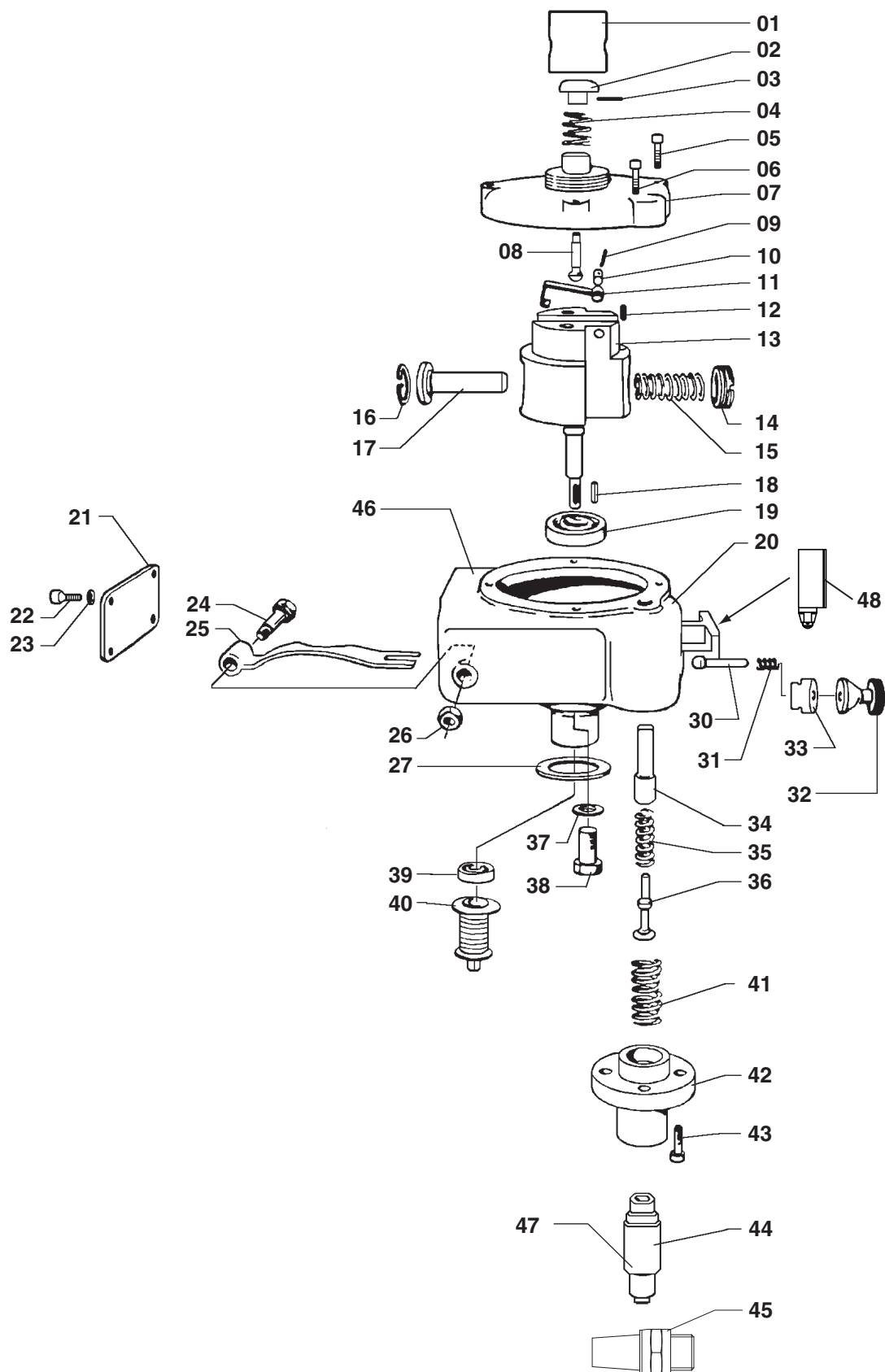
\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder  
 Qty./R = Qty./Regulation mechanism

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/Cylinder  
 Antal/R = Antal/Reguleringsmekanisme

|                     |                  |           |
|---------------------|------------------|-----------|
| Plate<br>Page 1 (2) | Overspeed Device | 60903-38H |
|---------------------|------------------|-----------|

L+V28/32H



|           |                  |                     |
|-----------|------------------|---------------------|
| 60903-38H | Overspeed Device | Plate<br>Page 2 (2) |
|-----------|------------------|---------------------|

## L+V28/32H

| Item No. | Qty. | Designation       | Benævnelse        | Item No. | Qty. | Designation  | Benævnelse  |
|----------|------|-------------------|-------------------|----------|------|--|---|
| 01       | 1/E  | Socket            | Muffe             | 32       | 1/E  | Button   | Knap  |
| 02       | 1/E  | Button            | Knap              | 33       | 1/E  | Nipple   | Nippel  |
| 03       | 1/E  | Spring pin        | Fjederstift       | 34       | 1/E  | Spindle  | Spindel   |
| 04       | 1/E  | Spring            | Fjeder            | 35       | 1/E  | Spring (left)  | Fjeder (venstre)  |
| 05       | 4/E  | Screw             | Skrue             | 36       | 1/E  | Spindle  | Spindel   |
| 06       | 1/E  | Screw             | Skrue             | 37       | 2/E  | Washer   | Skive   |
| 07       | 1/E  | Cover             | Dæksel            | 38       | 2/E  | Screw  | Skrue   |
| 08       | 1/E  | Spindle           | Spindel           | 39       | 1/E  | Ball bearing   | Kugleleje   |
| 09       | 1/E  | Spring pin        | Fjederstift       | 40       | 1/E  | Elastic coupling                                     | Elastisk kobling  |
| 10       | 1/E  | Cylindrical pin   | Cylindrisk stift  | 41       | 1/E  | Spring (right)                                       | Fjeder (højre)  |
| 11       | 1/E  | Lever             | Arm               | 42       | 1/E  | Valve attachment                                     | Ventilholder  |
| 12       | 1/E  | Screw             | Skrue             | 43       | 4/E  | Screw  | Skrue   |
| 13       | 1/E  | Flyweight housing | Hus for svingvægt | 44       | 1/E  | Pneumatic valve                                      | Pneumatisk ventil                                       |
| 14       | 1/E  | Adjusting screw   | Justeringssskrue  | 45       | 1/E  | Silencer   | Lyddæmper   |
| 15       | 1/E  | Spring            | Fjeder            | 46       | 1/E  | Overspeed device, complete excl. item 27, 37, 38, 44 | Overspeed anordning, komplet ekskl. item 27, 37, 38, 44 |
| 16       | 1/E  | Circlip           | Sikringsring      | 47       | 1/E  | Spare parts kit for item 44                          | Reservedelskit for item 44                              |
| 17       | 1/E  | Flyweight         | Svingvægt         | 48       | 1/E  | Limit switch (optional)                              | Afbryder (option)                                       |
| 18       | 1/E  | Key               | Not               |          |      |  |   |
| 19       | 1/E  | Ball bearing      | Kugleleje         |          |      |  |   |
| 20       | 1/E  | Housing           | Hus               |          |      |  |   |
| 21       | 1/E  | Cover             | Dæksel            |          |      |  |   |
| 22       | 4/E  | Washer            | Skive             |          |      |  |   |
| 23       | 4/E  | Screw             | Skrue             |          |      |  |   |
| 24       | 1/E  | Pin               | Stift             |          |      |  |   |
| 25       | 1/E  | Lever             | Arm               |          |      |  |   |
| 26       | 1/E  | Nut               | Møtrik            |          |      |  |   |
| 27       | 1/E  | Gasket            | Pakning           |          |      |  |   |
| 30       | 1/E  | Spindle           | Spindel           |          |      |  |   |
| 31       | 1/E  | Spring            | Fjeder            |          |      |  |   |

When ordering spare parts, see also page 600.50.

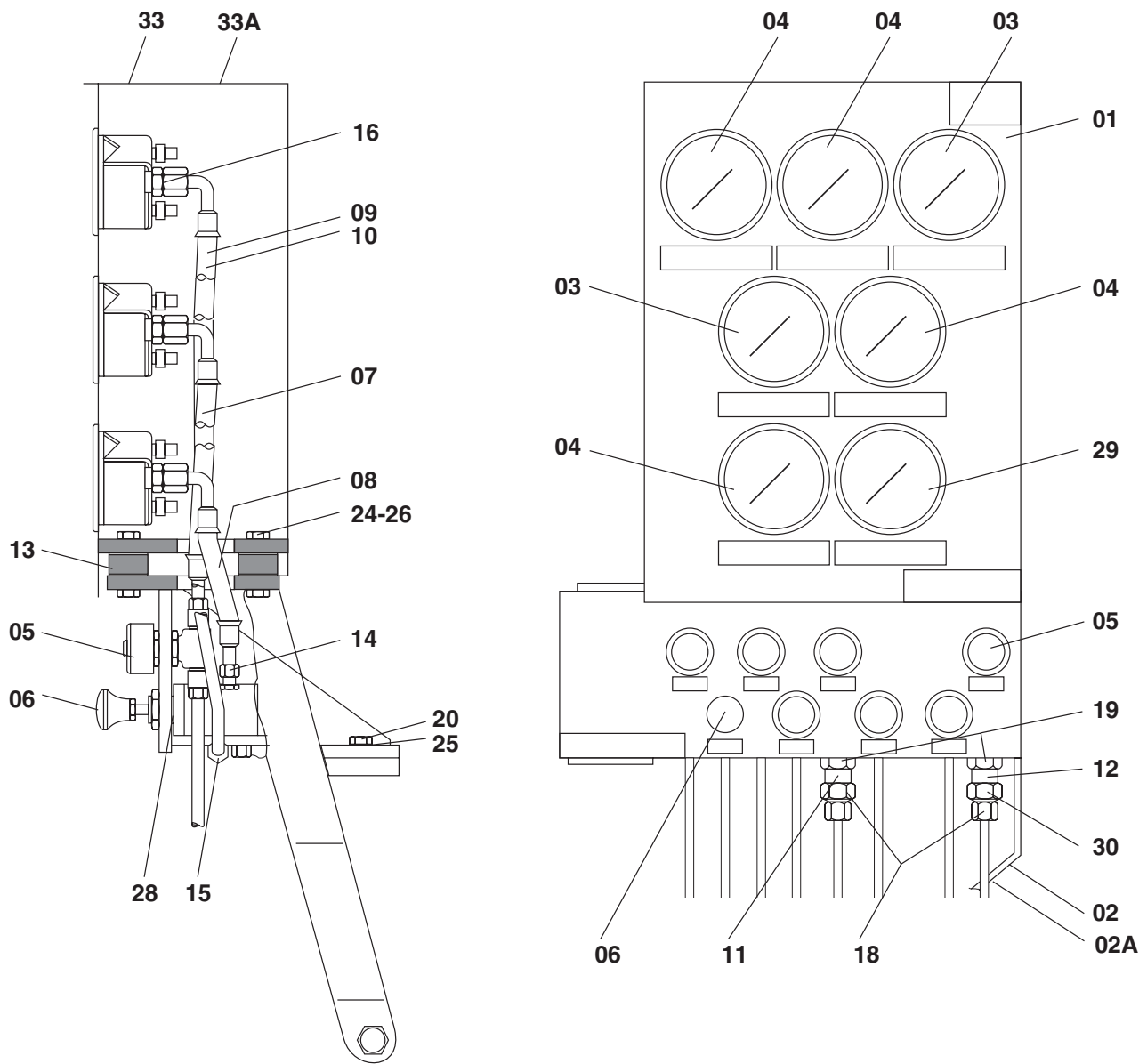
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

|                     |                  |           |
|---------------------|------------------|-----------|
| Plate<br>Page 1 (2) | Instrument Panel | 60905-20H |
|---------------------|------------------|-----------|

L28/32H



|          |   |
|----------|---|
| PI 01    | LT fresh water, inlet to air cooler     |
| PI 10    | HT fresh water, inlet engine            |
| PI 21/22 | Lubricating oil, inlet/outlet to filter |
| PI 23    | Lub. oil, inlet to turbocharger         |
| PI 31    | Charge air, outlet from cooler          |
| PI 40    | Fuel oil, inlet to engine               |
| PI 50    | Nozz. cool. oil, inlet to fuel valves   |

60905-20H

## Instrument Panel

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation   | Benævnelse                                       |
|----------|------|---|--|
| 01       | 1/E  | Housing for instrument panel                          | Hus for instrument panel                         |
| 02       | 1/E  | Bracket for instrument panel, L23/30H                 | Konsol for instrument panel, L23/30H             |
| 02A      | 1/E  | Bracket for instrument panel, L28/32H                 | Konsol for instrument panel, L28/32H             |
| 03       | 2/E  | Pressure gauge 0-3 bar (PI 31 and PI 23)              | Manometer 0-3 bar (PI 31 og PI 23)               |
| 04       | 4/E  | Pressure gauge 0-6 bar, PI 01, PI 10, PI 50, PI 21-22 | Manometer 0-6 bar, PI 01, PI 10, PI 50, PI 21-22 |
| 05       | 8/E  | Needle valve  | Nåleventil                                       |
| 06       | 1/E  | 3-way valve for PI 21-22                              | 3-vejsventil for PI 21-22                        |
| 07       | 3/E  | Pressure gauge hose 195 mm                            | Manometer slange 195 mm                          |
| 08       | 2/E  | Pressure gauge hose 140 mm                            | Manometer slange 140 mm                          |
| 09       | 1/E  | Pressure gauge hose 300 mm                            | Manometer slange 300 mm                          |
| 10       | 2/E  | Pressure gauge hose 340 mm                            | Manometer slange 340 mm                          |
| 11       | 1/E  | Damper (charging air)                                 | Dæmper (ladeluft)                                |
| 12       | 1/E  | Damper (fuel oil)                                     | Dæmper (fuel oil)                                |
| 13       | 4/E  | Rubber clutch   | Gummikobling                                     |
| 14       | 2/E  | Union   | Forskruning                                      |
| 15       | 1/E  | Screwed connection                                    | Skrue forbindelse                                |
| 16       | 8/E  | Packing ring  | Pakningsring                                     |
| 18       | 2/E  | Union   | Forskruning                                      |
| 19       | 2/E  | Union   | Forskruning                                      |
| 20       | 3/E  | Screw   | Skrue  |
| 24       | 8/E  | Nut   | Møtrik   |
| 25       | 4/E  | Serrated washer                                       | Stjerneskrue                                     |
| 26       | 8/E  | Washer  | Skive  |

| Item No. | Qty. | Designation                         | Benævnelse                         |
|----------|------|-------------------------------------|------------------------------------|
| 28       | 1/E  | Washer                              | Skive                              |
| 29       | 1/E  | Pressure gauge 0-10 bar, PI 40      | Manometer 0-10 bar, PI 40          |
| 30       | 4/E  | Packing ring                        | Pakningsring                       |
| 33       | 1/E  | Instrument panel, complete, L23/30H | Instrument panel, komplet, L23/30H |
| 33A      | 1/E  | Instrument panel, complete, L28/32H | Instrument panel, komplet, L28/32H |

When ordering spare parts, see also page 600.50.

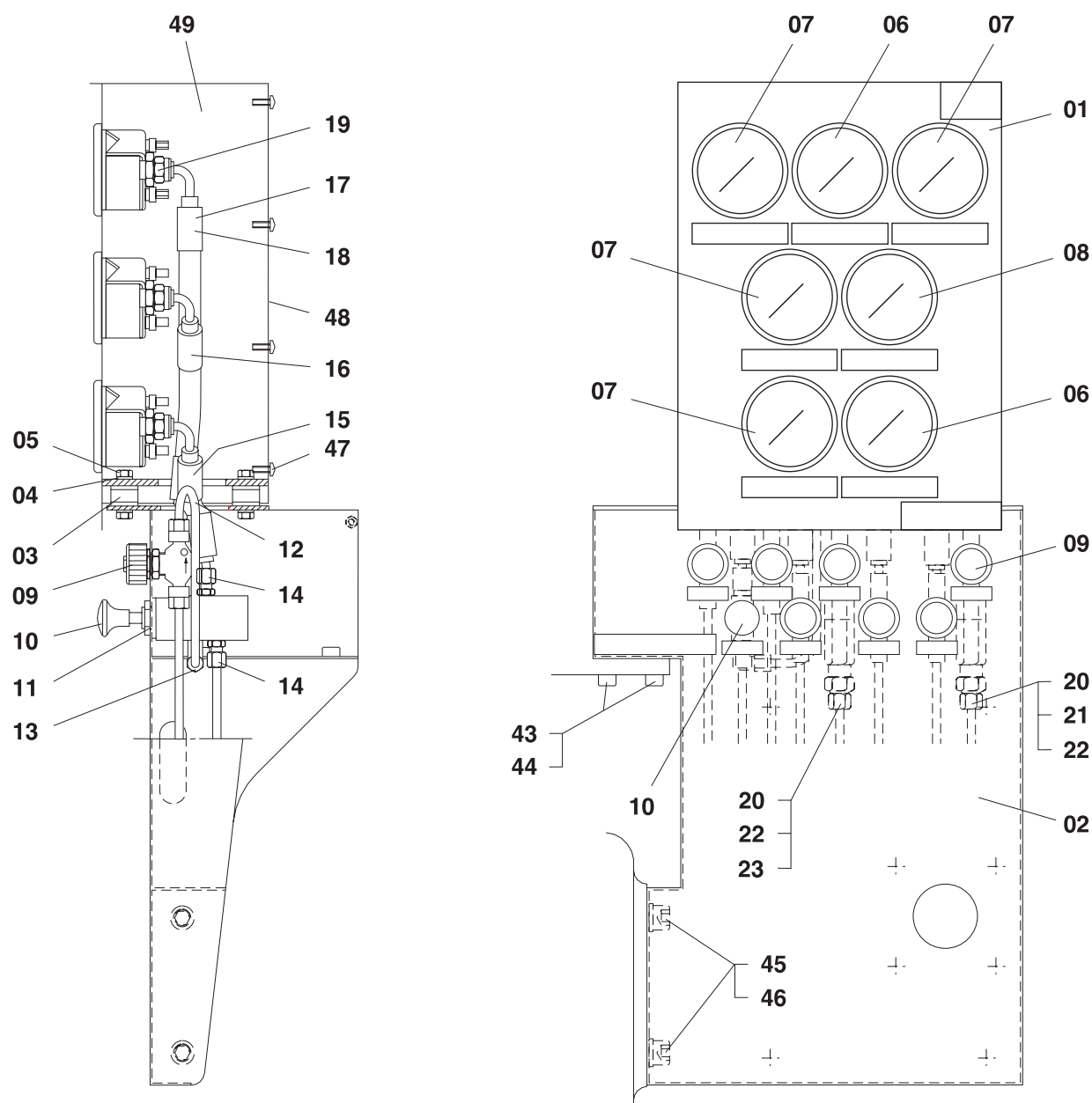
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor



L28/32H



|          |   |
|----------|---|
| PI 01    | LT fresh water, inlet to air cooler     |
| PI 10    | HT fresh water, inlet engine            |
| PI 21/22 | Lubricating oil, inlet/outlet to filter |
| PI 23    | Lub. oil, inlet to turbocharger         |
| PI 31    | Charge air, outlet from cooler          |
| PI 40    | Fuel oil, inlet to engine               |
| PI 50    | Nozz. cool. oil, inlet to fuel valves   |

60905-27H

## Instrument Panel

Plate  
Page 2 (2)

## L28/32H

| Item No | Qty. | Designation  | Benævnelse  | Item No | Qty. | Designation                | Benævnelse                |
|---------|------|--|---|---------|------|----------------------------|---------------------------|
| 01      | 1/E  | Housing for instrument panel                           | Hus for instrument-panel                          | 23      | 1/E  | Damper (charging air)      | Dæmper (ladeluft)         |
| 02      | 1/E  | Bracket for instrument panel                           | Konsol for instrument-panel                       | 43      | 4/E  | Screw                      | Skrue                     |
| 03      | 4/E  | Rubber clutch  | Gummikobling                                      | 44      | 4/E  | Serrated lock washer       | Stjernefjederskive        |
| 04      | 8/E  | Nut  | Møtrik  | 45      | 2/E  | Screw                      | Skrue                     |
| 05      | 8/E  | Spring lock  | Fjederskive                                       | 46      | 2/E  | Serrated lock washer       | Stjernefjederskive        |
| 06      | 2/E  | Pressure gauge 0-3 bar (PI 31 and PI 23)               | Manometer 0-3 bar (PI 31 og PI 23)                | 47      | 8/E  | Screw                      | Skrue                     |
| 07      | 4/E  | Pressure gauge 0-6 bar (PI 01, PI 10, PI 50, PI 21-22) | Manometer 0-3 bar (PI 01, PI 10, PI 50, PI 21-22) | 48      | 1/E  | Side plate                 | Sideplade                 |
| 08      | 1/E  | Pressure gauge 0-10 bar (PI 40)                        | Manometer 0-10 bar (PI 40)                        | 49      | 1/E  | Instrument panel, complete | Instrument panel, komplet |
| 09      | 7/E  | Needle valve   | Nåleventil  |         |      |                            |                           |
| 10      | 1/E  | 3-way valve for PI 21-22                               | 3-vejsventil for PI 21-22                         |         |      |                            |                           |
| 11      | 1/E  | Washer   | Skive   |         |      |                            |                           |
| 12      | 1/E  | Pipe   | Rør   |         |      |                            |                           |
| 13      | 1/E  | Angle union  | Vinkelforskruning                                 |         |      |                            |                           |
| 14      | 2/E  | Straight union   | Ligeforskruning                                   |         |      |                            |                           |
| 15      | 2/E  | Pressure gauge hose 195 mm                             | Manometer slange 195 mm                           |         |      |                            |                           |
| 16      | 2/E  | Pressure gauge hose 140 mm                             | Manometer slange 140 mm                           |         |      |                            |                           |
| 17      | 2/E  | Pressure gauge hose 300 mm                             | Manometer slange 300 mm                           |         |      |                            |                           |
| 18      | 1/E  | Pressure gauge hose 340 mm                             | Manometer slange 340 mm                           |         |      |                            |                           |
| 19      | 7/E  | Packing ring   | Pakningsring                                      |         |      |                            |                           |
| 20      | 2/E  | Reduction  | Reduktion   |         |      |                            |                           |
| 21      | 1/E  | Damper (fuel oil)                                      | Dæmper (fuel oil)                                 |         |      |                            |                           |
| 22      | 2/E  | Coupling for manometer                                 | Kobling for manometer                             |         |      |                            |                           |

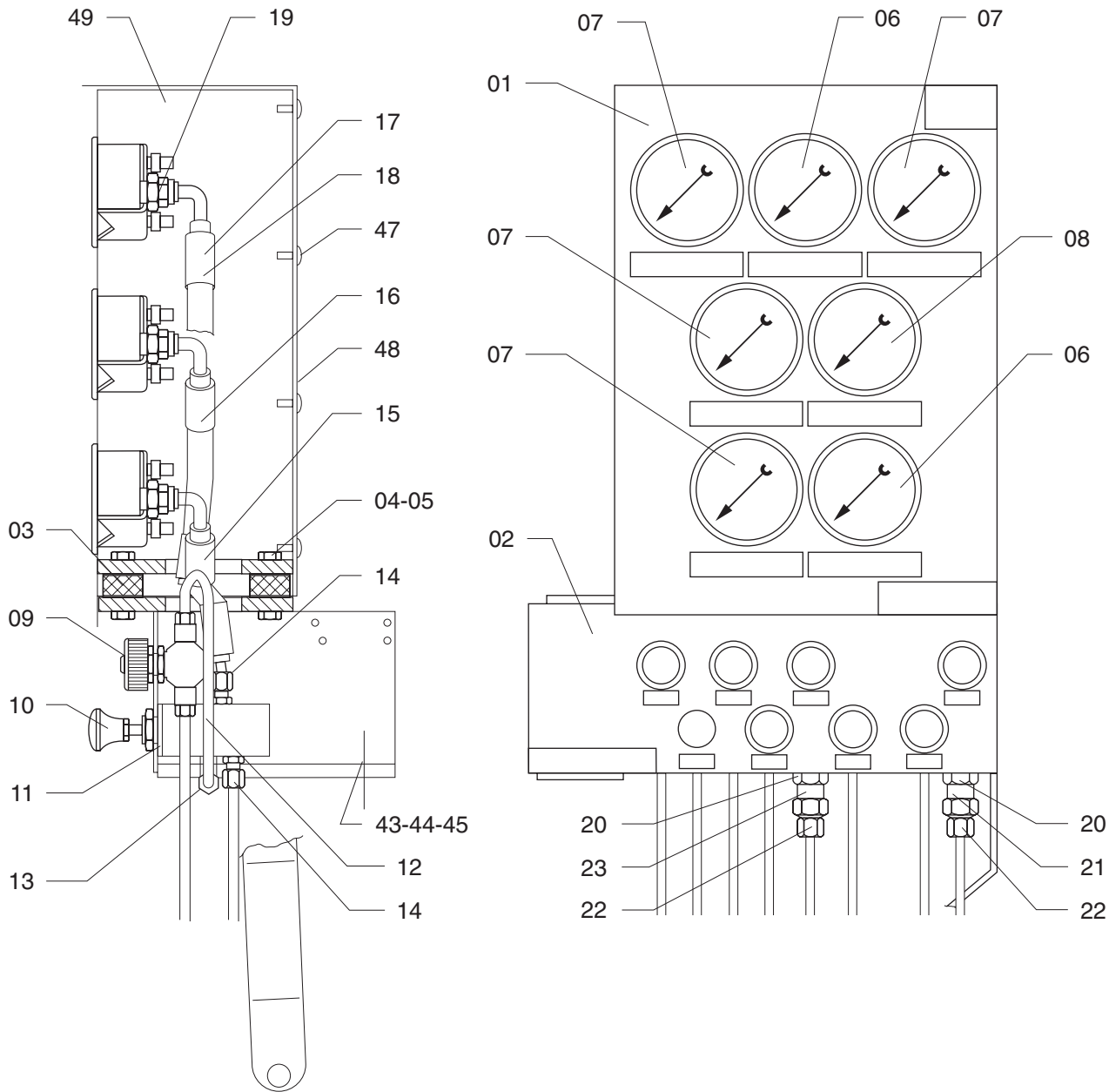
When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

L28/32H



|          |   |
|----------|---|
| PI 01    | LT fresh water, inlet to air cooler     |
| PI 10    | HT fresh water, inlet engine            |
| PI 21/22 | Lubricating oil, inlet/outlet to filter |
| PI 23    | Lub. oil, inlet to turbocharger         |
| PI 31    | Charge air, outlet from cooler          |
| PI 40    | Fuel oil, inlet to engine               |
| PI 50    | Nozz. cool. oil, inlet to fuel valves   |

60905-32H

## Instrument Panel

Plate  
Page 2 (2)

## L28/32H

| Item No | Qty. | Designation  | Benævnelse  | Item No | Qty. | Designation                | Benævnelse                |
|---------|------|--|---|---------|------|----------------------------|---------------------------|
| 01      | 1/E  | Housing for instrument panel                           | Hus for instrument-panel                          | 23      | 1/E  | Damper (charging air)      | Dæmper (ladeluft)         |
| 02      | 1/E  | Bracket for instrument panel                           | Konsol for instrument-panel                       | 43      | 4/E  | Screw                      | Skrue                     |
| 03      | 4/E  | Rubber clutch  | Gummikobling                                      | 44      | 4/E  | Lock washer                | Låseskive                 |
| 04      | 8/E  | Nut  | Møtrik  | 45      | 4/E  | Nut                        | Møtrik                    |
| 05      | 8/E  | Spring lock  | Fjederskive                                       | 47      | 8/E  | Screw                      | Skrue                     |
| 06      | 2/E  | Pressure gauge 0-3 bar (PI 31 and PI 23)               | Manometer 0-3 bar (PI 31 og PI 23)                | 48      | 1/E  | Side plate                 | Sideplade                 |
| 07      | 4/E  | Pressure gauge 0-6 bar (PI 01, PI 10, PI 50, PI 21-22) | Manometer 0-3 bar (PI 01, PI 10, PI 50, PI 21-22) | 49      | 1/E  | Instrument panel, complete | Instrument panel, komplet |
| 08      | 1/E  | Pressure gauge 0-10 bar (PI 40)                        | Manometer 0-10 bar (PI 40)                        |         |      |                            |                           |
| 09      | 7/E  | Needle valve   | Nåleventil  |         |      |                            |                           |
| 10      | 1/E  | 3-way valve for PI 21-22                               | 3-vejsventil for PI 21-22                         |         |      |                            |                           |
| 11      | 1/E  | Washer   | Skive   |         |      |                            |                           |
| 12      | 1/E  | Pipe   | Rør   |         |      |                            |                           |
| 13      | 1/E  | Angle union  | Vinkelforskruning                                 |         |      |                            |                           |
| 14      | 2/E  | Straight union   | Ligeforskruning                                   |         |      |                            |                           |
| 15      | 2/E  | Pressure gauge hose 195 mm                             | Manometer slange 195 mm                           |         |      |                            |                           |
| 16      | 2/E  | Pressure gauge hose 140 mm                             | Manometer slange 140 mm                           |         |      |                            |                           |
| 17      | 2/E  | Pressure gauge hose 300 mm                             | Manometer slange 300 mm                           |         |      |                            |                           |
| 18      | 1/E  | Pressure gauge hose 340 mm                             | Manometer slange 340 mm                           |         |      |                            |                           |
| 19      | 7/E  | Packing ring   | Pakningsring                                      |         |      |                            |                           |
| 20      | 2/E  | Reduction  | Reduktion   |         |      |                            |                           |
| 21      | 1/E  | Damper (fuel oil)                                      | Dæmper (fuel oil)                                 |         |      |                            |                           |
| 22      | 2/E  | Coupling for manometer                                 | Kobling for manometer                             |         |      |                            |                           |

When ordering spare parts, see also page 600.50.

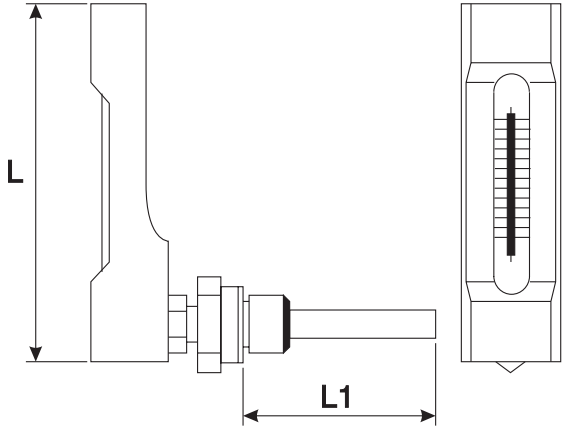
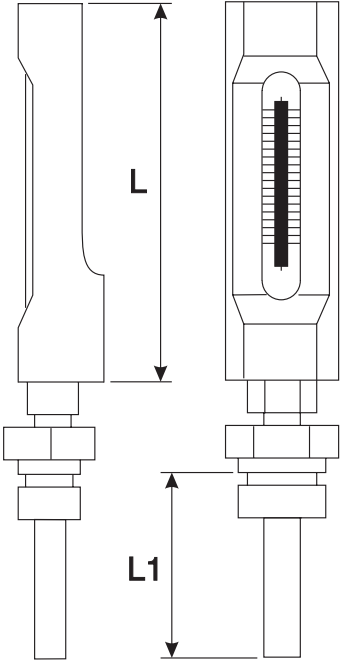
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

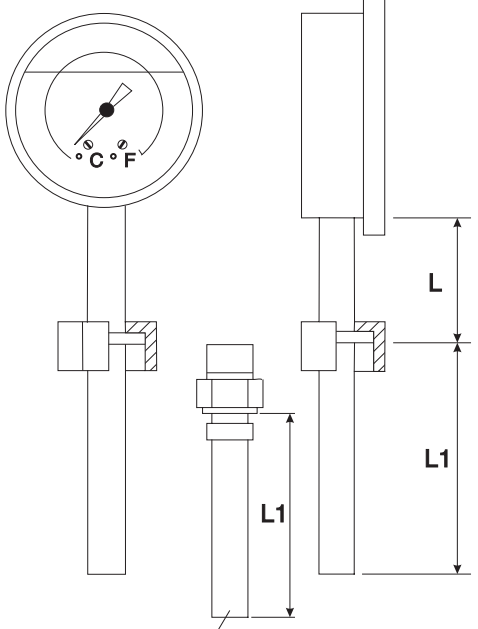
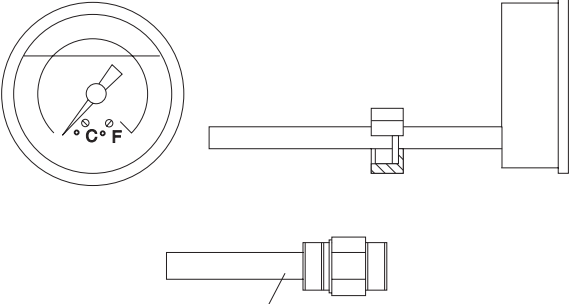
|                     |             |           |
|---------------------|-------------|-----------|
| Plate<br>Page 1 (3) | Thermometer | 60907-19H |
|---------------------|-------------|-----------|

L28/32H

| Fig.  | Scale  |       | Length |     | Code                    | Item No |
|---|--------|-------|--------|-----|-------------------------|---------|
|   | °F     | °C    | L      | L1  |                         |         |
|   | 40-240 | 0-120 | 110    | 100 | TI 01<br>TI 02<br>TI 31 | 01      |
|   | 40-240 | 0-120 | 110    | 63  | TI 22<br>TI 20          | 02      |
|   | 40-600 | 0-300 | 150    | 100 | TI 30                   | 03      |
|   | 40-400 | 0-200 | 110    | 40  | TI 40<br>TI 51          | 04      |
|  | 40-220 | 0-120 | 110    | 100 | TI 03<br>TI 10<br>TI 11 | 05      |

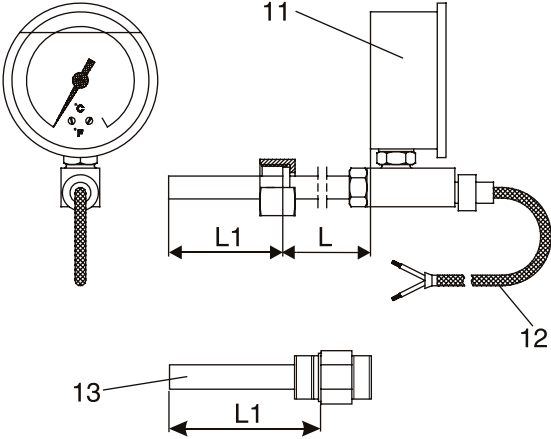
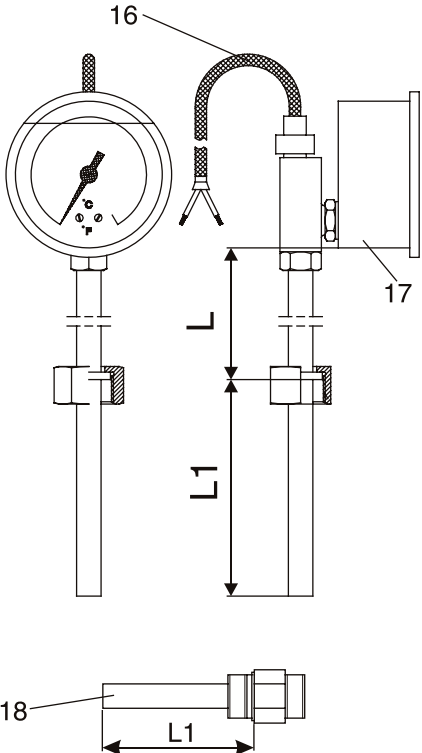
|           |             |                     |
|-----------|-------------|---------------------|
| 60907-19H | Thermometer | Plate<br>Page 2 (3) |
|-----------|-------------|---------------------|

L28/32H

| Fig.   | Scale    |        | Length |     | Code  | Item No. |
|--|----------|--------|--------|-----|-------|----------|
|  | °F       | °C     | L      | L1  |       |          |
| <br>335  | 100-1300 | 50-650 | 100    | 115 | TI 60 | 06       |
|  | Pocket   |        |        | 115 |       | 07       |
| <br>359 | 100-1300 | 50-650 | 65     | 215 | TI 61 | 08       |
|  | Pocket   |        |        | 215 |       | 09       |

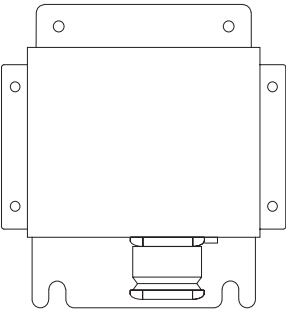
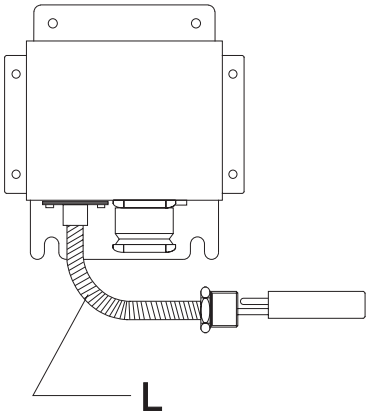
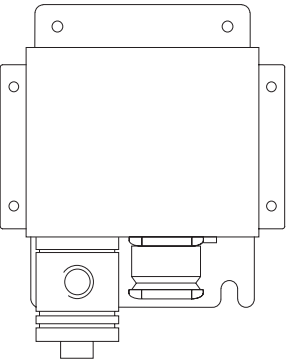
|                     |             |           |
|---------------------|-------------|-----------|
| Plate<br>Page 3 (3) | Thermometer | 60907-19H |
|---------------------|-------------|-----------|

L28/32H

| Fig.  | Scale             |        | Length |     | Code  | Item No. |
|---|-------------------|--------|--------|-----|-------|----------|
|   | °F                | °C     | L      | L1  |       |          |
|   | 120-1200          | 50-650 | 140    | 215 | TI 61 | 11       |
|   |                   |        |        |     | TI 62 |          |
|   | Thermo-<br>meter  |        |        |     |       |          |
|   | Feeler<br>NiCr-Ni |        |        |     |       | 12       |
|   | Pocket            |        |        | 100 |       | 13       |
|  | 120-1200          | 50-650 | 165    | 115 | TI 60 | 14       |
|   | 120-1200          | 50-650 | 190    | 115 | TI 60 | 15       |
|   | Feeler<br>NiCr-Ni |        |        |     |       | 16       |
|   | Thermo-<br>meter  |        |        |     |       | 17       |
|   | Pocket            |        |        | 200 |       | 18       |

|                     |   |                  |
|---------------------|---|------------------|
| Plate<br>Page 1 (2) | <b>Pressostate, Thermostate<br/>Difference Pressostate and Pressure Transmitter</b> | <b>60907-02H</b> |
|---------------------|---|------------------|

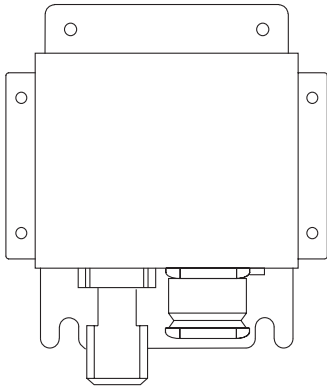
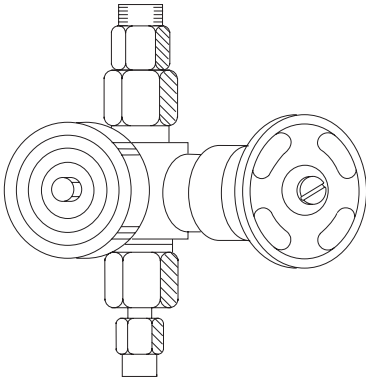
**General**

| Fig. and Description  | Range       | Code   | L          | Item No. |
|---|-------------|--|------------|----------|
| <br>Pressostate              | 0-8 bar     | PSL 22<br>PAL 10<br>PAL 22                     |            | 01       |
|   | 6-18 bar    | PAL 70<br>PAL 24                               |            | 02       |
|   | 10-35 bar   |  |            | 03       |
|   | 1-10 bar    | PAL 40   |            | 04       |
| <br>Thermostate            | 20-60°C     | TAL 10   | 2 m<br>5 m | 05<br>06 |
|   | 50-100°C    |  | 2 m        | 07       |
|   |             |  | 5 m        | 08       |
|   |             |  | 8 m        | 09       |
|   | 70-120°C    | TAH 12<br>TSH 12<br>TAH 20<br>TSH 22<br>TSH 12 | 2 m        | 10       |
|   |             |  | 5 m        | 11       |
|   |             |  | 8 m        | 12       |
|   |             |  |            |          |
| <br>Difference Pressostate | 0.2-2.5 bar | PDAH 21-22                                     |            | 13       |



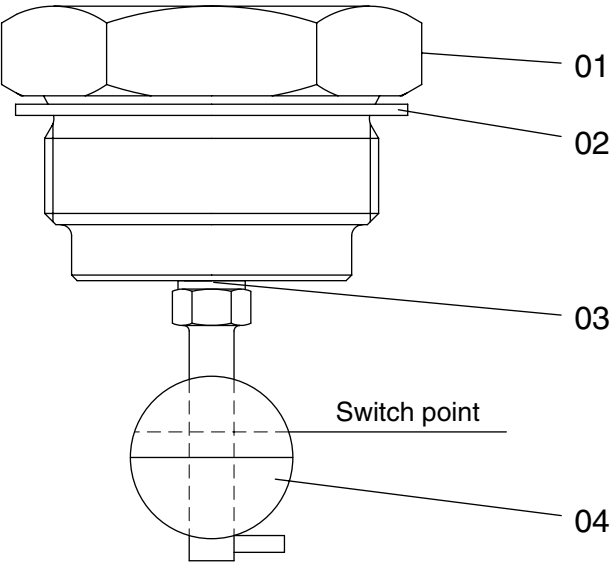
|           |   |                     |
|-----------|---|---------------------|
| 60907-02H | <b>Pressostate, Thermostate<br/>Difference Pressostate and Pressure Transmitter</b> | Plate<br>Page 2 (2) |
|-----------|---|---------------------|

General

| Fig. and Description  | Range                              | Code  | L | Item No. |
|---|------------------------------------|-------|---|----------|
| <br>Pressure Transmitter | 0-2.5 bar                          | PT 31 |   | 14       |
|   | 0-4 bar                            | PT 10 |   | 15       |
|   | 0-6 bar                            | PT 22 |   | 16       |
|   | 0-10 bar                           | PT 40 |   | 17       |
|   | 0-16 bar                           | PT 70 |   | 18       |
|   | 0-40 bar                           |       |   | 19       |
|   | 0-400 bar                          |       |   | 20       |
| <br>Needle Valve       | Needle Valve with 3/8" pipe thread |       |   | 25       |
|   | Needle valve with 1/2" pipe thread |       |   | 26       |
|   |                                    |       |   |          |

|                     |  |                  |
|---------------------|--|------------------|
| Plate<br>Page 1 (2) | <b>Prelubricating Oil Alarm (LAL 25)</b> | <b>60919-01H</b> |
|---------------------|--|------------------|

**L+V28/32H**



|           |                                   |                     |
|-----------|-----------------------------------|---------------------|
| 60919-01H | Prelubricating Oil Alarm (LAL 25) | Plate<br>Page 2 (2) |
|-----------|-----------------------------------|---------------------|

**L+V28/32H**

| Item No. | Qty. | Designation  | Benævnelse     | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--------------|----------------|----------|------|-------------|------------|
| 01       | 1/E  | Plug screw   | Propskrue      |          |      |             |            |
| 02       | 1/E  | Packing ring | Pakningsring   |          |      |             |            |
| 03       | 1/E  | Loctite 577  | Loctite 577    |          |      |             |            |
| 04       | 1/E  | Level switch | Niveaualfryder |          |      |             |            |

**When ordering spare parts, see also page 600.50.**

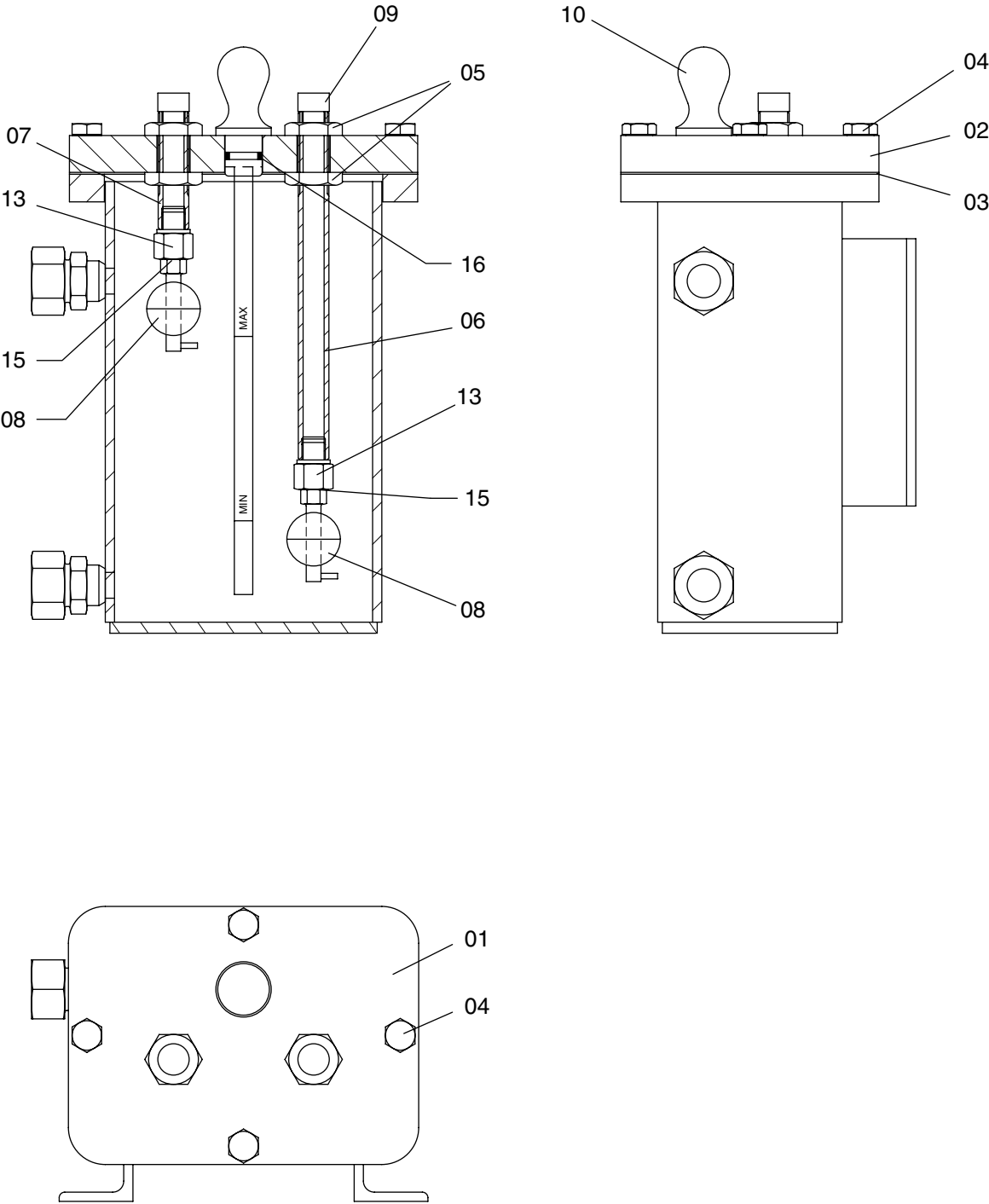
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor

|                     |                                       |           |
|---------------------|---------------------------------------|-----------|
| Plate<br>Page 1 (2) | Level Switch in Oil Sump (LAL/LAH 28) | 60920-01H |
|---------------------|---------------------------------------|-----------|

L28/32H



08028-0D/H5250/94.08.12

60920-01H

## Level Switch in Oil Sump (LAL/LAH 28)

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation       | Benævnelse        | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------------|-------------------|----------|------|-------------|------------|
| 01       | 1/E  | Level alarm       | Niveaualarm       |          |      |             |            |
| 02       | 1/E  | Flange            | Flange            |          |      |             |            |
| 03       | 1/E  | Packing           | Pakning           |          |      |             |            |
| 04       | 4/E  | Screw             | Skrue             |          |      |             |            |
| 05       | 4/E  | Nut               | Møtrik            |          |      |             |            |
| 06       | 1/E  | Pipe, LAL         | Rør, LAL          |          |      |             |            |
| 07       | 1/E  | Pipe, LAH         | Rør, LAH          |          |      |             |            |
| 08       | 2/E  | Level switch      | Niveauekontakt    |          |      |             |            |
| 09       | 2/E  | Reduction adaptor | Reduktionsadapter |          |      |             |            |
| 10       | 1/E  | Dipstick complete | Pejlestok komplet |          |      |             |            |
| 13       | 2/E  | Reduction adaptor | Reduktionsadapter |          |      |             |            |
| 15       | /l   | Loctite 577       | Loctite 577       |          |      |             |            |
| 16       | 1/E  | O-ring            | O-ring            |          |      |             |            |

When ordering spare parts, see also page 600.50.

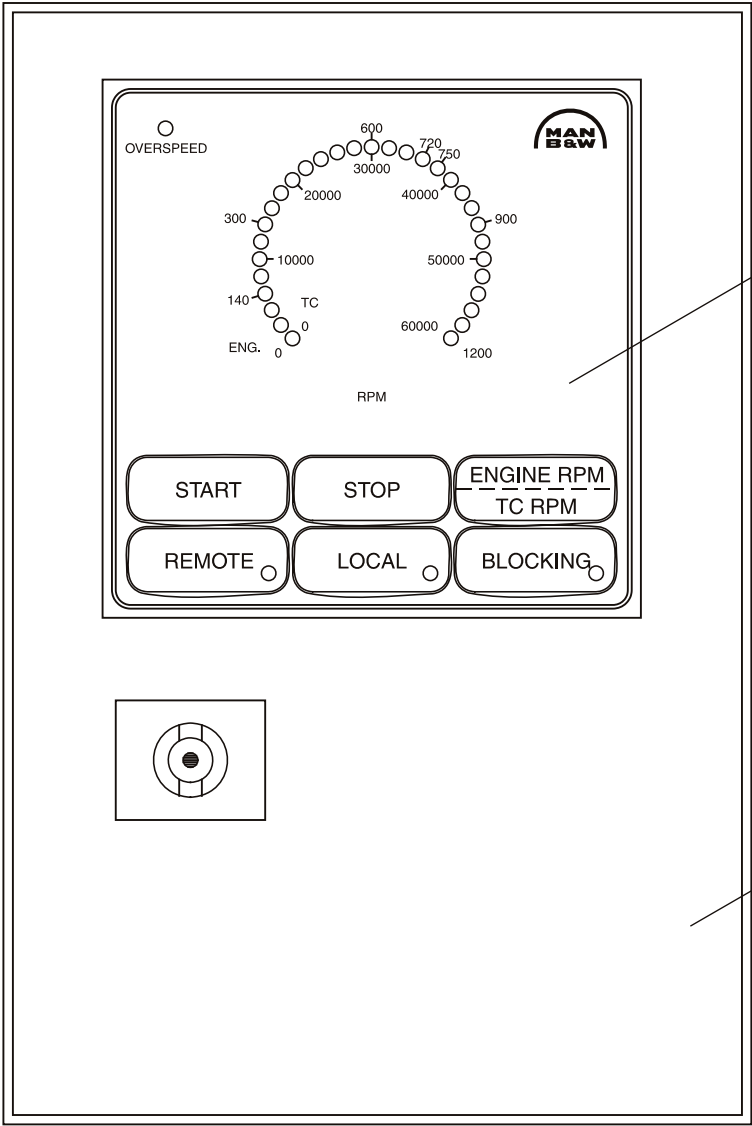
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

|                     |                           |           |
|---------------------|---------------------------|-----------|
| Plate<br>Page 1 (2) | Local Starting Box - No 1 | 60935-13H |
|---------------------|---------------------------|-----------|

L+V28/32H



029

017

**60935-13H****Local Starting Box - No 1**Plate  
Page 2 (2)**L+V28/32H**

| Item No. | Qty. | Designation  | Benævnelse |
|----------|------|--------------|------------|
| 017      | 1/E  | Panel        | Panel      |
| 029      | 1/E  | Starting box | Startboks  |

| Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|
|          |      |             |            |

When ordering spare parts, see also page 600.50.

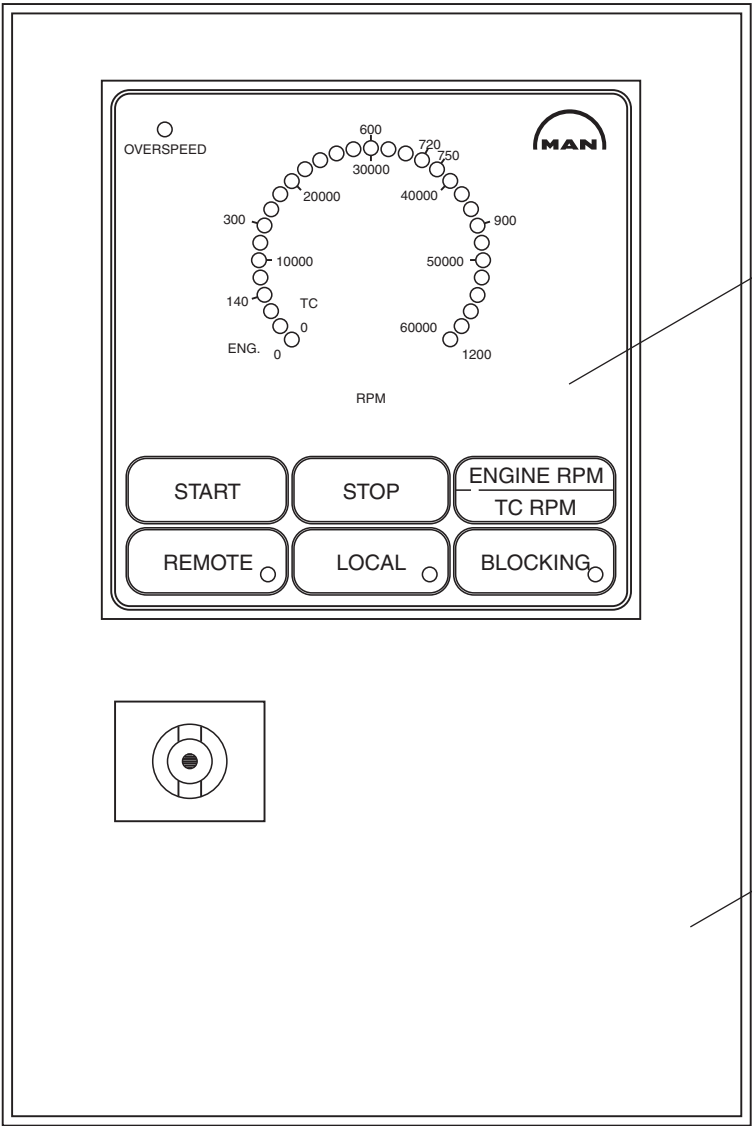
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine.

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Qty./E = Qty./Motor

|                     |                           |           |
|---------------------|---------------------------|-----------|
| Plate<br>Page 1 (2) | Local Starting Box - No 1 | 60935-16H |
|---------------------|---------------------------|-----------|

L28/32H



029

017



60935-16H

## Local Starting Box - No 1

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation  | Benævnelse |
|----------|------|--------------|------------|
| 017      | 1/E  | Panel        | Panel      |
| 029      | 1/E  | Starting box | Startboks  |

| Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|
|          |      |             |            |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Enigne.

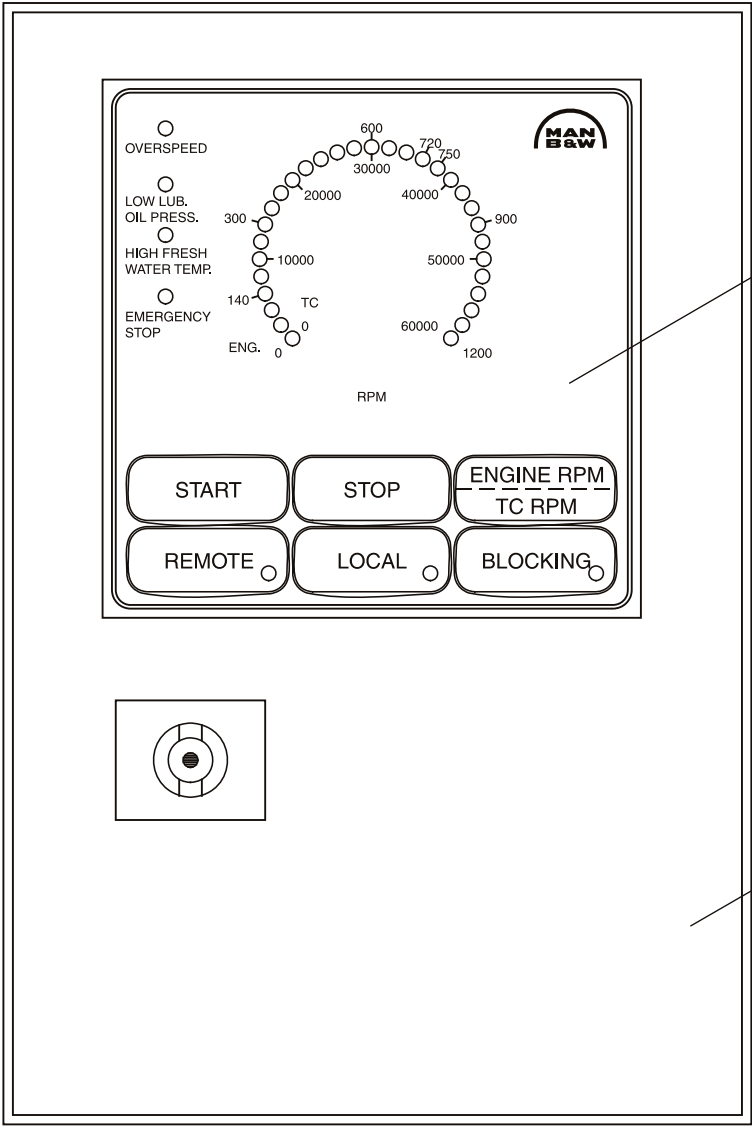
Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Qty./E = Qty./Motor

08028-0D/H5250/94.08.12

|                     |                           |           |
|---------------------|---------------------------|-----------|
| Plate<br>Page 1 (2) | Local Starting Box - No 2 | 60935-14H |
|---------------------|---------------------------|-----------|

L+V28/32H



**60935-14H****Local Starting Box - No 2**Plate  
Page 2 (2)**L+V28/32H**

| Item No. | Qty. | Designation  | Benævnelse |
|----------|------|--------------|------------|
| 017      | 1/E  | Panel        | Panel      |
| 029      | 1/E  | Starting box | Startboks  |

| Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|
|          |      |             |            |

When ordering spare parts, see also page 600.50.

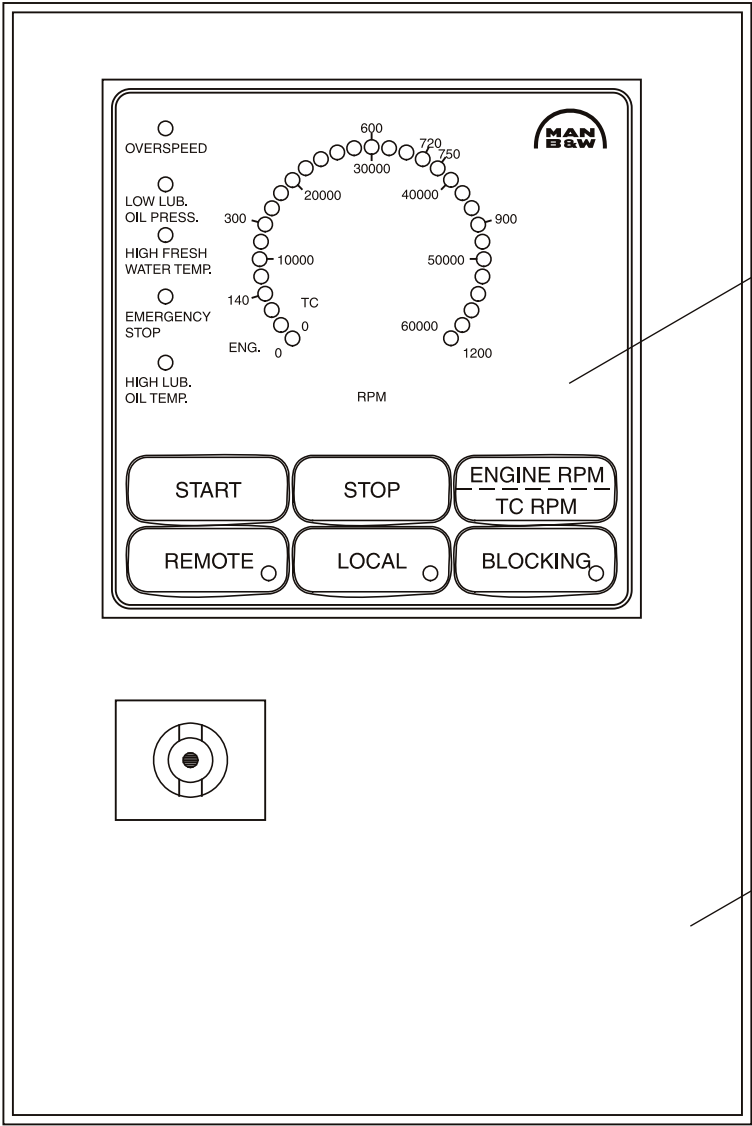
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Enigne.

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Qty./E = Qty./Motor

|                     |   |           |
|---------------------|---|-----------|
| Plate<br>Page 1 (2) | Local Starting Box - No 2 (incl. high lub. oil temp.) | 60935-15H |
|---------------------|---|-----------|

L+V28/32H



**60935-15H****Local Starting Box - No 2 (incl. high lub. oil temp.)**Plate  
Page 2 (2)**L+V28/32H**

| Item No. | Qty. | Designation  | Benævnelse |
|----------|------|--------------|------------|
| 017      | 1/E  | Panel        | Panel      |
| 029      | 1/E  | Starting box | Startboks  |

| Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|
|          |      |             |            |

When ordering spare parts, see also page 600.50.

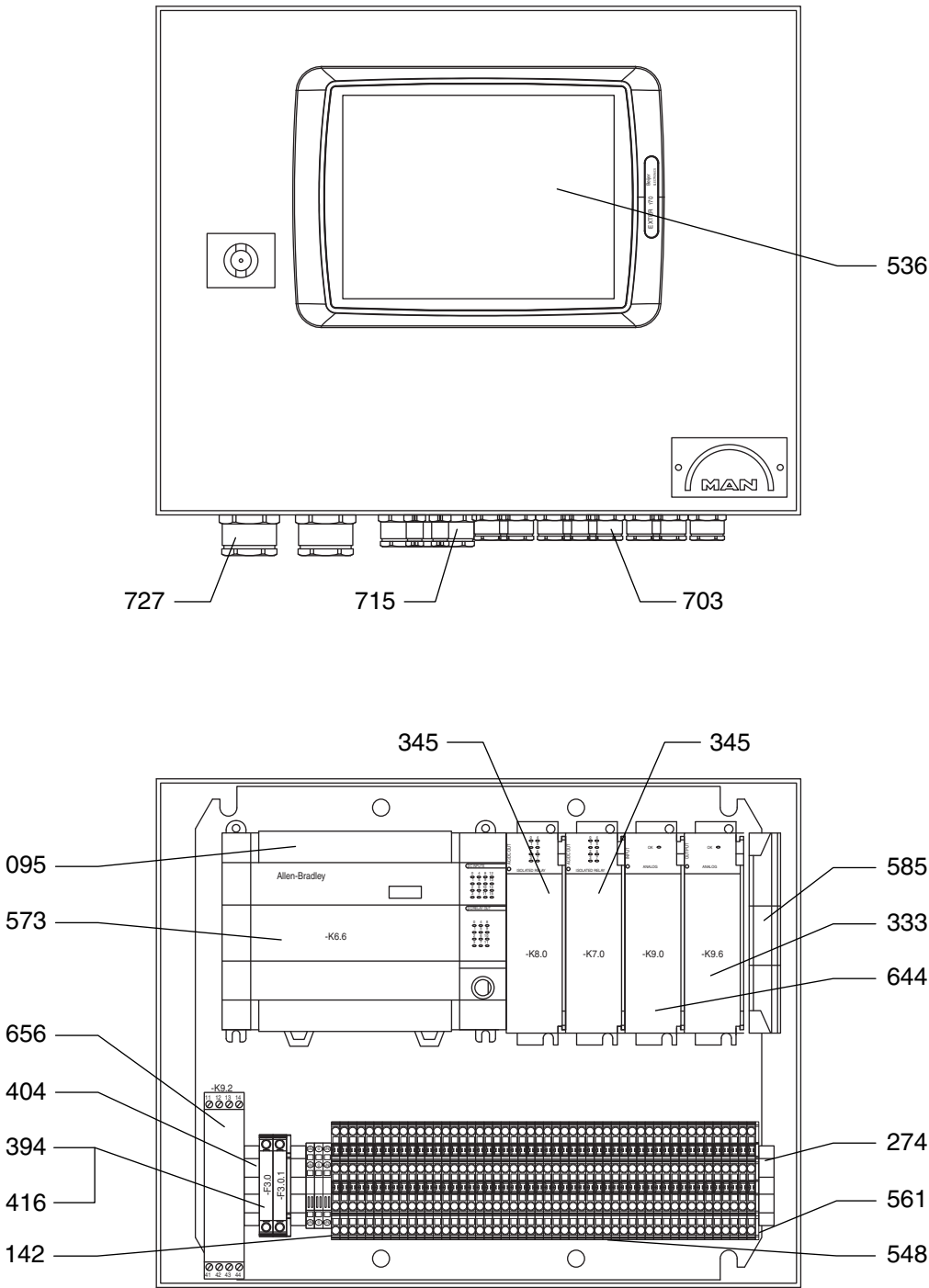
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Enigne.

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Qty./E = Qty./Motor

|                     |                    |           |
|---------------------|--------------------|-----------|
| Plate<br>Page 1 (2) | Engine Control Box | 60936-08H |
|---------------------|--------------------|-----------|

General



60936-08H

## Engine Control Box

Plate  
Page 2 (2)

## General

| Item no | Qty  | Designation              | Benævnelse                  | Item no | Qty | Designation | Benævnelse |
|---------|------|--------------------------|-----------------------------|---------|-----|-------------|------------|
| 095     | 1/E  | Safety system, Base unit | Sikkerhedssystem, Base unit |         |     |             |            |
| 142     | 1/E  | Terminal, earth          | Jordklemme                  |         |     |             |            |
| 274     | 3/E  | End stop                 | Endestop                    |         |     |             |            |
| 333     | 1/E  | Analog output module     | Analog outputmodul          |         |     |             |            |
| 345     | 2/E  | Digital output module    | Digital outputmodul         |         |     |             |            |
| 394     | 2/E  | Fuse terminal            | Sikringsklemme              |         |     |             |            |
| 404     | 1/E  | End plate                | Endeplade                   |         |     |             |            |
| 416     | 4/E  | Fuse                     | Sikring                     |         |     |             |            |
| 536     | 1/E  | Panel                    | Panel                       |         |     |             |            |
| 548     | 50/E | Terminal double          | Klemme, dobbelt             |         |     |             |            |
| 561     | 1/E  | End plate                | Endeplade                   |         |     |             |            |
| 573     | 1/E  | Processor unit (CPU)     | Processor unit (CPU)        |         |     |             |            |
| 585     | 1/E  | End cap                  | Endestykke                  |         |     |             |            |
| 644     | 1/E  | Analog input module      | Analog inputmodul           |         |     |             |            |
| 656     | 1/E  | Converter                | Konverter                   |         |     |             |            |
| 668     | 1/E  | Cable                    | Kabel                       |         |     |             |            |
| 703     | 8/E  | Cable union              | Kabelforskruning            |         |     |             |            |
| 715     | 3/E  | Cable union              | Kabelforskruning            |         |     |             |            |
| 727     | 2/E  | Cable union              | Kabelforskruning            |         |     |             |            |

When ordering spare parts, see also page 500.50.

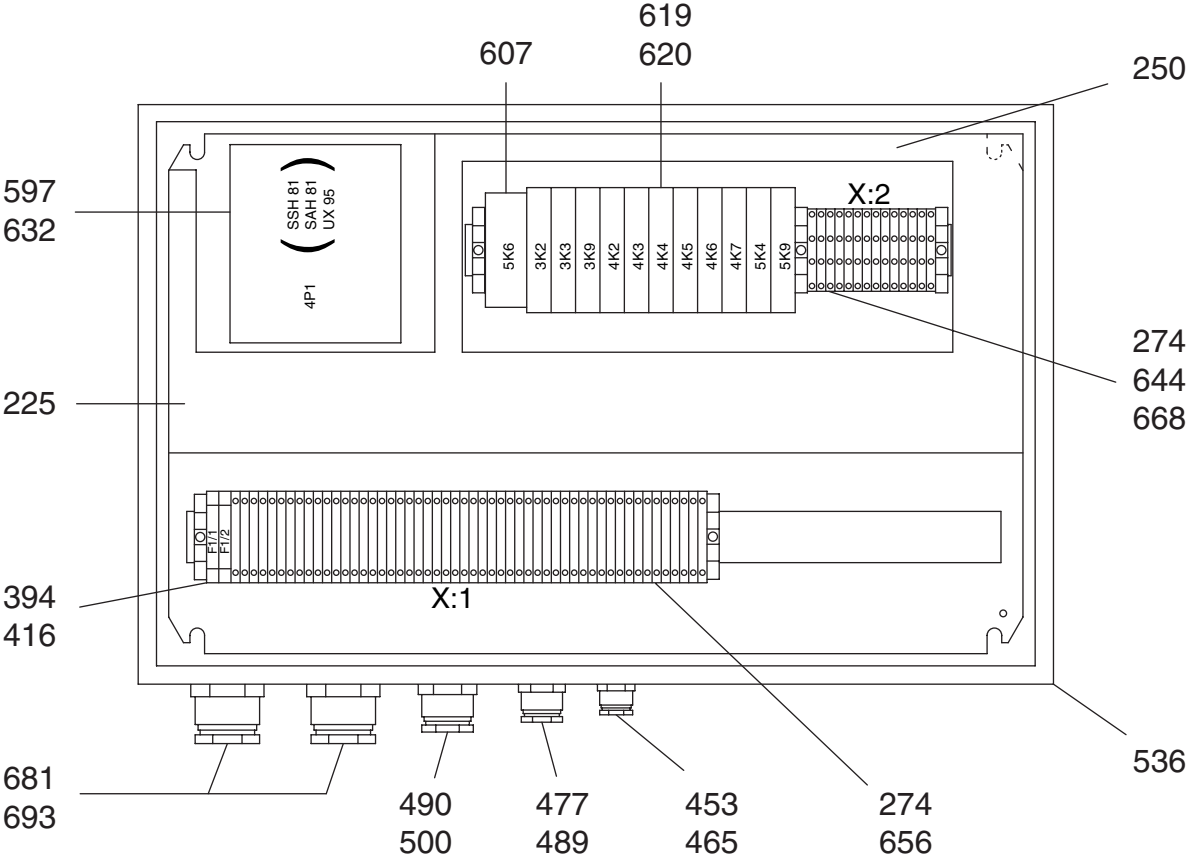
Ved bestilling af reservedele, se også side 500.50.

\* = Only available as part of a spare parts kit.  
Qty/E = Qty/Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Qty/E = Qty/Motor

|                     |              |           |
|---------------------|--------------|-----------|
| Plate<br>Page 1 (2) | Terminal Box | 60936-07H |
|---------------------|--------------|-----------|

L28/32H





60936-07H

## Terminal Box

Plate  
Page 2 (2)

## L28/32H

| Item no | Qty  | Designation                        | Benævnelse                         | Item no | Qty | Designation | Benævnelse |
|---------|------|------------------------------------|------------------------------------|---------|-----|-------------|------------|
| 225     | 1/E  | Conduit                            | Ledningskanal                      |         |     |             |            |
| 250     | 1/E  | Conduit                            | Ledningskanal                      |         |     |             |            |
| 274     | 4/E  | End stop                           | Endestop                           |         |     |             |            |
| 394     | 2/E  | Fuse terminal                      | Sikringsklemme                     |         |     |             |            |
| 416     | 2/E  | Fuse 2A                            | Sikring 2A                         |         |     |             |            |
| 453     | 2/E  | Cable union M16                    | Kabelunion M16                     |         |     |             |            |
| 465     | 2/E  | Nut M16                            | Møtrik M16                         |         |     |             |            |
| 477     | 2/E  | Cable union M20                    | Kabelunion M20                     |         |     |             |            |
| 489     | 2/E  | Nut M20                            | Møtrik M20                         |         |     |             |            |
| 490     | 2/E  | Cable union M25                    | Kabelunion M25                     |         |     |             |            |
| 500     | 2/E  | Nut M25                            | Møtrik M25                         |         |     |             |            |
| 536     | 1/E  | Panel                              | Panel                              |         |     |             |            |
| 597     | 1/E  | Speed converter,<br>engine 720 rpm | Speed converter,<br>motor 720 omdr |         |     |             |            |
| 607     | 1/E  | Timer                              | Timer                              |         |     |             |            |
| 619     | 11/E | Aux. relay                         | Hjælperelæ                         |         |     |             |            |
| 620     | 11/E | Socket                             | Sokkel                             |         |     |             |            |
| 632     | 1/E  | Speed converter,<br>engine 750 rpm | Speed converter,<br>motor 750 omdr |         |     |             |            |
| 644     | 12/E | Terminal                           | Klemme                             |         |     |             |            |
| 656     | 54/E | Terminal                           | Klemme                             |         |     |             |            |
| 668     | 2/E  | Diode terminal                     | Diode klemme                       |         |     |             |            |
| 681     | 3/E  | Cable union M32                    | Kabelunion M32                     |         |     |             |            |
| 693     | 3/E  | Nut M32                            | Møtrik M32                         |         |     |             |            |

When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

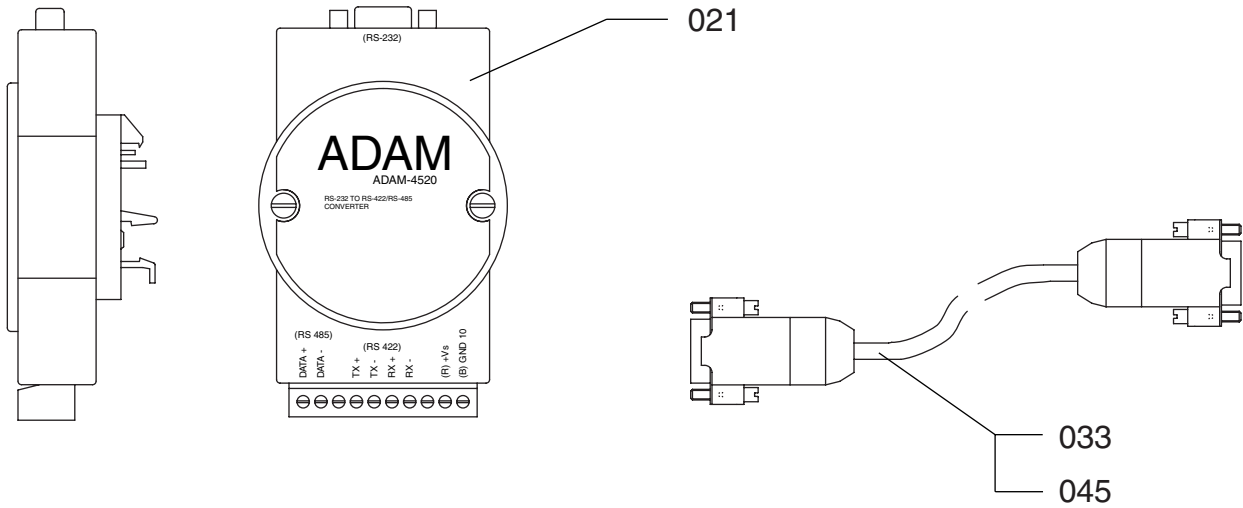
\* = Only available as part of a spare parts kit.  
Qty/E = Qty/Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Qty/E = Qty/Motor

08028-0D/H5250/94.08.12

|                     |           |          |
|---------------------|-----------|----------|
| Plate<br>Page 1 (2) | Converter | 60956-01 |
|---------------------|-----------|----------|

General



|                 |                  |                     |
|-----------------|------------------|---------------------|
| <b>60956-01</b> | <b>Converter</b> | Plate<br>Page 2 (2) |
|-----------------|------------------|---------------------|

## General

| Item no | Qty | Designation         | Benævnelse          |
|---------|-----|---------------------|---------------------|
| 021     | 1/E | Converter           | Converter           |
| 033     | 1/E | Cable, length 1.8 m | Kabel, længde 1.8 m |
| 045     | 1/E | Cable, length 10 m  | Kabel, længde 10 m  |

**When ordering spare parts, see also page 600.50.**

\* = Only available as part of a spare parts kit.  
Qty/E = Qty/Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Qty/E = Qty/Motor

**Crankshaft**

**510/610**

|                           |                                     |                              |
|---------------------------|-------------------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Crankshaft and Main Bearings</b> | <b>610.01</b><br>Edition 12H |
|---------------------------|-------------------------------------|------------------------------|

**L/V28/32H****Crankshaft**

The crankshaft, which is a one-piece forging with ground main bearing and crankpin journals, is suspended in inderslung bearings. The main bearings are equipped with insertion-type shells, which are coated with a wearing surface. To attain a suitable bearing pressure the crankshaft is provided with counterweights, which are attached to the crankshaft by means of dovetail joints and secured with a centrally placed screw.

At the flywheel end the crankshaft is fitted with a gear wheel which through an intermediate wheel drives the camshaft. Also fitted here is the flywheel and a coupling flange for connection of a reduction gear or a alternator. At the opposite end there is a claw-type coupling for the lub. oil pump or a flexible gear wheel connection for lub. oil and water pumps.

**Vibration Damper**

In special cases a vibration damper is mounted on the crankshaft to limit torsional vibrations. The damper consists essentially of a heavy flywheel totally enclosed in a light casing. A small clearance is allowed between the casing and the flywheel, and this space is filled with a highly viscous fluid. The casing is rigidly connected to the front end of the engine crankshaft and the only connection between the crankshaft and the damper flywheel is through the fluid. Under conditions of no vibration, the casing and damper flywheel tend to rotate as one unit, since the force required to shear the viscous film is considerable. As the torsional vibration amplitudes increase, the casing follows the movement of the crankshaft but the flywheel tends to rotate uniformly by virtue of its inertia, and relative motion occurs between the flywheel and the casing. The viscous fluid film therefore undergoes a shearing action, and vibration energy is absorbed and appears as heat.

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (6) | <b>Checking of Main Bearings Alignment (Deflection)</b><br><b>(Hydraulic Tightened Connecting Rod)</b> | <b>610-01.00</b><br>Edition 10H |
|----------------------------|--|---------------------------------|

**L28/32H****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description:**

Checking of main bearings alignment (deflection).

**Starting position:**

Turning gear in engagement. (If mounted).  
Cover for crankshaft has been removed from frame.  
All indicator valves open.

**Related procedure:****Man power:**

Working time : 1 1/2 hours  
Capacity : 2 men

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.                           |
|-----------|----------|---------------------------------|
| 62010     | 01       |                                 |
| 62010     | 05       |                                 |
| 62010     | 35       | Angle for mounting on crank web |

**Hand tools:****Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|-----------|----------|--------|

**L28/32H****Alignment of Main Bearings.**

The lower main bearing shells should be positioned so that they keep the main bearing journals of the crankshaft centered in a straight (ashore horizontal) line. Deviations from this centre line cause the crankshaft to bend and increase the load on some main bearings.

If two adjacent main bearings are placed too low, the crankshaft centre line will in this place be lowered to form an arc, causing the intermediate crank throw to bend in such a way that it "closes" when turned into bottom position and "opens" in top position.

As the magnitude of such axial lengthening and shortening during the turning of the throw increases in proportion to the difference in the height of the bearing, it is measured as a check on the alignment and condition of the bearing.

As the crankshafts of medium speed engines are very stiff, any great deviations in the alignment will result in clearance at the bottom shell of the bearings.

The cause of incorrect main bearing position may be wear of the bearings or misalignment of the engine.

**Effecting The Deflection Measurement.**

The deflection measurement is effected by placing a springloaded dial gauge in the centre punch marks provided for this purpose, see fig. 1.

"Closing" of the throw in top dead centre is regarded as negative, (compression of the gauge).

In the example, page 3, the deflection reading is therefore negative.

As during the turning of the throw, the gauge and the connecting rod will meet near the bottom position of the throw, the measurement for the bottom position is to be replaced by the average of the two near by positions on either side.

The dial gauge is set to zero, when the crank throw is in the near-bottom (x in fig. 8) and during the turning the throw is stopped in the position horizontal-top-horizontal-near bottom (P-T-S-Y in fig. 8) for reading of the gauge.

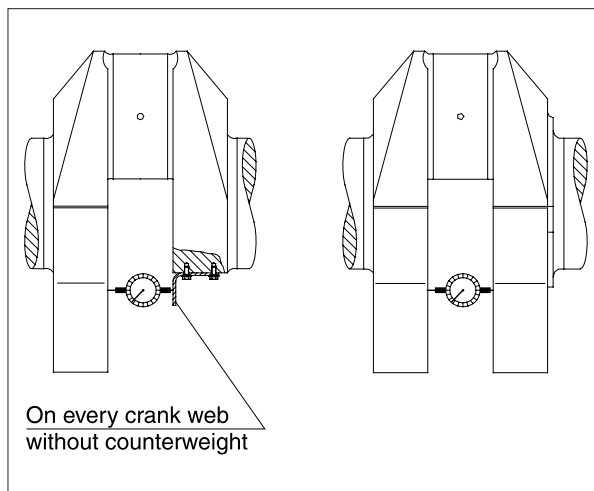


Fig. 1 Placing of dial gauge

**Checking The Deflection Measurement.**

The reading is entered in the table page 6, see example in fig. 2 - 6.

As "bottom" reading is used the mean value of the two "near bottom" readings X and Y, fig. 3.

The total deflection ("opening-closing") of the throw during the turning from bottom to top position is entered in fig. 4.

These figures are due to vertical misalignment of the main bearings.

Similarly, horizontal misalignment procedures the figures in the table fig. 5.

Besides misalignment of the bearings, the readings can be influenced by ovality or eccentricity of the journals.

**Engines Equipped with Turning Gear.**

When taking these 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 teeth of the turning wheel as this pressure may otherwise falsify the readings.

L28/32H

Deflection of crankshaft in 1/100 mm. (0.01 mm).

| Crank position |   | Cyl. No. |    |   |   |    |   |
|----------------|---|----------|----|---|---|----|---|
|                |   | 1        | 2  | 3 | 4 | 5  | 6 |
| Bottom start   | X | 0        | 0  | 0 | 0 | 0  | 0 |
| Left side      | P | 2        | 0  | 2 | 0 | -1 | 2 |
| Top            | T | 3        | -2 | 4 | 5 | -2 | 3 |
| Right side     | S | 3        | -2 | 2 | 0 | 0  | 1 |
| Bottom stop    | Y | 2        | -1 | 0 | 1 | 0  | 2 |

Fig. 2.

|                      |   |      |   |      |   |   |
|----------------------|---|------|---|------|---|---|
| Bottom (0,5 x Y) = B | 1 | -0.5 | 0 | -0.5 | 0 | 1 |
|----------------------|---|------|---|------|---|---|

Fig. 3.

|                                       |   |   |      |   |     |    |   |
|---------------------------------------|---|---|------|---|-----|----|---|
| Deflection from vertical misalignment |   |   |      |   |     |    |   |
| top - bottom or T - B =               | V | 2 | -1.5 | 4 | 4.5 | -2 | 2 |

Fig. 4.

|   |   |    |   |   |   |    |   |
|---|---|----|---|---|---|----|---|
| Deflection from horizontal misalignment |   |    |   |   |   |    |   |
| Right side - left side<br>or P - S =    | H | -1 | 2 | 0 | 0 | -1 | 1 |

Fig. 5.

|                         |           |   |      |   |     |    |   |
|-------------------------|-----------|---|------|---|-----|----|---|
| Check on gauge readings | T + B = C | 4 | -2.5 | 4 | 5.5 | -2 | 4 |
|                         | P + S = D | 5 | -2   | 4 | 0   | -1 | 3 |

Fig. 6.

C and D should be nearly the same, reading for cylinder 4 to be repeated.

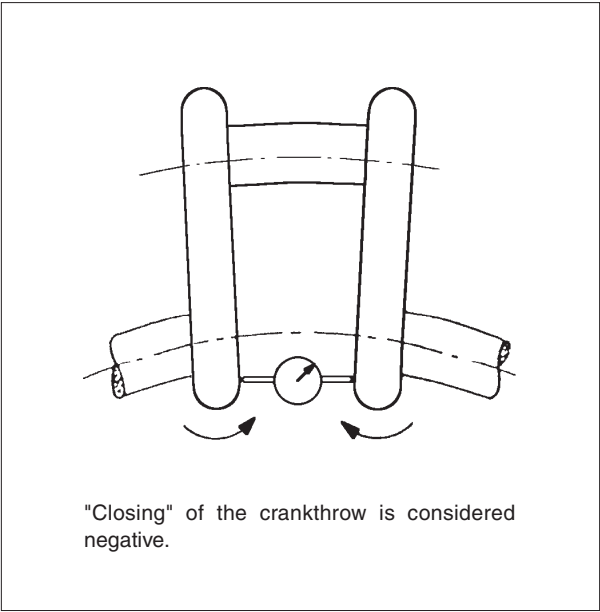


Fig. 7.

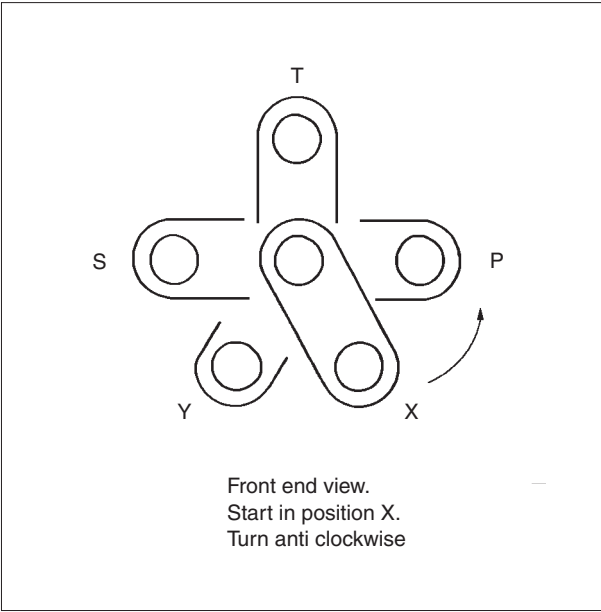


Fig. 8.



**L28/32H****Measurement of Crank Throw Deflections by Means of Dial Indicator (Autolog)**

|                        |   |   |
|------------------------|---|---|
| Crank throw deflection | = | Difference in dial indicator readings in two diametrically opposite crank throw positions, i.e. two positions displaced 180°. |
| Vertical deflection    | = | Difference in top-bottom readings.  |
| Horizontal deflection  | = | Difference in side-side readings.   |

**Vertical and Horizontal Deflections of Crank Throws**

Unless otherwise stated the values refer to cold engine.

|   |            |                  |
|---|------------|------------------|
| For new or realigned aggregate  | Aim for    | + or - 4/100 mm  |
|   | Acceptable | + or - 6/100 mm  |
| For aggregate in service realignment is recommended if deflections exceed |            | + or - 10/100 mm |

**Vertical Deflection of Crank Throw at Flywheel**

Unless otherwise stated the values refer to cold engine.

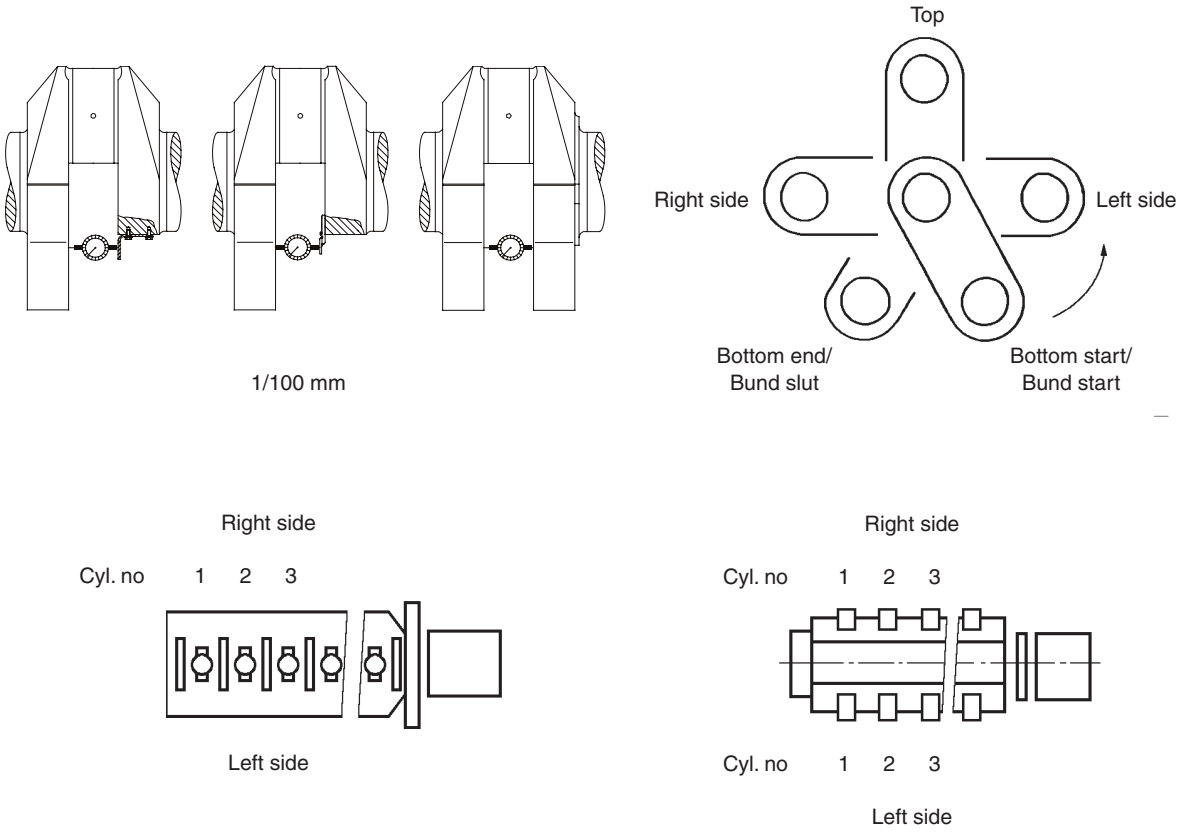
| Rigid coupling between diesel engine and driven machine   | Flexible coupling between diesel engine and driven machine                           |
|---|--|
| For new or realigned aggregate 0 to + 4/100 mm  | For new or realigned aggregate<br>Aim for - 7/100 mm<br>Acceptable - 10/100 mm       |
| For aggregate in service realignment is recommended if deflection measured on warm engine exceeds - 10/100 mm | For aggregate in service realignment recommendable if deflection exceeds - 14/100 mm |

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 5 (6) | <b>Checking of Main Bearings Alignment (Deflection)</b><br><b>(Hydraulic Tightened Connecting Rod)</b> | <b>610-01.00</b><br>Edition 10H |
|----------------------------|--|---------------------------------|

L28/32H

|                       |                   |                 |
|-----------------------|-------------------|-----------------|
| Process/Proces        |                   | I.D. no.        |
| Plant/Anlæg           |                   | Page of/Side af |
| Engine Type/Motortype | Engineer/Operator | Date/Dato       |

Instruction/Instruktion



Remarks/Bemærkninger

08028-0D/H5250/94.08.12

**610-01.00**

Edition 10H

## Checking of Main Bearings Alignment (Deflection) (Hydraulic Tightened Connecting Rod)

Working Card  
Page 6 (6)**L28/32H**

|                     |      |                 |
|---------------------|------|-----------------|
| Component/Komponent | Type | I.D. no.        |
| Process/Proces      |      | Page of/Side af |

|                          |  |                                    |   |   |   |   |   |   |   |
|--------------------------|--|------------------------------------|---|---|---|---|---|---|---|
| Test place/<br>Condition | <input type="checkbox"/> Test bed/prøvehal | <input type="checkbox"/> Cold/Kold |   |   |   |   |   |   |   |
|                          | <input type="checkbox"/> On board/Om bord  | <input type="checkbox"/> Warm/Varm |   |   |   |   |   |   |   |
| Teststed/<br>Tilstand    | <input type="checkbox"/> Plant/Maskinhal   |                                    |   |   |   |   |   |   |   |
| Engine no.:<br>Motornr.: |  |                                    |   |   |   |   |   |   |   |
| Cyl. no.                 | 1  | 2                                  | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Bottom X                 | 0  | 0                                  | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Left side P              |  |                                    |   |   |   |   |   |   |   |
| Top T                    |  |                                    |   |   |   |   |   |   |   |
| Right side S             |  |                                    |   |   |   |   |   |   |   |
| Bottom Y                 |  |                                    |   |   |   |   |   |   |   |

|                     |  |  |  |  |  |  |  |  |  |
|---------------------|--|--|--|--|--|--|--|--|--|
| Bottom<br>(0.5xY)=B |  |  |  |  |  |  |  |  |  |
|---------------------|--|--|--|--|--|--|--|--|--|

|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|
| Deflection from<br>vertical misalign-<br>ment.<br>Top - bottom<br>or T - B = V |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|

|  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|
| Deflection from<br>horizontal mis-<br>alignment.<br>Left side - Right<br>side or P - S = H |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|

|                             |  |  |  |  |  |  |  |  |  |
|-----------------------------|--|--|--|--|--|--|--|--|--|
| Check on gauge<br>readings. |  |  |  |  |  |  |  |  |  |
| T + B = C                   |  |  |  |  |  |  |  |  |  |
| P + S = D                   |  |  |  |  |  |  |  |  |  |

08028-0D/H5250/94.08.12

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (3) | <b>Inspection of Main Bearing Shells</b> | <b>610-01.05</b><br>Edition 05H |
|----------------------------|--|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description:**

Dismantling, inspection and/or replacement and mounting of main bearing shells.

**Starting position:****Related procedure:**

Inspection of guide bearing shell, 610-01.10  
Criteria for replacement of bearings, 606-01.16

**Manpower:**

Working time : 2 hours  
Capacity : 2 men

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no | Item no | Note            |
|----------|---------|-----------------|
| 62010    | 10      | 2 pieces        |
| 62010    | 20      |                 |
| 62010    | 01      |                 |
| 62010    | 15      | 2 pieces        |
| 62010    | 30      | Extra tools     |
| 62021    | 40      | Hydraulic tools |
| 62021    | 50      | 2 pieces        |
| 62021    | 51      |                 |
| 62021    | 20      |                 |

**Hand tools:**

Allen key, 12 mm.  
Socket spanner, 36 mm.  
Lead hammer.  
Silastene.  
Copaslip.

**Replacement and wearing parts:**

| Plate no | Item no | Qty/ |
|----------|---------|------|
|----------|---------|------|

**L+V28/32H****Make Ready for Dismantling of the Main Bearing**

- 1) Dismount crankcase covers in front and opposite the bearing concerned.
- 2) Turn the engine until the crank is in a convenient position for carrying out the work.
- 3) Dismount the bracing screw (side screw).
- 4) Mount the hydraulic tools and loosen the main bearing stud nuts. For operation of the hydraulic tools, see working card 620-01.05.

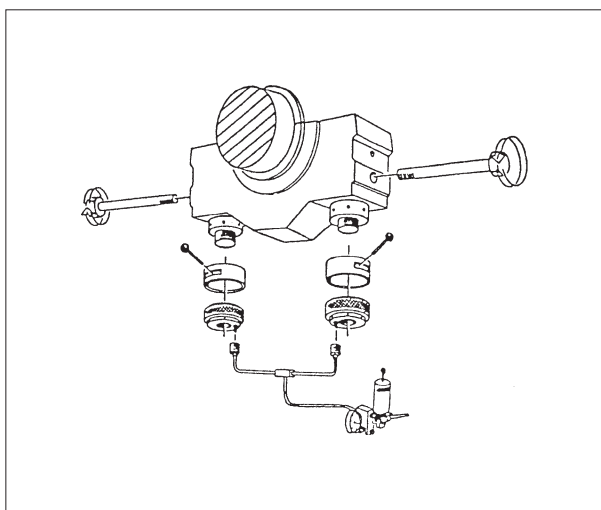


Fig 1. Mounting of Hydraulic Tools.

- 5) Dismount the hydraulic tools and slacken the nuts somewhat.

**Dismantling of the Main Bearing Cap**

- 6) Fit the eye screws, diagonally, in the threaded holes in the main bearing cap, see fig 2.

Pass the wire supplied through the eye screw and attach it as shown, so as to keep the bearing cap in place when the main bearing stud nuts are removed.

- 7) Work the main bearing cap loose from the engine frame with a lead hammer or similar.

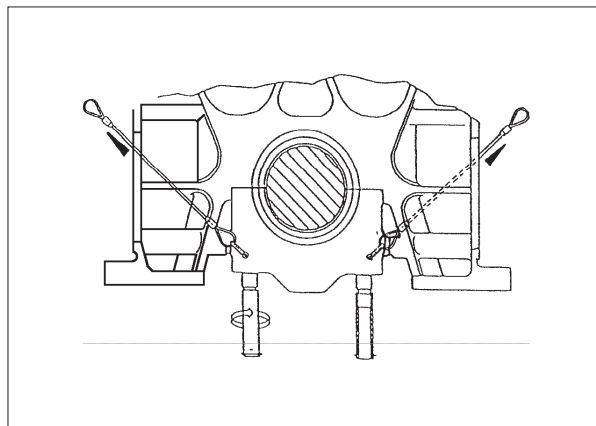


Fig 2. Mounting of Wire Straps.

- 8) Lift the main bearing cap a little and unscrew the bearing stud nut.

- 9) Fit guide tubes on the threads of the bearing studs and lower the bearing cap to make it rest on the collar of the guide tubes.

**Dismantling of the Main Bearing Shells**

- 10) Remove the locking piece from the bearing cap and take out the bearing shell.

- 11) Fit the tool for upper main bearing, for dismantling of upper main bearing shell, in the lubricating hole in the crankshaft and turn out the upper bearing shell by turning the crankshaft, see fig 3.

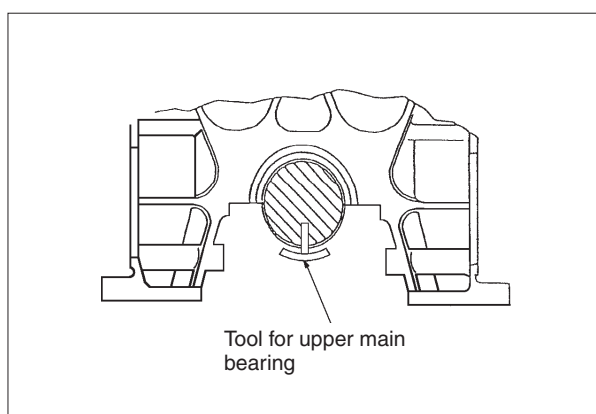


Fig 3. Mounting of tool for upper main bearing.

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 3 (3) | <b>Inspection of Main Bearing Shells</b> | <b>610.01-05</b><br>Edition 05H |
|----------------------------|--|---------------------------------|

**L+V28/32H****Cleaning**

- 12)** Clean all machined surfaces, on frame, bearing cap, stud, nuts and bearing shells.

**Inspection of Main Bearing Shells**

- 13)** Inspect the main bearing shells according to working card 606-01.16.

**Note:** The bearing is marked according to size and when replaced it must be by a new bearing of the same size.

**Mounting of the Main Bearing Shells**

- 14)** Push the upper bearing shell as far into position as possible.

- 15)** Fit the tool for upper main bearing in the lubricating hole in the crankshaft and turn in the upper bearing shell by turning the crankshaft.

Make sure that the shell enters its correct position then remove the tool for upper main bearing.

- 16)** Lubricate the end of the bearing shells with molycote pasta or similar.

- 17)** Insert the lower bearing shell in the bearing cap and mount the locking piece.

Lubricate the bearing shell and journal with clean lubricating oil.

**Mounting of the Main Bearing Cap**

- 18)** Raise the bearing cap into position, dismount the guide tubes, coat the bearing studs with molycote pasta or similar and fit the bearing stud nuts.

Make sure that the bearing cap and bearing shell are in their correct position.

- 19)** Dismantle the wire straps.

- 20)** Mount the hydraulic tools, see working card 620-01.05, and tighten the nuts as prescribed on page 600-40.

- 21)** Coat the back side of the bracing screws' (side screws') hexagonal head with a thin coat of silastene or similar.

- 22)** Mount the screws and tighten with a torque spanner as indicated on page 600.40.

## L+V28/32H

## Safety precautions

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

## Description

Dismantling, inspection and/or replacement and mounting of guide bearing shells and thrust washer.

## Starting position

## Related procedure

Inspection of main bearing shells. 610-01.05  
Criteria for replacement of bearing shells. 606-01.16

## Manpower

Working time : 2 hours  
Capacity : 2 men

## Data

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

## Special tools

| Plate no | Item no | Note            |
|----------|---------|-----------------|
| 62006    | 28      | 140 - 760 Nm    |
| 62010    | 10      | 2 pieces        |
| 62010    | 20      |                 |
| 62010    | 01      |                 |
| 62010    | 25      |                 |
| 62010    | 15      | 2 pieces        |
| 62010    | 30      | Extra tools     |
| 62021    | 40      | Hydraulic tools |
| 62021    | 50      | 2 pieces        |
| 62021    | 51      |                 |
| 62021    | 20      |                 |

## Hand tools

Allen key, 12 mm  
Socket spanner, 36 mm  
Lead hammer  
Silastene  
Molycote

## Replacement and wearing parts

| Plate no | Item no | Qty/ |
|----------|---------|------|
|----------|---------|------|

**L+V28/32H****Make Ready for Dismantling of the Guide Bearing**

- 1) Dismount the crankcase covers opposite the bearing concerned.
- 2) Turn the engine until the crank is in a convenient position for carrying out the work.
- 3) Dismount the bracing screw (side screw).
- 4) Mount the hydraulic tools, see fig 1, and loosen the guide bearing stud nuts. For operation of the hydraulic tools, see working card 620-01.05.

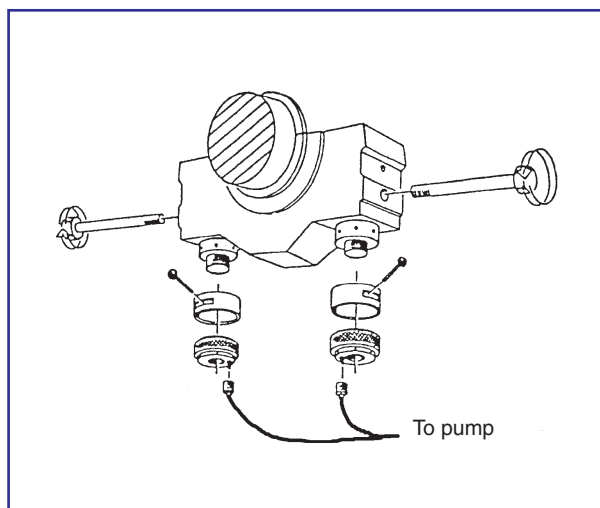


Fig 1 Mounting of Hydraulic Tools

- 5) Dismount the hydraulic tools and slacken the nuts somewhat.

**Dismantling of the Guide Bearing Cap**

- 6) Fit the eye screws, diagonally, in the threaded holes in the guide bearing cap, see fig 2.

Pass the wire supplied through the eye screw and attach it as shown, so as to keep the bearing cap in place when the guide bearing stud nuts are removed.

- 7) Work the guide bearing cap loose from the engine frame with a lead hammer or similar.

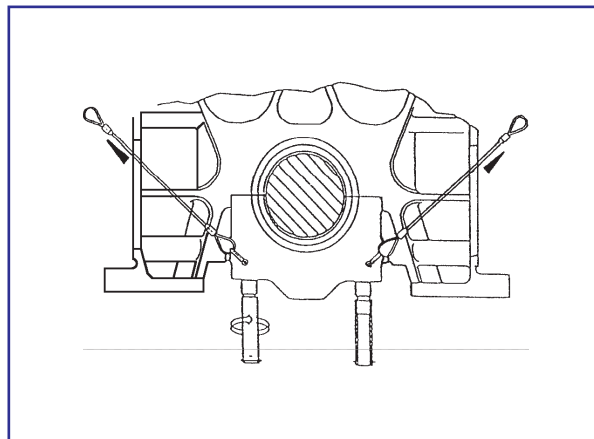


Fig 2 Mounting of Wire Straps

- 8) Lift the guide bearing cap a little and unscrew the bearing stud nut.
- 9) Fit guide tubes on the threads of the bearing studs and lower the bearing cap to make it rest on the collar of the guide tubes.

**Dismantling of the Guide Bearing Shells**

- 10) Remove the locking piece from the bearing cap and take out the bearing shell.

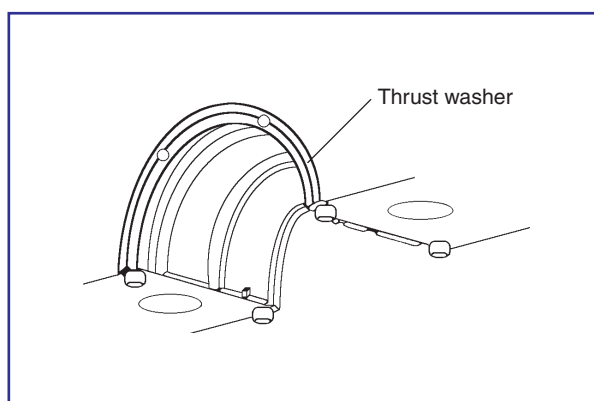
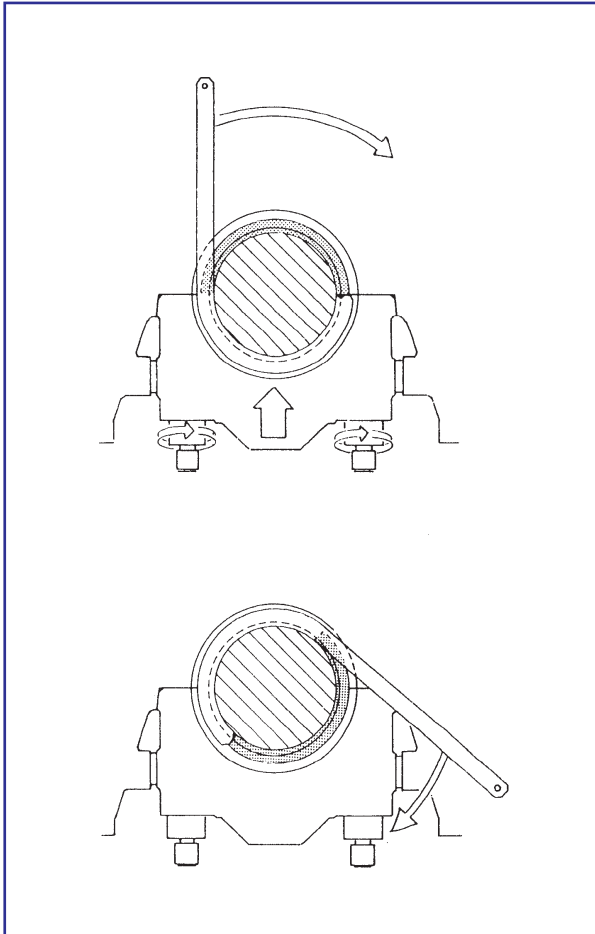


Fig 3 Guide Bearing with Thrust Washer

The thrust washer of the guide bearing is partially countersunk into the engine frame and attached by means of four screwed-on clamps which are visible after lowering the bearing cap, see fig 3.



**L+V28/32H***Fig 4 Dismounting of Upper Shell*

- 11) Unscrew the clamps and push out the thrust washers.
- 12) Fit the tools for dismantling of upper guide bearing shell, see fig 4, in the bearing cap and raise the bearing cap into position, making sure that the guide shell is not being damaged.

After that, dismount the guide tubes, fit and tighten the nuts slightly.

- 13) With the guide shell tool, which is guided by the bearing cap, the upper bearing shell is carefully turned out into the bearing cap. Then dismount the nuts and lower the bearing cap on the collar of the guide tubes. Take out the bearing shell and the guide shell tool.

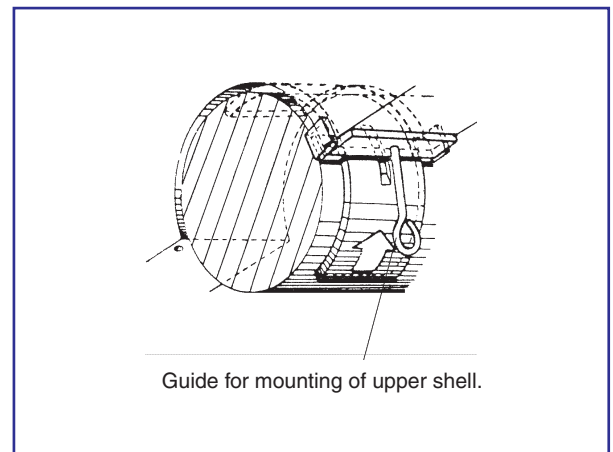
In case the guide shell tool is locked between guide bearing and bearing studs, use the bolt on the back of the guide shell tool to dislodge it.

### Cleaning of Components

- 14) Clean all machined surfaces, on frame, bearing cap, stud, nuts and bearing shells.

### Inspection of Guide Bearing Shells

- 15) Inspect the guide bearing shells according to working card 606-01.16.

*Fig 5 Mounting of Upper Shell in Guide Bearing*

### Mounting of the Guide Bearing Shells

The bearing shells of the guide bearing, which are identical to those of the main bearings, are narrower than the bore for the guide bearing and it is therefore essential that the shells are positioned perfectly correct in the bore.

For this purpose a guide tool is supplied for positioning on the engine frame when the upper bearing shell is to be fitted, see fig 5.

- 16) Push the bearing shell as far as possible into position through this guide tool.
- 17) Insert the guide shell tool in the bearing cap, which is resting on the collar of the guide tubes.

**L+V28/32H**

- 18)** Raise the bearing cap with the guide shell tool into its correct position, dismount the guide tubes, fit and tighten the bearing stud nuts slightly.
- 19)** Now push the bearing shell into its correct position with the guide shell tool. Make sure that the shell enters its correct position.
- 20)** Then unscrew the bearing stud nuts, fit the guide tubes and lower the bearing cap again.
- 21)** Fit the thrust washers and clamps.
- Note:** Clearance in guide bearing axially, see page 600.35.
- 22)** Lubricate the end of the bearing shells with molycote pasta or similar.
- 23)** Insert the lower bearing shell in the bearing cap, and mount the locking piece.

**Bearing Cap**

Lubricate the bearing shell and journal with clean lubricating oil.

- 24)** Raise the bearing cap into position, dismount the guide tubes, coat the bearing stud with molycote pasta or similar and fit the bearing stud nuts.
- Make sure that the thrust washers, bearing shell and bearing cap are in their correct position.
- 25)** Dismantle the wire straps.
- 26)** Mount the hydraulic tools, see working card 620-01.05, and tighten the nuts as prescribed on page 600-40.
- 27)** Coat the back side of the bracing screws' (side screws') hexagonal head with a thin coat of silastene or similar.
- 28)** Mount the screws and tighten with a torque spanner as indicated on page 600.40.

|                            |                         |                                 |
|----------------------------|-------------------------|---------------------------------|
| Working Card<br>Page 1 (3) | <b>Vibration Damper</b> | <b>610-04.00</b><br>Edition 01H |
|----------------------------|-------------------------|---------------------------------|

**General****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

**Description:**

Taking a silicone oil sample

**Starting position:****Related procedure:****Man power:**

Working time : 2-4 hours  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|           |          |       |

**Hand tools:**

Ring and open end spanner, 19 mm.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|           |          |        |

See plate 61004

## General

The vibration damper is equipped with extraction plugs which provide the opportunity of testing the viscosity of the silicone oil inside the damper without having to dismantle it.

Corresponding to the condition of the silicone oil an approximate assessment of the damper efficiency is possible.

A silicone oil sample should be extracted as follows by means of a special tube that can be required from MAN Diesel & Turbo, PrimeServ Holeby, see plate 61004.

1. After the engine is stopped let damper cool down to approximately 40°C.

2. For access to the damper remove the blank flange (A) on the front end cover (B) see fig. 1.

In some cases it is necessary to dismount the lub. oil pump or the cooling water pump, for access to the damper.

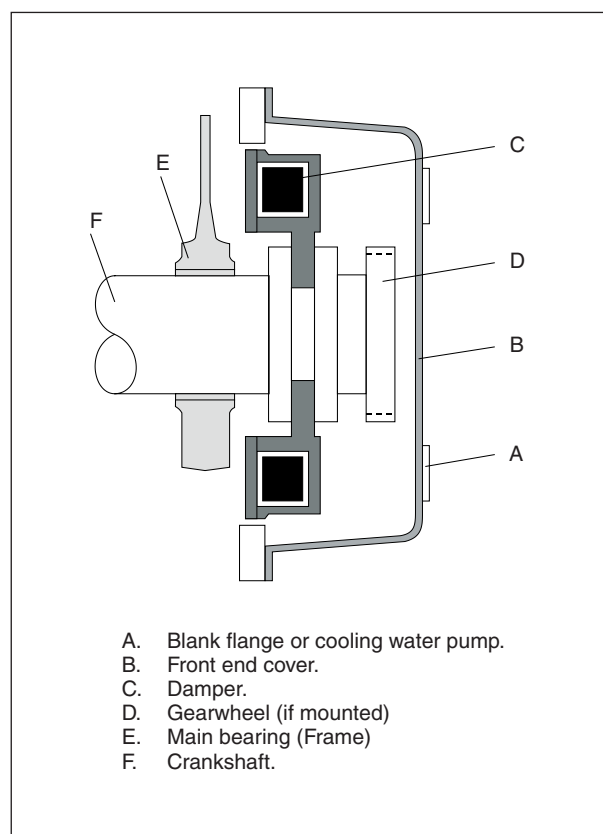


Fig. 1. Mounting of Vibration Damper.

3. Rotate the engine in order to bring the extraction plugs (6) of the damper in optimal position, see fig. 2 A.

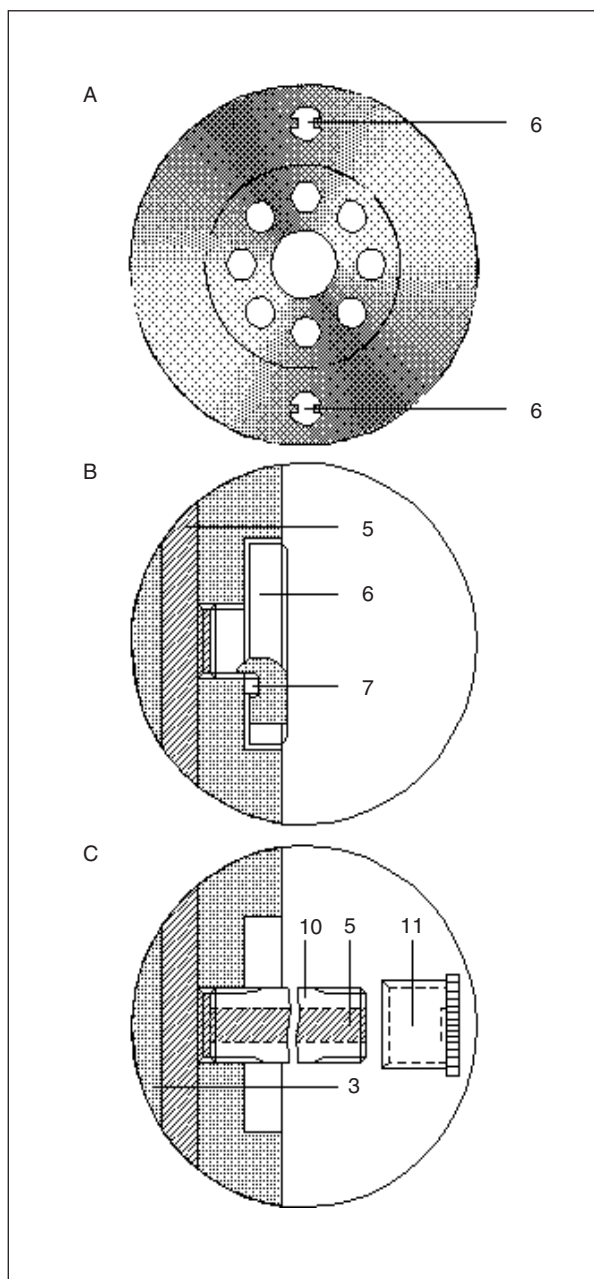


Fig. 2. Vibration Damper

4. Prepare the sample container (10) by removing one of its caps (11), see fig. 2 C.

**General**

5. Unscrew and remove one of the extraction plugs (6) and replace it with the sample container (10).

If meeting the inertia ring (3) unscrew the container one revolution.

6. Remove the second cap from the sample container and wait until silicone fluid (5) begins to flow out from the free end. Depending on the silicone viscosity the process needs a certain amount of time. If possible it, can be speeded up by means of:

- A Turning the damper until the sample container is underneath the crankshaft.
- B Temporarily removing the second extraction plug too.

7. As soon as the silicone fluid begins to flow, close the sample container by the cap. Remove the container from the damper casing, wipe off the sealing jace round the extraction hole and screw in the plugs together with new sealing washers (7). Now close the second side of the container.

8. Tighten both extraction plugs with thumb and forefinger then turn them further 45° (about 20 Nm). Seal both plugs by caulking their grooves.

9. Send the sample container to:

MAN Diesel & Turbo  
PrimeServ Holeby  
Østervej 2  
4960 Holeby  
Denmark

The sample must be marked in such a way that we can forward the result of the analysis correctly.

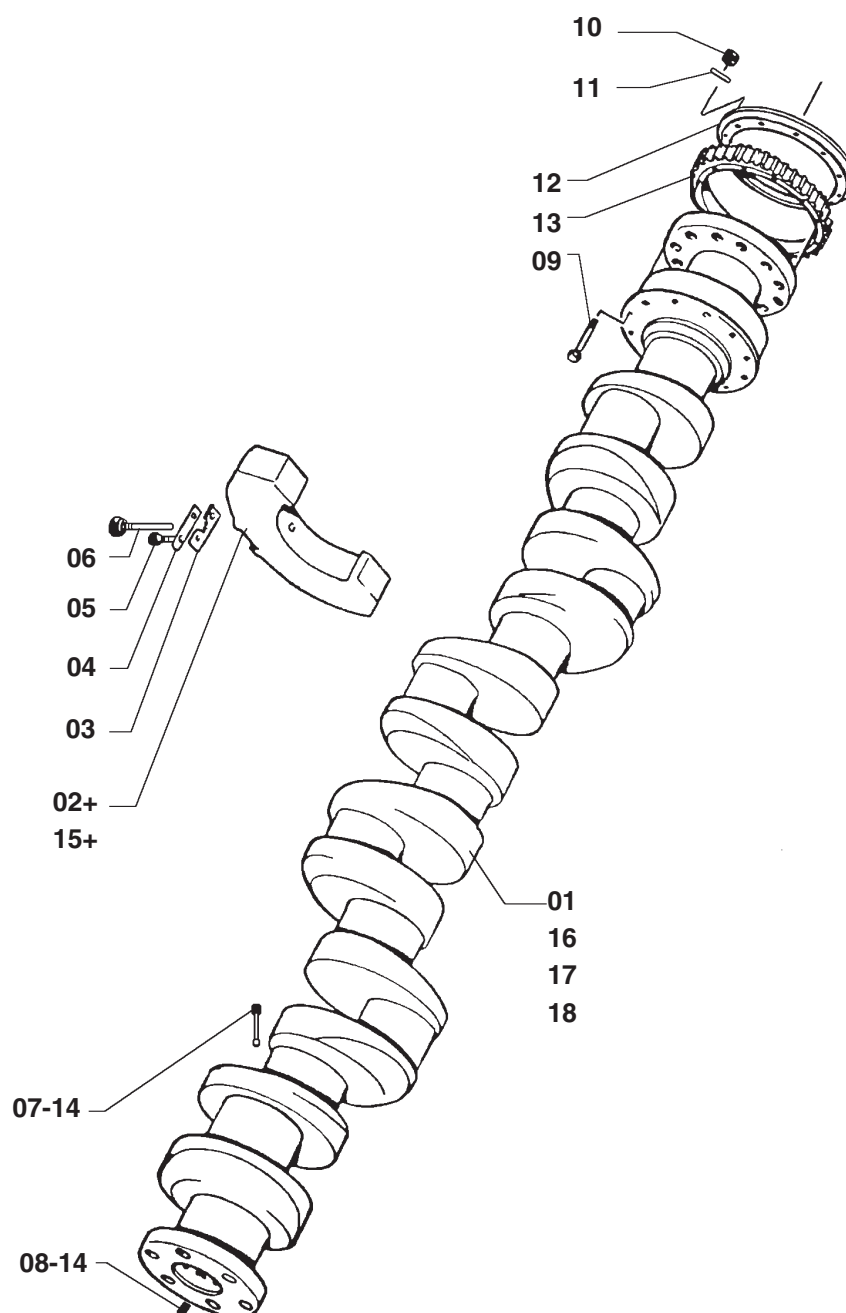
- Name of ship.
- Engine type.
- Engine no.
- Running hours.
- Data for vibration damper.

10. For hours between taking new samples, see page 600.25.

The quantity of silicone oil removed its so small that up to 10 such samples can be taken without risk.

|                     |                   |                  |
|---------------------|-------------------|------------------|
| Plate<br>Page 1 (2) | <b>Crankshaft</b> | <b>61001-15H</b> |
|---------------------|-------------------|------------------|

**L28/32H**



61001-15H

## Crankshaft

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation   | Benævnelse   | Item No. | Qty. | Designation | Benævnelse |
|----------|------|---|--|----------|------|-------------|------------|
| 01       | 1/E  | <b>Crankshaft<br/>6 cyl. engine</b>   | Krumtapaksel<br>6 cyl. motor   |          |      |             |            |
| 02+      | /I   | <b>Counterweight<br/>6,7,9 cyl. engine</b>  | Kontravægt<br>6,7,9 cyl. motor   |          |      |             |            |
| 03       | 1/W  | <b>Locking plate</b>  | Sikringsplade  |          |      |             |            |
| 04       | 1/W  | <b>Locking plate</b>  | Sikringsplade  |          |      |             |            |
| 05       | 2/W  | <b>Screw</b>  | Skrue  |          |      |             |            |
| 06       | 1/W  | <b>Screw for<br/>counterweight</b>  | Skrue for<br>kontravægt  |          |      |             |            |
| 07       | 1/C  | <b>Plug screw</b>   | Propskrue  |          |      |             |            |
| 08       | 1/E  | <b>Plug screw</b>   | Propskrue  |          |      |             |            |
| 09       | 12/E | <b>Screw</b>  | Skrue  |          |      |             |            |
| 10       | 12/E | <b>Self locking nut</b>   | Selvlåsende møtrik   |          |      |             |            |
| 11       | 12/E | <b>Washer</b>   | Skive  |          |      |             |            |
| 12       | 1/E  | <b>Oil throw ring</b>   | Olieafslyngningsring   |          |      |             |            |
| 13       | 1/E  | <b>Gear wheel<br/>(crankshaft)</b>  | Tandhjul<br>(krumtap)  |          |      |             |            |
| 14       | /I   | <b>Loctite 242</b>  | Loctite 242  |          |      |             |            |
| 15+      | /I   | <b>Counterweight<br/>8 cyl. engine</b>  | Kontravægt<br>8 cyl. motor   |          |      |             |            |
| 16       | 1/E  | <b>Crankshaft<br/>7 cyl. engine</b>   | Krumtapaksel<br>7 cyl. motor   |          |      |             |            |
| 17       | 1/E  | <b>Crankshaft<br/>8 cyl. engine</b>   | Krumtapaksel<br>8 cyl. motor   |          |      |             |            |
| 18       | 1/E  | <b>Crankshaft<br/>9 cyl. engine</b>   | Krumtapaksel<br>9 cyl. motor   |          |      |             |            |
|          |      | <b>+ Item No. 02 and 15<br/>require an individual<br/>matching before mounting<br/>contact MAN Diesel,<br/>Holeby</b> | <b>+ Item nr. 02 og 15<br/>kræver en individuel<br/>tilpasning før<br/>montering, kontakt<br/>MAN Diesel, Holeby</b> |          |      |             |            |

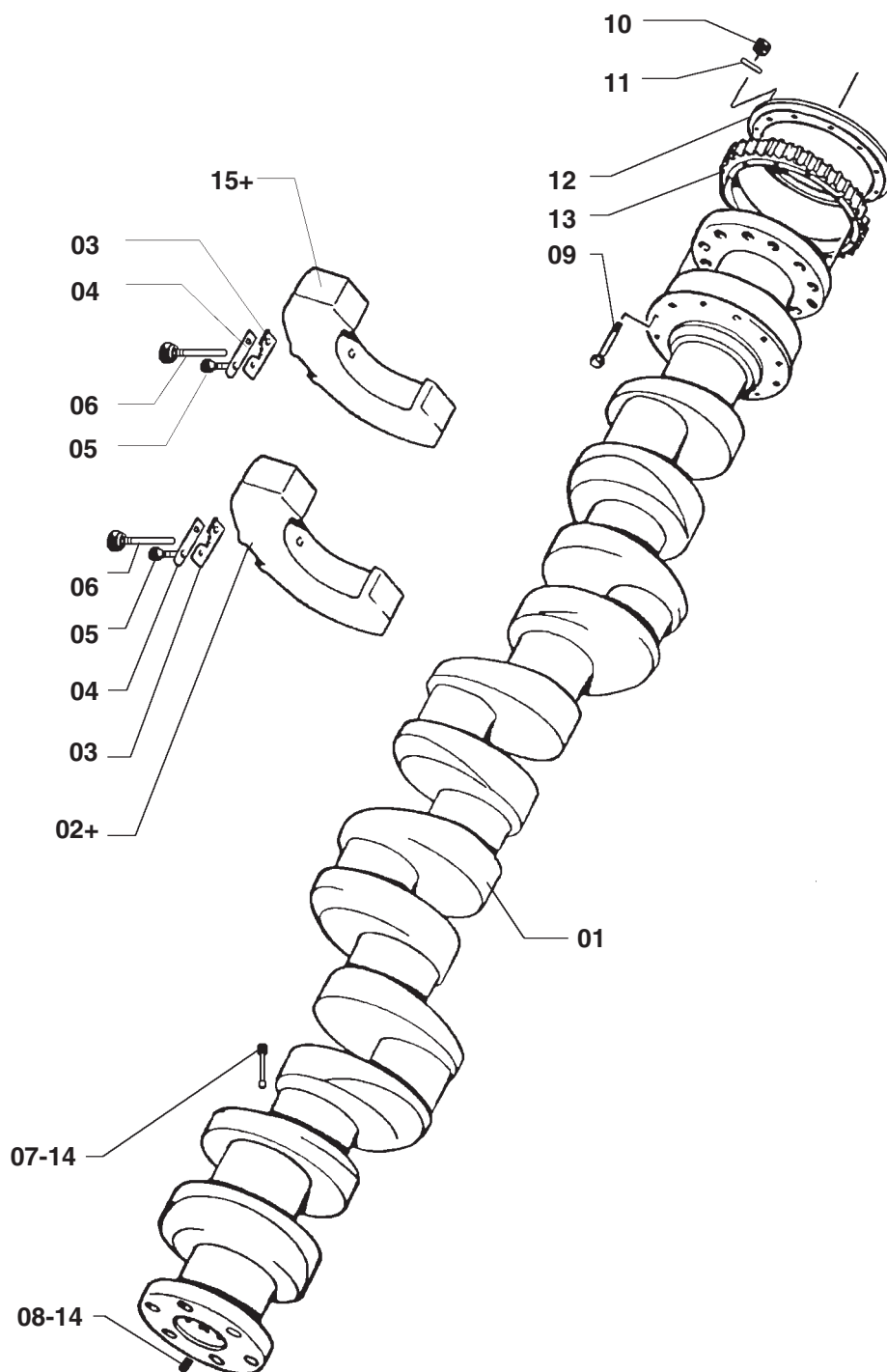
When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./W = Qty./Counterweight  
 Qty./I = Qty./Individual  
 Qty./C = Qty./Cylinder

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/W = Antal/Kontravægt  
 Antal/I = Antal/Individuelt  
 Antal/C = Antal/Cylinder

|                     |                   |                  |
|---------------------|-------------------|------------------|
| Plate<br>Page 1 (2) | <b>Crankshaft</b> | <b>61001-21H</b> |
|---------------------|-------------------|------------------|

**5L28/32H**



61001-21H

## Crankshaft

Plate  
Page 2 (2)

## 5L28/32H

| Item No. | Qty. | Designation   | Benævnelse           | Item No. | Qty. | Designation | Benævnelse |
|----------|------|---|----------------------|----------|------|-------------|------------|
| 01       | 1/E  | Crankshaft  | Krumtapaksel         |          |      |             |            |
| 02+      | /I   | Counterweight   | Kontravægt           |          |      |             |            |
| 03       | 1/W  | Locking plate   | Sikringsplade        |          |      |             |            |
| 04       | 1/W  | Locking plate   | Sikringsplade        |          |      |             |            |
| 05       | 2/W  | Screw   | Skrue                |          |      |             |            |
| 06       | 1/W  | Screw for counterweight   | Skrue for kontravægt |          |      |             |            |
| 07       | 1/C  | Plug screw  | Propskrue            |          |      |             |            |
| 08       | 1/E  | Plug screw  | Propskrue            |          |      |             |            |
| 09       | 12/E | Screw   | Skrue                |          |      |             |            |
| 10       | 12/E | Self locking nut  | Selvlåsende møtrik   |          |      |             |            |
| 11       | 12/E | Washer  | Skive                |          |      |             |            |
| 12       | 1/E  | Oil throw ring  | Olieafslyngningsring |          |      |             |            |
| 13       | 1/E  | Gear wheel (crankshaft)   | Tandhjul (krumtap)   |          |      |             |            |
| 14       | /I   | Loctite 242   | Loctite 242          |          |      |             |            |
| 15+      | /I   | Counterweight   | Kontravægt           |          |      |             |            |
|          |      | <b>+ Item No. 02 and 15 require an individual matching before mounting contact MAN Diesel, Holeby</b> |                      |          |      |             |            |
|          |      | + Item nr. 02 og 15 kræver en individuel tilpasning før montering, kontakt MAN Diesel, Holeby         |                      |          |      |             |            |

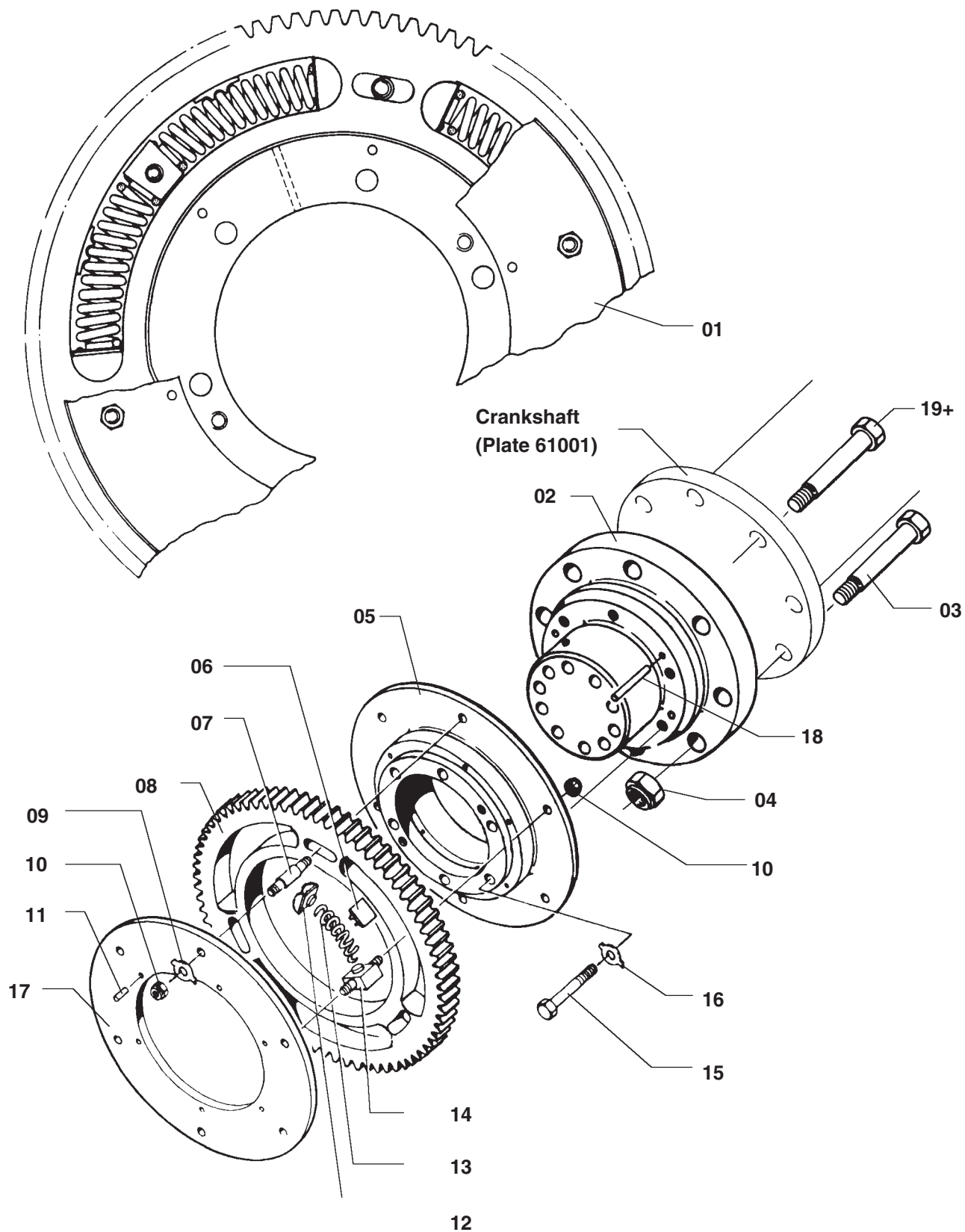
When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine  
Qty./W = Qty./Counterweight  
Qty./I = Qty./Individual  
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor  
Antal/W = Antal/Kontravægt  
Antal/I = Antal/Individuelt  
Antal/C = Antal/Cylinder

L28/32H



61002-07H

## Resilient Gear Wheel

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation   | Benævnelse  | Item No. | Qty. | Designation | Benævnelse |
|----------|------|---|---|----------|------|-------------|------------|
| 01       | 1/E  | <b>Resilient gear wheel, compl.</b>   | Fjedrende tandhjul, komplet   |          |      |             |            |
| 02       | 1/E  | <b>Axle journal</b>   | Akseltap  |          |      |             |            |
| 03       | 4/E  | <b>Screw</b>  | Skrue   |          |      |             |            |
| 04       | 6/E  | <b>Self locking nut, for Item No. 03 and 19</b>   | Selvlåsende møtrik, for Item nr. 03 og 19   |          |      |             |            |
| 05       | 1/E  | <b>Hub</b>  | Nav   |          |      |             |            |
| 06       | 6/E  | <b>Slide shoe</b>   | Glidesko  |          |      |             |            |
| 07       | 3/E  | <b>Distance piece</b>   | Afstandsstykke  |          |      |             |            |
| 08       | 1/E  | <b>Gear wheel</b>   | Tandhjul  |          |      |             |            |
| 09       | 12/E | <b>Locking washer for item No. 10</b>   | Låseblik for item nr. 10  |          |      |             |            |
| 10       | 12/E | <b>Nut</b>  | Møtrik  |          |      |             |            |
| 11       | 4/E  | <b>Cylindrical pin</b>  | Cylindrisk stift  |          |      |             |            |
| 12       | 6/E  | <b>Spring guide</b>   | Fjederstyr  |          |      |             |            |
| 13       | 6/E  | <b>Spring</b>   | Fjeder  |          |      |             |            |
| 14       | 3/E  | <b>Distance piece</b>   | Afstandsstykke  |          |      |             |            |
| 15       | 6/E  | <b>Screw</b>  | Skrue   |          |      |             |            |
| 16       | 6/E  | <b>Locking washer, for Item No. 15</b>  | Låseblik for Item nr. 15  |          |      |             |            |
| 17       | 1/E  | <b>Side plate</b>   | Sideplade   |          |      |             |            |
| 18       | 2/E  | <b>Cylindrical pin</b>  | Cylindrisk stift  |          |      |             |            |
| 19+      | 2/E  | <b>Fitted bolt</b>  | Pasbolt   |          |      |             |            |
|          |      | <b>+ Item 19 require an individual matching during mounting, contact MAN Diesel, Holeby</b> | + Item 19 kræver en individuel tilpasning før montering, kontakt MAN Diesel, Holeby |          |      |             |            |

When ordering spare parts, see also page 600.50.

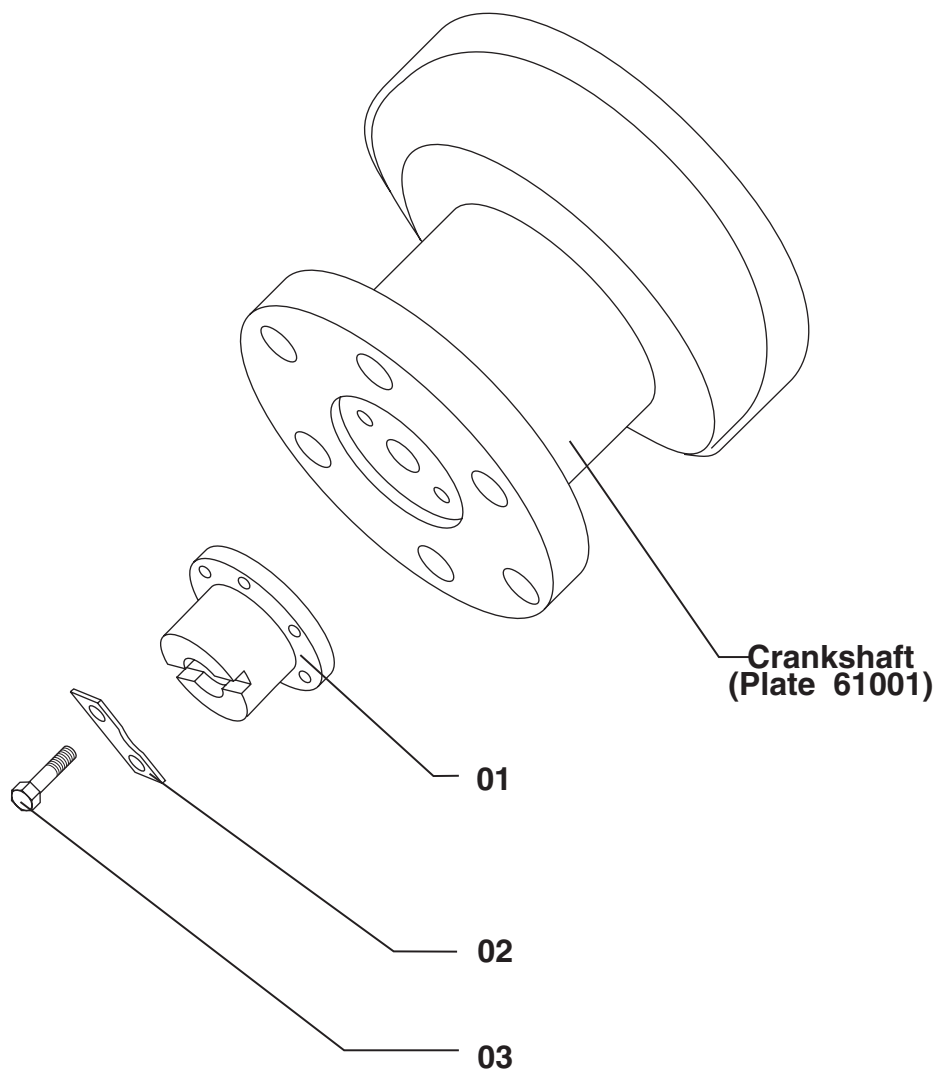
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

|                     |  |                  |
|---------------------|--|------------------|
| Plate<br>Page 1 (2) | <b>Coupling for Central Driven Lub. Oil Pump</b> | <b>61002-11H</b> |
|---------------------|--|------------------|

**6-7-8-9L28/32H**



|           |  |                     |
|-----------|--|---------------------|
| 61002-11H | <b>Coupling for Central Driven Lub. Oil Pump</b> | Plate<br>Page 2 (2) |
|-----------|--|---------------------|

## 6-7-8-9L28/32H

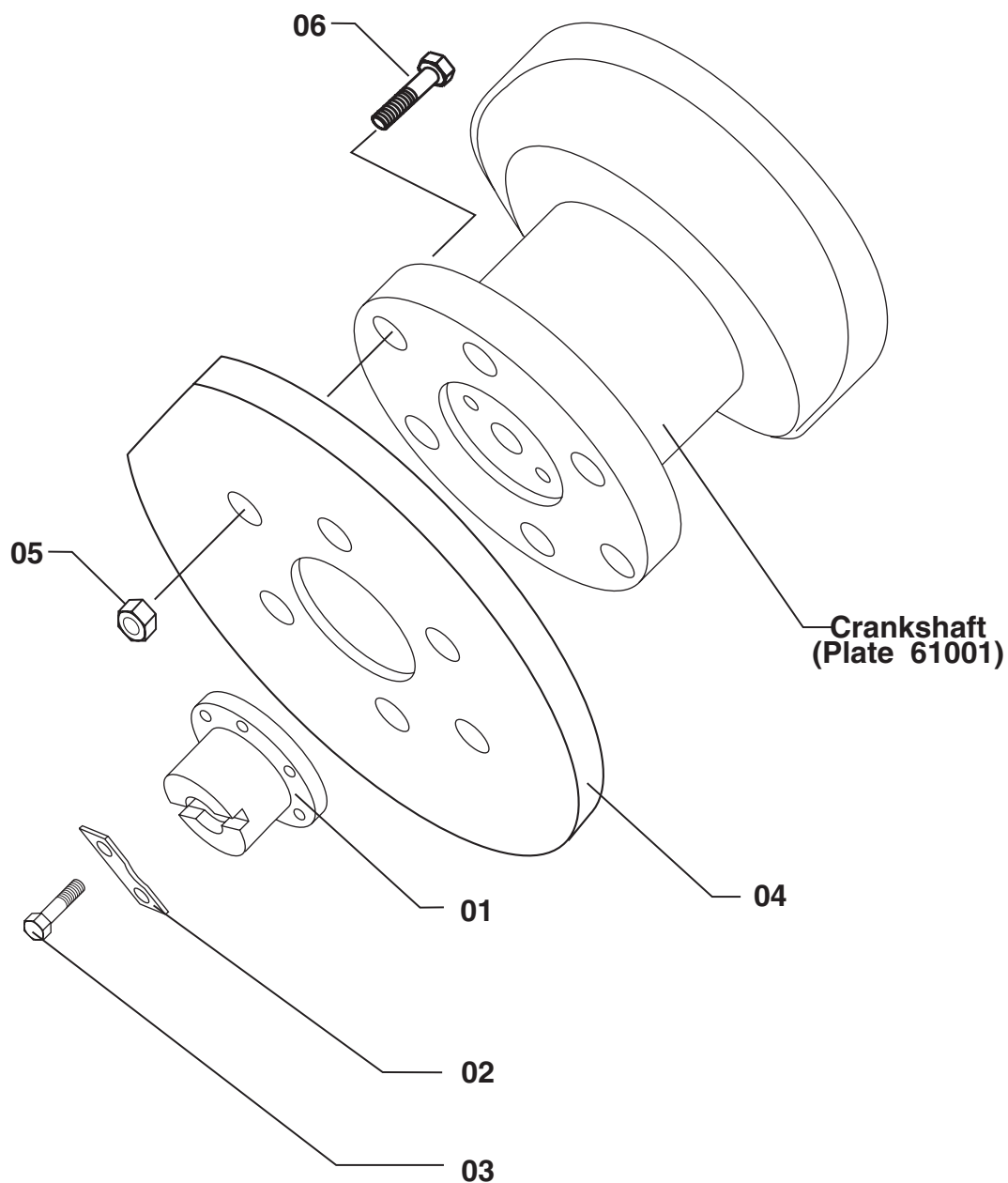
| Item No. | Qty. | Designation     | Benævnelse     |
|----------|------|-----------------|----------------|
| 01       | 1/E  | Coupling flange | Koblingsflange |
| 02       | 3/E  | Locking plate   | Låseplade      |
| 03       | 6/E  | Screw           | Skrue          |

**When ordering spare parts, see also page 600.50.**

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor

**5L28/32H**

|           |   |                     |
|-----------|---|---------------------|
| 61002-12H | Coupling for Central Driven Lub. Oil Pump | Plate<br>Page 2 (2) |
|-----------|---|---------------------|

## 5L28/32H

| Item No. | Qty. | Designation     | Benævnelse     | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-----------------|----------------|----------|------|-------------|------------|
| 01       | 1/E  | Coupling flange | Koblingsflange |          |      |             |            |
| 02       | 3/E  | Locking plate   | Låseplade      |          |      |             |            |
| 03       | 6/E  | Screw           | Skrue          |          |      |             |            |
| 04       | 1/E  | Flyweight       | Svingklods     |          |      |             |            |
| 05       | 6/E  | Nut             | Møtrik         |          |      |             |            |
| 06       | 6/E  | Screw           | Skrue          |          |      |             |            |

**When ordering spare parts, see also page 600.50.**

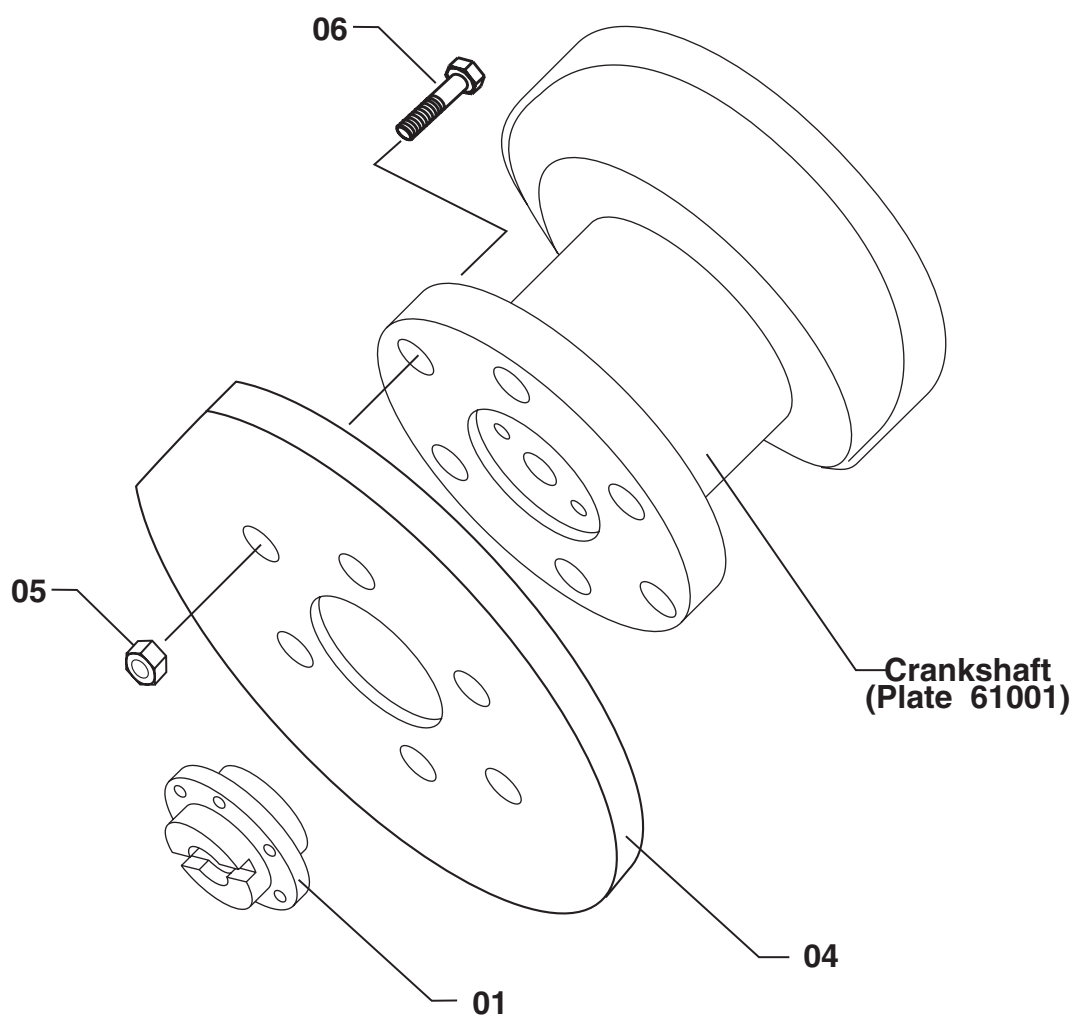
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor

|                     |  |                  |
|---------------------|--|------------------|
| Plate<br>Page 1 (2) | <b>Coupling for Central Driven Lub. Oil Pump</b> | <b>61002-13H</b> |
|---------------------|--|------------------|

**5L28/32H**





|           |   |                     |
|-----------|---|---------------------|
| 61002-13H | Coupling for Central Driven Lub. Oil Pump | Plate<br>Page 2 (2) |
|-----------|---|---------------------|

## 5L28/32H

| Item No. | Qty. | Designation     | Benævnelse     | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-----------------|----------------|----------|------|-------------|------------|
| 01       | 1/E  | Coupling flange | Koblingsflange |          |      |             |            |
| 04       | 1/E  | Flyweight       | Svingklods     |          |      |             |            |
| 05       | 6/E  | Nut             | Møtrik         |          |      |             |            |
| 06       | 6/E  | Screw           | Skrue          |          |      |             |            |

**When ordering spare parts, see also page 600.50.**

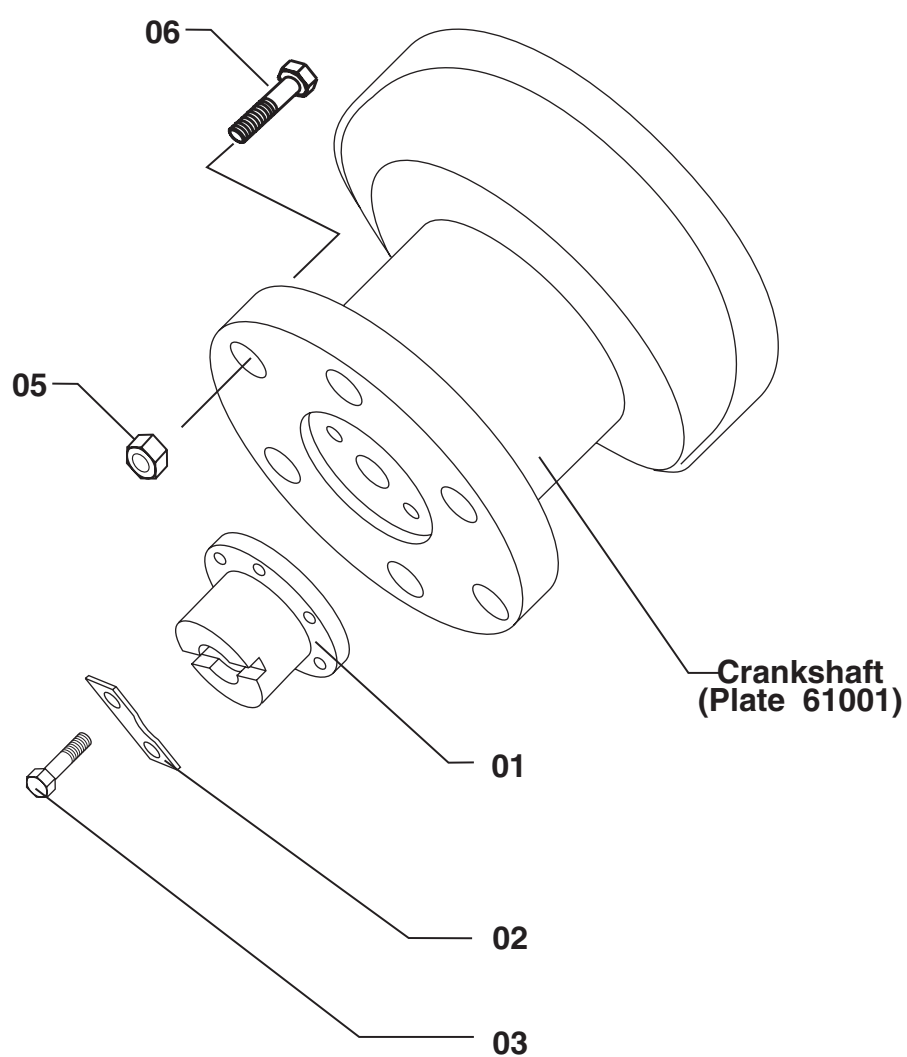
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor

|                     |  |                  |
|---------------------|--|------------------|
| Plate<br>Page 1 (2) | <b>Coupling for Central Driven Lub. Oil Pump</b> | <b>61002-14H</b> |
|---------------------|--|------------------|

**L28/32H**



|           |   |                     |
|-----------|---|---------------------|
| 61002-14H | Coupling for Central Driven Lub. Oil Pump | Plate<br>Page 2 (2) |
|-----------|---|---------------------|

## L28/32H

| Item No. | Qty. | Designation     | Benævnelse     | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-----------------|----------------|----------|------|-------------|------------|
| 01       | 1/E  | Coupling flange | Koblingsflange |          |      |             |            |
| 02       | 3/E  | Locking plate   | Låseplade      |          |      |             |            |
| 03       | 6/E  | Screw           | Skrue          |          |      |             |            |
| 05       | 6/E  | Nut             | Møtrik         |          |      |             |            |
| 06       | 6/E  | Screw           | Skrue          |          |      |             |            |

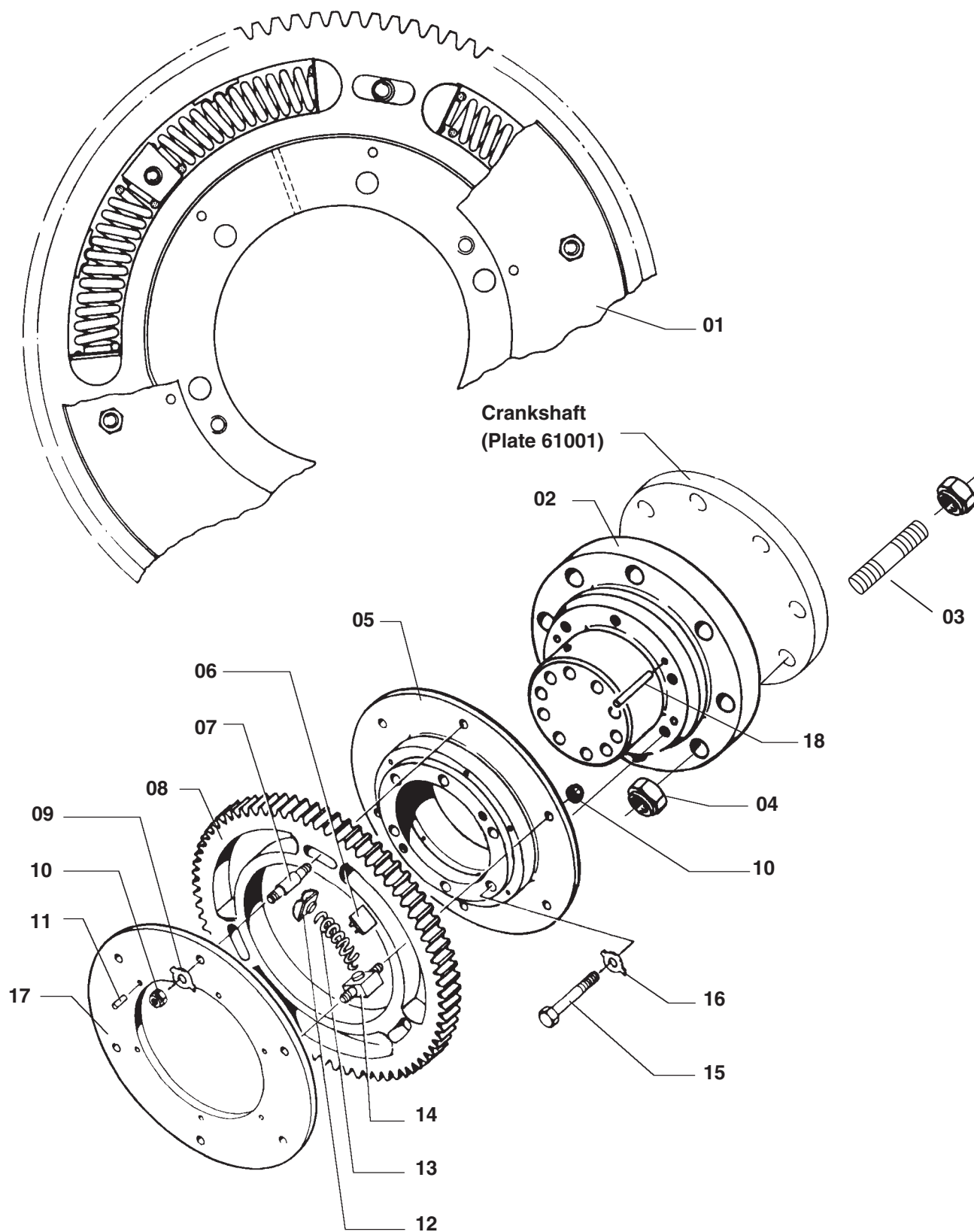
**When ordering spare parts, see also page 600.50.**

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor

L28/32H



**61002-15H****Resilient Gear Wheel**Plate  
Page 2 (2)**L28/32H**

| Item No. | Qty. | Designation                              | Benævnelse                          | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|-------------------------------------|----------|------|-------------|------------|
| 01       | 1/E  | <b>Resilient gear wheel, compl.</b>      | Fjedrende tandhjul, komplet         |          |      |             |            |
| 02       | 1/E  | <b>Axle journal</b>                      | Akseltap                            |          |      |             |            |
| 03       | 6/E  | <b>Stud</b>                              | Tap                                 |          |      |             |            |
| 04       | 12/E | <b>Self locking nut, for Item No. 03</b> | Selvlåsende møtrik, for Item nr. 03 |          |      |             |            |
| 05       | 1/E  | <b>Hub</b>                               | Nav                                 |          |      |             |            |
| 06       | 6/E  | <b>Slide shoe</b>                        | Glidesko                            |          |      |             |            |
| 07       | 3/E  | <b>Distance piece</b>                    | Afstandsstykke                      |          |      |             |            |
| 08       | 1/E  | <b>Gear wheel</b>                        | Tandhjul                            |          |      |             |            |
| 09       | 12/E | <b>Locking washer for item No. 10</b>    | Låseblik for item nr. 10            |          |      |             |            |
| 10       | 12/E | <b>Nut</b>                               | Møtrik                              |          |      |             |            |
| 11       | 4/E  | <b>Cylindrical pin</b>                   | Cylindrisk stift                    |          |      |             |            |
| 12       | 6/E  | <b>Spring guide</b>                      | Fjederstyr                          |          |      |             |            |
| 13       | 6/E  | <b>Spring</b>                            | Fjeder                              |          |      |             |            |
| 14       | 3/E  | <b>Distance piece</b>                    | Afstandsstykke                      |          |      |             |            |
| 15       | 6/E  | <b>Screw</b>                             | Skrue                               |          |      |             |            |
| 16       | 6/E  | <b>Locking washer, for Item No. 15</b>   | Låseblik for Item nr. 15            |          |      |             |            |
| 17       | 1/E  | <b>Side plate</b>                        | Sideplade                           |          |      |             |            |
| 18       | 2/E  | <b>Cylindrical pin</b>                   | Cylindrisk stift                    |          |      |             |            |

When ordering spare parts, see also page 600.50.

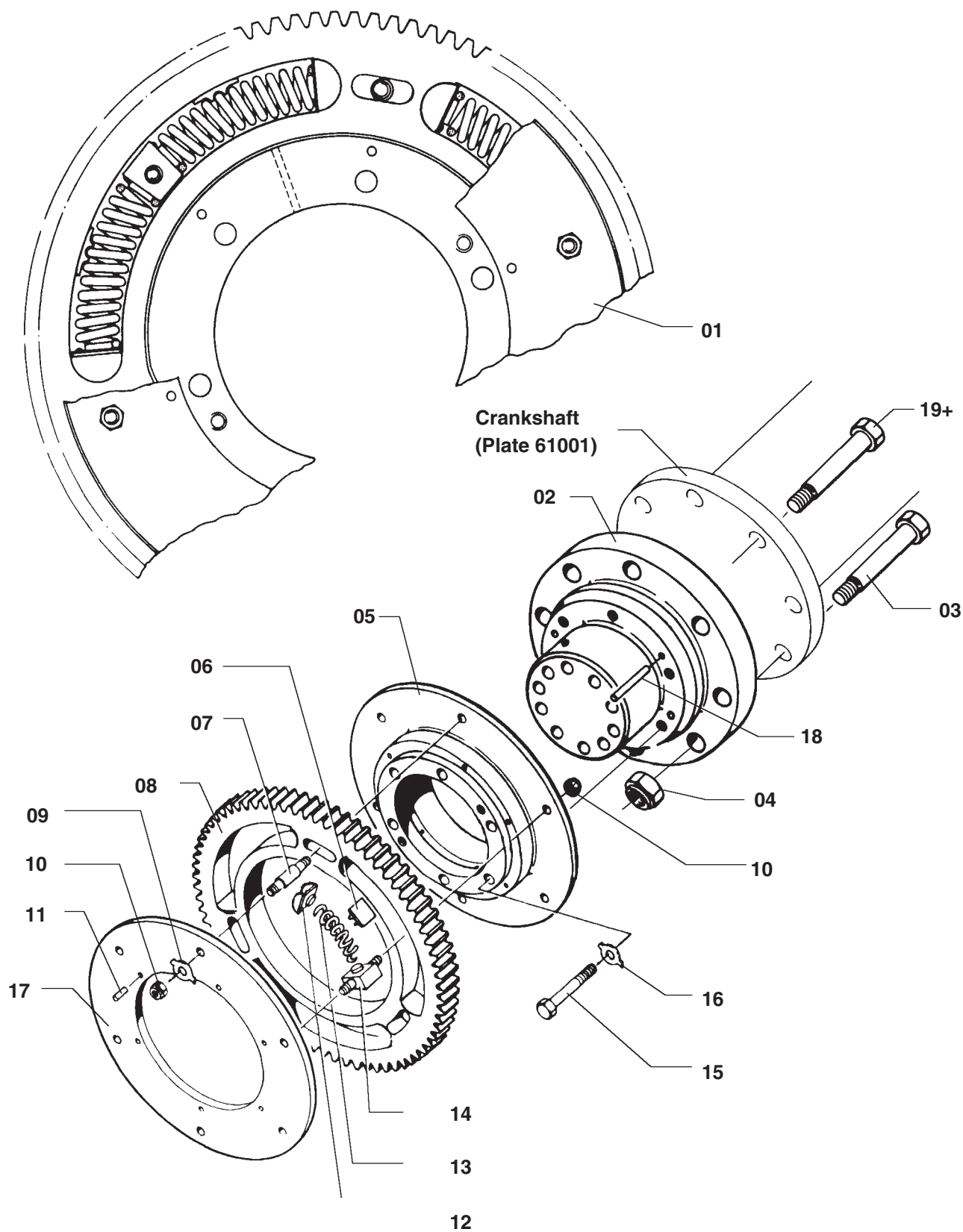
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

|                     |                             |                  |
|---------------------|-----------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Resilient Gear Wheel</b> | <b>61002-16H</b> |
|---------------------|-----------------------------|------------------|

**L28/32H**



**61002-16H****Resilient Gear Wheel**Plate  
Page 2 (2)**L28/32H**

| Item No. | Qty. | Designation   | Benævnelse  | Item No. | Qty. | Designation | Benævnelse |
|----------|------|---|---|----------|------|-------------|------------|
| 01       | 1/E  | <b>Resilient gear wheel, compl.</b>   | Fjedrende tandhjul, komplet   |          |      |             |            |
| 02       | 1/E  | <b>Axle journal</b>   | Akseltap  |          |      |             |            |
| 03       | 4/E  | <b>Screw</b>  | Skrue   |          |      |             |            |
| 04       | 6/E  | <b>Self locking nut, for Item No. 03 and 19</b>   | Selvlåsende møtrik, for Item nr. 03 og 19   |          |      |             |            |
| 05       | 1/E  | <b>Hub</b>  | Nav   |          |      |             |            |
| 06       | 6/E  | <b>Slide shoe</b>   | Glidesko  |          |      |             |            |
| 07       | 3/E  | <b>Distance piece</b>   | Afstandsstykke  |          |      |             |            |
| 08       | 1/E  | <b>Gear wheel</b>   | Tandhjul  |          |      |             |            |
| 09       | 12/E | <b>Locking washer for item No. 10</b>   | Låseblik for item nr. 10  |          |      |             |            |
| 10       | 12/E | <b>Nut</b>  | Møtrik  |          |      |             |            |
| 11       | 4/E  | <b>Cylindrical pin</b>  | Cylindrisk stift  |          |      |             |            |
| 12       | 6/E  | <b>Spring guide</b>   | Fjederstyr  |          |      |             |            |
| 13       | 6/E  | <b>Spring</b>   | Fjeder  |          |      |             |            |
| 14       | 3/E  | <b>Distance piece</b>   | Afstandsstykke  |          |      |             |            |
| 15       | 6/E  | <b>Screw</b>  | Skrue   |          |      |             |            |
| 16       | 6/E  | <b>Locking washer, for Item No. 15</b>  | Låseblik for Item nr. 15  |          |      |             |            |
| 17       | 1/E  | <b>Side plate</b>   | Sideplade   |          |      |             |            |
| 18       | 2/E  | <b>Cylindrical pin</b>  | Cylindrisk stift  |          |      |             |            |
| 19+      | 2/E  | <b>Fitted bolt</b>  | Pasbolt   |          |      |             |            |
|          |      | <b>+ Item 19 require an individual matching during mounting, contact MAN diesel, Holeby</b> | + Item 19 kræver en individuel tilpasning før montering, kontakt MAN Diesel, Holeby |          |      |             |            |

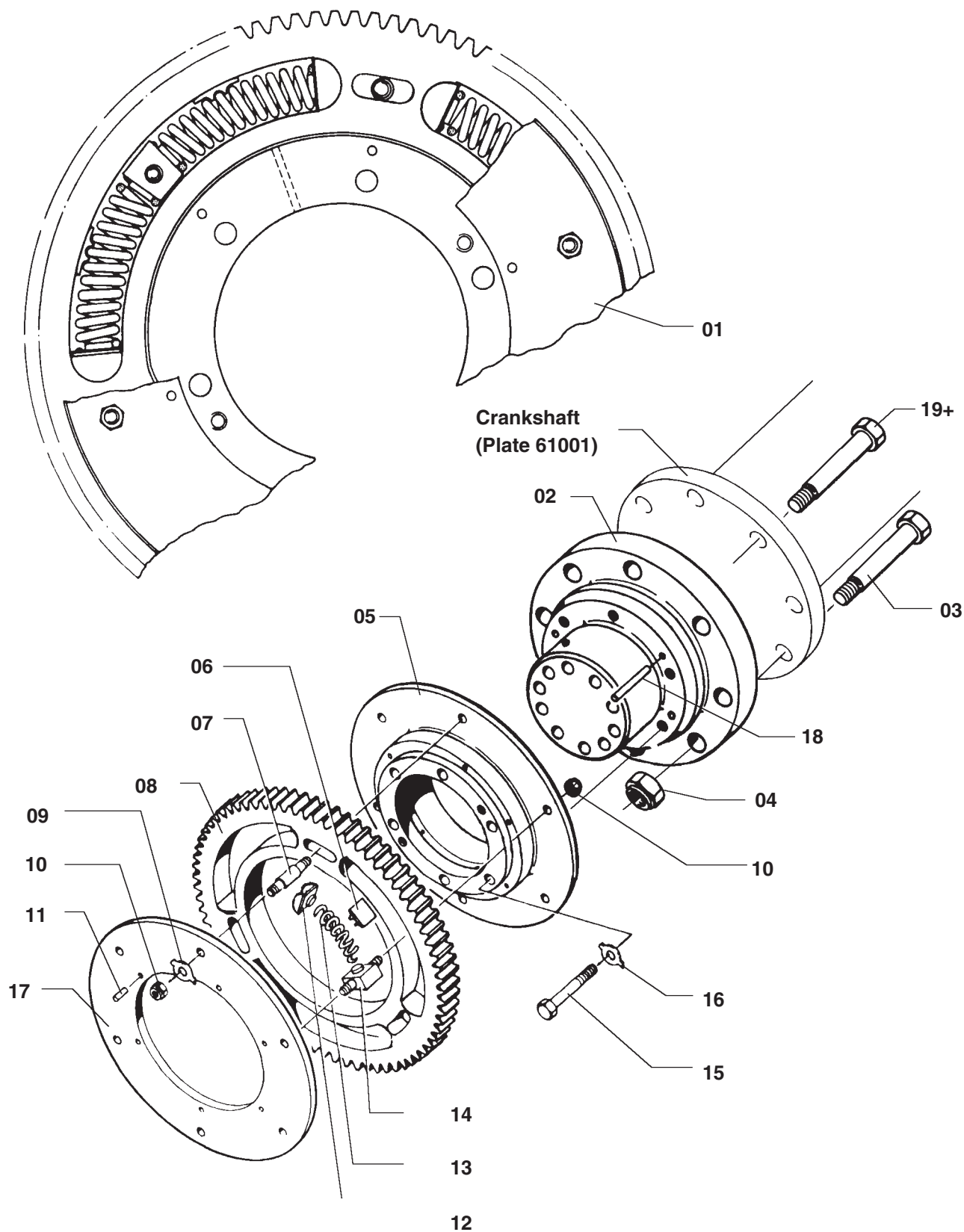
When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

L28/32H





**61002-17H****Resilient Gear Wheel**Plate  
Page 2 (2)**L28/32H**

| Item No. | Qty. | Designation   | Benævnelse  | Item No. | Qty. | Designation | Benævnelse |
|----------|------|---|---|----------|------|-------------|------------|
| 01       | 1/E  | <b>Resilient gear wheel, compl.</b>   | Fjedrende tandhjul, komplet   |          |      |             |            |
| 02       | 1/E  | <b>Axle journal</b>   | Akseltap  |          |      |             |            |
| 03       | 4/E  | <b>Screw</b>  | Skrue   |          |      |             |            |
| 04       | 6/E  | <b>Self locking nut, for Item No. 03 and 19</b>   | Selvlåsende møtrik, for Item nr. 03 og 19   |          |      |             |            |
| 05       | 1/E  | <b>Hub</b>  | Nav   |          |      |             |            |
| 06       | 6/E  | <b>Slide shoe</b>   | Glidesko  |          |      |             |            |
| 07       | 3/E  | <b>Distance piece</b>   | Afstandsstykke  |          |      |             |            |
| 08       | 1/E  | <b>Gear wheel</b>   | Tandhjul  |          |      |             |            |
| 09       | 12/E | <b>Locking washer for item No. 10</b>   | Låseblik for item nr. 10  |          |      |             |            |
| 10       | 12/E | <b>Nut</b>  | Møtrik  |          |      |             |            |
| 11       | 4/E  | <b>Cylindrical pin</b>  | Cylindrisk stift  |          |      |             |            |
| 12       | 6/E  | <b>Spring guide</b>   | Fjederstyr  |          |      |             |            |
| 13       | 6/E  | <b>Spring</b>   | Fjeder  |          |      |             |            |
| 14       | 3/E  | <b>Distance piece</b>   | Afstandsstykke  |          |      |             |            |
| 15       | 6/E  | <b>Screw</b>  | Skrue   |          |      |             |            |
| 16       | 6/E  | <b>Locking washer, for Item No. 15</b>  | Låseblik for Item nr. 15  |          |      |             |            |
| 17       | 1/E  | <b>Side plate</b>   | Sideplade   |          |      |             |            |
| 18       | 2/E  | <b>Cylindrical pin</b>  | Cylindrisk stift  |          |      |             |            |
| 19+      | 2/E  | <b>Fitted bolt</b>  | Pasbolt   |          |      |             |            |
|          |      | <b>+ Item 19 require an individual matching during mounting, contact MAN Diesel, Holeby</b> | + Item 19 kræver en individuel tilpasning før montering, kontakt MAN Diesel, Holeby |          |      |             |            |

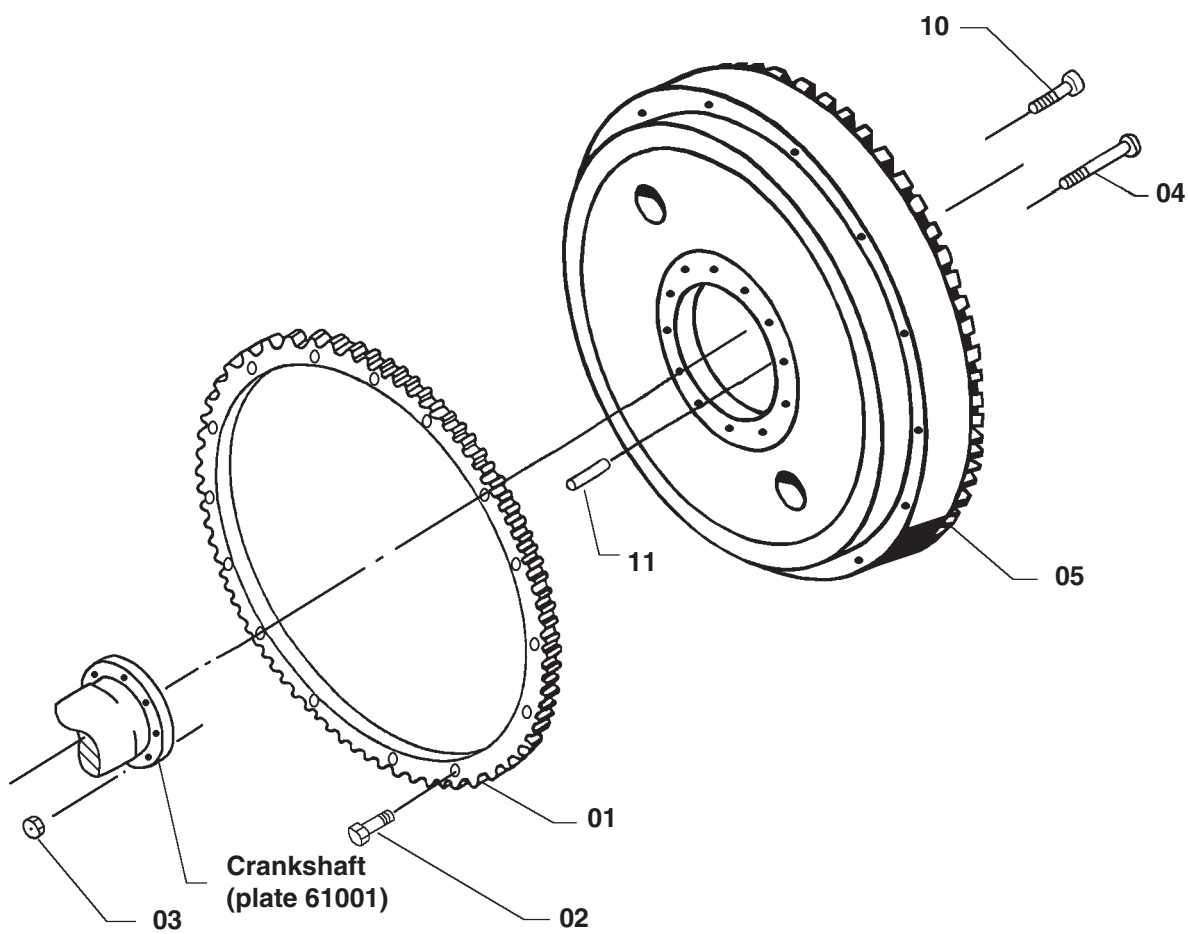
When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

5L28/32H



|           |                        |                     |
|-----------|------------------------|---------------------|
| 61003-02H | Flywheel with Gear Rim | Plate<br>Page 2 (2) |
|-----------|------------------------|---------------------|

## 5L28/32H

| Item No. | Qty. | Designation                       | Benævnelse                        | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-----------------------------------|-----------------------------------|----------|------|-------------|------------|
| 01       | 1/E  | Gear rim 2/2                      | Tandkrans 2/2                     |          |      |             |            |
| 02       | 18/E | Screw                             | Skrue                             |          |      |             |            |
| 03       | 12/E | Self locking nut, for item no. 04 | Selvlående møtrik for item nr. 04 |          |      |             |            |
| 04       | 12/E | Screw                             | Skrue                             |          |      |             |            |
| 05       | 1/E  | Flywheel                          | Svinghjul                         |          |      |             |            |
| 10       | 2/E  | Screw                             | Skrue                             |          |      |             |            |
| 11       | 1/E  | Guide pin                         | Styrestift                        |          |      |             |            |

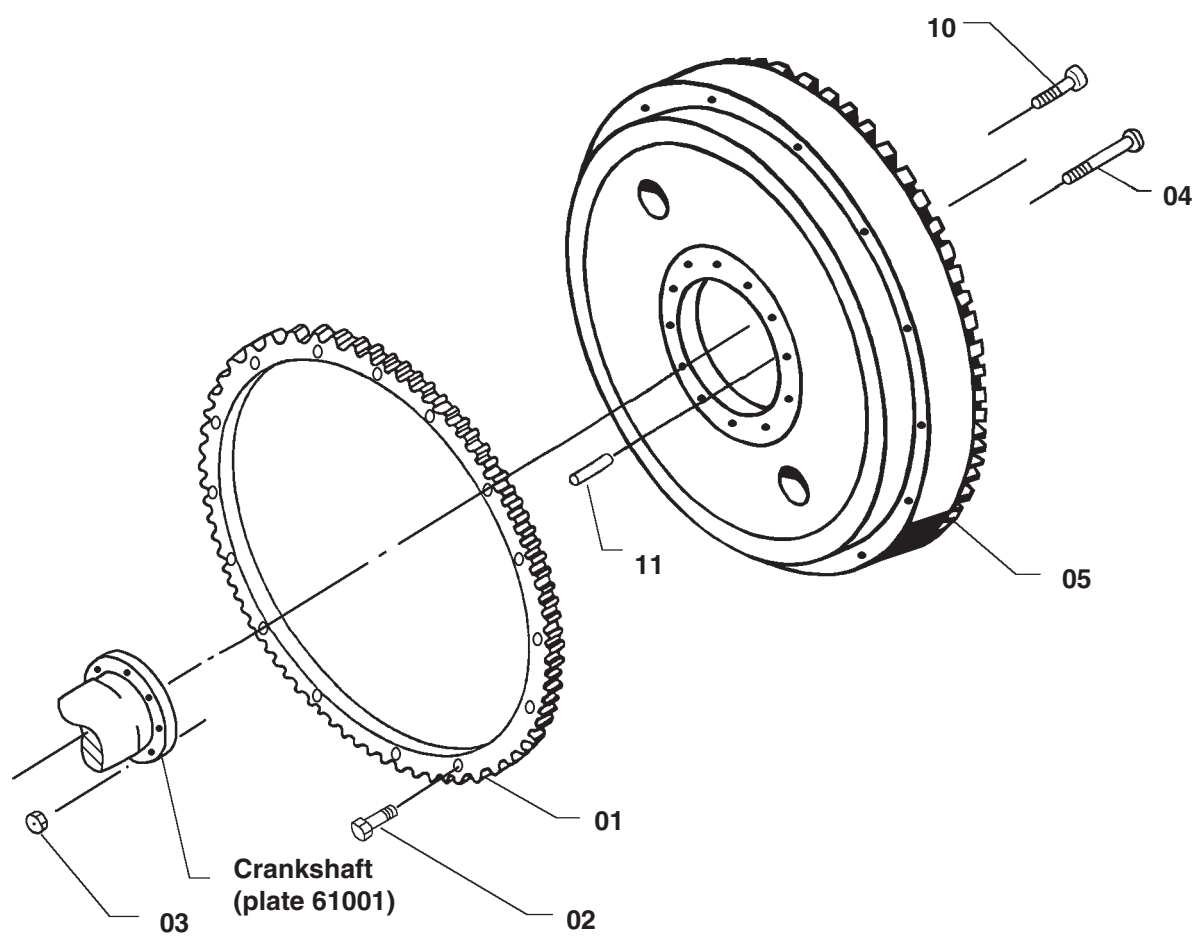
When ordering spare parts, see also page 600.50.

$$\text{Qty./E} = \text{Qty./Engine}$$

Ved bestilling af reservedele, se også side 600.50.

$$\text{Qty./E} = \text{Antal/Motor}$$

L28/32H



|           |                               |                     |
|-----------|-------------------------------|---------------------|
| 61003-05H | <b>Flywheel with Gear Rim</b> | Plate<br>Page 2 (2) |
|-----------|-------------------------------|---------------------|

**L28/32H**

| Item No. | Qty. | Designation                       | Benævnelse                        | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-----------------------------------|-----------------------------------|----------|------|-------------|------------|
| 01       | 1/E  | Gear rim 2/2                      | Tandkrans 2/2                     |          |      |             |            |
| 02       | 18/E | Screw                             | Skrue                             |          |      |             |            |
| 03       | 12/E | Self locking nut, for item no. 04 | Selvlående møtrik for item nr. 04 |          |      |             |            |
| 04       | 12/E | Screw                             | Skrue                             |          |      |             |            |
| 05       | 1/E  | Flywheel                          | Svinghjul                         |          |      |             |            |
| 10       | 2/E  | Screw                             | Skrue                             |          |      |             |            |
| 11       | 1/E  | Guide pin                         | Styrestift                        |          |      |             |            |

When ordering spare parts, see also page 600.50.

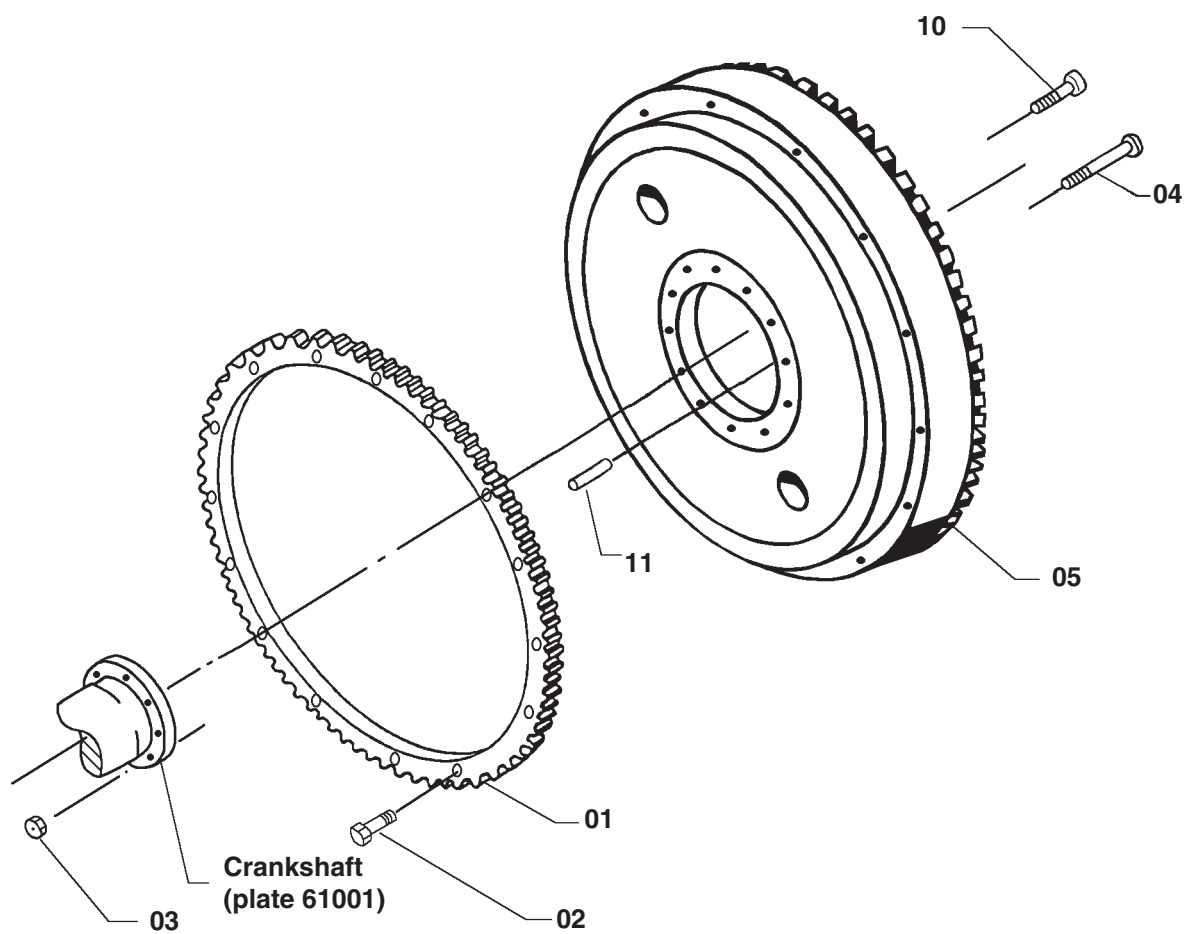
$$\text{Qty./E} = \text{Qty./Engine}$$

Ved bestilling af reservedele, se også side 600.50.

$$\text{Qty./E} = \text{Antal/Motor}$$

|                     |                               |                  |
|---------------------|-------------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Flywheel with Gear Rim</b> | <b>61003-06H</b> |
|---------------------|-------------------------------|------------------|

**L28/32H**



|           |                        |                     |
|-----------|------------------------|---------------------|
| 61003-06H | Flywheel with Gear Rim | Plate<br>Page 2 (2) |
|-----------|------------------------|---------------------|

## L28/32H

| Item No. | Qty. | Designation                       | Benævnelse                        | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-----------------------------------|-----------------------------------|----------|------|-------------|------------|
| 01       | 1/E  | Gear rim 2/2                      | Tandkrans 2/2                     |          |      |             |            |
| 02       | 18/E | Screw                             | Skrue                             |          |      |             |            |
| 03       | 12/E | Self locking nut, for item no. 04 | Selvlående møtrik for item nr. 04 |          |      |             |            |
| 04       | 12/E | Screw                             | Skrue                             |          |      |             |            |
| 05       | 1/E  | Flywheel                          | Svinghjul                         |          |      |             |            |
| 10       | 2/E  | Screw                             | Skrue                             |          |      |             |            |
| 11       | 1/E  | Guide pin                         | Styrestift                        |          |      |             |            |

When ordering spare parts, see also page 600.50.

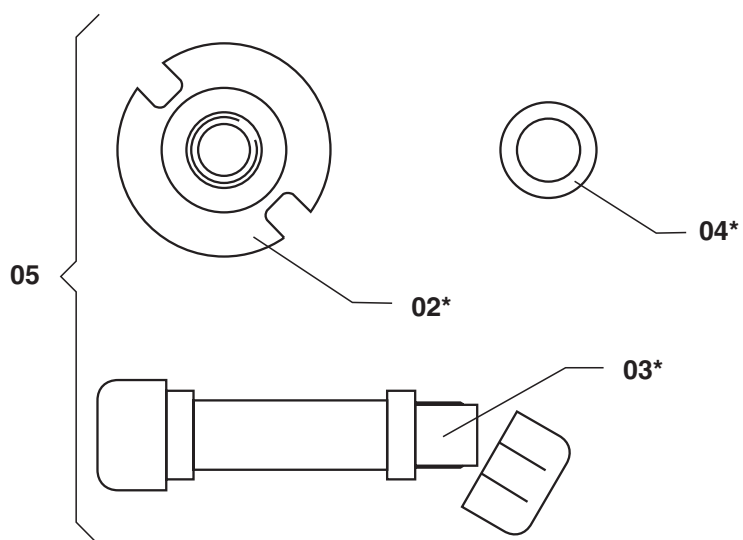
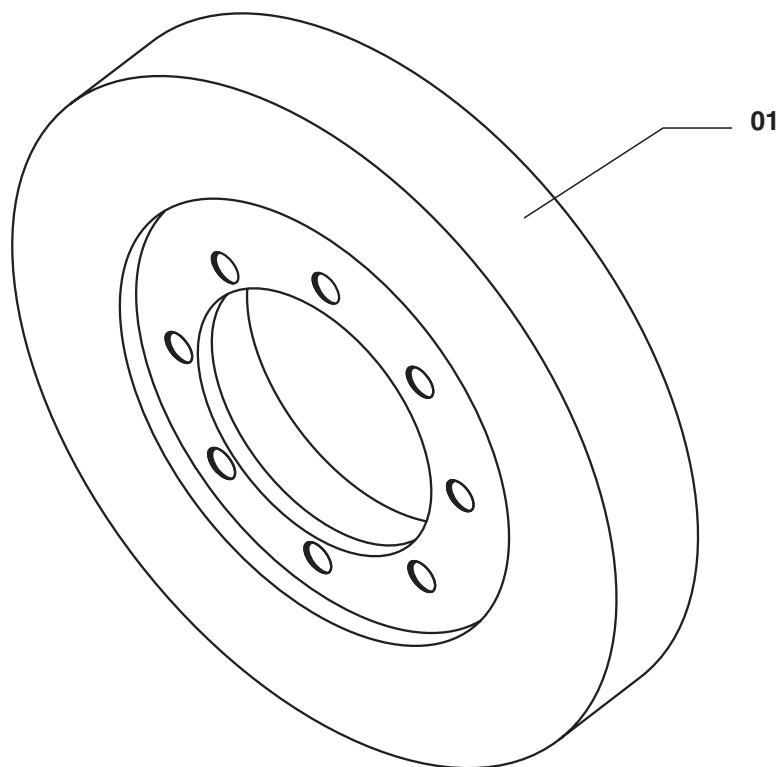
$$\text{Qty./E} = \text{Qty./Engine}$$

Ved bestilling af reservedele, se også side 600.50.

$$\text{Qty./E} = \text{Antal/Motor}$$

|                     |                                   |                  |
|---------------------|-----------------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Torsional Vibration Damper</b> | <b>61004-05H</b> |
|---------------------|-----------------------------------|------------------|

**L28/32H**





| Item No. | Qty. | Designation  | Benævnelse   |
|----------|------|--|--|
| 01       | 1/E  | <b>Torsional vibration damper, with 30 mm mounting flange</b>  | Svingningsdæmper med 30 mm monterings-flange   |
| 02*      | 1/E  | <b>Plug screw</b>  | Propskrue  |
| 03*      | 1/E  | <b>Sample container</b>  | Prøveudtagings-beholder  |
| 04*      | 1/E  | <b>O-ring</b>  | O-ring   |
| 05+      |      | <b>Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)</b> | Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet) |
|          |      | <b>+ See also working card 610-04.00</b>   | <b>+ Se også arbejdskort 610-04.00</b>   |

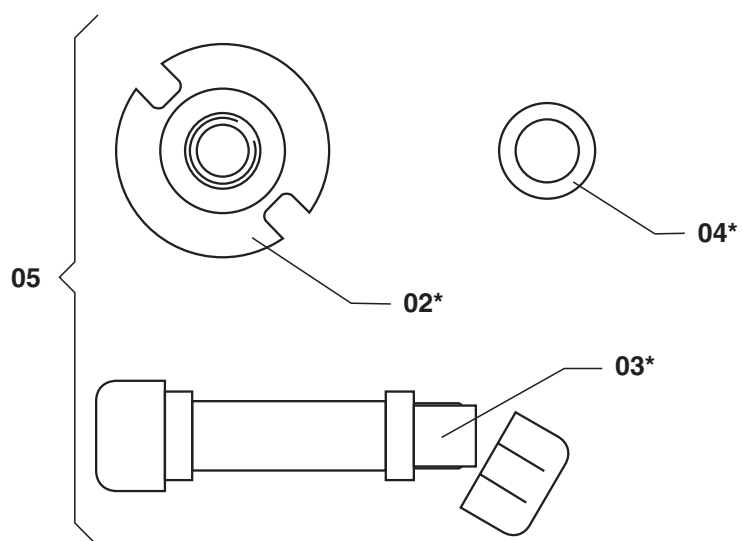
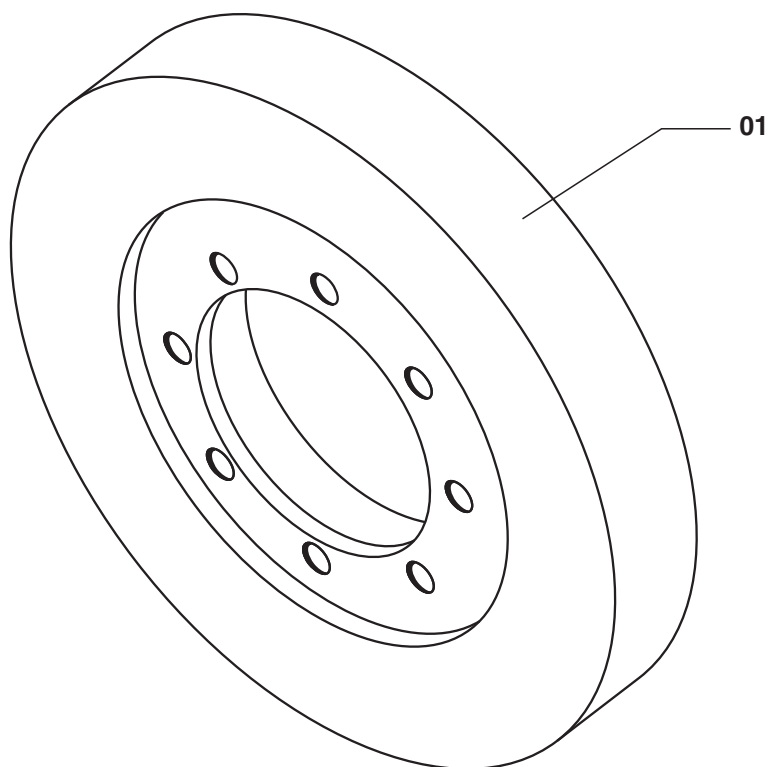
| Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|
|          |      |             |            |

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor

|                     |                                   |                  |
|---------------------|-----------------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Torsional Vibration Damper</b> | <b>61004-12H</b> |
|---------------------|-----------------------------------|------------------|

**L28/32H**



61004-12H

## Torsional Vibration Damper

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation  | Benævnelse   | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|--|----------|------|-------------|------------|
| 01       | 1/E  | <b>Torsional vibration damper, with 30 mm mounting flange</b>  | Svingningsdæmper med 30 mm monterings-flange   |          |      |             |            |
| 02*      | 1/E  | <b>Plug screw</b>  | Propskrue  |          |      |             |            |
| 03*      | 1/E  | <b>Sample container</b>  | Prøveudtagings-beholder  |          |      |             |            |
| 04*      | 1/E  | <b>O-ring</b>  | O-ring   |          |      |             |            |
| 05+      |      | <b>Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)</b> | Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet) |          |      |             |            |
|          |      | <b>+ See also working card 610-04.00</b>   | + Se også arbejdskort 610-04.00  |          |      |             |            |

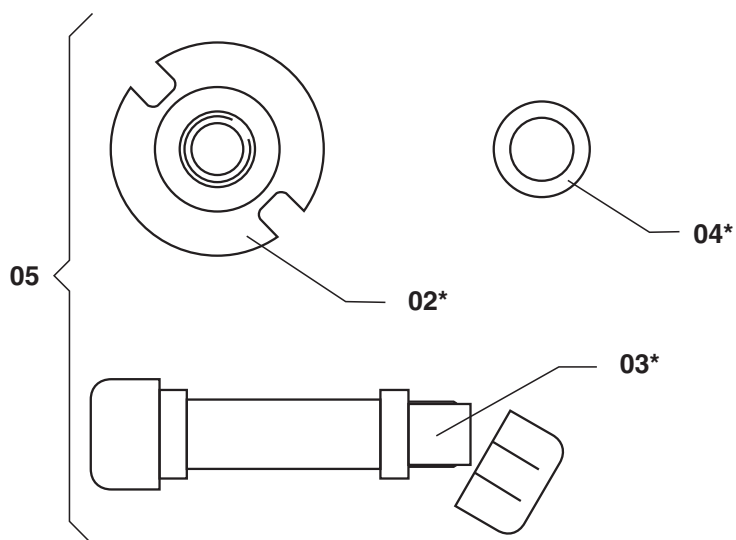
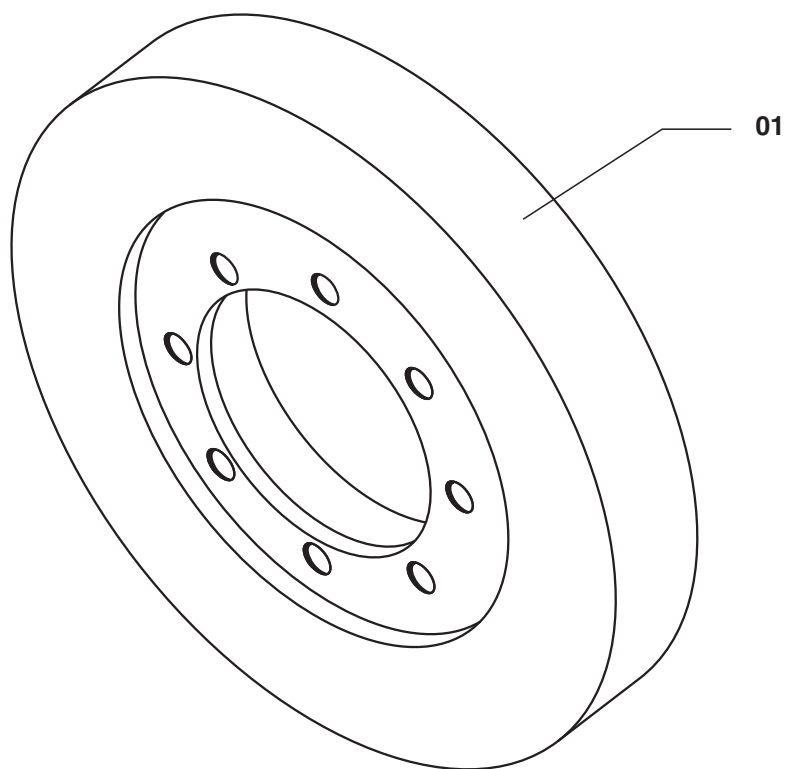
When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

L28/32H



61004-13H

**Torsional Vibration Damper**Plate  
Page 2 (2)**L28/32H**

| Item No. | Qty. | Designation  | Benævnelse   | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|--|----------|------|-------------|------------|
| 01       | 1/E  | <b>Torsional vibration damper, with 30 mm mounting flange</b>  | Svingningsdæmper med 30 mm monterings-flange   |          |      |             |            |
| 02*      | 1/E  | <b>Plug screw</b>  | Propskrue  |          |      |             |            |
| 03*      | 1/E  | <b>Sample container</b>  | Prøveudtagings-beholder  |          |      |             |            |
| 04*      | 1/E  | <b>O-ring</b>  | O-ring   |          |      |             |            |
| 05+      |      | <b>Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)</b> | Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet) |          |      |             |            |
|          |      | <b>+ See also working card 610-04.00</b>   | + Se også arbejdskort 610-04.00  |          |      |             |            |

When ordering spare parts, see also page 600.50.

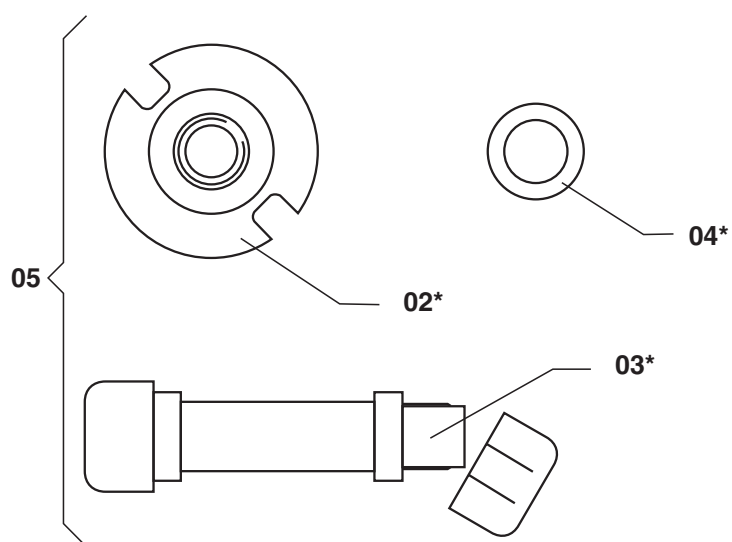
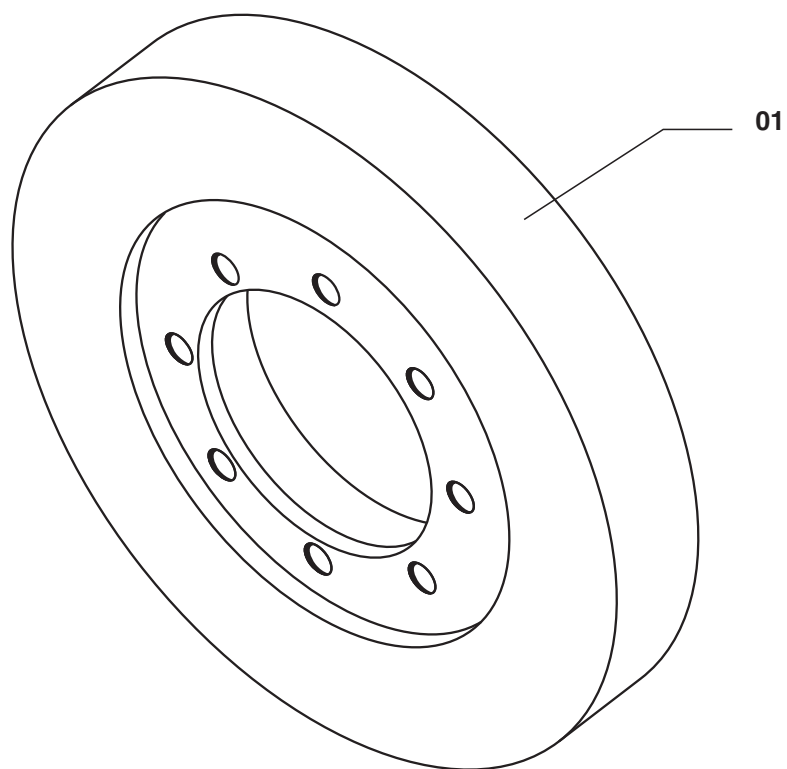
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

|                     |                                   |                  |
|---------------------|-----------------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Torsional Vibration Damper</b> | <b>61004-14H</b> |
|---------------------|-----------------------------------|------------------|

**L28/32H**



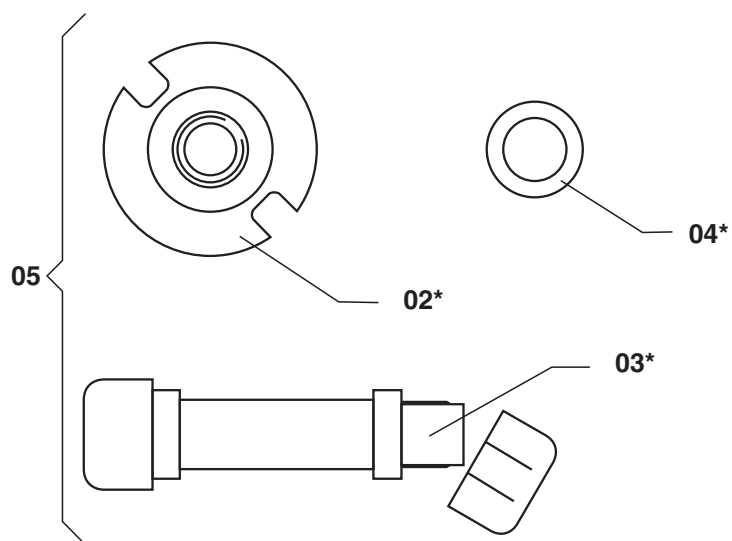
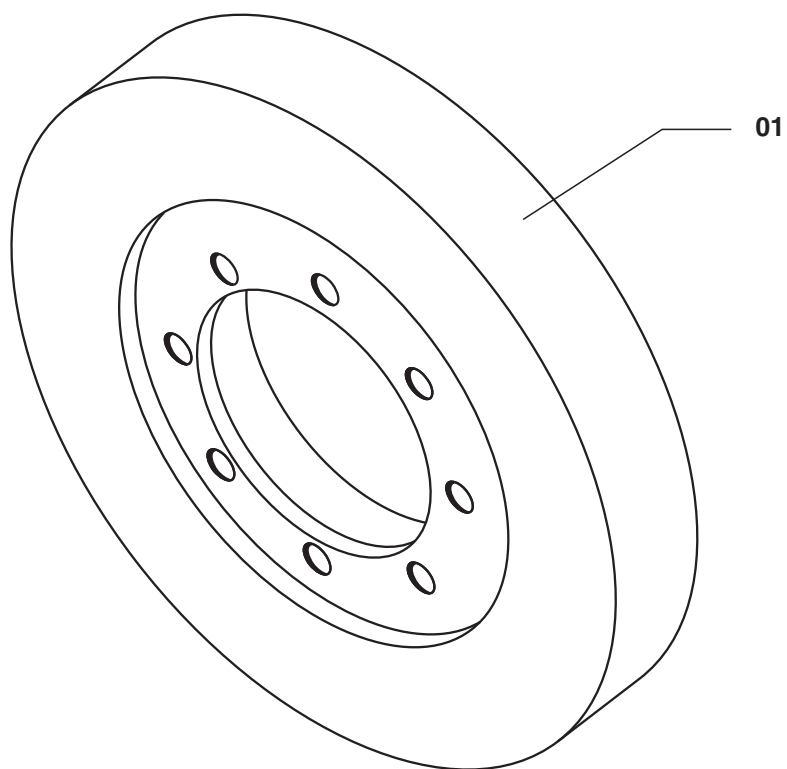
| Item No. | Qty. | Designation  | Benævnelse   |
|----------|------|--|--|
| 01       | 1/E  | <b>Torsional vibration damper, with 30 mm mounting flange</b>  | Svingningsdæmper med 30 mm monterings-flange   |
| 02*      | 1/E  | <b>Plug screw</b>  | Propskrue  |
| 03*      | 1/E  | <b>Sample container</b>  | Prøveudtagings-beholder  |
| 04*      | 1/E  | <b>O-ring</b>  | O-ring   |
| 05+      |      | <b>Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)</b> | Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet) |
|          |      | <b>+ See also working card 610-04.00</b>   | + Se også arbejdskort 610-04.00  |

| Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|
|          |      |             |            |

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor

|                     |                                   |                  |
|---------------------|-----------------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Torsional Vibration Damper</b> | <b>61004-15H</b> |
|---------------------|-----------------------------------|------------------|

**L28/32H**





61004-15H

## Torsional Vibration Damper

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation  | Benævnelse   | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|--|----------|------|-------------|------------|
| 01       | 1/E  | <b>Torsional vibration damper, with 30 mm mounting flange</b>  | Svingningsdæmper med 30 mm monterings-flange   |          |      |             |            |
| 02*      | 1/E  | <b>Plug screw</b>  | Propskrue  |          |      |             |            |
| 03*      | 1/E  | <b>Sample container</b>  | Prøveudtagings-beholder  |          |      |             |            |
| 04*      | 1/E  | <b>O-ring</b>  | O-ring   |          |      |             |            |
| 05+      |      | <b>Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)</b> | Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet) |          |      |             |            |
|          |      | <b>+ See also working card 610-04.00</b>   | + Se også arbejdskort 610-04.00  |          |      |             |            |

When ordering spare parts, see also page 600.50.

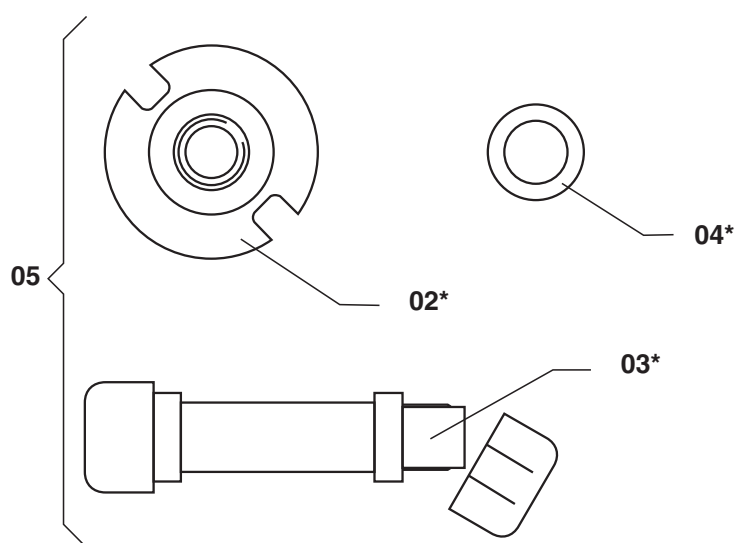
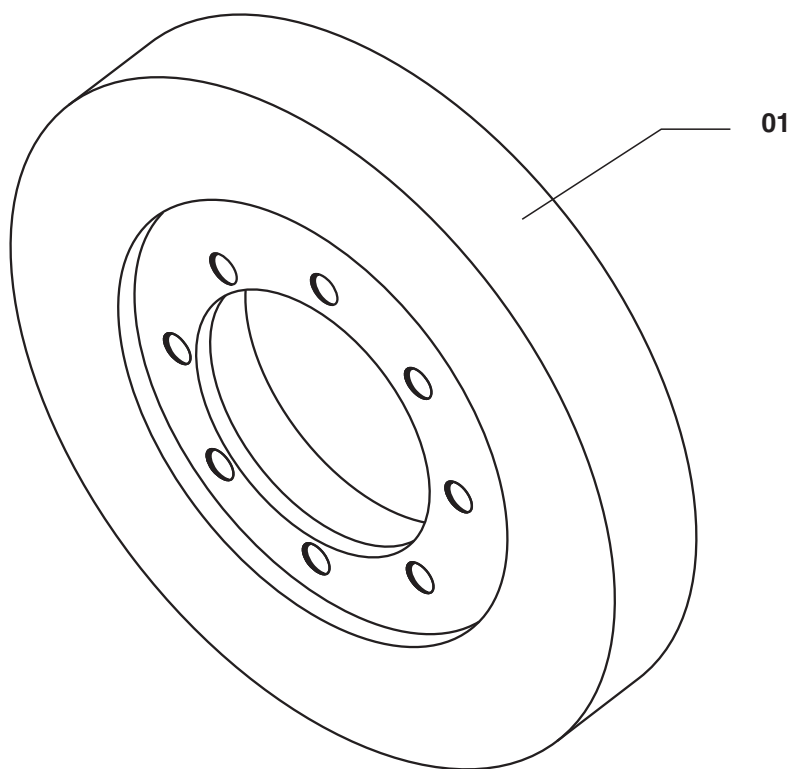
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

|                     |                                   |                  |
|---------------------|-----------------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Torsional Vibration Damper</b> | <b>61004-16H</b> |
|---------------------|-----------------------------------|------------------|

**L28/32H**



|           |                                   |                     |
|-----------|-----------------------------------|---------------------|
| 61004-16H | <b>Torsional Vibration Damper</b> | Plate<br>Page 2 (2) |
|-----------|-----------------------------------|---------------------|

## L28/32H

| Item No. | Qty. | Designation  | Benævnelse   | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|--|----------|------|-------------|------------|
| 01       | 1/E  | <b>Torsional vibration damper, with 30 mm mounting flange</b>  | Svingningsdæmper med 30 mm monterings-flange   |          |      |             |            |
| 02*      | 1/E  | <b>Plug screw</b>  | Propskrue  |          |      |             |            |
| 03*      | 1/E  | <b>Sample container</b>  | Prøveudtagings-beholder  |          |      |             |            |
| 04*      | 1/E  | <b>O-ring</b>  | O-ring   |          |      |             |            |
| 05+      |      | <b>Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)</b> | Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet) |          |      |             |            |
|          |      | <b>+ See also working card 610-04.00</b>   | + Se også arbejdskort 610-04.00  |          |      |             |            |

**When ordering spare parts, see also page 600.50.**

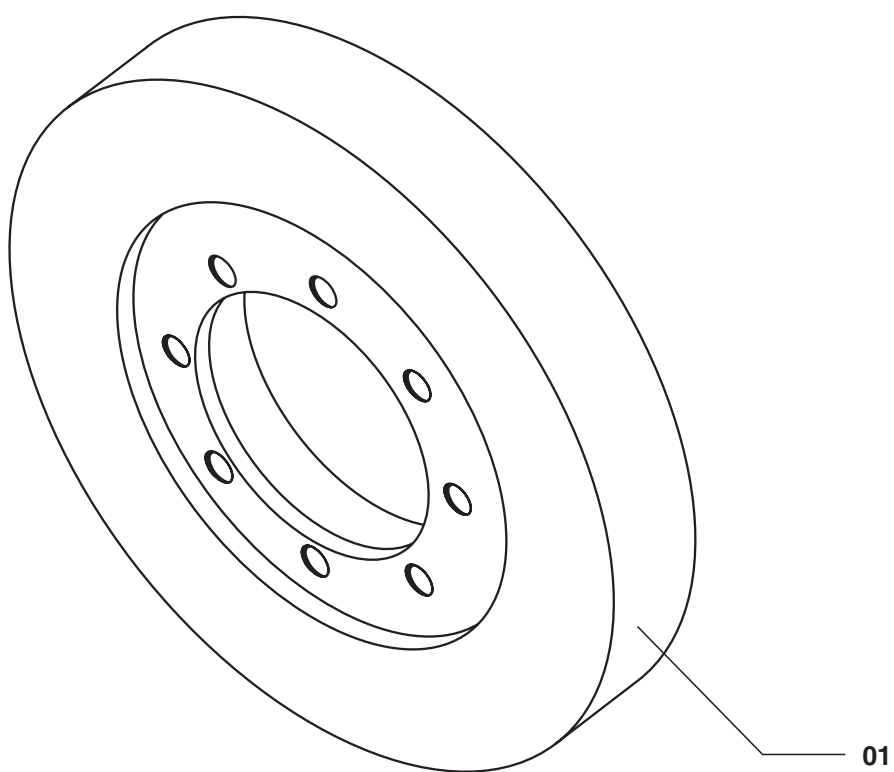
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor

|                     |                     |                  |
|---------------------|---------------------|------------------|
| Plate<br>Page 1 (2) | <b>Tuning Wheel</b> | <b>61004-06H</b> |
|---------------------|---------------------|------------------|

**L28/32H**



61004-06H

## Tuning Wheel

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation                              | Benævnelse                                 |
|----------|------|--|--|
| 01       | 1/E  | Tuning wheel with, 30 mm mounting flange | Afstemningshjul med 30 mm monteringsflange |

| Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|
|          |      |             |            |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

**Engine frame/Oil pan**

**5 1 1 / 6 1 1**

|                           |                                    |                              |
|---------------------------|------------------------------------|------------------------------|
| Description<br>Page 1 (1) | <b>Engine Frame and Base Frame</b> | <b>611.01</b><br>Edition 07H |
|---------------------------|------------------------------------|------------------------------|

**L28/32H****Frame**

The engine frame is made of cast iron, and is attached to the top of the base frame by means of bolts. The cross girders of the frame are provided with bores for the main bearings in which the crankshaft is underslung, i.e. it is carried by the main bearing caps.

The main bearing caps are attached by means of studs and nuts, which are loosened and tightened with the aid of hydraulic tools. After mounting, the main bearing caps are further secured by means of bracing screws, which are screwed horizontally into the sides of the caps and tightened against the sides of the engine frame. The main bearings are equipped with replaceable shells which are fitted without scraping.

The crankshaft guide bearing is located at the fly-wheel end of the engine.

On the sides of the frame there are covers for access to the camshaft, the charge air receiver and crankcase. Some of the covers are fitted with relief valves which will act, should oil vapours in the crankcase be ignited, for instance in the event of a hot bearing.

**Base Frame**

Engine and alternator (gear, pump) are mounted on a common base frame which is in welded design.

The base frame is used as lubricating oil reservoir "wet sump".

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Functional Test of Crankcase Safety Relief Valves</b> | <b>611-01.00</b><br>Edition 04H |
|----------------------------|--|---------------------------------|

General

Safety precautions:

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☒ Stopped lub. oil circul.

Description:

Functional test of crankcase safety relief valves.

Starting position:

Related procedure:

Man power:

Working time : 1/4 Hour  
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

Special tools:

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|-----------|----------|-------|

Hand tools:

Replacement and wearing parts:

| Plate no. | Item no. | Qty. /          |
|-----------|----------|-----------------|
| 61106     | 13       | 1/cyl.          |
| 61106     | 39       | 12/relief valve |
| 61106     | 45       | 1/relief valve  |

08028-0D/H5250/94.08.12



## General

### Functional Testing

Functional testing of the crankcase safety relief valves cannot be performed during operation of the engine, but it must be checked during overhauls that the valve flap is movable.

### When Painting

When painting the engine, take care not to block up the safety relief valves with paint.

### Check of Opening Pressure

To check the proper opening pressure, proceed as follows:

- 1) Remove the relief valve cover from the engine.
- 2) Place the cover on the floor with the pressure area upwards.
- 3) Apply a weight at 18 kg on the pressure area.

The relief valve must open under this pressure.

- 4) Remount the relief valve cover of the engine.

If the safety relief valves are actuated, the engine must be stopped immediately, and it must not be restarted until the cause is detected and the fault is detected, *see also description 503.04, Ignition in Crankcase.*

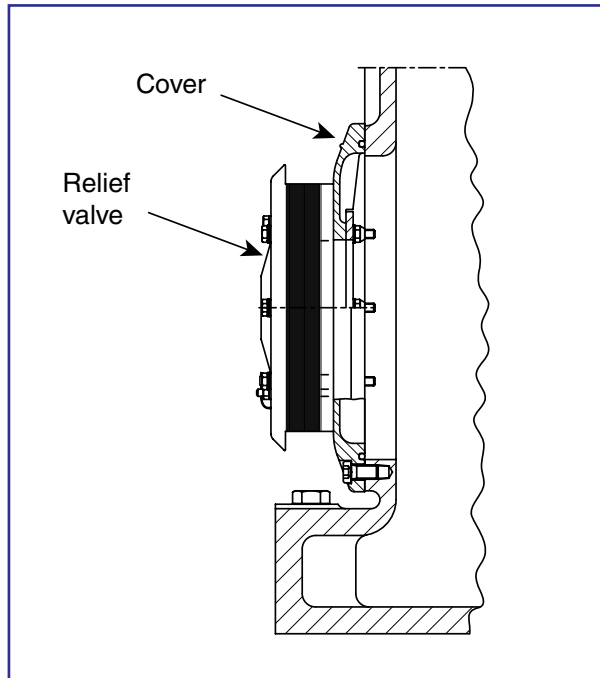
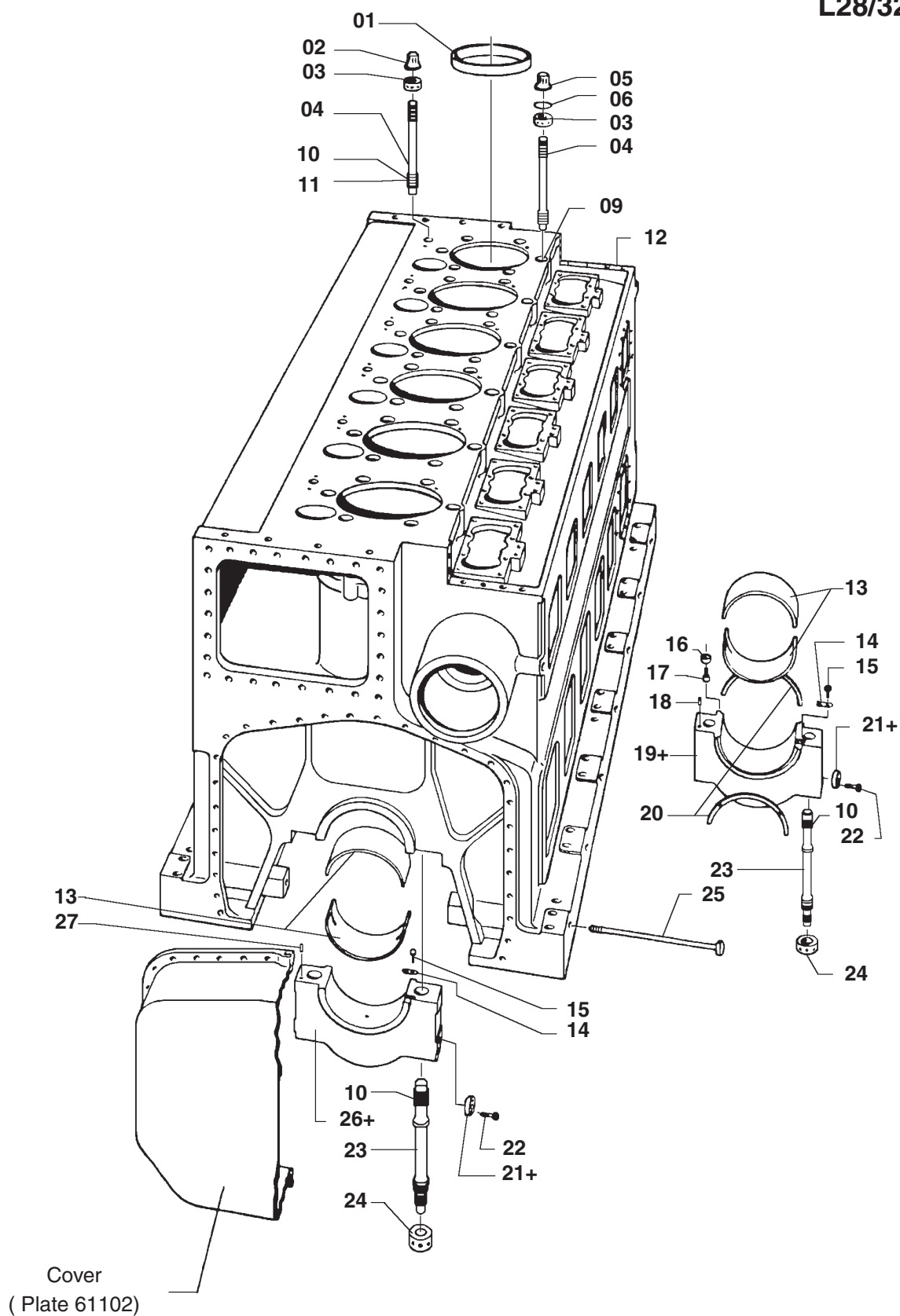


Fig 1 Cover with relief valve

L28/32H



**61101-11H****Frame with Main Bearings**Plate  
Page 2 (2)**L28/32H**

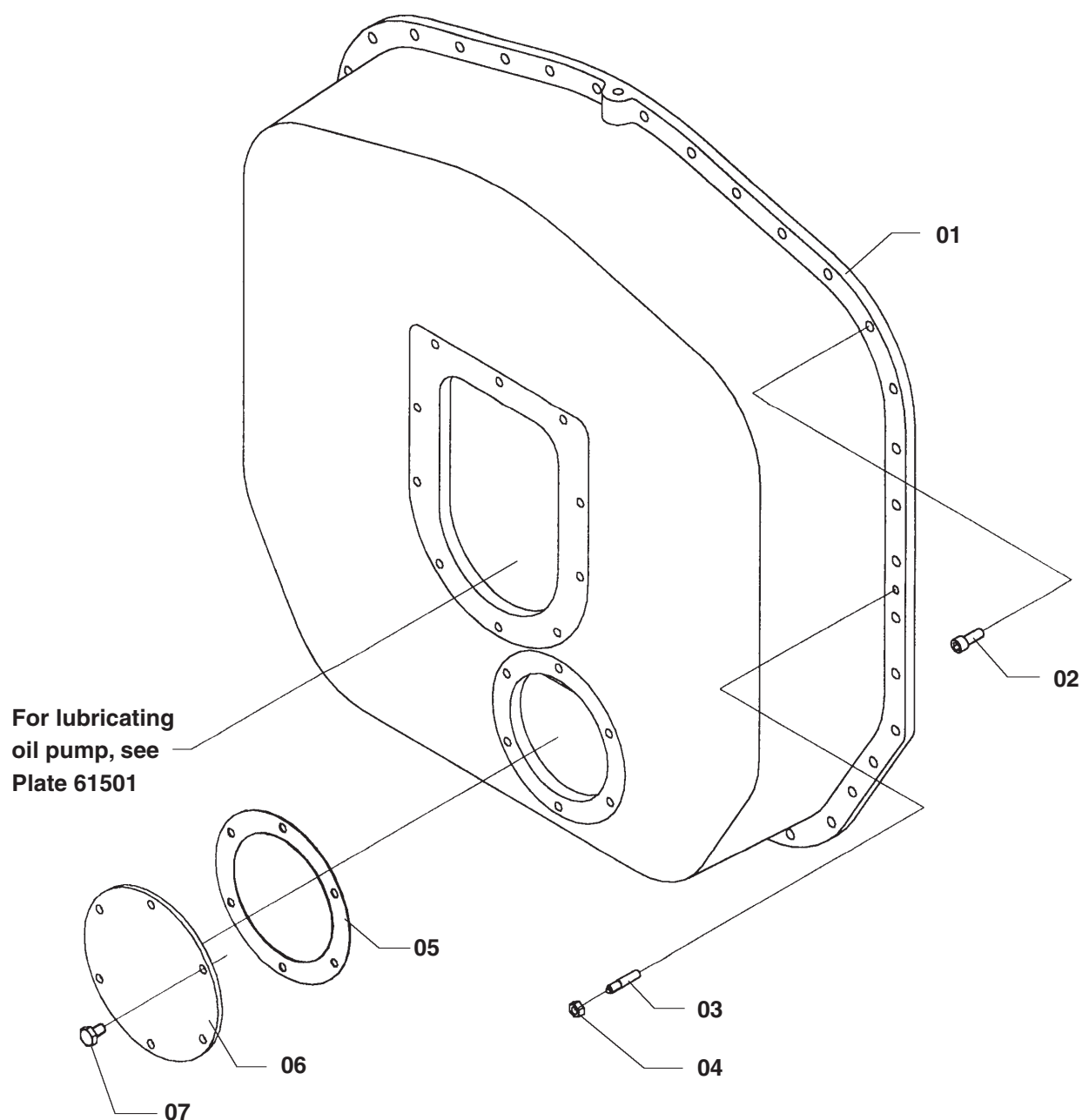
| Item No. | Qty. | Designation                      | Benævnelse                 | Item No.   | Qty. | Designation            | Benævnelse   |
|----------|------|----------------------------------|----------------------------|--|------|------------------------|--|
| 01       | 1/C  | <b>Wear ring</b>                 | Slidring                   | 27   | 1/C  | <b>Cylindrical pin</b> | Cylindrisk stift   |
| 02       | 3/C  | <b>Protective cap, plastic</b>   | Beskyttelseshætte, plastik | + Item No. 19, 21 and 26 require an individual matching before mounting, contact MAN B&W, Holeby |      |                        | + Item nr. 19, 21 og 26 kræver en individuel tilpasning før montering, kontakt MAN B&W, Holeby |
| 03       | 6/C  | <b>Nut for cylinder cover</b>    | Møtrik for cylinderdæksel  |  |      |                        |  |
| 04       | 6/C  | <b>Cylinder cover stud</b>       | Tap for cylinderdæksel     |  |      |                        |  |
| 05       | 3/C  | <b>Protective cap, metal</b>     | Beskyttelseshætte, metal   |  |      |                        |  |
| 06       | 3/C  | <b>O-ring</b>                    | O-ring                     |  |      |                        |  |
| 09       | 6/C  | <b>Sealing kit for cap</b>       | Tætningssæt for dæksel     |  |      |                        |  |
| 10       |      | <b>Loctite 243</b>               | Loctite 243                |  |      |                        |  |
| 11       |      | <b>Silicone oil</b>              | Silikoneolie               |  |      |                        |  |
| 12       | 1/E  | <b>Frame</b>                     | Stativ                     |  |      |                        |  |
| 13       | 1/B  | <b>Main bearing shell 2/2</b>    | Hovedlejeskaller 2/2       |  |      |                        |  |
| 14       | 1/B  | <b>Locking piece</b>             | Låsestykke                 |  |      |                        |  |
| 15       | 2/B  | <b>Screw</b>                     | Skrue                      |  |      |                        |  |
| 16       | 4/E  | <b>Safety sleeve</b>             | Sikkerhedsbøsning          |  |      |                        |  |
| 17       | 4/E  | <b>Screw</b>                     | Skrue                      |  |      |                        |  |
| 18       | 1/E  | <b>Cylindrical pin</b>           | Cylindrisk stift           |  |      |                        |  |
| 19+      | 1/E  | <b>Guide bearing cap</b>         | Styrelejedæksel            |  |      |                        |  |
| 20       | 2/E  | <b>Thrust bearing</b>            | Trykleje                   |  |      |                        |  |
| 21+      | 2/B  | <b>Distance piece</b>            | Afstandsstykke             |  |      |                        |  |
| 22       | 6/B  | <b>Screw</b>                     | Skrue                      |  |      |                        |  |
| 23       | 2/B  | <b>Main bearing stud</b>         | Hovedleje tap              |  |      |                        |  |
| 24       | 2/B  | <b>Nut for main bearing stud</b> | Møtrik for hovedlejetap    |  |      |                        |  |
| 25       | 2/B  | <b>Bracing screw</b>             | Sideskrue                  |  |      |                        |  |
| 26+      | 1/C  | <b>Main bearing cap</b>          | Hovedlejedæksel            |  |      |                        |  |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder  
 Qty./B = Qty./Bearing

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/Cylinder  
 Antal/B = Antal/Leje

**Front Cover for  
Lubricating Oil Pump****61102-09H****L28/32H**

|           |   |  |
|-----------|---|--|
| 61102-09H | <p align="center"><b>Front Cover for<br/>Lubricating Oil Pump</b></p> | <p align="center">Plate<br/>Page 2 (2)</p> |
|-----------|---|--|

## L28/32H

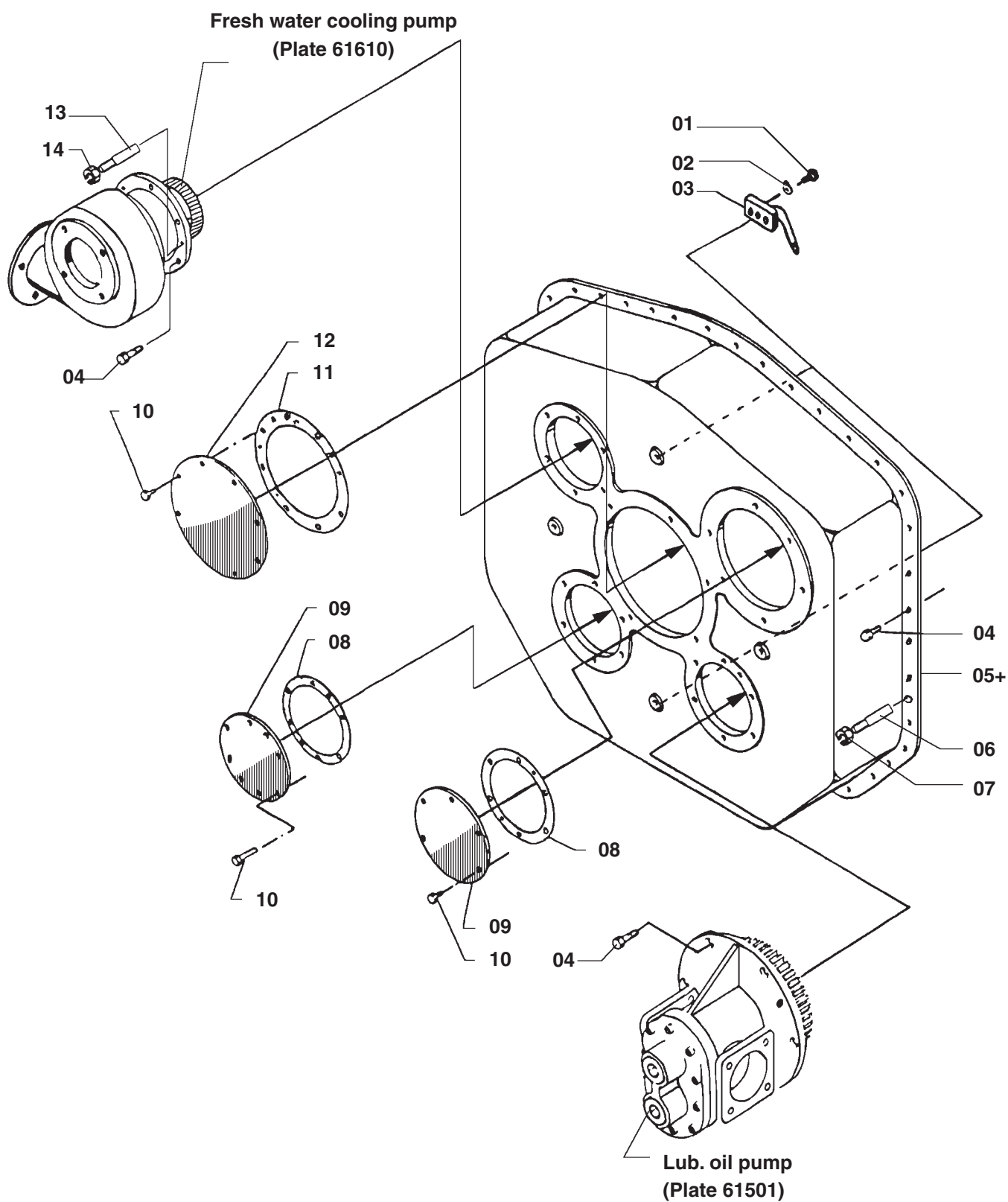
| Item No. | Qty. | Designation | Benævnelse | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|----------|------|-------------|------------|
| 01       | 1/E  | Cover       | Dæksel     |          |      |             |            |
| 02       | 40/E | Screw       | Skrue      |          |      |             |            |
| 03       | 2/E  | Guide pin   | Styrestift |          |      |             |            |
| 04       | 2/E  | Nut         | Møtrik     |          |      |             |            |
| 05       | 1/E  | Gasket      | Pakning    |          |      |             |            |
| 06       | 1/E  | Cover       | Dæksel     |          |      |             |            |
| 07       | 6/E  | Screw       | Skrue      |          |      |             |            |

**When ordering spare parts, see also page 600.50.**

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor

**Front Cover for  
Lubricating Oil Pump and Cooling Water Pump****61102-07H****L28/32H**

61102-07H

## Front Cover for Lubricating Oil Pump and Cooling Water Pump

 Plate  
Page 2 (2)

### L28/32H

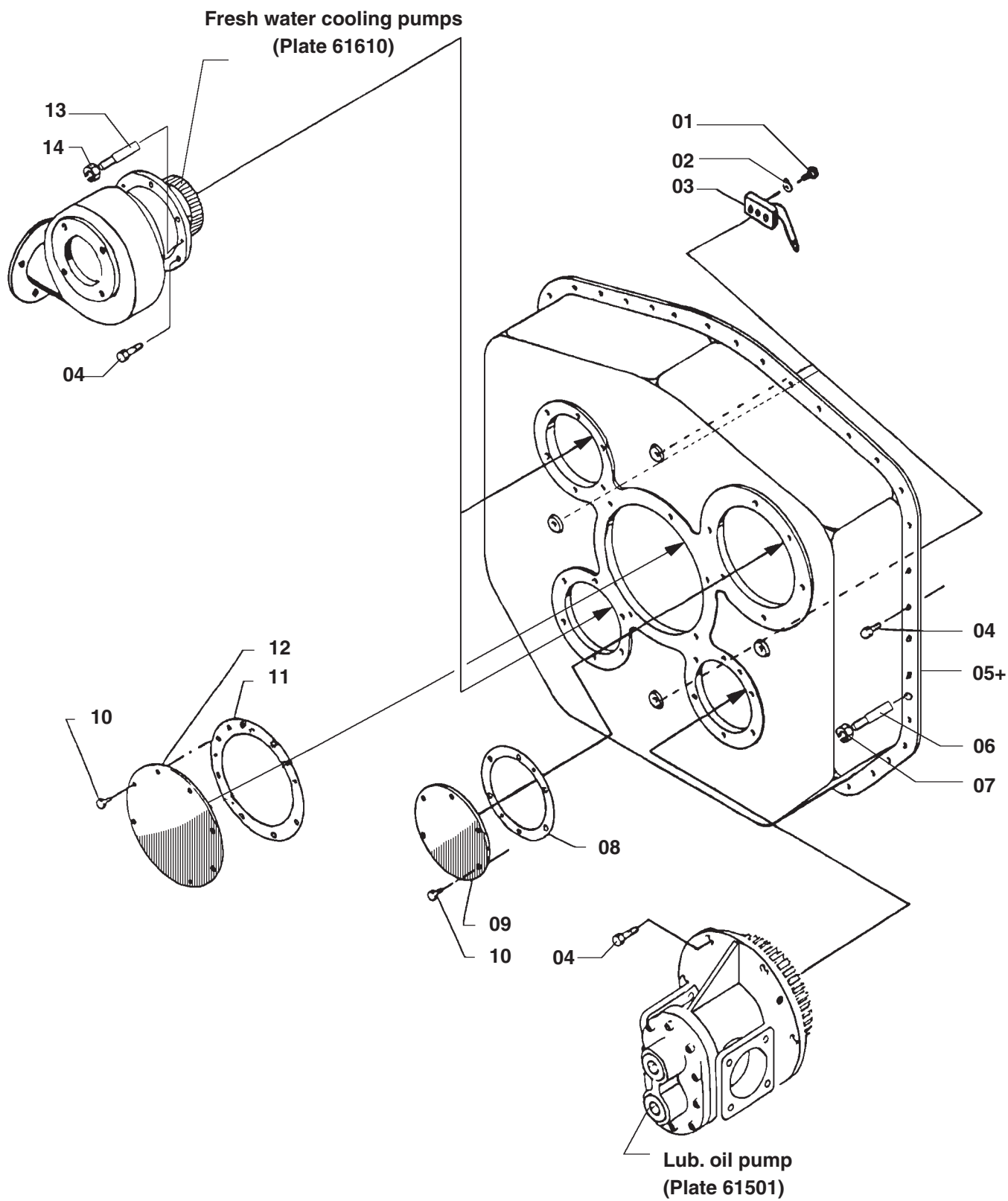
| Item No. | Qty. | Designation  | Benævnelse  | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|---|----------|------|-------------|------------|
| 01       | 4/E  | Screw  | Skrue   |          |      |             |            |
| 02       | 4/E  | Locking plate  | Låseskive   |          |      |             |            |
| 03       | 2/E  | Spray pipe   | Sprøjterør  |          |      |             |            |
| 04       | 52/E | Screw  | Skrue   |          |      |             |            |
| 05+      | 1/E  | Cover  | Dæksel  |          |      |             |            |
| 06       | 2/E  | Guide pin  | Styrestift  |          |      |             |            |
| 07       | 2/E  | Nut  | Møtrik  |          |      |             |            |
| 08       | 2/E  | Gasket   | Pakning   |          |      |             |            |
| 09       | 2/E  | Cover  | Dæksel  |          |      |             |            |
| 10       | 18/E | Screw  | Skrue   |          |      |             |            |
| 11       | 1/E  | Gasket   | Pakning   |          |      |             |            |
| 12       | 1/E  | Cover  | Dæksel  |          |      |             |            |
| 13       | 2/E  | Guide pin  | Styrestift  |          |      |             |            |
| 14       | 2/E  | Nut  | Møtrik  |          |      |             |            |
|          |      | <b>+ Item No. 05<br/>require an individual<br/>matching before<br/>mounting, contact<br/>MAN B&amp;W, Holeby</b> | <b>+ Item nr. 05 kræver<br/>en individuel til-<br/>pasning før montering,<br/>kontakt MAN B&amp;W,<br/>Holeby</b> |          |      |             |            |

When ordering spare parts, see also page 600.50.

 \* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

 \* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

**Front Cover for  
Lubricating Oil Pump and Cooling Water Pumps****61102-10H****L28/32H**



|                  |   |                     |
|------------------|---|---------------------|
| <b>61102-10H</b> | <b>Front Cover for<br/>Lubricating Oil Pump and Cooling Water Pumps</b> | Plate<br>Page 2 (2) |
|------------------|---|---------------------|

**L28/32H**

| Item No. | Qty. | Designation  | Benævnelse  | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|---|----------|------|-------------|------------|
| 01       | 6/E  | <b>Screw</b>   | Skrue   |          |      |             |            |
| 02       | 6/E  | <b>Locking plate</b>   | Låseskive   |          |      |             |            |
| 03       | 3/E  | <b>Spray pipe</b>  | Sprøjterør  |          |      |             |            |
| 04       | 58/E | <b>Screw</b>   | Skrue   |          |      |             |            |
| 05+      | 1/E  | <b>Cover</b>   | Dæksel  |          |      |             |            |
| 06       | 2/E  | <b>Guide pin</b>   | Styrestift  |          |      |             |            |
| 07       | 2/E  | <b>Nut</b>   | Møtrik  |          |      |             |            |
| 08       | 1/E  | <b>Gasket</b>  | Pakning   |          |      |             |            |
| 09       | 1/E  | <b>Cover</b>   | Dæksel  |          |      |             |            |
| 10       | 12/E | <b>Screw</b>   | Skrue   |          |      |             |            |
| 11       | 1/E  | <b>Gasket</b>  | Pakning   |          |      |             |            |
| 12       | 1/E  | <b>Cover</b>   | Dæksel  |          |      |             |            |
| 13       | 4/E  | <b>Guide pin</b>   | Styrestift  |          |      |             |            |
| 14       | 4/E  | <b>Nut</b>   | Møtrik  |          |      |             |            |
|          |      | <b>+ Item No. 05<br/>require an individual<br/>matching before<br/>mounting, contact<br/>MAN B&amp;W, Holeby</b> | <b>+ Item nr. 05 kræver<br/>en individuel til-<br/>pasning før montering,<br/>kontakt MAN B&amp;W,<br/>Holeby</b> |          |      |             |            |

When ordering spare parts, see also page 600.50.

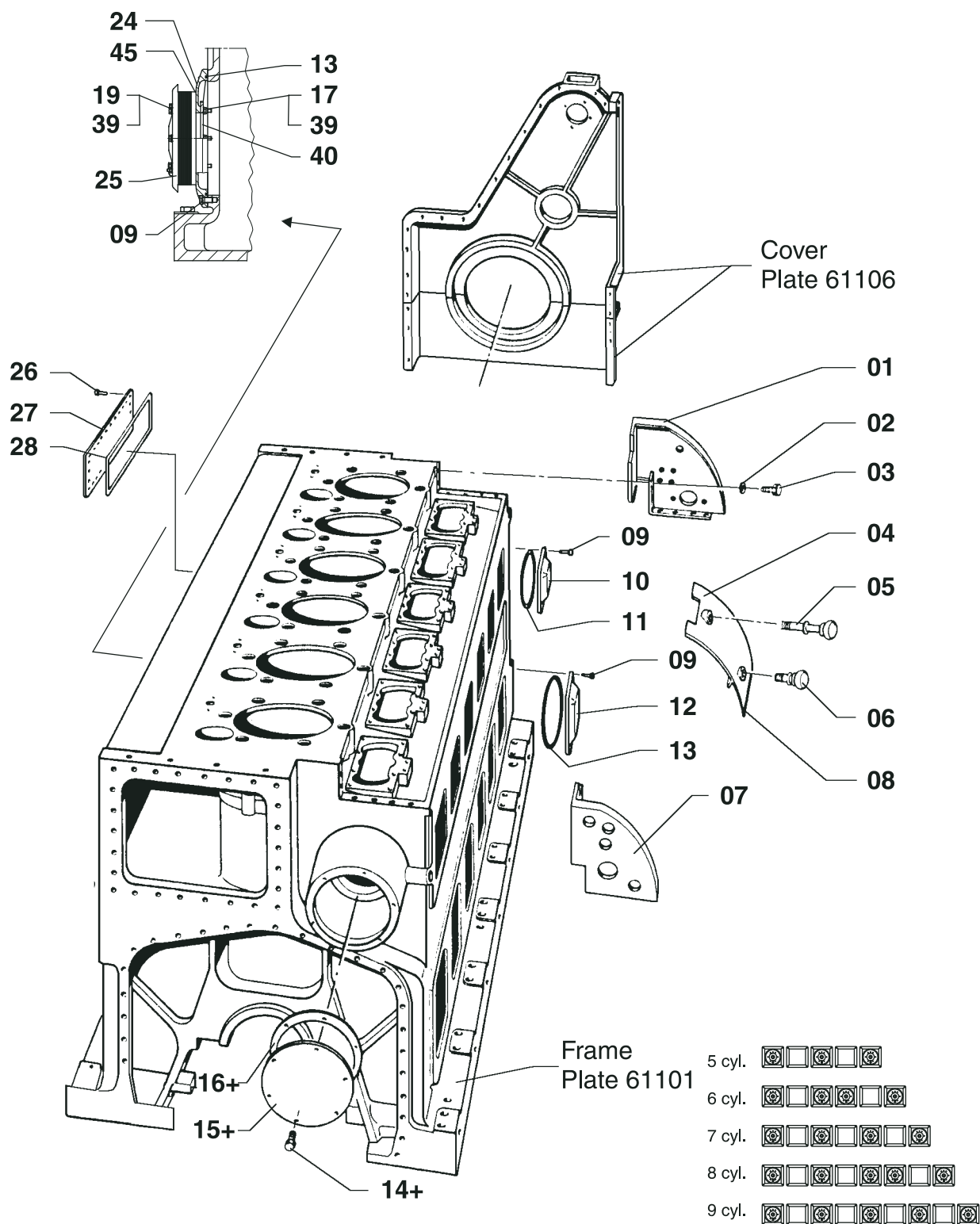
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

|                     |                 |           |
|---------------------|-----------------|-----------|
| Plate<br>Page 1 (2) | Covers on Frame | 61106-20H |
|---------------------|-----------------|-----------|

L28/32H



When ordering cover for  
crankshaft with relief valve,  
please see diagram with covers.

61106-20H

## Covers on Frame

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation                                     | Benævnelse                               | Item No. | Qty. | Designation   | Benævnelse   |
|----------|------|---|--|----------|------|---|--|
| 01       | 1/E  | Guard end aft                                   | Skærm, agter                             | 27       | /I   | Cover   | Dæksel   |
| 02       | 12/E | Washer  | Skive                                    | 28       | /I   | Gasket  | Pakning  |
| 03       | 12/E | Screw   | Skrue                                    | 39       | 12/D | Washer  | Skive  |
| 04       | 1/C  | Intermediate guard                              | Mellemskærm                              | 40       | 1/D  | Flange  | Flange   |
| 05       | 1/C  | Handle, upper                                   | Håndtag, øverst                          | 45       | 1/D  | O-ring  | O-ring   |
| 06       | 1/C  | Handle, lower                                   | Håndtag, nederst                         |          |      |   |  |
| 07       | 1/E  | Guard end fore                                  | Skærm, for                               |          |      |   |  |
| 08       | 1/C  | Intermediate gauge complete, Item 04, 05 and 06 | Mellemskærm, komplet, Item 04, 05 and 06 |          |      | + Item 14, 15 and 16 are only mounted if the engine is delivered without fuel oil feed pump | + Item 14, 15 og 16 er kun monteret hvis motoren er leveret uden fuel olieforpumpe |
| 09       | 12/C | Screw   | Skrue                                    |          |      |   |  |
| 10       | 1/C  | Cover for camshaft housing                      | Dæksel for Kamakselhus                   |          |      |   |  |
| 11       | 1/C  | O-ring  | O-ring                                   |          |      |   |  |
| 12       |      | Cover for crankcase                             | Dæksel for krumtaphus                    |          |      |   |  |
|          | 7/E  | 5 cyl. engine                                   | 5 cyl. motor                             |          |      |   |  |
|          | 8/E  | 6 cyl. engine                                   | 6 cyl. motor                             |          |      |   |  |
|          | 10/E | 7 cyl. engine                                   | 7 cyl. motor                             |          |      |   |  |
|          | 11/E | 8 cyl. engine                                   | 8 cyl. motor                             |          |      |   |  |
|          | 12/E | 9 cyl. engine                                   | 9 cyl. motor                             |          |      |   |  |
| 13       | 2/C  | O-ring  | O-ring                                   |          |      |   |  |
| +14      | 6/E  | Screw   | Skrue                                    |          |      |   |  |
| +15      | 1/E  | Cover   | Dæksel                                   |          |      |   |  |
| +16      | 1/E  | Gasket  | Pakning                                  |          |      |   |  |
| 17       | 6/D  | Self locking nut                                | Selvlåsende møtrik                       |          |      |   |  |
| 19       | 6/D  | Screw   | Skrue                                    |          |      |   |  |
| 24       |      | Cover with safety valve complete                | Dæksel med sikkerhedsventil komplet      |          |      |   |  |
|          | 3/E  | 5 cyl. engine                                   | 5 cyl. motor                             |          |      |   |  |
|          | 4/E  | 6 cyl. engine                                   | 6 cyl. motor                             |          |      |   |  |
|          | 4/E  | 7 cyl. engine                                   | 7 cyl. motor                             |          |      |   |  |
|          | 5/E  | 8 cyl. engine                                   | 8 cyl. motor                             |          |      |   |  |
|          | 6/E  | 9 cyl. engine                                   | 9 cyl. motor                             |          |      |   |  |
| 25       | 1/D  | Safety valve complete                           | Sikkerhedsventil, komplet                |          |      |   |  |
| 26       | /I   | Screw   | Skrue                                    |          |      |   |  |

When ordering spare parts, see also page 600.50.

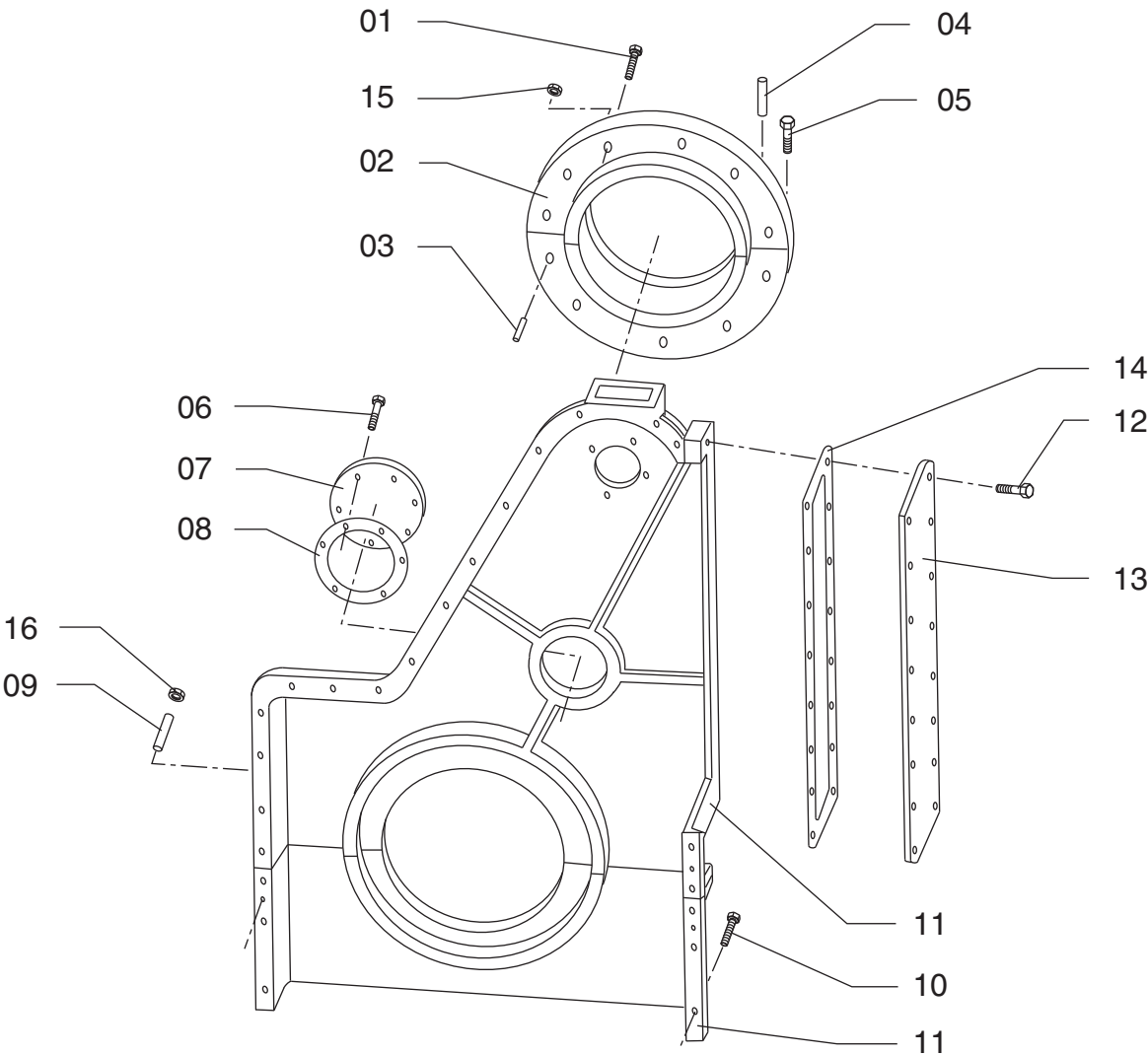
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder  
 Qty./D = Qty./Safety cover  
 Qty./I = Qty./Individual

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/Cylinder  
 Antal/D = Antal/Sikkerhedsdæksel  
 Antal/I = Antal/Individuelt

|                     |                 |           |
|---------------------|-----------------|-----------|
| Plate<br>Page 1 (2) | Covers on Frame | 61106-14H |
|---------------------|-----------------|-----------|

L28/32H



61106-14H

## Covers on Frame

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation      | Benævnelse       | Item No. | Qty. | Designation | Benævnelse |
|----------|------|------------------|------------------|----------|------|-------------|------------|
| 01       | 12/E | Screw            | Skrue            |          |      |             |            |
| 02       | 1/E  | Sealing ring 2/2 | Tætningsring 2/2 |          |      |             |            |
| 03       | 2/E  | Guide pin        | Styrestift       |          |      |             |            |
| 04       | 2/E  | Cylindrical pin  | Cylindrisk stift |          |      |             |            |
| 05       | 2/E  | Screw            | Skrue            |          |      |             |            |
| 06       | 6/E  | Screw            | Skrue            |          |      |             |            |
| 07       | 1/E  | Flange           | Flange           |          |      |             |            |
| 08       | 1/E  | Gasket           | Pakning          |          |      |             |            |
| 09       | 4/E  | Guide pin        | Styrestift       |          |      |             |            |
| 10       | 39/E | Screw            | Skrue            |          |      |             |            |
| 11       | 1/E  | Cover 2/2        | Dæksel 2/2       |          |      |             |            |
| 12       | 18/E | Screw            | Skrue            |          |      |             |            |
| 13       | 1/E  | Cover            | Dæksel           |          |      |             |            |
| 14       | 1/E  | Gasket           | Pakning          |          |      |             |            |
| 15       | 2/E  | Nut              | Møtrik           |          |      |             |            |
| 16       | 4/E  | Nut              | Møtrik           |          |      |             |            |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

**Turbocharger**

**51 2/6 1 2**

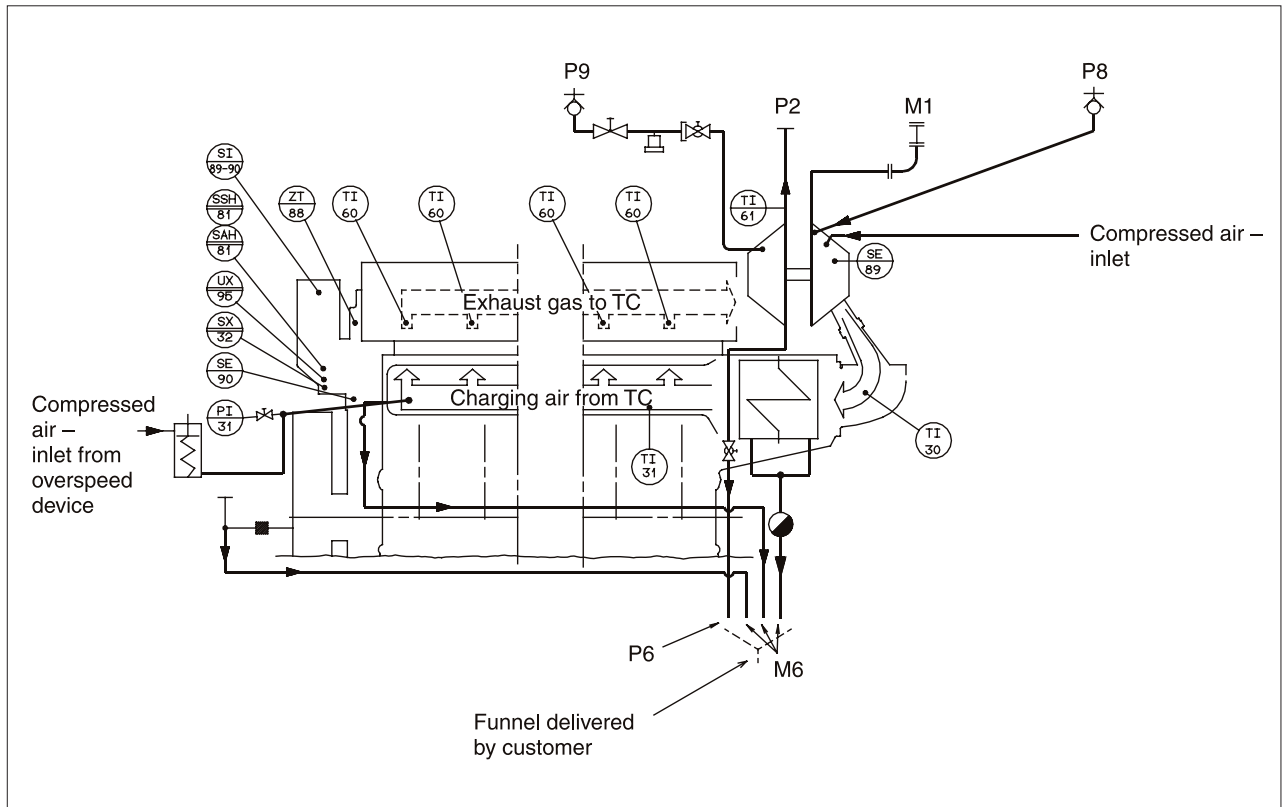
**L28/32H**

Fig. 1. Diagram for Turbocharger System

**Turbocharger System**

The turbocharger system of the engine, which is a constant pressure system, consists of an exhaust gas receiver, a turbocharger, a charging air cooler and a charging air receiver, the latter being integrated in the engine frame.

The turbine wheel of the turbocharger is driven by the engine exhaust gas, and the turbine wheel drives the turbocharger compressor, which is mounted on the same shaft.

Turbocharger, see separate manual.

The turbocharger pumps the air through the charging air cooler to the charging air receiver. From the charging air receiver, the air flows to each cylinder through the inlet valves.

The charging air cooler is of the compact tube-type with a large cooling surface. The cooling water is passed twice through the cooler, the end covers being designed with partitions which cause the cooling water to turn.

The cooling water tubes are fixed to the tube plates by expansion.

From the exhaust valves, the exhaust is led through water cooled intermediate pieces to the exhaust gas receiver where the pulsatory pressure from the individual exhaust valves is equalized and passed to the turbocharger as a constant pressure, and further to the exhaust outlet and silencer arrangement.

The exhaust gas receiver is made of pipe sections, one for each cylinder. The pipe sections are connected to each other with compensators. This prevents excessive stress in the pipes due to heat expansion.

**612.01**

Edition 28H

**Turbocharger System**Description  
Page 2 (2)**L28/32H**

In the cooled intermediate piece a thermometer for reading the exhaust gas temperature is fitted. It is also possible to fit a sensor for remote reading.

To avoid excessive thermal loss and to ensure a reasonably low surface temperature, the exhaust gas receiver is insulated.

The turbocharger is equipped with a jet system for supply of extra driving torque to the compressor.

The purpose is to increase the compressor performance. With this system the engine can take up a large momentary load increase.

The system is activated automatically and only when the engine is exposed to a large momentary load increase, see section 609.



|                           |   |                              |
|---------------------------|---|------------------------------|
| Description<br>Page 1 (1) | <b>Cleaning the Turbocharger In Service<br/>Water Washing of Compressor</b> | <b>612.05</b><br>Edition 07H |
|---------------------------|---|------------------------------|

## General

### Compressor

Fouling of the airways depends primarily on the purity of the inlet air and thus, in turn, on the general maintenance condition of the machinery, i.e. mainly of the gas and oil tightness of the engines and on the fresh air ventilation system of the engine room.

Fouling of air filter, compressor or charging air cooler may be observed as changes in performance parameters:

- Decreasing charging air pressure.
- Decreasing turbocharger rotor speed.
- Increasing exhaust gas temperature.
- Severe fouling of airways may even result in compressor surge.

Regular cleaning during operation by injection of water before the compressor wheel will reduce the fouling rate considerably, and consequently prolong the intervals between dismantling necessary for mechanical cleaning.

Chemical cleaning will not improve the cleaning process as this primarily is based on the mechanical effect from the impact of the water droplets.

Certain types of fluid solvents can give formation of deposits on the compressor wheel, and should under no circumstances be used.

The intervals between cleaning by injection of water should be adjusted after assessing the degree and rate of fouling in the particular plant, i.e. based on observations and experience.

**Cleaning the Turbocharger in Service  
Dry Cleaning - Turbine****612.10**

Edition 09H

**L+V28/32H****Description**

The tendency to fouling on the gas side of turbochargers depends on the combustion conditions, which are a result of the load and the maintenance condition of the engine as well as the quality of the fuel oil used.

Fouling of the gas ways will cause higher exhaust gas temperatures and higher wall temperatures of the combustion chamber components and will also lead to a higher fuel consumption rate.

Tests and practical experience have shown that radial-flow turbines can be successfully cleaned by the dry cleaning method.

This cleaning method employs cleaning agents consisting of dry solid bodies in the form of granules. A certain amount of these granules, depending on the turbocharger size, is, by means of compressed air, blown into the exhaust gas line before the gas inlet casing of the turbocharger.

The injection of granules is done by means of working air with a pressure of 5-7 bar.

On account of their hardness, particularly suited blasting agents such as nut-shells, broken or artificially shaped activated charcoal with a grain size of 1.0 mm to max. 1.5 mm should be used as cleaning agents.

The solid bodies have a mechanical cleaning effect which removes any deposits on nozzle vanes and turbine blades.

Dry cleaning can be executed at full engine load and does not require any subsequent operating period of the engine in order to dry out the exhaust system.

Experience has shown that regular cleaning intervals are essential to successful cleaning, as excessive fouling is thus avoided. Cleaning every second day during operation is recommended.

The cleaning intervals can be shorter or longer based on operational experience.

**Cleaning System**

The cleaning system consists of a cleaning agent container (2) with a capacity of approx. 0.5 liters and a removable cover. Furthermore the system consists of an air valve (3), a closing valve (1) and two snap connectors.

The position numbers (2) and (3) indicate the system's "blow-gun". Only one "blow-gun" is used for each engine plant. The blow-gun is working according to the ejector principle with pressure air (working air) at 5-7 bar as driven medium. Injection time approx. 2 min. Air consumption approx. 5 Nm<sup>3</sup>/2 min.

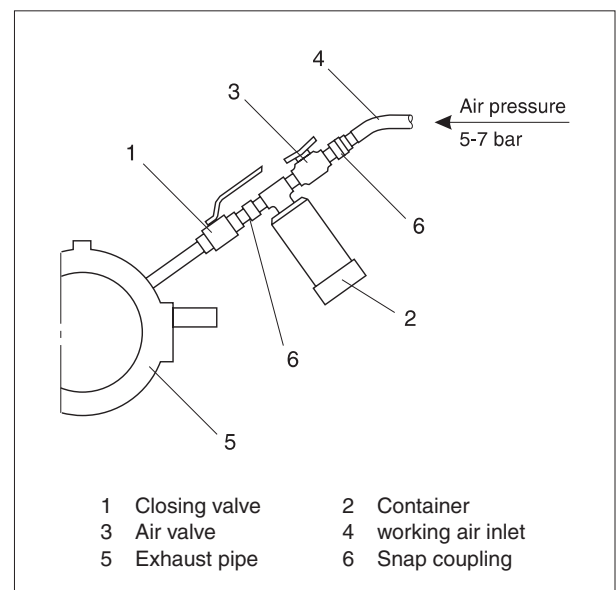


Fig 1 Arrangement of dry cleaning of turbocharger - Turbine.

**612.10**

Edition 09H

## Cleaning the Turbocharger in Service Dry Cleaning - Turbine

Description  
Page 2 (3)**L+V28/32H****Dry cleaning of turbochargers**

Suppliers of cleaning agents:

**1. "Solf Blast Grit, Grade 14/25"**

|   |   |
|---|---|
| TURCO Products B.V.<br>Verl. Blokkenweg 12,<br>Tel.: 08380 - 31380, | 617 AD EDE - Holland<br>Fax.: 08380 - 37069 |
|---|---|

**2. Designation unknown**

|   |  |
|---|--|
| Neptunes Vinke B.V.<br>Schuttevaerweg 24,<br>Potbus 11032,<br>Tel.: 010 - 4373166 | 3044 BB Rotterdam<br>3004 E.A. Rotterdam, Holland<br>Fax.: 4623466 |
|---|--|

**3. "Grade 16/10"**

FA. Poul Auer GmbH  
Strahltechnik  
D-6800 Mainheim 31, Germany

**4. "Granulated Nut Shells"**

Eisenwerke Würth GmbH + Co.  
4107 Bad Friederichshall, Germany  
Tel.: 0 71 36-60 01

**5. "Soft Blasting Grade 12/3a"**

|  |  |
|--|--|
| H.S. Hansen Eftf.<br>2100 Copenhagen Ø,<br>Tel.: (31) 29 97 00 | Kattegatvej 2<br>Denmark<br>Telex: 19038 |
|--|--|

**6. "Crushed Nutshells"**

Brigantine, Hong Kong

**7. "Turbine Wash"**

Ishikawajima-Harima Heavy Industries Co.  
Ishiko Bldg., 2-9-7 Yassu, Chuo-Ku  
Tokyo 104, Japan  
Tel.: 03-2 77-42 91

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 3 (3) | <b>Cleaning the Turbocharger in Service<br/>Dry Cleaning - Turbine</b> | <b>612.10</b><br>Edition 09H |
|---------------------------|--|------------------------------|

**L+V28/32H****8. "A-C Cleaner" (Activated Coal)**

Mitsui Kozan Co. Ltd. (Fuel Dept.)  
Yamaguchi Bldg., 2-1-1 Nihonbashi  
Muromachi, Chuo-Ku  
Tokyo 103, Japan

**9. "OMT-701"**

Marix KK  
Kimura Bldg., 6-2-1 Shinbashi  
Minato-Ku, Tokyo 105, Japan  
Tel.: 03-4 36-63 71, Telex: 242-7232 MAIX J

**10. "OMT-701"**

OMT Incorporated  
4F, Kiji Bldg., 2-8 Hatchobori,  
4-chome, Chuo-Ku, Tokyo 104, Japan  
Tel.: 03-5 53-50 77, Telex: 252-2747 OMTINC J

**11. "Marine Grid No. 14" (Walnut)**

Hikawa Marine  
Kaigan-Dori 1-1-1, Kobe 650, Japan  
Tel.: 0 78-3 21-66 56

**12. "Marine Grid No. 14"**

Mashin Shokai  
Irie-Dori, 3-1-13, Hyogo-Ku  
Kobe 652, Japan  
Tel.: 0 78-6 51-15 81

**13. Granulate**

MAN B&W Diesel A/S  
Teglholmsgade 41 2450 København SV, Danmark  
Tel.: +45 33 851100 Fax.: +45 33 851030

The list is for guidance only and must not be considered complete. We undertake no responsibility that might be caused by these or other products.

|                           |  |                              |
|---------------------------|--|------------------------------|
| Description<br>Page 1 (1) | <b>Cleaning the Turbocharger in Service<br/>Water Washing - Turbine Side</b> | <b>612.15</b><br>Edition 02H |
|---------------------------|--|------------------------------|

## General

### Description

The tendency to fouling on the gas side of turbochargers depends on the combustion conditions, which are a result of the load on and the maintenance condition of the engine as well as the quality of the fuel oil used.

Fouling of the gas ways will cause higher exhaust gas temperatures and higher surface temperatures of the combustion chamber components and will also lead to a lower performance.

Tests and practical experience have shown that radial-flow turbines can be successfully cleaned by injection water into the inlet pipe of the turbine. The cleaning effect is based on the water solubility of the deposits and on the mechanical action of the impinging water droplets and the water flow rate.

The necessary water flow is dependent on the gas flow and the gas temperature. Enough water must be injected per time unit so that, not the entire flow will evaporate, but about 0.25 l/min. will flow off through the drainage opening in the gas outlet. Thus ensuring that sufficient water has been injected.

Service experience has shown that the above mentioned water flow gives the optimal reduced or disappear. If the recommended water flow is exceeded, there is a certain risk of an accumulation of water in the turbine casing, which can result in damage on the turbocharger.

The best cleaning effect is obtained by cleaning at low engine load approx. 20% MCR. Cleaning at low load will also reduce temperature shocks.

Experience has shown, that washing at regular intervals is essential to successful cleaning, as excessive fouling is thus avoided. Washing at intervals of 100 hours is therefore recommended. Depending on the fuel quality these intervals can be shorter or longer. However, the turbine must be washed at the latest when the exhaust gas temperature upstream of the turbine has risen about 20° C above the normal temperature.

Heavily contaminated turbines, which were not cleaned periodically from the very beginning or after an overhaul, cannot be cleaned by this method.

If vibration in the turbocharger occurs after water-washing has been carried out, the washing should be repeated. If unbalance still exists, this is presumably due to heavy fouling, and the engine must be stopped and the turbocharger dismantled and manually cleaned.

The washing water should be taken from the fresh water system and not from the fresh cooling water system or salt water system. No cleaning agents or solvents need to be added to the water.

To avoid corrosion during standstill, the engine must, upon completing of water washing, run for at least 1 hour before stop so that all parts are dry.

### Water Washing System

The water washing system consists of a pipe system equipped with a regulating valve, a manoeuvring valve, a 3-way cock and a drain pipe with a drain valve from the gas outlet, see illustration on work card 612-15.00.

The water for washing the turbine, is supplied from the external fresh water system through a flexible hose with couplings. The flexible hose must be disconnected after water washing.

By activating the manoeuvring valve and the regulating valve, water is led through the 3-way cock to the exhaust pipe intermediate flange, equipped with a channel to lead the water to the gas inlet of the turbocharger.

The water which is not evaporated, is led out through the drain pipe in the gas outlet.

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Overhaul of Charging Air Cooler</b> | <b>612-01.00</b><br>Edition 02H |
|----------------------------|--|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☒ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Overhaul of charging air cooler.

**Starting position:****Related procedure:****Man power:**

Working time : 3-4 Hours  
Capacity : 2 men

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|           |          |       |

**Hand tools:**

Ring and open end spanner, 13 mm.  
Ring and open end spanner, 19 mm.  
Ring and open end spanner, 24 mm.  
Allen key, 10 mm.  
Wire rope.  
Tackle.

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. /   |
|-----------|----------|----------|
| 61203     | 14       | 8/cooler |
| 61203     | 35       | 1/cooler |
| 61203     | 37       | 1/cooler |
| 61203     | 39       | 1/cooler |

**L+V28/32H**

The charging air cooler is normally cleaned and overhauled at the intervals indicated in the "Planned Maintenance Program", or if observations prove that the cooler does not work satisfactory, see section 602.

**Overhaul of Charging Air Cooler.**

**1)** Close the cooling water inlet and outlet valves and disconnect the pipes.

**2)** Remove the screw (1), fig. 1, which secure the end cover of the cooler element to the cooler housing, and pull the cooler element half-way out.

Place a wire rope round the cooler element and attach a tackle hook, after which the elements are lifted and pulled out of the cooler housing and landed on a couple of wooden planks on the floor.

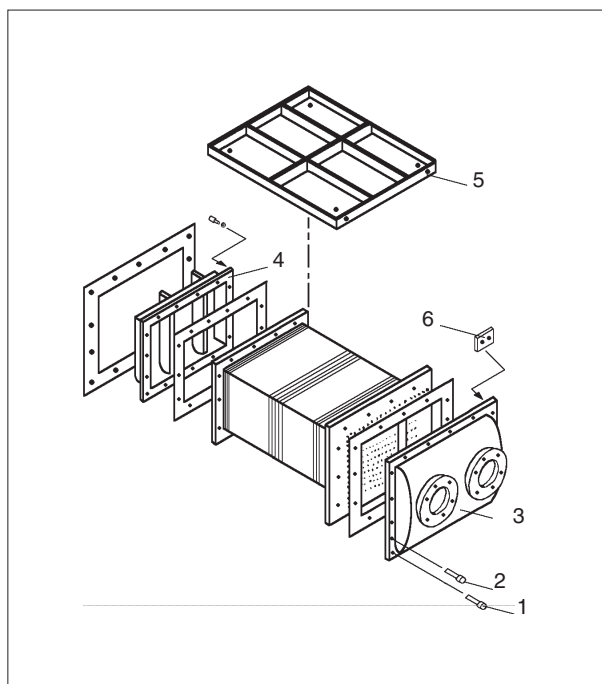


Fig. 1.

**3)** Remove screws (2) and end cover (3) reversal chamber (4) and side plates (5).

**4)** Clean the cooler element of the water and air sides.

After using cleaning agents the manufacturing recommending must be followed.

The greatest care must be exercised when dismantling cleaning and mounting the cooler element, as the thin fins of the tubes cannot stand impacts and pressure.

If nevertheless, the metal is damaged, it should be carefully straightened, as bent fins will increase the pressure drop across the cooler considerably.

Should one or more cooler tubes become leaky it/they must immediately be made tight, either by expanding the tube ends into the tube plates or by blanking of the tube(s) concerned with plugs.

It is important that the charging air cooler is not leaky as any sea water that leaks in will be carried along with the air to the cylinders where the salt contained in the water will damage valves, piston rings, and cylinder liners.

**5)** Also clean end cover and coat it on the inside with an anti-corrosion blocks agent. Inspect the anti-corrosion (6) and renew if necessary.

**Note:** That paint or similar must not be applied to these blocks.

**6)** Fouling and deposite in the pipes can be removed by using a hand or machine operated circular steel brush. The pipe inner diameter is 13 mm.

**7)** When mounting the air cooler, renew all gaskets.

**Out of Service Periods.**

At longer periods out of service the air cooler is drained if the coolant is sea water followed by flushing with fresh water and left with drain and venting cocks open.

At fresh water coolant systems recommendations for the entire system is followed.

|                            |   |                                 |
|----------------------------|---|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Charge Air Cooler Housing - Draining</b> | <b>612-01.05</b><br>Edition 02H |
|----------------------------|---|---------------------------------|

**L+V28/32H****Safety Precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Check of drain from charge air cooler housing.

**Starting Position:****Related Procedure:****Man Power:**

Working time :  
Capacity : 1 person

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special Tools:**

| Plate No | Item No | Note |
|----------|---------|------|
|----------|---------|------|

**Hand Tools:****Replacement and Wearing Parts:**

| Plate No | Item No | Qty. / |
|----------|---------|--------|
|----------|---------|--------|



**L+V28/32H**

In order to prevent water from collecting at the bottom of the gas outlet of the turbocharger, the charge air cooler and the charge air receiver, the charge air cooler is equipped with a drain and an automatic water discharger.

This installation will prevent water from the charge air to be sucked into the engine, where it will destroy the lubricating oil film on the cylinder walls, resulting in increasing wear. Further, the water will cause corrosion of the intake components.

Therefore, frequent control of the drain and the water discharger has to take place to secure that these components are free of foreign substances which could foul them.

1) The drain screw at the bottom of the water discharger has to be loosened and cleaned of impurities, if any.

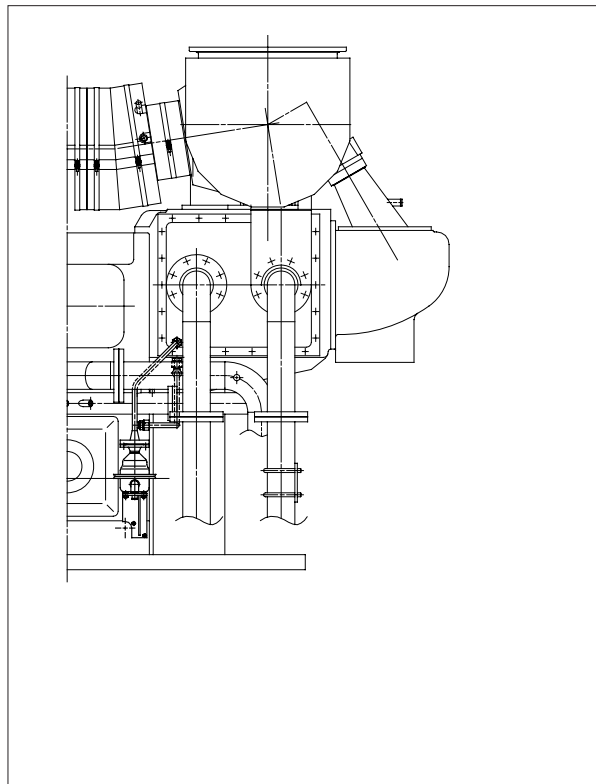


Fig 1 Placement of Steam Trap

| If, with the drain screw dismantled   | If, with the drain screw dismantled   |
|---|---|
| <p>- a constant air flow is present:</p> <ol style="list-style-type: none"> <li>1. Everything is all right.</li> <li>2. Mount the drain screw at the bottom of the water discharger.</li> </ol> | <p>- no constant air flow is present:</p> <ol style="list-style-type: none"> <li>1. Dismount the drain pipe and blow-through the pipe by means of compressed air. Clean the discharge hole in the charge air cooler in order to secure a clear passage of water.</li> <li>2. Mount the drain pipe and check with your hand that a constant air flow is present.</li> <li>3. Mount the drain screw at the bottom of the water discharger.</li> </ol> |

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (3) | <b>Water Washing of Compressor Side<br/>Turbocharger Type NR15/R - NR20/R - NR24/R - NR26/R.</b> | <b>612-05.00</b><br>Edition 03H |
|----------------------------|--|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Water washing of compressor side.  
Turbocharger cleaning with engine in service.

**Starting position:****Related procedure:****Man power:**

Working time : 1/4 hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no | Item no | Note |
|----------|---------|------|
|----------|---------|------|

**Hand tools:****Replacement and wearing parts:**

| Plate no | Item no | Qty. / |
|----------|---------|--------|
|----------|---------|--------|

See the special instructions for turbocharger.

**612-05.00**  
Edition 03H

## Water Washing of Compressor Side Turbocharger Type NR15/R - NR20/R - NR24/R - NR26/R

Working Card  
Page 2 (3)

### L+V28/32H

#### Before Cleaning

The cleaning process is only to be carried out when the engine is at operating temperature (see Operating Data 600.30) and when it is loaded as close as possible to full load (see Main Data 600.00).

See also "Description for Water Washing of Compressor side", 612.05.

#### Cleaning Procedure

**1)** Run the engine with as high a load as possible.

**2)** Discharge the excesspressure in the container by drawing out the spindle in the safety valve (see fig. 1) before loosening the top cover.

*The spindle returns automatically by means of a built-in spring.*

**3)** Fill the container with 2 litres fresh water (see the scale on the container).

**Warning:** Do not use sea water or cooling water.

**4)** Mount the top cover on the container.

**5)** Blow air into the container by means of a blow gun, until an operation pressure of 3 bar is reached (see fig 2).

*The safety valve will open at a pressure of 4 bar.*

*Excesspressure will discharge through the safety valve.*

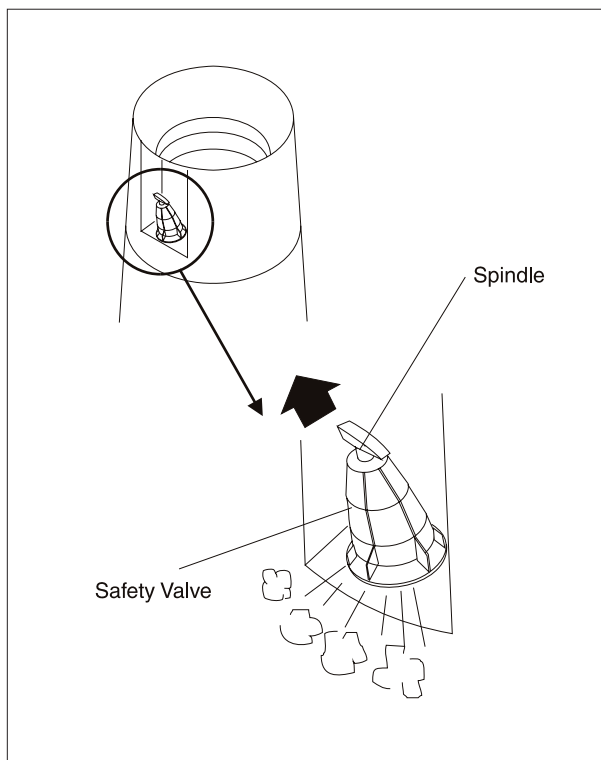


Fig 1

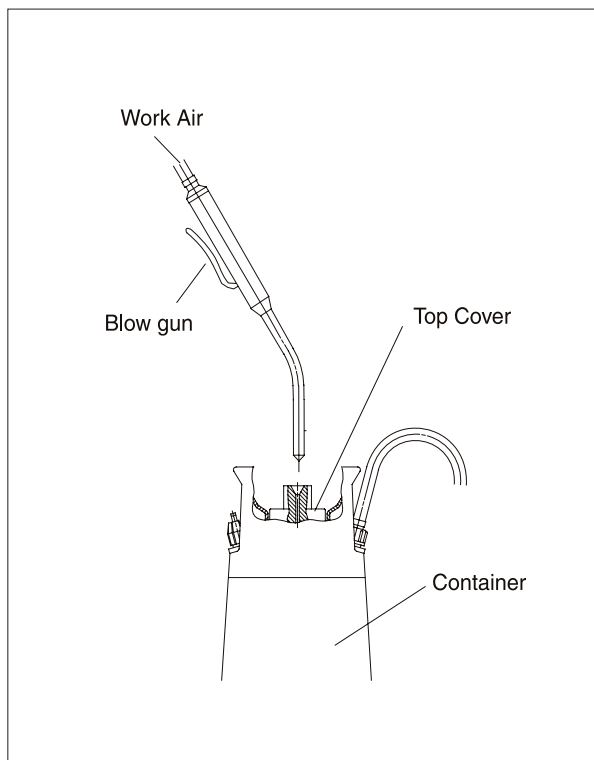


Fig 2

L+V28/32H

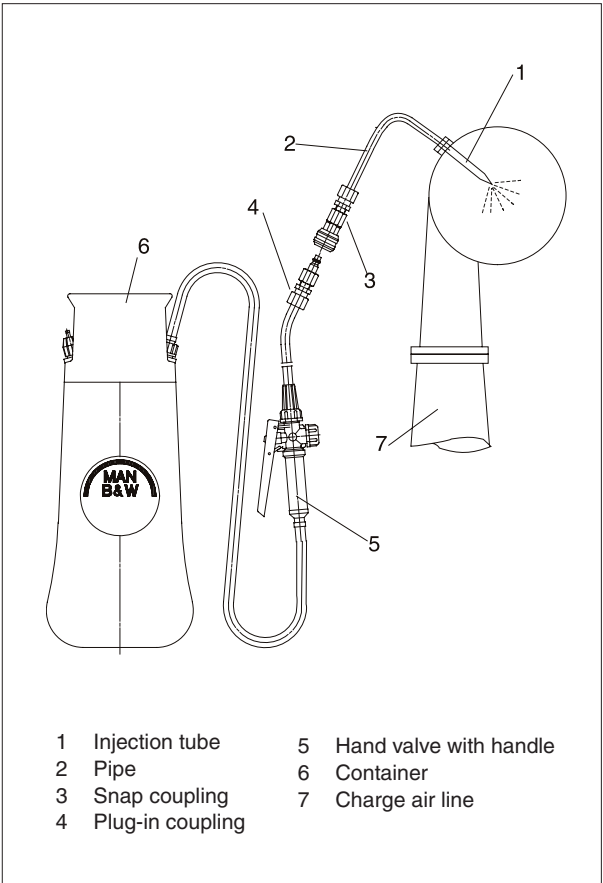


Fig 3

6) Connect the plug-in coupling of the lance to the snap coupling on the pipe (see fig 3).

7) Depress the handle on the hand valve until the water is completely injected into the compressor (approx. 30 seconds).

*The water will enter the compressor in atomized condition, impinge the vanes of the compressor wheel with high velocity and thus wash off the dirt deposited.*

8) Release the plug-in coupling and vent the container by drawing the spindle out of the safety valve.

**After Cleaning**

9) Run the engine for minimum 10 minutes at unaltered high load.

10) Compare the measurements of the operating data (see fig 4) before and after the cleaning procedure (see Operating Data 600.30).

| IF  | THEN  |
|---|---|
| the comparison indicates success of the washing procedure | the water washing of the compressor side is finished  |
| the comparison indicates lack of the washing procedure    | carry out the washing procedure from step 1 with 10 minutes interval from the initial washing                               |
| severe dirt is being deposited in the compressor          | dismantling of the compressor components for manual cleaning is necessary (see special turbocharger manual in section 612). |

Fig 4

|                            |  |                                 |
|----------------------------|--|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Dry Cleaning of Turbocharger - Turbine Side</b> | <b>612-10.00</b><br>Edition 02H |
|----------------------------|--|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Dry cleaning of turbine side, cleaning with engine in service.

**Starting position:****Related procedure:****Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no.                | Item no. | Note. |
|--------------------------|----------|-------|
| Blow gun with container. |          |       |

**Hand tools:****Replacement and wearing parts:**

| Plate no.                                     | Item no. | Qty. / |
|---|----------|--------|
| See the special instruction for turbocharger. |          |        |

**L+V28/32H****Cleaning Procedure.**

**1)** The cleaning is carried out during high engine load minimum 75 % at full load.

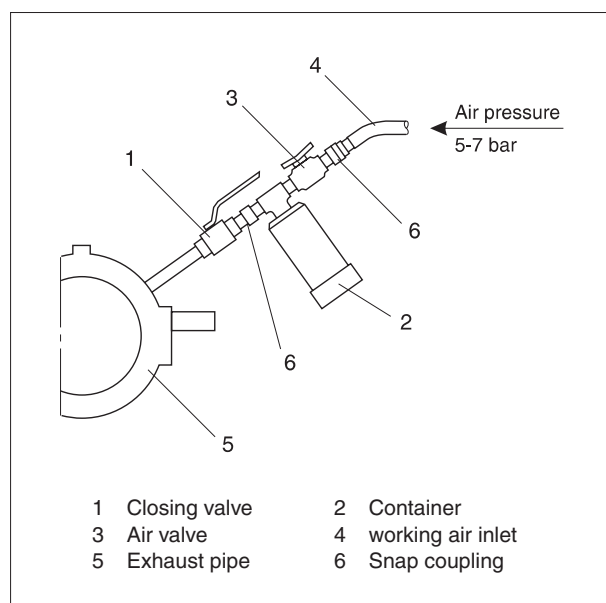


Fig 1 Arrangement of dry cleaning of turbocharger - Turbine.

**2)** Before connecting the "blow-gun" open the closing valve (1), see fig 1 and check whether there is free passage.

**3)** Fill cleaning granulated substance into the container (2) for turbocharger type:

|                  |                   |
|------------------|-------------------|
| NR20/R - NR20S:  | 0.2 - 0.3 liters. |
| NR24/R - NR26/R: | 0.3 - 0.4 liters. |

Connect to the working air system (4), 5 -7 bar.

**4)** Connect the "blow-gun" to valve (1). Open air valve (3).

Then open valve (1) slowly until a whistling sound indicates that blowing-in of granulated substance takes place.

Injection time approx. 2 min.

For dry cleaning of turbine side, see also description 612.10 "Cleaning the Turbocharger in Service, Dry Cleaning - Turbine Side.

|                            |                                      |                                 |
|----------------------------|--------------------------------------|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Water Washing of Turbine Side</b> | <b>612-15.00</b><br>Edition 01H |
|----------------------------|--------------------------------------|---------------------------------|

**General****Safety precautions:**

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Water washing of turbine side, cleaning with engine in service.

**Starting position:****Related procedure:****Man power:**

Working time : 1/2 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|           |          |       |

**Hand tools:****Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
|           |          |        |

See the special instruction for turbocharger.

## General

### Cleaning Procedure.

- 1) Adjust the engine load to approx. 20 % and let the engine stabilize for 10 min.
- 2) Open the drain cock at the turbocharger outlet and check for free passage, see fig. 1.

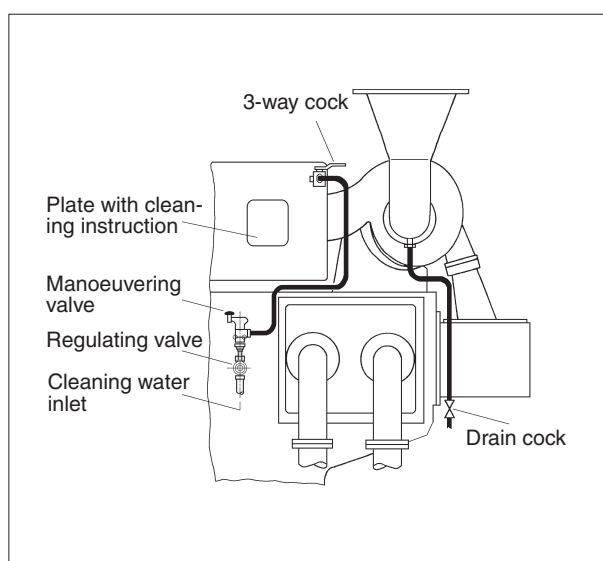


Fig. 1. Arrangement for water washing.

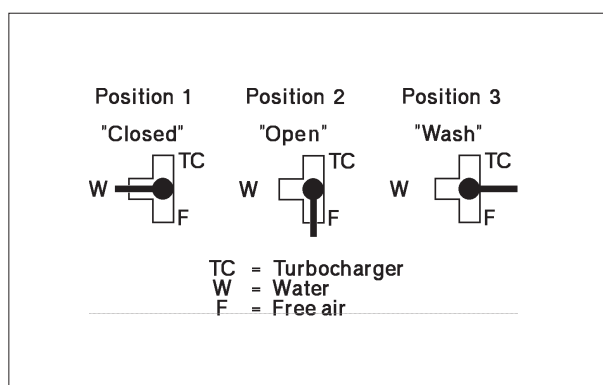


Fig. 2. 3-way cock.

- 3) Turn the 3-way cock to position 2 "Open", see fig. 2 and check for free passage. If ok turn to the water wash position 3 "Wash".

- 4) Connect the water supply to the water wash system.

- 5) Activate the manoeuvring valve, see fig. 1.

Then open the regulating valve and adjust the water flow until the drain flow is approx. 0,25 l/min.

- 6) Continue the water washing 5 - 10 min. or until the drain water is free of particles.

- 7) Release the manoeuvring valve and disconnect the water supply.

Turn the 3-way cock to position 1, "Closed" and check that the water drain flow has stopped.

- 8) Continue at this load at least 5 min. before increasing the load to the normal condition.

- 9) After the water washing, the engine should run for at least 1 hour before stop.

**Note:** The regulating valve has to be opened slowly.

The manoeuvring valve must not be locked in open position.

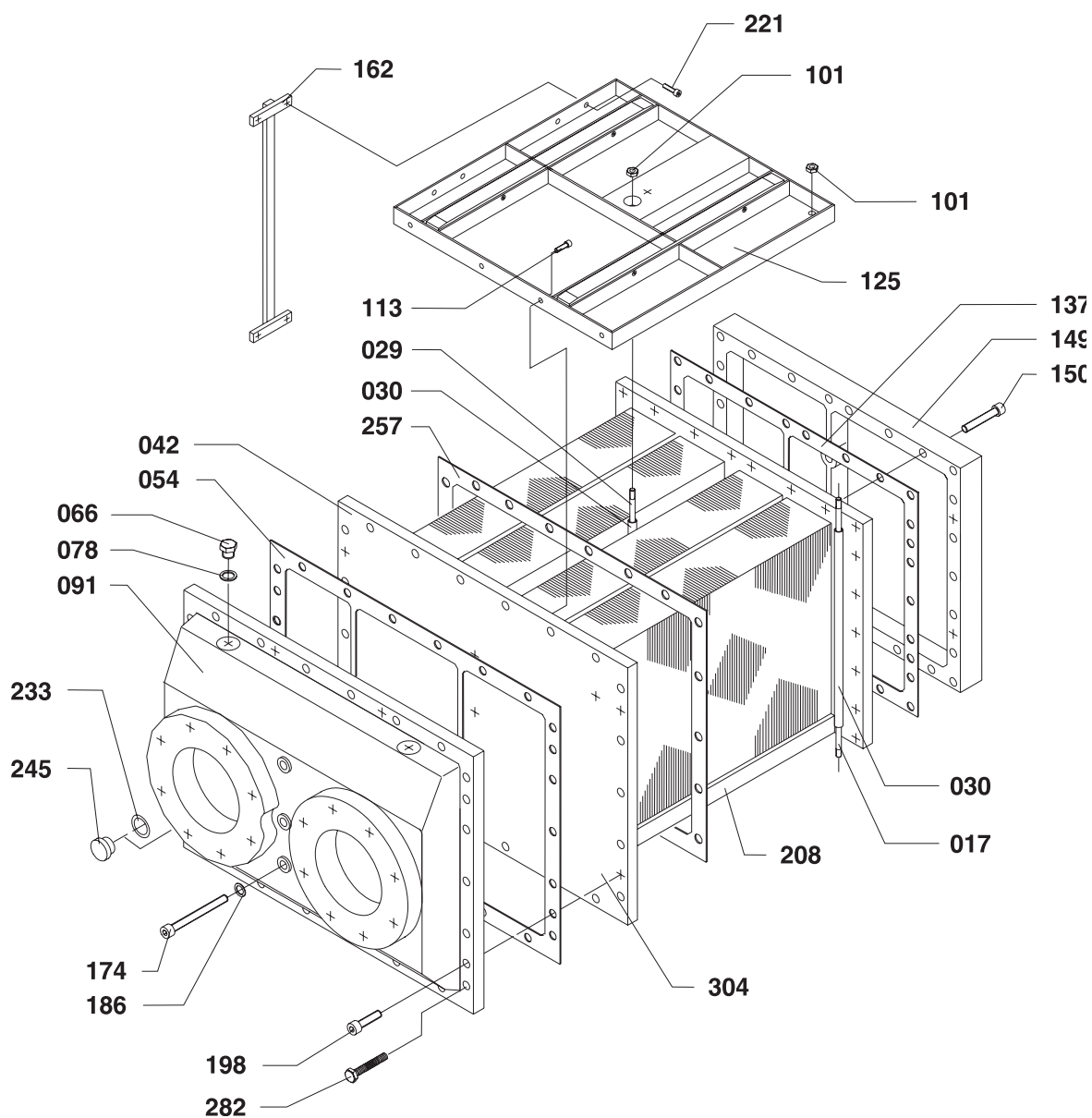
The water injection time mentioned in item 6 must be not exceeded.

For water washing of turbine side, see also description for water washing.



|                     |   |                  |
|---------------------|---|------------------|
| Plate<br>Page 1 (2) | <b>Charging Air Cooler - Freshwater</b> | <b>61201-12H</b> |
|---------------------|---|------------------|

**5-6L28/32H**



08028-0D/H5250/94.08.12

| Item No. | Qty. | Designation   | Benævnelse  |
|----------|------|---|---|
| 017      | 1/K  | Crossmember   | Travers   |
| 029      | 1/K  | Crossmember   | Travers   |
| 030      | 2/K  | Pipe  | Rør   |
| 042      | 1/K  | Cooler block  | Kølerblok   |
| 054      | 1/K  | Gasket end cover  | Pakning endedæksel  |
| 066      | 4/K  | Plug screw  | Propskrue   |
| 078      | 4/K  | Cu-washer   | Cu-skive  |
| 091      | 1/K  | End cover   | Endedæksel  |
| 101      | 4/K  | Nut   | Møtrik  |
| 113      | 8/K  | Screw   | Skrue   |
| 125      | 1/K  | Side plate right  | Sideplade højre   |
| 137      | 1/K  | Gasket reversing cover  | Pakning vendekammer   |
| 149      | 1/K  | Reversing cover   | Vendekammer   |
| 150      | 32/K | Screw   | Skrue   |
| 162      | 1/K  | Crossmember   | Travers   |
| 174      | 5/K  | Screw   | Skrue   |
| 186      | 5/K  | Cu-washer   | Cu-skive  |
| 198      | 5/K  | Screw   | Skrue   |
| 208      | 1/K  | Side plate left   | Sideplade venstre   |
| 221      | 4/K  | Screw   | Skrue   |
| 233      | 1/K  | O-ring  | O-ring  |
| 245      | 1/K  | Plug  | Prop  |
| 257      | 1/K  | Gasket  | Pakning   |
| 282      | 22/K | Screw   | Skrue   |
| 304      | 1/E  | Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 162, 174, 186, 198, 208, 221, 233 and 245 | Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 162, 174, 186, 198, 208, 221, 233 og 245 |

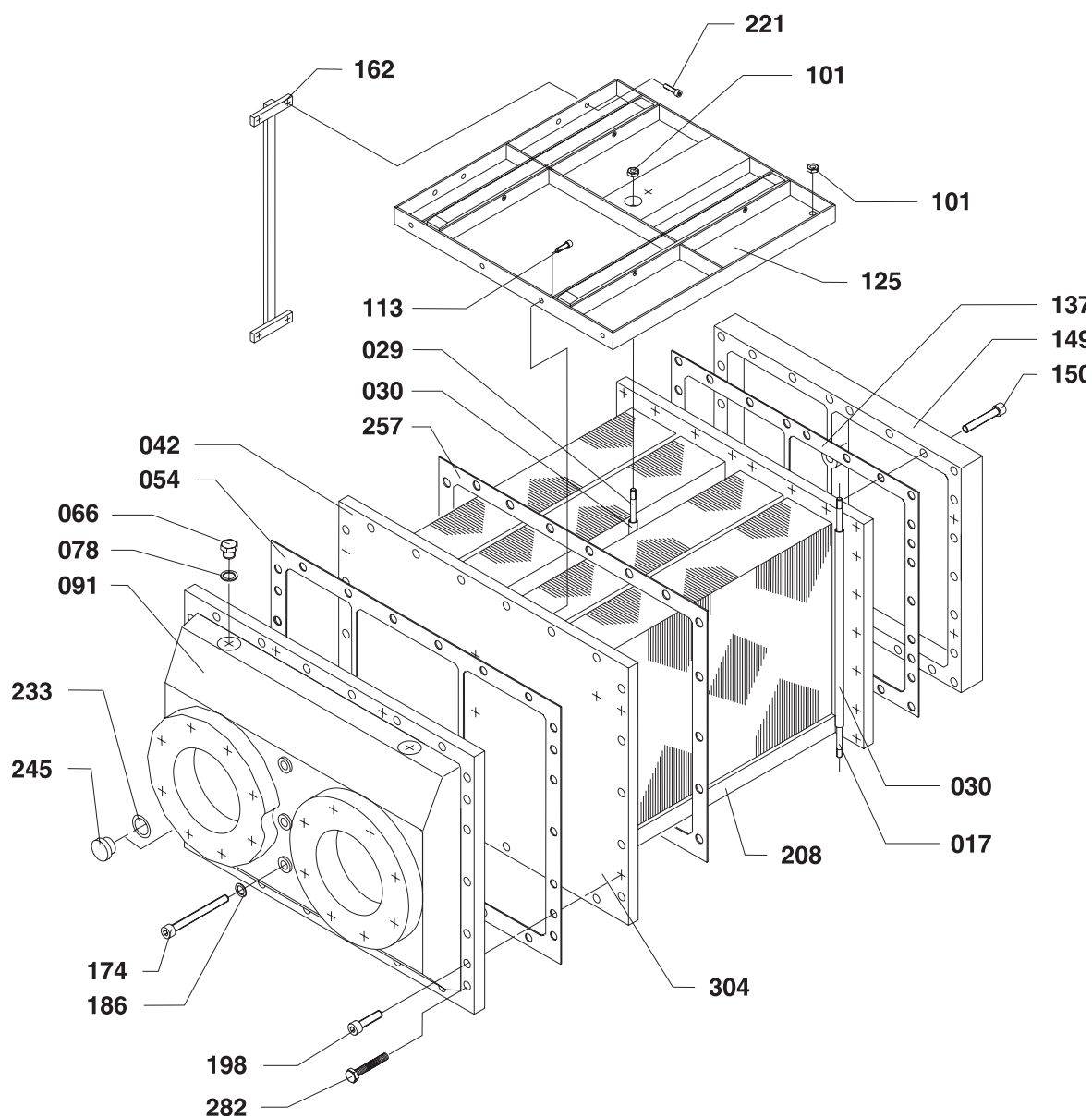
| Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|
|          |      |             |            |

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine.  
Qty./K = Cooler

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/K = Køler

|                     |   |                  |
|---------------------|---|------------------|
| Plate<br>Page 1 (2) | <b>Charging Air Cooler - Freshwater</b> | <b>61201-13H</b> |
|---------------------|---|------------------|

**7-8-9L28/32H**



61201-13H

## Charging Air Cooler - Freshwater

Plate  
Page 2 (2)

## 7-8-9L28/32H

| Item No. | Qty. | Designation   | Benævnelse  | Item No. | Qty. | Designation | Benævnelse |
|----------|------|---|---|----------|------|-------------|------------|
| 017      | 1/K  | Crossmember   | Travers   |          |      |             |            |
| 029      | 1/K  | Crossmember   | Travers   |          |      |             |            |
| 030      | 2/K  | Pipe  | Rør   |          |      |             |            |
| 042      | 1/K  | Cooler block  | Kølerblok   |          |      |             |            |
| 054      | 1/K  | Gasket end cover  | Pakning endedæksel  |          |      |             |            |
| 066      | 4/K  | Plug screw  | Propskrue   |          |      |             |            |
| 078      | 4/K  | Cu-washer   | Cu-skive  |          |      |             |            |
| 091      | 1/K  | End cover   | Endedæksel  |          |      |             |            |
| 101      | 4/K  | Nut   | Møtrik  |          |      |             |            |
| 113      | 8/K  | Screw   | Skrue   |          |      |             |            |
| 125      | 1/K  | Side plate right  | Sideplade højre   |          |      |             |            |
| 137      | 1/K  | Gasket reversing cover  | Pakning vendekammer   |          |      |             |            |
| 149      | 1/K  | Reversing cover   | Vendekammer   |          |      |             |            |
| 150      | 32/K | Screw   | Skrue   |          |      |             |            |
| 162      | 1/K  | Crossmember   | Travers   |          |      |             |            |
| 174      | 5/K  | Screw   | Skrue   |          |      |             |            |
| 186      | 5/K  | Cu-washer   | Cu-skive  |          |      |             |            |
| 198      | 5/K  | Screw   | Skrue   |          |      |             |            |
| 208      | 1/K  | Side plate left   | Sideplade venstre   |          |      |             |            |
| 221      | 4/K  | Screw   | Skrue   |          |      |             |            |
| 233      | 1/K  | O-ring  | O-ring  |          |      |             |            |
| 245      | 1/K  | Plug  | Prop  |          |      |             |            |
| 257      | 1/K  | Gasket  | Pakning   |          |      |             |            |
| 282      | 22/K | Screw   | Skrue   |          |      |             |            |
| 304      | 1/E  | Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 162, 174, 186, 198, 208, 221, 233 and 245 | Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 162, 174, 186, 198, 208, 221, 233 og 245 |          |      |             |            |

When ordering spare parts, see also page 600.50.

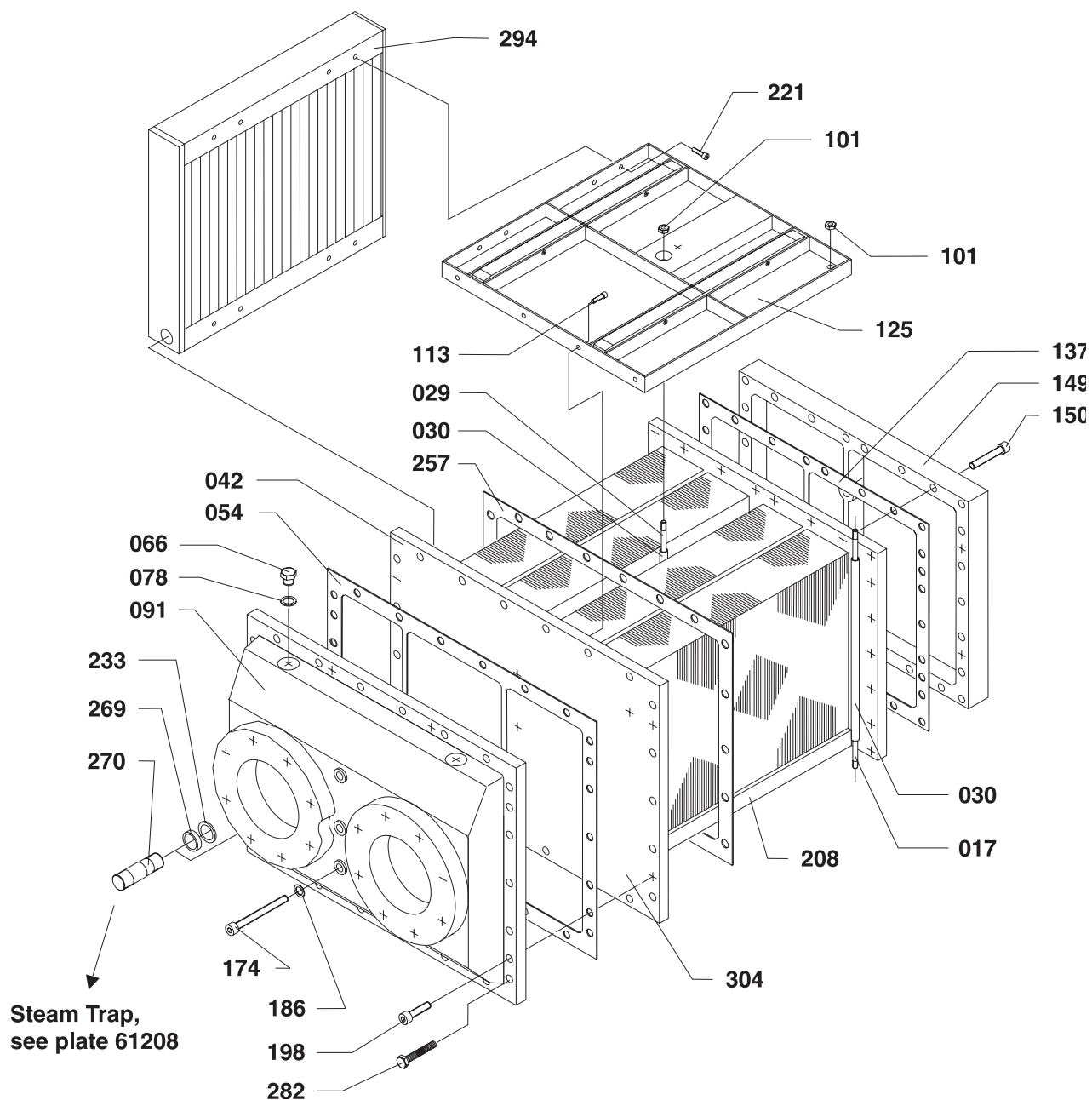
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine.  
 Qty./K = Cooler

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/K = Køler

08028-0D/H5250/94.08.12

5-6L28/32H



61201-14H

## Charging Air Cooler - Freshwater

Plate  
Page 2 (2)

## 5-6L28/32H

| Item No. | Qty. | Designation  | Benævnelse   | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|--|----------|------|-------------|------------|
| 017      | 1/K  | Crossmember  | Travers  |          |      |             |            |
| 029      | 1/K  | Crossmember  | Travers  |          |      |             |            |
| 030      | 2/K  | Pipe   | Rør  |          |      |             |            |
| 042      | 1/K  | Cooler block   | Kølerblok  |          |      |             |            |
| 054      | 1/K  | Gasket end cover   | Pakning endedæksel   |          |      |             |            |
| 066      | 4/K  | Plug screw   | Propskrue  |          |      |             |            |
| 078      | 4/K  | Cu-washer  | Cu-skive   |          |      |             |            |
| 091      | 1/K  | End cover  | Endedæksel   |          |      |             |            |
| 101      | 4/K  | Nut  | Møtrik   |          |      |             |            |
| 113      | 8/K  | Screw  | Skrue  |          |      |             |            |
| 125      | 1/K  | Side plate right   | Sideplade højre  |          |      |             |            |
| 137      | 1/K  | Gasket reversing cover   | Pakning vendekammer  |          |      |             |            |
| 149      | 1/K  | Reversing cover  | Vendekammer  |          |      |             |            |
| 150      | 32/K | Screw  | Skrue  |          |      |             |            |
| 174      | 5/K  | Screw  | Skrue  |          |      |             |            |
| 186      | 5/K  | Cu-washer  | Cu-skive   |          |      |             |            |
| 198      | 5/K  | Screw  | Skrue  |          |      |             |            |
| 208      | 1/K  | Side plate left  | Sideplade venstre  |          |      |             |            |
| 221      | 8/K  | Screw  | Skrue  |          |      |             |            |
| 233      | 1/K  | O-ring   | O-ring   |          |      |             |            |
| 257      | 1/K  | Gasket   | Pakning  |          |      |             |            |
| 269      | 1/K  | Ring   | Ring   |          |      |             |            |
| 270      | 1/K  | Drain pipe for WMC   | Drænrør for WMC  |          |      |             |            |
| 282      | 22/K | Screw  | Skrue  |          |      |             |            |
| 294      | 1/K  | Water mist catcher   | Vandudskiller  |          |      |             |            |
| 304      | 1/E  | Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270 and 294 | Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270 og 294 |          |      |             |            |

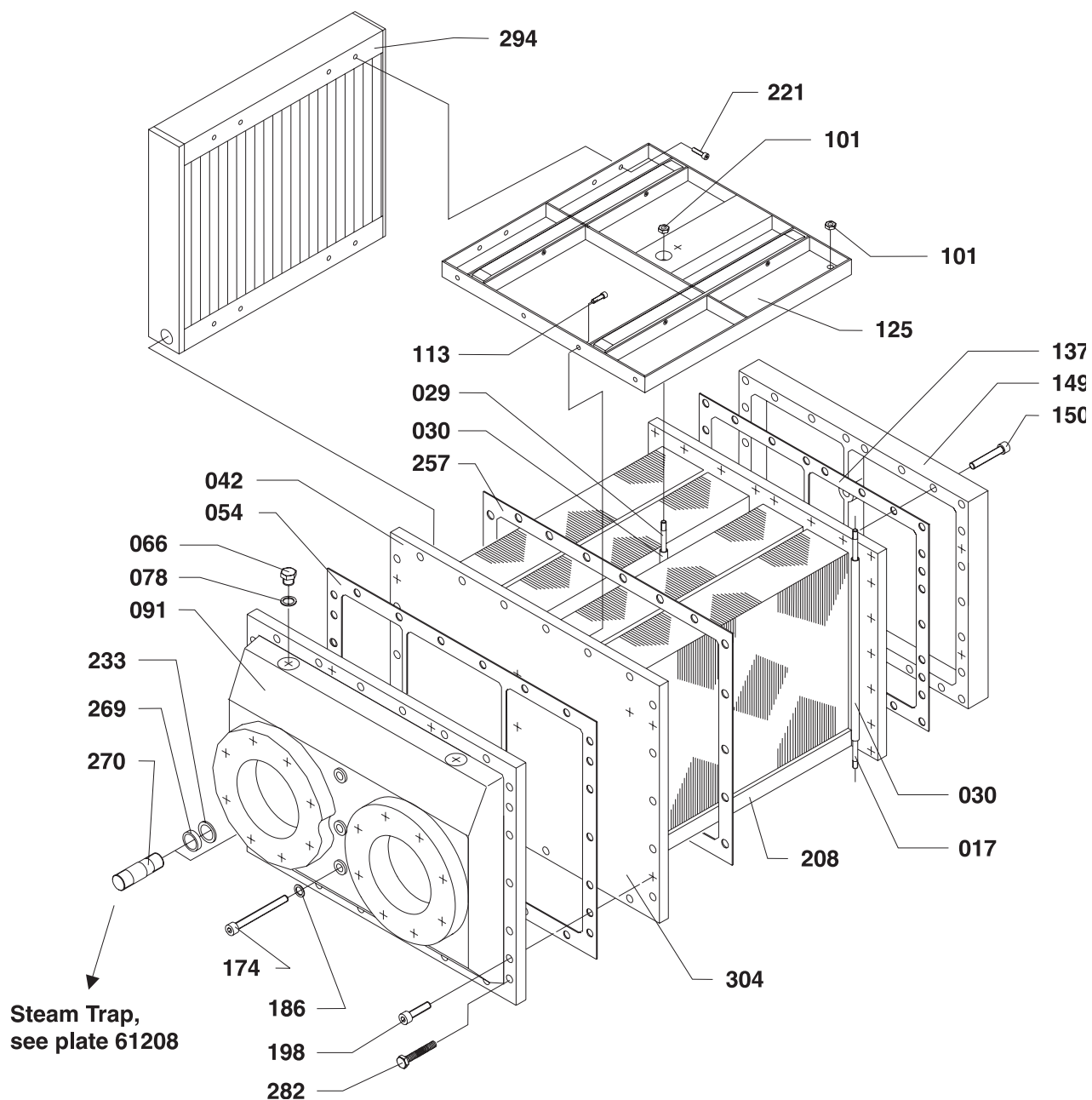
When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine.  
 Qty./K = Cooler

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/K = Køler

08028-0D/H5250/94.08.12

**7-8-9L28/32H**

|           |                                  |                     |
|-----------|----------------------------------|---------------------|
| 61201-15H | Charging Air Cooler - Freshwater | Plate<br>Page 2 (2) |
|-----------|----------------------------------|---------------------|

**7-8-9L28/32H**

| Item No. | Qty. | Designation   | Benævnelse   | Item No. | Qty. | Designation | Benævnelse |
|----------|------|---|--|----------|------|-------------|------------|
| 017      | 1/K  | Crossmember   | Travers  |          |      |             |            |
| 029      | 1/K  | Crossmember   | Travers  |          |      |             |            |
| 030      | 2/K  | Pipe  | Rør  |          |      |             |            |
| 042      | 1/K  | Cooler block  | Kølerblok  |          |      |             |            |
| 054      | 1/K  | Gasket end cover  | Pakning endedæksel   |          |      |             |            |
| 066      | 4/K  | Plug screw  | Propskrue  |          |      |             |            |
| 078      | 4/K  | Cu-washer   | Cu-skive   |          |      |             |            |
| 091      | 1/K  | End cover   | Endedæksel   |          |      |             |            |
| 101      | 4/K  | Nut   | Møtrik   |          |      |             |            |
| 113      | 8/K  | Screw   | Skrue  |          |      |             |            |
| 125      | 1/K  | Side plate right  | Sideplade højre  |          |      |             |            |
| 137      | 1/K  | Gasket reversing cover  | Pakning vendekammer  |          |      |             |            |
| 149      | 1/K  | Reversing cover   | Vendekammer  |          |      |             |            |
| 150      | 32/K | Screw   | Skrue  |          |      |             |            |
| 174      | 5/K  | Screw   | Skrue  |          |      |             |            |
| 186      | 5/K  | Cu-washer   | Cu-skive   |          |      |             |            |
| 198      | 5/K  | Screw   | Skrue  |          |      |             |            |
| 208      | 1/K  | Side plate left   | Sideplade venstre  |          |      |             |            |
| 221      | 8/K  | Screw   | Skrue  |          |      |             |            |
| 233      | 1/K  | O-ring  | O-ring   |          |      |             |            |
| 257      | 1/K  | Gasket  | Pakning  |          |      |             |            |
| 269      | 1/K  | Ring  | Ring   |          |      |             |            |
| 270      | 1/K  | Drain pipe for WMC  | Drænrør for WMC  |          |      |             |            |
| 282      | 22/K | Screw   | Skrue  |          |      |             |            |
| 294      | 1/K  | Water mist catcher  | Vandudskiller  |          |      |             |            |
| 304      | 1/E  | Charging air cooler, complete, incl. item 017,029,030,042,054,066,078,091,101,113,125,137,149,150,174,186,198,208,221,233,269,270 and 294 | Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270 og 294 |          |      |             |            |

**When ordering spare parts, see also page 600.50.**

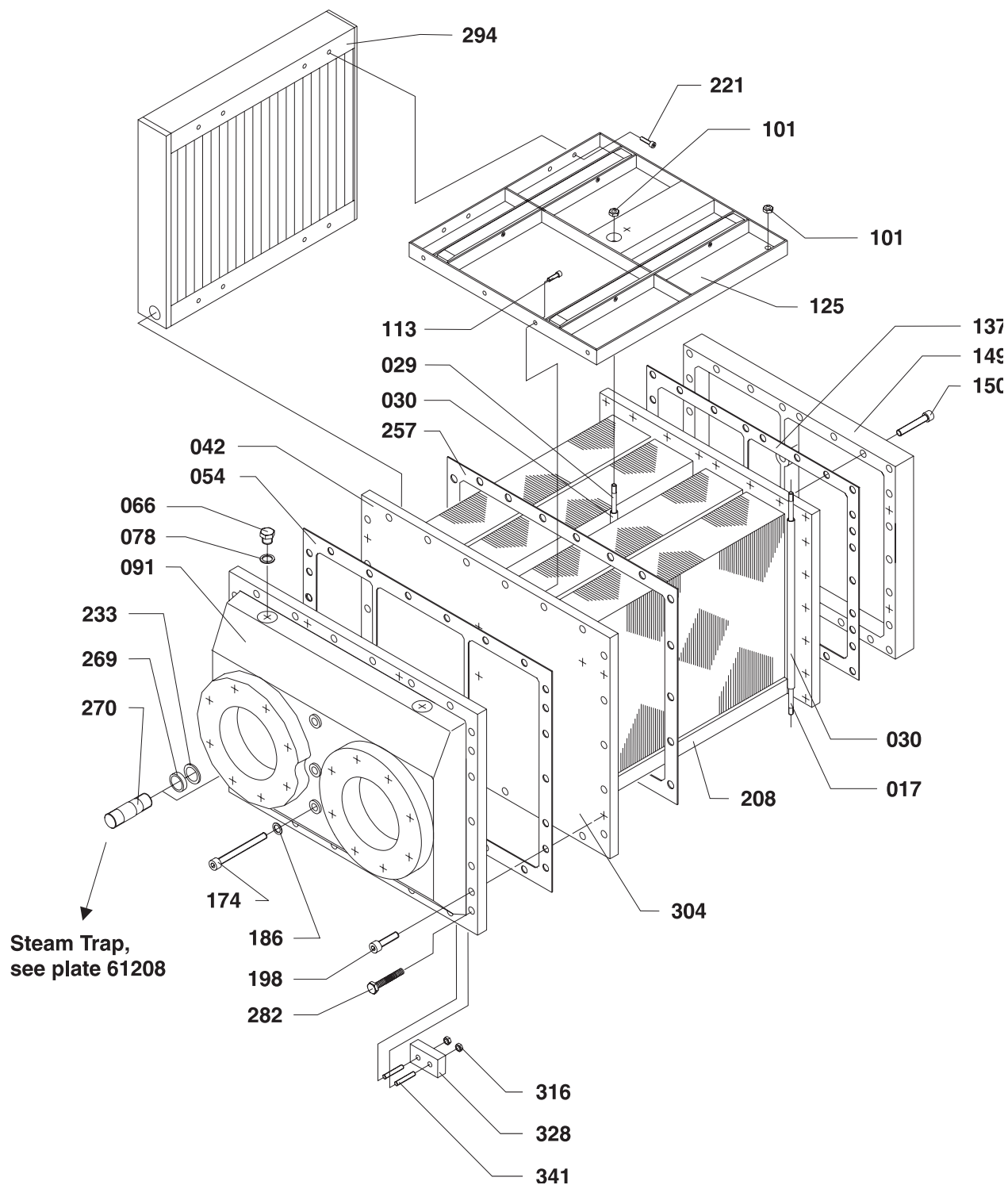
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine.  
Qty./K = Cooler

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/K = Køler



5-6L28/32H



61201-16H

## Charging Air Cooler - Seawater

Plate  
Page 2 (2)

## 5-6L28/32H

| Item No. | Qty. | Designation                       | Benævnelse                | Item No. | Qty. | Designation   | Benævnelse  |
|----------|------|-----------------------------------|---------------------------|----------|------|---|---|
| 017      | 1/K  | Crossmember                       | Travers                   | 304      | 1/E  | <b>Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270, 294, 316, 328, 341</b> | Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270, 294, 316, 328, 341 |
| 029      | 1/K  | Crossmember                       | Travers                   |          |      |   |   |
| 030      | 2/K  | Pipe                              | Rør                       |          |      |   |   |
| 042      | 1/K  | Cooler block                      | Kølerblok                 |          |      |   |   |
| 054      | 1/K  | Gasket end cover                  | Pakning endedæksel        |          |      |   |   |
| 066      | 4/K  | Plug screw                        | Propskrue                 | 316      | 12/K | Nut   | Møtrik  |
| 078      | 4/K  | Cu-washer                         | Cu-skive                  | 328      | 6/K  | Anti-corrosion block  | Anode   |
| 091      | 1/K  | End cover                         | Endedæksel                | 341      | 12/K | Stud  | Tapskrue  |
| 101      | 4/K  | Nut                               | Møtrik                    |          |      |   |   |
| 113      | 8/K  | Screw                             | Skrue                     |          |      |   |   |
| 125      | 1/K  | Top plate                         | Topplade                  |          |      |   |   |
| 137      | 1/K  | Gasket reversing cover            | Pakning vendekammer       |          |      |   |   |
| 149      | 1/K  | Reversing cover                   | Vendekammer               |          |      |   |   |
| 150      | 32/K | Screw                             | Skrue                     |          |      |   |   |
| 174      | 5/K  | Screw                             | Skrue                     |          |      |   |   |
| 186      | 5/K  | Cu-washer                         | Cu-skive                  |          |      |   |   |
| 198      | 5/K  | Screw                             | Skrue                     |          |      |   |   |
| 208      | 1/K  | Bottom plate                      | Bundplade                 |          |      |   |   |
| 221      | 8/K  | Screw                             | Skrue                     |          |      |   |   |
| 233      | 1/K  | O-ring                            | O-ring                    |          |      |   |   |
| 257      | 1/K  | Gasket                            | Pakning                   |          |      |   |   |
| 269      | 1/K  | Ring                              | Ring                      |          |      |   |   |
| 270      | 1/K  | Drain pipe for water mist catcher | Drænrør for vandudskiller |          |      |   |   |
| 282      | 22/K | Screw                             | Skrue                     |          |      |   |   |
| 294      | 1/K  | Water mist catcher                | Vandudskiller             |          |      |   |   |

When ordering spare parts, see also page 600.50.

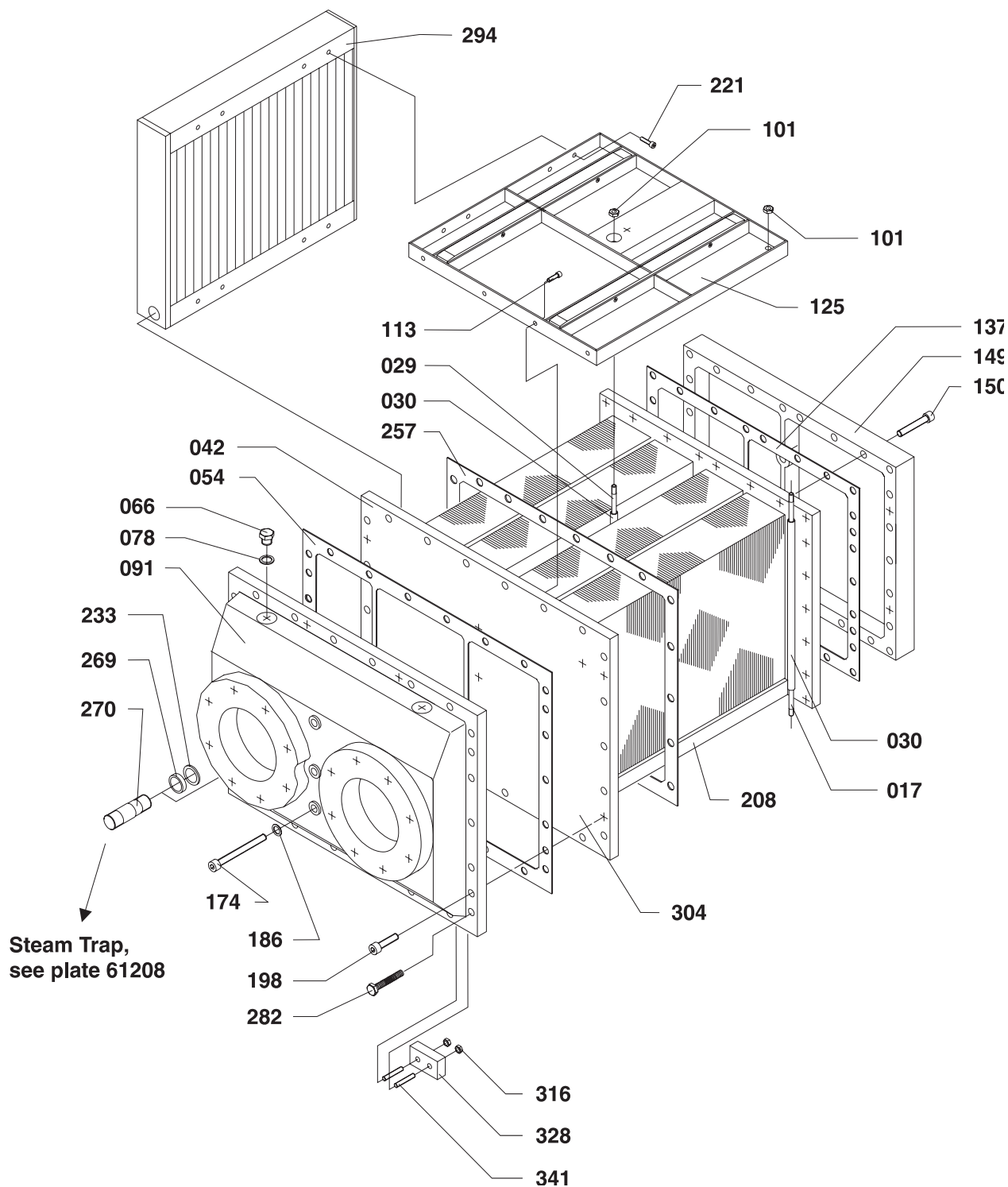
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine.  
 Qty./K = Cooler

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/K = Køler

08028-0D/H5250/94.08.12

7-8-9L28/32H



61201-17H

## Charging Air Cooler - Seawater

Plate  
Page 2 (2)

## 7-8-9L28/32H

| Item No. | Qty. | Designation                       | Benævnelse                | Item No. | Qty. | Designation   | Benævnelse  |
|----------|------|-----------------------------------|---------------------------|----------|------|---|---|
| 017      | 1/K  | Crossmember                       | Travers                   | 304      | 1/E  | <b>Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270, 294, 316, 328, 341</b> | Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270, 294, 316, 328, 341 |
| 029      | 1/K  | Crossmember                       | Travers                   |          |      |   |   |
| 030      | 2/K  | Pipe                              | Rør                       |          |      |   |   |
| 042      | 1/K  | Cooler block                      | Kølerblok                 |          |      |   |   |
| 054      | 1/K  | Gasket end cover                  | Pakning endedæksel        |          |      |   |   |
| 066      | 4/K  | Plug screw                        | Propskrue                 | 316      | 12/K | Nut   | Møtrik  |
| 078      | 4/K  | Cu-washer                         | Cu-skive                  | 328      | 6/K  | Anti-corrosion block  | Anode   |
| 091      | 1/K  | End cover                         | Endedæksel                | 341      | 12/K | Stud  | Tapskrue  |
| 101      | 4/K  | Nut                               | Møtrik                    |          |      |   |   |
| 113      | 8/K  | Screw                             | Skrue                     |          |      |   |   |
| 125      | 1/K  | Top plate                         | Topplade                  |          |      |   |   |
| 137      | 1/K  | Gasket reversing cover            | Pakning vendekammer       |          |      |   |   |
| 149      | 1/K  | Reversing cover                   | Vendekammer               |          |      |   |   |
| 150      | 32/K | Screw                             | Skrue                     |          |      |   |   |
| 174      | 5/K  | Screw                             | Skrue                     |          |      |   |   |
| 186      | 5/K  | Cu-washer                         | Cu-skive                  |          |      |   |   |
| 198      | 5/K  | Screw                             | Skrue                     |          |      |   |   |
| 208      | 1/K  | Bottom plate                      | Bundplade                 |          |      |   |   |
| 221      | 8/K  | Screw                             | Skrue                     |          |      |   |   |
| 233      | 1/K  | O-ring                            | O-ring                    |          |      |   |   |
| 257      | 1/K  | Gasket                            | Pakning                   |          |      |   |   |
| 269      | 1/K  | Ring                              | Ring                      |          |      |   |   |
| 270      | 1/K  | Drain pipe for water mist catcher | Drænrør for vandudskiller |          |      |   |   |
| 282      | 22/K | Screw                             | Skrue                     |          |      |   |   |
| 294      | 1/K  | Water mist catcher                | Vandudskiller             |          |      |   |   |

When ordering spare parts, see also page 600.50.

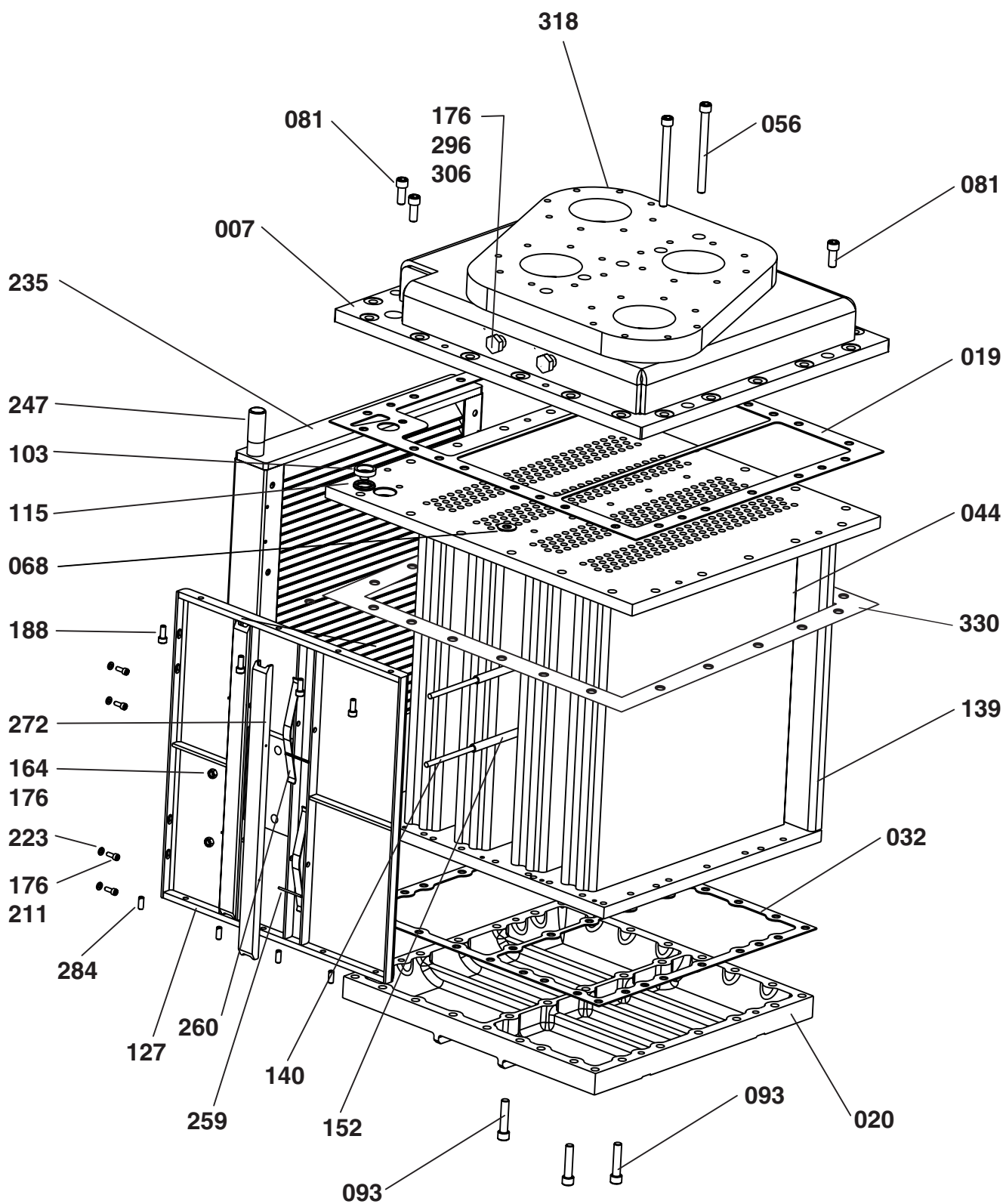
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine.  
 Qty./K = Cooler

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/K = Køler

08028-0D/H5250/94.08.12

L28/32H



61201-29H

## Charging Air Cooler - Freshwater

Plate  
Page 2 (2)

## L28/32H

| Item No. | Qty. | Designation                       | Benævnelse                | Item No. | Qty. | Designation                 | Benævnelse             |
|----------|------|-----------------------------------|---------------------------|----------|------|-----------------------------|------------------------|
| 007      | 1/K  | End cover                         | Endedæksel                | 306      | 4/K  | Gasket                      | Pakning                |
| 019      | 1/K  | Gasket for end cover              | Pakning for endedæksel    | 318      | 1/E  | Charge air cooler, complete | Ladeluftkøler, komplet |
| 020      | 2/K  | Reversing chamber                 | Vendekammer               | 330      | 1/K  | Gasket                      | Pakning                |
| 032      | 1/K  | Gasket for reversing chamber      | Pakning for vendekammer   |          |      |                             |                        |
| 044      | 1/K  | Cooler block                      | Kølerblok                 |          |      |                             |                        |
| 056      | 5/K  | Screw                             | Skrue                     |          |      |                             |                        |
| 068      | 5/K  | Gasket ring                       | Pakningsring              |          |      |                             |                        |
| 081      | 5/K  | Screw                             | Skrue                     |          |      |                             |                        |
| 093      | 32/K | Screw                             | Skrue                     |          |      |                             |                        |
| 103      | 1/K  | Ring by drain pipe                | Ring ved drænrør          |          |      |                             |                        |
| 115      | 1/K  | O-ring                            | O-ring                    |          |      |                             |                        |
| 127      | 1/K  | Side cover- right                 | Sidedæksel - højre        |          |      |                             |                        |
| 139      | 1/K  | Side cover- left                  | Sidedæksel - venstre      |          |      |                             |                        |
| 140      | 2/K  | Crossmember                       | Travers                   |          |      |                             |                        |
| 152      | 2/K  | Distance pipe                     | Afstandsrør               |          |      |                             |                        |
| 164      | 4/K  | Nut                               | Møtrik                    |          |      |                             |                        |
| 176      | /I   | Locktite                          | Locktite                  |          |      |                             |                        |
| 188      | 8/K  | Screw                             | Skrue                     |          |      |                             |                        |
| 211      | 8/K  | Screw                             | Skrue                     |          |      |                             |                        |
| 223      | 8/K  | Washer                            | Skive                     |          |      |                             |                        |
| 235      | 1/K  | Water mist catcher                | Vandudskiller             |          |      |                             |                        |
| 247      | 1/K  | Drain pipe for water mist catcher | Drænrør for vandudskiller |          |      |                             |                        |
| 259      | 8/K  | Spring, straight pin slotted      | Spændestift               |          |      |                             |                        |
| 260      | 8/K  | Spring, side cover                | Fjeder, sideplade         |          |      |                             |                        |
| 272      | 4/K  | Lock, side cover                  | Lås, sideplade            |          |      |                             |                        |
| 284      | 8/E  | Screw                             | Skrue                     |          |      |                             |                        |
| 296      | 4/K  | Plug screw                        | Propskrue                 |          |      |                             |                        |

When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

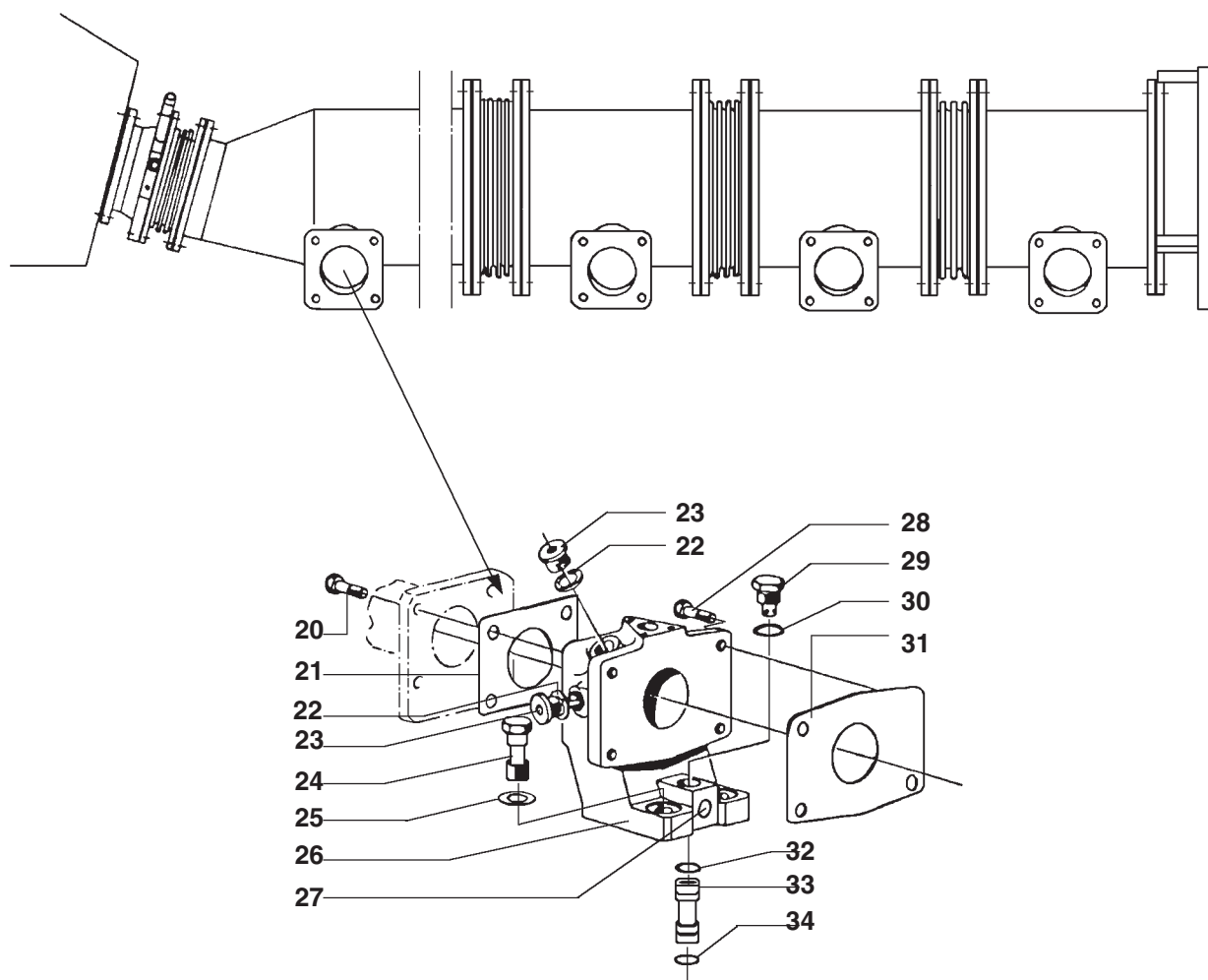
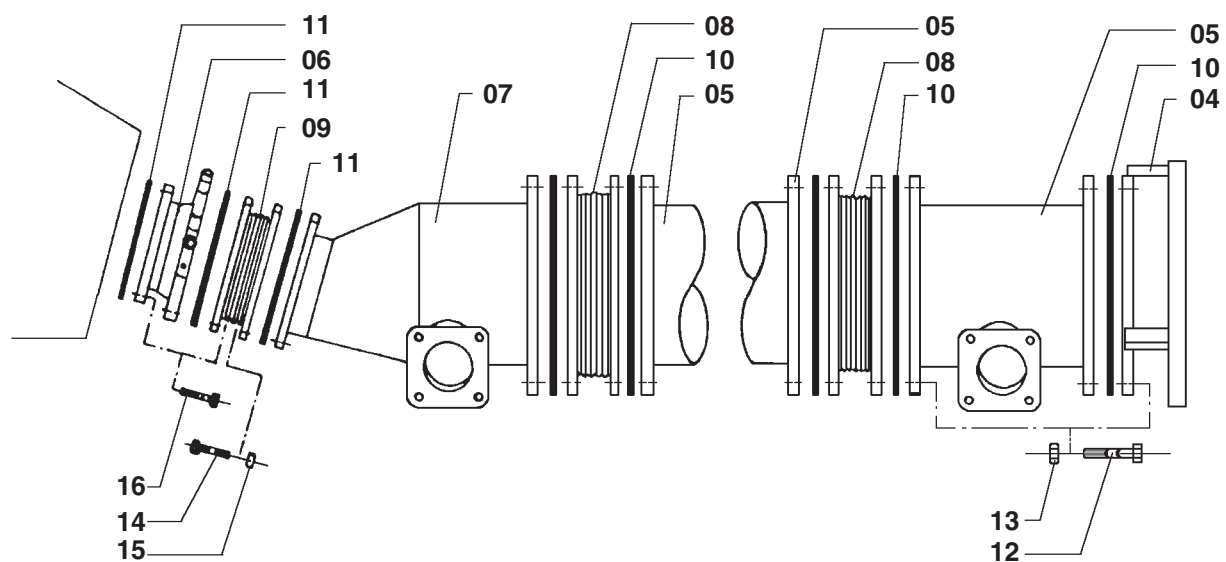
\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine.  
 Qty./K = Cooler  
 Qty./I = Individual

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/K = Køler  
 Antal/I = Individuelt

08028-0D/H5250/94.08.12

|                     |                                 |                  |
|---------------------|---------------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Exhaust Pipe Arrangement</b> | <b>61202-23H</b> |
|---------------------|---------------------------------|------------------|

**5,6L28/32H**



**61202-23H****Exhaust Pipe Arrangement**Plate  
Page 2 (2)**5,6L28/32H**

| Item No. | Qty.           | Designation   | Benævnelse                                  | Item No. | Qty. | Designation                     | Benævnelse      |
|----------|----------------|---|---|----------|------|---------------------------------|-----------------|
| 04       | 1/E            | <b>End cover, aft</b>                                   | Endeplade, bag                              | 30       | 1/C  | <b>Gasket</b>                   | Pakning         |
| 05       | 4/E<br>5/E     | <b>Exhaust pipe<br/>5 cyl. engine<br/>6 cyl. engine</b> | Udstødsrør<br>5 cyl. motor<br>6 cyl. motor  | 31       | 1/C  | <b>Gasket</b>                   | Pakning         |
| 06       | 1/E            | <b>Exhaust pipe,<br/>inlet TC.</b>                      | Udstødsrør, tilgang<br>turbolader           | 32       | 1/C  | <b>O-ring</b>                   | O-ring          |
| 07       | 1/E            | <b>Exhaust pipe for<br/>cyl. 1</b>                      | Udstødsrør for<br>cyl. 1                    | 33       | 1/C  | <b>Cooling water<br/>nipple</b> | Kølevandsnippel |
| 08       | 4/E<br>5/E     | <b>Compensator<br/>5 cyl. engine<br/>6 cyl. engine</b>  | Kompensator<br>5 cyl. motor<br>6 cyl. motor | 34       | 1/C  | <b>O-ring</b>                   | O-ring          |
| 09       | 1/E            | <b>Compensator</b>                                      | Kompensator                                 |          |      |                                 |                 |
| 10       | 9/E<br>11/E    | <b>Gasket<br/>5 cyl. engine<br/>6 cyl. engine</b>       | Pakning<br>5 cyl. motor<br>6 cyl. motor     |          |      |                                 |                 |
| 11       | 3/E            | <b>Gasket</b>   | Pakning                                     |          |      |                                 |                 |
| 12       | 108/E<br>132/E | <b>Screw<br/>5 cyl. engine<br/>6 cyl. engine</b>        | Skrue<br>5 cyl. motor<br>6 cyl. motor       |          |      |                                 |                 |
| 13       | 108/E<br>132/E | <b>Nut<br/>5 cyl. engine<br/>6 cyl. engine</b>          | Møtrik<br>5 cyl. motor<br>6 cyl. motor      |          |      |                                 |                 |
| 14       | 8/E            | <b>Screw</b>  | Skrue                                       |          |      |                                 |                 |
| 15       | 8/E            | <b>Nut</b>  | Møtrik                                      |          |      |                                 |                 |
| 16       | 16/E           | <b>Screw</b>  | Skrue                                       |          |      |                                 |                 |
| 20       | 4/C            | <b>Screw</b>  | Skrue                                       |          |      |                                 |                 |
| 21       | 1/C            | <b>Gasket</b>   | Pakning                                     |          |      |                                 |                 |
| 22       | 4/C            | <b>Gasket</b>   | Pakning                                     |          |      |                                 |                 |
| 23       | 4/C            | <b>Plug</b>   | Prop  |          |      |                                 |                 |
| 24       | 2/C            | <b>Screw</b>  | Skrue                                       |          |      |                                 |                 |
| 25       | 2/C            | <b>Washer</b>   | Skive                                       |          |      |                                 |                 |
| 26       | 1/C            | <b>Intermediate piece</b>                               | Mellemstykke                                |          |      |                                 |                 |
| 27       | 1/C            | <b>Plug screw</b>                                       | Propskrue                                   |          |      |                                 |                 |
| 28       | 4/C            | <b>Screw</b>  | Skrue                                       |          |      |                                 |                 |
| 29       | 1/C            | <b>Plug screw</b>                                       | Propskrue                                   |          |      |                                 |                 |

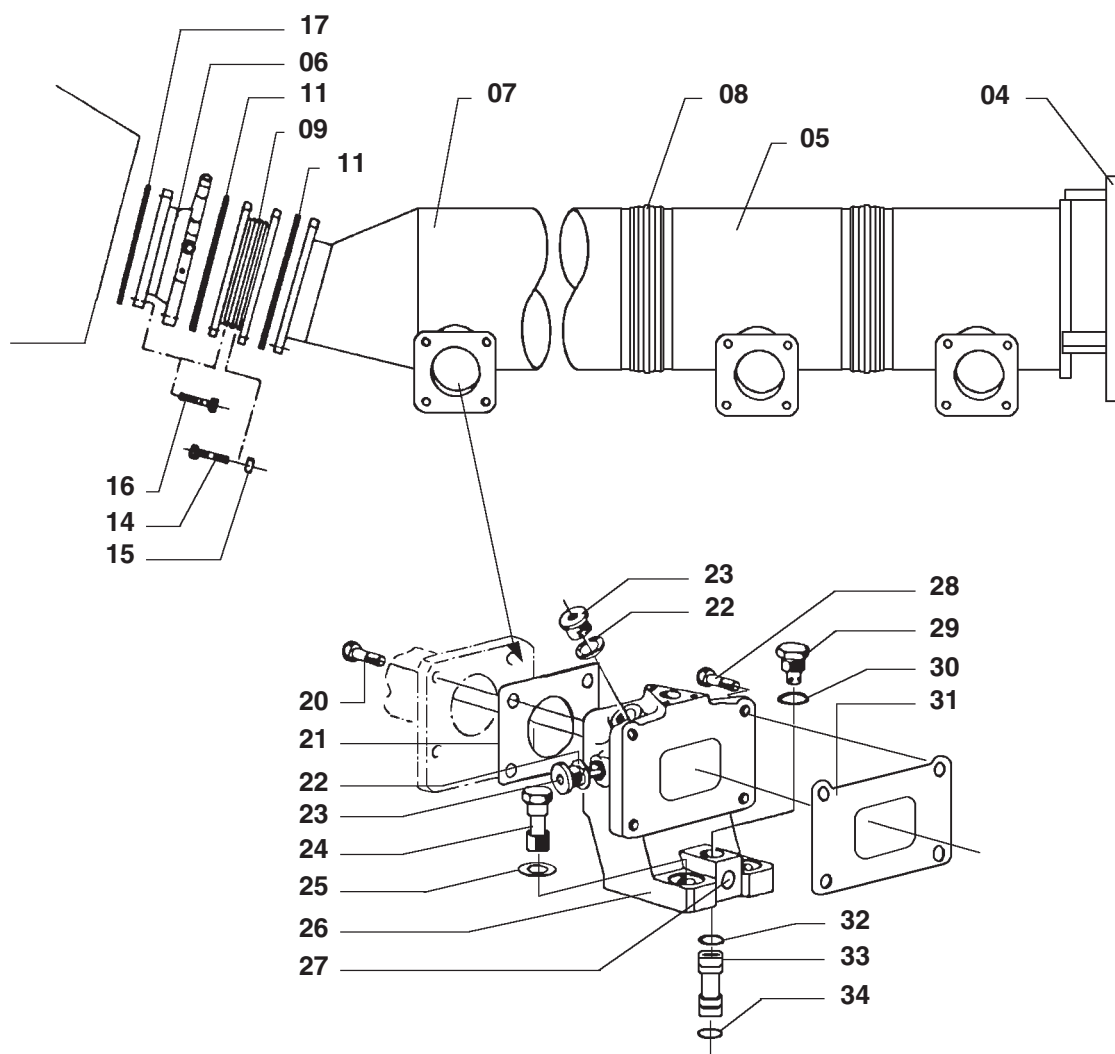
When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/cylinder



**5,6L28/32H**

**61202-32H****Exhaust Pipe Arrangement with Welded Compensator**Plate  
Page 2 (2)**5,6L28/32H**

| Item No. | Qty.       | Designation                                    | Benævnelse                                  | Item No. | Qty. | Designation | Benævnelse |
|----------|------------|--|---|----------|------|-------------|------------|
| 04       | 1/E        | End cover, aft                                 | Endeplade, bag                              |          |      |             |            |
| 05       | 4/E<br>5/E | Exhaust pipe<br>5 cyl. engine<br>6 cyl. engine | Udstødsrør<br>5 cyl. motor<br>6 cyl. motor  |          |      |             |            |
| 06       | 1/E        | Exhaust pipe,<br>inlet TC.                     | Udstødsrør, tilgang<br>turbolader           |          |      |             |            |
| 07       | 1/E        | Exhaust pipe for<br>cyl. 1                     | Udstødsrør for<br>cyl. 1                    |          |      |             |            |
| 08       | 4/E<br>5/E | Compensator<br>5 cyl. engine<br>6 cyl. engine  | Kompensator<br>5 cyl. motor<br>6 cyl. motor |          |      |             |            |
| 09       | 1/E        | Compensator                                    | Kompensator                                 |          |      |             |            |
| 11       | 2/E        | Gasket   | Pakning                                     |          |      |             |            |
| 14       | 8/E        | Screw  | Skrue                                       |          |      |             |            |
| 15       | 8/E        | Nut  | Møtrik                                      |          |      |             |            |
| 16       | 16/E       | Screw  | Skrue                                       |          |      |             |            |
| 17       | 1/E        | Gasket   | Pakning                                     |          |      |             |            |
| 20       | 4/C        | Screw  | Skrue                                       |          |      |             |            |
| 21       | 1/C        | Gasket   | Pakning                                     |          |      |             |            |
| 22       | 4/C        | Gasket   | Pakning                                     |          |      |             |            |
| 23       | 4/C        | Plug   | Prop  |          |      |             |            |
| 24       | 2/C        | Screw  | Skrue                                       |          |      |             |            |
| 25       | 2/C        | Washer   | Skive                                       |          |      |             |            |
| 26       | 1/C        | Intermediate piece                             | Mellemstykke                                |          |      |             |            |
| 27       | 1/C        | Plug screw                                     | Propskruer                                  |          |      |             |            |
| 28       | 4/C        | Screw  | Skrue                                       |          |      |             |            |
| 29       | 1/C        | Plug screw                                     | Propskruer                                  |          |      |             |            |
| 30       | 1/C        | Gasket   | Pakning                                     |          |      |             |            |
| 31       | 1/C        | Gasket   | Pakning                                     |          |      |             |            |
| 32       | 1/C        | O-ring   | O-ring                                      |          |      |             |            |
| 33       | 1/C        | Cooling water<br>nipple                        | Kølevandsnippel                             |          |      |             |            |
| 34       | 1/C        | O-ring   | O-ring                                      |          |      |             |            |

When ordering spare parts, see also page 600.50.

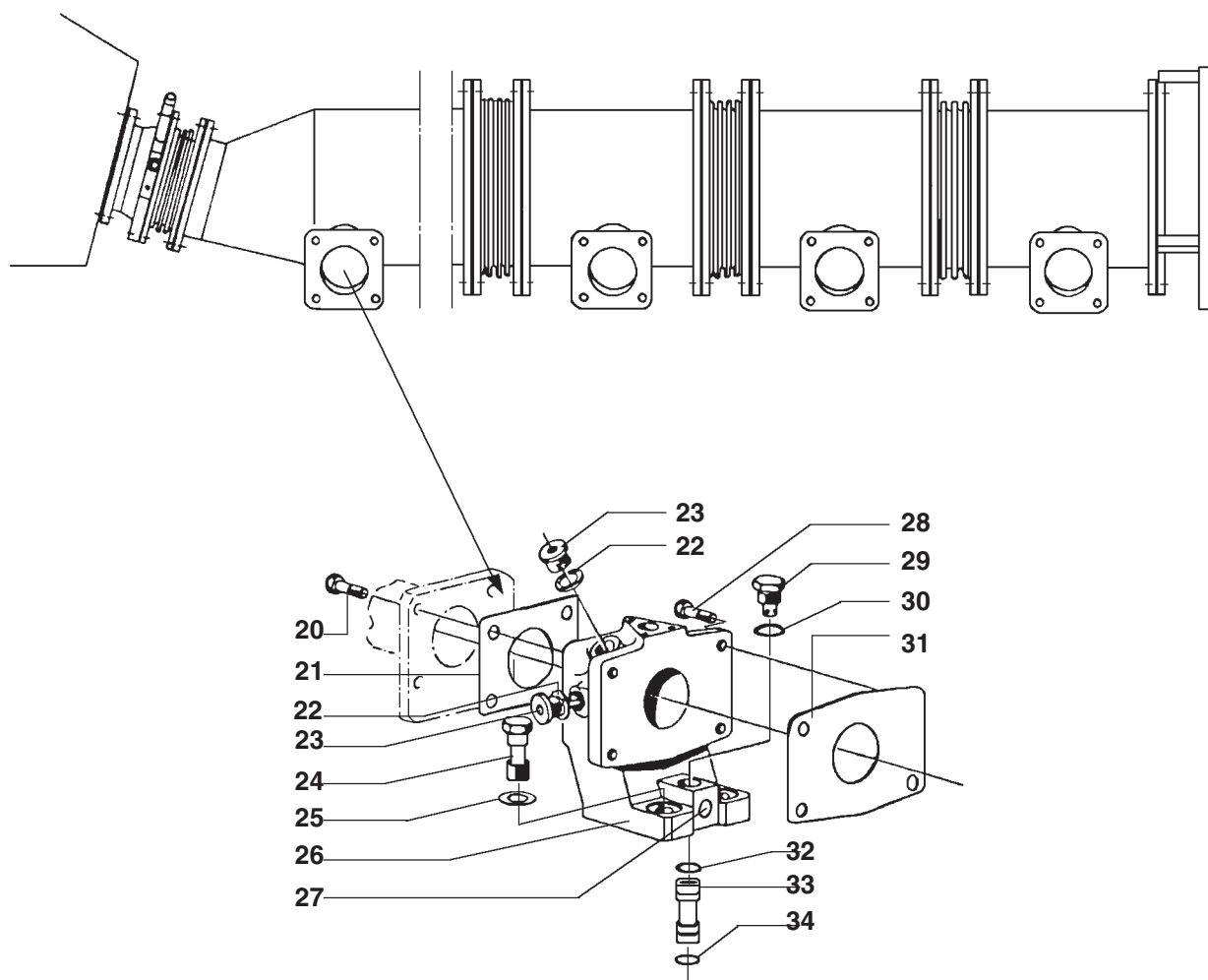
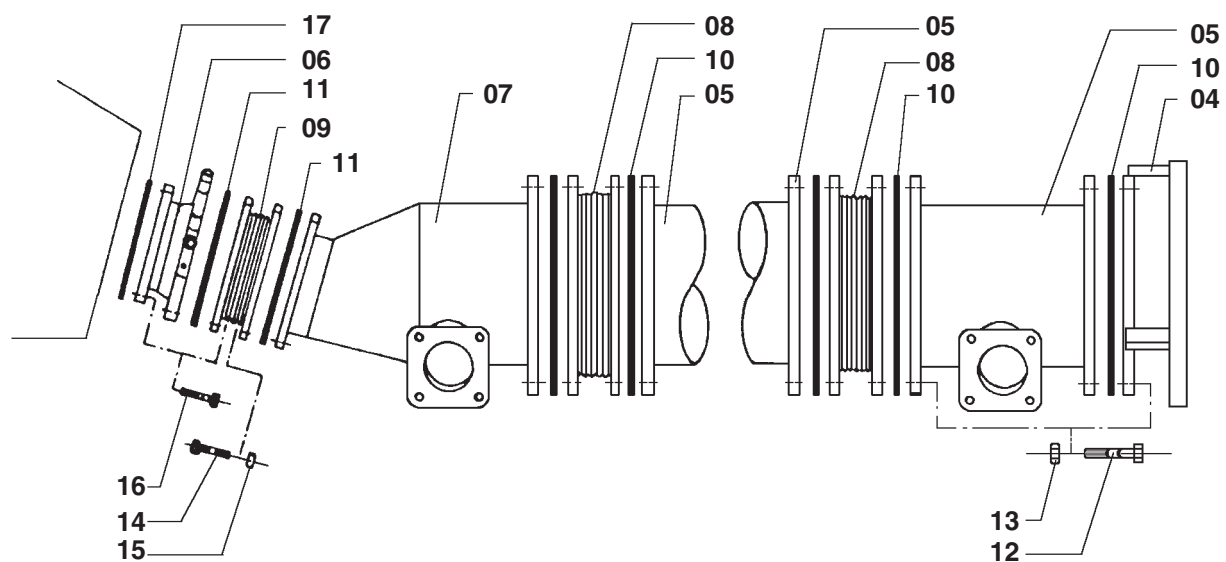
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/cylinder

|                     |                                 |                  |
|---------------------|---------------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Exhaust Pipe Arrangement</b> | <b>61202-26H</b> |
|---------------------|---------------------------------|------------------|

**7,8L28/32H**



**61202-26H****Exhaust Pipe Arrangement**Plate  
Page 2 (2)**7,8L28/32H**

| Item No. | Qty.           | Designation                                    | Benævnelse                                  | Item No. | Qty. | Designation          | Benævnelse      |
|----------|----------------|--|---|----------|------|----------------------|-----------------|
| 04       | 1/E            | End cover, aft                                 | Endeplade, bag                              | 29       | 1/C  | Plug screw           | Propskrue       |
| 05       | 6/E<br>7/E     | Exhaust pipe<br>7 cyl. engine<br>8 cyl. engine | Udstødsrør<br>7 cyl. motor<br>8 cyl. motor  | 30       | 1/C  | Gasket               | Pakning         |
| 06       | 1/E            | Exhaust pipe, inlet TC.                        | Udstødsrør, tilgang turbolader              | 31       | 1/C  | Gasket               | Pakning         |
| 07       | 1/E            | Exhaust pipe for cyl. 1                        | Udstødsrør for cyl. 1                       | 32       | 1/C  | O-ring               | O-ring          |
| 08       | 6/E<br>7/E     | Compensator<br>7 cyl. engine<br>8 cyl. engine  | Kompensator<br>7 cyl. motor<br>8 cyl. motor | 33       | 1/C  | Cooling water nipple | Kølevandsnippel |
| 09       | 1/E            | Compensator                                    | Kompensator                                 | 34       | 1/C  | O-ring               | O-ring          |
| 10       | 13/E<br>15/E   | Gasket<br>7 cyl. engine<br>8 cyl. engine       | Pakning<br>7 cyl. motor<br>8 cyl. motor     |          |      |                      |                 |
| 11       | 2/E            | Gasket   | Pakning                                     |          |      |                      |                 |
| 12       | 156/E<br>180/E | Screw<br>7 cyl. engine<br>8 cyl. engine        | Skrue<br>7 cyl. motor<br>8 cyl. motor       |          |      |                      |                 |
| 13       | 156/E<br>180/E | Nut<br>7 cyl. engine<br>8 cyl. engine          | Møtrik<br>7 cyl. motor<br>8 cyl. motor      |          |      |                      |                 |
| 14       | 8/E            | Screw  | Skrue                                       |          |      |                      |                 |
| 15       | 8/E            | Nut  | Møtrik                                      |          |      |                      |                 |
| 16       | 16/E           | Screw  | Skrue                                       |          |      |                      |                 |
| 17       | 1/E            | Gasket   | Pakning                                     |          |      |                      |                 |
| 20       | 4/C            | Screw  | Skrue                                       |          |      |                      |                 |
| 21       | 1/C            | Gasket   | Pakning                                     |          |      |                      |                 |
| 22       | 4/C            | Gasket   | Pakning                                     |          |      |                      |                 |
| 23       | 4/C            | Plug   | Prop  |          |      |                      |                 |
| 24       | 2/C            | Screw  | Skrue                                       |          |      |                      |                 |
| 25       | 2/C            | Washer   | Skive                                       |          |      |                      |                 |
| 26       | 1/C            | Intermediate piece                             | Mellemstykke                                |          |      |                      |                 |
| 27       | 1/C            | Plug screw                                     | Propskrue                                   |          |      |                      |                 |
| 28       | 4/C            | Screw  | Skrue                                       |          |      |                      |                 |

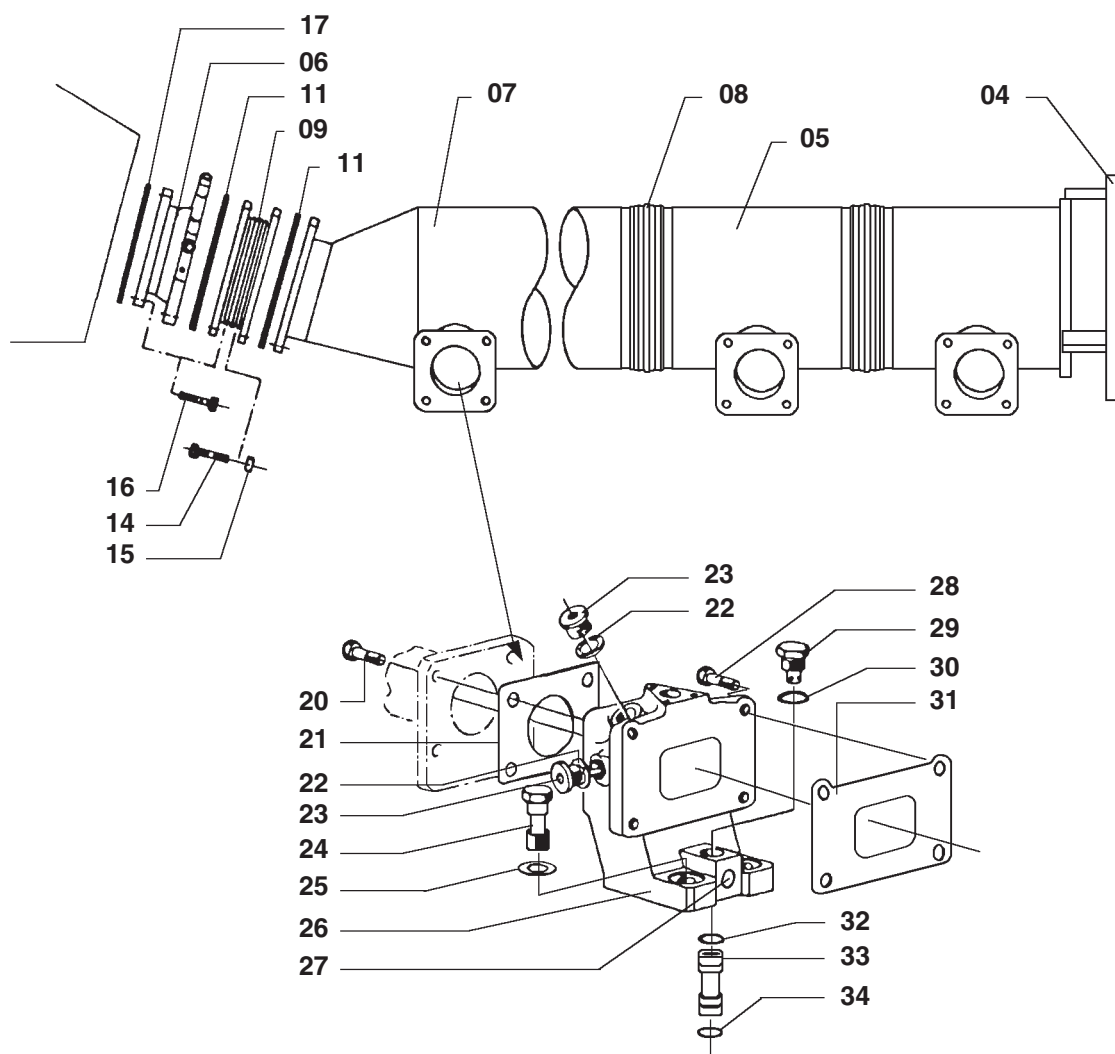
When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/cylinder

**7,8L28/32H**



**61202-28H****Exhaust Pipe Arrangement with Welded Compensator**Plate  
Page 2 (2)**7,8L28/32H**

| Item No. | Qty.       | Designation                                    | Benævnelse                                  | Item No. | Qty. | Designation | Benævnelse |
|----------|------------|--|---|----------|------|-------------|------------|
| 04       | 1/E        | End cover, aft                                 | Endeplade, bag                              |          |      |             |            |
| 05       | 6/E<br>7/E | Exhaust pipe<br>7 cyl. engine<br>8 cyl. engine | Udstødsrør<br>7 cyl. motor<br>8 cyl. motor  |          |      |             |            |
| 06       | 1/E        | Exhaust pipe, inlet TC.                        | Udstødsrør, tilgang turbolader              |          |      |             |            |
| 07       | 1/E        | Exhaust pipe for cyl. 1                        | Udstødsrør for cyl. 1                       |          |      |             |            |
| 08       | 6/E<br>7/E | Compensator<br>7 cyl. engine<br>8 cyl. engine  | Kompensator<br>7 cyl. motor<br>8 cyl. motor |          |      |             |            |
| 09       | 1/E        | Compensator                                    | Kompensator                                 |          |      |             |            |
| 11       | 2/E        | Gasket   | Pakning                                     |          |      |             |            |
| 14       | 8/E        | Screw  | Skrue                                       |          |      |             |            |
| 15       | 8/E        | Nut  | Møtrik                                      |          |      |             |            |
| 16       | 16/E       | Screw  | Skrue                                       |          |      |             |            |
| 17       | 1/E        | Gasket   | Pakning                                     |          |      |             |            |
| 20       | 4/C        | Screw  | Skrue                                       |          |      |             |            |
| 21       | 1/C        | Gasket   | Pakning                                     |          |      |             |            |
| 22       | 4/C        | Gasket   | Pakning                                     |          |      |             |            |
| 23       | 4/C        | Plug   | Prop  |          |      |             |            |
| 24       | 2/C        | Screw  | Skrue                                       |          |      |             |            |
| 25       | 2/C        | Washer   | Skive                                       |          |      |             |            |
| 26       | 1/C        | Intermediate piece                             | Mellemstykke                                |          |      |             |            |
| 27       | 1/C        | Plug screw                                     | Propskruer                                  |          |      |             |            |
| 28       | 4/C        | Screw  | Skrue                                       |          |      |             |            |
| 29       | 1/C        | Plug screw                                     | Propskruer                                  |          |      |             |            |
| 30       | 1/C        | Gasket   | Pakning                                     |          |      |             |            |
| 31       | 1/C        | Gasket   | Pakning                                     |          |      |             |            |
| 32       | 1/C        | O-ring   | O-ring                                      |          |      |             |            |
| 33       | 1/C        | Cooling water nipple                           | Kølevandsnippel                             |          |      |             |            |
| 34       | 1/C        | O-ring   | O-ring                                      |          |      |             |            |

When ordering spare parts, see also page 600.50.

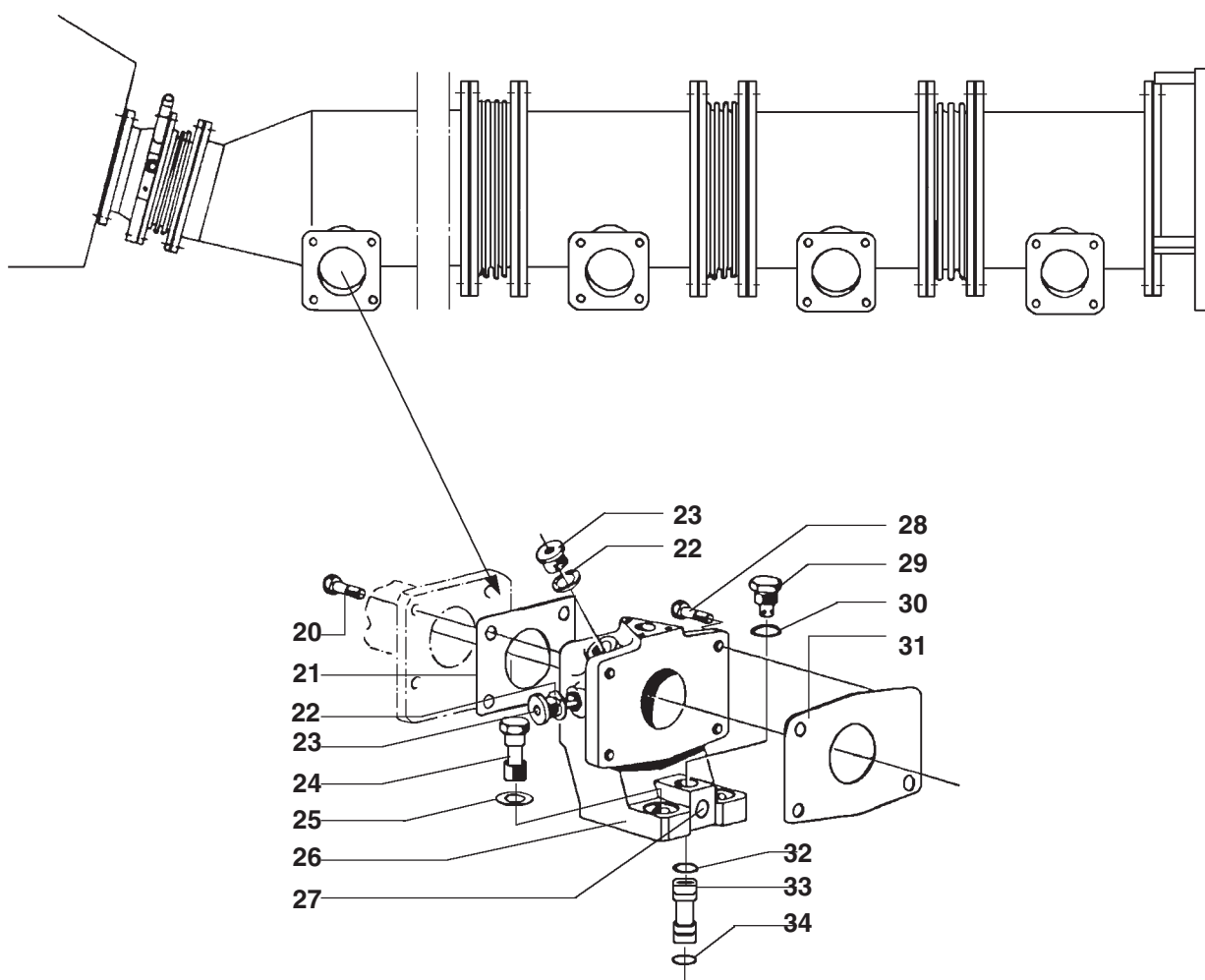
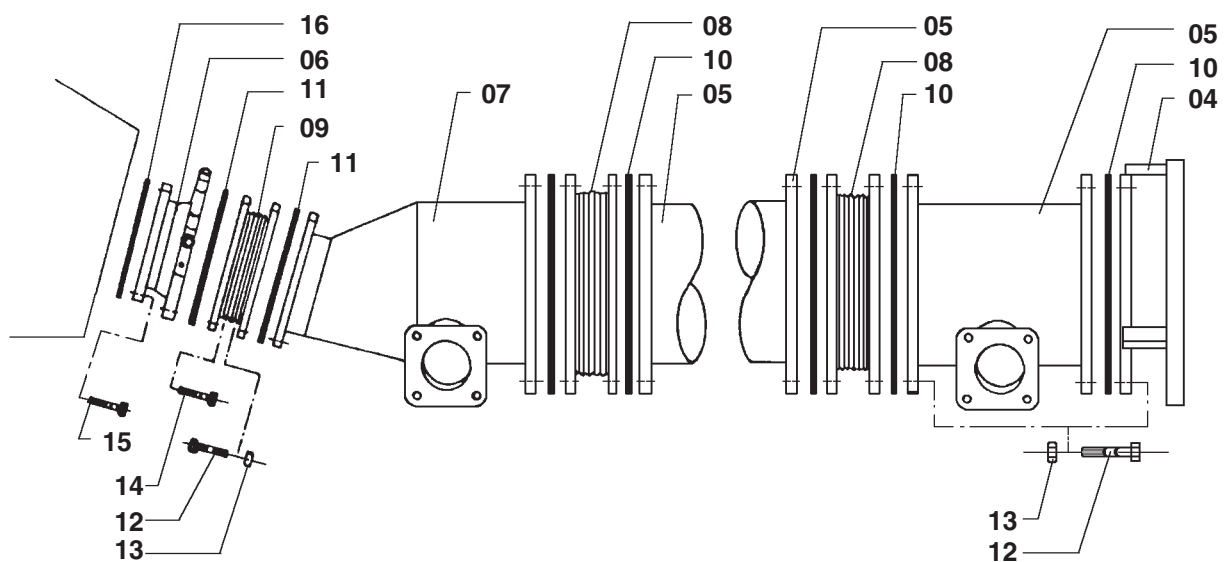
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/cylinder

|                     |                                 |                  |
|---------------------|---------------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Exhaust Pipe Arrangement</b> | <b>61202-27H</b> |
|---------------------|---------------------------------|------------------|

**9L28/32H**



61202-27H

## Exhaust Pipe Arrangement

Plate  
Page 2 (2)

## 9L28/32H

| Item No. | Qty.  | Designation             | Benævnelse                     | Item No. | Qty. | Designation | Benævnelse |
|----------|-------|-------------------------|--------------------------------|----------|------|-------------|------------|
| 04       | 1/E   | End cover, aft          | Endeplade, bag                 |          |      |             |            |
| 05       | 8/E   | Exhaust pipe            | Udstødsrør                     |          |      |             |            |
| 06       | 1/E   | Exhaust pipe, inlet TC. | Udstødsrør, tilgang turbolader |          |      |             |            |
| 07       | 1/E   | Exhaust pipe for cyl. 1 | Udstødsrør for cyl. 1          |          |      |             |            |
| 08       | 8/E   | Compensator             | Kompensator                    |          |      |             |            |
| 09       | 1/E   | Compensator             | Kompensator                    |          |      |             |            |
| 10       | 17/E  | Gasket                  | Pakning                        |          |      |             |            |
| 11       | 2/E   | Gasket                  | Pakning                        |          |      |             |            |
| 12       | 216/E | Screw                   | Skrue                          |          |      |             |            |
| 13       | 216/E | Nut                     | Møtrik                         |          |      |             |            |
| 14       | 12/E  | Screw                   | Skrue                          |          |      |             |            |
| 15       | 12/E  | Screw                   | Skrue                          |          |      |             |            |
| 16       | 1/E   | Gasket                  | Pakning                        |          |      |             |            |
| 20       | 4/C   | Screw                   | Skrue                          |          |      |             |            |
| 21       | 1/C   | Gasket                  | Pakning                        |          |      |             |            |
| 22       | 4/C   | Gasket                  | Pakning                        |          |      |             |            |
| 23       | 4/C   | Plug                    | Prop                           |          |      |             |            |
| 24       | 2/C   | Screw                   | Skrue                          |          |      |             |            |
| 25       | 2/C   | Washer                  | Skive                          |          |      |             |            |
| 26       | 1/C   | Intermediate piece      | Mellemstykke                   |          |      |             |            |
| 27       | 1/C   | Plug screw              | Propskruer                     |          |      |             |            |
| 28       | 4/C   | Screw                   | Skrue                          |          |      |             |            |
| 29       | 1/C   | Plug screw              | Propskruer                     |          |      |             |            |
| 30       | 1/C   | Gasket                  | Pakning                        |          |      |             |            |
| 31       | 1/C   | Gasket                  | Pakning                        |          |      |             |            |
| 32       | 1/C   | O-ring                  | O-ring                         |          |      |             |            |
| 33       | 1/C   | Cooling water nipple    | Kølevandsnippel                |          |      |             |            |
| 34       | 1/C   | O-ring                  | O-ring                         |          |      |             |            |

When ordering spare parts, see also page 600.50.

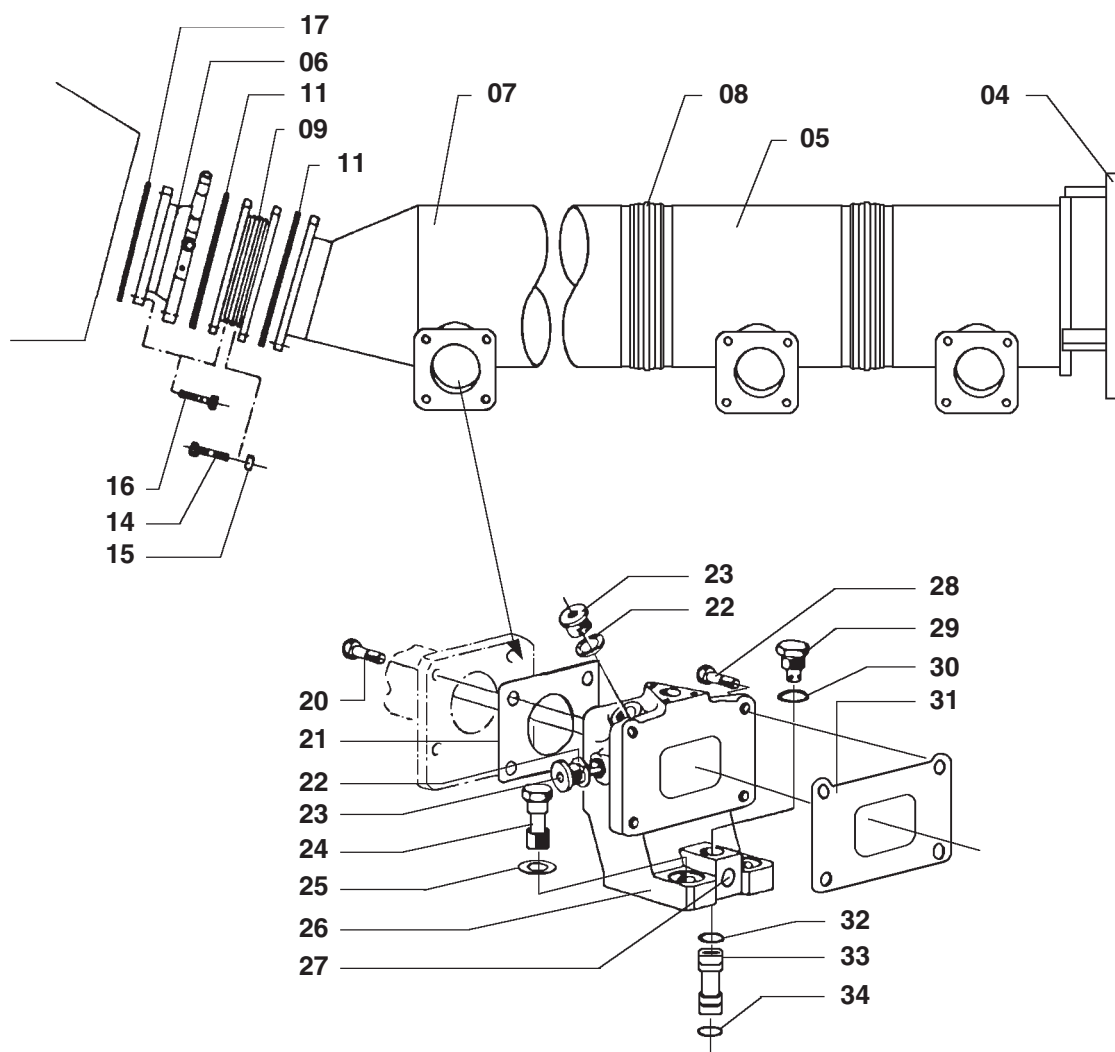
\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/cylinder



**9L28/32H**



**61202-42H****Exhaust Pipe Arrangement with Welded Compensator**Plate  
Page 2 (2)**9L28/32H**

| Item No. | Qty. | Designation             | Benævnelse                     | Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------------------|--------------------------------|----------|------|-------------|------------|
| 04       | 1/E  | End cover, aft          | Endeplade, bag                 |          |      |             |            |
| 05       | 8/E  | Exhaust pipe            | Udstødsrør                     |          |      |             |            |
| 06       | 1/E  | Exhaust pipe, inlet TC. | Udstødsrør, tilgang turbolader |          |      |             |            |
| 07       | 1/E  | Exhaust pipe for cyl. 1 | Udstødsrør for cyl. 1          |          |      |             |            |
| 08       | 8/E  | Compensator             | Kompensator                    |          |      |             |            |
| 09       | 1/E  | Compensator             | Kompensator                    |          |      |             |            |
| 11       | 2/E  | Gasket                  | Pakning                        |          |      |             |            |
| 14       | 12/E | Screw                   | Skrue                          |          |      |             |            |
| 15       | 12/E | Nut                     | Møtrik                         |          |      |             |            |
| 16       | 24/E | Screw                   | Skrue                          |          |      |             |            |
| 17       | 1/E  | Gasket                  | Pakning                        |          |      |             |            |
| 20       | 4/C  | Screw                   | Skrue                          |          |      |             |            |
| 21       | 1/C  | Gasket                  | Pakning                        |          |      |             |            |
| 22       | 4/C  | Gasket                  | Pakning                        |          |      |             |            |
| 23       | 4/C  | Plug                    | Prop                           |          |      |             |            |
| 24       | 2/C  | Screw                   | Skrue                          |          |      |             |            |
| 25       | 2/C  | Washer                  | Skive                          |          |      |             |            |
| 26       | 1/C  | Intermediate piece      | Mellemstykke                   |          |      |             |            |
| 27       | 1/C  | Plug screw              | Propskruer                     |          |      |             |            |
| 28       | 4/C  | Screw                   | Skrue                          |          |      |             |            |
| 29       | 1/C  | Plug screw              | Propskruer                     |          |      |             |            |
| 30       | 1/C  | Gasket                  | Pakning                        |          |      |             |            |
| 31       | 1/C  | Gasket                  | Pakning                        |          |      |             |            |
| 32       | 1/C  | O-ring                  | O-ring                         |          |      |             |            |
| 33       | 1/C  | Cooling water nipple    | Kølevandsnippel                |          |      |             |            |
| 34       | 1/C  | O-ring                  | O-ring                         |          |      |             |            |

When ordering spare parts, see also page 600.50.

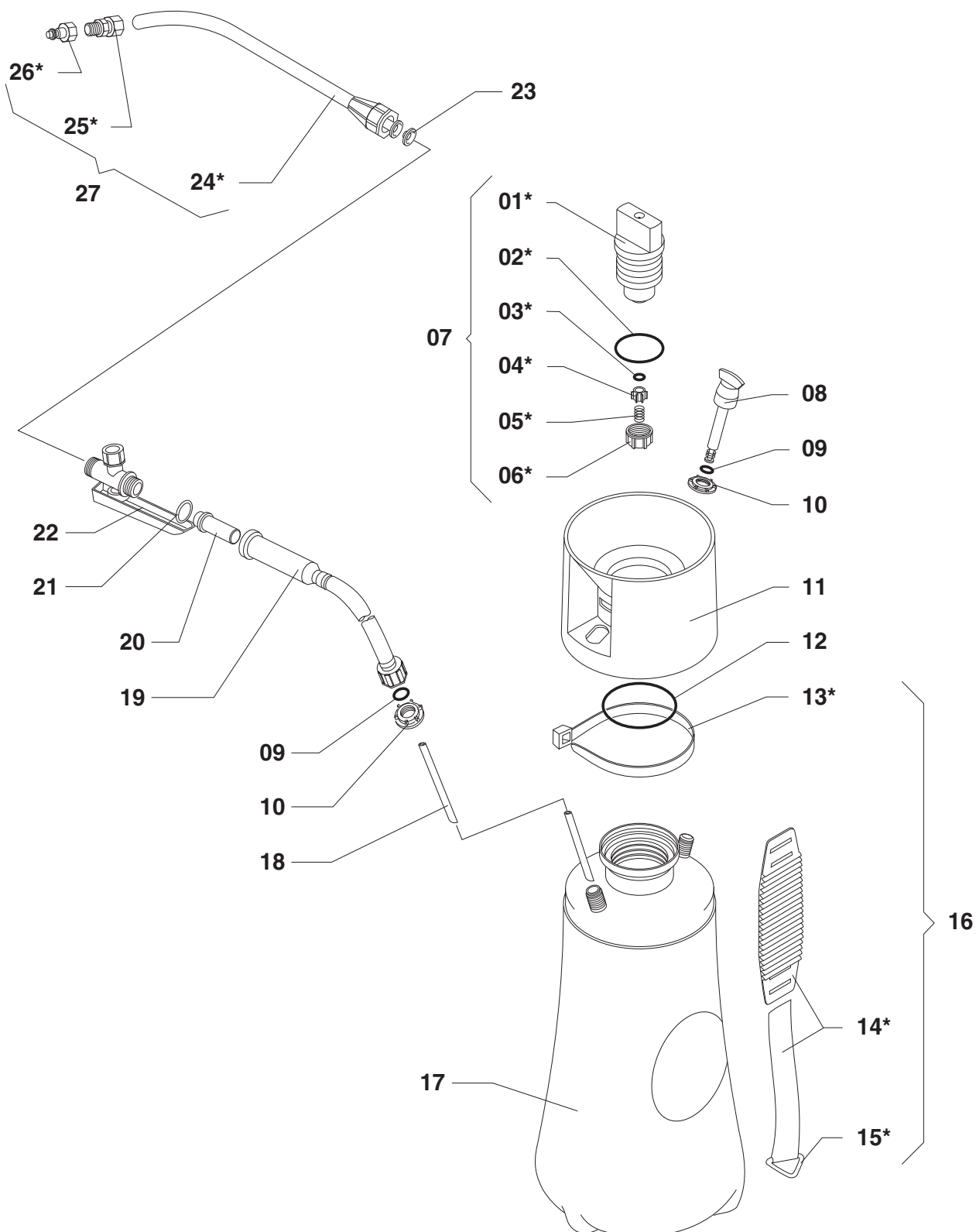
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./C = Qty./Cylinder

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/E = Antal/Motor  
 Antal/C = Antal/cylinder

|                     |                                  |           |
|---------------------|----------------------------------|-----------|
| Plate<br>Page 1 (2) | Water Washing of Compressor Side | 61205-02H |
|---------------------|----------------------------------|-----------|

L+V28/32H



61205-02H

## Water Washing of Compressor Side

Plate  
Page 2 (2)

## L+V28/32H

| Item No. | Qty. | Designation  | Benævnelse  | Item No. | Qty. | Designation                             | Benævnelse                            |
|----------|------|--|---|----------|------|---|---------------------------------------|
| 01*      | 1/E  | Top cover with non-return valve  | Topdæksel med kontraventil  | 25*      | 1/E  | Straight male stud coupling             | Ligeforskruning                       |
| 02*      | 1/E  | O-ring for top cover   | O-ring for topdæksel  | 26*      | 1/E  | Plug in coupling                        | Kobling                               |
| 03*      | 1/E  | O-ring for non-return valve  | O-ring for kontraventil   | 27       | 1/E  | Lance complete, incl. item 24-25 and 26 | Lanse komplet, inkl. item 24-25 og 26 |
| 04*      | 1/E  | Valve seat   | Ventilsæde  | 28       | 1/E  | Container complete, as shown on plate   | Beholder komplet, som vist på plate   |
| 05*      | 1/E  | Spring for non-return valve  | Fjeder for kontraventil   |          |      |   |                                       |
| 06*      | 1/E  | Cap screw for non-return valve   | Omløber til kontraventil  |          |      |   |                                       |
| 07       | 1/E  | Top cover with non-return valve complete, incl. item 01-02-03-04-05 and 06 | Topdæksel med kontraventil komplet, inkl. item 01-02-03-04-05 og 06 |          |      |   |                                       |
| 08       | 1/E  | Safety valve   | Sikkerhedsventil  |          |      |   |                                       |
| 09       | 2/E  | O-ring   | O-ring  |          |      |   |                                       |
| 10       | 2/E  | Finger nut   | Fingermøtrik  |          |      |   |                                       |
| 11       | 1/E  | Cap  | Top   |          |      |   |                                       |
| 12       | 1/E  | Gasket for the cap   | Pakning for top   |          |      |   |                                       |
| 13*      | 1/E  | Cable binder   | Kabelbinder   |          |      |   |                                       |
| 14*      | 1/E  | Strap  | Gjord   |          |      |   |                                       |
| 15*      | 1/E  | Eye for strap  | Øje for gjord   |          |      |   |                                       |
| 16       | 1/E  | Strap complete, incl. item 13-14 and 15                                    | Gjord komplet, inkl. item 13-14 og 15                               |          |      |   |                                       |
| 17       | 1/E  | Container  | Beholder  |          |      |   |                                       |
| 18       | 1/E  | Flexible pipe  | Fleksibel slange  |          |      |   |                                       |
| 19       | 1/E  | Handle with flexible pipe and cap screw                                    | Håndtag med fleksibel slange og omløber                             |          |      |   |                                       |
| 20       | 1/E  | Filter insert  | Filterindsats   |          |      |   |                                       |
| 21       | 1/E  | Gasket for handle  | Pakning til håndtag   |          |      |   |                                       |
| 22       | 1/E  | Hand valve   | Håndventil  |          |      |   |                                       |
| 23       | 1/E  | Gasket for hand valve  | Pakning til håndventil  |          |      |   |                                       |
| 24*      | 1/E  | Lance  | Lanse   |          |      |   |                                       |

When ordering spare parts, see also page 600.50.

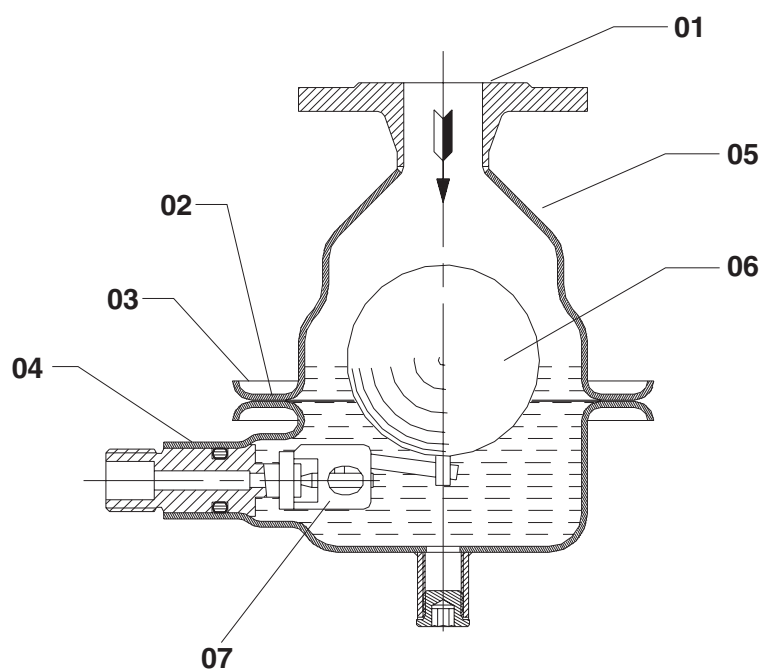
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

\* = Kun tilgængelig som en del af et reservedelssæt.  
Antal/E = Antal/Motor

|                     |                   |                  |
|---------------------|-------------------|------------------|
| Plate<br>Page 1 (2) | <b>Steam Trap</b> | <b>61208-01H</b> |
|---------------------|-------------------|------------------|

**L+V28/32H**



|           |            |                     |
|-----------|------------|---------------------|
| 61208-01H | Steam Trap | Plate<br>Page 2 (2) |
|-----------|------------|---------------------|

**L+V28/32H**

| Item No. | Qty. | Designation          | Benævnelse           | Item No. | Qty. | Designation | Benævnelse |
|----------|------|----------------------|----------------------|----------|------|-------------|------------|
| 01       | 1/E  | Steam trap, complete | Vandudlader, komplet |          |      |             |            |
| 02       | 1/E  | Packing              | Pakning              |          |      |             |            |
| 03       | 1/E  | Clip                 | Klemme               |          |      |             |            |
| 04       | 1/E  | House, bottom        | Hus, bund            |          |      |             |            |
| 05       | 1/E  | House, top           | Hus, top             |          |      |             |            |
| 06       | 1/E  | Swimmer              | Svømmer              |          |      |             |            |
| 07       | 1/E  | Valve                | Ventil               |          |      |             |            |

**When ordering spare parts, see also page 600.50.**

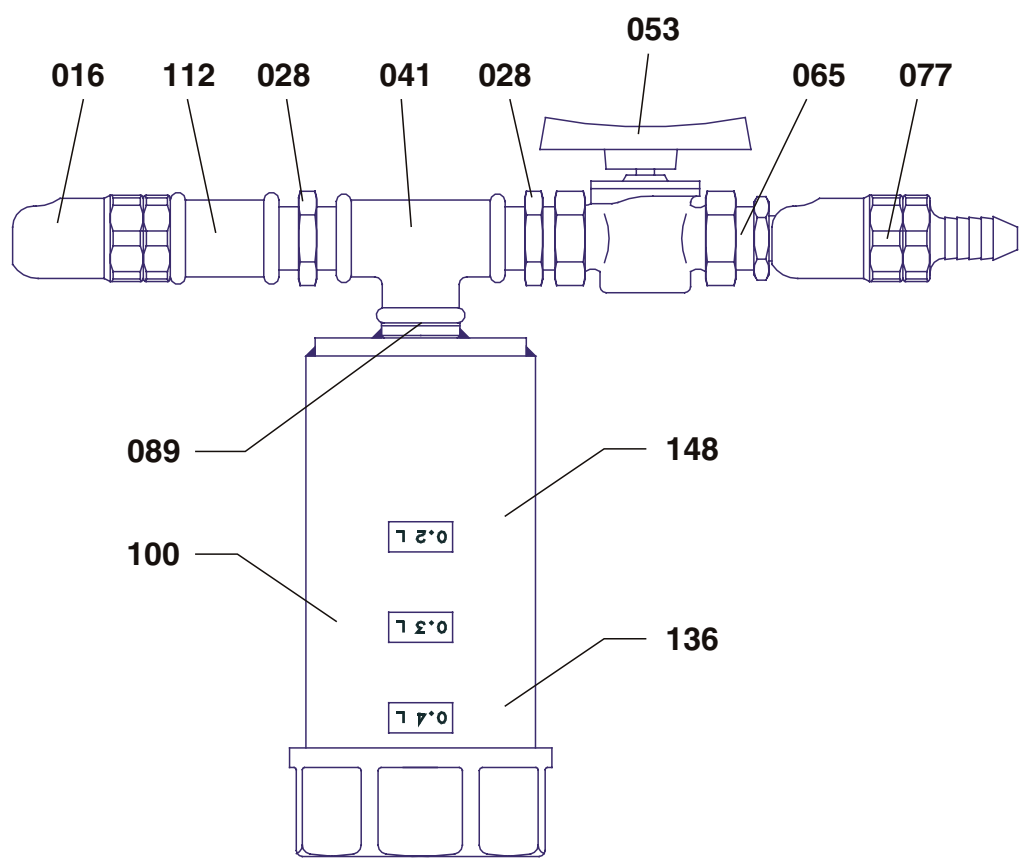
\* = Only available as part of a spare parts kit.  
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
Qty./E = Qty./Motor

|                     |   |                  |
|---------------------|---|------------------|
| Plate<br>Page 1 (2) | <b>Blowgun for Dry Cleaning of Turbocharger</b> | <b>61210-02H</b> |
|---------------------|---|------------------|

General



08028-0D/H5250/94.08.12

**61210-02H****Blowgun for Dry Cleaning of Turbocharger**Plate  
Page 2 (2)**General**

| Item No. | Qty. | Designation         | Benævnelse            | Item No. | Qty. | Designation | Benævnelse |
|----------|------|---------------------|-----------------------|----------|------|-------------|------------|
| 016      | 1/E  | Snap coupling       | Snapkobling           |          |      |             |            |
| 028      | 2/E  | Nipple              | Nippel                |          |      |             |            |
| 041      | 1/E  | Tee                 | T-stykke              |          |      |             |            |
| 053      | 1/E  | Ball valve          | Kugleventil           |          |      |             |            |
| 065      | 1/E  | Snap coupling       | Snapkobling           |          |      |             |            |
| 077      | 1/E  | Snap coupling       | Snapkobling           |          |      |             |            |
| 089      | 1/E  | Packing ring        | Pakningsring          |          |      |             |            |
| 100      | 1/E  | Container, complete | beholder, komplet     |          |      |             |            |
| 112      | 1/E  | Socket              | Muffe                 |          |      |             |            |
| 136      | 1/E  | Blowgun, complete   | Rensepistol, complete |          |      |             |            |
| 148      | /I   | Granulate           | Granulat              |          |      |             |            |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./I = Qty./Individual

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Qty./E = Qty./Motor  
 Qty./I = Qty./Individuelt



**Compressed air system**

**513/613**

|                           |                              |                              |
|---------------------------|------------------------------|------------------------------|
| Description<br>Page 1 (2) | <b>Compressed Air System</b> | <b>613.01</b><br>Edition 20H |
|---------------------------|------------------------------|------------------------------|

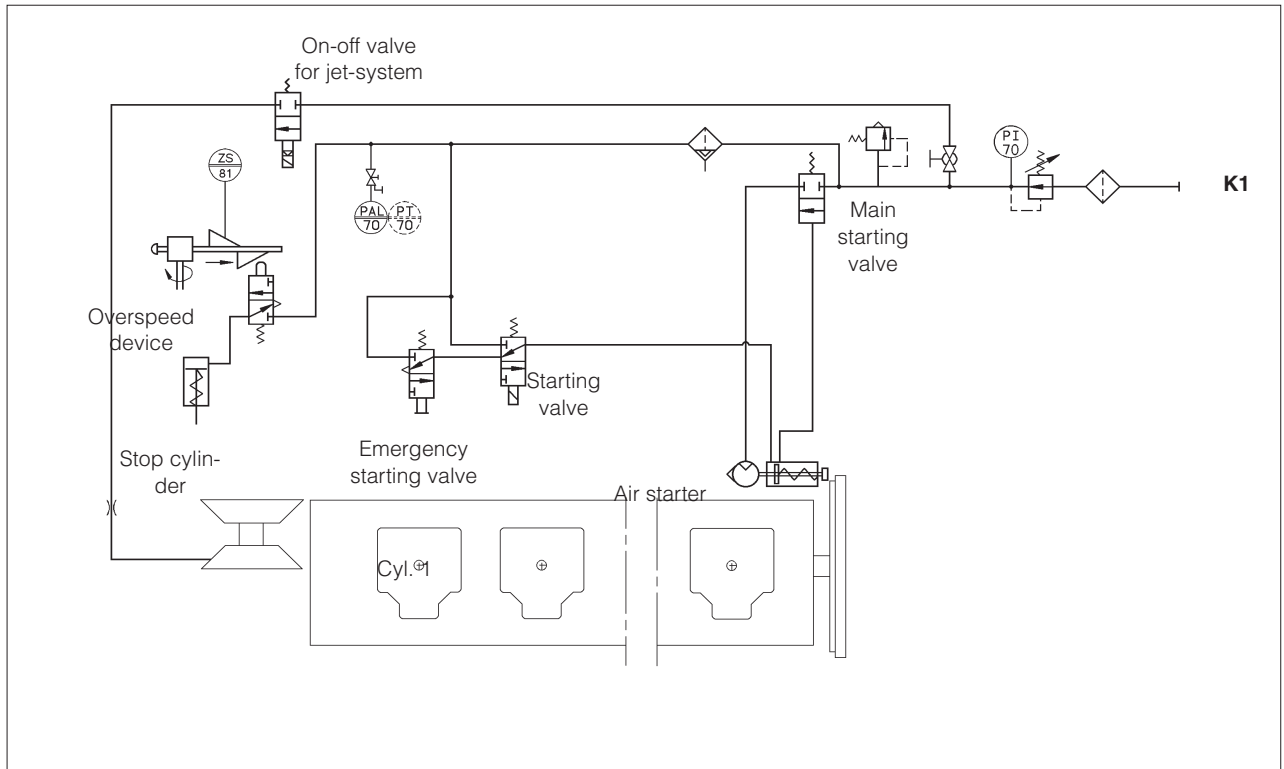
**L28/32H**

Fig. 1. Diagram for Compressed Air System

**General**

The compressed air system on the engine contains a starting system, starting control system and safety system. Further, the system supplies air to the jet system.

The compressed air is supplied from the starting air receivers (30 bar) through a reduction station, where from compressed air is supplied to the engine.

To avoid dirt particles in the internal system, a dirt separator is mounted in the inlet line to the engine.

The intervals between cleaning and draining will depend on the condition of the air in the main supply system, and has therefore to be determined according to service experience gained with the particular plant.

**Note:** Due to the safety system, the air supply to the engine must not be interrupted during operation of the engine.

**Starting System**

The engine is started by means of a built-on air starter, which is of the turbine starter motor type with gear box, safety clutch and drive shaft with pinion. Further, the starting system consists of a main starting valve.

**Control System**

The air starter is activated electrically with a pneumatic 3/2 way solenoid valve (starting valve).

The valve can be activated manually from the starting box on the engine, and it can be arranged for remote control, manual or automatic.

For remote activation, the starting spool must be connected so that every starting signal to the starting spool goes through the converter for engine RPM signal or via the engine control box if supplied.

**L28/32H**

Further, the system is equipped with an emergency starting valve which makes it possible to activate the air starter manually in case of a power failure.

**Emergency Starting Valve**

The emergency starting valve is activated by means of a screw-driver or similar as illustrated in fig. 2.

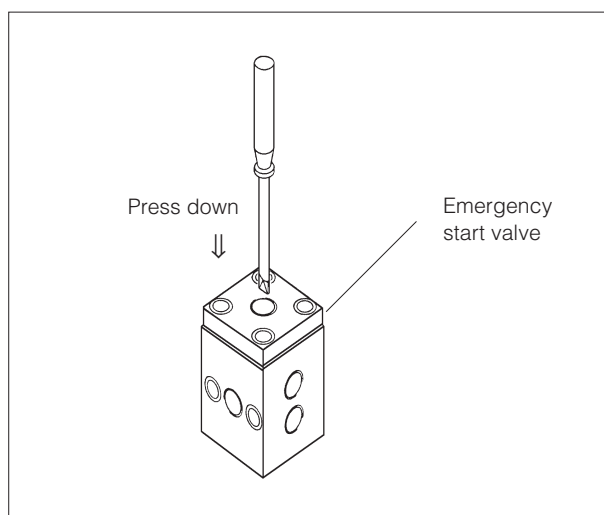


Fig. 2. Emergency start valve

**Safety System**

As standard the engine is equipped with a pneumatically/mechanically overspeed device, which starts to operate if the maximum permissible RPM is exceeded. This device is fitted to the end cover of the engine driven lubricating pump and is driven from the pump through a resilient coupling, see section 609.

When the maximum permissible RPM is exceeded, the overspeed device will activate a pneumatically controlled stop cylinder, which will bring the fuel index to zero and stop the engine.

**Pneumatic Start Sequence**

When the starting valve is opened, air will be supplied to the drive shaft housing of the air starter.

The air supply will - by activating a piston - bring the drive pinion into engagement with the gear rim on the engine fly wheel.

When the pinion is fully engaged, the pilot air will flow to, and open the main starting valve, whereby air will be led to the air starter, which will start to turn the engine.

Simultaneously with air supply for the air starter, air will be supplied to the fuel limiting cylinder, thus limiting the fuel supply during the start sequence.

When the RPM exceeds approx. 110, at which firing has taken place, the starting valve is closed whereby the air starter is disengaged.

|                            |                   |                                 |
|----------------------------|-------------------|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Air Filter</b> | <b>613-01.21</b><br>Edition 02H |
|----------------------------|-------------------|---------------------------------|

General

Safety precautions

- ☒ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description

Cleaning and/or maintenance of air filter.

Starting position

Related procedure

Manpower

Working time : hours  
Capacity : man

Data

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

Special tools

| Plate no | Item no | Note |
|----------|---------|------|
|----------|---------|------|

Hand tools

Replacement and wearing parts

| Plate no | Item no | Qty/ |
|----------|---------|------|
|----------|---------|------|

08028-0D/H5250/94.08.12

## General

### Cleaning Air Filter

- 1) Depressurize unit.
- 2) Remove bowl and bowl guard assembly by turning counter-clockwise.
- 3) Inspect bowl for damage seals and replace, if necessary.
- 4) If bowl becomes dirty clean it by wiping the bowl with a soft dry cloth or mild detergent.
- 5) Before returning to service, insure that all seals have been reinstalled or replaced.
- 6) Reinstall bowl and bowl guard assembly and rotate bowl guard clockwise to securely lock in place. Align arrow on bowl guard with arrow on filter body.

### To replace filter element

- 7) Depressurize unit.
- 8) Remove bowl and bowl assembly by turning counter-clockwise.
- 9) Unscrew baffle by turning counter-clockwise.
- 10) Remove filter element and discard.
- 11) Install new filter element and reassemble in reverse order.
- 12) Before returning to service, insure that all seals have been reinstalled or replaced.
- 13) Reinstall bowl and bowl guard assembly and rotate bowl guard clockwise to securely lock in place. Align arrow on bowl guard with arrow on filter body.

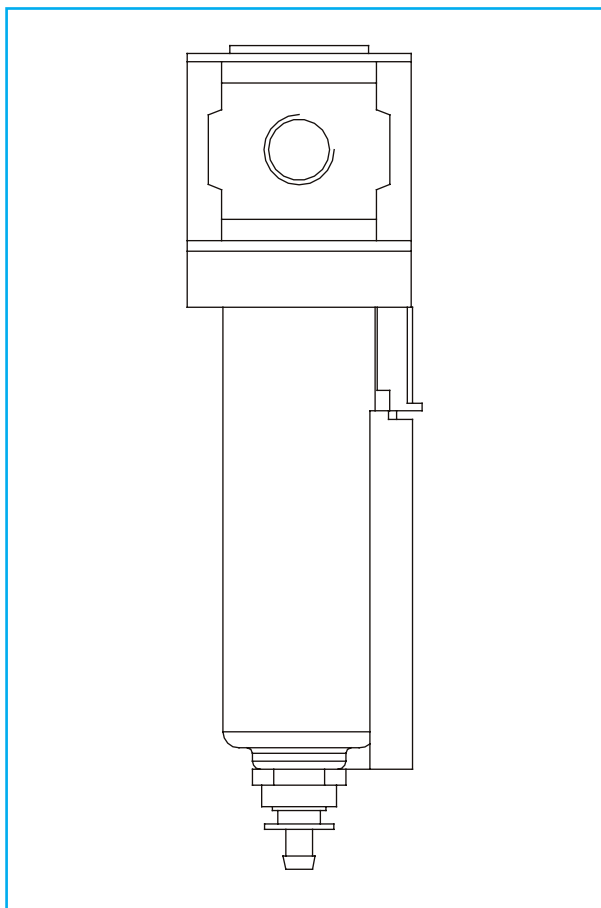


Fig 1 Air Filter

**L+V28/32H****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Disassembly, overhaul and assembly of the air starter.

**Starting position:**

All connection to the air starter have been removed, and air starter is removed.

**Related procedure:****Man power:**

Working time : 4 Hours  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note.        |
|-----------|----------|--------------|
| 62006     | xx       | 20 - 120 Nm. |

**Hand tools:**

Allen key, 4 mm.  
Allen key (long), 8 mm.  
Screwdriver.  
Big screwdriver.  
Chisel.  
Retaining ring pliers.  
Plastic hammer.  
Lubricating oil.  
Copaslip or similar.  
Sleeve.  
Bearing puller.  
Impact Wrench  
Bearing pressing tool.

**Replacement and wearing parts:**

| Plate no.        | Item no. | Qty./ |
|------------------|----------|-------|
| See plate 61309. |          |       |

## L+V28/32H

## General Information

1. Always mark adjacent parts on the housing exhaust cover (1), motor housing (8), intermediate gear case (13), gear case (28) and drive housing (38) so these members can be located in the same relative position when the starter is reassembled.

**Note:** Do not disassemble the starter any further than necessary to replace worn or damaged parts.  
Never reuse old seals or o-rings.  
Never wash the inertia drive in a solvent.

2. Do not remove any part which is a press fit in or on a subassembly unless the removal of that part is necessary for replacement or repairs.

3. Always have a complete set of seals and o-rings on hand before starting any overhaul of the turbine starter.

4. When grasping a part in a vise, always use copper-covered vise jaws to protect the surface of the part and help prevent distortion. This is particularly true of threaded members.

## Housing Exhaust Cover, Motor Assembly, and Motor Housing

1. If replacing the motor assembly (12), remove both housing plugs (10) and drain the oil from the gearing before beginning disassembly of the starter. Inspect the magnetic housing plugs (10) for metal particles. Very fine metal particles are normal. Remove particles and reinstall plugs. Large particles or chips are an indication of a problem. Disassemble gear case (28) and inspect.

2. Using a screw driver, unscrew the exhaust cover (67) from the housing exhaust cover (1).

3. Using an 8 mm hex-head wrench, unscrew and remove the starter assembly cap screws (6) and washers (7), See fig 1.

4. Pull the housing exhaust cover (1) from the motor housing (8). To dislodge the housing exhaust cover, rotate it until the ears clear the motor housing. Using a plastic hammer, tap the ears alternately until the housing cover can be removed from the motor housing.

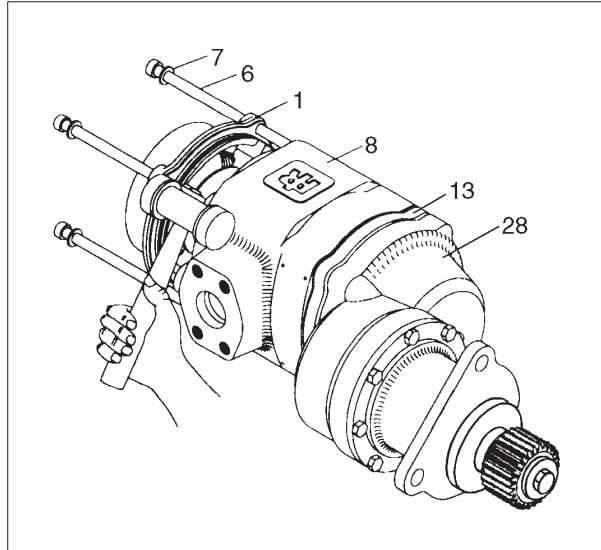


Fig 1.

5. Remove the deflector retaining screw (5), deflector retaining spring (4) and the splash deflector (3) from the housing exhaust cover (1), See fig 2.

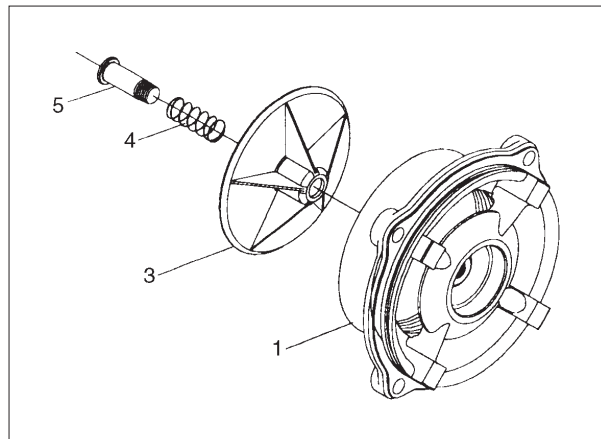


Fig 2.

6. Tap the motor housing with a plastic hammer to dislodge it from the intermediate gear case (13).

7. Grasp the rear of the motor assembly (12) and pull it from the rear of the motor housing (8). If the motor assembly (12) is difficult to remove, lightly push the motor pinion which is on the front of the motor assembly toward the exhaust side of the motor housing in order to free the motor assembly.

## L+V28/32H

8. Tap the intermediate gear case (13) with a plastic hammer to dislodge it from the gear case (28).

9. Position the intermediate gear case (13) on a bench in a copperfaced vise so that the intermediate pinion (26) is secured in the jaws of the vise. Tighten the vise only enough to hold the intermediate pinion securely.

10. Loosen the intermediate pinion retaining screw (27) 1-1/2 turns only. Do not remove.

**Warning:** If the intermediate gear case is not supported on a bench and if the intermediate pinion retaining screw is completely removed, the intermediate gear case and components could fall causing injury.

11. Tap the intermediate pinion lightly to back the planet gear frame assembly out of the intermediate gear case.

12. Remove the intermediate gear case assembly from the vise and remove the intermediate pinion (26). Remove the rear gear case o-ring (14) and front gear case o-ring (15) from the intermediate gear case (13), See fig 3.

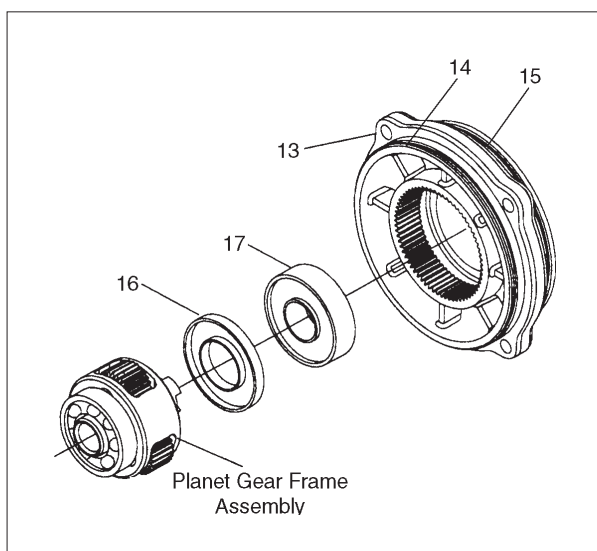


Fig 3.

13. Remove the planet gear frame assembly from the intermediate gear case. Using a sleeve that contacts the outer race of the front gear frame bearing (17), press the planet gear frame shaft seal (16) and the front gear frame bearing (17) from the front end and out of the rear of the intermediate gear case.

14. Remove the rear gear frame bearing (24) from the planet gear frame (18), using a bearing puller and remove the gear shaft retaining washer (23), See fig. 4.

Remove the planet gear shafts (22), planet gears (19), planet gear bearings (20) and bearing spacers (21).

15. Remove the front bearing spacer (25), using a bearing puller and the gear shaft retaining washer (23) from the front of the planet gear frame by pressing on the front of the planet gear frame shaft. Remove the gear shaft retaining washer only if the washer or front bearing spacer is damaged.

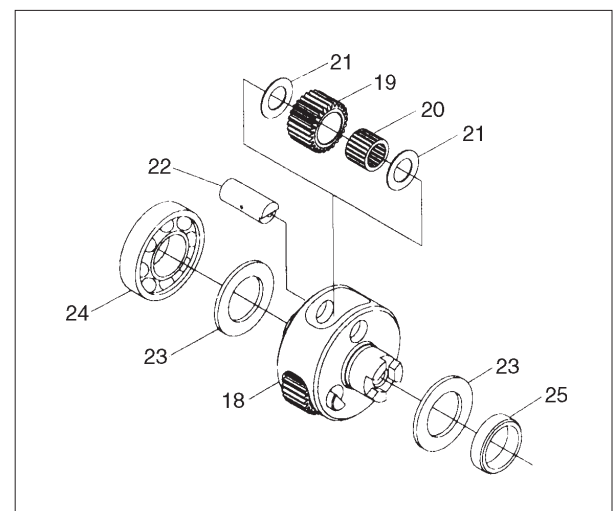


Fig 4.

## Drive Housing

1. Grasp the drive pinion (63) in a copper-faced vise with the starter supported on the workbench.



|                          |  |                            |
|--------------------------|--|----------------------------|
| 613-01.30<br>Edition 02H | Overhaul, Test and Inspection of Turbine Starter | Working Card<br>Page 4 (9) |
|--------------------------|--|----------------------------|

L+V28/32H

- 2. Remove the drive pinion retaining screw (61) which has a right-hand thread.
- 3. Remove the starter from the vise.
- 4. Remove the drive pinion washer (62) and the drive pinion (63).
- 5. Slide the pinion spring sleeve (64) and the pinion spring (65) off the drive shaft (57).
- 6. Unscrew the drive gear screw (34). Using an impact wrench with a 5/16" (8 mm) x 8" (203 mm) log hex inserted into the end of the drive shaft.
- 7. Unscrew and remove the drive housing cap screws (38) and lock washers (39).
- 8. Tap the drive housing (40) with a plastic hammer to help dislodge it from the gear case (28).

**Warning:** Failure to follow this procedure could result in injury to personnel.

- 9. Place the drive housing (40) in an arbor press, piston end up. Apply a load to the piston (54) using the arbor press to compress the piston return spring (59) before removing the bulkhead retainer (45). Do not use compressed air to load the piston.
- 10. Remove the bulkhead retainer (45). Using a screwdriver and the arbor press.
- 11. Remove the bulkhead (46) from the piston (54).
- 12. Remove the outer bulkhead ring (47) and the inner bulkhead ring (48).
- 13. Slide the drive shaft (57) from the drive housing (40).
- 14. Pull the piston return spring (59) off the drive shaft.

**Note:** Do not remove the front drive shaft bearing (42) or the drive housing seal (43) unless replace-

ment is necessary and new parts are available. The bearing and/or the seal will always be damaged when removed from the drive housing.

- 15. Remove the piston ring (55) from the piston (54).
- 16. Press the clutch spring cup (50) down and remove the clutch spring cup retainer (49).
- 17. Remove the clutch spring cup and clutch spring (51).
- 18. Remove the two clutch jaws (52).
- 19. Remove the front drive gear bearing (30), drive gear cup (36), drive gear lock washer (35), drive gear screw ring (37) and drive gear screw (34).
- 20. Remove the large drive shaft bearing retainer (53) using a screwdriver.
- 21. Press the rear drive shaft bearing and drive shaft (57) out of the piston. If the rear drive shaft bearing needs to be replaced, proceed as follows:
  - a. Cut and remove the small drive shaft bearing retained in the drive shaft, using a small chisel.
  - b. Press the rear drive shaft bearing (58) off the drive shaft.
- 22. Place the gear case (28) on a workbench.
- 23. Remove the drive gear bearing retainer (32), using retaining ring pliers and working through the access holes in the gear web, See fig 5.
- 24. Pull the drive gear (29) out of the gear case.
- Note:** Do not disassemble the drive gear and clutch parts of the turbine powered starters. If the drive shaft is defective, install a new or factory-rebuilt unit.
- 25. Remove the drive gear shaft bearing retainer (33), using retaining ring pliers.
- 26. Remove the rear drive gear bearing (31) from the drive gear.

08028-0D/H5250/94.08.12

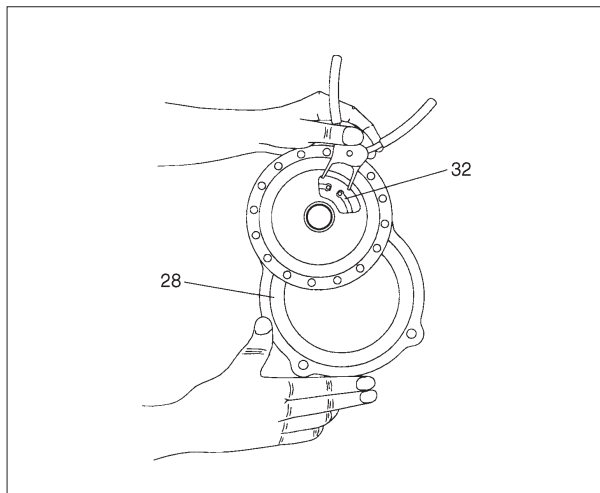
**L+V28/32H**

Fig 5.

**Assembly of the Starter**

1. Always press on the inner ring of a ball bearing when installing the bearing on a shaft.
2. Always press on the outer ring of a ball bearing when pressing the bearing in a bearing recess.
3. Whenever grasping a part in a vise, always use leather-covered, copper-covered vise jaws to protect the surface of the part and help prevent distortion. This is particularly true of threaded members.
4. Always clean every part, and wipe every part with a thin film of oil before installation.

**Gear Case**

1. Place the drive gear bearing retainer over the rear end of the drive gear.
2. Press the rear drive gear bearing (31) onto the rear end of the drive gear, using an arbor press.
3. Seat the rear drive gear bearing into the gear case by tap-ping the opposite end of the drive gear, using a plastic hammer.
4. Install the drive gear shaft bearing retainer (33), using retaining ring pliers.

5. Install the drive gear bearing retainer, using retaining ring pliers and working through the access holes in the gear web.

6. Lubricated the drive gear with approximately 240 ml of SHELL ALVANIA EPO grease.

7. Press the rear drive shaft bearing (58) onto the drive shaft.

8. Slide the small bearing retainer convex side first, onto the drive shaft. Press it into position in accordance with the in-structions packaged with the new retainer.

9. Assemble the drive gear Schrew (34), drive gear lock washer (35), drive gear cup (36) and drive gear screw o-ring (37).

10. Grasp the drive shaft (57) in a vise, external splined end down. Place assembled drive shaft screw Unit into the drive shaft, screwhead down. Lubricate the inside diameter of the drive shaft with SHELL ALVANIA EPO grease.

11. Slide the drive gear bearing (30) into the drive shaft.

12. Lubricate with SHELL ALVANIA EPO grease and install the driving clutch jaw teeth facing up and driven clutch jaw teeth facing down into the drive shaft.

13. Insert the clutch spring (51) into the drive shaft.

14. Insert the clutch spring cup (50) into the drive shaft.

15. Press the inserted parts into the drive shaft, and install the clutch spring cup retainer (49).

**Note:** If it is necessary to replace the drive housing (40) and drive components, make sure that the piston seal has been removed from the rear of the new piston (54). The piston seal must be removed to prevent pressure build-up which will cause movement of the planet gear frame shaft seal (16). If this conditions occurs, the piston cannot retract and the drive pinion (63) will remain in engagement with the

**L+V28/32H**

flywheel, causing damage to the starter drive train and/or starter motor. To remove the piston seal, insert a screwdriver inside the lip of the seal and pry it loose from the piston.

16. Install the piston (54) onto the drive shaft until the rear drive shaft bearing seats into the piston.

17. Coil the large drive shaft bearing retainer (53) into the groove of the piston to retain the outer race of the drive shaft bearing, using a thin flat blade screwdriver to assist in this operation.

18. Lubricate the piston o-ring (55) and install it in the groove of the piston.

19. Position the drive housing in an arbor press, pinion-end down and install the drive housing seal (43) into the drive housing. Using a pressing sleeve of the proper size, press the seal into the drive housing so that the lip of the seal faces away from the drive pinion.

20. Press the bearing into the drive housing until it seats, using a sleeve that contacts the outer race of the front drive shaft bearing (42). Drop the piston return spring seat (60) on top of front drive shaft bearing.

21. Slide the piston return spring (59) onto the drive shaft and snap it into the front of the piston so that it is against the large drive shaft bearing retainer (53).

22. Lubricate and insert the assembled drive shaft into the drive housing.

23. Lubricate and install the outer bulkhead o-ring (47) and the Inner bulkhead o-ring (48) on the bulkhead (46).

24. Slide the bulkhead onto the piston.

25. With the drive housing in the arbor press, press down on the rear face of the piston.

**Note:** Feel the underside of the drive housing to make sure the drive shaft passes through the bearing.

26. Install the bulkhead retainer (45), using a screwdriver.

**Warning:** Make sure the bulkhead retainer is properly seated in the motor housing groove before easing off the arbor press. Failure to do so will allow improperly retained parts to separate when removed from the arbor press resulting in injury to personnel.

27. Remove the drive housing from the arbor press.

28. Lubricate and install the drive housing o-ring (41) in the groove of the drive housing.

29. Position the assembled gear case on a workbench. The as-assembled unit must be upright to accept the drive housing.

Carefully position the assembled drive housing (40) onto the gear case so as not to damage the piston seal. Align the punch marks of the gear case and drive housing.

30. Install the drive housing cap screw lock washers (39) and the drive housing cap screws (38) and tighten to 28 Nm torque.

31. Tighten the drive gear screw (34) 77.3 Nm torque, using an impact wrench with a 8 mm x 203 mm long hex inserted into the end of drive shaft.

32. Grease and slide the pinion spring (65) and the pinion spring sleeve (64) over the pinion end of the drive shaft.

33. Grease the pinion end of the drive shaft and install the drive pinion (63).

34. Grasp the drive pinion in a copper-covered vise with the starter supported on a workbench.

35. Place the drive pinion washer (62) onto drive pinion retaining screw (61).

**Note:** The thread on the drive pinion retaining screw is right-hand thread.

36. Install the drive pinion retaining screw into the end of the drive shaft and tighten it to 108.5 Nm torque.

**L+V28/32H****Intermediate Gear Case, Motor Housing, Motor Assembly and Housing Exhaust Cover**

1. Press the front gear frame bearing (17) into the rear of the intermediate gear case (13), using a bearing pressing tool of the proper size.

2. Press the planet gear frame shaft seal (16) into the rear of the intermediate gear case over the front gear frame bearing, using a sleeve which contacts the outer ring of the seal.

**Note:** Make sure the flat side of the seal is installed against the bearing.

3. Install the rear gear case o-ring (14) in the groove at the rear of the intermediated gear case and the front gear case o-ring (15) in the groove at the front of the intermediate gear case. coat both o-rings.

4. Install one gear shaft retaining washer (23) on the front of the planet gear frame (18). Press the front bearing spacer (25) on the front shaft of the planet gear frame to hold the gear shaft retaining washer snugly in position.

**Note:** Coat the front bearing spacer with gear Lube before installing it. Be careful not to gouge or scratch the front bearing spacer during installation as this could result in leakage between the planet gear frame and gear case.

5. Place planet gear frame on a bench, shaft side down. Place the planet gear bearing (20) inside of planet gear (19). Place bearing spacers (21) on top and bottom of bearing and gear. Slide the components into the slots in the side of the planet gear frame. Align holes in spacers and bearing with holes in planet gear frame and insert planet gear shaft (22), integral keyed end down, through the spacers and bearing so that the larger portion of the keyed end of the shaft contacts the planet gear shaft retaining washer (23). Repeat the procedure for the two remaining planet gears and components.

**Note:** Do not move or turn over the planet gear frame until step 6 and 7 have been completed. Movement of the planet gear frame assembly could dislodge assembled components, making it necessary to repeat step 5.

6. Install the other planet gear shaft retaining washer over the shaft at the rear of the planet gear.

7. Press the rear gear frame bearing (24) on the shaft at the rear of the planet gear frame, using the proper size bearing inserting tool.

8. Slide the planet gear frame assembly, coupling end first, into the rear of the intermediate gear case (13), making sure that the planet gears mesh with the ring gear. Use care so as to not damage the seal.

9. Install the intermediate pinion (26), making sure that the notches at the rear of the pinion align with the notches and tangs in the shaft of the planet gear frame.

10. Clean the threads of the intermediate pinion retaining screw (27) and apply 2-3 drops of Permabond HM 118 to the threads approximately 3 mm from the end of the screw. Install screw and tighten enough to hold assembly together.

11. For final tightening, position the intermediate gear case so the intermediate pinion is secured in the jaws of the copperfaced vise. Tighten the intermediate pinion retaining screw to 122 Nm torque.

12. Remove the intermediate gear case from the vise and set it on a bench.

**Note:** The intermediate gear case will work in only one orientation.

Align the punch marks on the intermediate gear case and gear case and tap the intermediate gear case with a plastic hammer until it seats in the rear of the gear case. Make sure the intermediate pinion meshes with the drive gear.

Coat the o-rings on the motor assembly and the inside of the cylinder before installing the motor assembly.

13. Install the motor assembly through the rear of the motor housing with the geared end of the rotor toward the front.

## L+V28/32H

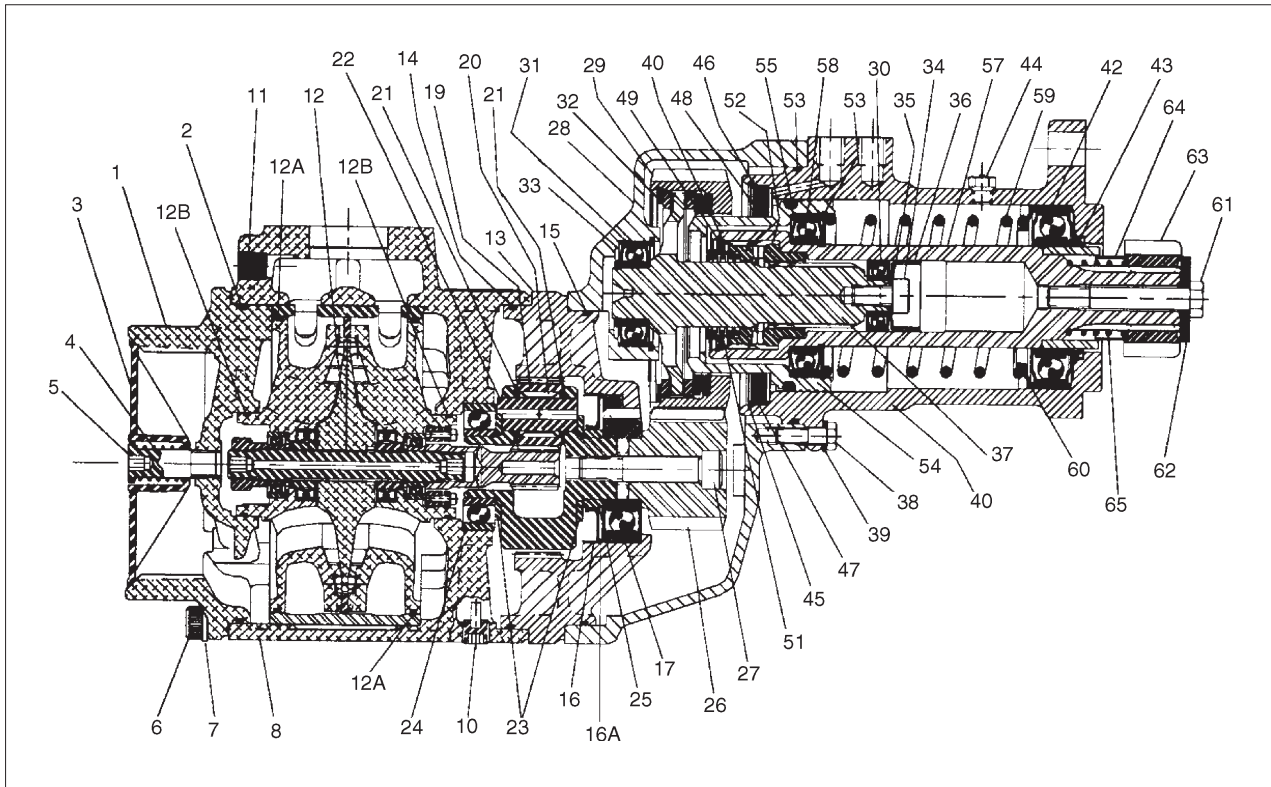


Fig 6. Turbine Starter.

**Note:** Turn the intermediate pinion so that the gear on the rotor meshes with the planet gears. Make sure that the rear of the motor assembly is installed flush with the rear of the cylinder.

14. Align the punch marks on the motor housing with the punch marks on the intermediate gear case and tap the motor housing with a plastic hammer until it seats on the rear of the intermediate gear case.

15. Install the splash deflector (3), deflector retaining spring (4) and deflector retaining screw (5) in the rear of the housing exhaust cover.

**Note:** Coat the threads of the deflector retaining screw with Ingersoll-Rand SMB-441 sealant.

16. Coat the exhaust cover seal (2) and install it in the groove on the housing exhaust cover.

17. Align the punch marks on the housing exhaust cover with the punch marks on the motor housing and tap the housing exhaust cover with a plastic hammer until it seats.

18. Install the housing exhaust cover on the rear of the motor housing using the starter assembly cap screws (6) and cap screw washers (7). Use an 8 mm hex-head wrench to tighten each a little at a time to a final torque of 61 to 68 Nm increments.

19. Mount the exhaust cover (68) on the housing exhaust cover (1).

**Note:** Use Intersoll-Rand SMB-441 pipe sealant on all plugs.

20. Install the bottom housing plug (10) and the housing plug inlet boss (11). Put the starter on its side with the side plug hole upward. Add 175 ml automatic transmission fluid fulfilling DEXRON II D specification, e.g. SHELL DONAX TA, through the side plug hole.



## L+V28/32H

**Caution: Do not overfill.**

Install the side housing plug (10) and tighten all plugs to 6.8 to 13.6 Nm torque.

**Test and Inspection Procedure**

1. **Clutch Ratcheting:** Turn the drive shaft pinion (63) by hand in the direction of the starter rotation. The clutch should ratchet smoothly with a slight click-in action.

2. **Motor and Gearing Freeness:** Turn the drive shaft pinion (63) opposite the direction of the starter rotation. The drive shaft pinion should turn by hand.

**Note:** Inadvertent application of air pressure to the "OUT" port will result in drive malfunction (pinion will fail to retract). If this condition occurs, loosen the drive housing cap screws (38) to vent gear case (28). Also, loosen housing plugs (10) and (11) to vent motor.

3. **Pinion Engagement:** Apply 50 psig (3.4 bar/345 kPa) pressure to the engagement "IN" port. drive shaft pinion (63) should move outward and air should escape from the "OUT" port.

Plug the "OUT" port and apply 150 psig (10.3 bar/1034 kPa) pressure to the "IN" port. Check and make sure that no air is escaping.

Measure the dimension from the face of the drive shaft pinion (63) to the face of the mounting flange. It should be 69.0 +2.0 mm).

Remove the pressure from the "IN" port. Measure the distance from the face of the drive shaft pinion to the face of the mounting flange. It should be 45.0 +2.0 mm.

4. **Motor Action:** Secure starter in a vise and apply 90 psig (6.2 bar/620 kPa) pressure using a 3/8" (9 mm) supply line to the inlet of the motor. starter should run smoothly.

5. **Motor Seals:** Plug the exhaust and slowly apply 20 psig (1.38 bar/138 kPa) pressure to the inlet of the motor. Immerse the starter for 30 seconds in a non-flammable, bubble-producing liquid. If the starter is properly sealed, no bubbles will appear.

6. **Gear Case Seals:** Plug the exhaust and slowly apply 20 psig (1.38 bar/138 kPa) pressure to the inlet of the motor. Immerse the starter for 30 seconds in a non-flammable, bubble-producing liquid.

There should be no leakage in the housing joints in the gear case area or in the shaft seal in the intermediate gear system. If the starter is properly sealed, no bubbles will appear.

7. **Confirm Drive Rotation:** Apply low pressure to the motor and observe rotation. drive pinion (63) must rotate in the direction stamped on the nameplate. Chamfer on pinion teeth should be on the trailing edge of the gear tooth.

|                            |                            |                                 |
|----------------------------|----------------------------|---------------------------------|
| Working Card<br>Page 1 (2) | <b>Main Starting Valve</b> | <b>613-01.40</b><br>Edition 01H |
|----------------------------|----------------------------|---------------------------------|

**L+V28/32H****Safety precautions:**

- ☒ Stopped engine
- ☒ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

**Description:**

Lubricating, disassembly and reassembly of main starting valve in starting system.

**Starting position:****Related procedure:****Man power:**

Working time : 1 Hour  
Capacity : 1 man

**Data:**

Data for pressure and tolerance (Page 600.35)  
Data for torque moment (Page 600.40)  
Declaration of weight (Page 600.45)

**Special tools:**

| Plate no. | Item no. | Note. |
|-----------|----------|-------|
|           |          |       |

**Hand tools:**

Soft hammer.  
Locking ring plier.  
Allen key, 1/4".

**Replacement and wearing parts:**

| Plate no. | Item no. | Qty. / |
|-----------|----------|--------|
| 61310     | 02       | 1/eng. |
| 61310     | 03       | 1/eng. |
| 61310     | 04       | 1/eng. |
| 61310     | 07       | 1/eng. |

## L+V28/32H

**Warning:**

Do not attempt any maintenance on the main starting valve before the starting air system has been bled off.

**Important:**

The main starting valve should be periodically lubricated as follows:

- 1) Blend off the air pressure.
- 2) Remove the plug screw (A) , see fig. 1. and squirt about 30 g of 10 w oil into the valve through the plug opening.
- 3) Reinstall the plug.

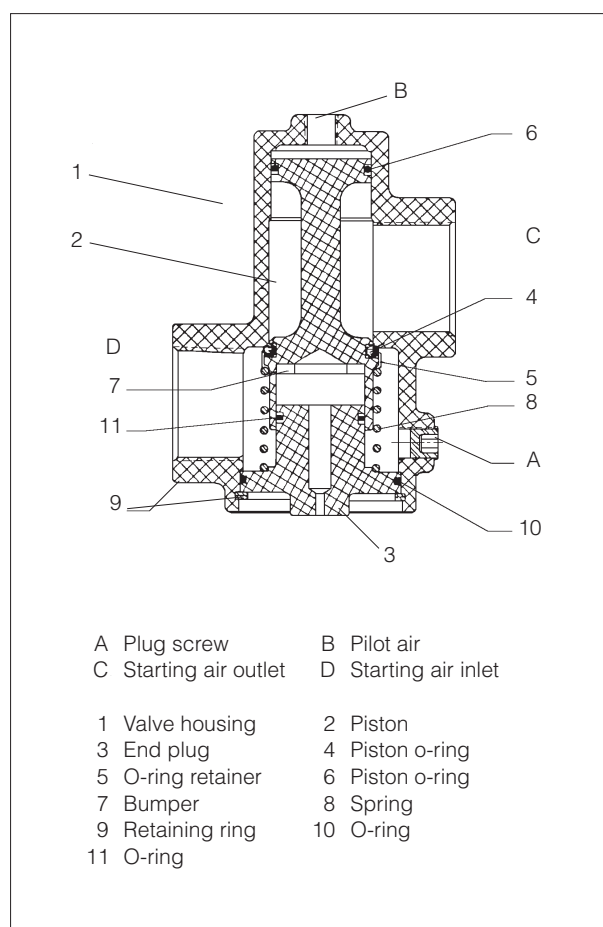


Fig. 1. Main starting valve.

**Disassembly:**

- 4) Clamp the main starting valve, in a vice with the locking ring (9) end up.
- 5) Carefully remove the locking ring (9). The end plug (3) should spring out. If it does not, tap the valve housing (1) lightly with a soft hammer until it does.
- 6) Remove the end plug (3), spring (8) and piston (2) assembly.
- 7) Remove and discard all used o-rings, o-rings retainer (5), bumper (7) and spring (8).
- 8) Wash all other parts in a clean, nonflammable solvent.

**Reassembly:**

- 9) Using o-ring lubricant, lubricate and install the new piston o-ring (4) and the new upper piston o-ring (6) on the piston (2).

**Note:** The upper piston o-ring (6) is slightly larger in diameter than the end plug o-ring (11).

- 10) Turn the piston over and insert the new bumper (7).
- 11) Using o-ring lubricant, lubricate and install the new end plug seal o-ring (10) and the new end plug o-ring (11) on the end plug (3).
- 12) Lubricate the lower small bore of the valve housing (1) with o-ring lubricant.
- 13) Insert the piston assembly into the valve housing. Push on the piston until the piston o-ring seats against the beveled face.
- 14) Install the new o-ring retainer (5) with the large opening over the piston o-ring.
- 15) Place the new piston spring (8) on the piston.
- 16) Place the end plug assembly on the piston spring.
- 17) Using a press to hold down the end plug assembly, install the end plug locking ring (9).





**L+V28/32H****With air connected.**

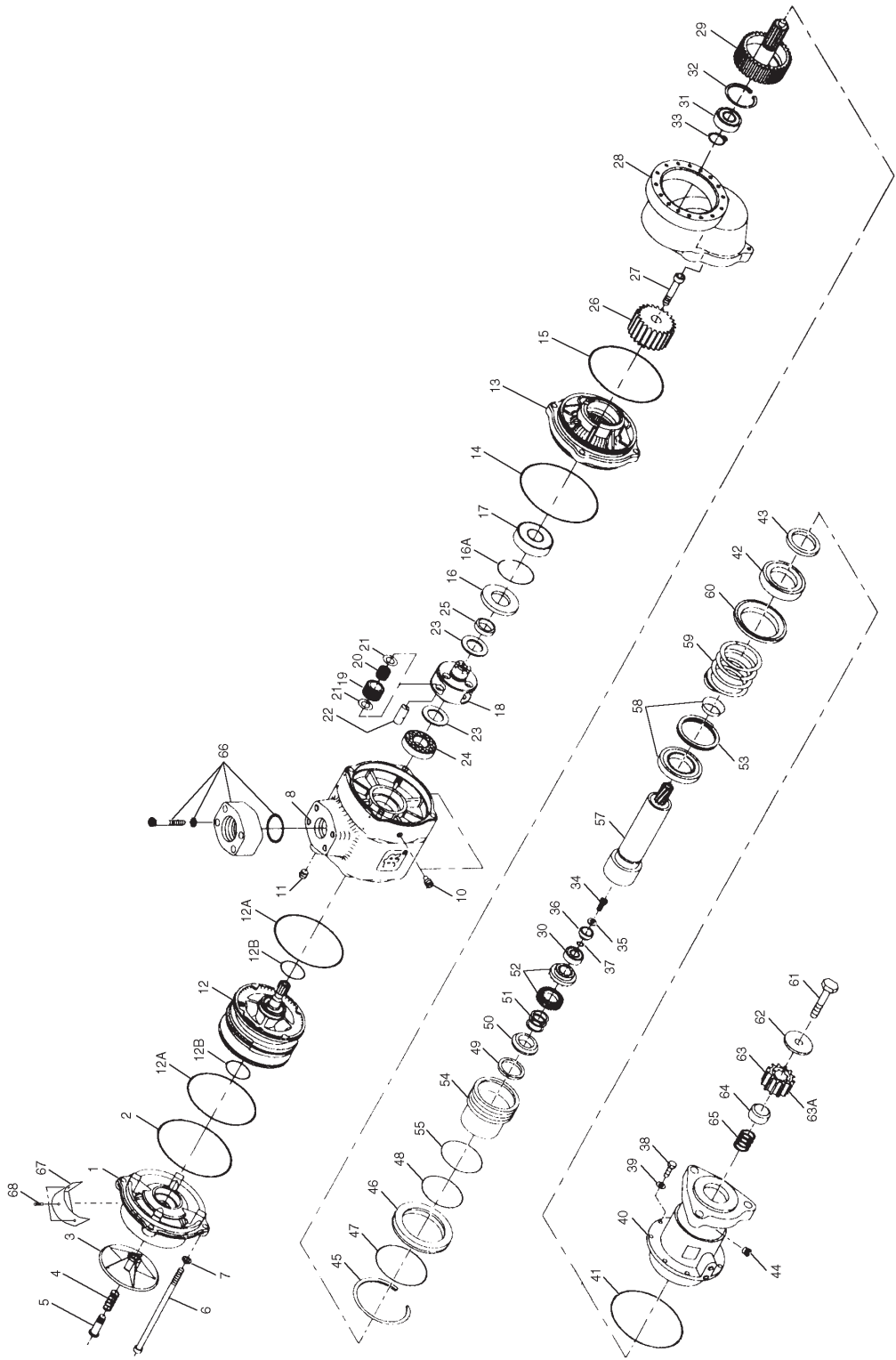
- 1) Examine the piping system for leaks.
- 2) Retighten all bolts and nuts in the piping system.
- 3) Drain the system for condensed water. - This should be based on observations.
- 4) Check flexible connections for leaks and damages.
- 5) Check manometers.

**With air disconnected and stopped engine.**

- 6) Move all valves and cocks in the piping system. Lubricate valve spindles with graphite or similar.
- 7) Connect the air supply and make a function test of the emergency valve. See description 613.01.

|                     |                        |                  |
|---------------------|------------------------|------------------|
| Plate<br>Page 1 (3) | <b>Turbine Starter</b> | <b>61309-05H</b> |
|---------------------|------------------------|------------------|

L+V28/32H



61309-05H

## Turbine Starter

Plate  
Page 2 (3)

## L+V28/32H

| Item No. | Qty. | Designation                   | Benævnelse                              | Item No. | Qty. | Designation                          | Benævnelse                             |
|----------|------|-------------------------------|---|----------|------|--------------------------------------|--|
| 1        | 1/S  | Housing exhaust cover.        | Hus for udstøds-dæksel.                 | 22       | 1/S  | Planet gear shaft.                   | Planetgearaksel.                       |
| 2        | 1/S  | Exhaust cover seal.           | Tætningsring for udstødsdæksel.         | 23       | 2/S  | Gear shaft retainer washer.          | Spænderingsskive for gearaksel.        |
| 3        | 1/S  | Splash deflector.             | Stænk deflektor.                        | 24       | 1/S  | Rear gear frame bearing.             | Bagerste gearstøtte.                   |
| 4        | 1/S  | Deflector return spring.      | Returfjeder for deflektor.              | 25       | 1/S  | Front bearing spacer.                | Forreste gearstøtte.                   |
| 5        | 1/S  | Deflector retaining screw.    | Spændeskive for deflektor.              | 26       | 1/S  | Intermediate pinion.                 | Mellemtandhjul.                        |
| 6        | 4/S  | Starter assembly cap screw.   | Dækselskrue for montage af starter.     | 27       | 1/S  | Intermediate pinion retaining screw. | Spændeskrue for mellemtandhjul.        |
| 7        | 4/S  | Cap screw washer.             | Skive for dækselskrue.                  | 28       | 1/S  | Gear case.                           | Gearkasse.                             |
| 8        | 1/S  | Motor housing.                | Motorhus.                               | 29       | 1/S  | Drive gear.                          | Drivgear.                              |
| 10       | 1/S  | Housing plug.                 | Prop til motorhus.                      | 30       | 1/S  | Front drive gear bearing.            | Forreste drivgearstøtte.               |
| 11       | 1/S  | Housing plug inlet boss.      | Tilgangsknast for prop til motorhus.    | 31       | 1/S  | Rear drive gear bearing.             | Bagerste drivgearstøtte.               |
| 12       | 1/S  | Motor assembly.               | Motor samling.                          | 32       | 1/S  | Drive gear bearing retainer.         | Spændeskrue for drivgearstøtte.        |
| 12A      | 2/S  | Cylinder o-ring seal.         | O-ringstætning for cylinder.            | 33       | 1/S  | Drive gear shaft bearing retainer.   | Spændeskrue for drivgearakselstøtte.   |
| 12B      | 2/S  | Housing o-ring seal.          | O-ringstætning for motorhus.            | 34       | 1/S  | Drive gear screw.                    | Drivgearskruer.                        |
| 13       | 1/S  | Intermediate gear case.       | Mellem gearkasse.                       | 35       | 1/S  | Drive gear lock washer.              | Skive for drivgear.                    |
| 14       | 1/S  | Rear gear case o-ring.        | Bagerste gearkasse o-ring.              | 36       | 1/S  | Drive gear cup.                      | Dæksel for drivgear.                   |
| 15       | 1/S  | Front gear case o-ring.       | Forreste gearkasse o-ring.              | 37       | 1/S  | Drive gear screw o-ring.             | O-ring for drivgearskruer.             |
| 16       | 1/S  | Planet gear frame shaft seal. | Tætningsring for planetgearakselstøtte. | 38       | 8/S  | Drive housing cap screw.             | Dækselskrue for drivgearhus.           |
| 16A      | 1/S  | Spacer ring.                  | Afstandsring.                           | 39       | 8/S  | Drive housing cap screw lock washer. | Skive for dækselskrue til drivgearhus. |
| 17       | 1/S  | Front gear frame bearing.     | Forreste gearstøtte.                    | 40       | 1/S  | Drive housing kit.                   | Drivgearhus.                           |
| 18       | 1/S  | Planet gear frame.            | Planetgearstøtte.                       | 41       | 1/S  | Drive housing o-ring                 | O-ring for drivgearhus.                |
| 19       | 1/S  | Planet gear.                  | Planetgear.                             | 42       | 1/S  | Front shaft bearing.                 | Forreste akselstøtte.                  |
| 20       | 1/S  | Planet gear needle roller.    | Nålevalse for planetgear.               | 43       | 1/S  | Drive housing seal.                  | Tætningsring for drivgearhus.          |
| 21       | 1/S  | Bearing spacer.               | Ligemellemstykke.                       | 44       | 1/S  | Drive housing vent plug.             | Afluftningsprop for drivgearhus.       |

When ordering spare parts, see also page 600.50.

Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./S = Qty./Turbine Starter

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Qty./E = Qty./Motor  
 Qty./S = Qty./Turbinestarter

|                     |                        |                  |
|---------------------|------------------------|------------------|
| Plate<br>Page 3 (3) | <b>Turbine Starter</b> | <b>61309-05H</b> |
|---------------------|------------------------|------------------|

**L+V28/32H**

| Item No. | Qty. | Designation                                | Benævnelse                         | Item No. | Qty. | Designation  | Benævnelse   |
|----------|------|--|------------------------------------|----------|------|--|--|
| 45       | 1/S  | <b>Bulkhead retainer.</b>                  | Skotholder                         | 69A      | 2/E  | <b>Turbine starter, complete. V28/32H.</b>   | Turbinestarter, komplet. V28/32H.  |
| 46       | 1/S  | <b>Bulkhead kit.</b>                       | Skotsæt                            | 70       |      | <b>Spare parts kit, incl. item 2, 12A, 12B, 14, 15, 16, 16A, 17, 21, 23, 24, 25, 41, 45, 47, 48, 55, 61 and 62</b> | Reservedels-sæt incl. item 2, 12A, 12B, 14, 15, 16, 16A, 17, 21, 23, 24, 25, 41, 45, 47, 48, 55, 61 og 62. |
| 47       | 1/S  | <b>Outer bulkhead o-ring.</b>              | Ydre skot o-ring.                  |          |      |  |  |
| 48       | 1/S  | <b>Inner bulkhead o-ring.</b>              | Indre skot o-ring.                 |          |      |  |  |
| 49       | 1/S  | <b>Clutch spring cup retainer.</b>         | Fjedertallerken holder.            |          |      |  |  |
| 50       | 1/S  | <b>Clutch spring cup.</b>                  | Fjedertallerken.                   |          |      |  |  |
| 51       | 1/S  | <b>Clutch spring.</b>                      | Koblingsfjeder.                    |          |      |  |  |
| 52       | 1/S  | <b>Clutch jaw kit.</b>                     | Koblingssæt.                       |          |      |  |  |
| 53       | 1/S  | <b>Large drive shaft bearing retainer.</b> | Stor lejespændering for drivaksel. |          |      |  |  |
| 54       | 1/S  | <b>Piston kit.</b>                         | Stempelsæt.                        |          |      |  |  |
| 55       | 1/S  | <b>Piston o-ring.</b>                      | Stempel o-ring.                    |          |      |  |  |
| 57       | 1/S  | <b>Drive shaft kit.</b>                    | Drivakselsæt.                      |          |      |  |  |
| 58       | 1/S  | <b>Rear drive shaft bearing.</b>           | Bagerste drivakselleje.            |          |      |  |  |
| 59       | 1/S  | <b>Piston return spring.</b>               | Stempel returfjeder.               |          |      |  |  |
| 60       | 1/S  | <b>Seat.</b>                               | Sædering.                          |          |      |  |  |
| 61       | 1/S  | <b>Drive pinion retaining screw.</b>       | Tandhjulsspændeskrue.              |          |      |  |  |
| 62       | 1/S  | <b>Drive pinion washer.</b>                | Tandhjulsskive.                    |          |      |  |  |
| 63       | 1/S  | <b>Drive pinion. L28/32H</b>               | Tandhjul. L28/32H.                 |          |      |  |  |
| 63A      | 1/S  | <b>Drive pinion. V28/32H</b>               | Tandhjul. V28/32H.                 |          |      |  |  |
| 64       | 1/S  | <b>Pinion spring sleeve.</b>               | Tandhjulsbøsning.                  |          |      |  |  |
| 65       | 1/S  | <b>Pinion spring.</b>                      | Tandhjulfjeder.                    |          |      |  |  |
| 66       | 1/S  | <b>Inlet flange kit.</b>                   | Tilgangsflangesæt.                 |          |      |  |  |
| 67       | 3/S  | <b>Cover</b>                               | Dæksel                             |          |      |  |  |
| 68       | 1/S  | <b>Self drilling screws</b>                | Selvborende skruer                 |          |      |  |  |
| 69       | 1/E  | <b>Turbine starter, complete. L28/32H</b>  | Turbinestarter, komplet. L28/32H.  |          |      |  |  |

When ordering spare parts, see also page 600.50.

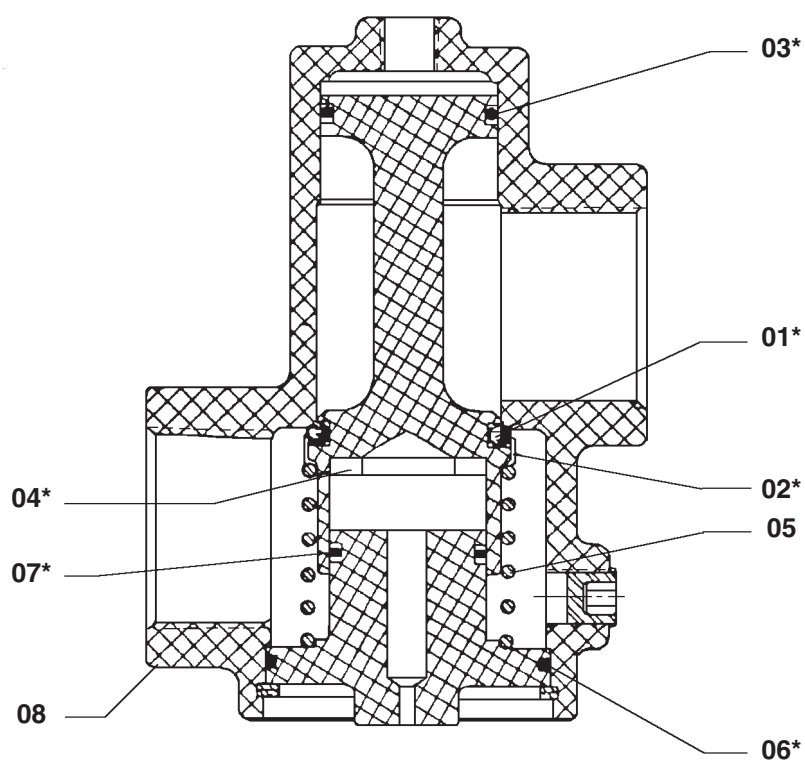
Ved bestilling af reservedele, se også side 600.50.

\* = Only available as part of a spare parts kit.  
 Qty./E = Qty./Engine  
 Qty./S = Qty./Turbine Starter

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Qty./E = Qty./Motor  
 Qty./S = Qty./Turbinestarter

|                     |                            |                  |
|---------------------|----------------------------|------------------|
| Plate<br>Page 1 (2) | <b>Main Starting Valve</b> | <b>61310-03H</b> |
|---------------------|----------------------------|------------------|

**L+V28/32H**



|           |                     |                     |
|-----------|---------------------|---------------------|
| 61310-03H | Main Starting Valve | Plate<br>Page 2 (2) |
|-----------|---------------------|---------------------|

L+V28/32H

| Item No. | Qty. | Designation  | Benævnelse  | Item No. | Qty. | Designation | Benævnelse |
|----------|------|--|---|----------|------|-------------|------------|
| 01*      | 1/V  | O-ring   | O-ring  |          |      |             |            |
| 02*      | 1/V  | O-ring retainer                                      | O-ring holder                                       |          |      |             |            |
| 03*      | 1/V  | O-ring   | O-ring  |          |      |             |            |
| 04*      | 1/V  | Bumper   | Stødfanger  |          |      |             |            |
| 05       | 1/V  | Spring   | Fjeder  |          |      |             |            |
| 06*      | 1/V  | O-ring   | O-ring  |          |      |             |            |
| 07*      | 1/V  | O-ring   | O-ring  |          |      |             |            |
| 08       | 1/E  | Main starting valve, complete                        | Hovedstartventil, komplet                           |          |      |             |            |
| 09       | 1/V  | Spare part kit<br>Item No. 01, 02, 03, 04, 06 and 07 | Reservedelssæt<br>Item nr. 01, 02, 03, 04, 06 og 07 |          |      |             |            |

When ordering spare parts, see also page 600.50.

\* = Only available as part of a spare parts kit.

Qty./E = Qty./Engine

Qty./V = Qty./Valve

Ved bestilling af reservedele, se også side 600.50.

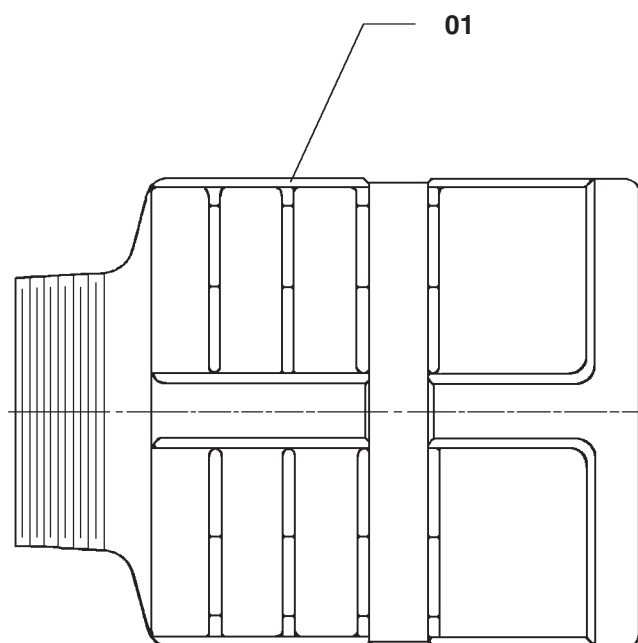
\* = Kun tilgængelig som en del af et reservedelssæt.

Antal/E = Antal/Motor

Antal/V = Antal/Ventil

|                     |                |                  |
|---------------------|----------------|------------------|
| Plate<br>Page 1 (2) | <b>Muffler</b> | <b>61312-02H</b> |
|---------------------|----------------|------------------|

**L+V28/32H**





|           |         |                     |
|-----------|---------|---------------------|
| 61312-02H | Muffler | Plate<br>Page 2 (2) |
|-----------|---------|---------------------|

**L+V28/32H**

| Item No. | Qty. | Designation | Benævnelse |
|----------|------|-------------|------------|
| 01       | 1/S  | Muffler     | Dæmper     |

**When ordering spare parts, see also page 600.50.**

\* = Only available as part of a spare parts kit.  
Qty./S = Qty./Starting air motor

Ved bestilling af reservedele, se også side 600.50.

\* = Kun tilgængelig som en del af et reservedelssæt.  
 Antal/S = Antal/Startemotor