MEPRODUCTION

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Gearbox Excellence...

Operators' Manual

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Document status

Document title:	Gearbox Manual
Purpose:	Defining the extent of Mekanord reduction gearbox installation, operation, maintenance/service and spare part. This document is primary source of information exchange between manufacturer, installer and operator and is intended to respond to technical queries between these parties.
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Revisions

List of document revisions

Date	Initials	Revision no	Remark
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1 General information

This generic manual applies to all Mekanord gearbox types (excl. Type 60 + 70 + 80 and Hybrid gearboxes) designed for ship propulsion. Specific technical information of the individual gearbox is to be found in the project specific technical specification.

Make note of the actual revision number and please refer to this revision number when approaching ME Production for any questions/queries regarding installation, operation or maintenance/spare parts.

1.1 Contact information

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Please study our website for further information.

1.2 Using this manual

This manual contains relevant and important information for the installation, alignment, start-up, operation and maintenance of the gearbox. In the last pages the spare part catalogue can be found. The manual is intended for the personnel installing and afterwards operating the gearbox on board the vessel.

The manual is divided in sections according to the content section making navigation in manual easy.

Important information

- The manual must be kept available and in a legible condition. Personnel responsible for the operation of the gearbox must have read and understood the entire manual. In the event of doubt, uncertainty or the need for more information, please do not hesitate to contact ME Production. In such case, please refer to manual revision as well as gearbox serial number. See bottom of content section or rear page for contact details, alternatively go to www.meproduction.dk for further contact details.

If the local authority rules or requirements of a specific classification society differ from the content of the manual, the local authority rules or classification society's requirement will always apply above manual specifications. It is always up to the reduction gearbox owner to keep themselves up to date regarding all requirements from class society or likewise.

The information in the manual has been carefully checked. ME Production will take no responsibility for any direct or indirect costs caused by possible misprints, outdated or incorrect documentation.

1.2.1 Pictograms

The manual contains pictograms which indicates where danger and/or risk may occur and caution is required from operation personnel. ME Production can however not be held liable for injury to personnel or material damage arising from failure to follow the manual or even if recommendations/guidelines has been followed.

Pictograms used in the manual:

Warning

Describes specific situations, components or actions, which are to be noticed with special caution. Specific recommendations are in most cases mentioned and are to be followed to optimize personnel safety of the operation, handling or action.

Important information

Describes specific cases, techniques, guidelines or component features, which are important to notice. In most cases the information advises specific reference for easy locating of additional information.

1.3 Safety

Warning

- The gearbox contains rotating shafts. Danger to personnel if coming into contact. Check that personnel and equipment are not in contact with the rotating parts before starting engine and/or propeller.
- The gearbox reaches a high surface temperature during operation. Danger of burns if touched.
- Pipes mounted on the gearbox contains oil under pressure. Do not disconnect pipes during operation. Danger to personnel and risk of pollution. Always make sure, that pipes are pressure-less prior disassembling.
- Do not remove inspection covers during operation, as this will lead to severe oil splashes. Danger to personnel, risk of pollution and damage to the reduction gearbox.
- Secure the system mechanically or electrically against accidental unintended start up when servicing the gear.

1.4 Warranty

Important information

- The gearbox has been manufactured in accordance with the order acknowledgement and technical specification. All vital components (including but not limited to safety switches of the gearbox) have been sealed after value setting. Do not break seals without prior written approval of ME Production. The warranty will be void if components are adjusted without prior written approval of ME Production.

Warranty terms (scope and duration) are described in the order acknowledgement. In case of any warranty claim, please contact service department as soon as the failure has been discovered. Always refer to gear box serial number when claiming any defect.

ME Production cannot be held liable for any consequential damage or loss caused by the defect, unless specifically mentioned in the order acknowledgement. Maximum reliability can never exceed total order sum.

2 Storage & Lifting

To prevent corrosion of the gearbox, it has been treated with VpCI corrosion protection (Vapor phase Corrosion Inhibitors).
Incorrect storage of the equipment can cause corrosion and severely shortened lifetime of components, as well as reduced performance after installation. ME Production requires following criteria for storage and installation.

Two different VpCI corrosion protection methods are available. Please check technical specification for the type chosen for your gearbox.

- **Standard VpCI protection** gives up to 12 months corrosion protection.

- **Enhanced VpCI protection** gives up to 36 months corrosion protection.

2.1 Storage conditions

Storage requirements:

- Store transport crate indoor in a warehouse or similar.
- Relative humidity must not exceed 75% RF.
- Normal air pollution levels.
- The VpCI protective enclosure must not be breached to maintain corrosion/contamination protection.

2.2 Lifting

The gearbox is fitted with eye bolts for lifting.

Gearbox type	Approx. dry net. weight	Approx. PTO weight
190HS	200 kg	20 kg
200HSC	275 kg	25 kg
235HSC	400 kg	25 kg
270HS	375 kg	20 kg
280HSC	700 kg	30 kg
337HS	550 kg	25 kg
350HS	600 kg	25 kg
400HS	900 kg	40 kg
430-1HS	1340 kg	40 kg
430-2HS	1840 kg	40 kg
450HS	2400 kg	70 kg
500-1HS	2400 kg	70 kg
500-2HS	3000 kg	70 kg
580HS	4900 kg	70 kg
650HS	5500 kg	70 kg
Type 35HS	3000 kg	40 kg
Type 60	6800 kg	N/A
Type 70	6750 kg	N/A
Type 80	14300 kg	N/A

The installer must ensure correct installation method avoiding any equipment on the gearbox to be damaged. The gearbox may not balance. In such case, attach a 3rd lifting strap to the output flange for balancing.

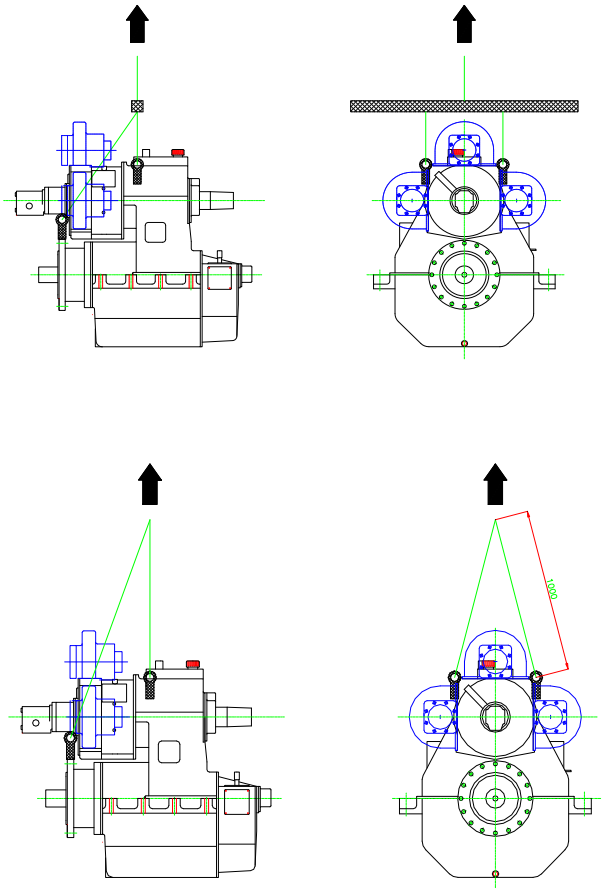


Figure 2-1: shows example of lifting vertical gearbox.

3 Installation

The gearbox is delivered as a compact unit with all components remounted; except from oil cooler (if MEP supply) and standby oil pump (if MEP supply). The underside foundation of the gearbox is machined for installation on an aligned rigid steel bed plate. Between gearbox and bed plate installation of chocks are required; either of steel or epoxy resin. Further information on chocks to be found in section 3.5 in this manual.

The gearbox can be either a freestanding unit or an engine-fixed-mounted unit. In the technical specification the specific frame type is mentioned.

Fitting to engine is must always take place via flexible coupling.
The propeller shaft is fitted directly to the output flange of the gearbox.

The gearing, 1 or 2 steps, is built into a cast iron housing on which a mechanically driven oil pump is fitted. The pump supplies the servo system, the clutch system and the lubrication system with the necessary pressure and flow of oil.

The gearbox must be installed in the ship's engine room in such way, that all inspection covers are accessible. Access is required to internal components for servicing, which can only be achieved through the inspection covers. Additionally the electrical junction box must also be accessible for maintenance/service purposes.

Important information

- Pipes, hoses, bed plates or cables must not block the inspection covers or electrical junction box.
- Prior installation and alignment of gearbox it is important that all interface parts have obtained the same temperature incl. surrounding temperature.

3.1 Alignment of gearbox

The gearbox must be aligned correctly in relation to the engine and propeller shaft to avoid unnecessary stress on the shaft and bearings in the gearbox. If a PTO is fitted on the gear, the generator shaft must also be correctly aligned.
The gearbox cannot be placed at an angle exceeding more than 8° lengthwise and ±3° sideways. (see Figure 3-1.

The foundation on which the gear stands must be rigid and integrated into the engine bed plates to avoid dangerous strain on the gearbox. Consideration must be given to forward-acting forces in the drive line caused by the propeller thrust reactions from the gear and torque on the ship’s hull.
Major constructional welding must be completed before alignment of gearbox can commence.
The engine's oil tank must not be placed in the immediate vicinity of the gearbox to avoid the effects of heat on the gear.

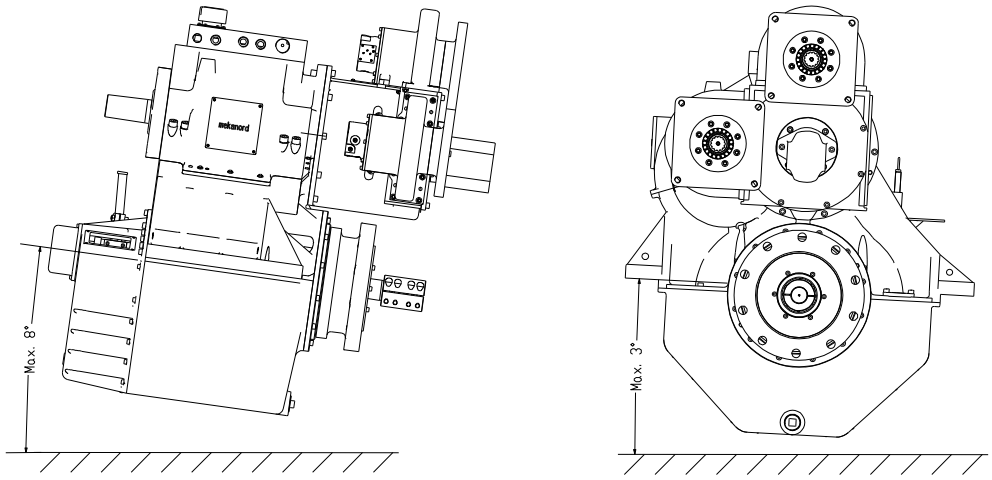


Figure 3-1: shows the maximum angle of the gear in relation to the horizontal level

3.2 Thermal expansion

When in operation, Mekanord gearboxes are subject to thermal expansion caused by heat generated by gearwheels and oil. Thermal expansion must be considered when installing the gearbox, so that the bearings in the gearbox are not subjected to unnecessary stress when in operation.

Designations for length are:

A : the length between the centre of the input shaft and centre of the output shaft [mm]
A_i : the length between the mounting surface and the centre of the input shaft [mm]
A_u : the length between the mounting surface and the centre of the output shaft [mm]
A_p : the length between the centre of the input shaft and centre of the PTO shaft [mm]

Whether the lengths are in relation to each other can be seen in below Figure 3-2. Please note that the figure shows a diagram of a gearbox, which can differ from the specific product supplied.

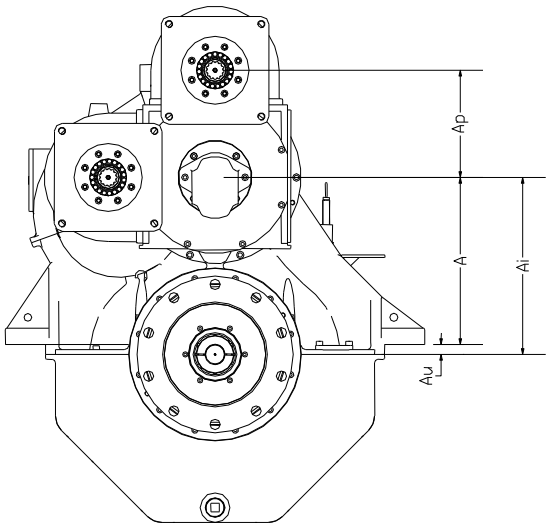


Figure 3-2 shows lengths A, Ai, Au and Ap in relation to the gearbox.

Table for thermal expansion of Mekanord gearboxes:

Gearbox type	Expansion Length A	Expansion Length Au	Expansion Length Ai	Expansion Length Ap
190HS	0,048	0,023	0,071	0,050
200HSC	0,047	0,032	0,015	0,049
235HSC	0,055	0,040	0,015	0,052
270HS	0,102	0,039	0,065	0,081
280HSC	0,066	N/A	N/A	0,057
337HS	0,110	N/A	0,110	N/A
350HS	0,132	0,048	0,084	0,087
Type 35HS	0,132	0,023	0,155	0,104
400HS	0,152	N/A	0,152	0,098
430-1HS	0,163	N/A	0,163	0,098
430-2HS	0,163	N/A	0,163	0,098
450HS	0,169	0,035	0,206	0,129
500HS	0,136	0,026	0,161	0,093
580HS	0,136	0,023	0,159	0,088
650HS	0,245	0,037	0,284	0,142
Type 60	0,227	0,038	0,265	0,189
Type 70	0,265	0,038	0,302	0,189

Table 3-1: Values for thermal expansion

Thermal expansion is calculated with ΔT=35°C with a cold start temperature of 25°C and operating temperature of 60°C.

3.3 Alignment of gearbox to main engine

Alignment must be performed by measuring the radial and axial deviation between the main engine flywheel and gearbox input shaft. The maximum allowable deviation radially and axially must be complied with to avoid unfavourable working conditions for the built-in bearings of the gearbox.

The maximum permitted values can be seen in Table 3-2. The thermal expansion of the gearbox must be taken into consideration in the alignment phase. Data for thermal expansion can be seen in Figure 3-1.

Important information

Connection between gearbox and main engine	190HS-430HS	450HS-650HS, Type60, Type70
Maximum radial deviation	+/- 0.03 mm	+/- 0.05 mm
Maximum axial deviation	+/- 0.03 mm	+/- 0.05 mm

Table 3-2: contains maximum permitted tolerance value during alignment of gearbox and main engine.

Important information

When fitting the flexible coupling between main engine and gearbox, check whether supplier of the flexible coupling applies stricter requirements to the alignment procedure than ME Production. If this is the case, the coupling supplier's recommendations MUST be complied with.

Please note that the smaller a deviation during alignment, the better the entire construction will be. Fewer vibrations will extend the service life of the flexible coupling and the gearbox bearings will be exposed to less unfavourable stress via the input shaft.

3.4 Alignment of gearbox to propeller shaft

The following guidelines for alignment of gearbox in relation to the propeller shaft must be followed and complied with to avoid stresses on the gearbox' output shaft. This will ensure longer service life of the gearbox.
Below guidelines are subject for matching with similar guidelines from propeller manufacturer. If propeller alignment instructions have smaller alignment tolerances, they are to be followed.

The following conditions must be fulfilled for alignment between gearbox and propeller shaft:

- The vessel must be afloat.
- The assembly between the gear's pull-push rod and the propeller's pull-push rod must not be connected.

Consideration must also be given to the thermal expansion of the gearbox at normal operating temperatures. Specific data for this gear can be seen in Figure 3-1.
When aligning the gearbox to achieve the correct height it may be necessary to adjust the adjustment screws. Figure 3-3 illustrates with arrows where adjustment screws are used on the side feet. The adjustment screws are not part of the scope of supply. Please refer to dim. sketch of gearbox for thread size for adjustment screws.

Figure 3-3: illustrates adjustment screws for length & lateral adjustment.

Please note that their location may differ from the product supplied.

Always check that the output flange on the gear centres with the propeller shaft flange. Table 3-3 shows permitted tolerances.

When the two flanges are joined, measure the axial gap with a feeler gauge, as GAP/SAG see Figure 3-4. Rotate one flange to 90°, 180° and 270° respectively, taking measurements at each position. Keep the other flange in the same position.

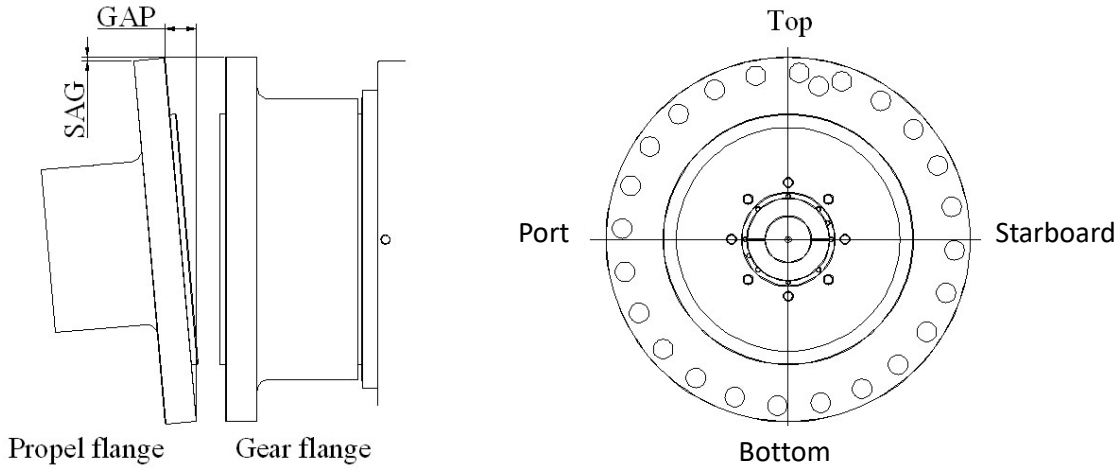


Figure 3-4: illustrates the gear's output flange with the propeller flange.

Important information

Connection between gearbox and propeller shaft	190HS-430HS	450HS-650HS, Type60, Type70
Maximum radial deviation	+/- 0.03 mm	+/- 0.05 mm
Maximum axial deviation	+/- 0.03 mm	+/- 0.05 mm

Table 3-3: contains maximum permitted tolerance values during alignment of gearbox and propeller shaft..

Important information

- Measure GAP and SAG at all four positions (top, starboard, bottom and port) to achieve the best alignment. Figure 2.3 shows how GAP and SAG are measured between the two flanges.
- For more details, please refer to the propeller supplier's manual.

3.5 Fastening of gearbox to foundation

The gearbox must be secured by tightening bolts which are sufficiently long to achieve the necessary tension. Please refer to dim. sketch of gearbox for dimensions of holes for foundation bolts.
The gearbox can be mounted on steel blocks or resin chocks. Figure 3-5 illustrates two possible types of securing. “A” shows mounting on steel blocks, “B” shows mounting on resin chocks.

For further details, contact the supplier of the mounting materials.

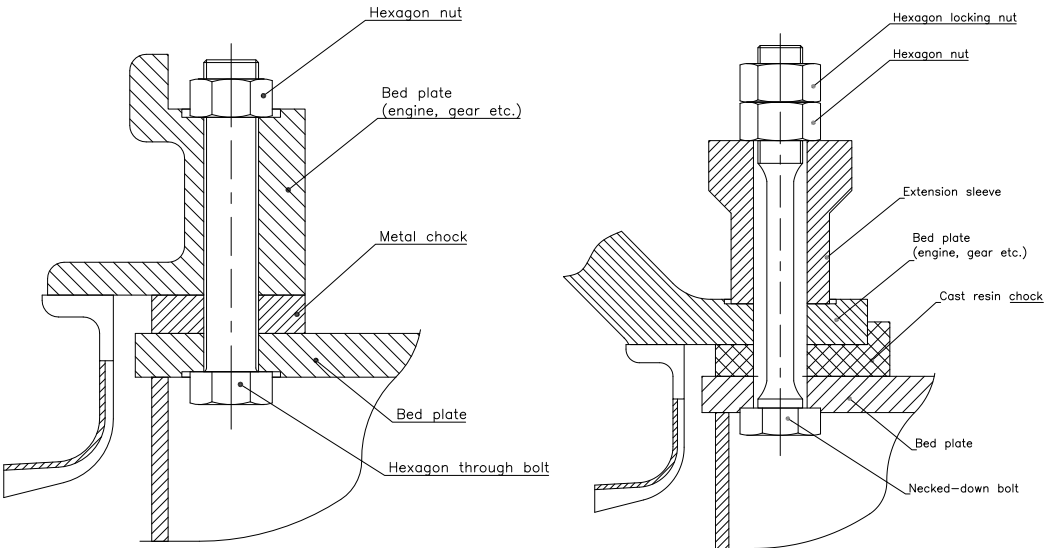


Figure 3-5: illustrates mounting on steel blocks or resin chocks.

"A" shows steel blocks, **"B" shows resin chocks.**

End chocks must be installed both forward and aft as well as side chocks on starboard and port side which can transmit three times nominal propeller thrust. Figure 3-6 illustrates mounting on end chocks. For adjustment of the gearbox in transversal and longitudinal direction, an adjustment screw should be fitted to each chock. If side chocks are not applied, fitted bolts are to be mounted in all foundation holes. End chocks forward and aft must be installed, class requirement.

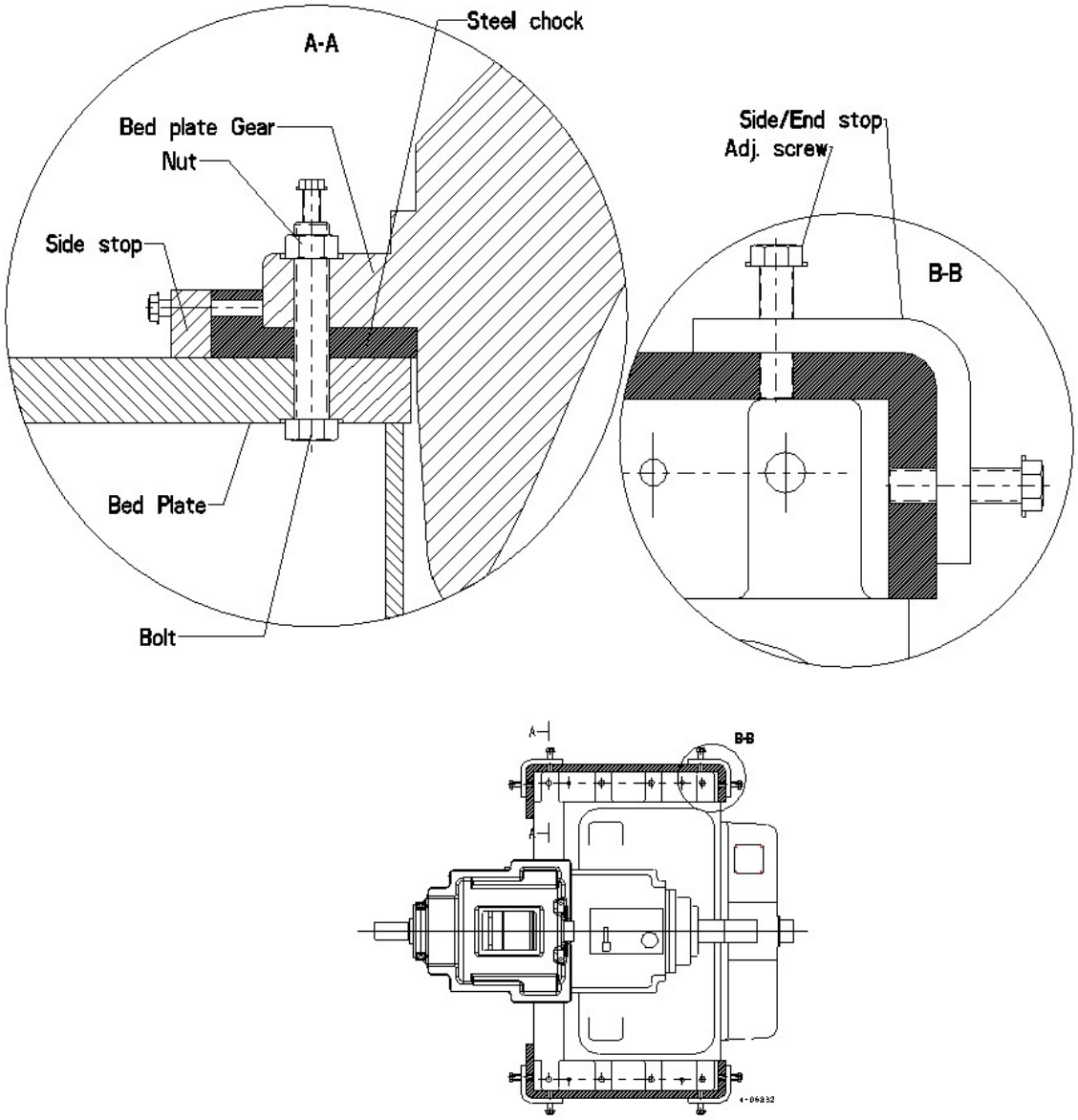


Figure 3-6: illustrates mounting on end chocks.

3.6 Power take off (PTO) equipment

The reduction gear box can be delivered with power take off (PTO) connections. Depending on gearbox type, the gearbox can host up to three PTOs. The PTOs will all have the same ratio but can be clutched in and out individually.

Installation of PTO consumer depends on connection method, which can either be freestanding or via SAE flanges. Regardless of method, then alignment and proper fastening is important. Below sub-sections describes both solutions.

3.6.1 Alignment of gear PTO to freestanding consumer

Correct alignment is important to secure long service life of both gearbox and connected PTO consumer. Adjust the consumer's position in accordance with the PTO shaft using the adjustment screws on the bed plate of the consumer.
Below guidelines are subject for matching with similar guidelines from consumer manufacturer. If consumer alignment instructions have smaller alignment tolerances, they are to be followed.

Always check that the PTO shaft on the gear is centred in relation to the consumer shaft. This is performed by bringing the PTO and consumer shafts (or their mounted flanges) close together (GAP/SAG principle as described in section 3.4.
Rotate one flange to 90°, 180° and 270° respectively, taking measurements at each position. Keep the other flange in the same position.

Important information

- Tolerance range for alignment is shown in Table 3-4.
- Always take thermal expansion under normal operating conditions into account, see Table 3-1 for more details.

Connection between PTO and generator	190HS-650HS, Type60, Type70
Maximum radial deviation	+/- 0.03 mm
Maximum axial deviation	+/- 0.03 mm

Table 3-4: contains maximum permitted tolerance values for alignment PTO shaft and generator shaft.

- Once alignment is completed, the generator must be secured to keep it in position during operation. For more details on securing, please refer to the consumer supplier's manual.

3.6.2 Flange-mounted PTO consumer

Hydraulic pumps etc. are easily attached to the PTO using 2 or 4 bolts on the PTO's standard SAE flange. Mounted pumps may require support if heavy or long. Please refer to consumer's manual for supporting information.

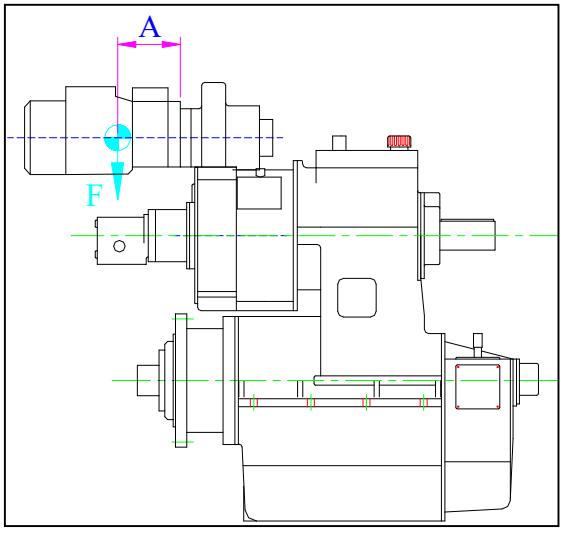


Figure 3-7: definition of max bending torque, M.

The need for support can be calculated as follows:

Max. bending torque, M=60Nm.
M = F x A [Nm]
F = m x g = m x 9.82 [N]
m = pump mass [kg]
A = distance to pump gravity point [m]

Warning

- The gearbox is to be delivered with correct matching flanges/splines. Do not use spline or flange adaptors.

3.7 Installation of standby pump (if MEP Supply)

The gearbox can be supplied with an electrical standby oil pump.

- **Standby pump** is an electrical oil pump which provides the same pressure and flow as the main forced driven pump, which is mounted on the gearbox. The pump is intended to serve as backup in case of emergency, where forced driven pump has failed.

The standby pump must be installed on a solid foundation close to the gearbox. If standby pump is MEP supply the gearbox pipe work will already be prepared for connecting the standby pump. Piping between connecting flanges on gearbox to standby pump must be carried out in steel pipe material suitable for the purpose. Pipe dimension are to follow at least same dimension as oil pipes on gearbox connecting pipes.

Important information

- Keep pipe distance to minimum possible to avoid pressure loss.
- Do not use pipes with less diameter than connecting oil pipes from gearbox to avoid pressure loss.
- If long distances or several bends are required, the pipe must be calculated with a max flow velocity of 4,5m/second.
- Pump must be located max. 0.5m above the gear's oil level.
- Pipes and hoses between oil pan and pump must be sealed. Leaks will cause pump cavitation.
- Minimum internal dimension from oil pan to pump suction side:
  - 3kW pump 1 ⅜" dia.
  - 5.5kW pump 1 ⅜" dia.
  - 7.5kW pump 1 ½" dia.
- Minimum internal dimension for pump pressure side to the hydraulic block:
  - 3kW pump ¾" dia.
  - 5.5kW pump ¾" dia.
  - 7.5kW pump 1" dia.

When gearbox is prepared for standby pump installation it will have a pressure switch mounted, which will trip at preadjusted pressure. Please refer to commissioning report for actual pressure value.
The switch can be used for automatic start of the standby pump, if the control system can handle this.

The switch is a potential free relay (normally open). Please check electrical drawing for specific terminal numbers relevant to be used for automatic start of standby pump.

It is recommended to install a “local/remote” manual switch at the standby pump to obtain the possibility to start the standby pump manually (manual override or manual activation in case control system cannot handle auto start).

The standby pump motor is a 3 phased motor and is to be supplied directly from the main switch board or sub switch board, whichever is most appropriate. Consider connecting to “essential service section” for first supply after possible black out. The starting of the pump can be done with a normal motor protection unit

and starting should happen via a 3 phased relay controlled by the control signal from the control system (or the manual start breaker).

Electrical installation is to be approved by class society, if applicable.

Commissioning of the standby pump follows the commissioning of the entire gearbox installation. Make sure that standby pump's suction line is filled with oil (de-aired) prior first startup.

3.8 Installation of oil cooler (if MEP supply)

The gear must have an oil cooler fitted to cool the gear oil. Correct installation of the oil cooler is important to ensure sufficient cooling of the circulating gear oil. This cooler can be supplied with the gearbox from ME Production.

Installation to follow below guidelines:

In addition to the manufacturer's requirements, ME Production applies the following requirements for installation etc. to ensure optimum cooling effect:

- The oil cooler must be fitted at the same level as the oil connections on the gearbox. If the cooler is higher or lower than the connections, reduced cooling effect may be caused.
- The connection made from gear to cooler must be as short as possible and flexible in both ends.
- The cooler's oil side must be connected to the gearbox via the hydraulic system on the top of the gearbox via the intended connections.
- Water coolant pipes to the oil cooler must be same size as oil cooler in and outlets.
- The oil cooler must be supplied with coolant (water) which does not exceed the temperature calculated for the specific system. See Technical Specification for temperature.
- If the oil cooler for the gearbox is part of an extended cooler circuit (e.g. which also provides coolant to the engine) the circuit must be constructed in a way that ensures constant flow of coolant to the oil cooler. We recommend placing the cooler as number one. Failure to do so can result in overheating and damage to the gear.

Commissioning of the oil cooler follows the commissioning of the entire gearbox installation. Make sure to de-air both oil and coolant side of the cooler. Also make sure that sacrificial anode is properly installed prior first startup.

Warning

- If connection is provided exclusively by hydraulic pipes, vibrations can be transferred from the gear to the cooler. This can result in damage to the gearbox, the pipes and cooler.
- Oil leaks or spillage between cooler and cooler connections can cause pollution and slippery decks. This can result in injury to personnel.

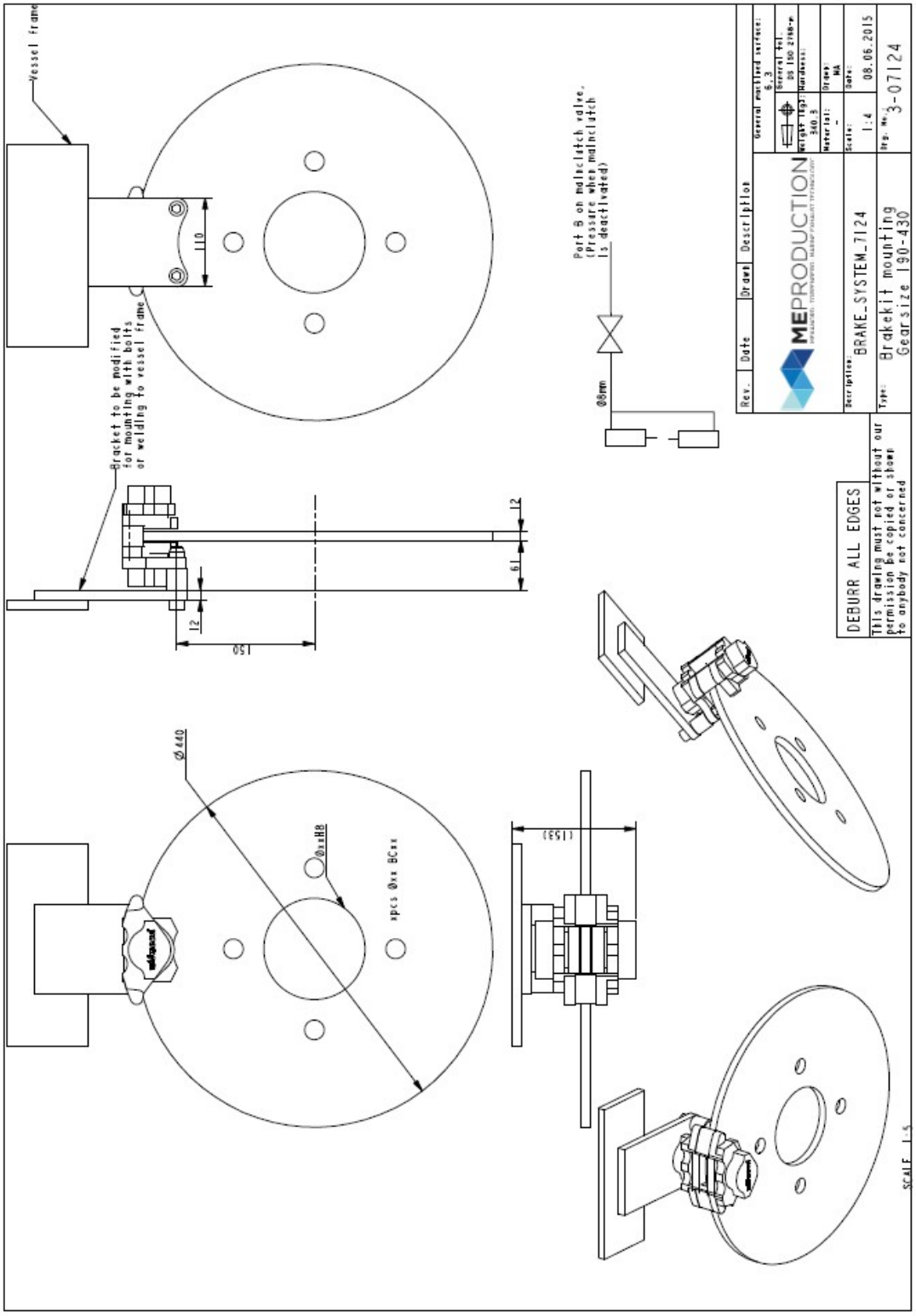
Important information

Instructions for correct connection of cooler to reduction gear:

- Pipe or hose assemblies between cooler and gear must be checked for leaks. Leaks can result in reduced cooling effect.
- Pipes and hoses between oil cooler and reduction gear must not obstruct service access through the inspection covers.

3.9 Installation of shaft brake kit (if MEP supply)

The gear must be hydraulic prepared with port for applying the brake calibre. Mounting of brake disc and calibre according to drawing 3-07124.



3.10 System oil

Installer to provide and ensure correct oil level of gearbox as a final part of installation prior first startup.

Important information

All types of oil used to fill the gearbox must comply with the following:

- Viscosity: ISO VG 150
- *FZG ≥ 12

Oil must fulfil the specifications of

- DIN 51517 part 3, CLP 150
- ISO 12925-1, CKD 150

*FZG = method of testing loading capacity of gear oil.

Below table shows approximate amount of oil according to gearbox.

Gearbox type	Approx. amount of oil (liters)
190HS	17
200HSC	20
235HSC	37
270HS	21
280HSC	40
337HS	30
350HS	38
Type 35HS	40
400HS	68
430-1HS	70
430-2HS	70
450HS	90
500-1HS	110
500-2HS	110
580HS	240
650HS	240
Type 60	300
Type 70	300

3.11 System commissioning

Only when installation is complete the commissioning may be initiated.

For commissioning of the reduction gearbox installation, please refer to separate commissioning report document.
Prior commissioning please verify that all hydraulic pipe work is properly installed, pressure tested and de-aired. Please also verify that all electrical connections are established and I/O tested. It is particularly important to make sure, that all safety functions are tested and confirmed functioning.

4 Operation of gearbox

The gearbox in operation consists of three major systems; hydraulic system, electric system and cooling system. Below will describe each system to gain knowledge of the system's operation and functionality.

4.1 Hydraulic system

The gear is fitted with an integrated hydraulic system for operation of main clutch, pitch servo, PTO clutches and lubricating system. The hydraulic system is combined of internal bores and blocks and of external piping connecting the different internal sections and external components, such as pumps and cooler.

4.1.1 Description of function of the hydraulic system

Introduction

To understand the functions of the hydraulic system, familiarity with hydraulic symbols and systems is required.

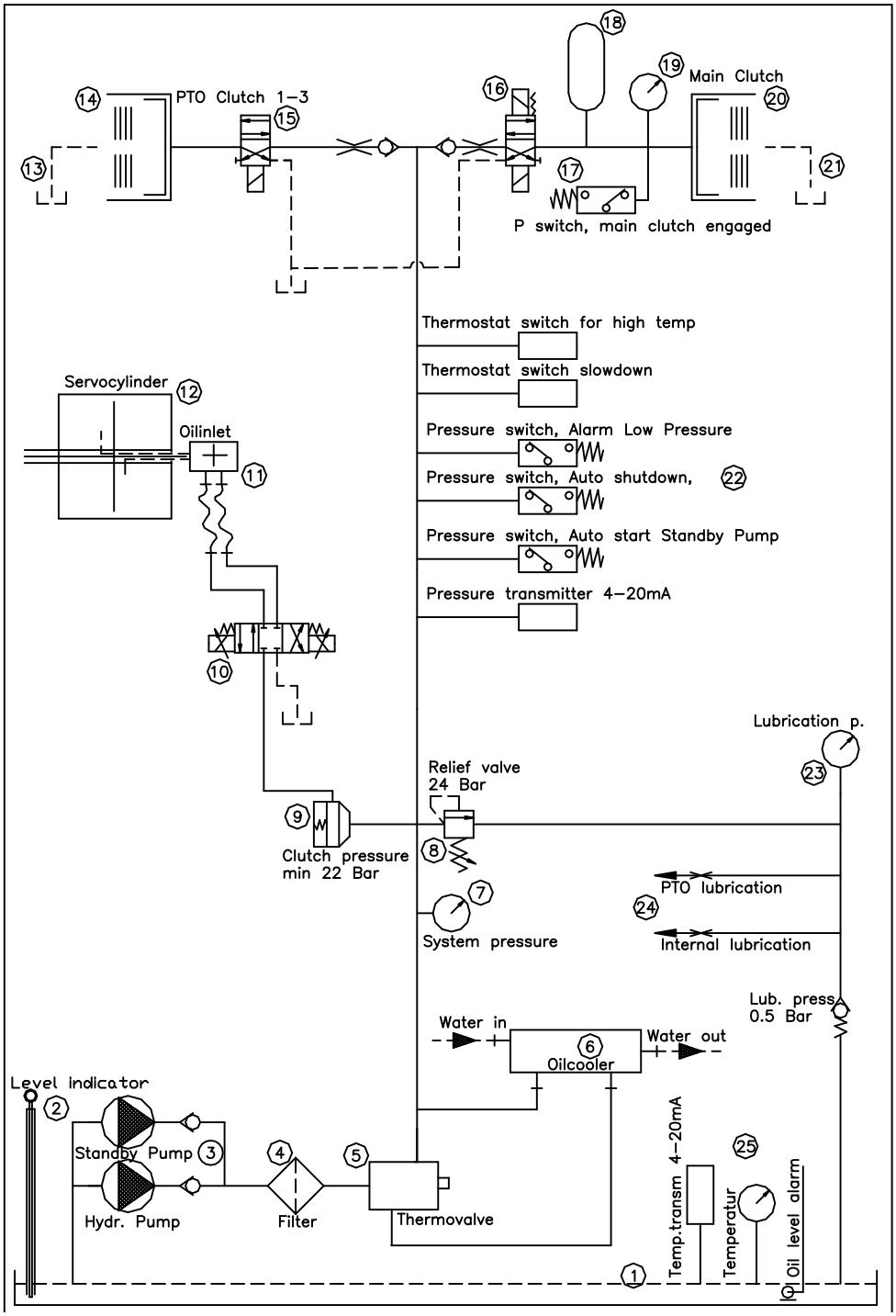


Figure 4-1: Example of hydraulic system.

Hydraulic diagram 4-06929 **Error! Reference source not found.** is referred to in the following section, which shows standard components and optional extras. Some optional extras might not occur on the specific gearbox. Please refer to technical specification for exact info on delivered parts/functions.

Oil tank

The system consists of an oil tank (Pos. 1). The gearbox oil pan is usually used as the oil tank. Oil level is checked manually using a dipstick (Pos. 2). The oil level must be between the two marks.

Hydraulic pump

The oil tank and mechanical main pump are connected. An electric standby pump may also be fitted in parallel (Pos. 3). The pumps must be separated with check valves.

Filter

The oil passes from the oil pump to a filter (Pos. 4). The filter can be single or duplex and fitted with an electric differential pressure switch to warm of clogging.

Cooling system

From the filter the oil runs through a thermostatic valve (Pos. 5). The thermostatic valve controls the temperature in the gearbox in the optimal 50-60°C operating range.
Depending on demand, the thermostatic valve will distribute the oil either partly through the water-cooled oil cooler (Pos. 6) or bypass it.
After cooling, the oil is now at the main supply line.

System pressure

The main supply line to the manometer (Pos. 7) runs from the cooler for reading system pressure. System pressure is controlled by a pressure relief valve (Pos. 8).
The pressure relief valve (Pos. 8) is set to the highest possible working pressure, normally 24 bar. Refer to specific commissioning report for exact value.

Servo cylinder

The oil runs from the main supply line to the servo cylinder (Pos. 12) for propeller pitch regulation.
This is achieved through a slide (Pos. 11), which transfers the oil to the rotating servo cylinder.
The servo cylinder is controlled by a proportional valve (Pos. 10).
The oil runs from the main supply line to the proportional valve via a pressure relieve valve (Pos. 9). This ensures that the servo cylinder cannot take in so much oil that the system pressure drops below 22 bar.
Servo cylinder pressure is read on the manometer (Pos. 7).

Main clutch

The oil runs from the main supply line to the main clutch (Pos. 20) to engage the gearbox.
Engaging and disengaging is controlled by a 2-way directional valve (Pos. 16), which ensures soft engagement of the main clutch via an accumulator (Pos. 18).
The clutch is fitted with a cooling system to provide a continuous supply of cooled oil, and hot oil is drained away (Pos. 21).

Main clutch pressure is read on a manometer (Pos. 19), and the main clutch can also be fitted with an electric feedback switch (Pos. 17).

PTO clutch

The oil runs from the main supply line to one or more PTO clutches (Pos. 14) to engage PTO-driven components, e.g. an external hydraulic pump, electric generator or fire pump.
Engaging and disengaging of the PTO is controlled by a 2-way directional valve (Pos. 15).
The clutch is fitted with a cooling system to provide a continuous supply of cooled oil, and hot oil is drained away (Pos. 13).

Cooling and lubrication system

Oil not used for operations runs from the main oil supply line through the pressure valve (Pos. 8). After the pressure valve, some of the oil is run to lubrication points (Pos. 24) in the gearbox and to the PTO outlets.
The lubrication pressure, read on a manometer (Pos. 23), is controlled by a 0.5 bar check valve.

4.2 Electric system

The gearbox is fitted with an electrical system to control and monitor the operation of the hydraulic system. The electrical system is an important integrated part of the gear box and can be delivered only with safety components, but also extended to monitor and operate the gearbox from remote.

4.2.1 Description of electrical system

Introduction

To understand the functions of the electrical system, it's components and functions is required. The components are to be connected to a gearbox control system, which must be able to handle the signals delivered.

Description is referring to Figure 4-3, which shows examples of the most common sensors/switches in use.

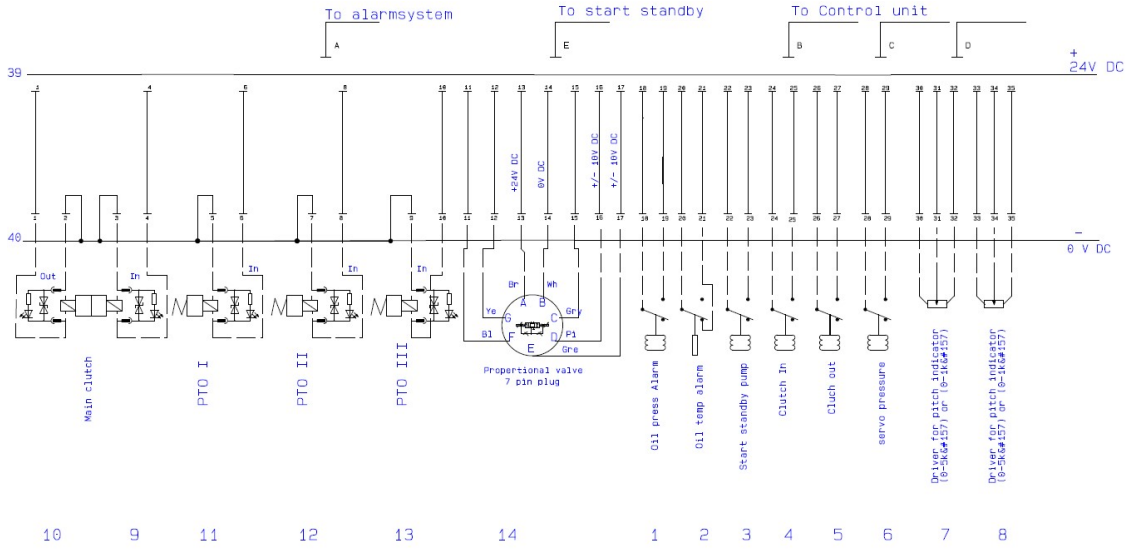


Figure 4-2: Example of electrical connection diagram.

Safety components

All Mekanord gearboxes is being delivered with a low oil pressure switch and a high oil temperature switch. Both switches if potential free relays and must be connected to the control system for immediate disengaging of the gearbox, which is considered as an *emergency shutdown*.

Monitoring of oil level

Oil in the sump of the gearbox (Pos. 25) can be monitored by an oil level switch (potential free relay), which trips if level is below minimum value. In such case, the tripping signal can be used for *shutdown* or alarming the operator via the control system. This component is mandatory if classification approval is required.

Monitoring of oil temperature

Besides the safety *shutdown* temperature switch, the oil temperature can be monitored with an analogue temperature transmitter. The transmitter will deliver 4-20mA to the control system. The signal can be used to give an *high* oil temperature alarm with a lower setpoint than the safety *shutdown* temperature switch. Temperature transmitter(s) can also be used for monitoring oil temperature in other locations, as well as for monitoring cooling water temperature or any other media. Additionally the thrust bearing temperature can be monitored by a temperature transmitter, which is mandatory if classification approval is required.

Additionally a *high high* oil temperature switch can be installed to monitor oil temperature in the oil sump. This switch is a potential free relay and must be connected to the control system for immediate disengaging of the gearbox, which is considered as an emergency shutdown. This *high high* switch is mandatory if classification approval is required.

Monitoring of oil pressure

Beside the safety *shutdown* oil pressure switch, the oil pressure can be monitored with an analogue pressure transmitter. The transmitter will deliver 4-20mA to the control system. The signal can be used to give a *high* oil pressure alarm with a lower setpoint than the safety *shutdown* pressure switch. Pressure transmitter(s) can also be used for monitoring oil pressure in other locations, as well as for monitoring cooling water pressure or any other media.

Additionally a *high high* oil pressure switch can be installed to give start signal to control system for starting the electrical standby pump. This switch is a potential free relay and must be connected to the control system for immediate startup of standby pump. This *high high* switch is mandatory if classification approval is required.

Monitoring of oil filter clogging

The oil filter differential pressure can be monitored by a differential pressure switch, which trips if the pressure loss across the filter element reaches the adjusted level. The switch is a potential free relay to be connected to control system and is intended to give alarm for *high diff.* pressure on oil filter. This *high diff.* pressure switch is mandatory if classification approval is required.

Control and monitoring of clutch position

On both hydraulic main clutch and PTO clutch(es) an electrical solenoid valve is mounted. On main clutch the valve is double acting and on PTOs the clutch is single acting with spring return. The valve is operated with a 24VDC control signal from control system. Additionally, a feedback switch can be mounted for

monitoring the clutch position. The switch is a potential free relay and must be connected to control system to give *clutch in/clutch out* indication.

Control and monitoring of servo piston position

The pitch of the propeller blades is controlled with a proportional valve. The valve is operated with solenoids, which requires 24VDC power supply and control signal of either 4-20mA or -10/0/+10V (depending on type). Please refer to technical specification for type on specific gearbox. The control signal must be delivered by control system. The servo piston position is monitored with a 0-5kOhm potentiometer, which resistance varies depending on actual position. The variable resistance is to be connected to control system for *pitch position* indication. Double potentiometer (redundancy) is mandatory if classification approval is required.

Monitoring of output shaft RPM

On the gearbox output shaft a tacho pickup sensor can be mounted for counting RPM. The pickup requires 24VDC power supply and delivers 1 signal (negative or positive depending on type) per revolution. The tacho pickup sensor must be connected to control system directly. Alternatively the tacho sensor can be mounted with a transmitter, which gives scaled 4-20mA control signal to control system for easier interface.

Important information

- Do not change any settings of hydraulic or electrical components without the written approval of ME Production. The components can be sealed after calibration and testing. Do not break seals without the prior written approval of ME Production.
- The guarantee will be void if components are adjusted without the prior written agreement of ME Production.
- Log of all settings was performed as part of the factory test and can be found in commissioning report.

4.3 Cooling system

4.3.1 Description of cooling system

The gearbox is supplied with a cooling system to maintain operation temperature. During gearbox operation, the oil temperature must not exceed 60°C.
To keep oil temperature within acceptable limits and oil cooler is installed. ME Production supplies oil cooler of tube cooler design.

The oil cooler can be installed in either freshwater cooling water circuit or directly in sea water cooling circuit. To protect the oil cooler against corrosion the cooler is fitted with anodes of special iron material. The anodes need inspection and replacement with a frequency depending on the cooling water salinity. Please see maintenance section for description of how to service the cooler.

Special feature of the tube cooler design:
The double O-ring construction makes it possible to inspect the tube side while the shell side remains pressurized. This feature also prevents intermixing of fluids in the event of damage to the O-ring.

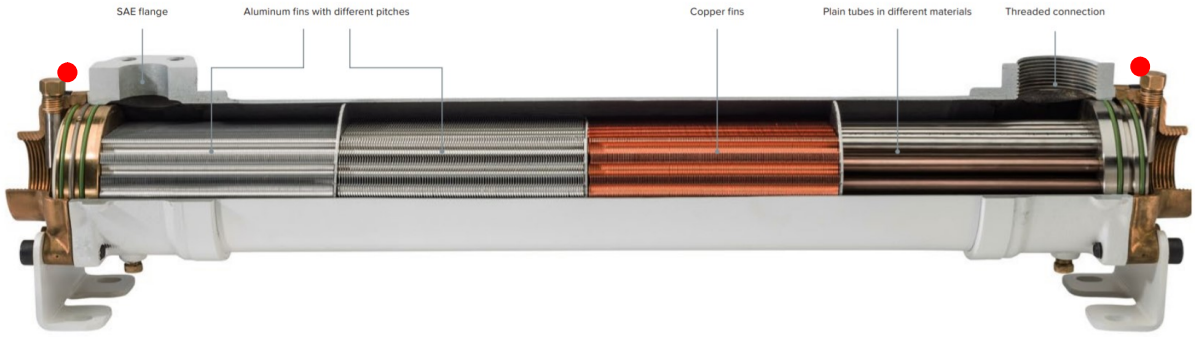


Figure 4-3 shows an oil cooler.

Important information

- To ensure effective gear oil cooling, the oil cooler must be inspected and cleaned in accordance with the maintenance schedule.
- The cooler is fitted with anodes (marked with red, fig. 5.8) to prevent corrosion inside the cooler. The anode must be checked in accordance with the maintenance schedule. See section 5.1.

Warning

- If gear oil temperature exceeds 60°C, the oil will reduce its ability to lubricate between the gearwheels. There is a risk of damage to the gearwheels.
- If the oil cooler becomes damaged and leaks, cooling capacity can be reduced. This will result in a temperature increase and possible damage to the gearbox. Damage to the cooler can include external physical damage, internal corrosion etc.
- Pipe connections to the cooler can be very hot. Danger of burns.

4.4 Gearbox operation

Following describes special precautions to be taken into considerations when operating the gearbox.

4.4.1 Operating the hydraulic main clutch

The main clutch is only allowed to operate when engine is in idle speed and when propeller pitch is in neutral/zero position.

Important information

Failure to operate main clutch as described can lead to damage to the gearbox and reduce its service life severely. Incorrect operation of clutch and consequential damage hereof will not be covered by warranty.

4.4.2 Operating the hydraulic PTO clutch

If the gearbox is fitted with one or more PTOs with built-in hydraulic clutch, operator to ensure engine idling prior PTO clutch in or out.

Important information

Failure to operate main clutch as described can lead to damage to the gearbox and reduce its service life severely. Incorrect operation of clutch and consequential damage hereof will not be covered by warranty.

4.4.3 Standby pump (if MEP supply)

If the mechanically driven main pump fails, the installed electrical standby pump will start automatically, if function is supported by control system, when the pressure reaches the preadjusted low limit. If control system cannot handle the automatic start, the standby pump must be started manually from the switch board or locally at the pump start breaker, if installed.

The failed mechanically driven pump may be left mounted on the gearbox, as counter valves will ensure no backflow of oil. In case failed mechanical pump is seized it must be removed and housing opening sealed off.

Warning

- If pump housing opening from seized mechanical pump is required to be sealed, please make sure to use appropriate material to secure proper sealing.
- Be aware of hot surfaces and possible oil spray, which can lead to personnel injury.

4.5 Emergency operation

4.5.1 Manual override of the hydraulic main clutch

When the hydraulic main clutch is engaged, an electric signal is sent to the hydraulic valve. If electric activation fails, the hydraulic valve can be activated mechanically.

The hydraulic valve is fitted with an internal detent. Activation of the clutch is performed by pressing in the centre of the coil with an appropriate tool. The detent function keeps the valve slides in the required position.

Deactivation is performed by pressing the coil at the opposite end of the valve.

Figure 4-4: active the valve manually

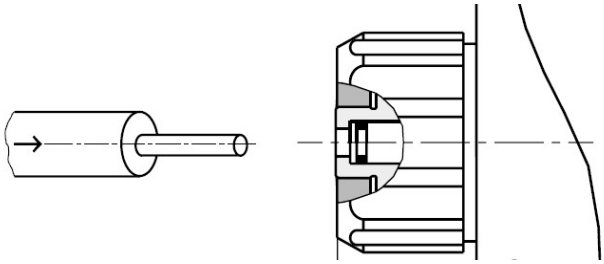


Figure 4-5: illustrates an example of how to activate the valve manually.

4.5.2 Manual override of the PTO clutch

The hydraulic PTO can be manually overridden in an emergency if electrical activation fails. Manual override operation is performed by operating the hydraulic valve mechanically.

Activation of the clutch is performed by pressing in the centre of the coil with an appropriate tool.

Refer to Figure 4-4 and Figure 4-5.

4.5.3 Towing of ship

In special emergency where emergency operation of the gearbox is not possible a towing of the ship might be the only solution.

In such case, please follow below recommendations:

- Start standby pump to ensure lubrication of the gear's rotating components.

If impossible to use standby pump:

- Lock the propeller shaft against rotation.

Or finally

- Fill the gearbox with oil up to a level equal to the hydraulic unit interface. This means the gearbox will be filled to the top with oil.

5 Maintenance

5.1 Maintenance schedule for the gearbox

Working hours interval	Daily	Weekly	Monthly	Half yearly	Yearly		
							Log book
	■						Running hours, gearbox
	■						Oil temperature measured at gearbox
		■					ΔT of oil. Measured at **Oil Inlet** and **Outlet** at the oil cooler
		■					ΔT of coolant. Measured at **Coolant Inlet** and **Outlet** at the oil cooler
	■						Oil pressure (clutch, lubrication)
	■						Oil level
	■						Observation of abnormal conditions: Temperature, pressure, vibration, noise etc.
							Oil
200h/1000h							Change oil
1000h							Analyse oil sample
	■						Check oil level
							Filtration
200h/1000h							Change oil filter
	■						Check filters for oil leaks
							Oil cooler
			■				Inspect oil cooler
			■				Check coolant flow
			■				Check anodic protection
					■		Clean oil cooler
							Flexible coupling
			■				Visual inspection
							Shaft brake (optional)
			■				Friction plate wear
	■						Oil leaks
							Storage
			■				Check VpCI packaging. Packaging must be airtight.
							Gearbox in general
	■						Check gearbox for oil leaks
							Pressure switches and transmitters
				■			Functionality test and range setting

5.2 Frequent routines

Following section will describe the maintenance, which is required to secure long service life and minimum operational issues.

5.2.1 Checking oil level

Check the oil level daily.

Run engine at idle with propeller disengaged when checking oil level. The oil level must be between the minimum and maximum marks on the dipstick. If found to be too low, refill the gearbox with accepted oil immediately prior further operation.

5.2.2 Controlling pressure in the hydraulic system

The hydraulic pressure of the system must be checked daily during normal operation.

A manifold on the hydraulic unit is fitted with manometers and Minimess test points for monitoring and controlling hydraulic pressure, see Figure 5-1.

Figure 5-1: illustrates gauges.

Important information

- The manometers are only indicative. Calibrated measurement equipment must be used for correct hydraulic pressure.

The actual pressure needed for changing propeller pitch can be read on manometer during operation.

5.2.3 Changing oil filter

Replace the filter element incl. o-ring for the first time after 200 hours operation and every 1000 hours thereafter. Oil filters must additionally be renewed with every oil change.

The filter may be fitted with a Δp-switch (optional), which will activate an alarm in the control system if filter pressure drop is too high. If pressure drop triggers an alarm, the filter must be changed immediately.

The filter has a bypass valve that bypasses the oil when the difference pressure becomes too high. This is to prevent the filter from collapsing, which may cause damage to the gearbox.

Warning

- If the oil bypasses the filter there is a risk of damage to the gearbox because of lack of oil filtration.
- Gear oil can be very hot. Danger of burns.

5.2.4 Oil change

Change gear oil first time after 200 hours and thereafter every 1000 hours or once annually, whichever occurs first. Exemption: The oil change interval can be increased to once annually if an approved particle measurement and analysis of the oil is performed for every 1000 hours operation.

Oil which has been particle-measured must meet the following purity criteria:

- ISO 4406 1999 Class 18/16/13
- NAS 1638 Class 7
- SAE AS 4059 Class 8

The oil analysed must meet the following values:

Iron Fe, Copper Cu, Lead Pb	Comments	Action
0-60 ppm	Normal value	Non
60-130 ppm	Slightly higher value, no negative influence on the gearbox	Reduce interval between particle measurement to 500h
130-xxx ppm	High wear value	Inspection

- Higher copper and lead values can occur in the commissioning phase, first 1000h. After 1000h the values will reduce to normal values.
- Oxidation value Ox 10
- Normally the values will be stabile. If a sudden higher value occurs this demand attention.

Always change oil with engine stopped:

1. Remove the filter bowl. Use a wrench if necessary.
2. Change the filter element and the o-ring.
3. Replace the filter bowl. Do not use any tools to tighten filter bowl. Only tighten by hand.
4. Check for oil leaks from the filter bowl after pressurising the oil system.

Warning

- Always ensure that the oil fulfils specifications. See section 3.10 for oil type. Wrong oil can cause damage to the gearbox. The warranty will be void if the wrong oil is used.
- Draining and filling of oil must be performed under calm conditions. Oil spillage can cause pollution and slippery decks. This can result in injury to personnel.
- Gear oil can be very hot. Danger of burns.

After an oil change and top-up of the oil volume in accordance with the arrow marker on the dipstick, start and run the engine for 5 minutes to circulate the oil inside the gear. Operate propeller pitch to bleed any air out of the system.
Check oil level again after 5 minutes circulation using the dipstick. Run the engine at idle with the hydraulic clutch disengaged. The oil level must be between the minimum and maximum marks on the dipstick.

5.2.5 Verification of pressure switches in the oil system

All mounted hydraulic pressure switches must be checked of the system must be checked during normal operation.

The pressure switches can be tested with a pressure calibration device. Testing can be done without removing the switch if the switch is mounted on an appropriate test block. If not connect switch to a test block.

1. Close shut-off valve.
2. Unscrew the test pressure connection plug.
3. Connect the pressure calibrator.
4. Check and adjust the switch point. If the deviation is very high, we recommend replacing the switch with a new one.
5. If the contact system of the switch does not break at any pressure, check:
   Wiring and connections
   Power supply
   Switch damages
6. After the test remove the calibrator, remount plug and open shut-off valve.

Warning

- Failure to observe the above can result in damage to the bearings and hydraulic clutches. The function of these components depends on a constant supply of lubricating oil. If the gearbox rotates without lubrication, damage will occur very quickly.
  Damage arising as a result of the ship being towed without the supply of lubricating oil to the gearbox, or without locking the propeller will not be covered by the warranty.