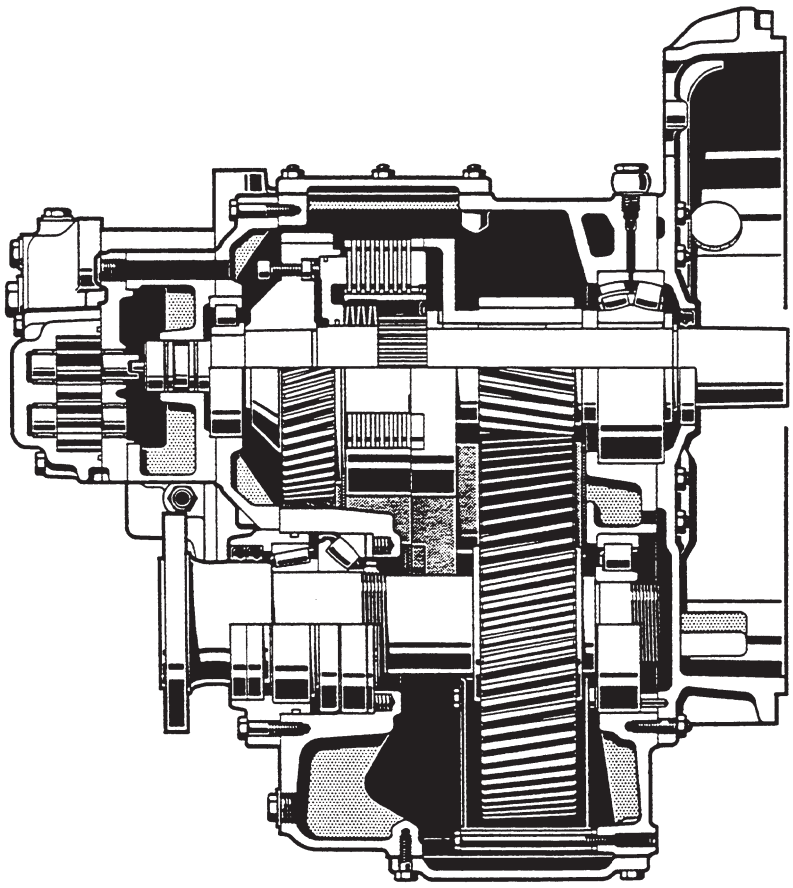
ZF Marine gears
ZF W650 Family

Description
installation
operation
and maintenance

The description, operation and maintenance sections are applicable to the standard gearbox version.
Variations are possible according to special customer requirements and operating conditions. If the data in the description, installation, operation and maintenance sections are different from those in the technical or commercial specification, then the data in the specifications apply.

The “ZF list of lubricants TE-ML 04 for ZF marine gears” is valid.



Important Note:

For gearboxes, guarantee conditions agreed with ZF apply. However, ZF can only take over a guarantee if

- the gearbox has benn installed, monitored, operated and maintained in accordance with the specifications contained in this
- the specified limiting values for the ratio between input power and input speed and for input speed — dependent on the gearbox application range in question — are adhered to on the gearbox.

It must also be noted that:

The gearbox manufacturer, being a supplier of one individual component of the overall drive system of the ship, cannot be responsible for the operation of the overall system and also has no influence on vibrational problems arising from the drive system of the ship.

Consequently, ZF can accept no liability for gearbox noise caused by vibrations or for damage to the gearbox, the flexible coupling or to other parts of the drive unit caused by this kind of vibration.

We therefore recommend that you perform a vibrational calculation in wich the gearbox parts not subject to load are also included.

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Monitoring values BW 160 Family

	Monitoring function	Filter blockage	Clutch oil pressure	Oil temperature
	Measuring point	5	2	11, 12, 41
Version with nominal pressure 16 bar	Nominal reading	max. 24 bar	15 to 16.5 bar [4] 3.5 to 6.0 bar [5]	normal: 30 to 80 °C max. 90 °C (normal operation) for trailing operation: max. 105 °C with secondary oil pump max. 75 °C without secondary oil pump (see section III. 2)
	Warning	24 bar ▲	13 bar ▼ [1] [2]	95 °C ▲ [1]
	Minimum monitoring facility	Pressure sensing switch	Pressure gauge 0 to 25 bar	Thermometer 0 to 120 °C
	Additional monitoring	Pressure gauge 0 to 25 bar	Pressure sensing switch [3] [6] or pressure gauge 0 to 25 bar	Temperature sensing switch [1] or thermometer 0 to 120 °C

	Monitoring function	Filter blockage	Clutch oil pressure	Oil temperature
	Measuring point	5	2	11, 12, 41
Version with nominal pressure 17 bar	Nominal reading	max. 24 bar	16.5 to 18 bar [4] 3.5 to 6.0 bar [5]	normal: 30 to 80 °C max. 90 °C (normal operation) for trailing operation: max. 105 °C with secondary oil pump max. 75 °C without secondary oil pump (see section III. 2)
	Warning	24 bar ▲	14 bar ▼ [1) 2)]	95 °C ▲ [1)]
	Minimum monitoring facility	Pressure sensing switch	Pressure gauge 0 to 25 bar	Thermometer 0 to 120 °C
	Additional monitoring	Pressure gauge 0 to 25 bar	Pressure sensing switch [3) 6)] or pressure gauge 0 to 25 bar	Temperature sensing switch [1)] or thermometer 0 to 120 °C

Details see section II. 8

1) For optical and acoustic warning

2) With 5 to 10 sec. time delay

3) Use branch pipe

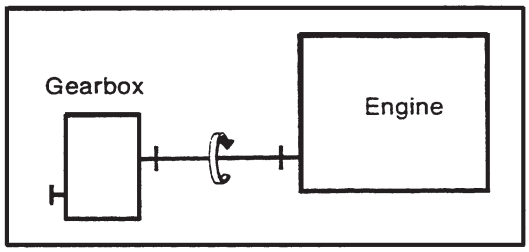
4) At an oil temperature of 60 to 80 °C, "engine or counter–enginewise" position

5) In neutral

6) Warning system must be put out of action when in neutral

Summary of technical data (general)

Direction of rotation of gearbox input shaft of standard version



Identification mark for the oil pump	**Design engine speed** (continuous rating)	**Engine idling speed**
A	approx. 1 600 to 2 600	≧ 400
B	approx. 1 000 to 1 600	≧ 250

Additional forces on gearbox input	in radial direction	max. 1 200 N
	in axial direction	max. 400 N

Alignment of propeller shaft

max. angular displacement "x" [mm]	max. shaft misalignment "y" [mm]	smallest bearing distance "L" [mm]
0.05	0.10	500 for d < 60 1 000 for d 60 to 90 2 000 for d > 90

Cooler data

- **Max. water pressure on cooling water inlet** 3 bar
- **Max. cooling water inlet temperature** 40 °C
- **Max. ambient temperature of gearbox** 60 °C

Oil grade

according to MIL-L-2104 C or MIL-L-46152;
API-CC, CD, SC, SD, SE specifications.

Viskosity grades SAE 30 or SAE 40 for oil sump temperatures <80 °C
Viskosity grade SAE 40 for oil sump temperatures >80 °C

Multi-grade oils not permissible.

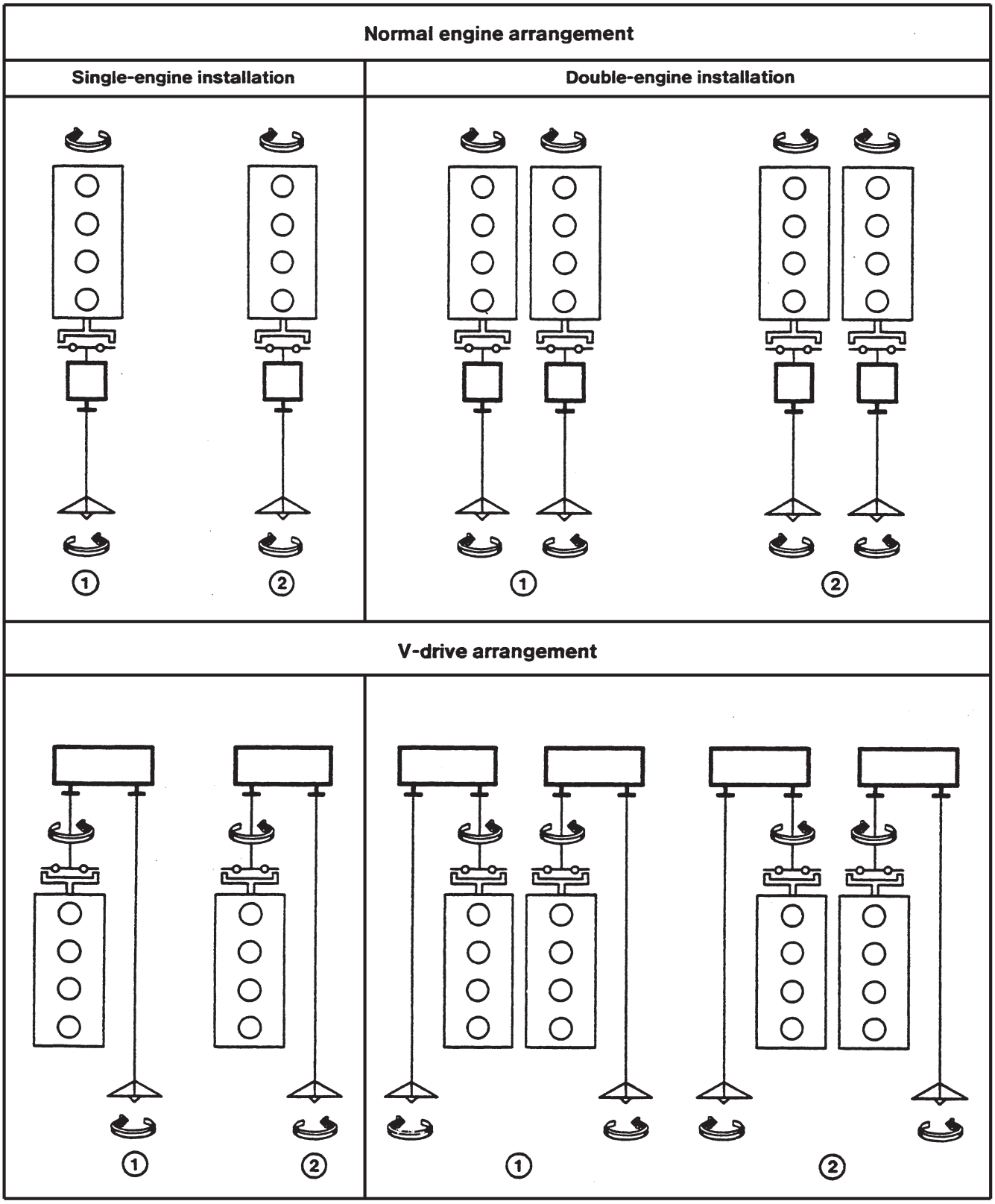
The relevant ZF lubricants list TE-ML 04 for ZF marine gears is applicable.This list can be obtained from any ZF service station.

Oil capacity approx. 28 dm^3

Gearbox ratio see gearbox type plate

Gearbox mass according to scope of supply — see gearbox type plate

Direction of propeller rotation for forward drive



① **Preferable**

② **Admissible**

I Description of basic gearbox

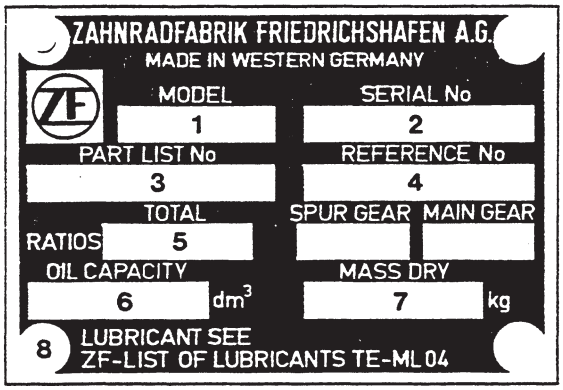
1 Power, speed, rotational direction, ratio, type plate

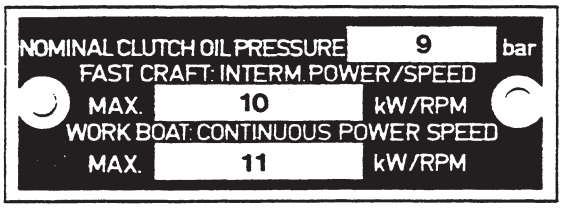
The ZF marine gears are designed and manufactured according to the regulations of the various Classification Societies. The input power approved by the Classification Societies depends on the input speed, the class of the craft and the differing design regulations currently in force. In most cases the maximum torques approved by ZF are also fully accepted by the Classification Societies.

Upon request, either a full test or a factory acceptance test is carried out by the Classification Society specified by the customer.

Normally the input shaft rotates clockwise (looking at the gearbox input flange). For anti-clockwise input shaft rotation a special version is required. The correct input shaft rotation direction can be noted from the rotation direction sign situated on the top of the gearbox housing.

The respective ratio is stamped on the gearbox type plate which is mounted on top of the gearbox housing.





1 *Model*
2 *Serial No.*
3 *Part list No.*
4 *Reference No.*
5 *Gearbox ratios and code letter for oil pump*
6 *Oil capacity*
7 *Mass (dry)*
8 *Lubricant see ZF-List of lubricants TE-ML 04*
9 *nominal clutch oil pressure*
10 *max. power / speed ratio on intermittent operation for fast craft*
11 *max. power / speed ratio on continuous operation for work boats*

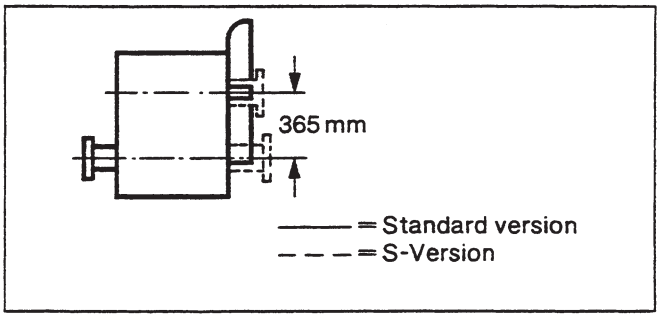
For spare parts orders and inquiries the items shown in the spaces 1, 2, 3, and 5 are necessary.

Code letter 5 after gearbox ratio in space 5 means:

Letter	Design engine speed at continous rating	Engine idling speed
A	approx. 1 600 to 2 600	≧ 400
B	approx. 1 000 to 1 600	≧ 250

The oil pump A is the standard version.

2 General design



Gearboxes of series ZF W650 are 3-shaft reversing and reduction units with offset shafts and clutches on the input shaft and the reversing shaft.
The general design is the same for all gearbox

The principal components exposed to wear are accessible through a cover on the gearbox casing even when the gearbox is installed.

Size 1 bell-housing (per SAE J 617) is part of basic gearbox version. Size 0 can be supplied in scope of special supply.

Covers are fitted to seal input-side openings in housing on special version (without bell-housing).
On the basic gearbox version, these covers are integrated in the bell-housing

In order to ensure an extended working life an quiet running, all drive gears are rated for a high margin of strength, casehardened, ground and given a special finishing treatment.
The shafts run in antifriction bearings. Propeller shaft thrust bearings are incorporated into the gearbox. The reversing clutches on the input and reversing shafts are of multi-disc type, with steel/ sintered plates pressed together by oil pressure.

The high pump discharge rate ensures that the clutches respond rapidly when actuated. During the shift process the clutches' contact pressure is modulated to ensure a smooth shift.

At the same time the clutch in engagement receives an increased flow of oil so that the heat generated during the shift process is rapidly dispersed and the clutches' load-bearing capacity enhanced.

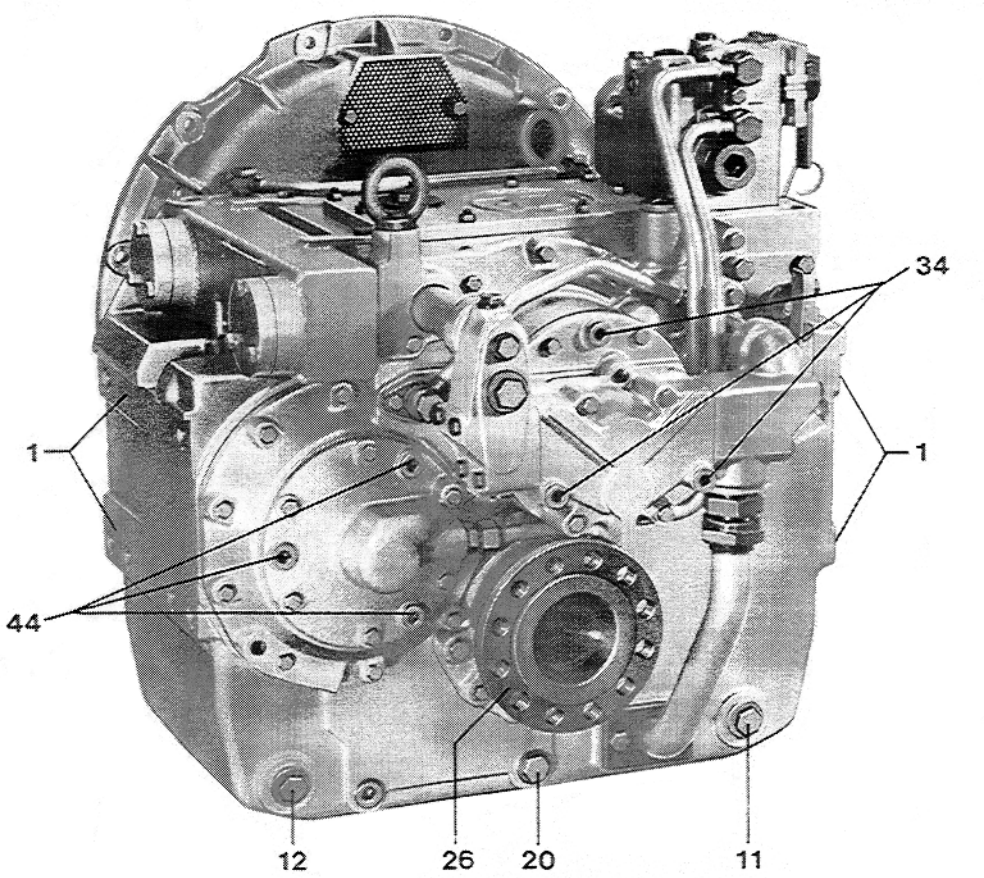
In the event of a fault in the actuating hydraulic circuit the two multi-disc clutches can be pressed together mechanically by means of 3 bolts accessible externally (but only when the gearbox is at a standstill). This emergency control method permits either enginewise or counter-enginewise rotation of the output shaft to be used.

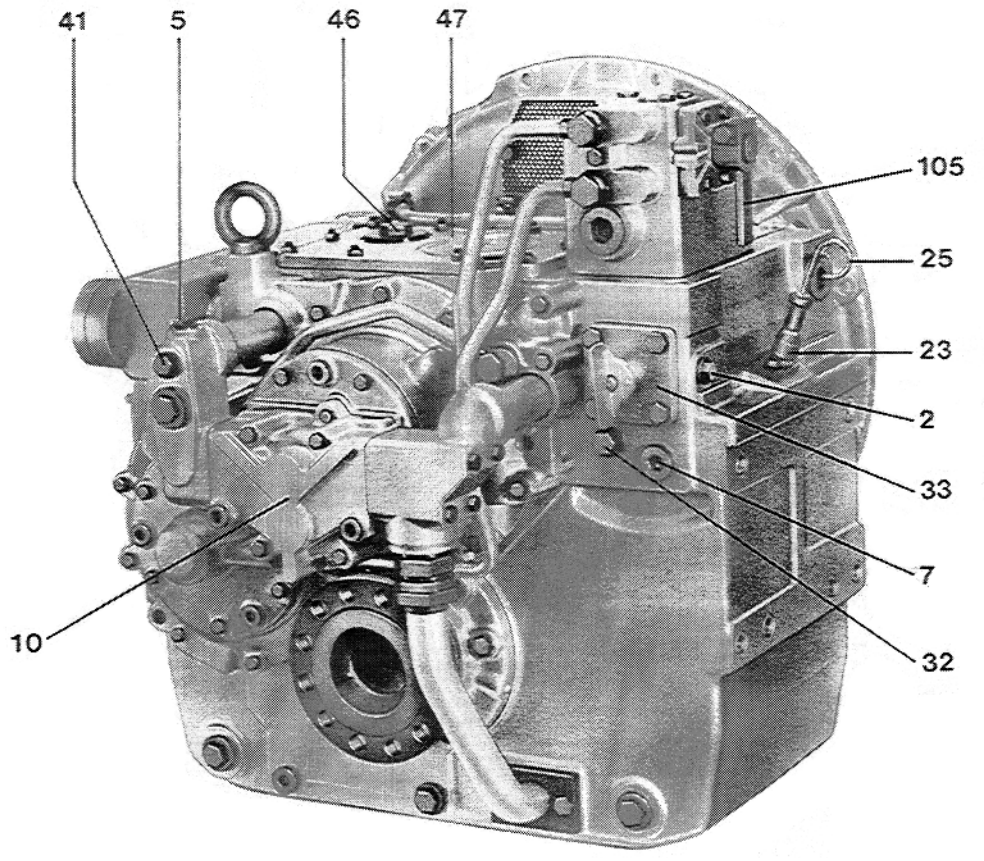
To operate the gear shift an easily interchangeable control unit with all the necessary valves, spool valves and other control devices for the actuating and lubricating oil circuits is mounted on the gearbox casing. The unit is operated mechanically with a lever.
Pneumatic or electrical operation can also be specified.

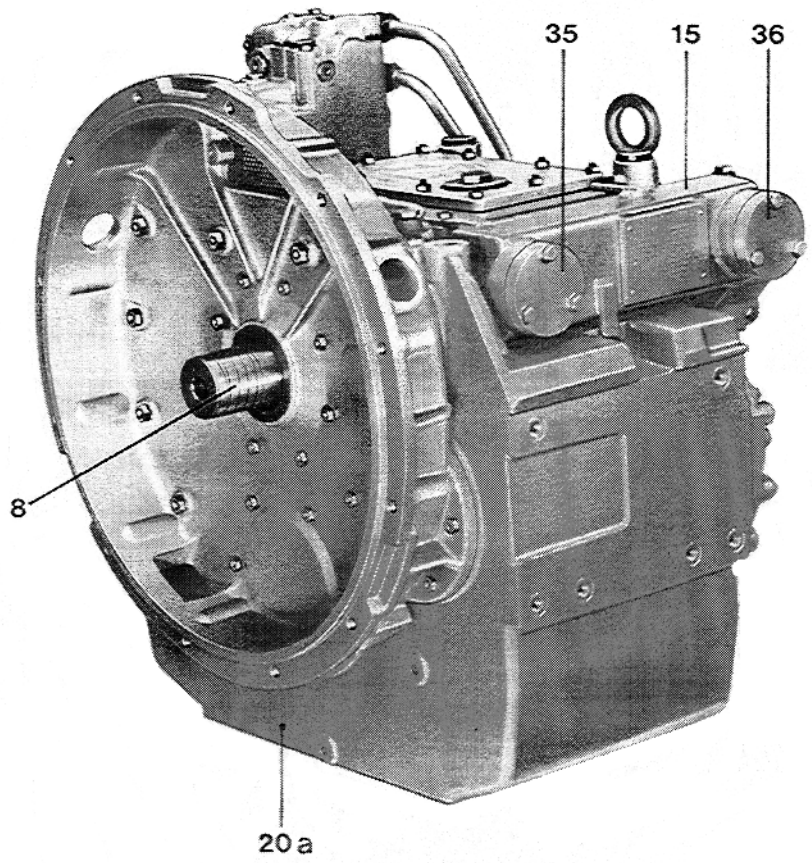
Differences in the "BU" series

The "BU" series gears are reduction gears with one clutch, which can be fitted either on the input shaft or the reversing shaft. The output shaft rotates in either the opposite or the same direction as the input shaft depending on the version.
Otherwise the design and external dimensions are identical to those of the"ZF W"range.

ZF Marine gears BW 160, BU 160, BW 165, BU 165 (basic gearbox)







Key to drawings

1 *Mounting faces for gearbox*

2 *Pressure measuring point for clutch oil*

5 *Pressure measuring point before oil cooler and filter*

7 *Oil sludge drain plug*

8 *Input*

10 *Engine driven oil pump*

11, 12, 41 *Oil temperature measuring points*

15 *Oil cooler*

20 *Oil drain plug*

20 a *Position of oil drain plug on V–drive version*

23 *Gearbox breather*

25 *Oil dipstick*

26 *Output*

32 *Oil chamber drain plug*

33 *Oil filter*

34 *Emergency control counter-enginewise rotation*

35 *Cooling water inlet*

36 *Cooling water outlet*

44 *Emergency control enginewise rotation*

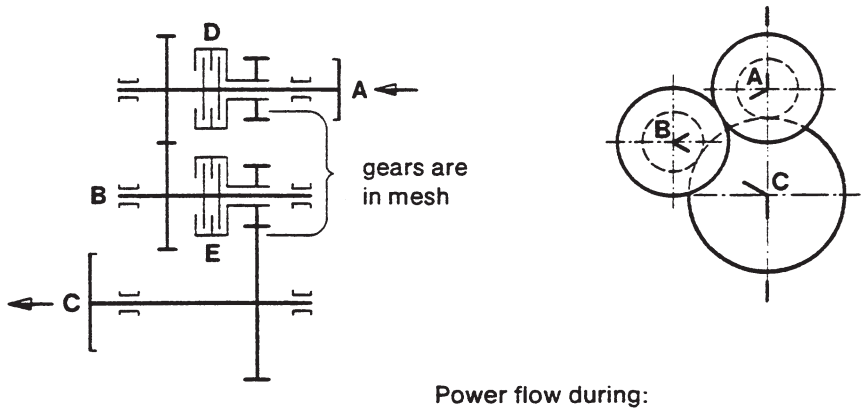
46 *Oil filling*

47 *Inspection cover gearbox housing*

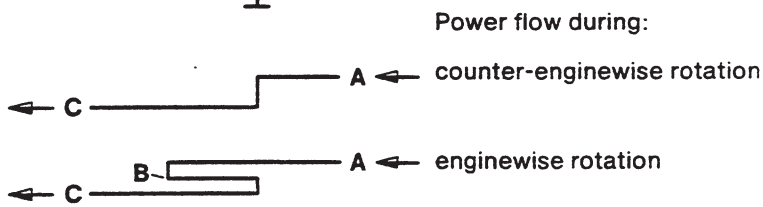
105 *Control lever for mechanical auxiliary actuation*

3 Functional description

Gearbox and power flow diagram



A - Input shaft
B - Reversing shaft
C - Output shaft
D - Clutch for counter-enginewise rotation
E - Clutch for enginewise rotation



The power for "enginewise rotation" (output shaft rotation in same direction as input shaft) and for "counter-enginewise rotation" (output shaft rotating in opposite direction to input shaft) is transmitted as shown in the above diagram.

The full torque can be transmitted in both directions of rotation. Even the gearbox ratio is the same for both rotational directions of the output shaft. Identical gearboxes can therefore be used for multi-engine installations. This requires fewer spare parts and permits the use of standardized replacement assemblies.

The oil pump is driven by the gearbox input shaft. Two pump versions are availlable to suit different engine speeds

Gearbox oil is cooled by an oil cooler mounted on the gearbox and manufactured from salt water resistant material. After cooling, the oil passes through a slot-type filter to the control unit and then to the clutches and the gearbox lubrication points.

Connecting unions are provided as standard equipment for monitoring gearbox temperature, oil pressure ahead of the filter, and clutch oil pressure. For their locations and designations, see the gearbox monitoring diagram on page 19.

4 Oil supply and gearbox cooling

The gearbox casings are designed as oil reservoirs. One gear pump is installed to supply oil for gearbox lubrication, cooling and engagement of the multi-disc clutches.

This pump supplies oil to the pressure oil circuit at a rate dependent on the speed of the gearbox input shaft. In order to ensure ample oil for gearbox lubrication and cooling even at a low driving speed, a high-output pump is used.

5 Control unit and gearbox actuation

The control system is arranged as a complete unit on the gearbox housing. It comprises:

- the control valve for charging and draining the clutch packs
- the control valve for the clutch pressure level
- the time switch for modulating the clutch pressure.

The oil wich flows out of the control unit is used to lubricate and cool the clutch discs, meshing gears and bearings.
Different control units are used according to gearbox actuation.

When the gearbox is actuated *mechanically* the control valve (rotary valve) is moved by means of the shift lever, laterally mounted on the control unit, via a push-pull cable or a linkage. A dial shows the particular shift position engaged. The manual actuation belongs to the basic version of the gearbox.

When the gearbox is actuated *pneumatically* the same control unit as for mechanical actuation is used. The control valve is moved into the shift positions, i. e. enginewise or counter-enginewise rotation, by means of a 3-way cylinder actuating on the shift lever, and reset to neutral by spring pressure. The pneumatic gearbox actuation is a part of the scope of special supplies.

When the gearbox is actuated *electrically* the control valve acts as a spool valve. It is moved axially into the shift positions, i. e. enginewise or counter-enginewise rotation, by means of oil pressure. Resetting to the neutral position is effected by spring load or oil pressure according to version (I or II. see section II. 7.3). The necessary oil flow is taken from the control unit. The oil flow itself is controlled by solenoid valves. The electrical gearbox actuation is a part of the scope of special supplies.

6 Test run and storage

Before the ZF marine gears are delivered to our customers, they are tested under load on the test bench and during this test every function, oil pressure, temperature and noise level is checked thoroughly and recorded. After the test run the interior of the gearbox is slushed with oil as a preservation measure. The gearbox can now be stored in a dry place for up to 12 months without taking any further special measures.

Any necessary preservation measures on the exterior of the gearbox depend on storage conditions and should be undertaken by the customer. Preservation measures for long storage periods should be specified when ordering the equipment.

II Gearbox installation

When planing the power pack care must be taken that sufficient free space is available for replacing the oil cooler and filter and for checking the dipstick. (The dimensions for these procedures are given in the gearbox installation drawings.)
The oil drain plug should also be easily accessible. If there is not enough space available to place a pan under the oil drain opening for collecting the oil during oil changes, then it is advisable to fit a suction pipe positively to the gearbox instead of the oil drain plug to carry out oil changes by this way.

Important !

The following screw connections for which the customer is responsible must be rated according to the operating loads supplied:

- suspension brackets – gearbox (as far as not ZF scope of supplies)
- suspension brackets – foundation
- flywheel housing – gearbox bell–housing
- flexible coupling – engine/ gearbox
- gearbox – propeller shaft

The necessary safety equipment for rotating components must be available, e. g.:

- protective covers for output flange, flexible coupling or engine flywheel drive shaft.
- protective covers and guard equipment for artic shaft.

1 Permissible installation position

The installation documents applicable to the gearbox supply contract shall apply (see "Direction of propeller rotation", page 7).

2 Gearbox attachments for transportation

The lifting gear used for lifting the gearbox for transportation should only be attached to the lugs mounted on the top of the gearbox housing.

Under no circumstances may the lifting gear be attached in other places, particularly not to the input shaft, the output shaft, the covers, the oil pumps or the pipes.

3 Gearbox mountings on foundation

The sides of the gearbox housing are provided with machined pads and bolt holes. The surfaces of the mounting brackets which face the gearbox must be finished with surface machining.

If required, dowels may be used in those points indicated in the installation drawing.

The gearboxes can be mounted in the foundation separately, or can be mounted together with the engine (on versions where the units are flanged) either rigidly or elastically.

In the case of a flexibly mounted gearbox the natural frequency of the resilient supports chosen must also be calculated. This may, on no account, coincide with the exciting frequency of the engine unit. If the propeller thrust is taken up by the gearbox (propeller thrust bearings for ahead and astern thrust are incorporated in the gearbox) the supports must also be suitable for taking up the propeller thrust.

To align the gearbox on the foundation (see connection to propeller shaft) very strong supports must be used. Individual supports — only around the individual foundation bolts — are not permissible. The mounting brackets supplied by ZF are provided with aligning screws. These screws must be removed again after the support have been placed in position.
We recommend the use of fitted bolts to secure the mounting brackets to the foundation. If through bolts are used, solid stops should be fitted with, at least in the direction "ahead propeller thrust"
The size of the mounting bolts (No., diameter, grade) depends on the operating loads, and is to be specified by the shipyard.

4 Connection to engine

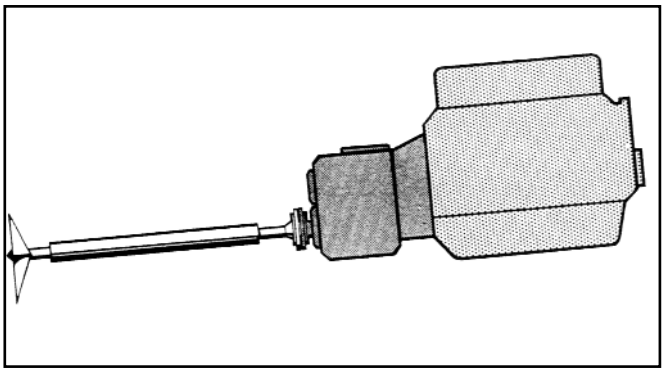
If a rigid connection between engine and gearbox is not possible due to the vibration calculation, the engine torque must be transmitted to the gearbox by means of a flexible coupling. This is to prevent any detrimental vibration resonances within the operating speed range by controlling the natural frequency of the engine, gearbox and propeller. If, in special cases, a critical speed within the operating speed range is inevitable, a limiting range must be specified for certain speeds. This is dependent on the value of the calculated vibration amplitude.

The flexible coupling to be used is generally selected by the engine manufacturer with the aid of a torsional vibration calculation. The gearbox data necessary for this calculation can be taken from our "Data for torsional vibration calculation" sheet.

If a flexible coupling is supplied by ZF according to the selection of the engine manufacturer or as stipulated by the shipyard, ZF can in no way be held responsible for the suitability or durability of the flexible coupling.

The assembly and disassembly of the clutch hub or the input flange i. e. the part of the flexible coupling on the input side facing the gearbox side has to be carried out according to the workshop manual of this gearbox range.

4.1 "Normal" engine arrangement



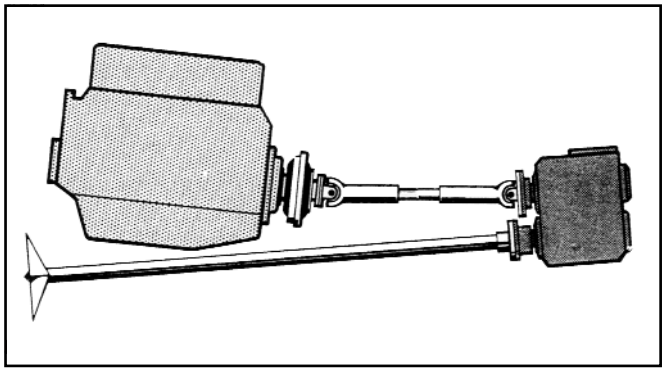
Normally the gearbox is flanged to the engine. In this case, the two units are properly centered. In addition, the torsionally flexible connection is not required to absorb any additional forces created by shaft misalignment.

The engine/ gearbox assembly can be mounted either rigidly or elastically in the foundation. If it is mounted elastically, care must be taken that the conditions laid down in section 5 are fully complied with.

If the gearbox is installed separately, the foundation mounting will be either rigid or elastic. Normally the engine is mounted elastically. The torsionally flexible input connection must also be capable of absorbing misalignments of the engine axis to the gearbox axis.

The elasticity of the engine mounting, as well as the aligning accuracy between the engine and the gearbox must, related to the gearbox, be selected so that the axial and radial forces bearing on the gearbox due to the retro-active forces of the flexible coupling do not exceed the permissible limit (see page 6).

4.2 V-drive arrangement



Gearboxes with both the input and output flanges at the same end of the gearbox are used for the V-drive engine arrangement (..160 S, ..165 S, ..161 S).

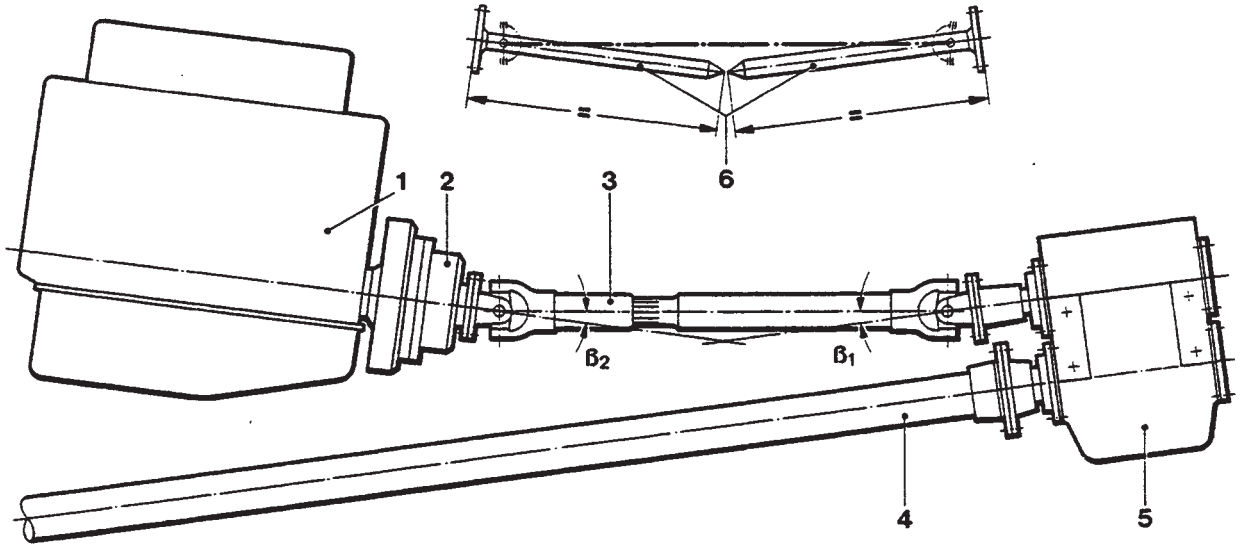
The same conditions as in section 4.1 apply to the connection between the engine and the gearbox, but an additional, variable-lenght drive shaft is used between the torsionally flexible connection and the gearbox input flange. The joints of the drive shaft create radial forces and flexural torque. In addition, the changes in the distance between the engine and gearbox cause such axial forces to occur, as can be transmitted by the joints in the additional drive shaft. The total value of all these forces and bending moments depends on the torque transmitted, the length of the drive shaft and the size of the joint angle.

These forces and bending moments are absorbed by the foundation at the gearbox end by the gearbox input shaft, gearbox housing and mounting bracket, and at the engine end by the torsionally flexible connection, crankshaft and engine housing. For this reason, the torsionally flexible connection must be fitted with additional suspension elements between the primary and secondary sides. If the torsionally flexible connection or the engine crankshaft are not capable of absorbing the forces and bending moments created by the drive shaft, an additional bearing must be installed between the drive shaft and the torsionally flexible connection. This bearing can be supported by a flange on the engine, or else an intermediate shaft can be installed and mounted in the foundation. This latter solution can also be applied in cases where an elastic engine mounting is not capable of absorbing the additional forces which occur. The forces and bending moments created by the drive shaft occur periodically at twice the engine speed of rotation. The mounting brackets for the engine, or for the intermediate shaft and gearbox, must be of adequate dimensions to prevent and impermissible distorsions, which would cause vibration and noise. If necessary, the foundation must be strengthened.

The size of the drive shaft is dependent on engine output, the size of the joint angle and the desired life of the drive shaft. The drive shaft-manufacturer will normally make recommendations in accordance with the actual operating conditions to be encountered. In order that the drive shaft can operate at the optimum kinematics, the joint angles must be of the same size at both ends and the joint forks in the same plan. Efforts should be made to ensure that the joint angles are as small as possible (max. approx. 7° to 8°) and that the middle section of the drive shaft has as small a dynamic rotating mass as possible. The technical information supplied by the drive-shaft manufacturer will give details.

To check the joint angles when aligning the engine, two alignment shafts of equal length can be installed in place of the drive shaft. The engine will be properly alignet (and the joint angles of equal size) when the ends of the two alignments shafts meet - see installation diagram.

V-drive arrangement installation diagram



1 *Power unit*

2 *Self-centering torsional flexible connection. Specified according to engine output and torsional vibration calculation*

3 *Variable-lenght drive shaft*
Selected in accordance with manufacturer's recommendations. Comply with installation instructions ($\beta_1 = \beta_2$, *joint forks mounted in the same plane)*

4 *Propeller shaft*

5 *Marine gearbox with input and output at the same end*

6 *Installation to help in the correct alignment of the engine and gearbox, i.e. to achieve equal joint angles* β_1 *and* β_2. *Install two alignment shafts in place of the drive shaft. The shafts must be of equal length. Align the two units so that the ends of the shafts meet. Finally remove the alignment shafts and install the drive shaft.*

5 Connection to propeller shaft

The rating of the propeller shaft mounting is dependent on the operating loads and must be specified by the shipyard.
If body-fit bolts are used, the bores of the propeller-shaft flange together with those of the gearbox-output flange (material strength 750 bis 900 N/ mm²) may be opened out by drilling and reaming.

The output flange of the gearbox is so designed that the maximum permissible torque for the gearbox can be transmitted frictionally. For this purpose, *all* bolt holes and bolts M 16 of material quality 8.8 (minimum tensile strength 800 N/ mm²) must be used.

5.1 Aligning the gearbox

If the gearbox mounting is extremely flexible the connection between the gearbox output flange and the propeller shaft must normally be capable of absorbing relative movements (e. g. joint coupling or flexible coupling). This does not apply if the propeller shaft is also extremely flexible. If the propeller shaft is connected rigidly to the output flange of the gearbox, the gearbox must be aligned with the propeller shaft. To do this, the vessel must be fully fitted-out and afloat. If necessary, the alignment procedure must be repeated before the vessel goes into service.

Shafts with only one propeller–shaft bearing
(Fig A)

It must be possible to move the propeller shaft axially and radially so that the propeller–shaft flange can be fitted in the centering of the gearbox output flange. The gearbox must be so aligned — see also section 3 — that the permissible angle error "x", referred to measuring radius "r", does not exeed the value stated in the table (value "y" is disregarded).

Shafts with two or more propeller-shaft bearings
(Fig. B)

It must be possible to move the propeller shaft axially so that the propeller-shaft flange can be fitted in the centering of the gearbox output flange. The gearbox must be so aligned — see also section 3 — that the offset "y" and the angle error "x" (referred to measuring radius "r") do not exceed the values stated in the table. Both errors may be present at the same time. If the propeller shaft has a very small diameter and the distance "L" is very great, it may not be possible to measure the value "y". If the propeller shaft can be installed in the centering of the gearbox output flange with a maximum radial force not exceeding 500 N, the "y" value can be disregarded. If this is the case, the alignment instructions for shafts with only one propeller-shaft bearing apply.

Note:
The values given for "x" and"y" only apply when distance "L", between the propeller–shaft flange and the final shaft bearing, is great enough in relation to shaft diameter "d".

x [mm]	max. 0.05
y [mm]	max. 0.1
L [mm]	min. 500 for d < 60 mm min. 1 000 for d 60 to 90 mm min. 2 000 for d > 90 mm

Fig. A

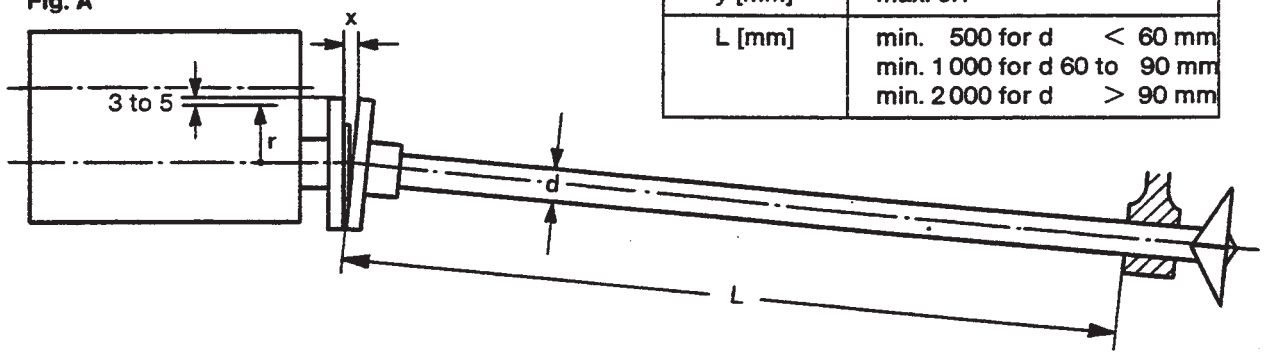
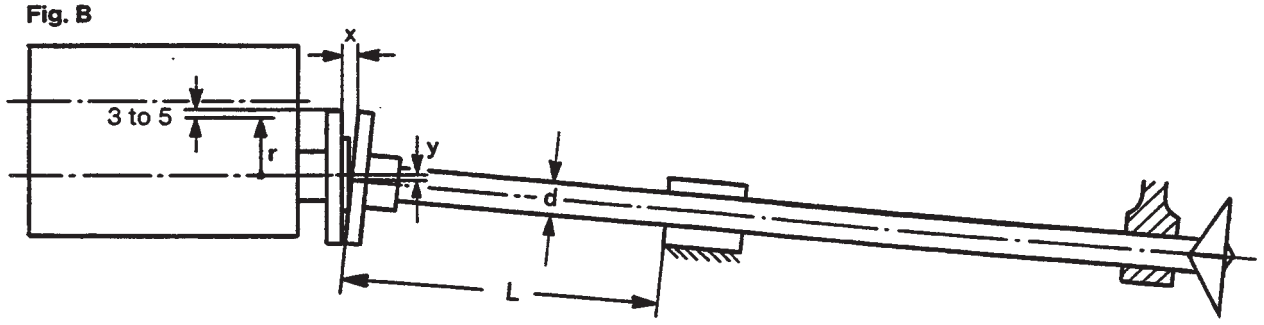


Fig. B



6 Connections for gearbox cooling and monitoring

6.1 Cooling water connection
(Data applies only to coolers mounted as standard by ZF)

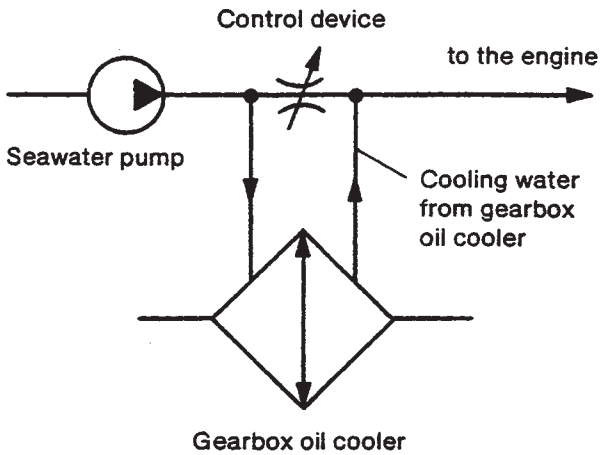
The volume of heat generated in the gearbox is removed partly by radiating from the surface of the housing and partly through the oil cooler. The oil cooler included in the basic version of the gearbox is mounted on the housing. All the necessary oil lines are securely attached and ready for operation

The cooling water inlet and outlet parts are located on the oil cooler sides and blanked off for shipment. The blanking-off flanges can be used as welding-on flanges when installing the cooling water line. The positions of the cooling water inlet and outlet connections are shown in the gearbox installation drawings.

The direction of water flow is to be maintained i.e. water inlet and water outlet may not be interchanged.

For permissible water flow rate and pressure loss between cooling water inlet and outlet see "Summary of technical data" The specified water pressure at the cooling water inlet must not be exceeded. The cooler is designed to ensure adequate heat dissipation at a gearbox ambient temperature of 60 °C and a water inlet temperature of 40°C – even at full gearbox load and maximum speed.

Arrangement of the gearbox oil cooler in the seawater circuit



The correct gearbox temperature is achieved by adjustment of the cooling water flow rate. A replaceable orifice, valve or similar must be included in the circuit for this purpose. For this reason, the gearbox water circuit should be arranged in a by-pass from the engine cooling water circuit.

The maximum temperature increase of the cooling water in the gearbox oil cooler is 3 °C and is of no significance to the engine oil circuit. The stated maximum cooling water flow through the gearbox oil cooler must not be exceeded, since this may lead to cavitation in the cooler. Similarly, the minimum flow rate must always be maintained or else sludge may form in the cooler after only a relatively short period of operation.

The pipes and shut-off valves for the sea water circuit must be manufactured from copper or material containing copper for operation in sea or brackish water. Galvanized steel pipes may not be used due to the risk that the zinc coating may be eroded by galvanic processes and rust debris be deposited on webs of flanged pipes of the cooler. Within a short period of time, this would lead to the cooler being damaged by corrosion.

The water pipes have to be connected to the cooler in such a way that stresses and recoil forces caused by thermal expansion will be avoided. If routing of the water pipes makes this impossible, flexible connections must be fitted and arranged as closely as possible to the cooler.

6.2 Connection of monitoring devices

The minimum monitoring facilities specified in the monitoring diagram page 4 must be provided (monitoring equipment is not included in the standard scope of supplies).
The equipment necessary should be installed in such a way that reliable instrument readings can be taken at any time even under unfavorable operating conditions. The display scales of the monitoring equipment should be selected so as to achieve the maximum possible pointer deflection in the operating range. In addition to the specified minimum monitoring facilities, further indicating or warning equipment can be connected to the points sealed by screw plugs.

7 Gearbox actuation devices

The gearbox can be actuated mechanically, pneumatically or electrically according to choice. The mechanical actuation is standard equipment. The actuation mechanism must be designed so that a gear change can only occur when the engine throttle control lever is set at idling. This can best be obtained with "single lever control" whereby engine throttle control and gearbox control are interlocked. When using "dual lever control", a locking device should be incorporated in the gearbox actuation system so that a gear change can only be carried out when the engine throttle control lever is set at idling.
A cutout device for the gearbox should also be provided for single lever control, so that the engine can be run at high speed for inspection or warming-up purposes without having to actuate the gearbox.

7.1 Mechanical gearbox actuation

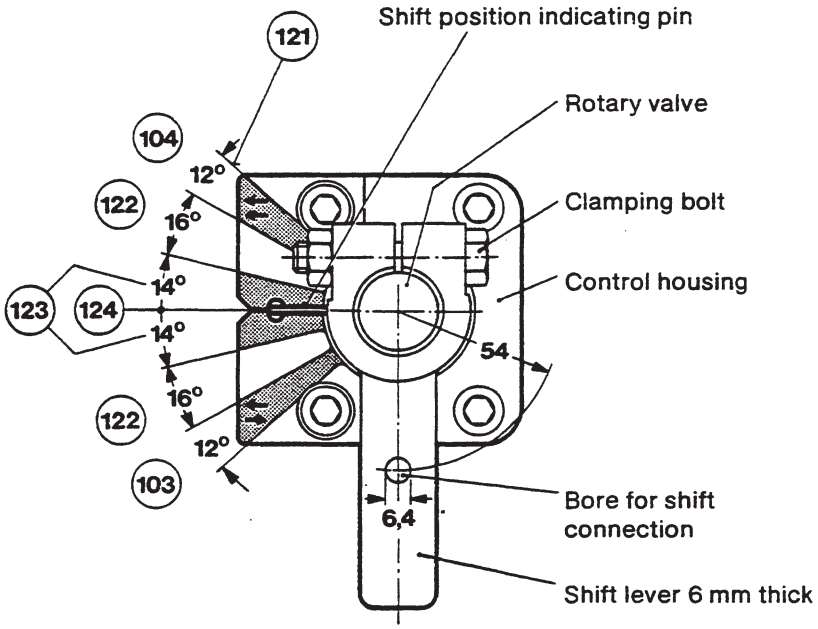
The rotary valve is installed horizontally in the control housing. The selector lever is mounted on the splined shaft which emerges from the control housing and held with a clamping bolt. The bore hole in the gear selector lever is for attaching the push/ pull cable or the gear shift linkage. After loosening and removing the clamping bolt, the selector lever can be pulled off and then re-mounted 10° further round the shaft axis — a distance of 8 mm measured at the bore hole connection. The distance of the bore from the pivot and the required rotary-valve shift angles are selected so that standard remote-control devices with a shift stroke of app. 25 to 35 mm (from neutral to the forward or reverse position) can be attached directly. The control housing has two M8 bore holes for attaching a reaction bearing for the push/ pull cable. The dimensions of the reaction bearing and the position of the gear shift lever are to be selected so that the push/ pull cable is at an angle of app. 90° to the shift lever. A notch indicates the theoretical neutral position of the rotary valve.

Checking selector positions:
From neutral, select the forward or reverse position at the shift lever on deck an check the shift angle at the gear selector lever. The indicating pin on the lever must point within the raised area designating enginewise or counter-enginewise rotation — see diagram.

Checking neutral position:
From the forward or reverse position, select neutral at the shift lever on deck. The indicating pin on the gear selector lever must point within the raised area designating the neutral shift position.
Operations within the undefined ranges might damage the reversing clutches. For this reason the shift movements in the gearbox must be checked at regular intervals and after all repairs or overhauls and adjusted, if necessary.
When the distance between actuation device and gearbox control lever is too large, it is difficult to maintain the specified control position by mechanical means. In such cases we recommend the use of pneumatic or electric gearbox actuation devices.

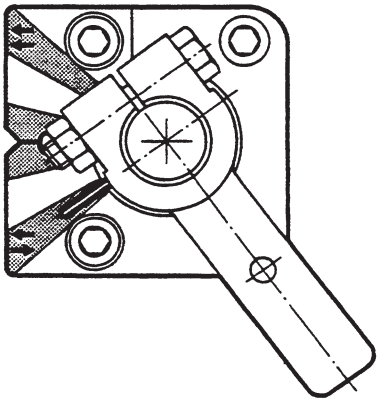
Mechanical gearbox actuation

Neutral position

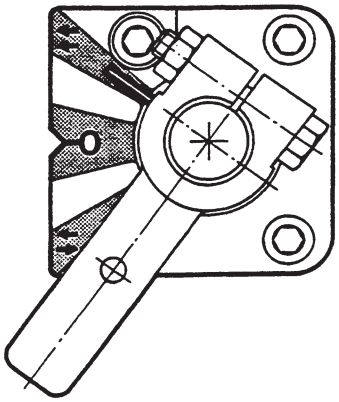


103 Counter-enginewise position
104 Enginewise position
121 Selector lever stop
122 Undefined selector position (pass through this area quickly)
123 Reliable neutral range
124 Neutral detent position

Counter-enginewise position



Enginewise position



7.2 Pneumatic gearbox actuation

For pneumatic gearbox actuation the same control unit is used as for mechanical actuation. A 3-way cylinder shifts pneumatically to the enginewise or counter-enginewise position by means of the selector lever. If a failure occurs in the pneumatic system the gearbox can be actuated mechanically by the selector lever (see section III. 3.2).

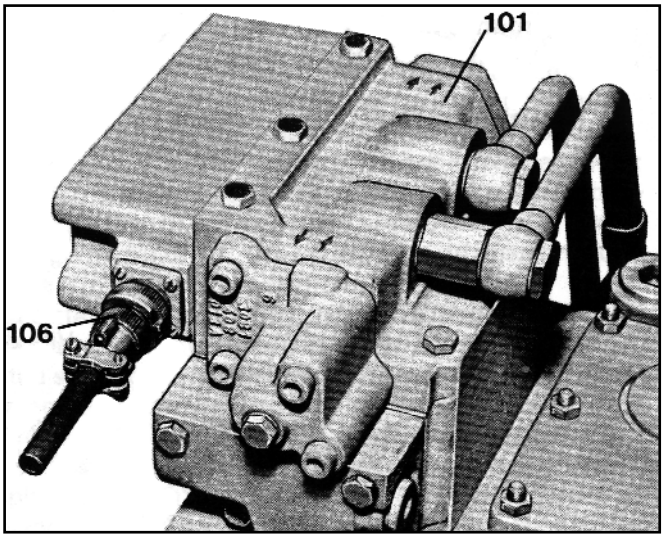
The compressed air supply must be arranged according to the pneumatic circuit diagram supplied with the equipment. Losses caused by leakage are so small in the pneumatic system that apart from the small quantities lost during the shift procedures, compressed air consumption does not have to be checked.

Warning !
If the air supply should fail, the gearbox will shift to neutral automatically.

7.3 Electric gearbox actuation

In the case of electric gearbox actuation the control valve (spool valve) is moved axially by oil pressure. The electric control unit can be supplied in two versions.

The necessary data of the electric connections and the soldering procedures of the plug element are shown in the documentation supplied with the gearbox.
If there is a failure in the power supply, the gearbox can be actuated manually (see section III, 3.3).



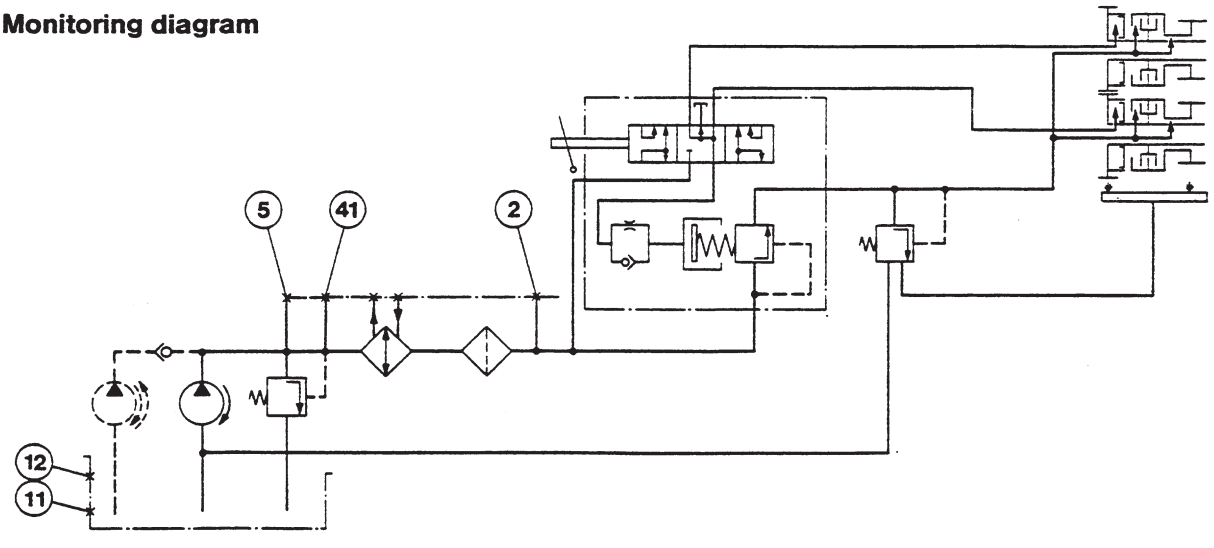
8 Gearbox monitoring

The monitoring facilities stated in section 8.1 are essential as a check on the operating reliability of the gearbox and must always be installed. In addtion, the gearbox is provided with measuring outputs for additional monitoring equipment (see section 8.2).

101 Electric actuation device

106 Electrical connections (plug connection included in ZF scope of supply)

Monitoring diagram



8.1 Minimum gearbox monitoring facilities
(for values, see table on page 4 and 5)

Pressure reading before oil cooler and filter (measuring point 5)

This measuring point is intended as a means of monitoring the oil filter. At normal operating temperature and with the filter clean the pressure drop through the filter is 0.5 to 1.0 bar, in clean cooler max. 1.0 bar, so that the pressure reading ahead of the cooler and filter will be that much higher than the pressure at measuring point 2. Any additional rise in pressure indicates that filter and/ or oil cooler are becoming increasingly blocked.

A pressure sensing switch must be used for monitoring. It should be set to change over when pressure rises above the preset valve, and transmit a warning signal.

Clutch oil pressure (measuring point 2)
Depending on the gearbox version and its input torque, the clutch oil pressure setting will vary. The nominal clutch oil pressure is confirmed in the technical documentation forming part of each order, and also stamped on the gearbox type plate (see page 8, pos. 9).

The clutch oil pressure indication applies to both the enginewise and counter-enginewise shift positions. In neutral the oil pressure at this measuring point drops to 6.0 to 3.5 bar, depending on input speed and oil temperature. To monitor clutch oil pressure, a pressure gauge must be used.

If clutch oil pressure is in accordance with the specified values and the conditions stated above apply, gearbox lubrication will be assured. For this reason, separate monitoring of lubricating oil pressure is unnecessary.

Oil temperature (measuring point 12)
A thermometer must be used to monitor gearbox oil temperature. The volume of water flow through the gearbox oil cooler must be regulated until the gearbox oil temperature remains within the recommended normal range during normal operation. The maximum gearbox oil temperature must not be exceeded during continuous operation (see section III. 2).

8.2 Additional gearbox monitoring
(for values, see table on page 4 and 5)

Additonal measuring points are provided in the form of unions on the gearbox if a higher level of gearbox function monitoring is desired. The relevant values are the same as those at the measuring points for the minimum monitoring facility.

Pressure reading before oil cooler and filter (measuring point 5)

If monitoring is to take place by means of a pressure gauge and a warning device, a T-union can be attached at measuring point 5 for the simultaneous connection of a pressure gauge and a pressure sensing switch. It is also possible to use a pressure sensor with built-in switch contact for an alarm device if a remote reading instrument is to be provided.The oil pressure must not exceed the corresponding value at measuring point 2 by more than 6 bar, nor exceed the value at which the warning signal is transmitted.

Oil temperature (measuring points 11 and 41)
Additional temperature transmitters for thermometers or temperature switches for warning devices can be installed at measuring points 11 and 41. The temperature sensing switches must be adjusted according to the warning values specified for the gearbox version.

Important !
Measuring point 41 is not located in the oil sump. It can only be used for monitoring oil temperature if the oil is being circulated (engine running or, on version with secondary oil pump, either with engine running or rotating propeller shaft).

9 Necessary measures before putting the gearbox into operation for the first time

9.1 Oil filling, oil level check

See section "Maintenance", for correct procedures.

9.2 Installation check

First rotate the engine by hand and then the prop shaft. Check for ease of operation.

Check that clamping bolts of mounting brackets on gearbox and foundation are tightened positively. Check that connecting bolts between propeller shaft flange and gearbox output shaft flange as well as those on the gearbox input side are tightened correctly and secured. Check connections for supervision instruments, cooling water connection and electrical connections — as far as possible.

Functional test of control mechanism

On *mechanically controlled gearboxes* the indicating pin on the gear selector lever must point to the appropriate area of the control housing for every shift position. If necessary, the shift mechanism must be adjusted.

On *pneumatically controlled gearboxes* check shifting operation (appropriate position of selector lever) when engine is at stand still.

On *electrically controlled gearboxes* check operating voltage or power consumption at an appropriate place as near as possible to the plug connection of the electrical control unit.

III Operation

During operation the gearbox does not require any attention except for the supervision of the indicating devices for the gearbox temperatures and oil pressures.

1 Change-over procedure

According to our experience the change-over procedures as described in the following sections, procedure the best operational behaviour, with regard to the shortest possible time required for changing the travel direction of the vessel and, at the same time the greatest possible protection for the gearbox reversing clutches and the entire power transmission system.
We would therefore strongly recommend that the change-over sequences specified here are maintained.

Shift procedures from neutral to ahead or astern, or vice versa, should be carried out rapidly. It is forbidden to rest in the undefined areas between shift positions.

1.1 Change-over from neutral to ahead or neutral to astern

(The propeller shaft is at rest or only rotates very slowly.)

Move engine throttle control to idling, select desired travel direction and keep lever in this position for 1 or 2 secs. before increasing the engine speed to the required operating speed.

1.2 Change-over from ahead to astern with vessel moving at low speed (not applicable to BU ...)

Move engine throttle control to idling. Change position of gearbox control lever from present travel direction to opposite direction and keep it in this position for approx. 1 or 2 secs. before increasing the engine speed to the required operation speed.

1.3 Change-over from ahead to astern with vessel moving at higher speed (not applicable to BU ...)

Move engine throttle control to idling. Leave geabox control lever in "ahead", in order to utilize the engine braking effect on the propeller until the engine speed has dropped to approx. 1.2 x idling speed. Now move gearbox control lever to "astern" and keep it in this position for approx. 1 or 2 secs. before increasing the engine speed to the required operating speed.

1.4 Emergency change-over in case of danger (not applicable to BU...)

In case of emergency, it is of course possible to carry out a change-over from "ahead" to "astern" at higher engine speeds too. However, in this case as well we would recommend that there is a time lag of approx. 1 or 2 secs. after the "astern" direction has been engaged, before increasing the engine speed .
During such manoeuvres please note that in many cases (depending on the type of vessel etc.) the time needed to bring the vessel to a stop is not shortened at all or only very slightly compared with the change-over sequence described above. Therefore, in spite of the increased load on the propulsion unit, in most cases the chances of avoiding a collision are not greatly reduced.

2 Operation with engine stationary and propeller trailing

2.1 Occasional trailing operation

It is possible to carry out occasional trailing operations with the basic gearbox version installed (without secondary oil pump).

The gearbox oil temperature has to be monitored (measuring points 11 and 12 located in oil sump). The max. oil temperature must not exceed 75 °C. If the temperature exceeds this, the ships' speed must be reduced. Should it prove necessary, the engine can be started up for a short time until the gearbox oil temperature is brought below the max. permissible value by the cooling water circulation (gearbox in forwards or neutral position). A trailing operation of max. 24 hours is permissible in emergencies.

2.2 Regular trailing operation

If regular trailing operation is necessary and if it should take more than 5 hours without interruption, a secondary oil pump must be installed (refer to section IV. 5.1).

The oil temperature must be monitored and may not exceed 105 °C (the oil sump temperature is approximately equal to the clutch disc temperature). If the oil temperature is too high, it is cooled either by reducing the trailing speed of the ship or by passing water through the gearbox oil cooler
The cooling water can either be taken, via a special valve, from the engine cooling system in operation, or it can be delivered through a separately driven water pump. With these dimensions one can count on a cooling water capacity wich corresponds to max. 25% of the water capacity during normal operation.

If the gearbox oil temperature rises to above 90 °C, the gearbox must remain in neutral after the engine has been started until the temperature drops below 90 °C. Only then is normal operation possible as described in section 1.

3 Operation with the mechanical hand actuation

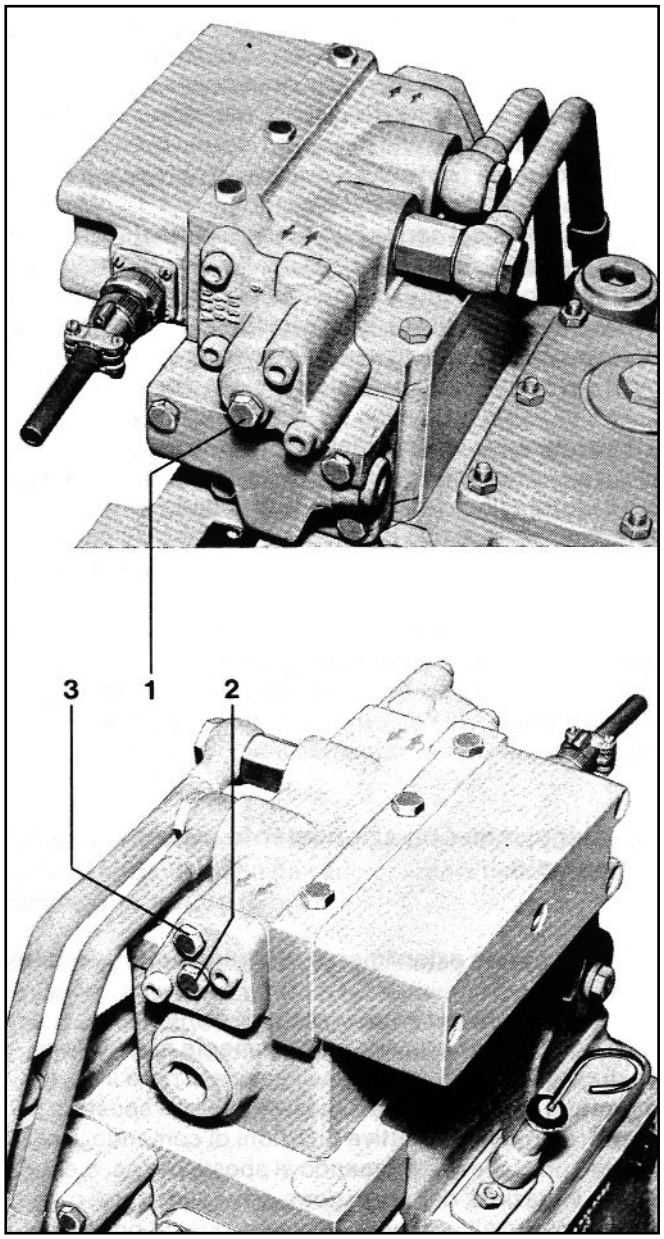
3.1 Version with mechanical gearbox actuation

If a fault should develop in the actuating system, the gearbox can be shifted at the gearbox selector lever after first detaching the push/ pull cable or shift linkage. The lever must be moved as far as the detent indicating each gear shift position. Appropriate measures must be taken to secure the lever and prevent it from jumping out of the ahead or astern position, wich might otherwise occur on account of vibrations for example. Comply with the gear shift instructions in paragraph 1.

3.2 Version with pneumatic gearbox actuation

The three-way cylinder which operates on the selector lever is designed in such a way that should the air pressure fail the gearbox is reset to neutral by spring pressure.
For manual control the selector lever must be moved against the spring load to the desired position and secured by appropriate means.

3.3 Version with electric gearbox actuation



"In case of power failure gearbox automatically reset to neutral".

The gearbox actuation is designed to shift automatically to the neutral position in case of a power failure.
In case of a defect in the electrical actuation device or a power failure the gear can be controlled manually by moving the valve (spool valve) mechanically with an auxiliary screw into the required control position.

Gear change operation

- Switch-off main switch on electric gearbox actuation
- For enginewise rotation remove screw plug 2 and replace with auxiliary screw 3
- For counter-enginewise rotation remove screw plug 1 and replace with auxiliary screw 3
- Cut-off is effected in the inverse order

Version II for BU ... serie
"In case of power failure position maintained"

This gearbox actuation is designed to maintain the position should a power failure occur.
In case of a defect in the electrical actuation device or a power failure the gear can be changed manually by moving the control valve (spool valve) mechanically with a pin to the required position (auxiliary screw 3 not used).

Gear change operation

- Switch-off main switch on electric gearbox actuation
- Remove screw plug 1 or 2 (according to version: enginewise or counter-enginewise rotation)
- Place pin (max. dia 6 mm; min length 80 mm) into appropriate opening and move control valve into desired end position
- Replace screw plug to original position and secure
- Cut-off is effected in the inverse order. The pin must however be inserted from the opposite side (e. g. 1 = engaging; 2 = cut-off)

Important !

- If the gear change operation is carried out whilst the engine is running the same safety precaution as for revolving engine elements are to be observed
- Small oil leak is possible when screw plug is removed
- Auxiliary / screw plugs to be provided with seal ring before insertion

4 Operation with emergency control

If no power transmission occurs despite manual control (section III, 3) there is a fault in the gearbox. In such cases, the clutch discs of the shift clutches can be pressed together mechanically by the clamp bolts in the gearbox.
The clutch for counter-enginewise direction of rotation and that for enginewise direction of rotation both have three clamp bolts which are accessible from outside the gearbox, on the front end of the housing opposite the gearbox input side. The openings in the housing are sealed with screw plugs.

The emergency control can be used in compliance with the following conditions:

a) with the gearbox at operating temperature, the oil pressure at measuring point 2 must be at least 3.5 bar, in which case unrestricted operation is permissible.

b) the oil pressure at measuring point 2 is not available. In this case max. 50 % engine speed operation is permissible.

The special key required for operating the emergency control (SW 8 Allen key, length 280 mm) is available from ZF with the order number 1 X 56 137 055.

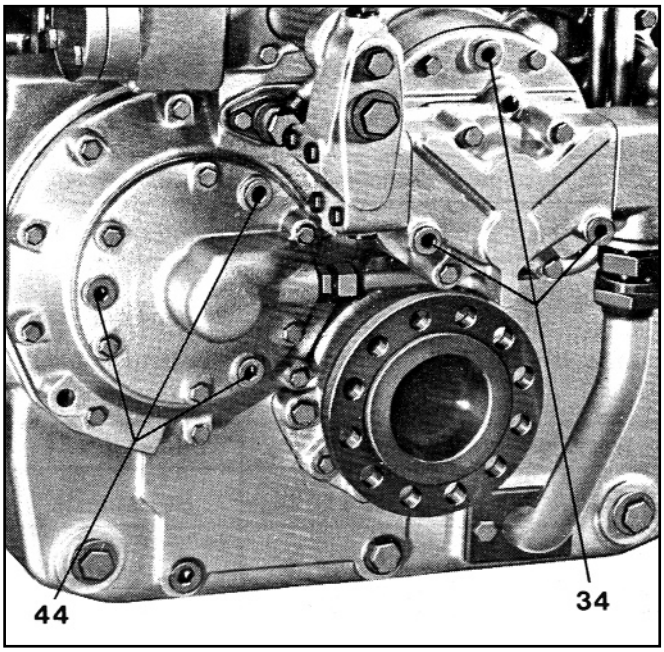
Only one shift clutch on the gearbox may be closed at any one time, otherwise power will be transmitted in both directions of rotation and the gearbox will be jammed. When the emergency control is in use the normal gearbox actuation mechanism must be rendered inoperative for the same reason, and the selector lever on the control unit (for mechanically or pneumatically actuated gearboxes) must be in neutral. For electrical gearbox actuation the control valve must be in neutral (see section III. 3.3).

The emergency control is to be operated in the following sequence:

1. Stop the engine.
2. Decide which clutch is to be used.
3. Loosen and remove the screw plugs.
4. Insert the key as far as possible in one of the three holes. Turn the engine or gearbox input shaft slowly until clamp bolt contacts Allen key. The direction of rotation is unimportant, but the required position must be reached after a maximum 120° turn. Withdraw Allen key approx. 30 mm and turn engine or gearbox input shaft very slightly (approx. 1°) until Allen key can be inserted in clamp bolt.
5. Tighten the clamp bolt right down by turning it several times in clockwise direction. Repeat this procedure with the other two clamp bolts by inserting the key in the appropriate openings; turning the input shaft will not be necessary. Then tighten all three bolts to a torque of app. 25 Nm.
6. Seal the bores in the housing with the screw plugs.

With the emergency control set up in this way, the engine can be started and the vessel taken to the nearest repair dock.

To make the emergency control inoperative, proceed as for setting it up by following points 1 to 4. Then turn clamp bolt anti-clockwise as far as the stop (a torque of approx. 10 Nm is necessary). Repeat the procedure with the other two clamp bolts. Finally seal the bores in the housing with the screw plugs.



34 Emergency control for counter-enginewise direction of rotation

44 Emergency control for enginewise direction of rotation

IV Maintenance

1 Maintenance schedule

Regular maintenance

Maintenance level	Operating hours	Max. value
A 1	every day of operation	3 months see also K 1, K 2
A 2	after 500 each	6 months
A 3	after 1000 each	1 year
A 4	after 4000 to 6000 each	5 years
A 5	during every basic overhaul of engine	operating condition of gearbox

Additional maintenance jobs on new or overhauled gearboxes, necessary only once

Maintenance level	Operating hours	Max. value
Z 1	50 to 100	12 months

Necessary measures for protection against corrosion after a long period out of use

Maintenance level	Procedure	Period out of use
K 1	every 10 to 20 days	up to 6 months
K 2	at end of operating period	9 months
K 3	at end of operating period	max. 36 months

The operating hours given in the maintenance schedule as well as the test and maintenance jobs given in the maintenance work plan are the results of *average* operating data. Therefore the data can only be guide values. Under special service conditions it may be necessary to change the time schedule and maintenance work plan.

Also, it is useful to adapt the maintenance periods given in the operating hours to the corresponding maintenance periods of the engine, as long as the operating hours given are not exceeded to a great extent. This is especially applicable for the maintenance levels A 4, A 5 and K.

The necessary protective measures against corrosion after a long period out of use for a gearbox installed in a ship are largely dependent on temperature fluctuations, atmospheric humidity and the salt content of the atmosphere in the machine room. Therefore the recommended measures and data can only be seen as rough guide values. In case of doubt we recommend implementing the protective measures on the marine gear similar to the ones on the engine.

For a period up to *3 months* out of use, in normal cases, no protective measures against corrosion are necessary.

If the period of non-use is *less than 6 months* we recommend that the measure K 1 is carried out every 10 to 20 days. Before the craft is put into operation again it may be necessary to change the oil (see Maintenance stage Z 1), according to the condition of the oil already in the gearbox.

K 2 is a preservation measure and should be implemented immediately at the end of operation if a period of more than 6 months out of use is intended. K 2 may be implemented also in the case of shorter periods out of use, instead of K 1.

K 3 is a long term preservation measure and allows for a period of non-use of the marine gear up to a max. of 36 months. The preservation can also be carried out acc. to K 2 instead of K 3. This preservation measure must, however, be repeated every 9 months.

2 Protection against corrosion. Preservation

K 1 Protection against corrosion

Start the engine and let it run at idling speed or somewhat above idling for at least 5 minutes in order to lubricate the gearbox thoroughly. The gearbox can be in neutral, or in either direction of rotation. Repeat this procedure every 10 or 20 days. Before putting marine gear into service again check the oil for condensation water (emulsion effect). This check must take place immediately after the engine has been turned off — the oil must not show any turbid aspect.

K 2 Preservation

After operation, drain the gearbox oil and top up with anti-corrosion oil to at least the low oil level mark on the dipstick (see description of maintenance work).
Use anti-corrosion oil grades C 642 or C 644 acc. to MIL-L-21 260.

Immediately afterwards allow the engine to run in the position "enginewise rotation" or "counter-enginewise rotation" for approx. 5 to 10 minutes with increased engine speed (max. 50 % of the nominal operating speed). Shut off the engine. Protect exterior steel parts against corrosion.

Extension of preservation period for another 9 months

Allow engine to run for approx. 5 minutes. Then drain off the preservation oil and fill the gearbox with the correct grade and amount of oil specified for operation.

Start the engine again and allow to run for at least 15 minutes. During this period the gearbox selector clutches must be actuated several times. Then repeat "K2 preservation" procedure.

Putting into operation after the K 2 preservation procedure

Start the engine and allow to run for approx. 5 minutes so that any condensation water which may have collected in the gearbox is mixed with the anti-corrosion oil. Drain off the anti-corrosion oil and fill gearbox with the specified oil grade (see "Maintenance work 141").

K 3 Long term preservation

Drain off the oil in the gearbox after operation and fill with anti-corrosion oil up to the low oil level mark on the dipstick (see description of maintenance work). Use anti-corrosion oil C 642 or C 644 acc. to MIL-L-21 260.

Immediately afterwards allow gearbox to run in the position "enginewise rotation" or "counter-enginewise rotation" for approx. 5 to 10 minutes at increased engine speed (max. 50 % of the nominal operating speed). Shut off the engine, then *completely* fill the gearbox with anti-corrosion oil. Protect the exterior steel parts against corrosion.

Putting into operation after the K 3 long term preservation procedure

Drain off anti-corrosion oil down to usual oil level and allow the engine to run for approx. 5 minutes. Then drain off the anti-corrosion oil completely and fill the gearbox with the specified oil grade (see "Maintenance work 141").

3 Maintenance work plan

Maintenance level							Maintenance jobs		Tools required
	regularly				once				
A 5	A 4	A 3	A 2	A 1	Z 1				
						101	Oil level check	none
						102	Turning of oil filter handle	none
						103	Visual check	none
						104	Draining of water separator of compressed air system	none
						121	Cleaning outside of gearbox	none
						122	Re-tightening of all bolt connections accessible from the outside	tool kit
						123	Check shift position adjustment	none
						124	Lubrication of external moving parts	none
						141	Oil change	tool kit
						142	Cleaning of oil filter	tool kit
						161	Flexible coupling; visual check	none
						162	Flexible mountings of engine and gearbox; visual check	none
						163	Clutch discs; visual check	tool kit
						164	Gearings; visual check	tool kit
						165*	Check of oil pump	W 1
						166*	Check of control unit	W 1
						168	Re-adjust indicator devices	—
						169*	Cleaning of oil cooler	—
						200*	Basic overhaul of gearbox	W 2
T 1 + T 2 + NB	T 1 + T 2	T 1	—	—	T 1		Spare parts required	

*See workshop manual for instructions

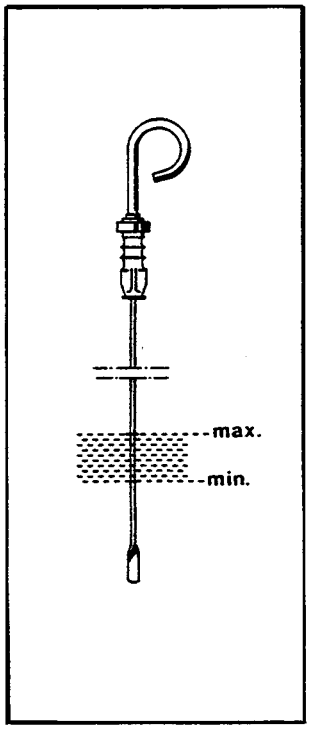
NB = Spare parts according to requirements
T 1, T 2 = Part sets — see spare parts list
W 1, W 2 = Tool sets — see workshop manual

4 Description of maintenance work

Maintenance job 101 – Oil level check

The oil level must only be checked with the engine at a standstill and at least 2 minutes after switching off the engine.

The control oil level lies between the top and bottom marks on the oil dipstick.



When the gearbox is filled with oil for the first time after repair or cleaning the oil filters, please note that some of the oil stays in the oil cooler, the oil pipes and in the oil filter chambers and that it does not flow back into the gearbox housing. Therefore the oil level must be checked again after a brief period of operation and a delay of app. 2 minutes after switching off the engine. If necessary fill up with oil through the opening for the dipstick.

Please note!
Only pull the dipstick when the engine is at rest, otherwise there is the danger of getting scorched if any hot oil splashes out.

Maintenance job 102 – Turning of oil filter handle

Slowly turn the handle of the slot type filter one to two revolutions in a clockwise direction.

Maintenance job 103 – Visual check

Check the input and output shaft locations at the gearbox housing, and the oil-pipe, monitoring-device and cooling-water connections for leaks (visual check).

Maintenance job 104 – Draining of water separator of compressed air system

Only on gearboxes with pneumatic actuation. To be carried out according to the instructions of water separator manufacturer.

Maintenance job 121 – Cleaning outside of gearbox

Clean the outside of the gearbox wit a cold cleaning agent, diesel oil or a similar cleaning agent to make the visual check easier (see 103).

Important!
Do not allow the rubber components, hose pipes or shaft sealing rings to come into contact with the cleaning agent.

Maintenance job 122 – Re-tighten of all bolt connections accessible from the outside.

Re-tighten all accessible bolt connections, particularly the following:

- Engine/ flexible coupling
- Flywheel housing/ gearbox bell housing
- Gearbox output flange/ propeller shaft flange
- Mounting bracket/ gearbox
- Mounting bracket/ foundation

The connections "to" and "from" the oil cooler and of the monitoring devices also have to be examined and re-tightened if necessary.
In order for the tightening torques (see workshop manual) to be maintained these jobs should be done when the gearbox is cold (approx. 20 °C).

Maintenance job 123 – Check shift position adjustment

Only necessary on gearbox version with "mechanical actuation".

Loosen the mechanical connection between the gearbox control lever and the actuating linkage or the push-pull cable. Put control unit and gearbox control lever into "neutral" (rest position). Hole on gearbox control lever and control linkage or fork head of push-pull cable should be in alignment. Engage "ahead" position on control unit and move gearbox control lever to "enginewise" or "counter-enginewise" position until stop. The hole on the gearbox control lever must align with the hole on the linkage or on the fork head. Check "astern" position in the same way. The specified control positions must be reached positively. The actuating linkage may be re-adjusted if necessary. On no account should the control lever get stuck in the intermediate range between "neutral" and "ahead" or "neutral" and "astern".

Maintenance job 124 – Lubrication of external moving parts

Only necessary on gearbox version with "mechanical or pneumatic actuation".

Lubricate the moving parts of the gearbox actuation (fork head on gearbox control lever, linkage connections and connection to control unit) lightly with lithium-saponified multi-purpose grease.

Maintenance job 141 – Oil change

(These jobs should be carried out, as far as possible, togehter with the maintenance job 142.)

Remove dipstick, unscrew oil drain plug and drain off the oil.

Put a new sealing ring on the oil drain plug. Screw the plug back in and tighten it.

If an oil suction unit has been attached to the gearbox, suck off the oil and then close the suction unit again.

For filling in oil remove oil filler plug or inspection cover.

Fill in new oil.

Use new sealings on filler plug or inspection cover and tighten bolts.

Then check oil level acc. to maintenance job 101.

Oil grade

(See "Summary of technical data")

Oils in the current "ZF list of lubricants TE-ML 04 for ZF marine gears" are permitted. A current list of lubricants is supplied together with the gearbox. It can be obtained from any ZF service station.

Measurement with the oil dipstick is binding.

Maintenance job 142 – Cleaning of oil filter

(This job should be done, as far as possible, together with maintenance job 141).

Turn handle of oil filter while gearbox is stationary as described under maintenance job 102.

Unscrew oil chamber drain plug by approx 20 to 25 mm (this allows most of the oil from the filter chamber to flow back into the gearbox housing).
Then unscrew sludge drain plug and empty the filter sediment bowl); use a pan to catch the oil running out (approx. 0.5 to 1.0 dm^3).

After the four hexagon bolts have been removed from the filter head the filter element can be pulled out. Care must be taken that no dirt gets into the clean oil space in the filter housing.
Clean the oil filter with diesel oil or paraffine; turn the handle several times during this process.
Only use brushes for cleaning purposes, never fibrous cloths, mechanical devices, screw drivers or scrapers.
Use a new filter gasket and sealing rings for the installation of the filter, the oil chamber drain plug and the sludge drain plug.Install filter according to previous description.

Maintenance job 161 – Flexible coupling/visual check

Check the rubber components of the flexible coupling for cracks, embrittlement and signs of overheating.

Maintenance job 162 – Flexible mountings of engine and gearbox/visual check

Check the rubber bonded metal supports of engine and gearbox for perfect condition. Rubber components should not show any signs of cracks, embrittlement or other damage.

Maintenance job 163 – Clutch discs/visual check

(This job should be carried out, as far as possible, at the same time as the oil change – see maintenance job 141).

Remove inspection cover and check the clutch packs. The discs should not show any signs of overheating and must be able to move axially (disc clearance approx. 1.2 to 3.0 mm for each pack).

Maintenance job 164 – Gearings/visual check

(This job should be carried out, as far as possible, at the same time as the oil change – see maintenance job 141).

Remove the inspection cover and check gears on the input shaft, the reversing shaft and the output shaft. The gears should not show any signs of pittings or other defects.

Maintenance jobs 165 and 166

See workshop manual for instructions

Maintenace job 168 – Re-adjust indicator devices

Check that the indicators for the oil pressure and oil temperature give the correct values.

1st alternative:
Operate standardazied indicator devices alongside and compare the values indicated. The indicator should not deviate by more than 10% in the range used.

2nd alternative:
Dismantle indicator devices and have them re-adjusted, or use new indicator devices.

Maintenance jobs 169 and 200

See workshop manual for instructions.

5 Special versions/Special scope of supply

Should there be diffferences in the operation and maintenace of special versions or special supply ranges wich are not dealt within the following sections the data can be obtained from the appropriate specifications.

5.1 Special scope of supply – Gearboxes with additional secondary oil pump

This oil pump is mounted on the gearbox housing at the opposite gearbox end to the input end. It is driven by a layshaft from the gearbox output shaft. The pump delivers oil to the oil circuit in a constant direction, regardless of the direction of rotation of the output shaft (see diagram, page 19). During operation with engine stationary and propeller trailing, the pump is responsible for supplying lubricating oil to the gearbox. It is thus permissible to operate in this mode for an unlimited periode of time.

Additional operating requirements(see section III. 2)

During operation with engine stationary and propeller trailing, the selector lever on the control unit must be in neutral. For electrical actuation the control valve must be in neutral (see section III. 3.3).

Additional monitoring

Oil pressure need not be monitored when the engine is stationary. The gearbox oil temperature must be monitored, according to the data in section III. 2.

Additional note for maintenance

The Maintenance jobs 101 and 102 are also to be carried out daily during operation with stationary engine and with rotating propeller (see section IV. 3).

5.2 Special scope of supply – Gearboxes with trolling device

See separate leaflet for trolling device.

6 Trouble shooting

If defects occur in the drive system the gearbox is very often assumed to be the cause. But in many cases faults may arise from external influences acting on the gearbox.
The trouble shooting table below lists the principle faults which may occur, their possible causes and remedies. If it proves impossible to rectify a fault using this information you are advised to contact the nearest ZF service station. If you wish to repair faults or perform repairs to the gearbox yourself, you should request a copy of the workshop manual and the gearbox spare parts list from the service department of our Friedrichshafen Works.

Fault	Possible causes	Remedies
Excessive gear oil temperature (measuring points 11*, 12* and 41*)	Insufficient water flow through cooler	Increase water flow
	Sludge in oil cooler	Clean water side of cooler, see workshop manual
	Gear ratio not properly engaged, clutch slipping	Adjust shift mechanism
Insufficient gear oil temperature	Excessive water flow through cooler	Decrease water flow
Pressure before oil cooler and filter too high (measuring point 5*)	Clogged filter Clogged oil cooler	Clean filter and drain off oil slugde Clean oil side of cooler
No operating oil pressure (measuring point 2*)	No oil in gearbox	Add oil
	Wrong direction of rotation at gearbox input	Use special gearbox version
	Defective indicator	Repair fault
Insufficient operating oil pressure (measuring point 2*)	Oil viscosity too low	Use a recommended oil grade (see list of lubricants)
	Incorrect oil pump version	Select oil pump in accordance with engine operating speed range
	Devective oil pump	Renew
	Overpressure valve leaking	Repair fault
	Time switch for pressure modulation defective	See remedy for clutch slipping
If the fault cannot be rectified, the lubricating oil supply to the gearbox is also at risk. Proceed at reduced engine speed until repairs can be carried out.		
Excessive operating oil pressure (measuring point 2*)	Oil viscosity too high	Use a recommended oil grade (see list of lubricants)
	Incorrect oil pump version	Select oil pump in accordance with engine operating speed range

*See monitoring diagram page 19

Fault	Possible causes	Remedies
Drive interrupted betweeen gearbox input and output; clutch not transmitting torque	For mechanical gearbox actuation Shifting angles incorrect	Adjust (see section II. 7.1)
	For pneumatic gearbox actuation Compressed air system defective (Shift lever not moved)	Repair
	Shifting angles incorrect	Adjust (see section II. 7. 1)
	For electric gearbox actuation Electrical system defective	Repair
	Defective solenoid valve	Renew solenoid valve
	Spool valve blocked	Repair
	No operating oil pressure	See remedy for no or insufficient operating oil pressure
Drive between gearbox input and output cannot be interrupted; clutch does not open	For possible causes and remedies refer to "clutch not transmitting torque"	
Clutch slips at high engine speeds	Insufficent operating oil pressure (measuring point 2*)	See remedy for insufficent operating oil pressure. If the fault cannot be rectified on board, proceed with reduced engine speed — so that the clutch does not slip — until repairs can be carried out. Avoid changes in direction, but if unavoidable the ship's propeller should be almost at a standstill and the engine idle speed as low as possible
Oil level sinks rapidly (as indicated by the dipstick); see section IV. 4 — oil level check	Leaks at housing joints, oil pipes or shaft sealing rings	Repair faults
	Oil cooler leaking into cooling water system	Repair fault, renew cooler if necessary
Oil level increases (see section IV. 4 — oil level check)	Water entering the oil circuit from the cooling system	Repair fault
Gearbox operates too loud in certain speed ranges	Torsional vibration resonance of drive unit in engine speed range	Avoid critical speed range. Install a more suitable torsionally flexible coupling (see section II. 4)
Gearbox operates too loud in engine idle speed range	Torsional vibration resonance of drive unit in engine idle speed range	Increase engine idle speed
Engine stalls during rapid change from "ahead" to "astern"	Engine idle speed too low	Increase engine idle speed
	Change in direction effected too quickly or with travel speed to high	Changes in direction should be carried out as recommended in section III. 1.3

*See monitoring diagram page 19

7 Customer service stations, Spare parts

If a gearbox fault cannot be rectified using the remedies in section 6 "Trouble shooting", please contact the nearest ZF service station.

A list of ZF Service stations with the current telex and telephone numbers can be obtained from ZF Friedrichshafen AG.

When carrying out repairs, use only original ZF spare parts.

Please give the following information when ordering spare parts and in inquiries.

- Model
- Serial number
- Parts list number
- Gearbox ratio

This information is stamped on the gearbox type plate.

In the case of marine gears with classification, note that spare parts without classification are always supplied under the item numbers stated. If a version with classification is required, the desired type of test must be stated in addition to the item number. This is also necessary if the gearbox parts list is quoted when ordering, and when requesting exchange gearbox units.