

# OPERATING INSTRUCTIONS

ZF 2000 SERIES

MARINE PROPULSION SYSTEMS





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## Foreword

These Operating Instructions are a fundamental part of the transmission and must always be available.

These Operating Instructions serve avoiding malfunctions and damage during operation and should therefore be made available for maintenance and operating personnel.

The warranty terms and conditions agreed upon with ZF Friedrichshafen AG for the transmission are to be applied. ZF Friedrichshafen AG will only accept warranty claims when:

- The transmission is installed, monitored, operated and maintained according to these Operating Instructions.
- Lubricants approved by ZF are used (ZF TE-ML 04).
- Limit values for the maximum engine output speed ratio according to the type plate as well as the engine speed according to the transmission classification have not been exceeded.

ZF Friedrichshafen AG does not assume any liability or warranty obligations for damage and defects resulting from unauthorized changes or modifications to the transmission and transmission components.

These Operating Instructions apply to standard transmissions. Differences due to customisation and operating conditions are possible. The information in the specifications is binding when the information in the Operating Instructions deviates from these technical and/or commercial specifications.











## 1 Safety

### 1.1 Conventions for safety information in text

|   |                |
|---|----------------|
|              | <b>DANGER</b>  |
| Describes a dangerous situation that will lead to serious injuries or death when not avoided. |                |
|              | <b>WARNING</b> |
| Describes a dangerous situation that can lead to serious injuries or death when not avoided.  |                |
|              | <b>CAUTION</b> |
| Describes a dangerous situation that can lead to minor or moderate injuries when not avoided. |                |
| <b>NOTICE</b>   |                |
| Describes a situation which can lead to material damage when not avoided.                     |                |

 Serves to draw attention to special procedures, methods, information, use of aids and tools, etc.

This document specially highlights safety information according to US standard ANSI Z535 by marking the text with the above signal words according to the degree of danger.

#### 1.1.1 Safety information

1. Ensure that you read and understand all warnings prior to commissioning or repairing the product!
2. Also pass on all safety information to operating, service, and repair personnel and/or transport personnel!

## 1.2 General information

### 1.2.1 General

In addition to these Operating Instructions, generally valid local, legal and other compulsory regulations on accident prevention and environmental protection are to be observed. This transmission was constructed according to the current state of the art and the applicable rules and regulations. However, the transmission can still present personal and physical risks, through:

- Usage other than the intended use
- Operating, servicing and commissioning by unqualified personnel
- Changes or modifications
- Noncompliance with safety information

#### 1.2.2 Intended use

The transmission is designed exclusively for the purpose defined in the contract and/or as foreseen at delivery. Any other or further use is considered as not being in accordance with the intended use.

The manufacturer of the transmission does not assume any liability for damage resulting from such use. The risk will be borne solely by the user. The intended use also includes compliance with the Operating Instructions as well as compliance with the Service and Repair Instructions. Limit special and emergency running states to the maximum admissible time or number of cycles according to the Operating Instructions.

#### 1.2.3 Changes or modifications

Unauthorized changes to the transmission impair the safety.

ZF Friedrichshafen AG will not assume any liability or warranty obligations for damage resulting from unauthorized changes or modifications.

#### 1.2.4 Spare parts

Only ZF original spare parts may be used when replacing components or subassemblies. All liability and warranty claims against the manufacturer of the transmission will become void for damage resulting from the use of other spare parts.



## 1.3 Personnel and organisational requirements

### 1.3.1 Demands on personnel

Work on transmissions may only be carried out by trained and instructed qualified personnel. Based on their appropriate training and experience, the qualified personnel must be capable of recognizing risks and avoiding possible hazards which may be caused when operating or repairing the transmission.

Observe the minimum legal age.

The Operating Instructions must be read and understood by the personnel.

The responsibilities of the personnel for operation, service, and repair are to be defined.

### 1.3.2 Organisational measures

Pass these Operating Instructions on to the operating, service, repair and/or transport personnel. Always keep them readily available at the site where the transmission is operated and accessible to the operating, service, repair and/or transport personnel.

Instruct personnel on handling and repairing the transmission using these Operating Instructions and pay particular attention to information relevant for safety. This applies especially to personnel only working occasionally on the transmission. Such personnel should be instructed repeatedly.

### 1.3.3 Work clothing and protective equipment

Wear work clothing corresponding to safety requirements during all work.



Depending on the type of the work, use additional protective equipment, e.g. goggles, protective gloves, safety helmet, apron.

Work clothing must fit tightly to ensure that it does not get caught by rotating or protruding parts. Do not wear jewellery (rings, necklaces, etc.).

## 1.4 Safety regulations for service and repair work

### 1.4.1 Safety regulations for commissioning

Before using the transmission for the first time, install and connect it to the monitoring system according to these Operating Instructions.

Ensure for every use of the transmission and/or plant:

- All service and repair work has been completed
- All loose parts of rotating machine parts have been removed
- Nobody is within the danger area of moving machine parts.

Immediately after commissioning the transmission and/or the plant, ensure operating and display instruments and monitoring, signalling, and alarm systems operate properly.

### 1.4.2 Safety regulations for operation

- The operator must be familiar with the operating and display elements.
- The operator must be aware of the effects of every operating step to be performed. The operator must perform individual operating steps according to the instructions.
- During operation, observe display instruments and monitoring assemblies constantly according to the momentary operating states to ensure compliance with limit values as well as warning and alarm messages.

If a malfunction is detected on the system or is reported by the system:

- Inform the responsible supervisory personnel.
- Evaluate the message.
- Perform possible emergency measures, e.g. operating with the emergency control.

### 1.4.3 Operation of power plant

- Wear hearing protection while engine is running.
- Ensure good ventilation of machine room.
- Immediately wipe up leaked or spilled service fluids or soak up with corresponding absorbent.
- Inappropriate shielding of electrical parts can cause severe electric shock and subsequent injuries.
- Never remove water, oil, compressed air or hydraulic lines while the engine is running.



#### 1.4.4 Servicing and repair

An essential safety factor is compliance with the Service and Repair Instructions.

Observe the following points before starting maintenance and repair work:

- Unless expressly approved, do not carry out servicing and/or repair work while the engine is running.
- Secure engine against unintended start.
- Attach a "Do not operate" sign in the operator room or on the control unit.
- Keep uninvolved persons away!



Never clear malfunctions or perform repairs without the required experience or special tools.

- Leave all service and repair work to authorized qualified personnel.
- Only use calibrated tools suitable for the function.
- Do not work on transmissions or components only held by lifting devices or a crane. Always support these with suitable means and according to regulations before starting any service or repair work.
- Before turning the engine, make sure nobody is within the danger area of the power plant. After completing work on the transmission, check that all protective equipment has been fitted and all tools and loose parts have been removed from the transmission.
- Seal all openings using caps and covers when removing or opening lines.
- Do not damage pipes and tubes during service and/or repair work.
- Apply correct torque when tightening connections fitted between lines. Ensure all brackets and dampers are installed properly.
- Ensure all electrical cables and oil pressure lines have enough clearance to prevent contact with other components.
- Collect service fluids in a container, soak up spilled liquids using absorbent and/or wipe up.
- When working above body height, use ladders and working platforms meeting safety requirements. Ensure stable positioning of transmission parts put down!

Adults must not carry or lift more than a maximum of 10 kg to 30 kg, depending on age and sex, to avoid back injuries when lifting components, therefore:

- Use lifting equipment or get help.
- Make sure all chains, hooks, eyes, etc. are tested and approved, have sufficient load capacity and hooks are positioned correctly.

- Do not load lifting lugs from the side.
- Pay particular attention to cleanness when performing service and repair work on the power plant. Make sure no loose parts are in/near the machinery after completing service and repair work.

#### 1.4.5 Welding work

- Welding on the transmission or attached equipment is not allowed!
- Never place the welding cable above or near cable harnesses of ZF plants.
- Do not connect the ground connection of the welding device more than 60 cm from the welding location.

#### 1.4.6 Pressing on and off

Only use press on/off devices specified in the Work Plan as well as in the Assembly Instructions. Do not exceed the maximum admissible slip-on pressure for the press on/off device. High-pressure lines for hydraulic pressing on and off are tested with 3,800 bar.

- Do not bend lines under pressure or apply force!
- Before starting the pressing process, observe the following:
  - Vent the press on/off device, the pumps as well as the pipework used at the positions intended for the relevant unit (e.g. open vent screws, pump until oil discharges free of air, tighten vent screws).
- To press on, screw the device on with the plunger retracted.
- To press off, screw the device on with the plunger extended.
- When using a press on/off device with central widening pressure application, screw the spindle into the shaft end until the sealing effect is achieved.
- During hydraulic pressing on and off of components, make sure nobody is in close vicinity of the component to be pressed on.
- There is a risk that the component to be pressed on suddenly "jumps off" the pressure connection when the system is under pressure.
- Check the devices in specified intervals prior to use (crack detection test).



### 1.4.7 Working on electric/electronic subassemblies

- Obtain the authorization of the responsible supervisory personnel before starting any service and repair work and/or shutting off parts of the electronic system.
- Disconnect the relevant electric supply before starting any work on subassemblies. The documentation draws attention to specific measures requiring power.
- Do not damage cables during dismantling work and refit the cables so that these are not damaged through contact with sharp edges, rubbing on parts or contact with hot surfaces during operation.
- Do not attach cables to lines carrying liquid!
- Reconnect and fasten any cables removed after completing service and/or repair work!
- After every repair, perform a functional inspection of the device and/or the installation using corresponding functional tests. Separate inspection of the repaired component without integration in the component assembly is not sufficient.
- Use suitable cable clamps to fasten cables fitted close to mechanical components with a risk of fraying!
- Do not use cable straps for fastening because cable straps removed during service and/or repair work might not be refitted.
- Store spare parts properly until used for replacement, i.e. protected against moisture in particular.
- Pack defective electronic components or subassemblies properly for transporting for repair work, i.e. protected against moisture in particular, shockproof and, where necessary, in antistatic foil.

### 1.4.8 Operating electric devices

Certain parts of electric devices are live during operation. Failure to comply with warnings applicable for the devices can result in severe injuries or material damage.

## 1.5 Consumables and service fluids, fire and environmental protection

### 1.5.1 Fire prevention

- Repair oil leaks immediately because small amounts of oil or cleaning agent on hot parts can cause fires.
- Always keep the transmission clean.
- Do not leave cloths impregnated with service fluids on the transmission.
- Do not store combustible objects/material near the power plant.

- Do not perform welding work on pipes and parts containing oil or fuel!
- Clean with non-combustible liquid before starting welding work.
- Always keep suitable extinguishing equipment (fire extinguisher) ready and be aware and capable of its usage.

### 1.5.2 Noise

Noise can increase the risk of accidents when perception of acoustic signals, warning cries or noises indicating danger is impaired.

- Wear hearing protection (protective cotton, ear plugs or earmuffs) at all work places with a sound pressure level above 85 db(A)!

### 1.5.3 Environmental protection

- Dispose of used service fluids, cleaning agents, and filter in accordance with local regulations.
- Do not drain service fluids and cleaning agents into soil, ground water or sewer systems.
- Request and observe Safety Data Sheets from the responsible environmental agency for relevant products.
- Collect used oil in container of sufficient size.
- Observe manufacturer's regulations when handling service fluids and cleaning agents.

### 1.5.4 Service fluids and consumables

- Only use service fluids tested and approved by ZF (lubricant list TE-ML 04)!
- Store service fluids and consumables in suitable and correctly labelled containers!
- Observe safety regulations applicable for the product when handling service fluids and other chemical substances.
- Take care when handling hot, undercooled or caustic substances.
- Avoid contact with ignition sources, do not smoke, when handling flammable substances!

### 1.5.5 Used oil

Used oils can contain combustion residues harmful to health.

- Apply skin barrier cream to hands!
- Clean hands after contact with used oil!



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## 1.6 Transport

- Always use the lifting lugs or suspension brackets provided to suspend the transmission.
- Never use transmission components such as cooler, oil pump, pipework, brackets, sensors, input or output shafts for attaching lifting devices.
- Do not stand under the transmission and stay clear of the danger area during lifting and lowering.
- Observe centre of gravity of transmission. When transporting, always keep the transmission in the installation position with a maximum admissible inclined hoist of 10 degrees.
- Always keep the lifting rope or chain a minimum distance of 20 mm away from the transmission components.
- The load capacity of the lifting device must be at least 4,000 kg.
- Secure the transmission against tilting during transport. Secure the transmission against slipping and tilting when using slopes and ramps.

### 1.6.1 Transmission without suspension bracket

Lifting lugs are screwed on machined surfaces used for attaching the suspension bracket.

- Do not use lifting lugs other than for transmission transport. They must not be used for transporting the complete power unit (engine and transmission).
- Remove the lifting lugs before attaching the suspension bracket.

### 1.6.2 Transmission with suspension brackets

If the transmission is delivered with original ZF suspension brackets, the outer reinforcing ribs are designed to be used as lifting lugs.

- Always use these holes for all sling gear (e.g. shackle A4 according to DIN 82101, not supplied by ZF).
- If suspension brackets are not supplied by ZF, the shipyard or engine manufacturer must provide an appropriate transmission suspension.

### 1.6.3 Lowering the transmission after transport

- Always lower the transmission on a flat, solid surface.
- Observe condition, load capacity of the floor and/or surface.
- Never place the transmission on the oil sump unless expressly authorized by ZF for the individual transmission.







## 2 Product overview

### 2.1 Transmission overview

#### 2.1.1 General design principle

ZF marine transmissions are designed and manufactured in accordance with the regulations of the individual Classification Societies. The power rating approved by the Classification Society depends on the input speeds, the class of the ship, and the various applicable construction specifications. In most cases, the maximum torques approved by ZF are also approved by the Classification Society up to the same maximum values.

Full testing or final inspection by the Classification Society specified by the customer is possible on request.

The normal input direction is clockwise as viewed on the transmission input flange. A corresponding arrow is fixed on the transmission input side for special version transmissions with anticlockwise input direction (left as viewed on the transmission input flange).

ZF 2000 series transmissions are hypoid reversing and reduction transmissions with triple gearing. One hydraulic multi-disc clutch is located on the input shaft and one on the intermediate shaft (also reversing shaft) of the transmission.

ZF 2000 NR series transmissions are reduction transmissions with a multi-disc clutch that can be fitted on either the input shaft or intermediate shaft. The output direction is either against or the same as the input direction depending on the version.

The cast iron housings of the transmissions have high torsion resistance and are mainly made of light alloy resistant to sea water. Machined surfaces required for fitting transmission mounting brackets and bell housing, including threaded holes are provided as standard.

To achieve a long service life and a high degree of quietness in operation, all power-transferring gearing is designed to highest safety standards, case-hardened, polished, and subsequently submitted to a special treatment. The shafts rotate in antifriction bearings. Propeller thrust bearings are incorporated in the transmission to absorb the propeller thrust. The clutch fitted on the input shaft and the intermediate shaft is a multi-disc clutch with steel/sinter friction interface. It is pressured by oil pressure and thus closed.

#### 2.1.1.1 Oil supply and transmission cooling

The transmission housing is designed as an oil container. A continuous delivery gear pump serves for delivering the oil flow for transmission lubrication, transmission cooling, and for pressuring the multi-disc clutch.

The transmission housing has threaded holes for connecting sensors for monitoring purposes as standard. The following oil supply values can be measured on the transmission: Transmission oil temperature, oil pressure before the filter (when using a gap filter), lubricating oil pressure and clutch oil pressure.

An oil cooler made of sea water resistant material is mounted on the transmission housing for cooling the transmission oil. This oil cooler has a pipe bundle design.

An oil filter with one filter cartridge or a gap filter serves for cleaning the transmission oil.

#### 2.1.1.2 Control unit and transmission actuation

The control unit is fitted as complete subassembly on the transmission housing and comprises the following essential components:

- Control piston (filling and venting of multi-disc clutch)
- Control valve (clutch pressure level)
- Timer (modulating clutch pressure)

Transmission actuation is made electrically or mechanically using a pilot valve located on top of the control unit. Electrical actuation is part of the transmission basic version.

#### 2.1.1.3 Transmission as A and parallel version

The flange of the transmission input shaft is always located above the flange of the output shaft. The vertical axial distance between the two shafts is measure "A".

Transmission input and output are located on opposite sides of the housing.

##### Parallel version

Also referred to as vertical arrangement because of the vertical distance between input and output shaft (measure "A"). The shafts in the transmission are arranged on parallel axes.

The transmission identifier is just transmission type "ZF 2000" without a letter as suffix.



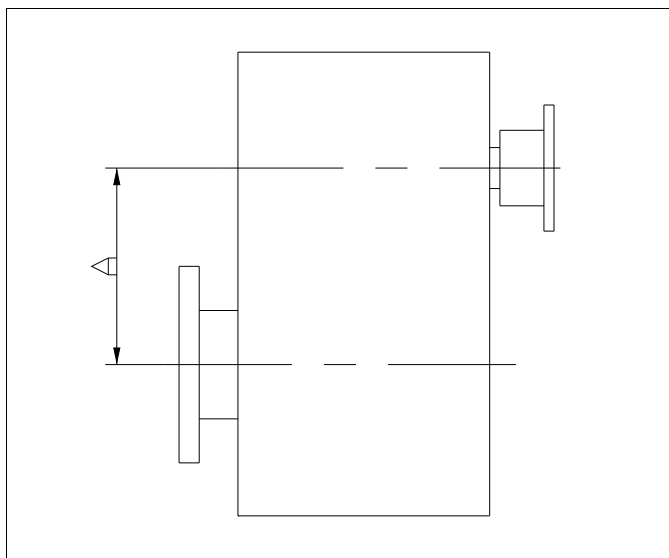


Fig. 1: Parallel version

### A version

The axis of the output shaft is inclined towards the axis of the input shaft by angle " $\alpha$ ". The transmission type has suffix "A", for example, ZF 2000 A.

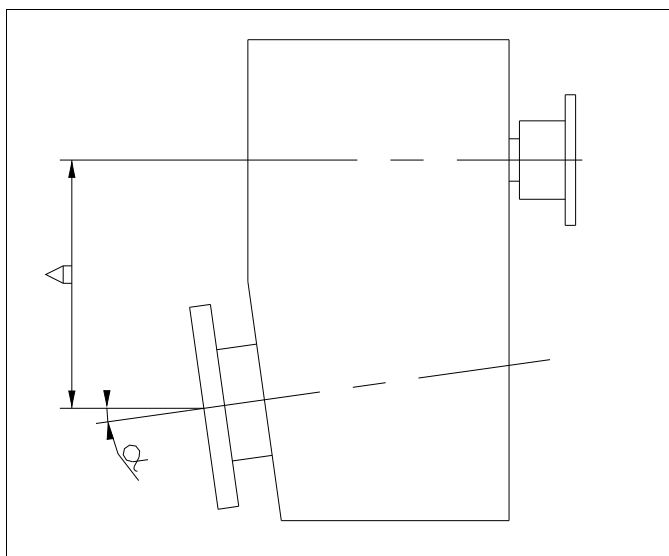


Fig. 2: A version

#### 2.1.1.4 Transmission as V and U version

In this version, input and output flanges are located on the same transmission side. The flange of the transmission input shaft is always above the flange of the output shaft. The vertical axial distance between the two shafts is measure "A".

### U version

The shafts in the transmission are arranged on parallel axes. The transmission type has suffix "U", for example, ZF 2350 U.

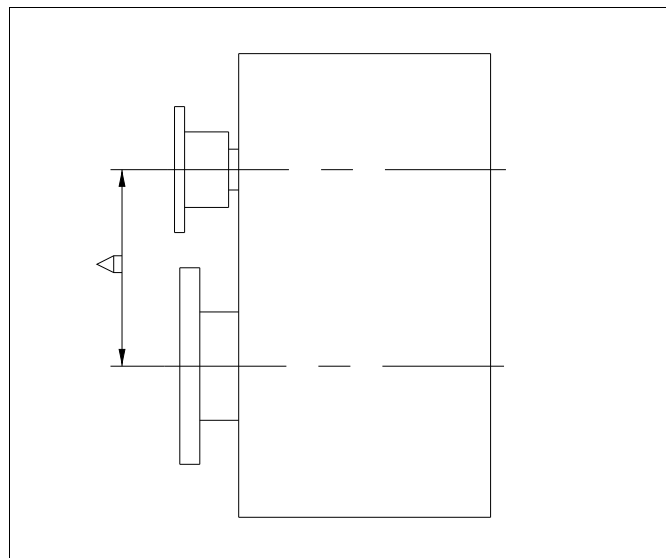


Fig. 3: U version

### V version

The axis of the output shaft is inclined towards the axis of the input shaft by angle " $\alpha$ ". The transmission type has suffix "V", for example, ZF 2000 V.

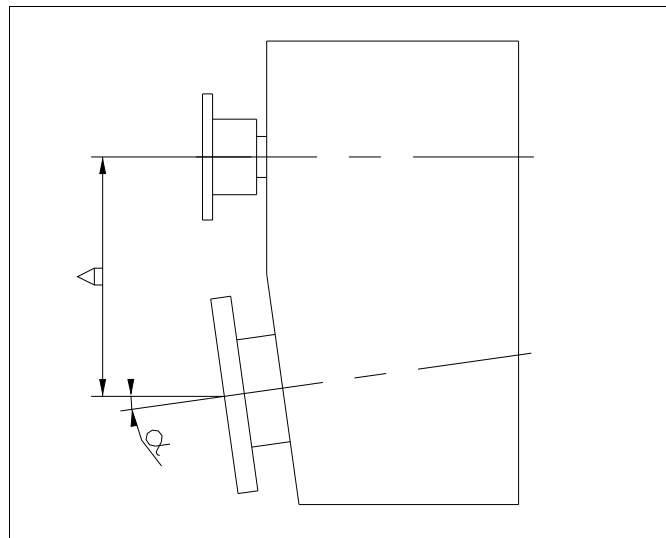


Fig. 4: V version



### 2.1.1.5 Transmission as B version

The flange of the transmission input shaft is always located below the flange of the output shaft. The vertical axial distance between the two shafts is measure "A".

Transmission input and output are located on opposite sides of the housing. The transmission type has suffix "B", for example, ZF 2200 B.

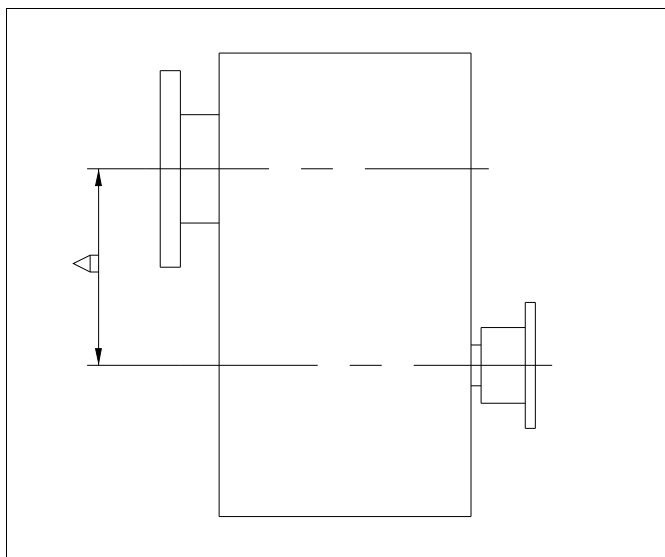


Fig. 5: B version

## 2.1.2 Installation position on the ship

### 2.1.2.1 Engine-transmission arrangement "standard"

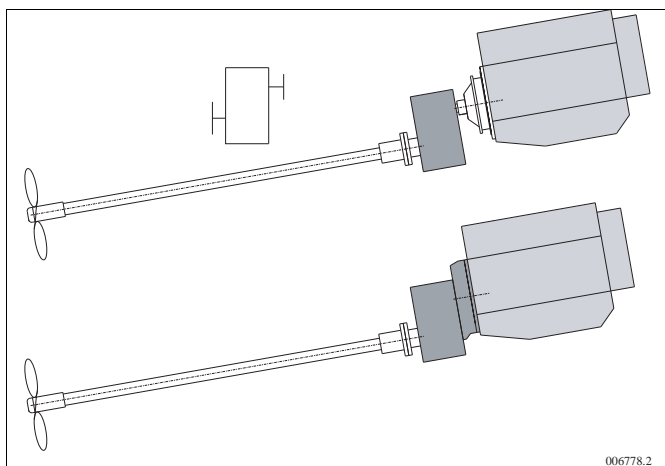


Fig. 6: Vertical offset

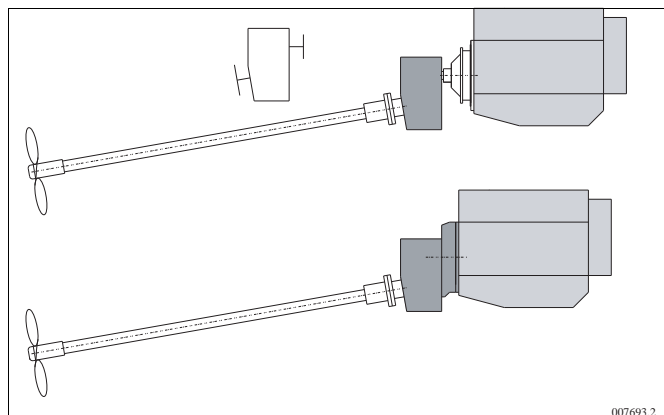


Fig. 7: Down angle

The transmission can be mounted on the engine as "free-standing" or "flanged".

#### Free-standing installation

The transmission is rigidly or elastically supported in the foundation and the engine is normally elastically supported. A flexible clutch serves as drive connection between engine and transmission. The clutch serves as torsional vibration damper and must also compensate axial, angular, and, to a minor extent, radial displacement of connected equipment.

Select the elasticity of the engine bearing and alignment of engine and transmission so that the admissible loads acting on the transmission in axial and radial direction due to the aligning forces of the flexible connection are not exceeded.

#### Flanged installation

The engine is connected to the transmission via the transmission bell housing.

This ensures good centring between engine and transmission. The flexible clutch does not need to compensate additional forces which could otherwise occur due to shaft displacement.

### 2.1.2.2 Engine-transmission arrangement in "U and V shape"

For arrangement in U or V shape, transmissions are used with input and output flange on the same transmission side. In U shape, transmission and engine are fitted inclined towards the longitudinal axis by angle „ $\beta_1$ “ or „ $\beta_2$ “.



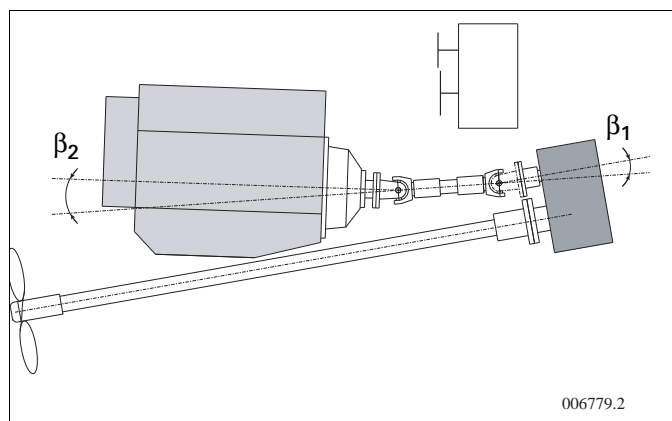


Fig. 8: U drive (U arrangement)

In V shape, engine and transmission are connected on one level by means of a joint shaft. In the same manner as the output flange of the transmission, the propeller shaft is inclined towards the longitudinal axis of the power unit by angle " $\alpha$ ".

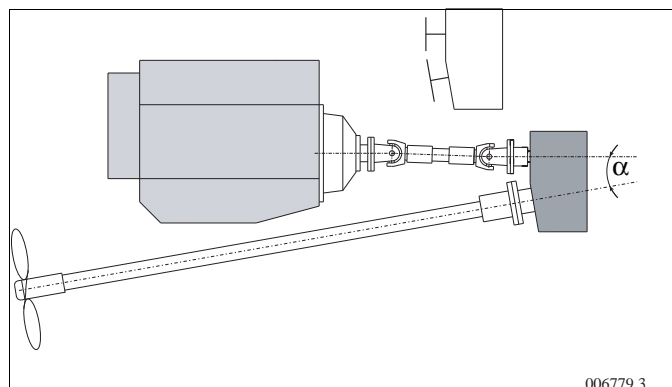


Fig. 9: V drive (V arrangement)

A distinction is made between two arrangements depending on the installation position of the joint shafts: W and Z arrangement, each under the condition that both joint angles are equal ( $\beta_1 = \beta_2$ ). For installation instructions and alignment guidelines, see Sections 4.1.2 *Connection to the engine* and 4.1.4 *Connection to the joint shaft*.

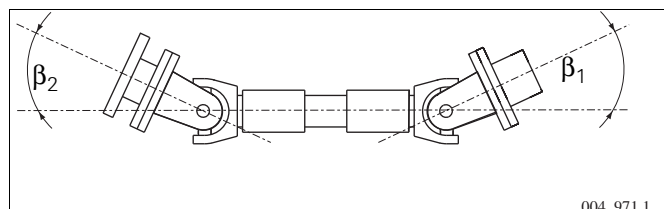


Fig. 10: W arrangement with  $\beta_1 = \beta_2$

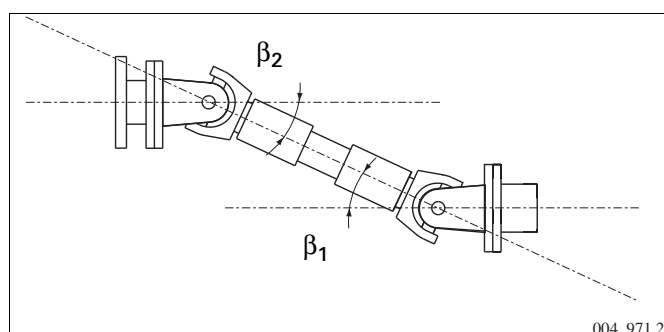


Fig. 11: Z arrangement with  $\beta_1 = \beta_2$

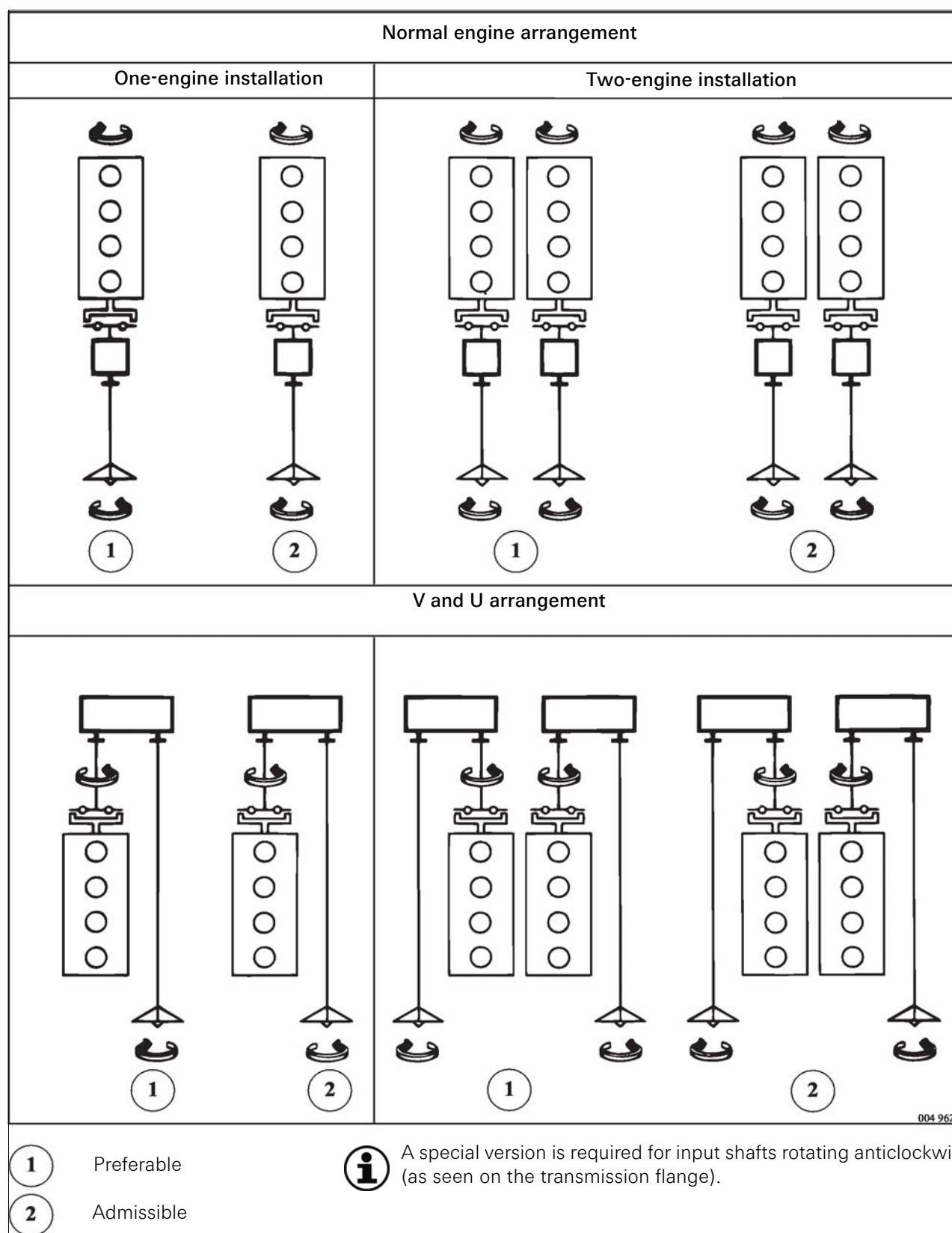
Both the V and U arrangement require free-standing installation of engine and transmission. The transmission is supported rigidly or elastically in the foundation. The engine is normally elastically supported. Engine and transmission are connected via a joint shaft allowing a length change between these two units, with compensation in all operating states.

A flexible clutch is fitted on the engine side for vibrational decoupling of engine and transmission.

Radial and axial forces occur on the joint shaft. Additional support points may be required depending on the length of the joint shafts used. If one support point between the flexible clutch of the engine and joint shaft is sufficient, it is fitted on the engine as a bell housing. Alternatively, the joint shaft can be supported directly in the foundation.



## 2.1.3 Propeller rotation direction during ahead travel

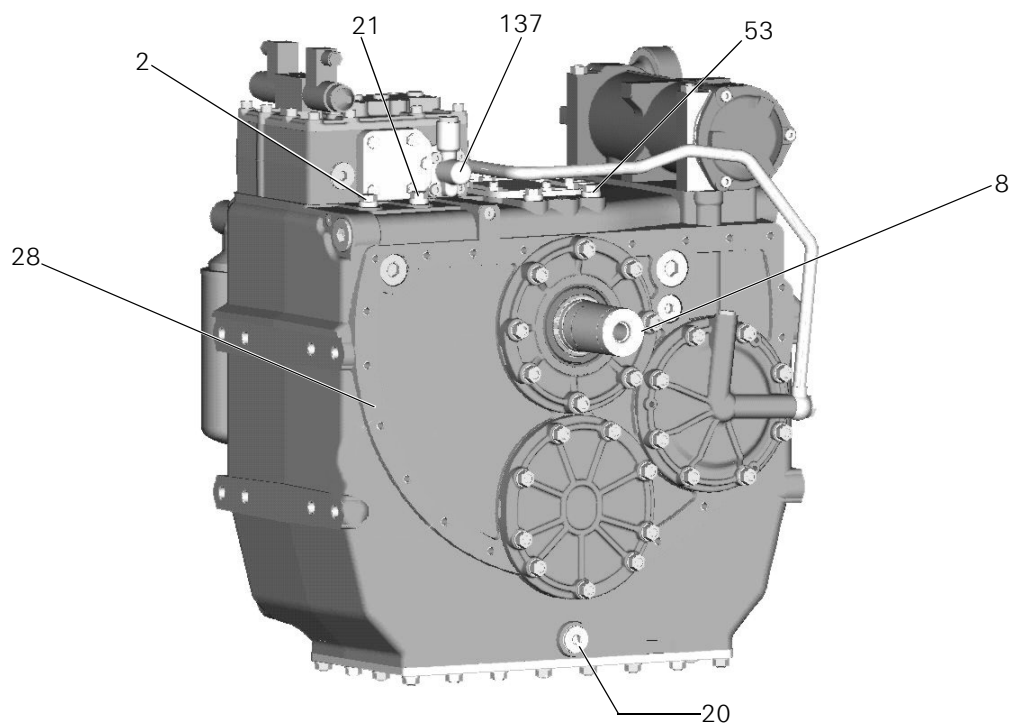
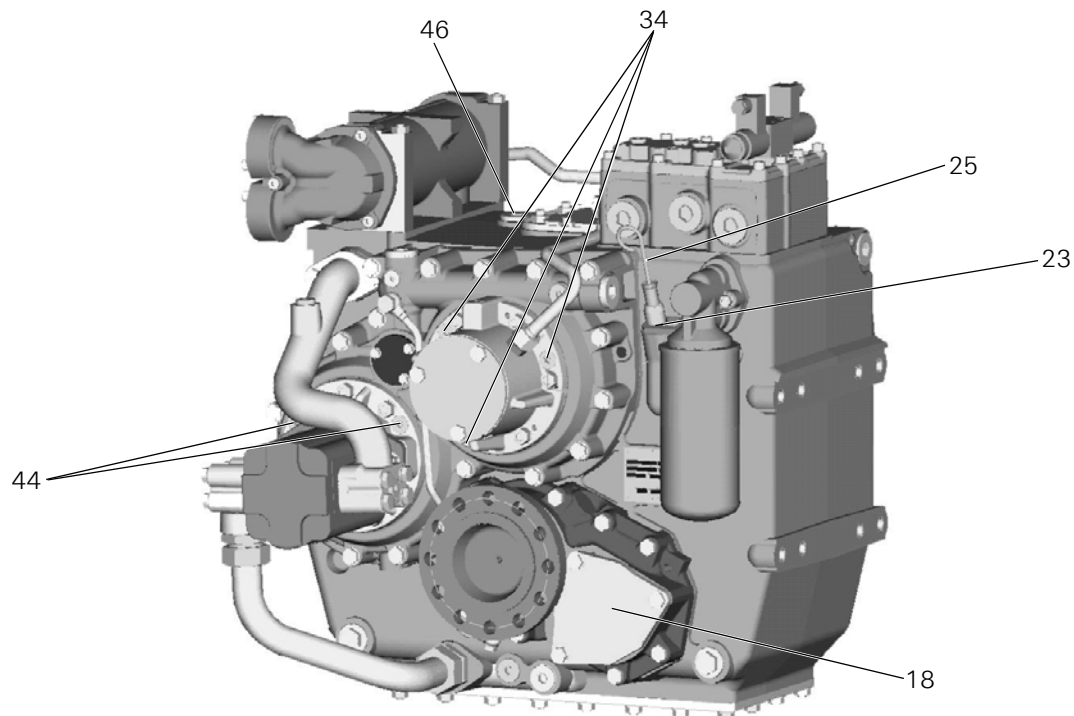




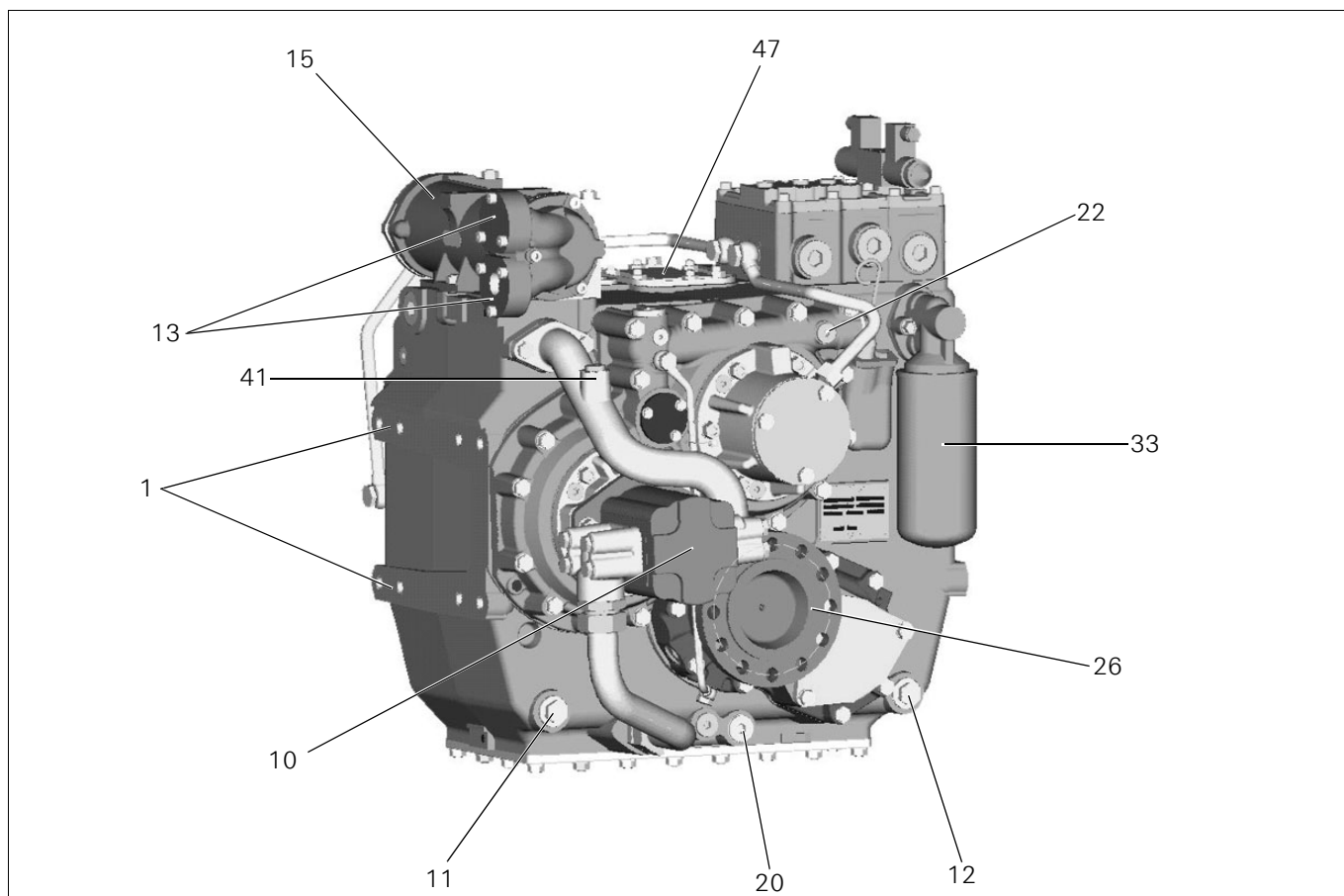
## 2.1.4 Transmission views

### 2.1.4.1 ZF 2000 / ZF 2050 / ZF 2060 / ZF 2070 / ZF 2075 / ZF 2150 / ZF 2000 NR / ZF 2050 NR / ZF 2060 NR / ZF 2070 NR / ZF 2075 NR / ZF 2150 NR

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







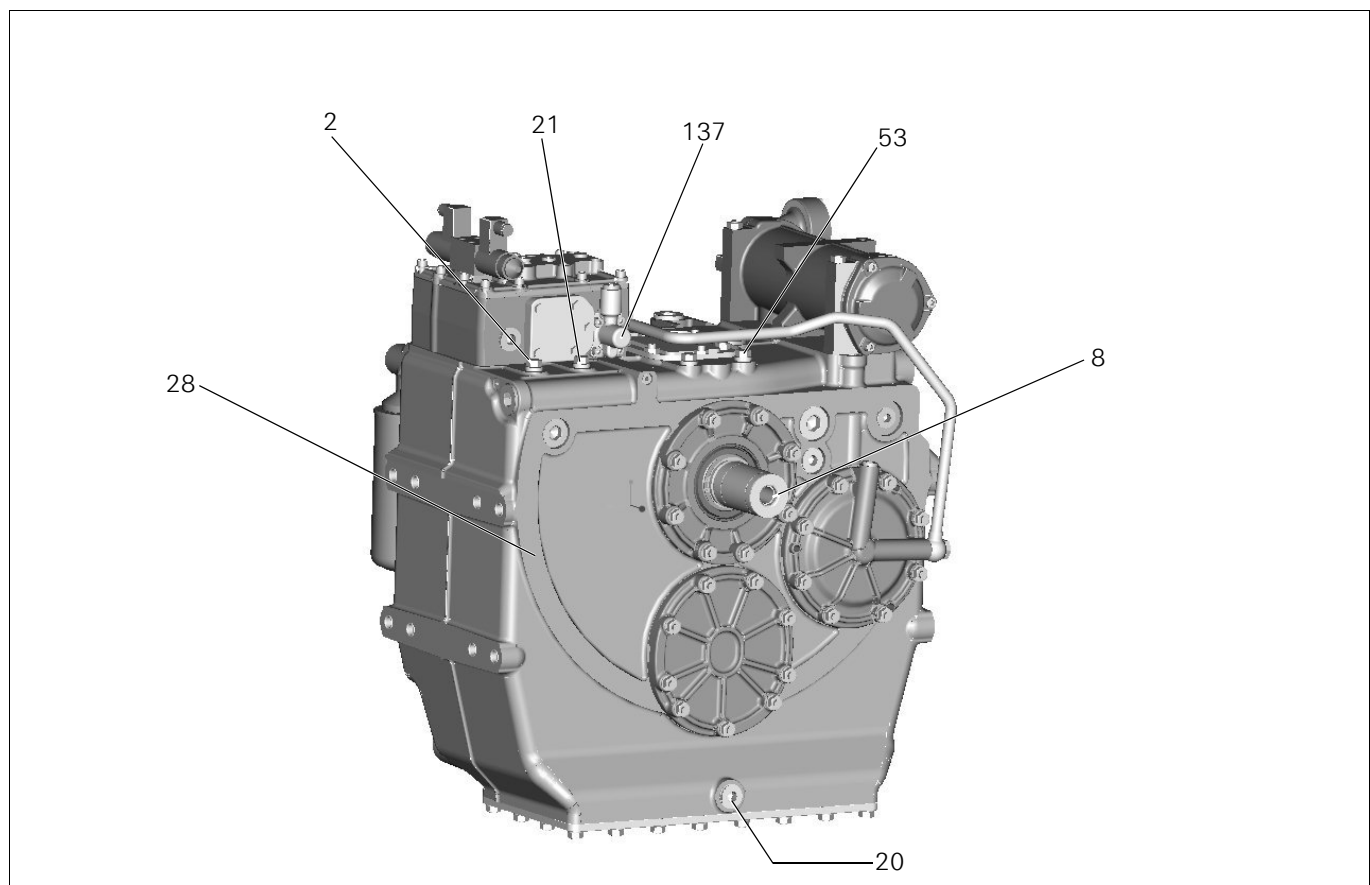
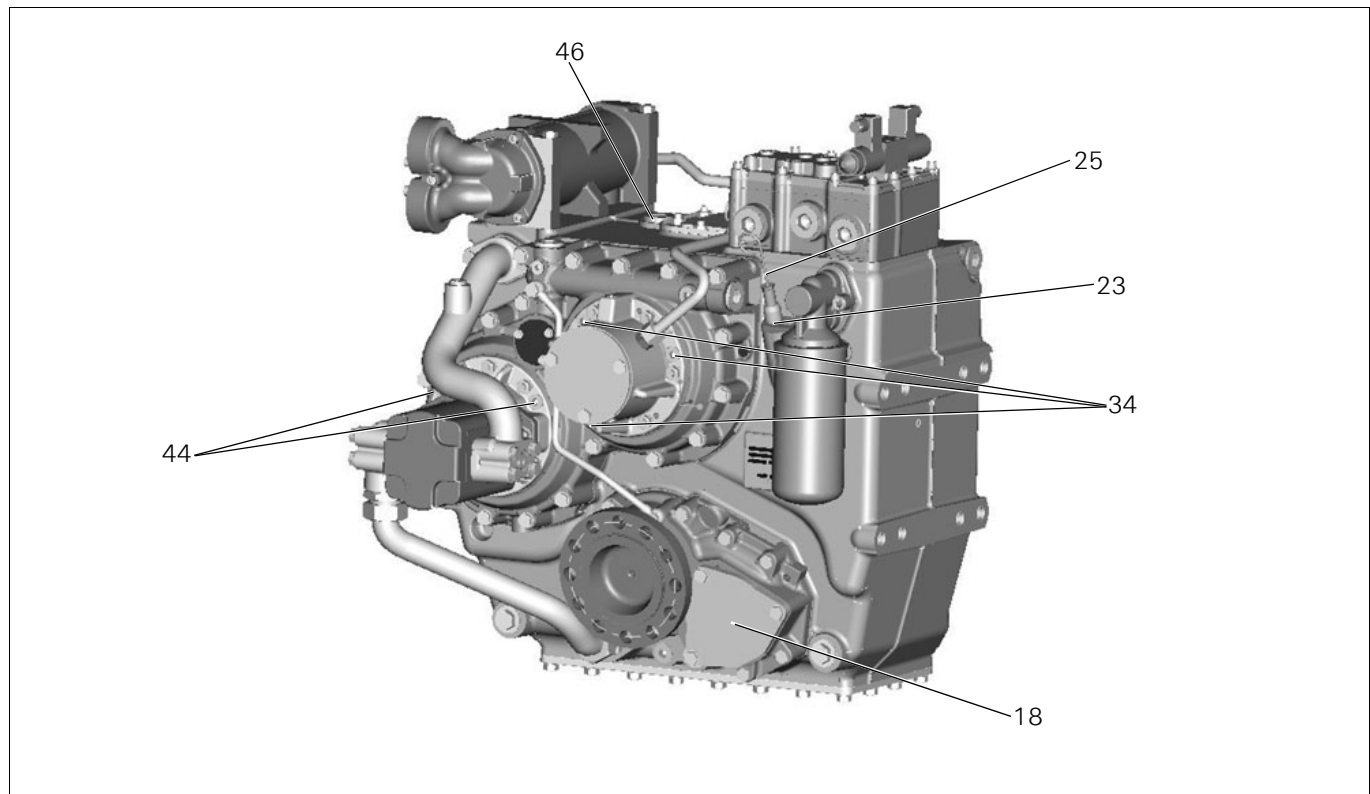
Key to drawing:

|       |   |     |   |
|-------|---|-----|---|
| 1     | Transmission fastening surface                  | 26  | Output  |
| 2/21  | Measuring points for clutch oil pressure        | 28  | Flanging surface for bell housing                   |
| 8     | Input (input flange, special scope of delivery) | 33  | Oil filter  |
| 10    | Engine-dependent oil pump<br>(primary oil pump) | 34  | Emergency control<br>(counter-engine wise rotation) |
| 11/12 | Measuring points for oil temperature            | 41  | Measuring point for oil temperature                 |
| 13    | Water connection flange                         | 44  | Emergency control (engine wise rotation)            |
| 15    | Oil cooler                                      | 46  | Oil filler hole                                     |
| 18    | Position for trailing oil pump                  | 47  | Inspection cover                                    |
| 20    | Oil drain                                       | 53  | Measuring point for oil temperature after<br>cooler |
| 22    | Measuring point for lubricating oil pressure    | 137 | Neutral switch                                      |
| 23    | Transmission vent                               |     |   |
| 25    | Oil dipstick                                    |     |   |

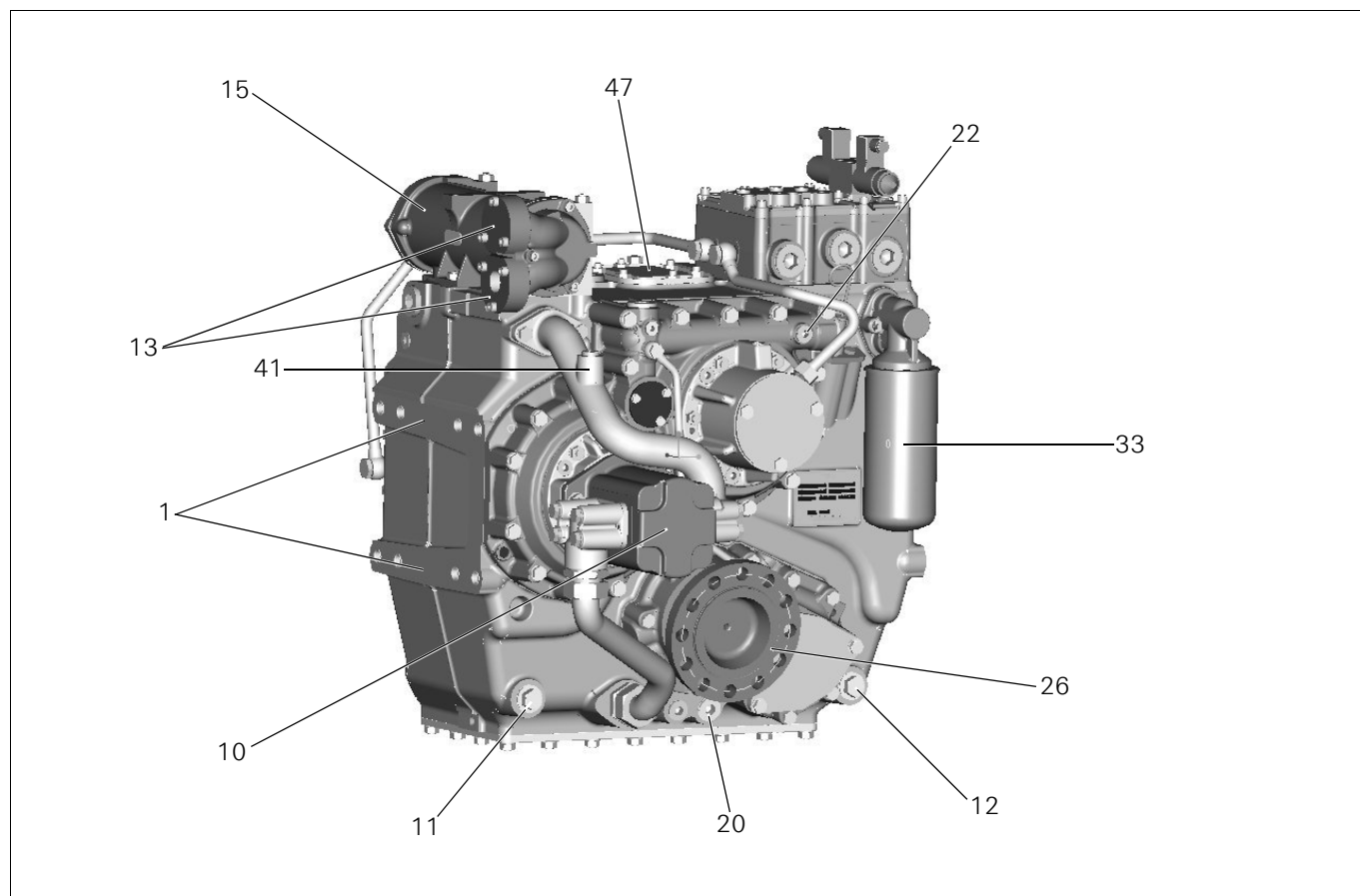


2.1.4.2 ZF 2000 A / ZF 2050 A / ZF 2060 A / ZF 2070 A / ZF 2075 A / ZF 2150 A / ZF 2000 NRA / ZF 2050 NRA / ZF 2060 NRA / ZF 2070 NRA / ZF 2075 NRA / ZF 2150 NRA

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







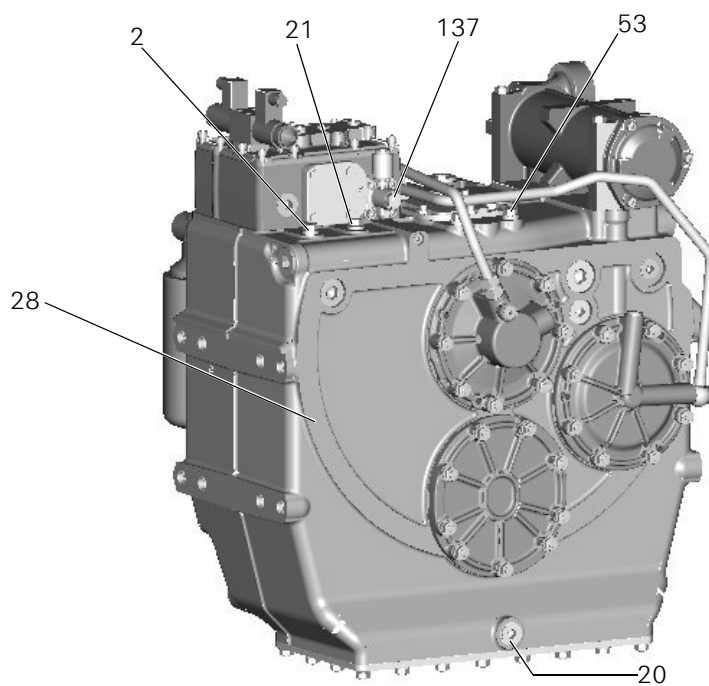
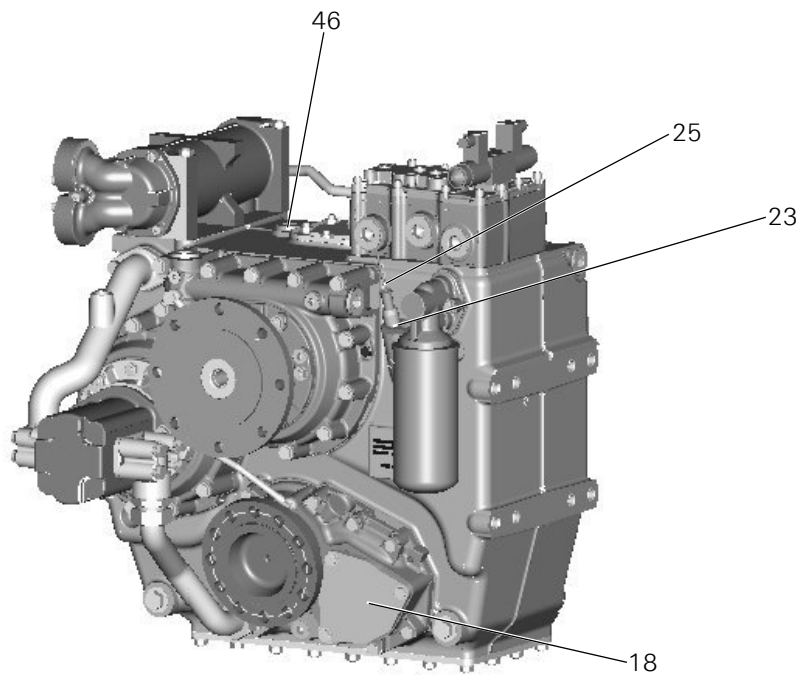
Key to drawing:

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|-------|---|-----|--|
| 1     | Transmission fastening surface                  | 26  | Output   |
| 2/21  | Measuring points for clutch oil pressure        | 28  | Flanging surface for bell housing                |
| 8     | Input (input flange, special scope of delivery) | 33  | Oil filter                                       |
| 10    | Engine-dependent oil pump (primary oil pump)    | 34  | Emergency control (counter-engine wise rotation) |
| 11/12 | Measuring points for oil temperature            | 41  | Measuring point for oil temperature              |
| 13    | Water connection flange                         | 44  | Emergency control (engine wise rotation)         |
| 15    | Oil cooler                                      | 46  | Oil filler hole                                  |
| 18    | Position for trailing oil pump                  | 47  | Inspection cover                                 |
| 20    | Oil drain                                       | 53  | Measuring point for oil temperature after cooler |
| 22    | Measuring point for lubricating oil pressure    | 137 | Neutral switch                                   |
| 23    | Transmission vent                               |     |  |
| 25    | Oil dipstick                                    |     |  |

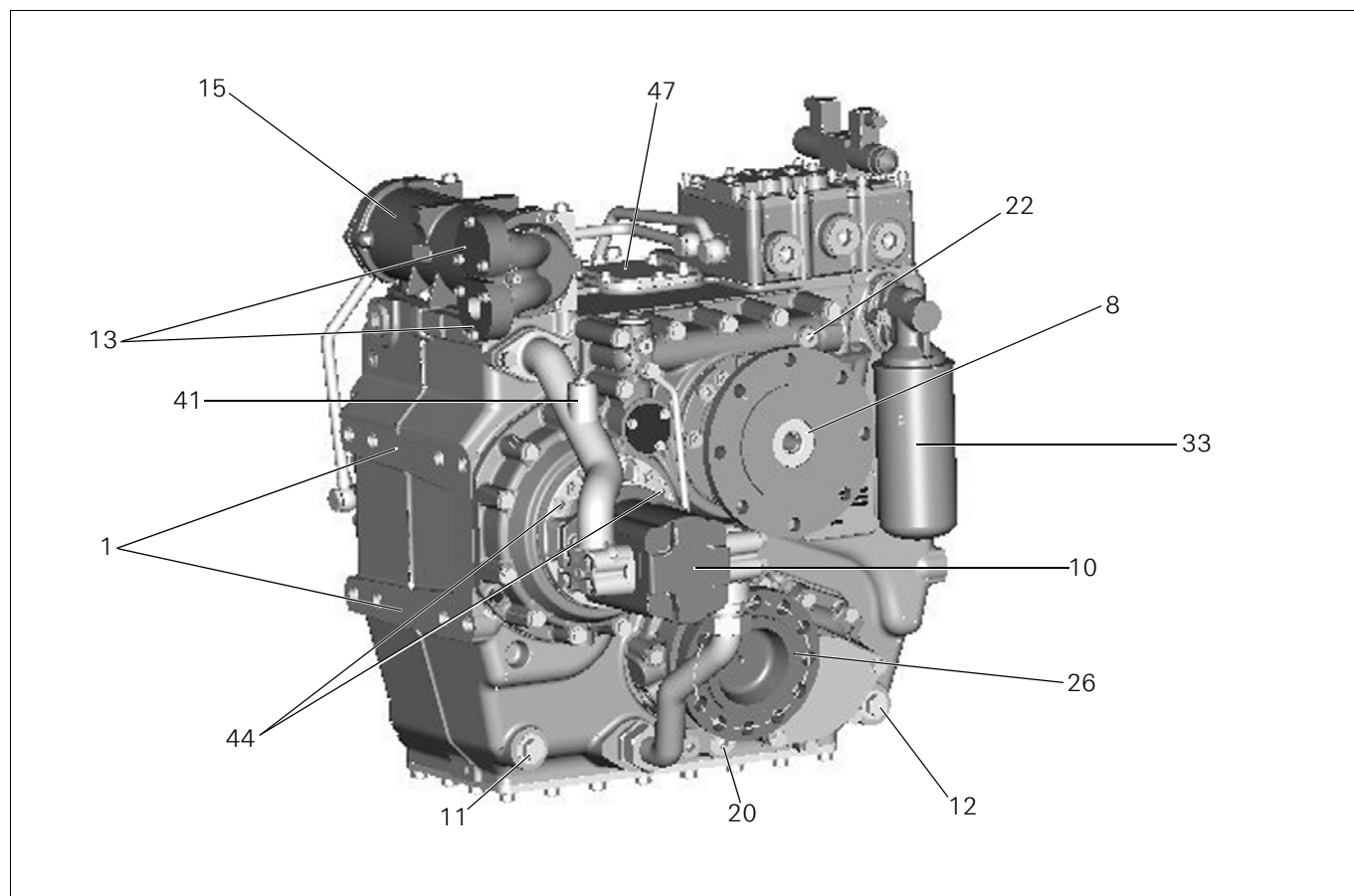


**2.1.4.3 ZF 2000 V / ZF 2050 V / ZF 2060 V / ZF 2070 V / ZF 2075 V / ZF 2150 V / ZF 2000 NRV / ZF 2050 NRV / ZF 2060 NRV / ZF 2070 NRV / ZF 2075 NRV / ZF 2150 NRV**

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







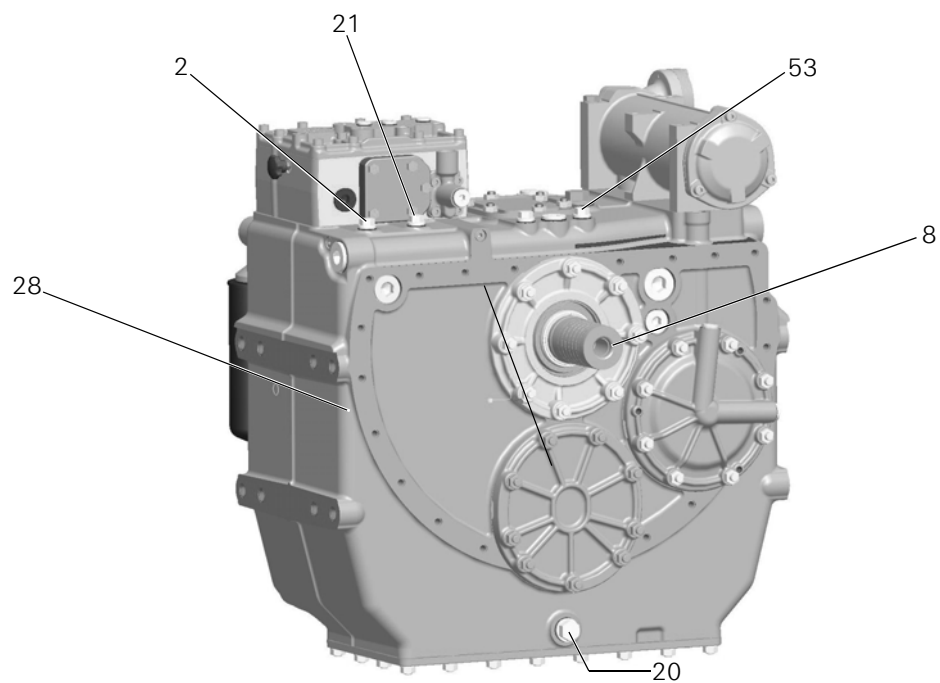
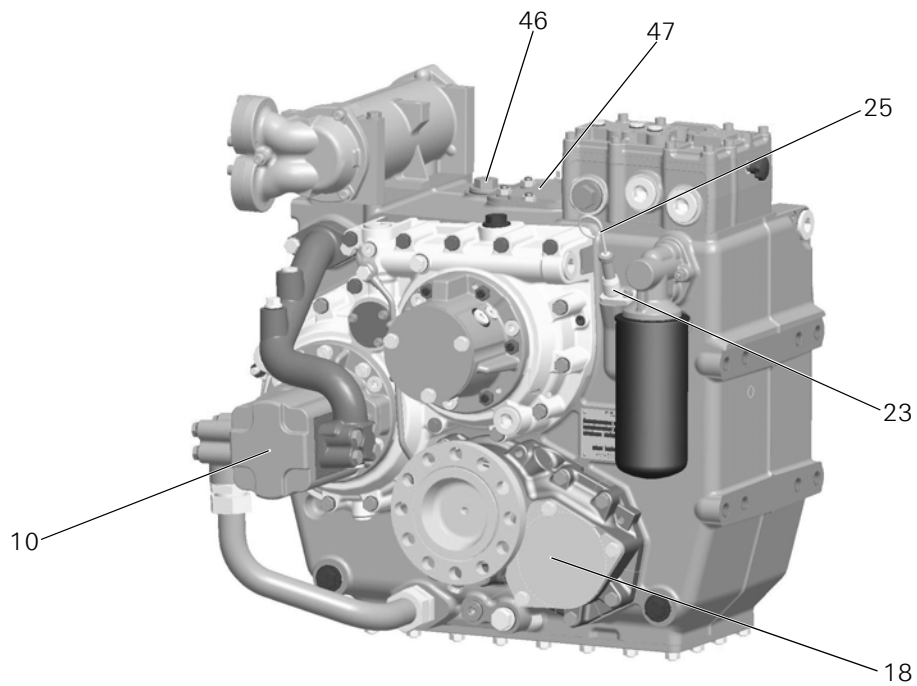
Key to drawing:

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|-------|---|-----|--|
| 1     | Transmission fastening surface                  | 26  | Output   |
| 2/21  | Measuring points for clutch oil pressure        | 28  | Flanging surface for bell housing                |
| 8     | Input (input flange, special scope of delivery) | 33  | Oil filter                                       |
| 10    | Engine-dependent oil pump (primary oil pump)    | 41  | Measuring point for oil temperature              |
| 11/12 | Measuring points for oil temperature            | 44  | Emergency control (engine wise rotation)         |
| 13    | Water connection flange                         | 46  | Oil filler hole                                  |
| 15    | Oil cooler                                      | 47  | Inspection cover                                 |
| 18    | Position for trailing oil pump                  | 53  | Measuring point for oil temperature after cooler |
| 20    | Oil drain                                       | 137 | Neutral switch                                   |
| 22    | Measuring point for lubricating oil pressure    |     |  |
| 23    | Transmission vent                               |     |  |
| 25    | Oil dipstick                                    |     |  |

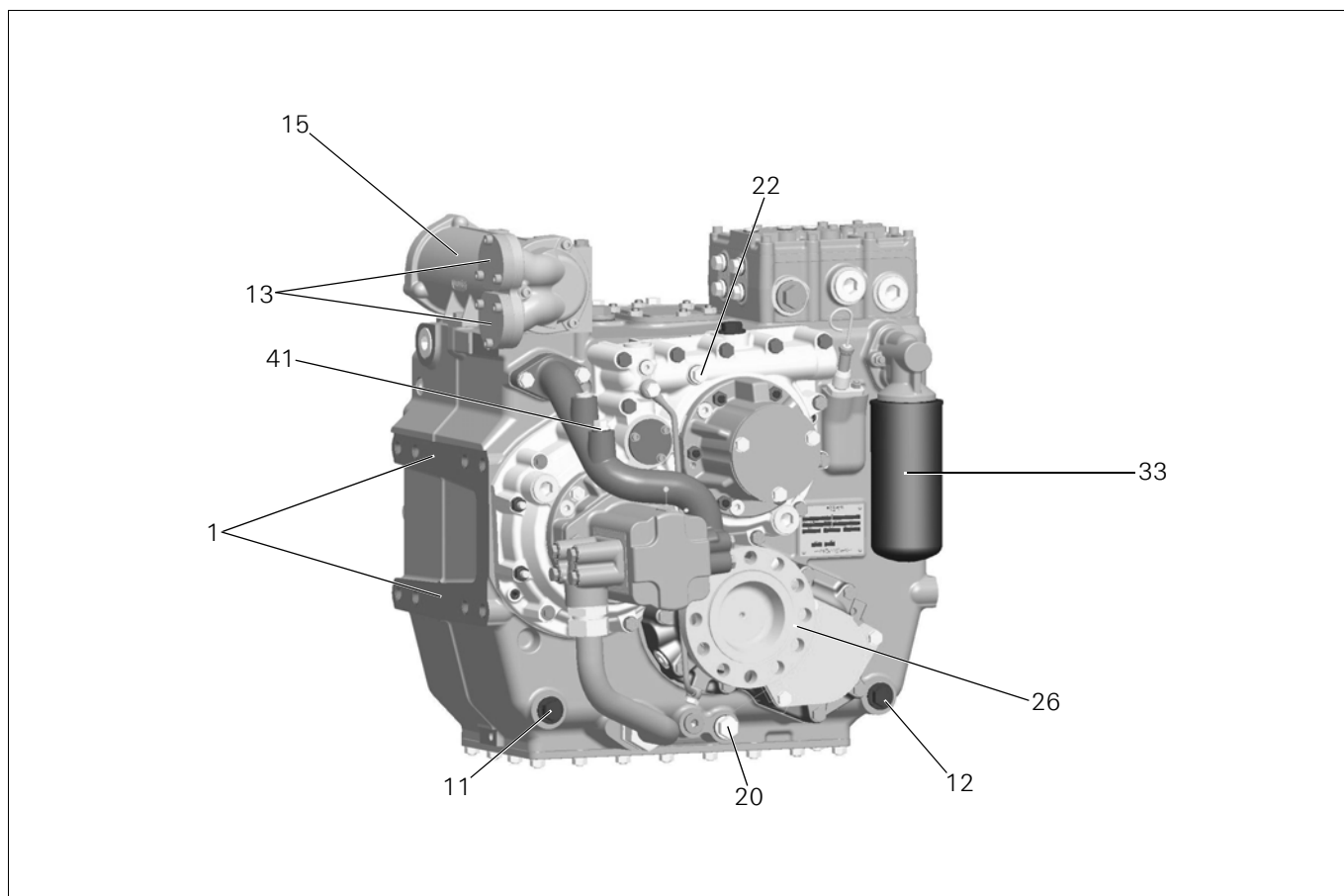


#### 2.1.4.4 ZF 2150 NC

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







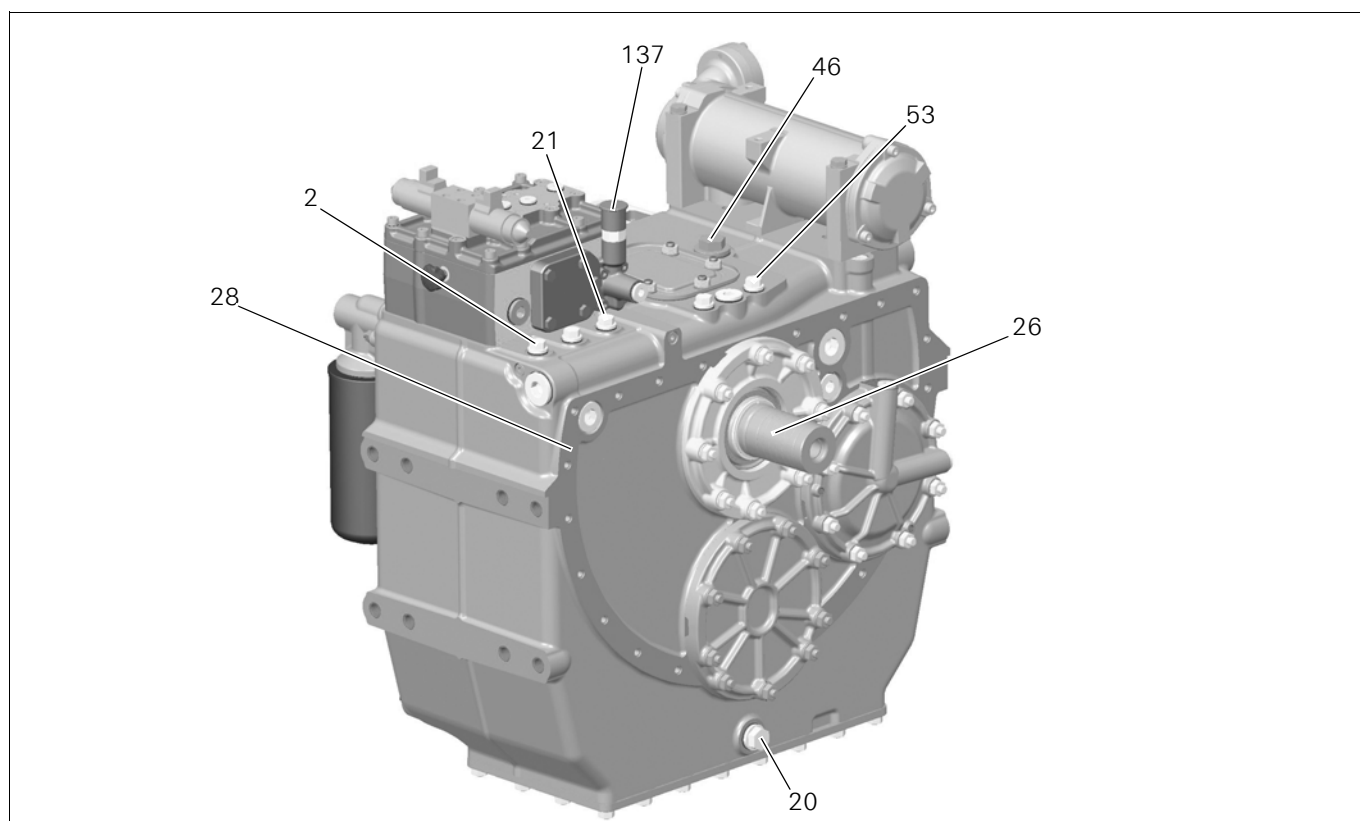
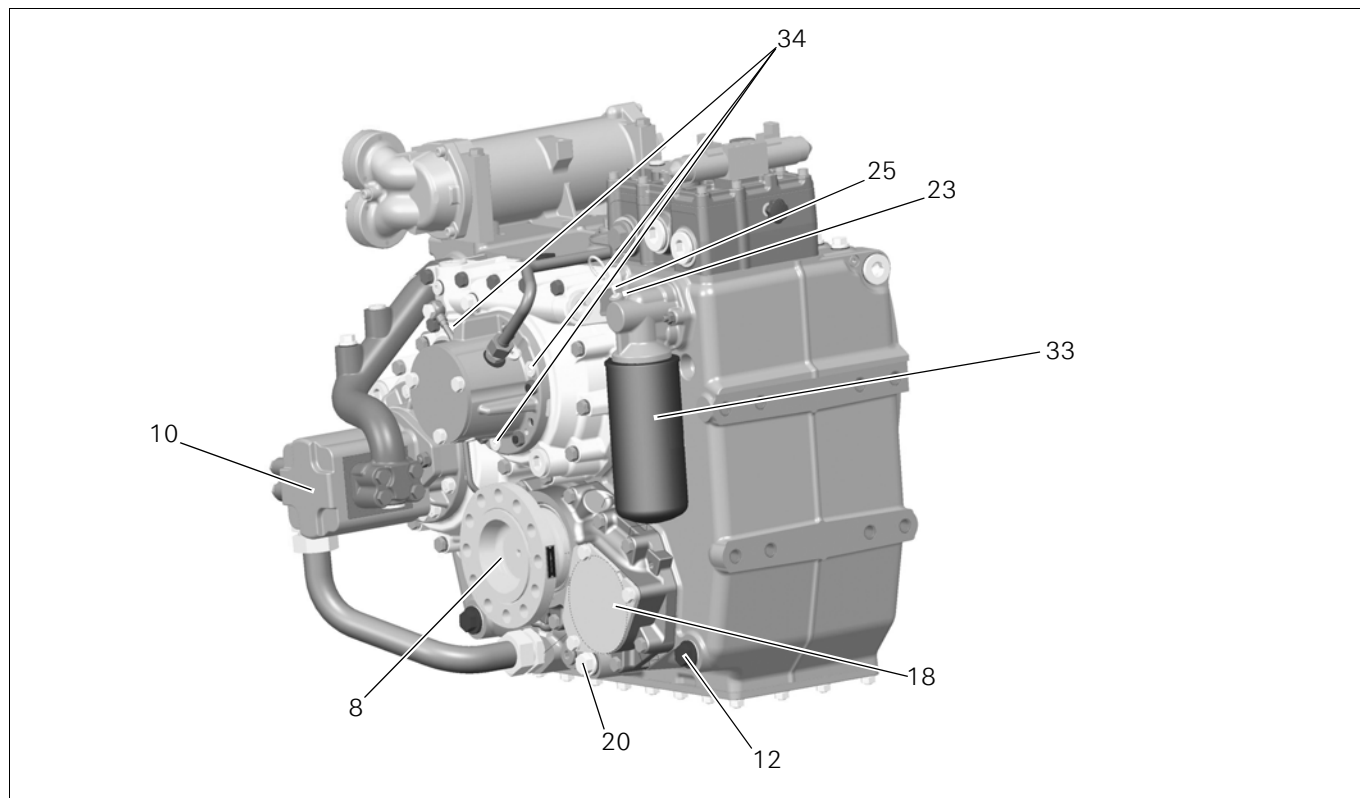
Key to drawing:

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|-------|---|----|--|
| 1     | Transmission fastening surface                  | 26 | Output   |
| 2/21  | Measuring points for clutch pressure            | 28 | Flanging surface for bell housing                |
| 8     | Input (input flange, special scope of delivery) | 33 | Oil filter                                       |
| 10    | Engine-dependent oil pump (primary oil pump)    | 41 | Measuring point for oil temperature              |
| 11/12 | Measuring points for oil temperature            | 46 | Oil filler hole                                  |
| 13    | Water connection flange                         | 47 | Inspection cover                                 |
| 15    | Oil cooler                                      | 53 | Measuring point for oil temperature after cooler |
| 18    | Position for trailing oil pump                  |    |  |
| 20    | Oil drain                                       |    |  |
| 22    | Measuring point for lubricating oil pressure    |    |  |
| 23    | Transmission vent                               |    |  |
| 25    | Oil dipstick                                    |    |  |

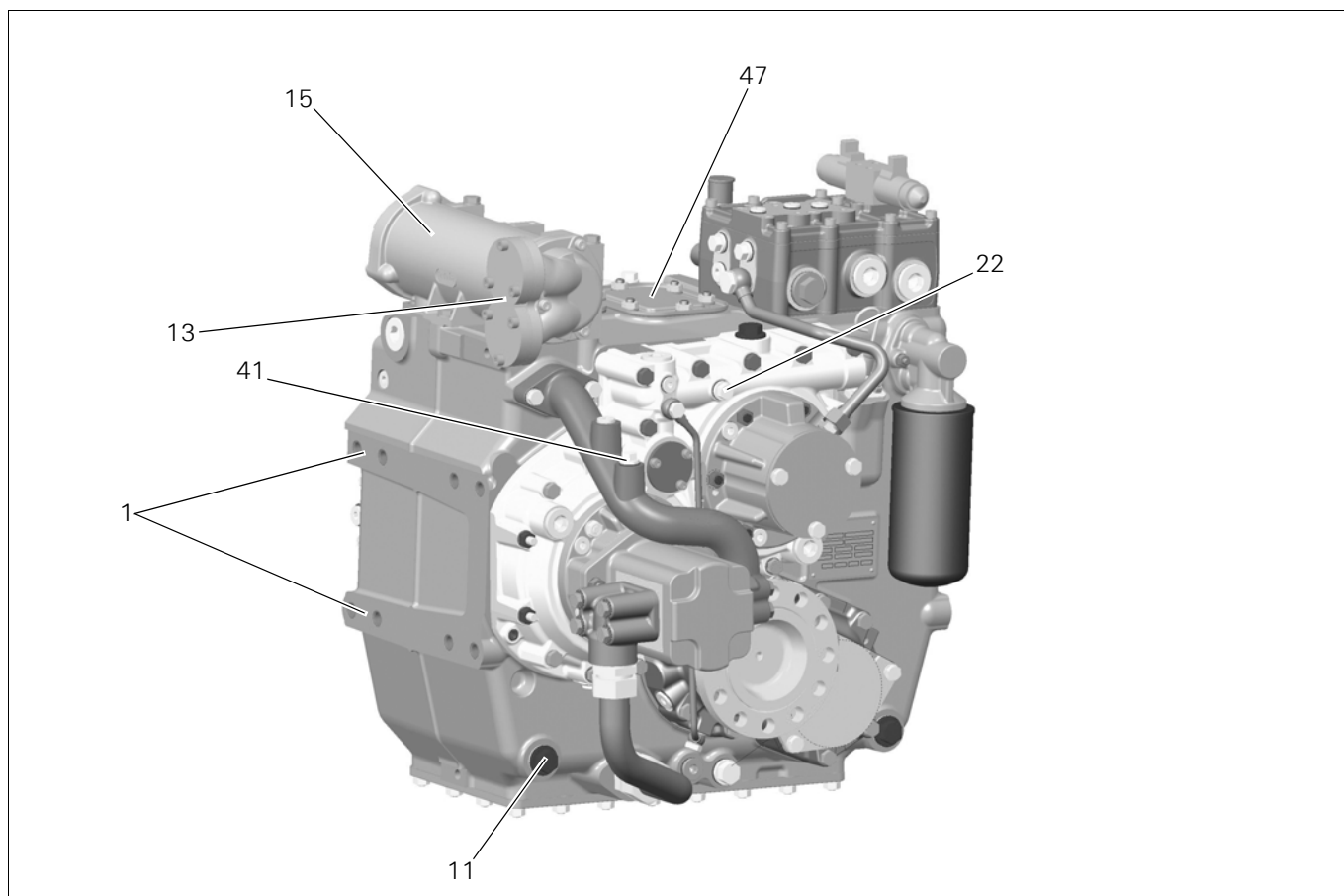


#### 2.1.4.5 ZF 2000 NRB

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







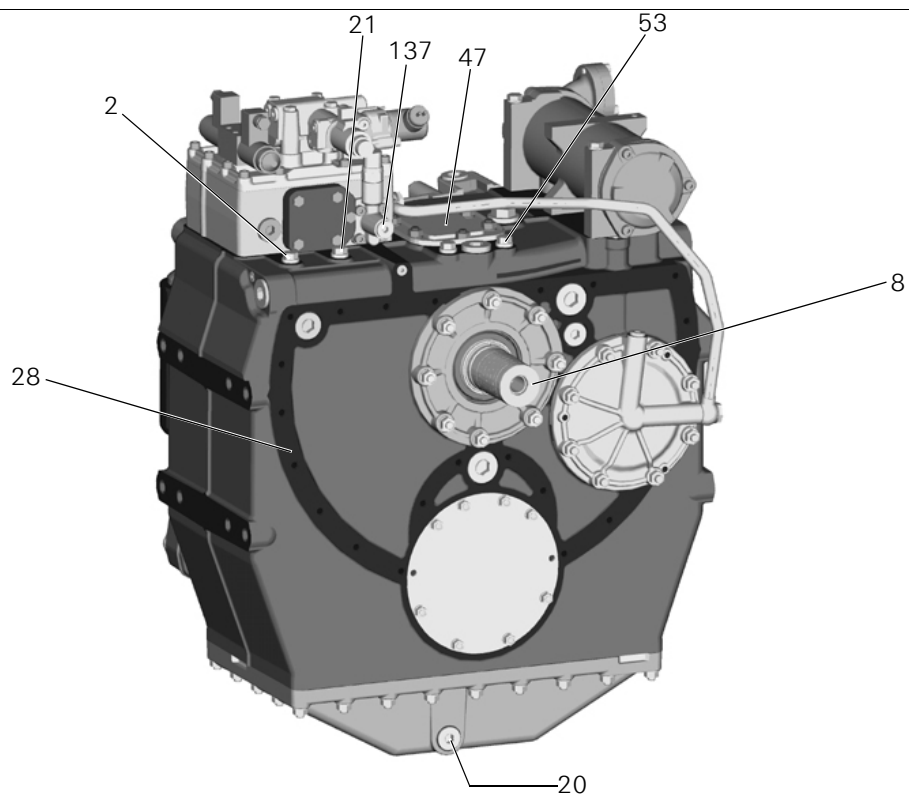
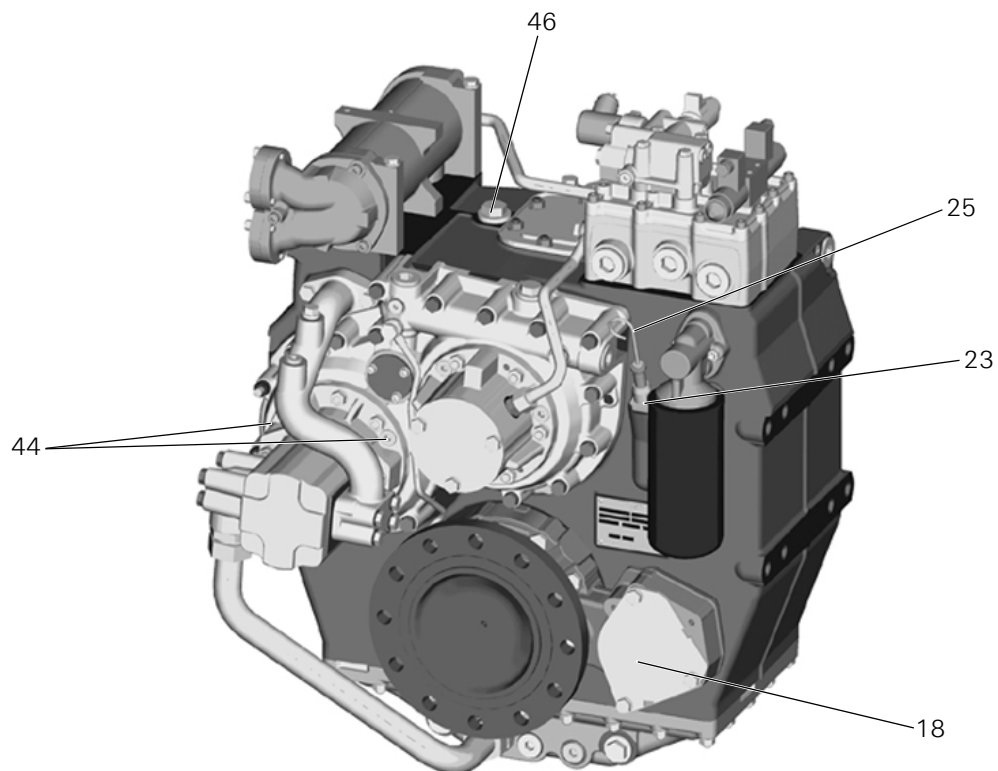
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|-------|---|-----|---|
| 1     | Transmission fastening surface                  | 26  | Output  |
| 2/21  | Measuring points for clutch pressure            | 28  | Flanging surface for bell housing                   |
| 8     | Input (input flange, special scope of delivery) | 33  | Oil filter  |
| 10    | Engine-dependent oil pump<br>(primary oil pump) | 34  | Emergency control<br>(counter-engine wise rotation) |
| 11/12 | Measuring points for oil temperature            | 41  | Measuring point for oil temperature                 |
| 13    | Water connection flange                         | 46  | Oil filler hole                                     |
| 15    | Oil cooler                                      | 47  | Inspection cover                                    |
| 18    | Position for trailing oil pump                  | 53  | Measuring point for oil temperature after<br>cooler |
| 20    | Oil drain                                       | 137 | Neutral switch                                      |
| 22    | Measuring point for lubricating oil pressure    |     |   |
| 23    | Transmission vent                               |     |   |
| 25    | Oil dipstick                                    |     |   |

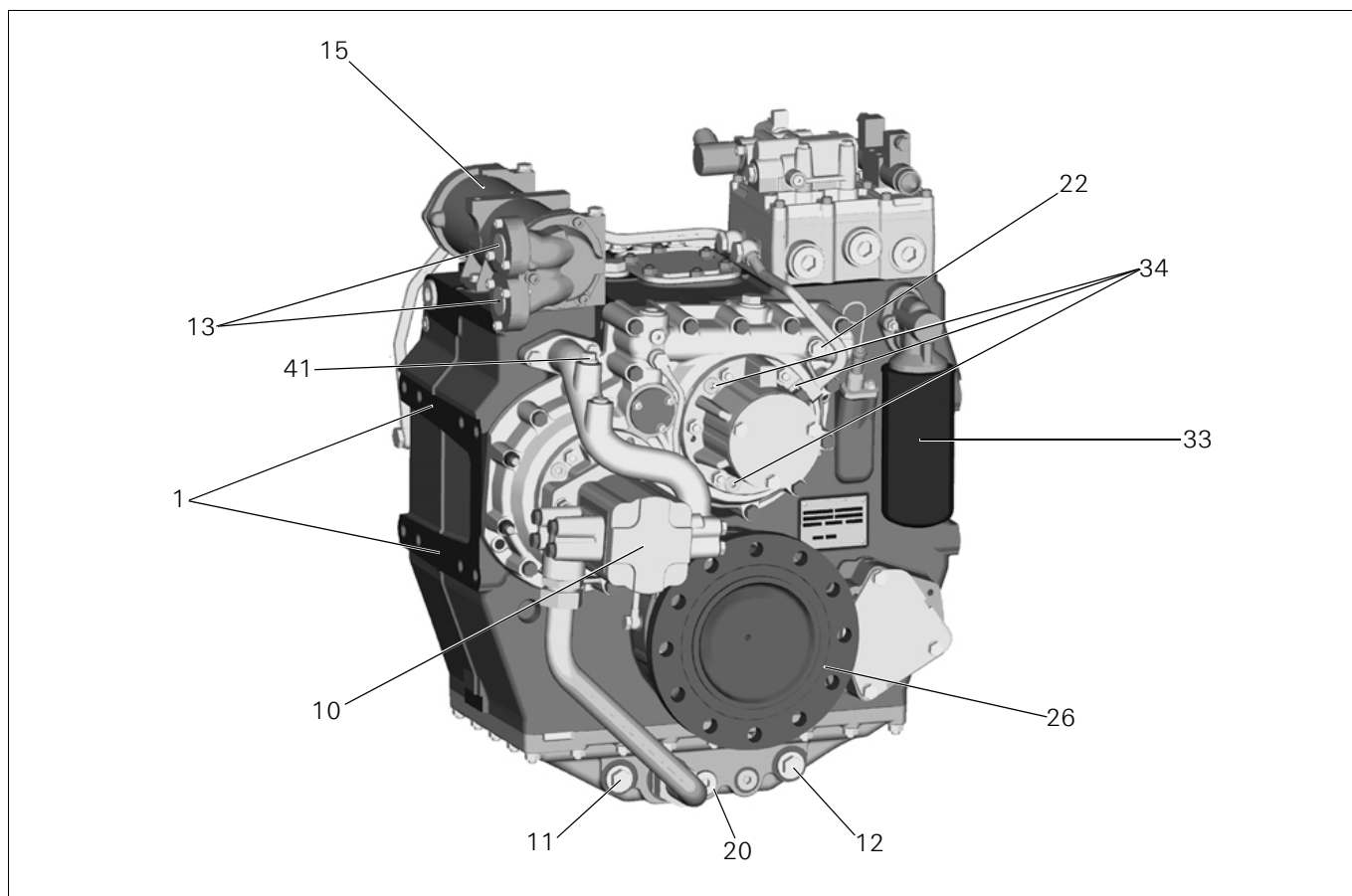


**2.1.4.6 ZF 2200 / ZF 2250 / ZF 2260 / ZF 2270 / ZF 2275 /  
ZF 2200 NR / ZF 2250 NR / ZF 2260 NR / ZF 2270 NR / ZF 2275 NR**

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







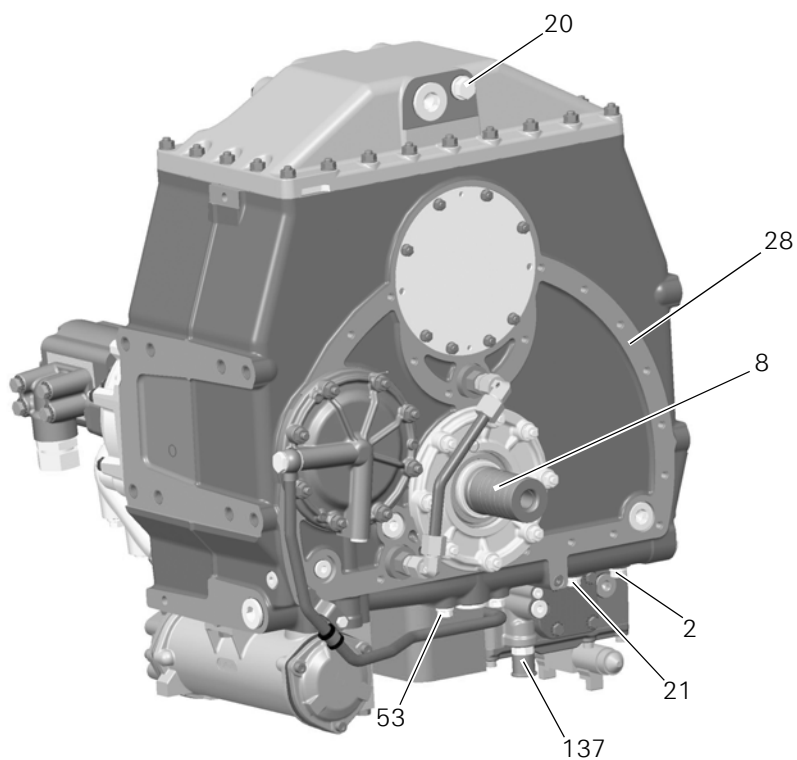
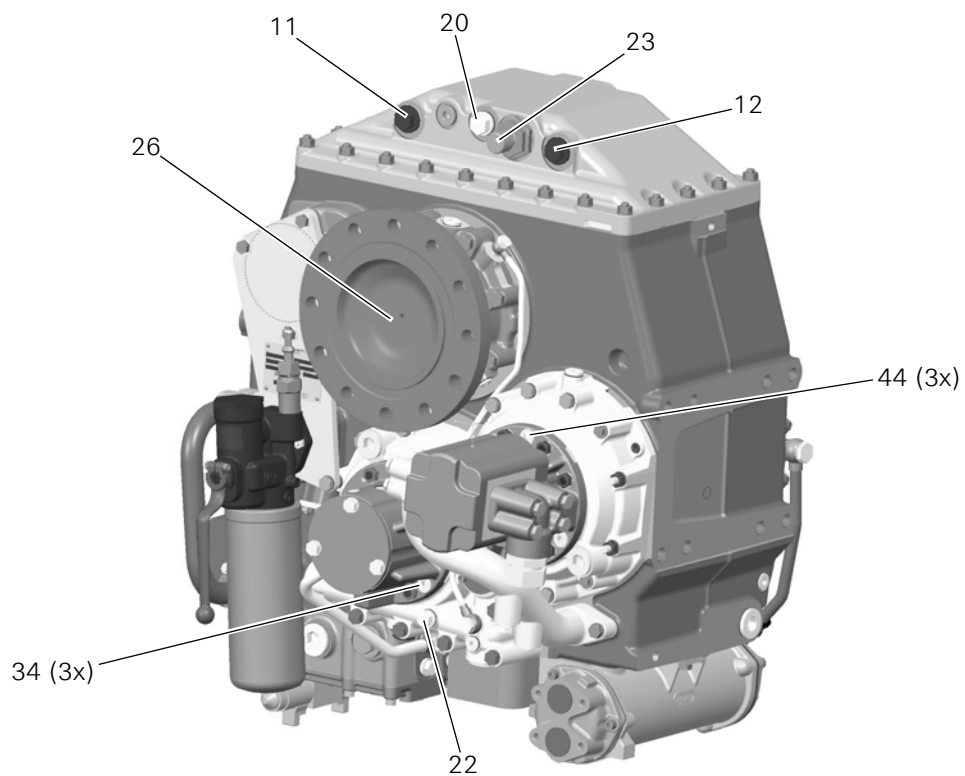
Key to drawing:

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|-------|---|-----|--|
| 1     | Transmission fastening surface                  | 26  | Output   |
| 2/21  | Measuring points for clutch oil pressure        | 28  | Flanging surface for bell housing                |
| 8     | Input (input flange, special scope of delivery) | 33  | Oil filter                                       |
| 10    | Engine-dependent oil pump (primary oil pump)    | 34  | Emergency control (counter-engine wise rotation) |
| 11/12 | Measuring points for oil temperature            | 41  | Measuring point for oil temperature              |
| 13    | Water connection flange                         | 44  | Emergency control (engine wise rotation)         |
| 15    | Oil cooler                                      | 46  | Oil filler hole                                  |
| 18    | Position for trailing oil pump                  | 47  | Inspection cover                                 |
| 20    | Oil drain                                       | 53  | Measuring point for oil temperature after cooler |
| 22    | Measuring point for lubricating oil pressure    | 137 | Neutral switch                                   |
| 23    | Transmission vent                               |     |  |
| 25    | Oil dipstick                                    |     |  |

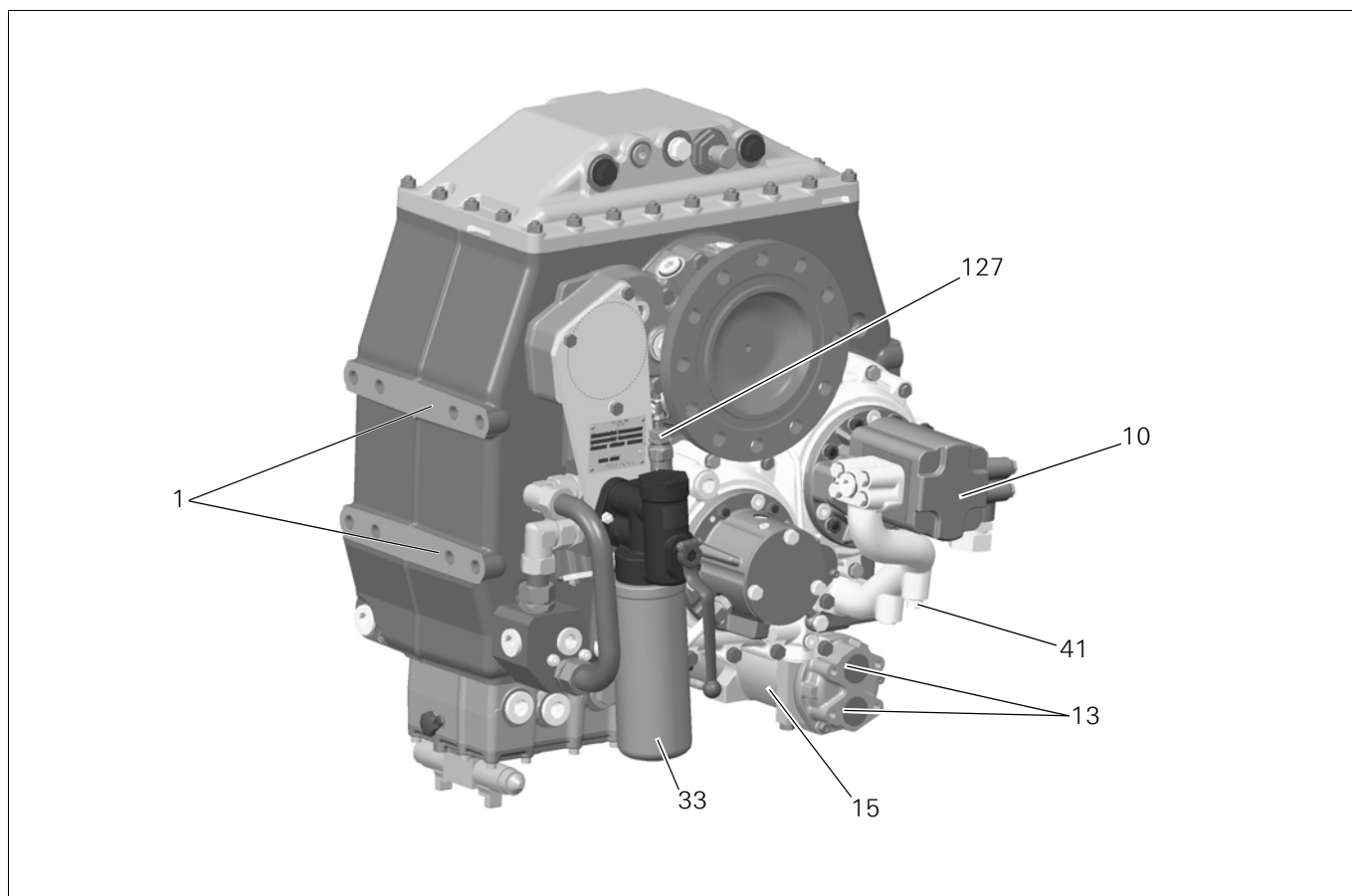


### 2.1.4.7 ZF 2200 B

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







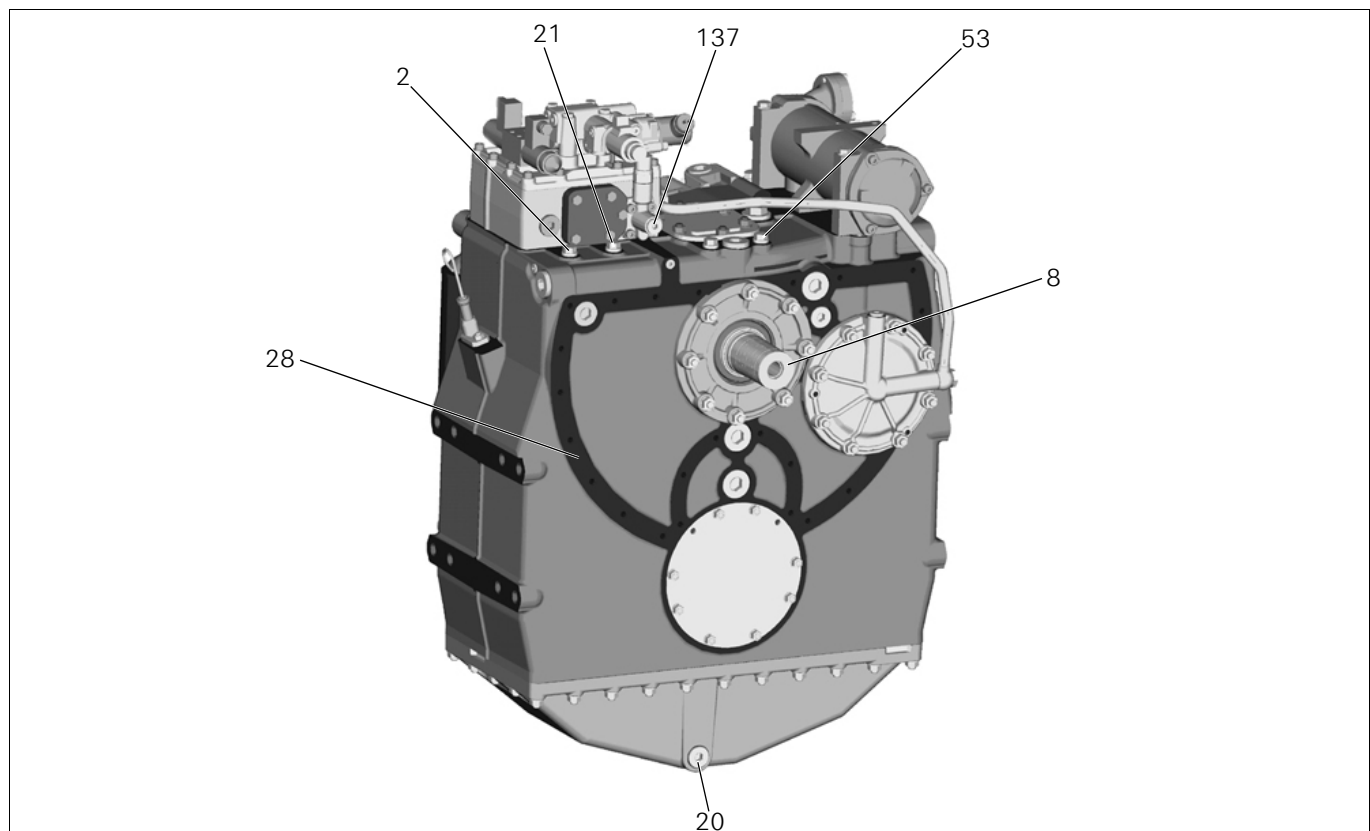
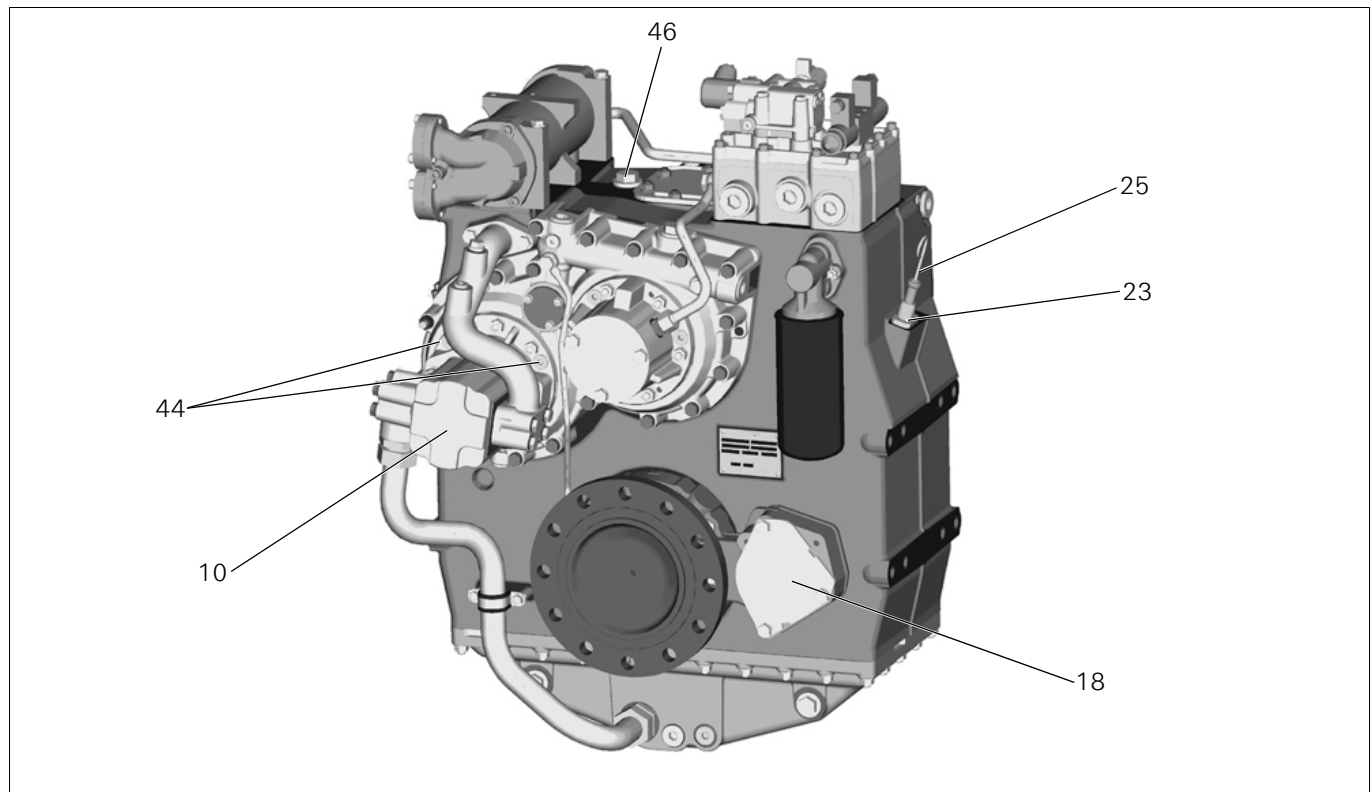
Key to drawing:

|       |   |     |   |
|-------|---|-----|---|
| 1     | Transmission fastening surface                  | 26  | Output  |
| 2/21  | Measuring points for clutch oil pressure        | 28  | Flanging surface for bell housing                     |
| 8     | Input (input flange, special scope of delivery) | 33  | Oil filter  |
| 10    | Engine-dependent oil pump (primary oil pump)    | 34  | Emergency control (counter-engine wise rotation)      |
| 11/12 | Measuring points for oil temperature            | 41  | Measuring point for oil temperature                   |
| 13    | Water connection flange                         | 44  | Emergency control (engine wise rotation)              |
| 15    | Oil cooler                                      | 53  | Measuring point for oil temperature after cooler      |
| 20    | Oil drain                                       | 127 | Differential pressure switch for filter contamination |
| 22    | Measuring point for lubricating oil pressure    | 137 | Neutral switch  |
| 23    | Transmission vent                               |     |   |
| 25    | Oil dipstick                                    |     |   |

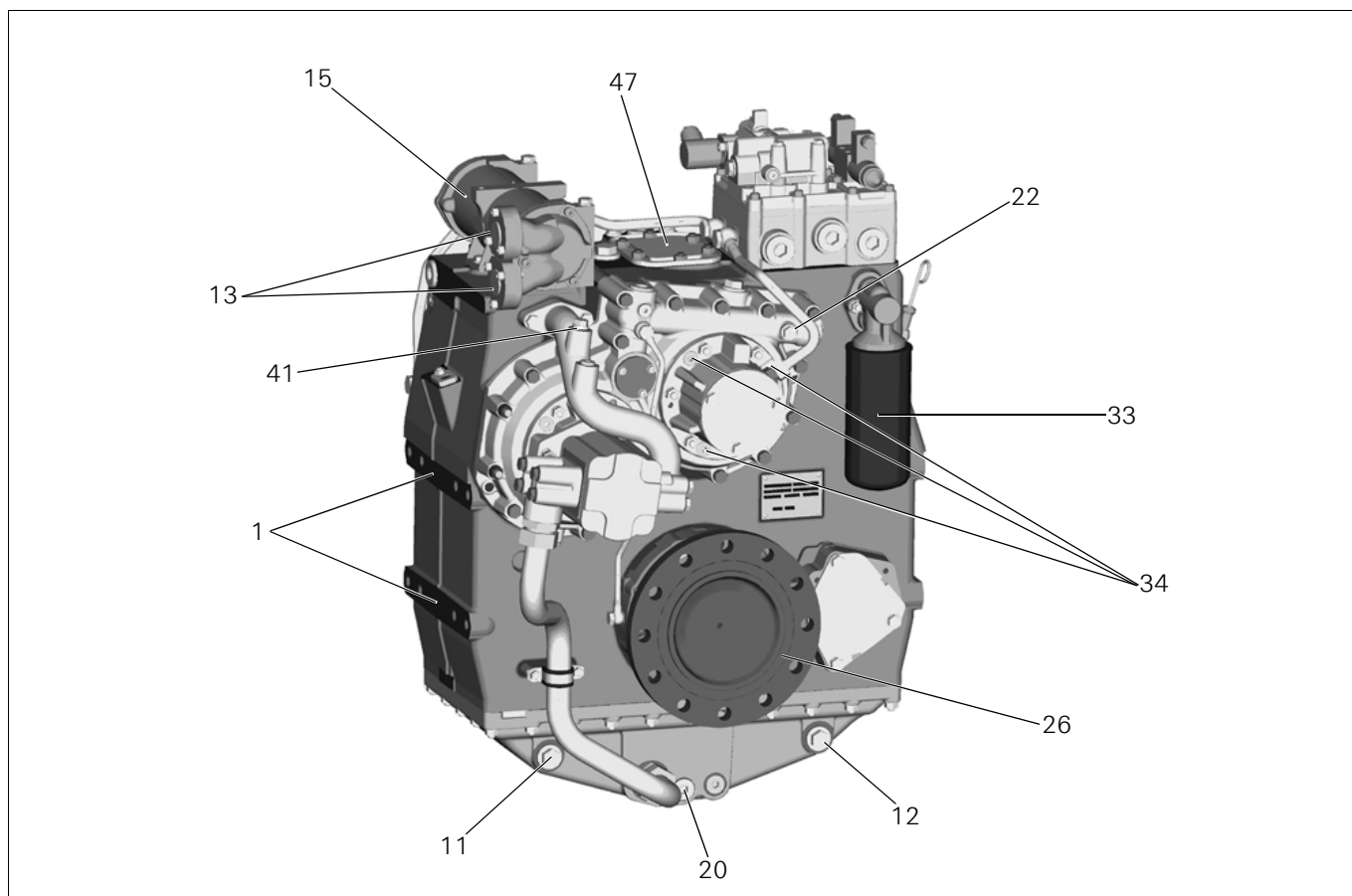


**2.1.4.8 ZF 2300 / ZF 2350 / ZF 2360 / ZF 2370 / ZF 2375 / ZF W2300 / ZF W2350 / ZF 2300 NR / ZF 2350 NR / ZF 2360 NR / ZF 2370 NR / ZF 2375 NR / ZF W2300 NR / ZF W2350 NR**

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







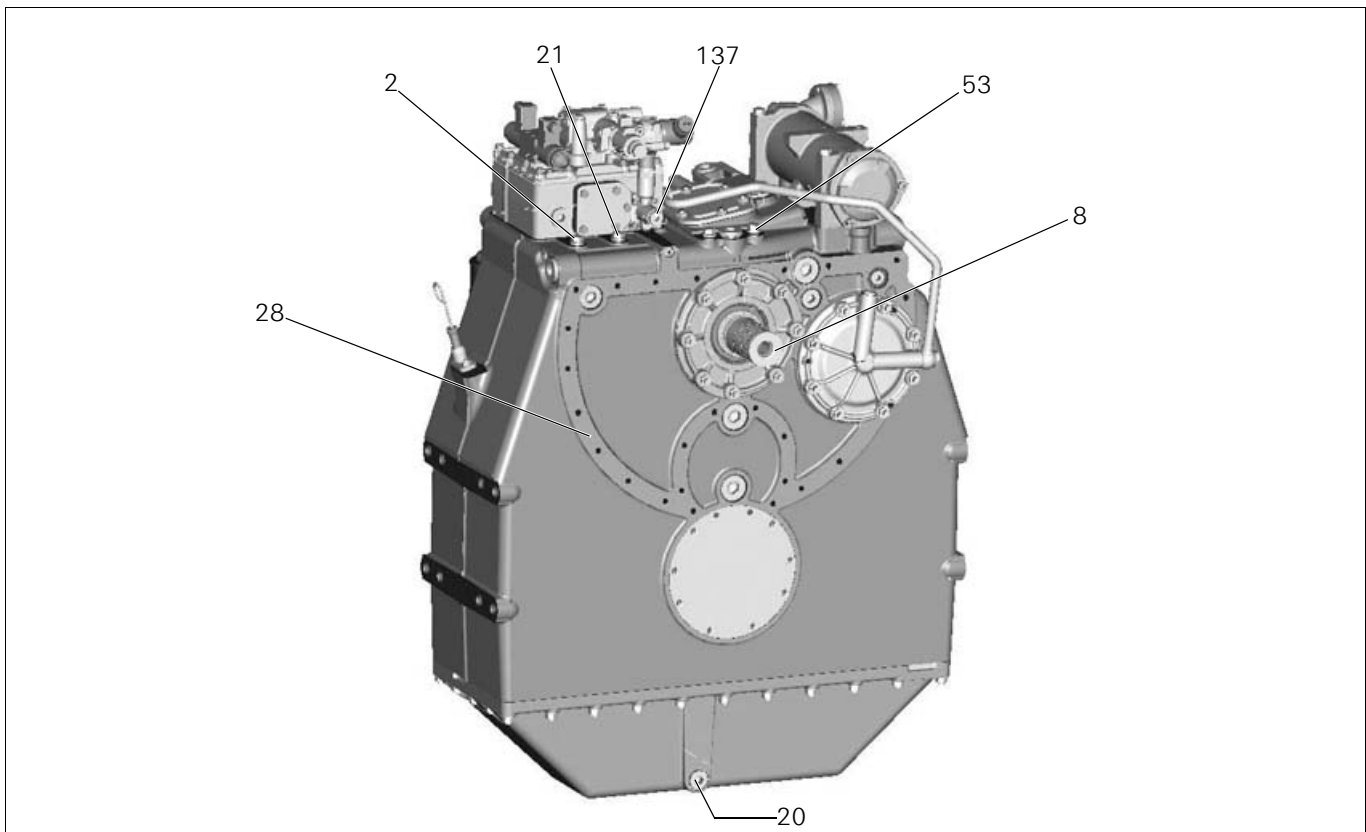
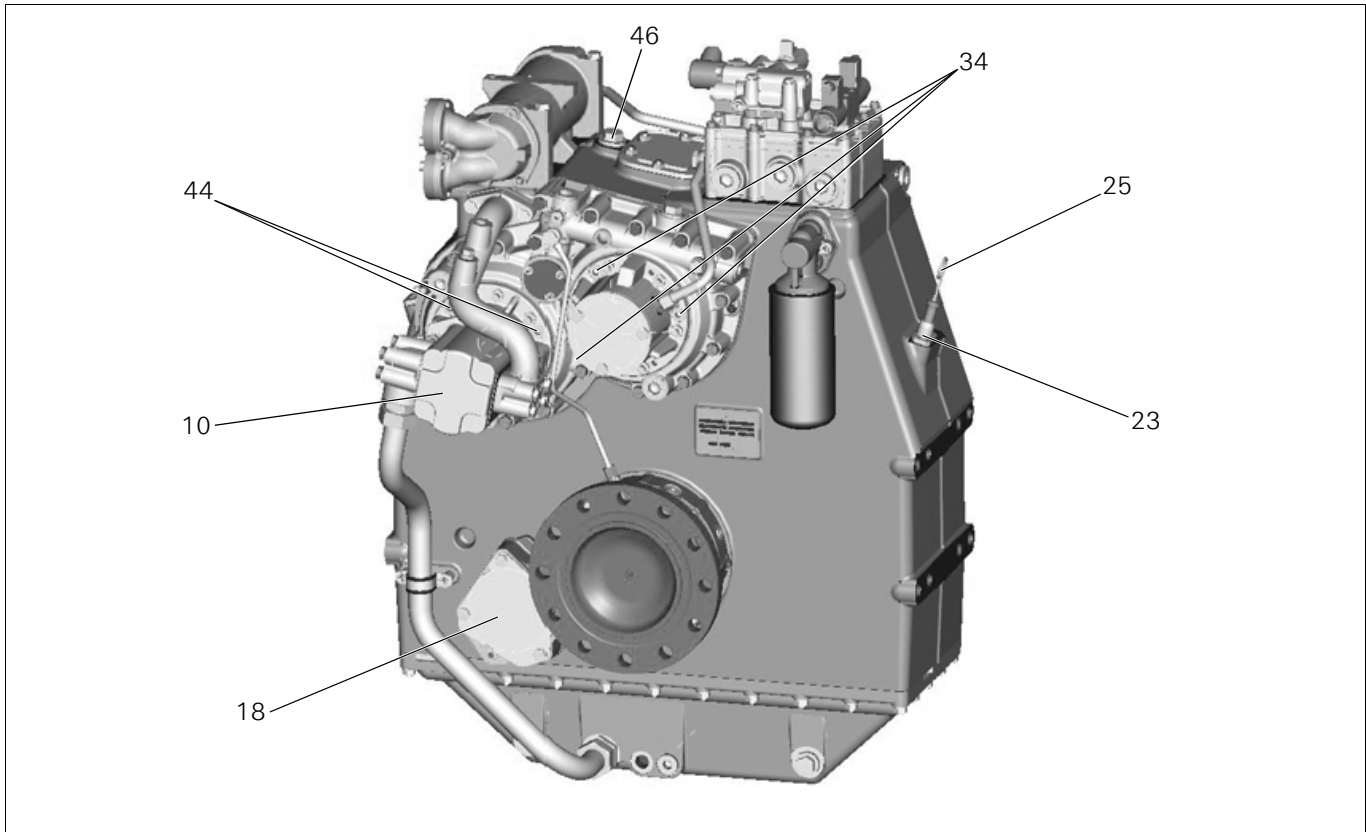
Key to drawing:

|       |   |     |  |
|-------|---|-----|--|
| 1     | Transmission fastening surface                  | 26  | Output   |
| 2/21  | Measuring points for clutch oil pressure        | 28  | Flanging surface for bell housing                |
| 8     | Input (input flange, special scope of delivery) | 33  | Oil filter                                       |
| 10    | Engine-dependent oil pump (primary oil pump)    | 34  | Emergency control (counter-engine wise rotation) |
| 11/12 | Measuring points for oil temperature            | 41  | Measuring point for oil temperature              |
| 13    | Water connection flange                         | 44  | Emergency control (engine wise rotation)         |
| 15    | Oil cooler                                      | 46  | Oil filler hole                                  |
| 18    | Position for trailing oil pump                  | 47  | Inspection cover                                 |
| 20    | Oil drain                                       | 53  | Measuring point for oil temperature after cooler |
| 22    | Measuring point for lubricating oil pressure    | 137 | Neutral switch                                   |
| 23    | Transmission vent                               |     |  |
| 25    | Oil dipstick                                    |     |  |

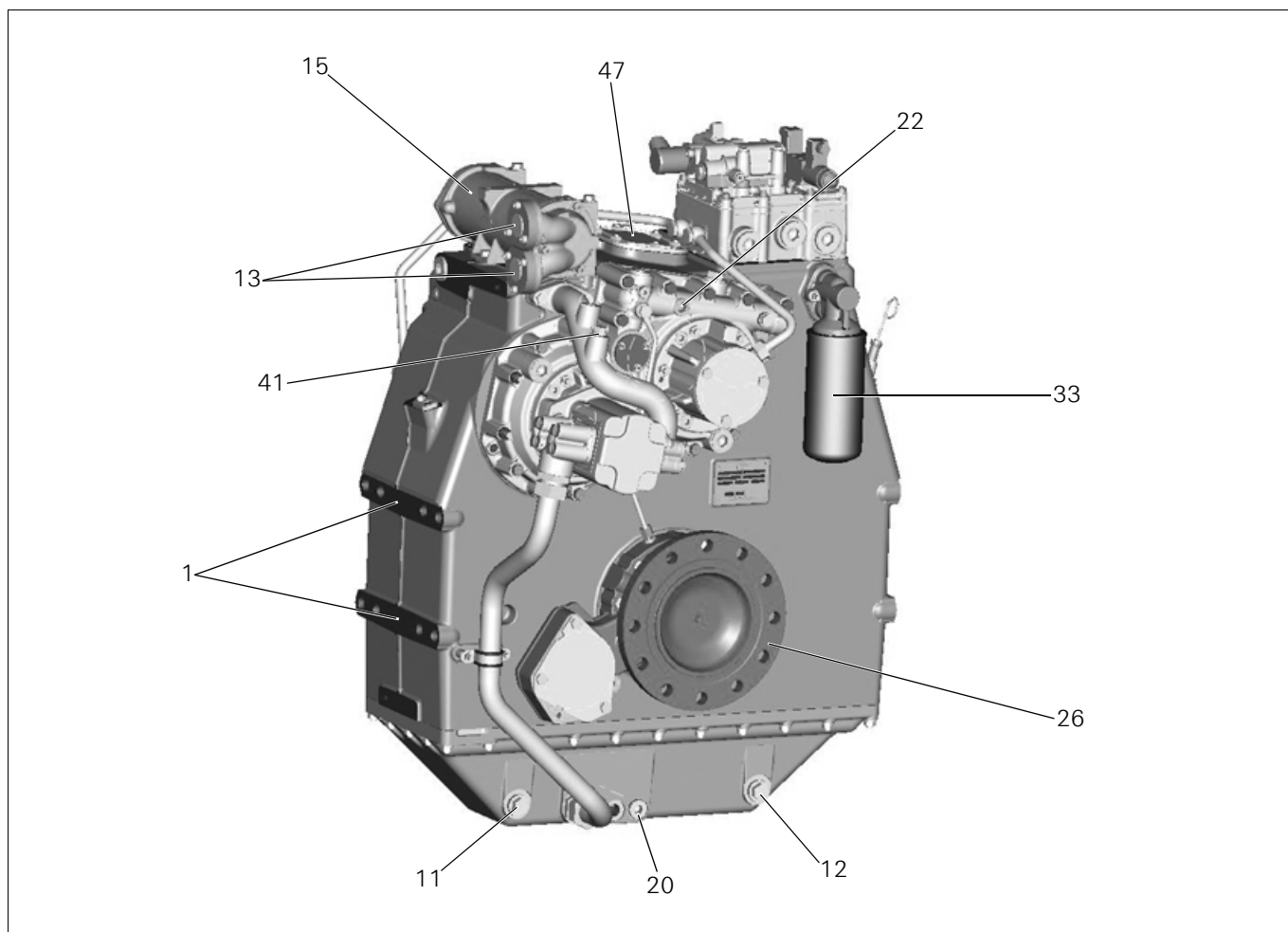


#### 2.1.4.9 ZF W2400 / ZF W2450 / ZF W2400 NR / ZF W2450 NR

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







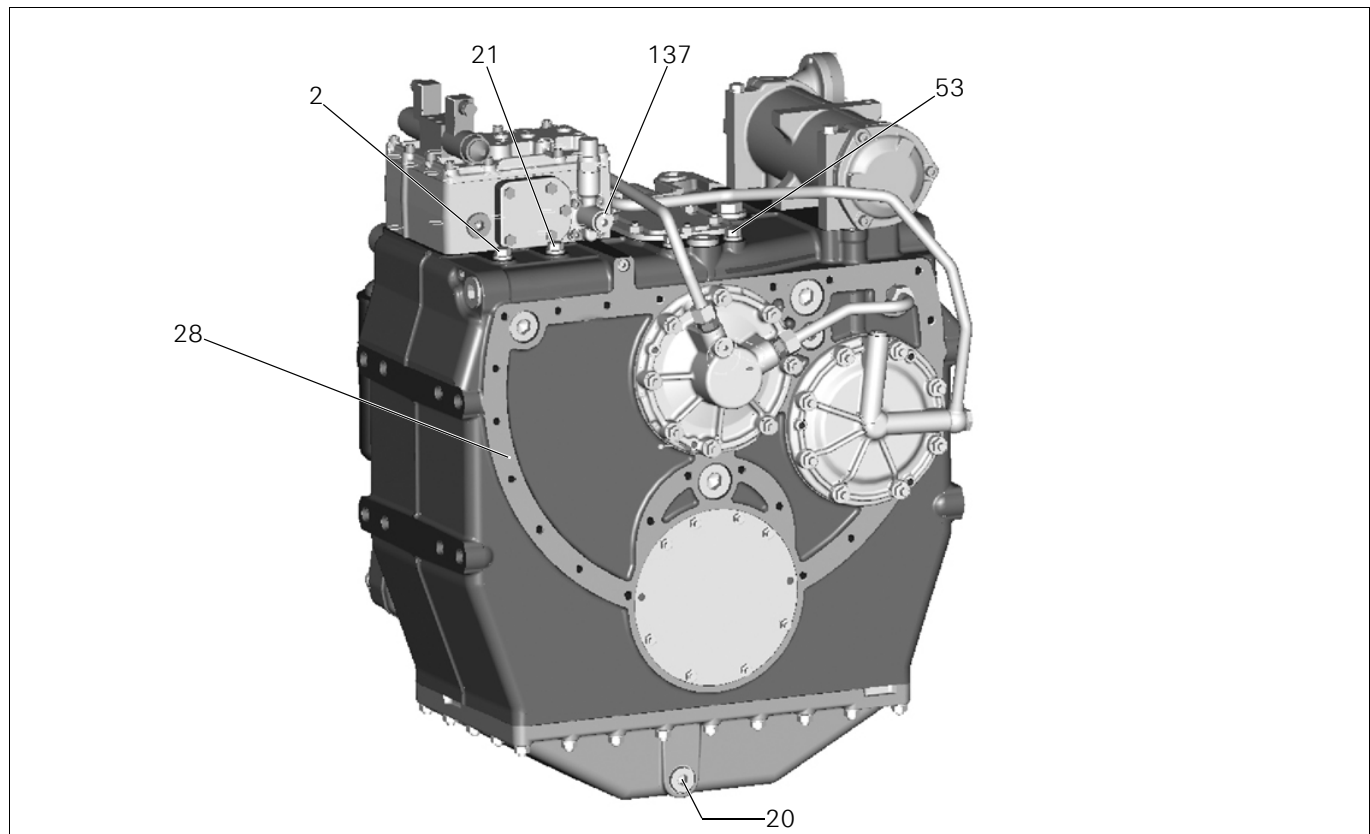
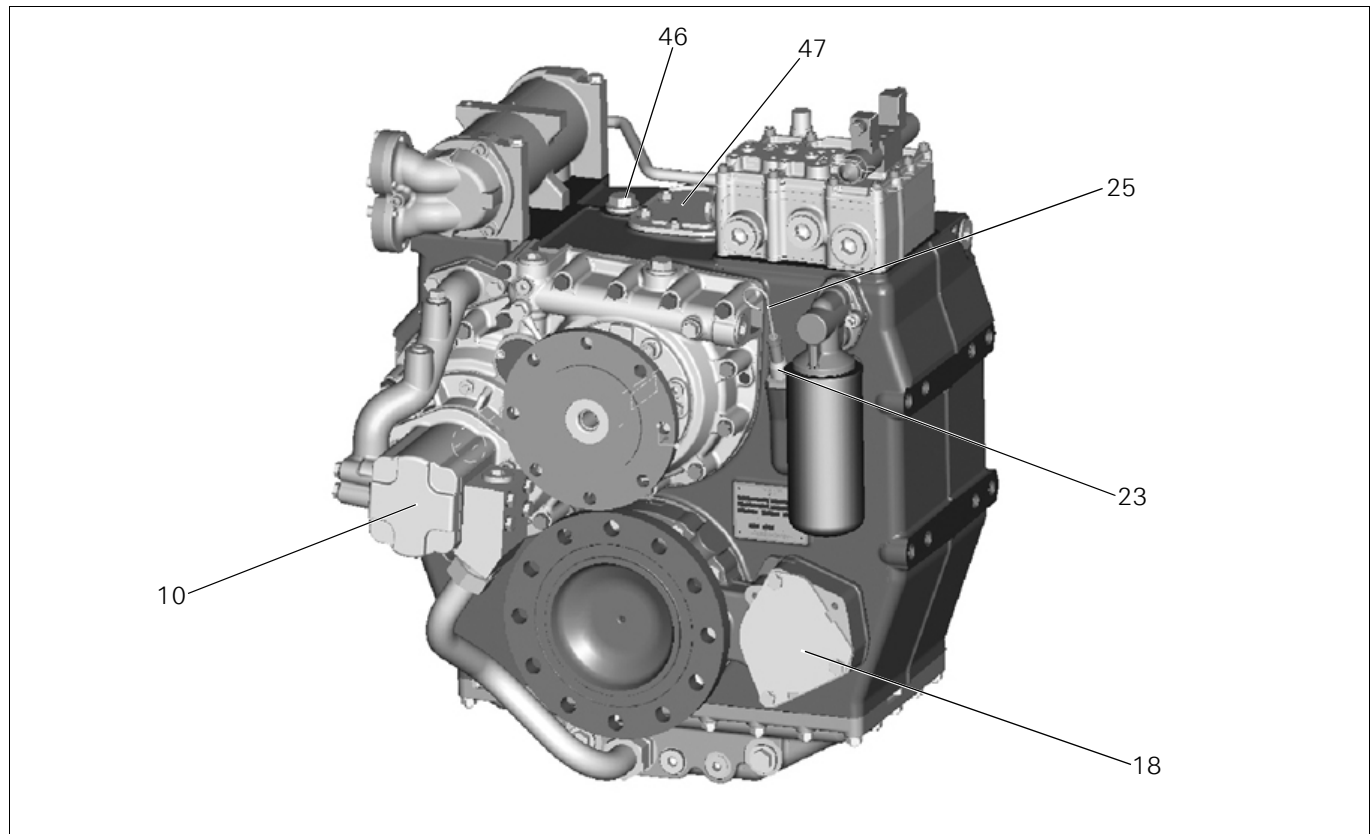
Key to drawing:

|       |   |     |  |
|-------|---|-----|--|
| 1     | Transmission fastening surface                  | 26  | Output   |
| 2/21  | Measuring points for clutch pressure            | 28  | Flanging surface for bell housing                |
| 8     | Input (input flange, special scope of delivery) | 33  | Oil filter                                       |
| 10    | Engine-dependent oil pump (primary oil pump)    | 34  | Emergency control (counter-engine wise rotation) |
| 11/12 | Measuring points for oil temperature            | 41  | Measuring point for oil temperature              |
| 13    | Water connection flange                         | 44  | Emergency control (engine wise rotation)         |
| 15    | Oil cooler                                      | 46  | Oil filler hole                                  |
| 18    | Position for trailing oil pump                  | 47  | Inspection cover                                 |
| 20    | Oil drain                                       | 53  | Measuring point for oil temperature after cooler |
| 22    | Measuring point for lubricating oil pressure    | 137 | Neutral switch                                   |
| 23    | Transmission vent                               |     |  |
| 25    | Oil dipstick                                    |     |  |

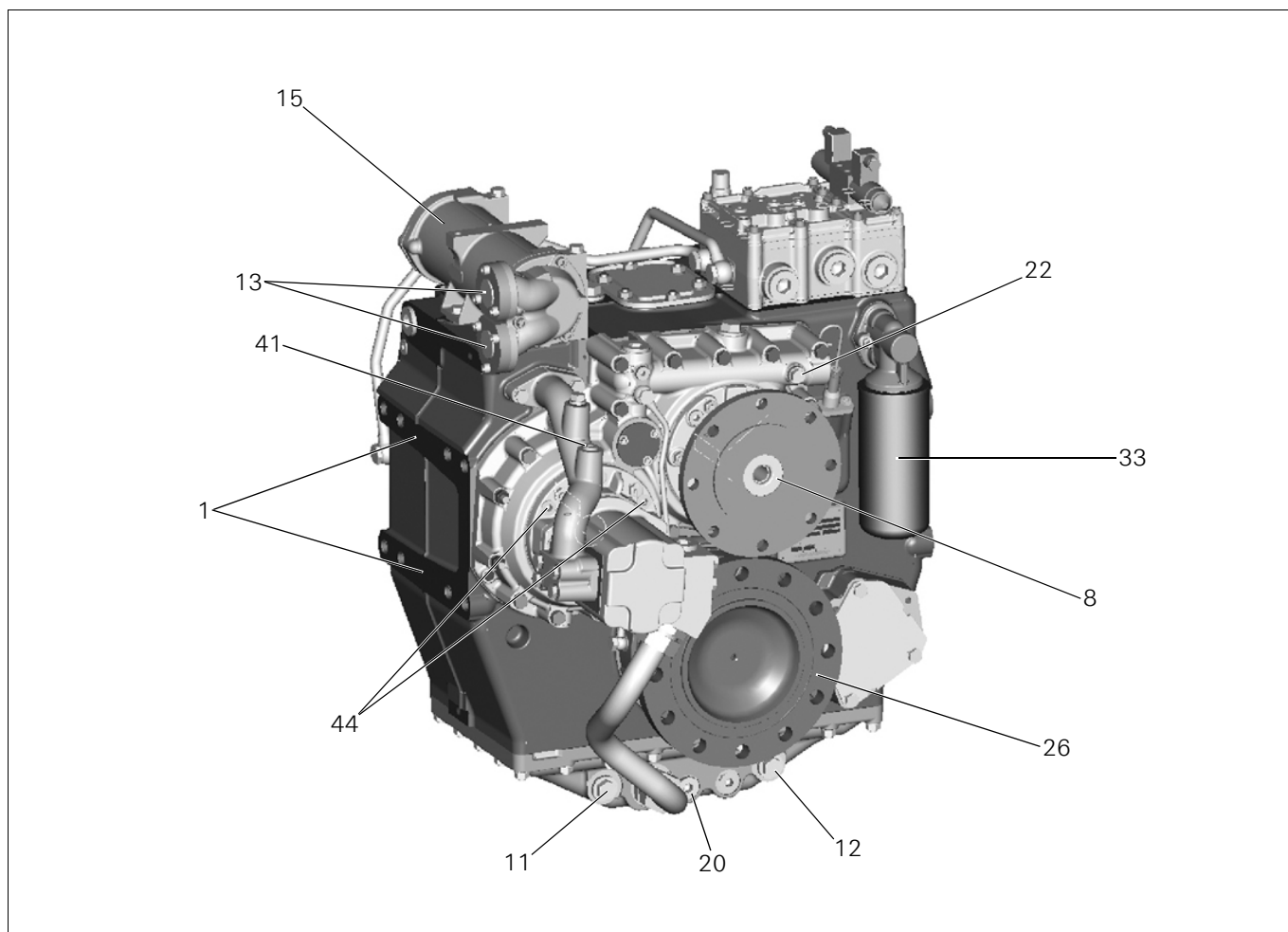


#### 2.1.4.10 ZF 2350 U

Your transmission may vary from the Figures shown here with regard to structure, connections, and pipework.







Key to drawing:

|       |   |     |  |
|-------|---|-----|--|
| 1     | Transmission fastening surface                  | 26  | Output   |
| 2/21  | Measuring points for clutch pressure            | 28  | Flanging surface for bell housing                |
| 8     | Input (input flange, special scope of delivery) | 33  | Oil filter                                       |
| 10    | Engine-dependent oil pump (primary oil pump)    | 41  | Measuring point for oil temperature              |
| 11/12 | Measuring points for oil temperature            | 44  | Emergency control (engine wise rotation)         |
| 13    | Water connection flange                         | 46  | Oil filler hole                                  |
| 15    | Oil cooler                                      | 47  | Inspection cover                                 |
| 18    | Position for trailing oil pump                  | 53  | Measuring point for oil temperature after cooler |
| 20    | Oil drain                                       | 137 | Neutral switch                                   |
| 22    | Measuring point for lubricating oil pressure    |     |  |
| 23    | Transmission vent                               |     |  |
| 25    | Oil dipstick                                    |     |  |



2.2 Technical data

The normal input direction is - as viewed on the transmission input flange - clockwise. A corresponding arrow is fixed on the transmission input side for special version transmissions with anticlockwise input direction (left as viewed on the transmission input flange).

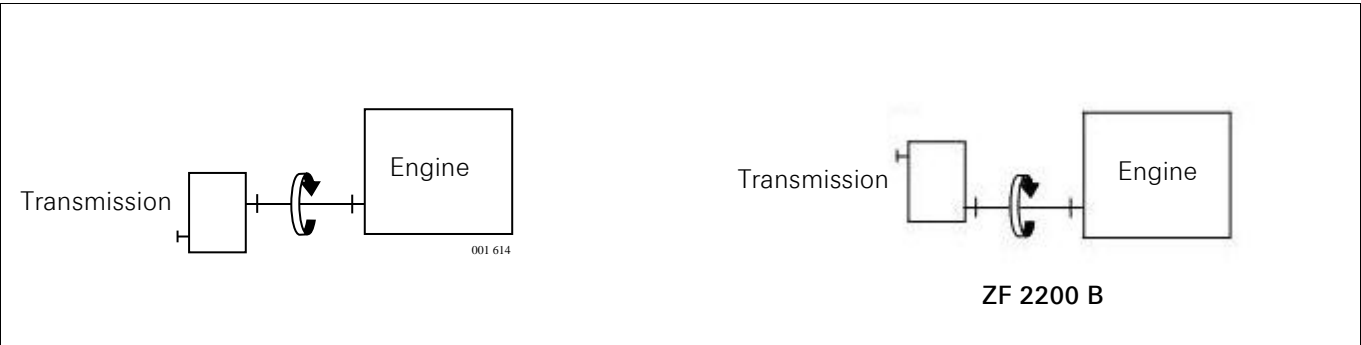


Fig. 12: Direction of rotation, transmission input shaft (standard version)

Observe maximum admissible loads (forces) on the transmission input in accordance with Section 4.1.2 *Connection to the engine*. On the front side of the input shaft, additional forces must not exceed 2,000 N in radial direction and 1,000 N in axial direction.

Section 4.1.3 *Connection to propeller shaft* describes the alignment of transmission and propeller shaft. The maximum admissible radial force is 500 N (A = up to 279.8 mm) and 1,000 N (A = 280 mm, A = 335 mm and A = 390 mm) when assembling and/or centring the transmission output flange and propeller shaft.

Alignment accuracy of the propeller shaft varies for the individual transmission versions and is shown in the following Table:

| Measure "A" according to Section 2.1.1 General design principle in [mm] | Max. admissible alignment error "x" in [mm] | Max. shaft alignment offset "y" in [mm] | Min. admissible bearing spacing "L" - depending on propeller shaft diameter "d" (see Section 4.1.3) in [mm] |
|---|---|---|---|
| A = up to 279.8   | 0.05  | 0.10                                    | 500 for d<70<br>1,000 for d=70 to 100<br>2,000 for d>100  |
| A = 280<br>A = 335<br>A = 390   | 0.10  | 0.15                                    | 500 for d<90<br>1,000 for d=90 to 120<br>2,000 for d>120  |

Tab. 1: Alignment accuracy of propeller shaft



### 2.2.1 Cooler data

- Maximum admissible cooling water flow volume: . . . . . 12,000 dm<sup>3</sup>/h
- Minimum admissible cooling water flow volume: . . . . . 3,900 dm<sup>3</sup>/h
- Pressure loss between cooling water inlet / outlet at 12,000 dm<sup>3</sup>/h: . . . . . 0,5 bar
- Maximum admissible water pressure at cooling water inlet: . . . . . 2 bar
- Maximum cooling water inlet temperature for P, L, M applications: . . . . . 40°C
- Maximum cooling water inlet temperature for ZF 2070, ZF 2270 (P application) . . . . . 32°C
- Maximum cooling water inlet temperature for C applications: . . . . . 50°C
- Maximum transmission ambient temperature: . . . . . 60°C

### 2.2.2 Cooler data ZF 2000 NRB

- Maximum admissible cooling water flow volume: . . . . . 8,000 dm<sup>3</sup>/h
- Minimum admissible cooling water flow volume: . . . . . 3,900 dm<sup>3</sup>/h
- Pressure loss between cooling water inlet / outlet at 8,000 dm<sup>3</sup>/h: . . . . . 0.5 bar
- Maximum admissible water pressure at cooling water inlet: . . . . . 2 bar
- Maximum cooling water inlet temperature: . . . . . 40 °C
- Maximum transmission ambient temperature: . . . . . 60 °C

### 2.2.3 Oil types

The valid ZF lubricant list TE-ML 04 is binding for ZF marine transmissions. This list is available from all ZF Service branches. It can be downloaded free of charge on the internet in PDF format under [www.zf.com](http://www.zf.com).

Viscosity class SAE 30 or SAE 40 for oil sump temperatures < 80°C

Viscosity class SAE 40 for oil sump temperatures > 80°C

### 2.2.4 Oil quantities

- ZF 2000 / ZF 2050 / ZF 2060 / ZF 2070 / ZF 2075 / ZF 2150 / ZF 2000 NR / ZF 2050 NR / ZF 2060 NR / ZF 2070 NR / ZF 2075 NR / ZF 2150 NR . . . . . approx. 20 dm<sup>3</sup>
- ZF 2150 NC . . . . . approx. 20 dm<sup>3</sup>
- ZF 2000 A / ZF 2050 A / ZF 2060 A / ZF 2070 A / ZF 2075 A / ZF 2150 A, ZF 2000 NRA / ZF 2050 NRA / ZF 2060 NRA / ZF 2070 NRA / ZF 2075 NRA / ZF 2150 NRA . . . . . approx. 21 dm<sup>3</sup>
- ZF 2000 V / ZF 2050 V / ZF 2060 V / ZF 2070 V / ZF 2075 V / ZF 2150 V, ZF 2000 NRV / ZF 2050 NRV / ZF 2060 NRV / ZF 2070 NRV / ZF 2075 NRV / ZF 2150 NRV . . . . . approx. 21 dm<sup>3</sup>
- ZF 2000 NRB . . . . . approx. 21 dm<sup>3</sup>
- ZF 2200 / ZF 2250 / ZF 2260 / ZF 2270 / ZF 2275 / ZF 2200 NR / ZF 2250 NR / ZF 2260 NR / ZF 2270 NR / ZF 2275 NR . . . . . approx. 21 dm<sup>3</sup>
- ZF 2300 / ZF 2350 / ZF 2360 / ZF 2370 / ZF 2375 / ZF W2300 / ZF W2350 / ZF 2300 NR / ZF 2350 NR / ZF 2360 NR / ZF 2370 NR / ZF 2375 NR / ZF W2300 NR / ZF W2350 NR . . . . . approx. 27 dm<sup>3</sup>
- ZF W2400 / ZF W2450 / ZF W2400 NR / ZF W2450 NR approx. 36 dm<sup>3</sup>
- ZF 2350 U . . . . . approx. 27 dm<sup>3</sup>



### 2.2.5 Transmission ratio

The relevant ratio is shown on the transmission type plate. (See Section 2.2.7 *Transmission description* for explanations)

### 2.2.6 Transmission weight

The overall weight of the transmission depends on the transmission version and the special equipment supplied. The overall weight is shown on the transmission type plate.

### 2.2.7 Transmission description

The type plate is located on the same side of the housing as the output flange and is also clearly visible after installation.

If the transmission has been classified, the certificate number and seal of the Classification Society are embossed on the housing next to the type plate.

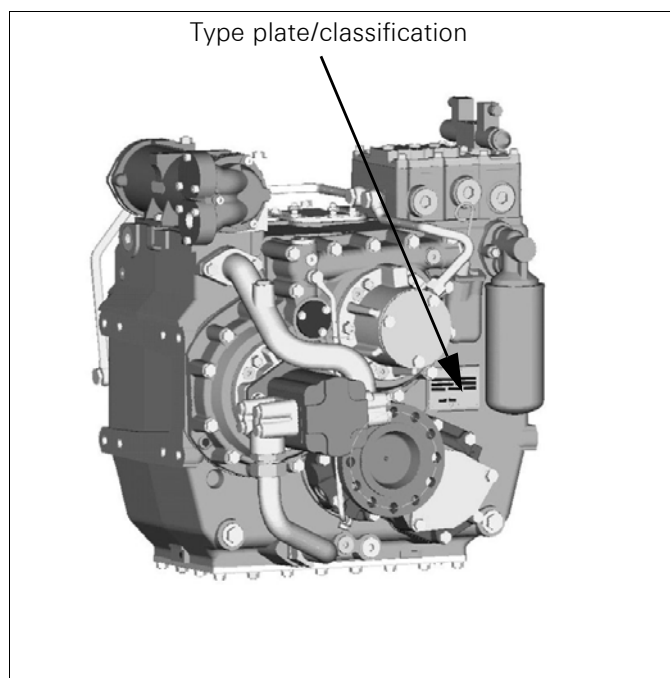


Fig. 13: Transmission ZF 2000 (example)


|   |              |                          |            |
|---|--------------|--------------------------|------------|
|  ZF FRIEDRICHSHAFEN AG<br>MARINE PROPULSION SYSTEMS<br>MADE IN GERMANY |              |                          |            |
| MODEL   |              | SERIAL NO.               |            |
| 1   |              | 2                        |            |
| PART LIST NO.   |              | REFERENCE NO.            |            |
| 3   |              | 4                        |            |
| RATIO TOTAL   | MAIN GEAR    | SPUR GEAR                |            |
| 5   | 5a           | 5b                       |            |
| OIL CAPACITY(dm <sup>3</sup> )  | MASS DRY(kg) | CLUTCH OIL PRESSURE(bar) |            |
| 6   | 7            | 9                        |            |
| PLEASURE  |              | LIGHT                    | MEDIUM     |
| 10  |              | 11                       | 12         |
|   |              |                          | CONTINUOUS |
|   |              |                          | 13         |
| kW/R.P.M.<br>OIL CHANGE:<br>2000 hours or 2 years, whichever occurs first.<br>Approved Lubricants see ZF TE-ML 04                                       |              |                          |            |

Fig. 14: Type plate (example)

#### Specifications on the type plate:

- 1) Design
- 2) Serial number
- 3) Parts list number
- 4) Customer reference number
- 5) Overall transmission ratio and code letter for oil pump ratio
- 5a) Main transmission ratio
- 5b) Primary transmission ratio (if applicable)
- 6) Oil capacity
- 7) Weight (dry)
- 9) Clutch oil pressure (nominal)
- 10) Maximum performance ratio/speed ratio for intermittent operation with very high differences in engine speeds
- 11) Maximum performance ratio/speed ratio for intermittent operation with high differences in engine speeds
- 12) Maximum performance ratio/speed ratio for intermittent operation with different engine speeds
- 13) Maximum performance ratio/speed ratio for continuous operation with maximum engine performance

Fields 1 to 3 and 5 are mandatory should questions arise on transmission, troubleshooting, servicing, spare part orders, ordering optional equipment, etc.

See Chapter 8 *Maintenance*, Section 8.1 *Application area* for further details on fields 10 to 13.

The respective ratio installed is embossed on the type plate.



The code letter entered in field 5 after the overall ratio refers to the primary oil pump ratio. Oil pump ratio A is standard version.

| Code letter | Design engine speed during continuous performance [rpm] | Engine idle speed [rpm] |
|-------------|---|-------------------------|
| A           | 1,650 to 2,600  | $\geq 500$              |

Tab. 2: Primary oil pump ratios



2.2.8 Monitoring values for ZF 2000/2150/2200/2300/W2300/W2400 series

| Filterverschmutzung                  |   | Clutch oil pressure                                |  | Lubricating oil pressure                      | Oil temperature   |  |
|--------------------------------------|---|--|--|---|---|--|
| Measuring point <sup>1)</sup>        | 5 <sup>20)</sup>  | 127 <sup>21)</sup>                                 | 2, 21  | 22  | 11, 12, 41  |  |
| Operating state                      | Shift position <sup>9)</sup><br>"Neutral", "Engine wise or counter-engine wise" | ---  | Shift position <sup>9)</sup><br>"Engine wise or counter-engine wise" | ---   | Operation   | Trailing operation <sup>8)</sup>                 |
| Rated value                          | ---   | ---  | P <sub>KN</sub> <sup>7)</sup>  | ---   | ---   | ---  |
| Nominal display value                | Min   | ---  | P <sub>K</sub> = P <sub>KN</sub> -1 bar <sup>4)</sup>                | 0.4 bar                                       | 30°C  | ---  |
|                                      | Max   | 26 bar <sup>20)</sup><br>28 bar <sup>20) 22)</sup> | P <sub>K</sub> = P <sub>KN</sub> +3 bar <sup>4)</sup>                | 13 bar  | 90°C  | 75°C <sup>8) 11)</sup><br>95°C <sup>8) 12)</sup> |
| Warning                              | 26 bar <sup>20)</sup><br>28 bar <sup>20) 22)</sup>                              | 5 bar <sup>2) 5)</sup><br><sup>23)</sup>           | P <sub>K</sub> = P <sub>KN</sub> -3 bar <sup>2) 5) 6) 18) 19)</sup>  | 0.25 bar <sup>2) 5)</sup>                     | 95°C <sup>2) 5)</sup>   | ---  |
| Minimum monitoring <sup>14)</sup>    | Druckschalter   | Druckschalter                                      | Pressure gauge 0 to 40 bar   | ---   | Thermometer 0 to 120°C  |  |
| Additional monitoring <sup>14)</sup> | ---   | ---  | Pressure switch or pressure sensor <sup>16)</sup><br>0 to 40 bar     | Pressure switch or pressure gauge 0 to 16 bar | Temperature switch <sup>2)</sup> or<br>temperature sensor <sup>16)</sup> 0 to 120°C |  |

- 1) Location of measuring points on the transmission – see Section 2.1.4 *Transmission views* on page 20
- 2) For optical and acoustic warning
- 3) Not included in the above Table
- 4) At 60°C to 80°C oil temperature
- 5) Warning with time delay of 3 to 10 s (the monitoring devices described in the monitoring plan are supplied by ZF). A superordinate monitoring system, not supplied by ZF, is required for processing these signals (e.g. for warning purposes)
- 6) Disable the warning in "Neutral" shift position.
- 7) The rated clutch pressure is specified in the binding, order-specific technical documents and also embossed on the type plate
- 8) During operation with engine switched off and propeller driven by current (Section 5.3 *Trailing operation*)
- 9) During normal operation
- 10) Not included in the above Table
- 11) Without trailing pump
- 12) With trailing pump (not supplied by ZF)
- 13) Not included in the above Table
- 14) Not part of standard ZF scope of delivery
- 15) Not included in the above Table
- 16) For remote display
- 17) Not included in the above Table
- 18) Warning point measured by a pressure sensor
- 19) Disable the warning in trolling operation only using a gap filter
- 20) only using a changeover filter
- 21) ZF 2060/2260/2360 series, ZF 2070/2270/2370 series
- 22) Customer must disable the warning for an oil temperature < 35°C
- 23)   
 ▲ Increasing  
 ▼ Decreasing  
 P<sub>K</sub> Clutch oil pressure  
 P<sub>KN</sub> Rated clutch pressure



### 3 Description - basic transmission and variants

#### 3.1 Functions

The transmission and power flow diagram shows the power transmission for the "engine wise rotation" output direction (input and output rotate in same direction) and for the "counter-engine wise rotation" output direction (input and output rotate in opposite directions). The engine performance can be transmitted to the full extent in both output directions. The ratio shown on the type plate applies for both output directions. This means fully identical transmission versions can be used for installations with several engines. This reduces spare parts and enables using uniform replacement units.

##### 3.1.1 Transmission as parallel version

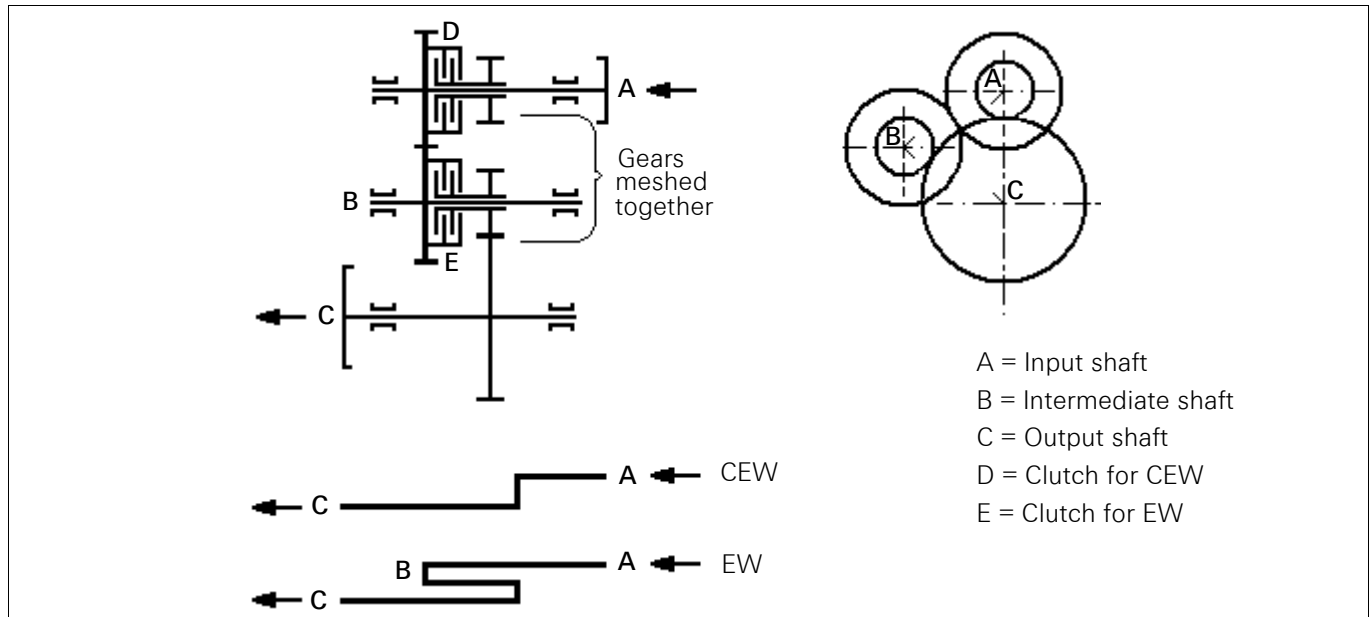
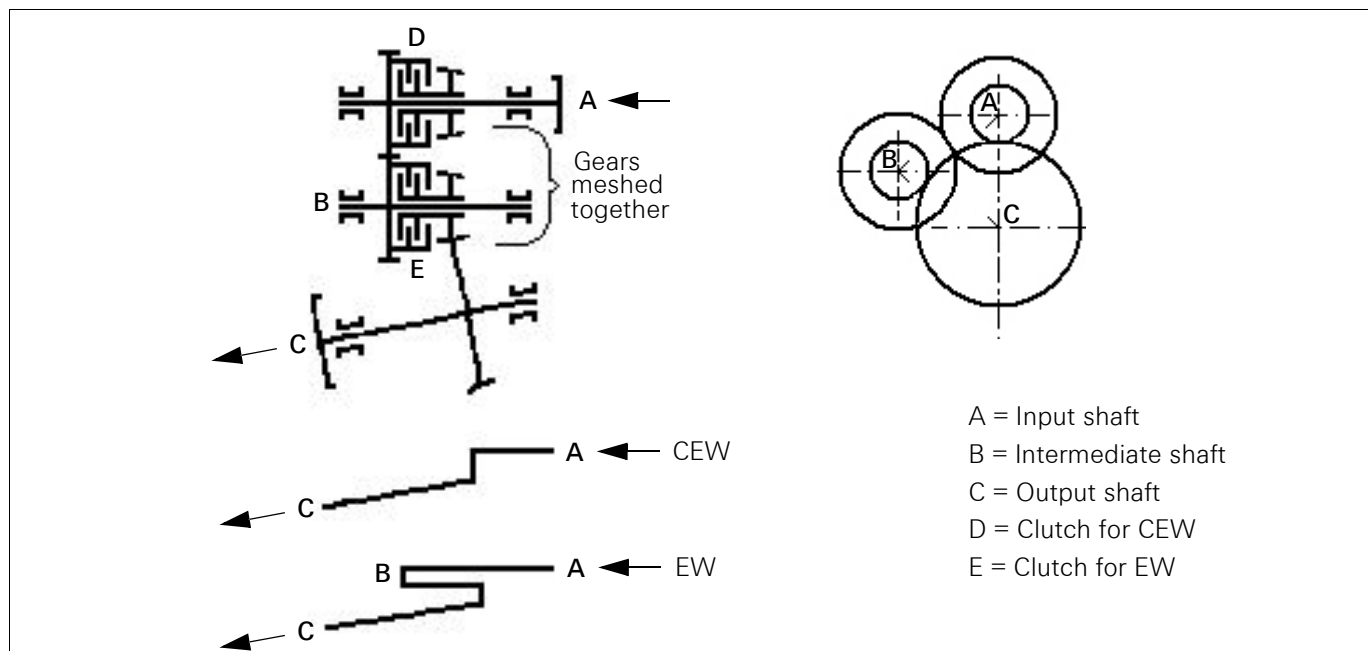


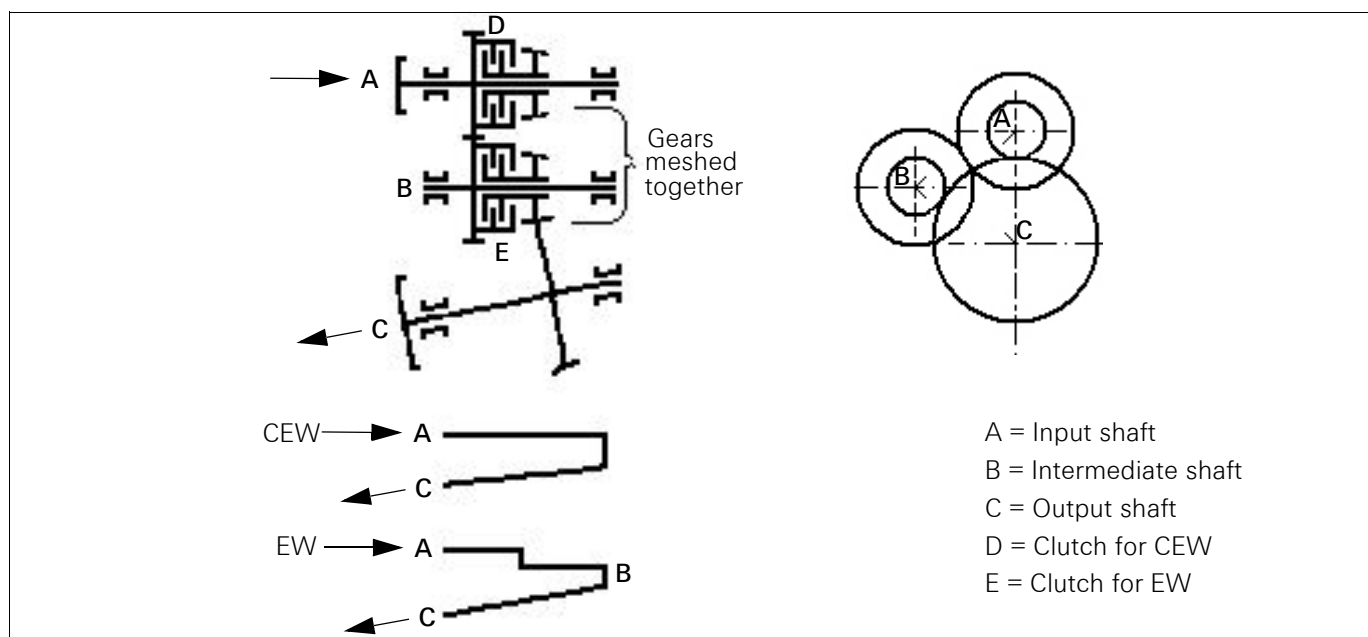
Fig. 15: Power flow diagram of the parallel version  
(example, EW = engine wise rotation, CEW = counter-engine wise rotation)



### 3.1.2 Transmission as A version



### 3.1.3 Transmission as V version





### 3.1.4 Transmission as U version

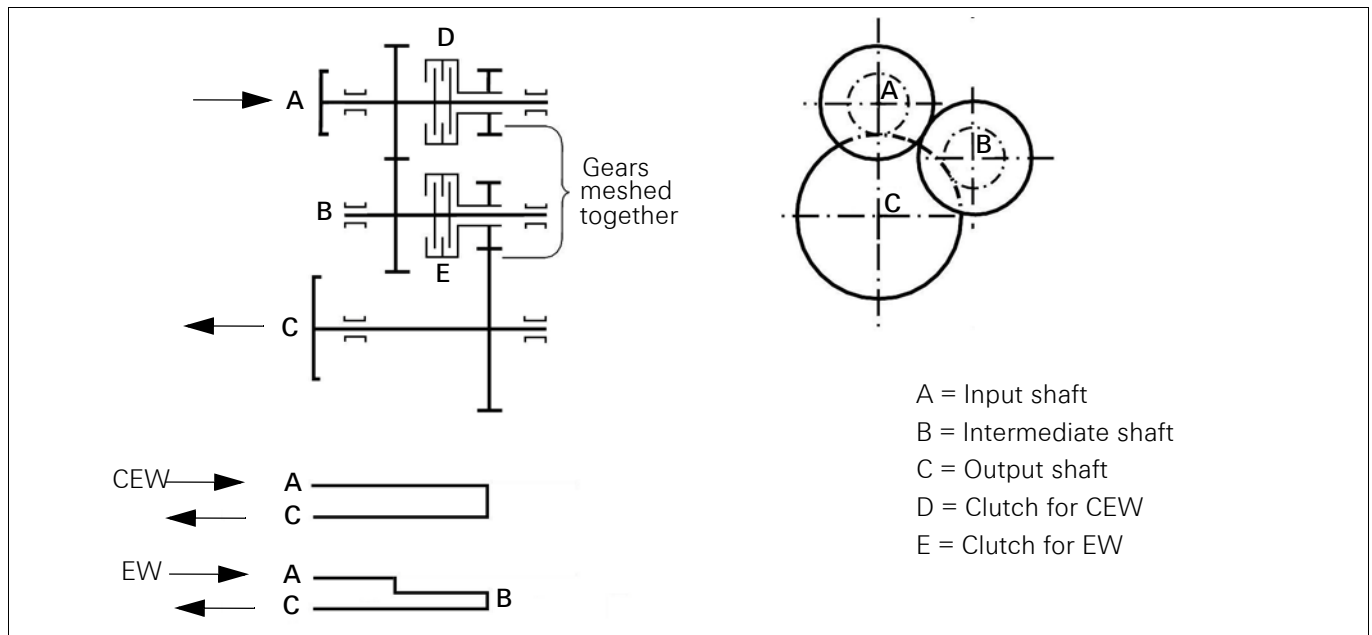


Fig. 18: Power flow diagram of the U version  
(example, EW = engine wise rotation, CEW = counter-engine wise rotation)

### 3.1.5 Transmission as B version

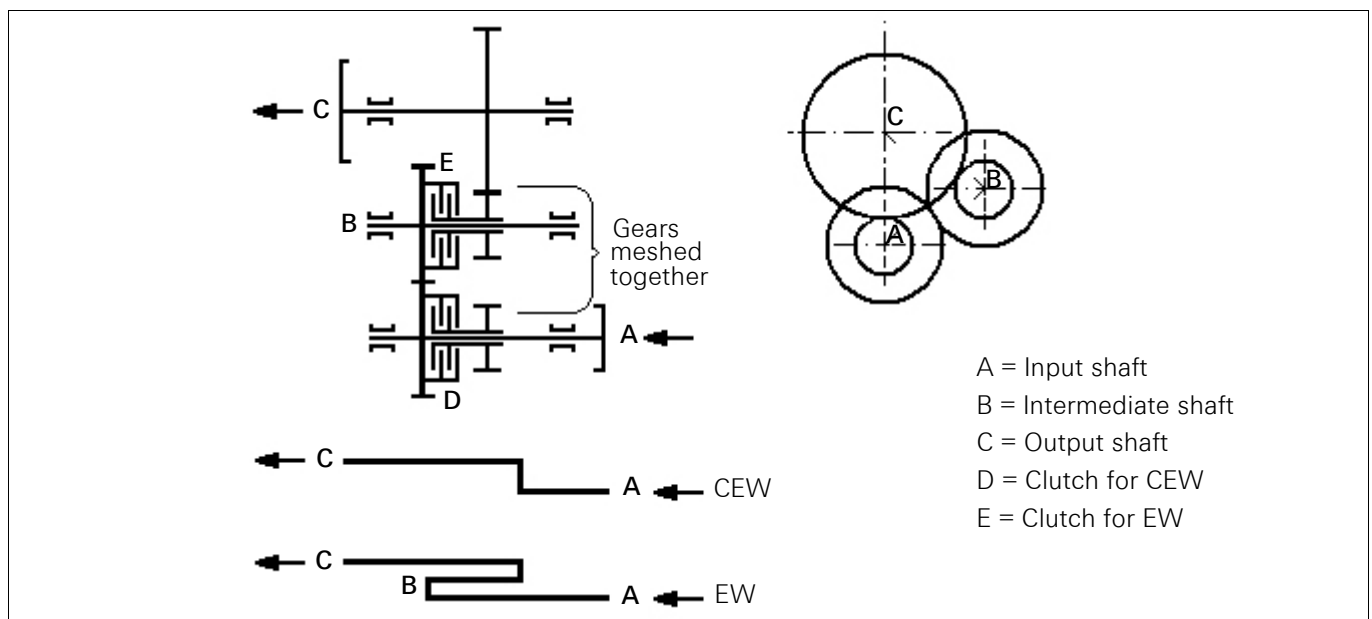


Fig. 19: Power flow diagram of the B version  
(example, EW = engine wise rotation, CEW = counter-engine wise rotation)



### 3.1.6 Transmission as NRB version

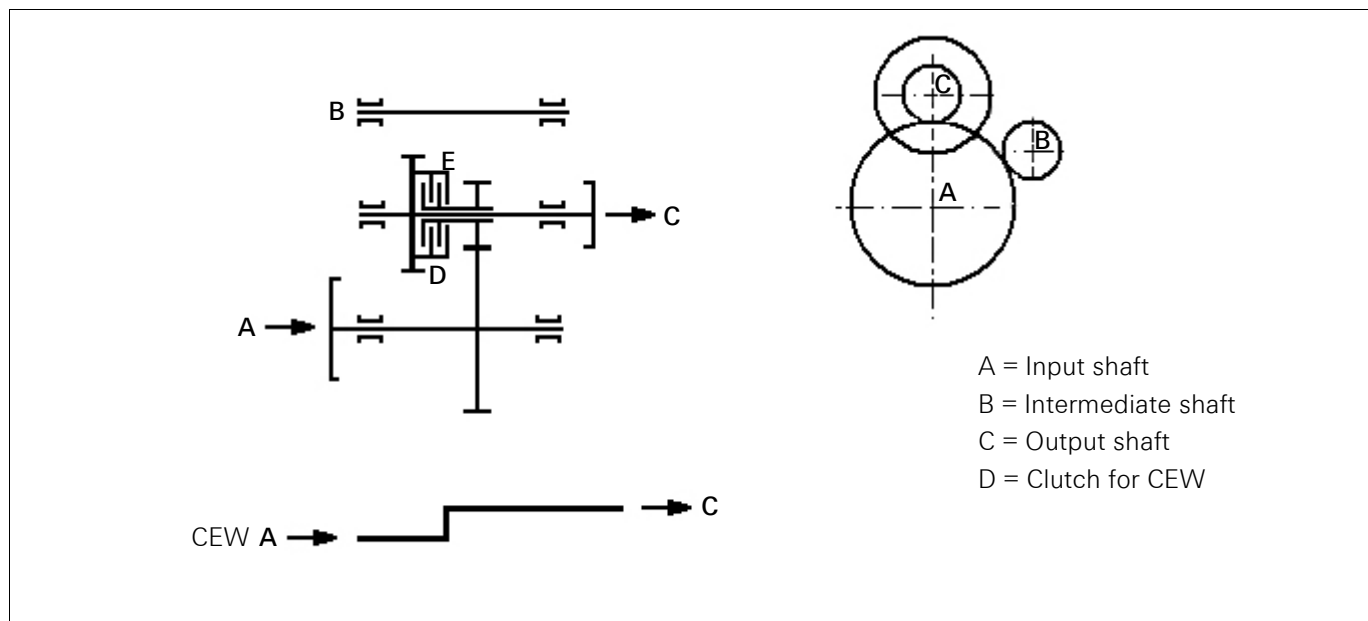


Fig. 20: Power flow diagram of the NRB version (example, CEW = counter-engine wise rotation)

### 3.1.7 Oil supply

The engine-dependent primary oil pump is driven by the transmission intermediate shaft via a driver. The continuous delivery gear pump operates according to the positive displacement principle and is largely self-priming.

The delivery rate of this primary oil pump depends on the speed of the transmission input shaft. The gear pump has a high delivery rate to ensure sufficient oil for lubrication and cooling of the transmission is available, also at low input speed. The high delivery rate also ensures rapid response of the respective clutch switched.

### 3.1.8 Hydraulic multi-disc clutch

Actuating the hydraulic multi-disc clutch effects even and reliable shift procedure. During switching, the contact pressure of the clutch is modulated which results in smooth creation and/or interruption of the power flow in the transmission. An increased oil flow is supplied to the switched multi-disc set to dissipate heat occurring during the shift procedure more quickly and thus increase the load capacity of the clutch.

A mechanical emergency control is available for operating should malfunctions occur in the pressure oil circuit. For this purpose, the multi-disc clutch(es) is/are pressed together mechanically using three screws accessible from the outside while the transmission is idle.

This emergency control can be used to operate reverse transmissions with "engine wise rotation" (EW) or "counter-engine wise rotation" (CEW) input direction.

### 3.1.9 Transmission cooling

The transmission oil cooler is designed according to the pipe bundle principle as a compact and lightweight unit.

All standard transmission versions are fitted with an oil filter equipped with one filter cartridge.

The cooled oil flows through an oil filter, from there into the control unit and finally to the clutches and lubricating points of the transmission.



### **3.1.10 Control unit and transmission actuation**

The control piston is moved axially to the relevant shift position "Neutral" / "Engine wise rotation" / "Counter-engine wise rotation". This is done either mechanically or hydraulically depending on the actuation version. The oil flowing out of the control unit is used for lubricating and cooling the clutch discs, meshing gears and bearings.

With mechanical transmission actuation, the control piston is moved axially through oil pressure via a mechanically operated pilot valve. The pilot valve is mounted on top of the control unit.

With electrical transmission actuation, the control piston is moved axially through oil pressure via an electrically operated pilot valve. The pilot valve is mounted on top of the control unit. Electrical transmission actuation is included in the basic transmission version.







## 4 Initial installation and start-up

### 4.1 Initial installation

When planning the power plant, provide sufficient clearance for disassembling the oil cooler, oil filter, oil pump, transmission clutch and/or clutch discs and for removing the oil dipstick. Disassembling the transmission clutch and/or clutch discs is possible with the transmission installed.



Dimensions for disassembly are specified in the transmission installation documents.

Oil drain plugs must also be easily accessible. If there is not sufficient space under the oil drain for collecting oil drained during oil changes, we recommend installing a suction line fixed on the transmission instead of the oil drain plug. In this case the oil must be sucked off during oil changes.

The bolts of the mechanical emergency control must be accessible to allow manual closing of the multi-disc clutch(es). See the transmission installation documents for required clearances.

As manufacturer of an individual component of a ship propulsion system, the transmission manufacturer cannot be held responsible for vibrations or vibration problems occurring in this system. Accordingly, ZF will not assume any liability for transmission noises or damage to the transmission, the flexible coupling or other parts of the power chain caused by such vibrations.

We therefore recommend performing a vibration calculation and, where applicable, also including unloaded transmission parts.

See the binding installation documents valid for the transmission delivery contract for the admissible installation position in the ship.

The following screw connections listed are to be performed by the customer and must be sized according to their respective loads:

- Transmission mounting bracket – transmission (when not supplied by ZF)
- Transmission mounting bracket – foundation
- Flexible clutch – engine / transmission
- Propeller shaft – transmission

Required safety equipment for rotating and moving parts must be present:

- Guard on the transmission output flange
- Guard on the flexible clutch
- Guard on the engine fly wheel and input shaft
- Guard and arresting device in joint shaft proximity

### 4.1.1 Transmission support in the foundation

Machined surfaces and fastening threads are provided on the side of the transmission housing for attaching the suspension bracket. If suspension brackets are provided by the shipyard, attention must be paid to the vertical distance between transmission output shaft and foundation contact surface of the suspension bracket. This distance measure "x" must be within the following range:

$$x < (0.6 \cdot A) \text{ and } > (-0.2 \cdot A)$$

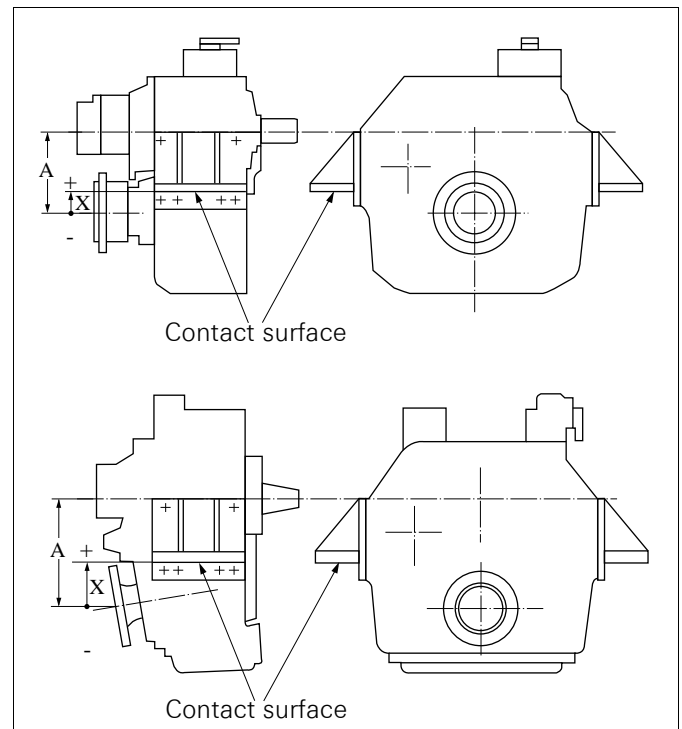


Fig. 21: Transmission with assembly dimensions (example)

Suspension bracket surfaces on the transmission side must be machined plane.

The transmission can be installed as free-standing in the foundation or flanged on, supported either rigidly or elastically together with the engine.

Do not brace the transmission on the foundation during installation, i.e. all support brackets must be flat on the foundation. When selecting support elements for elastic support of transmissions, ensure the inherent frequency of the elastically supported transmission does not coincide with the excitation frequency of the power plant or the propeller. Consider foundation rigidity as well when calculating the inherent frequency.

Low foundation rigidity can cause resonance and thus extreme loads on transmission components. This reduces the service life of these components.



Recommendations for the foundation rigidity are contained in the relevant drawings of the elastic transmission support.



If the propeller thrust is absorbed by the transmission (the propeller thrust bearings for forward and reverse thrust are integrated in the reverse transmission), the support elements must also be suitable for absorbing the propeller thrust. For elastic transmission suspension and a rigidly connected propeller shaft, transmission shift should not have a lasting effect on alignment. Please contact us in case of doubt..

Use solid supports for aligning the transmission on the foundation (see Section 4.1.3 *Connection to propeller shaft*). Individual supports - in the area of the foundation bolts only - are not allowed. Suspension brackets supplied by ZF include alignment bolts. Remove the alignment bolts used after the supports have been installed.

We recommend using fitting bolts for securing suspension brackets in the foundation. Fit fixed end stops at least in "forward propeller thrust" direction when using through bolts. Fitting and fastening bolt dimensions (quantity, diameter, quality) depend on the operational load and must be defined by the shipyard. Ensure that not only the propeller thrust and the weight are supported on the transmission support but also the reaction forces of the torque and the ratio-dependent output torque.

The contact surface of the ZF suspension bracket (flexible and rigid) is designed for direct support on a rigid surface (e.g. foundation frame). If the transmission support is to be made on cast resin, it may be necessary to enlarge the contact surfaces using an adapter plate supplied by the shipyard.

The space between ship foundation and adapter plate is filled with cast resin. Design the adapter plate so that transmission disassembly and assembly are possible without severely damaging the cast resin foundation. Also provide fixed end stops for transmission of the propeller thrust on the foundation. After the cast resin has hardened, the transmission should be supported through the cast resin only and not through the alignment bolts or other alignment tools. Cast resin shrinkage during hardening must already be considered during transmission alignment.

We recommend working with the cast resin supplier and/or a qualified expert company when planning support on cast resin. Such an expert company can provide relevant preliminary consultation and is capable of preparing the calculations and drawings required for approval by a Classification Society and submitting these for approval.

#### **4.1.2 Connection to the engine**

Fit a flexible clutch between engine and transmission. The flexible clutch has the task of influencing inherent frequencies of the rotating masses of the engine, transmission, and propeller so that no detrimental vibration resonance occurs within the operating speed range.

Specifying an exclusion range for certain speeds may be necessary when, in special cases, a resonance speed within the operating speed range cannot be avoided. This range depends on the magnitude of the calculated vibration amplitudes.

Normally, the flexible clutch is selected by the engine manufacturer using a torsional vibration calculation. The torsional vibration calculation must also include excitations induced by the motor controller. Details concerning the transmission required for the calculation can be found in our calculation sheet "Data for torsional vibration calculation". No warranty can be assumed for the suitability or durability of the torsionally flexible connection when the torsionally flexible connection is supplied by ZF according to a selection made by the engine manufacturer or a specification made by the shipyard.

Perform assembly and disassembly of clutch hub or input flange and/or the transmission-side part of the torsionally flexible input connection in accordance with the instructions of the Service Manual for this transmission series.

The engine-transmission unit can be fitted rigidly or flexibly in the foundation. Ensure the conditions according to Section 4.1.1 *Transmission support in the foundation* are maintained when using elastic support.

#### **4.1.3 Connection to propeller shaft**

Connection dimensioning depends on the operating load and must be defined by the shipyard.

The transmission output flange is designed so that the highest admissible transmission output torque can be transmitted through frictional contact.

For this purpose, use the following bolts for all existing bolt holes:



**Bolts M18 x 1.5****Quality 10.9****Min. tensile strength 1,000 N/mm<sup>2</sup>**

for

ZF 2000 / ZF 2050 / ZF 2060 / ZF 2070 /  
ZF 2075 / ZF 2150ZF 2000 NR / ZF 2050 NR / ZF 2060 NR /  
ZF 2070 NR / ZF 2075 NR / ZF 2150 NR

ZF 2150 NC

ZF 2000 A / ZF 2050 A / ZF 2060 A / ZF 2070 A /  
ZF 2075 A / ZF 2150 AZF 2000 NRA / ZF 2050 NRA / ZF 2060 NRA /  
ZF 2070 NRA / ZF 2075 NRA / ZF 2150 NRAZF 2000 V / ZF 2050 V / ZF 2060 V / ZF 2070 V /  
ZF 2075 V / ZF 2150 VZF 2000 NRV / ZF 2050 NRV / ZF 2060 NRV /  
ZF 2070 NRV / ZF 2075 NRV / ZF 2150 NRV**Bolts M20 x 1.5****Quality 10.9****Min. tensile strength 1,000 N/mm<sup>2</sup>**

for

ZF 2200 / ZF 2250 / ZF 2260 / ZF 2270 / ZF 2275

ZF 2200 NR / ZF 2250 NR / ZF 2260 NR /  
ZF 2270 NR / ZF 2275 NR

ZF 2200 B

ZF 2300 / ZF 2350 / ZF 2360 / ZF 2370 / ZF 2375 /  
ZF W2300 / ZF W2350ZF 2300 NR / ZF 2350 NR / ZF 2360 NR /  
ZF 2370 NR / ZF 2375 NR / ZF W2300 / ZF W2350 NR

ZF W2400 / ZF W2450 / ZF W2400 NR / ZF W2450 NR

ZF 2350 U

When using fitting bolts, the holes of the propeller shaft flange can be bored and reamed together with those of the transmission output flange (material strength 750 to 900 N/mm<sup>2</sup>).



#### 4.1.3.1 Shaft installation with only one bearing for the propeller shaft (Fig. A)

Axial and radial movement of the propeller shaft must be so flexible that the propeller shaft flange can be inserted in the centring of the transmission output flange. Align the transmission so that admissible angular misalignment "x" relative to measured radius "r" does not exceed the value specified in the Table "Alignment accuracy of the propeller shaft" in Section 2.2 *Technical data* (value "y" is not considered).

#### 4.1.3.2 Shaft installation with two or more bearings for the propeller shaft (Fig. B)

Axial movement of the propeller shaft must be so flexible that the propeller shaft flange can be inserted in the centring of the transmission output flange. Align the transmission so that admissible angular misalignment "x" relative to measured radius "r" does not exceed the value specified in the Table "Alignment accuracy of the propeller shaft" in Section 2.2 *Technical data*.

Both errors "x" and "y" may occur at the same time. Measuring value "y" is often not possible when using very thin shafts and a large distance "L". Value "y" can be ignored when the propeller shaft can be inserted in the centring of the transmission output flange with a radial force not exceeding the value specified in the Table "Alignment accuracy of the propeller shaft" in Section 2.2 *Technical data*. In this case, the specifications for "shaft installations with only one bearing for the propeller shaft" are applicable.

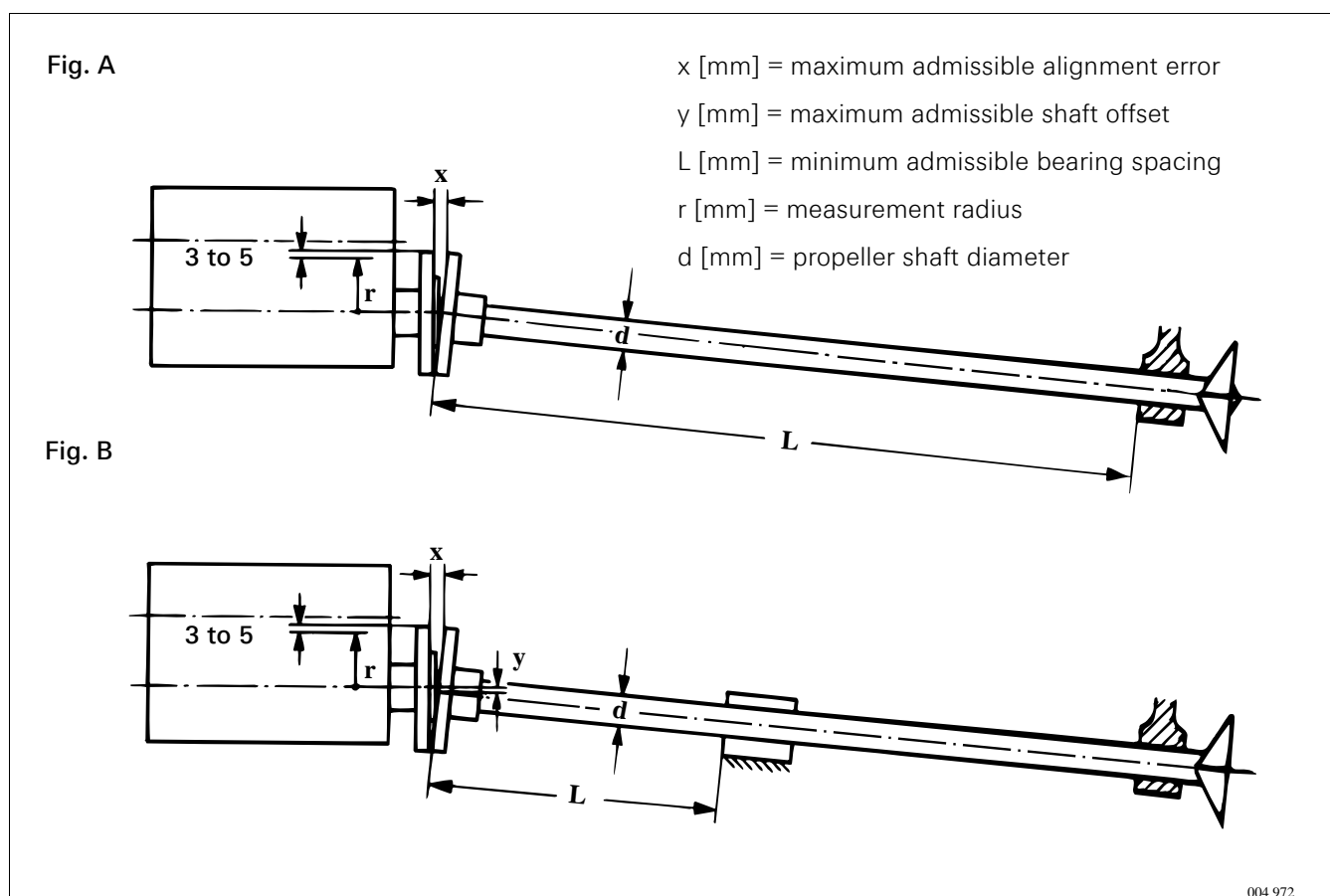


Fig. 22: Propeller shaft alignment (example)



The values for "x" and "y" are only valid when distance "L" between propeller shaft flange and last shaft bearing is large enough depending on shaft diameter "d".



#### 4.1.4 Connection to the joint shaft

The specifications according to Section 4.1.2 *Connection to the engine* apply to the rotary joint between engine and transmission, complemented by the use of a joint shaft with length compensation between the flexible clutch and transmission input flange. Radial forces and bending moments are generated by the joints of the joint shaft. In addition, length changes between engine and transmission create axial forces in a magnitude that can be transmitted by the length compensation of the joint shaft. Ensure that length compensation remains operational under load (axial forces only due to longitudinal friction, no tilting, no excess lubrication) and that the stroke is sufficient even in extreme situations (shock loads). The magnitude of all these forces and bending moments depends on the torque transmitted, the joint shaft length and the size of the joint angles.

On the transmission side, these forces and bending moments are supported on the foundation through the transmission input shaft, transmission housing, and suspension bracket, and on the engine side through the flexible clutch, crankshaft, and engine housing. Therefore, equip the flexible clutch with additional bearing elements between the primary and secondary sides. Install an additional bearing between joint shaft and flexible clutch when the flexible clutch or the engine crankshaft cannot absorb the forces and bending moments generated by the joint shaft. Bearing support can be provided by a bell housing on the engine, or an intermediate shaft installed and supported in the foundation.

The forces and bending moments generated by the joint shaft occur periodically at double engine speed. The maximum value for the additional load on the transmission input shaft (see Section 2.2 *Technical data*) must not be exceeded. Dimension suspension brackets for engine and/or intermediate shaft and transmission as well as for the foundation adequately so that inadmissible deformations are excluded. This would result in noise and vibrations. Reinforcement of the foundation may be necessary.

The joint shaft size to be used depends on the engine performance, engine speed, size of the joint angle, and the required service life of the joint shaft. A recommendation is normally given by the joint shaft manufacturer according to the specific application case.

To ensure proper kinematic operation of the joint shafts, the joint angles must be the same size on both sides and the joint forks mounted on one level. Keep joint angles as small as possible. The reference value for transmissions with parallel input and output shafts is maximum 7° to 8°.

The output shaft is already inclined by 10° on transmissions in V arrangement. This allows reducing the joint angle to the minimum value required for the joint bearings of the joint shafts. It is recommended to utilize the benefit offered by the inclined output shaft and not to exceed a maximum joint angle of 3°. Keep the dynamic rotating mass of the joint shaft centre body as small as possible.



For detailed information on joint shafts, see the technical documents of the joint shaft manufacturer.

Two alignment shafts of equal length can be fitted instead of the joint shaft to control the joint angles when aligning the engine. The engine is aligned correctly (both joint angles are equal) when the tips of the two alignment shafts meet - see Installation diagram (page 56). After alignment, remove the alignment shafts and fit the joint shaft.



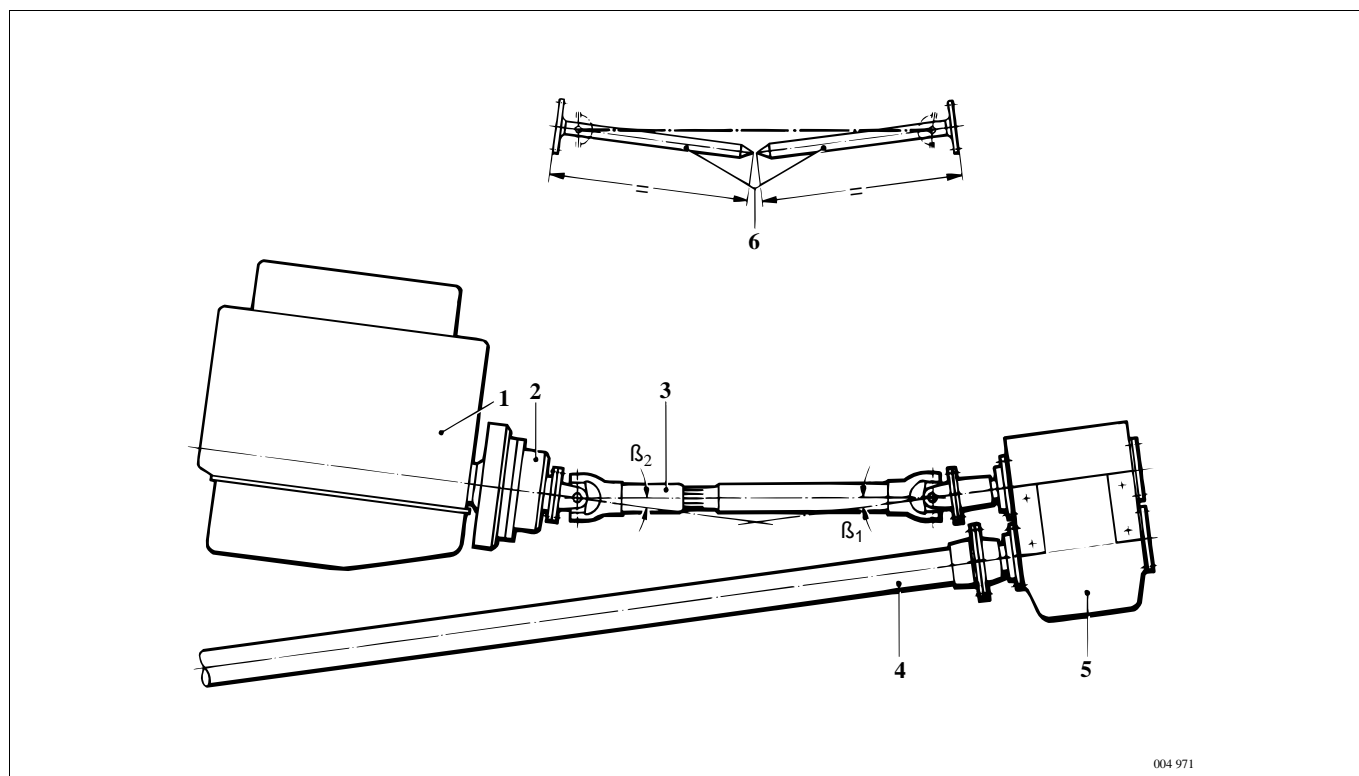


Fig. 23: Installation diagram for joint shafts in W arrangement (example)



Joint angles  $\beta_1$  and  $\beta_2$  may only deviate from each other by maximum  $0.5^\circ$ .

Use suitable safety devices (e.g. safety bows, stable protective grids) to prevent joint shaft parts being catapulted out or ejected.

- 1 Engine
- 2 Flexible clutch with self-centring mechanism. Size and design according to engine performance and torsion vibration calculation.
- 3 Joint shaft with length compensation. Selection according to manufacturer's recommendation. Observe Installation Instructions ( $\beta_1 = \beta_2$ , joint forks installed on one level).
- 4 Propeller shaft.
- 5 Marine transmission with input and output on one side.
- 6 Auxiliary device for aligning the engine and transmission to achieve equal joint angles  $\beta_1 = \beta_2$ .

A laser-based alignment device can be used to control the joint angles during alignment. The engine is aligned correctly when the two joint angles are the same size.

Provide a catch device for the joint shaft at all positions where the rotating shaft presents a hazard. The user and/or operator must take adequate safety measures.

#### 4.1.5 Alignment of the transmission

A highly flexible support of the transmission normally requires a torsionally flexible connection between transmission output flange and propeller shaft in order to enable absorption of relative movements (e.g. joint clutch or flexible clutch). This is not necessary when the propeller shaft also has a very flexible design.

Align the transmission to the propeller shaft in propeller shaft installations with rigid connection to the transmission output shaft. To do so, the ship must float on water and be fully equipped. It might be necessary to repeat the alignment procedure prior to commissioning.



#### 4.1.6 Trolling

**i** This Section is only applicable for transmissions with a mounted and controlled trolling valve. The trolling valve does not belong to the standard ZF scope of delivery.

Trolling operation allows operating at propeller speeds below those possible in non-trolling operation.

##### 4.1.6.1 Electrical actuation device for trolling operation

**i** Transmissions with a trolling device are not fitted with a speed safeguard for the trolling operation. A speed safeguard installed additionally by the shipyard can block an inadmissible speed range during trolling operation and therefore prevent incorrect operation.

The electrical actuation device for trolling operation comprises a directional valve operated electrically for switching the trolling function on or off as well as a proportional valve for setting the clutch pressure. The shipyard is responsible for actuation of both valves. The directional valve is actuated continually with 24 V voltage and 18 W capacity during trolling operation, see position 147 in Fig. 24. A current input in the range 150 to 450 mA is specified for the proportional valve with a resistance of 23.5 to 26.5 Ohm, see position 150 in Fig. 24, for setting the clutch pressure. A high current input creates a low clutch pressure and therefore a low propeller speed. On the other hand, a low current input creates a high clutch pressure and therefore a high propeller speed. Specifications concerning the electrical connections are contained in the associated installation documents. Direct current can also be used for the proportional valve instead of the chopper frequency specified in the installation documents. The chopper frequency only has a positive effect on the response behavior. The trolling function switches off automatically after a power failure.

**i** The delivered sign with operating instructions for trolling operation must be fitted visible and as close as possible to the trolling shift lever, and be easily readable during operation.

**i** Refer to the Operating Instructions of the actuation manufacturer on operating the trolling actuation.

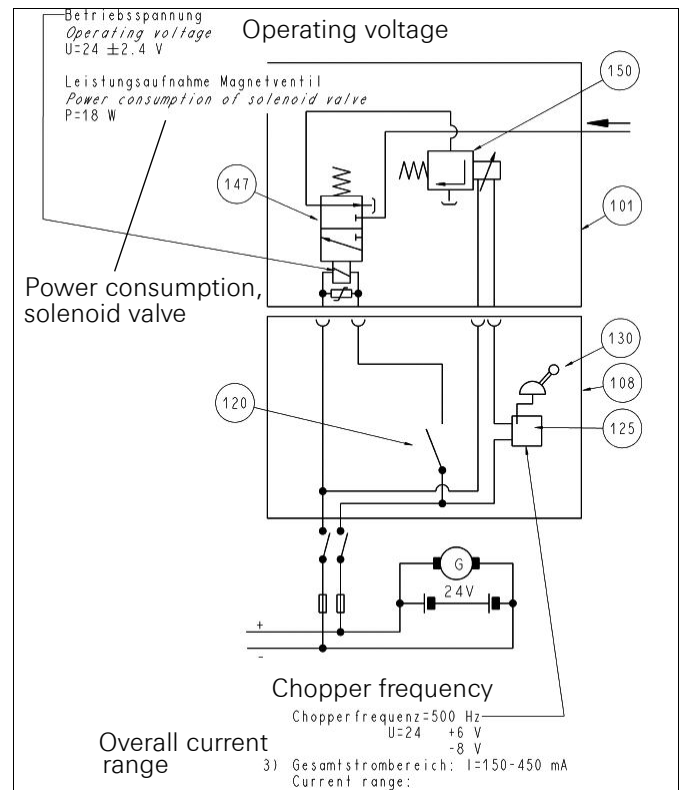


Fig. 24: Electrical circuit diagram (example)

- 101 Electrical actuation device for trolling operation (ZF scope of delivery)
- 106 Electrical plug connection (ZF scope of delivery)
- 108 Deck switch (not ZF scope of delivery)
- 120 Switch to switch trolling operation on and off (not ZF scope of delivery)
- 125 Trolling control (not ZF scope of delivery)
- 130 Deck switch trolling MIN/MAX (not ZF scope of delivery)
- 147 Solenoid valve (ZF scope of delivery)
- 150 Proportional valve (ZF scope of delivery)

#### Maximum admissible engine speed in trolling operation

For submerged standard propellers (with parabolic propeller curve): 50% of maximum admissible operating speed (engine speed), however up to a maximum of 1,000 rpm.

For surface propellers: Engine idling speed up to the maximum operating speed (engine speed) of 700 rpm.

#### Maximum admissible lubricating oil temperature in trolling operation

The maximum lubricating oil temperature in trolling operation is 90°C.




#### 4.1.6.2 Retrofitting the trolling valve

The electrical trolling valve can be fitted afterwards. Retrofitting the trolling valve must be carried out by a qualified technician authorized to carry out the work.

#### 4.1.6.3 ZF AUTOTROLL

The electronically controlled trolling device ZF AUTOTROLL can be used in connection with the electrical transmission actuation. Propeller speeds below the engine idle speed are possible when using this trolling device.

 Separate installation instructions can be requested from ZF Customer Service for fitting the electronically controlled trolling device ZF AUTOTROLL.

#### 4.1.7 Transmission cooling (cooling systems)

Specifications in this Section only apply for coolers fitted as standard!

##### 4.1.7.1 Open sea water circuit

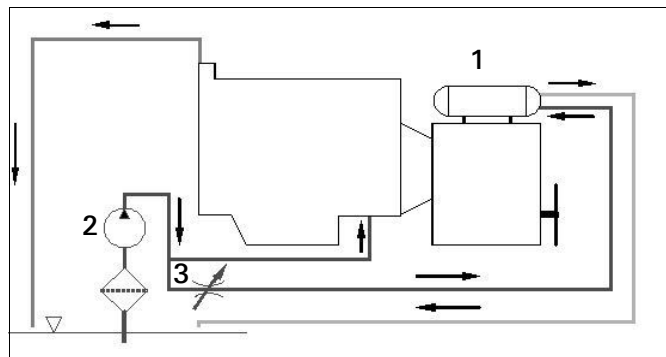


Fig. 25: Position of the transmission oil cooler in the open sea water circuit (example)

- 1 Transmission oil cooler
- 2 Sea water pump
- 3 Control device

In an open cooling water circuit, sea water flows through the transmission oil cooler as cooling medium. Design pipework so that, in case of plant standstill, either the feed or return line of the transmission oil cooler can drain. Connect the respective line to the lower connection of the transmission oil cooler.

##### 4.1.7.2 Closed cooling water circuit

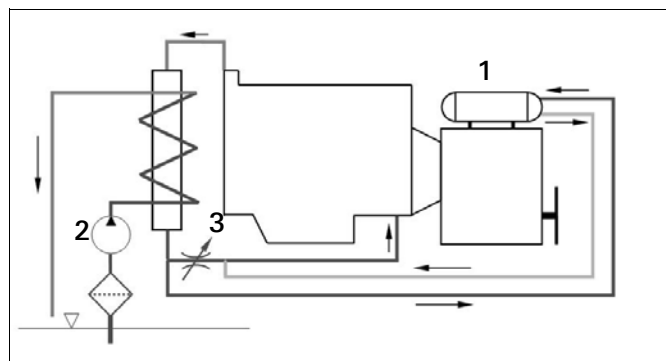


Fig. 26: Position of the transmission oil cooler in the closed cooling water circuit (example)

- 1 Transmission oil cooler
- 2 Sea water pump
- 3 Control device

Here, the cooling water circuit for the engine and transmission is separate from the sea water circuit.



Heat transmission from the engine/transmission cooling circuit to the sea water runs via a separate heat exchanger or via surface area coolers in the outer shell of the ship. Normally, the heat transfer medium in the engine cooling circuit is a mixture of water and a corrosion preventative. Corrosion in the cooling system is thus largely reduced. The purity of the cooling medium means the transmission oil cooler is hardly exposed to siltation or pitting corrosion.

#### 4.1.8 Transmission cooling (cooler design)

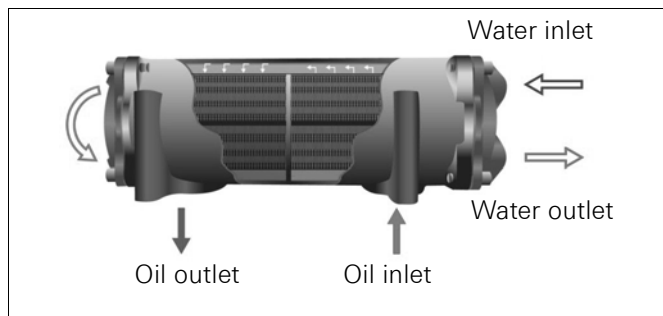


Fig. 27: Schematic display of cooler design (example)

##### 4.1.8.1 Requirements for the cooling water circuit

The amount of heat generated in the transmission is dissipated through the transmission oil cooler. The transmission oil cooler, as part of the basic transmission version, is mounted at or on the transmission housing.

See the technical specifications in the transmission installation drawing or Section 2.2 *Technical data* for the admissible water flow rate as well as the admissible pressure loss between cooling water inlet and outlet. The water pressure shown on the cooling water inlet must not be exceeded. The transmission oil cooler is designed so that heat dissipation is ensured for a transmission ambient temperature of 60°C and a water inlet temperature matching the specification in the transmission installation drawing (also at full transmission load and maximum speed).

##### Position of the transmission oil cooler in the cooling water circuit

The correct transmission temperature is set by adjusting the cooling water flow rate. For this purpose, provide a replaceable gland, a valve or a similar device in the pipe-work. Therefore, locate the water circuit of the transmission oil cooler in the "bleed off" of the engine cooling water circuit [see Section 4.1.6 *Trolling*]. The closed cooling circuit is preferable due to its clean cooling water.

#### Temperatures

Maximum cooling water inlet temperature:  
See transmission installation drawing and Section 2.2 *Technical data*.

#### Flow rates

Maximum admissible cooling water flow rate:  
See transmission installation drawing and Section 2.2 *Technical data*.

Minimum admissible cooling water flow rate:  
See transmission installation drawing and Section 2.2 *Technical data*.

#### Water pressure

Maximum permissible water pressure at the cooling water inlet: See transmission installation drawing and Section 2.2 *Technical data*.

#### Filtration

Suction filter on the water side required with mesh size:  
See transmission installation drawing.

This is necessary to keep contamination (such as solid matters or shells) away from the transmission oil cooler and the pipes because these clog the transmission oil cooler. A clogged transmission oil cooler or individual cooler pipes result in reduced cooling performance.

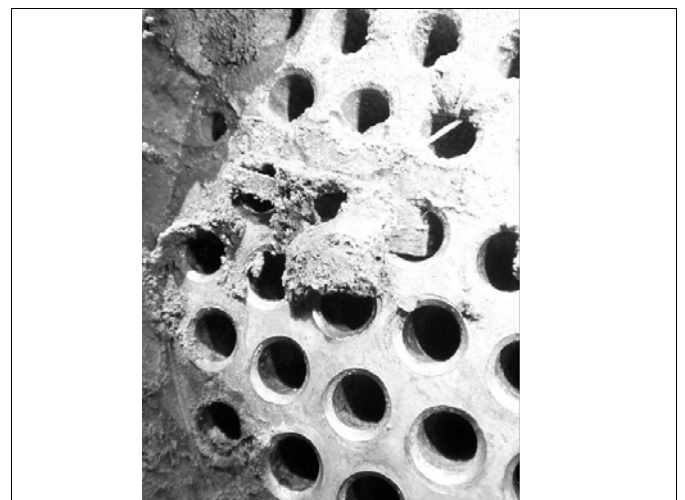


Fig. 28: Contamination (wood chips) caused by a filter screen where the mesh size is too large (example)



The required flow rates will not be achieved when cooling pipes are clogged. This may cause deposits or fouling which then lead to pitting corrosion.



#### 4.1.8.2 Earthing

To avoid galvanic corrosion, it is important that there is no electric potential difference on components transporting sea water. This means the transmission and, therefore, the transmission oil cooler, as well as all other components transporting sea water, must be connected to the earth bus to be electroconductive.

Material: Copper  
Minimum diameter: 16 mm<sup>2</sup>

Before connecting, ensure the junctions of the earth strap are free from paint or other electrically insulating materials.

#### Free-standing transmission

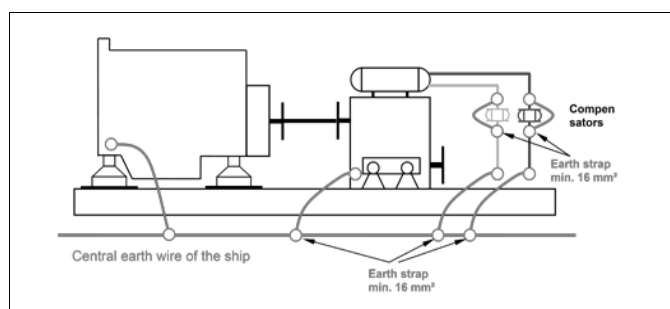


Fig. 29: Earthing for free-standing transmission (example)

#### Flanged transmission

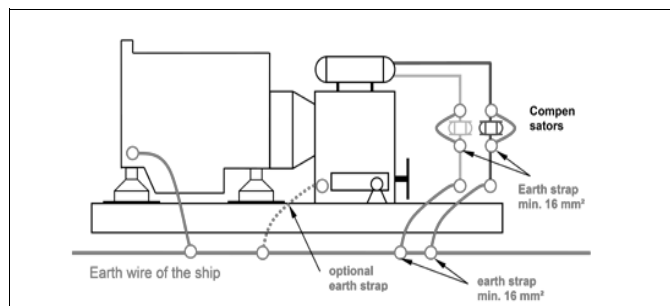


Fig. 30: Earthing for flanged transmission (example)

#### 4.1.8.3 Drainage of the transmission oil cooler

Ideally, plan the cooling water circuit so that the transmission oil cooler is automatically drained when the cooling water pump is idle.

**i** Bacteria in the standing water create decomposition products which deposit in the transmission oil cooler. This can lead to pitting corrosion when transmission oil cooler surfaces have not been passivated yet. Surface passivation only builds up after some time of operation in water rich in oxygen.

#### Drainage of water for longer idle time

Drain the water off with the sea water circuit open when the system is to be switched off for a longer period of time (for standstill time, see Chapter 8 *Maintenance*, Section 8.2.2 *Maintenance work before taking out of operation/standstill*).

**i** This is only required when the transmission oil cooler is not automatically drained when the cooling water pump is idle.

Provide a drain plug or drain valve in the pipe to allow draining the cooling circuit. Position the connection lower than the transmission oil cooler to ensure complete drainage of the transmission oil cooler.

#### 4.1.9 Transmission cooling (pipework)

##### 4.1.9.1 Installation

All required oil pipes are connected fixed and ready for operation. Connections for the cooling water inlet and outlet are closed with blind flanges when delivered. For further information, see the respective transmission installation drawings. The blind flanges can be used as welding flanges during installation of the cooling water pipe. Install an elastic adapter (compensator, hose piece) between these flanges and the ship-side cooling water pipes to enable uncoupling. The exact position of the connections can be seen in the corresponding transmission installation drawing. Comply with the water flow direction, i.e. do not swap the water inlet and water outlet.

The temperature increase of the cooling water in the transmission oil cooler is maximum 5°C. The mixing temperature of the engine cooling circuit increases by approx. 0.5°C and is therefore irrelevant. The indicated maximum cooling water flow rate through the transmission oil cooler must not be exceeded; otherwise there is the risk of cavitation in the cooler. The minimum flow rate must also be adhered to otherwise the flow rate is too low which can lead to the transmission oil cooler silting up prematurely or the water flow being impaired by salt precipitation.

##### 4.1.9.2 Flow velocity

|                        |         |
|------------------------|---------|
| Minimum flow velocity: | 1.5 m/s |
| Maximum flow velocity: | 3.0 m/s |

Plan pipe diameters so that, at nominal speed, the minimum flow velocity is reached and the maximum flow velocity is not exceeded.





Fig. 31: Fouling: Organic deposits on the pipe bundle caused by a low flow velocity and a long standstill time (example)

#### 4.1.9.3 Materials for cooling water pipes

When choosing materials for water pipes, take into account that different materials cannot be combined at random. Less precious metal will corrode when combined with more precious metal.

Material for pipes and stop valves in the sea water circuit: Copper alloy (e.g. CuNi10Fe1Mn).

Do not use galvanised steel pipes because there is a risk that galvanic processes corrode parts of the zinc coating and that iron corrosion parts can deposit on the discs or flange pipes of the transmission oil cooler. Pitting corrosion would damage the transmission oil cooler within a short time.

#### 4.1.9.4 Earthing for the cooling water pipe

To avoid galvanic corrosion, it is important that there is no electric potential difference on components transporting sea water.

Therefore, connect all cooling water pipes to the earth bus of the ship electroconductive. If there is an insulation separation line in the pipe (hose or compensator), it must be bridged electroconductive using an earth strap (see Section 4.1.8.2 *Earthing*).

#### 4.1.10 Transmission cooling (general information)

##### 4.1.10.1 Clearance for maintenance jobs

Inspect and maintain the cooler in regular intervals according to the Maintenance Instructions. For this purpose, provide a corresponding clearance for disassembling the pipe bundle.

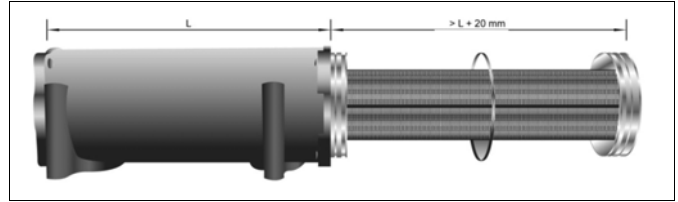


Fig. 32: Required clearance for disassembling the pipe bundle (example)

#### 4.1.11 Oil filling and oil level control

ZF marine transmissions are not filled with oil when leaving the factory. A corresponding sign is attached to the transmission for delivery.

Every transmission receives an initial filling and is connected to the oil circuit of the test rig for the functional test performed at the factory. After the successful test run, rinsing with conserving oil serves to conserve the transmission interior.

For suitable oil types, see "ZF lubricant list TE-ML 04 for marine transmissions". A lubricant list valid at the time of delivery is included with the transmission.

Any lost list can be requested from every ZF Customer Service Centre. It can be downloaded free of charge in PDF format on the internet under [www.zf.com](http://www.zf.com).

Refer to the type plate for the amount of oil required.

For correct performance of oil filling and oil level control, see Chapter 8 *Maintenance*.

#### 4.1.12 Connection of monitoring equipment

Always plan the minimum monitoring specified in Section 2.2 *Technical data*, 2.2.8 *Monitoring values for ZF 2000/2150/2200/2300/W2300/W2400 series* (monitoring equipment not supplied as standard).

Arrange equipment required for monitoring so that reliable device reading is always ensured, even under poor operating conditions. Indicating scales on the monitoring equipment are to be selected so that the highest possible needle deflection in the operating range is achieved.

In addition to the obligatory minimum monitoring, further display or warning devices can be connected to the measuring points sealed with blind plugs.

#### 4.2 Installation control and commissioning

ZF marine transmissions are tested on test rigs prior to delivery to our customers. All functions, oil pressures, temperature, and noise characteristics are checked and documented in detail within the scope of this test. Conservation of the transmission interior is performed by rinsing with anti-corrosive oil during the test run. This ensures storage in dry rooms for up to 12 months without further measures.



### Perform the following work and a complete installation control prior to the first operation:

- Oil filling and oil level control as described in *Chapter 8 Maintenance*
- First rotate the engine and then the propeller shaft manually, and check for free movement
- Check fixing screws of suspension brackets on transmission and foundation for tight fit
- Check connecting bolts between propeller shaft flange and transmission output flange for tight fit and fastening
- Check connecting bolts on transmission input for tight fit and fastening
- Check connections of monitoring devices at the measuring points
- Check oil cooler for connection to cooling system
- Ensure all water valves to the oil cooler are opened
- When using an oil cooler installed away from the transmission, check for secure connection of the cooler to the transmission lubricating system
- Check all rotating components for protective equipment
- Check all transmission components (pipework, sensors, plugs, electrical connections) for possible damage
- Check all electrical connections on the transmission for complete wiring and check sealing and isolation of all cable/wire connections
- Check all hoses, wires, and cables for signs of wear

### Functional test of operating mechanism

With mechanical transmission actuation, carefully check that shift positions are actually reached.

With electrical transmission actuation, check the operating voltage (24v) or current input at suitable positions, as close as possible to the plugs of electromagnets.

### 4.3 Commissioning after standstill

In general, shutdown periods can last up to 3 months without requiring any corrosion protection measures and operation can be continued without removing the corrosion protection.

After longer shutdown periods or scheduled shutdowns (> 3 months), measures for commissioning depend on the previous corrosion protection and the environmental conditions of the transmission.

Corrosion protection of the transmission interior is performed at the factory during the test run by rinsing with an anti-corrosive oil. This ensures storage in dry rooms for up to 12 month without requiring any further special measures.



Conservation measures for long-term storage must be specified in the transmission order.

#### 4.3.1 Standstills of 3 to 6 months

Level K1 corrosion protection measures should have been performed for shutdown periods under 6 months.

An oil change according to maintenance level Z1 is required prior to re-commissioning depending on the condition of the oil in the transmission.

##### *Commissioning after K1 conservation*

Test oil for condensate (emulsion) prior to re-commissioning. Perform this test immediately after switching off the engine - oil must not be milky.

1. Start the engine and run for approx. 5 minutes to mix any condensed water possibly accumulated in the transmission with the anti-corrosive oil.
2. Drain the anti-corrosive oil off and fill the transmission with the specified oil type (see Maintenance Job 141).

#### 4.3.2 Standstills of 6 to 9 months

Level K2 conservation should have been performed for a shutdown period longer than 6 months.

##### *Commissioning after K2 conservation*

1. Drain the anti-corrosive oil off until reaching the normal oil level.
2. Start the engine and run for approx. 5 minutes.
3. Drain the anti-corrosive oil off completely and fill the transmission with the specified oil type (see Maintenance Job 141).

#### 4.3.3 Standstills of 36 months and more

Transmissions can be decommissioned for a maximum of 36 months when long-term conservation K3 has been performed. Alternatively, conservation level K2 can be repeated every 9 months.

##### *Commissioning after K3 long-term conservation*

1. Drain the anti-corrosive oil off until reaching the normal oil level.
2. Start the engine and run for approx. 5 minutes.
3. Drain the anti-corrosive oil off completely and fill the transmission with the specified oil type (see Maintenance Job 141).



## 4.4 Operation monitoring

The minimum monitoring specified in Section 2.2 *Technical data*, 2.2.8 *Monitoring values for ZF 2000/2150/2200/2300/W2300/W2400 series* is required for assessing operational safety of the transmission and must be installed. In addition to the obligatory minimum monitoring, further display or warning devices can be connected to the measuring points sealed with blind plugs.

### 4.4.1 Minimum transmission monitoring

*Oil pressure before the oil filter (measuring point 5)*



This measuring point is only available for transmission versions with gap filter.

This measuring point serves for monitoring the oil filter. An increase in oil pressure indicates increasing filter contamination. Use a pressure switch for monitoring. Set this switch so that the pressure switch switches and an alarm is triggered should the pressure rise exceed the specified value.

*Differential pressure on the oil filter (measuring point 127)*



This measuring point is only available for transmission versions with changeover filter.

This measuring point is used for monitoring the differential pressure on the oil filter. An oil filter with a filter cartridge is used on the ZF 2000 series. A protective filter in the form of a wire sieve is fitted in the filter head to enable switching the oil filter and exchanging the filter cartridge during operation. The oil filter has an integral differential pressure switch.

*Clutch oil pressure (measuring point 2)*

The clutch oil pressure is set to different values depending on the transmission version and/or input torque. The rated clutch pressure is specified in the technical documents binding for the respective order and is also embossed on the type plate (see Section 2.2.7 *Transmission description*).

The specified clutch oil pressure is valid for "Engine wise rotation" or "Counter-engine wise rotation" shift positions. In the "Neutral" shift position, the oil pressure at this measuring point drops to the value specified in Section 2.2.8 *Monitoring values for ZF 2000/2150/2200/2300/W2300/W2400 series* depending on the input speed and oil temperature. The same applies to the clutch oil pressure in trolling operation. Use a pressure gauge to monitor the clutch oil pressure. Transmission lubrication is also ensured when the clutch oil pressure corresponds to the specified values under the existing conditions. Specific monitoring of the lubricating oil pressure (measuring point 22) is therefore not required.

*Oil temperature (measuring point 12)*

Use a thermometer to monitor the transmission oil temperature. Regulate the water flow rate through the transmission oil cooler so that the transmission oil temperature is within the recommended normal range during normal operation. The maximum transmission oil temperature must not be exceeded during continuous operation.

### 4.4.2 Additional transmission monitoring

Additional measuring points are provided on the transmission for additional transmission monitoring purposes in case a higher level of functional monitoring is desired or required by the Classification Societies. The relevant measuring values are equal to those at the measuring points for the minimum monitoring.

*Oil pressure before the oil filter (measuring point 5)*



This measuring point is only available for transmission versions with gap filter.

A T-piece can be mounted on measuring point 5 for simultaneous connection of the pressure gauge and pressure switch when monitoring is to be realised using a pressure gauge and a monitoring device. A pressure sensor with integrated switching contact can also be used for the alarm device for remote pressure display.

*Clutch oil pressure (measuring point 21)*

An additional pressure switch can be connected to measuring point 21 in connection with a monitoring device or pressure gauge. When monitoring with a pressure switch, set the switch so that the alarm is triggered when the pressure drops below the alarm value.

In "Neutral" shift position, the oil pressure drops below the alarm value of the pressure switch, i.e. an alarm is also triggered for normal oil pressure in this shift position. To prevent this, disable the alarm unit in "Neutral" shift position and during trolling operation, e.g. using a neutral switch operated by the transmission actuation (ZF special scope of delivery). Integrate a time-delay relay with a delay of at least 3 s and maximum 10s to prevent the alarm being triggered during the time between the control being actuated and the full clutch oil pressure being built up (approx. 1 to 2 s).

*Lubricating oil pressure (measuring point 22)*

Measuring point 22 can be used for monitoring the lubricating oil pressure. Monitoring can be realised using a pressure gauge or pressure switch. The lubricating oil pressure is within the range of the values specified in Section 2.2.8 *Monitoring values for ZF 2000/2150/2200/2300/W2300/W2400 series* depending on the transmission input speed and transmission oil temperature. When



monitoring using a pressure switch, set the switch so that the alarm is triggered for a lubricating oil pressure below the alarm value according to Section 2.2.8 *Monitoring values for ZF 2000/2150/2200/2300/W2300/W2400 series*.

### *Oil temperature (measuring point 11)*

Measuring point 11 can be used for additional installation of a temperature sensor for a remote thermometer or a temperature switch for monitoring devices. Set the temperature to the alarm value specified for the relevant transmission version.

### *Oil temperature (measuring point 41)*

Additional use of this measuring point is possible for versions with a trailing oil pump.

Measuring point 41 is not located in the oil sump. It may only be used for monitoring the oil temperature when oil circulation is available - with the engine running or propeller shaft rotating with the trailing oil pump mounted.

### *Neutral switch*

The Neutral switch checks whether the control piston in the control unit is in "Neutral" shift position.



## 5 Operation

### 5.1 Operating elements

Control units with mechanical and electrical transmission actuation are available. Electrical transmission actuation is included as standard in the ZF 2000 series scope of delivery.

Actuation units must be constructed so that shift operations on the transmission are only possible when the engine is idling. The safest way to achieve this is using a "single-lever control" where the engine throttle control and the transmission actuation are coupled to each other. When using a "two-lever control", install a locking device in the transmission actuation unit which only allows shifting the transmission when the movement lever is in idle position.

The "single-lever control" must have an emergency shutoff option for transmission actuation to allow high engine speeds for inspection or warm-up purposes without switching in the transmission.

The following transmission actuation variants are possible:

| Transmission              | Number of solenoid valves | Function "Maintain shift position during power failure" available | See Section   |
|---------------------------|---------------------------|---|---|
| ZF 2000 series without NR | 2 (1x CEW, 1x EW)         | No  | <i>5.1.1 Electrical transmission actuation with two solenoid valves (for ZF 2000 series without NR)</i> |
| ZF 2000 NR (CEW) series   | 2 (1x CEW, 1x NEUTRAL)    | Yes   | <i>5.1.2 Electrical transmission actuation (for ZF 2000 NR (CEW) series)</i>                            |
| ZF 2000 NR (EW) series    | 2 (1x EW, 1x NEUTRAL)     | Yes   | <i>5.1.3 Electrical transmission actuation (for ZF 2000 NR (EW) series)</i>                             |

Tab. 3: Electrical transmission actuation variants for the ZF 2000 series

| Transmission   | See Section  |
|----------------|--|
| ZF 2000 series | <i>5.1.4 Mechanical transmission actuation (for ZF 2000 series) on page 75</i> |


Tab. 4: Mechanical transmission actuation for the ZF 2000 series



### 5.1.1 Electrical transmission actuation with two solenoid valves (for ZF 2000 series without NR)

With this electrical transmission actuation, the control piston is moved axially in the control unit using oil pressure through one electrical actuation unit mounted on the control unit. The actuation unit comprises electromagnets "a" ("Engine wise rotation" shift position) and "b" ("Counter-engine wise rotation" shift position) as well as a pilot valve.

Disable mechanical emergency actuation to allow control using electrical transmission actuation. For this purpose, unscrew the set screws on both electromagnets "a" and "b" of the actuation unit until flush with the plane surface (see Section 5.1.1.2).

 Ensure the pilot valve is not in emergency actuation prior to starting operation.

#### 5.1.1.1 Electrical transmission actuation elements

- **Shift position "Engine wise rotation"**  
Electromagnet "a" pointing towards the output is responsible for output direction the same as input direction.
- **Shift position "Counter-engine wise rotation"**  
Electromagnet "b" opposite the output is responsible for output direction against the input direction.

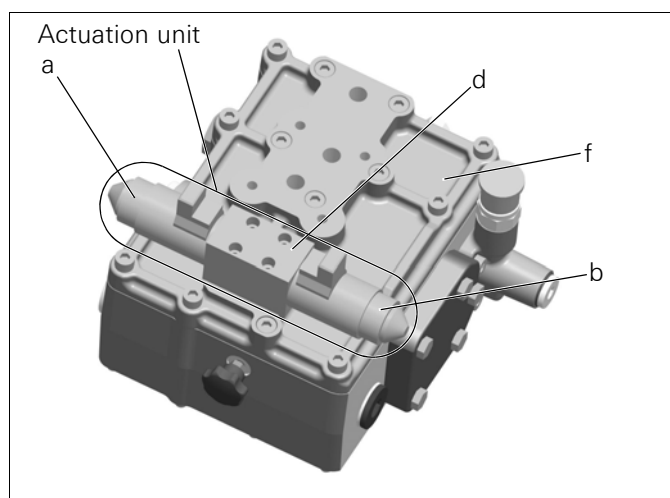


Fig. 33: Electrical transmission actuation elements (example)

- a - Electromagnet for "Engine wise rotation" shift position
- b - Electromagnet for "Counter-engine wise rotation" shift position
- d - Pilot valve for "Engine wise rotation" and "Counter-engine wise rotation" shift positions
- f - Control unit

Activating these electromagnets allows selecting the shift position as follows:

- Neutral:** No voltage is applied to electromagnets "a" and "b".
- Engine wise rotation:** Voltage is only applied to the output-side electromagnet "a".
- Counter-engine wise rotation:** Voltage is only applied to electromagnet "b" (opposite "a").

#### DANGER

**Risk of injury due to rotating parts.**

**Death or serious injury possible.**

⇒ Install propshaft brake or propshaft lock.

The propeller shaft can still rotate even when the transmission clutch is open in "Neutral" shift position. Provide a propeller shaft brake or other shaft locking device when the propeller shaft must be idle.

#### WARNING

**Risk of accident due to a non-functioning operating element.**

**Death or serious injury possible.**

⇒ Adapt driving method when on open waters.

⇒ Do not drive in tight and heavily-frequented waters.

⇒ Allow the ship to be towed.

The transmission switches to the "Neutral" shift position automatically when a power failure occurs. This can make the ship unmanoeuvrable.

#### 5.1.1.2 Mechanical emergency actuation with two solenoid valves (for ZF 2000 series without NR)

Manual actuation of the transmission is possible (i.e. emergency actuation) in case of actuation device malfunctions.

#### WARNING

**Risk of accident due to an inadequate access to the tool for emergency actuation.**

**Death or serious injury possible.**

⇒ Ensure a free access.





# **WARNING**

**Risk of accident due to a insufficient clearance to actuate mechanical emergency actuation.**

**Death or serious injury possible.**

⇒ Provide a clearance of at least 20 cm.

Mechanical emergency actuation of electromagnets "a" ("Engine wise rotation" shift position) or "b" ("Counter-engine wise rotation" shift position) of the actuation unit is performed manually using a set screw with the tool fitted on the control unit (hexagon socket wrench, opening 3 mm). The set screw is located on the front side of the electromagnets.

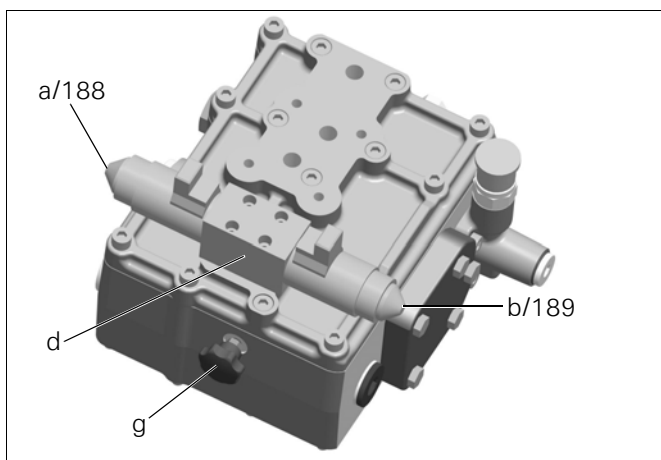


Fig. 34: Mechanical emergency actuation of the actuation unit with electromagnets "a" and "b" (example)

- a/188 Electromagnet "a": Position of set screw for "Engine wise rotation" shift position (output direction same as input direction)
- b/189 Electromagnet "b": Position of set screw for "Counter-engine wise rotation" shift position (output direction against input direction)
- d Pilot valve for "Engine wise rotation" and "Counter-engine wise rotation" shift positions
- g Tool for emergency actuation of electromagnets "a" ("Engine wise rotation" shift position) and "b" ("Counter-engine wise rotation" shift position)

The set screw on electromagnets "a" and "b" on both sides of the pilot valve of the upper actuation unit has two positions. An intermediate position is not admissible. Resistance (i.e. stopper) can be noticed when the end position is reached in both positions.

- Unscrewed:** Approx. flush with plane surface (set screw protrudes approx. 0.2 to 0.3 mm)
- Screwed in:** Screwed in approx. 6.0 to 6.2 mm (dimension, plane surface-set screw)

## **Neutral shift position**

Electromagnet "a": Set screw unscrewed (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm)

Electromagnet "b": Set screw unscrewed (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm)

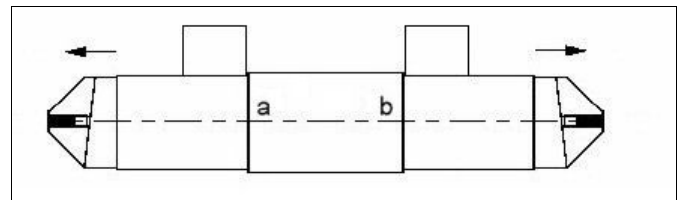


Fig. 35: Pilot valve in "Neutral" shift position

## **Engine wise rotation shift position**

Electromagnet "a": Set screw screwed in (approx. 6.0 to 6.2 mm from plane surface)

Electromagnet "b": Set screw unscrewed (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm)

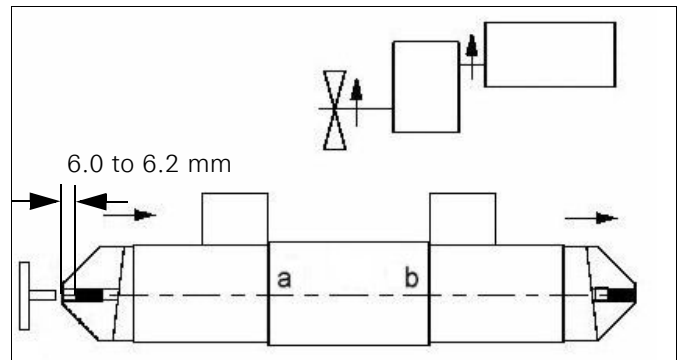


Fig. 36: Pilot valve in "Engine wise rotation" shift position



### Counter-engine wise rotation shift position

Electromagnet "a": Set screw unscrewed (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm)

Electromagnet "b": Set screw screwed in (approx. 6.0 to 6.2 mm from plane surface)

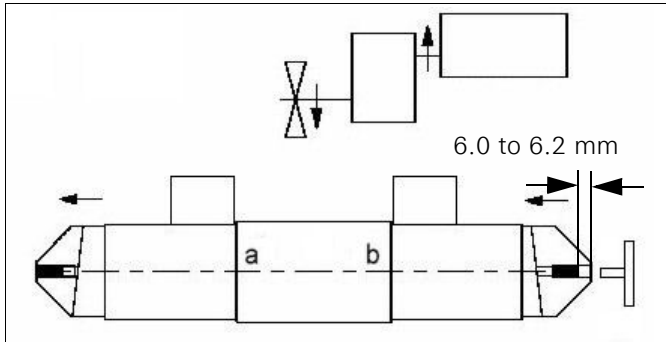


Fig. 37: Pilot valve in "Counter-engine wise rotation" shift position

#### 5.1.1.3 Operation using mechanical emergency actuation

##### **! WARNING**

**Risk of accident due to a non-functioning operating element.**

**Death or serious injury possible.**

- ⇒ Adapt driving method when on open waters.
- ⇒ Do not drive in tight and heavily-frequented waters.
- ⇒ Allow the ship to be towed.

The clutch set through the corresponding electromagnet of the upper actuation unit is always closed when the engine is running. The transmission actuated mechanically cannot be switched or reversed to the "Neutral" shift position using the movement lever.

**i** Prior to starting operation, ensure the tool for mechanical emergency actuation is available on the control unit or a key for hexagon socket screws (Allen key, opening 3 mm) is available with the on-board tools.

### Switching on the mechanical emergency actuation

Requirements:

- If the mechanical emergency actuation is used, the electrical transmission actuation must be switched off (e.g. by switching off the transmission control or by disconnecting the plugs on the electromagnets).

##### **! CAUTION**

**Risk of burns due to contact with hot surfaces.**

**Slight or moderate injury possible.**

- ⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.

##### **! WARNING**

**Risk of accident due to incorrect direction of motion.**

**Death or serious injury possible.**

- ⇒ Ensure correct direction of motion.

2. Use the tool on the control unit to screw in the electromagnet set screw for the corresponding shift position (set screw on electromagnet "a" for "Engine wise rotation" shift position, set screw on electromagnet "b" for "Counter-engine wise rotation" shift position) to the stop (approx. 6.0 to 6.2 mm).
3. Return the tool to the respective holder of the control unit.
4. Check for correct direction.



## Switching off the mechanical emergency actuation

### CAUTION

**Risk of burns due to contact with hot surfaces.**

**Slight or moderate injury possible.**

⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.
2. Use the tool on the control unit to unscrew the set screw of both electromagnets "a" and "b" to the stop (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm).
3. Return the tool to the respective holder of the control unit.
4. Ensure electrical transmission actuation is switched on (e.g. by switching on the transmission control or by connecting the plugs to the electromagnets).
5. Check whether all shift positions can be selected with the movement lever.

### 5.1.2 Electrical transmission actuation (for ZF 2000 NR (CEW) series)

With this electrical transmission actuation, the control piston is moved axially in the control unit using oil pressure through one electrical actuation unit mounted on the control unit. The actuation unit comprises electromagnets "a" ("Neutral" shift position) and "b" ("Counter-engine wise rotation" shift position) as well as a pilot valve.

Disable mechanical emergency actuation to allow control using electrical transmission actuation. For this purpose, unscrew the set screws on both electromagnets "a" and "b" of the actuation unit until flush with the plane surface (see Section 5.1.2.2).



Ensure the pilot valve is not in emergency actuation prior to starting operation.

### 5.1.2.1 Electrical transmission actuation elements

- **Shift position "Counter-engine wise rotation"**  
Electromagnet "b" opposite the output is responsible for output direction against the input direction.
- **"Neutral" shift position**  
Electromagnet "a" pointing towards the output is responsible for the "Neutral" shift position.

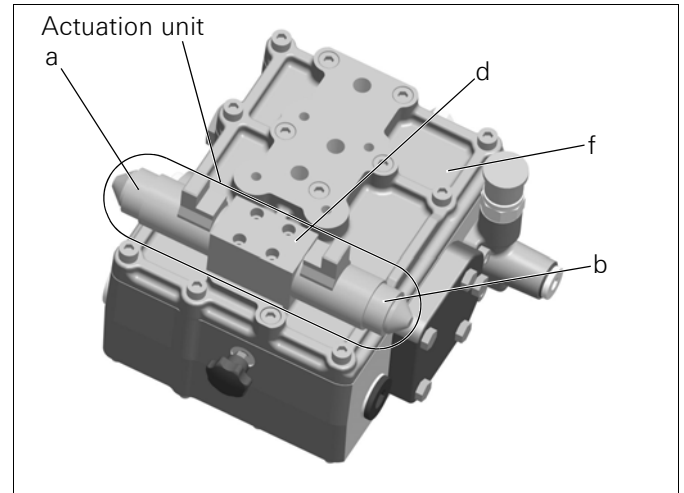


Fig. 38: Electrical transmission actuation elements (example)

- a - Electromagnet for "Neutral" shift position
- b - Electromagnet for "Counter-engine wise rotation" shift position
- d - Pilot valve for "Neutral" and "Counter-engine wise rotation" shift positions
- f - Control unit

Activating these electromagnets allows selecting the shift position as follows:

#### Neutral:

Voltage is only applied to the output-side electromagnet "a".

#### Counter-engine wise rotation:

Voltage is only applied to electromagnet "b" (opposite "a").



### ! DANGER


**Risk of injury due to rotating parts.**

**Death or serious injury possible.**

⇒ Install propshaft brake or propshaft lock.

The propeller shaft can still rotate even when the transmission clutch is open in "Neutral" shift position. Provide a propeller shaft brake or other shaft locking device when the propeller shaft must be idle.



**WARNING**

**Risk of accident due to a non-functioning operating element.**

**Death or serious injury possible.**

⇒ Adapt driving method when on open waters.


⇒ Do not drive in tight and heavily-frequented waters.

⇒ Allow the ship to be towed.

The current shift position of the transmission is maintained following a power failure.

**5.1.2.2 Mechanical emergency actuation (for ZF 2000 NR (CEW) series)**


Manual actuation of the transmission is possible (i.e. emergency actuation) in case of actuation device malfunctions.

**WARNING**

**Risk of accident due to an inadequate access to the tool for emergency actuation.**

**Death or serious injury possible.**

⇒ Ensure a free access.

**WARNING**

**Risk of accident due to a insufficient clearance to actuate mechanical emergency actuation.**

**Death or serious injury possible.**

⇒ Provide a clearance of at least 20 cm.

Mechanical emergency actuation of electromagnets "a" ("Neutral" shift position) or "b" ("Counter-engine wise rotation" shift position) of the actuation unit is performed manually using a set screw with the tool fitted on the control unit (hexagon socket wrench, opening 3 mm). The set screw is located on the front side of the electromagnets.

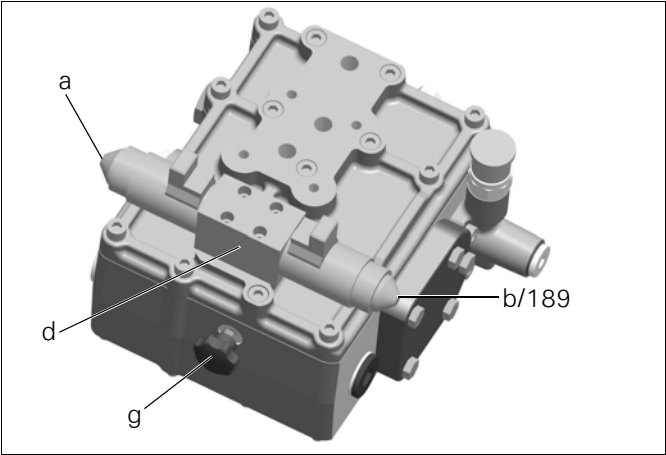


Fig. 39: Mechanical emergency actuation of the actuation unit with electromagnets "a" and "b" (example)

- |       |   |
|-------|---|
| a     | Electromagnet "a": Position of set screw for "Neutral" shift position   |
| b/189 | Electromagnet "b": Position of set screw for "Counter-engine wise rotation" shift position (output direction against input direction) |
| d     | Pilot valve for "Neutral" and "Counter-engine wise rotation" shift positions  |
| g     | Tool for emergency actuation of electromagnets "a" ("Neutral" shift position) and "b" ("Counter-engine wise rotation" shift position) |

The set screw on electromagnets "a" and "b" on both sides of the pilot valve of the upper actuation unit has two positions. An intermediate position is not admissible. Resistance (i.e. stopper) can be noticed when the end position is reached in both positions.

- |                    |  |
|--------------------|--|
| <b>Unscrewed:</b>  | Approx. flush with plane surface (set screw protrudes approx. 0.2 to 0.3 mm) |
| <b>Screwed in:</b> | Screwed in approx. 6.0 to 6.2 mm (dimension, plane surface-set screw)        |



### Neutral shift position

Electromagnet "a": Set screw screwed in (approx. 6.0 to 6.2 mm from plane surface)

Electromagnet "b": Set screw unscrewed (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm)

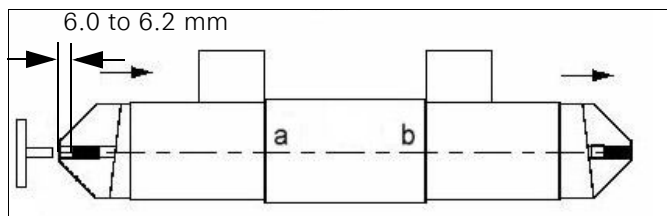


Fig. 40: Pilot valve in "Neutral" shift position

### Counter-engine wise rotation shift position

Electromagnet "a": Set screw unscrewed (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm)

Electromagnet "b": Set screw screwed in (approx. 6.0 to 6.2 mm from plane surface)

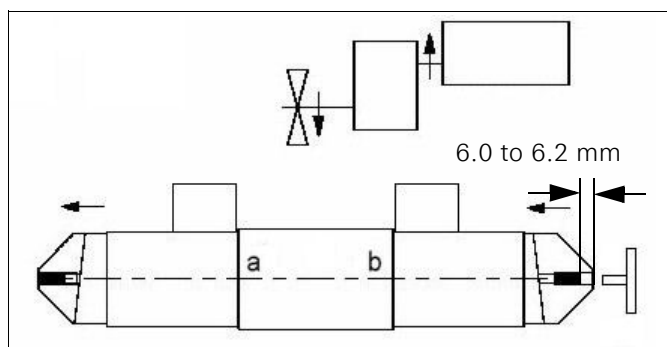


Fig. 41: Pilot valve in "Counter-engine wise rotation" shift position

### 5.1.2.3 Operation using mechanical emergency actuation

#### WARNING

**Risk of accident due to a non-functioning operating element.**

**Death or serious injury possible.**

- ⇒ Adapt driving method when on open waters.
- ⇒ Do not drive in tight and heavily-frequented waters.
- ⇒ Allow the ship to be towed.

The clutch set through electromagnet "b" of the actuation unit is always closed when the engine is running. The transmission actuated mechanically cannot be switched or reversed to the "Neutral" shift position using the movement lever.



Prior to starting operation, ensure the tool for mechanical emergency actuation is available on the control unit or a key for hexagon socket screws (Allen key, opening 3 mm) is available with the on-board tools.

#### Switching on the mechanical emergency actuation

Requirements:

- If the mechanical emergency actuation is used, the electrical transmission actuation must be switched off (e.g. by switching off the transmission control or by disconnecting the plugs on the electromagnets).

#### CAUTION

**Risk of burns due to contact with hot surfaces.**

**Slight or moderate injury possible.**

- ⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.
2. Use the tool on the control unit to screw in the electromagnet set screw for the corresponding shift position (set screw on electromagnet "a" for "Neutral" shift position, set screw on electromagnet "b" for "Counter-engine wise rotation" shift position) to the stop (approx. 6.0 to 6.2 mm).
3. Return the tool to the respective holder of the control unit.
4. Check for correct direction.



## Switching off the mechanical emergency actuation

### CAUTION

**Risk of burns due to contact with hot surfaces.**

**Slight or moderate injury possible.**


⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.
2. Use the tool on the control unit to unscrew the set screw of both electromagnets "a" and "b" to the stop (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm).
3. Return the tool to the respective holder of the control unit.
4. Ensure electrical transmission actuation is switched on (e.g. by switching on the transmission control or by connecting the plugs to the electromagnets).
5. Check whether all shift positions can be selected with the movement lever.

### 5.1.3 Electrical transmission actuation (for ZF 2000 NR (EW) series)

With this electrical transmission actuation, the control piston is moved axially in the control unit using oil pressure through one electrical actuation unit mounted on the control unit. The actuation unit comprises electromagnets "a" ("Engine wise rotation" shift position) and "b" ("Neutral" shift position) as well as a pilot valve.

Disable mechanical emergency actuation to allow control using electrical transmission actuation. For this purpose, unscrew the set screws on both electromagnets "a" and "b" of the actuation unit until flush with the plane surface (see Section 5.1.3.2).

 Ensure the pilot valve is not in emergency actuation prior to starting operation.

#### 5.1.3.1 Electrical transmission actuation elements

- **Shift position "Engine wise rotation"**  
Electromagnet "a" pointing towards the output is responsible for output direction the same as input direction.
- **"Neutral" shift position**  
Electromagnet "b" opposite the output is responsible for the "Neutral" shift position.

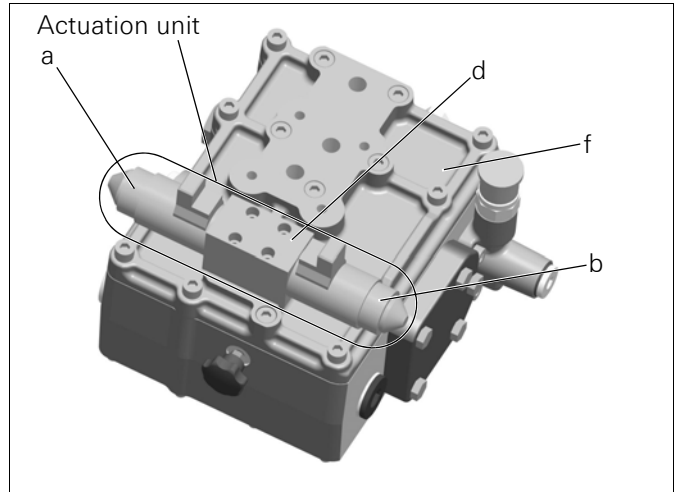


Fig. 42: Electrical transmission actuation elements (example)

- a - Electromagnet for "Engine wise rotation" shift position
- b - Electromagnet for "Neutral" shift position
- d - Pilot valve for "Neutral" and "Engine wise rotation" shift positions
- f - Control unit

Activating these electromagnets allows selecting the shift position as follows:

#### Engine wise rotation:

Voltage is only applied to the output-side electromagnet "a".

#### Neutral:

Voltage is only applied to electromagnet "b" (opposite "a").

### DANGER

**Risk of injury due to rotating parts.**

**Death or serious injury possible.**

⇒ Install propshaft brake or propshaft lock.

The propeller shaft can still rotate even when the transmission clutch is open in "Neutral" shift position. Provide a propeller shaft brake or other shaft locking device when the propeller shaft must be idle.



I

**! WARNING**

**Risk of accident due to a non-functioning operating element.**

**Death or serious injury possible.**

- ⇒ Adapt driving method when on open waters.
- ⇒ Do not drive in tight and heavily-frequented waters.
- ⇒ Allow the ship to be towed.

The current shift position of the transmission is maintained following a power failure.

### 5.1.3.2 Mechanical emergency actuation (for ZF 2000 NR (EW) series)

Manual actuation of the transmission is possible (i.e. emergency actuation) in case of actuation device malfunctions.

**! WARNING**

**Risk of accident due to an inadequate access to the tool for emergency actuation.**

**Death or serious injury possible.**

- ⇒ Ensure a free access.

**! WARNING**

**Risk of accident due to a insufficient clearance to actuate mechanical emergency actuation.**

**Death or serious injury possible.**

- ⇒ Provide a clearance of at least 20 cm.

Mechanical emergency actuation of electromagnets "a" ("Engine wise rotation" shift position) or "b" ("Neutral" shift position) of the actuation unit is performed manually using a set screw with the tool fitted on the control unit (hexagon socket wrench, opening 3 mm). The set screw is located on the front side of the electromagnets.

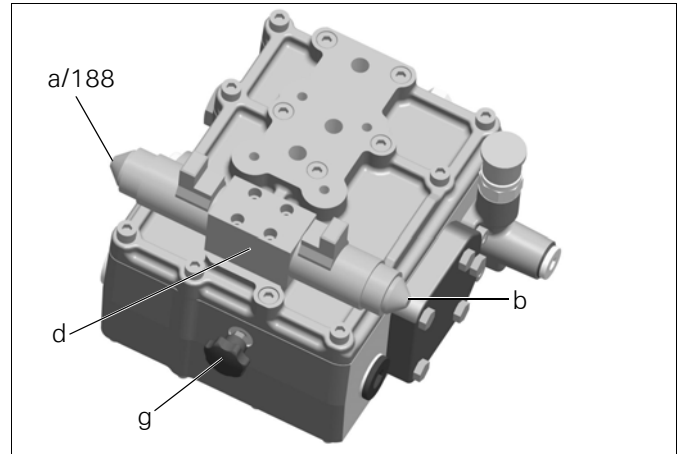


Fig. 43: Mechanical emergency actuation of the actuation unit with electromagnets "a" and "b" (example)

- |       |   |
|-------|---|
| a/188 | Electromagnet "a": Position of set screw for "Engine wise rotation" shift position (output direction same as input direction) |
| b     | Electromagnet "b": Position of set screw for "Neutral" shift position   |
| d     | Pilot valve for "Neutral" and "Engine wise rotation" shift positions  |
| g     | Tool for emergency actuation of electromagnets "a" ("Engine wise rotation" shift position) and "b" ("Neutral" shift position) |

The set screw on electromagnets "a" and "b" on both sides of the pilot valve of the upper actuation unit has two positions. An intermediate position is not admissible. Resistance (i.e. stopper) can be noticed when the end position is reached in both positions.

- |                    |  |
|--------------------|--|
| <b>Unscrewed:</b>  | Approx. flush with plane surface (set screw protrudes approx. 0.2 to 0.3 mm) |
| <b>Screwed in:</b> | Screwed in approx. 6.0 to 6.2 mm (dimension, plane surface-set screw)        |

#### Neutral shift position

Electromagnet "a": Set screw unscrewed (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm)

Electromagnet "b": Set screw screwed in (approx. 6.0 to 6.2 mm from plane surface)

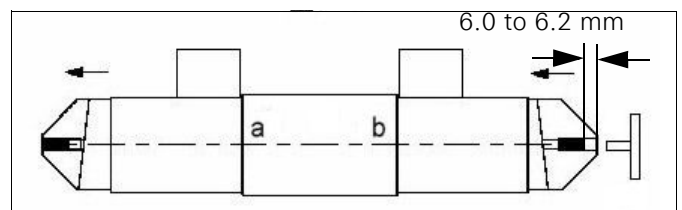


Fig. 44: Pilot valve in "Neutral" shift position



### Engine wise rotation shift position

Electromagnet "a": Set screw screwed in (approx. 6.0 to 6.2 mm from plane surface)

Electromagnet "b": Set screw unscrewed (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm)

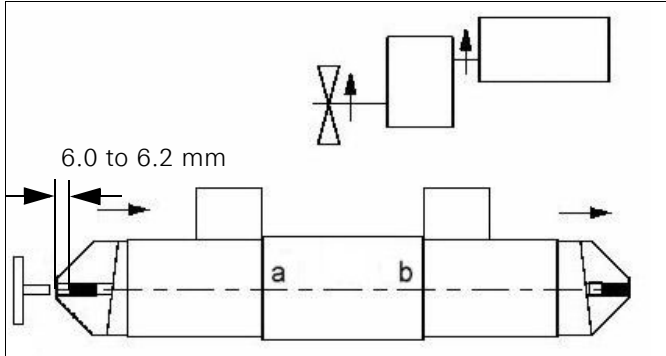


Fig. 45: Pilot valve in "Engine wise rotation" shift position

#### 5.1.3.3 Operation using mechanical emergency actuation

**! WARNING**

**Risk of accident due to a non-functioning operating element.**  
**Death or serious injury possible.**

- ⇒ Adapt driving method when on open waters.
- ⇒ Do not drive in tight and heavily-frequented waters.
- ⇒ Allow the ship to be towed.

The clutch set through electromagnet "a" of the actuation unit is always closed when the engine is running. The transmission actuated mechanically cannot be switched or reversed to the "Neutral" shift position using the movement lever.

**i** Prior to starting operation, ensure the tool for mechanical emergency actuation is available on the control unit or a key for hexagon socket screws (Allen key, opening 3 mm) is available with the on-board tools.

### Switching on the mechanical emergency actuation

Requirements:

- If the mechanical emergency actuation is used, the electrical transmission actuation must be switched off (e.g. by switching off the transmission control or by disconnecting the plugs on the electromagnets).

#### **! CAUTION**

**Risk of burns due to contact with hot surfaces.**  
**Slight or moderate injury possible.**

⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.
2. Use the tool on the control unit to screw in the electromagnet set screw for the corresponding shift position (set screw on electromagnet "a" for "Engine wise rotation" shift position, set screw on electromagnet "b" for "Neutral" shift position) to the stop (approx. 6.0 to 6.2 mm).
3. Return the tool to the respective holder of the control unit.
4. Check for correct direction.

### Switching off the mechanical emergency actuation

#### **! CAUTION**

**Risk of burns due to contact with hot surfaces.**  
**Slight or moderate injury possible.**

⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.
2. Use the tool on the control unit to unscrew the set screw of both electromagnets "a" and "b" to the stop (approx. flush with plane surface, set screw protrudes approx. 0.2 to 0.3 mm).
3. Return the tool to the respective holder of the control unit.
4. Ensure electrical transmission actuation is switched on (e.g. by switching on the transmission control or by connecting the plugs to the electromagnets).
5. Check whether all shift positions can be selected with the movement lever.



#### 5.1.4 Mechanical transmission actuation (for ZF 2000 series)

With mechanical transmission actuation, the control piston is moved axially through oil pressure via a mechanically operated pilot valve.

##### 5.1.4.1 Mechanical transmission actuation elements

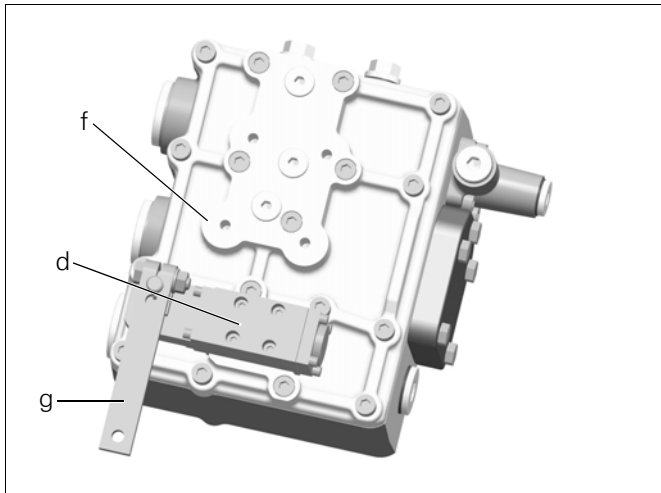


Fig. 46: Mechanical transmission actuation elements (example)

- d - Pilot valve for "Engine wise rotation" and "Counter-engine wise rotation" shift positions
- f - Control unit
- g - Shift lever

The pilot valve is mounted on the top of the control unit. The pilot valve has a lever for actuation. The shift position is selected by moving the shift lever. The shift lever is actuated by a push/pull cable. The shift lever can be moved 40° on its own rotation axis.

The pivoting range must be limited by stops provided by the customer. The central position between these stops corresponds to the "Neutral" shift position. Each shift position has an internal latching position.

The following shift positions are possible (by looking onto the shift lever):

- |                                      |  |
|--------------------------------------|--|
| <b>Neutral:</b>                      | The shift lever is in the latched central position.      |
| <b>Engine wise rotation:</b>         | The shift lever is rotated anticlockwise by approx. 20°. |
| <b>Counter-engine wise rotation:</b> | The shift lever is rotated clockwise by approx. 20°.     |



**! DANGER****Risk of injury due to rotating parts.****Death or serious injury possible.**

⇒ Install propshaft brake or propshaft lock.

The propeller shaft can still rotate even when the transmission clutch is open in "Neutral" shift position. Provide a propeller shaft brake or other shaft locking device when the propeller shaft must be idle.

The actuation force is approx. 25 N with a distance of 100 mm to the rotation axis of the shift lever. To ensure reliable shifts, check shift movements in the transmission at regular intervals and after any repair or maintenance work and adjust if necessary.



It is very difficult to maintain the specified shift position by mechanical means when the distance between the selector unit and shift lever is too large. ZF Friedrichshafen AG recommends using an electrical transmission actuation in such cases.

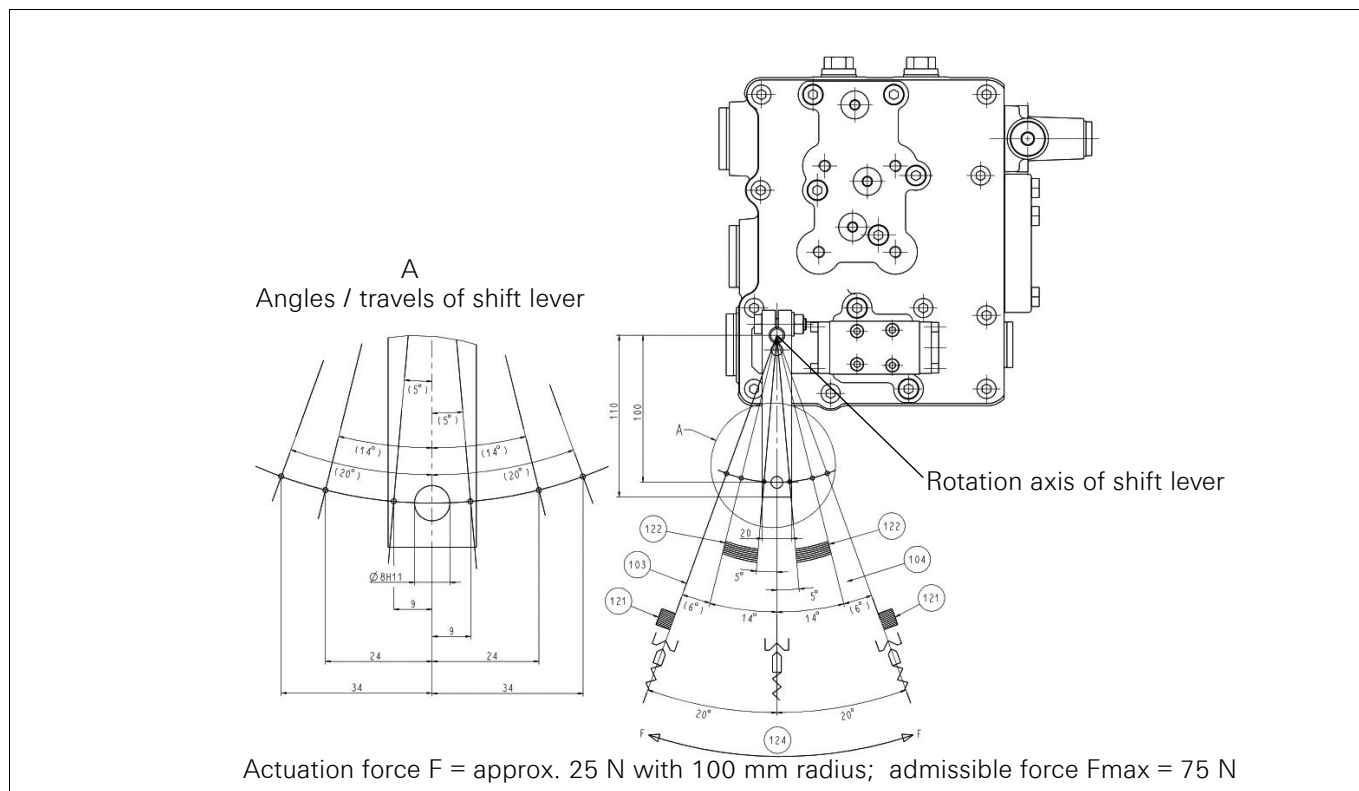


Fig. 47: Shift angles of mechanical transmission actuation (example)

- 103 - Latching position for shift position "Counter-engine wise rotation"
- 104 - Latching position for shift position "Engine wise rotation"
- 121 - Shift lever stop (not supplied by ZF)
- 122 - Undefined shift position (pass through this area quickly)
- 124 - Latching position for shift position "Neutral"



#### 5.1.4.2 Mechanical emergency actuation (for ZF 2000 series)

Manual actuation of the transmission is possible (i.e. emergency actuation) in case of actuation device malfunctions.

Mechanical emergency actuation of the transmission (i.e. movement of the control piston) is performed manually using a shift lever.

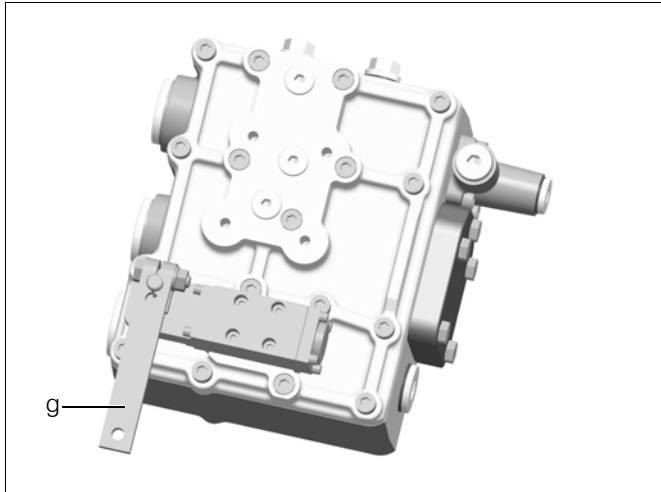


Fig. 48: Mechanical emergency actuation (example)

g - Shift lever for mechanical emergency actuation of the transmission

The shift lever for mechanical emergency actuation can be operated manually when the mechanical transmission actuation is disconnected.

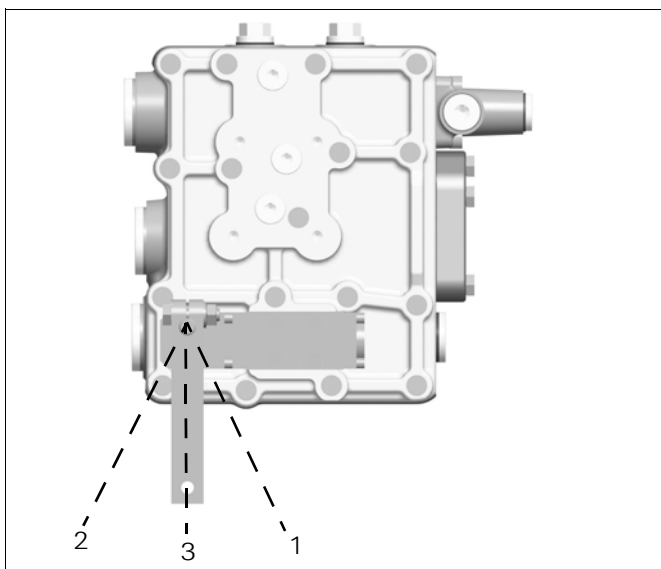


Fig. 49: Positions of the shift lever of mechanical emergency actuation (example)

The following shift positions are possible (by looking onto the shift lever):

- |                                   |  |
|-----------------------------------|--|
| Neutral (3):                      | Shift lever is in the latched central position. The fixing nut on the clamping screw to align the shift lever must be tightened with a tightening torque of 23 Nm. |
| Engine wise rotation (1):         | The shift lever is rotated anticlockwise by approx. 20°.   |
| Counter-engine wise rotation (2): | The shift lever is rotated clockwise by approx. 20°.   |

#### 5.1.4.3 Operation using mechanical emergency actuation

##### **WARNING**

**Risk of accident due to a non-functioning operating element.**

**Death or serious injury possible.**

- ⇒ Adapt driving method when on open waters.
- ⇒ Do not drive in tight and heavily-frequented waters.
- ⇒ Allow the ship to be towed.

The clutch set through the mechanical emergency actuation is always closed when the engine is running. The transmission actuated mechanically cannot be switched or reversed to the "Neutral" shift position using the movement lever.

#### Switching on the mechanical emergency actuation

Requirements:

- If the mechanical emergency actuation is used, the push/pull cable or the linkage of the mechanical remote control on the shift lever of the control unit must be unhooked.

##### **CAUTION**

**Risk of burns due to contact with hot surfaces.**

**Slight or moderate injury possible.**

- ⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.
2. Move and latch the shift lever of the control unit manually to shift position "Neutral". Remain in this position for approx. 0.5 s.



**! WARNING**

**Risk of accident due to incorrect direction of motion.**  
**Death or serious injury possible.**  
 ⇒ Ensure correct direction of motion.

3. Move the shift lever of the control unit manually to the stop in the desired shift position.

**i** Should vibrations influence operation, take appropriate measures to secure the shift lever against jumping out of the current shift position and slipping to the unsafe shift range.

4. Check for correct direction.

#### Changing from "Counter-engine wise rotation" shift position to "Engine wise rotation" shift position

**! CAUTION**

**Risk of burns due to contact with hot surfaces.**  
**Slight or moderate injury possible.**  
 ⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.
2. Move and latch the shift lever of the control unit manually to shift position "Neutral". Remain in this position for approx. 0.5 s.
3. Move the shift lever of the control unit manually to shift position "Engine wise rotation" to the stop.
4. Check for correct direction.

#### Changing from "Engine wise rotation" shift position to "Counter-engine wise rotation" shift position

**! CAUTION**

**Risk of burns due to contact with hot surfaces.**  
**Slight or moderate injury possible.**  
 ⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.
2. Move and latch the shift lever of the control unit manually to shift position "Neutral". Remain in this position for approx. 0.5 s.
3. Move the shift lever of the control unit manually to the stop in shift position "Counter-engine wise rotation".
4. Check for correct direction.

#### Switching off the mechanical emergency actuation

**! CAUTION**

**Risk of burns due to contact with hot surfaces.**  
**Slight or moderate injury possible.**  
 ⇒ Wear protective gloves.

1. Set the engine speed adjusting device to idling speed.
2. Move and latch the shift lever of the control unit manually to shift position "Neutral".
3. Move the movement lever to shift position "Neutral".
4. Hook the push/pull cable or the linkage of the mechanical remote control on the shift lever of the control unit.
5. Check whether all shift positions can be selected with the movement lever.

### 5.2 Shift procedure

During operation, the transmission does not require any attention apart from monitoring display devices for transmission temperature and transmission oil pressures.

According to our experience, the shift sequences described in the following provide optimal switching performance with regard to a possibly short stopping distance of the ship with simultaneous best possible protection of the transmission reversing clutches and thus the overall power plant. Therefore the ZF Friedrichshafen AG strongly recommends compliance with the proposed shift sequences.

Perform shift movement from the "Neutral" shift position to the "Ahead" or "Astern" shift position and vice-versa quickly. Pausing in the undefined areas between shift positions is not admissible.

#### 5.2.1 Shifting Neutral > Ahead and Neutral > Astern

1. Set the engine speed adjusting device to idling speed.
2. Select the required direction of motion and remain in this position for approx. 1 to 2 s.
3. Increase the engine speed to the required operating speed.



### 5.2.2 Shifting Ahead > Astern and vice versa

1. Set the engine speed adjusting device to idling speed.
2. Maintain the shift position in order to use the engine braking effect on the propeller until the engine speed has decreased to approximately 1.2 times the idling speed (max. 720 rpm).
3. Move the movement lever to the "Neutral" shift position and remain in this position for approx. 0.5 s.
4. Move the movement lever further in the opposite direction and remain in this position for approx. 1 to 2 s.
5. Increase the engine speed to the required operating speed.



Not usable for reduction transmission NR!

### 5.2.3 Shifting in case of danger (crash stop)

In the event of an emergency, reversing from "ahead" to "astern" is also possible even at higher engine speeds (20% above idling speed, however, max. 720 rpm).

ZF Friedrichshafen AG recommends also using the engine braking effect in this case and not to increase the engine speed to the required operating speed until 1 to 2 s after selecting the "astern" shift position. During such manoeuvres, you should consider that, in many cases (among others depending on the ship type), no or only a slight reduction in the stopping distance is achieved as against the shift sequence described above.



Crash stop manoeuvres create extreme loads on the power plant. The astern clutch of the reversing transmission in particular is subjected to heavy loads.

An interval of half an hour is necessary between any crash stop manoeuvres during the first trial of the ship. This allows components subjected to extreme thermal load during the crash stop manoeuvre to cool down to normal temperature.



ZF Friedrichshafen AG recommends not to perform more than 1 to 5 crash stop manoeuvres for test purposes.

## 5.3 Trailing operation

Trailing or towing operation refers to operation with the engine off and the propeller being driven by the current. Regular or occasional trailing operation is possible depending on the transmission version.



Shift the transmission actuation to the "Neutral" shift position for trailing operation with the engine off and the propeller shaft rotating.

### 5.3.1 Occasional trailing operation

The basic transmission version (without trailing oil pump) allows occasional trailing operation (< 5 hours).

Monitor the transmission oil temperature (measuring points 11 and 12 are located in the oil sump). The maximum oil temperature must not exceed 75°C. Reduce ship speed when the temperature exceeds this limit value. If necessary, the engine may operated for a short period until the transmission oil temperature has fallen below the maximum admissible value due to the cooling water circulation (transmission in "Ahead" or "Neutral" shift position).



Trailing operation is admissible for up to 15 hours in case of an emergency.

### 5.3.2 Regular trailing operation

A trailing oil pump is required when regular trailing operation is intended or this condition continues for more than 5 hours without interruption. See Chapter 6 *Special equipment / special versions*.

This oil pump ensures lubricating oil supply to the transmission when the engine is off with the output shaft rotating. This allows unlimited operation with the engine off and the propeller rotating.

Monitor the oil temperature which must not exceed a maximum of 95°C (the oil sump temperature roughly corresponds to the disc temperature). If the oil temperature is too high, either reduce the ship speed or feed cooling water through the transmission oil cooler.


The cooling water volume can either be taken from a special valve of the engine installation in operation or fed by a separately driven water pump. For dimensioning, a cooling water volume corresponding to a maximum of 25% of the water volume required for normal operation can be assumed.

If the transmission oil temperature should increase above 90°C, make sure that, after starting the engine, the transmission remains in the "Neutral" shift position until the transmission oil temperature has fallen below 90°C. Normal operation is not admissible until then.



## 5.4 Operation using the emergency control ("Come home screws")

If, despite mechanical emergency actuation, [Section 5.1.1.2 *Mechanical emergency actuation with two solenoid valves (for ZF 2000 series without NR)*, 5.1.2.2 *Mechanical emergency actuation (for ZF 2000 NR (CEW) series)*, 5.1.3.2 *Mechanical emergency actuation (for ZF 2000 NR (EW) series)* or 5.1.4.2 *Mechanical emergency actuation (for ZF 2000 series)*] no power transmission occurs, there is a malfunction in the transmission. In such cases, the clutch discs of the main clutches can be pressed together mechanically using the clamping bolts integrated in the transmission.

 The clamping bolts of the input shaft of the V and U versions cannot be accessed.

Three clamping bolts each are available for the clutch for engine wise rotation and/or for the clutch for counter-engine wise rotation and can be accessed from the outside through the transmission output side.

The housing openings are sealed with screw plugs.

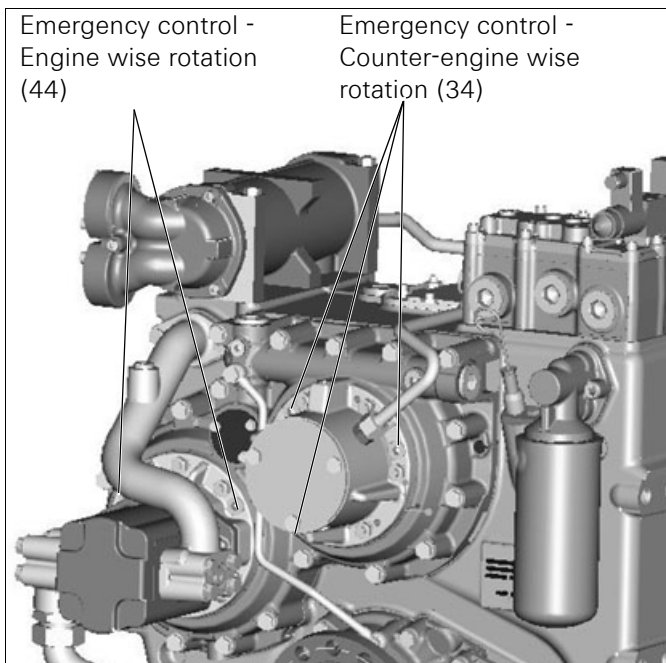


Fig. 50: Position of clamping bolts for engine wise and counter-engine wise rotation (ZF 2000 A, example)

Operation using the emergency control is admissible under the following conditions:

- The oil pressure at measuring point 2 is at least >4.0 bar at engine idle speed with the transmission warmed up. Operation at 50% of the maximum engine speed is admissible in this case.
- No oil pressure at measuring point 2. Sufficient oil in the transmission (oil level between Min. and Max. on the oil dipstick). Operation at maximum 10% above the engine idle speed is admissible in this case.

The special wrench required for operating the emergency control (hexagon socket wrench, SW 10) is available from ZF Friedrichshafen AG under Part No. 1X56.186.369.

Only one shifting clutch may be closed on each transmission at the same time because otherwise both output rotation directions are force-closed and the transmission blocks. Therefore normal transmission actuation must be disabled during operation using the emergency control.



### WARNING

**Risk of accident due to a non-functioning operating element.**

**Death or serious injury possible.**

- ⇒ Adapt driving method when on open waters.
- ⇒ Do not drive in tight and heavily-frequented waters.
- ⇒ Allow the ship to be towed.

When operated using the emergency control, the transmission cannot be switched to "Neutral" or reversed using the movement lever.

### 5.4.1 Activating emergency control

Requirements:

- The actuation of the pilot valve has been taken out of operation. With the electric transmission actuation, the pilot valve is deactivated by disconnecting the plugs and with the mechanical transmission actuation, the pilot valve is deactivated by unhooking the push/pull cable.
- The mechanical emergency actuation is in the "Neutral" shift position.

- Turn off the engine and ensure the engine cannot be restarted while switching on the emergency control.
- Determine the clutch to be switched.
- Loosen and remove the screw plugs.
- Insert the wrench in one of the three openings to the stop. Rotate the engine or transmission input shaft slowly until the clamping bolt head is positioned to the wrench.





The direction of rotation is irrelevant because the required position should be reached after maximum 120° rotary displacement.

5. Pull the wrench back approx. 30 mm and rotate the engine or transmission input shaft slightly (approx. 1°) until the wrench can be inserted in the clamping bolt hexagon.

#### NOTICE

##### Property damage caused by incomplete torque transmission possible.

- ⇒ Screw in the clamping screws equally.
- ⇒ Do not tilt the clutch piston.

6. Screw the clamping bolt in clockwise to the stop.
7. Repeat this procedure for the other two clamping bolts through the corresponding housing openings. Further rotation of the transmission input shaft is not required.
8. In a second cycle, tighten all three clamping bolts with approx. 35 Nm tightening torque.
9. Seal housing openings with screw plugs.

After the emergency control has been set up as described, the engine can be started and the ship navigated to the closest service station.

#### 5.4.2 Deactivating emergency control

Requirements:

- The actuation of the pilot valve has been taken out of operation. With the electric transmission actuation, the pilot valve is deactivated by disconnecting the plugs and with the mechanical transmission actuation, the pilot valve is deactivated by unhooking the push/pull cable.
- The mechanical emergency actuation is in the "Neutral" shift position.

1. Turn off the engine and ensure the engine cannot be restarted while switching off the emergency control.
2. Determine the switched clutch.
3. Loosen and remove the screw plugs.
4. Insert the wrench in one of the three openings to the stop. Rotate the engine or transmission input shaft slowly until the clamping bolt head is positioned to the wrench.



The direction of rotation is irrelevant because the required position should be reached after maximum 120° rotary displacement.

5. Pull the wrench back approx. 30 mm and rotate the engine or transmission input shaft slightly (approx. 1°) until the wrench can be inserted in the clamping bolt hexagon.

#### NOTICE

##### Property damage caused by incomplete torque interruption possible.


- ⇒ Unscrew the clamping screws equally.
- ⇒ Do not tilt the clutch piston.

6. Loosen the clamping bolt anticlockwise to the stop.
7. Repeat this procedure for the other two clamping bolts through the corresponding housing openings.
8. In a second cycle, tighten all three clamping bolts with approx. 20 Nm tightening torque.
9. Seal housing openings with screw plugs.
10. Enable pilot valve control. This is done by connecting the plugs for electrical transmission actuation and by hooking on the push/pull cable for mechanical transmission actuation.



## 5.5 Exchanging the filter cartridge during operation

The filter cartridge of the oil filter can be exchanged during operation.

 The changeover filter is only available for classified transmissions.

Requirements:

- The filter cartridge is filled with a clean oil.
- Only use a lubricant from the currently valid ZF List of Lubricants.

### DANGER

**Risk of crushing due to rotating parts.**

**Death or serious injury possible.**

- ⇒ Install protection devices.
- ⇒ Wear tight-fitting clothing.
- ⇒ Wear a hair net.

1. Move the change lever anticlockwise to the stop in the 3 o'clock position.



Fig. 51: Change lever in the 3 o'clock position (example)

2. Unscrew the vent screw cautiously two turns to allow the pressure to escape.



Fig. 52: Vent screw on the oil filter (example)

Contaminated filter cartridge

### CAUTION

**Risk of burns due to contact with hot oil.**

**Slight or moderate injury possible.**

- ⇒ Wear protective goggles
- ⇒ Wear protective gloves.

3. Remove the filter cartridge with an oil filter remover and collect the drained oil in a suitable container.

New filter cartridge

4. Lubricate the O-ring of the new filter cartridge.
5. Screw the new filter cartridge onto the filter head until contact is noticeable.
6. Tighten the new filter cartridge by hand.
7. Check the oil filter for leak-tightness.
8. Screw the vent screw in cautiously to the stop and tighten with a tightening torque of 10 Nm.

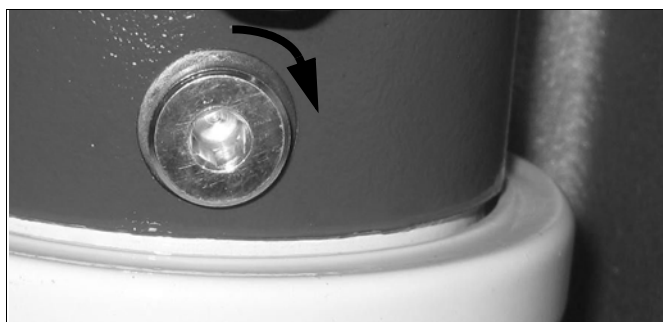


Fig. 53: Vent screw on the oil filter (example)

9. Move the change lever very slowly clockwise to the stop in the 6 o'clock position.




Fig. 54: Change lever in the 6 o'clock position (example)




## 6 Special equipment / special versions


A wide range of parts and accessories not manufactured or recommended by ZF are available on the market. Unauthorized modifications and alterations which impair the function and safety are not allowed.

 Only use spare parts and accessories authorized by ZF.

The operating data especially approved by ZF for application classes M and C are fully accepted by the major Classification Societies. Type approvals or certificates for classification are available on request.

 If special scopes of delivery or versions include deviations in operation and maintenance not described in the following Sections, refer to the specifications applicable for the relevant order for such details.

### 6.1 Trolling

 Only for transmissions with mounted and controlled trolling valve (special scope of delivery).

A trolling system facilitates operation and manoeuvring at slow speeds. This installation allows selecting propeller speeds below the minimum propeller speed and result from the transmission ratio and the engine idling speed.

This enables operation at lower ship speeds than for normally switched transmissions at the lowest admissible engine speed.

Typical applications are:

- Passages at limited speed, e.g. canal passages
- Manoeuvring in ports and at landing places
- Holding position for police boats, life boats
- Towing smaller boats
- Sport fishing at optimum trolling speed

The following trolling devices are available for ZF 2000 series transmissions:


- Electrical trolling
- ZF AUTOTROLL

### 6.1.1 Functional description


Trolling operation allows operating at propeller speeds below those in non-trolling operation. This means trolling operation is used for travelling at low ship speeds. In trolling operation, the propeller speed can be reduced by up to 0.3 - 0.7 times the propeller speed in non-trolling operation.

This reduction in propeller speed is achieved by a defined slipping process of the clutch discs. For this purpose, in trolling operation, the clutch oil pressure (oil pressure with which the clutch discs are pressed against each other) is decreased until a defined slipping process is created.

The transmission oil circuit is designed so that friction heat arising in the clutch is discharged. The trolling valve for adjusting the clutch oil pressure is located in the centre of the clutch control.


 Trolling refers to operation with slipping clutch. Trolling operation allows reversing and manoeuvring in the port area. However, attention is drawn to the fact that the propeller thrust generated by the low propeller speed in trolling operation might not be high enough for sufficient movement of the ship.

Manoeuvring larger displacement boats with a relatively weak engine is not possible, or only slowly, in trolling operation. On the other hand, light sport boats with more powerful engines and planing hull show good reactions.

 ZF Friedrichshafen AG therefore recommends testing the reaction of the ship during manoeuvring in trolling operation in open water. The captain or responsible officer in charge must prohibit use in port areas when results are not satisfactory enough.

### 6.1.2 Electrical trolling

In trolling operation, the clutch oil pressure in the transmission is adjusted using an electrical control signal. The required actuation device is not part of the transmission.

 Refer to the Operating Instructions of the actuation manufacturer on operating the trolling actuation.

The trolling device can be used for ahead or astern travel without time limit providing the admissible engine speed values and lubricating oil temperature are not exceeded.



### Maximum admissible engine speed for trolling operation

- For submerged standard propellers (with parabolic propeller curve): 50% of maximum admissible operating speed (engine speed), however up to a maximum of 1,000 rpm
- For surface propellers: Engine idling speed up to the maximum operating speed (engine speed) of 700 rpm


### Maximum admissible lubricating oil temperature: 90°C

Transmissions with an electrical trolling device are not secured against excessive engine speeds in trolling operation. Stop trolling operation when the admissible engine speed values or lubricating oil temperature are exceeded.

### 6.1.3 ZF AUTOTROLL

ZF AUTOTROLL can be used in combination with electrical transmission actuation. ZF AUTOTROLL is a regulated trolling device. In trolling operation, the propeller speed specified by the actuation device is adjusted via the direct drive rate (i.e. through clutch slip) from the transmission.

The actuation device itself is not part of the transmission.

 Refer to the Operating Instructions of the actuation manufacturer on operating the trolling actuation. Reading these instructions in regular intervals is recommended.

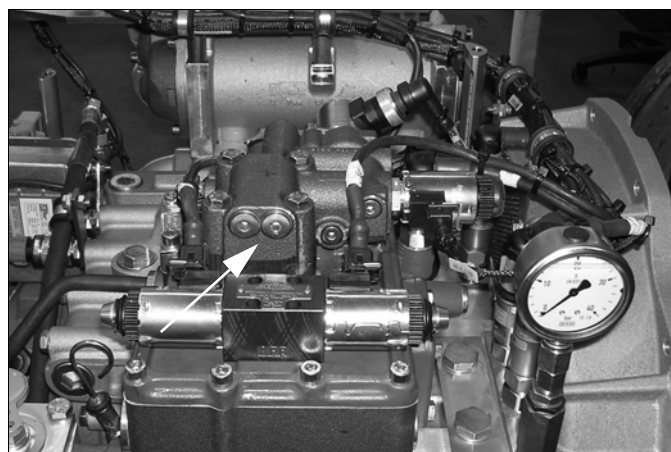



Fig. 55: Control unit with trolling valve for ZF AUTOTROLL (example)

The ship can be reversed even during operation when using ZF AUTOTROLL. In this case, the reversing aid integrated in the electronic system significantly improves the reaction of the ship.

### The ZF AUTOTROLL system has the following main characteristics:

- The propeller speed set using the trolling shift lever is automatically held constant.
- Easy manoeuvring even for displacement boats with a weak engine by a reversing sequence (short-term rise in clutch pressure during reversing).
- Incorrect transmission operating is ruled out.

 Transmissions with ZF AUTOTROLL are delivered fully assembled and tested.

### The ZF AUTOTROLL scope of delivery includes:

- Trolling valve mounted on the transmission
- Electronic control device mounted on the transmission
- Application-based programming of the control
- Speed sensor on the input shaft
- Speed sensor on the output shaft
- Cable harness for connecting all ZF AUTOTROLL components mounted on the transmission
- Plug socket mounted on the transmission with counterplug as electrical interface to the ship control

### The ZF AUTOTROLL scope of delivery does not include:

- Ship-based actuation device for electrical transmission actuation
- Ship-based actuation device for trolling actuation
- Voltage supply
- All indicator lamps
- Possible dimmer devices for indicator lamps
- Ship-based cabling up to the electrical interface on the transmission


### 6.2 Trailing oil pump (trailing pump)

Regular trailing operation is admissible only with a trailing oil pump. Retrofitting such a trailing pump is possible on all parallel, V, U, and A transmission versions.

Three transmission ratios are available for the trailing pump according to the engine speed in continuous operation and the transmission ratio.

This oil pump is mounted on the transmission housing on the transmission side opposite the input (parallel and A) or on the input side (V and U versions). It is driven via a spur gear by the transmission output shaft. Pump feed to the oil circuit is always in the same direction irrespective of the input direction. This oil pump ensures lubricating oil supply to the transmission when the engine is off with the output shaft rotating. This allows unlimited operation with the engine off and the propeller rotating.



 Switch transmission actuation to the "Neutral" shift position for trailing operation with the engine off and the propeller shaft rotating!

Oil pressures do not require monitoring while the engine is off. Monitor the transmission oil temperature according to the specifications in Section 2.2.8 *Monitoring values for ZF 2000/2150/2200/2300/W2300/W2400 series*! An additional measuring point (41) for the oil temperature is also available (see Section 4.4 *Operation monitoring*).

Perform Maintenance Jobs 101 and 102 daily during operation with the engine off and propeller rotating (see Chapter 8 *Maintenance*).

### 6.3 PTO=Power Take-Off


The power take-offs are used to drive pumps, hydraulic systems for water jet applications or even generators. All ZF 2000 series transmissions are available as special versions with power take-off (PTO). In general, power take-offs cannot be switched but are permanently driven by the transmission. This is practical for most pump transmissions because the hydraulic system must be ready to operate immediately after engine start-up.

The dimensions of the power take-offs are designed for various output performances and the mounting dimensions are standardized according to SAE standard (A, B, B-B, C or C-C).

The power take-off is located on the input shaft or implemented in a separate housing as top PTO according to customer requirements and the maximum torque to be picked up.


#### PTO on the input shaft

Basic transmission versions are fitted with a connection facility for a power take-off on the input shaft. This makes retrofitting with a PTO possible at any time.

 The power take-off cannot be mounted to the input shaft on V and U transmission versions!

#### Top PTO with separate housing

An additional housing is required when implementing the power take-off via the constant gearing of the input shaft. This housing is mounted on the top of the transmission housing. The name Top PTO is derived from the top location.

 Top PTOs are fitted at the factory and cannot be refitted!







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## 7 Troubleshooting

### 7.1 Troubleshooting information

Malfunctions in the power plant frequently suggest a transmission defect even though, in many cases, the malfunctions are caused by external influences on the transmission.

The minimum monitoring specified in Section 2.2 *Technical data*, 2.2.8 *Monitoring values for ZF 2000/2150/2200/2300/W2300/W2400 series* is required for assessing operational safety of the transmission and must be installed. Every basic transmission version has the measuring points for minimum monitoring.



Monitoring devices such as sensors, warning equipment, and display instruments are not supplied by ZF Friedrichshafen AG as standard.

It is expressly pointed out that malfunction messages can only be displayed when the transmission uses the connection options.

The following Table of possible malfunctions shows the primary malfunctions, causes and corrective measures.

Contact your nearest ZF service branch when malfunctions cannot be cleared using the following information.



## 7.2 Table of possible malfunctions

### 7.2.1 Table of possible malfunctions (overall transmission)

| Fault  | Possible cause  | Corrective measures   |
|--|---|---|
| Transmission oil temperature too high (measuring points 11*, 12*, and 41*)   | Water flow rate through cooler too low  | Increase water flow rate  |
|  | Oil cooler clogged  | Clean oil cooler  |
| Transmission oil temperature too low   | Water flow rate through cooler too high   | Reduce water flow rate  |
| When using a gap filter: Oil pressure before oil cooler and filter too high (measuring point 5*)   | Oil cooler contaminated   | Clean oil cooler oil-side   |
|  | Oil filter contaminated   | Clean oil filter  |
| When using a changeover filter: Filter difference pressure too high (measuring point 127*)   | Filter cartridge contaminated   | In operation:<br>See Section 5.5 <i>Exchanging the filter cartridge during operation</i><br>Not in operation:<br>See <i>Maintenance Job 142</i> |
|  | Warning interruption for oil temperatures < 35 °C is not installed  | Install warning interruption  |
| No operating oil pressure (measuring points 2* and 21*)  | No oil filled in transmission   | Fill with oil   |
|  | Incorrect transmission input direction  | Use special transmission version  |
|  | Display device defective  | Clear fault   |
|  | Oil pump defective  | Replace oil pump  |
| Operating oil pressure too low (measuring points 2* and 21*)   | Viscosity of oil used too low   | Use specified oil type (see ZF lubricant list TE-ML 04)   |
|  | Oil pump defective  | Replace oil pump  |
|  | Pressure limiting valve leaking   | Clear fault   |
|  | Timer for pressure modulation not working correctly   | See fault: Clutch slips at high engine speed  |
| If the fault cannot be cleared, the lubricating oil supply of the transmission is also at risk. Continue operation only at reduced input speed until next repair facility. |   |   |
| Operating oil pressure too high (measuring points 2* and 21*)  | Viscosity of oil used too high  | Use specified oil type (see ZF lubricant list TE-ML 04)   |
| No power transmission from transmission input to transmission output, clutch does not transfer torque  | For mechanical transmission actuation: Shift angles not maintained  | Adjust shift angles [see Section 5.1.4 <i>Mechanical transmission actuation (for ZF 2000 series)</i> ]  |
|  | For electrical transmission actuation: Fault in electric system   | Clear fault in electric system  |
|  | Check option:<br>Normal power transmission when operating the transmission using mechanical emergency actuation |   |
|  | No operating oil pressure   | Possible causes and corrective measures, see fault: No operating oil pressure or operating oil pressure too low                                 |

\* See monitoring values (Section 2.2.8) and transmission views (Section 2.1.4)

Tab. 5: Table of possible malfunctions (overall transmission)



| Fault   | Possible cause  | Corrective measures   |
|---|---|---|
| Power transmission from transmission input to output cannot be interrupted; clutch does not open  | For mechanical transmission actuation:<br>Shift angles not maintained   | Adjust shift angles [see <i>Section 5.1.4 Mechanical transmission actuation (for ZF 2000 series)</i> ]  |
|   | For electrical transmission actuation:<br>Fault in electric system<br>Check option:<br>Normal power transmission when operating the transmission using mechanical emergency actuation | Clear fault in electric system  |
|   | No operating oil pressure   | Possible causes and corrective measures, see fault: No operating oil pressure or operating oil pressure too low   |
| Clutch slips at high engine speed   | Operating oil pressure too low (measuring points 2* and 21*)  | Corrective measure as for fault: "Operating oil pressure too low (measuring points 2* and 21*)". If the fault cannot be cleared on board, operation may be continued at reduced speed - at which the clutch does not slip - until the next repair facility is reached.<br><br>Avoid reversing and perform only with propeller almost idle and at the lowest possible engine idle speed. |
| Oil level decreases strongly (determined using the measuring marks of the oil dipstick).<br>Note: Maintenance Job 101 "Oil level control" | Leaks at housing joint faces or oil pipes, oil leaks at shaft seals   | Clear mechanical fault  |
|   | Oil loss through oil cooler in cooling water system   | Clear fault, replace oil cooler, if required  |
| Oil level increases (see Maintenance Job 101 "Oil level control")   | Water enters oil circuit from cooling system  | Clear mechanical fault  |
| Transmission too loud in certain speed ranges   | Torsional vibration resonance of power plant in engine speed range  | Avoid critical speed ranges. Use more suitable flexible clutches  |
| Transmission too loud in engine idle speed range  | Torsional vibration resonance of power plant in engine idle speed range   | Increase engine idle speed  |
| Engine stalls when reversing quickly from "ahead" to "astern"   | Engine idle speed too low   | Increase engine idle speed  |
|   | Reversing manoeuvre performed too quickly or at too high ship speed   | Reverse as recommended in 5.2.3   |

\* See monitoring values (Section 2.2.8) and transmission views (Section 2.1.4)

Tab. 6: Table of possible malfunctions (overall transmission, continued)



### 7.2.2 Table of possible malfunctions (transmission oil cooler)

| Fault                                      |   | Possible cause                                     | Corrective measures   |
|--|---|--|---|
| Oil escapes into the water                 | Oil level too low   | Pipes in transmission oil cooler are leaking       | Drain and disassemble transmission oil cooler<br>Disassemble receiver/cover<br>Secure pipe bundle with screw and washers<br>Apply 5 bar compressed air on the jacket<br>Locate defective pipe on pipe plates<br>Seal defective pipe |
| Oil escapes from transmission oil cooler   | Visible oil leakage at the cover                                | O-ring on pipe plate/housing defective             | Drain transmission oil cooler on the water side and on the oil side and disassemble it<br>Disassemble receiver/cover<br>Pull the pipe bundle<br>Replace all O-rings   |
|  | Visible oil leak on transmission                                | O-ring on transmission flange connection defective | Drain transmission oil cooler on the water side and on the oil side and disassemble it<br>Replace all O-rings   |
| Water escapes from transmission oil cooler | Water leak into the oil<br>Oil level too high, milky appearance | O-ring on pipe plate/water chamber defective       | Drain transmission oil cooler on the water side and on the oil side and disassemble it<br>Disassemble receiver/cover<br>Secure pipe bundle with screw and washers<br>Replace all O-rings  |
|  | Visible water leak at the cover                                 | O-ring on pipe plate/cover defective               | Drain transmission oil cooler on the water side<br>Disassemble receiver/cover<br>Secure the pipe bundle with screw and washers<br>Replace all O-rings   |
|  | Visible water leak at pipe connection                           | Sealing pipe connection defective                  | Replace seal on pipe socket   |

Tab. 7: Table of possible malfunctions (transmission oil cooler)



| Fault                                 |  | Possible cause                                 | Corrective measures  |
|---------------------------------------|--|--|--|
| Transmission oil temperature too high | Cooling water outlet temperature too high<br>Temperature measurement using a click-on sensor, determine whether water inlet and water outlet have a temperature difference of approx. 2°C to 5°C | Cooling water inlet temperature too high       | Water inlet temperature too high<br>Observe nominal values in the transmission installation drawing  |
|                                       |  | Water flow rate too low                        | Delivery rate of cooling water pump too low<br>Observe nominal values in the transmission installation drawing<br>Increase delivery rate   |
|                                       |  | Water flow in transmission oil cooler impaired | Foreign material in the pipe line or transmission oil cooler causing clogging<br>Clean pipe line/pipe bundle<br><br>Water side more contaminated than usual (e.g. due to thick deposits)<br>Clean the pipe bundle<br><br>More than 10% of the pipes are leaking<br>Replace transmission oil cooler                                   |
|                                       | Cooling water outlet temperature not too high  | Heat transfer from oil to water impaired       | Oil side more contaminated than usual (e.g. due to thick deposits)<br>Clean the baffle plates and the clearance between the pipes<br><br>Pipe bundle installed correctly?<br>If this is not the case, assemble the pipe bundle correctly<br><br>All pressure chambers vented?<br>If this is not the case, vent all pressure chambers |

Tab. 8: Table of possible malfunctions (transmission oil cooler, continued)




## 7.3 Clearing faults (transmission oil cooler)


### 7.3.1 Leaking pipes

If it is suspected that pipes of the pipe bundle are leaking, proceed according to Chapter 8 *Maintenance*, Section *Disassembling the transmission oil cooler (without extracting the pipe bundle)*. After the pipe plates have been cleaned, the escaping medium (e.g. compressed air) shows which pipe is leaking. Seal the leaking pipe from both sides.

1. Disassemble the transmission oil cooler as described in Chapter 8 *Maintenance*, Section *Disassembling the transmission oil cooler (without extracting the pipe bundle)*.
2. Clean the defective pipe thoroughly down to the press-in depth of the sealing plug.


 Keep this area free from corrosion and pitting on the inside of the pipe.


3. Press the sealing plug in flush with a suitable tool.

 Do not press the sealing plug in too hard otherwise the adjacent rolled points can be damaged. It is possible to seal a maximum of 10% of the pipes without a noticeable drop in performance. It is not possible to remove the defective pipe. If more than 10% of the pipes are defective, this repair work is not allowed because cooling performance will then sink too low.

### 7.3.2 Leaking O-rings

An O-ring of the pipe plate is defective when leakage is discovered between the receiver or cover and the housing. The type of the escaping medium shows at which groove of the pipe plate the defect is located. For defects on the water side, proceed as described in Chapter 8 *Maintenance*, Section *Disassembling the transmission oil cooler (without extracting the pipe bundle)*. For defects on the oil side, proceed as described in Chapter 8 *Maintenance*, Section *Disassembling the transmission oil cooler (with extraction of the pipe bundle)*.

 In this case, the pipe bundle need not be removed completely from the housing.

 Spare O-rings are available from the Customer Service of ZF Friedrichshafen AG. Fit the O-ring as described in Chapter 8 *Maintenance*, Section *Assembling the transmission oil cooler (after extracting the pipe bundle)*.

## 7.4 Diagnosis for ZF AUTOTROLL (Special scope of delivery)

The ZF AUTOTROLL control not only has control functions but also an intelligent diagnosis system.

The diagnosis system has the following functions:

- System monitoring, monitoring operating parameters, fault detection, generation of emergency operation properties
- Registering faults that have occurred in the fault memory and communication with the ZF diagnosis device "TESTMAN"

Diagnosis is active as soon as operating voltage is connected to the ZF AUTOTROLL control. This means that system faults are diagnosed even in non-trolling operation.

A "TESTMAN" diagnosis device can be adapted to the ZF AUTOTROLL control to support system service. Leave the relevant work to trained qualified personnel from the Friedrichshafen Service Centre. The "TESTMAN" diagnosis device which is not supplied as standard with ZF AUTOTROLL is also available from the Service Centre.



## 8 Maintenance

### 8.1 Application area

ZF Marine ship transmissions are classified in four application groups according to their type of operation:

- P = Pleasure
- L = Light
- M = Medium
- C = Continuous

The classification is based on experience from the various application areas on how typical ship types are operated.

The application group for which the transmission is designed is indicated on the type plate. The admissible performance/speed factors in the individual application groups are specified.

#### 8.1.1 Application group P

- Engine data for transmission classification: Maximum performance for intermittent operation
- Operation type: Intermittent operation with widely varying engine speeds
- Operating hours per year: Up to approx. 500 hours
- Preferred hull type: Planing hull
- Typical application area: Fun and leisure boats for private use
- Typical application example: Fun and leisure boats for private use

#### 8.1.2 Application group L

- Engine data for transmission classification: Maximum performance for intermittent operation
- Operation type: Intermittent operation with widely varying engine speeds
- Operating hours per year: Up to approx. 2,500 hours
- Preferred hull type: Semi-planing hull, planing hull
- Typical application area: Navy, official, and equivalent ships, private charter boats
- Typical application examples: Fast ships, yachts, patrol, police, customs, coastguard, pilot, fire, life, angler boats, etc.

#### 8.1.3 Application group M

- Engine data for transmission classification: Maximum performance for intermittent operation
- Operation type: Intermittent operation with varying engine speeds
- Operating hours per year: Up to approx. 4,000 hours
- Preferred hull type: Semi-planing hull, planing hull
- Typical application area: Workboats, charter boats
- Typical application examples: Crew, supply, fishing, coastguard, passenger ships, ferries, yachts, etc.

#### 8.1.4 Application group C

- Engine data for transmission classification: Maximum continuous performance
- Operation type: Continuous operation with maximum engine performance
- Operating hours per year: Unlimited
- Preferred hull type: Displacement hull, semi-planing hull
- Typical application area: Workboats
- Typical application examples: Towboats, pushers, supply boats, fishing, passenger ships, freighters, ferries, etc.



## 8.2 Maintenance schedule

### 8.2.1 Maintenance schedule concept

The maintenance system for ZF ship transmissions is based on a preventive maintenance concept. Preventive maintenance facilitates advance planning and secures high availability.

Time intervals, according to which maintenance work is to be carried out, as well as the scope of the inspection and maintenance work described, are the average result of operational experience and therefore may only be regarded as guidelines. Additional maintenance work and/or changes in the maintenance intervals may become necessary for special application conditions as well as technical requirements.

Furthermore, it is practical to adapt the operational hours stated in the maintenance schedule to the corresponding maintenance time of the engine when this does not considerably exceed the stated operational hours. This applies to maintenance levels A4, A5 and K in particular.

The Maintenance Job Number stated in the Maintenance System Job Sheet identifies the respective maintenance position. It serves as reference for the tools needed and the scope of parts.

| Maintenance level | Application groups | After respective operational hours              | Limit value                         |
|-------------------|--------------------|---|-------------------------------------|
| A1                | All                | On every day of operation                       | 3 months (see also K1; K2)          |
| A2                | All                | 500 h   | 6 months                            |
| A3.1              | All                | ---   | Yearly                              |
| A3                | All                | 2,000 h   | 2 years                             |
| A4                | C and M            | ---   | 5 years                             |
|                   | L and P            | ---   | 8 years                             |
| A5                | All                | During every major reconditioning of the engine | Operating state of the transmission |

Tab. 9: Periodical maintenance work

| Maintenance level | Operational hours | Limit value |
|-------------------|-------------------|-------------|
| Z1                | 50 to 100 h       | 12 months   |

Tab. 10: Additional nonrecurring maintenance work for a transmission repaired or overhauled outside the plant

| Maintenance level | Operational hours | Limit value |
|-------------------|-------------------|-------------|
| Z2                | ---               | 2 months    |

Tab. 11: Additional nonrecurring maintenance work for a new transmission



## 8.2.2 Maintenance work before taking out of operation/standstill

### 8.2.2.1 For closed cooling circuit

The cooler can remain filled when the cooling circuit is closed.

### 8.2.2.2 For open cooling circuit

The transmission oil cooler can remain filled when the plant standstill will only last for a short period of time (< 2 weeks).

Drain the transmission oil cooler on the water side when the system is to be taken out of operation for a longer period of time.



This is only necessary when the transmission oil cooler is not automatically drained when the cooling water pump is idle.

| Cooling system        | Standstill time | Measures  |
|-----------------------|-----------------|---|
| Open system/sea water | > 2 weeks       | Drain transmission oil cooler on the water side.<br>Additionally rinse with clean water.<br>If possible, dry pipe bundle from inside with compressed air. |

Tab. 12: Standstill time / draining cooling water

## Maintenance information

Refer to the ZF lubricant list TE-ML 04 for ZF marine transmissions for specifications on service fluids and list of manufacturers. This list is available from every ZF Service branch. It can be downloaded free of charge on the internet in PDF format under [www.zf.com](http://www.zf.com).

The following list contains consumables (cleaning agents, lubricants, and sealants) recommended by ZF Marine. Associated service fluid regulations are available from the respective manufacturer. Only consumables and service fluids complying with the ZF specification and/or approved by the respective manufacturer may be used.

Instructions on use from the respective manufacturer are binding!

Manufacturer specifications apply for maintenance of all components not listed in the maintenance schedule.

Perform a functional test after completing maintenance work!

It is also recommended to keep a maintenance protocol providing the following information:

- Person in charge of, and performing the maintenance work
- Maintenance level
- Time of maintenance work (date, operating hours)

## Cleaning agents for removing grease from tapered surfaces for oil press fits

Acetone, spirit (caution - flammable!) or conventional cleaning agents without regreasing.

## Glycerine

For pressing on oil press fits. As an alternative, oil can be used for pressing on.

## Grease

See ZF lubricant list TE-ML 04!



| Sealant              |  |  |   |  |
|----------------------|--|--|---|--|
| Manufacturer         | Description  | Use  | Instructions for use  | Supply source  |
| Loctite              | Loctite 574<br>Temperature resistant:<br>-55°C to +150°C   | Used for sealing surfaces of housing and cover   | <ul style="list-style-type: none"> <li>- Clean parts</li> <li>- Apply sufficient material to fill gaps</li> <li>- Join parts</li> <li>- Allow material to harden</li> </ul> | Henkel Loctite Deutschland GmbH, Munich, Germany<br>Henkel Central Eastern Europe GmbH, Vienna, Austria                        |
|                      | Loctite 243<br>Temperature resistant:<br>-55°C to +180°C<br>Loctite 262<br>Temperature resistant:<br>-55°C to +150°C | Used for threadlocking   | <ul style="list-style-type: none"> <li>- Clean parts</li> <li>- Apply sufficient material to fill gaps</li> <li>- Join parts</li> <li>- Allow material to harden</li> </ul> | Henkel Loctite Deutschland GmbH, Munich, Germany<br>Henkel Central Eastern Europe GmbH, Vienna, Austria                        |
| Varnishes and paints |  |  |   |  |
| Manufacturer         | Description  | Use  | Instructions for use  | Supply source  |
| Dykem Red            | Dykem Red<br>DX-296/8 oz<br>(Made in Germany)  | For representing tooth flank surface appearances for transmissions with acceptance specification by Classification Societies |   | Helling GmbH, Spöckerdamm 2, 24536 Heidgraben (near Hamburg), Germany<br>Tel. +49 (04122) 922-0<br>Telefax +49 (04122) 922-201 |

Tab. 13: Recommended consumables and service fluids



### 8.3 Corrosion protection and conservation

Series transmissions supplied by ZF have corrosion protection according to Level I of "Guidelines for marine transmissions on anticorrosion protection, packing type, storage conditions and storage periods".

Specify conservation measures for long-term storage in the transmission order.

Measures according to the guideline for conserving marine transmissions are binding when transmissions are stored at ZF branches and ZF distributors. Conservation measures described in the guideline must be performed by personnel authorized by ZF otherwise the warranty is void!

Corrosion protection measures required for longer shutdown periods for a transmission installed on a ship are very dependent on temperature variations, air humidity, and salt content of the air in the engine room. Therefore, the recommended measures and time specifications may only be regarded as rough guidelines. In case of doubt, we recommend performing the corrosion protection measures on the transmission analog to those for the engine.

Shutdown periods up to 3 months do not normally require corrosion protection measures.

We recommend performing corrosion protection measure K1 every 10 to 20 days when the shutdown period is less than 6 months. An oil change according to maintenance level Z1 may be necessary prior to re-commissioning depending on the condition of the lubricating oil in the transmission.

K2 is a conservation measure and should be performed when the operation period is finished before shutdown periods longer than 6 months. K2 can also be performed instead of K1 for shorter shutdown periods.

K3 is a long-term conservation measure and allows taking the installed transmission out of operation for a maximum of 36 months. Conservation can also be performed according to K2 instead of K3. In this case, conservation has to be repeated every 9 months.

| Maintenance level | Performance                        | Shutdown period | Information (Annex)  |
|-------------------|------------------------------------|-----------------|--|
| K1                | Every 10 to 20 days                | Up to 6 months  | Guidelines for marine transmissions: Corrosion protection, packing types, storage conditions and storage periods |
| K2                | At the end of the operating period | 9 months        |  |
| K3                | At the end of the operating period | Max. 36 months  |  |

Tab. 14: Corrosion protection measures for longer shutdown periods

#### K1 Corrosion protection

Start the engine and run at engine idle speed or slightly above for at least 5 minutes to ensure transmission lubrication. The transmission can be in the "Neutral" or "Counter-engine wise rotation" or "Engine wise rotation" shift position. Repeat this process every 10 to 20 days. Test oil for condensate (emulsion) prior to re-commissioning. Make this check immediately after switching off the engine; oil must not be milky.

#### K2 Conservation

When operation has completed, drain the transmission oil and fill with the anti-corrosive oil to at least the bottom measuring mark of the oil dipstick (see maintenance work for implementation). Use anti-corrosive oil C 642 or C 644 according to MIL-L-21260.

Immediately afterwards, run the engine in the "Engine wise rotation" or "Counter-engine wise rotation" shift position at increased engine idle speed (max. 50% of nominal operating speed) for approx. 5 to 10 minutes. Switch off the engine. Protect outer steel parts against corrosion.

Run the engine for approx. 5 minutes to extend the conservation by another 9 months. Then drain the conserving oil and fill the transmission with the oil type and volume specified for operation and then restart the engine and run for at least 15 minutes. Operate the transmission clutches several times during this time. Then perform "K2 conservation".



#### *Commissioning after K2 conservation*

Start the engine and run for approx. 5 minutes to mix any condensed water possibly accumulated in the transmission with the anti-corrosive oil. Drain the anti-corrosive oil and fill the transmission with the specified oil type (see "Maintenance job No. 141").

#### **K3 Long-term conservation**

When operation has completed, drain the transmission oil and fill with the anti-corrosive oil to at least the bottom measuring mark of the oil dipstick (see maintenance work for implementation). Use anti-corrosive oil C 642 or C 644 according to MIL-L-21260.

Immediately afterwards, run the engine in the "Engine wise rotation" or "Counter-engine wise rotation" shift position at increased engine idle speed (max. 50% of nominal operating speed) for approx. 5 to 10 minutes. Switch off the engine. Then fill the transmission completely with the anti-corrosive oil. Protect outer steel parts against corrosion.

#### *Commissioning after K3 long-term conservation*

Drain the anti-corrosive oil off until reaching the normal oil level. Then run the engine for approx. 5 minutes. Then drain the anti-corrosive oil off completely and fill the transmission with the specified oil type (see "Maintenance job No. 141").



## 8.4 Maintenance work plan

| Maintenance level |           |      |    |    |    |         |    | Maintenance work   | Required tools |
|-------------------|-----------|------|----|----|----|---------|----|--|----------------|
| Periodic          |           |      |    |    |    | One-off |    |  |                |
| A5                | A4        | A3.1 | A3 | A2 | A1 | Z1      | Z2 |  |                |
|                   |           |      |    |    |    |         |    | 101 Check oil level  | None           |
|                   |           |      |    |    |    |         |    | 102 Rotate rotary handle of oil filter   | None           |
|                   |           |      |    |    |    |         |    | 103 Visual inspection  | None           |
|                   |           |      |    |    |    |         |    | 121 Clean outside of transmission  | None           |
|                   |           |      |    |    |    |         |    | 122 Retighten all bolts accessible from the outside                                | On-board tools |
|                   |           |      |    |    |    |         |    | 123 Check shift settings   | None           |
|                   |           |      |    |    |    |         |    | 124 Lubricate external moving parts  | None           |
|                   |           |      |    |    |    |         |    | 141 Oil change   | On-board tools |
|                   |           |      |    |    |    |         |    | 142 Renew oil filter; clean changeover filter; clean gap filter and filter housing | On-board tools |
|                   |           |      |    |    |    |         |    | 161 Flexible clutch: Visual inspection   | None           |
|                   |           |      |    |    |    |         |    | 162 Flexible engine and transmission support; Visual inspection                    | None           |
|                   |           |      |    |    |    |         |    | 163 Clutch discs: Visual inspection  | On-board tools |
|                   |           |      |    |    |    |         |    | 164 Running gears: Visual inspection   | On-board tools |
|                   |           |      |    |    |    |         |    | 165 Check oil pumps  | W1             |
|                   |           |      |    |    |    |         |    | 166 Check control unit   | W1             |
|                   |           |      |    |    |    |         |    | 167 Check actuation device   | W1             |
|                   |           |      |    |    |    |         |    | 168 Recalibrate display devices  | None           |
|                   |           |      |    |    |    |         |    | 169 Inspect visually and clean oil cooler  | W1             |
|                   |           |      |    |    |    |         |    | 172* Check spray line valve  | W1             |
|                   |           |      |    |    |    |         |    | 173 Check shaft seal of input shaft  | None           |
|                   |           |      |    |    |    |         |    | 174 Check shaft seal of output shaft   | None           |
|                   |           |      |    |    |    |         |    | 200* Major transmission overhaul   | W2             |
| T1+<br>T2+<br>NB  | T1+<br>T2 | T1   | T1 | -- | -- | T1      | -- | Required spare parts   |                |

Tab. 15: Maintenance levels and maintenance work

\* = For implementation, see Service Manual

NB = Spare parts as necessary

T1, T2 = Parts kits, see Spare Parts list

W1 = Tool kit, see Operating Instructions

W2 = Tool kit, see Service Manual



## 8.5 Tool kit

### 8.5.1 Tool kit W1 for maintenance

Tool kit W1 comprises standard commercial tools.

Standard commercial implies, for example:

#### General hand tools

|  |             |
|--|-------------|
| Open-end wrenches up to width . . . . .                      | 63 mm       |
| Flat ring wrenches up to width . . . . .                     | 46 mm       |
| Offset ring wrenches up to width . . . . .                   | 46 mm       |
| Set of sockets . . . . .                                     | 4-13 mm     |
| Set of sockets . . . . .                                     | 11-32 mm    |
| Set of sockets . . . . .                                     | 22-50 mm    |
| Set of sockets for hexagon socket screws . . . . .           | 5-22 mm     |
| Tongs (flat) for locking rings (internal securing) . . . . . | I 1-4 (No.) |
| Tongs (flat) for locking rings (external securing) . . . . . | A 1-4 (no.) |
| Screwdriver . . . . .  | up to 13 mm |
| Hammers (metal + plastic), punches                           |             |

#### Measuring and testing tools

|                                       |                                |
|---------------------------------------|--------------------------------|
| Torque wrench . . . . .               | 10-350 Nm                      |
| Calliper gauge, depth gauge . . . . . | measurement range up to 300 mm |
| Thickness gauge . . . . .             | measurement range 0.05-1.0 mm  |

#### Others

Oil filter remover

#### Tools for mechanical emergency actuation of transmission

|  |      |
|--|------|
| Key for hexagon socket screws (Allen key), . . . . . | 3 mm |
|--|------|

#### Tools for emergency control of transmission

|   |       |
|---|-------|
| Key for hexagon socket screws (ZF Part No. 1X56.186.369), . . . . . | 10 mm |
|---|-------|

#### Tools for cleaning oil cooler

Nylon brush (ZF Part No. AA00.335.649)



## 8.6 Spare parts and spare parts orders

### Spare parts orders

Only ZF original spare parts may be used for maintenance work and repairs requiring replacement of components or subassemblies.

Keep the following details, located on the transmission type plate, at hand for spare part orders and inquiries:

- Type / MODEL ..... (Field No. 1)
- Transmission number / SERIAL NO ..... (Field No. 2)
- Parts list number / PARTS LIST NO ..... (Field No. 3)
- Overall ratio / RATIO TOTAL ..... (Field No. 5)

The details in fields 1 to 3 and 5 on the type plate are essential for all inquiries concerning the transmission, troubleshooting, maintenance, order of special equipment, etc.

For transmissions with classification, note that, in general, spare parts without classification are delivered under the specified Part numbers.



If a version with classification is required, specify the required test type for the spare parts in addition to the Part number.

This is also required when the transmission parts list is specified during ordering and when requesting replacement transmissions.

Parts required according to the maintenance level can be ordered as maintenance kit or on-board kits for carrying out periodic maintenance work.

The required spare parts are also available as repair and/or spare part kits for major overhauls of transmissions or subassemblies.

### ZF Service branches

If a transmission malfunction cannot be cleared with the corrective measures listed in Chapter 7 *Troubleshooting*, please contact your nearest ZF branch.



Repair instructions applicable to your transmission type and up-to-date technical information, such as ZF Service News are available from ZF Service branches and ZF dealers.



You can find the ZF Sales and Service Organization responsible for your region on [www.zf.com](http://www.zf.com) in the top navigation bar, under pull-down menu "Products & Services".

A list with the ZF Service branches with up-to-date telephone and fax numbers is available from ZF Friedrichshafen AG in Friedrichshafen on request.



## 8.7 Maintenance System Job Sheets

### Job Sheet contents

| Maintenance work . . . . .   | Page |
|--|------|
| 101 Check oil level . . . . .  | 104  |
| 102 Rotate rotary handle of oil filter. . . . .  | 106  |
| 103 Visual inspection . . . . .  | 108  |
| 121 Clean outside of transmission . . . . .  | 110  |
| 122 Retighten all bolts accessible from the outside . . . . .                                | 112  |
| 123 Check shift settings . . . . .   | 114  |
| 124 Lubricate external moving parts. . . . .   | 118  |
| 141 Oil change. . . . .  | 120  |
| 142 Renew oil filter; clean changeover filter; clean gap filter and filter housing . . . . . | 122  |
| 161 Flexible clutch: Visual inspection . . . . .   | 126  |
| 162 Flexible engine and transmission support: Visual inspection . . . . .                    | 128  |
| 163 Clutch discs: Visual inspection. . . . .   | 130  |
| 164 Running gears: Visual inspection . . . . .   | 132  |
| 165 Check oil pumps . . . . .  | 134  |
| 166 Check control unit . . . . .   | 138  |
| 167 Check actuation device (mechanical / electrical) . . . . .                               | 140  |
| 168 Recalibrate display devices. . . . .   | 142  |
| 169 Inspect visually and clean oil cooler. . . . .   | 144  |
| 173 Check shaft seal of input shaft. . . . .   | 152  |
| 174 Check shaft seal of output shaft. . . . .  | 154  |









# MAINTENANCE SYSTEM JOB SHEET

|                                |  |  |                          |
|--------------------------------|--|--|--------------------------|
| Transmission type:             |  | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level  | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 101                            | A1   | -----  | 10                       |
| Description of maintenance job | 101 Check oil level  |  |                          |
| Safety measures                | <p>Wait for 10 minutes after switching engine off before removing oil dipstick otherwise risk of burns through hot oil spurting out.</p> <p>Always switch engine off to top up oil otherwise risk of burns through hot oil spurting out.</p> |  |                          |
| Tools                          | -----  |  |                          |
| Parts                          | -----  |  |                          |
| Material                       | Lint-free cloths   |  |                          |
| Test equipment                 | -----  |  |                          |
| Procedure                      | See opposite page.   |  |                          |
| Location:                      |  | Date:  | Page: 1<br>of: 2         |



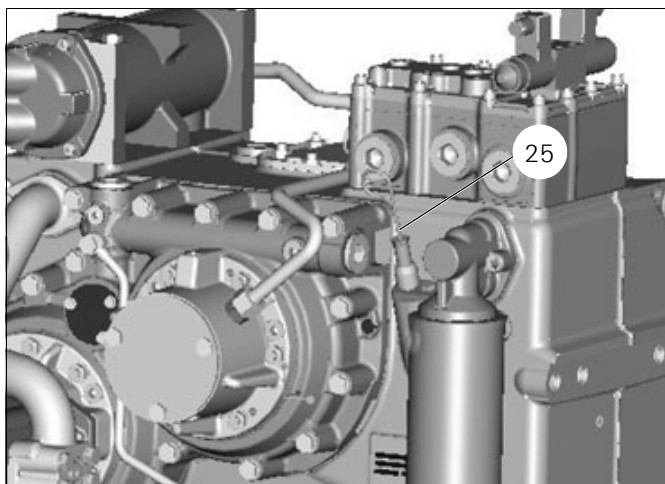


Fig. 56: Oil dipstick (25) on transmission (example)

During the first filling following oil filter repairs or cleaning, consider that part of the oil remains in the oil cooler and the oil pipes and does not flow back in the transmission housing. Therefore, check oil level again after a short period of operation.

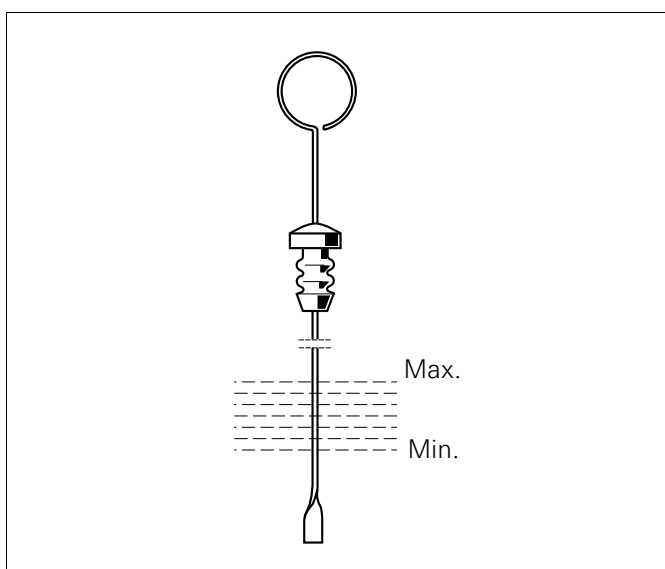


Fig. 57: Oil dipstick (example)

The correct oil level is between the top and the bottom measuring mark of the oil dipstick.



Wait for approx. 10 minutes until the oil level has settled after switching the engine off. Now remove the oil dipstick and read off the oil level!

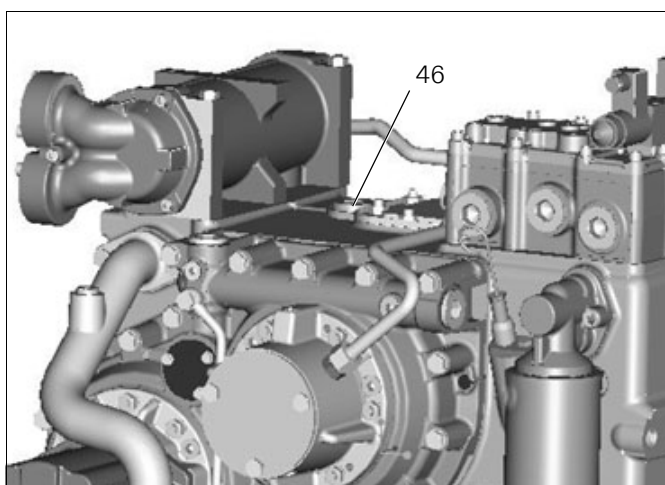


Fig. 58: Oil filler screw (46) on transmission ZF 2000 (example)

If the oil needs to be topped up, unscrew the oil filler screw and top up the oil.





# MAINTENANCE SYSTEM JOB SHEET

|                                |  |  |                          |
|--------------------------------|--|--|--------------------------|
| Transmission type:             |  | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level                      | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 102                            | A1                                     | -----  | 5                        |
| Description of maintenance job | 102 Rotate rotary handle of oil filter |  |                          |
| Safety measures                | -----                                  |  |                          |
| Tools                          | -----                                  |  |                          |
| Parts                          | -----                                  |  |                          |
| Material                       | -----                                  |  |                          |
| Test equipment                 | -----                                  |  |                          |
| Procedure                      | See opposite page.                     |  |                          |
| Location:                      |  | Date:  | Page: 1 of: 2            |



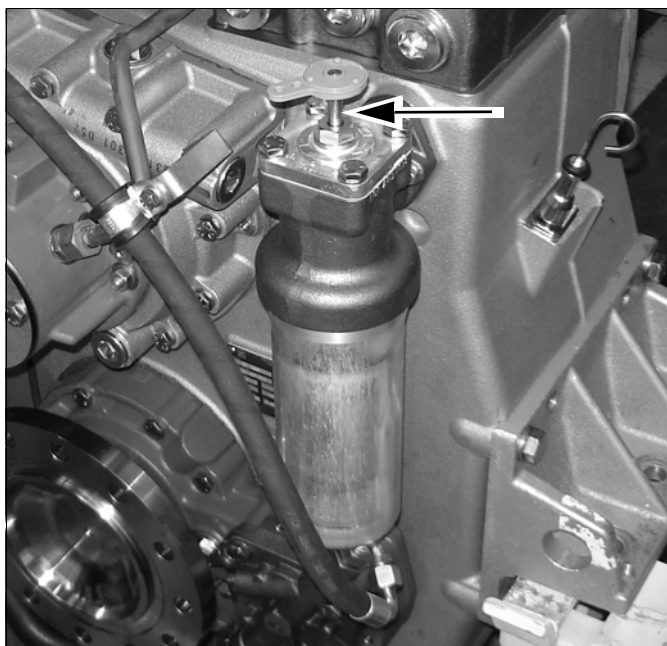


Fig. 59: Rotary handle on gap filter (example)

Slowly rotate rotary handle of gap filter clockwise 1 to 2 turns.





# MAINTENANCE SYSTEM JOB SHEET

|                                       |  |   |                                 |
|---------------------------------------|--|---|---------------------------------|
| <b>Transmission type:</b>             |  | <b>ZF 2000 series</b>   |                                 |
| <b>Maintenance Job No.</b>            | <b>Maintenance level</b>   | <b>When possible, to be performed in conjunction with Maintenance Job No.</b> | <b>Time required in minutes</b> |
| 103                                   | A1   | 121   | 10                              |
| <b>Description of maintenance job</b> | 103 Visual inspection  |   |                                 |
| <b>Safety measures</b>                | Keep a safe distance when performing visual inspections on rotating parts otherwise risk of being caught by the rotating part. |   |                                 |
| <b>Tools</b>                          | -----  |   |                                 |
| <b>Parts</b>                          | -----  |   |                                 |
| <b>Material</b>                       | -----  |   |                                 |
| <b>Test equipment</b>                 | -----  |   |                                 |
| <b>Procedure</b>                      | See opposite page.   |   |                                 |
| <b>Location:</b>                      |  | <b>Date:</b>  | <b>Page: 1</b><br><b>of: 2</b>  |



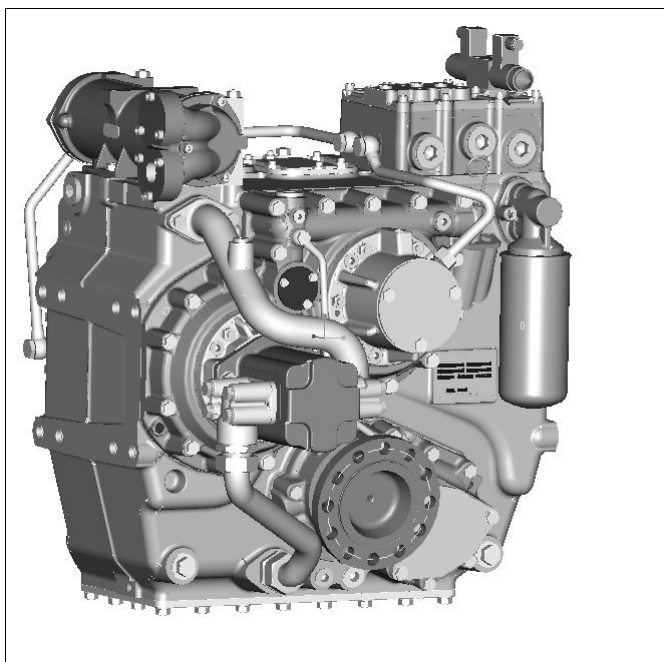


Fig. 60: Transmission ZF 2000 A (example)

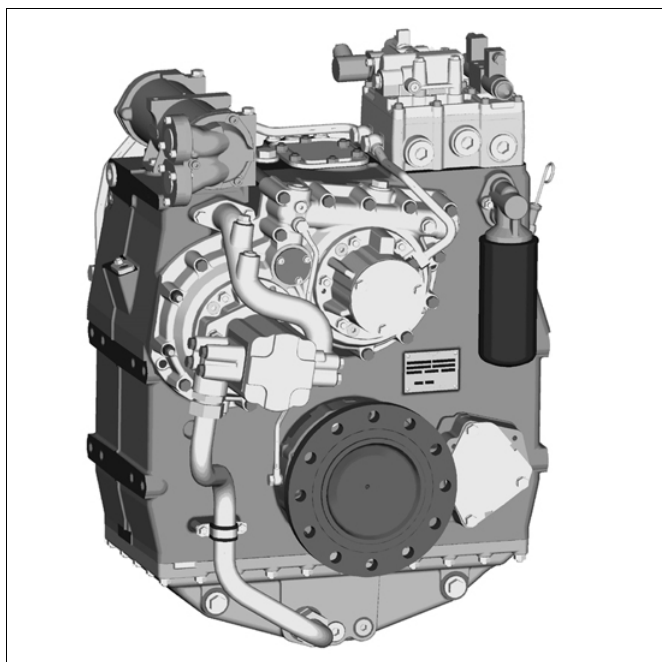


Fig. 62: Transmission ZF 2250 (example)

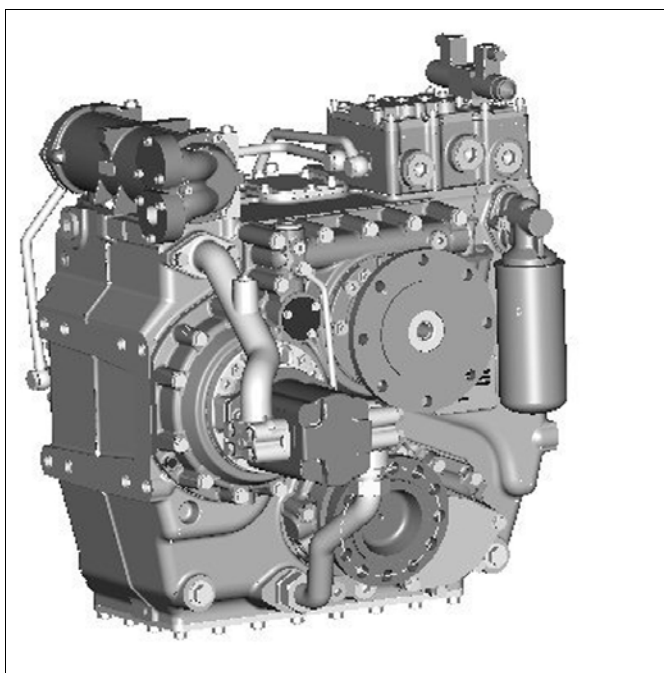


Fig. 61: Transmission ZF 2000 V (example)

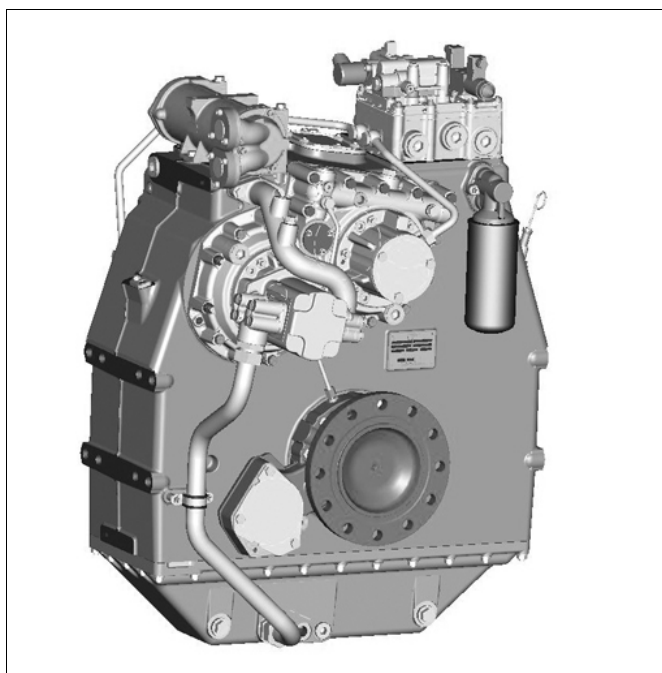


Fig. 63: Transmission ZF W2400 (example)

Check outlet points of input and output shafts out of the transmission housing, connections to oil pipes and monitoring devices, cooling water connections as well as the transmission oil cooler for leaks (visual inspection). Also check the oil level (water leaking in oil or oil leaking in water when engine is switched off).





# MAINTENANCE SYSTEM JOB SHEET

|                                       |   |   |                                 |
|---------------------------------------|---|---|---------------------------------|
| <b>Transmission type:</b>             |   | <b>ZF 2000 series</b>   |                                 |
| <b>Maintenance Job No.</b>            | <b>Maintenance level</b>  | <b>When possible, to be performed in conjunction with Maintenance Job No.</b> | <b>Time required in minutes</b> |
| 121                                   | A2  | 103   | 30                              |
| <b>Description of maintenance job</b> | 121 Clean outside of transmission   |   |                                 |
| <b>Safety measures</b>                | Only use cleaning agents complying with Accident Prevention regulations valid at the site of operation. |   |                                 |
| <b>Tools</b>                          | On-board tools  |   |                                 |
| <b>Parts</b>                          | Cleaning agent  |   |                                 |
| <b>Material</b>                       | -----   |   |                                 |
| <b>Test equipment</b>                 | -----   |   |                                 |
| <b>Procedure</b>                      | See opposite page.  |   |                                 |
| <b>Location:</b>                      |   | <b>Date:</b>  | <b>Page: 1 of: 2</b>            |



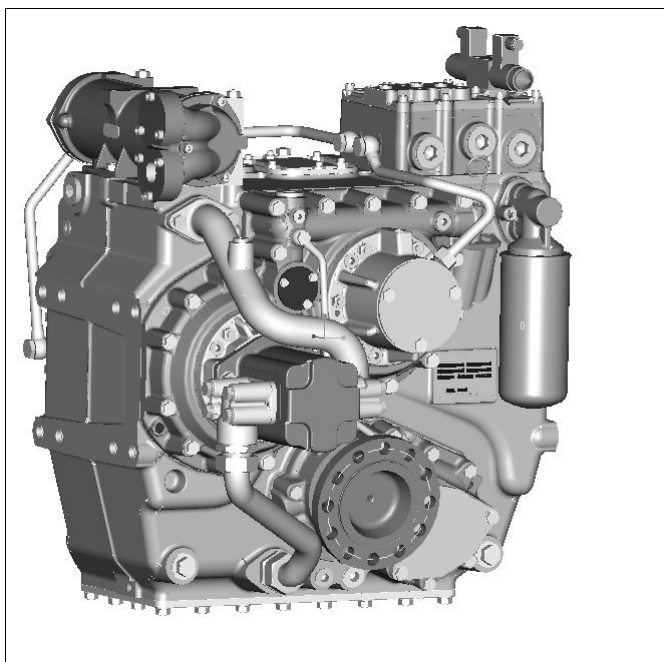


Fig. 64: Transmission ZF 2000 A (example)

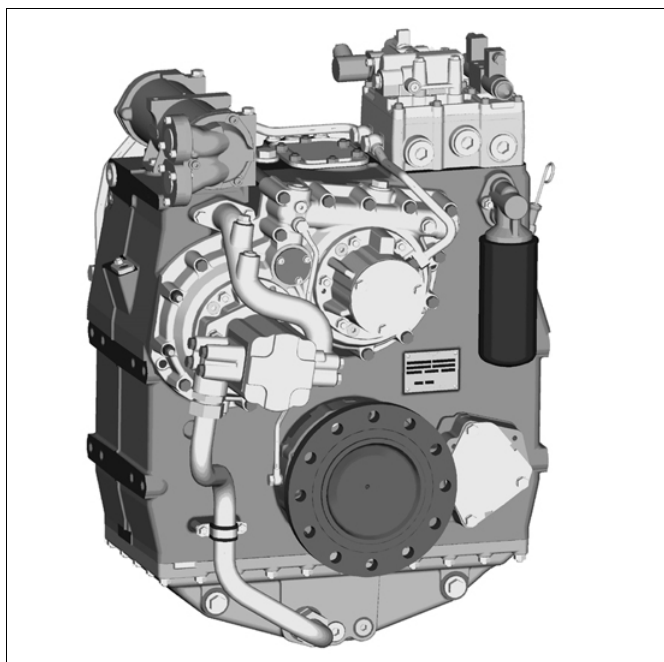


Fig. 66: Transmission ZF 2250 (example)

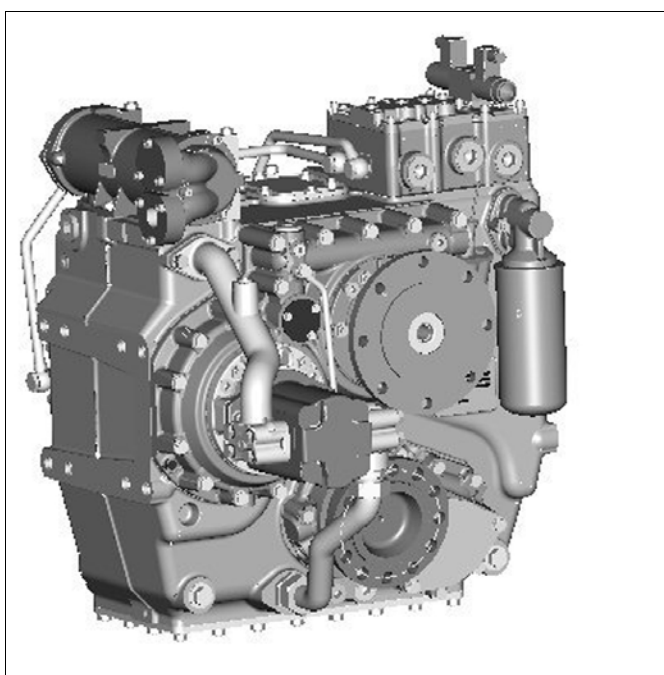


Fig. 65: Transmission ZF 2000 V (example)



Do not bring the following parts into contact with the cleaning agent:

- Rubber parts
- Hose lines
- Shaft sealing rings

#### NOTICE

**Property damage caused by contact with aggressive liquid possible.**

⇒ Do not bring the part into contact with aggressive liquid.

1. Clean transmission exterior with a cleaning agent so that the visual inspection can be performed.





# MAINTENANCE SYSTEM JOB SHEET

|                                       |  |   |                                 |
|---------------------------------------|--|---|---------------------------------|
| <b>Transmission type:</b>             |  | <b>ZF 2000 series</b>   |                                 |
| <b>Maintenance Job No.</b>            | <b>Maintenance level</b>   | <b>When possible, to be performed in conjunction with Maintenance Job No.</b> | <b>Time required in minutes</b> |
| 122                                   | Z1, A2   | -----   | 20                              |
| <b>Description of maintenance job</b> | 122 Retighten all bolts accessible from the outside                  |   |                                 |
| <b>Safety measures</b>                | Do not perform retightening work while transmission is in operation. |   |                                 |
| <b>Tools</b>                          | -----  |   |                                 |
| <b>Parts</b>                          | -----  |   |                                 |
| <b>Material</b>                       | -----  |   |                                 |
| <b>Test equipment</b>                 | -----  |   |                                 |
| <b>Procedure</b>                      | See opposite page.   |   |                                 |
| <b>Location:</b>                      |  | <b>Date:</b>  | <b>Page: 1 of: 2</b>            |



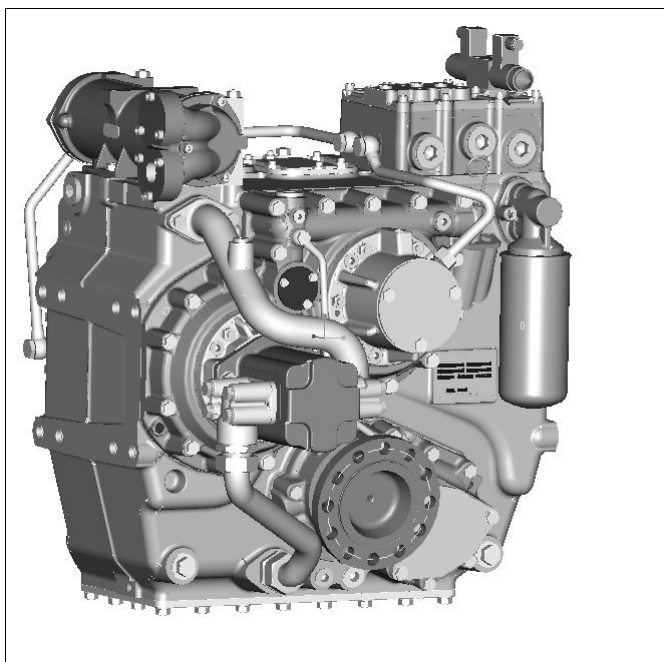


Fig. 67: Transmission ZF 2000 A (example)

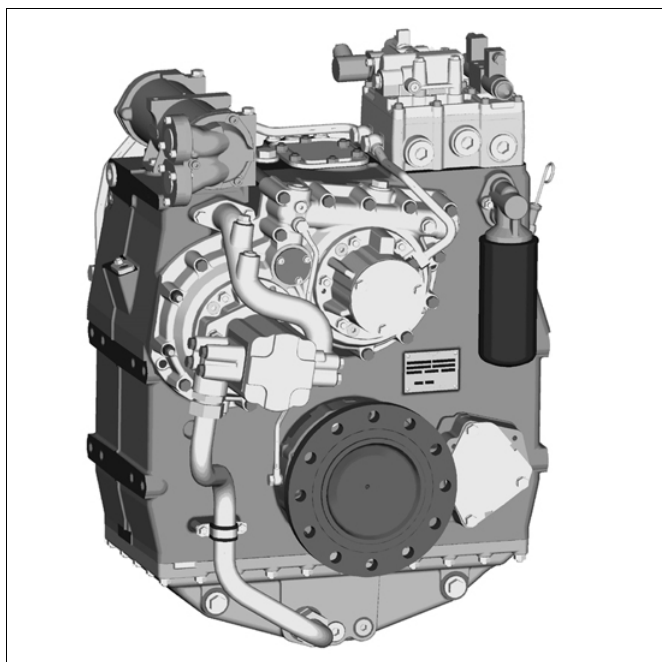


Fig. 69: Transmission ZF 2250 (example)

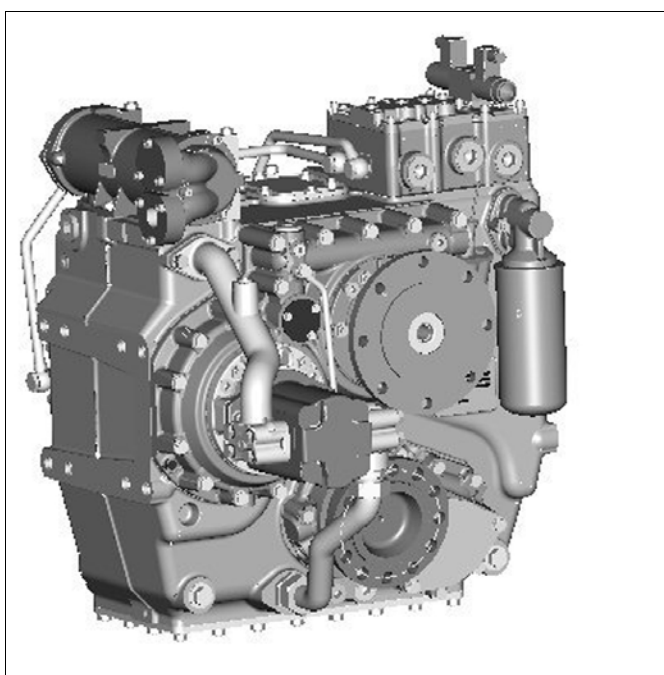


Fig. 68: Transmission ZF 2000 V (example)

Retighten all accessible bolt connections.

Pay particular attention to the following connections:

- Engine / flexible clutch
- Flywheel housing / bell housing of transmission
- Angle plate / transmission
- Angle plate / foundation

Also check connections "from" and "to" the transmission oil cooler as well as monitoring device connections and retighten when necessary.



Retighten screws according to tightening torque while the transmission is cold (approx. 20°C).





# MAINTENANCE SYSTEM JOB SHEET

|                                |   |  |                          |
|--------------------------------|---|--|--------------------------|
| Transmission type:             |   | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level   | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 123                            | Z1, A2  | -----  | 15                       |
| Description of maintenance job | 123 Check shift settings (mechanical transmission actuation)          |  |                          |
| Safety measures                | Lock engine starting device.<br>Otherwise risk of ship gaining speed. |  |                          |
| Tools                          | -----   |  |                          |
| Parts                          | -----   |  |                          |
| Material                       | -----   |  |                          |
| Test equipment                 | -----   |  |                          |
| Procedure                      | See opposite page.  |  |                          |
| Location:                      |   | Date:  | Page: 1 of: 3            |



1. Unhook the push/pull cable or the shift linkage of the mechanical remote control on the shift lever of the control unit.
2. Set selector unit to shift position "Neutral".
3. Move and latch the shift lever of the control unit to shift position "Neutral".

**i** Align the holes on the shift lever of the control unit and the shift linkage or fork head of the push/pull cable.

4. Set selector unit to shift position "Ahead".
5. Move the shift lever of the control unit to shift position "Engine wise rotation" or "Counter-engine wise rotation" to the stop depending on the "Ahead" shift position.

**i** Align the holes on the shift lever of the control unit and the shift linkage or fork head of the push/pull cable.

6. Set selector unit to shift position "Astern".
7. Move the shift lever of the control unit to shift position "Engine wise rotation" or "Counter-engine wise rotation" to the stop depending on the "Astern" shift position.

**i** Align the holes on the shift lever of the control unit and the shift linkage or fork head of the push/pull cable.

**i** Shift positions must be reliably reached. Make sure the shift lever of the control unit does not stop in an undefined shift position between shift positions "Neutral" and "Counter-engine wise rotation" or shift positions "Neutral" and "Engine wise rotation". Adjust the mechanism on the transmission rods when necessary.

8. Hook the push/pull cable or the shift linkage of the mechanical remote control on the shift lever of the control unit.

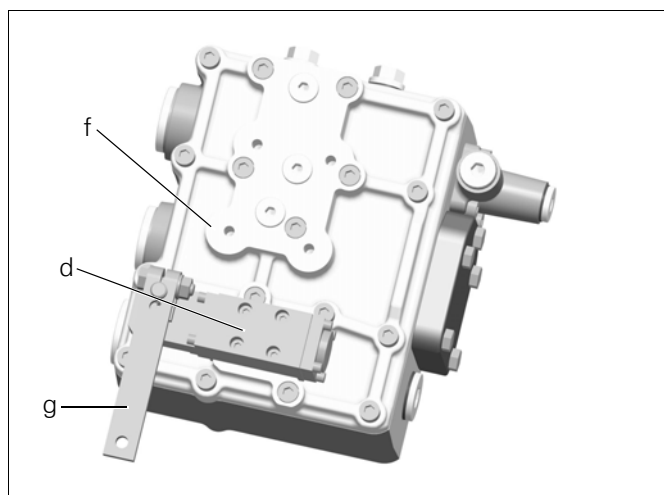
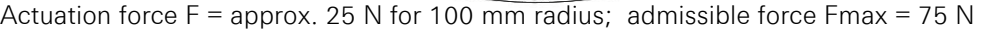


Fig. 70: Mechanical transmission actuation elements (example)

- d - Pilot valve for "Engine wise rotation" and "Counter-engine wise rotation" shift positions
- f - Control unit
- g - Shift lever





103 Latching position for shift position "Counter-engine wise rotation"

104 Latching position for shift position "Engine wise rotation"

121 Shift lever stop (not supplied by ZF)

122 Undefined shift position (pass through this area quickly)

124 Latching position for shift position "Neutral"









# MAINTENANCE SYSTEM JOB SHEET

|                                |   |  |                          |
|--------------------------------|---|--|--------------------------|
| Transmission type:             |   | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level   | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 124                            | A2  | -----  | 15                       |
| Description of maintenance job | 124 Lubricate external moving parts (mechanical transmission actuation)   |  |                          |
| Safety measures                | -----   |  |                          |
| Tools                          | -----   |  |                          |
| Parts                          | -----   |  |                          |
| Material                       | -----   |  |                          |
| Test equipment                 | -----   |  |                          |
| Procedure                      | Lightly grease moving parts of the mechanical transmission actuation (fork head on transmission shift lever, linkage connections and connection to selector unit) with lithium soap grease. |  |                          |
| Location:                      |   | Date:  | Page: 1 of: 1            |









# MAINTENANCE SYSTEM JOB SHEET

|                                       |  |   |                                 |
|---------------------------------------|--|---|---------------------------------|
| <b>Transmission type:</b>             |  | <b>ZF 2000 series</b>   |                                 |
| <b>Maintenance Job No.</b>            | <b>Maintenance level</b>   | <b>When possible, to be performed in conjunction with Maintenance Job No.</b> | <b>Time required in minutes</b> |
| 141                                   | Z1, A3   | 142 / 163 / 164   | 30                              |
| <b>Description of maintenance job</b> | 141 Oil change   |   |                                 |
| <b>Safety measures</b>                | <p>Lock engine starting device.</p> <p>Perform oil change at maximum 40 - 50°C oil temperature otherwise risk of burns.</p> <p>Collect used oil in oil collection containers of sufficient size otherwise risk of environmental pollution.</p>   |   |                                 |
| <b>Tools</b>                          | On-board tools   |   |                                 |
| <b>Parts</b>                          | New gasket / seal rings  |   |                                 |
| <b>Material</b>                       | <p>Oil type:</p> <p>Admissible oils according to the currently applicable "ZF lubricant list TE-ML 04 for ZF marine transmissions". A lubricant list valid at the time of delivery of the transmission is enclosed with the transmission. Available from all ZF Service branches on request.</p> |   |                                 |
| <b>Test equipment</b>                 | -----  |   |                                 |
| <b>Procedure</b>                      | See opposite page.   |   |                                 |
| <b>Location:</b>                      |  | <b>Date:</b>  | <b>Page: 1</b><br><b>of: 2</b>  |



**When possible, to be performed in conjunction with Maintenance Job Nos. 142, 163, and 164!**

### CAUTION

**Risk of burns due to contact with hot oil.  
Slight or moderate injury possible.**

- ⇒ Wear protective goggles
- ⇒ Wear protective gloves.

1. Remove the oil dipstick, open oil drain screw (20) and drain the oil.
2. Suck off the oil when an oil suction device has been fitted to the transmission.
3. Fit a new seal ring on oil drain screw (20), insert and tighten the screw.
4. Close the suction device when used.
5. To fill with oil, unscrew oil filler screw (46) or remove inspection cover (47).

### NOTICE

**The use of a non-approved lubricant can lead to property damage.**

- ⇒ Only use lubricant from the currently valid ZF List of Lubricants.

6. Fill with new oil.

### Oil quantities

ZF 2000 / ZF 2050 / ZF 2060 / ZF 2070 / ZF 2075 /  
ZF 2150 / ZF 2000 NR / ZF 2050 NR / ZF 2060 NR /  
ZF 2070 NR / ZF 2075 NR / ZF 2150 NR approx. 20 dm<sup>3</sup>

ZF 2150 NC approx. 20 dm<sup>3</sup>

ZF 2000 A / ZF 2050 A / ZF 2060 A / ZF 2070 A /  
ZF 2075 A / ZF 2150 A / ZF 2000 NRA / ZF 2050 NRA /  
ZF 2060 NRA / ZF 2070 NRA / ZF 2075 NRA /  
ZF 2150 NRA approx. 21 dm<sup>3</sup>

ZF 2000 V / ZF 2050 V / ZF 2060 V / ZF 2070 V /  
ZF 2075 V / ZF 2150 V / ZF 2000 NRV / ZF 2050 NRV /  
ZF 2060 NRV / ZF 2070 NRV / ZF 2075 NRV /  
ZF 2150 NRV, ZF 2000 NRB approx. 21 dm<sup>3</sup>

ZF 2200 / ZF 2250 / ZF 2260 / ZF 2270 / ZF 2275 /  
ZF 2200 NR / ZF 2250 NR / ZF 2260 NR /  
ZF 2270 NR / ZF 2275 NR approx. 21 dm<sup>3</sup>

ZF 2300 / ZF 2350 / ZF 2360 / ZF 2370 / ZF 2375 /  
ZF W2300 / ZF W2350 / ZF 2300 NR / ZF 2350 NR /  
ZF 2360 NR / ZF 2370 NR / ZF 2375 NR /  
ZF W2300 NR / ZF W2350 NR approx. 27 dm<sup>3</sup>

ZF W2400 / ZF W2450 / ZF W2400 NR /  
ZF W2450 NR approx. 36 dm<sup>3</sup>

ZF 2350 U approx. 27 dm<sup>3</sup>

7. Fit oil filler screw (46) with a new seal ring or inspection cover (47) with a new gasket and retighten.
8. Then check the oil level according to Maintenance Job No. 101.



Measurement using the oil dipstick is decisive!

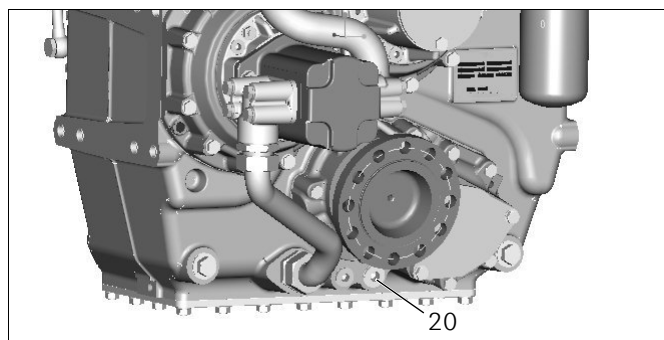


Fig. 72: Oil drain screw (20), ZF 2000 A (example)

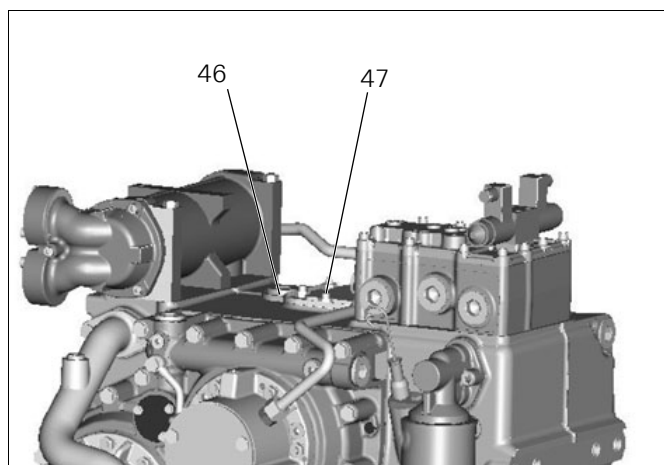


Fig. 73: Oil filler screw (46) and inspection cover (47) for ZF 2000 A (example)





# MAINTENANCE SYSTEM JOB SHEET

|                                |   |  |                          |
|--------------------------------|---|--|--------------------------|
| Transmission type:             |   | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level   | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 142                            | Z1, A3  | 141 / 163 / 164  | 30                       |
| Description of maintenance job | 142 Renew oil filter<br>142 Clean changeover filter<br>142 Clean gap filter and filter housing  |  |                          |
| Safety measures                | For safety reasons, do not change the filter until 30 minutes after the engine has stopped! Otherwise hot oil under pressure will escape abruptly out of the oil filter seal! Risk of burns.<br>Perform cleaning and replacing elements at a maximum oil temperature of 40 - 50°C.<br>Lock engine starting device.<br>Collect used oil in oil collection containers of sufficient size otherwise risk of environmental pollution. |  |                          |
| Tools                          | On-board tools  |  |                          |
| Parts                          | Oil filter ( <b>Attention: Operating pressure 24 bar</b> ), gasket / seal rings<br>Changeover filter: Oil filter ( <b>Attention: Operating pressure 34,5 bar</b> ), seal rings  |  |                          |
| Material                       | Oil type:<br>Admissible oils according to the currently applicable "ZF lubricant list TE-ML 04 for ZF marine transmissions". A lubricant list valid at the time of delivery of the transmission is enclosed with the transmission. Available from all ZF Service branches on request.   |  |                          |
| Test equipment                 | -----   |  |                          |
| Procedure                      | See opposite page.  |  |                          |
| Location:                      |   | Date:  | Page: 1<br>of: 4         |



**When possible, to be performed in conjunction with Maintenance Job Nos. 141, 163, and 164!**

### Replace oil filter

**i** This oil filter is only used for unclassified transmissions.

Do not replace the filter immediately after switching of the engine. For safety reasons, wait 30 minutes after the engine has stopped before replacing the filter. Otherwise hot oil under pressure will escape abruptly out of the oil filter seal!

Avoid skin contact and do not inhale oil vapours.

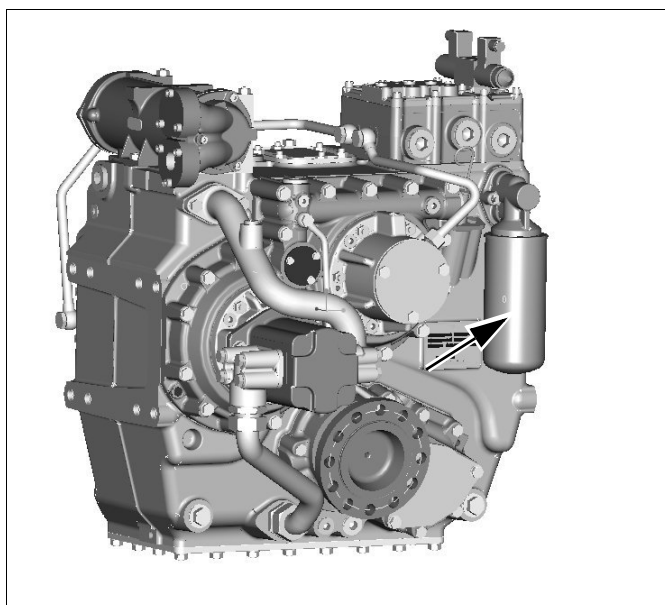


Fig. 74: Oil filter on transmission ZF 2000 A (example)

### **CAUTION**

**Risk of burns due to contact with hot oil.  
Slight or moderate injury possible.**

- ⇒ Wear protective goggles
- ⇒ Wear protective gloves.

1. Dismantle filter using an oil filter remover. Collect drained oil in a container.
2. Fit filter cartridge according to manufacturer's specifications:
  - a) Grease gasket.
  - b) Screw filter in until contact noticeable.
  - c) Tighten filter manually.
  - d) Check filter for leaks.

### Replace filter cartridge of the changeover filter

**i** The changeover filter is used for classified transmissions.

Do not replace the filter immediately after switching of the engine. For safety reasons, wait 30 minutes after the engine has stopped before replacing the filter. Otherwise hot oil under pressure will escape abruptly out of the oil filter seal!

Avoid skin contact and do not inhale oil vapours.

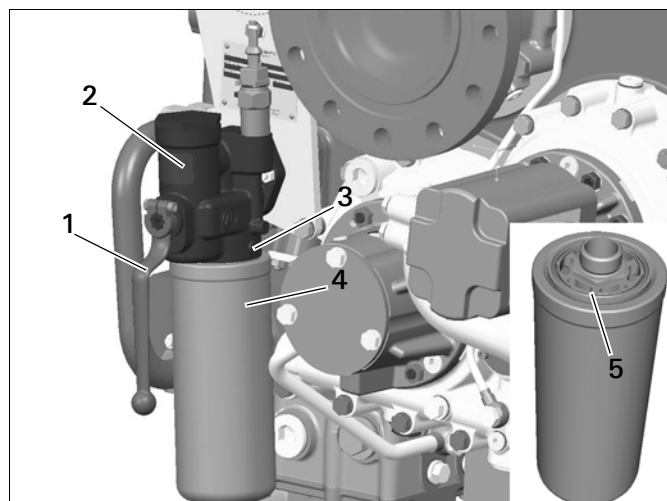


Fig. 75: Changeover filter

- |                |                    |
|----------------|--------------------|
| 1 Change lever | 2 Filter head      |
| 3 Vent screw   | 4 Filter cartridge |
| 5 O-ring       |                    |

1. Move change lever (1) anticlockwise to the stop in the 3 o'clock position.



Fig. 76: Change lever in the 3 o'clock position (example)

2. Open vent screw (3) cautiously two turns to allow the pressure to escape.



## Contaminated filter cartridge

**CAUTION**

**Risk of burns due to contact with hot oil.**

**Slight or moderate injury possible.**

⇒ Wear protective goggles

⇒ Wear protective gloves.

3. Remove filter cartridge (4) with an oil filter remover and collect the drained oil in a suitable container.

## New filter cartridge

4. Oil O-ring (5) of the new filter cartridge.
5. Screw the new filter cartridge onto filter head (2) until contact is noticeable.
6. Tighten new filter cartridge (4) by hand.
7. Check the oil filter for leak-tightness.
8. Screw the vent screw in cautiously and tighten with a tightening torque of 10 Nm.
9. Move change lever (1) clockwise to the stop in the 6 o'clock position.



Fig. 77: Change lever in the 6 o'clock position (example)

## Cleaning the protective filter of the changeover filter



Only clean the protective filter when the oil filter has been switched to the protective filter due to a filter alarm.

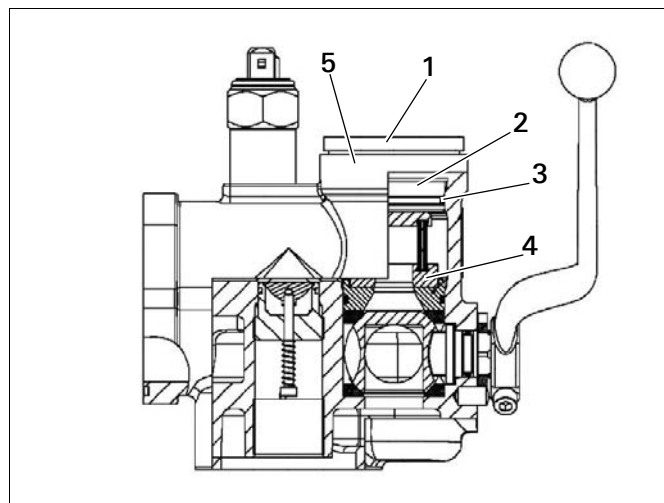


Fig. 78: Filter head with protective filter

- |               |                     |
|---------------|---------------------|
| 1 Nut         | 2 Screw             |
| 3 O-ring      | 4 Protective filter |
| 5 Filter head |                     |

1. With the engine switched off, unscrew and remove nut (1) and screw (2) completely.
2. Remove O-ring (3).
3. Pull protective filter (4) out upwards.



Ensure no dirt penetrates the clean oil chamber of filter head (5).

**NOTICE**

**Property damage caused by using unsuitable cleaning tools possible.**

⇒ Use a brush.

⇒ Use nonlinting cloth.

4. Clean protective filter (4) thoroughly with diesel oil or cleaning benzene.
5. Insert protective filter (4) in filter head (5).
6. Position O-ring (3) on fixing nut (1).
7. Screw screw (2) in to the stop and tighten nut (1) with a tightening torque. At the same time, counter screw (2) against nut (1).



## Clean gap filter and filter housing



The gap filter is used for classified transmissions.

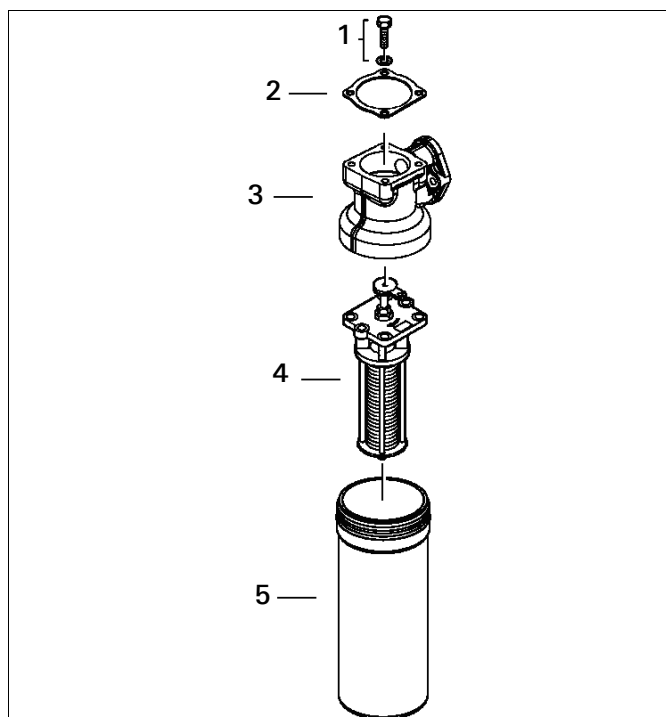


Fig. 79: Gap filter

- |                  |          |
|------------------|----------|
| 1 Screw          | 2 Seal   |
| 3 Filter head    | 4 Filter |
| 5 Filter housing |          |

1. Rotate the rotary handle of the oil filter as described in Maintenance Job No. 102 with transmission idle.
2. Remove the four fixing screws on filter head (3) and pull filter (4) out upwards. Ensure no dirt penetrates the clean oil chamber of the filter housing.
3. Dismantle filter housing (5) using an SW 32 open-end wrench. Collect drained oil in a container.

### NOTICE

**Property damage caused by using unsuitable cleaning tools possible.**

- ⇒ Use a brush.
- ⇒ Use nonlinting cloth.

4. Clean filter housing (5) and filter (4) thoroughly using diesel oil or cleaning benzene. To do this, rotate rotary handle several times (do not dismantle filter).



Use a new filter seal when installing the filter and filter housing.

Perform assembly in reverse disassembly sequence.

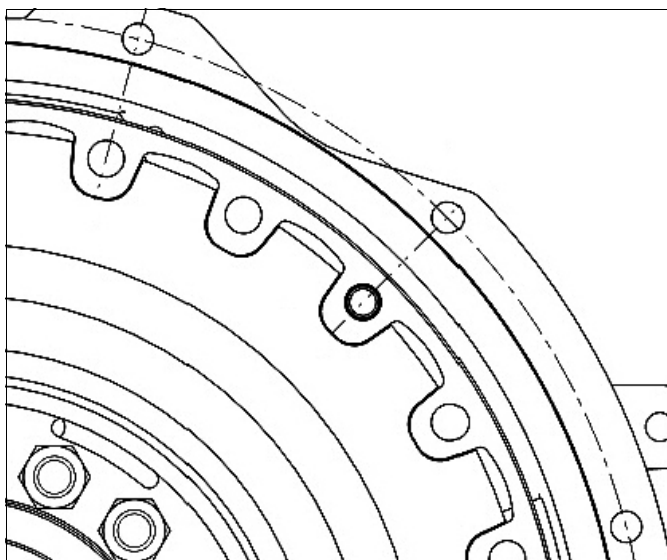




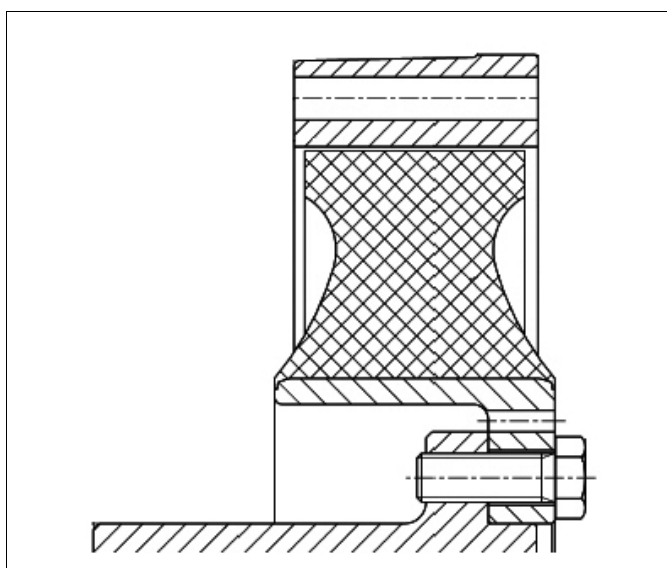
# MAINTENANCE SYSTEM JOB SHEET

|                                |  |  |                          |
|--------------------------------|--|--|--------------------------|
| Transmission type:             |  | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level                      | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 161                            | A4                                     | -----  | 30                       |
| Description of maintenance job | 161 Flexible clutch: Visual inspection |  |                          |
| Safety measures                | Lock engine starting device.           |  |                          |
| Tools                          | -----                                  |  |                          |
| Parts                          | -----                                  |  |                          |
| Material                       | -----                                  |  |                          |
| Test equipment                 | -----                                  |  |                          |
| Procedure                      | See opposite page.                     |  |                          |
| Location:                      |  | Date:  | Page: 1 of: 2            |





Check rubber rings of flexible clutch for flawless condition. To do this, rotate engine slowly and check elastomers through inspection hole of bell housing.



Check elastomers for cracks, embrittlement, and overheating symptoms.





# MAINTENANCE SYSTEM JOB SHEET

|                                |   |  |                          |
|--------------------------------|---|--|--------------------------|
| Transmission type:             |   | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level   | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 162                            | A4  | -----  | 15                       |
| Description of maintenance job | 162 Flexible engine and transmission support: Visual inspection   |  |                          |
| Safety measures                | -----   |  |                          |
| Tools                          | -----   |  |                          |
| Parts                          | -----   |  |                          |
| Material                       | -----   |  |                          |
| Test equipment                 | -----   |  |                          |
| Procedure                      | Check rubber-bonded metal bearings on engine and transmission for flawless condition. Rubber parts must not show cracks, embrittlement, and other damage. |  |                          |
| Location:                      |   | Date:  | Page: 1 of: 1            |









# MAINTENANCE SYSTEM JOB SHEET

|                                |  |  |                          |
|--------------------------------|--|--|--------------------------|
| Transmission type:             |  | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level  | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 163                            | A4   | 141 / 142 / 164  | 15                       |
| Description of maintenance job | 163 Clutch discs; Visual inspection  |  |                          |
| Safety measures                | Lock engine starting device.<br>Remove all parts which could penetrate the transmission interior after opening the inspection cover (keep chest pockets of technicians empty). |  |                          |
| Tools                          | On-board tools   |  |                          |
| Parts                          | Gasket   |  |                          |
| Material                       | -----  |  |                          |
| Test equipment                 | -----  |  |                          |
| Procedure                      | See opposite page.   |  |                          |
| Location:                      |  | Date:  | Page: 1<br>of: 2         |



It is practical to combine this work with the oil change (Maintenance Job No. 141).

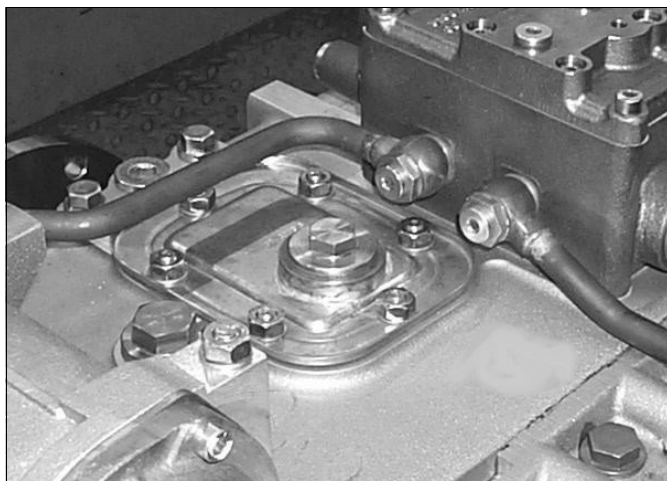


Fig. 80: Inspection cover - top view (example)

#### NOTICE

**Property damage caused by a falling part possible.**

⇒ Secure the part against falling.

1. Remove the inspection cover.

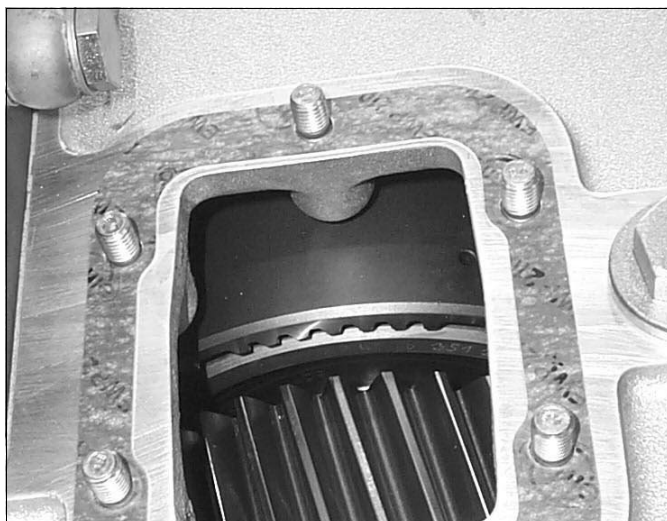


Fig. 81: Outer disc carrier (example)

2. Check the multi-disc clutch.



The outer disc carrier must not show any overheating symptoms.



Fig. 82: Inspection cover - top view (example)

3. Install the inspection cover.





# MAINTENANCE SYSTEM JOB SHEET

|                                |  |  |                          |
|--------------------------------|--|--|--------------------------|
| Transmission type:             |  | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level  | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 164                            | A4   | 141 / 142 / 163  | 15                       |
| Description of maintenance job | 164 Running gears: Visual inspection   |  |                          |
| Safety measures                | Lock engine starting device.<br>Remove all parts which could penetrate the transmission interior after opening the inspection cover (keep chest pockets of technicians empty). |  |                          |
| Tools                          | On-board tools   |  |                          |
| Parts                          | Gasket   |  |                          |
| Material                       | -----  |  |                          |
| Test equipment                 | -----  |  |                          |
| Procedure                      | See opposite page.   |  |                          |
| Location:                      |  | Date:  | Page: 1<br>of: 2         |



It is practical to combine this work with the oil change (Maintenance Job No. 141).

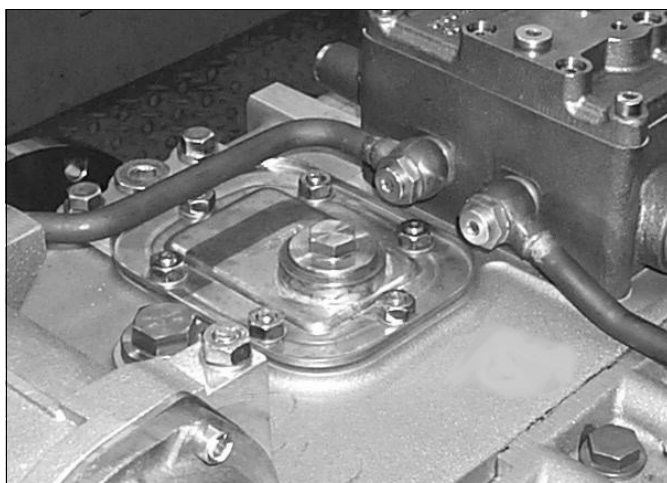


Fig. 83: Inspection cover - top view (example)

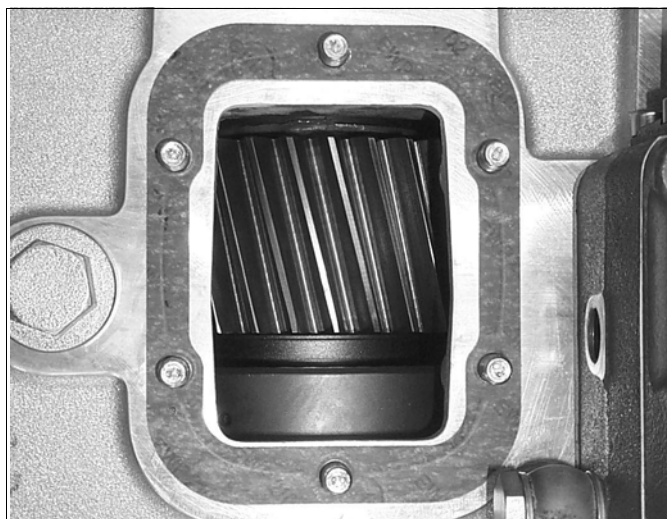


Fig. 84: View on the gears (example)

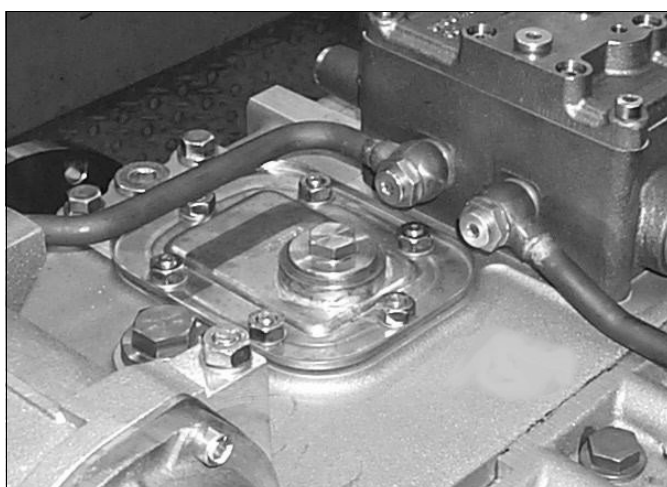


Fig. 85: Inspection cover - top view (example)

#### NOTICE

**Property damage caused by a falling part possible.**

⇒ Secure the part against falling.

1. Remove the inspection cover.
2. Check the gearing of wheels on input shaft, intermediate shaft, and output shaft. Tooth flanks must not show pittings or similar signs of wear.
3. Install the inspection cover.





# MAINTENANCE SYSTEM JOB SHEET

|                                |   |  |                          |
|--------------------------------|---|--|--------------------------|
| Transmission type:             |   | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level   | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 165                            | A4  | -----  | 180                      |
| Description of maintenance job | 165 Check oil pumps<br>Engine-dependent oil pump (primary oil pump)<br>Trailing operation oil pump (trailing pump) - special equipment! |  |                          |
| Safety measures                | Lock engine starting device when the oil pump is to be dismantled.  |  |                          |
| Tools                          | Tool kit W1   |  |                          |
| Parts                          | Seal kit  |  |                          |
| Material                       | -----   |  |                          |
| Test equipment                 | -----   |  |                          |
| Procedure                      | See opposite page.  |  |                          |
| Location:                      |   | Date:  | Page: 1<br>of: 4         |



### Engine-dependent oil pump (primary oil pump)

Correct dimensioning in accordance with operating conditions and correct installation of the gear pumps provide structural conditions ensuring long and trouble-free operation. The pumps have low maintenance requirements which, however, are indispensable for trouble-free operation because, according to experience, a high proportion of the malfunctions and damage occurring are due to dirt and insufficient maintenance.

### Maintenance

Regular checks of all operating data such as filter contamination degree, pressure, temperature, etc. can help detect malfunctions at an early stage.



The oil pump is a complete part and is normally not dismantled. However, inspection or cleaning work might require dismantling the pump.

### Measures for dismantling the oil pump

All work requires highest cleanness standards. Clean the surrounding area before loosening screw connections.

- Depressurize connection lines before removal!
- Collect and dispose of leaking fluids so that all risks for persons and environment are excluded.
- Seal pump connections and pipe lines against penetration by dirt.
- Always use lint-free cloths for cleaning pump parts.

### Commissioning the oil pumps

- Before starting a plant, ensure a sufficient amount of transmission oil is available to avoid dry running.

### Engine-dependent oil pump (primary oil pump)

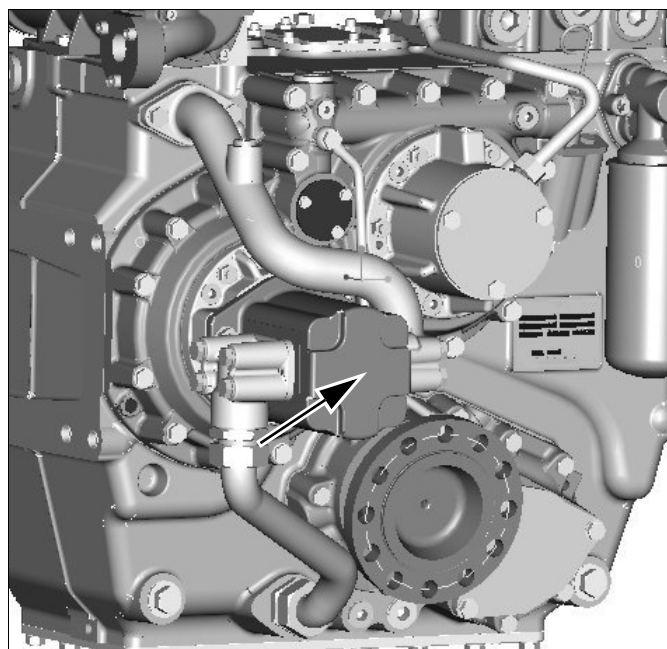


Fig. 86: Primary oil pump on ZF 2000 A (example)

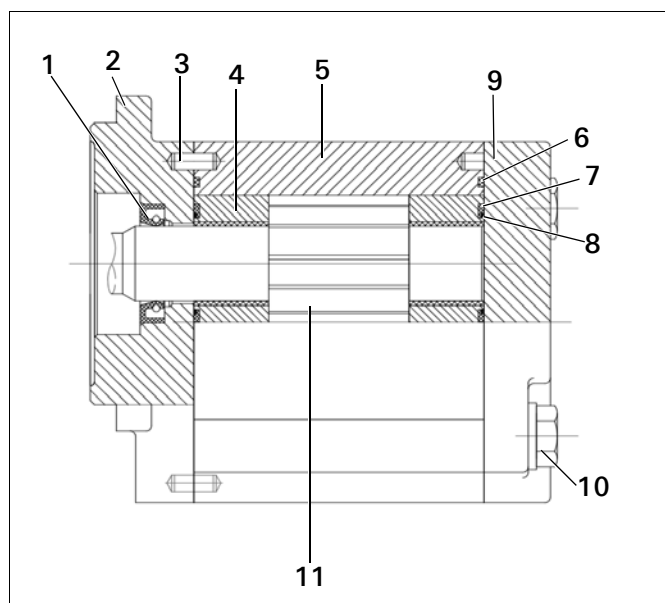


Fig. 87: Primary oil pump design (example)

- |                  |                              |
|------------------|------------------------------|
| 1 Shaft seal     | 7 Support ring               |
| 2 Mounting plate | 8 Rubber pressure field seal |
| 3 Set screw      | 9 Pump cover                 |
| 4 Double bearing | 10 Hexagon screw             |
| 5 Housing        | 11 Gear set (shaft)          |
| 6 Seal element   |                              |



### Removing and dismantling the oil pump

1. Dismantle the suction and pressure pipe.
2. Remove O-rings.
3. Dismantle the pump by loosening the fixing nuts.
4. Remove the O-ring.
5. Mark positions of pump parts.
6. Remove screws on pump cover (9) and dismantle the pump.

### Cleaning and testing the oil pump

1. Thoroughly clean parts with a lint-free cloth.
2. Check double bearing (4) for grooves.
3. Check gear set (11) for wear and indentation.
4. Apply thin layer of oil to movable parts.

### Assembling the oil pump

1. Press shaft seal (1) in mounting plate (2) from the front side of the centring collar to the stop.
2. Insert housing (5) in mounting plate (2).
3. Lay support ring (7) and rubber pressure field seal (8) in the first double bearing.
4. Install double bearing (4) so that the axial pressure field points in the high-pressure side direction.
5. Mount both gear sets (11).
6. Lay support ring (7) and rubber pressure field seal (8) in the second double bearing.
7. Install double bearing (4) so that the axial pressure field points in the high-pressure side direction.
8. Insert seal element (6) in housing (5).
9. Mount pump cover (9) on housing (5).
10. Secure pump cover (9) on housing (5) by tightening the fixing screws crosswise (with torque).
11. Insert the O-ring.
12. Insert the pump in the pump flange and mount it by tightening the fixing screws crosswise (with torque).
13. Insert the O-rings.
14. Mount the suction line to the pump by tightening the fixing screws (with torque).
15. Mount the pressure line to the pump by tightening the fixing screws (with torque).

### Trailing operation oil pump (trailing pump)

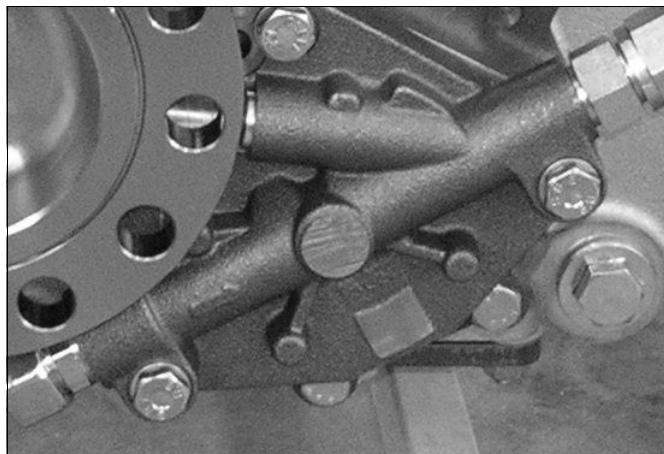
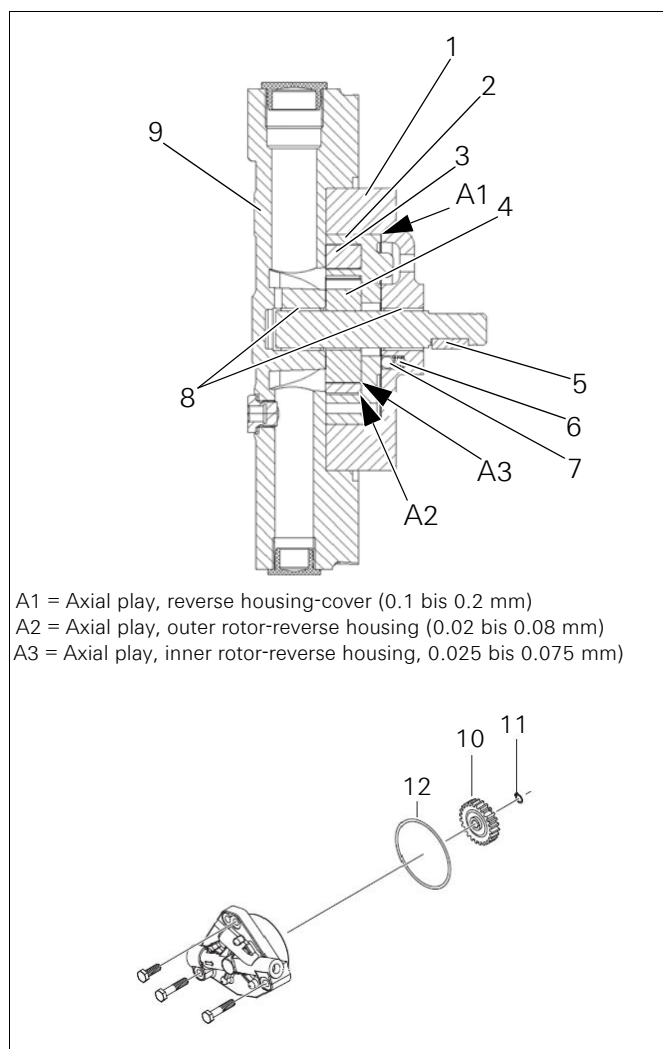


Fig. 88: Trailing oil pump on transmission ZF 2000 (example)



A1 = Axial play, reverse housing-cover (0.1 bis 0.2 mm)  
 A2 = Axial play, outer rotor-reverse housing (0.02 bis 0.08 mm)  
 A3 = Axial play, inner rotor-reverse housing, 0.025 bis 0.075 mm)

Fig. 89: Trailing oil pump design (example)



- |                   |                   |
|-------------------|-------------------|
| 1 Cover           | 7 Steel ball      |
| 2 Reverse housing | 8 Bearing bushing |
| 3 Outer rotor     | 9 Housing         |
| 4 Inner rotor     | 10 Drive pinion   |
| 5 Parallel key    | 11 Locking ring   |
| 6 Pressure spring | 12 O-ring         |

11. Mount the trailing oil pump by tightening the fixing screws (with torque) on the output shaft cover.
12. Mount the suction and pressure line.

### Removing and dismantling the trailing oil pump

1. If required, dismantle the suction and pressure line.
2. Dismantle the trailing oil pump by loosening the fixing screws.
3. Dismantle the trailing oil pump.
4. Remove O-ring (12).
5. Unclip locking ring (11).
6. Pull drive pinion (10) off.
7. Remove parallel key (5).
8. Remove fixing screws on cover (1) and dismantle housing (9).
9. Measure axial play A1, A2 and A3 (see *Fig. 89*).
10. Disassemble pump.

### Cleaning and testing the trailing oil pump

1. Thoroughly clean parts with a lint-free cloth.
2. Check inner (4) and outer rotor (3) for wear.
3. Check reverse housing (2) for wear.
4. Check bearing bushings (8) for wear.
5. Apply thin layer of oil to movable parts.

### Assembling the trailing oil pump

1. Insert three pressure springs (6) in cover (1) and fill them with grease to ensure the three steel balls (7) stay in position.
2. Insert reverse housing (2) in cover (1).
3. Insert inner rotor (4) in cover (1).
4. Insert outer rotor (3) in reverse housing (2).
5. Place housing (9) on cover (1).
6. Mount cover (1) by tightening the fixing screws (with torque).
7. Mount parallel key (5) on the pump shaft.
8. Heat drive pinion (10) to approx. 85 °C and mount it on the pump shaft.
9. Clip locking ring (11) in the ring groove of the pump shaft.
10. Insert O-ring (12).





# MAINTENANCE SYSTEM JOB SHEET

|                                       |                              |   |                                 |
|---------------------------------------|------------------------------|---|---------------------------------|
| <b>Transmission type:</b>             |                              | <b>ZF 2000 series</b>   |                                 |
| <b>Maintenance Job No.</b>            | <b>Maintenance level</b>     | <b>When possible, to be performed in conjunction with Maintenance Job No.</b> | <b>Time required in minutes</b> |
| 166                                   | A4                           | -----   | 120                             |
| <b>Description of maintenance job</b> | 166 Check control unit       |   |                                 |
| <b>Safety measures</b>                | Lock engine starting device. |   |                                 |
| <b>Tools</b>                          | Tool kit W1                  |   |                                 |
| <b>Parts</b>                          | Seal kit                     |   |                                 |
| <b>Material</b>                       | -----                        |   |                                 |
| <b>Test equipment</b>                 | -----                        |   |                                 |
| <b>Procedure</b>                      | See opposite page.           |   |                                 |
| <b>Location:</b>                      |                              | <b>Date:</b>  | <b>Page: 1</b><br><b>of: 2</b>  |



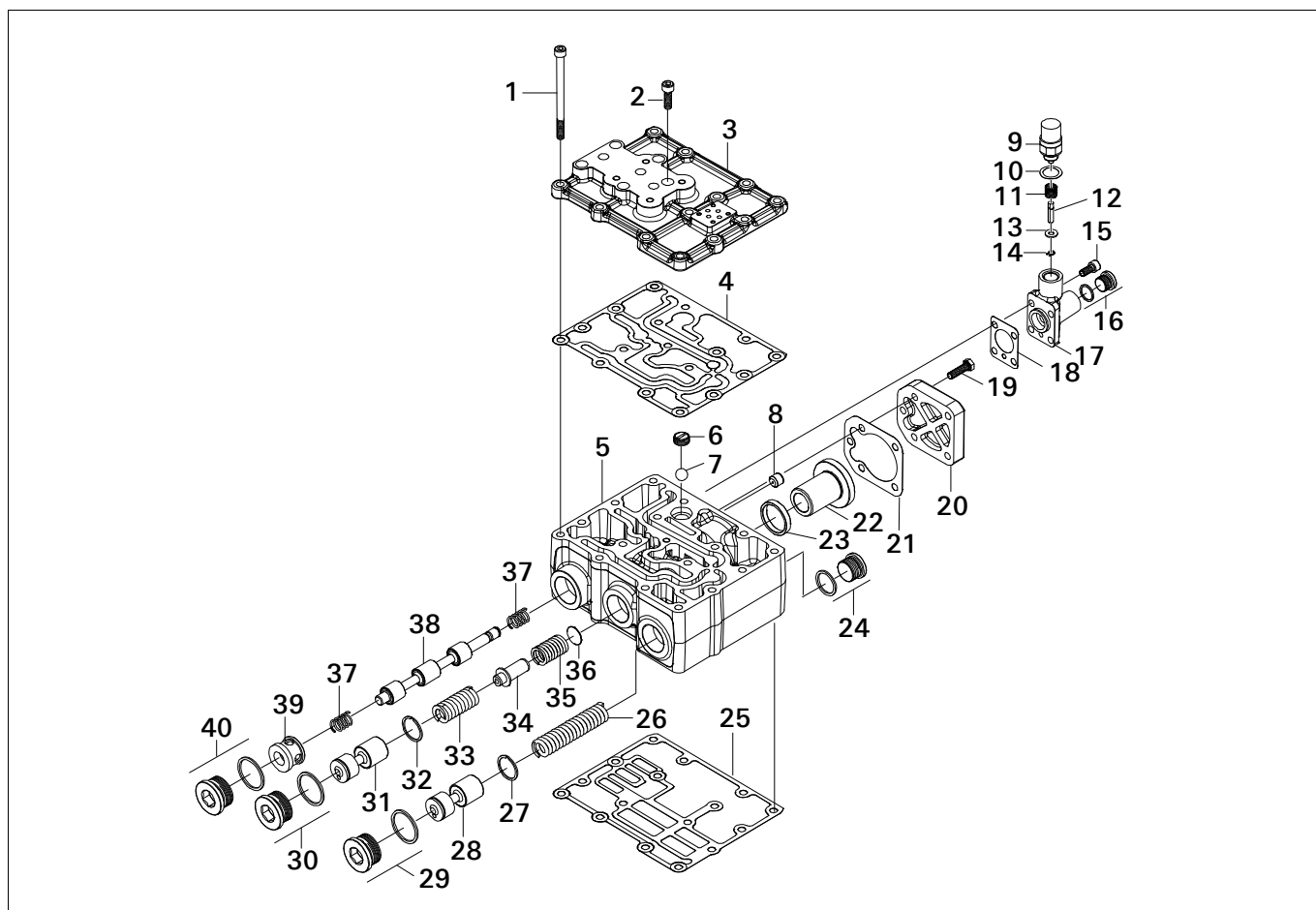


Fig. 90: Control unit ZF 2000 series (example)

- |                    |                    |               |
|--------------------|--------------------|---------------|
| 1 Cylinder screw   | 20 Cover           | 39 Bushing    |
| 2 Cylinder screw   | 21 Seal            | 40 Screw plug |
| 3 Cover            | 22 Piston          |               |
| 4 Seal             | 23 Spacer sleeve   |               |
| 5 Control housing  | 24 Screw plug      |               |
| 6 Slotted plug     | 25 Seal            |               |
| 7 Ball             | 26 Pressure spring |               |
| 8 Gland            | 27 Retaining ring  |               |
| 9 Switch           | 28 Control piston  |               |
| 10 Disc            | 29 Screw plug      |               |
| 11 Pressure spring | 30 Screw plug      |               |
| 12 Stop bolt       | 31 Control piston  |               |
| 13 Disc            | 32 Retaining ring  |               |
| 14 Locking ring    | 33 Pressure spring |               |
| 15 Cylinder screw  | 34 Bushing         |               |
| 16 Screw plug      | 35 Pressure spring |               |
| 17 Cover           | 36 Disc            |               |
| 18 Seal            | 37 Pressure spring |               |
| 19 Hexagon screw   | 38 Control piston  |               |

#### Checking the control unit:

If possible, replace rather than dismantle the complete control unit.



Readjustment of the control unit is not required when dismantling is necessary for cleaning or replacing individual pressure springs. However, a pressure test on the transmission is required.





# MAINTENANCE SYSTEM JOB SHEET

|                                       |  |   |                                 |
|---------------------------------------|--|---|---------------------------------|
| <b>Transmission type:</b>             |  | <b>ZF 2000 series</b>   |                                 |
| <b>Maintenance Job No.</b>            | <b>Maintenance level</b>                             | <b>When possible, to be performed in conjunction with Maintenance Job No.</b> | <b>Time required in minutes</b> |
| 167                                   | A4   | -----   | 180                             |
| <b>Description of maintenance job</b> | 167 Check actuation device (mechanical / electrical) |   |                                 |
| <b>Safety measures</b>                | Lock engine starting device.                         |   |                                 |
| <b>Tools</b>                          | Tool kit W1  |   |                                 |
| <b>Parts</b>                          | Parts kits T1 and T2                                 |   |                                 |
| <b>Material</b>                       | Cleaning agent                                       |   |                                 |
| <b>Test equipment</b>                 | -----  |   |                                 |
| <b>Procedure</b>                      | See opposite page.                                   |   |                                 |
| <b>Location:</b>                      |  | <b>Date:</b>  | <b>Page: 1 of: 2</b>            |



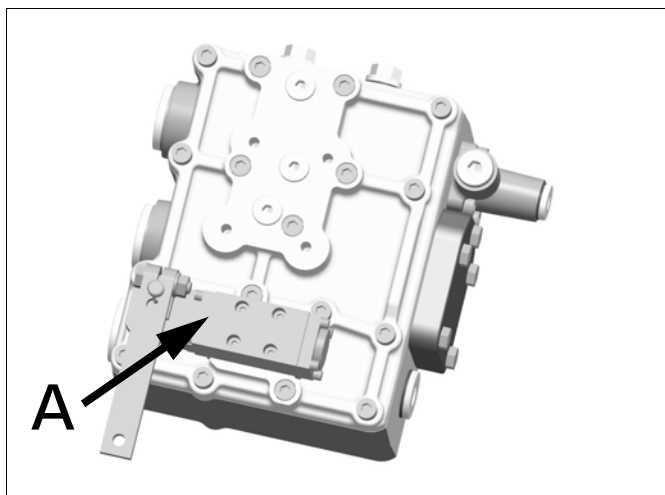


Fig. 91: Mechanical actuation (example)

#### Checking the mechanical actuation device:

##### Removing:

1. Loosen fixing screws and remove mechanical actuation (A).

**i** The mechanical actuation is supplied as a complete unit and cannot be dismantled. Replace the complete unit when the actuation unit is defective.

##### Testing:

1. Make sure mechanical actuation (A) runs freely.

##### Assembling:

1. Mount mechanical actuation (A) on the control unit by tightening the fixing screws (with torque).

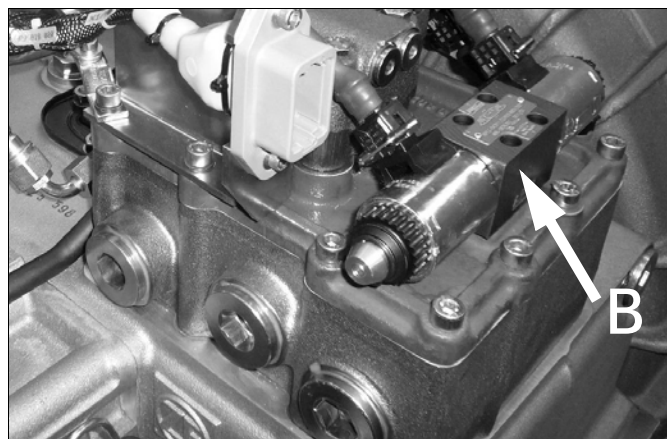


Fig. 92: Electrical actuation (example)

#### Checking the electrical actuation device:

##### Removing:

**i** The electrical actuation is supplied as a complete unit and cannot be dismantled. Replace the complete unit when the actuation unit is defective.

##### Testing:

1. Measure the electrical resistance (26.7 ohm +/- 8% at 20°C).





# MAINTENANCE SYSTEM JOB SHEET

|                                |                                 |  |                          |
|--------------------------------|---------------------------------|--|--------------------------|
| Transmission type:             |                                 | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level               | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 168                            | A4                              | -----  | -----                    |
| Description of maintenance job | 168 Recalibrate display devices |  |                          |
| Safety measures                | -----                           |  |                          |
| Tools                          | On-board tools                  |  |                          |
| Parts                          | -----                           |  |                          |
| Material                       | -----                           |  |                          |
| Test equipment                 | -----                           |  |                          |
| Procedure                      | See opposite page.              |  |                          |
| Location:                      |                                 | Date:  | Page: 1 of: 2            |



Check display devices for oil pressures and oil temperatures for correct display values.

**Option 1:**

Connect calibrated display devices in parallel and compare values displayed. Display errors must not exceed 10% of individual operating ranges.

**Option 2:**

Dismantle display devices and arrange for recalibration and/or use replacement display devices.





# MAINTENANCE SYSTEM JOB SHEET

|                                |   |  |                          |
|--------------------------------|---|--|--------------------------|
| Transmission type:             |   | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level                         | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 169                            | Z2, A3.1, A4                              | -----  | 180                      |
| Description of maintenance job | 169 Inspect visually and clean oil cooler |  |                          |
| Safety measures                | -----                                     |  |                          |
| Tools                          | Tool kit W1                               |  |                          |
| Parts                          | Seal kit                                  |  |                          |
| Material                       | -----                                     |  |                          |
| Test equipment                 | -----                                     |  |                          |
| Procedure                      | See opposite page.                        |  |                          |
| Location:                      |   | Date:  | Page: 1 of: 7            |



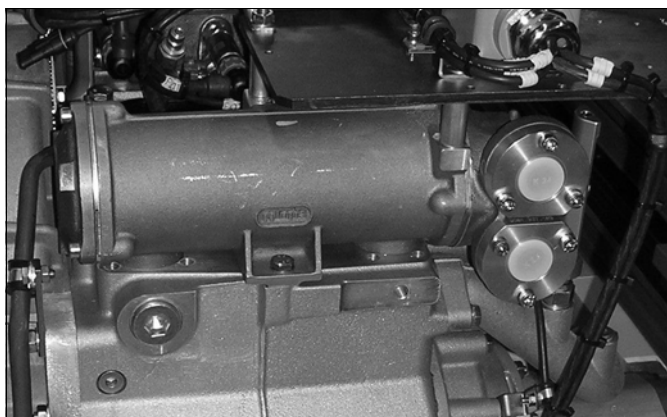


Fig. 93: Transmission oil cooler (example)

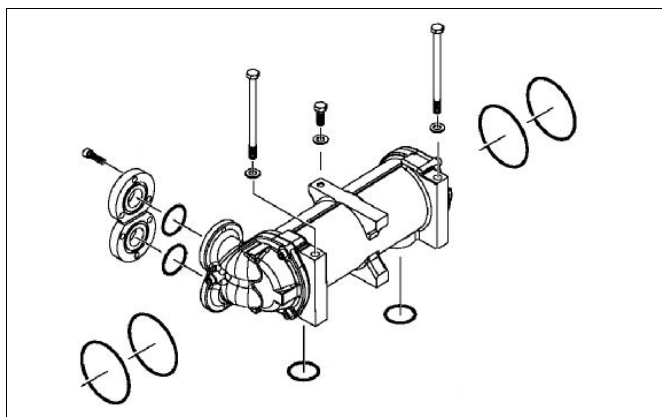


Fig. 94: Transmission oil cooler design (example)

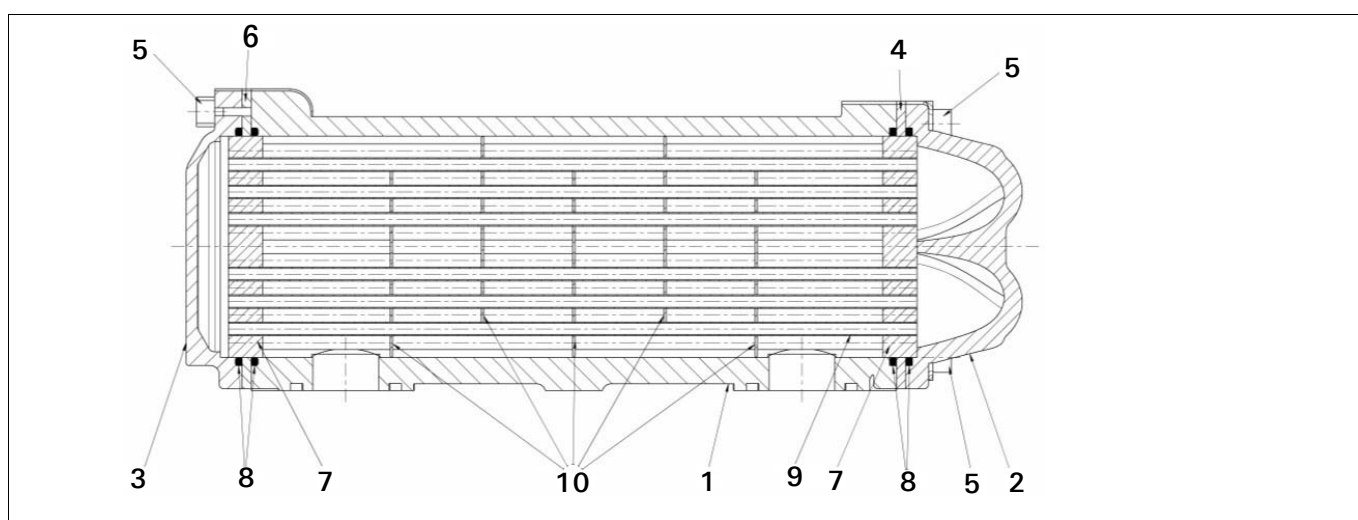


Fig. 95: Schematic design of transmission oil cooler (example)

- |                         |                  |                  |
|-------------------------|------------------|------------------|
| 1 Housing               | 5 Cylinder screw | 9 Pipe           |
| 2 Receiver              | 6 Spacer sheet   | 10 Baffle plates |
| 3 Cover                 | 7 Pipe plate     |                  |
| 4 Pipe bundle, complete | 8 O rings        |                  |



Numbers in brackets refer to *Fig. 95*.



The actual design of the transmission oil cooler may vary in details.

### Pipe bundle

Pipe bundle (4) comprises two identical pipe plates (7) opposite each other and cooling pipes (9). The cooling pipes are rolled into the pipe plates. Five baffle plates (10) are fitted on the cooling pipes on the pipe bundle. These direct the oil flow through the housing. One O-ring (8) each on the cover side and on the receiver side seal the pipe bundle against the housing on the oil side.

Outer O-rings (8) serve for sealing the water side on cover (3) and receiver (2). This prevents the media mixing should the seals leak.

### Housing

Housing (1) serves for fitting the pipe bundle and constitutes the outer pressure chamber for the oil. It is a standardised cast housing made of an aluminium alloy.

### Receiver

Receiver (2) is fitted on the water connection side of the cooler. The receiver is made of bronze cast iron. The receiver is fastened on housing (1) with three screws (5). Pipe bundle (4) is fixed between the receiver and housing over the sheet connected to the pipe plate.



### Cover

Baffle cover (3) is fitted on the other side. This cover is also made of bronze cast iron. The cover is fastened on housing (1) with three screws (5). Spacer sheet (6) is fitted between the cover and housing. The spacer sheet serves for fixing O-rings (8).

### Seals

The water side connecting flanges are sealed with gaskets. The pipe plates are sealed with four identical O-rings (8). The oil connections of the transmission oil cooler flanged directly onto the housing are sealed with O-rings laid in the grooves. The pipe connecting threads of an external transmission oil cooler are sealed using a copper ring.

**i** O-rings are available from ZF Friedrichshafen AG Customer Service by specifying the Part No. Exchange the O-rings removed during every maintenance.

### Disassembling the transmission oil cooler (without extracting the pipe bundle)

1. Clearly mark the positions of the bolted flanges to each other.
2. Close off all pipe lines.
3. Drain the transmission oil cooler on the water side.
4. Remove the pipe lines on the water side.
5. Wait for at least 30 minutes after stopping the plant for the oil pressure to sink.
6. Remove the fixing screws on the transmission oil cooler and take the transmission oil cooler off.

**i** Steps 5 to 6 are only required for transmissions on which cover (3) cannot be removed for reasons of space.

7. Remove receiver (2) and cover (3) by loosening the screws on the receiver/cover-housing connection.
8. Remove the O-rings on both sides of the pipe bundle.



Fig. 96: Removing the O-rings (example)

9. Secure the pipe bundle against housing (1) with one screw and the appropriate number of washers.



Fig. 97: Pipe bundle secured with one screw (example)



**i** The water side can now be inspected and mechanically cleaned.

### Cleaning process on the water side

Clean the water side of the transmission oil cooler at least once per year. Avoid excessive contamination of the pipes.

**i** Reduce time intervals for maintenance for long-term operation of the ship in harbours and other soiled waters, and according to the operator's experience.

The water side can be cleaned mechanically for just slight contamination:

1. Disassemble the transmission oil cooler as described in Section *Disassembling the transmission oil cooler (without extracting the pipe bundle)*.
2. Use a nylon brush to clean the inside of every pipe in the pipe bundle (see Section 8.5 *Tool kit*).



Fig. 98: Cleaning pipes with a nylon brush (example)

**i** Do not use metal brushes for cleaning pipes.

**i** Do not use tools to remove firmly adhering deposits. Clean the pipe bundle chemically in such cases. This can be done in assembled condition by spraying the chemical cleaning solution into the pipes. Ensure the chemical solution does not affect the condition of the O-rings. Chemical cleaning should only be carried out by qualified personnel.

**i** Suppliers of suitable cleaning agents are, for example, Ashland Chemicals ([www.ash-chem.com](http://www.ash-chem.com)), Henkel Oberflächentechnik ([www.henkel.com](http://www.henkel.com)) and Ondeo Nalco ([www.nalco.com](http://www.nalco.com)). Suppliers of complete cleaning services are, for example, Vecom ([www.vecom.nl](http://www.vecom.nl)) and Ondeo Nalco ([www.nalco.com](http://www.nalco.com)).

### Disassembling the transmission oil cooler (with extraction of the pipe bundle)

1. Clearly mark the positions of the bolted flanges to each other.
2. Close off all pipe lines.
3. Drain the transmission oil cooler on the water side.
4. Remove the pipe lines on the water side.
5. Wait for at least 30 minutes after stopping the plant for the oil pressure to sink.
6. Remove the fixing screws on the transmission oil cooler and take the transmission oil cooler off.
7. Remove receiver (2) and cover (3) by loosening the screws on the receiver/cover-housing connection.
8. Remove the O-rings on both sides of the pipe bundle.



Fig. 99: Removing the O-rings (example)

9. Remove spacer sheet (6) on the side opposite the water side.



Fig. 100: Removing the spacer sheet (example)

10. Push the pipe bundle far enough through to the water side (use an auxiliary tool when necessary) until the O-ring on the opposite side is free.



11. Remove the O-ring.



Fig. 101: Removing the O-ring on the side opposite the water side (example)

12. Pull the pipe bundle out towards the water side. In doing this, remove the pipe bundle very carefully from the housing to avoid damaging the baffle plates.



Fig. 102: Removing the pipe bundle (example)

13. Remove the O-ring on the water side of the pipe bundle by pushing it over the pipe bundle.



Fig. 103: Removing the O-ring on the water side (example)

### Assembling the transmission oil cooler (without extracting the pipe bundle)

Assemble the transmission oil cooler in reverse disassembly sequence.

1. Remove the locking screw with the washers from the pipe bundle.
2. Grease the outer O-rings with a suitable grease and fit these on the pipe bundle.



Fig. 104: Fitting the outer O-ring (example)

3. Place receiver (2) and cover (3) parallel on both sides of the transmission oil cooler and slide them evenly onto the outer O-ring.



Make sure O-rings do not shear off when sliding receiver (2) and cover (3) on.



4. Tighten receiver (2) and cover (3) each with three screws with the tightening torque (see *Table 16*).

| Transmission type | Screw / Strength | Tightening torque |
|-------------------|------------------|-------------------|
| ZF 2000 series    | M8 / 8.8         | 23 Nm             |

Tab. 16: Tightening torques

5. If the transmission oil cooler has been removed from the transmission housing, position and screw the transmission oil cooler tight on the transmission housing with the fixing screws.
6. Fit the pipe connections on receiver (2) with new seals.
7. Connect the pipe lines on the water side.
8. Open and refill all pipe lines.
9. Bleed the transmission oil cooler on the water side.

#### Assembling the transmission oil cooler (after extracting the pipe bundle)

Assemble the transmission oil cooler in reverse disassembly sequence.

1. Grease the O-ring on the water side of the pipe bundle.
2. Push the O-ring carefully over the pipe bundle on the water side to the stop.



Fig. 105: Fitting the O-ring on the water side (example)

**i** Make sure the O-ring does not shear off during fitting.

3. Insert the pipe bundle into housing (1).



Fig. 106: Fitting the pipe bundle (example)

4. Grease the O-ring for the side of the pipe bundle opposite the water side and then insert it in the side opposite the water side.



Fig. 107: Fitting the O-ring on the side opposite the water side (example)

**i** Make sure the O-ring does not shear off during fitting.

5. Fit spacer sheet (6) on the side opposite the water side.





Fig. 108: Fitting the spacer sheet (example)

6. Grease the outer O-rings with a suitable grease and fit these on the pipe bundle.



Fig. 109: Fitting the outer O-ring (example)

7. Place receiver (2) and cover (3) parallel on both sides of the transmission oil cooler and slide them evenly onto the outer O-ring.



Make sure O-rings do not shear off when sliding receiver (2) and cover (3) on.

8. Tighten receiver (2) and cover (3) each with three screws with the tightening torque (see *Table 17*).

| Transmission type | Screw / Strength | Tightening torque |
|-------------------|------------------|-------------------|
| ZF 2000 series    | M8 / 8.8         | 23 Nm             |

Tab. 17: Tightening torques

9. Position the transmission oil cooler onto the transmission housing and screw it tight to the housing with the fixing screws.
10. Fit the pipe connections on receiver (2) with new seals.
11. Connect the pipe lines on the water side.

12. Open and refill all pipe lines.

13. Bleed the transmission oil cooler on the water side.

### Testing

Check the oil side and the water side after assembly. At the same time, ensure the pressure (oil side and water side) does not exceed the value shown in the transmission installation drawing and on the type plate.










# MAINTENANCE SYSTEM JOB SHEET

|                                |                                     |  |                          |
|--------------------------------|-------------------------------------|--|--------------------------|
| Transmission type:             |                                     | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level                   | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 173                            | A4                                  | 121  | 15                       |
| Description of maintenance job | 173 Check shaft seal of input shaft |  |                          |
| Safety measures                | -----                               |  |                          |
| Tools                          | -----                               |  |                          |
| Parts                          | -----                               |  |                          |
| Material                       | -----                               |  |                          |
| Test equipment                 | -----                               |  |                          |
| Procedure                      | See opposite page.                  |  |                          |
| Location:                      |                                     | Date:  | Page: 1 of: 2            |



**Whenever possible, combine this work with Maintenance Job 121!**

1. Check shaft seal of input shaft for leaks (collect escaping oil when necessary).

 Replace the input shaft seal as soon as possible when damage is visible.

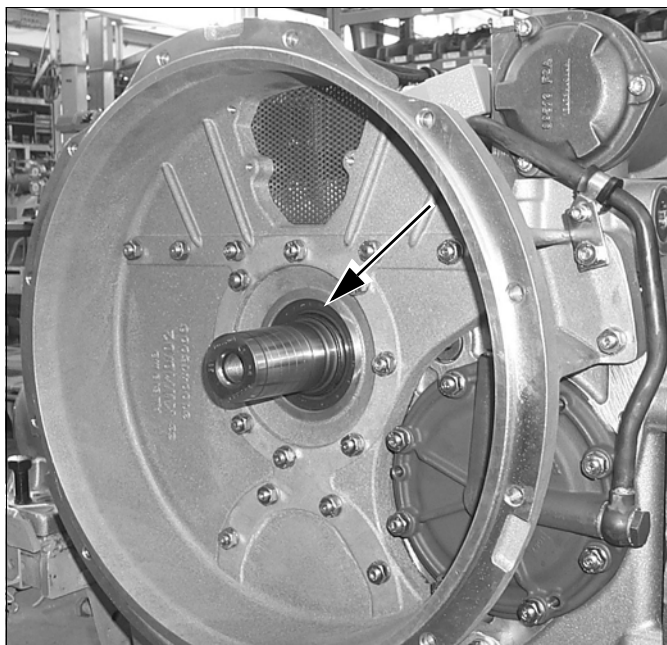


Fig. 110: Input shaft seal ZF 2150 (example)



Fig. 111: Input shaft seal ZF 2150 V (example)






# MAINTENANCE SYSTEM JOB SHEET

|                                |                                      |  |                          |
|--------------------------------|--------------------------------------|--|--------------------------|
| Transmission type:             |                                      | ZF 2000 series   |                          |
| Maintenance Job No.            | Maintenance level                    | When possible, to be performed in conjunction with Maintenance Job No. | Time required in minutes |
| 174                            | A4                                   | 121  | 15                       |
| Description of maintenance job | 174 Check shaft seal of output shaft |  |                          |
| Safety measures                | -----                                |  |                          |
| Tools                          | -----                                |  |                          |
| Parts                          | -----                                |  |                          |
| Material                       | -----                                |  |                          |
| Test equipment                 | -----                                |  |                          |
| Procedure                      | See opposite page.                   |  |                          |
| Location:                      |                                      | Date:  | Page: 1 of: 2            |



**Whenever possible, combine this work with Maintenance Job 121!**

1. Check shaft seal of output shaft for leaks (collect escaping oil when necessary).

 Replace the output shaft seal as soon as possible when damage is visible.

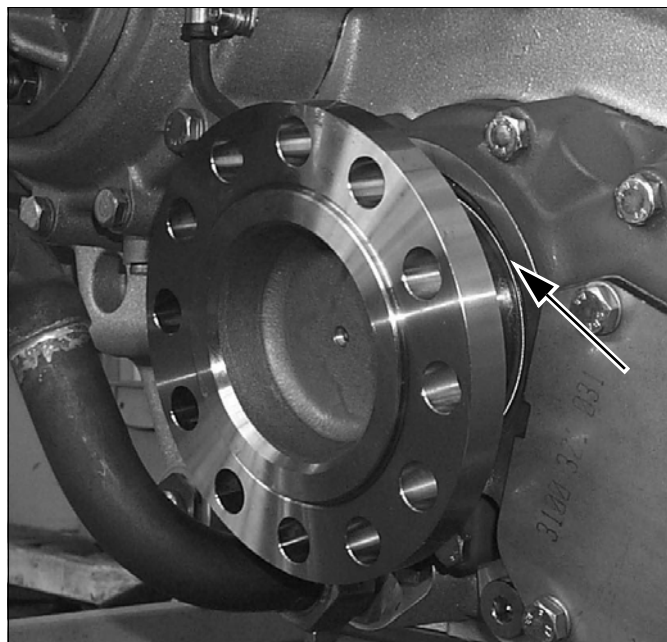


Fig. 112: Output shaft seal ZF 2150 (example)







## 9 Annex

### 9.1 Guidelines for marine transmissions concerning corrosion protection, packing types, storage conditions and storage periods

| Level | Storage period  | Corrosion protection at the factory  | Packing type  | Storage conditions  |
|-------|---|--|---|---|
| I     | Max. 12 months before first operation   | <b>Internal conservation:</b><br>Anti-corrosive oil according to MIL-L-21260 or TL 9150-0037, C-640<br><b>External conservation:</b> <ul style="list-style-type: none"> <li>■ Uncoated parts with corrosion preventative according to MIL-C-16173D Type 4, K 19, or TL 8030-015, Type 4.</li> <li>■ Housing               <ul style="list-style-type: none"> <li>a) Finished by ZF using water-based varnish, standard shade RAL 7001, other shades according to parts list.</li> <li>b) Wash priming by ZF, customer must apply water-based varnish as soon as packing materials have been removed. Repack as described in Level II for interim storage longer than 12 months.</li> </ul> </li> </ul> | Transmission covered with a polythene sack in a wet-strength, glued plywood case.   | Remove packing materials immediately after receipt and check the external conservation. If the protective film is damaged, touch up or completely recoat with a suitable corrosion preventative. Store in enclosed area at a steady temperature and low relative humidity. Protect from dirt and damp between installation and first operation. |
| II    | Max. 36 months before installation + max. 12 months between installation and first operation      | <b>Internal conservation:</b><br>Anti-corrosive oil according to MIL-L-21260 or TL 9150-0037, C-640<br><b>External conservation:</b> <ul style="list-style-type: none"> <li>■ Uncoated parts with corrosion preventative to MIL-C-16173D type 4, K 19, or TL 8030-015, type 4.</li> <li>■ Finished on housing using water-based varnish, standard shade RAL 7001, other shades according to parts list.</li> </ul> All transmission openings are securely sealed.  | Packed in drying agent in accordance with TL 8100-001, packing grade A by a commissioned specialist. Amount of drying agent according to DIN 55474 resp. TL 8100-004. Packing contains a humidity gauge which can be read from outside. | Do not open the packing on receipt! Check for damage. Check reading on humidity gauge. Store in enclosed area at a steady temperature and low relative humidity. Protect from dirt and damp between installation and first operation.   |
| III   | More than 36 months before installation + max. 12 months between installation and first operation | As II  | As II   | As II<br><br>In addition, after 36 months of storage, read the humidity gauge every 4 months to check the humidity inside the packing. If humidity is too high, call in a commissioned specialist to replace the drying agent and the barrier foil and to check the external conservation.  |



Guidelines in "Chapter Maintenance", "Section Corrosion protection and conservation" in the Operating Instructions of the corresponding transmission series apply to the period between first operation and entry into regular operation and to shutdown periods.



## 9.2 Guideline for conserving marine transmissions during storage at ZF branches and intermediaries.



Conservation measures described below must be carried out by ZF-authorized personnel. Otherwise, warranty claims shall be deemed null and void.

Series transmissions supplied by ZF have corrosion protection according to Level I of "*Guidelines for marine transmissions about anticorrosion protection, packing type, storage conditions and storage periods*".

Storage conditions stipulated in these guidelines apply: Store in enclosed area at a steady temperature and low relative humidity.

Renew conservation after 12 months at the latest. Transmissions may then be stored for a further 12 months. Renew conservation every 6 months when transmissions need to be stored for a further period.

### 9.2.1 Conservation procedure

1. Fill transmission with anti-corrosive oil up to the upper measuring mark of the oil dipstick. Use anti-corrosive oil C 642 or C 644 according to MIL- L-21260.
2. Remove inspection cover.
3. Spray internal transmission components with anti-corrosive oil while rotating the input and output shafts.
4. Close inspection cover.
5. Repeat conservation on uncoated outer steel parts.

#### 9.2.1.1 Renewing conservation

Remove the inspection cover, inspect internal transmission components and spray with anti-corrosive oil while rotating the input and output shafts. Renew conservation on uncoated outer steel parts.

#### 9.2.1.2 Measures to be taken before delivering stored transmissions

Renew conservation and drain anti-corrosive oil before delivering the stored transmission. Inform the customer that marine transmissions purchased through ZF agencies provide corrosion protection for a maximum of 12 months.

## 9.3 Corrosion protection and conservation for ZF transmissions installed in a ship

Corrosion protection measures required for a transmission installed in a ship for longer shutdown periods strongly depend on temperature variations, air humidity, and salt content of the air in the engine room. Therefore, the recommended measures and time indications may only be regarded as rough guidelines. In case of doubt, we recommend performing the corrosion protection measures for the transmission analog to those for the engine.

Shutdown periods up to 3 months do not normally require corrosion protection measures.

If the transmission shutdown period is going to be longer than 3 months, perform conservation when possible immediately after the ship is taken out of operation, but within 3 months at the latest, alternatively K1 or K2 conservation is required depending on individual requirements. Flush and clean the cooler with fresh water during the initial corrosion protection measures on the transmission. Do not seal the drainage opening. If draining is not possible, flush with fresh water and fill with 20% antifreeze solution.

### K1 Conservation

- Storage time: 12 months.
- Then renew conservation every 6 months.

### K2 long-term conservation

- Storage time: 36 months.
- Repeat every 36 months.



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### 9.3.1 K1 Conservation

1. At the end of operation, drain transmission oil and fill with anti-corrosive oil to at least the upper measuring mark on the oil dipstick. Refer to Maintenance Jobs for implementation. Use anti-corrosive oil C 642 or C 644 according to MIL- L-21260.
2. Immediately afterwards, run the engine in "Engine wise rotation" or "Counter-engine wise rotation" shift position at increased engine idle speed (max. 50% of nominal operating speed) for approx. 5 to 10 minutes. Then switch the engine off.
3. Spray or brush uncoated outer steel parts with corrosion preventative.
4. Grease protruding shaft sections.

#### 9.3.1.1 Renewing conservation

Remove the inspection cover and inspect internal transmission components. While rotating the input and output shafts (if possible), spray internal transmission components with corrosion preventative. Renew conservation on uncoated outer steel parts.

#### 9.3.1.2 Commissioning after K1 conservation

1. Start the engine and run for approx. 5 minutes to mix any condensed water possibly accumulated in the transmission with the corrosion preventative.
2. Drain corrosion preventative and fill transmission with the specified oil type (see "Maintenance Job 141").

### 9.3.2 K2 Long-term conservation

1. As soon as possible after operation, but at the latest after 3 months, drain transmission oil and fill with anti-corrosive oil to the lower measuring mark of the oil dipstick (see Maintenance Jobs for implementation). Use anti-corrosive oil C 642 or C 644 according to MIL-L-21260.
2. Immediately afterwards, run the engine in "Engine wise rotation" or "Counter-engine wise rotation" shift position at increased engine idle speed (max. 50% of nominal operating speed) for approx. 5 to 10 minutes. Then switch the engine off.
3. Then fill the transmission completely with anti-corrosive oil.
4. Spray or brush uncoated outer steel parts with corrosion preventative.
5. Grease protruding shaft sections.

#### 9.3.2.1 Commissioning after K2 long-term conservation

1. Drain anti-corrosive oil to normal oil level.
2. Then run the engine for approx. 5 minutes.
3. Then drain anti-corrosive oil completely and fill transmission with the specified oil type (see "Maintenance Job 141").











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