

Operating Instructions

ZF 400 Family



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This document is a translation of the Italian original.

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1 Introduction

This document is to be intended only as a support material for the design and analysis of the Vessel Designer and Shipyard in their role of unique Responsible of the final performance analysis, design, selection and decisions. ZF Padova S.r.l. accept no liability for lack of performance for any expressed or unexpressed result. In no way, this document is to be intended as a performance and/or commercial promise. ZF Padova S.r.l. keeps the right to modify procedures, shapes, equipment, optionals, material, etc. mentioned or shown in the attached figures. Also, some mentioned equipment might be optional. The actual scope of supply will be limited to that mentioned in the offers issued by ZF Sales Dept

Notice

Read this handbook before proceeding with the installation. The following symbols are used to highlight important information on technical reliability and safety:

DANGER

This symbol denotes a procedure that could result in physical injury to the operator or to other persons in the vicinity if not followed correctly.

CAUTION

This symbol denotes a procedure that could damage the gearbox or associated equipment if not followed correctly.

NOTE:

When this symbol is displayed, the text alongside contains important information.

1.1 Conversion table

S.I. International System (of Units)			Others	
1	(mm)	=	0.03937	(in)
10	(mm)	=	0.3937	(in)
25.4	(mm)	=	1	(in)
64.516	(cm ²)	=	1	(sq. in)
1	(m ²)	=	1550	(sq. in)
16.387	(cm ³)	=	1	(cu. in)
0.473	(dm ³)	=	1	(U.S. pint)
1	(l)	=	61.02	(cu. in)
1	(l)	=	0.2642	(U.S. gal)
1.772	(g)	=	1	(oz)
0.4536	(kg)	=	1	(lb)
0.00070308	(kg/mm ²)	=	1	(lb/sq. in)
1	(bar)	=	14.51	(psi)
1	(kg·m)	=	7.246	(lb·ft)
30.48	(cm)	=	1	(feet)

1.2 Conventions for safety information in text

The following conventions apply for the safety information in these Operating Instructions:

DANGER

Describes a dangerous situation that can lead to serious injuries or death when not avoided.

WARNING

Describes a dangerous situation that can lead to serious injuries or death when not avoided.

CAUTION

Describes a dangerous situation that can lead to minor or moderate injuries when not avoided.

NOTICE

Describe a situation which can lead material damage when not avoided.

NOTE:

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.

- Ensure you read and understand all warnings prior to commissioning or repairing the product!
- Pass on all safety information to personnel involved in operating, maintenance, repair and transport!

1.3 Responsibilities

The customer/operator is responsible for the maintenance checks described in this manual to ensure the proper operation of the reverse transmission in fully safe conditions.

1.3.1 Manufacturer's address and contact info

All gearboxes supplied by ZF Padova S.r.l. are accompanied by the relative operating manual.

Further copies of this manual or of other technical documentation can be obtained from:

ZF Padova S.r.l.

Via Penghe 48,

35010 Caselle di Selvazzano (PD), Italy

Tel. +39 049 8299485

Fax +39 049 8299560

1.4 Reverse transmission identification

The identification plate is affixed to the reverse transmission. Before proceeding with the installation, we recommend reading the instruction manual.

For important information regarding technical reliability and safety, the following conventions have been adopted:

NOTE:

The notes contain important information, to which the user must pay careful attention.

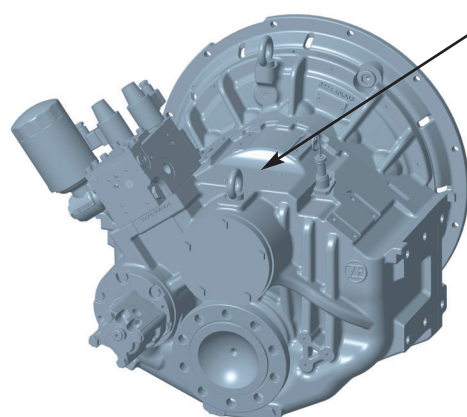


Fig. 1

		
TYPE		
SERIAL No		RATIO
PART LIST No	CUSTOMER No	MASS DRY (Kg)
Pleasure Light Medium Continuous		
OIL TYPE	OIL CAPACITY (dm ³)	CLUTCH OIL PRESSURE(bar)
OIL CHANGE: after first 50 hours of operation and every 1000 hours or 12 months, whichever occurs first.		
CHECK OIL LEVEL WEEKLY		

1.5 Operating principles

The main functions of a marine reverse transmission include:

- coupling the engine with the propeller axle and reducing the propeller speed;
- inverting the direction of motion;
- interrupting the movement of the propeller shaft (idling mode).

Below is a simplified diagram of the hydraulics.

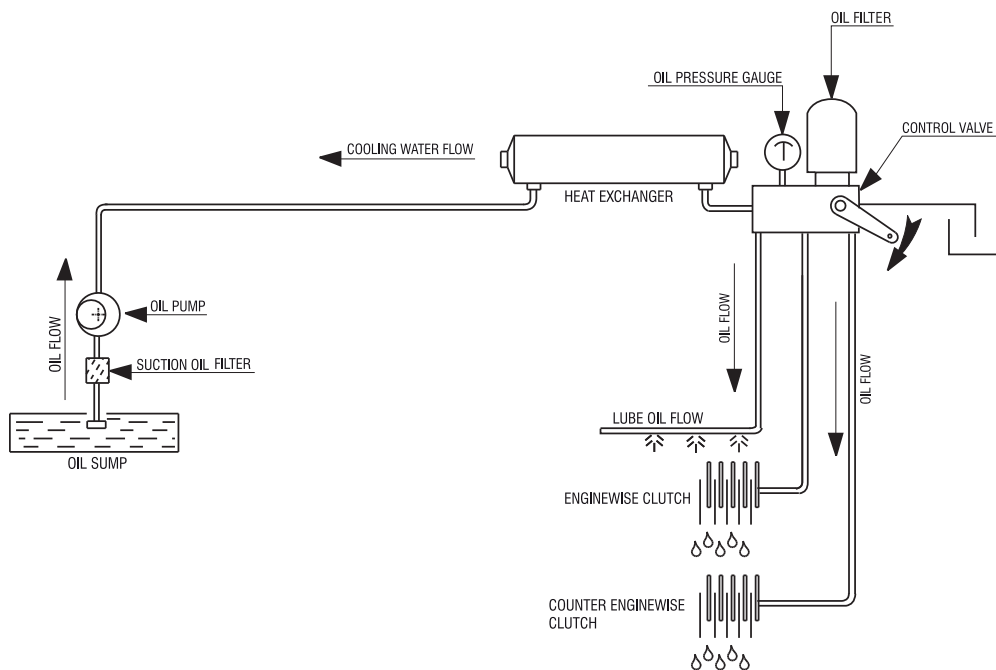


Fig. 2

The marine gearbox allows for obtaining the following three types of operation:

Neutral

The output shaft (2) connected to the propeller axle does not transmit any rotation.

The clutches are disengaged.

Engine rotation

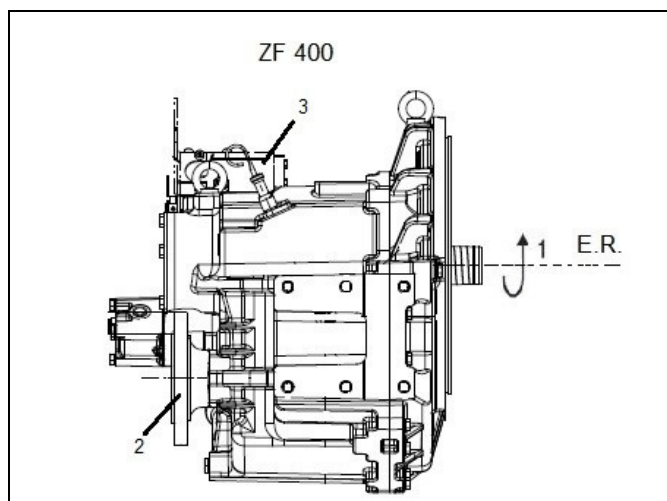
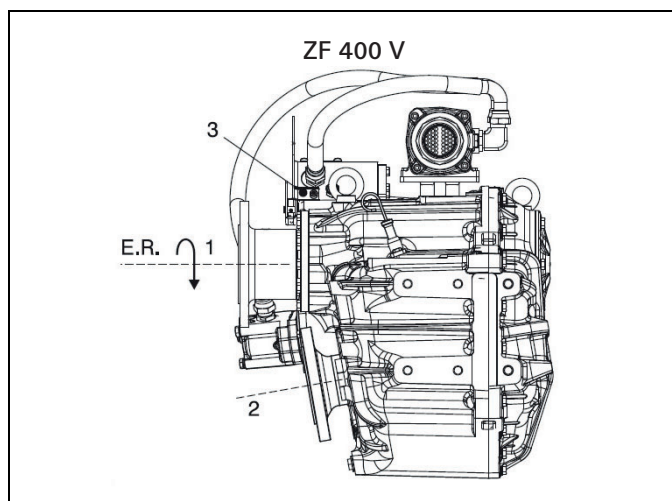
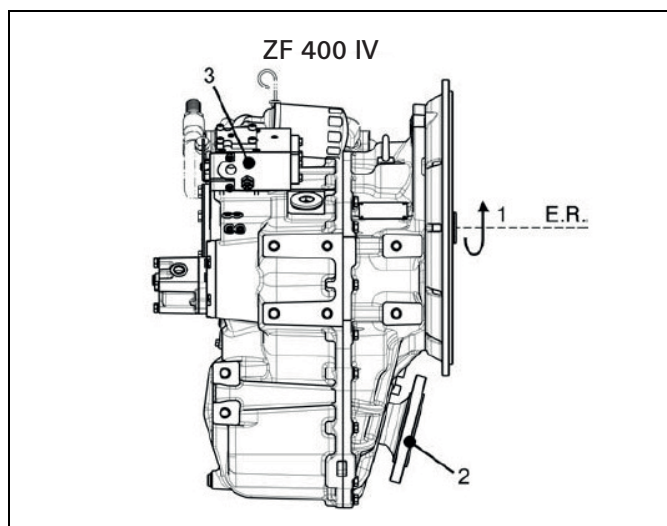
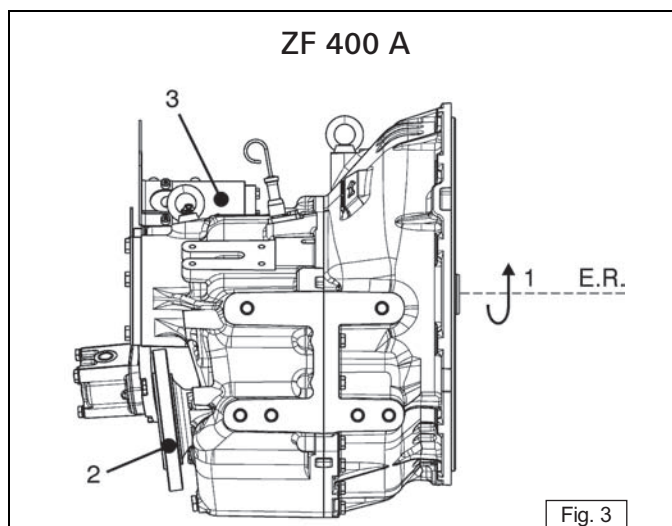
The output shaft (2) connected to the propeller axle rotates in the same direction as the input shaft (1).

Counter engine rotation

The output shaft (2) connected to the propeller axle rotates in the opposite direction to the input shaft (1).

The concordant and/or discordant motion transmission occurs with the transmission ratio indicated on the identification plate.

The three operating modes are controlled by the oil control block (3) (mechanical or electrical).

**E.R.**

The rotation direction matches the engine rotation.

C.E.R.

The rotation direction is contrary to the engine rotation.

The reverse transmission can be supplied with or without accessories (heat exchanger, flexible coupling, brackets, trolling valve).

The reverse transmission is supplied without oil.

⚠ CAUTION

Before putting the reverse transmission into operation, the oil must be topped up and its level checked. (Refer to section "Maintenance" (p. 21)).

Using the reverse transmission with too little oil can damage the gears.

Too much oil can cause the seals and bleed to leak and can considerably increase the operating temperature.

In normal operating conditions, the direction reversals must be made with the engine at minimum power.

In case of emergency, the direction of motion can be reversed with the engine at full speed.

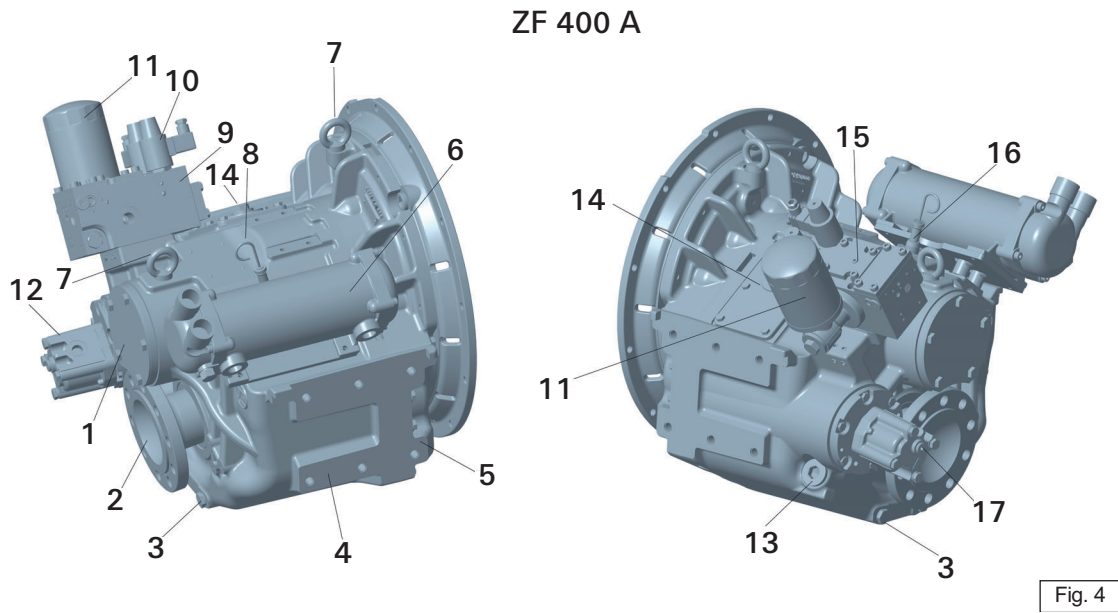
Motion reversals with the engine at full speed significantly reduce the working life of the clutches.

⚠ DANGER

Intervene on the reverse transmission only when both the engine and the propeller are stationary.

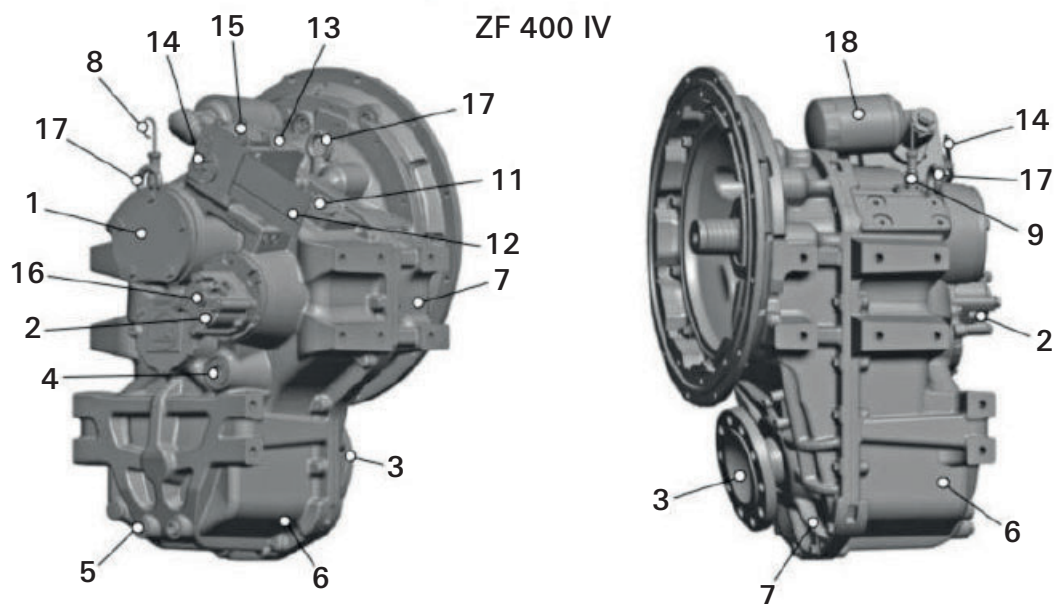
1.6 Main subgroups

1.6.1 ZF 400 A



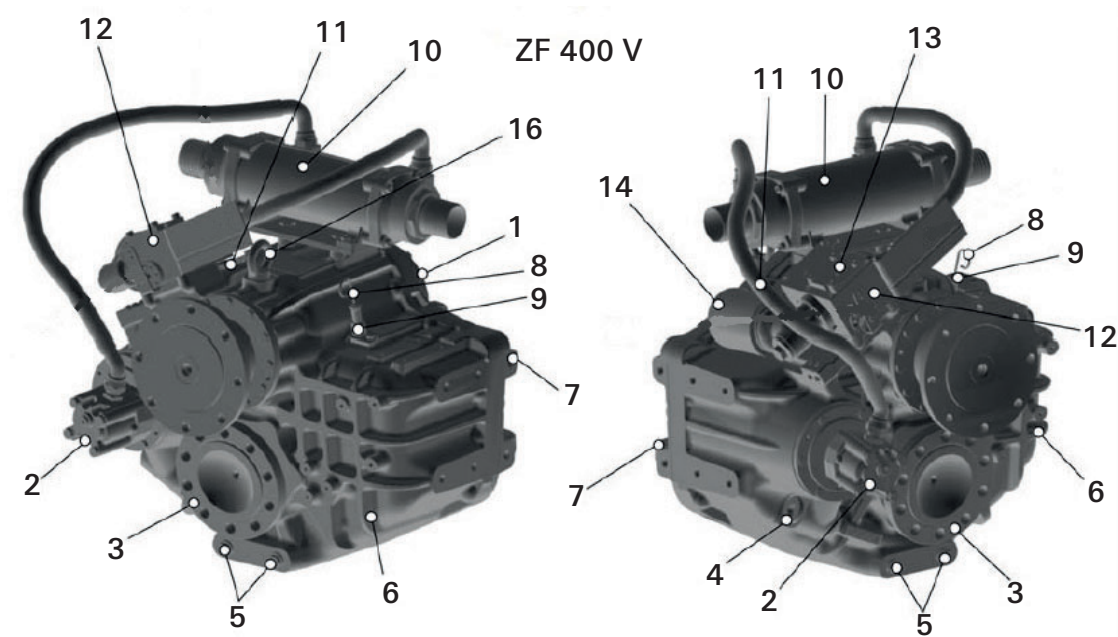
POS.	DESCRIPTION
1	PTO cover
2	Output shaft
3	Drain plugs
4	Rear half-carcase
5	Front half-carcase
6	Heat exchanger
7	Lifting eyebolt
8	Level rod
9	Oil control block
10	Solenoid valve
11	Oil filter
12	Oil pump
13	Mesh filter
14	Load plug
15	Pressure socket
16	Bleed
17	M14x1.5 plug

1.6.2 ZF 400 IV



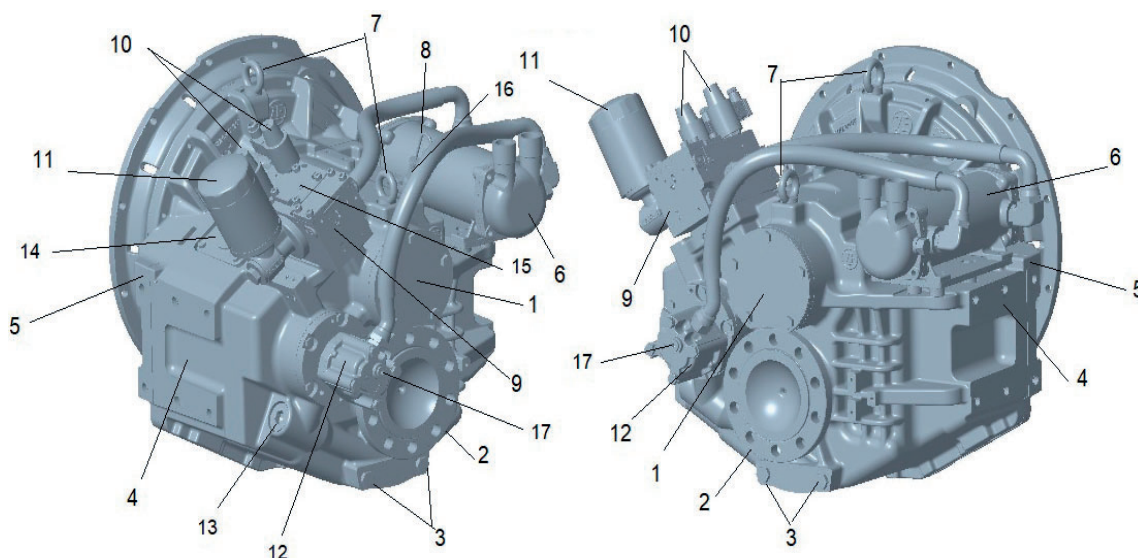
POS.	DESCRIPTION
1	PTO cover
2	Oil pump
3	Output shaft
4	Strainer / Screen filter
5	Drain plugs
6	Rear half housing
7	Front half housing
8	Oil dipstick
9	Breather
10	Oil cooler
11	Filler plug
12	Shift control linkage bracket
13	Control valve
14	Control valve lever
15	1/8 NPTF pressure connector
16	M14x1.5 plug
17	Lifting eyebolt
18	Oil filter

1.6.3 ZF 400 V



POS.	DESCRIPTION
1	PTO cover
2	Oil pump
3	Output shaft
4	Strainer / Screen filter
5	Drain plugs
6	Rear half housing
7	Front half housing
8	Oil dipstick
9	Breather
10	Oil cooler
11	Filler plug
12	Control valve
13	1/8 NPTF pressure connector
14	Oil filter

1.6.4 ZF 400



POS.	DESCRIPTION
1	PTO cover
2	Output shaft
3	Drain plugs
4	Rear half-carcase
5	Front half-carcase
6	Heat exchanger
7	Lifting eyebolt
8	Level rod
9	Oil control block
10	Solenoid valve
11	Oil filter
12	Oil pump
13	Mesh filter
14	Load plug
15	Pressure socket
16	Bleed
17	M14x1.5 plug

Introduction

1.6.5 Mechanical trolling valve (MTV)

The trolling valve is a device that allows for varying the speed of the propeller, regardless of the engine's rotation speeds. The MTV is commonly applied in the following cases:

1. the watercraft's speed is too high even though the engine is at minimum power.
2. the rotation speed of the PTO must exceed the propeller's rotation speed.

CAUTION

The MTV can be used in both directions of motion and the maximum usage speeds are:

- Maximum rotation speed = (max engine revolutions x 0.5) rpm, for engines with maximum rotation speed below 2000 rpm.
- Maximum rotation speed = (1000) rpm, for engines with maximum rotation speed above 2000 rpm.

Depending on the reverse transmission's reduction ratio, the propeller's dimensions and the features of the watercraft, the actual rotation speed of the propeller can be reduced by a percentage varying between 30% and 70% of the useful speed.

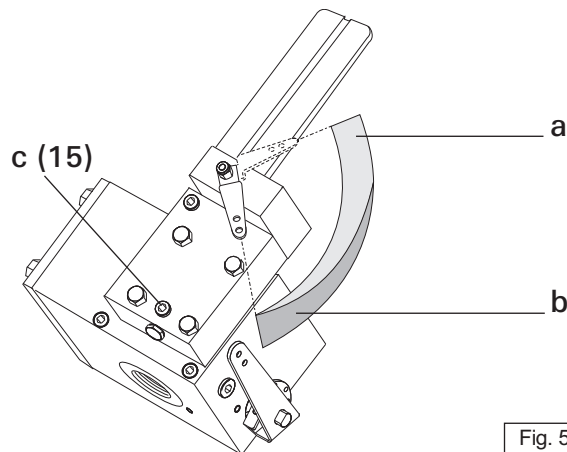
Recommended range of use: 60-80°C.

NOTE:

Mode of use

Verify that the MTV is excluded before engaging the gear. After engaging the gear, gradually move the MTV lever until reaching the desired maneuver speed.

The number of revolutions can be varied during operation in trolling mode within the limits mentioned above.



- a. Clutch slipping
- b. Clutch pressure
- c. pressure gage fitting (15)

1.6.6 Electrical trolling valve (ETV)

An electrical device with the same functions and mode of use as the MTV.

The ETV is activated by means of a proportional solenoid valve.

1.6.7 Remote controls for oil control block

CAUTION

When installing remote controls, make sure that the stroke of the lever, activated from the control on the bridge, is suitable for reaching the limit switches.

If this condition is not met, the clutches may burn due to insufficient oil flow.

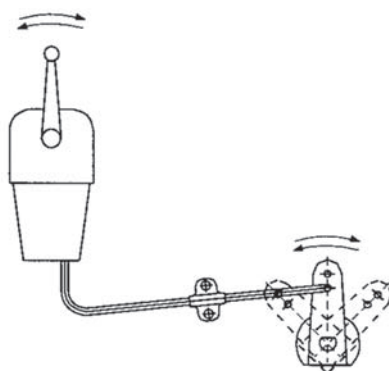


Fig. 6

1.6.8 Tugging

Tugging can be performed continuously for 8 hours. Check that the oil temperature does not exceed 80°C. When the engine is off, the position of the operating lever is irrelevant.

DANGER

Do not perform any work on the transmission during tugging, as the propeller may rotate.

2 Technical data

TYPE	*OIL QUANTITY (DM ³)	PUMP FLOW RATE (L/ MIN AT 1000 RPM)	**OPERATING PRES-SURE (BAR)	TEMPERATURE (°C)
ZF 400 A	8,5 ÷ 9,5	19	23 ÷ 24	40 ÷ 80
ZF 400 IV	9 ÷ 10	19	23 ÷ 24	40 ÷ 80
ZF 400 V	12 ÷ 14	22	23 ÷ 24	40 ÷ 80
ZF 400	11 ÷ 12	19	23 ÷ 24	40 ÷ 80

- *) reverse transmission without accessories; (for further details, see chapter "Oil level inspection" (p. 23));
- **) reference rpm: 1500.

The values must be measured using holes (5) and (15), indicated on page "Main subgroups" (p. 10).

NOTE:

We suggest installing a pressure indicator (range 0-50 bar) on hole (15) and an oil temperature sensor on hole (5).

2.1 Types of oil

Use the following oils (refer to the ZF-TLM 04 standard, edition 02/2009):

2.1.1 Lubricant class 04A

Single-grade engine oils (API CD/CE/CF-4/CF/CG-4/CH-4/CI-4/SF/SG/SH/SJ/SL or ACEA categories, A/B/E)

Viscosity classes: SAE 30, in warm countries or when the temperature in the oil pan exceeds +80°C SAE 40 is also accepted.

WARNING

All commercial products formulated with mineral oil that meet the above-mentioned specifications are allowed. No product list is available.

WARNING

As for gearboxes certified by DNV, class 04A lubricants cannot be used. Therefore, these gearboxes must be filled with class 04B or 04C lubricants.

2.1.2 Lubricant class 04B

Single-grade engine oil

Viscosity class: SAE 30, in warm countries or when the temperature in the oil pan exceeds +80°C, SAE 40 is also accepted.

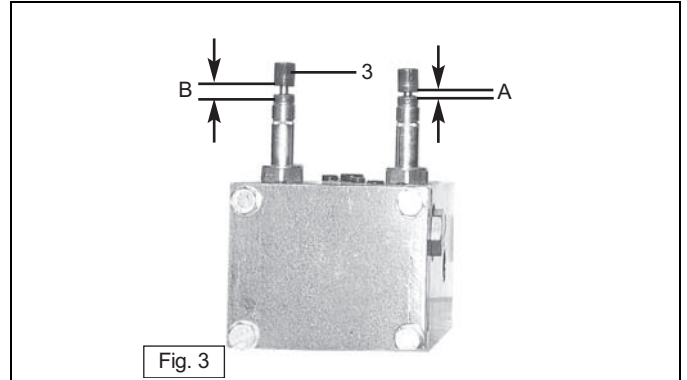
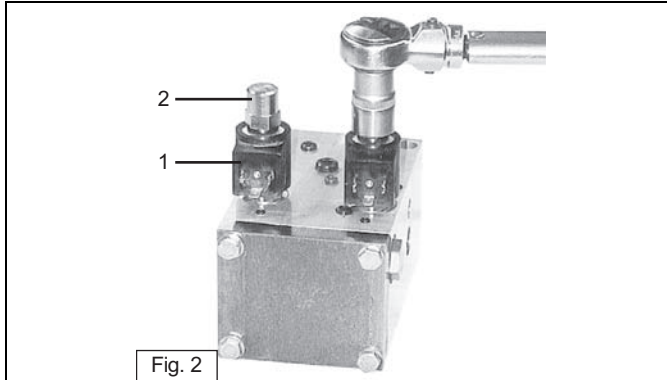
2.1.3 Lubricant class 04C

Multi-grade engine oil

Viscosity classes: SAE 5W-40 / 10W-40 / 15W-40

3 Emergency devices

3.1 Electrical circuit failure



A. valve closed (normal position)

B. valve open (emergency position)

To reset the electrical oil control block, tighten the protection cap (2) to 7 Nm.

Tighten the solenoid valves to 27 Nm if they have been replaced or removed.

DANGER

This operation must never be performed on the two valves simultaneously, as this would cause the transmission to lock due to the simultaneous engagement of the two clutches.

4 Installation

If the reverse transmission is not flange-mounted directly onto the engine, check that the connecting cardan shaft does not transmit dangerous vibrations to the transmission.

If the reverse transmission is installed separately with the universal joint, it can be fastened to the base both elastically and rigidly (V-DRIVE).

If necessary, besides the normal flexible coupling applied to the engine, install a further element capable of absorbing the vibrations caused by imperfect alignment.

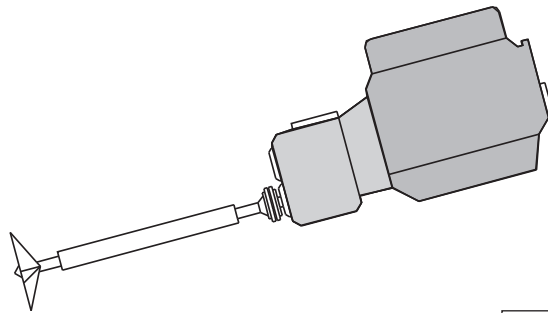


Fig. 1

4.1 Connection of the propeller axle

We recommend using a thrust support to ease the axial stresses that inevitably bear on the reverse transmission. The performance of the propeller axle support depends on the operating loads and must be specified by the shipbuilding yard.

The alignment must be verified with the watercraft in the water, since the deformations of a submerged hull are capable of altering the alignment made with the watercraft on the cradle.

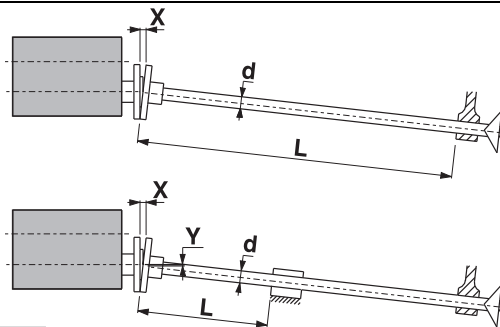


Fig. 2

! CAUTION

$X = \text{max. } 0.05 \text{ mm}$

! CAUTION

$Y = \text{max. } 0.1 \text{ mm}$

! CAUTION

$L = [\text{mm}]$
 min. 500 for $d < 60 \text{ mm}$
 min. 1000 for $d 60\text{-}90 \text{ mm}$
 min. 2000 for $d > 90 \text{ mm}$

4.2 V-DRIVE reverse transmission

The above considerations apply. If the reverse transmission is mounted separately, a universal joint of variable length is used. For the joint to work in optimal conditions (homokinetic transmission) and without damaging the reverse transmission or the engine, it is necessary to follow a few simple installation rules, as shown in the following diagrams.

4.3 Alignment method

4.3.1 Alignment method with parallel-face flanges

⚠ CAUTION

The engine and reverse transmission must be installed so that flanges A and B lie parallel to each other.

1. Engine.
2. Flexible coupling.
3. Variable-length universal joint.

Selected according to the instructions of the manufacturer.

In compliance with the installation instructions.

4. Propeller axle.
5. Marine reverse transmission with input and output on the same face.

⚠ CAUTION

Make sure that the longitudinal axes of the flexible coupling, universal joint and reverse transmission input shaft are aligned on the same vertical plane.

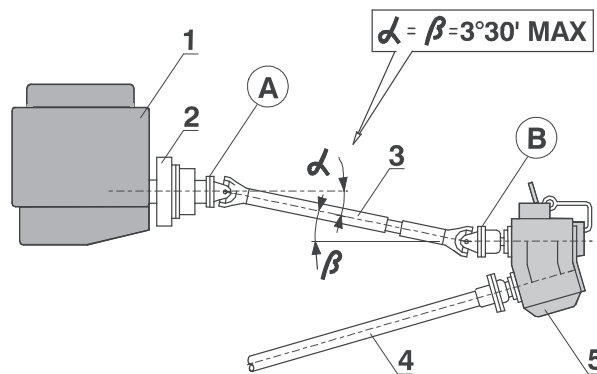


Fig. 3

4.3.2 Alignment method with tailstock shafts

- 1. Engine.
- 2. Reverse transmission.
- 3. Variable-length universal joint.
 - Selected according to the instructions of the manufacturer.
 - In compliance with the installation instructions.
- 4. Propeller axle.

To facilitate the correct alignment of the engine and reverse transmission, that is to obtain identical connection angles β_1 and β_2 :

 - install two alignment shafts 6 in place of the universal joint;
 - the shafts must have the same length;
 - align the two units so that the ends of the shafts meet, to ensure that angles β_1 and β_2 are identical;
 - at the end, remove the alignment shafts and install the universal joint;
 - make sure that the longitudinal axes of the flexible coupling, alignment shafts and reverse transmission input shaft are aligned on the same vertical plane.

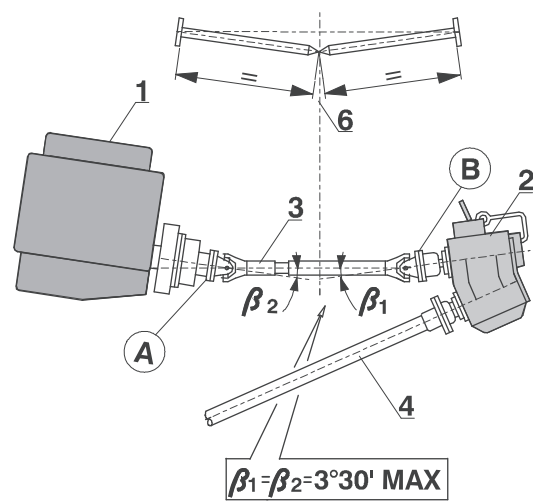


Fig. 3

CAUTION

Defective alignment can cause irreversible damage to the transmission, noise, vibrations, and damage to the hull's sealing systems.
ZF Padova S.r.l. is not required to perform warranty repairs in case of ruptures.

Make sure that the transmission was installed by leaving enough space for performing proper maintenance to replace the filter, oil and pump, and for accessing the oil level rod.
Verify that the oil drain plug is easily accessible.

	LONGITUDINAL STATIC	PITCH MODE	ROLL MODE
ALLOWED INSTALLATION ANGLES DURING NAVIGATION (°)(With reference to the perpendicular and longitudinal axes of the input shaft with respect to the horizontal plane)	-5 ÷ +10	-10 ÷ +25	-15 ÷ +15

5 Maintenance

5.1 Maintenance schedule

MAINTENANCE DESCRIPTION	MAINTENANCE LEVEL					
	A1	A2	A3	A4	A5	Z1
Check oil level	x	x	x	x		x
Rotate rotary handle of oil filter	x	x	x	x	x	
General conditions visual inspection	x	x	x	x	x	x
Clean transmission externally		x	x	x		x
Re-tighten all bolts accessible from the outside	x	x	x	x	x	
Check control position settings		x	x	x	x	
Lubricate external moving parts		x	x	x	x	
Oil change		x	x	x	x	x
Replace oil filter; clean gap filter and filter housing				x		x
Torsionally flexible clutch visual inspection				x		
Clutch discs visual inspection				x	x	
Running gears visual inspection				x	x	
Replace oil pump			x	x		
Check control unit					x	
Replace control unit				x	x	
Recalibrate indicators		x	x	x	x	
Inspect and clean oil cooler (check cooling system)		x	x	x		
Check shaft seal of input flange		x	x	x		
Check shaft seal of output shaft					x	
Major transmission overhaul				x	x	
Check the grounding circuit for possible corrosion			x	x	x	x

 NOTE:

* every 250h

** every 750h

Maintenance

MAINTENANCE LEVEL	GROUPS OF APPLICATION	AFTER RESPECTIVE OPERATIONAL HOURS	LIMIT VALUE
A1	all	before every day of operation	3 months
A2	all	500 hrs	1 year
A3	all	2.000 hrs	2 years
A4	P	according to operating hrs limit of duty	8 years
	L, M, C	according to operating hrs limit of duty	5 years
A5	all	starting 12.000 hrs	For every major reconditioning of the engine
Z1	all	50 hrs	After commissioning

- P = Pleasure*
- L = Light Duty*

NOTE:

* For any additional information please refer to the ZF Product Selection Guide.

5.2 Oil level inspection

The oil level check must be performed two minutes after the engine is switched off. The oil level must be between the upper and lower marks on the control rod, as shown in the picture.

After the first top-up, or after performing repairs or oil filter cleaning, the reverse transmission must be operated for two minutes. Subsequently, check the oil level again two minutes after the engine is switched off.

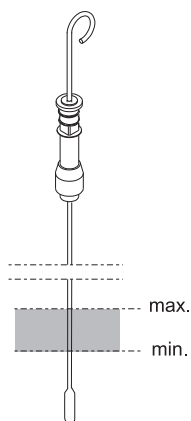


Fig. 1

5.3 Oil change

Remove the fill cap (3) and extract the oil level rod (1) as shown in the picture.

Drain the lubricant oil by removing the drain plugs (2) and recover the respective seals.

Recover the waste oil in compliance with the applicable regulations for the disposal of special waste.

Screw the plugs (2) back on with a torque of 90 Nm, then top up the oil through the fill cap (3) and screw on the cap with a torque of 80 Nm.

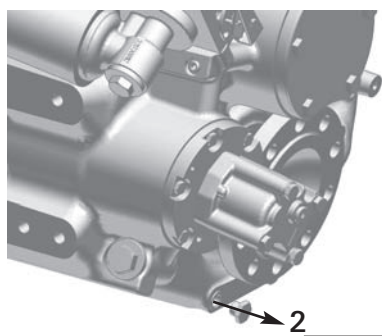


Fig. 2

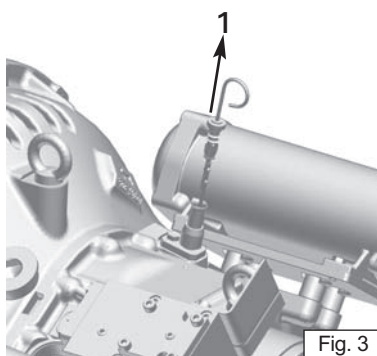


Fig. 3

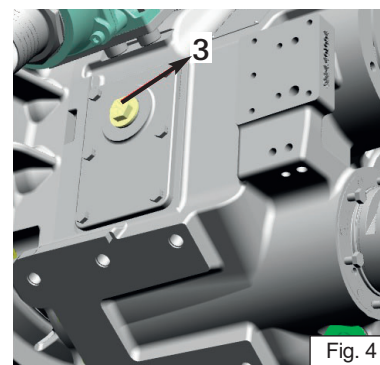


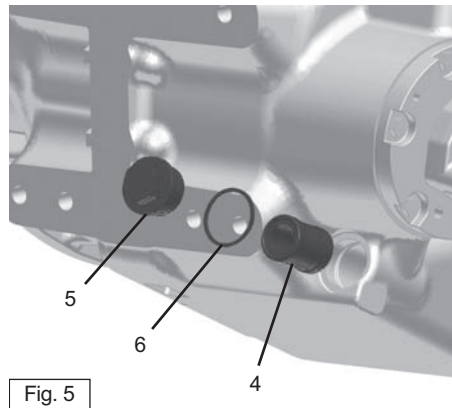
Fig. 4

5.4 Intake filter check

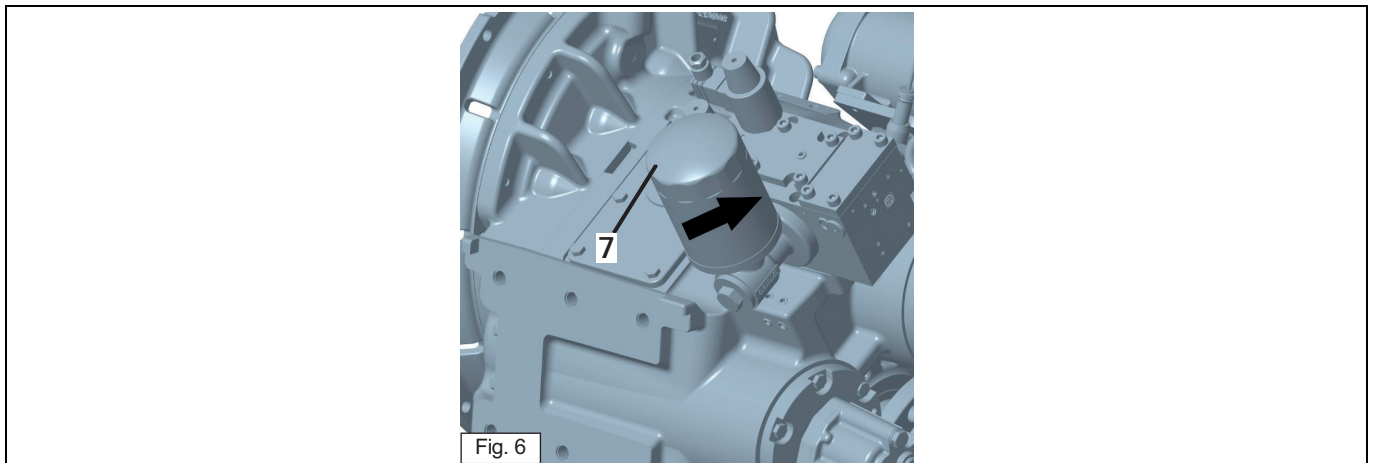
The intake filter must be inspected and cleaned after the first 50 hours of navigation, and subsequently every 250 hours and/or 6 months. The filter is located upstream of the pump.

Removal procedure:

remove the cap (5), the filter (4) and the seal (6), replacing it with a new one, then clean the filter. The cap (5) must be tightened with a torque of 100 Nm.



5.5 Oil filter replacement



Turn the cartridge (7) counter-clockwise using an appropriate tool until it has been completely removed. Clean the filter attachment base. Dampen the seal of the new cartridge with oil, then tighten it firmly using the hands alone.

Storage

If the transmission must be stored away for an extended period of time, it must be completely filled with oil through the oil level rod. Change the oil when the transmission is put into operation.

5.6 Remote control adjustment

With the engine switched off, remove the plug connecting the remote control cable to the oil control block lever. Put the lever into the forward drive position. Put the lever on the control bridge in the forward drive position and check that the connectors (cable-lever) match. Repeat the operation for the opposite direction of motion and, if any abnormal condition occurs, adjust the linkage accordingly. Lastly, check that the neutral position of the lever on the control bridge matches the neutral position of the stator lever. Perform the same check on the "Flying Bridge", if present. This operation must be verified also after the first few hours of operation.

INSPECTION OF THE FLEXIBLE COUPLING

Replace the flexible coupling if, after a rigorous inspection, its rubber part appears to be torn or contaminated with lubricant oil.

SHAFT LINE INSPECTION

When changing the oil through the fill cap and the oil drain plug, the shaft lines can be checked with an endoscope.



Remove the ignition key before proceeding with the operation.

NOTE:

Do not use chemical compounds on rubber parts. Make sure that you adjust the tightness of the screws and couplings. Periodically lubricate the external control mechanisms according to the manufacturer's recommendations.

6 Troubleshooting guide

FAULT	CAUSE	CORRECTIVE ACTION
1) No oil pressure in the main circuit and in the lubrication circuit in neutral or drive position	1 - No oil in the marine gearbox	- Fill the marine gearbox with oil
	2 - Intake filter completely clogged	- Remove the filter and clean it
	3 - The pump driver coupling is broken	- Remove the pump and replace the coupling
2) Insufficient oil pressure in drive position	1 - Insufficient oil level	- Restore the oil level
	2 - Incorrect position of the gear engagement selection lever	- Adjust the gear shift linkage
	3 - Intake filter partially clogged	- Remove the filter and clean it
	4 - Use of a non-recommended oil	- Replace the oil with a recommended type
	5 - Trolling lever positioned in the trolling range (if present)	- Bring the lever back to the trolling excluded position
3) Excessively high oil temperature	1 - Insufficient flow of water to the heat exchanger	- Replace valves and pipelines with others of larger internal diameter
	2 - Heat exchanger dirty	- Clean the heat exchanger
	3 - Excessively high or insufficient oil level	- Restore the normal level
	4 - Use of a non-recommended oil	- Replace the oil with a recommended type
	5 - Slipping clutches	- Check the operating pressure
4) Oil level variation	1 - Water-oil exchange through the heat exchanger	- Check and replace the heat exchanger

To resolve errors marked with the aforementioned symbol, we recommend contacting the ZF authorized service centers.

7 Service centers

COMPETENT CENTERS FOR SALES, AFTER-SALES AND SERVICES

ZF uses a global network of proprietary branches and independent business partners to support its customers.

Roughly 400 partners worldwide are dedicated to sales, after-sales services and assistance for ZF marine products.

To find the nearest ZF support center, contact the regional center of competence from the following list, or visit the website www.zf.com and go to: Products and services / network services to find a ZF partner in your country.

service.marine@zf.com

www.zf.com/contact

8 Maintenance certificates

A
Ore lavoro / Heures de marche
Horas de trabajo / Arbeitsstunden

B
Data, timbro, firma / Date, timbre, signature
Fecha, sello, firma / Datum, Stempel, Unterschrift

A
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- A. Work hours
- B. Date, stamp, signature

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