

# Operating Instructions

ZF-DUOPLAN

Two-speed Gearbox

2K120 / 2K121

Industrial Drives



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## 1 Preface

In addition to the ZF documentation, observe the provisions of the body manufacturer.

### 1.1 Validity and field of application

This documentation applies to the following ZF products:

- 2K120
- 2K121


### 1.2 Service products

Product	Name/specification	Quantity (approx.) [dm <sup>3</sup> ]	Use	Remarks
Grease	Shell Avania WR2 Fuchs Renolit CXEP2 Esso Beacon EP2		General assembly aid	
Gearbox oil	HLP 68 according to ISO VG 68	1.0 1.4	Gearbox oil for splash lubrication 2K120 – Installation position B5 2K121 – Installation position B5	Can also be used for recirculating lubrication and recirculating lubrication with heat exchanger
Gearbox oil	HLP 46 according to ISO VG 46		Gearbox oil for recirculating lubrication	Can also be used for recirculating lubrication with heat exchanger
Gearbox oil	HLP 32 according to ISO VG 32		Gearbox oil for recirculating lubrication with heat exchanger	
Bonding agent (liquid seal)	Loctite 574		Sealing end cover in hub	
End disc	28 DIN 470	1	Hub sealing	Exchange after disassembling the hub


## 2 Safety

### 2.1 Signal words and symbols


This document contains specifically highlighted safety instructions which are marked with one of the following signal words depending on the severity of the danger.

 **DANGER**

**DANGER**  
The signal word **DANGER** indicates a dangerous situation that, if not prevented, will lead to a severe injury or death.  
⇒ Information as to how the hazard can be prevented.

 **WARNING**

**WARNING**  
The signal word **WARNING** indicates a dangerous situation that, if not prevented, can lead to a severe injury or death.  
⇒ Information as to how the hazard can be prevented.


 **CAUTION**


**CAUTION**  
The signal word **CAUTION** indicates a dangerous situation that, if not prevented, can lead to a slight or moderate injury.  
⇒ Information as to how the hazard can be prevented.

**NOTICE**

The signal word **NOTE** indicates a situation that, if not prevented, can lead to property damage.  
⇒ Information as to how the property damage can be prevented.

The following symbols are also used:

 This symbol refers to additional, safety-relevant information.

 This symbol indicates information concerning special workflows, methods, application of auxiliary materials, etc.

### 2.2 General safety instructions

Read all safety instructions and information. Failure to comply with safety instructions and information may lead to property damage, serious injuries or death.

#### Intended use

The ZF product is exclusively intended for the application as defined in the contract and as agreed on at the time of delivery. Any other or more extensive form of use does not comply with this definition of intended use. The intended use includes compliance with this documentation and other applicable documents, in order to avoid malfunctions and damage in operation.

The ZF product is designed and produced in line with state-of-the-art technology. The ZF product is safe to operate in its delivery status. However, the ZF product may pose dangers if improperly used by unauthorized, untrained and uninstructed staff or if not used according to its intended use.

Figures might deviate from the ZF product and are not drawn to scale. No conclusions can be drawn with regard to size and weight.

#### Assembly, commissioning, maintenance and repair

Only perform assembly, commissioning, maintenance and repair work according to this documentation and other applicable documents.

Observe the following points:

- Employ authorized, trained and instructed staff.
- Observe technical provisions.
- Only use genuine ZF spare parts.
- Only use genuine ZF accessories.
- Only use genuine ZF special tools.
- Unauthorized changes and modifications lead to the expiry of the operator's license, warranty or guarantee.

In case of damage, contact ZF and have the following information on the product to hand:

- Type
- Parts list [BoM] number
- Serial number
- Kilometer reading
- Description of damage

Observe safety instructions, valid safety regulations and legal requirements to prevent malfunctions and damage.

The country-specific safety regulations, accident prevention regulations and environmental protection provisions also apply.

Wear workwear in accordance with safety requirements for all work. Depending on the work, also wear personal protective equipment.

After completing the work, check correct function and functional security.

### Handling of ZF product

Unauthorized changes and modifications may impair functional security.

Changes, modifications and applications are only permitted with the written approval of ZF Friedrichshafen AG.

Observe the following when working on the ZF product:

- Secure workspace.
- Only carry out work at the unit when in a voltage-free state.
- Protect unit against being started accidentally. Attach information sign in a clearly visible position.
- Perform work when motor is switched off.

- Protect motor against being started accidentally. Attach information sign in a clearly visible position.
- Do not stand beneath a suspended load.
- Do not work on a suspended load.
- Only use permitted means of transport and lifting appliances with sufficient load-bearing capacity.
- Close open pipelines and hoses and avoid damage.
- Observe tightening torques.
- Protect cables against mechanical damage.

### Noise

Noise may cause irreversible damage to hearing.

The perception of acoustic signals, warning calls or sounds warning of impending danger is impaired by noise.

Observe the following when working on the ZF product:

- Avoid noise.
- Wear ear protection.

### Operating supplies and auxiliary materials

Operating supplies and auxiliary materials may cause permanent damage to health and environmental damage.

Observe the following when selecting operating supplies and auxiliary materials:

- Health risks
- Environmental compatibility
- Material safety data sheets

Observe the following when handling operating supplies and auxiliary materials:

- Store operating supplies and auxiliary materials in suitable and correctly labeled containers.
- Seek medical help in case of injuries due to hot, cold or caustic operating supplies or auxiliary materials.

Observe the following to protect the environment:

- Collect leaking operating supplies and auxiliary materials in containers of a sufficient size.
- Observe disposal regulations.
- Observe material safety data sheets.

### 2.3 Product-specific safety instructions

- Remove any traces of old seals or gaskets from mating faces. Burrs or other similar rough surfaces are to be carefully removed with an oil stone.
- Carefully cover opened gearboxes to prevent the entry of foreign matter.



## 3 Application and Design

### 3.1 Application

The ZF-DUOPLAN two-speed gearbox is mainly used in machine tool drives.

By way of example, the gearbox can be used in turning machines (horizontal B5) or machining centers (vertical V1) thanks to its variable installation position. The gearbox is also suitable for use in many systems in which torque increase or speed reduction is required.

The gearboxes have coaxial output and are suitable for the high speeds generated in machine tool construction.



### 3.2 Features

- Two-speed gearboxes for AC and DC main spindle drives in machine tools
- Compact thanks to planetary design
- Flange-mountable to all AC, DC and standard motors
- High running smoothness and low-noise operation thanks to helical gearing
- Low torsional backlash
- Easy to install
- High radial forces permitted on output end
- Combined axial and radial force thanks to flexible output bearings
- High efficiency
- Electromotive gear change

### 3.3 Design

The gearbox primarily comprises the following assemblies:

**Connecting parts:**

- Drive hub (1)
- Adapter plate (2) with radial shaft seal (3) and hub bearings (4), as necessary

**Housing:**

- Gearbox housing (5)

**Input:**

- Sun gear (6)
- Ring gear (7)
- Ring gear bearings (8)

**Output:**

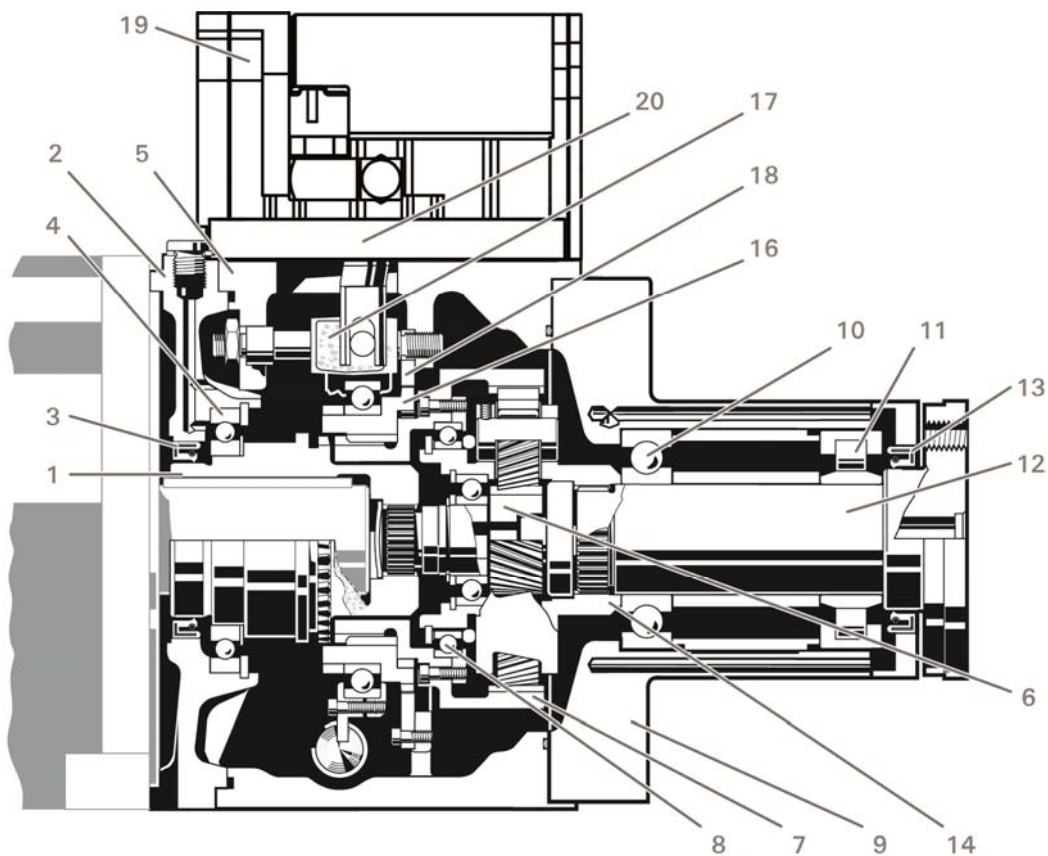
- Bearing housing (9)
- Output bearings (10, 11)
- Output shaft (12)
- Radial shaft seal (13)
- Planet carrier (14)
- Sun gear bearings (15)

**Shift mechanism:**

- Sliding sleeve (16)
- Shift fork (17)
- Brake disc (18)

**Shift unit:**

- Shift unit (19)
- Selector finger (20)



### 3.4 Technical data

Nominal power max. 19 kW  
 Nominal speed 1,500 rpm  
 Input torque (continuous operation): max. 120 Nm  
 Max. speed  
 in ratio  $i \neq 1$  8,000 rpm  
 in direct drive  $i=1$  (with gearbox oil cooling) 12,000 rpm  
 See chap. 4.6.3.2 "Connections for circulating lubrication" (Values apply as of 01/2004).


Nominal input torque (continuous operation) max. 120 Nm  
 Max. output torque for  
 $i = 1.00$  120 Nm  
 $i = 3.16$  379 Nm  
 $i = 4.00$  480 Nm  
 $i = 4.91$  589 Nm  
 Weight approx. 42 kg (2K120)  
 approx. 52 kg (2K121)

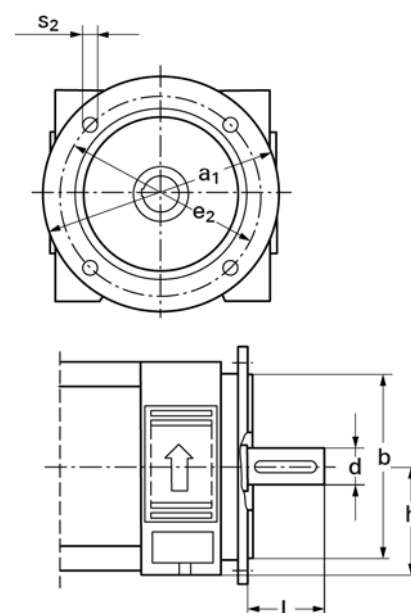
**i** When using engine brakes/counterflow to brake the spindles (e. g. emergency stop) ensure that the moments of inertia do not exceed the admissible output torques. Braking times must be adjusted accordingly.

Standard fixing dimension (in mm) in accordance with EN 50347:2001

Two-speed gearbox	2K120 FF215	2K121 FF265
Motor size	100	112
h	100	112
d	28/32/38	28/32/38
l	80±0.1	80±0.1
b	180	230
e <sub>2</sub>	215	265
a <sub>1</sub>	-	-
s <sub>2</sub>	14	14

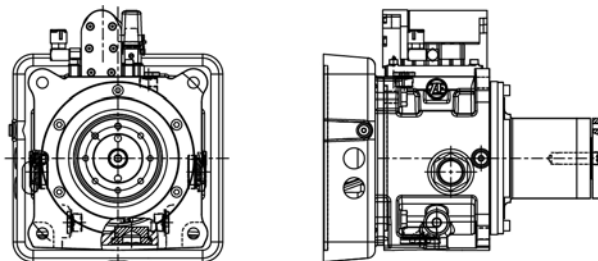
Model plate (standard) (affixed to gearbox housing)

		ZF FRIEDRICHSHAFEN AG MADE IN GERMANY	
TYPE _____	PARTS LIST _____		
RATIO $i$ _____	SERIAL-NO. _____		
BACKLASH MAX. _____ MIN.	INPUT TURN _____ RPM		
	POWER MAX. _____ KW		
INPUT TORQUE _____ NM	OIL GRADE _____		
SHITING _____ V	OIL QUANTITY _____		
UNIT _____ W			



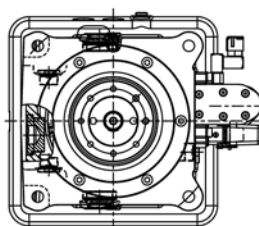
### 3.5 Installation positions

Horizontal B5

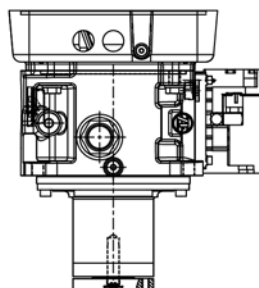


Horizontal B5

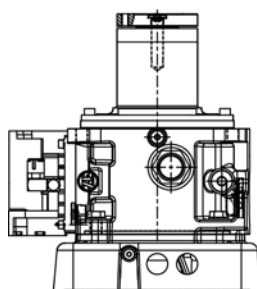
Shift unit on right side  
Gearbox turned around longitudinal axis  
(view to output end)



Vertical V1



Vertical V3



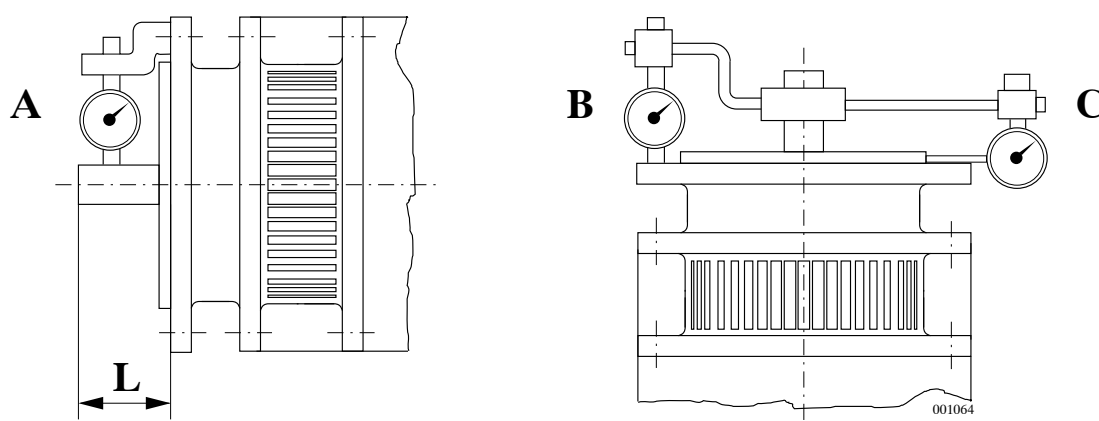
Possible damage to gearbox due to oil leaks.

**The breather outlet must always be at the top, regardless of the installation position.**

## 4 Initial Installation

### 4.1 Axial runout, radial runout and length tolerances – drive motor

In order to guarantee fault-free operation, the motor must not exceed the specified tolerances.



Axial runout, radial runout and length tolerances – electric motor mounting flange:

Gearbox type	Tolerance			
	A	B	C	L
2K120/ 2K121	0.025	0.050	0.050	$\pm 0.100$

Tolerances A, B, C according to DIN 42955R

Please note that the tolerance of the shaft length

"L" is restricted in relation to the DIN standard

Take into account the motor shaft elongation caused by heating in motors with fixed bearing on the B-side (opposite the motor output shaft).

#### NOTICE

The gearbox function will be impaired by incorrect tolerances.

⇒ Comply with tolerance of shaft length "L".

The special tolerance for shaft length "L" must be maintained in order to guarantee fault-free gearbox operation. Undersize shafts must be compensated for by using shims when mounting to the motor. Oversize shafts must be machined to the correct length.

Take into account the permitted axial forces on the motor shaft. Also see ZF-DUOPLAN catalog (4161.750.102), "Performance data" chapter.

## 4.2 Balancing

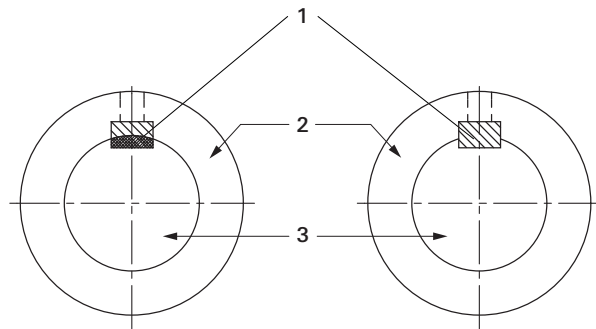
**i** If using motors with parallel keys, note the balancing type.

The hubs (2) come with a keyway (1) for transmitting power from the motor shaft (3) as standard.

There are two balancing types for the motor and gearbox: semi-key and full-key, which are described in more detail in DIN ISO 8821.

It must be ensured that the hub is balanced in the same way as the motor.

This is why it is very important to indicate the motor data, dimensions and balancing type when ordering.



Semi-key balancing

Full-key balancing

### Motor output shafts with standard fitted key in accordance with EN 50347:2001

Shaft diameter	Fitted key	Fitted key length
28 mm	A7x7	45 mm
32/38 mm	A10x8	70 mm
42 mm	A12x8	90 mm
48 mm	A14x9	90 mm

**i** In the case of motor shafts with open ends of the keyway, the parallel key is to be glued into the groove in order to avoid axial migration of the parallel key and/or the hub.

Clamping hubs are used for motors without parallel keys. A balancing type is not required.

### 4.2.1 Semi-key balancing

In semi-key balancing, the keyway is filled with a balance compensation corresponding to approximately half a key, shape B by default. This is based on the original key, shape, length and position used by the motor manufacturer and is defined as a counterweight. In semi-key balancing – in contrast to full-key balancing – the joint passes through a shared component. This means imbalance can arise after assembly due to tolerance factors.

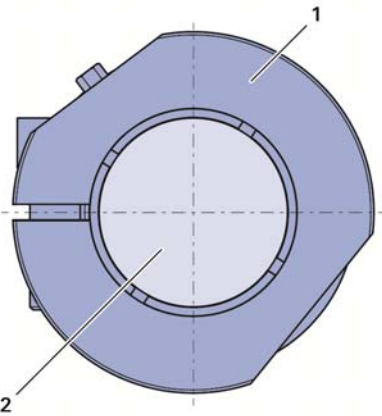
As a result, it is recommended that rebalancing should be performed after the joined parts have been assembled.

### 4.2.2 Full-key balancing

In full-key balancing, the motor shaft is balanced with a full key whereas the hub is not. The parallel key, shape, length and position are not important in this case.

### 4.2.3 Motor shafts/hubs without keyways

Clamping hubs are available for motor shafts with diameters of 38 mm, 42 mm and 48 mm.



- 1 Hub
- 2 Motor shaft

### 4.3 Adaptation, motor/gearbox

The motors must have a flange-mounting option for mounting the gearboxes.

The gearbox housing is fitted to the motor by means of the centering adapter on the bearing housing. This is standard.

There is also a foot mounting on the gearbox housing for 2K120.

Different gearbox variants are used depending on the motor type. Gearbox mounting also differs accordingly.

#### Reference dimensions for hub position

Gearbox type	Dimension C in mm
2K120	33.3-0.2
2K121	53.3-0.2

In the case of motors with fixed bearing, on the B side, the dimension is  $C = 32.8-0.2$  (2K120) or  $52.8-0.2$  (2K121).

#### 4.3.1 Open design

The open version is the gearbox without adapter plate but with seal on the motor output shaft (2) to prevent gearbox oil ingress.

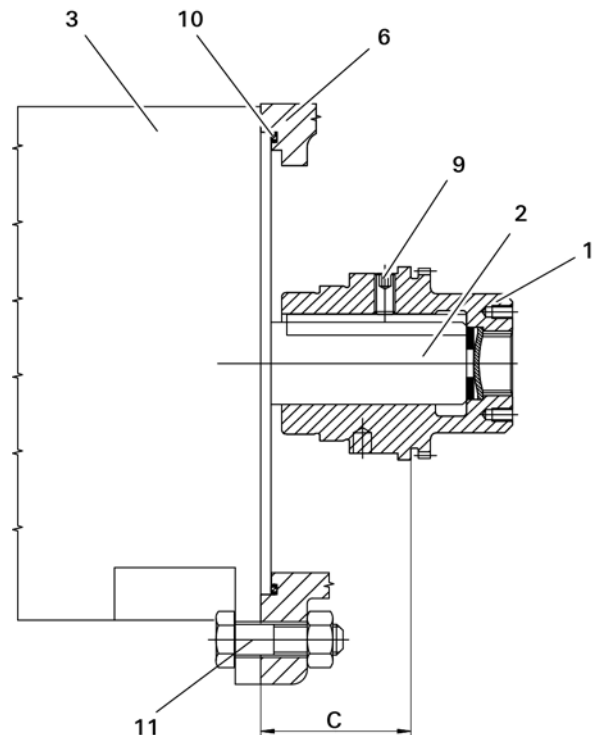
The drive hub (1) is delivered loose with the gearbox. Clean the fitting surfaces of the motor (3) and drive hub. Check the motor shaft for concentricity, axial runout and length according to chapter 4.1. Also lightly grease the motor shaft.

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

After cleaning the fitting surfaces, heat the drive hub to approx. 120 °C from the opening and slide it onto the motor shaft until it reaches the stop.

**NOTICE**  
**Risk of motor shaft damage if the drive hub is not sufficiently heated.**  
 ⇒ Heat drive hub to approx. 120 °C.

Tighten the threaded pin (9) and secure it to prevent it from turning, see chap. 4.3.6.





### 4.3.2 Closed design with hub bearing and shaft sealing ring

Variant with ball bearing (4), in which the hub (1) is also mounted in bearings to ensure easy installation. No parts need to be measured and shims are no longer required, since the hub is supplied with the adapter plate and hub bearings already in the correct position.

No internal axial forces occur with 2K120/2K121 that can affect the hub.

When assembling, separate the drive hub (1) with adapter plate (5) from the gearbox housing (6). Clean the fitting surfaces of motor and drive hub. Check the motor shaft for concentricity, axial runout and length according to chapter 4.1. Also lightly grease the motor shaft.

#### **CAUTION**

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

⇒ Wear protective gloves.

After cleaning the fitting surfaces, heat the drive hub to approx. 120 °C from the opening and slide it onto the motor shaft until it reaches the motor flange stop.

Reference dimension "C" is set at the factory.

#### **NOTICE**

**Risk of motor shaft damage if the drive hub is not sufficiently heated.**

⇒ Heat drive hub to approx. 120 °C.

When assembling, it must be possible to easily slide the hub onto the motor shaft until the adapter plate is against the motor flange.

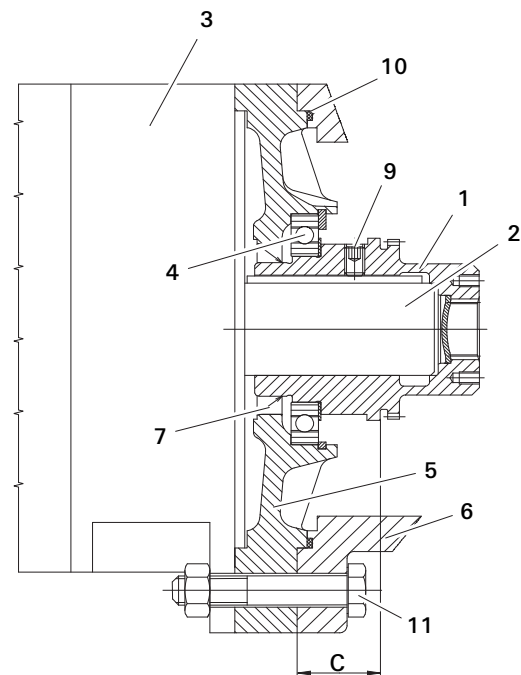


Do not use the adapter plate to help slide the hub onto the motor shaft.

Check by ensuring that the fitted adapter plate can be turned freely. This ensures that there is no hub bearing preload.

Tighten the threaded pin (9) and secure it to prevent it from turning, see chap. 4.3.6.

The radial shaft sealing ring in the drive motor must be removed on the output end when the closed design is used.



**4.3.3 Closed version  
(with shaft seal)**

This variant incorporates an adapter plate (5) with shaft seal (7), which means that the gearbox forms a compact, closed unit.

The adapter plate and drive hub (1) are delivered separately and loose. Clean the fitting surfaces of the motor (3) and drive hub. Check the motor shaft (2) for axial and radial runout as described in chapter 4.1. Also lightly grease the motor shaft.

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

After cleaning the fitting surfaces, place the adapter plate with radial shaft seal onto the motor housing. Heat the drive hub to approx. 120 °C from the opening and slide it onto the motor shaft until it reaches the stop, using shims (13) if required.

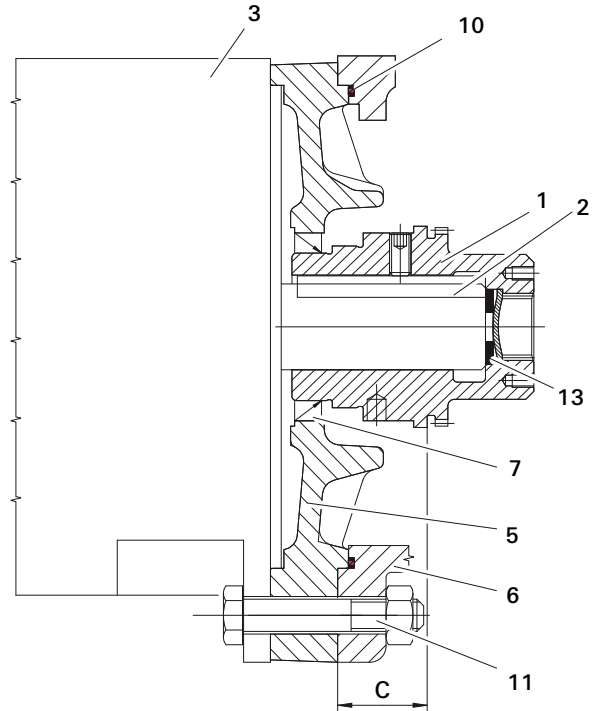
Then check reference dimension "C" and change using shims if necessary.

**NOTICE**  
**Risk of motor shaft damage if the drive hub is not sufficiently heated.**  
⇒ Heat drive hub to approx. 120 °C.

Tighten the threaded pin (9) and secure it to prevent it from turning, see chap. 4.3.6.

**i** Thoroughly grease the radial shaft seal and the drive hub before installation. When installing, make sure that the sealing lip and the radial shaft seal are in the correct position.

**NOTICE**  
**The radial shaft sealing ring in the drive motor must be removed on the output end when the closed design is used.**



#### 4.3.4 Open design with adapter ring

The adapter ring allows adaptation to different connecting dimensions. A seal is required on the motor output shaft.

The adapter ring (5) and drive hub (1) are delivered loose. Clean the fitting surfaces of the motor (3) and drive hub. Check the motor shaft (2) for axial and radial runout as described in chapter 4.1. Also lightly grease the motor shaft.

#### **CAUTION**

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

⇒ Wear protective gloves.

After cleaning the fitting surfaces, place the adapter ring onto the motor housing. Then heat the drive hub to approx. 120 °C from the opening and slide it onto the motor shaft (2) until it reaches the stop, using shims (13) if required.

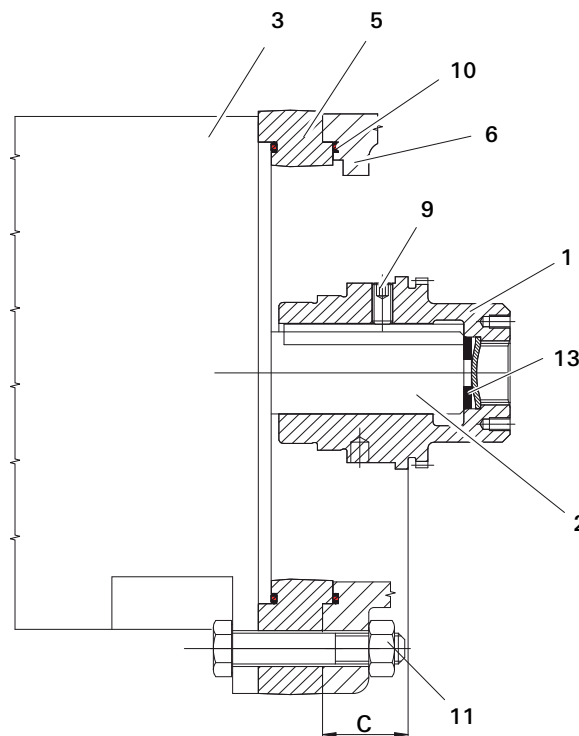
Then check reference dimension "C" and change using shims if necessary.

#### **NOTICE**

**Risk of motor shaft damage if the drive hub is not sufficiently heated.**

⇒ Heat drive hub to approx. 120 °C.

Tighten the threaded pin (9) and secure it to prevent it from turning, see chap. 4.3.6.



**4.3.5 Closed design with hub bearing, shaft seal and keyless hub**

When mounting on motors with a smooth motor shaft without a keyway, it is necessary to use ring clamping elements and pressure pieces between the motor shaft and the input hub in order to transmit the torque. There must be a central thread in the motor output shaft.

The mating surfaces of the motor (3), motor shaft (2) and input hub (1) must be cleaned.

Check the motor shaft (2) for axial and radial runout as described in chapter 4.1.

Loosely mount the counter-holder (4), ring clamping elements (5+6), bush (12), pressure piece (7) and screw connection with thread lock (8) in advance. Watch out for the position of the ring clamping elements when doing this. **First install the inner (5) then the outer (6) ring clamping elements** in the pack on the motor shaft.

Push the input hub onto the motor shaft with or without adapter plate (9), depending on the version.

By hand, move the ring clamping elements into contact using the screw connection. Tightening the screw connection causes the hub (and the adapter plate, if fitted) to move axially towards the motor. Take this into consideration with a lead dimension of +0.4 mm.

Tighten screw connection (8) to 90 Nm for M12.

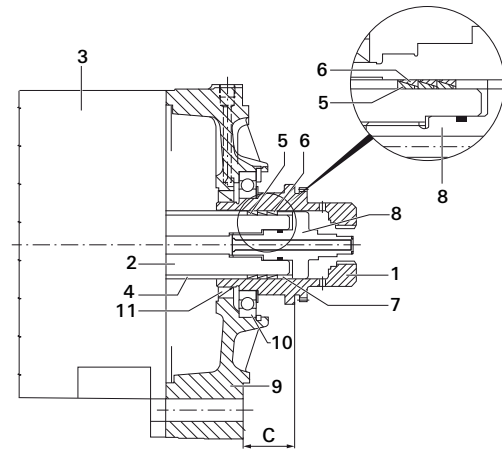
Take note of the maximum torque permitted for the thread in the motor shaft. Screws with a strength category of 10.9 must be used with adaptations without a coolant flow.

Check dimension C and the concentricity of the hub.

There is no longer any need for an additional internal seal in conjunction with ring clamping elements. The number of ring clamping elements and bushes can vary depending on the motor.

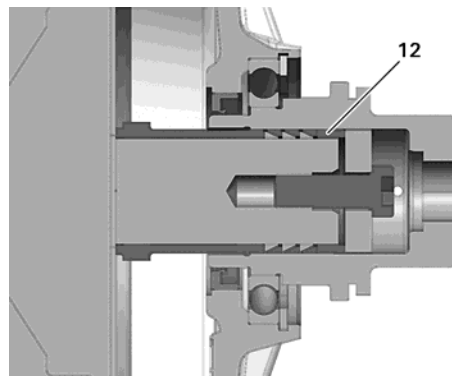
In screw connections with a hole for the coolant to flow through, watch out for the O-rings and grease them before installation.

The input hub must be blocked in order to prevent twisting of the motor shaft and input hub when tightening. This can be done using a special tool ZF 1X46.190.227.



**DO NOT GREASE** the motor shaft (2) and the hole in the input hub (1). **Lightly oil** the cone surface of the ring clamping elements (5+6).

The counter-holder is supported on the shoulder of the motor shaft. It is necessary to have a large contact surface.



10\_003548\_01

In the closed version without hub bearing, grease the seal running surface for the radial oil seal on the input hub before installation. Watch out for the position of the sealing lip when pushing on the input hub.



When using the enclosed design with hub bearing (10) and radial oil seal (11), do not push the input hub onto the motor shaft using the adapter plate. Once the screw connection has been tightened, the adapter plate must be in contact with the motor housing and it must be possible to turn it freely. This means the hub bearing is free from tension.

#### 4.3.6 Gearbox – fit

The M8 set screw (9) (see Fig. on page 16, 17, 19) must be screwed in and tightened at the parallel key with 18 Nm until firmly home. Make sure you coat the threaded pin with liquid seal before installing it.

Make sure that the O-ring (10) is in the correct position during installation (see Fig. on page 16, 17, 18, 19). The O-ring is delivered loose with the gearbox and has to be coated with grease before being inserted into the seal groove in the housing.

Check the position of the gearbox shift mechanism. The sliding sleeve must be in the 1<sup>st</sup> gear position (“low” gear ratio).

Take up the gearbox and place it onto the motor flange. Carefully bring the sun gear/hub connection together when doing this.



The external spline of the sun gear must be guided into the internal spline of the hub.

This can be made easier by turning to the left or right at the gearbox output.

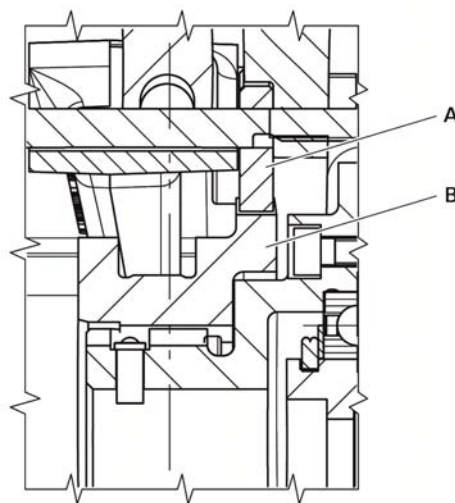
The gearbox housing, adapter plate and motor are bolted together using four or eight hexagon bolts (11) (see Fig. on page 16, 17, 18, 19).

Fill the gearbox with oil and connect up the recirculating lubrication system and the power supply. The breather outlet must always be at the top, regardless of the installation position. The breather is screwed in to position B5 ex works.

The gearbox is now ready for use.

**The gearboxes can be operated under the same degrees of protection as those defined for AC and DC motors.**

When setting up, make sure that the motor cooling air can flow in and out unhindered.



**1<sup>st</sup> gear position:**

- A Brake disk
- B Sliding sleeve

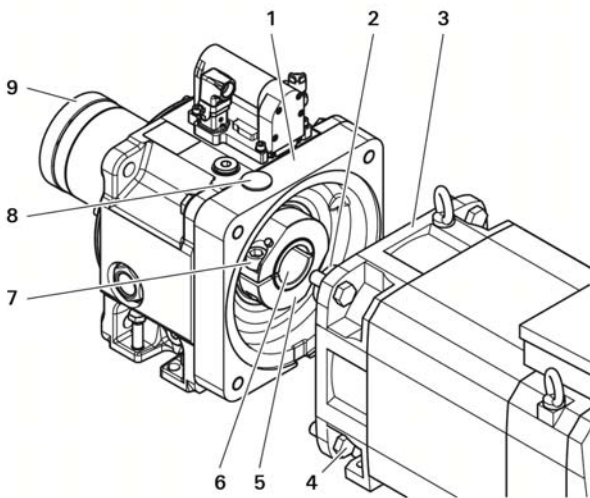
Before taking the electric motor/gearbox assembly into operation, check that the gearbox output can be turned by hand.

In the case of drive units that are fixed on the gearbox flange or housing, the motor can be supported on the B-side so that it does not vibrate.

**4.3.7 Closed design with hub bearing, shaft seal and clamping hub**

**i** The motor is mounted on the gearbox using an adapter flange with clamping hub. The motor shaft is connected to the clamping hub with a force fit.

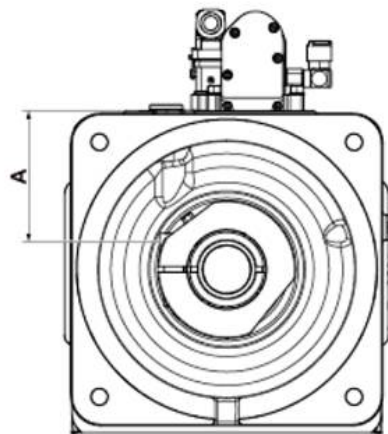
The gearbox with clamping hub may only be fitted on motors with a smooth motor shaft.



- 1 Adapter plate
- 2 Motor shaft
- 3 Motor flange
- 4 Mounting screw
- 5 Clamping hub
- 6 Sleeve
- 7 Clamping screw
- 8 Cover
- 9 Output shaft

**Mounting gearbox on motor:**

First the motor shaft (2), the bore of the clamping hub (5) and, if present, the sleeve (6) must be degreased. Then insert the sleeve into the clamping hub until the stop is reached. The clamping hub (5) must be positioned so that the clamping screw (7) can be tightened via the access hole. The cover plate (8) is removed for this purpose. The motor shaft (2) is guided (centered) into the clamping hub (5) until the motor flange (3) makes contact with the adapter plate (1). Ensure that the motor shaft does not jam in the clamping hub. The fixing holes on the motor flange and adapter plate must match precisely. The motor is mounted on the gearbox with four appropriate mounting screws (4), with a screw-in depth into the adapter plate of 15 to 25 mm. Tighten clamping screw (7) to 115 Nm with torque wrench, socket wrench extension and hex socket insert (WAF 10). If necessary, block the output shaft (9). Close off the access hole again with cover plate (8).



Dimension A for extension of hexagon socket wrench

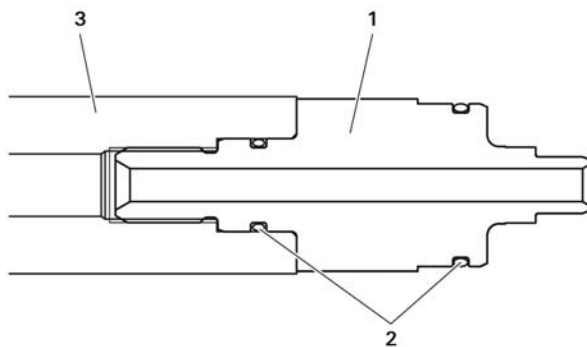
Adapter plate 2K120, A = 100 mm

Adapter plate 2K121, A = 125 mm

#### 4.3.7.1 Spindle cooling (TSC) version, feeding emulsions, hydraulic oils or air-oil mixtures

##### Mounting gearbox on motor:

Coat thread of connecting piece (1) with bonding agent. Screw connecting piece with pre-assembled and greased O-rings (2) into motor shaft (3) by hand until stop is reached. Use torque wrench (WAF 14) to tighten connecting piece to 130 Nm, blocking the motor shaft in the process. Follow the description provided in Chapter 4.3.7 for the rest of the mounting process.



- 1 Connecting piece
- 2 O-rings
- 3 Motor shaft (hollow shaft)

### 4.4 Output

#### 4.4.1 Version with belt output

The belt pulley must be centered on the outer diameter of the output flange (tolerance K6), fastened with the bolts so that it is frictionally engaged and secured. Comply with the specified tightening torques.

The belt pulley is to be balanced to quality 6.3 as per VDI Directive 2060 in order to ensure low-vibration operation.

#### **NOTICE**

**Possible damage due to bearing overload.**

⇒ Note maximum tensioning strength of belts.

Note the maximum specified tensioning force when tightening the belts in order to prevent bearing overload.

The average belt force must be between the bearings. When assembling, it must be possible to easily slide the belt pulley onto the output shaft. Heat the belt pulley if necessary.

#### 4.4.2 Version with coaxial output

In the case of the version with coaxial output (shaft stub), also note the balancing type for the output (see chap. 4.2). The gearbox is delivered with full-key balancing.

Refer to the installation drawing for the fitted key dimensions. Always fix the fitted key in place using a threaded pin.

#### 4.4.3 Version with TSC

The version with TSC (Through Spindle Coolant) is used for carrying cooling lubricant, hydraulic oils or air/oil mixtures<sup>1)</sup> through the gearbox to the spindle. A rotary transmission lead through is necessary to ensure that the fluid can be conveyed in a ratio operating at differential speed. This lead through is subject to wear depending on the load and the status of the medium. System conditions can cause leakage drips to occur when switching on and off and the relative design measures must be implemented in the coolant circuit to retrieve them. A transparent coolant return enables an evaluation using the status of the rotary feed.

The warranty for the rotary transmission lead is limited to 12 months.

Information about the product, function, operation and installation of the rotary transmission lead through can be found in the operating instructions

4161.758.030 (German)

4161.758.130 (English)

<sup>1)</sup> **No abrasive or solvent additives are permitted in the fluids.**

### 4.5 Electrical connection, gear change

The gearbox is electrically connected using the supplied 8-pole Harting connector (HAN 8 U). The plug-in connection is located on the shift unit.

#### 4.5.1 Shift unit

##### Technical data:

Power consumption	84 W
Supply voltage	24 V DC ±10%
Max. pickup current	5 A
Nominal current:	3.5 A
Index of protection	IP64

The required cable lead diameter is 1.5 mm<sup>2</sup>.

The 24 V DC connection voltage and 5 A power consumption must be assured on the shift unit connector.


Losses due to cable length and transition resistors must be taken into account.

##### Scope of supply:

Sleeve housing, screw connection, socket insert and 8 jacks, type Harting AWG16. The shift unit can only be obtained as a complete part.



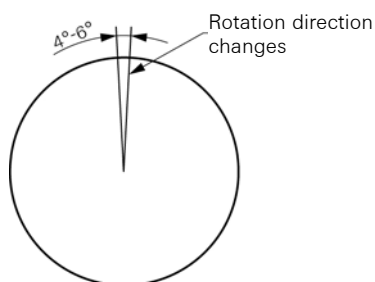
**Gearbox shift mechanism:**

 During the gear change, the motor shaft and/or gearbox output is without load (unbraked).

Gear changes are effected when the 24 V voltage is applied to pin 2 and 3. The polarity of the applied 24 V DC voltage dictates which gear is engaged.

In 1st gear                      => Pin 2: + / Pin 3: -  
 In 2nd and 3rd gear        => Pin 2: - / Pin 3: +

During the gear change, the main spindle motor should make the shaft oscillate  $+5^\circ$  or  $-5^\circ$  at a rate of 1 to 5 rotation direction changes per second. A larger pendulum motion may lead to damage at the meshing gears. The gears usually already mesh at the first rotation direction change, so that the switchover time is approx. 300 to 400 ms.



In average, this means:  $n_{Mot} = 5^\circ/s = 5^\circ \cdot 60/min = 300^\circ/min = 300/360 \text{ rpm} = 0.83 \text{ rpm}$ .

**Conversion**

**Pendulum speed ↔ pendulum rotary motion**

Speed [rpm]	Angle [°/min]	Time [sec]	Angle [°/sec]
0.25	90	3.33	5
0.50	180	1.67	5
1.00	360	0.83	5
2.00	720	0.42	5
3.00	1080	0.28	5
4.00	1440	0.21	5
5.00	1800	0.17	5

The machine optimum is to be determined on the basis of shift tests in relation to the different masses and the associated drag torques of the spindle.

The limit switch signals of S1 – gear 1 (contact 4) and S2 – gear 2 (contact 6) serve to shut off the shift unit once the gear change is complete.

After the limit switch signals have been reached, the shift unit is allowed to be live for a maximum of 0.5 seconds. The limit switch signals must be monitored during the operating time.

The limit switches must only be energized with the control current (0.1 – 0.5 A) and not with the changeover current (5 A).

If the number of resistors is rather small, a lower control current may also be used.

The control current for end-position monitoring is to be set according to length, line and transition resistance and the number of connection points. Increased resistance due to corrosion after some time must be taken into consideration. Switching of inductive loads by means of the control current requires it to be wired parallel to the load by a diode.

**If the limit switches detect that a gear is no longer securely engaged, steps such as emergency shut-off, etc., must be initiated through the control system.**

**NOTICE**

**Electromagnetic fields can falsify the limit position monitoring.**

⇒ Do not route control lines in parallel with cables for the voltage supply or shield control lines.

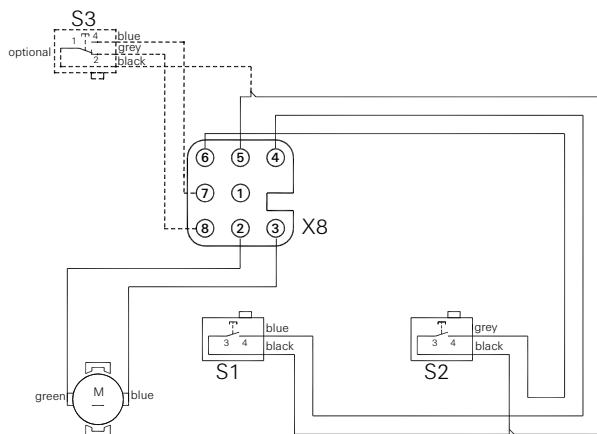
The shift sequence must be monitored. If necessary, a timer should be used to cancel the shift sequence after approx. 2 seconds if there is no limit switch signal (S1/S2). The main spindle motor cannot be operated until a new shift command is present.

## Initial Installation

---

**Diagram for shift unit** with two positions (standard) or three positions (with neutral position):

- 1st gear ==> e.g. 4:1
- 2nd gear ==> 1:1
- 3rd gear ==> S3 neutral position, idling (option)

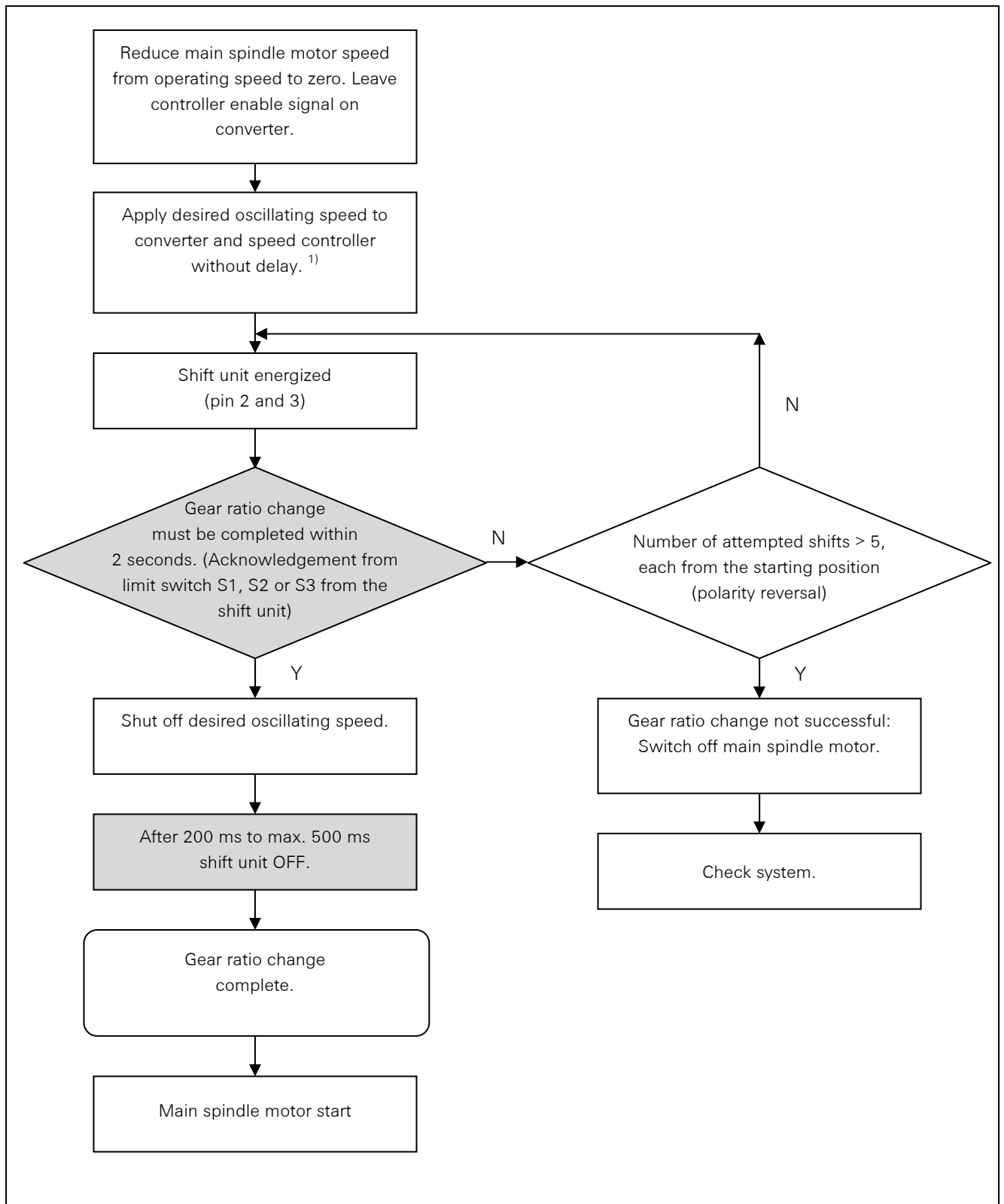


The electromotive gear change is performed by a shift unit on the gearbox which is driven by a DC motor (24 V DC). The gearbox shift element is a positively locking, axially movable selector fork that acts on a sliding sleeve.

The limit positions are monitored by limit switches in the shift unit. The time sequence is monitored in the control unit.

The motor must be energized when shifting from gear 1 to 2 or vice versa. The direction of rotation is changed over by reversing the polarity.

## 4.5.2 Control logic



1) Alternatively, the first switching test can be performed without oscillating, but this requires a de-energized main spindle motor or minor output-end masses.

### 4.6 Lubrication

#### 4.6.1 Splash lubrication

The standard B5 version of the gearbox has splash lubrication.



Splash lubrication is suitable for intermittent operation. Intermittent operation requires frequent gear changes, varying speeds and idle times (e.g. due to retooling).

#### NOTICE

##### Possible damage to gearbox due to insufficient oil quantity and/or running dry.

⇒ The gearbox oil must be filled up to the middle of the oil sight glass in such applications.

The actual oil level is all-important when it comes to filling up with oil. The quantity in liters indicated on the gearbox model plate is intended as a guide only.

If the gearbox is installed at an angle – as is the case in certain belt tensioners – an oil level tube with calibration mark must be fitted in place of the oil sight glass.

The oil level in the gearbox must be the same as for a gearbox installed in horizontal position (also see installation drawing).



An oil sensor can occasionally be used to check the oil level before starting the machine. The oil sensor can be screwed into connections D or E (Figure, page 30) of the gearbox housing. (Oil sensor order no. 4161.298.045, Balluff data sheet available on request)

#### 4.6.2 Recirculating lubrication

Two connecting pieces (hose fittings) with M42x1.5 and M22x1.5 thread are optional accessories, order no. 4161.106.016.

Recirculating lubrication enables efficient gearbox lubrication and cooling. This improves gearbox performance and less heat is introduced into the machine.

#### NOTICE

##### Gearbox failure due to insufficient lubrication.

⇒ Recirculating lubrication is required for gearboxes installed in the vertical V1 and vertical V3 positions.

In the 2K120/2K121 gearboxes, the V1 vertical and V3 vertical installation positions require recirculating lubrication. In this instance, the type of recirculating lubrication depends on the operating temperature level required.

The centrifugal forces acting on the oil can lead to insufficient lubrication of the gearing during continuous direct-drive operation.

Occasionally changing gear (ratio) and then starting the motor ( $n_{Mot}=1,000$  rpm) supplies oil to the gearing and prevents one-sided, position-specific loading of the gearing.

Some applications require a very low operating temperature level which can be reached by connecting an adapted gearbox oil supply with oil cooling. The respective gearbox versions are prepared accordingly.

The gearbox has different ports and connections for recirculating lubrication – depending on the installation position and the operating type – in order to ensure optimum gearbox cooling without affecting lubrication.

The diagrams on page 30 show the oil inlet and outlet points on the gearbox. Please refer to the relevant installation drawings for precise details.

The oil level must remain in the middle of the oil sight glass following operation for the first time, top up to this level if necessary.



The pump, oil tank and heat exchanger components must be arranged below the gearbox oil level. Connecting an oil return as described in chapter 4.6.3.2 assures limp-home (emergency control) characteristics.

#### 4.6.2.1 Recirculating lubrication for V1/B5 operation

Refer to chapter 4.6.3.2 for the position of the oil inlets and outlets.

The oil inlet is connected in place of the oil drain plug.

Oil inlet quantity 1.5 to 2 l/min.

One oil sight glass is removed and replaced with a screw-in drain pipe (M42x1.5).

If the gearbox is installed in vertical position V3, the gearbox oil can be supplied both radially and centrally.

The outlet line should be dimensioned so as to prevent oil return blockages in the gearbox ( $D_i$  approx. 20 mm).

#### 4.6.2.2 Recirculating lubrication with heat exchanger

A heat exchanger is installed in the recirculating lubrication system to ensure additional temperature reduction.

#### 4.6.2.3 Recirculating lubrication with intermediate tank

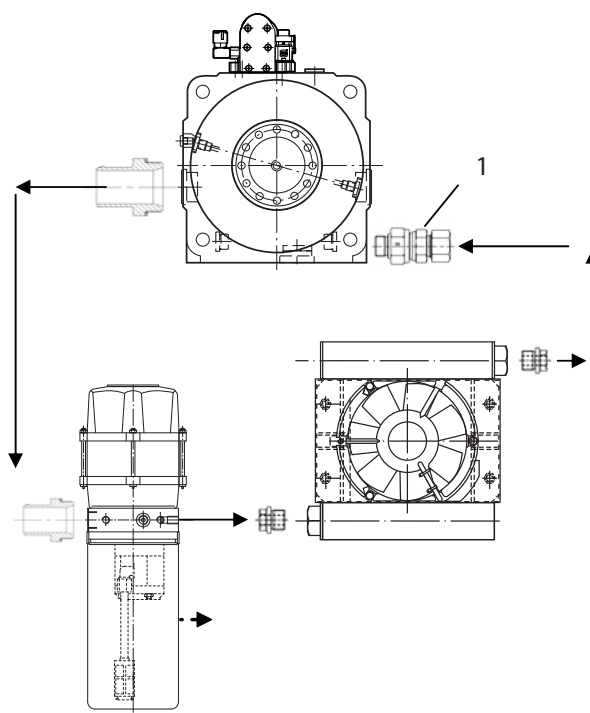
The tank volume should be at least ten times the recirculating oil quantity in order to ensure effective oil cooling.

To prevent gearbox damage due to lack of oil, ZF recommends you install an oil level sensor at the intermediate tank.

A 60  $\mu\text{m}$  filter and a safety non-return valve (1) must be used at the gearbox oil inlet.

This arrangement ensures continued operation using splash lubrication, see chap. 4.6.1.

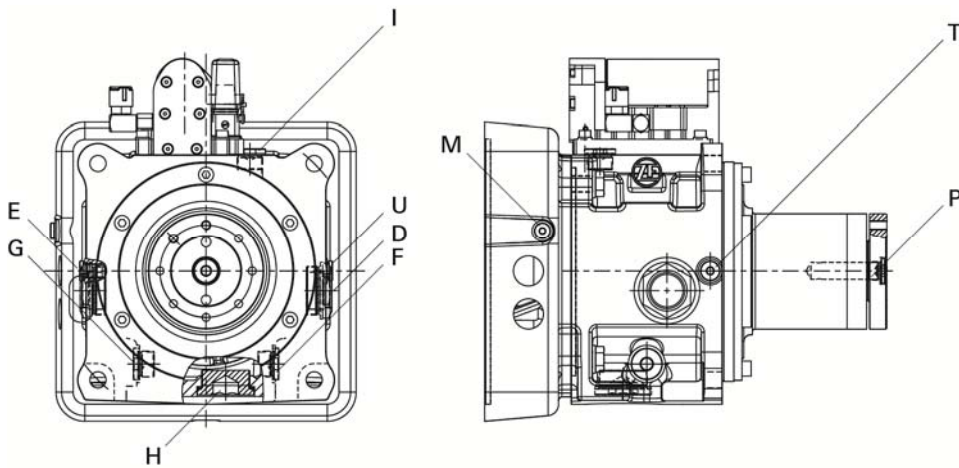
Installation example B5



### 4.6.3 Ports and connections for lubrication

#### 4.6.3.1 Ports and connections for initial fill/oil change

Installation position	Oil fill	Oil drain
B5	I	G, F, H
V1		D, E through suction (for version with output shaft)  P (for version with output flange)
V3		H



## 4.6.3.2 Connections for circulating lubrication

Installation position	Oil inlet port	Max. pressure	Oil return port
V1 (closed variant)	M (0.5 l/min) and T and/or U (1.0 l/min)	0.5 bar 0.5 bar	D Main rotation direction counter-clockwise*
V1 (open variant)	T and/or U (1.5 l/min)	0.5 bar	
B5 (closed variant)	M (0.5 l/min) and T and/or U (1.0 l/min)	0.5 bar 0.5 bar	E Main rotation direction clockwise*
B5 (open variant)	G (1.5 l/min) main rotation direction counter-clockwise* or F (1.5 l/min) main rotation direction clockwise*	1.5 bar	
V3 (closed variant)	M (0.5 l/min) and T and/or U (1.0 l/min)	0.5 bar 0.5 bar	H
V3 (open variant)	T and/or U or P (1.5 l/min)	1.5 bar	H

\* As seen when facing gearbox output



The principal factor in determining the oil supply volume is always the volume that flows out of the oil return.

In case of **maximum speed 12,000 rpm**, the connection **T and/or U** with 1.5 l/min must be connected. Furthermore, a gearbox oil cooler with >0.3 kW and a circulating oil volume of >15 liters is required.

## 5 Taking into Operation

### 5.1 Initial inspection

Check that the gearbox is correctly installed before taking it into operation.

- Mechanical fastening
- Motor flange-mounting
- Gearbox oil ports and connections
- Oil supply/oil fill assured
- Electrical connections
- Ease of movement (can be turned by hand)
- Vertical breather position

## 6 Maintenance

### 6.1 Oil change

**Oil change interval: every 5,000 operating hours**



#### **CAUTION**

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

**Slight to moderate injury possible.**

⇒ Wear protective goggles.

⇒ Wear protective gloves.

Drain used gearbox oil into a suitable container if it is at operating temperature.

The drain ports differ depending on the installation position and gearbox version (see chap. 4.6.3.1).

Pour new gearbox oil through port I.

The oil level is deemed correct when it reaches the middle of the oil sight glass when the gearbox is idle.

The oil level itself is all important. The oil quantity in liters indicated on the model plate is a reference value only.

If available, let the oil pump operate briefly after filling with oil to remove any air and top up with oil again if necessary.



## 7 Repair

In the event of gearbox malfunctions, first check the connected components and their ports and connections.

Carefully document the type of fault so as to assist manufacturer diagnosis (see chap. 7.1).

Repairs on the gearbox itself may only be carried out by ZF Friedrichshafen AG or by authorized ZF after-sales points.

### 7.1 Gearbox fault checklist

If you encounter drive unit faults, please refer to the remedies in chapter 7 first of all for help.

If this does not solve the problem, you will need to provide the following information for diagnosis at ZF Friedrichshafen AG or an authorized ZF after-sales point:

#### Gearbox data on the model plate:

Typ: ...  
(Type)

Stückliste: 4161 ... ..  
(Parts list no.)

Serien-Nr.: ... ..  
(Serial no.)

#### Motor data on the model plate

Manufacturer: ...

Type/Size: ...

#### Questions for fault diagnosis:

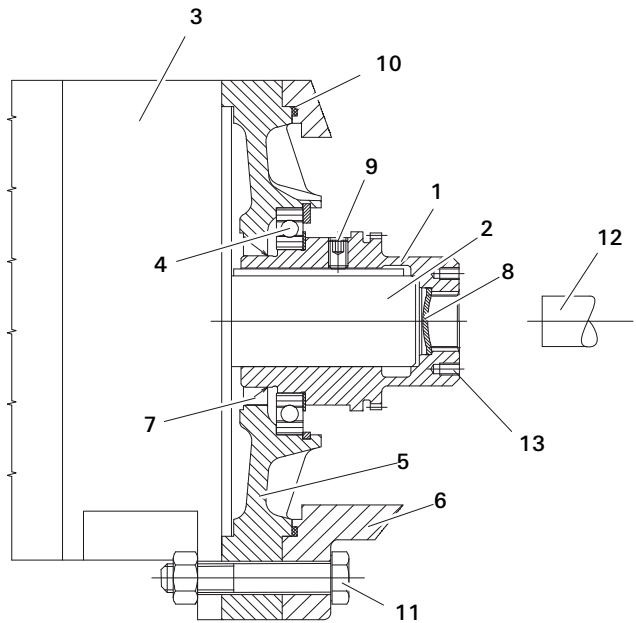
- Is gearbox oil sight glass dark/discolored black?
- Smell of burning oil at oil breather?
- Gearbox running noise in 1:1 or 4:1 gear ratio, or only in one rotation direction or in both rotation directions?
- Before the running noise occurred, was the machine operated in only one gear ratio (1:1) for an extended period of time?
- Did the running noise occur after changing the machine's cycle or was the machine cycle unchanged?
- Was any maintenance carried out on the machine before the fault occurred and if yes, what did this maintenance work involve?
- No gear change or gear loss in the event of a shift problem?
- Does shift logic conform to ZF specifications? (See page 27)
- What is the shift unit voltage during the shift sequence?

### 7.2 Gearbox – disassemble

(e.g. version with adapter plate, shaft seal and hub bearings)

Proceed accordingly in the case of other versions.

- Switch off the machine
- Switch off the power supply
- Disconnect the electrical connections
- Disconnect the gearbox oil connections, drain the gearbox oil
- Undo the mounting bolts (11)
- Pull gearbox (6) off the adapter plate (5) and drive hub (1)



### 7.3 Input hub with fitted key

- Undo the threaded pin (9) used to radially secure the fitted key.
- Use a removing device, e.g. three-arm puller, to pull off the drive hub against the motor shaft without heating the hub:  
Alternatively, there are two threads (13) at the front of the input hub that can be used to fasten the counter-holder of the removing device. Press off against a removing aid (12) on the cover (8). Keep turning the puller until the cover is at the motor shaft.

- 1 Drive hub
- 2 Motor shaft
- 3 Motor
- 4 Hub bearing
- 5 Adapter plate
- 6 Gearbox housing
- 7 Shaft seal
- 8 Cover
- 9 Threaded pin
- 10 O-ring
- 11 Mounting bolt
- 12 Removing aid (cylinder  $\varnothing$  20x50 mm)
- 13 Thread for removing aid

**NOTICE**  
**The cover plate may cause the input hub to jam when being pulled off.**  
 ⇒ Position cover plate (8) centrally on motor shaft.

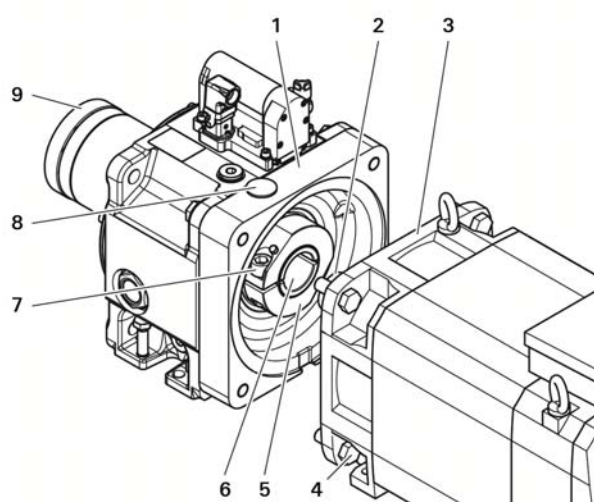
Replace the end disk 28 DIN 470 after disassembly. Clean before installing and coat the sealing edge with liquid seal. Visually check the shaft seal and O-ring and fit new ones if necessary.

## 7.4 Disassembly of gearbox with clamping hub

Note chapter 7.2.

Turn motor shaft (2) until clamping screw (7) can be seen through access hole in the adapter plate (1). Loosen clamping screw.

Loosen mounting screws (4) and pull gearbox off motor.



- 1 Adapter plate
- 2 Motor shaft
- 3 Motor flange
- 4 Mounting screw
- 5 Clamping hub
- 6 Sleeve
- 7 Clamping screw
- 8 Cover
- 9 Output shaft

## 8 Frequently Asked Questions (FAQ)

Error	Cause of error	Remedy
Gearbox is loud, knocking noises	<ul style="list-style-type: none"> <li>• Loose contact on motor speed sensor, which causes permanent motor governing</li> <li>• Speed sensor dirty, no clear signals sent</li> </ul>	<p>Check speed sensor and electrical lines to motor, clean speed sensor if necessary</p> <p>Check engine management system, adjust speed control accordingly (softer setting).</p>
Gearbox is loud, running noise	Long periods at high cutting speed in ratio 1:1 followed by change to machining in ratio 4:1	<p>No gearbox damage</p> <p>Gearbox running noise normalizes after several gear changes.</p>
Gearbox leaking at gearbox input/output	Defective seals	Replace seals, send gearbox to ZF for inspection if necessary
Gearbox leaking at breather	<ul style="list-style-type: none"> <li>• Oil has aged</li> <li>• Too much oil added during oil change</li> </ul>	<ul style="list-style-type: none"> <li>• Change the oil.</li> <li>• Check the oil level and correct if necessary.</li> </ul>
Machine control receives no shift position signals from the gearbox shift unit	<ul style="list-style-type: none"> <li>• Loose contact in the plug connection on the gearbox shift unit</li> <li>• Error in the shift unit</li> </ul>	<ul style="list-style-type: none"> <li>• Check plug connection and clean if necessary, secure connectors using clips.</li> <li>• Send gearbox to ZF for inspection.</li> </ul>
Gear disengages	<ul style="list-style-type: none"> <li>• Limit position switch defective</li> </ul>	<ul style="list-style-type: none"> <li>• Send gearbox to ZF Friedrichshafen AG for inspection.</li> </ul>



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