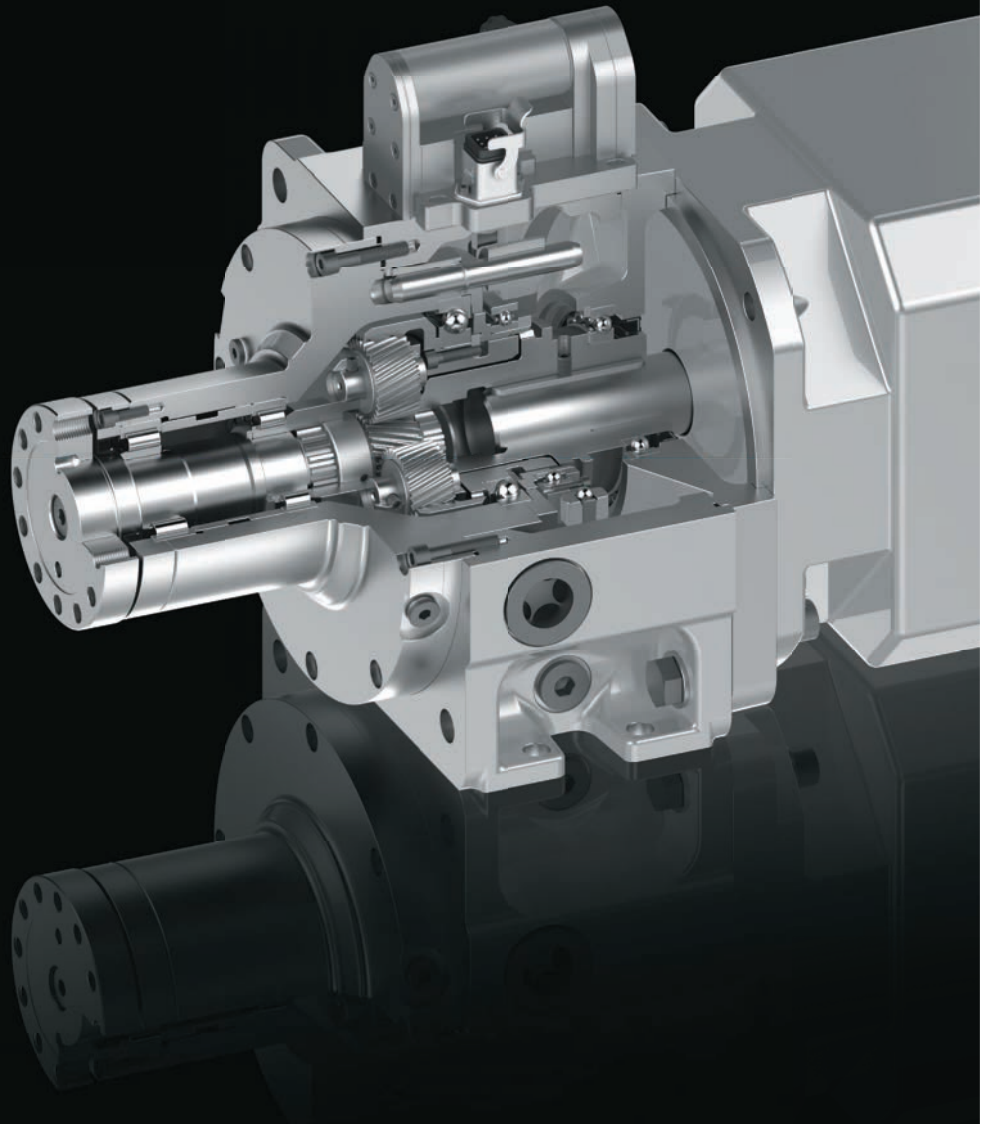


# POWER AND DYNAMICS

TWO-SPEED GEARBOX FOR MACHINE TOOLS  
ZF-DUOPLAN 2K





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## THE EXPERT FOR THE INDUSTRY

Our enthusiasm for innovative products and processes and our uncompromising pursuit of quality have made us a global leader in driveline and chassis technology as well as active and passive safety technology. We are contributing towards a sustainable future by producing advanced technology solutions with the goal of improving mobility, increasing the efficiency of our products and systems, and conserving resources. Our customers in the automotive and industrial sectors welcome our determined focus on products and services, which provide great customer value.

# OUR WORLD REVOLVES AROUND YOUR DRIVE



In more than three decades, ZF has evolved into an expert for developing and manufacturing tailor-made driveline technology for industrial machinery. Renowned manufacturers trust in our competence and product quality.

ZF Friedrichshafen AG with its Special Driveline Technology business unit offers already since decades a wide range of industrial drives, brakes, and clutches for mechanical engineering applications as well as customized drive solutions. The focus of development and production activities is on servogearboxes for automation technology, two-stage manual drives for machine tools, as well as customized drives, for instance for printing machines or robotics applications. The range of innovative products covers low-play servogearboxes (ZF-Servoplan), robust two-stage gearboxes (ZF-Duoplan), as well as hysteresis applications that transfer torque without contact (ZF-Tiratron).

Even under continuously high machine loads, ZF industrial drives work in a highly reliable and precise manner. Their size is so small and their weight so low that they can be smoothly integrated into the respective manufacturing concept. Low-scale maintenance efforts and longevity guarantee high availability.

## **Experience that counts**

Tens of years of intensive cooperation and development work with renowned machine manufacturers worldwide have made us what we are today. Know-how, product quality, and precision combine to create a perfect, flexible unit. Thanks to our experience, we know all about the requirements in mechanical engineering and work closely with our customers to offer tailor-made drive solutions.

Furthermore, our engineers constantly interact with the ZF Research and Development Center and utilize state-of-the-art technologies to continue to find even more innovative solutions for mechanical engineering and plant engineering. The internal company processes at ZF demonstrate a high level of quality that is recognized within the automotive industry. Competence and process quality that benefit our customers.

## **Worldwide service**

ZF considers itself not only a manufacturer, but also a



reliable partner who supports its customers throughout the lifecycle of their machines – worldwide. With our own comprehensive service network and full range of aftersales services. From prompt original-manufacturer parts supplies via technical service, up to consultancy and training. Quickly, directly, reliably. In short, ZF links powerful top-quality products with excellent services to provide a unique offer.

#### **Perfect solutions for machine tools**

Today, a machine tool must be universally applicable in order to process different materials. The two-speed ZF-Duoplan manual gearboxes live up to these demands. The ZF Duoplan two-speed gearbox is mainly used in machine tool main-spindle drives, test-benches and applications where high torque is needed.

By way of example, the gearbox can be used in turning machines (horizontal B3/B5), machining centers (vertical V1/V3) thanks to its variable installation position. The gearbox is also suitable for use in many systems in

which torque increase and/or speed reduction is required. Machine tools are designed to be universal so that they can process different materials. This requires both high cutting speeds for soft materials as well as high cutting forces for hard materials requirements which a two-speed gearbox can fulfill, since it can either retain high motor speeds ( $i = 1:1$ ) or multiply the motor torque (e.g. ratio  $i = 4.00$ ) and reduce the speeds, both by the same factor.

In order to optimize machine utilization and reconcile the contradictory requirements for high speed plus high torque, ZF developed the Duoplan HS and Duoplan HWG two-speed manual gearboxes for AC and DC main spindle drives. They are used in high-speed machine tool drives for high-speed cutting (HSC) and in RAM installations.

# ONE SOLUTION FOR EVERY DEMAND



Precision gearboxes of the ZF-Duoplan model range cover all common performance, torque, and motor classes of industrial machine drives. This allows the performance range of machine tools to be used in an optimal and energy-efficient way.

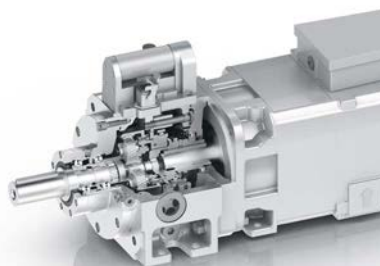
The ZF-Duoplan model range offers more than ten different gearbox variants for diverse applications and installation positions. They can be used to operate motors with an axle height from 100 to 280 millimeters; the range of the transferred nominal power is between 19 and 120 kW, and the range of the nominal input torque is between 120 and 2,100 Nm. With this extensive spectrum of gearboxes, engineering companies and production facilities benefit from further increases in efficiency and improved cost-effectiveness because an optimally adjusted motor/gearbox unit also reduces energy consumption.

A range of output housing variants cater to different spindle drive designs: E.g. ZF-Duoplan Standard with wide bearing base for belt drives with high cantilever forces, ZF-Duoplan INLINE with short output housing and angular contact bearings for direct drive and ZF-Duoplan TSC (Through-Spindle-Cooling) to facilitate the transfer of cutting liquids like emulsions, hydraulic oils and air-oil mixtures with up to 140 bars of pres-

sure at a flow rate of 35 l/min through the gearbox and spindle, directly to the tool.

Further features of the two-speed manual gearbox include the smaller space requirements thanks to the planetary design, low running noise, and direct installation on all kinds of main spindle motors. Concentricity and center distance changes are compensated for by the floating sun gear, whereby the planetary gearset is much less sensitive to tolerances. Low circumferential backlash, high efficiency, and easy assembly are additional benefits.

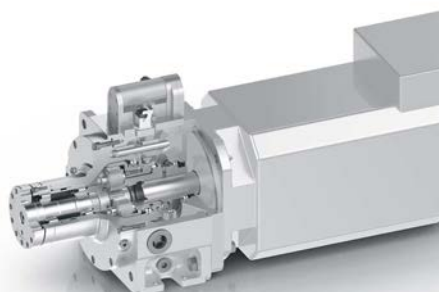
**FLEXIBLE FOR ANY APPLICATION** The Duoplan gearbox family, a perfect solution for every use case.



ZF-Duoplan 2K 120



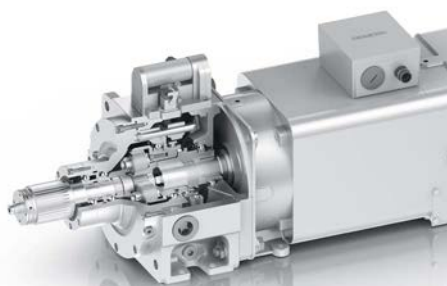
ZF-Duoplan 2K 450 - 600



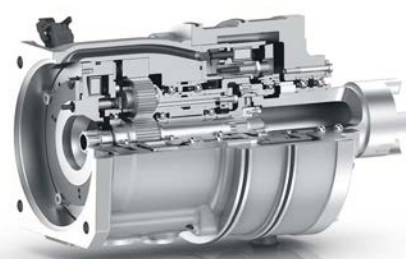
ZF-Duoplan 2K 250



ZF-Duoplan 2K 800



ZF-Duoplan 2K 250 TSC



ZF-Duoplan 2K 150 HS



ZF-Duoplan 2K HWG

**HIGHSPEED** Two-speed hollow shaft drives of the ZF-Duoplan model range allow an input speed in direct drive of up to

**16,000 rpm**

# New Generation

## Power and dynamics of a new generation

The innovative high-speed hollow shaft drives of the ZF gearbox series Duoplan New Generation make machine tools more powerful, efficient and flexible.

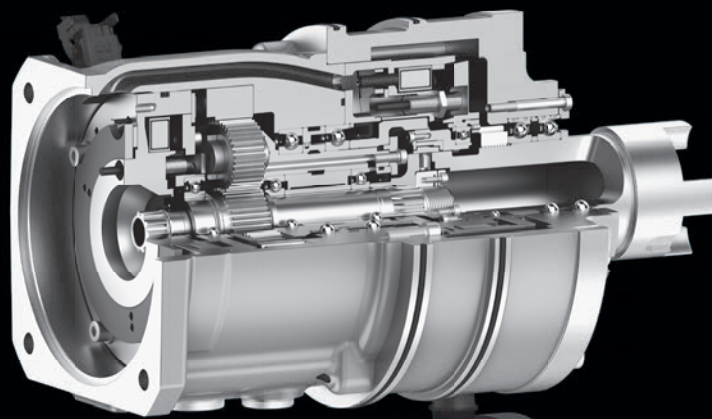
As a world market leader for two-speed manual drives for stationary applications, ZF has pooled its comprehensive know-how for the new hollow shaft drives from the Duoplan model range. Consequently, the ZF Duoplan 2K 150 HS that was already presented in 2012 features a top speed of 16,000 rpm with up to 24 kilowatt (kW) drives with 600 newton meters (Nm) of nominal output torque.

Now, a further version for higher performance range is available: The 2K 380 HWG is predestined for up to 60 kW or 1,900 Nm and thus, scores with a maximum of 12,500 revolutions.

The new Duoplan variants increase the bandwidth of possible applications and consequently improve the workload of each machine. Furthermore, they can be vertically or horizontally docked in a direct manner to highly dynamic spindle motors in a flange design that enable shorter cycle times. For the first time, the ZF two-speed drives are therefore also an option for machines that were previously only suitable for direct drives.



tion



### ZF-DUOPLAN 2K 150 HS

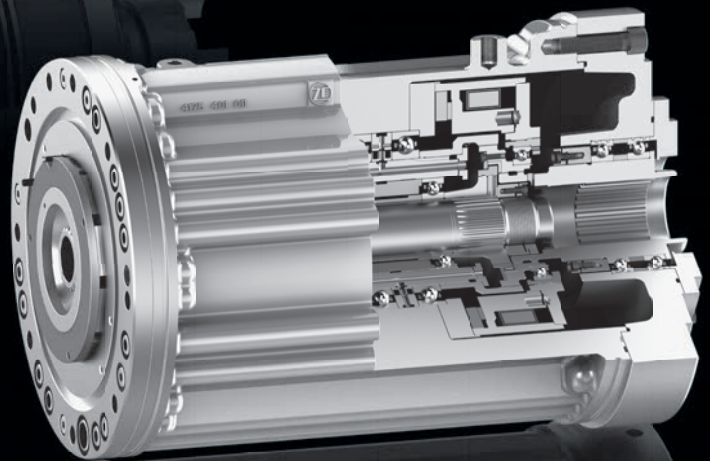
The highlights at a glance:

- Input speeds of up to 16,000 rpm
- Gear ratio of  $i = 4$
- Horizontal installation

### ZF-DUOPLAN 2K 380 HWG

The highlights at a glance:

- Shaft bore of up to 32 mm
- Gear ratio of  $i = 5$
- Horizontal or vertical installation



A further advantage: The hollow shaft design allows pushrods for release units or even coolants to be passed through the drive. As it is the case with all other products from the Duoplan family, these innovations are also maintenance-free and particularly durable.

The special features of the ZF hollow shaft drives can be attributed to the innovative design for which there is a patent pending: The extremely compact planetary gearset is only active when it is actually required. In the event of high speeds in direct drive (gear ratio 1:1), it remains decoupled which drastically reduces the rotating masses.

The resulting advantages over conventional planet or spur gear drives go far beyond high rotation speeds: They range from the short ramp-up times to the excellent efficiency and the low temperature level of a maximum of 37 degrees to vibration values that always remain below one millimeter per second.

### Special features of the ZF-Duoplan gearbox platform

- Speed-resistant
- Optimum temperature properties ( $< 37^{\circ}\text{C}$ )
- Minimum vibrations ( $< 1 \text{ mm/s}$ )
- Minimum run-up times ( $< 0.1 \text{ sec}$  delayed motor rev-up)
- Large hollow shaft diameters for release units or cooling lubricants
- Very good efficiency
- Maintenance-free and extremely long service life
- Supreme dynamics thanks to low mass moments of inertia
- No churning losses by making optimal use of installation space
- Suitable for direct installation on motor and spindle
- Can be installed directly in RAM
- Designed for adaption with built-in torque motors

## ZF-DUOPLAN – TECHNICAL DATA

Performance values		i	2K 120 2K 121	2K 250	2K 300	2K 450	2K 600
<b>Nominal data</b>							
Motor frame size			100/112	132	160	160/180	180
Nominal power	[kW]		19	39	47	47	63
Nominal speed	[rpm]		1,500	1,500	1,500	1,000	1,000
Nominal input torque (continuous operation S1)	[Nm]		120	250	300/250**	450	600
Output torque	[Nm]	1.00	120	250	300	450	600
	[Nm]	3.16	379	-	-	-	-
	[Nm]	3.17	-	792	951	1,426	1,902
	[Nm]	4.00	480	1,000	1,200	1,800	2,400
	[Nm]	4.91	589	-	-	-	-
	[Nm]	5.00	-	-	-	2,250	3,000
	[Nm]	5.50	-	1,375	1,375	-	-
<b>Maximum data</b>							
Maximum torque in Nm (intermittent loading S6 cycle duration 10 min, ED. max. 60%)							
Input	[Nm]		140	400	400	630	840
Output	[Nm]	1.00	140	400	400	630	840
(max. accelerating torque)	[Nm]	3.16	442	-	-	-	-
	[Nm]	3.17	-	1,268	1,268	1,997	2,662
	[Nm]	4.00	560	1,600	1,600	2,520	3,360
	[Nm]	4.91	687	-	-	-	-
	[Nm]	5.00	-	-	-	3,150	4,200
	[Nm]	5.50	-	2,200	2,200	-	-
Maximum permitted input speed							
▪ in reduction	[rpm]	≠1	8,000	6,300	6,300	5,000	5,000
▪ for direct drive	[rpm]	1 <sup>2)</sup>	12,000 <sup>3)</sup>	10,000 <sup>3)4)</sup>	10,000 <sup>3)4)</sup>	8,000	5,000
Maximum vibration value	[mm/s]		2.0	1.4	1.4	≤ 2.0	≤ 2.5
Reduced vibration value	[mm/s]		1.2	1.0	1.0		
Maximum vibration value ZF INLINE	[mm/s]		1.0	1.0	1.0		
Reduced vibration value ZF INLINE	[mm/s]		0.7	0.7	0.7		
At reference speed	[rpm]		6,000	5,000	5,000	4,000	4,000
Max. axial force in reduction ratio <sup>5)</sup>	[N]	3.16	-	-	-	-	-
	[N]	3.17	-	3,090	3,710	-	-
	[N]	4.00	-	3,964	4,756	5,439	7,253
	[N]	4.91	-	-	-	-	-
	[N]	5.00	-	-	-	7,139	9,519
	[N]	5.50	-	5,288	5,288	-	-
Mass moment of inertia <sup>1)</sup>		1.00	110	270	270	736	736
Output	[J in kgcm <sup>2</sup> ]	4.00	144	570	570	3,272	3,272
Input	[J in kgcm <sup>2</sup> ]	4.00	9	36	36	197	197
<b>Operating data</b>							
Weight (standard)	[approx kg]		42/52	68	86	155	165
<b>Electrical connection for shift unit</b>							
Power consumption	[W]		84	84	84	84	84
Supply voltage (at shift unit)	[V]		24±10%	24±10%	24±10%	24±10%	24±10%
Current supply at 24 V	[A]		5.0	5.0	5.0	5.0	5.0

Operator is free to define bearing load and lifetime.  
See installation drawings or page 15-16 for bearing data.

<sup>1)</sup> Mass moments of inertia for other ratios on request

<sup>2)</sup> Admissible with oil cooler, otherwise  $n_{max}$  for reduction ratio

<sup>3)</sup> Max. speed only permitted with oil connection at port K+ T (see pages 20-22 for oil recirculation systems connections)

<sup>4)</sup> Max. speed only permitted with integrated oil channel versions

<sup>5)</sup> Note the permissible axial power on the motor shaft

\* On request

\*\* i = 5.5 = reduced input torque

## ZF-DUOPLAN – TECHNICAL DATA

Performance values		i	2K 800 801/802	2K 2100	2K 150 HS	2K 380 HWG
<b>Nominal data</b>						
Motor frame size			180/200/225	225/280		
Nominal power	[kW]		84	120	23	60
Nominal speed	[rpm]		1,000	500	1,500	1,500
Nominal input torque (continuous operation S1)	[Nm]		800	2,100	150	380
Output torque	[Nm]	1.00	800	2,100	150	380
	[Nm]	3.19	2,552	-	-	-
	[Nm]	4.00	3,200	8,400	600	-
	[Nm]	5.00	*	-	-	1,900
<b>Maximum data</b>						
Maximum torque in Nm (intermittent loading S6 cycle duration 10 min, ED. max. 60%)						
Input	[Nm]		900	*	210	532
Output	[Nm]	1.00	900	-	210	532
(max. accelerating torque)						
	[Nm]	3.19	2,871	-	-	-
	[Nm]	4.00	3,600	-	840	-
	[Nm]	5.00	-	-	-	2,660
Maximum permitted input speed						
▪ in reduction	[rpm]	≠1	5,000	3,500	12,500	12,500
▪ for direct drive	[rpm]	1 <sup>2)</sup>		3,000	12,000	10,400
Maximum vibration value	[mm/s]		3.0	5.0	<1.2	<1.6
At reference speed	[rpm]		4,000	2,500	12,500	12,500
Mass moment of inertia <sup>1)</sup>	[J in kgcm <sup>2</sup> ]	1.00	1,956	*	49	65
Output	[J in kgcm <sup>2</sup> ]	4.00	1,766	*	363	
Input	[J in kgcm <sup>2</sup> ]	4.00	110	*	21	
Output	[J in kgcm <sup>2</sup> ]	5.00				1,795
Input	[J in kgcm <sup>2</sup> ]	5.00				60
<b>Operating data</b>						
Weight (standard)	[approx kg]		175	180	52	120
<b>Electrical connection for shift unit</b>						
Power consumption	[W]		84	85	120	120
Supply voltage (at shift unit)	[V]		24±10%	24±10%	24 ±10%	24 ±10%
Current supply at 24 V	[A]		5.0	5.0	5.0	5.0

Operator is free to define bearing load and lifetime.  
See installation drawings or page 15-16 for bearing data.

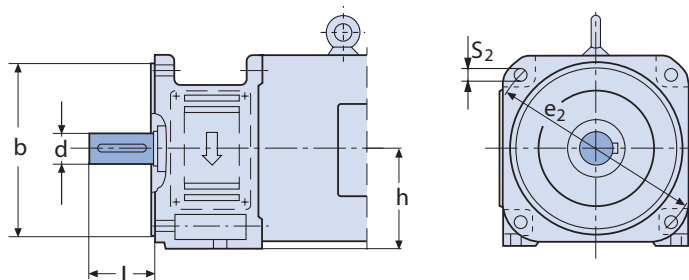
<sup>1)</sup> Mass moments of inertia for other ratios on request

<sup>2)</sup> Admissible with oil cooler, otherwise  $n_{max}$  for reduction ratio

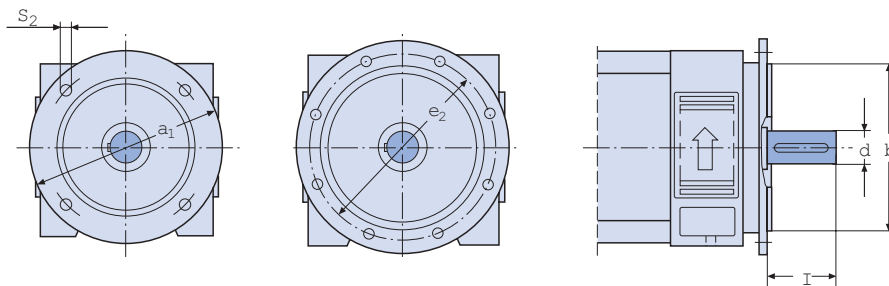
\* on request

## STANDARD MOTOR CONNECTION DIMENSIONS

ZF-Duoplan	2K 120	2K 121	2K 250	2K 300	2K 450	2K 600	2K 801	2K 802	2K 2100	2K 2100
Motor frame size	100	112	132	160	160/180	180	200	225	225	280
Standard motor connection dimension										
h	100	112	132	160	160/180	180	200	225	225	280
d	38	48	42	55	55/60	65	65	75	75	90
l	80±0.1	110±0.1	110-0.2	110-0.2	110-0.2	140-0.2	140±0.2	140±0.2	140±0.2	170±0.2
b	180	230	250	300	300	300	350	450	450	550
e <sub>2</sub>	215	265	300	350	350	400	400	500	500	600
a <sub>1</sub>	-	-	-	-	400	450	450	550	550	660
s <sub>2</sub>	14	15	18	18	18	18	19	19	19	24



2K 120 / 2K 121 / 2K 250 / 2K 300 / 2K 450 / 2K 600

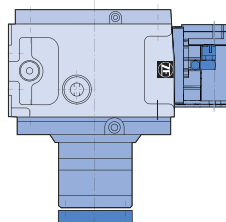
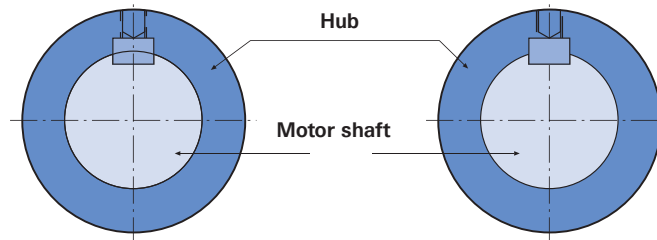


2K 800 / 2K 801 / 2K 802 / 2K 2100

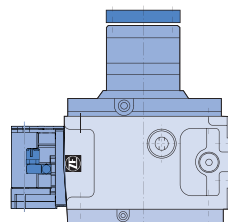
## MOTOR OUTPUT SHAFTS WITH STANDARD FITTED KEY

Gearbox sizes ZF-Duoplan	Shaft diameter [mm]	Fitted key b x h [mm]	Fitted key length [mm]
<b>2K 120 / 2K 121</b>	38	10x8	70
	32	10x8	70
	42	12x8	90
<b>2K 250</b>	42	12x8	90
	48	14x9	90
	55	16x10	90
<b>2K 300</b>	55	16x10	90
	48	14x9	90
	42	12x8	90
	60	18x11	125
<b>2K 450</b>	60	18x11	125
	55	16x10	90
<b>2K 600</b>	65	18x11	125
<b>2K 800 / 2K 801</b>	60/65	18x11	125
<b>2K 802 / 2K 2100</b>	75	20x12	125
	80	22x14	150

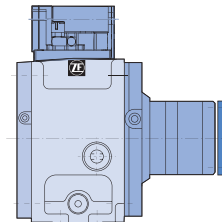
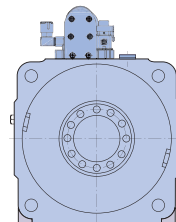
- See DIN ISO 21940-32.
- For half-key balancing the key type B is standard.
- For a full-key balanced motorshaft both types can be used.
- Application with smooth motorshaft without keyway on request.
- If a Siemens motor is used, only the full-key balanced shaft is possible.



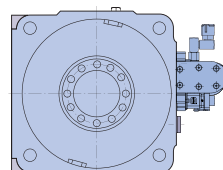
Vertical V1



Vertical V3



Horizontal B5



Horizontal B5  
Shift unit on right side  
(view from output)

B5 clockwise rotation for:  
2K 120 / 2K 250 / 2K 300 / 2K 450 /  
2K 600

# OUTPUT / MOTOR INTERFACE



## Output

There is a choice of two different output variants. The standard long bearing base output flange version is used for beltdrives, allowing high cantilever forces. For the 2K 300 an extended output version is optional for even higher belt forces. Further options include short output housings as ZF-Duoplan INLINE for space saving direct drives. This version is supplied as a standard with angular contact bearings. ZF-Duoplan TSC (Through-Spindle-Cooling) allows cutting liquids like emulsions, hydraulic oils and air-oil mixtures with up to 140 bars of pressure at a flow rate of 35 l/min through the gearbox and spindle, directly to the tool.

## Motor connection

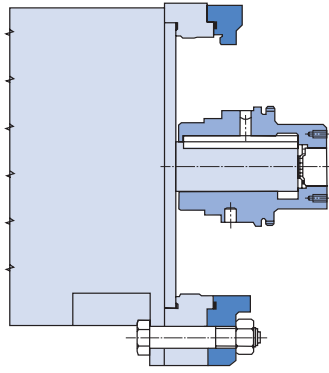
The hubs are generally fitted with a keyway for power gearbox. It should be noted that the hub must be balanced in the same way as the motor. There are two types of balancing: Half-key and full-key. In the case of full-key balancing, the motor shaft is balanced with a fitted key, the hub without. The length of the fitted key is unimportant in this instance.

In the case of half-key balance, however, the keyway is filled out with a balance compensator. The shape, length, and position of the keyway must be adapted. For this reason, it is necessary to provide ZF with details of the motor – including the relevant dimensions and balancing type – when ordering. For straight motor shaft a keyless hub with clamping ring is mandatory. To this end and in accordance with DIN 332-2, the motor shaft must feature a centering bore with a thread. If the motor connection dimensions do not permit direct mounting to the ZF-Duoplan, an adapter plate or adapter ring is required. These adapter parts can be included in the supply on request, depending to motor manufacturer.

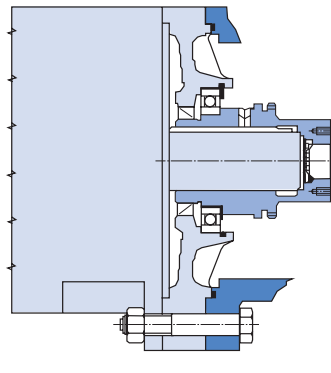
## Note

For motor-gearbox units that are fixed in the machine with the gearbox output housing/flange only, no preload support on motor B-side is permitted.

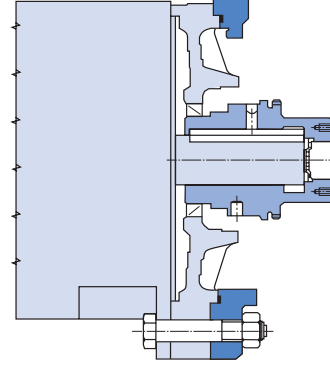
## POSSIBLE CONNECTIONS



Open Design  
(with/without adapter ring)



Closed Design  
(with hub bearing and shaft seal)



Closed Design  
(with shaft seal)

## GEARBOX INTERFACE

### Open design

The open version gearbox is without adapter plate. Sealing with motor shaft seal.

### Closed design (with hub bearing and shaft seal)

There is a version with ball bearing available for certain motors. The hub in this version is also fixed by the bearing to prevent axial hub movement, resp. present axial forces from the helical gearing onto the motor shaft (see technical data page 9). Assembly onto spindle motor is made easier due to a fixed hub position as supplied by the factory.

### Closed version (with shaft seal)

This version incorporates an adapter plate with shaft seal, which means that the gearbox forms a compact, closed unit.

### Adapter ring

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

### Input flange (2K 250 / 2K 300 / 2K 800 / 2K 2100)

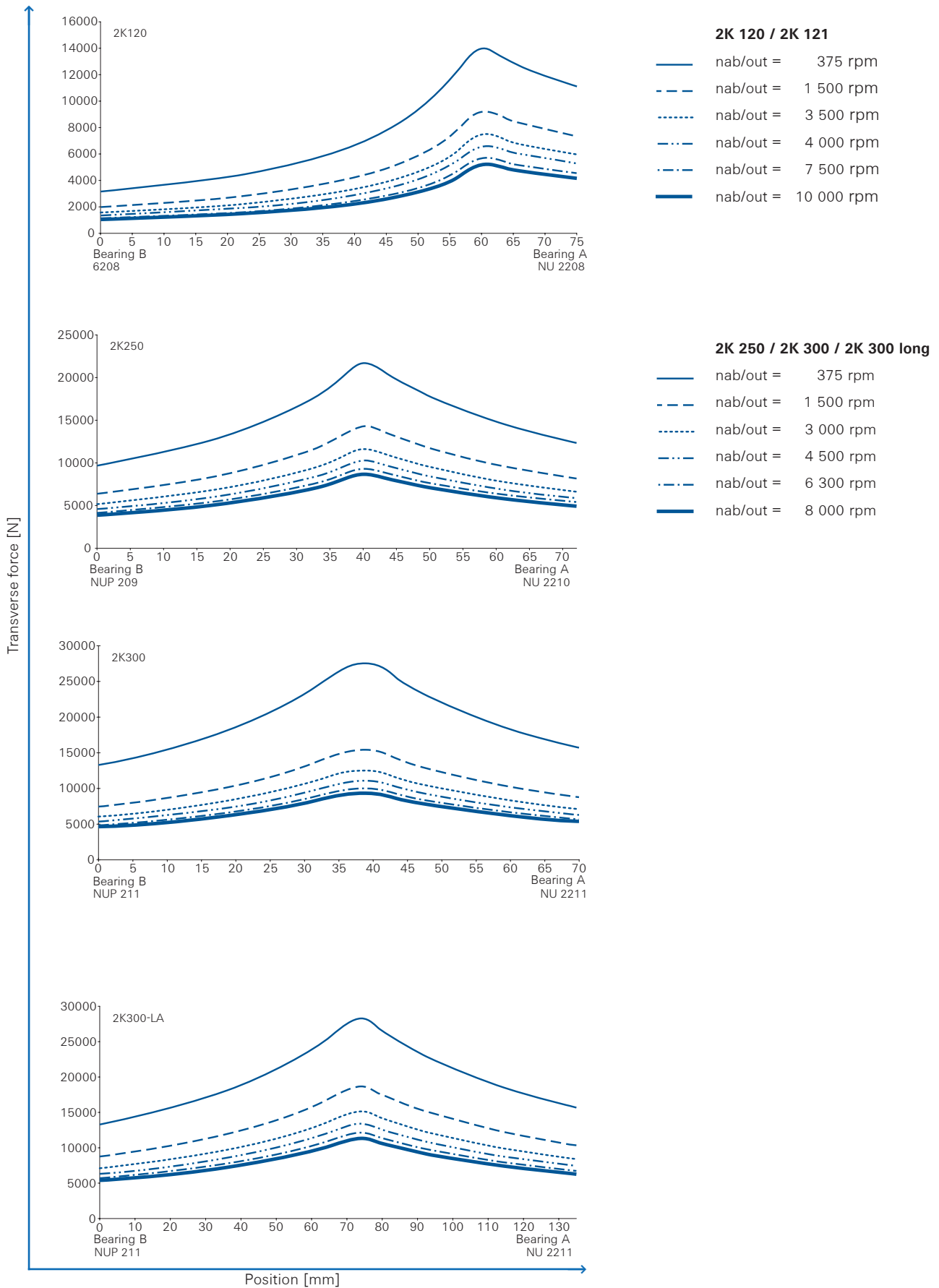
Besides the classic motor-gearbox-adaptation (motor shaft, key way, hub) we offer – on request – a gearbox with input flange to mount a pulley, clutch or similar (as shown on page 24).

### Output bearings

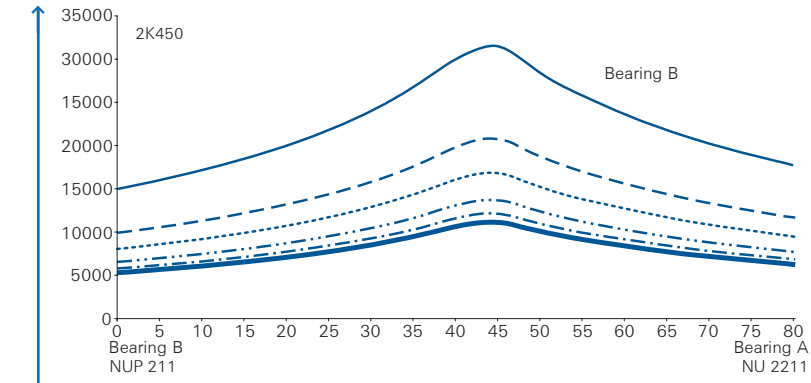
The output bearings vary depending on the type and level of load on the output shaft. Cylindrical roller bearings are used to cope with high radial forces, e.g. in belt pulley drives. In contrast, angular-contact ball bearings are suitable for coaxial drives, low radial backlash or axial forces. The flexible design of the output housings and shafts allows a range of selections.

## Versions and Lifetime Calculation based on XY-method

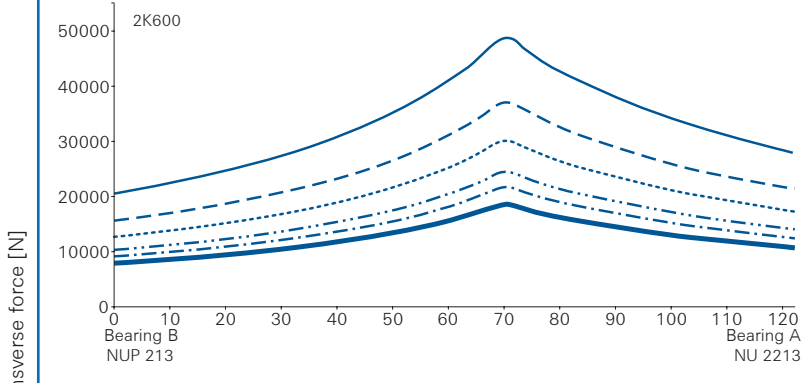
### The medium lateral force must be between the output bearings



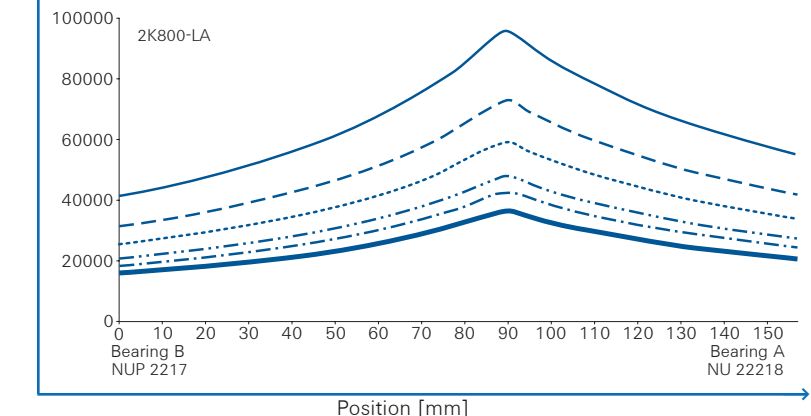
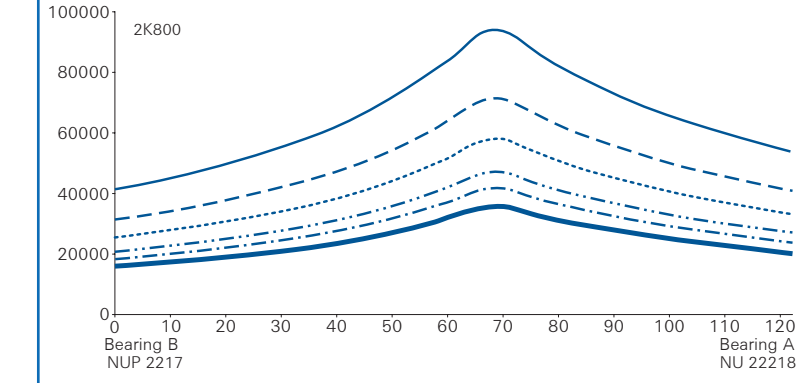




- 2K 450**
- nab/out = 250 rpm
  - - nab/out = 1 000 rpm
  - · · nab/out = 2 000 rpm
  - · - nab/out = 4 000 rpm
  - · - nab/out = 6 000 rpm
  - nab/out = 8 000 rpm

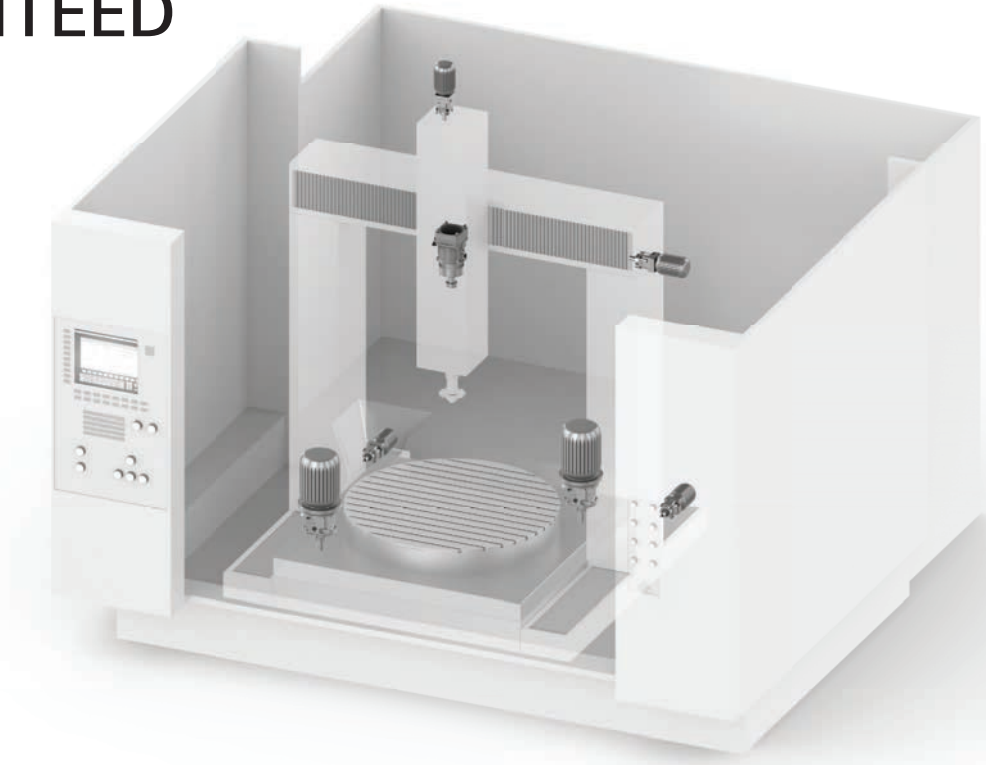


- 2K 600 / 2K 800 / 2K 800 long**
- nab/out = 200 rpm
  - - nab/out = 500 rpm
  - · · nab/out = 1 000 rpm
  - · - nab/out = 2 000 rpm
  - · - nab/out = 3 000 rpm
  - nab/out = 5 000 rpm



Position [mm]

# ZF-DUOPLAN – HIGH PERFORMANCE GUARANTEED



ZF-Duoplan gearboxes function as the core component of any machine tool and provide a powerful drive solution.

## **Torsional backlash**

- Three backlash classes in reduction mode are available: The circumferential backlash classes of the gearbox sizes can be found from page 32 onward.

## **Workpiece processing with constant cutting force**

- Class 3\*: Normal torsional backlash < 30 arcmin.
- Only for turning machine drives involving workpiece processing with constant cutting force.
- For turning machine drives when cutting is uninterrupted while the workpiece is being processed or in the case of predominant facing involving cutting speed adjustment.
- For boring mills, milling machines and machining centres.

## **Extreme milling work**

- Class 2: Reduced torsional backlash < 20 arcmin.
- For milling machines and machining centres used to execute extreme milling work, e.g. tool side milling cutters with very coarse index/division (interrupted cutting), workpieces made from tough material, milling of ribbed workpieces.

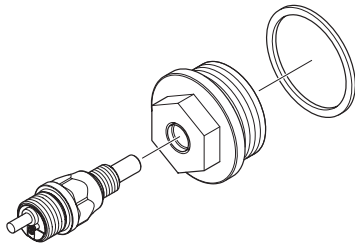
## **Highly-dynamic machine tools**

- Class 1: Especially reduced torsional backlash < 15 arcmin.
- As class 2: Except in lightweight highly-dynamic machine tools incorporating components with high internal elasticity; designed to prevent resonance vibration.

## LUBRICATION

### Splash type lubrication

The standard gearbox version B5 has splash type lubrication. Splash type lubrication is suitable for intermittent operation. In this instance, frequent gear changes, varying speeds and idle time (e.g. due to retooling) are a prerequisite.



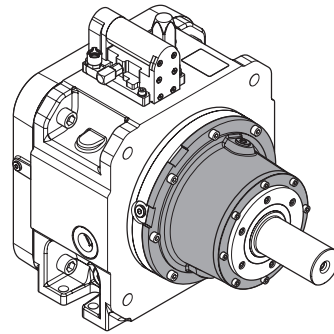
For applications with immersion lubrication, we recommend using an oil sensor to occasionally check the oil level before machine startup. (Oil sensor order number 4161.298.045)

### Recirculating lubrication

The 2K 120 / 2K 121 / 2K 250 / 2K 300 / 2K 450 / 2K 600 gearboxes (vertical V1 and V3 installation positions) require recirculating lubrication. In this instance, the type of recirculating lubrication depends on the operating temperature levels required. The 2K 800 / 2K 801 / 2K 802 and 2K 2100 gearboxes must always be operated with recirculating lubrication (refer also to installation drawings).

Figures on page 20-22 show the possible oil inlet and outlet positions on the gearbox. Please refer to the relevant installation drawings for detailed dimensions.

To ensure efficient cooling of the gearbox output, an optional cooling flange is available for the 2K 300. Other gearbox dimensions are available on request.



### Standard recirculating lubrication in V1/B5 with oil tank installation

The oil inlet is attached in place of the oil drain plug. The oil flow rate is approx. 1.5 l/min. (only for 2K 120 / 2K 121 / 2K 250 / 2K 300); approx. 2.0 l/min. (only for 2K 450 / 2K 600); approx. 2.5 l/min. (only for 2K 800). In the case of V3 vertical installation position, the lubrication oil can be supplied in either radial direction or centrally.

The tank of the pump unit must be ventilated. Oil back pressure in the return pipe to the gearbox must be avoided ( $\varnothing$  min. 20 mm). The tank capacity should be at least ten times the recirculating oil quantity. A 60  $\mu$ m filter and a pressure limitation valve should also be used as a safeguard.

### Recirculating lubrication with heat exchanger

A heat exchanger is installed in the recirculating lubrication system to assure additional temperature reduction. For best cooling results without any influence on lubrication, various connection parts for different installation positions and operating modes are provided. In order to achieve an optimal temperature development of the gearbox and to enable the max. speeds, an integrated oil channel version is offered (oil port connection see pages 20-22, ordering code see pages 32-37). In addition, it is possible to operate the 2K 250 / 300 without oil level (dry sump lubrication).



## CONNECTIONS FOR RECIRCULATING LUBRICATION

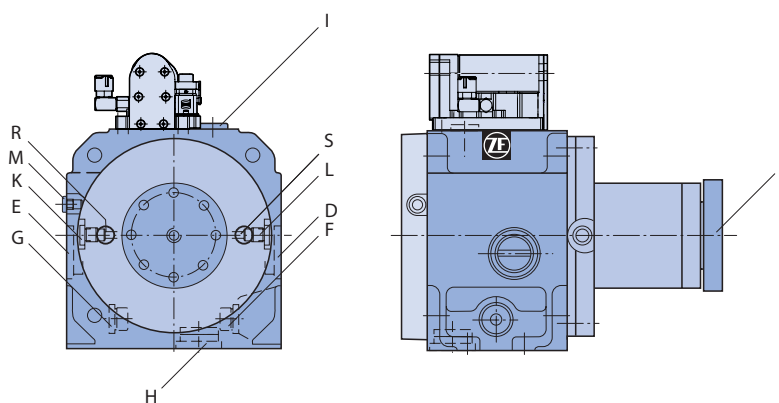
### 2K 120 / 2K 121

Installation position	Oil inlet*	Max. pressure	Oil outlet*
<b>V1 (closed version)</b>	M (0.5 l /min)	0.5 bar	D/E
	K/R und/oder L/S (1.0 l /min)	0.5 bar	
<b>V1 (open version)</b>	K/R und/oder L/S (1.5 l /min)	0.5 bar	D/E
<b>B5</b>	G (1.5 l /min)	1.5 bar	D/E
	F (1.5 l /min)	1.5 bar	
<b>B5 turned, right*</b>	I oder F (1.5 l /min)	1.5 bar	H
<b>V3</b>	P (1.5 l /min)	1.5 bar	H
	or K/R and/or L/S (1.5 l /min)	0.5 bar	

\* View toward gearbox output:  
D/G = Mainly counter clockwise rotation  
E/F = Mainly clockwise rotation

#### Note:

For applications using max. speeds of 12,000 rpm, it is mandatory to use port K and/or L with 1.5 dm<sup>3</sup>/min. In addition an oil recirculating system using an oil chiller with > 0.3 kW capacity and oil volume >15 liter is necessary.



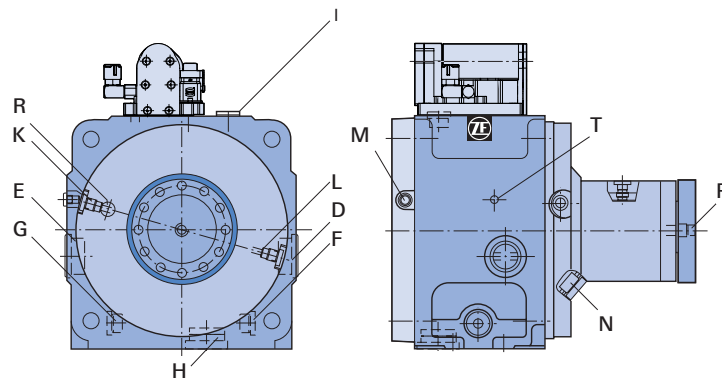
## CONNECTIONS FOR RECIRCULATING LUBRICATION

2K 250 / 2K 300				2K 450 / 2K 600		
Installation position	Oil inlet*	Max. pressure	Oil outlet*	Oil inlet*	Max. pressure	Oil Outlet*
<b>V1 (closed version)</b>	M (0.5 l /min)	0.5 bar	D/E	M (0.5 l /min)	0.5 bar	D/E
	K or R (1.0 l /min)	0.5 bar		T (1.5 l /min)	0.5 bar	
	L additional possible	1.5 bar		L additional possible	1.5 bar	
<b>V1, V3 (open version)</b>	K or R (1.5 l /min)	0.5 bar	D/E	T (2.0 l /min)	0.5 bar	D/E
	L additional possible	1.5 bar				
<b>B5</b>	G (1.5 l /min)	1.5 bar	D/E	G (2.0 l /min)	1.5 bar	D/E
	F (1.5 l /min)	1.5 bar		or F (2.0 l /min)	1.5 bar	
<b>B5 turned, right* (open version)</b>	I or F (1.5 l /min)	1.5 bar	H	I or F (2.0 l /min)	1.5 bar	H
<b>V3</b>	P (1.5 l /min)	1.5 bar	H	T (2.0 l /min)	1.5 bar	H
	K or R (1.5 l /min)	0.5 bar				
	L additional possible	1.5 bar				

\* View toward gearbox output:  
D/G = Mainly anti-clockwise rotation  
E/F = Mainly clockwise rotation  
In V1/V3 recirculation lubrication necessary for 2K 250 / 300

### Note:

For applications using max. speeds of 10,000 rpm port K or R is mandatory.  
In addition an oil recirculating system using an oil chiller > 0.3 kW and oil volume >15 litres is necessary.  
The integrate oil channel version is available for 2K 250 / 300 / 450 / 600 (see note page 33-35).  
This permits a gearbox operation without oil level, however a safety check of oil supply needs to be included in the oil system. A safeguard for the oil circulation amount is required however. See operating instructions for connections and delivery quantities. Essential for the oil circulation amount is always the amount which flows through the oil return.



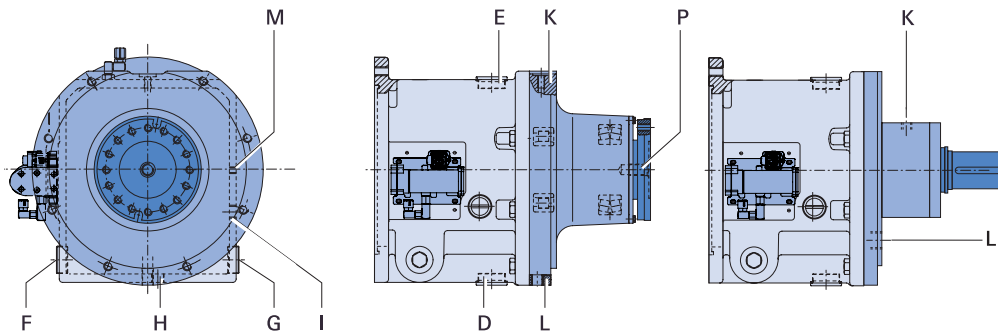
## CONNECTIONS FOR RECIRCULATING LUBRICATION

Installation position	2K 800 / 2K 801 / 2K 802			2K 2100		
	Oil inlet*	Max. pressure	Oil Outlet*	Oil inlet*	Max. pressure	Oil Outlet*
<b>B5</b>	M (0.5 l/min) K (2.5 l/min)	3 bar 5 bar	G or F or D	M (min. 3.0 l/min)	3 bar	E or F
<b>V1</b>	M (0.5 l/min) K (2.5 l/min)	3 bar 5 bar	D or E or L (with suction)	M (min. 3.0 l/min)	3 bar	D or E
<b>V3</b>	M (0.5 l/min) K (2.5 l/min) or M (0.5 l/min) P (2.5 l/min)	3 bar 5 bar 3 bar 5 bar	H und I (with suction) or G or F			

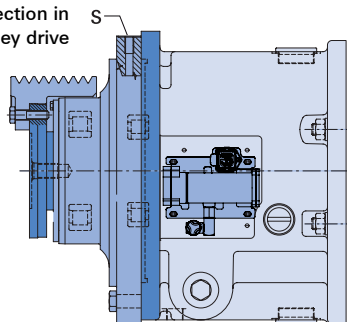
\* View toward gearbox output

\* Recirculating lubrication for all installation positions mandatory

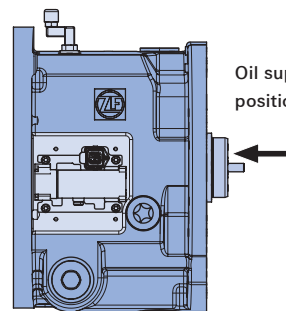
### 2K 800 / 2K 801 / 2K 802



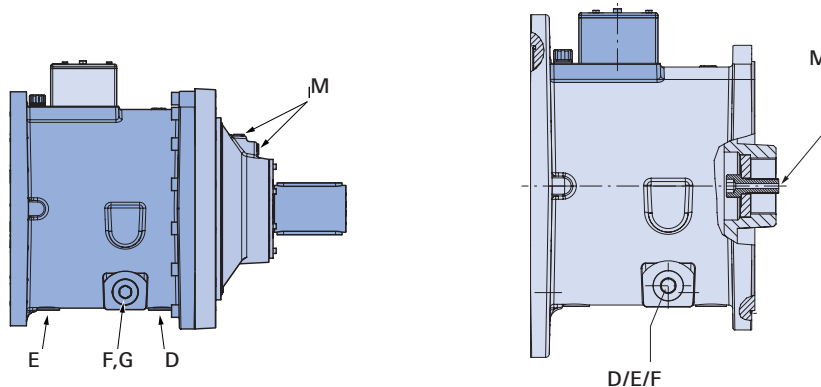
Oil feed for additional (0.5-1 l/min) connection in case of pulley drive



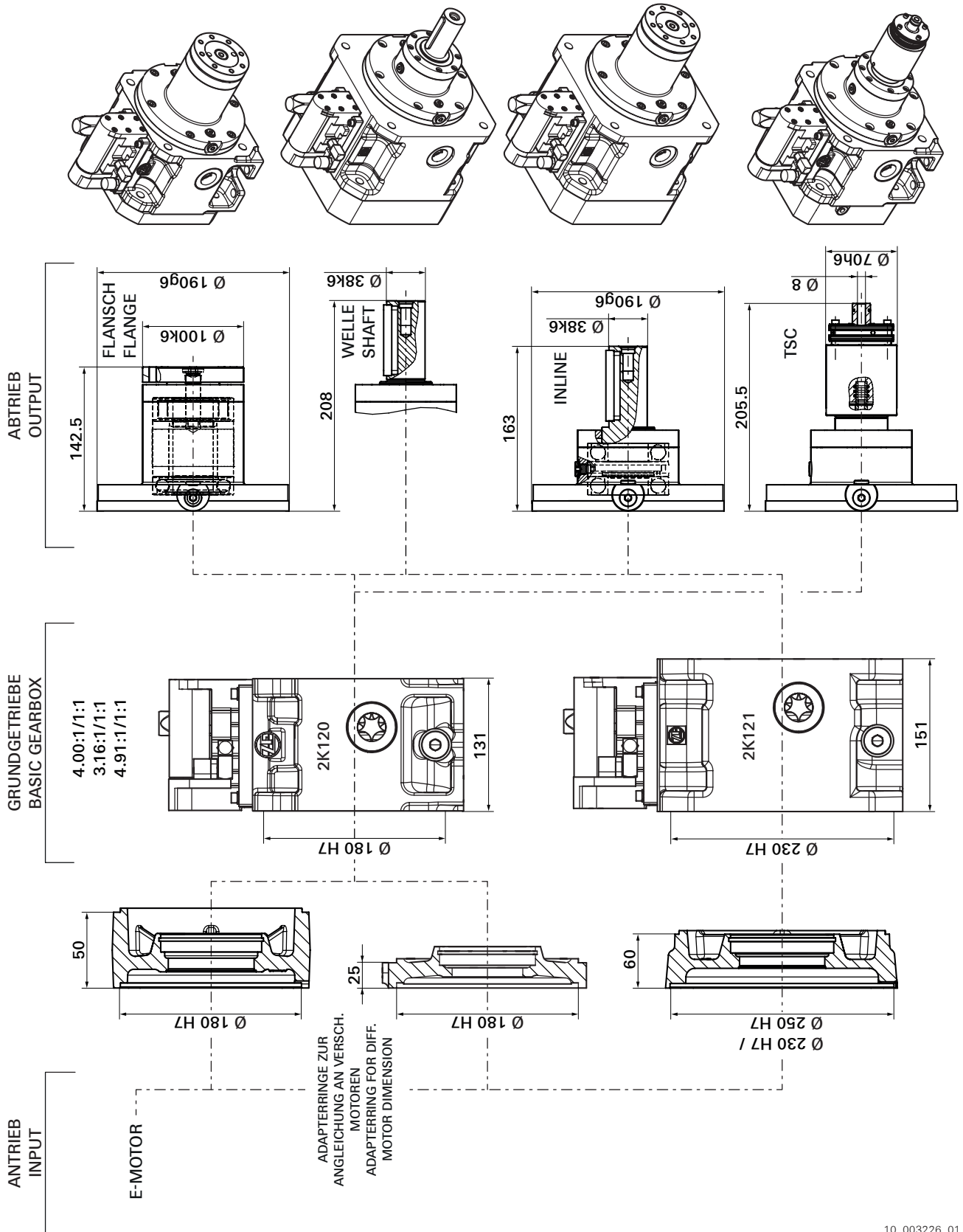
Oil supply in all installation positions 2.5 l/min



### 2K 2100



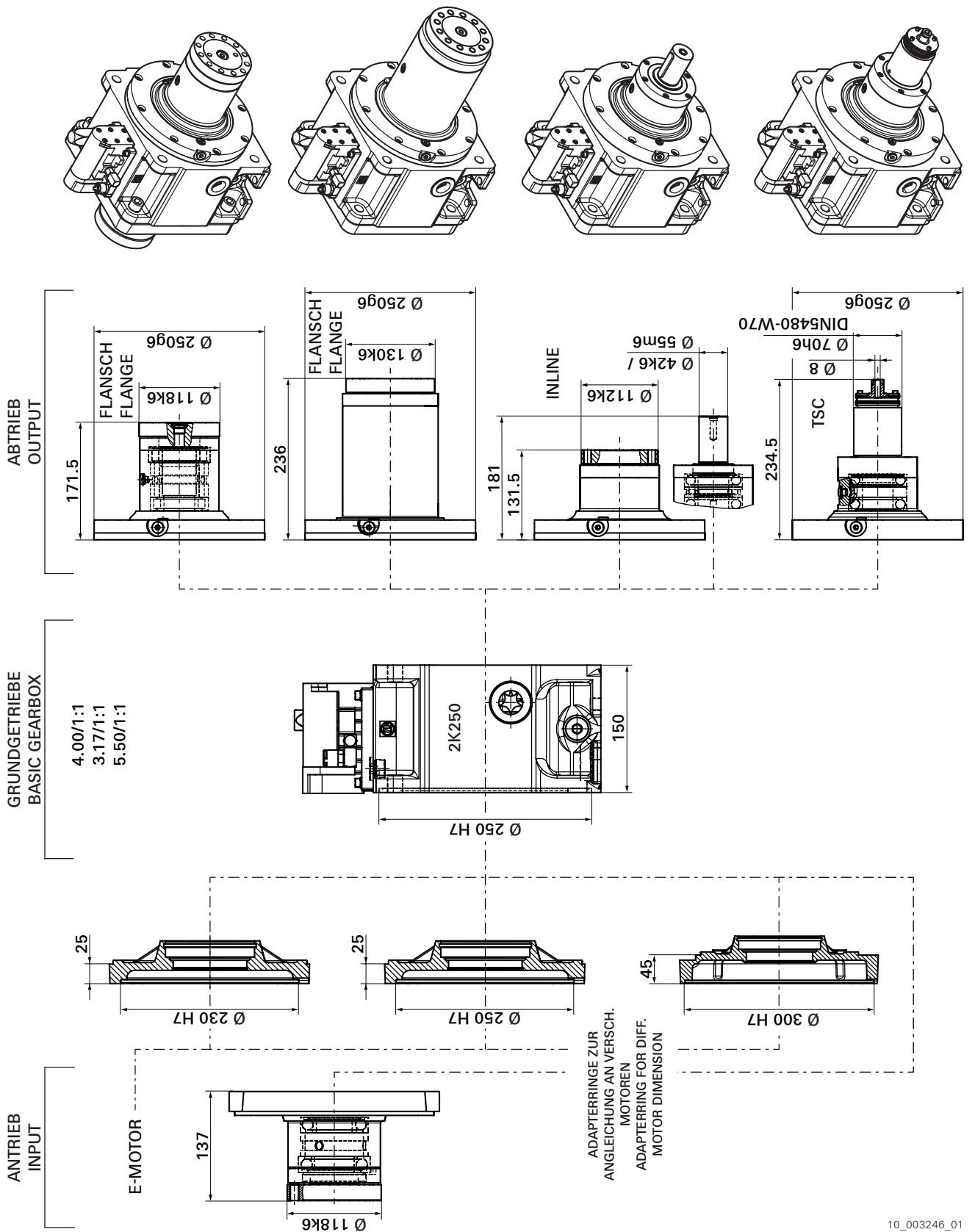
# GEARBOX SELECTION 2K 120 / 2K 121



10\_003226\_01

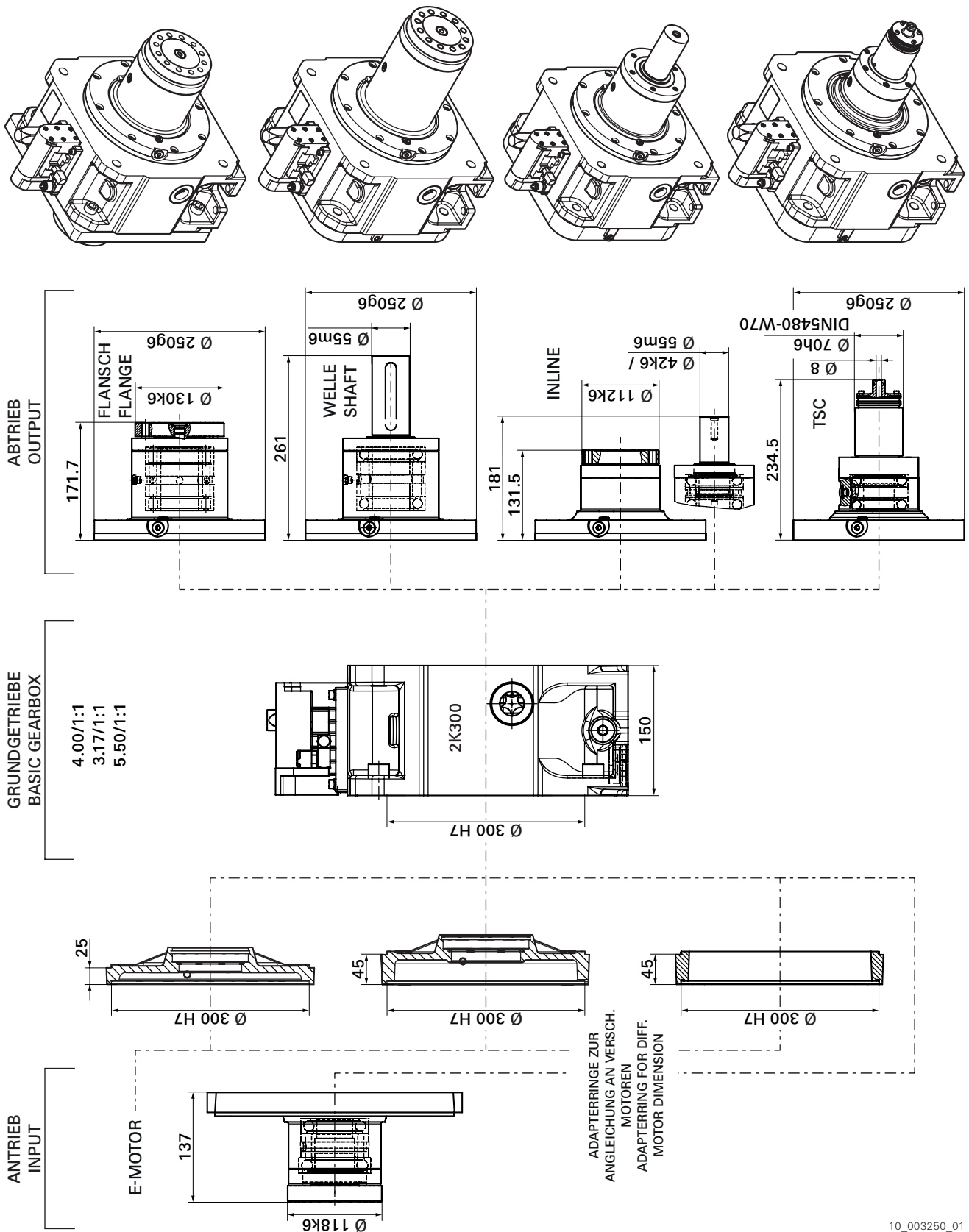


# GEARBOX SELECTION 2K 250



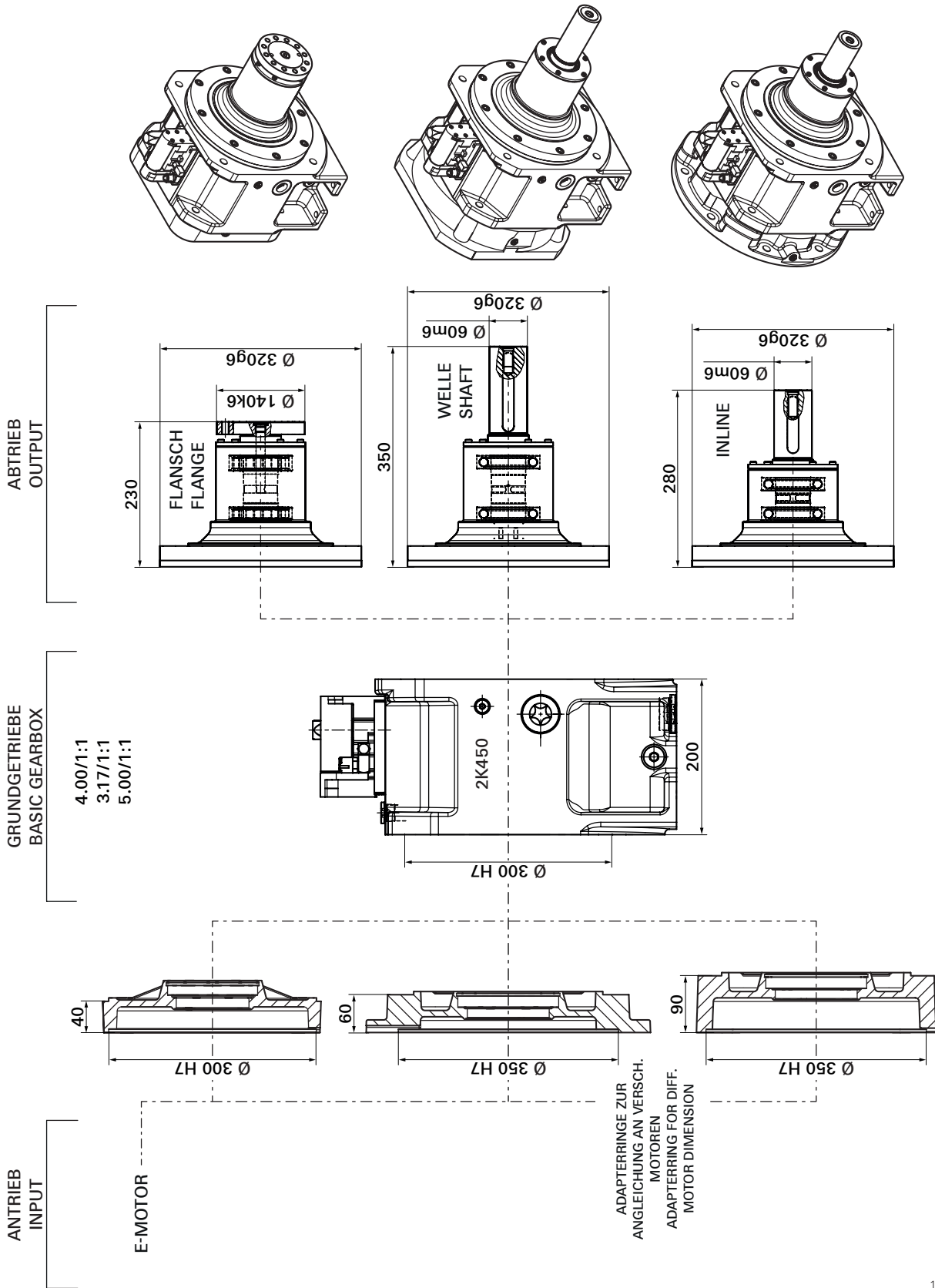
10\_003246\_01

# GEARBOX SELECTION 2K 300



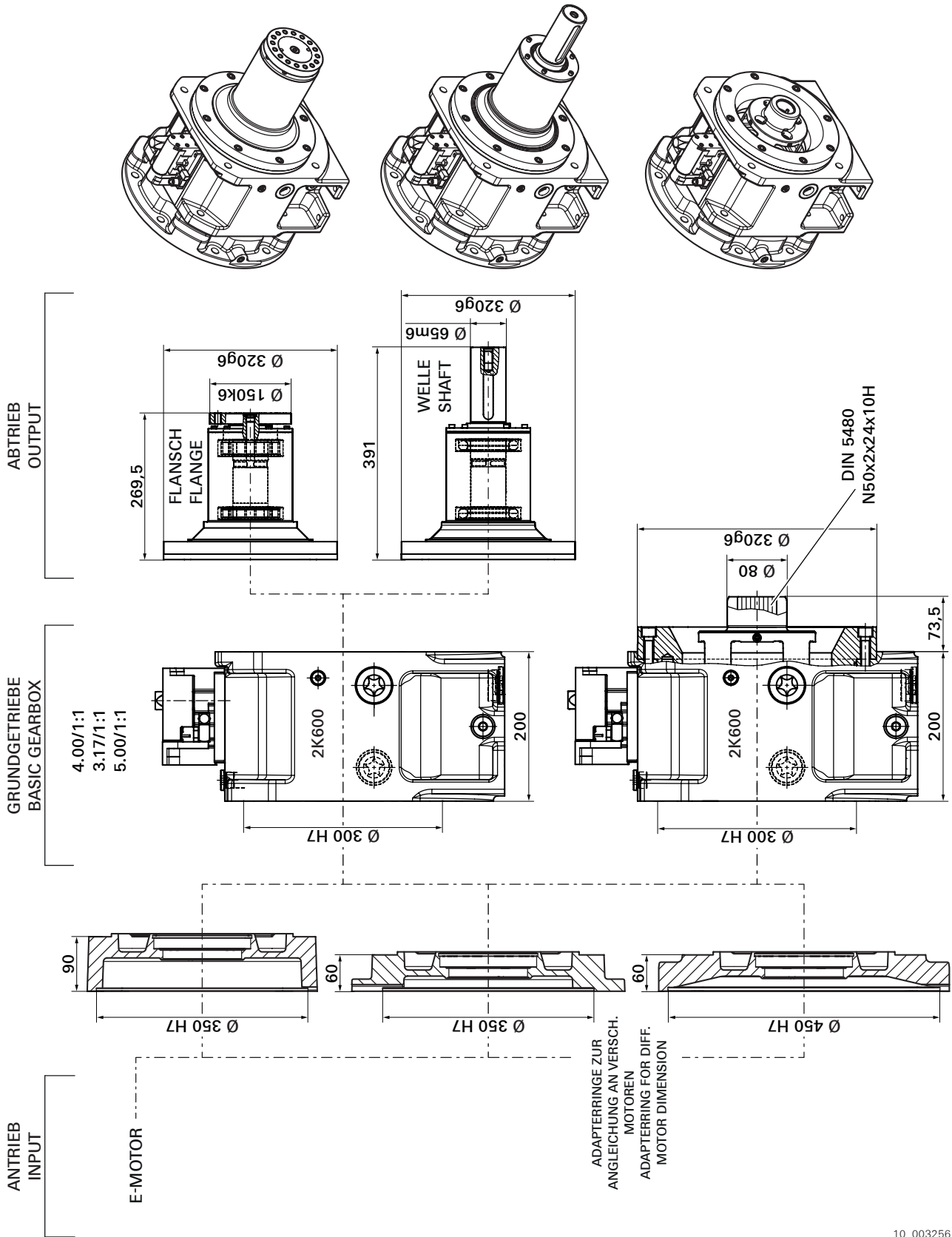
10\_003250\_01

# GEARBOX SELECTION 2K 450

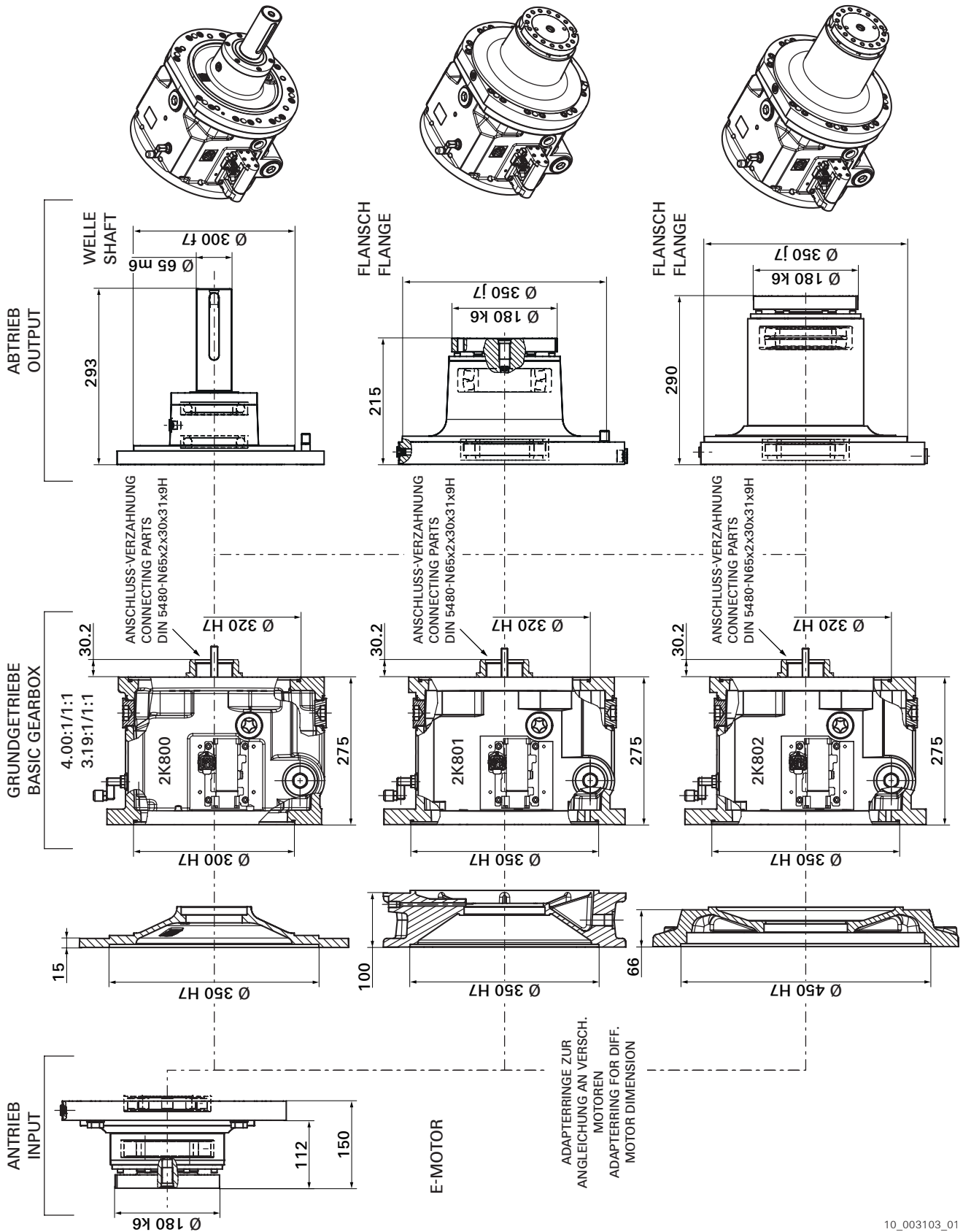


10\_003255\_01

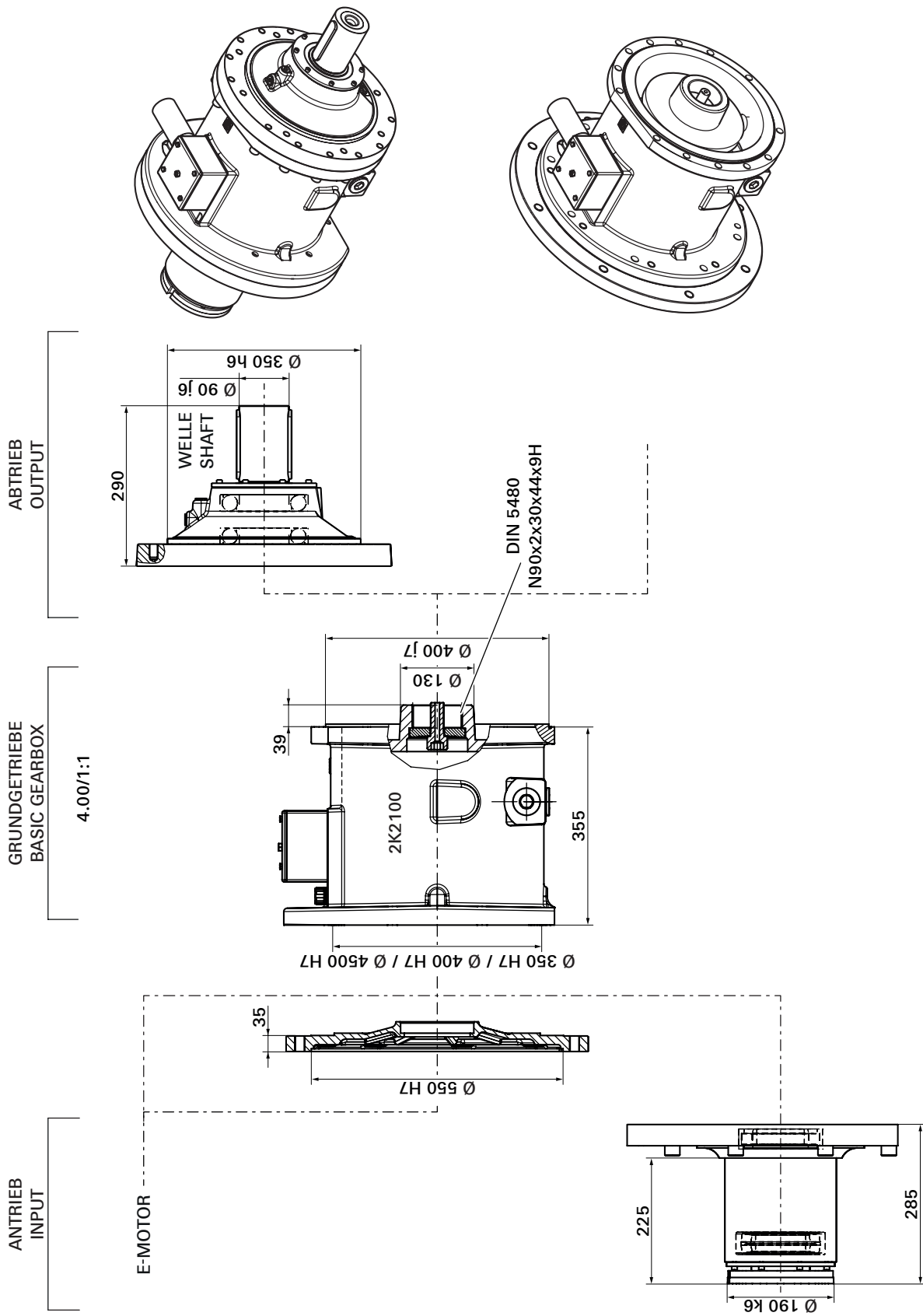
# GEARBOX SELECTION 2K 600



10\_003256\_01

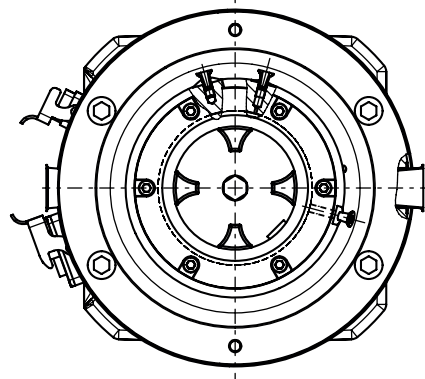
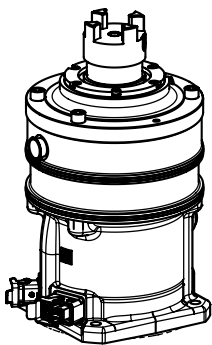
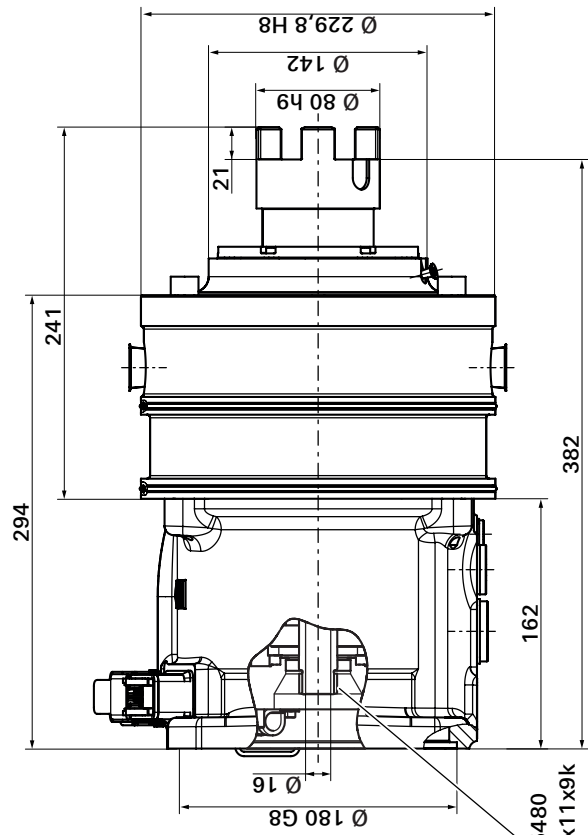
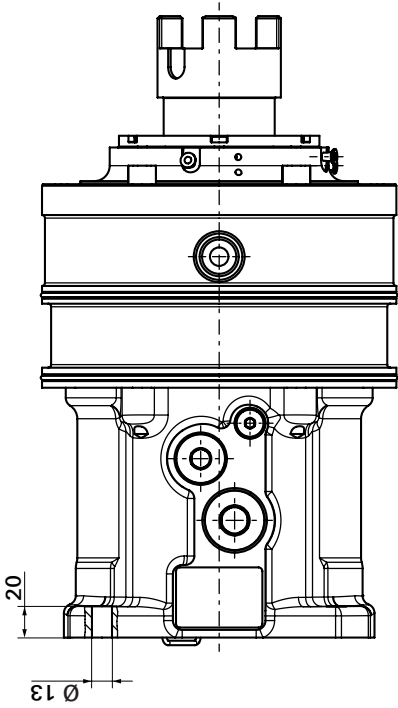
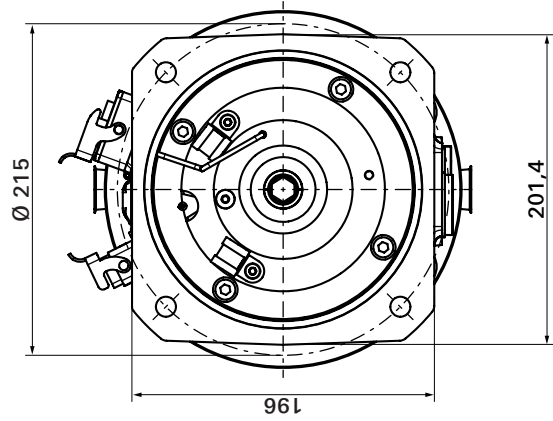
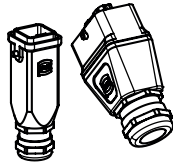


# GEARBOX SELECTION 2K 2100



10\_003257\_01

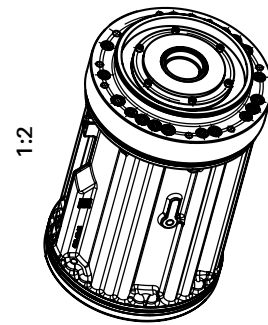
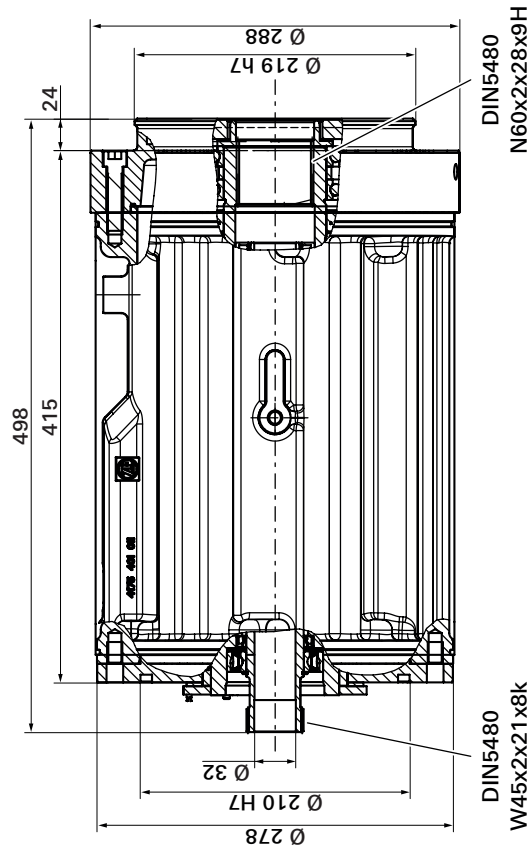
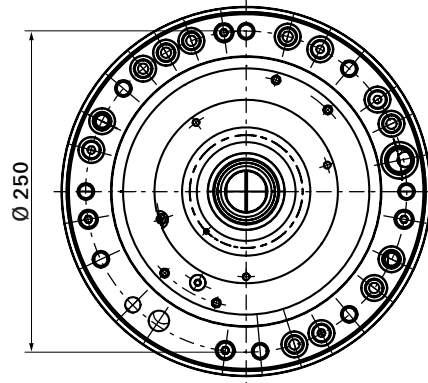
# GEARBOX SELECTION 2K 150 HS



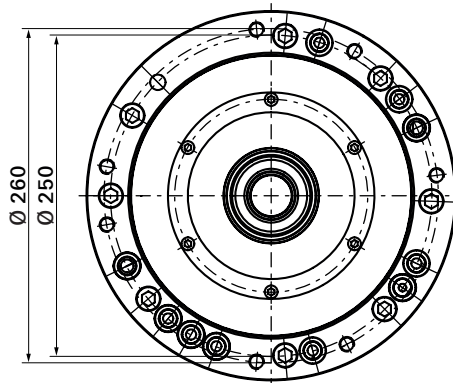
DIN5480  
W25x2x11x9k

GEARBOX SELECTION 2K 380 HWG

Input connection



Output connection





# ZF-DUOPLAN 2K 120 / 2K 121 STANDARD, INLINE, TSC – ORDER NUMBER

Note:  
**Standard = Bold type**  
 Option = Normal type

1) RWDR = Radial shaft seal  
 \* motor-specific, on request

2	L	G					-						-		0
---	---	---	--	--	--	--	---	--	--	--	--	--	---	--	---

## Two-speed gearbox

### Motor balancing

Without keyway\* central thread mandatory, motor shaft Ø max. 38 mm

#### Full-key

Half-key\*

### Gearbox interface (see page 14)

Open without hub

Open with hub

#### Closed with hub and hub bearing and RWDR<sup>1)</sup> \*

Closed with hub and RWDR<sup>1)</sup> \*

Open with hub and adapter ring \*

### ZF gearbox type for motor frame size / ratio

**100/i<sub>1</sub> = 4.00**

100/i<sub>1</sub> = 3.16

100/i<sub>1</sub> = 4.91

**112/i<sub>1</sub> = 4.00**

112/i<sub>1</sub> = 3.16

100/i<sub>1</sub> = 4.91

### Output bearings

#### Cylindrical roller / ball bearings

Angular-contact ball bearings

### Gearbox output

a<sub>1</sub> = 38 mm

**a<sub>1</sub> = 100 mm**

a<sub>1</sub> = 38 mm, smooth, without keyway

a<sub>1</sub> = 38 mm, INLINE

a<sub>1</sub> = 38 mm, INLINE, smooth, without keyway

a<sub>1</sub> = 70 x 70 mm, INLINE, TSC

a<sub>1</sub> = 70 x 70 mm, DIN 5480, INLINE, TSC

### Installation position

#### V1 / V3 / B5 / B5 (clockwise rotation)

V3 central lube oil supply in output shaft / radial lube oil

supply in bearing housing

### Motor shaft diameter "d"

Without hub

28 mm x 60 mm

32 mm x 80mm

**38 mm x 80 mm**

42 mm x 110 mm

48 mm x 110 mm

### Torsional backlash on gearbox output

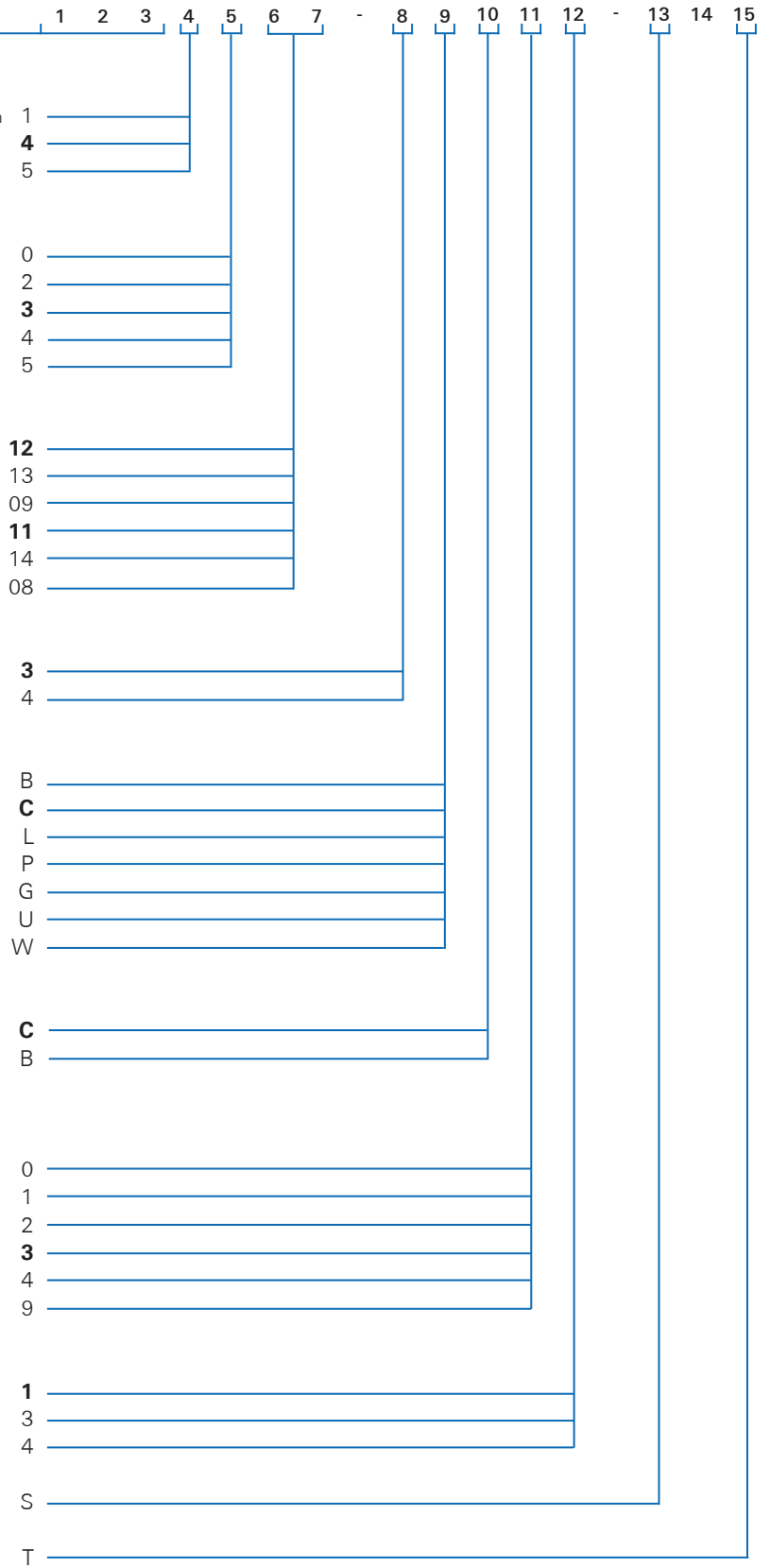
**Normal backlash max. 30 arcmin**

Reduced backlash max. 20 arcmin

Minimal reduced backlash max. 15 arcmin

### Reduced vibration

### Rotary union for output shaft



# ZF-DUOPLAN 2K 250 STANDARD, INLINE, TSC – ORDER NUMBER

Note:  
**Standard = Bold type**  
 Option = Normal type

1) RWDR = Radial shaft seal  
 \* motor-specific, on request

## Two-speed gearbox

### Motor balancing

Without keyway\*, central thread mandatory,  
 motor shaft Ø max. 55 mm

### Full-key

Half-key\*

### Gearbox interface (see page 14)

Open without hub

Open with hub

### Closed with hub and hub bearing and RWDR<sup>1)</sup> \*

Closed with hub and RWDR<sup>1)</sup> \*

Open with hub and adapter ring \*

Input flange D = 118 (2K 250 standard)

### Gearbox type

**132/i<sub>1</sub> = 4.00**

132/i<sub>1</sub> = 3.17

132/i<sub>1</sub> = 5.50 (not for TSC)

### Output bearings

#### Cylindrical roller / ball bearings

Angular-contact ball bearings

Spindle ball bearings

### Gearbox output

**a<sub>1</sub> = 118 mm**

a<sub>1</sub> = 130 mm

a<sub>1</sub> = 130 mm, wide bearing base

a<sub>1</sub> = 42 mm

a<sub>1</sub> = 42 mm, smooth, without keyway

a<sub>1</sub> = 42 mm, INLINE

a<sub>1</sub> = 42 mm, INLINE, smooth, without keyway

a<sub>1</sub> = 55 mm

a<sub>1</sub> = 55 mm, smooth, without keyway

a<sub>1</sub> = 55 mm, INLINE

a<sub>1</sub> = 55 mm, INLINE, smooth, without keyway

a<sub>1</sub> = 70 x 70 mm, INLINE, TSC

a<sub>1</sub> = 70 x 70 mm, DIN 5480, INLINE, TSC

a<sub>1</sub> = 112 mm, INLINE

### Installation position

**B5**

V1 / B5 (clockwise rotation)

V3 central lube oil supply in output shaft / radial lube oil

supply in bearing housing

### Motor shaft diameter "d"

Without hub

**42 mm x 110 mm**

48 mm x 110 mm

55 mm x 110 mm

60 mm x 140 mm

### Torsional backlash on gearbox output

**Normal backlash max. 30 arcmin**

Reduced backlash max. 20 arcmin

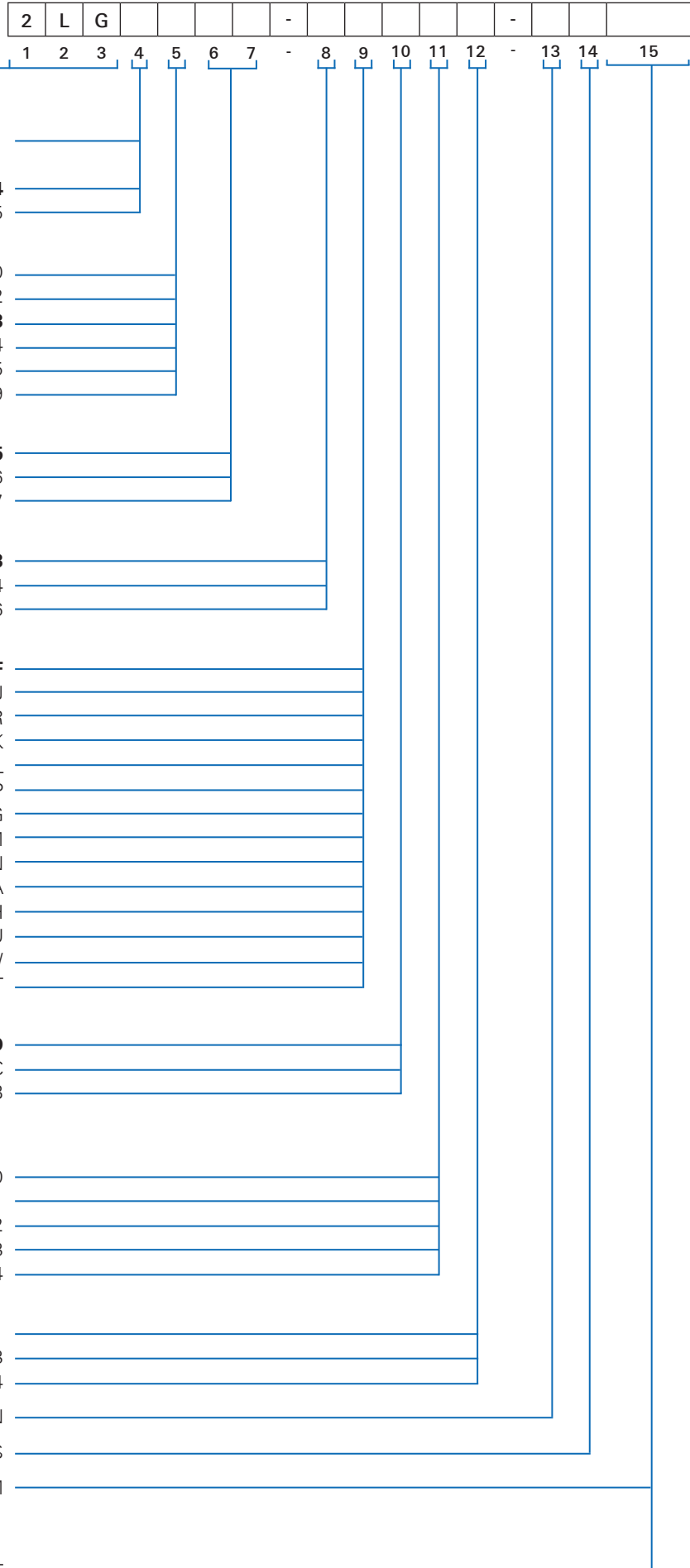
Minimal reduced backlash max. 15 arcmin

### Neutral shift position

### Reduced vibration

**Integrated oil channel version** for max. speeds and dry  
 sump lubrication (for B5 please order V1 version)

### Rotary union for output shaft



# ZF-DUOPLAN 2K 300 STANDARD, INLINE, TSC – ORDER NUMBER

Note:  
**Standard = Bold type**  
 Option = Normal type

1) RWDR = Radial shaft seal  
 \* motor-specific, on request

2	L	G					-						-			
1	2	3	4	5	6	7	-	8	9	10	11	12	-	13	14	15

## Two-speed gearbox

### Motor balancing

Without keyway\*, central thread mandatory, motor shaft Ø max. 55 mm

#### Full-key

Half-key\*

### Gearbox interface (see page 14)

Open without hub

Open with hub

#### Closed with hub and hub bearing and RWDR<sup>1)</sup> \*

Closed with hub and RWDR<sup>1)</sup> \*

Open with hub and adapter ring \*

Input flange D = 118

### Gearbox type

**160/i<sub>1</sub> = 4.00**

160/i<sub>1</sub> = 3.17

160/i<sub>1</sub> = 5.50 (not for TSC)

### Output bearings

#### Cylindrical roller / ball bearings

Angular-contact ball bearings

Spindle ball bearings

### Gearbox output

a<sub>1</sub> = 118 mm

**a<sub>1</sub> = 130 mm**

a<sub>1</sub> = 130 mm, wide bearing base

a<sub>1</sub> = 42 mm

a<sub>1</sub> = 42 mm, smooth, without keyway

a<sub>1</sub> = 42 mm, INLINE

a<sub>1</sub> = 42 mm, INLINE, smooth, without keyway

a<sub>1</sub> = 55 mm

a<sub>1</sub> = 55 mm, smooth, without keyway

a<sub>1</sub> = 55 mm, INLINE

a<sub>1</sub> = 55 mm, INLINE, smooth, without keyway

a<sub>1</sub> = 70 x 70 mm, INLINE, TSC

a<sub>1</sub> = 70 x 70 mm, DIN 5480, INLINE, TSC

a<sub>1</sub> = 112 mm, INLINE

### Installation position

#### B5

V1 / B5 (clockwise rotation)

V3 central lube oil supply in output shaft / radial lube oil

supply in bearing housing

### Motor shaft diameter "d"

Without hub

**55 mm x 110 mm**

48 mm x 110 mm

42 mm x 110 mm

60 mm x 140 mm

### Torsional backlash on gearbox output

**Normal backlash max. 30 arcmin**

Reduced backlash max. 20 arcmin

Minimal reduced backlash max. 15 arcmin

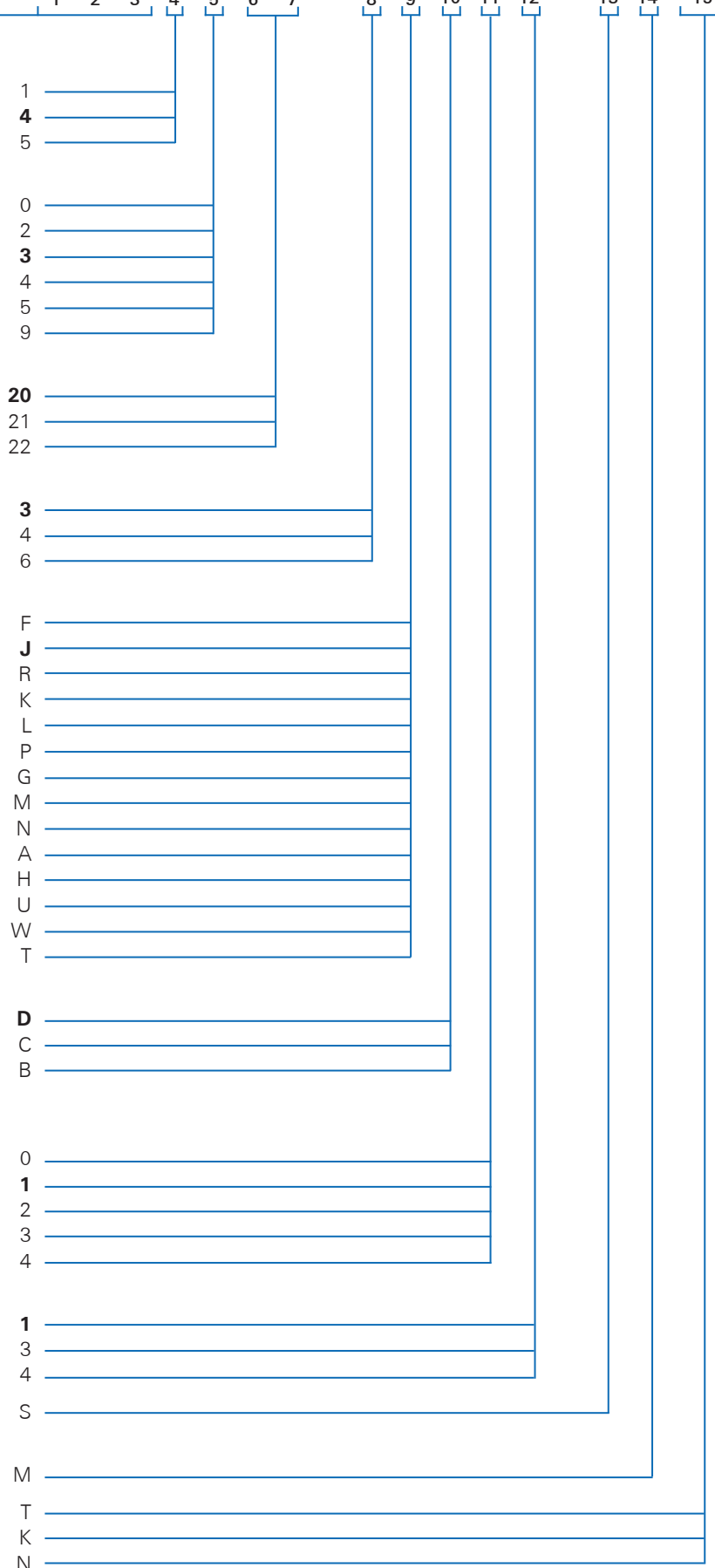
### Reduced vibration

**Integrated oil channel version** for max. speeds and dry sump lubrication (for B5 please order V1 version)

### Rotary union for output shaft

**Cooling flange in combination with ordering „M“**

**Neutral shift position**



# ZF-DUOPLAN 2K 450 / 2K 600 STANDARD, INLINE – ORDER NUMBER

Note:  
**Standard = Bold type**  
 Option = Normal type

1) RWDR = Radial shaft seal  
 \* motor-specific, on request

2	L	G					-						-			0	0
1	2	3	4	5	6	7	-	8	9	10	11	12	-	13	14	15	

## Two-speed gearbox

### Motor balancing

**Full-key**

Half-key\*

### Gearbox interface (see page 14)

Open without hub

Open with hub

**Closed with hub and hub bearing and RWDR<sup>1)</sup> \***

### Gearbox type

**160/i<sub>1</sub> = 4.00 Spigot Ø 300 mm**

160/i<sub>1</sub> = 5.00 Spigot Ø 300 mm

160/i<sub>1</sub> = 3.172 Spigot Ø 300 mm

**180/i<sub>1</sub> = 4.00 Spigot Ø 300 mm**

180/i<sub>1</sub> = 5.00 Spigot Ø 300 mm

180/i<sub>1</sub> = 3.172 Spigot Ø 300 mm

**200/i<sub>1</sub> = 4.00 Spigot Ø 350 mm**

200/i<sub>1</sub> = 5.00 Spigot Ø 350 mm

200/i<sub>1</sub> = 3.172 Spigot Ø 350 mm

**225/i<sub>1</sub> = 4.00 Spigot Ø 450 mm**

225/i<sub>1</sub> = 5.00 Spigot Ø 450 mm

225/i<sub>1</sub> = 3.172 Spigot Ø 450 mm

### Output bearings

Without output

**Cylindrical roller ball bearings**

Angular-contact ball bearings

### Gearbox output

Without, driving spline N50

**a<sub>1</sub> = 140 mm (2K 450)**

**a<sub>1</sub> = 150 mm (2K 600)**

a<sub>1</sub> = 60 mm (2K 450)

a<sub>1</sub> = 60 mm, smooth, without keyway (2K 450)

a<sub>1</sub> = 60 mm, INLINE (2K 450)

a<sub>1</sub> = 60 mm, INLINE (2K 450), smooth, without keyway

a<sub>1</sub> = 65 mm (2K 600)

a<sub>1</sub> = 65 mm, smooth, without keyway (2K 600)

### Installation position

**B5 / V1 / V3**

### Motor shaft diameter "d"

Without hub

**60 mm x 140 mm (2K 450)**

**65 mm x 140 mm (2K 600)**

70 mm x 140 mm

75 mm x 140 mm

80 mm x 170 mm

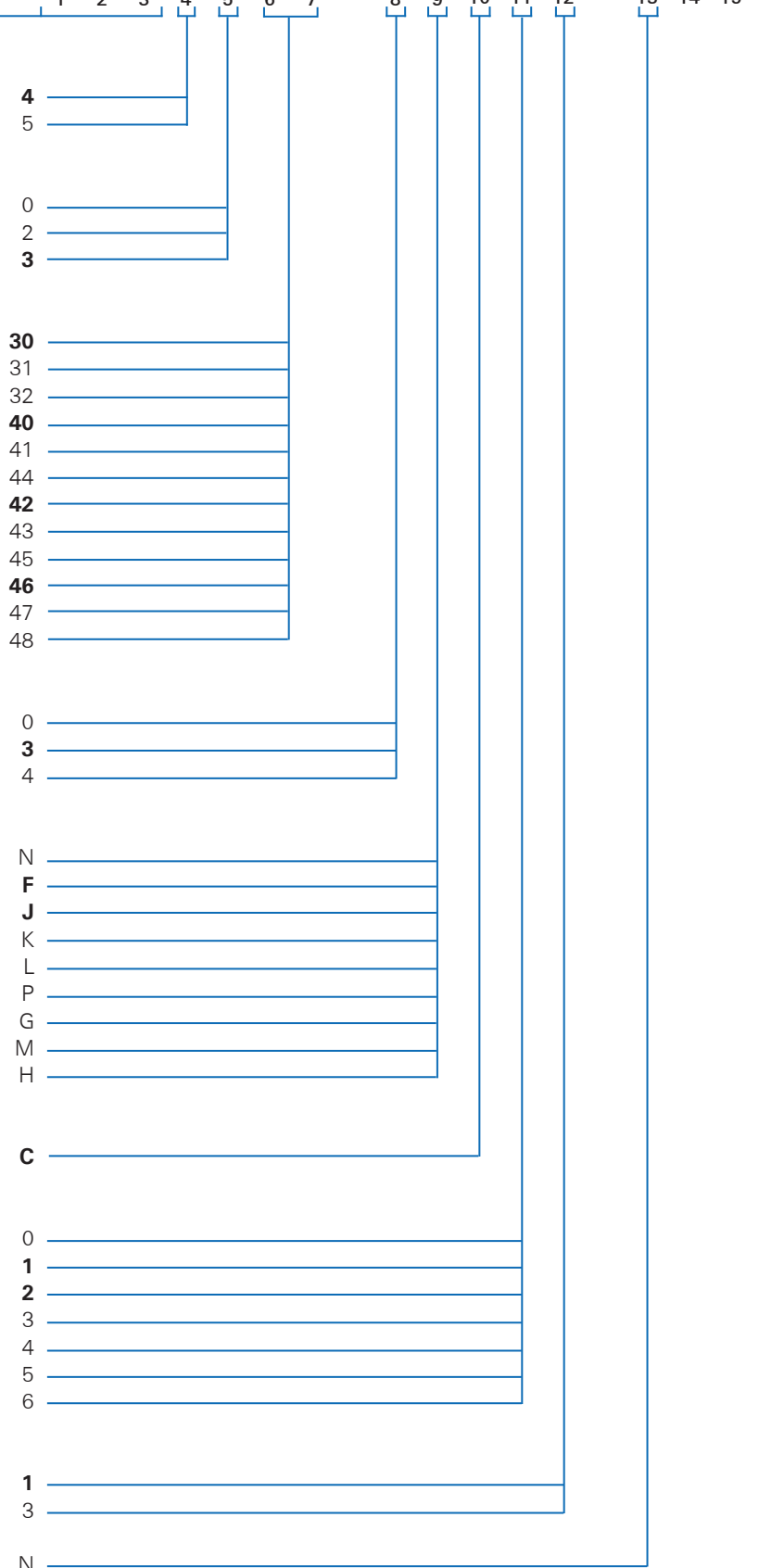
55 mm x 110 mm

### Torsional backlash on gearbox output

**Normal backlash max. 30 arcmin**

Reduced backlash max. 20 arcmin

### Neutral shift position



# ZF-DUOPLAN 2K 2K 800 / 2K 801 / 2K 802 STANDARD – ORDER NUMBER

Note:  
**Standard = Bold type**  
 Option = Normal type

1) RWDR = Radial shaft seal  
 \* motor-specific, on request

2	L	G					-					-		0	0
1	2	3	4	5	6	7	-	8	9	10	11	12	-	13	14 15

## Two-speed gearbox

### Motor balancing

**Full-key**  
 Half-key\*

### Gearbox interface (see page 14)

Open without hub  
 Open with hub  
 Closed with hub and RWDR<sup>1)</sup> \*  
 Open with hub and adapter ring \*  
 Input flange (Ø = 180 k6)

### Gearbox type

**180/i<sub>1</sub> = 4.00**      **Spigot Ø 300 mm**  
 180/i<sub>1</sub> = 3.19      Spigot Ø 300 mm  
**200/i<sub>1</sub> = 4.00**      **Spigot Ø 350 mm**  
 200/i<sub>1</sub> = 3.19      Spigot Ø 350 mm  
**225/i<sub>1</sub> = 4.00**      **Spigot Ø 450 mm**  
 160/i<sub>1</sub> = 3.19      Spigot Ø 450 mm  
 Ratio i = 5.00\*\*

### Holding brake

**without holding brake**

### Gearbox output

Without, driving spline N65  
 Without, driving spline N80\*\*  
 a<sub>1</sub> = 65 mm  
 a<sub>1</sub> = 65 mm, smooth without keyway  
**a<sub>1</sub> = 180 mm**  
 a<sub>1</sub> = 180 mm, wide bearing base

### Installation position

**V1 / B5**  
 V3

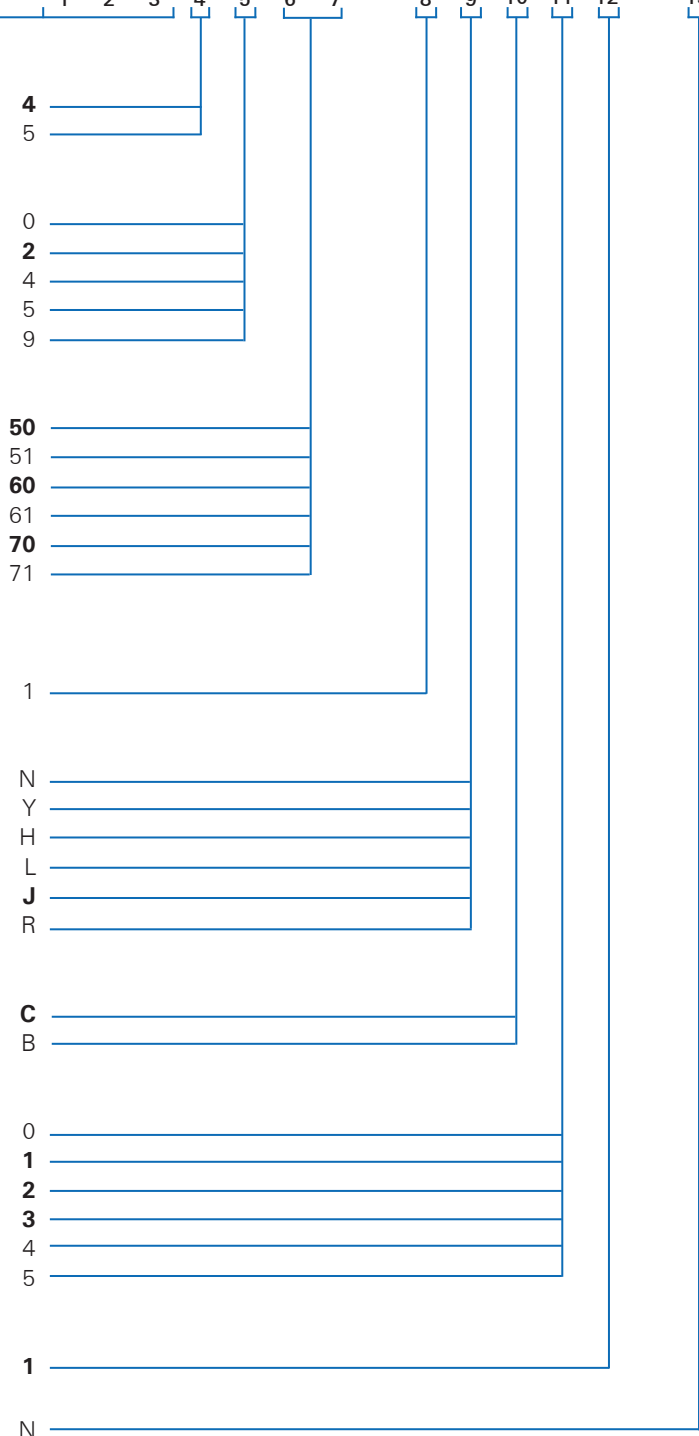
### Motor shaft diameter "d"

Without hub  
**60 mm x 140 mm**  
**65 mm x 140 mm**  
**75 mm x 140 mm**  
 80 mm x 170 mm  
 70 mm x 140 mm

### Torsional backlash on gearbox output

**Normal backlash max. 40 arcmin**

### Neutral shift position



\*\* On request

## ZF-DUOPLAN 2K 2100 STANDARD – ORDER NUMBER

Hinweis:  
**Standard = Fett gedruckt**  
 Option = Normal gedruckt

1) RWDR = Radial shaft seal  
 \* motor-specific, on request

2	L	G					-						-		0	0
1	2	3	4	5	6	7	-	8	9	10	11	12	-	13	14	15

### Two-speed gearbox

#### Motor balancing

**Full-key**  
 Half-key\*

#### Gearbox interface (see page 14)

Open without hub

#### Open with hub

Closed with hub and hub bearing and RWDR<sup>1)</sup> \*  
 Open with hub and adapter ring \*  
 Input flange (Ø = 190 k6)

#### Gearbox type

##### Spigot Ø 450 mm, FF500

Spigot Ø 400 mm, special motor  
 Spigot Ø 350 mm, FF400  
 Spigot Ø 550 mm, FF600  
 Spigot Ø 680 mm, FF740

#### Holding brake

**Without holding brake**

#### Gearbox output

##### Without output, driving spline N90

STW, i = 3.196 on request  
 $a_1 = \text{Ø } 90 \times 140$ , keyway 2 x 25 x 14 x 125  
 $a_1 = \text{Ø } 90 \times 140$ , smooth

#### Installation position

##### V1 / B5

V3 central lube oil supply in output shaft

#### Torsional backlash on gearbox output "d"

Without hub

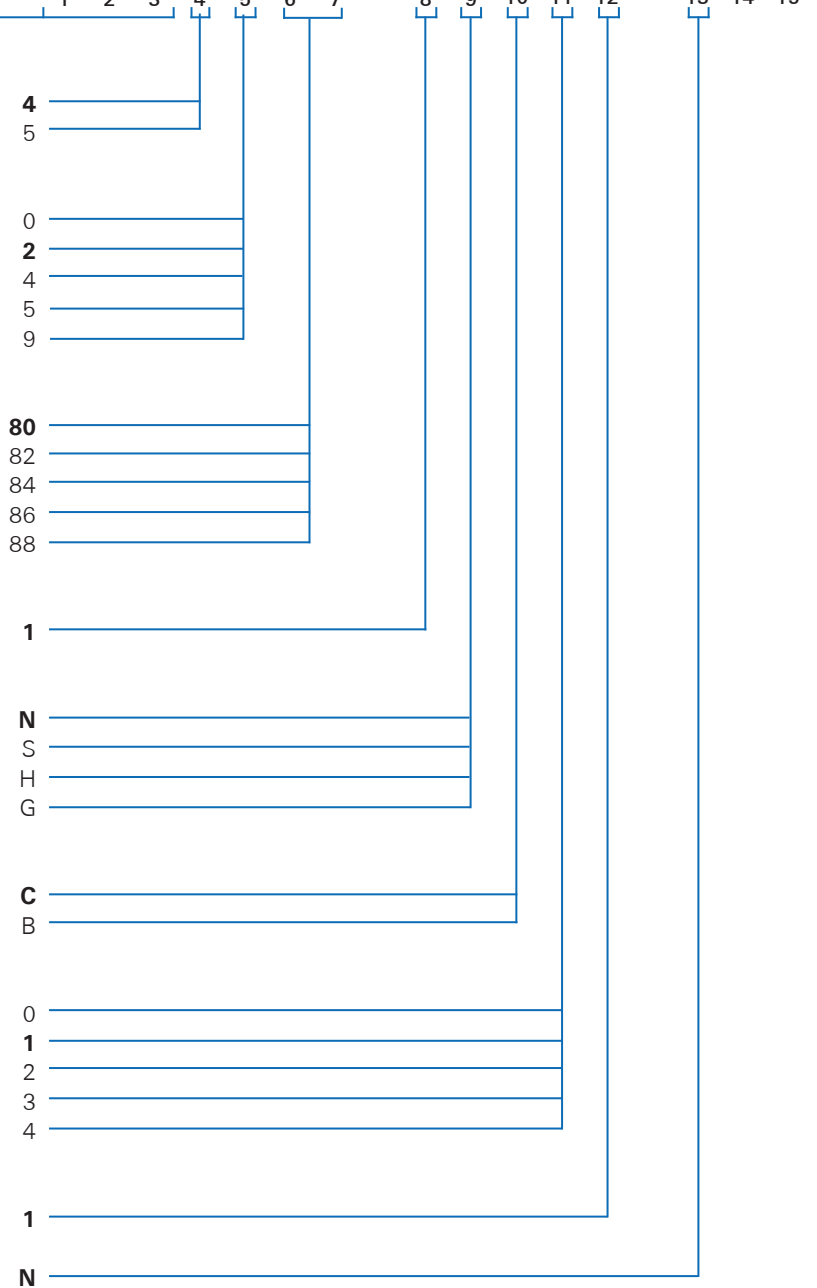
##### 75 mm x 140

80 mm x 170  
 90 mm x 170  
 95 mm x 170

#### Torsional backlash on gearbox output

**Normal backlash max. 40 arcmin**

#### Neutral shift position



## REQUEST FOR QUOTATION?

Please fill out the questionnaire below and send to:

Fax +49 7541 77-2379 or

Email industrial-drives@zf.com

### 1. Motor (enclose motor data form)

Motor brand \_\_\_\_\_

Type \_\_\_\_\_

Size \_\_\_\_\_

Nominal power (kW) \_\_\_\_\_

Max. torque (Nm) \_\_\_\_\_

Motor operating speed  $n_1$  to  $n_2$  (rpm) at constant power \_\_\_\_\_

Max. speed (rpm) \_\_\_\_\_

Motor shaft diameter  $d$  (mm) \_\_\_\_\_

Motor shaft length  $l$  (mm) \_\_\_\_\_

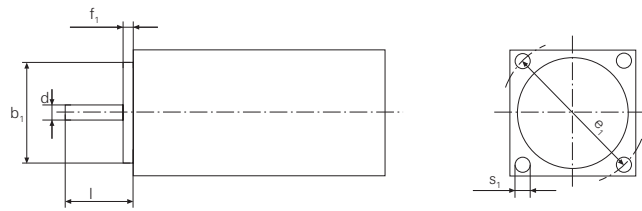
Pilot diameter  $b_1$  (mm) \_\_\_\_\_

Pilot width  $f_1$  (mm) \_\_\_\_\_

Pcd  $e_1$  (mm) \_\_\_\_\_

Hole diameter  $s_1$  (mm) \_\_\_\_\_

Fitting key  $l \times b \times h$  (mm) \_\_\_\_\_



- |  |   |
|--|---|
| <input type="checkbox"/> Motor shaft with keyway       | <input type="checkbox"/> Motor shaft without keyway     |
| <input type="checkbox"/> Motor shaft with shaft seal   | <input type="checkbox"/> Motor shaft without shaft seal |
| <input type="checkbox"/> Full-key balanced motor shaft | <input type="checkbox"/> Half-key balanced motor shaft  |

### 2. ZF-Duoplan type

- |                                 |                                 |                                 |                                     |
|---------------------------------|---------------------------------|---------------------------------|-------------------------------------|
| <input type="checkbox"/> 2K 120 | <input type="checkbox"/> 2K 300 | <input type="checkbox"/> 2K 800 | <input type="checkbox"/> 2K 2100    |
| <input type="checkbox"/> 2K 121 | <input type="checkbox"/> 2K 450 | <input type="checkbox"/> 2K 801 | <input type="checkbox"/> 2K 150 HS  |
| <input type="checkbox"/> 2K 250 | <input type="checkbox"/> 2K 600 | <input type="checkbox"/> 2K 802 | <input type="checkbox"/> 2K 380 HWG |

	<b>Standard</b>	<b>Option</b>
<b>Gearbox interface</b>	<input type="checkbox"/> Open	<input type="checkbox"/> With adapter plate, hub bearing and shaft seal <input type="checkbox"/> With adapter plate and shaft seal <input type="checkbox"/> With adapter ring <input type="checkbox"/> With input flange (2K 250 / 300 / 800 / 2100)
<b>Ratio <math>i_1</math></b>	<input type="checkbox"/> 4,00 Standard <input type="checkbox"/> 3,1 (2K 120 / 121 / 250 / 450 / 600 / 800)	<input type="checkbox"/> 5,0 (2K 450 / 600) <input type="checkbox"/> 5,5 (2K 250 / 300) <input type="checkbox"/> 4,91 (2K 120 / 121)
<b>Installation position</b>	<input type="checkbox"/> B5 <input type="checkbox"/> B5 clockwise rotation	<input type="checkbox"/> V1 <input type="checkbox"/> V3
<b>Output bearings</b>	<input type="checkbox"/> Cylindrical roller bearings <input type="checkbox"/> Cylindrical roller bearings/ roller bearings (2K 120 / 121)	<input type="checkbox"/> Angular-contact ball bearings <input type="checkbox"/> Self aligning- and cylinder ball bearings (2K 800 / 801 / 802)
<b>Lubrication system</b>	<input type="checkbox"/> Splash type lubrication <input type="checkbox"/> Integrated oil channel system <input type="checkbox"/> Dry sump lubrication	
<b>Gearbox output</b>	<input type="checkbox"/> Gearbox with output flange <input type="checkbox"/> 100 mm (2K 120 / 121) <input type="checkbox"/> 118 mm (2K 250 / 300) <input type="checkbox"/> 130 mm (2K 300 / 250) <input type="checkbox"/> 140 mm (2K 450) <input type="checkbox"/> 150 mm (2K 600) <input type="checkbox"/> 180 mm (2K 800 / 801 / 802) <input type="checkbox"/> Rotary union for output shaft	<input type="checkbox"/> Gearbox with output shaft <input type="checkbox"/> 38 mm (2K 120 / 121) INLINE <input type="checkbox"/> 42 mm (2K 250 / 300) <input type="checkbox"/> 42 mm (2K 250 / 300) INLINE <input type="checkbox"/> 55 mm (2K 300 / 250) <input type="checkbox"/> 60 mm (2K 450) <input type="checkbox"/> 65 mm (2K 600 / 800 / 801 / 802) <input type="checkbox"/> 70 mm DIN 5480 (2K 120 TSC / 121 TSC / 250 TSC / 300 TSC) <input type="checkbox"/> 90 mm (2K 2100) <input type="checkbox"/> Gearboxes for direct mounting without output (2K 600 / 800 / 801 / 802 / 2100)
<b>Torsional backlash at gearbox output</b>	<input type="checkbox"/> < 30 arcmin <input type="checkbox"/> < 40 arcmin	<input type="checkbox"/> < 20 arcmin <input type="checkbox"/> < 15 arcmin

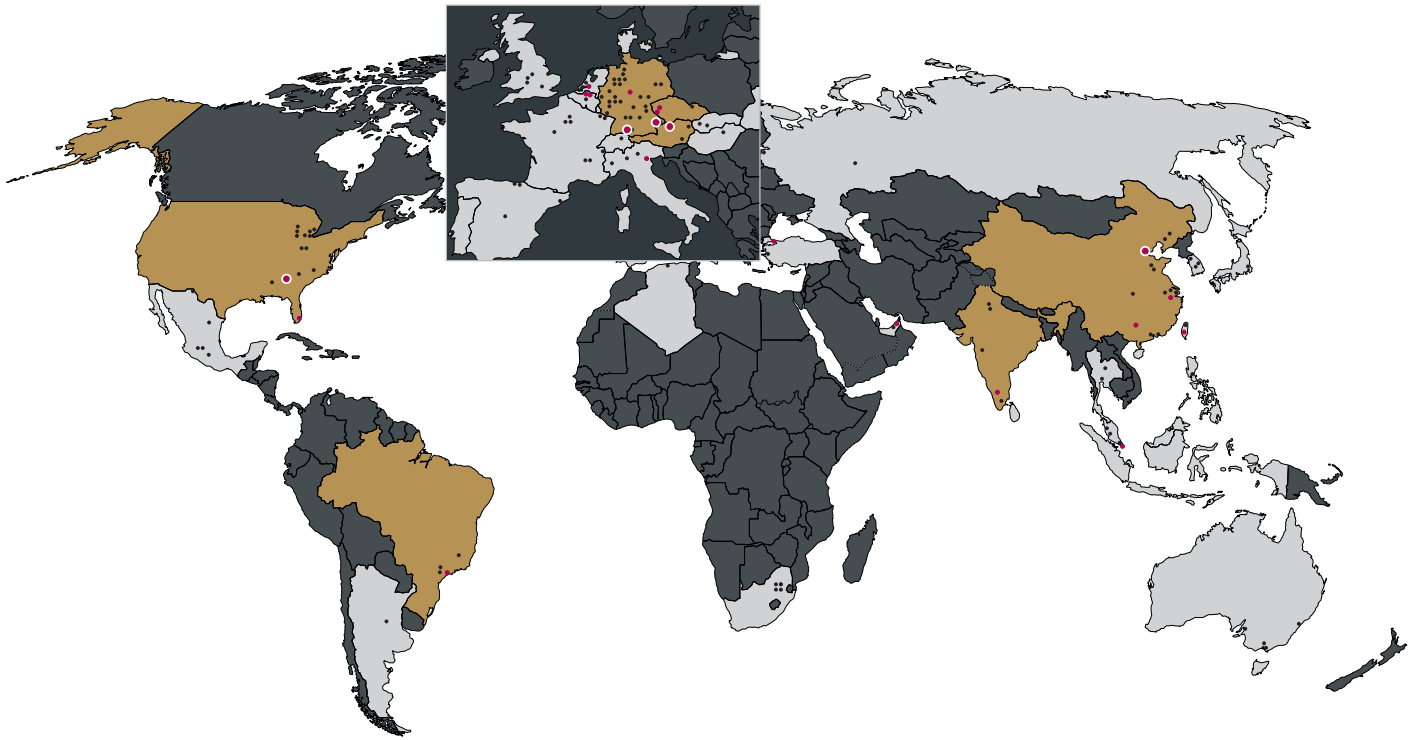
Quantity per year \_\_\_\_\_

Order-No. \_\_\_\_\_

Application \_\_\_\_\_

Subject to technical change without notice.  
For installation investigation purposes,  
please request installation drawings; only  
the data contained therein is binding.





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