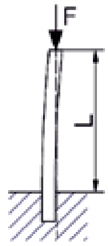
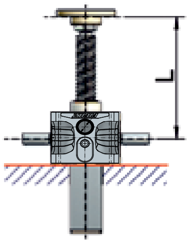
Critical buckling force of the screw

Euler 1





unguided

Formula:

$$I = \frac{F \times v \times (L \times 2)^2}{\pi^2 \times E} \qquad \text{then } d = \sqrt[4]{\frac{I \times 64}{\pi}}$$

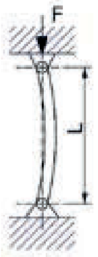
Example:

$$I = \frac{45.000\ N \times 3 \times (1.320\ mm \times 2)^2}{\pi^2 \times 210.000\ N/mm^2} = \frac{9{,}40896^{11}\ mm^4}{2.072.616{,}924} = 453.965{,}22\ mm^4$$

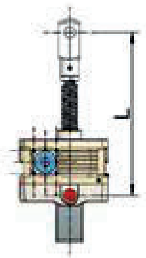
$$d = \sqrt[4]{\frac{453.965{,}22\ mm^4 \times 64}{\pi}}$$

= 55,15 mm minimum core diameter
= Z-250 (screw coreØ = 59,6 mm)

Euler 2



S-version
guided



Pivot
drive

Formula:

$$I = \frac{F \times v \times L^2}{\pi^2 \times E} \qquad \text{then } d = \sqrt[4]{\frac{I \times 64}{\pi}}$$

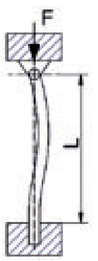
Example:

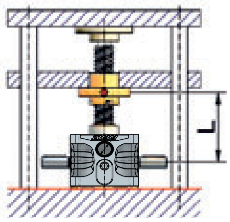
$$I = \frac{45.000\ N \times 3 \times (1.320\ mm)^2}{\pi^2 \times 210.000\ N/mm^2} = \frac{2{,}35224^{11}\ mm^4}{2.072.616{,}924} = 113.491{,}305\ mm^4$$

$$d = \sqrt[4]{\frac{113.491{,}305\ mm^4 \times 64}{\pi}}$$

= 38,99 mm minimum core diameter
= ZE-100 (screw coreØ = 43,6 mm)

Euler 3





R-version
guided

Formula:

$$I = \frac{F \times v \times (L \times 0{,}7)^2}{\pi^2 \times E} \qquad \text{then } d = \sqrt[4]{\frac{I \times 64}{\pi}}$$

Example:

$$I = \frac{45.000\ N \times 3 \times (1.320\ mm \times 0{,}7)^2}{\pi^2 \times 210.000\ N/mm^2} = \frac{1{,}15259^{12}\ mm^4}{2.072.616{,}924} = 55.610{,}7396\ mm^4$$

$$d = \sqrt[4]{\frac{55.610{,}739\ mm^4 \times 64}{\pi}}$$

= 32,62 mm minimum core diameterr
= ZE-50/Tr50 (screw coreØ = 39,8 mm)

	GSZ-2	ZE-5	ZE-10	ZE-25	ZE-35/50	ZE-50/ Tr50	ZE-100	ZE-150	ZE-200	Z-250	Z-350	Z-500	Z-750	Z-1000
Trapezoidal screw Tr Core-Ø in mm (minimum)	16x4	18x4	20x4	30x6	40x7	50x8	55x9	60x9	70x12	80x16	100x16	120x16	140x20	160x20
	10,9	12,9	14,9	22,1	31	39,8	43,6	48,6	55,2	59,6	80,6	99,6	115	135
Ball screw KGT Ømm Core-Ø in mm (minimum*)	16	16	25	32	40	-	50	63	80	80	100	125	140	160
	12,9	12,9	21,5	27,3	34,1	-	43,6	51,8	67	67	87,4	107,8	117	132,8

Depending on the pitch, the core Ø may be even larger. See the KGT pages in chapter 2 for the exact core Ø values.

Explanatory notes:
I = = 2nd moment of area expressed in mm^4
F = Max. load/gearbox in N
L = Free screw length in mm
E = Modulus of elasticity for stee (210.000N/mm^2)
v = Safety factor (normally 3)
d = Minimum core diameter of the screw

Example:

F = 45.000N/gearbox
L = 1320 mm
v = 3

Critical whirling speed for R gearboxes

Maximum permissible screw rotational speed

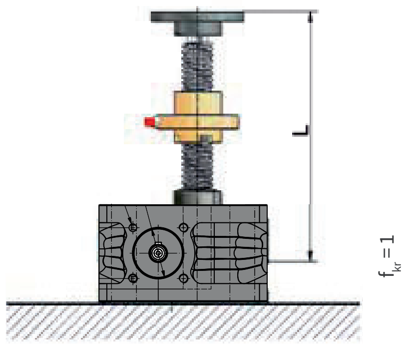
$n_{zul} = 0{,}8 \times n_{kr} \times f_{kr}$

n_{zul} Maximum permissible screw speed (rpm)

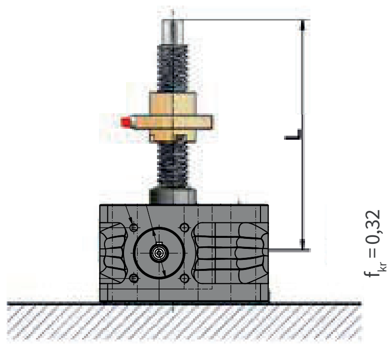
n_{kr} Theoretical critical screw speed (rpm) leading to resonant vibrations (see diagram)

f_{kr} Correction factor which makes allowance for the type of screw bearing

The operating rotational speed must not exceed 80% of the maximum rotational speed

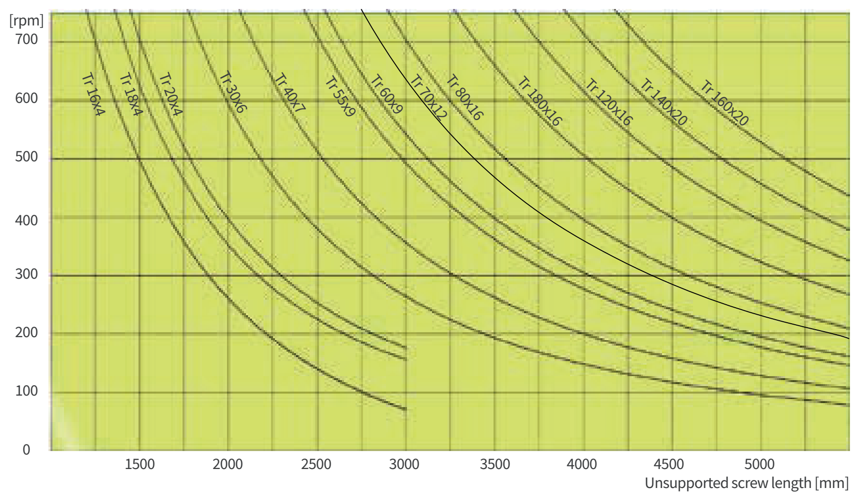


with end mounted bearings
(preferred solution)



without end mounted bearings
(avoid as far as possible)

$$\text{Screw speed} = \frac{\text{Input drive speed}}{i_{gearbox}}$$



The maximum allowable screw speed must be calculated for R version gearboxes (with rotating screws) with long thin screws. To do this, read the theoretical critical speed nkr from the diagram. Take into account also the additional lengths for screw covers etc. when calculating unsupported screw lengths. Now use the formula together with the correction factor for the screw bearing arrangement to calculate the maximum allowable screw speed.

If the calculated maximum screw speed is lower than the required speed, select a larger screw or a double-pitch screw with half the speed. This must then be checked also. You have the option to use a “increased screw” for the R version (screw for the next larger gearbox). Bear in mind that a larger pitch demands a higher drive torque.

CAUTION:
Long, thin screws can tend to squeak even though they satisfy the critical whirling speed! Therefore allow a sufficient margin of safety in the calculation.

Drive torque [MG] of a single screw jack

The following specifications serve to calculate the required drive torque.
For gearboxes with single-pitch trapezoidal screws the load can simply be multiplied by the factor stated on the corresponding gearbox.

Formula:	Example:
1) Drive torque: $M_G = \dfrac{F\,[kN] \times P\,[mm]}{2 \times \pi \times \eta_{Getriebe} \times \eta_{Spindel} \times i}$	1) $M_G = \dfrac{12\ kN \times 6\ mm}{2 \times \pi \times 0{,}87 \times 0{,}39 \times 6}$ = **5,63**
2) Motor power: $P_M [kW] = \dfrac{M_G\,[Nm] \times n\,[min^{-1}]}{9550}$	2) $P_M = \dfrac{5{,}63\ Nm \times 1500\ min^{-1}}{9550}$ = **0,88 kW**
3) Safety factor: We recommend multiplying the calculated value by a safety factor of 1.3 to 1.5. For small sizes, low speeds and especially low temperatures, a safety factor of up to 2 is calculated. **Minimum load:** With low dynamic loads, the no-load losses have a proportionally greater effect. Therefore calculate the drive with at least 15% of the gearbox rated load, even if the effective load is lower (e.g. Z-50 with at least 7.5 kN).	3) Example: 0,88 kW x 1,5 = 1,32 kW → Motor 1,5 kW

Explanatory notes:

M_G	**Necessary drive torque [Nm] for a screw jack**
F	**Lifting load (dynamic) [kN]**
$\eta_{Gearbox}$	**Efficiency of the screw jack (without screw)**
η_{Screw}	**Efficiency of the screw**
P	**Screw pitch [mm]**
i	**Drive ratio of the screw jack**
P_M	**Motor drive power**

Example:

ZE-25-SN
F = 12 kN (dynamic lift load)
ηGearbox = 0,87 ηScrew = 0,39
i = 6 P = 6

Efficiencies of the screw jack $\eta_{Gearbox}$ (without screw)

i	rpm	GSZ-2	ZE-5	ZE-10	ZE-25	ZE-35	ZE-50	ZE-100	ZE-150	ZE-200	Z-250	Z-350	Z-500	Z-750	Z-1000
N	3000	0,87	0,81	0,83	0,87	-	-	-	-	-	-	-	-	-	-
N	1500	0,87	0,82	0,84	0,87	0,87	0,87	0,88	0,89	0,90	0,91	-	-	-	-
N	1000	0,86	0,82	0,82	0,86	0,87	0,86	0,87	0,89	0,90	0,90	0,91	0,92	0,88	0,90
N	750	0,86	0,82	0,84	0,85	0,86	0,85	0,87	0,88	0,90	0,90	0,91	0,92	0,88	0,90
N	500	0,85	0,82	0,84	0,83	0,85	0,84	0,85	0,87	0,90	0,89	0,9	0,92	0,87	0,89
N	100	0,74	0,77	0,79	0,78	0,78	0,78	0,78	0,8	0,85	0,83	0,86	0,87	0,81	0,84
L	3000	0,78	0,74	0,78	0,76	-	-	-	-	-	-	-	-	-	-
L	1500	0,77	0,70	0,74	0,72	0,64	0,66	0,67	0,67	0,77	0,78	-	-	-	-
L	1000	0,75	0,67	0,72	0,7	0,64	0,66	0,65	0,66	0,77	0,77	0,78	0,76	0,67	0,76
L	750	0,74	0,65	0,7	0,68	0,64	0,66	0,65	0,65	0,77	0,76	0,78	0,75	0,66	0,76
L	500	0,71	0,62	0,67	0,65	0,63	0,65	0,65	0,63	0,76	0,75	0,77	0,73	0,65	0,75
L	100	0,54	0,53	0,59	0,54	0,52	0,55	0,57	0,53	0,67	0,65	0,67	0,61	0,58	0,66

Efficiencies of the screws η_{Screw} calculated for coefficient of friction $\mu = 0{,}11$

Tr-screw, single-pitch	16x4	18x4	20x4	30x6	40x7	50x8	55x9	60x9	70x12	80x16	100x16	120x16	140x20	160x20	Ball screw
Efficiency	0,45	0,42	0,39	0,39	0,35	0,33	0,34	0,32	0,35	0,39	0,33	0,29	0,30	0,27	
Tr-screw, double-pitch	16x8P4	18x8P4	20x8P4	30x12P6	40x14P7	50x16P8	55x18P9	60x18P9	70x24P12	80x32P16	100x32P16	120x32P16	140x40P20	160x40P20	0,9
Efficiency	0,62	0,59	0,56	0,56	0,53	0,50	0,51	0,48	0,52	0,56	0,50	0,45	0,47	0,44	

Maximum torques

Maximum input torque

In order to achieve optimum service life, do not exceed the values shown.
If operating hours are lower, higher values may be achieved. Please contact us for advice.

max. input drive torques MR [Nm]

i	rpm	GSZ-2	ZE-5	ZE-10	ZE-25	ZE-35	ZE-50	ZE-50/Tr50	ZE-100	ZE-150	ZE-200	Z-250	Z-350	Z-500	Z-750	Z-1000
N	3000	1,2	4	11	17	-	-		-	-	-	-	-	-	-	-
N	1500	1,4	4,7	13,5	18	19,8	31,5	31,5	53,4	75,1	155	152	-	-	-	-
N	1000	1,5	5,6	14	22	20,8	36,8	36,8	60,8	77,7	155	152	265	408	480	680
N	500	1,6	6,1	16,7	28	24,8	46,5	46,5	75,3	95	156	160	350	500	640	960
L	3000	0,5	1,4	5,7	8,5	-	-		-	-	-	-	-	-	-	-
L	1500	0,5	1,5	7,5	10	9	10,4	10,4	13,5	20,7	61	41,4	-	-	-	-
L	1000	0,5	1,8	8,7	11	9,7	14,9	14,9	15,4	23,7	61	47,4	100	170	210	450
L	500	0,6	2,2	10,7	14	11,1	19,2	19,2	18,9	29,4	62	63,5	112	220	240	580

The stated limit values are mechanically-based - thermal factors may be relevant depending on the duty cycle

max. drive-through torque

Where several gearboxes are arranged in series the drive-through torque may be significantly greater than the maximum input drive torque. Only the torsional load on the shaft needs to be considered, not the load on the gear teeth.

max. worm shaft drive-through torqu [Nm]

GSZ-2	ZE-5	ZE-10	ZE-25	ZE-35	ZE-50	ZE-50/Tr50	ZE-100	ZE-150	ZE-200	Z-250	Z-350	Z-500	Z-750	Z-1000
9	39	57	108	130	260	260	540	540	700	770	1800	1940	4570	4570

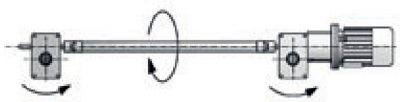
Drive torque for screw jacks
– approximate calculation

Calculation

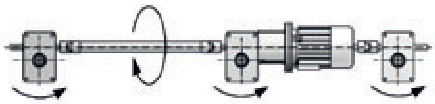
The drive torque required for a lifting system is the sum of the torques for the individual screw jacks and increases due to frictional losses on transfer components such as couplings, connecting shafts, bevel gearboxes etc.

To simplify the calculation, the following factors are used to determine the drive torque for the most common system layouts.

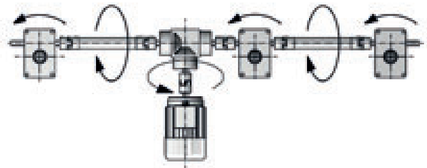
M_R – Overall drive torque for the entire system
M_G - Drive torque for an single gearbox
M_A – Starting torque max. 1,5 x M_R



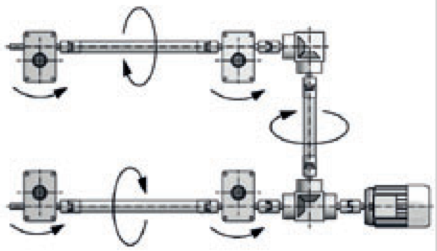
$M_R = M_G \times 2,1$



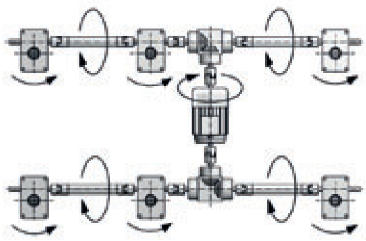
$M_R = M_G \times 3,1$



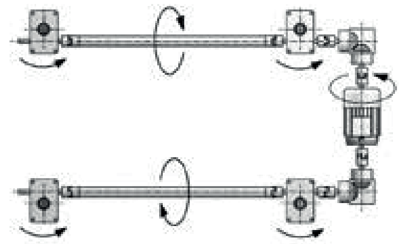
$M_R = M_G \times 3,6$



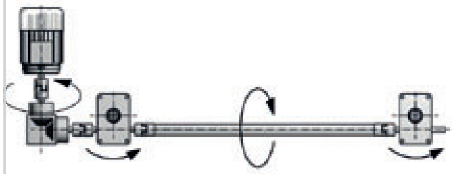
$M_R = M_G \times 4,9$



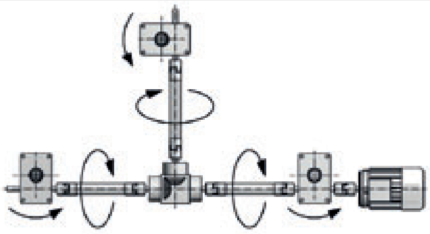
$M_R = M_G \times 7,1$



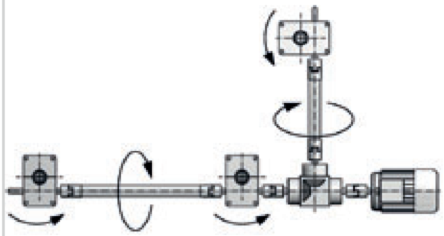
$M_R = M_G \times 4,8$



$M_R = M_G \times 2,4$



$M_R = M_G \times 3,5$

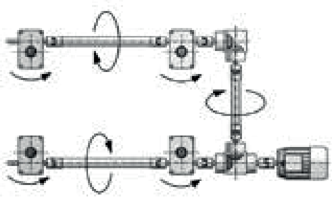


$M_R = M_G \times 3,6$

CAUTION

We recommend multiplying the calculated value by a safety factor of 1.3 to 1.5. For small sizes, low speeds and especially low temperatures, a safety factor of up to 2 is calculated.

Example (12 kN per gearbox)

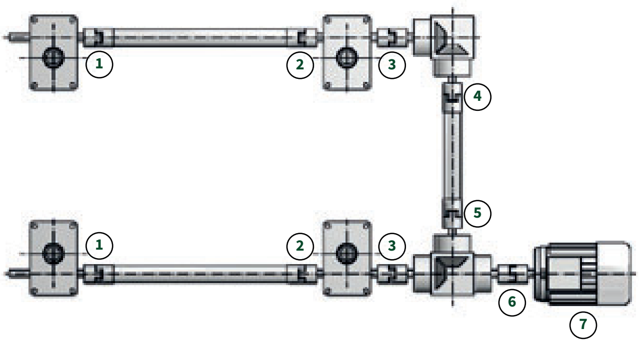


$M_R = M_G \times 4,9 = 5,63$ Nm x 4,9 = **27,59 Nm**
⟶ x safety factor 1,5 = **41,38 Nm**
$M_A = M_R \times 1,5 = 41,38$ Nm x 1,5 = **62,07 Nm**

Drive torque for screw jacks

– precise calculation

The following calculation example takes account of the efficiency of the connecting shafts (η 0.95) and bevel gearboxes (η 0.9).



Formula for the gearbox:

Drive torque: $M_G = \dfrac{F\,[kN] \times P\,[mm]}{2 \times \pi \times \eta_{Getriebe} \times \eta_{Spindel} \times i}$

Efficiencies:

Connecting shafts:	η 0,95
Bevel gearbox:	η 0,90

Example:

1)	$MG = \dfrac{12kN \times 6mm}{2 \times \pi \times 0{,}87 \times 0{,}39 \times 6}$	= **5,63**	
2)	$\dfrac{5{,}63\ Nm}{0{,}95}$ (efficiency of the connecting shaft)	= **5,93 Nm**	
3)	5,63 Nm + 5,93 Nm	= **11,56 Nm**	
4)	$\dfrac{11{,}56\ Nm}{0{,}9}$ (efficiency of the bevel gearbox)	= **12,84 Nm**	
5)	$\dfrac{12{,}84\ Nm}{0{,}95}$	= **13,52 Nm**	
6)	(11,56 Nm + 13,52 Nm)/0,9	= **27,87 Nm**	
7)	27,87 Nm x 1,5	= **41,8 Nm**	

Z-25-SN
F = 12 kN (dynamic lift load per gearbox)
$\eta_{Gearbox} = 0{,}87$ $\eta_{Screw} = 0{,}39$
i = 6 P = 6

11,56 Nm x 1,5 = 17,34 Nm
(KSZ-H-25-L is okay - see chapter 5)

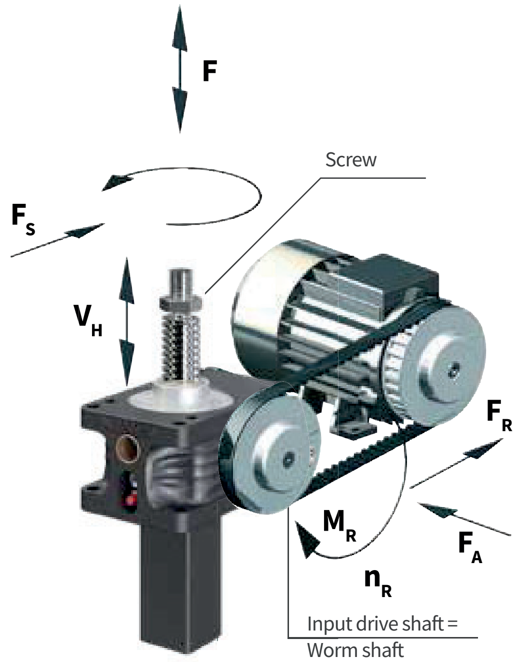
41,8 Nm
(KSZ-H-35-T is needed - see chapter 5)

Motor selection: 132M-P4-7,5 kW (50 Nm)
(for motors see Section 3)

CAUTION

We recommend multiplying the calculated value by a safety factor of 1.3 to 1.5. For small sizes, low speeds and especially low temperatures, a safety factor of up to 2 is calculated.

maximum forces / torques



Lateral forces on the lifting screw

The maximum permissible lateral forces are shown in the table on the right. Lateral forces should generally be taken by linear guides. The guide bushing in the gearbox functions only as a secondary guide. The maximum lateral forces actually occurring must be less than the values shown in the table!

CAUTION: Only applies to static forces!

maximum lateral force F_S [N] (only static) — **extended screw length in mm**

ZE/Z	100	200	300	400	500	600	700	800	900	1000	1200	1500	2000	2500	3000
5	360	160	100	70	55	45	38	32	28	25	20	18	12	-	-
10	600	280	180	130	100	80	70	60	50	47	40	30	20	15	-
25	900	470	300	240	180	150	130	110	100	90	70	60	45	35	30
35	1300	700	450	360	270	220	190	160	150	130	100	90	60	50	40
50	3000	2000	1300	900	700	600	500	420	380	330	280	230	160	130	100
100	5000	4000	3000	2300	1800	1500	1300	1100	950	850	700	600	400	350	250
150	5500	5000	3900	2800	2300	1800	1500	1300	1200	1000	850	750	500	400	350
200	7500	7200	5400	4000	3200	2500	2100	1800	1700	1500	1200	1050	700	600	500
250	9000	9000	6500	4900	3800	3000	2500	2200	2000	1900	1450	1250	900	760	660
350	15000	13000	12000	10000	8800	7000	6000	5500	4800	4300	3500	3000	2000	1600	1400
500	29000	29000	29000	29000	24000	20000	17000	15000	15000	14000	12000	9000	7000	5600	4900
750	34800	34800	34800	34800	34800	28800	24000	20400	18000	16800	14400	10800	8400	6720	5880
1000	46000	46000	39000	36000	320000	30000	25000	290000	25000	23500	20000	17000	12000	10000	8000

Radial load on the input shaft

Make sure that the radial forces arising where chain or belt drives are used do not exceed the values stated in the table alongside.

maximum radial load on the input shaft F_R [N]

	ZE-5	ZE-10	ZE-25	ZE-35	ZE-50	ZE-100	ZE-150	ZE-200	Z-250	Z-350	Z-500	Z-750	Z-1000
FR max.	110	190	260	260	420	650	670	1000	1100	1400	2600	3000	3400

Loading definitions:

- F - Lifting load tensile and/or compressive
- F_S - Lateral loads on the screw
- V_H - Lifting speed of the screw (or nut if the R version)
- F_A - Axial load on the input shaft
- F_R - Radial load on the input shaft
- M_R - Input torque
- n_R - Input speed

Length calculation – screw and protective tube

A quicker method

Take advantage of the ZIMM online configurator to easily and conveniently determine the required spindle and protection tube extension.
This lets you quickly calculate the fitting dimensions of your screw jack.

Principle

Depending on the version and accessories used the screw (and the protective tube on the S version) are extended. These dimensions are minimum requirements.
For special fitting situations, please provide a drawing or contact our project technicians.

Stroke + basic length (+ various extensions for variants/accessories)

Example S:

ZE-25-SN, stroke 250 mm:
- Bellows ZE-25-FB-300 (ZD=70mm)
- Fixing flange BF (means the bellows do not require an fixing ring)
- Rotation protection VS
- Limit switch ESSET

Screw length Tr:

250 Stroke	+	180 Basic length	+	44 Bellows (70 - 26 = 44)	+	45 Limit switch + Rotation protection	=	**519 mm Screw length**

Screw length SRO:

250 Stroke	+	53 Basic length	+	72 Limit switch + Rotation protection	=	**375 mm Protective tube length**

Example R:

ZE-25-RN, stroke 250 mm:
- Screw with end support (opposed bearing plate GLP)
- Bellows ZE-25-FB-300 (ZD=70mm) underneath and above
- Duplex nut DM

Screw length Tr:

250 Stroke	+	189 Basic length	+	60 Bellows gearbox side (70 - 10 = 60)	+	55 2nd bellowsg (70 - 15 = 55)	+	50 Duplex nut	=	**554 mm Screw length**

See Section 4 for the length calculation for connecting shafts.