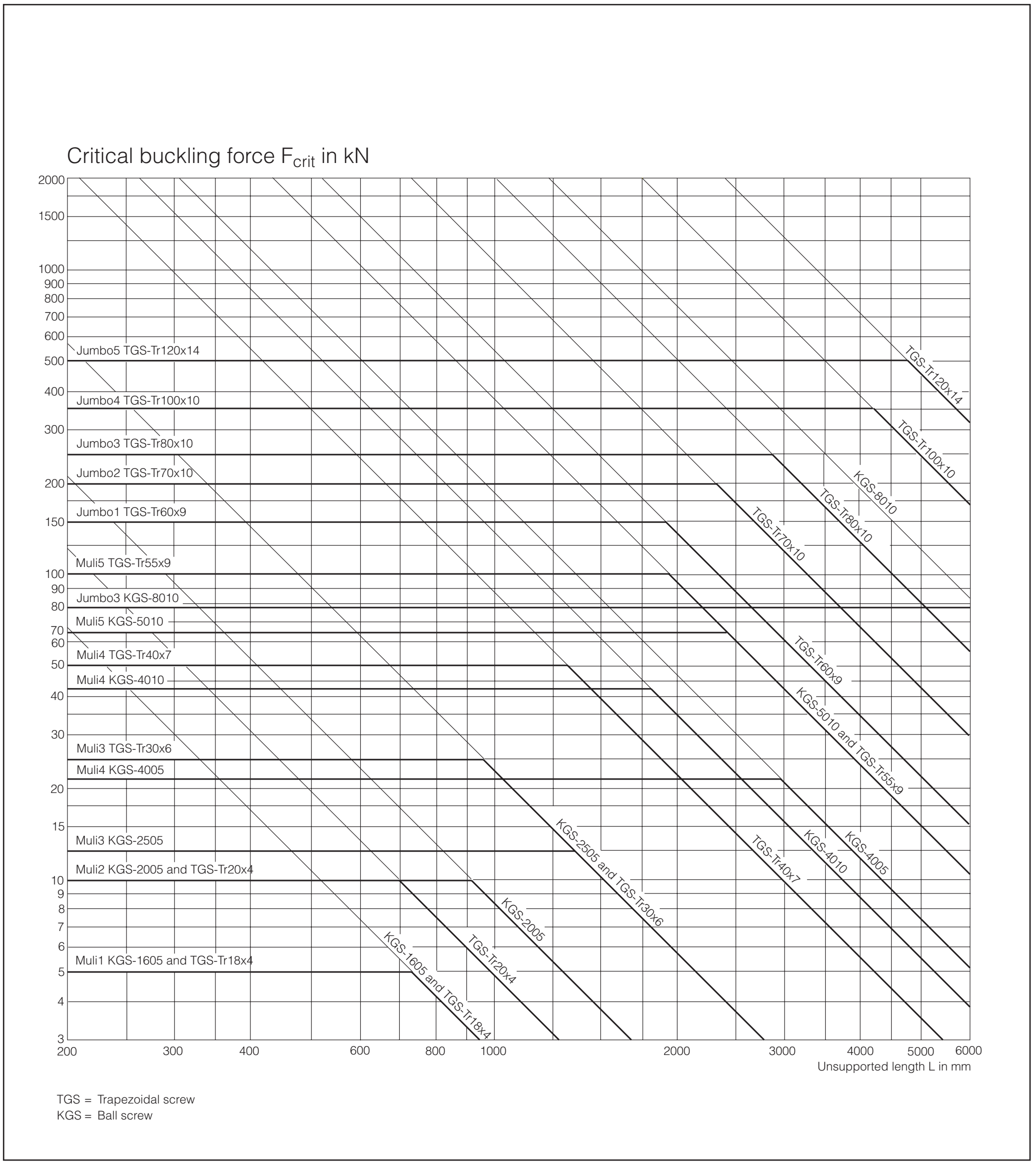
Selection and calculation

Critical buckling force of a screw jack under compressive loads

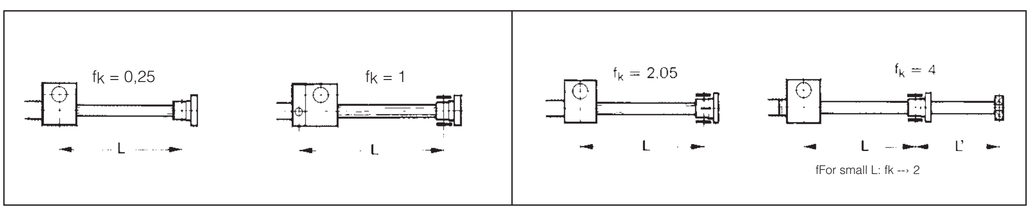
Thin lifting screws may buckle sideways when subjected to compressive loads. Before the permissible compressive force is defined for the screw. allowance must be made for safety factors as appropriate to the installation.

$$F_{eff} \le f_k \cdot F_{crit} \cdot 1/S_k$$

- F_{eff} is the actual axial force (compressive force) acting on the jack screw in kN.
- f_k is a correction factor which makes allowance for the type of screw bearing. Sufficiently rigid mounting of the worm gear screw jack is consequently a prerequisite for cases 2. 3 and 4.
- F_{crit} is the critical buckling force as a function of the unsupported length L.
- S_k is the safety factor and depends on the application in question. Values between 3 and 6 are customary in general mechanical engineering.



Case 1 **Case 2** **Case 3** **Case 4**



Selection and calculation

Critical speed of jack screws

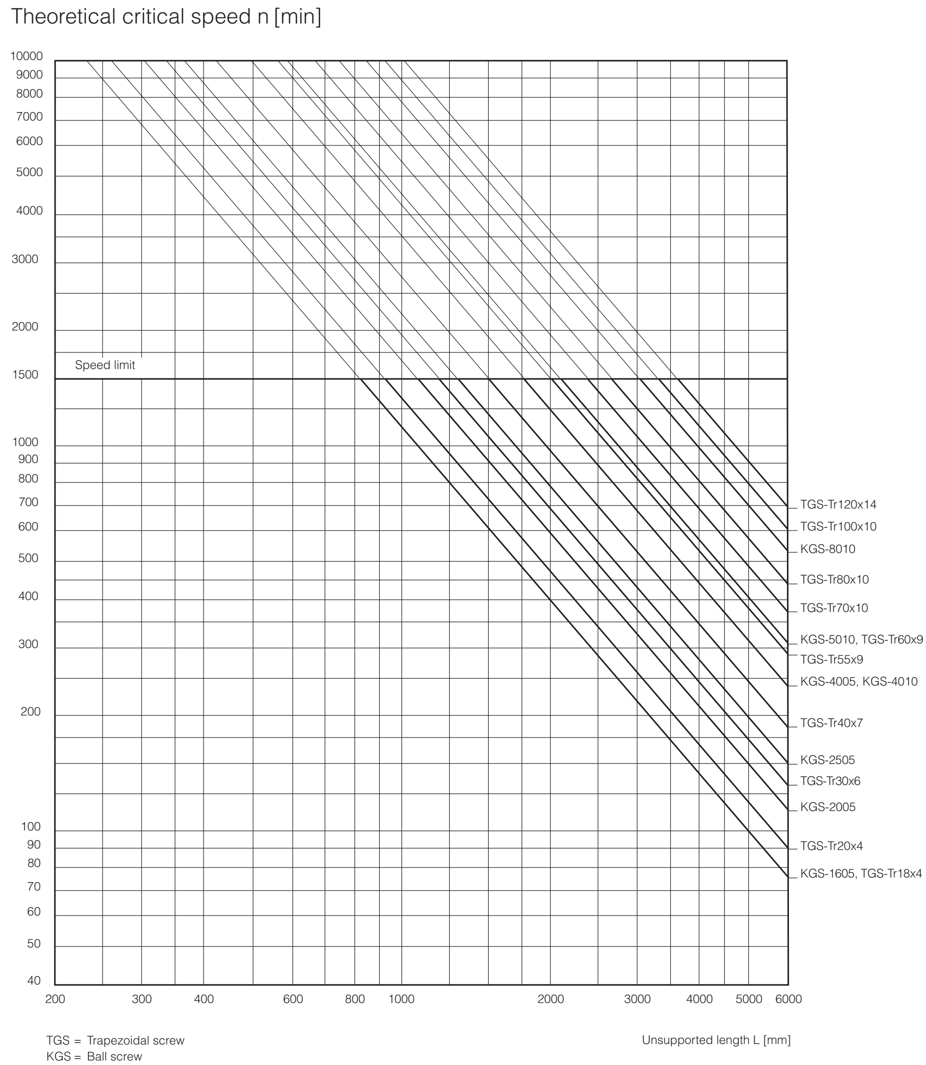
(Version R only)
Resonant bending vibration may develop with thin screws rotating at high speed. Assuming a sufficiently rigid assembly. the resonant frequency can be estimated with the aid of the following method.

$$n_{perm} = f_{kr} \cdot n_{crit} \cdot 0.8$$

n_{perm} is the maximum permissible screw speed in rpm.

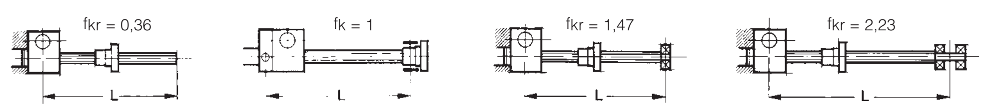
f_{kr} is a correction factor which makes allowance for the type of screw bearing. Sufficiently rigid mounting of the worm gear screw jack and bearing is consequently a prerequisite for cases 2. 3 and 4.

n_{crit} is the critical screw speed; it corresponds to the basic bending vibration of the screw and leads to resonance effects.



Worm gear screw jacks with multi-start screws are also available for applications with high lifting speeds. These versions run at a considerably lower screw speed and better efficiency for the same lifting speed. They are generally not self-locking.

Case 1 **Case 2** **Case 3** **Case 4**



Selection and calculation

Required drive torque for a worm gear screw jack

The required drive torque for a worm gear screw jack is governed by the axial load acting on the jack screw. the transmission ratio and the efficiency. It should be noted that the breakaway torque may be considerably higher than the torque required for continuous running. This applies in particular to worm gear screw jacks with low efficiency after a long standstill period. The acceleration torque should be checked if necessary in cases with large screw pitches and very short run-up times.

$$M_T = \frac{F_{eff}}{2 \cdot \pi \cdot \eta} \cdot \frac{P}{i} + M_O$$

M_T is the required drive torque of the worm gear screw drive at the worm shaft in Nm.

F_{eff} is the actual force acting on the jack screw in N.

η is the efficiency of the worm gear screw jack in decimal notiation. e.g. 0.32 instead of 32% (for values. see table on page 11). η is an average value determined by measurement.

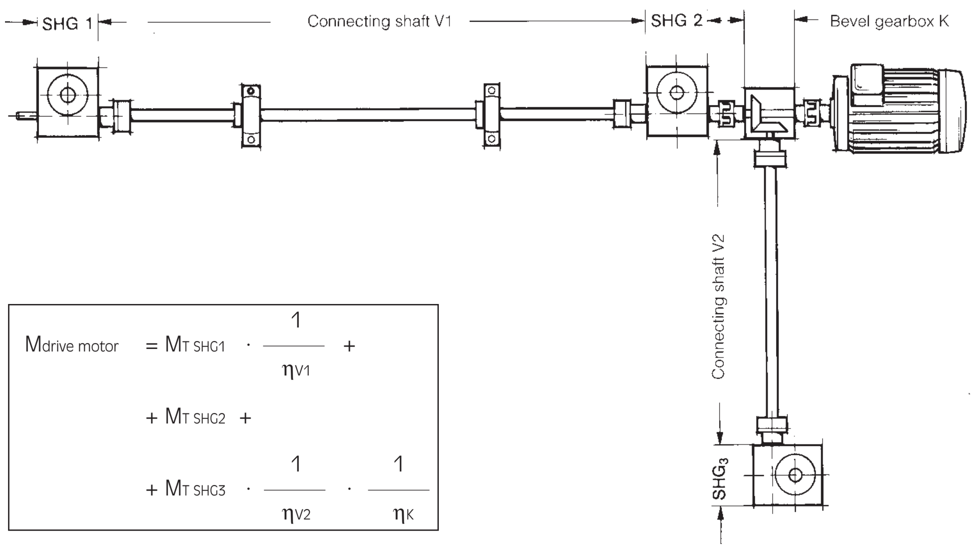
$\frac{p}{i}$ is the transmission ratio of the worm gear screw drive in mm stroke length per revolution of the worm shaft.

M_O is the idle torque of the worm gear screw drive in Nm. Mo is determined by measurements undertaken after a brief running-in period with liquid grease lubrication at room temperature. It represents an average value which may vary to a greater or lesser extent. depending on the running-in state. lubricant and temperature. For values. see table on page 11

Required drive torque for a worm gear screw jack system

The required drive torque for a worm gear screw jack system is governed by the drive torque values for the individual jacks. with allowance for the static and dynamic frictional losses in transmission components (coupling. connecting shafts. pedestal bearings. angle gearboxes. etc.). It is useful to draw a diagram illustrating the flow of forces.

Example



$$M_{drive\ motor} = M_{T\ SHG1} \cdot \frac{1}{\eta_{V1}} + M_{T\ SHG2} + M_{T\ SHG3} \cdot \frac{1}{\eta_{V2}} \cdot \frac{1}{\eta_K}$$

$M_{T\ SHG1}$
is the required drive torque for the worm gear screw jack SHG 1. It should be noted that the start-up torque (breakaway torque and possibly acceleration torque) may be considerably higher than the torque required for continuous running. This applies in particular to worm gear screw jacks with low efficiency after a long standstill period.

η_{V1} is the efficiency of connecting shaft V1

η_{V2} (V2) includes the static and dynamic frictional losses in the pedestal bearings and couplings.

η_V = 0.75...0.95 depending on the length of the shaft and number of pedestal bearings.

η_K is the efficiency of the bevel gearbox (only for the force flow via the toothing. i.e. between connecting shaft V2 and the drive motor).

$\eta_K = 0.90$

Selection and calculation

Maximum drive torque

If the worm gear screw jack jams as a result of the screw coming into contact with an obstacle. the toothing can still absorb the following maximum torque values M_T at the drive shaft.
In the case of screw jacks connected in series. the screw jack closest to the drive can absorb this torque at its drive shaft.

Size	$M_{T\,max}$ [Nm]
MULI 1	3.4
MULI 2	7.1
MULI 3	18
MULI 4	38
MULI 5	93
JUMBO 1	148
JUMBO 2	178
JUMBO 3	240
JUMBO 4	340
JUMBO 5	570

Forces and torque values acting on the drive shaft

If worm gear screw jacks are not driven free of lateral forces by means of a coupling connected to the motor shaft. but are instead driven by chains or belts. care must be taken to ensure that the radial force acting on the drive shaft does not become excessive. The values are specified in the following table.
In the worst case. the worm shaft will bend under radial force F_R and lift off the worm gear. This must be avoided. since it impairs the engagement between worm shaft and worm gear and leads to higher wear.

Size	$F_{R\,max}$ [kN]
MULI 1	0.1
MULI 2	0.2
MULI 3	0.3
MULI 4	0.5
MULI 5	0.8
JUMBO 1	0.8
JUMBO 2	1.3
JUMBO 3	1.3
JUMBO 4	2.1
JUMBO 5	3.1

Selection of drive motor

A suitable drive motor can be selected when the required drive torque and drive speed are known. After selecting a drive motor. check that it will not overload any of the worm gear screw jacks or transmission components. This risk may occur. in particular. in installations with several screw jacks if they are loaded unevenly. It will generally be necessary to install limit switches or torque-limiting couplings to protect the installation against impacting against end positions and obstacles.

Forces and torque values on the motor shaft

Toothed-belt or chain drives may exert considerable radial forces on the motor shaft if a very small sprocket is used. Please consult the motor manufacturer in cases of doubt.

Selection of a bevel gearbox

Selection of a bevel gearbox is governed by the following factors:

- Drive torque
- Drive speed (see dimensional tables)
- Duty cycle and drive power
- Forces and torque values acting on the ends of the shaft (please consult us in cases of doubt)

Required drive speed

The required drive speed is governed by the desired lifting speed. the transmission ratio of the jack and the transmission ratio of the other transmission components. A particular lifting speed can normally be achieved in several ways. Correct selection depends on the following criteria:

- Favourable efficiency
- Minimum load on transmission components in order to achieve compact. low-cost design
- Avoiding critical speeds for jack screws and connecting shafts.

Jack screw nut torques

The nut torque (M) of the jack screw is the torque that the jack screw exerts on the mounting plate (all N versions except V), or the torque that the screw applies to the travelling nut (R Version). It is not to be confused with the dirve torque (MT) of the screw jack gears on the worm shaft.

$$M\,[Nm] = F_{eff}\,[kN] \cdot f_M$$

(applicable in the areas of moderate and high loads)

M is the jack screw nut torque in Nm for the “Lift under Load” movement.

F_{eff} is the actual supported axial force in kN.

f_M is a conversion factor that accounts for screw geometry and friction. The value is applicable under normal lubrication conditions. In the case of ball screw dirves, f_M is practically constant.

Size	f_M (trapezoidal)	f_M (ball screw)
MULI 1	1.6	1.6
MULI 2	1.8	1.6
MULI 3	2.7	1.6
MULI 4	3.4	1.6/3.2
MULI 5	4.6	3.2
JUMBO 1	5.5	–
JUMBO 2	6.4	–
JUMBO 3	7.2	3.2
JUMBO 4	8.0	–
JUMBO 5	10.6	–