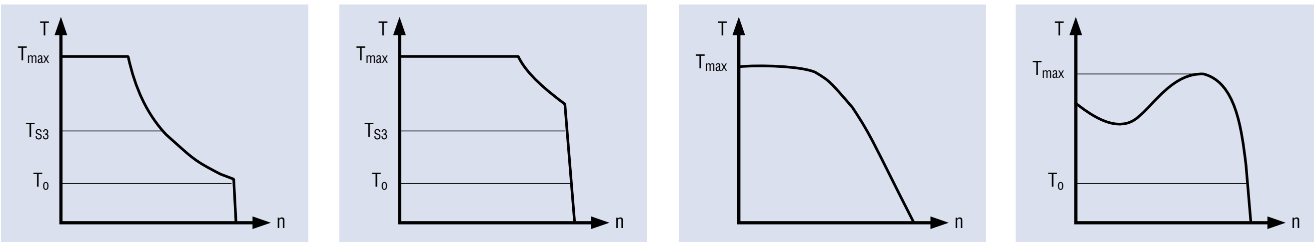
Backlash-free safety couplings

Calculation example

When determining the cut-out torque, brief torque peaks by the drive unit and the machine must be taken into consideration because safety couplings by System GERWAH® were developed for high-speed cut-out. Particular attention must be paid to the characteristic curves of the maximum acceleration torques of the motors (figure 10).

Figure 10: Characteristic curves of various driving motors



DC Servo drive *AC Servo drive* *Step motor drive* *Asynchronous motors*

In the case of dynamic drives (servo motors), e.g. in machine tools, we recommend that the relationships between the moments of inertia are also considered. Since the acceleration torque in both positive and negative direction is usually much higher than the nominal moment, dimensioning should always be based on the maximum acceleration torque.

The following dimensioning values have proven to be reliable in practice for couplings on high dynamic drives:

In general the following relationship applies:

$$T_A = K \times T_{max} \times \frac{J_{mach}}{J_{mot} + J_{mach}} = [Nm]$$

J_{mot} = Moment of inertia of motor
J_{mach} = Moment of inertia of machine
T_{max} = Max. acceleration torque
T_A = Cut-out torque (disengaging torque) of the coupling

K = Load factor, impact factor
K = 1.5 (regular movements)
K = 2 (irregular movements)
K = 2.5 – 4 (jerky movements)

A load/impact factor of K = 1.5 – 2 should be used for servo drives in machine tools. A greater load/impact factor K should be used for extreme applications.

Checking of resonance frequency

Although the complete coupling construction of a safety coupling in combination with a metal bellows or servo insert coupling is totally backlash-free, it should not be forgotten that the coupling links two rotating masses. We recommend that the resonance frequency should be checked by the following formula:

$$f_{res} = \frac{1}{2\pi}\sqrt{C_{T\,dyn} \times \frac{J_{mot} + J_{mach}}{J_{mot} \times J_{mach}}} = [Hz]$$

$C_{T\,dyn}$ = Dynamic torsional stiffness of coupling [Nm/rad]
J_{mot} = Moment of inertia of motor [kgm^2]
J_{mach} = Moment of inertia of machine [kgm^2]

In practice the resonance frequency calculated arithmetically should be twice as large as the excitation frequency of the drive. The excitation frequencies of servo drives usually range between 150 and 300 Hz.

In special cases the couplings can also be dimensioned on the basis of other criteria, e.g. shaft diameter, cutting force, etc.

Backlash-free safety couplings

Calculation example

This calculation example is for a safety coupling of the series DBK/DK on a machine tool drive (figure 11).

A safety coupling is to be selected from the DBK/DK series using the design data on the machine tool.

The motor is coupled directly to the ball screw (direct drive): the moment of inertia of the coupling is disregarded.

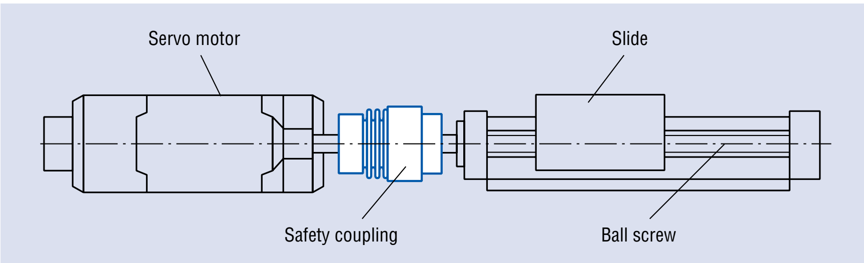


Figure 11: Direct drive protected with safety coupling from the series DBK/DK

Data: e.g. Motor type 1 FT 5104

T_{max} = 160 Nm

TS3 = 52 Nm

TO = 37 Nm

Drive data

1. Linearly moved masses referred to the ball screw (h = 10 mm) . . . . . . J_l = 2.6×10^{-3} kgm²
2. Ball screw (Ø 63; L = 1200 mm) . . . . J_{sp} = 14.4×10^{-3} kgm²
3. Motor 1 FT 5104 . . . . J_{mot} = 18.3×10^{-3} kgm²
4. Machine . . . . J_{mach} = $J_{Sp} + J_l = 17 \times 10^{-3}$ kgm²

Calculation of the cut-out torque T_A

$$T_A = K \times T_{max} \times \frac{J_{mach}}{J_{mot} + J_{mach}} = [\mathrm{Nm}]$$

$$T_A = 1.5 \times 160\ \mathrm{Nm} \times \frac{17 \times 10^{-3}\ \mathrm{kgm^2}}{18.3 \times 10^{-3}\ \mathrm{kgm^2} + 17 \times 10^{-3}\ \mathrm{kgm^2}} = 116\ \mathrm{Nm}$$

Selection: Safety coupling DBK/DK 150 (cut-out torque setting 116 Nm)

Dynamic torsional stiffness . . . . $C_{T\ dyn}$ = 151×10^3 Nm/rad

Checking of resonance frequency

$$f_{res} = \frac{1}{2\pi}\sqrt{C_{T\ dyn} \times \frac{J_{mot} + J_{mach}}{J_{mot} \times J_{mach}}} = [\mathrm{Hz}]$$

$$f_{res} = \frac{1}{2\pi}\sqrt{151000\ \mathrm{Nm/rad} \times \frac{0.0183\ \mathrm{kgm^2} + 0.017\ \mathrm{kgm^2}}{0.0183\ \mathrm{kgm^2} \times 0.017\ \mathrm{kgm^2}}} = 659\ \mathrm{Hz}$$

The resonance frequency calculated arithmetically is much higher than the likely resonance frequency. The coupling is adequately dimensioned.