SIZING AND SELECTION

According to DIN 740 part 2
SIZING AND SELECTION

SAFETY COUPLINGS

SYMBOLS

\[ T_{AR} = \text{Disengagement torque of the coupling (Nm)} \]
\[ K = \text{Service factor} \]
\[ T_{\text{max}} = \text{Maximum torque of the drive system (Nm)} \]
\[ T_{\text{AN}} = \text{Rated torque of the motor (Nm)} \]
\[ P_{\text{Drive}} = \text{Drive power (kW)} \]
\[ n = \text{Drive speed (min}^{-1}) \]
\[ \alpha = \text{Angular acceleration} \frac{\text{rad}}{\text{s}^2} \]
\[ t = \text{Acceleration time (s)} \]
\[ \omega = \text{Angular velocity (rad/s)} \]
\[ J_L = \text{Moment of inertia of load (kgm}^2) \]
\[ J_A = \text{Moment of inertia of drive (kgm}^2) \]
\[ T_{\text{AS}} = \text{Peak motor torque (Nm)} \]
\[ S = \text{Number of safety elements} \]
\[ F = \text{Tangential force (kN)} \]
\[ r = \text{Radius to element (m)} \]
\[ s = \text{Spindle pitch (mm)} \]
\[ F_v = \text{Feed force (N)} \]
\[ \eta = \text{Spindle efficiency} \]
\[ d_2 = \text{Pitch diameter (mm)} \]
\[ F_v = \text{Feed force (N)} \]
\[ C_T = \text{Torsional stiffness of coupling (Nm/ rad)} \]
\[ J_{\text{Total}} = \text{Total load inertia (kgm}^2) \]
\[ (\text{e.g. shaft + sprocket + chain + roller + 1/2 of coupling)} \]
\[ J_{\text{Mot.}} = \text{Total driving inertia (kgm}^2) \]
\[ (\text{e.g. motor shaft + 1/2 of coupling)} \]
\[ f_r = \text{Resonant frequency of the two mass system (Hz)} \]

<table>
<thead>
<tr>
<th>Shock or Load Factor ( S_a )</th>
<th>uniform load</th>
<th>non-uniform load</th>
<th>heavy shock load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

For many crushing and shredding applications load factors are commonly \( S_a = 2-3 \)

ACCORDING TO DISENGAGEMENT TORQUE

Safety couplings are normally selected according to the required disengagement torque, which must be greater than the maximum torque required for start-up and operation.

Disengagement torque values are often determined from the drive data and are typically a multiple of the nominal torque at the operating drive speed (TAN). In addition to a start-up torque (TMAX), the following values are used as further safety factors, depending on the load conditions:

\[ K = 1.3 \] uniform harmonious load
\[ K = 1.5 \] non-uniform load
\[ K = 1.8 \] heavy shock load

\[ T_{AR} \geq K \cdot T_{\text{max}} \text{ (Nm)} \]
or

\[ T_{\text{AN}} \geq 9,550 \cdot \frac{P_{\text{Drive}}}{n} \text{ (Nm)} \]

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ACCORDING TO ACCELERATION (START-UP WITH NO LOAD)

\[ T_{AR} \geq \alpha \cdot J_L = \frac{J_L}{J_A + J_L} \cdot T_{As} \cdot S_A \ (Nm) \]

\[ \alpha = \frac{\omega}{\pi \cdot \frac{n}{t \cdot 30}} \]

ACCORDING TO ACCELERATION (START-UP WITH LOAD)

\[ T_{AR} = \alpha \cdot J_L + T_{AN} = \left[ \frac{J_L}{J_A + J_L} \cdot (T_{As} - T_{AN}) + T_{AN} \right] \cdot S_A \ (Nm) \]

ACCORDING TO THE NUMBER OF SAFETY ELEMENTS

\[ T_{AR} = S \cdot F \cdot r \]

ACCORDING TO LINEAR FEED FORCE

Screw drive

\[ T_{AN} = \frac{s \cdot F_v}{2,000 \cdot \pi \cdot \eta} \ (Nm) \]

Rack and pinion drive

\[ T_{AN} = \frac{d_0 \cdot F_v}{2,000} \ (Nm) \]

ACCORDING TO RESONANT FREQUENCY

The torsional natural frequency of the coupling must be significantly higher or lower than that of the equipment. For the mechanical substitution model the two mass system applies.

\[ f_c = \frac{1}{2 \cdot \pi} \sqrt{C_f \cdot \frac{J_{Masch} + J_{Mot}}{J_{Masch} \cdot J_{Mot}}} \ (Hz) \]
SIZING AND SELECTION

SAFETY COUPLINGS

ELASTIC JAW COUPLING DESIGN ST2

<table>
<thead>
<tr>
<th>Size</th>
<th>ST2 / 10</th>
<th>ST2 / 25</th>
<th>ST2 / 60</th>
<th>ST2 / 160</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{in}$ Rated Torque (Nm)</td>
<td>10,000</td>
<td>15,000</td>
<td>40,000</td>
<td>80,000</td>
</tr>
<tr>
<td>$T_{max}$ Maximum Torque (Nm)</td>
<td>22,000</td>
<td>33,000</td>
<td>88,000</td>
<td>176,000</td>
</tr>
<tr>
<td>Torsional Stiffness (10^3 Nm/rad)</td>
<td>145</td>
<td>230</td>
<td>580</td>
<td>1000</td>
</tr>
<tr>
<td>Relative Damping</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

LOAD FACTORS BY MACHINE TYPE

EXCAVATORS
S bucket chain excavators
S traveling gear (caterpillar)
M traveling gear (rails)
S bucket wheels
M slewing gears

CONSTRUCTION MACHINERY
M mixers
M road construction machinery

CHEMICAL INDUSTRY
M mixers
G agitators (light fluids)
M dryer drums
G centrifuges

FEEDERS AND CONVEYORS
S belt conveyors
G belt conveyors (bulk materials)
M belt bucket conveyors
M screw conveyors
M circular conveyors
M hoists

BLOWERS AND FANS¹
G blowers (axial/radial) P:n ≤ 0.007
M blowers (axial/radial) P:n ≤ 0.007
S blowers (axial/radial) P:n > 0.007
G cooling tower fans P:n ≤ 0.007
M cooling tower fans P:n > 0.007
S cooling tower fans P:n > 0.007

GENERATORS AND TRANSFORMERS
S generators

RUBBER MACHINERY
S extruders
S calendars
M mixers
S rolling mills

WOOD PROCESSING MACHINERY
G woodworking machines

CRANES
S traveling gears
S hoisting gears
M slewing gears

PLASTICS MACHINERY
M mixers
M shredders

METALWORKING MACHINERY
M sheet metal bending machines
S plate straightening machines

FOOD PROCESSING MACHINERY
G filling machines
M kneading machines
M cane crushers
M cane cutters
S cane mills
M sugar beet cutters
M sugar beet washers

PAPER MACHINERY
S wood cutters
S calendars
S wet presses
S suction presses
S suction rollers
S drying cylinders

PUMPS
S piston pumps
G centrifugal pumps
S reciprocating pumps

STONE AND CLAY MACHINES
S breakers

ST SAFETY COUPLINGS

ST2 / 10 ST2 / 25 ST2 / 60 ST2 / 160

$T_{in}$ Rated Torque (Nm) 10,000 15,000 40,000 80,000
$T_{max}$ Maximum Torque (Nm) 22,000 33,000 88,000 176,000
Torsional Stiffness (10^3 Nm/rad) 145 230 580 1000
Relative Damping 1 1 1 1

¹) P = power of drive in kW
n = speed of drive in rpm

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### DESIGN FACTORS

**Shock or Load Factor** $S_A$

<table>
<thead>
<tr>
<th>Drive type</th>
<th>Load characteristics of driven machine</th>
<th>G</th>
<th>M</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric motors, turbines, hydraulic motors</td>
<td></td>
<td>1.25</td>
<td>1.6</td>
<td>2.0</td>
</tr>
<tr>
<td>internal combustion engines ≥4 cylinder</td>
<td></td>
<td>1.5</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>degree of uniformity ≥1:100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$G =$ smooth uniform load | $M =$ moderate load | $S =$ heavy shock load

**Temperature Factor** $S_v$

<table>
<thead>
<tr>
<th>Ambient Temperature</th>
<th>$S_v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40°C</td>
<td>1.0</td>
</tr>
<tr>
<td>+30°C</td>
<td>1.1</td>
</tr>
<tr>
<td>+60°C</td>
<td>1.4</td>
</tr>
<tr>
<td>+80°C</td>
<td>1.8</td>
</tr>
<tr>
<td>&gt; +80°C</td>
<td>on request</td>
</tr>
</tbody>
</table>

**Start Factor** $S_Z$

<table>
<thead>
<tr>
<th>Starts per Hour</th>
<th>$S_Z$</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1.0</td>
</tr>
<tr>
<td>60</td>
<td>1.1</td>
</tr>
<tr>
<td>120</td>
<td>1.2</td>
</tr>
<tr>
<td>240</td>
<td>1.3</td>
</tr>
<tr>
<td>&gt; 240</td>
<td>on request</td>
</tr>
</tbody>
</table>

### ACCORDING TO TORQUE

1. Calculate the drive torque $T_{AN}$:

   $T_{AN} \geq 9,550 \cdot \frac{P_{Drive}}{n} \quad (Nm)$

2. Base the coupling rated torque $T_{KN}$ on the drive torque $T_{AN}$ multiplied by the application factors. $T_{KN} \geq T_{AN} \cdot S_A \cdot S_v \cdot S_Z$

**Example:**

Coupling between an electric motor ($P=450$ kW and $n=980$ rpm) and a gearbox driving a conveyor.

- smooth uniform load $= G : S_A = 1.25$
- ambient temperature $40^\circ C : S_v = 1.1$
- starts $30/h : S_Z = 1.0$

Selected coupling: ST2 / 10 with elastomer coupling $T_{KN} = 6,030$ Nm

$T_{AN} = 9,550 \cdot \frac{450 \text{ kW}}{980 \text{ min.}^{-1}} = 4,385.2 \text{Nm}$

$T_{KN} \geq 4,385.2 \text{ Nm} \cdot 1.25 \cdot 1.1 \cdot 1.0 = 6,029.7 \text{Nm}$

Selected coupling: ST2 / 10 with elastomer coupling $T_{KN} = 6,030$ Nm
SIZING AND SELECTION

SAFETY COUPLINGS

GEAR COUPLING DESIGN ST4

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>T_{AN} Rated Torque (Nm)</td>
<td>16,000</td>
<td>22,000</td>
<td>62,000</td>
<td>174,000</td>
</tr>
<tr>
<td>T_{KMAX} Maximum Torque (Nm)</td>
<td>32,000</td>
<td>44,000</td>
<td>124,000</td>
<td>348,000</td>
</tr>
<tr>
<td>Volume of Grease (dm³)</td>
<td>0.52</td>
<td>0.8</td>
<td>1.51</td>
<td>3.29</td>
</tr>
<tr>
<td>n Ref (max speed) (min⁻¹)</td>
<td>6,050</td>
<td>5,150</td>
<td>3,600</td>
<td>3,050</td>
</tr>
</tbody>
</table>

*only allowable at reduced torque and misalignment levels (see table on page 13)

ACCORDING TO TORQUE

1. Calculate the drive torque, T_{AN}.

\[ T_{AN} \geq 9,550 \cdot \frac{P_{drive}}{n} \text{ (Nm)} \]

2. Base the coupling rated torque T_{KN} on the drive torque T_{AN} multiplied by the application factor. (see page 17 for shock or load factors S_A).

\[ T_{KN} \geq T_{AN} \cdot S_A \]

Example:
Coupling between an electric motor (P=1000kW and n=980 rpm) and a gearbox driving a screw conveyor (S_A = 1.6).

\[ T_{AN} = 9,550 \cdot \frac{100 \text{ kW}}{980 \text{ min}^{-1}} = 9,744 \text{ Nm} \]

\[ T_{KN} \geq T_{AN} \cdot S_A = 9,744 \text{ Nm} \cdot 1.6 = 15,591 \text{ Nm} \]

Selected coupling: ST4 / 10 with gear coupling T_{KN} = 16,000 Nm
RATINGS CHART

Maximum torque, speed and misalignment are related and cannot exist at the same time.

Evaluation of $T/T_{KN}$ and $n / n_{max}$

- Compare plotted values for combined limits

**Example: Coupling ST4 / 10**

\[
T = 5,600 \text{ Nm} \\
\frac{T}{T_{KN}} = \frac{5,600}{16,000} = 35% \\
n = 2,700 \text{ min.}^{-1} \\
\frac{n}{n_{max}} = \frac{2,700}{6,050} = 45% \\
\text{Angular misalignment: 0.4°}
\]

- Coupling is within operable range - ST4 / 10 can be used.
SIZING AND SELECTION

BELLOWS COUPLINGS

SYMBOLS

- $T_{KN}$ = Rated torque of coupling (Nm)
- $T_{AS}$ = Peak torque (Nm)
  e.g. maximum acceleration peak torque or maximum braking torque from the load
- $J_L$ = Moment of inertia of the load (load + drive line components + half of coupling) (kgm$^2$)
- $J_A$ = Drive inertia (rotor of motor + drive line components + half of coupling) (kgm$^2$)
- $C_T$ = Torsional stiffness of coupling (Nm/rad)
- $f_r$ = Resonant frequency of the two mass system (Hz)
- $f_{ex}$ = Excitation frequency of the drive (Hz)
- $\varphi$ = Angle of twist (degree)

<table>
<thead>
<tr>
<th>Shock or Load Factor $S_L$</th>
<th>uniform load</th>
<th>non-uniform load</th>
<th>heavy shock load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3-4</td>
</tr>
</tbody>
</table>

For many crushing and shredding applications load factors are commonly $S_L = 2-3$
SIZING

ACCORDING TO TORQUE

Couplings are normally sized for the highest torque to be regularly transmitted. The peak torque of the application should not exceed the rated torque of the coupling. The following calculation provides an approximation of the minimum required coupling size, and allows for the maximum rated speed and misalignment to exist in the application.

$$T_{KN} \geq 1.5 \cdot T_{AS} \text{ (Nm)}$$

ACCORDING TO ACCELERATION TORQUE

A more detailed calculation takes acceleration and the driving and driven moments of inertia into account. A strong inertia ratio diminishes the effect of the load factor in the sizing calculation.

$$T_{KN} \geq T_{AS} \cdot S_A \cdot \frac{J_l}{J_A + J_L} \text{ (Nm)}$$

ACCORDING TO RESONANT FREQUENCY

The torsional natural frequency of the coupling must be significantly higher or lower than that of the equipment. For the mechanical substitution model the two mass system applies.

In practice the following applies: $f_e \geq 2 \cdot f_w$

$$f_e = \frac{1}{2 \cdot \pi} \sqrt{\frac{C_I}{J_A + J_L} \cdot \frac{J_A \cdot J_L}{J_A + J_L}} \text{ (Hz)}$$

Two Mass System

ACCORDING TO TORSIONAL DEFLECTION

To calculate transmission error as a result of torsional stress:

$$\phi = \frac{180}{\pi} \cdot \frac{T_{AS}}{C_I} \text{ (degree)}$$
SIZING AND SELECTION

ELASTIC JAW COUPLINGS

SYMBOLS

\[ T_{Kn} = \text{Rated torque of the coupling (Nm)} \]
\[ T_{Kmax} = \text{Maximum torque rating of coupling (Nm)} \]
\[ T_S = \text{Peak torque applied to the coupling (Nm)} \]
\[ T_{AS} = \text{Peak torque of the drive system (Nm)} \]
\[ T_{AN} = \text{Nominal torque of the drive system (Nm)} \]
\[ T_{LN} = \text{Nominal torque of the load (Nm)} \]
\[ P = \text{Drive power (kW)} \]
\[ n = \text{Rotational speed (min.}^{-1}\text{)} \]
\[ J_A = \text{Total driving inertia (kgm}^2\text{)} \]
\[ \text{(motor [including gear ratio] + 1/2 of coupling)} \]
\[ J_L = \text{Total load inertia (kgm}^2\text{)} \]
\[ \text{(load + drive line components + half of coupling)} \]
\[ J_1 = \text{Moment of inertia of driving coupling half (kgm}^2\text{)} \]
\[ J_2 = \text{Moment of inertia of driving coupling half (kgm}^2\text{)} \]
\[ m = \text{Ratio of the moment of inertia of the drive to the load} \]
\[ \psi = \text{Temperature at the coupling (also consider radiant heat)} \]
\[ S_A = \text{Load factor} \]
\[ S_z = \text{Start factor} \]
\[ \text{(factor for the number of starts per hour)} \]
\[ Z_n = \text{Number of starts per hour (1/h)} \]

Temperature factor \( S_\psi \) | A | B | E
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>Sh 98 A</td>
<td>Sh 64 D</td>
<td>Sh 64 D</td>
</tr>
<tr>
<td>&gt; -30°C to -10°C</td>
<td>1.5</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>&gt; -10°C to +30°C</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>&gt; +30°C to +40°C</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>&gt; +40°C to +60°C</td>
<td>1.4</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>&gt; +60°C to +80°C</td>
<td>1.7</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>&gt; +80°C to +100°C</td>
<td>2.0</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>&gt; +100°C to +120°C</td>
<td>–</td>
<td>2.4</td>
<td>2.0</td>
</tr>
<tr>
<td>&gt; +120°C to +150°C</td>
<td>–</td>
<td>–</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Start factor \( S_z \) | \( S_{z1} \) | \( S_{z2} \)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 120</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>120 to 240</td>
<td>–</td>
<td>on request</td>
</tr>
<tr>
<td>over 240</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Shock / load factor \( S_A \) | uniform load | non-uniform load | heavy shock load
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.8</td>
<td>2.5</td>
<td></td>
</tr>
</tbody>
</table>
COUPLING SELECTION FOR OPERATION WITHOUT SHOCK OR REVERSAL

The rated torque of the coupling (\(T_{KN}\)) must be greater than the rated torque of the load (\(T_{LN}\)), taking into account the temperature at the coupling (Temperature factor \(S_\nu\)). Should \(T_{LN}\) be unknown, \(T_{AN}\) can be used as a substitute in the formula.

Calculation

\[ T_{KN} > T_{AN} \cdot S_\nu \]

Supplemental Calculation

\[ T_{AN} = \frac{9,550 \cdot P}{n} \]

Sample calculation: (without shock loads)

Coupling conditions

- \(\nu = 70^\circ\) C
- \(S_\nu = 1.7\) (for 70°/Elastomer Type A)

Drive for centrifugal pump

- \(T_{AN} = 85\) Nm

Calculation:

\[ T_{KN} > T_{AN} \cdot S_\nu \]
\[ T_{KN} > 85\text{ Nm} \cdot 1.7 \]
\[ T_{KN} > 144.5\text{ Nm} \]

Result: Coupling model EK2/150/A (\(T_{KN} = 160\) Nm) is selected.

COUPLING SELECTION FOR OPERATION WITH SHOCK LOADS

Same basic conditions as above. In addition, the maximum torque rating of the coupling (\(T_{Kmax}\)) is dictated by peak torque (\(T_s\)) due to shock loads.

Calculation

\[ T_{KN} > T_{AN} \cdot S_\nu \]

Supplemental Calculation

\[ T_{AN} = \frac{9,550 \cdot P}{n} \]

Calculation

\[ T_{Kmax} > T_s \cdot S_2 \cdot S_\nu \]

Supplemental Calculation

\[ T_s = \frac{T_{AS} \cdot S_A}{m + 1} \]
\[ m = \frac{J_A \cdot J_1}{J_1 \cdot J_2} \]
# SIZING AND SELECTION

## DRIVE SHAFT COUPLINGS

### SYMBOLS

- \( A \) = Overall length (mm)
- \( AB \) = Distance between flexures (mm)
  \[ AB = (A - 2\times N) \]
- \( Z \) = Tube length (mm)
  \[ Z = (A - 2\times H) \]
- \( H \) = Length of coupling ends (mm)
- \( N \) = Length to flexure (mm)
- \( T_{AS} \) = Peak torque of the drive (Nm)
- \( \varphi \) = Torsional deflection (degree)
- \( C_T^n \) = Torsional stiffness of both flexible elements (Nm/rad)
- \( C_{T,zen} \) = Torsional stiffness per 1m of tubing (Nm/rad)
- \( C_T^{ZA} \) = Total torsional stiffness (Nm/rad)
- \( n_k \) = Critical speed (1/min.)
- \( C_{typ}^{f} \) = Dynamic torsional stiffness of both elastomer inserts (Nm/rad)
- \( C_{typ}^{ez} \) = Total torsional stiffness (Nm/rad)

### TABLE 1

<table>
<thead>
<tr>
<th>Size</th>
<th>Torsional stiffness of both bellows bodies ( C_T^n ) (Nm/rad)</th>
<th>Torsional stiffness per 1m of standard tubing ( C_{T,zen} ) (Nm/rad)</th>
<th>Length of coupling ends ZA ( Z ) (mm)</th>
<th>Length to flexure ( N ) (mm)</th>
<th>Maximum axial misalignment ( \Delta Ka ) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500</td>
<td>1,400,000</td>
<td>775,000</td>
<td>92</td>
<td>56</td>
<td>4</td>
</tr>
<tr>
<td>4000</td>
<td>4,850,000</td>
<td>1,160,000</td>
<td>102</td>
<td>61</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1

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MODEL EZ

<table>
<thead>
<tr>
<th>Size</th>
<th>Torsional stiffness of both flexible elements</th>
<th>Torsional stiffness per m of tubing</th>
<th>Length to flange ends EZ</th>
<th>Length to flange ends MAT</th>
<th>Max. axial misalignment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elastomer insert A C_T^A (Nm/rad)</td>
<td>Elastomer insert B C_T^B (Nm/rad)</td>
<td>C_T^ZWR (Nm/rad)</td>
<td>H (mm)</td>
<td>N (mm)</td>
</tr>
<tr>
<td>2500</td>
<td>87,500</td>
<td>108,000</td>
<td>950,000</td>
<td>142</td>
<td>108</td>
</tr>
<tr>
<td>4500</td>
<td>168,500</td>
<td>371,500</td>
<td>2,200,000</td>
<td>181</td>
<td>137</td>
</tr>
<tr>
<td>9500</td>
<td>590,000</td>
<td>670,000</td>
<td>5,500,000</td>
<td>229</td>
<td>171</td>
</tr>
</tbody>
</table>

Table 2

MAXIMUM TRANSMITTABLE TORQUE BY BORE DIAMETER (Nm)

<table>
<thead>
<tr>
<th>Size</th>
<th>Ø 35</th>
<th>Ø 45</th>
<th>Ø 50</th>
<th>Ø 60</th>
<th>Ø 70</th>
<th>Ø 80</th>
<th>Ø 90</th>
<th>Ø 120</th>
<th>Ø 140</th>
</tr>
</thead>
<tbody>
<tr>
<td>2500</td>
<td>3900</td>
<td>2600</td>
<td>2900</td>
<td>3200</td>
<td>3500</td>
<td>3800</td>
<td>4000</td>
<td>4300</td>
<td>4600</td>
</tr>
<tr>
<td>4500</td>
<td>5300</td>
<td>5800</td>
<td>6300</td>
<td>7000</td>
<td>7600</td>
<td>8200</td>
<td>8800</td>
<td>9400</td>
<td>10600</td>
</tr>
<tr>
<td>9500</td>
<td>9200</td>
<td>10100</td>
<td>11100</td>
<td>12800</td>
<td>13800</td>
<td>14800</td>
<td>16700</td>
<td>22000</td>
<td>25600</td>
</tr>
</tbody>
</table>

TEMPERATURE FACTOR S

<table>
<thead>
<tr>
<th>Temperature (℃)</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; -30° to -10°</td>
<td>1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>&gt; -10° to +30°</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>&gt; +30° to +40°</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>&gt; +40° to +60°</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>&gt; +60° to +80°</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>&gt; +80° to +100°</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>&gt; +100° to +120°</td>
<td>–</td>
<td>2.4</td>
</tr>
</tbody>
</table>

ACCORDING TO TORSIONAL STIFFNESS

**Condition:** Line shaft ZA, Size 1,500 T_AS = 1,500 Nm

Wanted: Total torsional stiffness C_T^ZA

\[
(C_T^ZA) = \frac{C_T^A \cdot (C_T^ZWR/Z)}{C_T^B + (C_T^ZWR/Z)} \quad (Nm/rad)
\]

ACCORDING TO TORSIONAL DEFLECTION

**Condition:** Line shaft ZA, size 1,500 T_AS = 1,500 Nm

Wanted: Torsional deflection at maximum acceleration torque T_AS

Measurement (A) of line shaft = 1.5m

Length (Z) of tubing = A - 2xH = 1.344m

\[
ϕ = \frac{180 \times 1,500 \text{ Nm}}{\pi \times 390,867 \text{ Nm/rad}} = 0.21°
\]

With a maximum torque of 1,500 Nm the torsional deflection is 0.21°
SIZING AND SELECTION

DRIVE SHAFT COUPLINGS

According to Maximum Misalignment

Lateral misalignment $\Delta Kr$

Angular misalignment $\Delta Kw$

Axial misalignment $\Delta Ka$

Using proprietary software, R+W will calculate the specific mechanical details of exactly the model you plan to use. Overall length, tube materials (e.g. steel, aluminum, CFK), and other factors are used to determine a number of performance values unique to your line shaft coupling.

$\Delta Kr_{\text{max}} = \tan \Delta \phi \cdot AB$

$\Delta Kw_{\text{max}} = 2\phi$

$AB = A - 2xN$

R+W CALCULATION PROGRAM

Critical speed $n_z = 1/\text{min}$.

Torsional stiffness of tubing $C_{TZWR} = \text{Nm/rad}$

Overall stiffness $C_T = \text{Nm/rad}$

Torsional deflection $q_i = \text{degree-min-sec}$

Total Weight $m = \text{kg}$

Moment of inertia $J = \text{kgm}^2$

Maximum misalignment $\Delta Kr = \text{mm}$

See table 1+2

Pages 16+17
SIZING AND SELECTION

DISC PACK COUPLINGS

SYMBOLS

\( T_{Kn} \) = Rated torque of the coupling (Nm)
\( T_{As} \) = Peak torque of the drive system
  e.g. max. acceleration torque of drive (Nm)
  or max. braking torque of load (Nm)
\( J_L \) = Total load inertia (e.g. shaft + sprocket + chain +
  roller + 1/2 of coupling) (kgm\(^2\))
\( J_A \) = Total driving inertia (motor [including gear ratio] +
  1/2 of coupling) (kgm\(^2\))
\( C_t \) = Torsional stiffness of the coupling (Nm/rad)
\( f_e \) = Natural frequency of the two mass system (Hz)
\( f_{er} \) = Excitation frequency of the drive (Hz)
\( \varphi \) = Torsional deflection (degree)

<table>
<thead>
<tr>
<th>Shock or Load Factor ( S_n )</th>
<th>uniform load</th>
<th>non-uniform load</th>
<th>highly dynamic load</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S_n )</td>
<td>1</td>
<td>2</td>
<td>3-4</td>
</tr>
</tbody>
</table>

Common factor for servo drives in machine tools: \( S_n = 2-3 \)

ACCORDING TO TORQUE

Couplings are normally sized for the highest torque to be
regularly transmitted. The peak torque of the application
should not exceed the rated torque of the coupling. The fol-
lowing calculation provides an approximation of the mini-
mum required coupling size, and allows for the maximum
rated speed and misalignment to exist in the application.

\[
T_{Kn} \geq 1.5 \cdot T_{As} \quad \text{(Nm)}
\]

ACCORDING TO ACCELERATION TORQUE

A more detailed calculation takes acceleration and the driv-
ing and driven moments of inertia into account. A strong
inertia ratio diminishes the effect of the load factor in the
sizing calculation.

\[
T_{Kn} \geq T_{As} \cdot S_A \cdot \frac{J_L}{J_A + J_L} \quad \text{(Nm)}
\]
SIZING AND SELECTION

GEAR COUPLINGS

SYMBOLS

T_{KN} = Rated torque of the coupling (Nm)
T_{AN} = Rated torque of the drive (Nm)
S_A = Shock or load factor
P = Drive power (kW)
n = Rotational speed (rpm)

DESIGN FACTORS

Shock or Load Factor S_A

<table>
<thead>
<tr>
<th>Drive type</th>
<th>G</th>
<th>M</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric motors, turbines, hydraulic motors</td>
<td>1.25</td>
<td>1.6</td>
<td>2.0</td>
</tr>
<tr>
<td>internal combustion engines ≥ 4 cylinder degree of uniformity ≥ 1:100</td>
<td>1.5</td>
<td>2.2</td>
<td>2.5</td>
</tr>
</tbody>
</table>

G = smooth uniform load | M = moderate load | S = heavy shock load

LOAD FACTORS BY MACHINE TYPE

EXCAVATORS
S bucket chain excavators
S traveling gear (caterpillar)
M traveling gear (rails)
M suction pumps
S bucket wheels
M slewing gears

CONSTRUCTION MACHINERY
M concrete mixers
M road construction machinery

CHEMICAL INDUSTRY
M mixers
G agitators (light fluids)
M dryer drums
G centrifuges

FEEDERS AND CONVEYORS
S belt conveyors
G belt conveyors (bulk materials)
M belt bucket conveyors
M screw conveyors
M circular conveyors
M hoists

BLOWERS AND FANS¹
G blowers (axial/ radial) P:n ≤ 0.007
M blowers (axial/ radial) P:n ≤ 0.007
S blowers (axial/ radial) P:n > 0.007
G cooling tower fans P:n ≤ 0.007
M cooling tower fans P:n ≤ 0.007
S cooling tower fans P:n > 0.007

GENERATORS AND TRANSFORMERS
S generators

RUBBER MACHINERY
S extruders
S calendars
M mixers
S rolling millse

WOOD PROCESSING MACHINERY
G woodworking machines

CRANES
S traveling gears
S hoisting gears
M slewing gears

PLASTICS MACHINERY
M mixers
M shredders

METALWORKING MACHINERY
M sheet metal bending machines
S plate straightening machines

MACHINE TOOLS
S presses
M shears
S punch presses
M machine tools, main drives

FOOD PROCESSING MACHINERY
G filling machines
M kneading machines
M cane crushers
M cane cutters
M cane mills
S sugar beet cutters
S sugar beet washers

PAPER MACHINERY
S wood cutters
S calendars
S wet presses
S suction presses
S suction rollers
S drying cylinders

PUMPS
S piston pumps
G centrifugal pumps
S reciprocating pumps

STONE AND CLAY MACHINES
S breakers

G rotary kilns
S hammer mills
S brick presses

TEXTILE MACHINERY
M tanning vats
M willows
M looms

COMPRESSIONS
S reciprocating compressors
M centrifugal compressors

METAL ROLLING MILLS
M plate tilters
S ingot handling machinery
M winding machines (strip and wire)
S descaling machines
S cold rolling mills
M chain transfers
M cross transfers
M roller straighteners
S tube welding machines
S continuous casting plants
M roller adjustment drives

WASTEWATER TREATMENT PLANTS
M tumblerors
M washing machines

LAUNDRY MACHINES
M tumblerors
M washing machines

¹) P = power of drive in kW
n = speed of drive in rpm
1. Calculate the drive torque at speed $T_{AN}$.

$$T_{AN} \geq 9,550 \cdot \frac{P_{Drive}}{n} \text{ (Nm)}$$

2. Determine the required torque rating of the coupling $T_{KN}$ based on the drive torque $T_{AN}$ multiplied by the shock or load factor $S_A$ (see page 17).

$$T_{KN} \geq T_{AN} \cdot S_A$$

**Sample calculation:**
Coupling between an electric motor ($P=1000$ kW at $n=980$ rpm) and a transmission, driving a screw conveyor ($S_A=1.6$).

$$T_{AN} = 9,550 \cdot \frac{1,000 \text{ kW}}{980 \text{ min}^{-1}} = 9,744 \text{ Nm}$$

$$T_{KN} \geq T_{AN} \cdot S_A$$

$$T_{KN} \geq 9,744 \text{ Nm} \cdot 1.6 = 15,591 \text{ Nm}$$

**RATINGS CHART**

Maximum torque, speed and misalignment are related and cannot exist at the same time.
Evaluation of $T/T_{KN}$ and $n/n_{max}$
- Compare plotted values for combined limits.