| Racks Helical | m = 1.5 | ZA-30 |
| Racks Helical | m = 2 | ZA-31 |
| Racks Helical | m = 3 | ZA-32 |
| Racks Helical | m = 4 | ZA-33 |
| Racks Helical | m = 5 | ZA-34 |
| Racks Helical | m = 6 | ZA-35 |
| Racks Helical | m = 8 | ZA-36 |
| Racks Helical | m = 10 | ZA-37 |
| Racks Helical | m = 12 | ZA-38 |
| Racks Straight | m = 1 | ZB-36 |
| Racks Straight | m = 1.5 | ZB-37 |
| Racks Straight | m = 2 | ZB-38 |
| Racks Straight | m = 2.5 | ZB-39 |
| Racks Straight | m = 3 | ZB-40 |
| Racks Straight | m = 4 | ZB-41 |
| Racks Straight | m = 5 | ZB-42 |
| Racks Straight | m = 6 | ZB-43 |
| Racks Straight | m = 8 | ZB-44 |
| Racks Straight | m = 10 | ZB-45 |
| Racks Straight | m = 12 | ZB-46 |
| Integrated Racks | m = 2 | ZC-15 |
| Integrated Racks | m = 3 | ZC-16 |
| Integrated Racks | m = 4 | ZC-17 |
| Integrated Racks | p = 5 mm | ZC-18 |
| Integrated Racks | p = 10 mm | ZC-19 |
| Integrated Racks | p = 13.33 mm | ZC-20 |
| Calculation, Instruction | | ZD-2 |
| Calculation Example | Travelling Operation | ZD-3 |
| Calculation Example | Lifting Operation | ZD-4 |
| Actual size of modular gearing according to DIN 867 | | ZD-5 |
The values given in the load table are based upon uniform, smooth operation, $K_{Hß}=1.0$ and reliable grease lubrication. Since, in practice, the applications are very diverse, it is important to consider the given conditions by using appropriate factors $S_{B}$, $K_{A}$, $L_{Kßß}$ and $f_{n}$ (see below).

**Formulas for Determining the Tangential Force**

\[
a = \frac{\nu}{t_{b}} \quad [m/s^2]
\]

\[
F_{u} = \frac{m \cdot g + m \cdot a}{1000} \quad [kN] \quad \text{(for lifting axle)}
\]

\[
F_{u} = \frac{m \cdot g \cdot \mu + m \cdot a}{1000} \quad [kN] \quad \text{(for driving axle)}
\]

\[
F_{u \text{ perm.}} = \frac{F_{u \text{ Tab}}}{K_{A} \cdot S_{B} \cdot f_{n} \cdot L_{Kßß}} \quad [kN]
\]

Formula dimensions see page ZD-3

**The Condition $F_{u} < F_{u \text{ perm.}}$ Must be Fulfilled.**

**Load Factor $K_{A}$**

<table>
<thead>
<tr>
<th>Drive</th>
<th>Uniform</th>
<th>Medium Shocks</th>
<th>Heavy Shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>1.00</td>
<td>1.25</td>
<td>1.75</td>
</tr>
<tr>
<td>Light Shocks</td>
<td>1.25</td>
<td>1.50</td>
<td>2.00</td>
</tr>
<tr>
<td>Medium Shocks</td>
<td>1.50</td>
<td>1.75</td>
<td>2.25</td>
</tr>
</tbody>
</table>

**Safety Coefficient $S_{B}$**

The safety coefficient should be allowed for according to experience ($S_{B} = 1.1$ to $1.4$).

**Life-Time Factor $f_{n}$**

considering of the peripheral speed of the pinion and lubrication.

<table>
<thead>
<tr>
<th>Peripheral Speed of Gearing</th>
<th>Continuous</th>
<th>Daily</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>m/sec</td>
<td>m/min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>30</td>
<td>0.85</td>
<td>0.95</td>
</tr>
<tr>
<td>1.0</td>
<td>60</td>
<td>0.85</td>
<td>1.10</td>
</tr>
<tr>
<td>1.5</td>
<td>90</td>
<td>1.00</td>
<td>1.20</td>
</tr>
<tr>
<td>2.0</td>
<td>120</td>
<td>1.05</td>
<td>1.30</td>
</tr>
<tr>
<td>3.0</td>
<td>180</td>
<td>1.10</td>
<td>1.50</td>
</tr>
<tr>
<td>5.0</td>
<td>300</td>
<td>1.25</td>
<td>1.90</td>
</tr>
</tbody>
</table>

**Linear Load Distribution Factor $L_{Kßß}$**

The linear load distribution factor considers the contact stress, while it describes unintegrated load distribution over the tooth width ($L_{Kßß} = \sqrt{K_{Hß}}$).

- $L_{Kßß} = 1.1$ for counter bearing, e.g. Torque Supporter
- $L_{Kßß} = 1.2$ for preloaded bearings on the output shaft e.g. ATLANTA HT, HP and E servo-worm gear unit, BG bevel-gear unit
- $L_{Kßß} = 1.5$ for unpreloaded bearings on the output shaft e.g. ATLANTA B servo-worm gear unit
Calculation Example

Values Given

- Mass to be Moved: \( m = 820 \text{ kg} \)
- Speed: \( v = 2 \text{ m/s} \)
- Acceleration Time: \( t_b = 1 \text{ s} \)
- Acceleration Due to Gravity: \( g = 9.81 \text{ m/s}^2 \)
- Coefficient of Friction: \( \mu = 0.1 \)
- Load Factor: \( K_A = 1.5 \)
- Life-Time Factor: \( f_n = 1.05 \text{ (cont. lubrication)} \)
- Safety Coefficient: \( S_B = 1.2 \)
- Linear Load: \( L_{KH} = 1.5 \)

Calculation Process

\[
a = \frac{v}{t_b} \quad a = \frac{2}{1} = 2 \text{ m/s}^2
\]

\[
F_u = \frac{m \cdot g \cdot \mu + m \cdot a}{1000}
\]

\[
F_u = \frac{820 \cdot 9.81 \cdot 0.1 + 820 \cdot 2}{1000} = 2.44 \text{ kN}
\]

Condition

\( F_{u \text{ zul./per.}} > F_u \); \( 4.05 \text{ kN} > 2.44 \text{ kN} \) = > fulfilled

Result: Rack 27 30 101 Page ZB-13

Pinion 24 35 220 Page ZB-23 case hardened

Your Calculation

Values Given

- Mass to be Moved: \( m = \) kg
- Speed: \( v = \) m/s
- Acceleration Time: \( t_b = \) s
- Acceleration Due to Gravity: \( g = 9.81 \text{ m/s}^2 \)
- Coefficient of Friction: \( \mu = \) 
- Load Factor: \( K_A = \) 
- Life-Time Factor: \( f_n = \) 
- Safety Coefficient: \( S_B = \) 
- Linear Load: \( L_{KH} = \) 

Calculation Process

\[
a = \frac{v}{t_b} \quad a = \frac{\text{[value]}}{1} = \text{[value]} \text{ m/s}^2
\]

\[
F_u = \frac{m \cdot g \cdot \mu + m \cdot a}{1000} \quad F_u = \frac{\text{[value]}}{1000} = \text{[value]} \text{ kN}
\]

Permissible Feed Force \( F_{u \text{ Tab}} \)

\[
F_{u \text{ zul./per.}} = \frac{F_{u \text{ Tab}}}{K_A \cdot S_B \cdot f_n \cdot L_{KH}}
\]

\[
F_{u \text{ zul./per.}} = \frac{11.5 \text{ kN}}{1.5 \cdot 1.2 \cdot 1.05 \cdot 1.5} = 4.05 \text{ kN}
\]

Condition

\( F_{u \text{ zul./per.}} > F_u \); \( 4.05 \text{ kN} > 2.44 \text{ kN} \) = > fulfilled

Result: Rack 27 30 101 Page ZB-13

Pinion 24 35 220 Page ZB-23 case hardened
### Calculation Example

#### Values Given

- **Lifting Operation**
  - Mass to be Moved: \( m = 300 \text{ kg} \)
  - Speed: \( v = 1.08 \text{ m/s} \)
  - Acceleration Time: \( t_b = 0.7 \text{ s} \)
  - Acceleration Due to Gravity: \( g = 9.81 \text{ m/s}^2 \)
  - Load Factor: \( K_A = 1.2 \)
  - Life-Time Factor: \( f_n = 1.1 \) (Cont. Lubrication)
  - Safety Coefficient: \( S_B = 1.2 \)
  - Linear Load Distribution Factor: \( L_{KH\beta} = 1.2 \)

#### Calculation Process

\[
a = \frac{v}{t_b} = \frac{1.08}{0.27} = 4 \text{ m/s}^2
\]

\[
F_u = \frac{m \cdot g + m \cdot a}{1000} = \frac{300 \cdot 9.81 + 300 \cdot 4}{1000} = 4.1 \text{ kN}
\]

Assumed feed force: rack C45, ind. hardened, helical, module 2, pinion 16MnCr5, case hardened, 20 teeth, page ZA-31 with \( F_{u,tab} = 12 \text{ kN} \)

\[
F_{u,tab} = K_A \cdot S_B \cdot f_n \cdot L_{KH\beta} = 11.5 \text{ kN}
\]

\[
F_{u,zul./per.} = \frac{F_{u,tab}}{K_A \cdot S_B \cdot f_n \cdot L_{KH\beta}} = 5.9 \text{ kN}
\]

#### Condition

\( F_{u,zul./per.} > F_u ; 6.0 \text{ kN} > 4.1 \text{ kN} \) => fulfilled

**Result:** Rack 29 20 105 Page ZA-7

Pinion 24 29 520 Page ZA-24

### Your Calculation

#### Values Given

- **Lifting Operation**
  - Mass to be Moved: \( m = \underline{\text{__________}} \text{ kg} \)
  - Speed: \( v = \underline{\text{__________}} \text{ m/s} \)
  - Acceleration Time: \( t_b = \underline{\text{__________}} \text{ s} \)
  - Acceleration Due to Gravity: \( g = \underline{\text{__________}} \text{ m/s}^2 \)
  - Load Factor: \( K_A = \underline{\text{__________}} \)
  - Life-Time Factor: \( f_n = \underline{\text{__________}} \)
  - Safety Coefficient: \( S_B = \underline{\text{__________}} \)
  - Linear Load Distribution Factor: \( L_{KH\beta} = \underline{\text{__________}} \)

#### Calculation Process

\[
a = \frac{v}{t_b} = \underline{\text{__________}} \text{ m/s}^2
\]

\[
F_u = \frac{m \cdot g + m \cdot a}{1000} \quad F_{u, erf./req.} = \underline{\text{__________}} \text{ kN}
\]

Permissible Feed Force \( F_{u,tab} \)

\[
F_{u,zul./per.} = \frac{F_{u,tab}}{K_A \cdot S_B \cdot f_n \cdot L_{KH\beta}} = \underline{\text{__________}} \text{ kN}
\]

#### Condition

\( F_{u,zul./per.} > F_u ; \underline{\text{kN}} > \underline{\text{kN}} \) => fulfilled

**Result:** Rack 29 20 105 Page ZA-7

Pinion 24 29 520 Page ZA-24