

			Chapter
& =1.	Racks Helical	m = 1.5	ZA-30
		m = 2	ZA-31
		m = 3	ZA-32
		m = 4	ZA-33
		m = 5	ZA-34
		m = 6	ZA-35
		m = 8	ZA-36
		m = 10	ZA-37
		m = 12	ZA-38
	Racks Straight	m = 1	ZB-36
		m = 1.5	ZB-37
		m = 2	ZB-38
		m = 2.5	ZB-39
		m = 3	ZB-40
		m = 4	ZB-41
		m = 5	ZB-42
		m = 6	ZB-43
		m = 8	ZB-44
		m = 10	ZB-45
		m = 12	ZB-46
S	Integrated Racks	m = 2	ZC-15
	eg.a.ea . iae.ie	m = 3	ZC-16
		m = 4	ZC-17
		p = 5 mm	ZC-18
		p = 10 mm	ZC-19
		p = 13.33 mm	ZC-20
	Calculation, Instruction		ZD-2
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	Calculation Example	Travelling Operation Lifting Operation	ZD-3 ZD-4
	Actual size of modular ge	aring according to DIN 867	ZD-5











The values given in the load table are based upon uniform, smooth operation, $K_{H\beta}$ =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 , $L_{KH\beta}$ and f_n (see below).

Formulas for Determining the Tangential Force

$$\begin{array}{ll} a & = \frac{V}{t_b} & [\text{m/s}^2] \\ F_u & = \frac{m \cdot g + m \cdot a}{1000} \text{ (for lifting axle)} & [\text{kN}] \\ F_u & = \frac{m \cdot g \cdot \mu + m \cdot a}{1000} \text{ (for driving axle)} & [\text{kN}] \\ F_{u \, perm.} & = \frac{F_{u \, Tab}}{K_A \cdot S_B \cdot f_n \cdot L_{KHB}} & [\text{kN}] \end{array}$$

Formula dimensions see page ZD-3

The Condition $F_u < F_{u perm.}$ Must be Fulfilled.

Load Factor KA

Drive	Type of load from the machines to be driven Uniform Medium Shocks Heavy Shocks		
Uniform	1.00	1.25	1.75
Light Shocks	1.25	1.50	2.00
Medium Shocks	1.50	1.75	2.25

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.

Lubricati	on	Continuous	Daily	Monthly
Peripheral Speed of Gearing				
m/sec	m/min			
0.5	30	0.85	0.95	
1.0	60	0.95	1.10	from
1.5	90	1.00	1.20	3
2.0	120	1.05	1.30	to
3.0	180	1.10	1.50	10
5.0	300	1.25	1.90	



Linear Load Distribution Factor L_{KHB}

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

 $L_{KHB} = 1.1$ for counter bearing, e.g. Torque Supporter

= 1.2 for preloaded bearings on the output shaft e.g. ATLANTA HT, HP and E servo-worm gear unit, BG bevel-gear unit

= 1.5 for unpreloaded bearings on the output shaft e.g. ATLANTA B servo-worm gear unit



Calculation Example

Values Given

⊗ Travelling Operation

Mass to be Moved m = 820 kg

Speed v = 2 m/s

Acceleration Time $t_b = 1 s$

Acceleration Due to Gravity g = 9.81 m/s²

Coefficient of Friction $\mu = 0.1$

Load Factor $K_A = 1.5$

Life-Time Factor $f_n = 1.05$ (cont. lubrication)

Safety Coefficient $S_B = 1.2$

Linear Load $L_{KH\beta} = 1.5$

Distribution Factor

Your Calculation

Values Given

Mass to be Moved m = kg

Speed $v = \underline{\hspace{1cm}} m/s$

Acceleration Time $t_b =$ _____s

Acceleration Due to Gravity g = 9.81 m/s²

Coefficient of Friction $\mu =$

Load Factor K_A = _____

Life-Time Factor $f_n = \underline{\hspace{1cm}}$

Safety Coefficient S_B = _____

Linear Load $L_{KH\beta} =$

Distribution Factor

Calculation Process

Results

$$a = \frac{v}{t_b}$$
 $a = \frac{2}{1}$ = 2 m/s

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

 $F_u = 820 \cdot 9.81 \cdot 0.1 + 820 \cdot 2 = 2.44 \text{ kN}$

Assumed feed force: rack C45, ind. hardened, straight tooth, module 3, pinion 16MnCr5, case hardened, 20 teeth, page ZB-40 with Futab = 11.5 kN

$$\begin{split} F_{u\,zul./per.} &= \frac{F_{uTab}}{K_A \cdot S_B \cdot f_n \cdot L_{KH\beta}} \,; \\ F_{u\,zul./per.} &= \frac{11.5 \text{ kN}}{1.5 \cdot 1.2 \cdot 1.05 \cdot 1.5} = 4.05 \text{ kN} \end{split}$$

Condition

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

Result: Rack 27 30 101 Page ZB-13

Pinion 24 35 220 Page ZB-23 case hardened

Calculation Process

Results

$$a = \frac{V}{t_b}$$
 $a = ___ = __ m/s^2$

$$F_u = \underline{m \cdot g \cdot \mu + m \cdot a}_{1000}$$
; $F_u = \underline{\qquad}_{1000}$

Permissible Feed Force F_{u Tab}

$$F_{u \, zul./per.} = \frac{F_{u \, Tab}}{K_A \cdot S_B \cdot f_n \cdot L_{KH\beta}};$$

$$F_{u \, zul./per.} = \underline{\qquad} = \underline{\qquad} KN$$

Condition

 $F_{uzul/per} > F_u$; kN > kN = fulfilled





Calculation Example

Values Given

⊗ Lifting Operation

Mass to be Moved m = 300 kg

Speed v = 1.08 m/s

Acceleration Time $t_{b} = 0.7 \, s$

Acceleration Due to Gravity g = 9.81 m/s²

 $K_A = 1.2$ Load Factor

Life-Time Factor $f_n = 1.1$ (Cont. Lubrication)

 $S_B = 1.2$ Safety Coefficient

Linear Load $L_{KHR} = 1.2$

Distribution Factor

Calculation Process

Results

$$a = \frac{v}{t_b} \qquad a = \frac{1.08}{0.27}$$

$$= 4 \text{ m/s}^2$$

$$F_u = \underline{m \cdot g + m \cdot a}_{1000}$$

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

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

$$\mathsf{F}_{\text{u zul./per.}} = \frac{F_{\text{u Tab}}}{K_{A} \cdot S_{B} \cdot f_{n} \cdot L_{KH\beta}} \; ; \; \mathsf{F}_{\text{u zul./per.}} = \frac{11.5 \; \text{kN}}{1.2 \cdot 1.2 \cdot 1.1 \cdot 1.2} \\ = 5.9 \; \text{kN}$$

Condition

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

Result: Rack 29 20 105 Page ZA-7

> Page ZA-24 Pinion 24 29 520

Your Calculation

Values Given

⊗ Lifting Operation

m =____kgMass to be Moved

Speed $v = \underline{\hspace{1cm}} m/s$

Acceleration Time

Acceleration Due to Gravity g = 9.81 m/s²

Load Factor $K_A =$

Life-Time Factor f_n = _____

 $S_R = \underline{\hspace{1cm}}$ Safety Coefficient

Linear Load L_{KHB} = _____ Distribution Factor

Calculation Process

Results

$$= \frac{v}{t}$$
 $a = ___ = __ m/s^2$

$$F_u = \frac{m \cdot g + m \cdot a}{1000} \qquad F_{u \text{ erf./req.}} = \underline{\qquad} = \underline{\qquad} \text{kN}$$

Permissible Feed Force Futab

$$\mathsf{F}_{\mathsf{u}\;\mathsf{zul}./\mathsf{per.}} = \underbrace{F_{u\;\mathsf{Tab}}}_{\mathsf{K}_{A} \bullet \mathsf{S}_{B} \bullet \mathsf{f}_{n} \bullet \mathsf{L}_{\mathsf{KH}\beta}} \; \; ; \; \mathsf{F}_{\mathsf{u}\;\mathsf{zul}./\mathsf{per.}} = \underline{\hspace{1cm}} = \underline{\hspace{1cm}} \; \mathsf{kN}$$

Condition

 $F_{u \text{ zul./per.}} > F_{u}$; kN > kN=> fulfilled

