Data Sheets:

Bevel Gears

$$d = mN \qquad \tan\gamma = \frac{N_p}{N_G}, \qquad \tan\Gamma = \frac{N_G}{N_p}$$

$$r_{av_p} = r_p - \frac{F}{2}\sin\gamma$$

$$W_r^* = W_t^* \tan\varphi\cos\gamma$$

$$W_a^* = W_t^* \tan\varphi\sin\gamma$$

Use W without (*) for stress analysis

Strength :

Bending:

$$\sigma = \frac{W_t}{bmJ} K_v K_0 K_s K_H$$

$$\sigma^{\backslash}_{FP} = 0.3H_B + 14.48 \text{ MPa} \quad \text{for grade 1}$$

$$= 0.33H_B + 41.24 \text{ MPa} \quad \text{for grade 2}$$

The corrected strength:

$$\sigma_{FP} = \sigma^{\backslash}_{FP} \frac{Y_N}{Y_\theta Y_Z}$$

Contact Strength:

$$\sigma_c = C_p \sqrt{\frac{W_t}{bd_p I} K_v K_o K_s K_H C_{xc}}$$

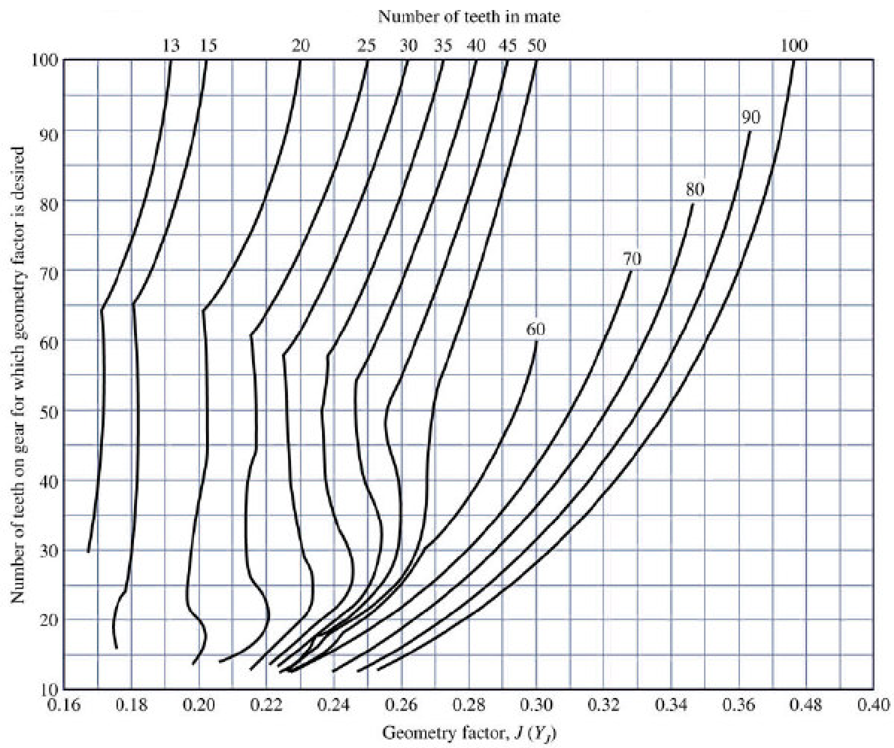
$$\sigma^{\backslash}_{HP} = 2.35H_B + 162.89 \text{ MPa} \quad \text{for grade 1}$$

$$= 2.51H_B + 203.86 \text{ MPA} \quad \text{for grade 2}$$

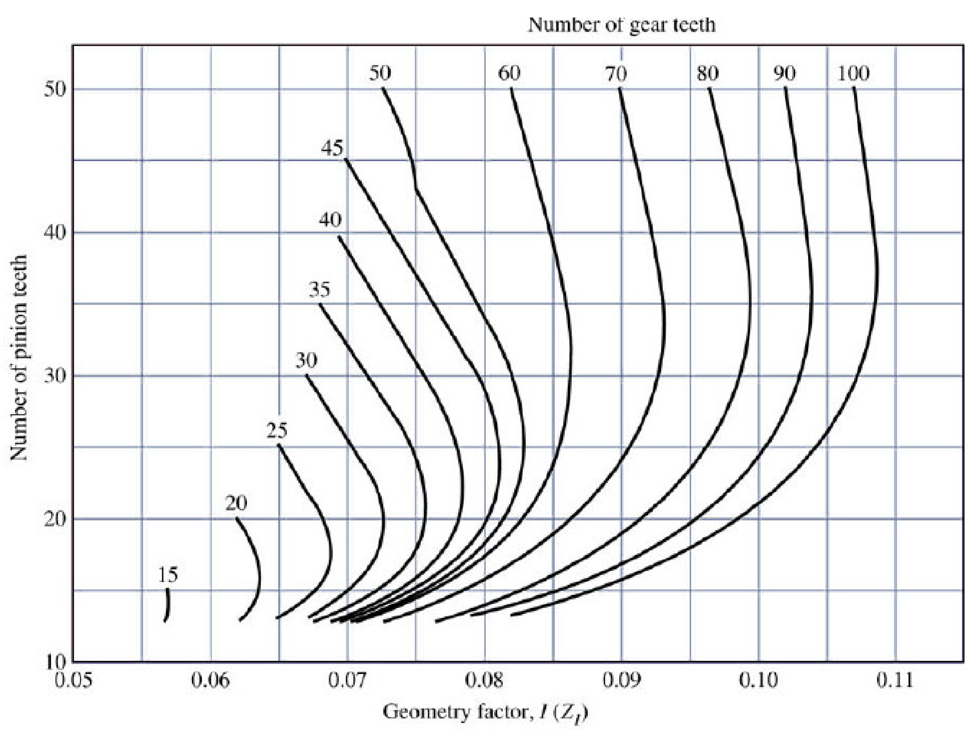
The corrected contact strength

$$\sigma_{\mathrm{HP}} = \sigma^{\backslash}_{HP} \frac{Z_N C_H}{Y_\theta Y_Z}$$

J-Factor



I-Factor



Reliability factor:

Reliability	Y_Z
0.9999	1.5
0.999	1.25
0.99	1
0.9	0.85
0.5	0.7

Helical Gears

$$d = mN$$

$$= \frac{m_n}{\cos \psi} N$$

$$\tan \varphi_n = \tan \varphi_t \cos \psi$$

Bending Stress:

$$\sigma = \frac{W_t}{bmJ} K_v K_0 K_s K_H K_B$$

$$\sigma_{FP}^{\backslash} = 0.703 \text{ HB} + 113 \quad \text{MPa}$$

$$\sigma_{FP} = \sigma_{FP}^{\backslash} \left(Y_N / Y_\theta Y_Z \right)$$

Contact Stress:

$$\sigma_c = C_p \sqrt{\frac{W_t}{bd_p I} K_v K_O K_s K_H C_f}$$

$$I = \frac{\cos \varphi_t \sin \varphi_t}{2 m_N} \frac{m_G}{m_G + 1}$$

$$m_N = \frac{p_N}{0.95\,Z}$$

$$p_N = p_n \cos\varphi_n$$

$$p_n = \pi m_n$$

$$Z = \sqrt{(r_p + a_p)^2 - (r_p \cos\varphi)^2} + \sqrt{(r_g + a_g)^2 - (r_g \cos\varphi)^2} - C \sin\varphi$$

r_p, r_g : are the pitch circle radii of pinion and gear.

a_p, a_g : are the addenda of pinion and gear

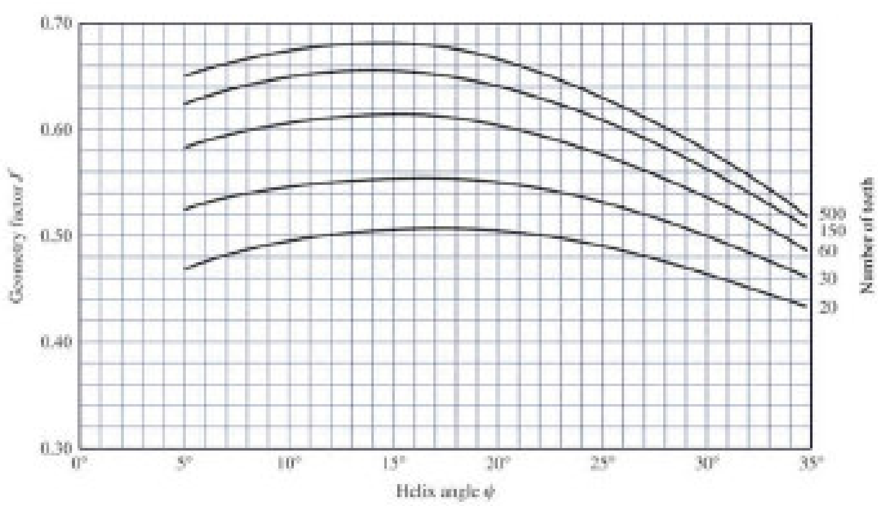
C : is the center distance

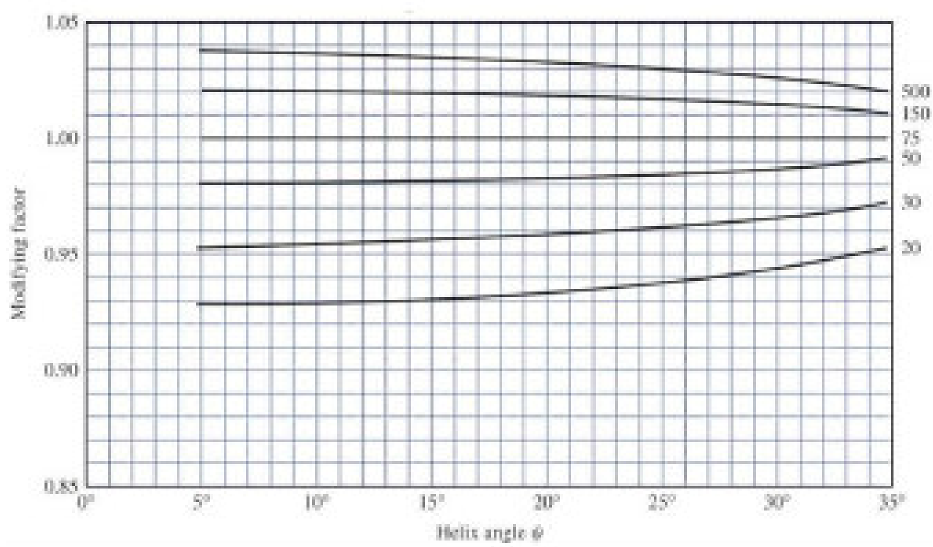
$a_p = a_g = m_n$ and $\varphi = \varphi_t$

<u>Strength:</u>

$$\sigma^{\backslash}_{HP} = 2.22\ HB + 200 \quad MPa$$

$$\sigma_{HP} = \sigma^{\backslash}_{HP}\ \frac{Z_N C_H}{Y_\theta Y_Z}$$





Worm Gearing:

$$W_{Wt} = -W_{Ga} = W_x$$
$$W_{Wr} = -W_{Gr} = W_y$$
$$W_{Wa} = -W_{Gt} = W_z$$

$$W_x = W\left(\cos\phi_n \sin\lambda + \mu\cos\lambda\right)$$
$$W_y = W\sin\phi_n$$
$$W_z = W\left(\cos\phi_n \cos\lambda - \mu\sin\lambda\right)$$

$$\mathbf{V}_W = \mathbf{V}_G + \mathbf{V}_S$$

$$H = H_o + H_l$$

$$V_S = \frac{V_W}{\cos\lambda}$$

$$W_{tg} = \beta\left(K_s d_g^{0.8} F_e K_m K_v\right)$$

$$\tan\lambda = \frac{L}{\pi d_W}$$

$$L = p_x N_W$$

$$d_G = \frac{N_G p_t}{\pi}$$

Note that: d_g == d_G

Bearings

$$\frac{L_1}{L_2} = \left(\frac{F_2}{F_1}\right)^a$$

$$F_2 = F_1\left(\frac{L_1}{L_2}\right)^{\frac{1}{a}}$$

$$C_R = k_A F_{eq}\left[\left(\frac{L_D}{L_R}\right)\left(\frac{n_D}{n_R}\right)\right]^{1/a}$$

Take L_R = 500 hours, and n_R = 100/3 rpm

Clutches:

Uniform Wear theory:

$$F = \int_{d/2}^{D/2} 2\pi p r dr = \pi p_{\max} d \int_{d/2}^{D/2} dr = \frac{\pi p_{\max} d}{2}(D-d)$$

$$T = m.\frac{fF}{4}(D+d)$$

Uniform pressure theory:

$$F = \frac{\pi p}{4}(D^2 - d^2)$$

$$T = m.\frac{fF}{3}\frac{(D^3-d^3)}{(D^2-d^2)}$$

Disk Brakes:

Uniform Wear

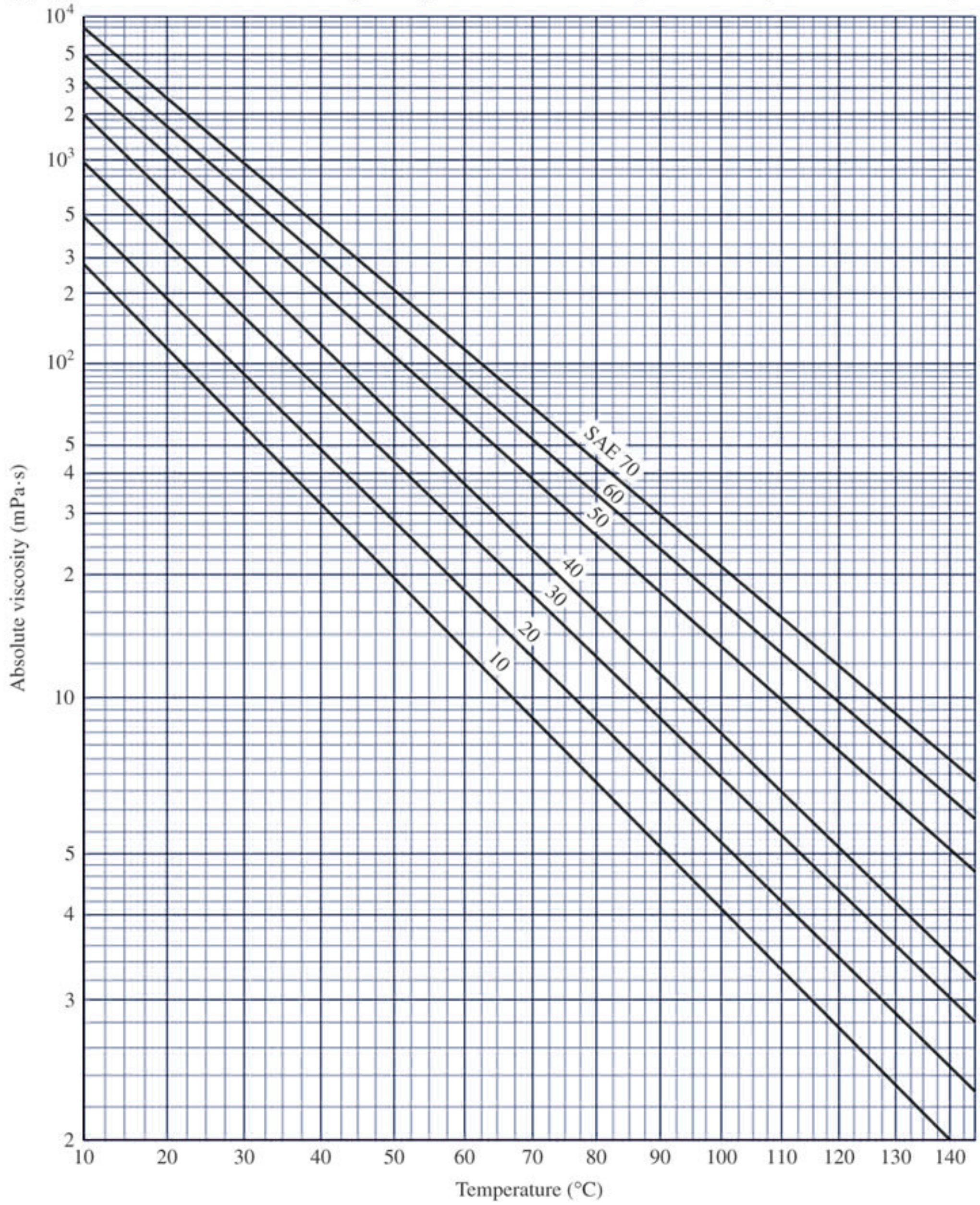
$$\therefore F = (\theta_2 - \theta_1)\, p_{\max} .r_i (r_o - r_i)$$

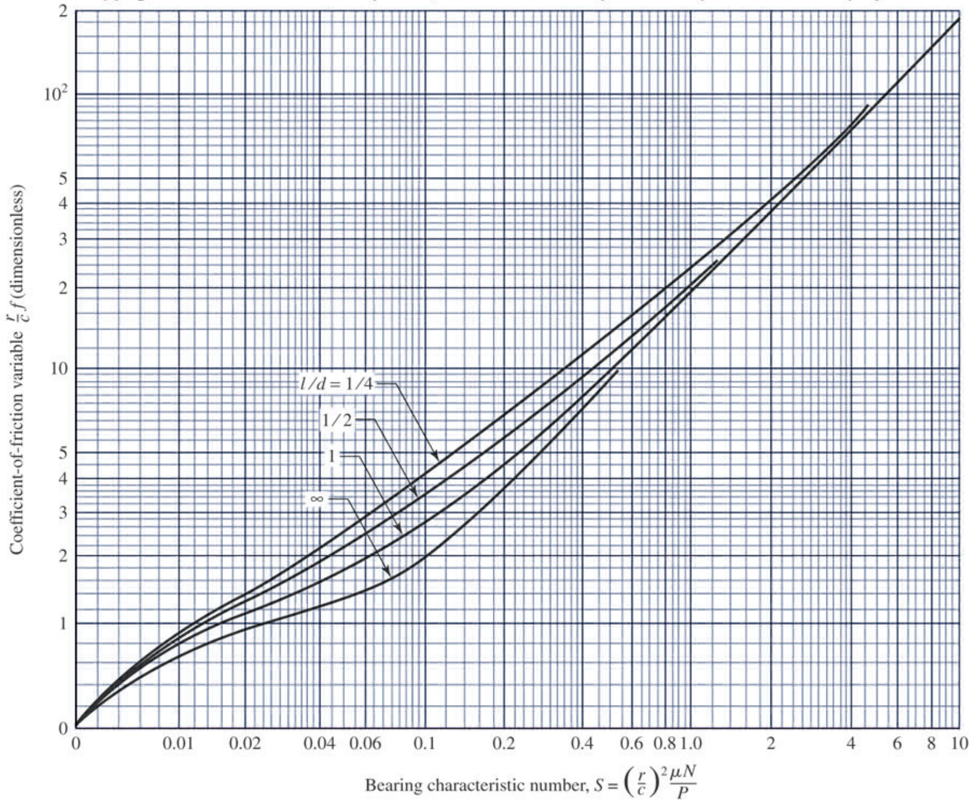
$$T = \tfrac{1}{2}(\theta_2 - \theta_1)\, f p_{\max} .r_i (r_o^2 - r_i^2)$$

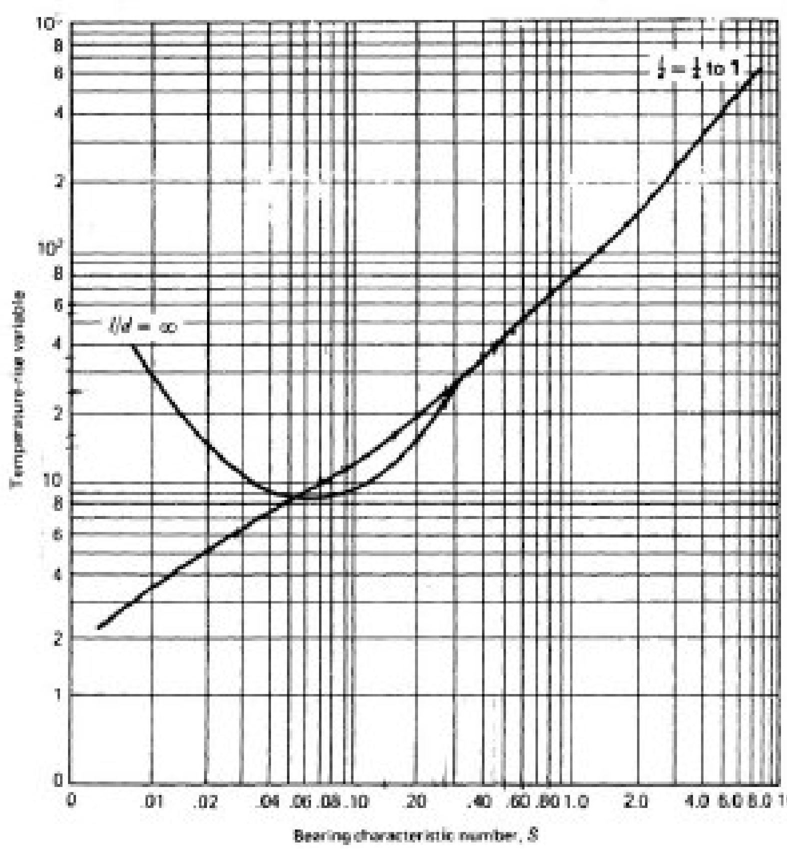
Uniform pressure

$$F = (\theta_2 - \theta_1)\, p \int_{r_i}^{r_o} r\,dr = \tfrac{1}{2}(\theta_2 - \theta_1)\, p (r_o^2 - r_i^2)$$

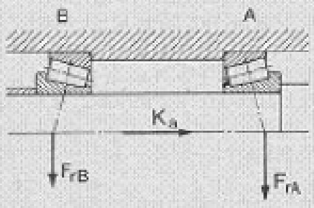
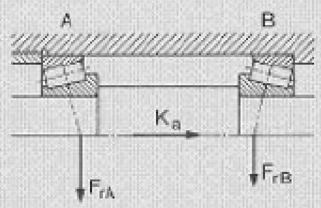
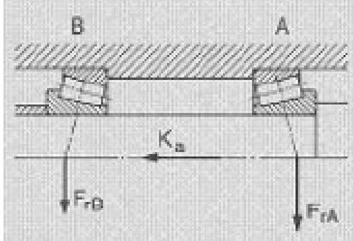
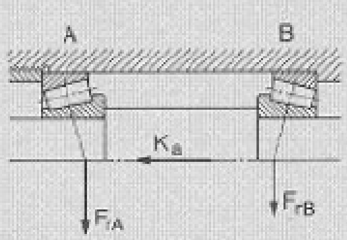
$$T = (\theta_2 - \theta_1)\, fp \int_{r_i}^{r_o} r^2\,dr = \tfrac{1}{3}(\theta_2 - \theta_1)\, fp (r_0^3 - r_i^3)$$




Coefficient-of-friction variable $\frac{r}{c}f$ (dimensionless)
Bearing characteristic number, $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P}$
$l/d = 1/4$
$1/2$
1
∞


Temperature-rise variable
Bearing characteristic number, S
$l/d = \infty$

Axial loading of taper roller bearings

Arrangement	Load case		Axial loads	
Back-to-back 	1a)	$\frac{F_{rA}}{Y_A} \geq \frac{F_{rB}}{Y_B}$ $K_a \geq 0$	$F_{aA} = \frac{0{,}5\,F_{rA}}{Y_A}$	$F_{aB} = F_{aA} + K_a$
	1b)	$\frac{F_{rA}}{Y_A} < \frac{F_{rB}}{Y_B}$ $K_a \geq 0{,}5\left(\frac{F_{rB}}{Y_B} - \frac{F_{rA}}{Y_A}\right)$	$F_{aA} = \frac{0{,}5\,F_{rA}}{Y_A}$	$F_{aB} = F_{aA} + K_a$
Face-to-face 	1c)	$\frac{F_{rA}}{Y_A} < \frac{F_{rB}}{Y_B}$ $K_a < 0{,}5\left(\frac{F_{rB}}{Y_B} - \frac{F_{rA}}{Y_A}\right)$	$F_{aA} = F_{aB} - K_a$	$F_{aB} = \frac{0{,}5\,F_{rB}}{Y_B}$
Back-to-back 	2a)	$\frac{F_{rA}}{Y_A} \leq \frac{F_{rB}}{Y_B}$ $K_a \geq 0$	$F_{aA} = F_{aB} + K_a$	$F_{aB} = \frac{0{,}5\,F_{rB}}{Y_B}$
	2b)	$\frac{F_{rA}}{Y_A} > \frac{F_{rB}}{Y_B}$ $K_a \geq 0{,}5\left(\frac{F_{rA}}{Y_A} - \frac{F_{rB}}{Y_B}\right)$	$F_{aA} = F_{aB} + K_a$	$F_{aB} = \frac{0{,}5\,F_{rB}}{Y_B}$
Face-to-face 	2c)	$\frac{F_{rA}}{Y_A} > \frac{F_{rB}}{Y_B}$ $K_a < 0{,}5\left(\frac{F_{rA}}{Y_A} - \frac{F_{rB}}{Y_B}\right)$	$F_{aA} = \frac{0{,}5\,F_{rA}}{Y_A}$	$F_{aB} = F_{aA} - K_a$