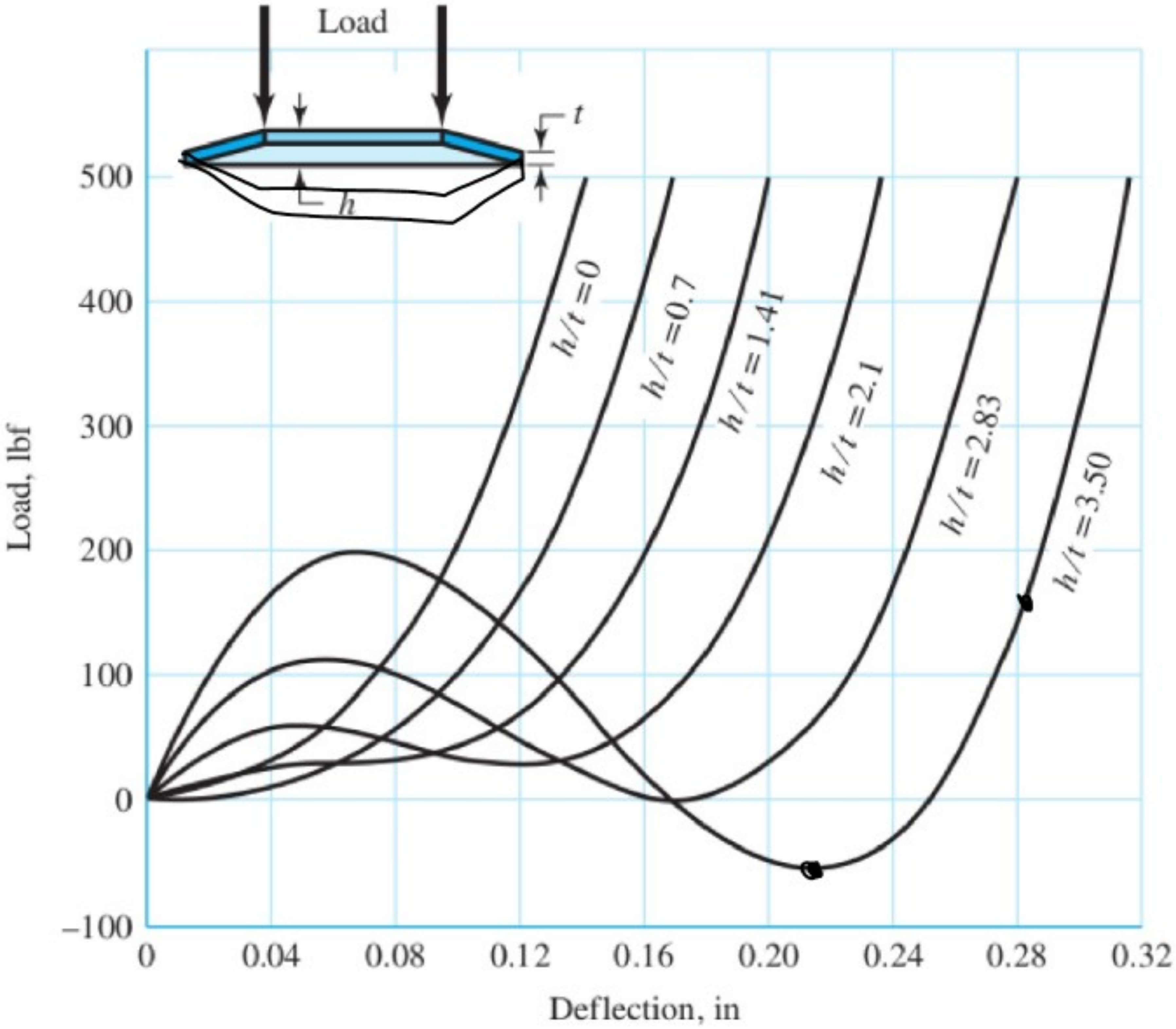

Load
t
h
500
400
300
200
100
0
−100
Load, lbf
0
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
Deflection, in
h/t = 0
h/t = 0.7
h/t = 1.41
h/t = 2.1
h/t = 2.83
h/t = 3.50

Buckling

$$L_0 < \frac{\pi D}{\alpha}\sqrt{\frac{2(E-G)}{2G+E}}$$

For steel

$$L_0 < 2.63\, D/\alpha$$

Table 10-2

End Condition	Constant α
Spring supported between flat parallel surfaces (fixed ends)	0.5
One end supported by flat surface perpendicular to spring axis (fixed); other end pivoted (hinged)	0.707
Both ends pivoted (hinged)	1
One end clamped; other end free	2

A helical compression spring is wound using 2.5-mm-diameter music wire. The spring has an outside diameter of 31 mm with plain ground ends, and 14 total coils.

(a) Estimate the spring rate.

(b) What force is needed to compress this spring to closure?

(c) What should the free length be to ensure that when the spring is compressed solid the torsional stress does not exceed the yield strength?

(d) Is there a possibility that the spring might buckle in service?

$N_t = 14$

$d = 2.5 \text{ mm}$

$D = 31 - 2.5 = 28.5 \text{ mm}$

$G = 79.3 \text{ GPa}$

$N_t = N_a + 1$

$N_a = N_t - 1 = 14 - 1 = 13$

$$K = \frac{d^4 G}{8 D^3 N} = \frac{2.5\,\text{mm}^4 \; 79.3\,\text{GPa}}{8 \cdot 28.5\,\text{mm}^3 \; 13}$$

$$= 1.29 \times 10^{-3} \text{ mm GPa} \; \frac{1 \text{ m}}{1000 \text{ mm}} \; \frac{1000 \text{ MPa}}{1 \text{ GPa}}$$

$$= 1.29 \times 10^{-3} \text{ m MPa} = 1.29 \times 10^{-3} \; \frac{\text{m MN}}{\text{m}^2} \; \frac{1 \times 10^6 \text{ N}}{1 \text{ MN}} = \boxed{1.29 \times 10^3 \; \text{N/m}}$$

$$L_s = d N_t = 2.5 \text{ mm } 14 = 35 \text{ mm}$$

$$C = D/d = 28.5/2.5 = 11.4$$

$$\frac{S_{sy}}{n_s} = \frac{4C+2}{4C-3}\left(\frac{8 F_s D}{\pi d^3}\right)$$

$$F_s = Kx \qquad x = L_0 - L_s$$

$$= 1.29 \times 10^3 (L_0 - L_s)$$

$$\boxed{F_s = 1.29 \times 10^3 (L_0 - 0.035)}$$

$$\frac{871 \times 10^6}{1} = \frac{4 \cdot 11.4 + 2}{4 \cdot 11.4 - 3}\left(\frac{8 \cdot 1.29 \times 10^3 (L_0 - 0.035)}{\pi \cdot 0.0025^3}\right)$$

$$871 \times 10^6 = 1.12 \cdot 2.1 \times 10^{11} (L_0 - 0.035)$$

$$= 2.35 \times 10^{11} (L_0 - 0.035)$$

$$= 2.35 \times 10^{11} L_0 - 0.035 \cdot 2.35 \times 10^{11}$$

$$\frac{871 \times 10^6 + 0.035 \cdot 2.35 \times 10^{11}}{2.35 \times 10^{11}} = L_0 = 0.039 \text{ m } \boxed{= 39 \text{ mm}}$$

$$S_{ut} = \frac{2211}{2.5^{0.145}} = 1936 \text{ MPa}$$

$$S_{sy} = 0.45 S_{ut} = 0.45 \cdot 1936 = 871 \text{ MPa}$$

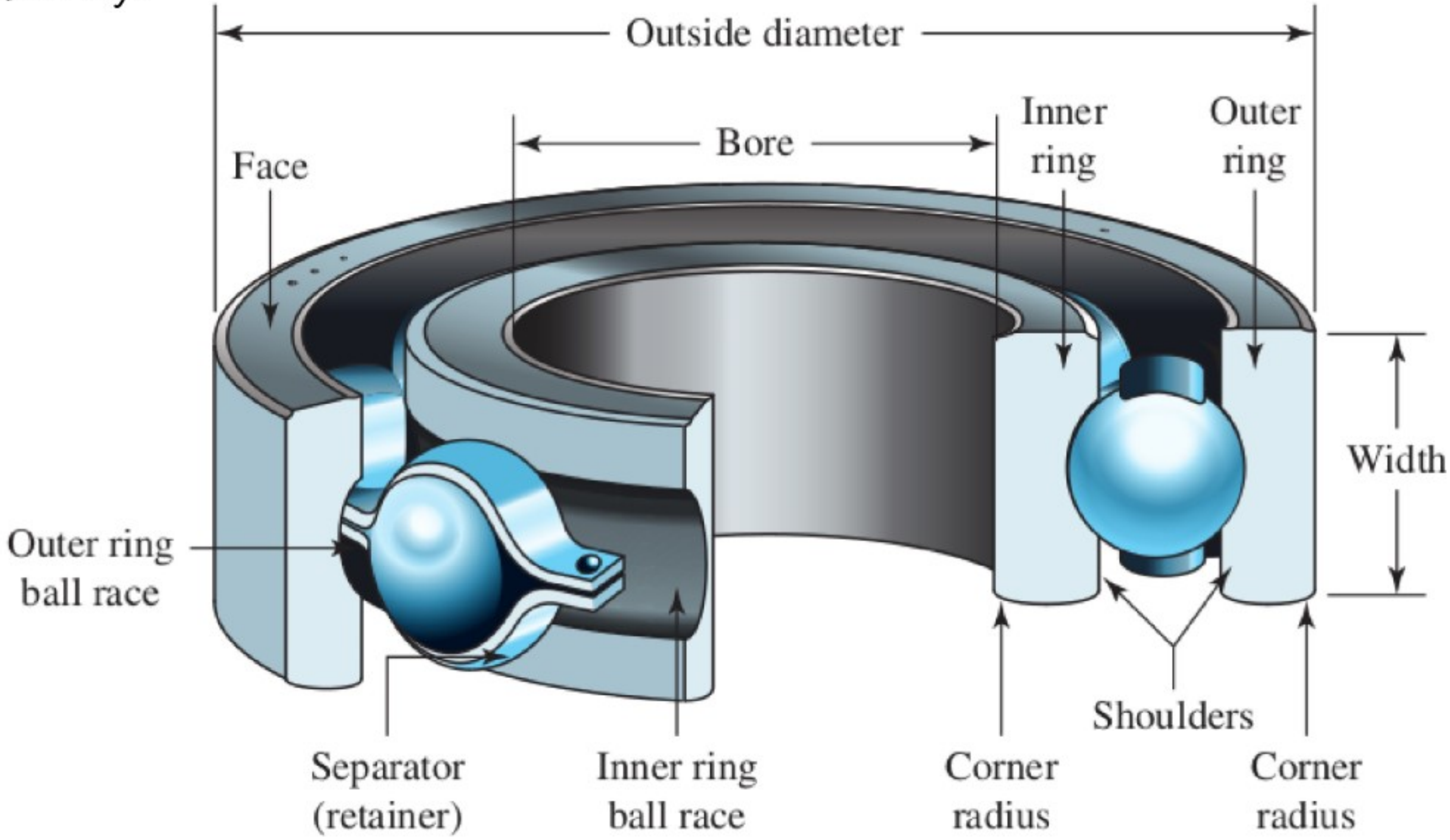
$$L_o < 2.63 \frac{D}{\alpha}$$

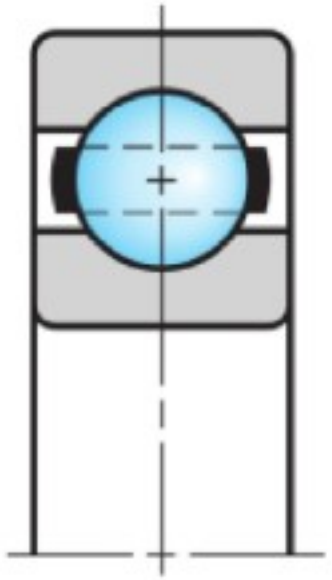
$$39 \text{ mm} < 2.63 \frac{28.5 \text{ mm}}{0.5}$$

$$39 \text{ mm} < 149.91 \text{ mm}$$

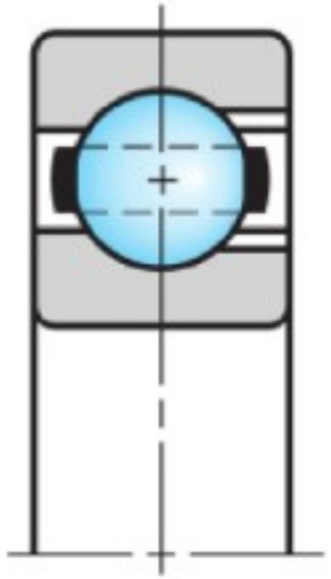
Will not buckle

Roller Bearings

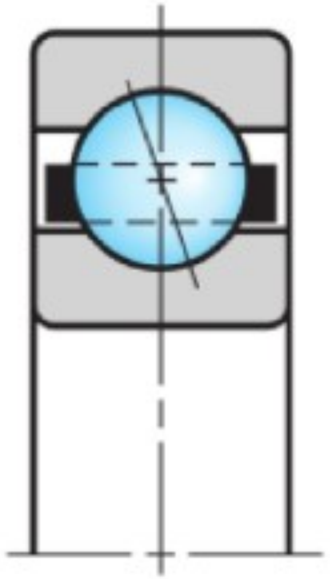




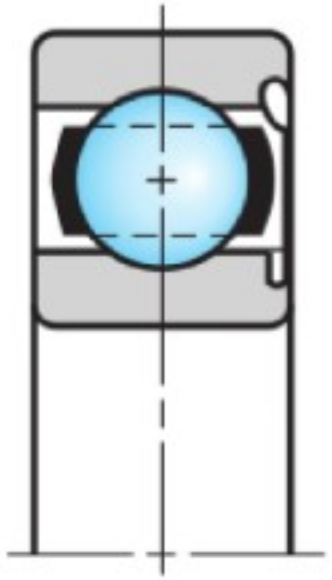
(*a*)
Deep groove



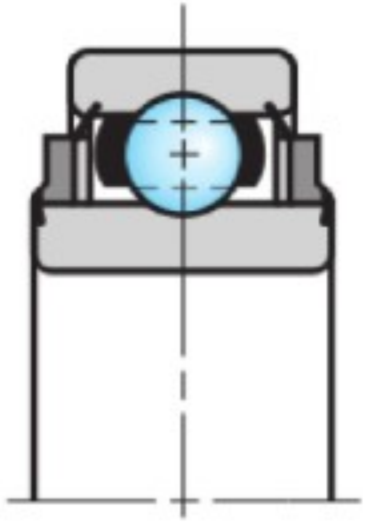
(*b*)
Filling notch



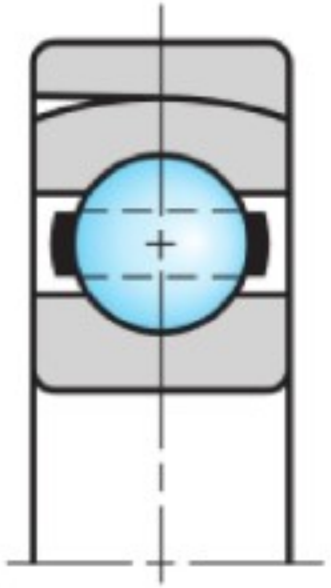
(*c*)
Angular contact



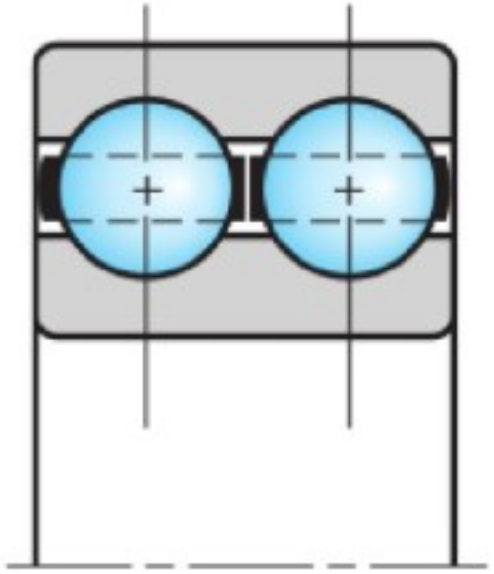
(*d*)
Shielded



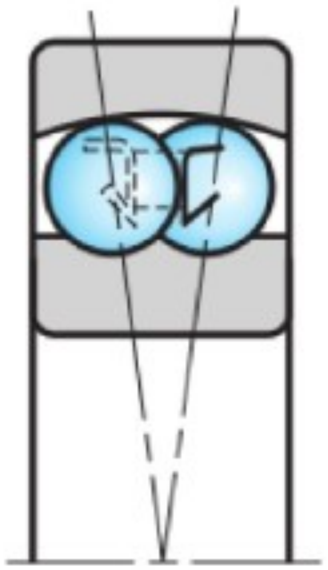
(*e*)
Sealed



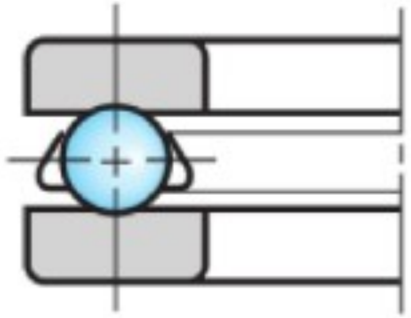
(*f*)
External
self-aligning



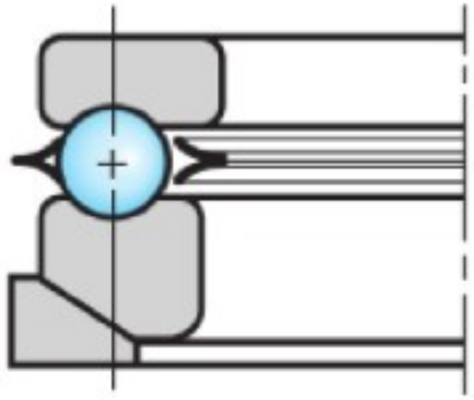
(*g*)
Double row



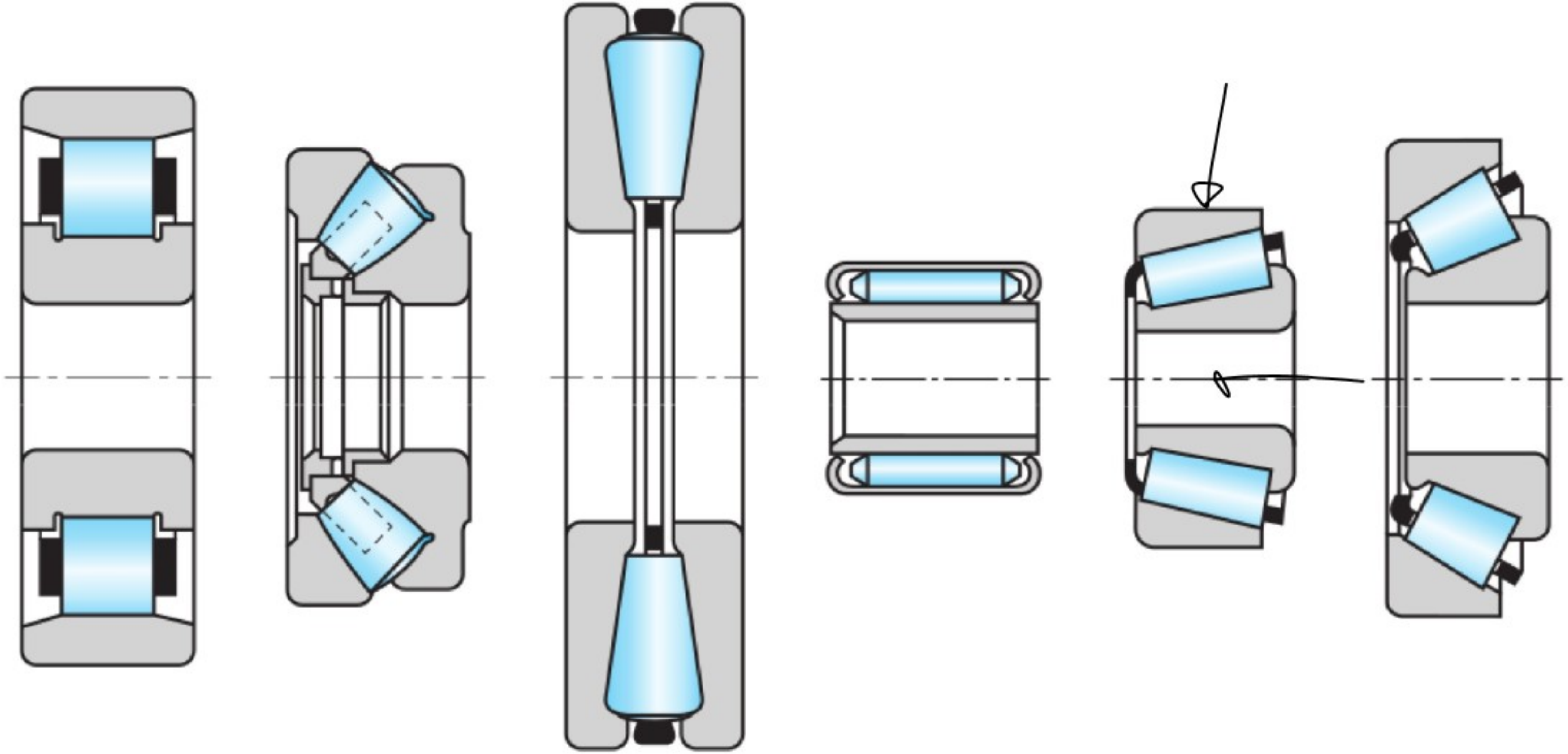
(*h*)
Self-aligning



(*i*)
Thrust



(*j*)
Self-aligning thrust



(a) (b) (c) (d) (e) (f)