BS EN 13906-3:2014

BSI Standards Publication

Cylindrical helical springs made from round wire and bar — Calculation and design

Part 3: Torsion springs

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National foreword

This British Standard is the UK implementation of EN 13906-3:2014. It supersedes BS EN 13906-3:2001 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee FME/9/3, Springs.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Cylindrical helical springs made from round wire and bar - Calculation and design - Part 3: Torsion springs

Ressorts hélicoïdaux cylindriques fabriqués à partir de fils ronds et de barres - Calcul et conception - Partie 3: Ressorts de torsion

Zylindrische Schraubenfedern aus runden Drähten und Stäben - Berechnung und Konstruktion - Teil 3: Drehfedern

This European Standard was approved by CEN on 10 November 2013.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Contents

Page

Foreword

This document (EN 13906-3:2014) has been prepared by Technical Committee CEN/TC 407 “Project Committee - Cylindrical helical springs made from round wire and bar - Calculation and design”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2014, and conflicting national standards shall be withdrawn at the latest by July 2014.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13906-3:2001.

This European Standard has been prepared by the initiative of the Association of the European Spring Federation ESF.

This European Standard constitutes a revision of EN 13906-3:2001 for which it has been technically reviewed. The main modifications are listed below:

- updating of the normative references;
- technical corrections.

EN 13906 consists of the following parts, under the general title *Cylindrical helical springs made from round wire and bar — Calculation and design*:

- *Part 1: Compression springs*;
- *Part 2: Extension springs*;
- *Part 3: Torsion springs*.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies the calculation and design of cold and hot coiled cylindrical helical torsion springs with a linear characteristic, made from round wire and bar of constant diameter with values according to Table 1.

Table 1

Characteristic	Cold coiled torsion spring	Hot coiled torsion spring[a]
Wire or bar diameter	$d \leq 20$ mm	$d \geq 10$ mm
Number of active coils	$n \geq 2$	$n \geq 2$
Spring index	$4 \leq w \leq 20$	$4 \leq w \leq 12$
[a] The user of this European Standard shall pay attention to the design of hot coiled springs, because there can be differences between the design and a real test.		

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10089, *Hot-rolled steels for quenched and tempered springs - Technical delivery conditions*

EN 10270-1, *Steel wire for mechanical springs - Part 1: Patented cold drawn unalloyed spring steel wire*

EN 10270-2, *Steel wire for mechanical springs - Part 2: Oil hardened and tempered spring steel wire*

EN 10270-3, *Steel wire for mechanical springs - Part 3: Stainless spring steel wire*

EN 12166, *Copper and copper alloys - Wire for general purposes*

EN ISO 26909:2010, *Springs - Vocabulary (ISO 26909:2009)*

ISO 26910-1, *Springs - Shot peening - Part 1: General procedures*

3 Terms and definitions, symbols, units and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 26909:2010 and the following apply.

3.1.1
spring
mechanical device designed to store energy when deflected and to return the equivalent amount of energy when released

[SOURCE: EN ISO 26909:2010, 1.1]

3.1.2
torsion spring
spring that offers resistance to a twisting moment around the longitudinal axis of the spring

[SOURCE: EN ISO 26909:2010, 1.4]

3.1.3

helical torsion spring

torsion spring normally made of wire of circular cross-section wound around an axis and with ends suitable for transmitting a twisting moment

[SOURCE: EN ISO 26909:2010, 3.14]

3.2 Symbols, units and abbreviated terms

Table 2 contains the symbols, units and abbreviated terms used in this standard.

Table 2

Symbols	Units	Terms
A_D	mm	coil diameter tolerance of the unloaded spring
a	mm	gap between active coils of the unloaded spring
$D = \frac{D_\mathrm{e} + D_\mathrm{i}}{2}$	mm	mean diameter of coil
D_d	mm	mandrel diameter
D_e	mm	outside diameter of the spring
$D_{\mathrm{e}\alpha}$	mm	outside coil diameter of the spring when deflected through and angle α in the direction of the coiling
D_h	mm	housing diameter
D_i	mm	inside diameter of the spring
$D_{\mathrm{i}\alpha}$	mm	inside coil diameter of the spring when deflected through and angle α in the direction of the coiling
D_p	mm	test mandrel diameter
d	mm	nominal diameter of wire (or bar)
d_max	mm	upper deviation of d
d_R	mm	diameter of loading pins
E	N/mm^2 (MPa)	modulus of elasticity (or Young's modulus)
F	N	spring force
F_1, F_2 ...	N	spring forces for the torsional angles α_1, α_2 ... and related lever arms $R_\mathrm{A}, R_\mathrm{B}$ at ambient temperature of 20 °C
F_n	N	spring force for the maximum permissible angle α_n and the lever arms $R_\mathrm{A}, R_\mathrm{B}$
L_K	mm	body length of the unloaded spring for close-coiled springs (excluding ends)
L_K0	mm	body length of the unloaded spring for open-coiled springs (excluding ends)
$L_{\mathrm{K}\alpha}$	mm	body length of close-coiled spring deflected through an angle α (excluding ends)
l	mm	developed length of active coils (excluding ends)
$l_\mathrm{A}, l_\mathrm{B}$	mm	length of ends
M	N mm	spring torque

Symbols	**Units**	**Terms**
M_1, M_2 ...	N mm	spring torque for the angles α_1, α_2 ... and related lever arms R_A, R_B at ambient temperature of 20 °C
M_n	N mm	spring torque for the maximum permissible angle, α_n
M_{max}	N mm	maximum spring torque, which occurs occasionally in practice, in test or during assembly of the spring
N	-	number of cycles up to rupture
n	-	number of active coils
q	-	stress correction factor (depending on D/d)
R, R_A, R_B	mm	effective lever arms of spring
R_m	N/mm^2 (MPa)	minimum value of the tensile strength
R_{MR}	Nmm/ Deg	angular spring rate (increase of spring torque per unit angular deflection)
$r, r_A, r_B \dots r_n$	mm	inner bending radii
$\overline{W}$	mm^3	sectional moment
W	N mm	spring work
$w = \frac{D}{d}$	-	spring index
z	-	decimal values of the number of active coils n
α	Deg	torsional angle
α_1, α_2 ...	Deg	torsional angle corresponding to spring torque M_1, M_2 ... to the spring forces F_1, F_2 ...
α_n	Deg	maximum permissible torsional angle
α'	Deg	corrected torsional angle α in the case of a long, unclamped radial end
α''	Deg	corrected torsional angle α in the case of a long, unclamped tangential end
α_h	Deg	angular deflection of spring (stroke) between two positions α_1 and α_2
α_{max}	Deg	maximum torsional angle which occurs occasionally in practice, in test or by mounting of the spring
β	Deg	increase of torsional angle α due to deflection of a long, unclamped radial end
β'	Deg	increase of torsional angle α due to deflection of a long, unclamped tangential end
γ	Deg	angle of tangential legs of unloaded spring
δ_0	Deg	angle of active coils of unloaded spring
ε_0	Deg	relative end fixing angle for unloaded spring
$\varepsilon_1, \varepsilon_2 \dots \varepsilon_n$	Deg	relative end fixing angle, corresponding to torsional angles $\alpha_1, \alpha_2 \dots \alpha_n$
ρ	kg/dm^3	density
σ	N/mm^2 (MPa)	uncorrected bending stress (without the influence of the wire curvature being taken into account)
σ_1, σ_2 ...	N/mm^2 (MPa)	uncorrected bending stress for the spring torques M_1, M_2

Symbols	Units	Terms
σ_n	N/mm^2 (MPa)	uncorrected bending stress for the spring torque M_n
σ_q	N/mm^2 (MPa)	corrected bending stress (according to the correction factor q)
$\sigma_\text{q1}, \sigma_\text{q2}$ ...	N/mm^2 (MPa)	corrected bending stress for the spring torque's M_1, M_2 ...
σ_qh	N/mm^2 (MPa)	corrected bending stress for the stroke α_h
σ_qH	N/mm^2 (MPa)	corrected bending stress range in fatigue strength diagram
σ_qO	N/mm^2 (MPa)	corrected maximum bending stress in the fatigue strength diagram
σ_qU	N/mm^2 (MPa)	corrected minimum bending stress in the fatigue strength diagram
σ_zul	N/mm^2 (MPa)	permissible bending stress
$\varphi_\text{A}, \varphi_\text{B}, \varphi_\text{C}$	Deg	bending angle of the end

4 Theoretical torsion spring diagram

The illustration of the torsion spring corresponds to EN ISO 2162-1:1996, Figure 6.1. The theoretical torsion spring diagrams are given in Figure 1.

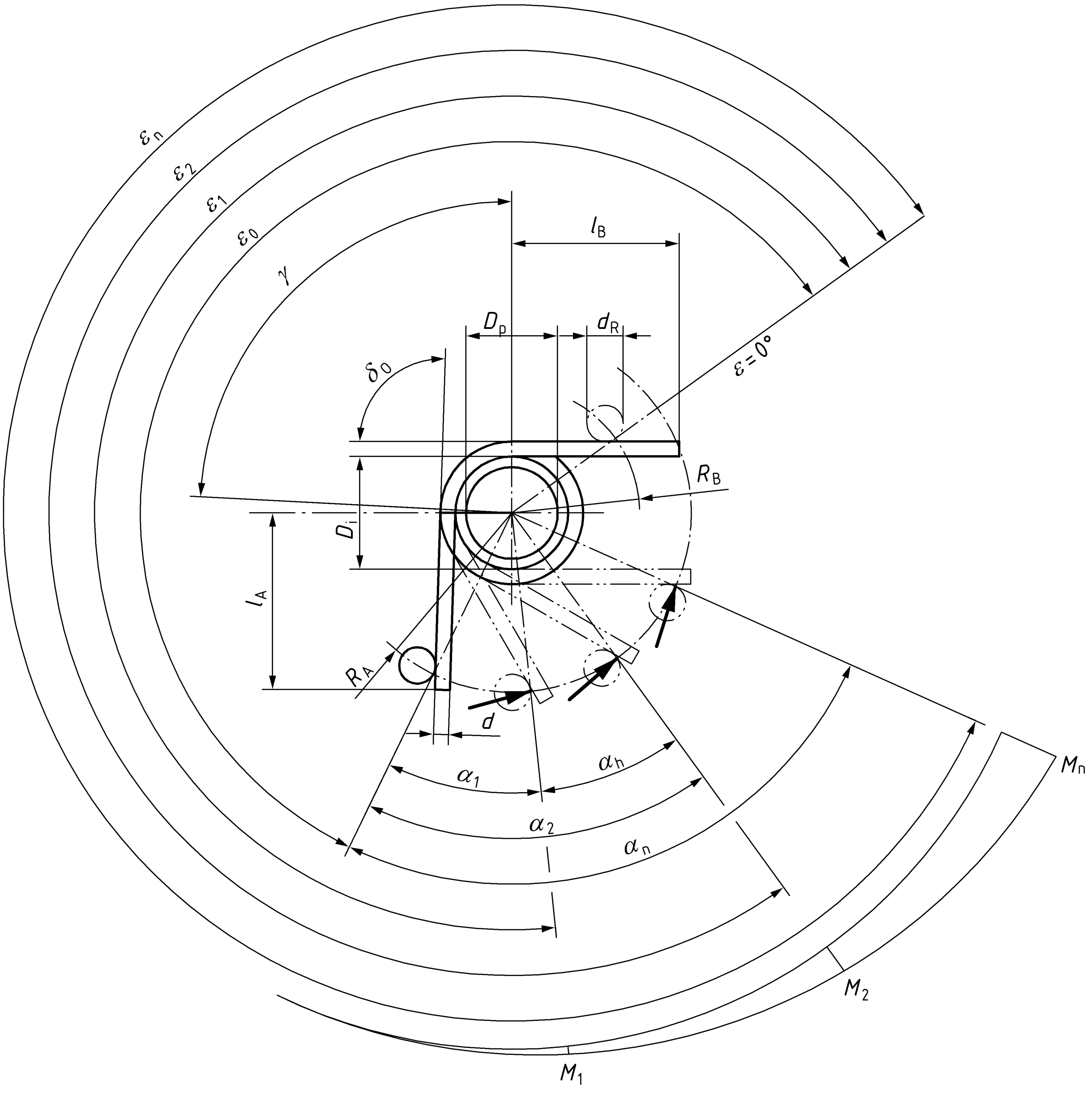


Figure 1 — Theoretical torsion spring diagram

Figure 2 to Figure 4 show different types of torsion springs and/or their end. The recommended arrangements are given in 5.3.

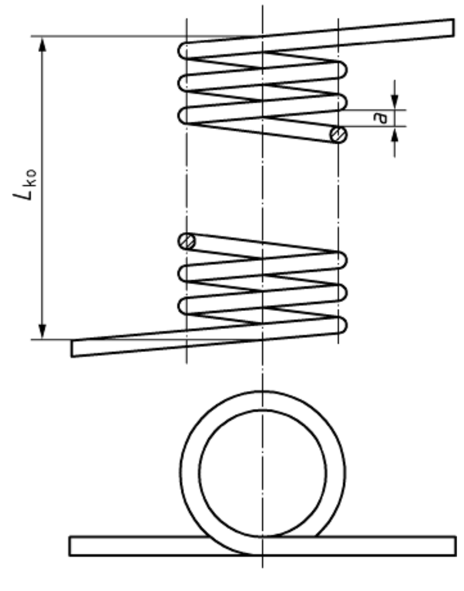


Figure 2 — Open coiled torsion spring

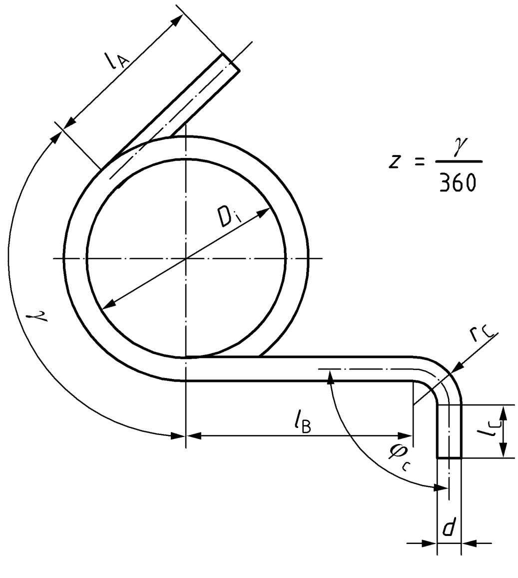
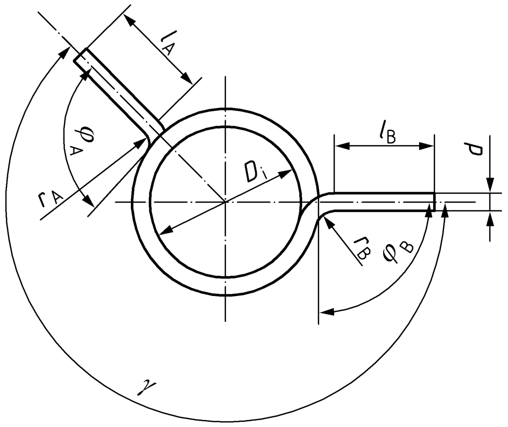


Figure 3 — Torsion spring with tangential ends



$$Z = \frac{\gamma - \varphi_{\mathrm{A}} - \varphi_{\mathrm{B}}}{360} \qquad (1)$$

$$\varphi_{\mathrm{A}} = \arcsin \frac{2r_{\mathrm{A}} + d}{D_{\mathrm{i}} + 2\left(d + r_{\mathrm{A}}\right)} \qquad (2)$$

$$\varphi_{\mathrm{B}} = \arcsin \frac{2r_{B} + d}{D_{\mathrm{i}} + 2\left(d + r_{B}\right)} \qquad (3)$$

Figure 4 — Torsion spring with radial ends

5 Design Principles

5.1 General

For the design of torsion springs, besides the housing space, the required maximum spring torque M_{max}, the related torsional angle α_{max} and the permissible dynamic stresses (see 10.1 and 10.2) are decisive.

If the torsion spring is guided on a mandrel or in a housing, care shall be taken to ensure enough clearance remains between the spring and its guide.

Reference values for the mandrel diameter are:

$$D_{\mathrm{d}} = 0{,}95 \left[\left\{ \left(D_{\mathrm{i}} - \left| A_{\mathrm{D}} \right| \right) \mathrm{x} \frac{n}{n + \frac{a_{\mathrm{max}}}{360}} \right\} - d \right] \qquad (4)$$

and for the housing diameter:

$$D_{\mathrm{h}} = 1{,}05 \left[\left\{ \left(D_{\mathrm{e}} - \left| A_{\mathrm{D}} \right| \right) \mathrm{x} \frac{n}{n + \frac{a_{\mathrm{max}}}{360}} \right\} + d \right] \qquad (5)$$

Furthermore, 5.2 and 5.4 and Clause 6 shall be taken into account.

5.2 Design of the ends

The ends can be adapted in many different ways to the requirements of a particular application. In the interest of economic manufacture the simplest possible design of the spring ends should be aimed at, i.e. tangential ends. For the sake of obtaining in the design a reproducible spring characteristic and an adequate standard of accuracy it is always desirable that both ends should be clamped. Clamping is any type of fixing which introduces a couple (see also 9.1).

The minimum internal bending radius r at the ends shall not be smaller than the wire diameter d.

The lengths l_{A}, l_{B}...l_{n} of straight ends or straight parts of ends, between two bends shall be at least $3d$.

5.3 Mounting of the ends

Figure 5 and Figure 6 show the recommended arrangements.

Preferably loaded legs should be clamped.

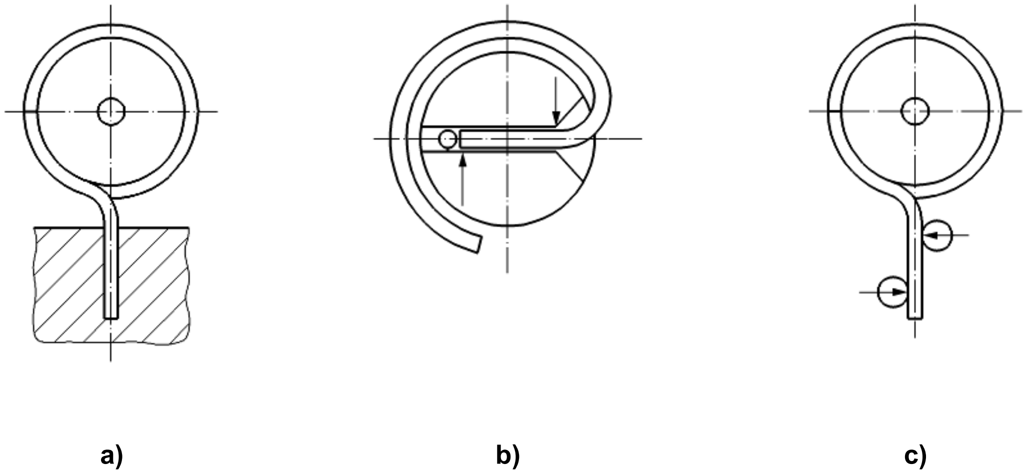


Figure 5 — Clamped end

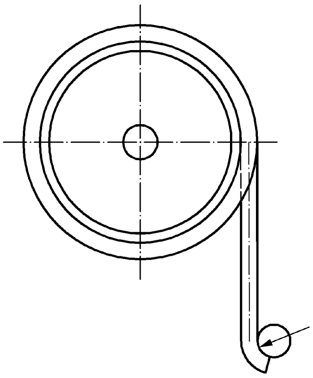


Figure 6 — Not clamped end

5.4 Design of the spring body

In order to avoid frictional forces the coils should not bear against one another or should exert only a small amount of pressure on one another. If a longer mounting space shall be filled by increasing a, the maximum permissible gap between active coils of the unloaded spring will be:

$$a_{\text{max}} = (0{,}24w - 0{,}64)d^{0{,}83} \qquad (6)$$

Preferably a reduction of the mean diameter of coil D and an increase of the number of active coils should be considered.

The coiling direction shall be specified to suit the design. Torsion springs are generally right hand coiled. If springs should be coiled in left hand direction this shall be stated clearly on the drawings or at the enquiry and order with the statement ”left hand coiled”.

As far as possible, torsion springs should be loaded only in the coiling direction so that the outside of the coils are stressed in tension. If the direction of rotation is opposite to this, thus tending to open the coils, there will be a greater tendency to relaxation or creep owing to the natural residual stress distribution over the cross-section and a reduction of fatigue life under dynamic loading.

6 Types of loading

6.1 General

Before carrying out design calculations it should be specified whether they will be subjected to static loading, quasi-static loading, or dynamic loading.

6.2 Static and quasi-static loading

A static loading is:

— a loading constant in time.

A quasi-static loading is:

— a loading variable with time with a negligibly small bending stress range (stroke stress) (e.g. bending stress range up to 10 % of the fatigue strength);

— a variable loading with greater bending stress range but only a number of cycles of up to 10^4.

6.3 Dynamic loading

In the case of torsion springs dynamic loading is, loading variable with time with a number of loading cycles over 10^4 and bending stress range greater than 10 % of the fatigue strength at:

a) constant bending stress range;

b) variable bending stress range.

Depending on the required number of cycles N up to rupture it is necessary to differentiate the two cases as follows:

c) infinite life fatigue in which the number of cycles:

    1) $N \geq 10^7$ for cold coiled springs.

    In this case the bending stress range is lower than the infinite life fatigue limit.

d) limited life fatigue in which:

    1) $N < 10^7$ for cold coiled springs.

    In this case the bending stress range is greater than the infinite life fatigue limit but smaller than the low cycle fatigue limit.

In the case of springs with time- variable bending stress ranges and mean bending stress (set of bending stress combinations), the maximum values of which are situated above the infinite life fatigue limit, the service life can be calculated as a rough approximation with the aid of cumulative damage hypotheses. In such circumstances the service life shall be verified by means of a service fatigue test.

7 Stress correction factor q

Due to the curvature of the wire or bar there is a non-symmetric distribution of the bending stress in the cross-section of the wire or bar when loading a torsion spring. The stress Formula (25) does not take account of the increase of stress at the inside of the cross-section due to the curvature of the wire. If this increase in stress needs to be calculated, the bending stresses σ shall be multiplied by the factor q, see Formula (26).

The stress correction factor, q, depends on the spring index *w* or, in the case of bent ends, on the ratio r/d.

The highest calculated stress can be determined by approximation with the aid of the stress correction factor “q”, depending on the ratio r/d (see Figure 7). This factor shall be taken into account in the design of torsion springs dynamically loaded in the coiling direction or loaded statically in the opposite coiling direction.

Generally the factor q can be calculated using Formula (7):

$$q=\frac{w+0{,}07}{w-0{,}75} \tag{7}$$

Its relation to the bending ratio can be calculated using Formula (7a):

$$q=\frac{2\frac{r}{d}+1{,}07}{2\frac{r}{d}+0{,}25} \tag{7a}$$

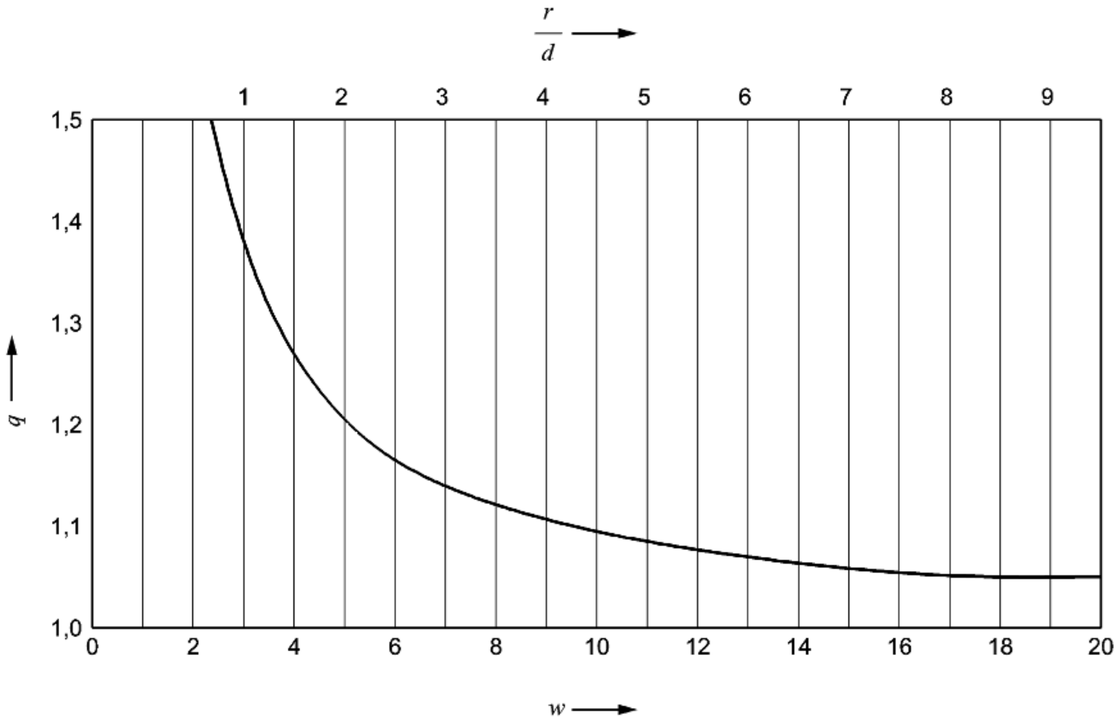


Figure 7 — Stress correction factor q depending on the spring index w and/or on the ration $\frac{r}{d}$

8 Material property values for the calculations of springs

8.1 The material property values are for ambient temperature only and are given in Table 3 and Table 4.

Table 3

Material	E **N/mm^2 (MPa)**	ρ **kg/dm^3**
Spring steel wire according to EN 10270-1	206 000	7,85
Spring steel wire according to EN 10270-2	206 000	7,85
Steel according to EN 10089	206 000	7,85
Copper-tin alloy CuSn6 R950 according to EN 12166 drawn spring hard	115 000	8,73
Copper-zinc alloy CuZn36 R700 according to EN 12166 drawn spring hard	110 000	8,40
Copper-beryllium alloy CuBe2 according to EN 12166	120 000	8,80
Copper-cobalt-beryllium alloy CuCo2Be according to EN 12166	130 000	8,80

NOTE Table 4 is extracted from EN 10270-3, the unit has been changed from GPa to MPa and for this standard only the modulus of elasticity E is used.

Table 4 — Reference data for the modulus of elasticity and shear modulus (mean values) [a, b, c] for stainless steel wire (according to EN 10270-3)

Steel grade		**Modulus of elasticity**[a] E		**Shear modulus**[b] G	
Name	Number	Delivery condition MPa[d]	Condition HT MPa[d]	Delivery condition MPa[d]	Condition HT MPa[d]
X10CrNi18-8	1.4310	180 000	185 000	70 000	73 000
X5CrNiMo17-12-2	1.4401	175 000	180 000	68 000	71 000
X7CrNiAl17-7	1.4568	190 000	200 000	73 000	78 000
X5CrNi18-10	1.4301	185 000	190 000	65 000	68 000
X2CrNiMoN22-5-3	1.4462	200 000	205 000	77 000	79 000
X1NiCrMoCu25-20-5	1.4539	180 000	185 000	69 000	71 000

[a] The reference data for the modulus of elasticity (E) are calculated from the shear modulus (G) by means of the formula $G = E/2\ (1+v)$ where v (Poisson’s constant) is set to 0,3. The data are applicable for a mean tensile strength of 1 800 MPa. For a mean tensile strength of 1 300 MPa, the values are 6 GPa lower. Intermediate values may be interpolated.

[b] The reference data for the shear modulus (G) are applicable to wires with a diameter ≤ 2,8 mm for measurements by means of a torsion pendulum, for a mean tensile strength of 1 800 MPa. For a mean tensile strength of 1 300 MPa, the values are 2 GPa lower. Intermediate values may be interpolated. Values ascertained by means of an Elastomat are not always comparable with values ascertained by means of a torsion pendulum.

[c] For the finished spring, lower values may be ascertained. Therefore, standards for calculation of springs may specify values different from those given here on the basis of measurement of wire.

[d] 1 MPa = 1 N/mm^2, 1 GPa = 1 kN/mm^2.

8.2 The influence of the operating temperature on the modulus of elasticity is given by the following formula, for averaged values, for the material listed in Tables 3 and 4.

$$E = E_{20} \times \left[1 - r \times (t - 20)\right] \tag{8}$$

with the following r values:

- 0,25 × 10^{-3} for springs steel wire according to EN 10270-1, EN 10270-2 and EN 10089;
- 0,40 × 10^{-3} for springs steel wire according to EN 10270-3;
- 0,40 × 10^{-3} for springs alloy wire according to EN 12166.

9 Design formulate

9.1 Design assumptions

Strictly speaking, the design formulae apply only to torsion springs with clamped ends guided in a circular manner under frictionless conditions. If the ends are not clamped, the spring shall be guided on a centre mandrel or in housing. The force exerted to the mandrel or in the housing, acting in conjunction with the force F, gives rise to a couple generating a moment M. The friction arising in this way influences the spring characteristic (hysteresis loop). The same also applies to close-coiled springs.

In the following design formulae the part of the torsional angle resulting from the bending of the spring ends is initially disregarded. In the case of torsion springs having a small number of coils and/or long ends, the effect due to the ends shall be taken into account (see Formulae (20) to (23)).

9.2 Formulae

9.2.1 General

In all the formulae the torsional angle is given in degrees.

9.2.2 Spring torque

$$M = FR \tag{9}$$

$$M = \overline{W} \times \sigma \quad \text{for round wire} \quad \overline{W} = \frac{\pi d^3}{32} \tag{10}$$

$$M = \frac{\pi d^3 \sigma}{32} \tag{11}$$

$$M = \frac{d^4 E \alpha}{3\,667\, D n} \tag{12}$$

9.2.3 Angular spring rate

$$R_{\mathrm{MR}} = \frac{M}{\alpha} = \frac{d^4 E}{3\,667\, D n} \tag{13}$$

9.2.4 Developed length of active coils

$$l = \frac{d^4 E \alpha}{1167 M} \tag{14}$$

9.2.5 Nominal diameter of wire or bar

$$d = \sqrt[3]{\frac{32 M}{\pi \sigma}} \tag{15}$$

9.2.6 Inside coil diameter of the spring

$$D_{\mathrm{i}\alpha} = \frac{D n}{n + \frac{\alpha}{360}} - d \tag{16}$$

9.2.7 Outside coil diameter of the spring

$$D_{\mathrm{e}\alpha} = \frac{D n}{n - \frac{\alpha}{360}} + d \tag{17}$$

9.2.8 Body length of the spring (excluding ends)

— Close coiled springs

$$L_{\mathrm{K}} \leq (n + 1{,}5) d_{\mathrm{max}} \tag{18}$$

$$L_{\mathrm{K}\alpha} \leq \left(n + 1{,}5 + \frac{\alpha}{360} \right) d_{\mathrm{max}} \tag{19}$$

— Open coiled

$$L_{\mathrm{K0}} \geq n\left(a + d_{\mathrm{max}}\right) + d_{\mathrm{max}} \tag{20}$$

9.2.9 Number of active coils

$$n = \frac{d^4 E \alpha}{3\,667 D M} \tag{21}$$

9.2.10 Torsional angle

$$\alpha = \frac{3\,667 D M n}{E d^4} \tag{22}$$

with unclamped radial ends

$$\beta \approx 48{,}63\frac{F\left(2R-D\right)^3}{E\,R\,d^4} \quad ^{1)} \tag{23}$$

with unclamped tangential ends

$$\beta' \approx 97{,}27\frac{F\left(4R^2-D^2\right)}{E\,d^4} \quad 1) \tag{24}$$

$$\alpha' = \alpha + \beta \tag{25}$$

$$\alpha'' = \alpha + \beta' \tag{26}$$

9.2.11 Spring work

$$W = \frac{M\,\alpha\,\pi}{360} \tag{27}$$

9.2.12 Uncorrected bending stress

$$\sigma = \frac{32\,M}{\pi\,d^3} \tag{28}$$

9.2.13 Corrected bending stress

$$\sigma_\mathrm{q} = q\sigma \tag{29}$$

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1) See also the dimensionless illustrations in Figure 8 and Figure 9.

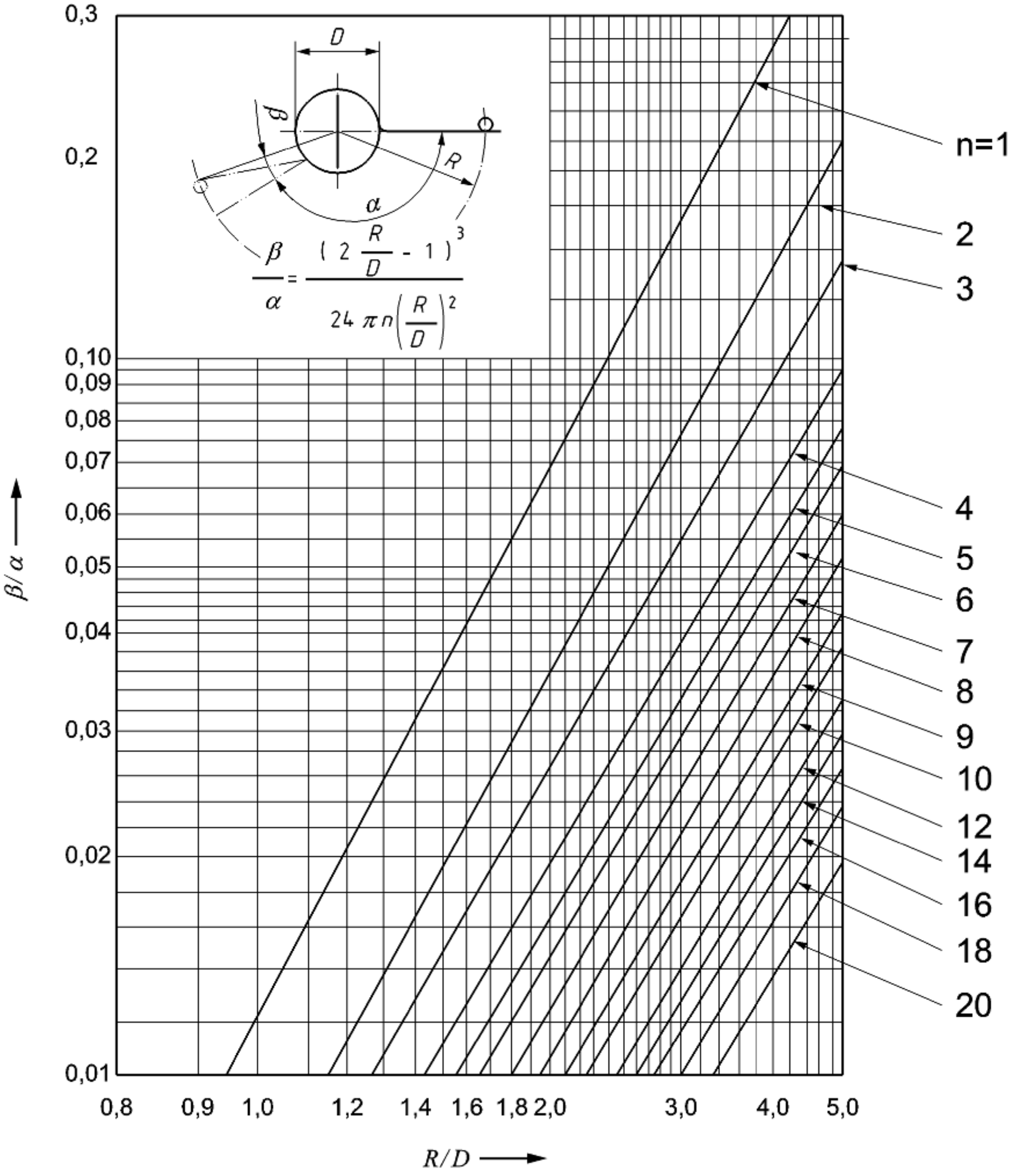


Figure 8 — $\frac{\beta}{\alpha}$ as a function $\frac{R}{D}$ for a radial end

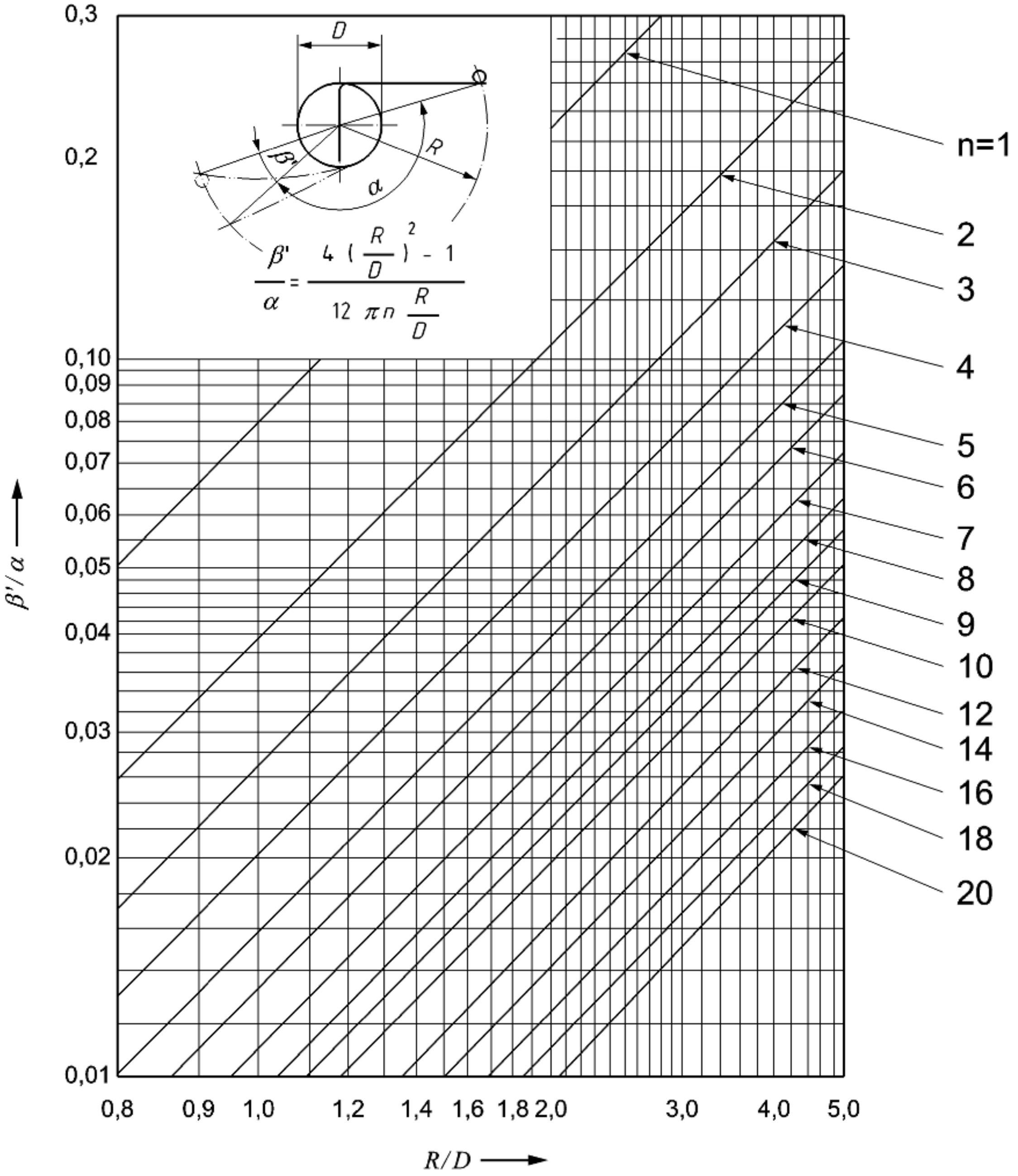


Figure 9 — $\frac{\beta'}{\alpha}$ as a function $\frac{R}{D}$ for a tangential end

10 Permissible bending stress

10.1 Permissible bending stress under static or quasi-static loading

For a torque M_n the uncorrected permissible bending stress is σ_{zul} which is equal to 0,7 R_m.

The value of R_m (minimum value of tensile strength) is determined from the relevant standards referred to in Table 3 and Table 4. The strength values used in the calculation shall be the tensile strength values for the tempered condition or for the artificially aged condition.

10.2 Permissible stress range under dynamic loading

10.2.1 Fatigue strength values

For dynamically loaded cold coiled torsional springs the patented drawn spring wire grade DH according to EN 10270-1 should preferably be used.

For dynamically loaded hot coiled and quenched torsional springs, a shot peening shall be made to achieve a sufficient fatigue life.

In the fatigue strength diagram, (see Figure 10), the values of the corrected bending stress range σ_{qH} are given as a function of the corrected minimum bending stress σ_{qU} for this material.

NOTE At the present time there are not sufficient fatigue strength data available for torsion springs made from other materials and for those made from wire diameters over 4 mm. If required, the spring manufacturer will provide information.

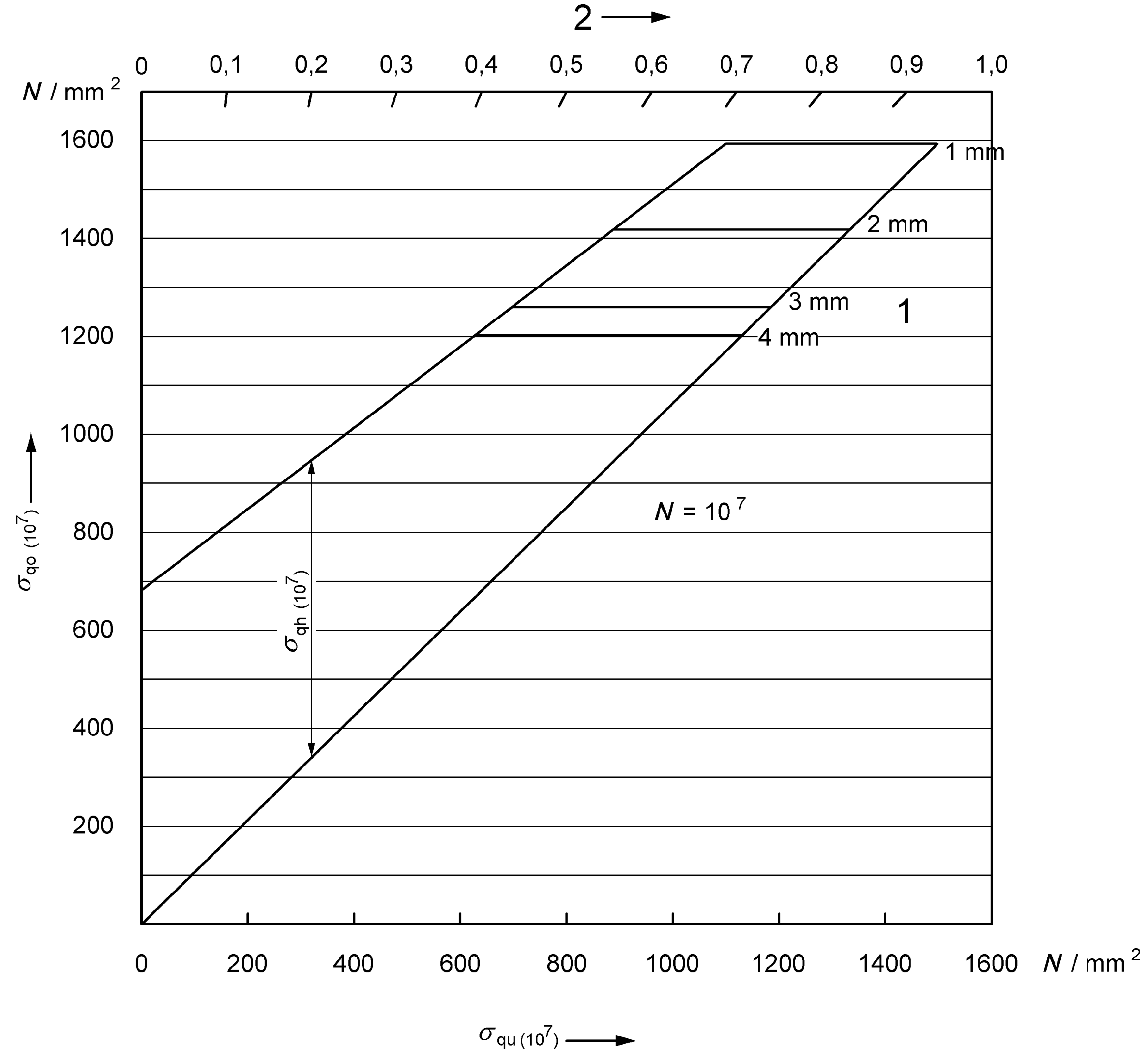
10.2.2 Permissible stress range

For given values of σ_{q1} equal to σ_{qU}, the value shall be $\sigma_{q2} \leq \sigma_{qO}$, i.e. the corrected value α_h, σ_{qh}, for the desired stroke of the torsion spring may not exceed the corrected value σ_{qH} for the corrected fatigue strength, which is obtained from Figure 10.

The corrected fatigue strength σ_{qH} depends largely on the surface quality and purity of the material as well as the mounting conditions and is subject to a fairly large spread.

Shot peening can generally be carried out on torsion springs with a wire diameter d > 1 mm and a spring index $w \leq 15$.

For dynamically loaded hot coiled and quenched torsional springs, a shot peening according to ISO 26910-1 shall be made to achieve a sufficient fatigue life.



Key

1	wire diameter
2	means stress ratio

Figure 10 — Fatigue strength diagram for torsion spring made of patented drawn wire grade DH according to EN 10270-1 without shot peening

10.2.3 Lines of equal stress ratio

Marked at equal spacing along the top horizontal line in Figure 10 are values denoting the values of spring torque M_1/M_2. Starting from these values, lines should be drawn to the origin of the coordinates and these are termed lines of equal stress ratio $\sigma_{q1} / \sigma_{q2}$. Each of these radiating lines intersects the line representing the corrected maximum bending stress σ_{qO} for a given wire diameter. Vertically below this intersection the corrected bending stress range α_h, σ_{qh} is read, for the given M_1/M_2. This value can now be used for the design calculation.

The lines of equal stress ratio are also useful for checking the design of a given spring.

Bibliography

[1] EN ISO 2162-1:1996, *Technical product documentation - Springs - Part 1: Simplified representation (ISO 2162-1:1993)*

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