

Coil springs —

Part 3: Guide for the design of helical torsion springs

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- British Railways Board
- London Regional Transport
- National Federation of Scale and Weighing Machine Manufacturers
- Railway Industry Association of Great Britain
- Royal Ordnance
- Spring Research and Manufacturers' Association

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Foreword

This Part of BS 1726 has been prepared under the direction of the General Mechanical Engineering Standards Committee. It is one of a series of three guides relating to the design of helical springs: Part 1 deals with helical compression springs and Part 2 with helical extension springs.

NOTE There are numerous methods of calculating the parameters necessary for the design of springs and initially the designer is free to use any one of these.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 1726 provides guidance on the design of parallel-sided helical torsion springs manufactured from either:

- circular section material, or
- rectangular and square section material.

It applies to springs which may or may not be stress relieved after forming (hereinafter referred to as group A springs) and to springs the material of which has undergone a structural change by heat treatment after forming (hereinafter referred to as group B springs).

In the case of torsion springs manufactured from square or rectangular material the ratio of the radial to axial dimensions of the section is important. This ratio (known as the shape factor, m) becomes significant at values greater than 2.5 or less than 0.4 because of the extreme difficulty in coiling springs accurately and repeatedly. For this reason this specification is only valid for shape factors in the range 2.5 to 0.4.

Appendix A gives two methods of specifying springs. Methods of testing springs are described in Appendix B. Values of the modulus of elasticity of some materials are given in Appendix C. Typical tolerances on rectangular section material are given in Appendix D.

NOTE 1 It is not recommended that torsion springs be loaded in the opposite direction to that of coiling. If this is necessary then discussions should take place between purchaser and supplier.

NOTE 2 The titles of the publications referred to in this Part of this standard are given on the inside back cover.

2 Definitions

For the purposes of this Part of BS 1726 the definitions given in BS 1726-1 apply.

3 Symbols

Symbol	Term	Unit
b	radial dimension of rectangular section material	mm
c	spring index	mm
D	mean coil diameter	mm
ΔD	change in mean coil diameter	mm
D_o	outside diameter	mm
D_{tol}	mean coil diameter tolerance	mm
d	material diameter	mm

Symbol	Term	Unit
d_{max}	maximum diameter of circular section material allowing for material size tolerance	mm
e	tolerance on size of material cross section	mm
E	modulus of elasticity (see Appendix C)	N/mm ²
F_T	tolerance factor for torque	—
h	axial dimension of rectangular section material	mm
h'	maximum axial dimension of rectangular section material after coiling	mm
h_{max}	maximum axial dimension of rectangular section material allowing for material size tolerance	mm
k	material constant for calculation of distortion and axial dimension of rectangular section material after coiling	—
K_o	stress correction factor for circular section wire	—
K_r	stress correction factor for rectangular section wire	—
l	combined effective length of legs	mm
L_o	free body length of spring	mm
$L_{o(tol)}$	tolerance on free body length	mm
L_t	loaded body length of spring	mm
m	shape factor	mm
n	number of active coils in spring	—
Δn	change in number of active coils during loading	—
N	total number of coils in spring	—
p	pitch	mm
R_{min}	minimum allowable inside radius of any bend	mm
S_θ	nominal torsional rate	N mm/degree

Symbol	Term	Unit
t	thickness of any surface coating	mm
T	torque at any angle	N mm
T_{tol}	tolerance on torque	N mm
ΔT	change in torque	N mm
α	relative leg orientation under torque	degrees
α_0	relative leg orientation in free state	degrees
α_{tol}	tolerance on relative leg orientation	degrees
θ	angular rotation of spring	degrees
σ	bending stress in spring	N/mm ²

4 General

4.1 When designing a spring certain characteristics have to be determined, for example, stress, rate, number of coils and the tolerances which can be permitted to ensure that it functions as required but which will allow it to be produced economically.

4.2 Two methods of specifying springs for general purposes are given in Appendix A. The first of these methods deals with the complete specification of a spring when all the relevant information is available for the spring manufacturer to produce the spring required. The information can be provided to the manufacturer by the customer completing data sheet 1. Advice on the completion of data sheet 1 is given in **A.2**.

When the customer does not have the information to complete data sheet 1, he may use the second method, by completing data sheet 2, which is an application for spring design. This is passed to the manufacturer who will then complete data sheet 1 and submit it to the customer for approval. Advice on the completion of data sheet 2 is given in **A.3**.

4.3 Methods of testing springs, to determine dimensional characteristics, properties and performance are given in Appendix B.

4.4 Appendix C gives information on the modulus of elasticity of some materials and Appendix D details typical tolerances on rectangular section material.

5 Methods of calculation

5.1 Stress correction factors

5.1.1 Stress correction factor K_o , for round section material, is given by the equation:

$$K_o = \frac{c}{c - 0.75}$$

where

$$c = D/d$$

5.1.2 Stress correction factor K_r , for rectangular section material, is given by the equation:

$$K_r = \frac{c}{c - 0.67}$$

where

$$c = D/b$$

5.2 Stress

5.2.1 The bending stress for round section material is given by the equation:

$$\sigma = \frac{32 TK_o}{\pi d^3}$$

5.2.2 The bending stress for rectangular section material is given by the equation:

$$\sigma = \frac{6TK_r}{hb^2}$$

NOTE The formulae in **5.2.1** and **5.2.2** do not take account of friction and deflections within the legs.

5.3 Torsional rate

5.3.1 The torsional rate for round section material is given by the equation:

$$S_\theta = \frac{\Delta T}{\theta} = \frac{Ed^4}{3667nD}$$

5.3.2 The torsional rate for rectangular section material is given by the equation:

$$S_\theta = \frac{\Delta T}{\theta} = \frac{Ehb^3}{2160nD}$$

NOTE The formulae in **5.3.1** and **5.3.2** do not take account of friction and deflection within the legs.

5.4 Torsion spring legs

A torsion spring consists of the body or active part and the legs which serve to convey the torque from the body to the mechanism. The legs can take four basic forms as shown in Figure 1 although combinations of any two of these forms can be used in one spring.

There are conventions for the relative orientation of the legs at each end of a spring. These are shown in Figure 2.

It is recommended that the maximum combined effective leg length does not exceed 10 % of the actual material length in the coils.

In cases where the length of leg is greater than 10 % of the length of material in the body of the spring, some deflection can occur within the leg and this should be taken into consideration as significant inaccuracies in the measurement of rate can occur.