

Coil springs —

Part 2: Guide for the design of helical extension springs

UDC 62 – 272.2

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The preparation of this British Standard was entrusted by the General Mechanical Engineering Standards Committee (GME/-) to Technical Committee GME/15, upon which the following bodies were represented:

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

This British Standard, having been prepared under the direction of the General Mechanical Engineering Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 March 1988

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The following BSI references relate to the work on this standard:
Committee reference GME/15
Draft for comment 86/70356 DC

ISBN 0 580 16393 8

Amendments issued since publication

Amd. No.	Date of issue	Comments
6110	October 1989	Indicated by a sideline in the margin

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Foreword

This Part of BS 7126 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 3¹⁾ with helical torsion springs.

NOTE There are numerous methods of calculating the parameters necessary for the design of springs and in an initial calculation 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⁾ In preparation.

1 Scope

This Part of BS 1726 provides guidance on the design of parallel sided helical extension springs manufactured from circular section material in two grades of tolerance, 1 and 2.

NOTE 1 These tolerances are based on experience gained within the spring industry, but no process control capability is implied. Where process control capability is required there will need to be agreement between the customer and the supplier.

Fifteen types of end coils are provided for, these being divided into three groups.

This standard applies to springs which have not been subjected to heat treatment other than stress relieving after coiling.

Appendix A gives two methods of specifying springs. Methods of testing springs are described in Appendix B. Values of the modulus of rigidity of some materials are given in Appendix C.

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

2 Definitions

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

3 Symbols

Symbol	Term	Unit
c	spring index	—
D	mean coil diameter	mm
D_i	inside diameter of spring	mm
D_o	outside diameter of spring	mm
d	material diameter	mm
e	material diameter tolerance	mm
f	natural frequency of unloaded spring	Hz
F	spring force	N
F_o	nominal initial tension	N
$F_1, F_2, \text{etc.}$	force at length $L_1, L_2, \text{etc.}$	N
ΔF	change in spring force	N
G	modulus of rigidity (see Appendix C)	N/mm ²
K	stress correction factor	—
L	spring length	mm
L_B	spring body length	mm
L_H	hook opening gap	mm
L_L	loop length	mm
$L_{\max}$	maximum length to which the spring will be extended in assembly or use	mm

L_o	free length of spring	mm
$L_o (\max)$	maximum free length of spring	mm
$L_o (\text{tol})$	free length tolerance	mm
ΔL	change in spring length	mm
n	number of active coils in spring	—
N	total number of coils in spring	—
R_m	minimum tensile strength	N/mm ²
S	spring rate	N/mm
$S_{(\text{tol})}$	spring rate tolerance	N/mm
δ	extension from nominal free length to loaded length	mm
ρ	density of material	kg/mm ³
τ	shear stress in spring	N/mm ²
$\tau_1, \tau_2, \text{etc.}$	shear stress in spring at $F_1, F_2, \text{etc.}$	N/mm ²

4 General

4.1 When designing a spring certain characteristics have to be determined, for example, stress, rate, natural frequency, 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 (see **A.2**) 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 (see Figure 5). Advice on the completion of the data sheet is given in **A.2**.

When the customer does not have the information to complete data sheet 1, he may use the second method (see **A.3**), by completing data sheet 2 (see Figure 6), 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, giving the modulus of rigidity of some materials, is for information purposes.

5 Methods of calculation

NOTE In respect of initial tension, an extension spring should be designed so that a residual stress is present which maintains the coils in contact with each other. The magnitude of this stress can be varied across a range but is limited by the dimensions of the spring, the material and the method of manufacture. An application of force will be necessary to cause the coils to open. If the coils are in contact some initial tension is present. If it is important that no initial tension whatever be present then the spring cannot be close coiled.

5.1 Equations

The various characteristics attributable to springs can be calculated using the equations given in 5.2 to 5.6.

5.2 Stress correction factor

The stress correction factor, K , is given by the equation

$$K = \frac{c + 0.2}{c - 1}$$

where

$$c = \frac{D}{d}$$

NOTE In the case of springs with an index of less than 5 this correction factor will lead to conservative results, and when such springs are subject only to static operating conditions the spring designer may make allowance for this fact.

5.3 Shear stress

The shear stress, τ , is given by the equation

$$\tau = \frac{8FDK}{\pi d^3}$$

NOTE This calculation only predicts the stress in the body of the spring. The point of maximum stress might occur elsewhere in the spring, e.g. in the end loops, if this is important, further analysis should be carried out. It should be noted that, when considering stresses in the end loops, a curvature correction factor for bending will have to be used.

5.4 Spring force

The spring force, F , is given by the equation

$$F = S\delta + F_0$$

5.5 Spring rate

The spring rate, S , is given by the equation

$$S = \frac{\Delta F}{\Delta L} = \frac{Gd^4}{8nD^3}$$

5.6 Natural frequency of unloaded spring

The natural frequency of the unloaded spring, f , is given by the equation

$$f = \frac{d}{2\pi nD^2} \sqrt{\frac{G \times 500}{\rho}}$$

5.7 Number of coils

It is possible to determine with reasonable accuracy the total number of coils. Some deflection, however, always occurs in the end loops and therefore the calculated number of active coils will not correspond with the actual number of total coils, the degree of variance depending on the end loop forms.

5.8 Effect of coating thickness on spring rate

Surface coating, e.g. electroplating, of a spring wire increases the effective diameter of the material and may cause a substantial increase in spring rate.

Account should be taken of this by the spring designer when specifying the spring.

6 Types of end loop

Three groups of end loop are dealt with in this Part of BS 1726 as follows.

a) *Group 1* (see Figure 1) to which the tolerances given in clause 7 can be applied.

b) *Group 2* (see Figure 2) to which the tolerances given in clause 7 can be applied with the following restrictions:

- 1) the length of loops, L_L , is restricted to a maximum of $1.75 \times$ the outside diameter of the spring, D_0 ;
- 2) only grade 2 load and length tolerances are applicable;
- 3) the minimum number of coils is 6.

c) *Group 3* (see Figure 3) for which the tolerances are to be agreed between the customer and the supplier.

NOTE The nomenclature associated with the various end loop configurations is not intended to define the method of manufacture.

7 Tolerances

7.1 General

The tolerances given in this clause are those recommended for economic production in two grades, 1 and 2, and only apply to springs with an index in the range 3.5 to 16 inclusive and a total number of coils, N , of not less than 3.5.

In the case of group 2 end loops the tolerances apply only to springs with a total number of turns of not less than 6.

NOTE The choice of tolerance grades will be governed by operational requirements. Grade 1 covers tolerances where close agreement with nominal specification is required, while grade 2 allows wider tolerances. Generally, where several features are toleranced, a combination of grades 1 and 2 is used. Where designers find it necessary to specify tolerances tighter than grade 1, they should consult their supplier as to the practicability or economy of the design in question. In certain cases, the use of wider tolerances may result in more economical production.