IS 7906-2 (1975): Helical Compression Springs, Part II: Cold Coiled Springs Made from Circular Section Wire and Bar [TED 21: Spring]

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UDC 621-272 272 (Sixth Reprint SEPTEMBER 2003)

Indian Standard

HELICAL COMPRESSION SPRINGS

PART II SPECIFICATION FOR COLD COILED SPRINGS MADE FROM CIRCULAR SECTION WIRE AND BAR

Springs Sectional Committee, EDC 75; Helical and Torsion Springs Subcommittee, EDC 75 : 1 [Ref: Doc: EDC 75 (2278)]

1. Scope — Covers cold coiled compression springs made from spring wires of up to 17 mm diameter.

1.1 This standard is applicable to springs having the following parameters:

a) Mean coil diameter; D_m up to 200 mm,
b) Unloaded length; L_0 up to 630 mm,
c) Number of working coils; $i_f \geq 2$, and
d) Coil ratio; w from 4 up to 20.

2. Symbols — Following symbols and units shall apply (*see* Fig. 1).

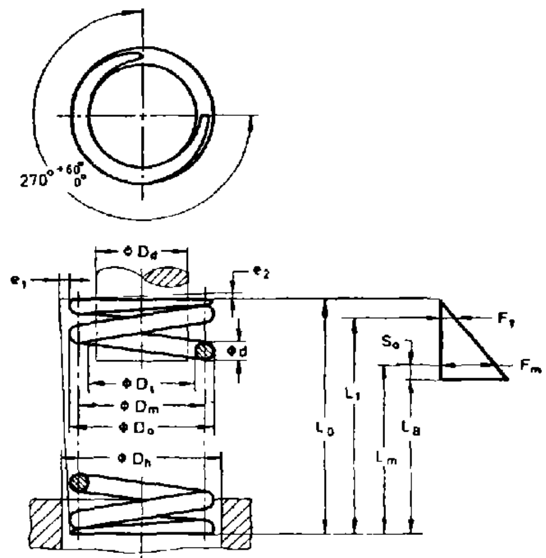

FIG. 1 COMPRESSION SPRING WITH ENDS CLOSED AND GROUND (WITH THEORETICAL CHARACTERISTIC CURVE)

D_d	=	Diameter of arbor (inner guide), mm
D_h	=	Diameter of sleeve (outer guide), mm
D_i	=	Inside diameter of coil, mm
D_o	=	Outside diameter of coil, mm
D_m	=	$\frac{D_o + D_i}{2}$ = Mean diameter of coil, mm
L_0	=	Unloaded length of spring, mm
L_B	=	Block length of spring, mm (all coils touching metal to metal)
L_1 to L_m	=	Loaded lengths corresponding to axial loads F_1 to F_m, mm
L_m	=	$L_B + S_a$ = Minimum permissible test length of spring, mm
F_1 to F_m	=	Axial loads corresponding to load lengths L_1 to L_m, N
F_{Bt}	=	Theoretical load at block length L_B, N. The actual load at block length is generally larger (*see* Fig. 9)

Adopted 30 December 1975 Gr 5

BUREAU OF INDIAN STANDARDS
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S_c $= \frac{\Delta F}{\Delta f}$ = Spring rate, N/mm

T_D = Tolerance on the coil diameter (D_o, D_i, D_m) of the unloaded spring, mm

T_{L_0} = Tolerance on the unloaded length, L_0 of the spring, mm

T_F = Tolerance on the axial load F at given loaded length L, N

d = Diameter of wire or bar, mm

d_{max} = Nominal diameter of wire increased by the upper allowance for materials given in 4

e_1 = Deviation in squareness of unloaded springs, mm

e_2 = Deviation in parallelism of ground spring faces, mm

f_1 to f_m = Deflections corresponding to axial loads F_1 to F_m, mm

f_B = $L_0 - L_B$ = Maximum deflection possible corresponding to the theoretical load F_{Bt}, mm

i_f = Number of working coils

i_g = Total number of coils

w $= \frac{D_m}{d}$ = Coil ratio

3. Manufacture

3.1 *Process* — The manufacturing process is governed by degree of stressing involved, the material for the manufacture and intended application of the spring. Cold coiling can generally be done with wires up to 17 mm in diameter. For wire and bar diameters between 10 and 17 mm hot coiling process may be used.

3.2 *Direction of Coiling* — Helical compression springs can be coiled in left-hand or right-hand directions. Normally they have right-hand coiling. Springs for application in nested sets (assemblies) or where one spring is working inside the other, direction of coiling is alternately left and right. The outer springs are generally with right-hand coiling. Where the springs require left-hand coiling, the same shall be mentioned in the order and enquiry or appropriately in IS : 7906 (Part III)-1975 'Helical compression springs: Part III Data sheet for specifications for springs made from circular section wire and bar'.

3.3 *Spring Ends* — For transmitting the axial loads on the connecting body, the spring ends shall be so formed that for any position of the spring, the spring action is axial as far as possible. This is generally achieved by decreasing the pitch at the runout coil. The spring end is then ground so that a flat seating surface is obtained (*see* Fig. 1). Other types of spring ends are shown in Fig. 2 to 5.

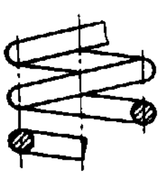

FIG. 2 ENDS OPEN AND UNGROUND

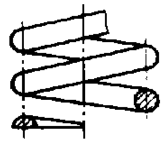

FIG. 3 ENDS OPEN AND GROUND

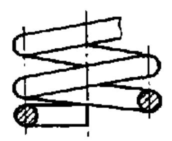

FIG 4 ENDS CLOSED AND UNGROUND

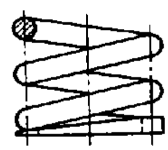

FIG. 5 ENDS TAPERED BEFORE COILING, CLOSED AND GROUND

3.3.1 If the springs can be used without end grinding, for example, for wire diameters less than 1 mm or for coil ratio above 15, it is preferable to do so for reasons of economy.

3.3.2 For compression springs with wire diameter less than 0·5 mm, grinding of the ends is not recommended.

3.3.3 For simultaneous grinding of both the ends of compression springs made of wire diameters 0·5 mm and above, care shall be taken to see that only those springs that allow sufficient contact pressure shall be so ground. It has been found that the contact pressure p is approximately given by:

$$p = \frac{S_c}{D_m} \geqslant 0{\cdot}03 \text{ N/mm}^2$$

3.3.4 If the grinding of spring ends is not required, the springs shall be made according to Fig. 2 or Fig. 4. The type of spring end required shall be specified on order and enquiry.

3.3.5 If an outside or inside chamfer at the coil runout is required, the chamfer width shall be indicated. The chamfer angle shall be 45° approximately.

AMENDMENT NO. 1 MAY 1990
TO
IS : 7906 (Part 2) - 1975 HELICAL COMPRESSION SPRINGS

PART 2 SPECIFICATION FOR COLD COILED SPRINGS MADE FROM CIRCULAR SECTION WIRE AND BAR

(*Page* 4, *clause* 5.3.1) — Substitute the following for the existing clause:

'**5.3.1** The tolerance on unloaded length shall be more than the load tolerances divided by the theoretical spring rate, that is,

$$T_{Lo} > \frac{T_F}{S_t}\text{'}$$

(LMD 17)

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3.4 *Block Length L_B* — (All coils in contact).

For springs with ends closed and ground as shown in Fig. 1

$$L_B \leqslant i_g \cdot d_{max}$$

For springs with ends closed and unground as shown in Fig 4

$$L_B \leqslant (i_g + 1)\, d_{max}$$

where

$i_g = i_f + 2$,

number of non-working coils = 2

3.5 *Surface Treatment*

3.5.1 *Shot-Peening* -- For increasing the fatigue life the spring may be subjected to shot-peening as per IS : 7001-1973 'Method for shot-peening and test for shot peened ferrous metal parts'. After the shot-peening the Almen arc heights shall not be less than those given below:

Wire Dia, mm		*Almen Arc Height A Scale (Min)*
Above	Up to	mm
2	4	0.20
4	6.5	0.30
6.5	9.5	0.40
9.5	13.0	0.45
13.0		0.50

3.5.1.1 The test shall be carried out inside the spring wherever possible in which case the Almen arc height on *A* scale may be lower by 0.1 mm than those given in **3.5.1**

3.5.2 *Surface protection* — To protect against corrosion, springs are smeared with grease or oil. Other anticorrosive treatment may be applied subject to agreement between the purchaser and the manufacturer.

4. Material — Springs shall be made from any of the materials specified below

4.1 *Group 1*

4.1.1 Patented and cold drawn spring steel wires, unalloyed, Grades 1, 2, 3 and 4 to IS : 4454 (Part I)-1975 'Steel wires for cold formed springs Part I Patented and cold drawn steel wires -- unalloyed (*first revision*)'.

4.1.2 Oil hardened and tempered spring steel wire and valve spring wire, unalloyed, Grades SW and VW to IS : 4454 (Part II)-1975 'Steel wires for cold formed springs Part II Oil hardened and tempered spring steel wire and valve spring wire — unalloyed (*first revision*)'

4.1.3 *Alloyed, oil hardened and tempered valve spring wire and spring steel wire for use under moderately* elevated temperatures, Grades 1S, 2S, 1D and 2D to IS 4454 (Part III)-1975 'Steel wires for cold formed springs: Part III Oil hardened and tempered steel wires — alloyed (*first revision*)'.

4.1.4 Stainless spring steel wire, Grade 1 and 2 to IS 4454 (Part IV)-1975 'Steel wires for cold formed springs: Part IV Stainless spring steel wires for normal corrosion resistance (*first revision*)'

4.2 *Group 2*

4.2.1 Hard-drawn brass wires to IS : 4076-1967 'Hard brass wires for spring and other special purposes'

4.2.2 Phosphor bronze wires to IS : 1385-1968 'Phosphor bronze rods and bars sheet and strip, and wire (*first revision*)'.

4.3 Other materials, subject to agreement between the purchaser and the manufacturer, may be used.

5. Tolerances — All tolerances specified in this standard apply to compression springs made from materials specified in **4.1**. For springs made from materials specified in **4.2** and other materials, the tolerances shall be fixed by agreement between the purchaser and the manufacturer. Normal tolerances for D_m, *F* and L_0 are specified in Table 1, **5.2** and **5.3**. For reasons of economy, wider tolerances given in Appendix A should be used. *However, where functionally required, springs can also be manufactured with closer tolerances* given in Appendix B. For certain types of springs, it may be essential to adopt wider tolerances given in Appendix A. For such cases reference should be made to the spring manufacturer.

5.1 *Tolerances T_D on Coil Diameter for Unloaded Springs* -- The tolerances shall be as given in Table 1. It is recommended that where a spring is working inside a sleeve or over an arbor or both in a sleeve and over an arbor, the minimum diameter of the sleeve and the maximum diameter of the arbor should be specified to ensure proper understanding of such requirements

5.2 *Tolerances T_F on Axial Load Corresponding to Load Lengths* — Shall be given by:

$$T_F = \pm \left(t_F \cdot k_t + \frac{1{\cdot}5\, F}{100} \right)$$

where

t_F is obtained from Fig. 6 and 7, and

k_t is obtained from Fig. 8

Note — t_F specified in Fig 6 and 7 apply only to springs which are resistant to buckling

5.3 *Tolerances T_{L0} on Unloaded Length* — Unloaded length L_0 shall be toleranced only in agreement with 6. Tolerance is given by:

$$T_{L0} = \pm \frac{t_F \cdot k_t}{S_c}$$

where

t_F is obtained from Fig. 6 and 7, and

k_t is obtained from Fig. 8

TABLE 1 TOLERANCES T_D ON COIL DIAMETERS FOR UNLOADED SPRINGS

(*Clauses* 5.5.1, A-0 *and* B-0)

All dimensions in millimetres

D_m		Tolerance T_D for Coil Ratio *w*		
Above	Up to	Above 4 Up to 8	Above 8 Up to 14	Above 14 Up to 20
0·63	1	±0·07	±0·1	±0·15
1	1·6	±0·08	±0·1	±0·15
1·6	2·5	±0·1	±0·15	±0·2
2·5	4	±0·15	±0·2	±0·25
4	6·3	±0·2	±0·25	±0·3
6·3	10	±0·25	±0·3	±0·35
10	16	±0·3	±0·35	±0·4
16	25	±0·35	±0·45	±0·5
25	31·5	±0·4	±0·5	±0·6
31·5	40	±0·5	±0·6	±0·7
40	50	±0·6	±0·8	±0·9
50	63	±0·8	±1·0	±1·1
63	80	±1·0	±1·2	±1·4
80	100	±1·2	±1·5	±1·7
100	125	±1·4	±1·9	±2·2
125	160	±1·8	±2·3	±2·7
160	200	±2·1	±2·9	±3·3

Note 1 — The tolerances specified for D_m apply equally for the corresponding inside and outside diameters D_i and D_o

Note 2 — The tolerances for *w* above 20 and D_m above 200 are subject to agreement between the purchaser and the manufacturer

5.3.1 The tolerances on unloaded length shall not be less than the load tolerances divided by the theoretical spring rate, that is,

$$T_{L0} \geqslant \frac{T_F}{S_c}$$

5.4 *Tolerances on Spring Rate* — Should be specified only when functionally required. It shall be 50 percent of the tolerance on load with a minimum of 3 percent (*see* **7.2**). Spring rates shall be measured between 0·3 and 0·7 f_n

5.5 *Tolerance on Squareness and Parallelism* — Shall be as given in Table 2. These tolerances shall be specified only when functionally required

TABLE 2 TOLERANCE ON SQUARENESS AND PARALLELISM OF GROUND FACES
(*Clause* 5.5)

Deviation in squareness, e_1	0·05 L_0 (2·9°)
Deviation in parallelism, e_2	0·03 D_0 (1·7°)

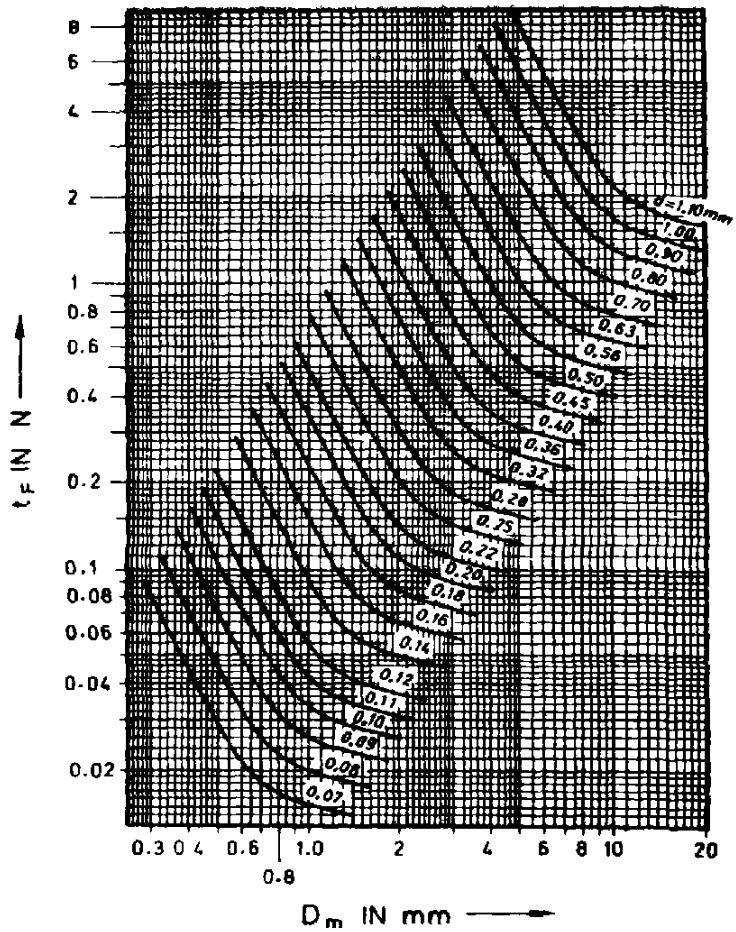

FIG 6 INFLUENCE OF THE SHAPE AND SIZE OF SPRING ON THE TOLERANCE OF LOAD AND LENGTH, FOR WIRE DIAMETERS FROM 0.07 TO 1.10 mm

5.5.1 Closer tolerances given in **B-4** can only be achieved in cases of springs having a coil ratio $w \leqslant 12$ and the slenderness ratio $\frac{L_0}{D_m} \leqslant 5$. In some cases, it may not be possible to achieve even the tolerance specified in Table 2 and for such springs it is recommended that a reference should be made to the manufacturer for squareness and parallelism tolerances.

5.5.2 Squareness and parallelism tolerances other than those specified in **5.5**, **A-4** and **B-4** may be agreed to between the purchaser and the manufacturer, if specially required.

5.6 *Tolerances on Number of Coils* — A total tolerance of 5 percent on number of total coils shall be allowed for springs where loads or spring rates are not specified. In case the loads or spring rates are specified, complimentary adjustments for manufacturing given in **6** shall apply.

5.7 Tolerance on wire diameters shall be in accordance with the relevant part of IS : 4454-1975.

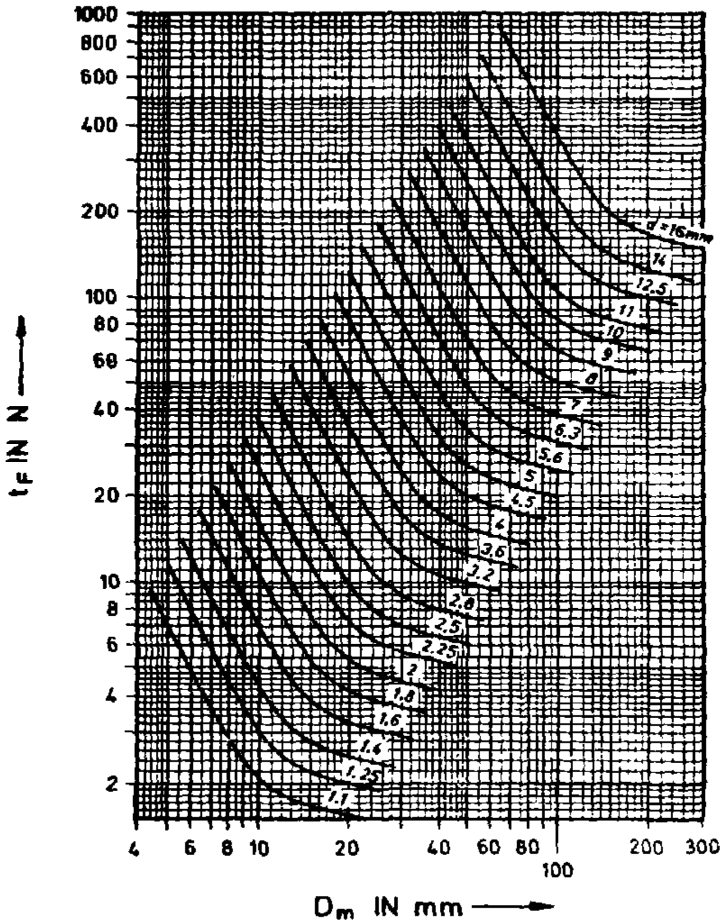

FIG. 7 INFLUENCE OF THE SHAPE AND SIZE OF SPRING ON THE TOLERANCE FOR LOAD AND LENGTH, FOR WIRE DIAMETERS FROM 1.1 TO 16 mm

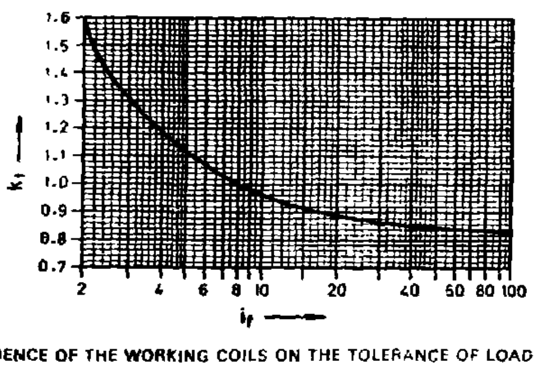

FIG. 8 INFLUENCE OF THE WORKING COILS ON THE TOLERANCE OF LOAD AND LENGTH

6. Complimentary Adjustment for Manufacturing — To enable springs to be held within specified limits of axial loads, the manufacturer requires complimentary adjustments during production. These shall be specified by the following method:

Complimentary Adjustments for Manufacturing	*Manufacturer's Discretion for*
If one axial load F and the corresponding load length L are specified	L_0
If one axial load F and the corresponding load length L and unloaded length L_0 are specified	i_t and d *or* i_t and D_0, D_1 (D_m)
If two axial loads and the corresponding load lengths are specified	L_0, i_t and d *or* L_0, i_t and D_0, D_1 (D_m)

6.1 The numerical values of the quantities allowed according to manufacturer's discretion for complimentary adjustment shall be specified in the drawing and apply as guide values only. When these are not given complimentary adjustments given in **6** shall apply.

6.2 While allowing complimentary adjustments, care should be taken to see that the maximum stress on the springs does not exceed the maximum allowable stress for the material.

7. Testing

7.1 *Static Load Test* — This test is carried out in the normal direction of loading with the spring standing vertically. In each case before carrying out the static test the spring shall be compressed 3 times in quick succession to the block length or to a length corresponding to the maximum permissible static stress values, whichever is more.

7.1.1 In the case of springs which are required to be tested over or in a guide, the test procedure is to be agreed upon with the manufacturer.

7.2 The theoretical characteristic curve [force-deflection diagram (*Fig. 9*)] of a cylindrical helical compression spring is a straight line. In practice, however, the start and finish of the spring characteristic show a departure from linearity. If it is intended to check the spring rate by finding the characteristic of the spring, this test must be carried out over the range $0 \cdot 3\, F_m$ to $0 \cdot 7\, F_m$ so as to cover the linearity with certainty. F_m here corresponds to the minimum permissible test length L_m of the spring. The spring rate S_c is thus:

$$S_c = \frac{\Delta F}{\Delta L} = \frac{\Delta F}{\Delta f} = \frac{F_2 - F_1}{L_1 - L_2} = \frac{F_2 - F_1}{f_2 - f_1}$$

where ΔF is the force increment due to the length reduction ΔL or to the deflection increment Δf (*see* Fig. 9).

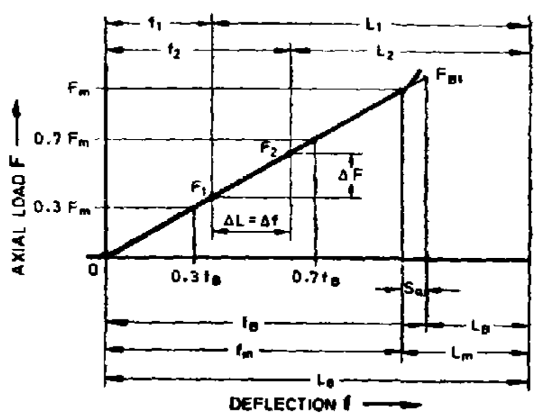

FIG 9 SPRING CHARACTERISTICS CURVE

7.3 *Test Load for Compressing to Block Length* — When compressing to the block length L_B for test purposes the maximum load to be applied would be 1·5 times the theoretical axial load corresponding to the block length L_B.

7.4 Special tests, such as testing for endurance, cramp and temperature relaxation are subject to agreement between the purchaser and the manufacturer.

8. ISI Certification Marking — Details available with the Indian Standards Institution.

APPENDIX A

(*Clause* 5)

WIDER TOLERANCES ON COIL DIAMETERS D_m, D_i AND D_e; UNLOADED LENGTH L_0, AXIAL LOAD F AND SQUARENESS AND PARALLELISM OF SPRINGS

A-0. Normal tolerances for D_m, F and L_0 are given in Table 1, 5.2 and 5.3. Tolerances given in this Appendix are wider than normally encountered. For reasons of economy, as far as possible, these tolerances should be used. For certain types of springs it may be essential to adopt these tolerances.

A-1. Tolerances T_D for Coil Diameter D_m for Unloaded Springs — Are given in Table 3.

TABLE 3 WIDER TOLERANCES T_D FOR COIL DIAMETERS

(*Clauses* 5 *and* A-1)

All dimensions in millimetres

D_m		Tolerances T_D for Coil Ratio w		
Above	Up to	*Above 4 Up to 8*	*Above 8 Up to 14*	*Above 14 Up to 20*
0·63	1	±0·1	±0·15	±0·2
1	1·6	±0·15	±0·2	0·3
1·6	2·5	±0·2	±0·3	0·4
2·5	4	±0·3	±0·4	0·5
4	6·3	±0·4	±0·5	0·6
6·3	10	±0·5	±0·6	0·7
10	16	±0·6	±0·7	±0·8
16	25	±0·7	±0·9	±1·0
25	31·5	±0·8	±1·0	±1·2
31·5	40	±1·0	±1·2	±1·5
40	50	±1·2	±1·5	±1·8
50	63	±1·5	±2·0	±2·3
63	80	±1·8	±2·4	±2·8
80	100	±2·3	±3·0	±3·5
100	125	±2·8	±3·7	±4·4
125	160	±3·5	±4·6	±5·4
160	200	±4·2	±5·7	±6·6

Note 1 — The tolerances specified for D_m are equally applicable for diameters D_i and D_o.

Note 2 — The tolerance T_D for w above 20 and D_m above 200 are subject to agreement between the purchaser and the manufacturer.

A-2. Tolerance T_F for Axial Loads Corresponding to Load Lengths

$$T_F = \pm\left(t_F \times k_t + \frac{1 \cdot 5\ F}{100}\right) \times 1 \cdot 6$$

where

t_F is obtained from Fig. 6 and 7, and

k_t is obtained from Fig. 8.

A-3. Tolerance T_{L_0} for Unloaded Lengths

$$T_{L_0} = \pm \frac{t_F \times k_t}{S_c} \times 1{\cdot}6$$

where

t_F is obtained from Fig. 6 and 7, and
k_t is obtained from Fig. 8.

A-4. Tolerance on Squareness and Parallelism of Ground Faces — Shall be as follows:

Deviation in squareness, e_1	0·08 L_0 (4·6°)
Deviation in parallelism, e_2	0·06 D_0 (3·4°)

APPENDIX B

(*Clause* 5)

CLOSER TOLERANCES ON COIL DIAMETERS D_m, D_i AND D_o; UNLOADED LENGTH L_0, AXIAL LOAD F AND SQUARENESS AND PARALLELISM OF SPRINGS

B-0. Normal tolerances for D_m, F and L_0 are given in Table 1, **5.2** and **5.3**. Tolerances given in this appendix are closer than those normally encountered. These tolerances should be specified only when functionally required

B-1. Tolerances T_D for Coil Diameters D_m for Unloaded Springs — Are given in Table 4.

TABLE 4 CLOSER TOLERANCES T_D FOR COIL DIAMETERS

(*Clauses* 5 *and* B-1)

All dimensions in millimetres.

D_m		Tolerances T_D for Coil Ratio w		
Above	Up to	Above 4 Up to 8	Above 8 Up to 14	Above 14 Up to 20
0·63	1	±0·05	±0·07	±0·1
1	1·6	±0·05	±0·07	±0·1
1·6	2·5	±0·07	±0·1	±0·15
2·5	4	±0·1	±0·1	±0·15
4	6·3	±0·1	±0·15	±0·2
6·3	10	±0·15	±0·15	±0·2
10	16	±0·15	±0·2	±0·25
16	25	±0·2	±0·25	±0·3
25	31·5	±0·25	±0·3	±0·35
31·5	40	±0·25	±0·3	±0·35
40	50	±0·3	±0·4	±0·5
50	63	±0·4	±0·5	±0·6
63	80	±0·5	±0·7	±0·8
80	100	±0·6	±0·8	±0·9
100	125	±0·7	±1·0	±1·1
125	160	±0·9	±1·2	±1·4
160	200	±1·2	±1·5	±1·7

Note 1 — The tolerances specified for D_m are equally applicable for diameters D_i and D_o.

Note 2 — The tolerance T_D for w above 20 and D_m above 200 are subject to agreement between the purchaser and the manufacturer.

B-2. Tolerance T_F for Axial Loads Corresponding to Loaded Lengths

$$T_F = \pm \left(t_F \times k_f + \frac{1 \cdot 5\, F}{100}\right) \times 0 \cdot 6$$

where

t_F is obtained from Fig. 6 and 7, and
k_f is obtained from Fig 8.

B-3. Tolerance T_{L_0} for Unloaded Lengths

$$T_{L_0} = \pm \frac{t_F \times k_f}{S_c} \times 0 \cdot 6$$

where

t_F is obtained from Fig. 6 and 7, and
k_f is obtained from Fig. 8.

B-4. Tolerance on Squareness and Parallelism of Ground Faces (*see also* 5.5.1) — Shall be as follows:

Deviation in squareness, e_1	0 03 L_0 (1 7°)
Deviation in parallelism, e_2	0·02 D_0 (1·15°)

EXPLANATORY NOTE

This standard is one of the series of standards on design calculation and specifications of helical coiled springs. Other standards in this series are

IS : 7906 (Part I)-1976 Helical compression springs: Part I Design and calculation for springs made from circular section wire and bar

IS : 7906 (Part III)-1975 Helical compression springs: Part III Data sheet for specifications for springs made from circular section wire and bar

IS : 7906 (Part IV) Helical compression springs Part IV Guide for selection of standard cold coiled springs made from circular section wire and bar (*under preparation*)

IS : 7906 (Part V) Helical compression springs. Part V Specification for hot coiled springs made from circular section bar (*under preparation*)

IS : 7907 (Part I)-1976 Helical extension springs Part I Design and calculation for springs made from circular section wire and bar

IS : 7907 (Part II)-1976 Helical extension springs Part II Specification for cold coiled springs made from circular section wire and bar

IS : 7907 (Part III)-1975 Helical extension springs: Part III Data sheet for specifications for springs made from circular section wire and bar

IS : 7907 (Part IV) Helical extension springs Part IV Guide for selection of standard cold coiled springs made from circular section wire and bar (*under preparation*)

In this standard unit of force used is newton (N) and that of stress is N/mm².

1 kgf = 9·806 65 N (exactly)
or 1 kgf ≃ 9 81 N (approx)
≃ 10 N (within 2 percent error)

1 N/mm² = 1 MN/m²
= 1 MPa [1 pascal (Pa) = 1N/mm²]
≃ 0·1 kgf/mm² (within 2 percent error)

In the preparation of this standard assistance has been derived from DIN 2095-1973 'Helical springs made of round wire; specifications for cold coiled compression springs', issued by DIN Deutsches Institut fur Normung.