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Indian Standard

HELICAL EXTENSION SPRINGS

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

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

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

a) Outside diameter of coil, D_m up to 340 mm;

b) Unloaded length of springs, L_0 up to 1 500 mm;

c) Number of working coils, $i_f \geqslant 3$; and

d) Coil ratio, w from 4 up to 20.

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

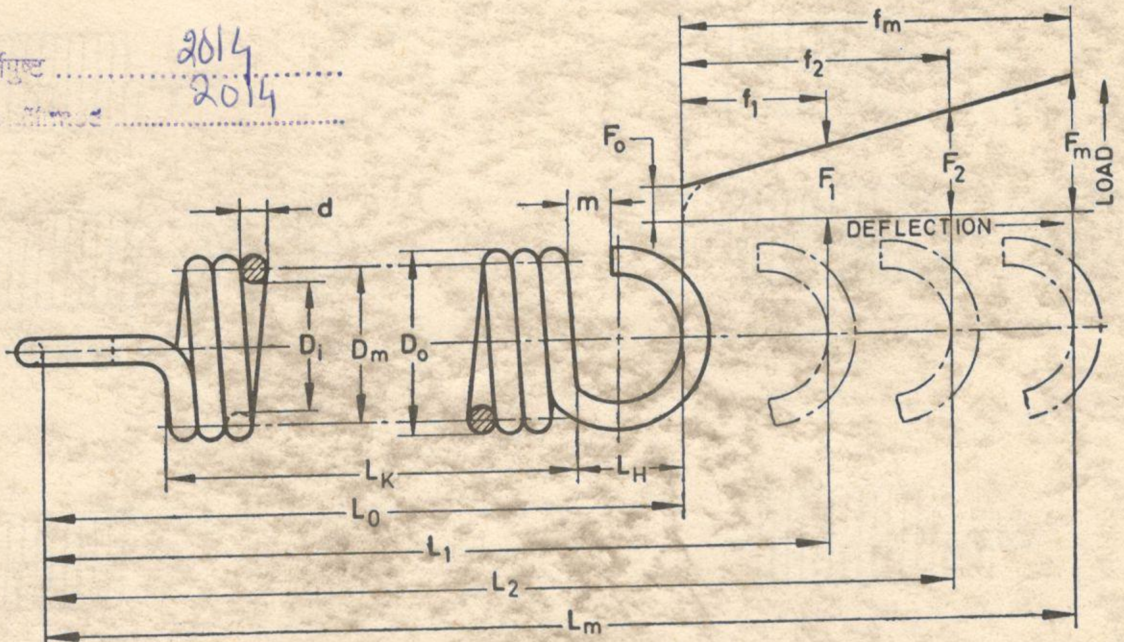

FIG. 1 EXTENSION SPRING DIAGRAM REPRESENTATION (WITH THEORETICAL CHARACTERISTIC LINE)

D_0 = Outside diameter of the coil, mm

D_1 = Inside diameter of the coil, mm

D_m = $\frac{D_0 + D_1}{2}$ = Mean coil diameter, mm

L_H = Distance of inside edge of the hook from body of spring, mm

L_K = Body length when not loaded but subject to initial tension, mm

L_0 = Unloaded length of the spring, measured between the inside edges of the hooks, mm

L_1 to L_m = Load lengths of the spring, measured between the inside edges of the hook corresponding to the axial loads F_1 to F_m, mm

F_1 to F_m = Axial loads corresponding to the load lengths L_1 to L_m, N

F_0 = Initial tension produced by coiling, N

T_D = Tolerance on the coil diameter (D_0, D_1, D_m) of the unloaded spring, mm

T_{L0} = Tolerance on unloaded length L_0 of the spring, mm

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

Springs Sectional Committee, EDC 75; Helical and Torsion Springs Subcommittee, EDC 75:1 [Ref: Doc: EDC 75 (2259)]

Adopted 30 January 1976 | | Gr 7

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T_o = Permissible deviation of the hook opening position of the unloaded spring, degrees

S_c = $\frac{\Delta F}{\Delta f}$ = spring load rate, N/mm

d = Wire diameter, mm

d_{max} = Nominal diameter of wire increased by its upper allowance for materials given in **4**, mm

f_1 to f_m = Extension of the spring corresponding to the axial loads F_1 to F_m, mm

i_f = Number of working coils

i_g = Total number of coils

m = Hook opening width, mm

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

3. Manufacture

3.1 *Direction of Coiling* — Optional subject to conformity of the relative angular hook opening position.

3.2 *Hook Forms* — The general hook forms for extension springs are shown in Fig. 2 to 14. The hooks may have other forms depending on individual requirements.

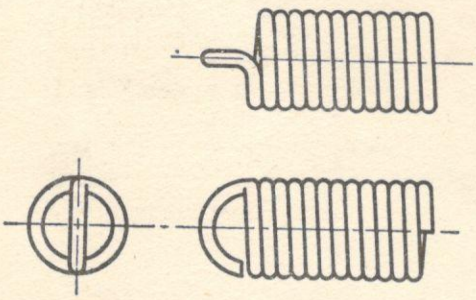


FIG. 2 FORM A ($L_H = 0{\cdot}55\,D_i$ TO $0{\cdot}8\,D_i$)

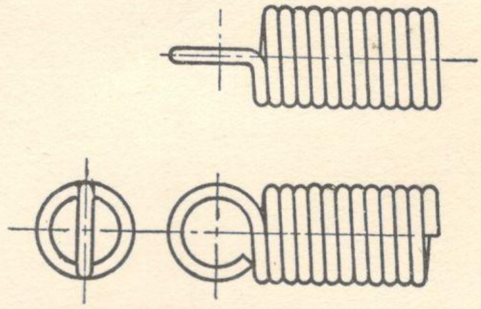


FIG. 3 FORM B ($L_H = 0{\cdot}8\,D_i$ TO $1{\cdot}1\,D_i$)

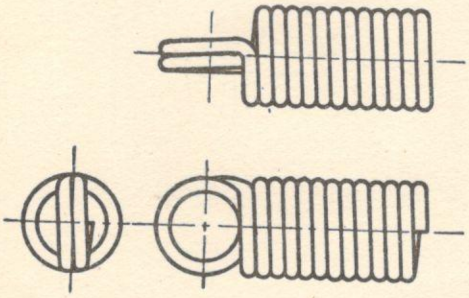


FIG. 4 FORM C ($L_H = 0{\cdot}8\,D_i$ TO $1{\cdot}1\,D_i$)

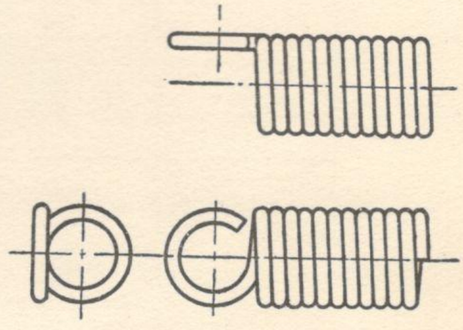


FIG. 5 FORM D ($L_H \approx D_i$)

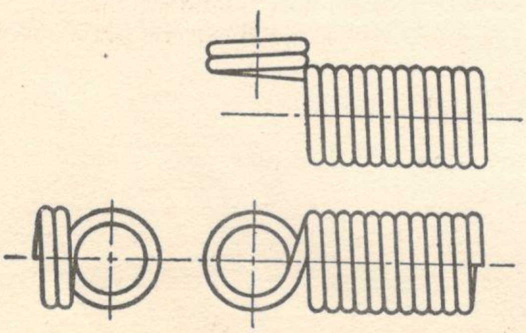


FIG. 6 FORM E ($L_H \approx D_i$)

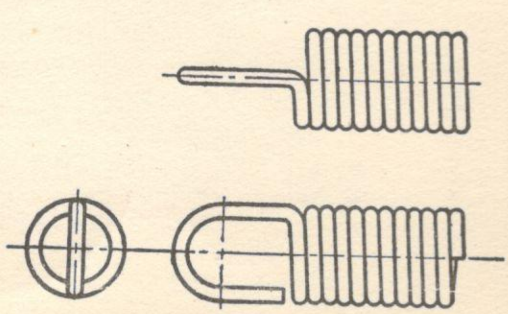


FIG. 7 FORM F (ELONGATED HOOK)

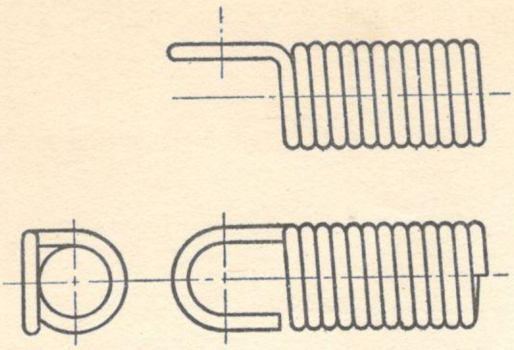


FIG. 8 FORM G (ELONGATED HOOK)

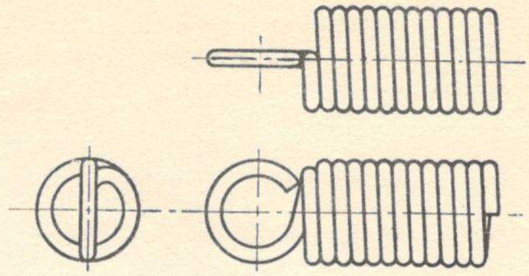


FIG. 9 FORM H ($L_H \simeq 1{\cdot}1\ D_i$)

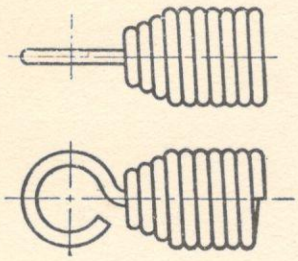


FIG. 10 FORM J (ROLLED-IN HOOK)

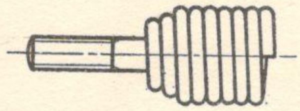


FIG. 11 FORM K (THREADED STUD ROLLED-IN)

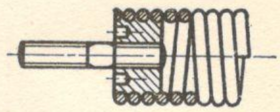


FIG. 12 FORM L (THREADED PLUG SCREWED-IN, 2 TO 4 THREADED COILS)

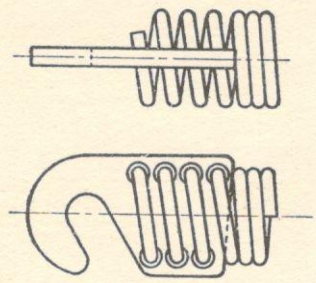


FIG. 13 FORM M (THREADED PLATE, HOOK THREADED OVER 2 TO 4 THREADED COILS)

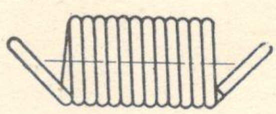


FIG. 14 FORM N (OBLIQUE POSITION)

3.3 The relative angular position of the hook opening in Fig. 1 is 90° in the manner of a right-hand thread. The relative angular position of hook openings are shown in Fig. 15.

3.3.1 The hook opening width *m* should be specified in the drawings, if required. If the hook opening width is not specified, the hooks can be closed to prevent hooking into one another (particularly in the case of small springs). If *m* is specified, it shall be 2 *d* or more.

3.4 *Exact Number of Coils* — For Fig. 1, the total number of coils end at $\frac{1}{4}$. For spring forms shown in Fig. 2 to 9 and Fig. 14, the total number of coils i_g is fixed by the position of the hooks (*see* Fig. 15).

3.4.1 In the simplified view when end connections of springs are not considered, $i_g = i_f$.

3.4.2 In case of springs with threaded-in or rolled-in end pieces (*see* Fig. 10 to 13):

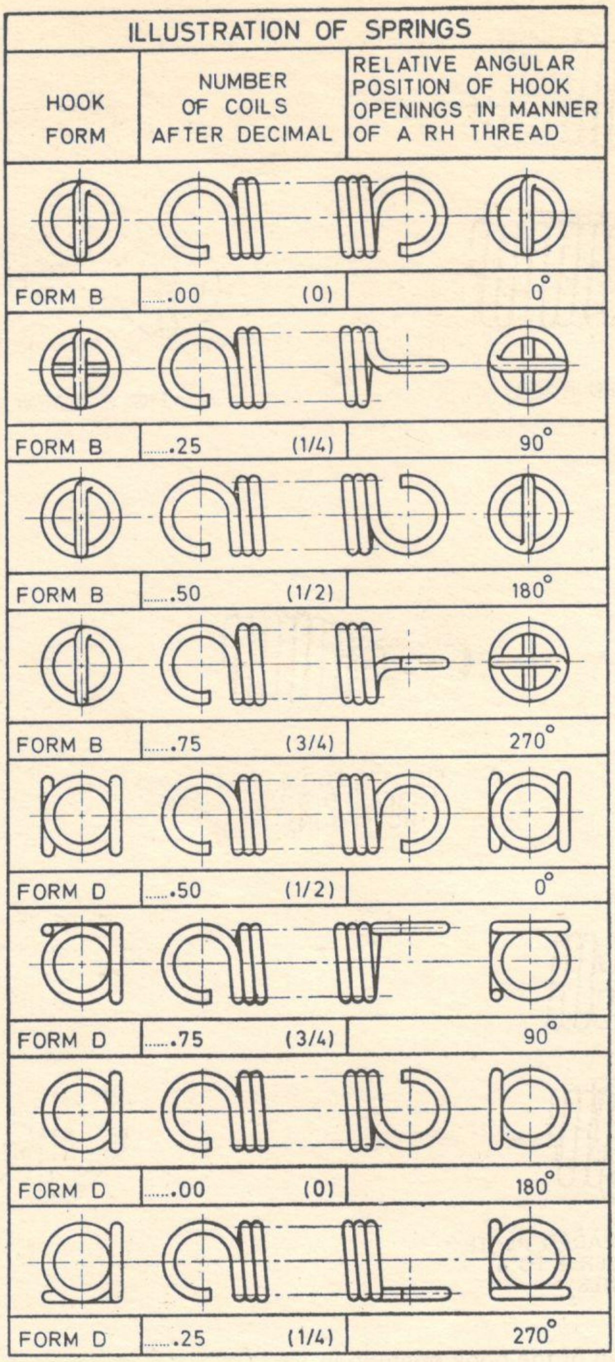
$$i_g = i_f + \text{number of coils that are rendered ineffective.}$$

3.5 *Distance Between the Working Coils* — In case of extension springs with initial tension, the coils touch each other. For extension springs without initial tension, the coils cannot always be made in such a way that they touch each other. In such cases tolerances on lengths are more (*see* **5.3.1**).

3.6 *Length of the Extension Springs*

3.6.1 The length, L_K of the spring body with initial tension is given by:

$$L_K \simeq (i_g + 1)\ d_{max}$$



Note — Relative angular positions of hook opening for Form B are also applicable for Form H.

FIG. 15 RELATIVE ANGULAR POSITIONS OF HOOK OPENING (SPRINGS WITH RH COILING)

3.6.2 The length L_0 of the unloaded spring, measured between the inside edges of the hooks is given by:

$$L_0 = L_K + 2\ L_H \text{ (for equal loops)}$$

3.6.3 Standard values for L_H are indicated in Fig. 2 to 6 and Fig. 9. However, L_H should be specified only as minimum.

3.7 *Spring Calculations* — Calculations shall be made according to IS : 7907 (Part I)-1976 'Helical extension springs: Part I Design and calculation for springs made from circular section wire and bar'.

3.8 *Surface Protection* — Normally oil or grease shall be smeared over the springs to protect against corrosion. Other types of protection shall be decided between the purchaser and the manufacturer.

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

4.1 *Group 1*

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

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

c) 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 'Specification for steel wires for cold formed springs: Part III Oil hardened and tempered steel wire — alloyed (*first revision*)'.

d) Stainless spring steel wire, Grades 1 and 2 of IS: 4454 (Part IV)-1975 'Specification for steel wires for cold formed springs: Part IV Stainless spring steel wire for normal corrosion resistance (*first revision*)'.

4.2 *Group 2*

a) Hard drawn brass wires to IS: 4076-1967 'Specification for hard brass wires for springs and other special purposes'.

b) Phosphor bronze wires to IS: 1385-1968 'Specification for cold coiled springs made from circular section wire and bar'.

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

5. Tolerances — All the tolerances specified in this standard apply to extension 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, L_0 and F are specified in Tables 1 and 2 and **5.2**. 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.

5.1 *Tolerances T_D for Coil Diameters for Unloaded Springs* — Shall be as given in Table 1.

TABLE 1 TOLERANCES T_D FOR COIL DIAMETERS FOR UNLOADED SPRINGS

(*Clauses* 5 *and* 5.1)

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	±0·07	±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

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

Note 2 — The tolerances for coil ratios w above 20, and D_m above 160 are subject to agreement between the purchaser and the manufacturer.

5.2 *Tolerance T_F for the Axial Load F for Load Length L (for Extension Springs with and Without Initial Tension Imparted During Coiling)* — Is given by:

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

where

k_t is obtained from Fig. 16, and

t_F is obtained from Fig. 17 and 18.

5.2.1 The tolerances in **5.2** shall apply in the range of $0{\cdot}3\ f_m$ to $0{\cdot}7\ f_m$.

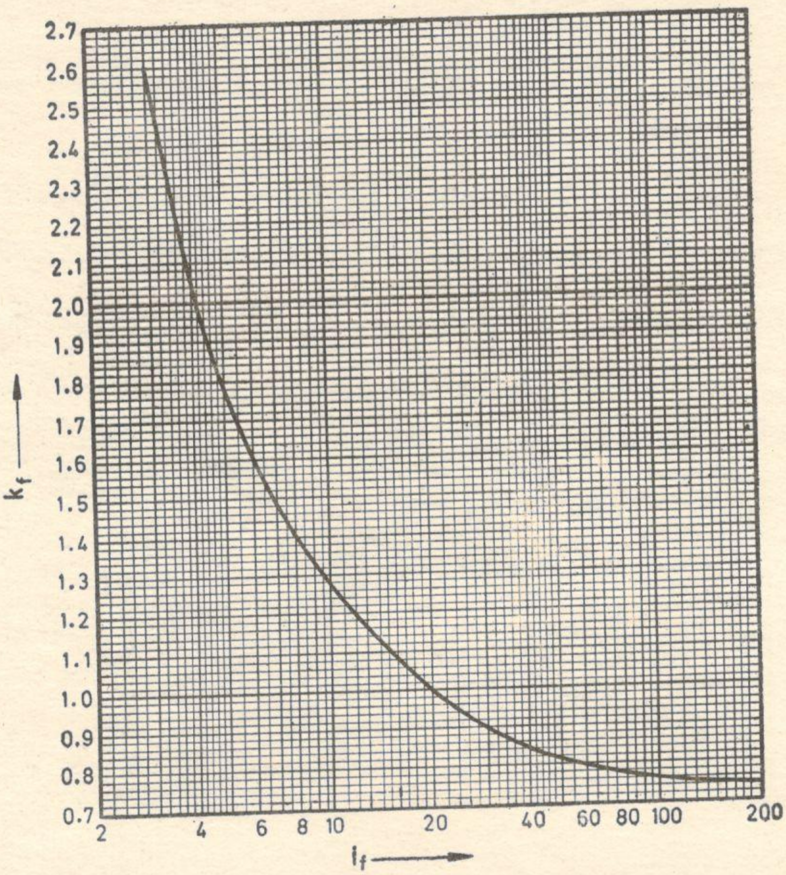


FIG. 16 INFLUENCE OF WORKING COILS ON DEVIATION OF LOADS AND LENGTHS

5.3 *Tolerance T_{L_0} for the Unloaded Length L_0 of Springs with Initial Tension* — Shall be according to Table 2.

TABLE 2 TOLERANCES T_{L_0} FOR THE UNLOADED LENGTH L_0 OF SPRINGS WITH INITIAL TENSION

(*Clauses* 5 *and* 5.3)

All dimensions in millimetres.

L_0		Tolerances T_{L_0} for Coil Ratio w	
Above	Up to	Above 4 Up to 8	Above 8 Up to 20
	10	±0·4	±0·5
10	16	±0·5	±0·6
16	25	±0·6	±0·7
25	40	±0·8	±0·9
40	63	±1·1	±1·3
63	100	±1·5	±1·8
100	160	±2·0	±2·4
160	250	±2·5	±3·0
250	400	±3·0	±4·0
400		±1·5% of L_0	±1·5% of L_0

5.3.1 Tolerance T_{L0} for the unloaded length L_0 of the spring without initial tension is given by:

$$T_{L0} = \pm \left[\frac{t_F \times k_f}{S_c} + 0.6 \times \text{(tolerance from Table 2)} \right]$$

where

k_f is obtained from Fig. 16, and

t_F is obtained from Fig. 17 and 18.

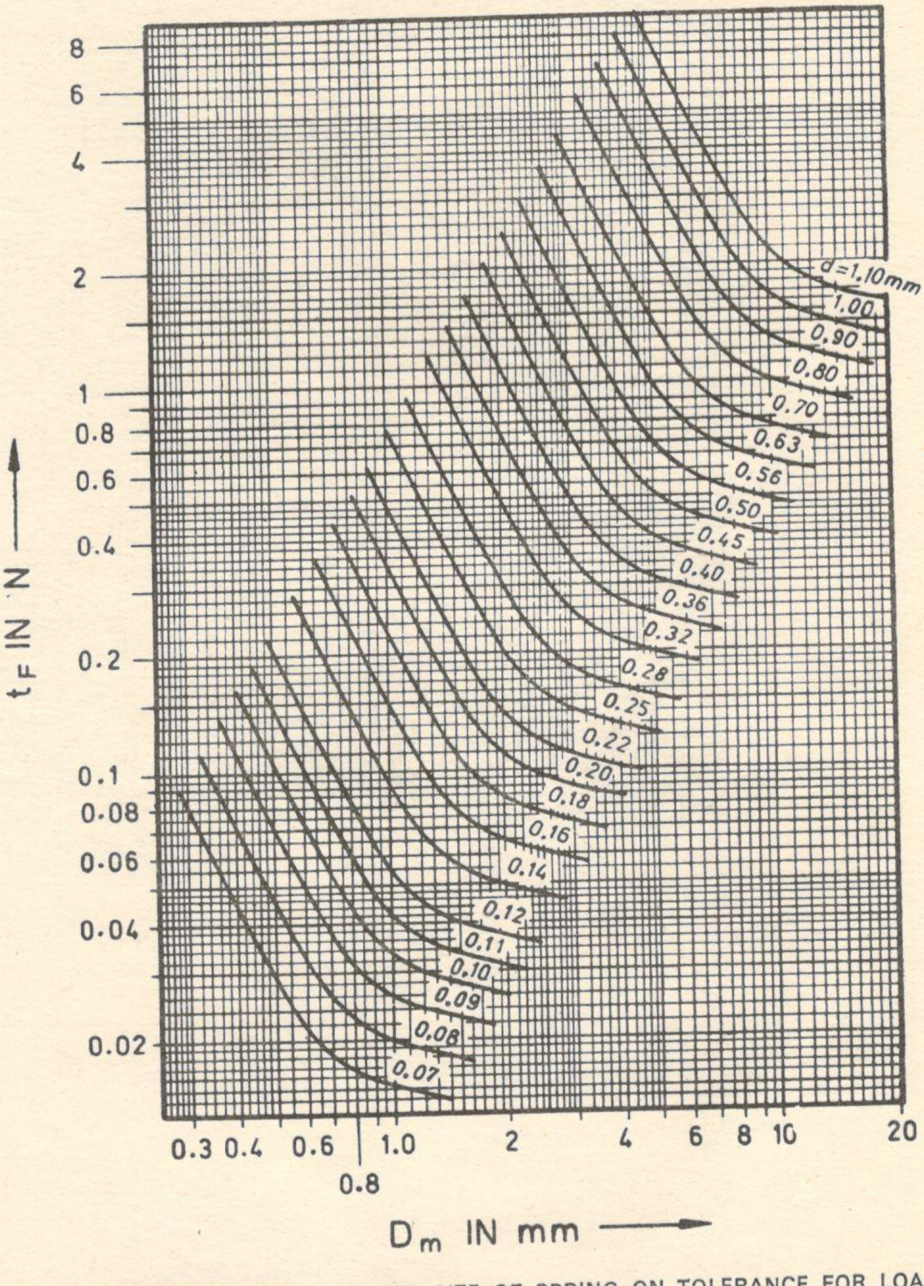


FIG. 17 INFLUENCE OF SHAPE AND SIZE OF SPRING ON TOLERANCE FOR LOAD AND LENGTH FOR WIRE DIAMETERS FROM 0·07 TO 1·10 mm

5.4 *Tolerance for Hook Position* — For unloaded springs tolerance is given by:

$$T_o = \pm t_o$$

where

t_o is taken from Fig. 19.

5.4.1 When the spring has initial tension, there is friction between the coils and there is a region in which the hook remains rigid in any position. Due to friction the deviation of the hook position appears magnified. This should be taken into account while testing.

5.5 *Tolerances for Initial Tension, F_0*— Are not specified since the desired initial tension is incorporated into the load specification at two load lengths.

5.6 *Tolerance on Hook Opening Width, m* — Shall be $\pm 0{\cdot}05(L_H - m)$ with a minimum hook gap of 0·3 mm.

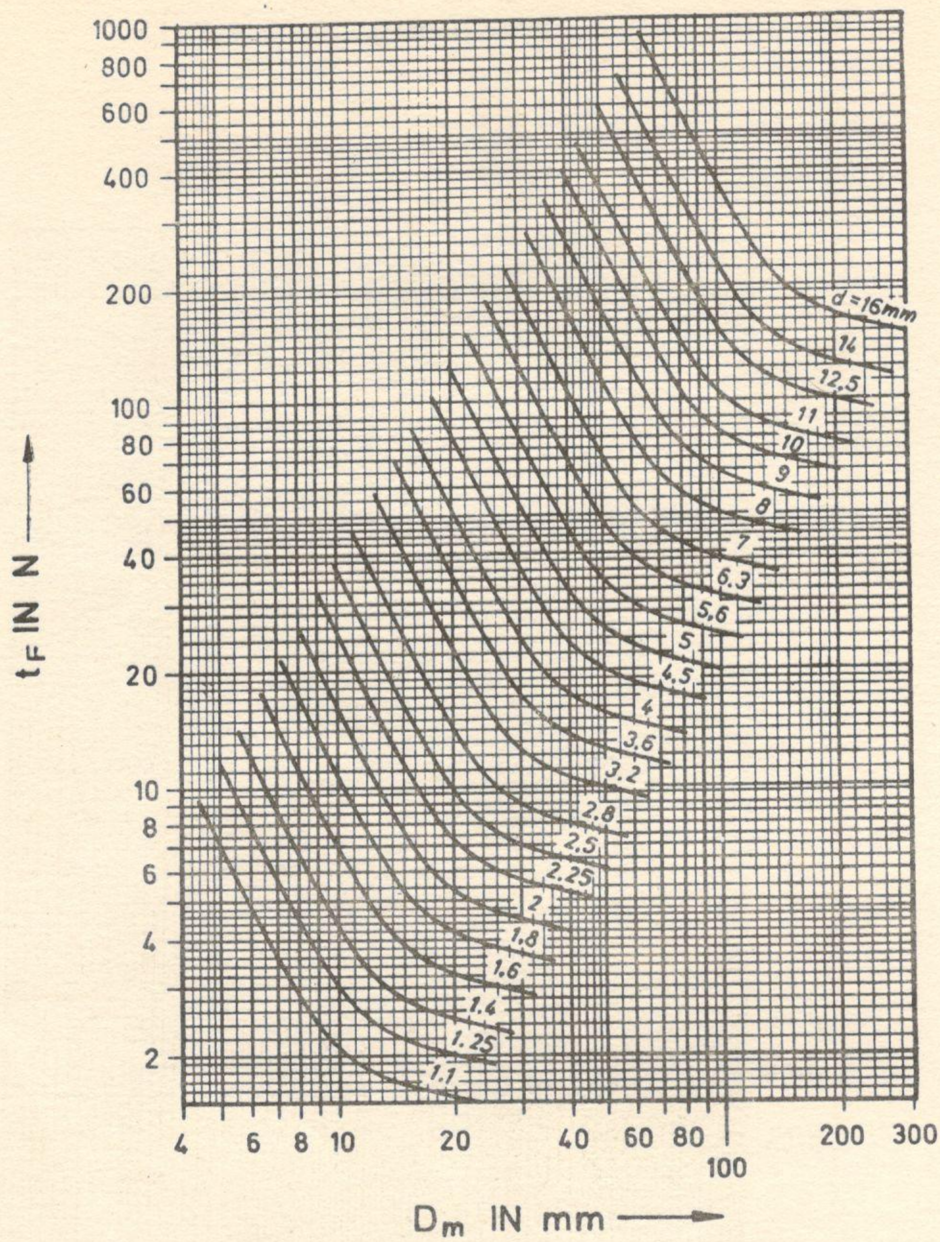


FIG. 18 INFLUENCE OF SHAPE AND SIZE OF SPRING ON TOLERANCE FOR LOAD AND LENGTH FOR WIRE DIAMETERS FROM 1·1 TO 16 mm

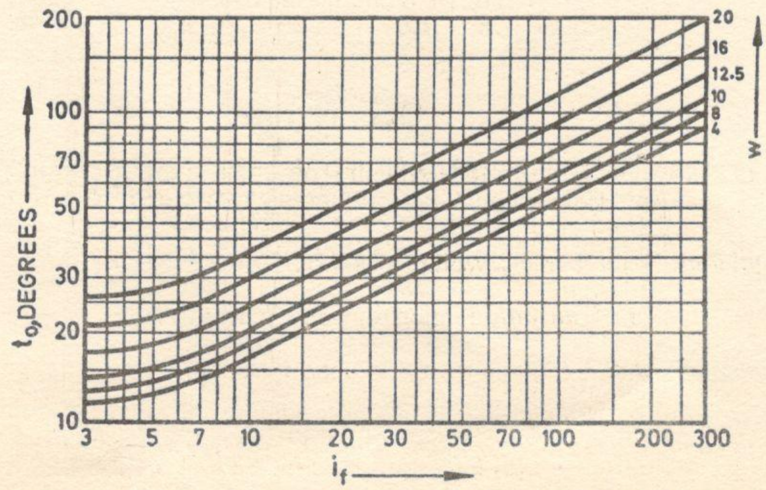


FIG. 19 INFLUENCE OF COIL RATIO *w* AND NUMBER OF COILS i_f ON HOOK OPENING POSITION DEVIATION

5.7 *Tolerance on Spring Rate* — Shall only be specified where essential to the functional requirement of the spring. If specified, it shall be half of the load tolerance with a minimum of ±3 percent.

6. Complimentary Adjustments for Manufacturing — Are required to maintain the prescribed axial loads. These shall be specified by the following method:

Complimentary Adjustments for Manufacturing	*Manufacturer's Discretion for*
If one axial load F and the corresponding loaded lengths L, and L_0 are specified	F_0, D_0 and D_1 (D_m)
If two axial loads and the corresponding loaded lengths are specified	L_0, i_f and d or F_0, D_0 and D_1 (D_m)

6.1 The numerical values of the quantities allowed according to manufacturer's discretion, as complimentary adjustments for manufacturing, shall be specified in the drawing and shall apply only as guide values.

6.2 While allowing the complimentary adjustments for manufacturing, care should be taken to see that the maximum stress of the springs does not exceed the maximum specified for the material and the relative angular hook opening positions are maintained.

7. Testing

7.1 All dimensions and loads shall be measured after the spring has been extended 3 times in quick succession by a load F_m.

7.2 *Testing of Load Lengths and Axial Loads* — The load lengths and axial loads shall be measured with the spring suspended vertically. An error of ±1 percent shall be allowed on load readings.

7.3 Characteristic curve of the extension spring shall be plotted according to calculations laid down in IS : 7907 (Part I)-1976. Theoretically, the curve is a straight line whose ordinate at origin represents the initial tension. In practice the curve is not a straight line from the Y-axis, so the spring shall be tested only between 0·3 and 0·7 f_m (*see* Fig. 20).

7.3.1 For determining the initial tension, the axial loads F_1 and F_2 corresponding to deflections f_1 and f_2 ($f_2 = 2 f_1$) between 0·3 and 0·7 f_m shall be measured. The initial tension is then given by:

$$F_0 = F_1 - (F_2 - F_1) = 2F_1 - F_2$$

and spring rate, $S_c = \dfrac{\triangle F}{\triangle f} = \dfrac{F_2 - F_1}{f_2 - f_1}$

where F is the increase in axial load for the increase in deflection $\triangle f$ (*see* Fig. 20).

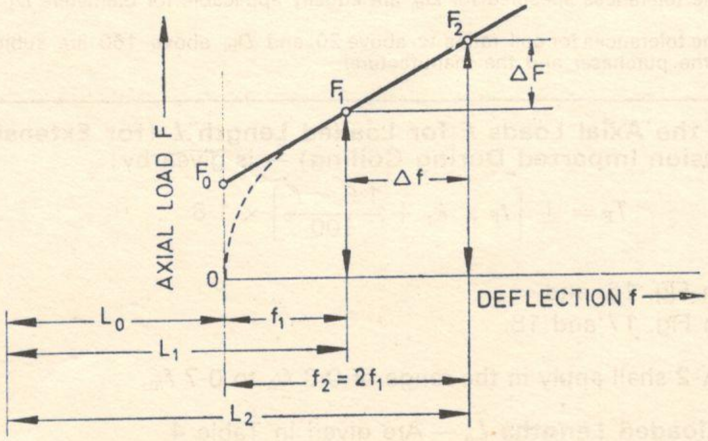


FIG. 20 TEST DIAGRAM

7.4 Special tests such as testing for endurance, cramp, 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_o; AXIAL LOADS F; AND UNLOADED LENGTHS L_0

A-0. Normal tolerances for D_m, L_0 and F are given in Tables 1 and 2 and **5.2**. 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 on Coil Diameters D_m for Unloaded Springs — Are given in Table 3.

TABLE 3 WIDER TOLERANCES T_D FOR COIL DIAMETERS FOR UNLOADED SPRINGS

(*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

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

Note 2 — The tolerances for coil ratios w above 20, and D_m above 160 are subject to agreement between the purchaser and the manufacturer.

A-2. Tolerances T_F for the Axial Loads F for Loaded Length L (for Extension Springs with and Without Initial Tension Imparted During Coiling) — Is given by:

$$T_F = \pm \left[t_F \times k_f + \frac{1{\cdot}5 \times F}{100} \right] \times 1{\cdot}6$$

where

k_f is taken from Fig. 16, and
t_F is taken from Fig. 17 and 18.

A-2.1 The tolerances in **A-2** shall apply in the range of 0·3 f_m to 0·7 f_m.

A-3. Tolerances for Unloaded Lengths L_0 — Are given in Table 4.

A-3.1 Tolerance T_{L0} or the unloaded length L_0 of the spring without initial tension is given by:

$$T_{L0} = \pm \left[\frac{t_F \times k_f \times 1{\cdot}6}{S_c} + 0{\cdot}4 \times (\text{tolerance from Table 4}) \right]$$

where

k_f is obtained from Fig. 16, and
t_F is obtained from Fig. 17 and 18.

TABLE 4 WIDER TOLERANCES T_{L_0} FOR THE UNLOADED LENGTH OF EXTENSION SPRINGS WITH INITIAL TENSION

(*Clauses* 5 *and* A-3)

All dimensions in millimetres.

L_0		Tolerance T_{L_0} for Coil Ratio w	
Above	Up to	Above 4 Up to 8	Above 8 Up to 20
	10	±0·6	±0·7
10	16	±0·8	±1·0
16	25	±1·0	±1·3
25	40	±1·3	±1·6
40	63	±1·8	±2·2
63	100	±2·4	±3·0
100	160	±3·0	±4·0
160	250	±4·0	±5·0
250	400	±5·0	±6·5
400		±2% of L_0	±2% of L_0

APPENDIX B

(*Clause* 5)

CLOSER TOLERANCES ON COIL DIAMETERS D_m, D_1 and D_0; AXIAL LOADS F; AND UNLOADED LENGTHS L_0

B-0. Normal tolerances for D_m, L_0 and F are given in Tables 1 and 2 and **5.2**. Tolerances given in this appendix are closer than those normally encountered. These tolerances should be specified only when functionally required.

B-1. Tolerances for Coil Diameter D_m for Unloaded Springs — Are given in Table 5.

TABLE 5 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

Note 1 — The tolerances specified for D_m are equally applicable for diameters D_1 and D_0.

Note 2 — The tolerances for coil ratio w above 20 and D_m above 100 are subject to agreement between the purchaser and the manufacturer.

B-2. Tolerances T_F for the Axial Loads F for Load Length L (for Extension Springs With and Without Initial Tension Imparted During Coiling) — Is given by:

$$T_F = \pm \left[t_F \times k_f + \frac{1.5\,F}{100} \right] \times 0.6$$

where

k_f is taken from Fig. 16, and

t_F is taken from Fig. 17 and 18.

B-2.1 The tolerances in **B-2** shall apply in the range of $0.3\,f_m$ to $0.7\,f_m$.

B-3. Tolerances for Unloaded Lengths L_0 for Springs With Initial Tension — Are given in Table 6.

TABLE 6 CLOSER TOLERANCES T_{L_0} FOR THE UNLOADED LENGTH OF SPRINGS

(*Clauses* 5 *and* B-3)

All dimensions in millimetres.

L_0		Tolerance T_{L_0} for Coil Ratio w	
Above	Up to	Above 4 Up to 8	Above 8 Up to 20
	10	±0·3	±0·4
10	16	±0·4	±0·5
16	25	±0·5	±0·6
25	40	±0·6	±0·8
40	63	±0·8	±1·1
63	100	±1·1	±1·5
100	160	±1·5	±2·0
160	250	±2·0	±2·5
250	400	±2·5	±3·0
400		±1% of L_0	±1% of L_0

B-3.1 Closer tolerance T_{L0} for extension springs without initial tension is given by:

$$T_{L0} = \pm \left[\frac{t_F \times k_f \times 0.63}{S_c} + \text{tolerance from Table 6} \right]$$

where

k_f is obtained from Fig. 16, and

t_F is obtained from Fig. 17 and 18.

EXPLANATORY NOTE

This standard is one of the series of Indian Standards on design, calculation and specification 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 II)-1975 Helical compression springs: Part II Specification for cold coiled 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 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*)

It has been found from studies carried out that the tolerance of the axial loads is a function of the spring dimensions D_m, d, i_t and axial load F and the relationship could be expressed as follows:

$$T_F = \pm \left[t_F \times k_t + \frac{1{\cdot}5\,F}{100} \right]$$

It has also been found that these tolerances agreed with the tolerances for the compression springs except for the influence of number of coils (Fig. 16).

In preparation of this standard considerable assistance has been derived from DIN 2097 'Helical springs made of round wire; specifications for cold coiled tension springs' issued by Deutsches Institut für Normung (DIN).

In this standard the unit of force used is newton (N) and that for 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) = 1 N/m²]

≃ 0·1 kgf/mm²

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