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**Coil springs—Part 1: Basic
calculation methods on helical
compression and extension springs**

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal for establishment of Japanese Industrial Standard submitted by Japan Spring Manufacturers Association (JSMA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law. Consequently **JIS B 2704**:2000 was withdrawn and partially replaced with this Standard.

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JIS B 2704 consists of the following 3 parts under the general title “*Coil springs*”:

Part 1: Basic calculation methods on helical compression and extension springs

Part 2: Expression of the specification on helical compression springs

Part 3: Expression of the specification on helical extension springs

Coil springs—Part 1: Basic calculation methods on helical compression and extension springs

1 Scope

This Japanese Industrial Standard specifies the requirements for basic calculation methods on helical compression and extension springs for general use, more specifically, cylindrical helical springs using materials with circular cross-section (hereafter referred to as “springs”).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 0103 *Glossary of terms used in springs*

JIS B 2711 *Shot peening*

JIS G 3521 *Hard drawn steel wires*

JIS G 3522 *Piano wires*

JIS G 3560 *Oil tempered wire for mechanical springs*

JIS G 3561 *Oil tempered wire for valve springs*

JIS G 4314 *Stainless steel wires for springs*

JIS G 4801 *Spring steels*

JIS H 3260 *Copper and copper alloy wires*

JIS H 3270 *Copper beryllium alloy, phosphor bronze and nickel silver rods, bars and wires*

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in **JIS B 0103** apply.

4 Materials

The materials used for the springs shall be as given in table 1. Materials other than those given in table 1 shall be subject to the agreement between the manufacturer and the purchaser.

Table 1 Materials for springs

Type	Standard number	Symbol	Application (informative)						NOTE
			General use	Electric conductivity	Non-magnetic	Heat resistance	Corrosion resistance	Fatigue resistance	
Spring steel	JIS G 4801	SUP 6 SUP 7 SUP 9 SUP 9A SUP 10 SUP 11A SUP 12 SUP 13	○					○	Used mainly for hot formed springs
Hard drawn steel wires	JIS G 3521	SW-B SW-C	○						Used mainly for cold formed springs
Piano wires	JIS G 3522	SWP	○					○	
Oil tempered wires for mechanical spring	JIS G 3560	SWO	○						
		SWOSC-B	○			○			
		SWOSM	○						
Oil tempered wires for valve springs	JIS G 3561	SWO-V						○	
		SWOCV-V				○		○	
		SWOSC-V				○		○	
Stainless steel wires for spring	JIS G 4314	SUS 302 SUS 304 SUS 304N1 SUS 316 SUS 631J1	○			○	○		
Brass wires	JIS H 3260	C 2600 W C 2700 W C 2800 W		○	○		○		
Nickel silver wires	JIS H 3270	C 7521 W C 7541 W C 7701 W		○	○		○		
Phosphor bronze wires		C 5102 W C 5191 W C 5212 W		○	○		○		
Copper beryllium alloy wires		C 1720 W		○	○		○		

5 Design calculation

5.1 General

In the spring design, generally, spring dimensions such as material diameter, coil inside and outside diameters, number of turns, free height and free length, and shape and material of spring and so on are decided so as to satisfy the spring characteristics requirements which are specified in the beginning in the form of a relationship between deflection or height and load (force). However, the spring dimensions such as the inside and outside diameters of coil, number of turns, free height and free length,

and the spring shape can be bound by spring installation space, the shape of counter parts, etc. Further, some applications of spring can demand special requirements such as fatigue resistance and corrosion resistance.

The appropriate steps in designing the springs, therefore, will be to set the rough values of material diameter, coil inside and outside diameters and number of turns corresponding to the spring characteristic requirement, calculate the spring characteristics, and review these by considering the mutual relationship of the rough values satisfying the restriction of dimensions and shape and other special requirement, and decide the final specifications such as dimensions, shape and material of spring.

5.2 Symbols

The symbols used in design calculation of spring shall be as given in table 2.

Table 2 Symbols

Symbol	Meaning of symbol	Unit
d	Diameter of material	mm
$d_{\max}$	Maximum permissible diameter of material	mm
D_i	Inside diameter of coil	mm
D_o	Outside diameter of coil	mm
D	Mean diameter of coil $D = (D_i + D_o)/2$	mm
N_t	Total coils (total number of turns)	—
N_a	Number of active coils (number of active turns)	—
H_f	Free height or length	mm
e	Inclination of outside face of coil	mm
H_s	Solid height	mm
p	Pitch	mm
P_i	Initial tension	N
c	Spring index $c = D/d$	—
G	G modulus	N/mm ²
P	Load (force) acting on spring	N
$P_{\max}$	Maximum load (force) acting on spring	N
δ	Deflection of spring	mm
k	Spring constant	N/mm
τ_0	Shear stress (torsional stress)	N/mm ²
τ	Corrected shear stress (corrected torsional stress)	N/mm ²
τ_i	Initial stress	N/mm ²
κ	Stress correction factor	—
f	Frequency	Hz
U	Energy stored in spring	J
m	Mass per unit volume of material	kg/mm ³
M	Mass of moving part of spring	kg
g	Acceleration of gravity ^{a)}	mm/s ²
NOTE : 1 N/mm ² = 1 MPa		
Note ^{a)} In Measurement Act, the standard acceleration of gravity is defined as 9 806.65 mm/s ² .		

5.3 Basic formulae used in the design of springs

5.3.1 In the case of compression springs and extension springs without initial tension

The basic formulae used for the design of compression springs and extension springs without initial tension shall be as follows:

- a) Deflection of spring δ shall be calculated by formula (1).

$$\delta = \frac{8N_a D^3 P}{Gd^4} \dots\dots\dots (1)$$

- b) Spring constant k shall be calculated by formula (2).

$$k = \frac{P}{\delta} = \frac{Gd^4}{8N_a D^3} \dots\dots\dots (2)$$

- c) Shear stress (torsional stress) τ_0 shall be calculated by formulae (3) or (4).

$$\tau_0 = \frac{8DP}{\pi d^3} \dots\dots\dots (3)$$

$$\tau_0 = \frac{Gd\delta}{\pi N_a D^2} \dots\dots\dots (4)$$

- d) Corrected shear stress (corrected torsional stress) τ shall be calculated by formula (5) with κ as stress correction factor.

$$\tau = \kappa \tau_0 \dots\dots\dots (5)$$

- e) Diameter of material d shall be calculated by formula (6).

$$d = \sqrt[3]{\frac{8DP}{\pi \tau_0}} = \sqrt[3]{\frac{8\kappa DP}{\pi \tau}} \dots\dots\dots (6)$$

- f) Number of active coils N_a shall be calculated by formula (7)

$$N_a = \frac{Gd^4 \delta}{8D^3 P} = \frac{Gd^4}{8D^3 k} \dots\dots\dots (7)$$

- g) Energy stored in spring U shall be calculated by formula (8).

$$U = \frac{P\delta}{2} = \frac{k\delta^2}{2} \dots\dots\dots (8)$$

5.3.2 In the case of extension springs with initial tension ($P > P_i$)

The basic formulae used for the design of extension springs with initial tension shall be as follows:

- a) Deflection of spring d shall be calculated by formula (1').

$$\delta = \frac{8N_a D^3 (P - P_i)}{Gd^4} \dots\dots\dots (1')$$