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**The design calculating formulas and
the procedures of decision of
specifications for flat springs**

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Contents

	Page
1 Scope.....	1
2 Normative references	1
3 Terms and definitions.....	1
4 Classification of flat springs	1
5 Materials	3
5.1 Main materials used for flat springs.....	3
5.2 Characteristics of materials.....	5
6 Feature of flat spring and selection of materials	9
6.1 Characteristics, type and feature of flat springs.....	9
6.2 Selection of material	10
7 Design calculation formula	11
7.1 Basic design calculation formula	11
7.2 Simple element breakdown type calculation formula (leaf-width-change type).....	14
7.3 Calculation formula of typically-shaped flat springs and examples.....	21
8 Determination of specification.....	25
8.1 Characteristics of flat springs	25
8.2 Design stress	26
8.3 Precautions on design and working.....	27

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 created from the association standard (SC005:2001) being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

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The design calculating formulas and the procedures of decision of specifications for flat springs

1 Scope

This Japanese Industrial Standard specifies the design calculating formulas and the procedures of decision of specifications for metallic flat springs (hereafter referred to as “flat spring”) except springs in the other product standards of Japanese Industrial Standards (coned disc springs, retaining rings, spring washers and spring pins).

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 2709 *Helical torsion springs—Requirements for design, performance test method*

JIS G 3311 *Cold rolled special steel strip*

JIS G 4313 *Cold rolled stainless steel strip for springs*

JIS G 4802 *Cold-rolled steel strips for springs*

JIS H 3130 *Copper beryllium alloy, copper titanium alloy, phosphor bronze, copper-nickel-tin alloy and nickel silver sheets, plates and strips for springs*

ISO 18265 *Metallic materials—Conversion of hardness values*

3 Terms and definitions

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

4 Classification of flat springs

Classification of flat springs is as shown in table 1.

Table 1 Classification of flat springs

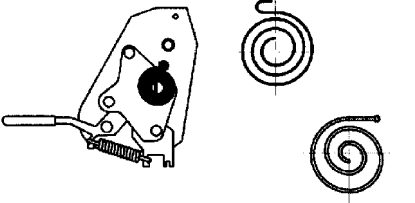
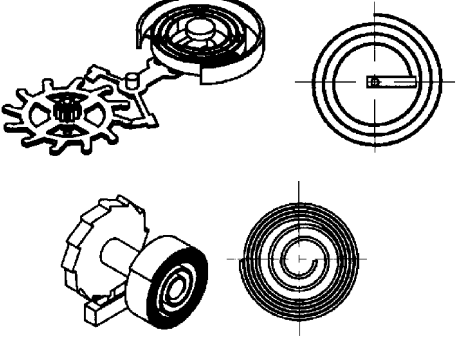
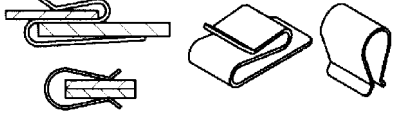
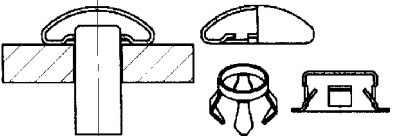
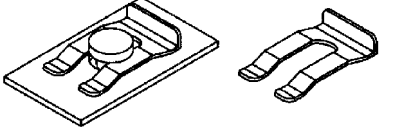
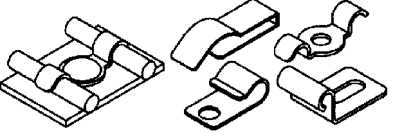
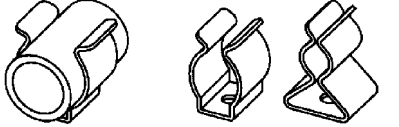
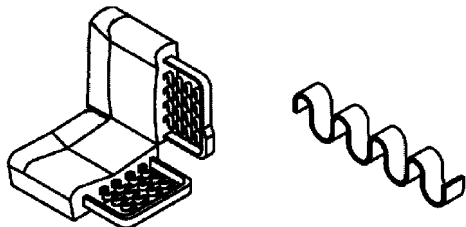
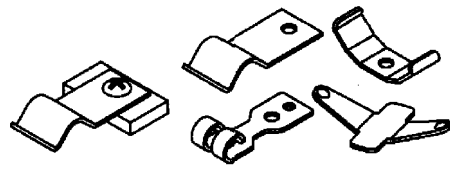
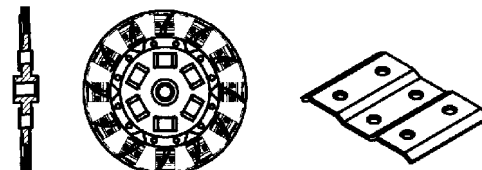
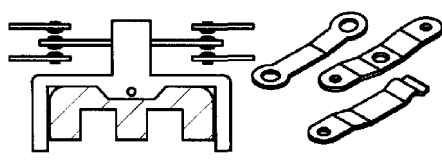
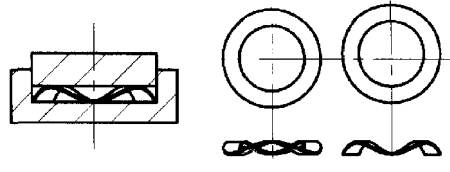
Large classification	Middle classification	Small classification	Example of use and typical shape
Spiral spring	Noncontact type	Noncontact type power spring	
		Hair spring	
	Contact type	Motor spring	
		Constant force spiral spring	
Clip		Binder clip	
		Cap spring	
		Cylinder lock spring	
		Wire harness spring	
		Rod lock clamp	

Table 1 (concluded)

Large classification	Middle classification	Small classification	Example of use and typical shape
Other various shaped springs		Zigzag spring	
		Hyperbolic spring	
		Even flat spring	
		Clutch fin spring	
		Spring for contact point	
		Waved spring (3 or more mountains)	

5 Materials

5.1 Main materials used for flat springs

Main materials used for flat springs can be classified roughly into ferrous metals and non-ferrous metals. These can be further classified into the following three materials according to the means to obtain the strength required as flat springs.

- a) Materials capable of obtaining strength by heat treatment such as quenching and tempering, or austempering
- b) Materials capable of obtaining strength by cold rolling
- c) Materials capable of obtaining strength by combination of cold rolling and heat treatment

For materials used for flat springs, there are standards of **JIS G 3311**, **JIS G 4313**, **JIS G 4802** and **JIS H 3130**. The main materials used for flat springs and their features shall be as given in table 2.

Table 2 Main materials used for flat springs

	With or without heat treatment	Material standards	Typical steel grade	Features
Ferrous metals	Materials capable of obtaining strength by heat treatment	JIS G 3311	S60CM, S70CM and SK85M	Strength is obtained by heat treatment (quenching and tempering, austempering, etc.) after spring working. Working into complex shapes is possible.
		Thermal refining symbols A and R in JIS G 4802	S60C-CSPA and S60C-CSPR	
		Thermal refining symbols H and B in JIS G 4802	S60C-CSPH and S60C-CSPB S70C-CSPH and S70C-CSPB SK85-CSPH and SK85-CSPB	Not suitable for working into complex shapes since heat treatment is performed according to the state of the material to obtain strength.
		JIS G 4313	SUS420J2-CSP (thermal refining symbol O)	Martensitic stainless steels: Strength is obtained by quenching and tempering after spring working. Magnetic in all states.
	Materials capable of obtaining strength by cold rolling		SUS301-CSP (thermal refining symbols 1/2H, 3/4H, H, EH and SEH) and SUS304-CSP (thermal refining symbols 1/2H, 3/4H and H)	Austenitic stainless steels: Hardness can be specified by thermal refining symbols. Corrosion resistance is good. Working into complex shapes is possible depending on hardness. Non-magnetic in the state of solution treatment, and weakly magnetic after strong working. The formability of SUS301 is better than that of SUS304 at the same hardness.
	Materials capable of obtaining strength by cold rolling and heat treatment		SUS631-CSP (thermal refining symbols O, 1/2H, 3/4H and H) and SUS632J1-CSP (thermal refining symbols 1/2H and 3/4H)	Precipitation hardening stainless steels: Strength is obtained by performing precipitation hardening treatment after spring working. Hardness can be specified by thermal refining symbols. More expensive than SUS301 and SUS304. Ferromagnetic after precipitation hardening.

Table 2 (concluded)

	With or without heat treatment	Material standards	Typical steel grade	Features
Non-ferrous metals	Materials capable of obtaining strength by cold rolling and heat treatment	JIS H 3130	Beryllium copper for spring and low beryllium copper for spring C1700P (sheet), C1700R (strip), C1720P (sheet), C1720R (strip), C1751P (sheet), C1751R (strip) (thermal refining symbols O, 1/2H and H)	Strength is obtained by performing aging hardening treatment after spring working. Hardness can be specified by thermal refining symbols. Maximum strength among non-ferrous metals. Corrosion resistance is good. Working into complex shapes is possible. Very expensive.
			Phosphor bronze for spring C5210P (sheet) and C5210R (strip) (thermal refining symbols 1/2H, H, EH, SH and ESH)	Most typical material among non-ferrous metals. Hardness can be specified by thermal refining symbols. Corrosion resistance is good. Working into complex shapes is possible depending on hardness.
			Nickel silver for spring C7701P (sheet) and C7701R (strip) (thermal refining symbols 1/2H, H, EH and SH)	Compared with phosphor bronze for spring, nickel silver for spring is inferior in conductivity, but good in corrosion resistance.

5.2 Characteristics of materials

The characteristic value of the main materials used for flat springs shall be as follows.

- a) **Modulus of longitudinal elasticity** For the modulus of longitudinal elasticity on bending, tension and compression, see table 3.

Table 3 Modulus of longitudinal elasticity

Unit: MPa

Material		Modulus of longitudinal elasticity E
Ferrous metals ^{a)}		2.06×10^5
Stainless steel for spring	SUS301-CSP SUS304-CSP	1.86×10^5
	SUS420J2-CSP SUS631-CSP SUS632J1-CSP	1.96×10^5
Beryllium copper for spring		1.27×10^5
Phosphor bronze for spring		0.98×10^5
Nickel silver for spring		1.08×10^5
Note ^{a)} Stainless steel is excluded.		

- b) **Density** The density of the main materials used for the mass calculation of flat springs, etc. shall be as given in table 4.

Table 4 Density of main materials

Unit: kg/mm³

Material	Density
Ferrous metals ^{a)}	7.85×10^{-6}
Stainless steel for spring	7.90×10^{-6}
Beryllium copper for spring	8.20×10^{-6}
Phosphor bronze for spring	8.80×10^{-6}
Nickel silver for spring	8.70×10^{-6}
Note ^{a)} Stainless steel is excluded.	

- c) **Hardness** For the design of flat springs, a life may be predicted by converting the hardness of the material to the tensile strength. The hardness of main materials shall be as given in table 5 to table 9.

Table 5 Range in which the hardness (central value) of thermal refining symbols H and B of cold rolled steel sheets and strips in coil for springs is allowed to be specified

Symbol of classification	H (Vickers hardness HV)	B (Vickers hardness HV)
S60C-CSP	350 to 500	360 to 440
S70C-CSP	350 to 550	—
SK85-CSP	350 to 600	—
The tolerance of hardness shall be ± 25 HV. However, variation in one steel strip in coil shall be within 30 HV.		

Table 6 Hardness of stainless steel strip in coil for springs

Symbol of classification	Symbol of thermal refining	In the state of cold rolling, or solution treatment or annealing	Precipitation hardening heat treatment condition	
		Vickers hardness HV	Symbol of heat treatment	Vickers hardness HV
SUS301-CSP	1/2H	310 min.	—	—
	3/4H	370 min.	—	—
	H	430 min.	—	—
	EH	490 min.	—	—
	SEH ^{a)}	530 min.	—	—
SUS304-CSP	1/2H	250 min.	—	—
	3/4H	310 min.	—	—
	H	370 min.	—	—
SUS420J2-CSP	O	247 max.	—	—
SUS631-CSP	O	200 max.	TH1050 RH950	345 min. 392 min.
	1/2H	350 min.	CH	380 min.
	3/4H	400 min.	CH	450 min.
	H	450 min.	CH	530 min.
SUS632J1-CSP	1/2H	350 max.	CH	400 min.
	3/4H	420 max.	CH	480 min.

Note ^{a)} The thermal refining symbol SEH is applied in the range of thermal refining symbol EH division when so specified by the purchaser.

Table 7 Hardness of sheets and strips of alloy numbers C1700, C1720, C5210 and C7701

Alloy number	Symbol of thermal refining	Symbol	Hardness	
			Thickness mm	Vickers hardness HV
C1700	O	C1700 P-O C1700 R-O	0.10 min. 1.6 max.	90 to 160
	1/4H	C1700 P-1/4H C1700 R-1/4H	0.10 min. 1.6 max.	145 to 220
	1/2H	C1700 P-1/2H C1700 R-1/2H	0.10 min. 1.6 max.	180 to 240
	H	C1700 P-H C1700 R-H	0.10 min. 1.6 max.	210 to 270
C1720	O	C1720 P-O C1720 R-O	0.10 min. 1.6 max.	90 to 160
	1/4H	C1720 P-1/4H C1720 R-1/4H	0.10 min. 1.6 max.	145 to 220
	1/2H	C1720 P-1/2H C1720 R-1/2H	0.10 min. 1.6 max.	180 to 240
	H	C1720 P-H C1720 R-H	0.10 min. 1.6 max.	210 to 270