SPRING CALCULATOR

INSTRUCTION MANUAL

PICKETT

THE PICKETT

MODEL N1090-ES SPRING CALCULATOR

This Spring Calculator has been developed to meet industry's need for solving most spring calculations simply and accurately.

In spring design the engineer must keep in mind the variables in material and manufacturing equipment. Even though calculations are theoretically correct, the actual tested rates and loads do not necessarily coincide; for this reason adjustable or reference dimensions should be given on specifications; preferably on number of coils, wire size and/or free length.

The engineer must remember that allowable safe working stress is a function of material type, size and application; also that tolerances and product cost are interdependent. A few of the most common contributors to high manufacturing costs are: test loads specified too close to solid height and excessive pitch angle (on compression springs), unusually large or small indexes and very high rates with tight load tolerances. Consulting with the spring manufacturer for information when needed will help to prevent costly designs and solve unusual problems.

FORMULAE FOR

COMPRESSION & EXT. SPRINGS:

$$R_f = \frac{Gd^4}{8\ D^3N}$$

$$S = \frac{2.55\ PD}{d^3} \text{ (Correct for } \frac{D}{d}\text{)}$$

TORSION SPRINGS:

$$R_t = \frac{Ed^4}{10.2\ DN}$$

$$S = \frac{10.2\ M}{d^3} \text{ (Correct for } \frac{D}{d}\text{)}$$

EXPLANATION OF FORMULAE OF SLIDE RULE SYMBOLS

d = Wire size (inches)

D = Mean diameter (inches) Comp. & Ext.

D_T = " " " Torsion Springs

N = Number of active coils (front side)

R_f = Rate in Comp. & Ext. (lbs. /inch)

R_t = " " Torsion (Inch-lbs. /Rev.)

S = Stress (lbs. /sq. inch) (back side)

P = Load (lbs.)

M = Moment (Inch-lbs.)

$\frac{D}{d}$ = Index correction (developed from Wahl factor)

CORRECTION FOR ROUND TO SQUARE WIRE:

⧫ ⧫ = Comp. & Ext. Springs (See Example I)

⧫ T ⧫ = Torsion Springs (See Example II)

PROPER USE OF SLIDE RULE

Example I

Problem: Design a compression spring using Music Wire to operate in a .350 hole and over a .200 rod with a 2-lb. load at .753 height and a 6-lb. load at .599 height.

Solution: Assume "D" = .275, and "d" - .041. To check for stress use the back side of the scale. Align .041 on the "d" scale with .275 on the "D" scale. Move the hairline to the arrow on the Index correction $(\frac{D}{d})$. Adjust the center slide to align index 6.7 with the hairline. This corrects the setting for coil curvature. Now move the hairline to 6 on the "P" scale and read stress on the "S" scale equal to 75,000 psi. For square wire proceed as above, but before reading "P" and "S" scales move the hairline to ϕ on right of center slide. Movecenter slide to the right to ϕ. Then read the "P" and "S" scale.

On the front side of the rule again line up .041 and .275 on the "d" and "D" scale respectively. The Rate "R_f" is calculated from the two loads and loaded heights above as 26 pounds per inch. Move the hairline to 26 on the "R_f" scale and read "N" equal to 7-1/2 just above. If the ends are to be closed the inactive coil at each end would give 9-1/2 total coils. From the above data the free length and solid height can be caluclated to complete the design. If square wire is used proceed as above, but before reading R_t and N scales move the hairline to ϕ at the right of the center slide. Move the center slide to the right to ϕ. Then read R_f and N scales. Note: There is no correction required for "G" for music wire or carbon steels, or where the modulus is 11.5×10^6.

Review:

d = .041 Music Wire
D = .275 (O.D. = .316 & I.D. = .234)
N = 7-1/2 (T.C. = 9-1/2)
S = 75,000 psi corrected, in torsional stress
F.L. = .830
S.H = .390 (9-1/2 x .041), if ends ground S.H. =
.430 (10-1/2 x .041), if ends not ground.
R_f = 26 pounds/inch
P_1 = 2 pounds @ .753
P_2 = 6 pounds @ .599 height

Example II

Problem: Design a helical torsion spring using type 302 stainless steel with 2.5 inch pounds torque at 30° deflection. Maximum O. D. to be .312".

Solution: Calculate the rate "R" = $\frac{2.5''\#}{30^\circ} \times \frac{360^\circ}{1 \text{ rev}} = \frac{30''\#}{1 \text{ rev}}$

Assume "D" = .240 and "d" = .062. On the back of the rule align .062 on the "d" scale with T ⏀ in the center of the slide. Move the hairline to the arrow on "$\frac{D}{d}$" correction. Align Index 3.9 on the center slide with the hairline to correct for curvature. Move the hairline to 2.5 on the "M" scale and read the stress on the "S" scale above as 152,000 psi. For square wire align the wire size on the "d" scale with the T ⏀ in the center of the slide and proceed as above. It should be noted that the correction factor $\frac{D}{d}$ for torsion springs is slightly less than shown on the scale (which is for Comp. Springs); however this provides a safety factor.

Turn the scale over to the front side and align the .062 on the "d" scale with .240 on the "D_T" in the middle of the slide. Move the hairline to the arrow on the "E" correction at the right end and adjust for E = 28.0×10^6 by moving the slide to the left. Now move the hairline to 30 on the "R_t" scale and read 5.6 just above on the "N" scale. If square wire is used proceed as above, but before reading R_t and N scales move the hairline to T ⏀ at the left of the slide. Adjust the slide to the right to T ⏀. Then read R_t and N scales.

Review:

d	=	.062 stainless steel type 302
D_T	=	.240 (O. D. = .302)
N	=	5.6 (Round wire) N = 9.6 (Square wire)
R_t	=	30 inch-pounds/rev. (M = $\frac{2.5''\#}{30^\circ \text{ deflection}}$)
S	=	152,000 psi (corrected Bending Stress) (for round wire)
S	=	90,000 psi (corrected Bending Stress) (for square wire)

Example III

Problem: Design an extension spring to work in a .675 hole with a load of 20 pounds at 5.36" length and 25 pounds at 5.91" length using Phosphor Bronze material.

Solution: Assume a safe design stress of 60,000 psi and an index of 5. On the back side of the rule align 25 pounds on the "P" scale with arrow on the "$\frac{D}{d}$" scale. Move the hairline to 5 on the "$\frac{D}{d}$" scale, and then align 60,000 on the "S" scale with the hairline. By comparing the relationship between "d" and "D" on their respective scales we can choose "d" = .090 and "D" = .540. Recheck stress using the above figures, but noting that the actual index is 6.

The rate "R_I" can be calculated between the two load points at 9.1 pounds/inch. Using the front side of the scale, set up this design in the same manner as described in Example I. Correct for "G" modulus move hairline to arrow on "G" correction scale, then move slide to left to 6 x 10^6.
If you have followed the correct procedure the number of active coils (N) will be 35.

When calculating the balance of the design, note that 35 coils of .090 wire gives a body coil length of 3.240 inches (35 + 1 wire dia. x .090). The hook length must be added to give a "Free Length Inside Hooks" of 3.92 inches. Further calculation reveals that this design requires 7 pounds of Initial Tension. The stress for 7 pounds initial tension can be determined by the same procedure described above as for checking load vs. stress. Be referring to Fig. 1 note that 7 pounds Initial Tension is readily obtainable. For square wire see Example I and proceed in same manner.

Review:

d	=	.090 inches
D	=	.540 inches
N	=	35
S	=	58,000 psi (corrected torsional stress)
Rate	=	9.1 pounds/inch
Free Length	=	3.92 inside hooks
Initial Tension	=	7 pounds (17,000 lbs./sq. in.)

TORSIONAL INDEX RESULTING FROM INITIAL TENSION IN CLOSE WOUND EXTENSION SPRINGS

Spring Index = $\frac{D}{d}$	Suggested Initial Tension Torsional Stress Min.		Max.	
3	20	to	30,000	lb/in^2
4	18	-	27,000	"
5	16	-	24,000	"
6	14	-	22,000	"
7	13	-	19,000	"
8	11	-	18,000	"
9	10	-	16,000	"
10	9	-	15,000	"
11	8	-	13,000	"
12	7	-	12,000	"
13	6.5	-	11,000	"
14	6	-	10,000	"
15	5	-	9,000	"

Figure 1

Initial tension can be calculated from basic formulae as follows:

$$P = \frac{Sd^3}{2.55\,D} = \text{Load in Pounds}$$

ALL-METAL SLIDE RULES

PICKETT

Manufactured by Pickett & Eckel, Inc.
Alhambra, Calif.