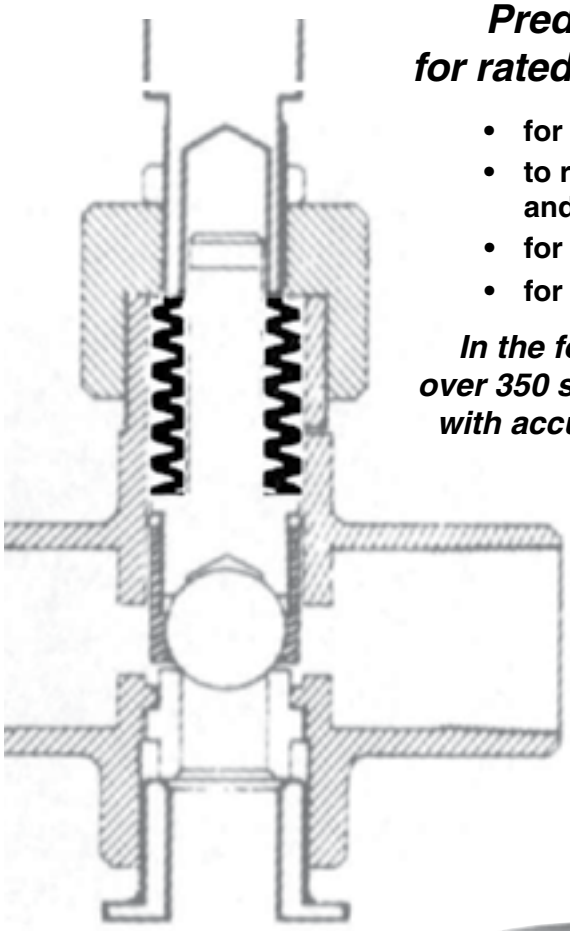
Disc Springs (Washers) - Introduction

Rondelles à ressort (Belleville) – introduction

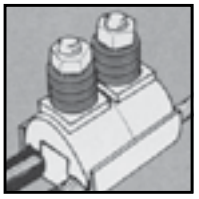


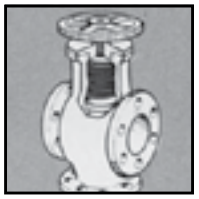
Predictable performance for rated load at given deflection

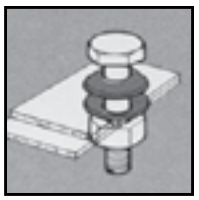
- for high loads in limited space
- to replace coil springs for economy and improved design
- for use with bolted sections
- for use with ball bearings

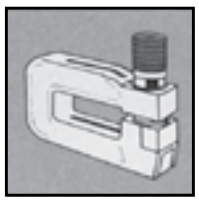
In the following pages, we have listed over 350 sizes of DISC SPRINGS, complete with accurate dimensional and technical data.

FINISH: All sizes are normally stocked in 'self-colour' (unplated). Plating and/or special finishes are NOT recommended due to risk of mechanical impairment.









D

CATALOG 14 SPAENAUR

Disc Springs (Washers) - Introduction (Continued)

Rondelles à ressort (Belleville) – introduction (suite)

Disc springs are precision springs made of high carbon spring steel, alloy steel, stainless, and heat resisting steels and non-ferrous materials. Conical in shape and made to special geometrical relationships of OD, ID, thickness, and height, they are subject to exacting manufacturing and quality control standards. Materials used are generally in annealed condition & hardened to range of RC 42-51 depending on material thickness used. Load/deflection relationships are closely controlled. Disc springs are made of cold rolled strip, hot rolled sheet, or forgings of flat or conical shape. After the spring is formed by stamping, it may be machined at the inner and outer diameters or on all surfaces. Machining operations eliminate surface defects obtained in the blanking operation and increase spring life, particularly under dynamic or fatigue loading conditions. All disc springs are “preset”. This is a controlled overstress of the spring so that it will not significantly relax under load when applied. Additionally, shot peening for surface consolidation may be employed. Accurate control of spring height and thickness is critical to predictable performance within close tolerances.

Disc springs are used singly or in stacks to achieve desired load and travel. In general, they function best under conditions requiring very high load in confined space or short travel. Under these design constraints it is often not practical or even possible to use a coil spring.

A further advantage of disc springs results from the various characteristic performance due to height/thickness ratio employed. The curve of the spring is non-linear (as distinguished from normal coil springs, which are linear) and may be progressive, regressive, or even exhibit a constant load over a significant portion of its useful deflection.

Disc springs used in parallel stack arrangements may be useful as load damping devices.The friction of the surface generates heat and dissipates energy under load release - a useful hysteresis effect under certain conditions.

When properly designed and used, disc springs have a long life, superior performance, and may result in significant cost reduction.

Typical disc spring applications are as follows:

1. Power transmission components such as clutches, brakes, transmissions, etc.
2. Valves, piping and drilling tools.
3. Screwed or bolted sections.
4. Bearing preload.
5. Hoists, cranes, and heavy engineering applications.
6. Electrical switchgear and buss bars.

The unique engineering value aspect of disc springs is that of the most efficient space utilization with energy employed. As machines and vehicles get smaller due to energy cost reduction needs, the designer is obliged to consider the disc spring element as the only practical solution to his problem in many cases.

While disc springs may not always be used interchangeably with coil springs because of their relatively long travel aspect when they are considered at the initial stages of design, they may be employed to great economic advantage. Disc springs and coil springs are complimentary.

Materials generally employed are C1075, SAE6150, Stainless 17/7 PH (ARMCO), Inconel X-750, Inconel 718, and Monels.

The company uses sophisticated computer programs for load and stress evaluation and performance prediction.

The manufacture and application of disc springs is widely known and understood in Europe. Their use in North American engineering and manufacturing industry is increasing in popularity and acceptance. Originally, the disc spring was first patented by J. Belleville (France) over 100 years ago. In early 1930’s the engineers (G.M.) Almen and Laszlo developed the theoretical foundation for disc springs calculation and use. This theory was formalized for general industrial use in West Germany at the end of World War II. The Germans standardized the theory, manufacture and quality requirements in DIN 2093 and DIN 2092. These specs became accepted world wide as the first industrial standardization of disc springs. The standard has spred throughout Europe and is now widely employed by multi-national engineering companies. The Japanese developed their own version of this standard.

No U.S.A. industry standard has yet been written on disc springs. Many U.S. manufacturers accept the DIN as a guide to performance and quality standards.

INTRODUCTION

TO COST-SAVING, SPACE-SAVING DISC SPRINGS

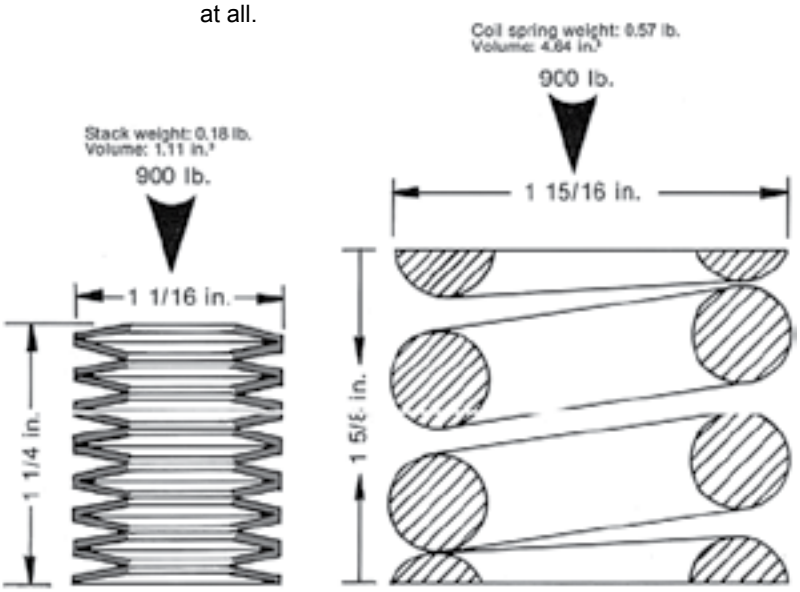
Compared to a coil spring, a disc spring achieves economy in design, and reduces the cost of the overall assembly by the maximum utilization of space.

The disc spring is unique among the various types of springs because it offers several distinct advantages over its counterparts. Among them are the following:

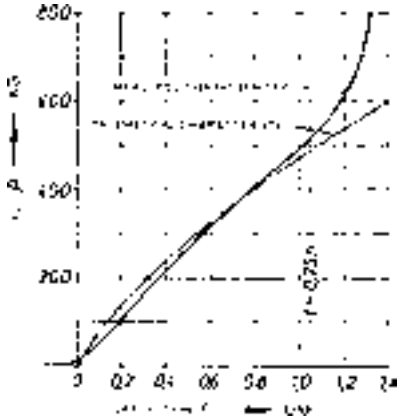
1. A choice of a wide range of load deflection characteristics, such as a straight line, progressive and regressive.
2. Flexibility in stack arrangement in order to achieve a desired performance.
3. Space saving.
4. Self-damping (especially when stacked in parallel).
5. Longer fatigue life.
6. Simplified inventory because an individual spring size can be used for a wide range of applications.

DISC SPRING STACK COMPARED TO HELICAL SPRING

Note that the same load is achieved at substantial reduction in space. Disc stacks may be designed for extremely high loads where coil springs are not feasible at all.



THEORETICAL VS. MEASURED CHARACTERISTIC OF A DISC SPRING



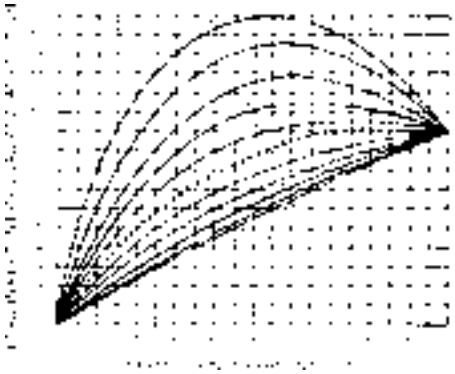
The characteristic of the individual disc spring is non-linear. Its shape depends on the ratio h/t. At the lower portion of the deflection range, the characteristic in practice departs slightly from the theoretical.

When f/h >0.75, the characteristic in practice again departs increasingly from the theoretical because the disc springs roll upon one another or upon the supporting surface, and this leads to a continuous shortening of the lever arm.

Disc springs of differing thickness can be stacked in series to obtain a progressively rising load. This effect is also obtained using same thickness springs but incrementally increasing the units in the stack. Care must be taken not to over-stress the spring in the stack.

(Note: Friction forces between springs must be considered.)

DISC SPRING CHARACTERISTICS

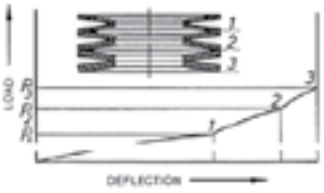


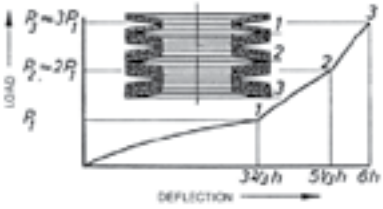
This is a graphic illustration of the values contained in Table 1, page D42

The characteristic or load-deflection relationship depends on the ratio of cone height h to the thickness t (h/t).

C = (characteristic) = h/t

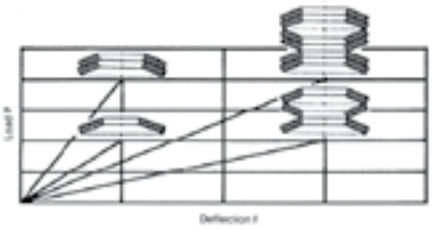
If C is small (up to 0.6), the graph is almost a straight line. If C is 1.4, the graph is nearly straight over a considerable range of deflection, and this is called a constant-load disc spring, and is shown above as a dotted line.





DISC SPRINGS MAY BE USED SINGLY OR IN COMBINATIONS

Stacked in Parallel	Series	Parallel-Series
TOTAL DEFLECTION= deflection of 1 disc TOTAL LOAD= load on 1 disc x no. of discs	TOTAL DEFLECTION= deflection of 1 disc x no. discs in stack TOTAL LOAD= load on 1 disc	COMBINATIONS can be designed to accommodate virtually any load or deflection, and to obtain progressive or regressive characteristics.



DISC SPRINGS

6 Styles

Disc Springs (Washers) - Load & Stress Calculations

Rondelles à ressort (Belleville) – calcul des charges et des contraintes

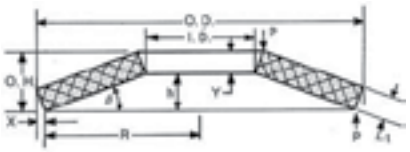


Fig. 1

Nomenclature

O.D. = Maximum outside dia. (upper surface)
I.D. = Minimum inside dia. (bottom surface)
h = Conical disc height (cone height)
O.H. = Overall height = Y + h
t = Actual thickness of disc
ß = Cone angle of disc
R = Radius from centreline to load bearing circle (bottom surface)
M = Ratio factor
μ = Poisson's ratio (.3 for steel)
E = Young's modulus (30,000,000 for steel)
f = Deflection of disc
∂ = Ratio of diameters (O.D./I.D.)
P = Load in lbs. at a given deflection
P_f = Load in lbs. at flat
X = Sinß • t
Y = Cosß • t

The load-deflection formula was developed by J. Almen and A. Laszlo, and published in the Transactions of Amer. Soc. of Mech. Engineers, May 1936, and is rendered as follows:

LOAD IN LBS. AT A GIVEN DEFLECTION

$$P = \frac{E \bullet f}{(1-\mu^2) \bullet M \bullet R^2} \bullet [(h-f/2) \bullet (h-f) \bullet t + t^3]$$

$$\text{WHERE } M = \frac{6}{\pi \bullet L_n \partial} \bullet \frac{(\partial-1)^2}{\partial^2}$$

DISC SPRING AT FLAT:

In the flattened condition, the deflection f is equal to the conical height h and the equation becomes:

$$P_f = \frac{E \bullet h \bullet t^3}{(1-\mu^2) \bullet M \bullet R^2}$$

SIMPLIFIED PROCEDURE FOR APPROXIMATE LOAD CALCULATIONS

In the flattened condition the load formula is as follows:

$$P_f = \frac{E \bullet h \bullet t^3}{(1-\mu^2) \bullet M \bullet R^2} \quad (1)$$

By simplification:

$$K = \frac{E}{(1-\mu^2) \bullet M \bullet R^2} \quad (2)$$

Where the K factor is dependent only on the diameters and the material.

Hence:

$$P_f = K \bullet h \bullet t^3 \quad (3)$$

For a specific disc spring curvature c = h/t and h = c • t.

The formula becomes by simplification:

$$P_f = K \bullet C \bullet t^4 \quad (4)$$

By solving this equation for t (thickness), we obtain:

$$t = \sqrt[4]{\frac{P_f}{K \bullet C}} \quad (5)$$

To find the load for any deflection, multiply the load at flat by a factor I, found in Table 1.

$$P = P_f \bullet I \quad (6)$$

With the above formulas we have a simple procedure for determining the load at different deflections or calculating the thickness for a given load:

1. Find value of constant M in Table 2
2. Solve for constant K
3. Choose C from Table 1
4. If load is given, solve for t (equation 5)
5. If thickness is given, solve for load (equation 4)
6. To find the load for different deflections (equation 6)

Also available Series AK Disc Springs for use with BALL BEARINGS, page D51.

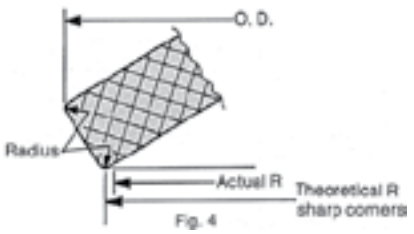


Fig. 4

A well designed disc spring has radii at all corners to reduce stress concentrations at the edges. A suitable radius is approx. = t/6. This radius further reduces dimension R (see Fig. 4).

Usually the overall height of the disc spring is specified because it is easy to measure and control. The cone height h, on the other hand, is difficult to measure (see Fig. 5).

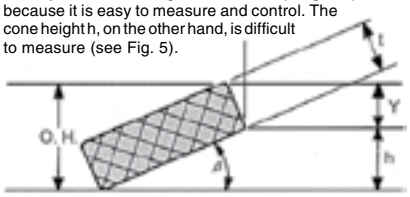


Fig. 5

For an approximate calculation, h= (overall height - t) is acceptable. However, this is not accurate. In fact, h = (overall height - Y), where Y = Cosß • t. For small thicknesses (under **2 mm**), this is not significant. With thicker disc springs, this becomes a major factor for accurate load and stress calculations. This has not been adequately considered in previous technical literature.

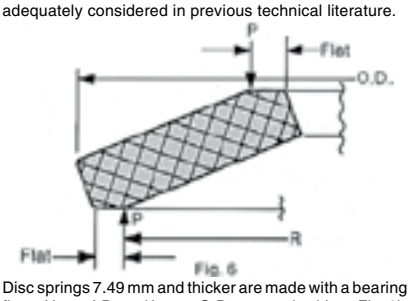


Fig. 6

Disc springs 7.49 mm and thicker are made with a bearing flat at Upper I.D. and Lower O.D. as standard (see Fig. 6). This bearing flat assures more uniform loading and better alignment of the disc stack.

The flat is equal approx. to O.D./150. For load calculations, R must be calculated to the inner edge of the flat.

DISC SPRING STRESS CALCULATIONS

$$S1 = \frac{E \bullet f}{(1-\mu 2) \bullet M \bullet R^2} \bullet [C_1 \bullet (h - f/2) + C_2 \bullet t]$$

$$S2 = \frac{E \bullet f}{(1-\mu^2) \bullet M \bullet R^2} \bullet [C_1 \bullet (h-f/2) - C_2 \bullet t]$$

$$S3 = \frac{E \bullet f}{(1-\mu^2) \bullet R^2} \bullet [T_1 \bullet (h-f/2) + T_2 \bullet t]$$

Where M, C_1 and C_2 are from Table 2, E and μ from Table 3, and

$$T1 = \frac{(\partial \bullet L_n \partial) - (\partial-1)}{L_n \partial} \bullet \frac{\partial}{(\partial-1)^2}$$

$$T2 = \frac{(.5) \bullet \partial}{\partial-1}$$

∂ = D/d and L_n = natural logarithm. Stress as given is psi

To calculate the load accurately, the following important factors must be considered:

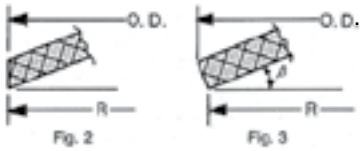
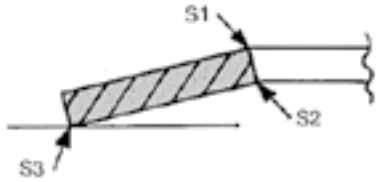


Fig. 2

Fig. 3

Disc with theoretical sharp corners. If the disc spring is made as in Fig. 2, which is unusual, then R = O.D./2. Most disc springs are made as in Fig. 3.

Therefore, the load bearing radius is not equal to half of the maximum outside diameter. To calculate R, the angle B first has to be determined.



For evaluation of compressive stress, use formula S1. It computes the compressive stress at the upper inner diameter. This compressive stress may be as high as 400,000 psi for certain bolted applications.

For dynamic applications, it is necessary to consider the tensile stresses at the points marked S2 and S3. The stresses at these points depend on the ratio of diameters (∂) and the spring characteristic (C) as well as on the deflection (f). This stress should not exceed 200,000 psi at .75h deflection.

SUMMARY

Precise load and stress calculations require the determination of the disc spring angle ß. Since this is not easily determined by physical measurement, we have developed a computer program that calculates the precise angle and arrives at the exact dimension for conical height h. This then determines accurate load and stress calculation. When designing special disc springs and wishing to evaluate the resultant load and stress with accuracy, please consult our Engineering Department.

The load and stress formulas are correct only with the assumption that the spring will be worked within the elastic limit of the material.

Table 1

To find the load at any intermediate point (between 10% h and flat), multiply the load at flat by the constant I found in Table 1 below.

C	Deflection in Percent of h									
h/t	10	20	30	40	50	60	70	75	80	90
0.30	0.11	0.21	0.32	0.42	0.52	0.62	0.71	0.76	0.81	0.91
0.40	0.11	0.22	0.33	0.43	0.53	0.63	0.72	0.77	0.82	0.91
0.50	0.12	0.24	0.35	0.45	0.55	0.64	0.73	0.78	0.82	0.91
0.60	0.13	0.25	0.36	0.47	0.57	0.66	0.75	0.79	0.84	0.92
0.70	0.14	0.27	0.39	0.49	0.59	0.68	0.77	0.81	0.85	0.92
0.80	0.16	0.29	0.41	0.52	0.62	0.71	0.79	0.83	0.86	0.93
0.90	0.17	0.32	0.45	0.56	0.65	0.74	0.81	0.85	0.88	0.94
1.00	0.19	0.34	0.48	0.59	0.69	0.77	0.84	0.87	0.90	0.95
1.05	0.19	0.36	0.50	0.61	0.71	0.79	0.85	0.88	0.91	0.96
1.10	0.20	0.37	0.52	0.63	0.73	0.80	0.87	0.89	0.92	0.96
1.15	0.21	0.39	0.54	0.65	0.75	0.82	0.88	0.91	0.93	0.97
1.20	0.22	0.41	0.56	0.68	0.77	0.84	0.90	0.92	0.94	0.97
1.25	0.23	0.43	0.58	0.70	0.79	0.86	0.91	0.93	0.95	0.98
1.30	0.25	0.44	0.60	0.73	0.82	0.88	0.93	0.95	0.96	0.98
1.35	0.26	0.46	0.63	0.75	0.84	0.91	0.95	0.96	0.98	0.99
1.40	0.27	0.48	0.65	0.78	0.87	0.93	0.97	0.98	0.99	1.00
1.50	0.29	0.52	0.70	0.83	0.92	0.98	1.01	1.01	1.02	1.01
1.60	0.32	0.57	0.76	0.89	0.98	1.03	1.05	1.05	1.05	1.03
1.80	0.38	0.67	0.88	1.02	1.12	1.14	1.14	1.13	1.11	1.06
2.00	0.44	0.78	1.01	1.17	1.25	1.27	1.25	1.22	1.18	1.10
2.50	0.63	1.10	1.40	1.60	1.67	1.65	1.55	1.48	1.40	1.21
3.00	0.87	1.48	1.91	2.13	2.19	2.11	1.93	1.81	1.66	1.35
3.50	1.15	1.96	2.49	2.75	2.80	2.66	2.37	2.19	1.98	1.51
4.00	1.47	2.50	3.16	3.50	3.50	3.29	2.88	2.63	2.34	1.69

Table 2
Constant M, C_1 and C_2

∂ OD/ID	M	C_1	C_2	∂ OD/ID	M	C_1	C_2
1.10	.166	.986	1.002	2.10	.706	1.242	1.416
1.15	.232	1.001	1.025	2.20	.721	1.264	1.453
1.20	.291	1.016	1.048	2.30	.733	1.286	1.490
1.25	.342	1.030	1.070	2.40	.742	1.307	1.527
1.30	.388	1.044	1.092	2.50	.750	1.328	1.563
1.35	.428	1.058	1.114	2.60	.757	1.348	1.599
1.40	.463	1.072	1.135	2.80	.767	1.388	1.669
1.45	.495	1.085	1.157	3.00	.773	1.426	1.738
1.50	.523	1.098	1.178	3.20	.776	1.464	1.806
1.60	.571	1.124	1.219	3.40	.778	1.500	1.873
1.70	.610	1.149	1.260	3.60	.778	1.535	1.938
1.80	.642	1.173	1.300	3.80	.777	1.570	2.003
1.90	.668	1.197	1.339	4.00	.775	1.604	2.067
2.00	.689	1.220	1.378				

Table 3
Modulus of elasticity and Poisson's ratio for different materials

Material	E Modulus Vs. Temperature in F° 68F°	250F°	400F°	600F°	Poisson's Ratio μ
Steel - 1075	30 x 10^6	29.5 x 10^6	—	—	0.30
Steel - 6150	30 x 10^6	29.8 x 10^6	28.5 x 10^6	—	0.30
Stainless 17/7 PH	29 x 10^6	N/A	N/A	26.5 x 10^6	0.34
Stainless 302	28 x 10^6	N/A	26.5 x 10^6	—	0.30
Inconel x -750	31 x 10^6	30.8 x 10^6	29.5 x 10^6	28.3 x 10^6	0.29

Disc Springs (Washers) - Dynamic Loading & Fatigue Life

Rondelles à ressort (Belleville) – charge dynamique et résistance à la fatigue

Dynamic Loading & Fatigue Life

Dynamic loading of disc springs occurs when the load continuously changes from preload to final load.

The "stress-time" curve of such disc springs which pulsate uniformly is sinusoidal. This is not true in cases of impact loading, and therefore it is difficult to predict their life and behaviour.

Disc spring "life" may be differentiated into 2 categories:

1) Limited life: where cycles vary without failure between 40,000 and 2,000,000 cycles.
2) Unlimited life: cycles in excess of 2.10^6 without failure. For virtually indefinite life, the table below indicates the appropriate values required, given in percent of travel, relating preload to final load AND considering the disc spring thickness:

Preload in % of h	Max. Deflection in % of h	
	Disc Thickness ≤.039"	Disc Thickness ≥.157"
15	50	44
25	56	49
50	67	64

Fatigue Life

Fatigue life for disc springs is defined by the effective number of stress cycles that can be sustained prior to failure under certain conditions. This depends on the minimum stress, maximum stress, and stress range.

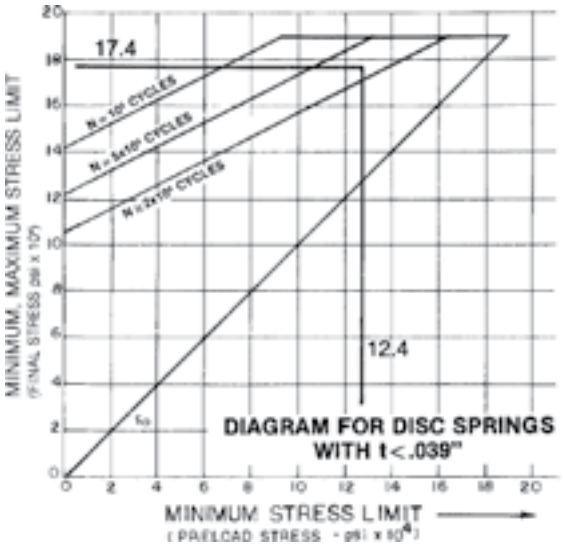
The diagrams presented here are for evaluating fatigue life of single disc springs or series stacks not more than 6 springs. There are three basic groups, depending on thickness (see legend under each diagram).

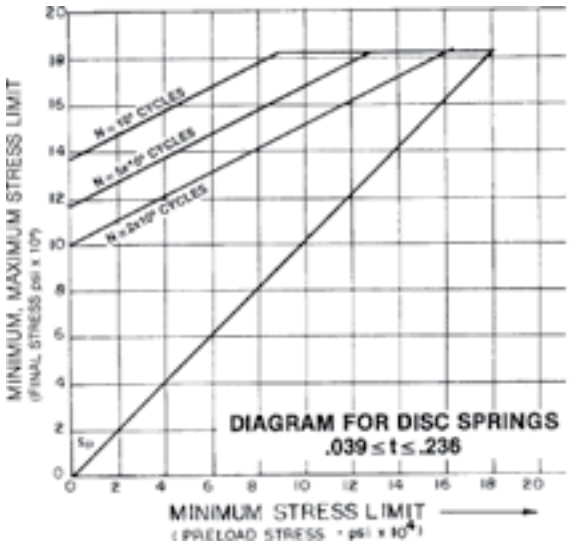
The horizontal axis represents PRELOAD STRESS.
The vertical axis represents FINAL STRESS.
The fatigue life is found at the intersection of these points on the graph. The ZONE in which they fall tells the predicted life. If they fall outside the zones, their life is not generally predictable.

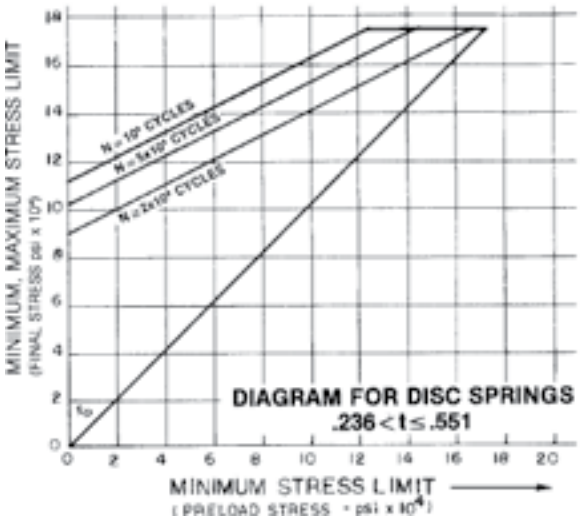
The horizontal border line enclosing the top portion of the graph (zone) represents the yield strength of the spring steel material.

Intersection points of min/max stress limits which fall outside the graph/zone boundaries are to be avoided as they indicate spring failure is likely at an early stage.

The graphs were developed based on empirical test data. The test loads were sinusoidally executed.







How to Use the Graphs

1. For standard catalog disc springs:
   a) Determine preload stress.
   b) Determine final load stress.

The intersection of the stress coordinates will indicate the range of fatigue life that may be expected.

2. For non-standard or special disc springs:
   a) Determine the preload stress for points S_2 and S_3. Use the HIGHER of the two values for preload and final load.
   b) Repeat above procedure for FINAL STRESS, using again the higher value found.

EXAMPLE (Dotted Line)

AM188207: .709 x .323 x .0276 (See catalog page D46)
Preload stress at deflection f = .5h: 124000 psi
Final load stress at deflection f = .75h: 174000psi
Intersection point between nearby 2MIO-cycles-line:
Predicted cycles: 1.5 MIO

Disc Springs (Washers) - Typical Characteristics

Rondelles à ressort (Belleville) – caractéristiques typiques

DISC SPRING Damping (Hysteresis)

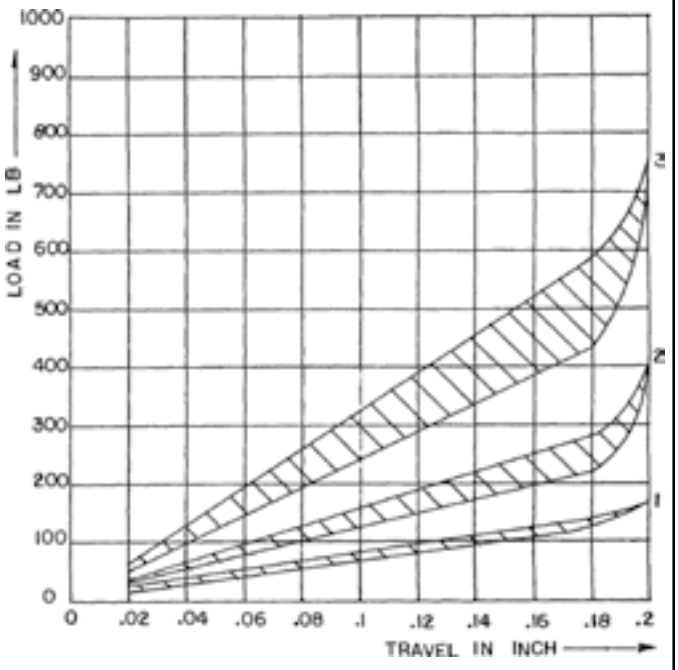
In disc spring stacks, particularly those with parallel units, friction must be considered. Friction occurs due to contact of the spring face (radial wall). As a result, the spring force increases on loading, and decreases on unloading....giving the damping effect. The load value is a function of the number of disc springs in parallel, as shown on the graph. An approximation of load increase or decrease is on the order of 2-3 per cent per each set of 2.

18 x 8.2 x 0.7 x 1.25 OA
(.709 x .323 x .0276 x .0492 OA)

Measured characteristic of various disc spring stacks:

Stacks consisting of 10 single disc springs or 10 multi spring components were tested.

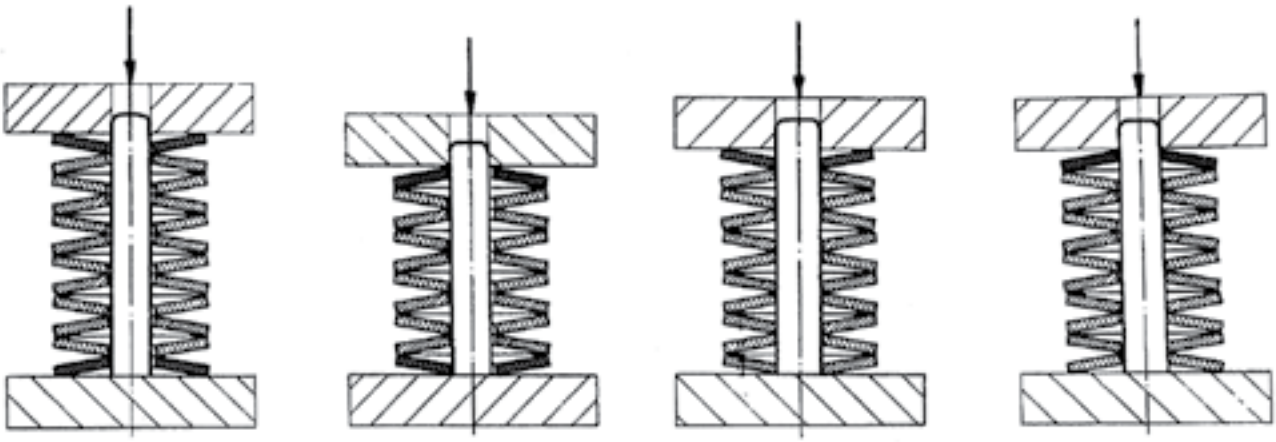
Curve 1: Single discs of 10 in series
Curve 2: 10 sets of 2 parallel
Curve 3: 10 sets of 3 parallel



GUIDING THE DISC SPRING

It is preferable to guide disc springs by means of a rod through the I.D. rather than in a sleeve over the O.D. The springs at either end of the stack should contact hardened thrust washers with their outer diameter. The surface finish of the thrust washer should match that of the guide rods.

Springs at the moving end of a stack are more or less over deflected by comparison to the calculated value. Springs at the opposite ends are under deflected. The greatest relative movement occurs between the last spring in a stack and the guide rod. Friction between the disc springs, as well as between the springs and the guide rod, are greatest at the moving end.



CORRECT **WRONG** **CORRECT** **WRONG**

Disc Springs (Washers) - Tolerances

Rondelles à ressort (Belleville) – tolérances

The tolerances shown on this page are for unplated AM series only. For tolerances on other series, consult *SPAENAUR*.

TOLERANCE AND THICKNESS

THICKNESS t		TOLERANCE	
mm	Inch	mm	Inch
0.3 0.4	.0118 .0157	+.02 -.06	+.0008 -.0024
0.5 0.6	.0197 .0236		
0.7 0.8	.0276 .0315	+.03 -.09	+.0012 -.0035
0.9 1.0	.035 .039		
1.1 1.25	.043 .049		
1.5 1.75	.059 .069	+.04 -.12	+.0016 -.0047
2.0	.078		
2.25 2.5	.088 .098		
3.0 3.5	.118 .138		
4.0 to 16.0	.157 to .630	±.127	±.005

OVERALL HEIGHT TOLERANCE

GROUP	SPRING THICKNESS Range		OVERALL HEIGHT TOLERANCE	
	mm	Inch	mm	Inch
1	less than 1.25	less than 0.049	+0.010 -0.05	+0.0004 -0.002
2	1.25 to 2.00	0.049 to 0.078	+0.15 -0.08	+0.006 -0.003
	over 2.00 to 3.00	over 0.078 to 0.118	+0.30 -0.10	+0.012 -0.004
	over 3.00 to 6.00	over 0.118 to 0.236	+0.30 -0.15	+0.012 -0.006
3	over 6.00 to 14.00	over 0.236 to 0.551	±0.30	±0.012

DISC SPRING HARDNESS RANGE

THICKNESS OF DISC		
mm	Inch	ROCKWELL C
0.2 to 0.9	.008 to .035	46 to 51
1.0 to 4.0	.039 to .157	44 to 49
4.25 to 16.0	.164 to .630	42 to 48

For Stainless Steel and Inconel, consult SPAENAUR.

CONVERSION TABLE

inches x 25.4 = millimetres
millimetres ÷ 25.4 = inches
1 lb. = **.454 kg**
1 kg = 2.2 lbs.
1 psi = **.0007 kg/mm²**
1 kg/mm² = 1422 psi
1 Newton (N) = .225 lbs. force
1 lb. force = **4.44 N**
1 N/mm² = **.102 kg/mm²** = 145 psi
1 kg/mm² = **9.81 N/mm²** = 1422 psi

OD AND ID GUIDE CLEARANCE

OD OR ID SIZE		CLEARANCE FOR OD OR ID	
mm	Inch	mm	Inch
up to 16	up to 0.63	0.2	0.008
over 16 to 20	0.63 to 0.79	0.3	0.012
over 20 to 26	0.79 to1.02	0.4	0.016
over 26 to 31.5	1.02 to 1.24	0.5	0.020
over 31.5 to 50	1.24 to 1.97	0.6	0.024
over 50 to 80	1.97 to 3.14	0.8	0.031
over 80 to 140	3.15 to 5.52	1.0	0.039
over 140 to 250	5.52 to 9.85	1.6	0.063

NOTE: Inside Guiding is preferred. Guide Bolts should be Rc55-60 ground and polished.

OD/ID TOLERANCE

OD/ID RANGE		TOTAL TOLERANCE	
mm	Inch	mm	Inch
1.6 to 3	.063 to .118	0.102	0.004
3.0 to 6	.118 to .236	0.127	0.005
6.0 to 10	.236 to .394	0.152	0.006
10 to 18	.394 to .709	0.178	0.007
18 to 30	.709 to 1.18	0.203	0.008
30 to 50	1.18 to 1.97	0.254	0.010
50 to 80	1.97 to 3.15	0.305	0.012
80 to 120	3.15 to 4.72	0.356	0.014
120 to 180	4.72 to 7.09	0.406	0.016
180 to 250	7.09 to 9.84	0.457	0.018

NOTE: For OD, tolerance is MINUS value shown.
For ID, tolerance is PLUS value shown.

LOAD TOLERANCE

GROUP	THICKNESS RANGE		TOLERANCE FOR LOAD AT DEFLECTION =.75h
	mm	Inch	
1	less than 1.25	0.049	+25% -7.5%
2	1.25 to 3.00	0.049 - 0.118	+15% -7.5%
	over 3.00 to 6.00	0.118 - 0.236	+10% -5%
3	over 6.00 to 14.00	0.236 - 0.551	±5%

NOTE: Load will vary in stacked springs in proportion to number of springs in stack.

*When thickness, OA Height **AND LOAD VALUES** are specified, the controlling factor shall be the **load shown.***

MATERIALS

High-grade spring steel of selected surface condition. Most commonly used are C-1075 or SAE 6150 chrome vanadium steel. Other alloy steels are also used. We use 17-7Ph stainless for corrosion resistance. It is slightly magnetic.

HARDNESS

Disc springs are carefully heat treated with austempering process, and in such a manner as to prevent surface decarburization.

D

Disc Springs (Washers) - Technical Data

Rondelles à ressort (Belleville) – données techniques

Size	Bolt Dia. D (in.)	Tensile Stress Area A (sq. in.)	SAE Grade 2 Bolts: Tensile Strength (min psi)	Proof Load (psi)	Clamp[2] Load P (lb.)	Tightening Torque Dry K=0.20	Tightening Torque Lub. K=0.15	SAE Grade 5 Bolts: Tensile Strength (min psi)	Proof Load (psi)	Clamp[2] Load P (lb.)	Tightening Torque Dry K=0.20	Tightening Torque Lub. K=0.15	SAE Grade 7[3]: Clamp[2] Load P (lb.)	Tightening Torque Dry K=0.20	Tightening Torque Lub. K=0.15	SAE Grade 8[4]: Clamp[2] Load P (lb.)	Tightening Torque Dry K=0.20	Tightening Torque Lub. K=0.15
						lb. in.	lb. in.				lb. in.	lb. in.		lb. in.	lb. in.		lb. in.	lb. in.
4-40	0.1120	0.00604	74,000	55,000	240	5	4	120,000	85,000	380	8	6	480	11	8	540	12	9
4-48	0.1120	0.00661			280	6	5			420	9	7	520	12	9	600	13	10
6-32	0.1380	0.00909			380	10	8			580	16	12	720	20	15	820	23	17
6-40	0.1380	0.01015			420	12	9			640	18	13	800	22	17	920	25	19
8-32	0.1640	0.01400			580	19	14			900	30	22	1100	36	27	1260	41	31
8-36	0.1640	0.01474			600	20	15			940	31	23	1160	38	29	1320	43	32
10-24	0.1900	0.01750			720	27	21			1120	43	32	1380	52	39	1580	60	45
10-32	0.1900	0.02000			820	31	23			1285	49	36	1580	60	45	1800	68	51
1/4-20	0.2500	0.0318			1320	66	49			2020	96	75	2500	120	96	2860	144	108
1/4-28	0.2500	0.0364			1500	76	56			2320	120	86	2860	144	108	3280	168	120
						lb. ft.	lb. ft.				lb. ft.	lb. ft.		lb. ft.	lb. ft.		lb. ft.	lb. ft.
5/16-18	0.3125	0.0524			2160	11	8			3340	17	13	4120	21	16	4720	25	18
5/16-24	0.3125	0.0580			2400	12	9			3700	19	14	4560	24	18	5220	25	20
3/8-16	0.3750	0.0775			3200	20	15			4940	30	23	6100	40	30	7000	45	35
3/8-24	0.3750	0.0878			3620	23	17			5600	35	25	6900	45	45	7900	50	35
7/16-14	0.4375	0.1063			4380	30	24			6800	50	35	8400	60	45	9550	70	55
7/16-20	0.4375	0.1187			4900	35	25			7550	55	40	9350	70	50	10700	80	60
1/2-13	0.5000	0.1419			5840	50	35			9050	75	55	11200	95	70	12750	110	80
1/2-20	0.5000	0.1599			6600	55	40			10700	90	65	12600	100	80	14400	120	90
9/16-12	0.5625	0.1820			7500	70	55			11600	110	80	14350	135	100	16400	150	110
9/16-18	0.5625	0.2030			8400	80	60			12950	120	90	16000	150	110	18250	170	130
5/8-11	0.6250	0.2260			9300	100	75			14400	150	110	17800	190	140	20350	220	170
5/8-18	0.6250	0.2560			10600	110	85			16300	170	130	20150	210	160	23000	240	180
3/4-10	0.7500	0.3340			13800	175	130			21300	260	200	26300	320	240	30100	380	280
3/4-16	0.7500	0.3730			15400	195	145			23800	300	220	29400	360	280	33600	420	320
7/8-9	0.8750	0.4620	60,000	33,000	11400	165	125			29400	430	320	36400	520	400	41600	600	460
7/8-14	0.8750	0.5090			12600	185	140			32400	470	350	40100	580	440	45800	660	500
1-8	1.0000	0.6060			15000	250	190			38600	640	480	47700	800	600	54500	900	680
1-12	1.0000	0.6630			16400	270	200			42200	700	530	52200	860	660	59700	1000	740
1-1/8-7	1.1250	0.7630			18900	350	270	105,000	74,000	42300	800	600	60100	1120	840	68700	1280	960
1-1/8-12	1.1250	0.8560			21200	400	300			47500	880	660	67400	1260	940	77000	1440	1080
1-1/4-7	1.2500	0.9690			24000	500	380			53800	1120	840	76300	1580	1100	87200	1820	1360
1-1/4-12	1.2500	1.0730			26600	550	420			59600	1240	920	84500	1760	1320	96600	2000	1500
1-3/8-6	1.3750	1.1550			28600	660	490			64100	1460	1100	91000	2080	1560	104000	2380	1780
1-3/8-12	1.3750	1.3150			32500	740	560			73000	1680	1260	104000	2380	1780	118400	2720	2040
1-1/2-6	1.5000	1.4050			34800	870	650			78000	1940	1460	111000	2780	2080	126500	3160	2360
1-1/2-12	1.5000	1.5800			39100	980	730			87700	2200	1640	124005	3100	2320	142200	3560	2660

Notes:

1. Tightening torque values are calculated from the formula $T = KDP$, where T = tightening torque, lb-in.; K = torque-friction coefficient; D = nominal bolt diameter, in.; and P = bolt clamping load developed by tightening. lb.

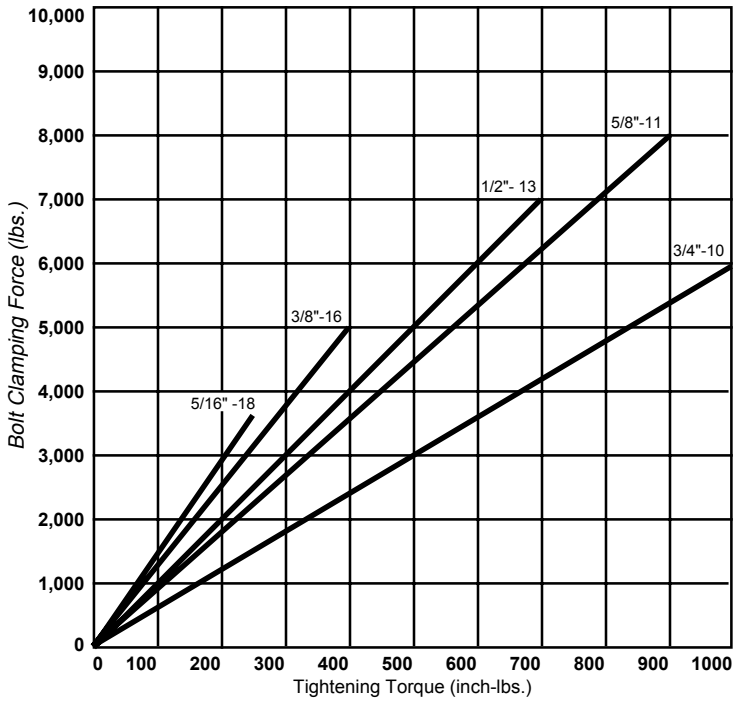
2. Clamp load is also known as preload or initial load in tension on bolt. Clamp load (lb.) is calculated by arbitrarily assuming usable bolt strength is 75% of bolt proof load (psi) times tensile stress area (sq. in.) of threaded section of each bolt size. Higher or lower values of clamp load can be used depending on the application requirements and the judgement of the designer.

3. Tensile strength (min psi) of all Grade 7 bolts is 125,000. Proof load is 105,000 psi.

4. Tensile strength (min psi) of all Grade 8 bolts is 150,000 psi. Proof load is 120,000 psi.

Ref.: Fastening Reference. Machine Design. Nov. 1977.

Bolt Clamping Force vs. Tightening Torque for Unlubricated Steel Bolts.



Disc Springs (Washers) - Technical Data

Rondelles à ressort (Belleville) – données techniques

Nominal Dia.	Bolt stress, psi											
	7,500		15,000		30,000		45,000		60,000		90,000	
	Torque ft-lb.	Load lb.	Torque ft-lb.	Load lb.	Torque ft-lb.	Load lb.	Torque ft-lb.	Load lb.	Torque ft-lb.	Load lb.	Torque ft-lb.	Load lb.
National Coarse Series												
1/4"	1	240	2	480	4	950	6	1,430	8	1,900	-	-
5/16"	2	390	4	780	8	1,570	12	2,350	16	3,130	-	-
3/8"	3	600	6	1,160	12	2,320	18	3,480	24	4,640	-	-
7/16"	5	800	10	1,590	20	3,180	30	4,770	40	6,360	-	-
1/2"	8	1,060	15	2,120	30	4,250	45	6,370	60	8,500	-	-
9/16"	12	1,360	23	2,720	45	5,450	68	8,170	90	10,900	-	-
5/8"	15	1,690	30	3,380	60	6,770	90	10,200	120	13,500	-	-
3/4"	25	2,510	50	5,010	100	10,000	150	15,000	200	20,000	-	-
7/8"	40	3,460	80	6,920	160	13,800	240	20,800	320	27,700	-	-
1"	62	4,540	123	9,080	245	18,200	-	-	-	-	-	-
1-1/8"	98	5,720	195	11,400	390	22,900	-	-	-	-	-	-
1-1/4"	137	7,260	273	14,500	545	29,100	-	-	-	-	-	-
1-3/8"	183	8,650	365	17,300	730	34,600	-	-	-	-	-	-
1-1/2"	219	10,500	437	21,100	875	42,100	-	-	-	-	-	-
1-3/4"	390	14,200	775	28,500	1,550	56,900	-	-	-	-	-	-
2"	563	18,700	1,125	37,500	2,250	74,900	-	-	-	-	-	-
8-thread Series												
1"	-	-	-	-	245	18,200	368	27,200	490	36,300	-	-
1-1/8"	-	-	-	-	355	23,700	533	35,500	710	47,400	-	-
1-1/4"	-	-	-	-	500	30,000	750	44,900	1,000	59,900	-	-
1-3/8"	-	-	-	-	680	37,000	1,020	55,400	1,360	73,900	-	-
1-1/2"	-	-	-	-	800	44,700	1,200	67,000	1,600	89,400	-	-
1-5/8"	-	-	-	-	1,100	53,200	1,650	79,800	2,200	106,300	-	-
1-3/4"	-	-	-	-	1,500	62,400	2,250	93,600	3,000	124,800	-	-
1-7/8"	-	-	-	-	2,000	72,300	3,000	108,500	4,000	144,600	-	-
2"	-	-	-	-	2,200	83,000	3,300	124,500	4,400	166,000	-	-
2-1/4"	-	-	-	-	3,180	106,600	4,770	159,800	6,360	213,100	-	-
2-1/2"	-	-	-	-	4,400	133,100	6,600	199,600	8,800	266,100	-	-
2-3/4"	-	-	-	-	5,920	162,500	8,800	243,700	11,840	325,000	-	-
3"	-	-	-	-	7,720	194,900	11,580	292,300	15,440	389,700	-	-
National Fine Series												
1/4"	-	-	-	-	6	1,090	9	1,630	12	2,120	18	2,930
5/16"	-	-	-	-	12	1,740	18	2,600	24	3,480	36	5,210
3/8"	-	-	-	-	22	2,630	31	3,940	44	5,260	66	7,880
7/16"	-	-	-	-	32	3,560	50	5,070	64	7,100	96	10,700
1/2"	-	-	-	-	50	4,790	76	7,100	100	9,600	150	14,200
9/16"	-	-	-	-	72	6,080	109	9,120	144	12,200	216	18,200
5/8"	-	-	-	-	98	7,670	148	11,500	196	15,300	294	23,000
3/4"	-	-	-	-	170	11,200	255	16,800	340	22,300	510	33,500
7/8"	-	-	-	-	270	15,300	404	22,800	540	30,500	810	45,800
1"	-	-	-	-	390	19,900	587	29,800	780	39,700	1,170	59,600
1-1/8"	-	-	-	-	574	25,600	860	38,500	1,148	51,300	1,722	76,900
1-1/4"	-	-	-	-	790	32,200	1,180	48,300	1,580	64,300	2,370	96,500
1-3/8"	-	-	-	-	1,044	42,400	1,565	59,000	2,088	78,800	3,132	118,200
1-1/2"	-	-	-	-	1,358	47,400	2,060	71,000	2,716	94,800	4,074	142,200

TECHNICAL DATA and RELATED INFORMATION can be found on pages D40 to D47 and D63.

Disc Springs (Washers)

Inch

Rondelles à ressort (Belleville)

Pouce

Disc springs can be used singly, or may be combined to make a stacked spring column.

For INCH Bolt Sizes

AI/SAI Series

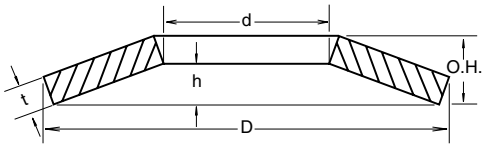
STEEL & STAINLESS STEEL

DISC SPRINGS - for BOLTS

Materials: 1075 high carbon steel or 6150 chrome vanadium steel, plain or phosphate finish, our option.

D

Series AI **pre-stressed** disc springs are used to maintain load or tension in bolted assemblies. Pressure begins at the outer radius and flattens gradually toward the bolt as deflection progresses. Disc springs exert a uniform pressure that remains constant in spite of tension losses caused by thermal expansion and contraction, compression set, or wear of parts. Because pressures are predictable, disc springs provide a simple and effective means of determining bolt tension that is far more accurate than "torque" readings.



Load Values for Stainless Steel approximate 95% of Spring Steel values shown.

See AM Series for LARGER SIZES

POWERFUL SPRING ACTION IN LIMITED SPACE

Note: Tested only at f = .75h.

P Load at flat in lbs.
f Deflection in inches

SPAENAUR No. STEEL	STAINLESS STEEL	•Cross-Reference AI/SAI Series Part No.	Nom. Bolt or Shaft Size	Inch Dimensions D	d	t	h	O.H.	f = .75h P	f	P max.	f max.
	680-806	180907	#2	.187	.093	.007	.006	.013	10	.005	12	.006
680-005	680-807	180910	#2	.187	.093	.010	.005	.015	23	.004	29	.005
680-006	680-808	251209	#4	.250	.125	.009	.008	.017	16	.006	19	.008
680-007	680-800	251213	#4	.250	.125	.013	.007	.020	39	.005	50	.007
680-113	680-809	281315	#6	.281	.138	.015	.008	.023	54	.006	69	.008
680-009		311511	5/32"	.312	.156	.011	.011	.022	26	.008	30	.011
680-019	680-B13-1K	311517	#6	.312	.156	.017	.008	.025	63	.006	82	.008
680-035	680-812	341619	#8	.343	.164	.019	.009	.028	80	.007	104	.009
DS-10	680-813	371915	3/16"	.375	.195	.015	.012	.027	49	.009	59	.012
	680-814	371920	3/16"	.375	.195	.020	.010	.030	92	.008	118	.010
	680-B14-1W	502518	1/4"	.500	.255	.018	.016	.034	64	.012	75	.016
■DS-20		502519	1/4"	.500	.258	.019	.016	.035	75	.012	89	.016
680-B02-1W		502523	1/4"	.500	.258	.023	.016	.039	130	.012	160	.016
	680-818	502525	1/4"	.500	.255	.025	.013	.038	129	.010	165	.013
	680-B04-1Y	502538	1/4"	.500	.255	.038	.010	.048	344	.008	454	.010
	680-820	623122	5/16"	.625	.317	.022	.020	.042	93	.015	110	.020
■680-100	680-821	623132	5/16"	.625	.317	.032	.016	.048	213	.012	273	.016
DS-40	680-801	753227	5/16"	.750	.320	.028	.024	.052	146	.018	174	.024
680-B11-1N		753231	5/16"	.750	.320	.032	.024	.056	213	.018	261	.024
DS-60		683823	3/8"	.688	.382	.024	.020	.044	104	.015	125	.020
DS-70		683827	3/8"	.688	.382	.028	.020	.048	162	.015	200	.020
	680-823	753828	3/8"	.750	.380	.028	.023	.051	150	.017	180	.023
■680-101	680-803	753831	3/8"	.750	.382	.032	.020	.052	188	.015	236	.020
DS-80	680-824	753835	3/8"	.750	.382	.035	.022	.057	272	.017	342	.022
DS-90	680-825	753840	3/8"	.750	.382	.040	.019	.059	343	.014	441	.019
	680-826	753856	3/8"	.750	.380	.056	.014	.070	679	.011	897	.014
	680-827	874431	7/16"	.875	.442	.031	.028	.059	185	.021	218	.028
	680-828	874445	7/16"	.875	.442	.045	.022	.067	413	.017	530	.022
■DS-100		104435	7/16"	1.000	.445	.035	.032	.067	219	.024	258	.032

Material and finish must be specified on order.

Continued on next page...

■ Conform to MIL-W-12133/1"B"

• Prefix Cross-Reference Part No. with an AI for Steel and SAI for Stainless Steel.

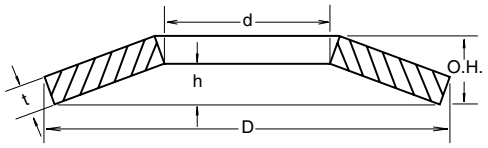
Contact Sales Desk For Package Quantities
See Page D45-D47 for Technical Data

…Continued from previous page.

For INCH Bolt Sizes

AI/SAI Series

STEEL & STAINLESS STEEL



POWERFUL SPRING ACTION IN LIMITED SPACE

Contact Sales Desk For Package Quantities

Note: Tested only at f = .75h.
P Load at flat in lbs.
f Deflection in inches

SPAENAUR No. STEEL	STAINLESS STEEL	●Cross-Ref. AI/SAI Series Part No.	Nom. Bolt or Shaft Size	Inch Dimensions D	d	t	h	O.H.	f = .75h P	f	P max.	f max.
DS-110		104439	7/16"	1.000	.445	.039	.032	.071	298	.024	359	.032
DS-120		104449	7/16"	1.000	.445	.049	.026	.075	455	.020	580	.026
680-102	680-830	105135	1/2"	1.000	.512	.035	.032	.067	236	.024	277	.032
DS-130		115139	1/2"	1.100	.512	.039	.036	.075	289	.027	339	.036
■DS-140		115149	1/2"	1.100	.512	.049	.030	.083	517	.025	640	.034
DS-150		115159	1/2"	1.100	.512	.059	.028	.087	717	.021	923	.028
	680-833	105173	1/2"	1.000	.512	.073	.018	.091	1092	.014	1442	.018
	680-835	115638	9/16"	1.125	.567	.038	.035	.073	258	.026	303	.035
	680-836	115656	9/16"	1.125	.567	.056	.028	.084	612	.021	784	.028
680-104	680-837	126340	5/8"	1.250	.630	.040	.042	.082	303	.031	344	.042
	680-839	126389	5/8"	1.250	.630	.089	.022	.111	1529	.017	2019	.022
DS-160		136349	5/8"	1.375	.637	.049	.046	.095	469	.034	549	.046
■DS-170		136359	5/8"	1.375	.637	.059	.043	.102	733	.032	901	.043
680-B10-1C	—	136378	5/8"	1.375	.637	.078	.032	.110	1198	.024	1556	.032
680-107	680-841	157545	3/4"	1.500	.755	.045	.048	.093	342	.036	386	.048
680-108	680-844	157572	3/4"	1.500	.755	.072	.037	.109	965	.028	1235	.037
■DS-190		157659	3/4"	1.500	.761	.059	.055	.114	871	.041	1019	.055
■DS-200		157678	3/4"	1.500	.761	.078	.044	.122	1495	.033	1897	.044
DS-210		157698	3/4"	1.500	.761	.098	.036	.134	2373	.027	3097	.036
	680-845	1575107	3/4"	1.500	.755	.107	.027	.134	2266	.020	2991	.027
■680-109	680-B16-1X	178885	7/8"	1.750	.880	.085	.043	.128	1354	.032	1735	.043
680-110	680-B15-1M	201065	1"	2.000	1.016	.065	.065	.130	778	.049	895	.065
■DS-220		201078	1"	2.000	1.016	.078	.060	.138	1178	.045	1436	.060
DS-230	680-B17-1A	201098	1"	2.000	1.016	.098	.060	.158	2290	.045	2881	.060
DS-240		201011	1"	2.000	1.016	.118	.047	.165	3033	.035	3944	.047
DS-250		231078	1"	2.375	1.016	.078	.079	.157	1073	.059	1231	.079
■DS-260		231098	1"	2.375	1.016	.098	.079	.177	2038	.059	2463	.079
DS-270		231011	1"	2.375	1.016	.118	.063	.181	2693	.047	3434	.063
680-111		251280	1-1/4"	2.500	1.250	.080	.080	.160	1131	.060	1301	.080
680-112		251212	1-1/4"	2.500	1.250	.120	.060	.180	2591	.045	3322	.060

●Prefix Cross-Reference Part No. with an AI for Steel and SAI for Stainless Steel.
■Conform to MIL-W-12133/1"B"

See "AM" Series for larger sizes on D52 to D61.
Also available Mechanical Zinc or Cadmium Plated Special to Order.

See Page D45-D47 for Technical Data

SP/SSP Series

STEEL AND STAINLESS STEEL

for HEAVY BOLTED SECTIONS

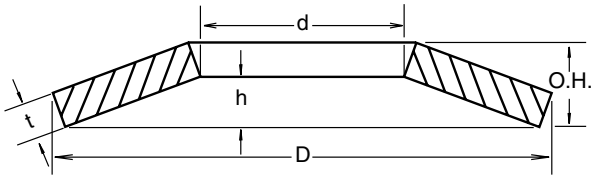
For INCH Bolt Sizes

- ELECTRICAL INDUSTRY APPLICATIONS
  Bus Bar Joints | Transformers
- AUTOMOTIVE
- FARM IMPLEMENTS

Materials: High-grade **SPRING STEEL**, in self colour or phosphate finish, our option. **17-7PH STAINLESS STEEL**

D

This series of Disc Springs has been specifically designed for heavy bolted sections, such as those used in electrical industries - on bus bar applications, transformers, etc. They are widely used to compensate for developed looseness due to thermal expansion of bolted sections. These conical spring washers are not as accurately formed as our AI series, which are generally used for lighter loads and more predictable load/deflection characteristics.
SP Disc Springs are made of high quality spring steel, heat treated to Rockwell C43-50. 17-7PH stainless steel is heat treated to Rockwell hardness C40-48.



IMPORTANT NOTE: SP Series Disc Springs are not pre-stressed. They are designed for static bolted applications only. ***See Series AM or AI as shown on other pages, for other applications.***

Load Values for Stainless Steel approx. 95% of Spring Steel values shown.

●Prefix Cross-Reference Part No. with an SP for Steel and SSP for Stainless Steel.

SPAENAUR No. STEEL	SPAENAUR No. STAINLESS STEEL	● Cross-Ref. SP/SSP Part No.	NOMINAL BOLT SIZE Inch	INCH DIMENSIONS D	d	t	1) O.H.	2) O.H.	3) Load Flat (in lbs.)	Weight per M (in lbs.)
—	**680-852**	52203	—	.197	.087	.012	.020	.016	65	0.08
680-203	**680-853**	62704	—	.236	.106	.016	.026	.020	146	0.16
680-205	**680-854**	73205	**1/8" #5**	.276	.126	.020	.030	.025	210	0.26
680-207	**680-855**	83705	**#6**	.315	.146	.020	.031	.027	176	0.34
680-209	**680-856**	94308	**5/32" #8**	.354	.169	.031	.043	.037	590	0.68
680-211	**680-804**	115310	**3/16" #10**	.433	.209	.039	.055	.047	1070	1.3
680-213	**680-B08-1C**	146412	**1/4"**	.551	.252	.050	.067	.056	1390	2.5
680-215	—	177415	—	.669	.291	.059	.079	.070	1800	4.8
680-217	**680-B07-1Y**	188420	**5/16"**	.709	.331	.078	.102	.088	4755	6.9
680-219	**680-861**	218425	**5/16"**	.827	.331	.098	.118	.108	5345	12.5
680-B18-1P	**680-B09-1N**	231120	**3/8"**	.906	.413	.078	.106	.094	3200	11.4
680-223	**680-B21-1Y**	241130	**3/8"**	.945	.413	.118	.146	.130	8000	18.9
680-225	**680-B06-1P**	291325	**1/2"**	1.142	.512	.098	.130	.116	4700	22.9
680-227	**680-864**	321335	**1/2"**	1.260	.512	.138	.169	.156	9900	40.0
680-229	**680-865**	351530	**9/16"**	1.378	.591	.125	.157	.141	6500	40.7
680-231	—	391540	**9/16"**	1.535	.591	.157	.197	.181	12000	70.0
▲**680-233**	**680-867**	391735	**5/8"**	1.535	.669	.138	.185	.162	10000	58.5
680-235	**680-868**	421740	**5/8"**	1.654	.669	.157	.204	.201	13000	90.0
680-237	—	471950	—	1.850	.748	.197	.244	.222	20000	125.0
680-239	**680-870**	522160	**3/4"**	2.047	.827	.236	.287	.246	31000	169.0
680-245	—	702870	**1"**	2.756	1.102	.276	.362	.317	46000	392.0
680-217ZP (Mechanical Zinc)		188420	**5/16**	.709	.331	.079	.102	.088	4755	6.9
680-221ZP (Mechanical Zinc)		231120	**3/8**	.906	.413	.0798	.106	.094	3200	11.4

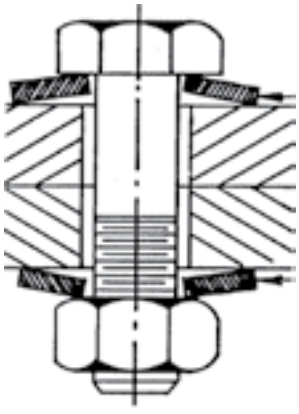
▲**680-233MZ** Mechanical Zinc

1) When delivered.

2) After first loading.

3) Load ± 20% of nominal shown.

Note: Values for Load at Flat shown in the table are computed.



A typical application of SP/SSP Series Disc Springs

Contact Sales Desk For Package Quantities
See Page D45-D47 for Technical Data

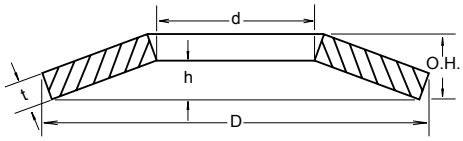
AK Series

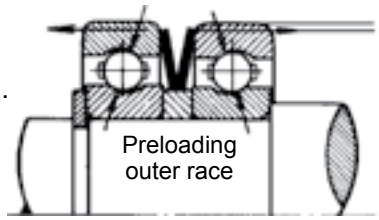
FOR BALL BEARING APPLICATIONS

Series AK disc springs are specially designed as preloading springs for use with radial ball bearings. They help maintain positioning accuracy of the bearing with no end play. They also minimize vibration and shaft deflection. Proper preloading will increase bearing rigidity and eliminate excessive running noise.

Material: C1075 STEEL, Not plated or phosphate finish, our option.

Hardness Range: depending on size, RC 40-51.





Load tolerances: ±20% at .75h

P Load in lbs. **Note:** Tested only
f Deflection in inches at f = .75h.

SPAENAUR No.	Ball Bearing Size	INCH DIMENSIONS D	d	t	h	O.H.	Ratio h/t	f = .75h P	f	PKG QTY.
680-250	AK-R-2	.366	.228	.0079	.0080	.0158	1.01	5.9	.0060	100
680-251	AK-623/EL-3	.386	.244	.0079	.0080	.0158	1.01	5.4	.0060	100
680-252	AK-R-3	.492	.319	.0098	.0100	.0197	1.02	8.3	.0075	100
680-253	AK-624/EL-4	.504	.283	.0098	.0099	.0197	1.01	6.7	.0075	100
680-255	AK-625/634/EL-5	.622	.323	.0098	.0119	.0217	1.22	5.3	.0089	100
680-256	AK-626/635/EL-6	.740	.362	.0118	.0138	.0256	1.17	7.2	.0104	100
680-257	AK-607/EL-7	.740	.402	.0138	.0138	.0276	1.00	11.8	.0104	100
680-B12-1T	AK-608/627/EL-8	.858	.484	.0138	.0157	.0295	1.14	10.7	.0118	100
680-259	AK-R-6	.862	.539	.0138	.0158	.0295	1.14	11.8	.0118	100
680-260	AK-609/EL-9	.933	.563	.0157	.0198	.0354	1.26	18.5	.0148	50
680-261	AK-6000/629	1.012	.563	.0157	.0198	.0354	1.26	14.5	.0148	50
680-262	AK-6001	1.091	.681	.0157	.0238	.0394	1.52	18.4	.0179	50
680-263	AK-R-8	1.110	.724	.0157	.0278	.0433	1.77	24.1	.0208	50
680-264	AK-6200	1.169	.685	.0157	.0277	.0433	1.77	19.0	.0208	50
680-265	AK-6002/6201	1.248	.803	.0157	.0277	.0433	1.77	18.6	.0208	50
680-266	AK-R-10	1.358	1.000	.0197	.0277	.0472	1.41	34.8	.0208	25
680-267	AK-6300	1.362	.803	.0157	.0277	.0433	1.76	14.1	.0208	25
680-268	AK-6003/6202	1.362	.882	.0197	.0276	.0472	1.40	27.3	.0207	25
680-269	AK-6301	1.441	.803	.0197	.0316	.0512	1.60	25.5	.0237	25
680-270	AK-6203	1.559	1.004	.0197	.0316	.0512	1.61	25.3	.0237	25
680-271	AK-6004/6302	1.638	1.004	.0197	.0355	.0551	1.80	26.1	.0266	10
680-272	AK-6005/6204/6303	1.831	1.201	.0236	.0357	.0591	1.51	35.3	.0267	10
680-273	AK-6205/6304	2.028	1.398	.0236	.0357	.0591	1.51	31.1	.0267	10
680-274	AK-6006	2.146	1.594	.0236	.0357	.0591	1.51	32.5	.0268	10
680-275	AK-6007/6206/6305	2.421	1.594	.0276	.0434	.0708	1.57	40.3	.0325	10
680-276	AK-6306	2.815	1.791	.0276	.0553	.0827	2.00	42.5	.0414	10
680-277	AK-6207	2.815	1.988	.0276	.0554	.0827	2.01	50.3	.0415	10
680-278	AK-6307	3.130	1.988	.0315	.0593	.0906	1.88	52.2	.0445	10
680-279	AK-6010/6208	3.130	2.185	.0315	.0594	.0906	1.88	60.6	.0445	10
680-280	AK-6209	3.327	2.382	.0354	.0633	.0984	1.79	82.4	.0475	10
680-281	AK-6308	3.524	2.382	.0354	.0632	.0984	1.79	65.9	.0474	1
680-282	AK-6011/6210	3.524	2.579	.0354	.0633	.0984	1.79	76.9	.0475	1
680-283	AK-6309	3.898	2.579	.0394	.0632	.1024	1.60	67.1	.0474	1
680-284	AK-6013/6211	3.898	2.776	.0394	.0633	.1024	1.61	76.4	.0474	1
680-286	AK-6014/6212	4.291	2.972	.0492	.0573	.1063	1.16	91.1	.0430	1
680-287	AK-6311	4.685	2.972	.0492	.0611	.1102	1.24	73.0	.0458	1
680-288	AK-6312	5.079	3.366	.0492	.0770	.1260	1.57	92.7	.0578	1

Larger bearing sizes available upon request

See Page D45-D47 for Technical Data

AM SERIES

METRIC DISC SPRINGS

NOTE 1. Disc springs are tested only at f = .75h.

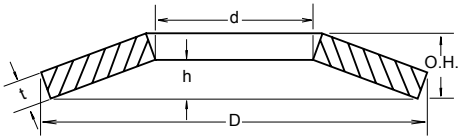
DIN 2093

NOMENCLATURE

P = load in lbs.

σ = stress in (psi) lbs./sq. in. x 10^3

f = deflection in inches



MATERIALS and HARDNESS

High grade spring steel of selected surface condition, plain or phosphate finish, our option.
Most commonly used are C-1075 or SAE 6150 chrome vanadium steel. Other alloys & 17-7 Stainless Steel available.

Disc springs are carefully heat treated with austempering process and in such a manner as to prevent surface decarburization.

SERIES AM DISC SPRING DIMENSIONS

D

SPAENAUR No.	Cross-Reference AM Series Part No.	SPRING DIMENSIONS in Millimetres D O.D.	d I.D.	t Thick	INCH DIMENSIONS Subject to normal commercial tolerances. D	d	t	h	O.H.
681-200	AM63203	6	3.2	0.3	.236	.126	.0118	.0060	.0177
681-D09-1C	AM83202	8	3.2	0.2	.315	.126	.0079	.0078	.0157
681-202	AM83203	8	3.2	0.3	.315	.126	.0118	.0099	.0216
▲681-203	AM83204	8	3.2	0.4	.315	.126	.0157	.0080	.0236
681-204	AM84202	8	4.2	0.2	.315	.165	.0079	.0099	.0177
681-001	AM84203	8	4.2	0.3	.315	.165	.0118	.0099	.0216
681-205	AM103203	10	3.2	0.3	.394	.126	.0118	.0139	.0256
681-206	AM103204	10	3.2	0.4	.394	.126	.0157	.0120	.0276
681-207	AM103205	10	3.2	0.5	.394	.126	.0197	.0099	.0295
681-208	AM104204	10	4.2	0.4	.394	.165	.0157	.0120	.0276
681-209	AM104205	10	4.2	0.5	.394	.165	.0197	.0099	.0295
681-210	AM105225	10	5.2	0.25	.394	.205	.0098	.0120	.0217
681-003	AM105204	10	5.2	0.4	.394	.205	.0157	.0120	.0276
681-004	AM105205	10	5.2	0.5	.394	.205	.0197	.0099	.0295
681-211	AM124204	12	4.2	0.4	.472	.165	.0157	.0159	.0315
681-212	AM124205	12	4.2	0.5	.472	.165	.0197	.0139	.0335
681-213	AM124206	12	4.2	0.6	.472	.165	.0236	.0159	.0394
681-214	AM125205	12	5.2	0.5	.472	.205	.0197	.0158	.0354
681-215	AM125206	12	5.2	0.6	.472	.205	.0236	.0139	.0374
681-216	AM126205	12	6.2	0.5	.472	.244	.0197	.0140	.0335
681-217	AM126206	12	6.2	0.6	.472	.244	.0236	.0140	.0374
681-218	AM135205	12.5	5.2	0.5	.492	.205	.0197	.0139	.0335
681-219	AM136235	12.5	6.2	0.35	.492	.244	.0138	.0178	.0315
681-005	AM136205	12.5	6.2	0.5	.492	.244	.0197	.0139	.0335
681-006	AM136207	12.5	6.2	0.7	.492	.244	.0276	.0119	.0394
681-220	AM147235	14	7.2	0.35	.551	.283	.0138	.0178	.0315
681-007	AM147205	14	7.2	0.5	.551	.283	.0197	.0158	.0354
681-008	AM147208	14	7.2	0.8	.551	.283	.0315	.0119	.0433
681-221	AM155204	15	5.2	0.4	.591	.205	.0157	.0218	.0374
681-222	AM155205	15	5.2	0.5	.591	.205	.0197	.0198	.0394
681-223	AM155206	15	5.2	0.6	.591	.205	.0236	.0178	.0413
681-224	AM155207	15	5.2	0.7	.591	.205	.0276	.0158	.0433
681-225	AM156205	15	6.2	0.5	.591	.244	.0197	.0198	.0394
681-226	AM156206	15	6.2	0.6	.591	.244	.0236	.0178	.0413
681-227	AM156207	15	6.2	0.7	.591	.244	.0276	.0158	.0433
681-228	AM158207	15	8.2	0.7	.591	.323	.0276	.0159	.0433
■681-229	AM158208	15	8.2	0.8	.591	.323	.0315	.0159	.0472
681-230	AM168204	16	8.2	0.4	.630	.323	.0157	.0198	.0354
681-009	AM168206	16	8.2	0.6	.630	.323	.0236	.0179	.0413
681-011	AM168207	16	8.2	0.7	.630	.323	.0276	.0179	.0453
681-231	AM168208	16	8.2	0.8	.630	.323	.0315	.0159	.0472

■ 681-836 17-7PH Stainless Steel ▲ 681-D29-1X 17-7PH Stainless Steel

Continues on Next Page

See Page D45-D47 for Technical Data

Metric

Métrique

NOMENCLATURE

P = load in lbs.
σ = stress in (psi) lbs./sq. in. x 10^3
f = deflection in inches

Disc Springs (Washers) Part 2

Rondelles à ressort (Belleville) 2e partie

	f = .25h		f = .50h		f = .75h			f = h		
SPAENAUR No.	**P Load**	**f Deflection**	**P Load**	**f Deflection**	**P Load (in lbs.)**	**f Deflection (in inches)**	**Stress σ**	**P Load**	**f Deflection**	**PKG QTY.**
681-200	11	.0015	20	.0030	29	.0045	188	37	.0060	100
681-D09-1C	3	.0020	5	.0039	6	.0059	89	7	.0078	100
681-202	11	.0025	19	.0049	25	.0074	159	30	.0099	100
▲681-203	17	.0020	31	.0040	44	.0060	196	56	.0080	100
681-204	5	.0025	8	.0049	9	.0074	155	10	.0099	100
681-001	12	.0025	21	.0050	28	.0074	199	33	.0099	100
681-205	12	.0035	19	.0069	23	.0104	146	26	.0139	100
681-206	18	.0030	32	.0060	43	.0090	173	52	.0120	100
681-207	25	.0025	47	.0049	66	.0074	218	85	.0099	100
681-208	19	.0030	33	.0060	45	.0090	164	55	.0120	100
681-209	26	.0025	49	.0049	70	.0074	192	90	.0099	100
681-210	7	.0030	11	.0060	14	.0090	147	15	.0120	100
681-003	21	.0030	37	.0060	50	.0090	198	61	.0120	100
681-004	29	.0025	54	.0050	78	.0074	186	99	.0099	100
681-211	20	.0040	34	.0079	42	.0119	152	48	.0159	100
681-212	28	.0035	50	.0069	68	.0104	174	84	.0139	100
681-213	54	.0040	98	.0080	135	.0120	248	168	.0159	100
681-214	36	.0040	63	.0079	84	.0119	199	101	.0158	100
681-215	47	.0035	87	.0070	122	.0105	210	154	.0139	100
681-216	32	.0035	57	.0070	78	.0105	195	97	.0140	100
681-217	52	.0035	95	.0070	133	.0105	223	168	.0140	100
681-218	27	.0035	48	.0069	65	.0104	148	80	.0139	100
681-219	20	.0045	31	.0089	36	.0134	194	38	.0178	100
681-005	29	.0035	51	.0070	70	.0104	171	87	.0139	100
681-006	58	.0030	110	.0060	159	.0090	213	206	.0119	100
681-220	16	.0045	25	.0089	29	.0134	159	31	.0178	100
681-007	28	.0040	50	.0079	66	.0119	167	80	.0158	100
681-008	68	.0030	131	.0060	191	.0090	201	249	.0119	100
681-221	24	.0055	36	.0109	41	.0164	152	42	.0218	100
681-222	32	.0050	52	.0099	66	.0149	150	76	.0198	100
681-223	41	.0045	72	.0089	96	.0134	164	118	.0178	100
681-224	51	.0039	94	.0079	133	.0118	197	168	.0158	100
681-225	33	.0050	54	.0099	69	.0149	166	79	.0198	100
681-226	42	.0045	74	.0089	100	.0134	161	123	.0178	100
681-227	53	.0040	98	.0079	138	.0119	182	174	.0158	100
681-228	61	.0040	114	.0080	159	.0119	198	202	.0159	100
■681-229	88	.0040	166	.0080	236	.0120	220	303	.0159	100
681-230	20	.0050	31	.0099	36	.0149	152	38	.0198	100
681-009	41	.0045	72	.0089	97	.0134	169	119	.0179	100
681-011	61	.0045	111	.0089	153	.0134	189	191	.0179	100
681-231	74	.0040	138	.0079	197	.0119	186	252	.0159	100

NOTE 1: Disc springs are tested only at f = .75h

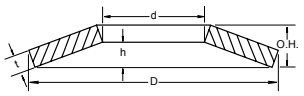
■ **681-836** 17-7PH Stainless Steel ▲ **681-D29-1X** 17-7PH Stainless Steel

DIN 2093

See pages B74-B77 for TAPCON ANCHOR SYSTEM

Disc Spring (Washers) Part 1

Rondelles à ressort (Belleville) 1re partie



Metric

Métrique

SPAENAUR No.	Cross-Reference AM Series Part No.	SPRING DIMENSIONS in Millimetres D O.D.	d I.D.	t Thick	INCH DIMENSIONS Subject to normal commercial tolerances. D	d	t	h	O.H.
681-010	AM168209	16	8.2	0.9	.630	.323	.0354	.0140	.0492
681-232	AM186204	18	6.2	0.4	.709	.244	.0157	.0238	.0394
681-233	AM186205	18	6.2	0.5	.709	.244	.0197	.0237	.0433
681-234	AM186206	18	6.2	0.6	.709	.244	.0236	.0237	.0472
681-235	AM186207	18	6.2	0.7	.709	.244	.0276	.0217	.0492
681-236	AM186208	18	6.2	0.8	.709	.244	.0315	.0198	.0512
681-237	AM188205	18	8.2	0.5	.709	.323	.0197	.0238	.0433
681-238	AM188207	18	8.2	0.7	.709	.323	.0276	.0218	.0492
681-239	AM188208	18	8.2	0.8	.709	.323	.0315	.0199	.0512
681-012	AM188210	18	8.2	1.0	.709	.323	.0394	.0158	.0551
681-240	AM189245	18	9.2	0.45	.709	.362	.0177	.0238	.0413
681-241	AM189207	18	9.2	0.7	.709	.362	.0276	.0198	.0472
681-242	AM189210	18	9.2	1.0	.709	.362	.0394	.0159	.0551
681-243	AM208206	20	8.2	0.6	.787	.323	.0236	.0278	.0512
681-244	AM208207	20	8.2	0.7	.787	.323	.0276	.0257	.0531
681-245	AM208208	20	8.2	0.8	.787	.323	.0315	.0238	.0551
681-246	AM208209	20	8.2	0.9	.787	.323	.0354	.0219	.0571
681-247	AM208210	20	8.2	1.0	.787	.323	.0394	.0218	.0610
681-248	AM201005	20	10.2	0.5	.787	.402	.0197	.0258	.0453
681-013	AM201008	20	10.2	0.8	.787	.402	.0315	.0218	.0531
681-249	AM201009	20	10.2	0.9	.787	.402	.0354	.0219	.0571
681-250	AM201010	20	10.2	1.0	.787	.402	.0394	.0219	.0610
681-014	AM201011	20	10.2	1.1	.787	.402	.0433	.0179	.0610
▲681-251	AM201013	20	10.2	1.3	.787	.402	.0492	.0200	.0689
681-252	AM201015	20	10.2	1.5	.787	.402	.0591	.0119	.0709
681-253	AM221106	22.5	11.2	0.6	.886	.441	.0236	.0317	.0551
681-015	AM221108	22.5	11.2	0.8	.886	.441	.0315	.0258	.0571
■681-016	AM221113	22.5	11.2	1.25	.886	.441	.0492	.0199	.0689
681-254	AM238207	23	8.2	0.7	.906	.323	.0276	.0317	.0591
681-255	AM238208	23	8.2	0.8	.906	.323	.0315	.0297	.0610
681-256	AM238209	23	8.2	0.9	.906	.323	.0354	.0278	.0630
681-257	AM238210	23	8.2	1.0	.906	.323	.0394	.0277	.0669
681-258	AM231009	23	10.2	0.9	.906	.402	.0354	.0299	.0650
681-259	AM231010	23	10.2	1.0	.906	.402	.0394	.0278	.0669
681-260	AM231013	23	10.2	1.3	.906	.402	.0492	.0259	.0748
681-261	AM231210	23	12.2	1.0	.906	.480	.0394	.0239	.0630
681-D13-1T	AM231213	23	12.2	1.3	.906	.480	.0492	.0239	.0728
681-263	AM231215	23	12.2	1.5	.906	.480	.0591	.0199	.0787
681-264	AM251010	25	10.2	1.0	.984	.402	.0394	.0297	.0689
681-265	AM251207	25	12.2	0.7	.984	.480	.0276	.0357	.0630
681-017	AM251209	25	12.2	0.9	.984	.480	.0354	.0278	.0630
681-266	AM251210	25	12.2	1.0	.984	.480	.0394	.0318	.0709
681-D10-1Y	AM251213	25	12.2	1.3	.984	.480	.0492	.0279	.0768
681-D20-1A	AM251215	25	12.2	1.5	.984	.480	.0591	.0218	.0807
681-268	AM281008	28	10.2	0.8	1.100	.402	.0315	.0376	.0689
681-269	AM281010	28	10.2	1.0	1.100	.402	.0394	.0356	.0748
681-D11-1C	AM281013	28	10.2	1.3	1.100	.402	.0492	.0317	.0807
681-D07-1P	AM281015	28	10.2	1.5	1.100	.402	.0591	.0277	.0866
681-272	AM281210	28	12.2	1.0	1.100	.480	.0394	.0377	.0768
681-273	AM281213	28	12.2	1.3	1.100	.480	.0492	.0338	.0827
681-274	AM281215	28	12.2	1.5	1.100	.480	.0591	.0298	.0886
681-275	AM281408	28	14.2	0.8	1.100	.559	.0315	.0398	.0709
681-019	AM281410	28	14.2	1.0	1.100	.559	.0394	.0318	.0709

DIN 2093

Chart continues across facing pages.

■681-016YZ Yellow Zinc Plated
▲681-838 17-7PH Stainless Steel

Metric

Métrique

NOMENCLATURE

P = load in lbs.
σ = stress in (psi) lbs./sq. in. x 10^3
f = deflection in inches

Disc Springs (Washers) Part 2

Rondelles à ressort (Belleville) 2e partie

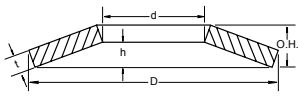
	f = .25h		f = .50h		f = .75h			f = h		
SPAENAUR No.	P Load	f Deflection	P Load	f Deflection	P Load (in lbs.)	f Deflection (in inches)	Stress σ	P Load	f Deflection	PKG QTY.
681-010	87	.0035	167	.0070	242	.0105	200	315	.0140	100
681-232	20	.0059	30	.0119	33	.0178	120	32	.0238	100
681-233	31	.0059	49	.0119	58	.0178	134	63	.0237	100
681-234	45	.0059	75	.0119	95	.0178	149	109	.0237	100
681-235	56	.0054	99	.0109	132	.0163	159	160	.0217	100
681-236	68	.0050	125	.0099	173	.0149	189	218	.0198	100
681-237	33	.0059	52	.0119	62	.0178	160	68	.0238	100
681-238	61	.0054	106	.0109	142	.0163	174	172	.0218	100
681-239	74	.0050	135	.0099	187	.0149	169	234	.0199	100
681-012	101	.0040	194	.0079	282	.0119	200	366	.0158	100
681-240	28	.0059	43	.0119	50	.0178	167	52	.0238	100
681-241	55	.0049	99	.0099	134	.0148	169	165	.0198	100
681-242	108	.0040	207	.0079	300	.0119	198	389	.0159	100
681-243	51	.0069	81	.0139	97	.0208	167	107	.0278	100
681-244	62	.0064	105	.0128	135	.0193	164	159	.0257	100
681-245	75	.0059	133	.0119	179	.0178	161	219	.0238	100
681-246	89	.0055	164	.0109	227	.0164	176	286	.0219	100
681-247	118	.0054	220	.0109	310	.0163	207	394	.0218	100
681-248	34	.0064	52	.0129	60	.0193	161	63	.0258	100
681-013	72	.0055	130	.0109	178	.0164	171	220	.0218	100
681-249	99	.0055	181	.0110	251	.0165	188	316	.0219	100
681-250	131	.0055	243	.0109	343	.0164	202	436	.0219	100
681-014	132	.0045	252	.0090	364	.0134	198	473	.0179	100
681-251	217	.0050	415	.0100	601	.0150	255	781	.0200	100
681-252	207	.0030	409	.0060	608	.0089	209	805	.0119	100
681-253	57	.0079	87	.0159	100	.0238	186	104	.0317	100
681-015	73	.0065	127	.0129	167	.0194	165	202	.0258	100
681-016	166	.0050	318	.0100	461	.0149	199	600	.0199	100
681-254	66	.0079	107	.0158	129	.0238	154	143	.0317	100
681-255	79	.0074	133	.0148	170	.0223	151	199	.0297	100
681-256	93	.0069	163	.0139	218	.0208	157	265	.0278	100
681-257	121	.0069	217	.0138	296	.0208	187	366	.0277	100
681-258	111	.0075	191	.0149	252	.0224	188	302	.0299	100
681-259	129	.0069	230	.0139	314	.0208	183	388	.0278	100
681-260	210	.0065	391	.0129	555	.0194	231	709	.0259	100
681-261	113	.0060	208	.0119	290	.0179	176	365	.0239	100
681-D13-1T	208	.0060	392	.0120	560	.0180	216	720	.0239	100
681-263	279	.0050	542	.0099	794	.0149	241	1040	.0199	100
681-264	117	.0074	207	.0149	279	.0223	160	342	.0297	100
681-265	79	.0089	122	.0178	142	.0268	191	150	.0357	100
681-017	87	.0070	153	.0139	204	.0209	156	248	.0278	100
681-266	140	.0080	245	.0159	325	.0239	202	393	.0318	100
681-D10-1Y	204	.0070	378	.0140	532	.0209	200	675	.0279	100
681-D20-1A	250	.0055	482	.0109	702	.0164	219	917	.0218	100
681-268	83	.0094	131	.0188	157	.0282	145	171	.0376	100
681-269	123	.0089	209	.0178	270	.0267	153	319	.0356	100
681-D11-1C	177	.0079	321	.0159	444	.0238	188	556	.0317	100
681-D07-1P	242	.0069	457	.0138	655	.0208	225	845	.0277	100
681-272	142	.0094	238	.0189	303	.0283	186	354	.0377	100
681-273	203	.0085	366	.0169	500	.0254	185	621	.0338	100
681-274	278	.0074	522	.0149	743	.0223	221	952	.0298	100
681-275	104	.0099	163	.0199	191	.0298	200	204	.0398	100
681-019	114	.0079	199	.0159	264	.0238	167	320	.0318	100

Continued Next page

NOTE 1: Disc springs are tested only at f = .75h
See Page D45-D47 for Technical Data

Disc Springs (Washers) Part 1

Rondelles à ressort (Belleville) 1re partie



Metric

Métrique

Chart continues across facing pages.

SPAENAUR No.	Cross-Reference AM Series Part No.	SPRING DIMENSIONS in Millimetres D O.D.	d I.D.	t Thick	INCH DIMENSIONS Subject to normal commercial tolerances. D	d	t	h	O.H.
681-D14-1K	AM281413	28	14.2	1.3	1.100	.559	.0492	.0339	.0827
681-020	AM281415	28	14.2	1.5	1.100	.559	.0591	.0258	.0846
681-277	AM321210	31.5	12.2	1.0	1.240	.480	.0394	.0436	.0827
681-278	AM321213	31.5	12.2	1.25	1.240	.480	.0492	.0377	.0866
681-279	AM321215	31.5	12.2	1.5	1.240	.480	.0591	.0336	.0925
681-280	AM321608	31.5	16.3	0.8	1.240	.642	.0315	.0416	.0728
681-021	AM321613	31.5	16.3	1.25	1.240	.642	.0492	.0358	.0846
681-281	AM321615	31.5	16.3	1.5	1.240	.642	.0591	.0359	.0945
681-022	AM321618	31.5	16.3	1.75	1.240	.642	.0690	.0278	.0965
681-282	AM321620	32	16.3	2.0	1.240	.642	.0787	.0300	.1083
681-839(S.S)	SAM321620	31.5	16.3	2.0	1.240	.642	.0787	.0300	.1083
681-283	AM341210	34	12.3	1.0	1.340	.484	.0394	.0495	.0886
681-285	AM341215	34	12.3	1.5	1.340	.484	.0591	.0396	.0984
681-286	AM341413	34	14.3	1.3	1.340	.563	.0492	.0457	.0945
681-287	AM341415	34	14.3	1.5	1.340	.563	.0591	.0417	.1004
681-288	AM341615	34	16.3	1.5	1.340	.642	.0591	.0417	.1004
681-289	AM341620	34	16.3	2.0	1.340	.642	.0787	.0339	.1122
681-290	AM361809	35.5	18.3	0.9	1.400	.720	.0354	.0456	.0807
681-023	AM361813	35.5	18.3	1.25	1.400	.720	.0492	.0398	.0886
681-024	AM361820	35.5	18.3	2.0	1.400	.720	.0787	.0319	.1102
681-291	AM401413	40	14.3	1.3	1.570	.563	.0492	.0554	.1043
681-292	AM401415	40	14.3	1.5	1.570	.563	.0591	.0495	.1083
681-293	AM401420	40	14.3	2.0	1.570	.563	.0787	.0417	.1201
681-294	AM401615	40	16.3	1.5	1.570	.642	.0591	.0515	.1102
681-295	AM401620	40	16.3	2.0	1.570	.642	.0787	.0437	.1220
681-296	AM401820	40	18.3	2.0	1.570	.720	.0787	.0458	.1240
681-297	AM402010	40	20.4	1.0	1.570	.803	.0394	.0516	.0906
♦**681-025**	AM402015	40	20.4	1.5	1.570	.803	.0591	.0456	.1043
681-298	AM402020	40	20.4	2.0	1.570	.803	.0787	.0439	.1220
■**681-026**	AM402023	40	20.4	2.25	1.570	.803	.0886	.0358	.1240
681-299	AM402025	40	20.4	2.5	1.570	.803	.0984	.0379	.1358
681-300	AM452213	45	22.4	1.25	1.770	.882	.0492	.0635	.1122
681-027	AM452218	45	22.4	1.75	1.770	.882	.0689	.0517	.1201
681-028	AM452225	45	22.4	2.5	1.770	.882	.0984	.0398	.1378
681-D15-1W	AM501813	50	18.4	1.3	1.970	.724	.0492	.0633	.1122
681-302	AM501815	50	18.4	1.5	1.970	.724	.0591	.0712	.1299
681-303	AM501820	50	18.4	2.0	1.970	.724	.0787	.0595	.1378
681-304	AM501825	50	18.4	2.5	1.970	.724	.0984	.0635	.1614
681-305	AM501830	50	18.4	3.0	1.970	.724	.1181	.0556	.1732
681-306	AM502020	50	20.4	2.0	1.970	.803	.0787	.0595	.1378
681-307	AM502025	50	20.4	2.5	1.970	.803	.0984	.0536	.1516
681-308	AM502220	50	22.4	2.0	1.970	.882	.0787	.0636	.1417
681-309	AM502225	50	22.4	2.5	1.970	.882	.0984	.0556	.1535
681-310	AM502513	50	25.4	1.25	1.970	1.000	.0492	.0634	.1122
681-311	AM502515	50	25.4	1.5	1.970	1.000	.0591	.0634	.1220
▲**681-312**	AM502520	50	25.4	2.0	1.970	1.000	.0787	.0557	.1339
681-029	AM502525	50	25.4	2.5	1.970	1.000	.0984	.0558	.1535
681-313	AM502530	50	25.4	3.0	1.970	1.000	.1181	.0438	.1614
681-314	AM562915	56	28.5	1.5	2.200	1.122	.0591	.0773	.1358
681-315	AM562920	56	28.5	2.0	2.200	1.122	.0787	.0636	.1417
681-316	AM562930	56	28.5	3.0	2.200	1.122	.1181	.0518	.1693
681-318	AM572320	57	23	2.0	2.250	.890	.0787	.0755	.1537

♦ **681-025YZ** Yellow Zinc ▲ **681-312YZ** Yellow Zinc ■ **681-825** 17-7PH Stainless Steel (PKG QTY. 25)

D

See Page D45-D47 for Technical Data

Metric

Métrique

NOMENCLATURE

P = load in lbs.
σ = stress in (psi) lbs./sq. in. x 10^3
f = deflection in inches

Disc Springs (Washers) Part 2

Rondelles à ressort (Belleville) 2e partie

	f = .25h		f = .50h		f = .75h			f = h		
SPAENAUR No.	**P Load**	**f Deflection**	**P Load**	**f Deflection**	**P Load (in lbs.)**	**f Deflection (in inches)**	**Stress σ**	**P Load**	**f Deflectio**	**PKG QTY.**
681-D14-1K	220	.0085	395	.0170	540	.0254	213	670	.0339	100
681-020	249	.0064	473	.0129	683	.0193	196	884	.0258	100
681-277	140	.0109	226	.0218	277	.0327	166	310	.0436	100
681-278	181	.0094	319	.0188	429	.0282	155	524	.0377	50
681-279	247	.0084	457	.0168	642	.0252	194	814	.0336	50
681-280	91	.0104	140	.0208	161	.0312	171	169	.0416	50
681-021	188	.0089	335	.0179	454	.0268	182	559	.0358	50
681-281	304	.0090	557	.0179	776	.0269	208	979	.0359	50
681-022	335	.0070	641	.0139	930	.0209	199	1209	.0278	50
681-282	535	.0075	1029	.0150	1497	.0225	251	1952	.0300	50
681-283	151	.0124	237	.0247	278	.0371	164	297	.0495	50
681-285	262	.0099	472	.0198	649	.0297	187	809	.0396	50
681-286	217	.0114	367	.0228	473	.0342	182	555	.0457	50
681-287	293	.0104	523	.0208	713	.0312	181	882	.0417	50
681-288	309	.0104	553	.0209	753	.0313	202	932	.0417	50
681-289	505	.0085	962	.0170	1389	.0254	234	1799	.0339	50
681-290	107	.0114	167	.0228	194	.0342	162	206	.0456	50
681-023	173	.0099	301	.0199	400	.0298	163	484	.0398	50
681-024	445	.0080	853	.0159	1236	.0239	204	1607	.0319	50
681-291	216	.0139	348	.0277	424	.0416	159	472	.0554	50
681-292	268	.0124	463	.0247	610	.0371	151	733	.0495	50
681-293	434	.0104	811	.0208	1149	.0313	214	1467	.0417	50
681-294	294	.0129	504	.0257	658	.0386	172	785	.0515	50
681-295	475	.0109	882	.0218	1244	.0328	208	1582	.0437	50
681-296	528	.0114	974	.0229	1365	.0343	206	1729	.0458	50
681-297	135	.0129	208	.0258	241	.0387	162	254	.0516	50
681-025	266	.0114	468	.0228	627	.0342	175	765	.0456	50
681-298	527	.0110	978	.0219	1377	.0329	204	1751	.0439	50
681-026	565	.0090	1083	.0179	1570	.0269	205	2042	.0358	50
681-299	817	.0095	1573	.0190	2286	.0284	246	2979	.0379	50
681-300	248	.0159	385	.0318	447	.0476	191	473	.0635	50
681-027	364	.0129	644	.0258	868	.0388	176	1064	.0517	50
681-028	666	.0100	1277	.0199	1851	.0299	199	2406	.0398	50
681-D15-1W	178	.0158	277	.0316	322	.0474	123	342	.0633	50
681-302	327	.0178	517	.0356	616	.0534	162	670	.0712	50
681-303	456	.0149	806	.0297	1085	.0446	159	1328	.0595	50
681-304	891	.0159	1618	.0318	2235	.0477	235	2798	.0635	50
681-305	1218	.0139	2303	.0278	3299	.0417	283	4252	.0556	50
681-306	468	.0149	826	.0298	1111	.0446	160	1360	.0595	50
681-307	720	.0134	1339	.0268	1891	.0402	204	2409	.0536	50
681-308	535	.0159	933	.0318	1240	.0477	187	1500	.0636	50
681-309	780	.0139	1445	.0278	2032	.0417	203	2580	.0556	50
681-310	201	.0159	312	.0317	363	.0476	156	384	.0634	50
681-311	293	.0159	479	.0317	592	.0476	173	668	.0634	50
681-312	464	.0139	829	.0279	1129	.0418	175	1396	.0557	50
681-029	834	.0139	1543	.0279	2169	.0418	206	2754	.0558	50
681-313	1021	.0110	1970	.0219	2871	.0329	218	3747	.0438	50
681-314	437	.0193	537	.0387	622	.0580	186	654	.0773	25
681-315	456	.0159	794	.0318	1055	.0477	167	1276	.0636	25
681-316	999	.0129	1903	.0259	2742	.0388	196	3549	.0518	25
681-317	460	.0186	764	.0372	966	.0558	158	1116	.0745	25
681-318	525	.0189	881	.0378	1123	.0566	166	1310	.0755	25

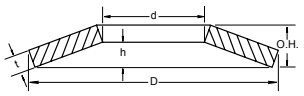
NOTE 1: Disc springs are tested only at f = .75h
DIN 2093

Continued Next Page

See Page D45-D47 for Technical Data

Disc Springs (Washers) Part 1

Rondelles à ressort (Belleville) 1re partie



Metric

Métrique

Chart continues across facing pages.

SPAENAUR No.	Cross-Reference AM Series Part No.	SPRING DIMENSIONS in Millimetres D O.D.	d I.D.	t Thick	INCH DIMENSIONS Subject to normal commercial tolerances. D	d	t	h	O.H.
▲681-319	AM602120	60	20.5	2.0	2.360	.807	.0787	.0832	.1614
681-320	AM602125	60	20.5	2.5	2.360	.807	.0984	.0713	.1693
681-321	AM602130	60	20.5	3.0	2.360	.807	.1181	.0674	.1850
681-323	AM602630	60	25.5	3.0	2.360	1.004	.1181	.0656	.0831
681-324	AM603125	60	30.5	2.5	2.360	1.201	.0984	.0717	.1693
681-325	AM603130	60	30.5	3.0	2.360	1.201	.1181	.0678	.1850
681-326	AM603135	60	30.5	3.5	2.360	1.201	.1378	.0599	.1969
681-327	AM633118	63	31	1.8	2.480	1.220	.0709	.0933	.1634
681-328	AM633125	63	31	2.5	2.480	1.220	.0984	.0695	.1673
681-329	AM633130	63	31	3.0	2.480	1.220	.1181	.0717	.1890
681-330	AM633135	63	31	3.5	2.480	1.220	.1378	.0557	.1929
681-331	AM702620	70	25.5	2.0	2.760	1.004	.0787	.0990	.1172
681-332	AM703125	70	30.5	2.5	2.760	1.201	.0984	.0953	.1929
681-333	AM703130	70	30.5	3.0	2.760	1.201	.1181	.0834	.2008
681-334	AM703630	70	35.5	3.0	2.760	1.398	.1181	.0836	.2008
681-335	AM703640	70	35.5	4.0	2.760	1.398	.1575	.0717	.2283
681-336	AM704140	70	40.5	4.0	2.760	1.595	.1575	.0641	.2205
681-337	AM704150	70	40.5	5.0	2.760	1.595	.1968	.0480	.2441
681-338	AM713620	71	36	2.0	2.800	1.420	.0787	.1033	.1811
681-339	AM713625	71	36	2.5	2.800	1.420	.0984	.0795	.1772
681-340	AM713640	71	36	4.0	2.800	1.420	.1575	.0637	.2205
681-341	AM803125	80	31	2.5	3.150	1.220	.0984	.1110	.2087
681-342	AM803130	80	31	3.0	3.150	1.220	.1181	.0990	.2165
681-343	AM803140	80	31	4.0	3.150	1.220	.1575	.0833	.2402
681-344	AM803630	80	36	3.0	3.150	1.420	.1181	.1072	.2244
681-345	AM803640	80	36	4.0	3.150	1.420	.1575	.0875	.2441
681-346	AM804123	80	41	2.25	3.150	1.610	.0886	.1172	.2047
681-D04-1M	AM804130	80	41	3.0	3.150	1.610	.1181	.0915	.2087
681-348	AM804140	80	41	4.0	3.150	1.610	.1575	.0877	.2441
681-349	AM804150	80	41	5.0	3.150	1.610	.1968	.0678	.2638
681-350	AM904625	90	46	2.5	3.540	1.810	.0984	.1271	.2244
681-351	AM904635	90	46	3.5	3.540	1.810	.1378	.0994	.2362
681-352	AM904650	90	46	5.0	3.540	1.810	.1968	.0797	.2756
681-353	AM1004140	100	41	4.0	3.940	1.610	.1575	.1270	.2835
681-354	AM1001450	100	41	5.0	3.940	1.610	.1968	.1092	.3051
681-355	AM1005127	100	51	2.7	3.940	2.010	.1063	.1389	.2441
681-356	AM1005135	100	51	3.5	3.940	2.010	.1378	.1112	.2480
681-357	AM1005140	100	51	4.0	3.940	2.010	.1575	.1194	.2756
■681-358	AM1005150	100	51	5.0	3.940	2.010	.1968	.1117	.3071
681-359	AM1005160	100	51	6.0	3.940	2.010	.2362	.0877	.3228
681-361	AM1125730	112	57	3.0	4.410	2.240	.1181	.1548	.2717
681-362	AM1125740	112	57	4.0	4.410	2.240	.1575	.1271	.2835
681-363	AM1125760	112	57	6.0	4.410	2.240	.2362	.0995	.3346
681-365	AM1254140	125	41	4.0	4.920	1.610	.1575	.1661	.3228
681-366	AM1255140	125	51	4.0	4.920	2.010	.1575	.1783	.3346
681-367	AM1255150	125	51	5.0	4.920	2.010	.1968	.1548	.3504
681-368	AM1255160	125	51	6.0	4.920	2.010	.2362	.1350	.3701
681-370	AM1256150	125	61	5.0	4.920	2.400	.1968	.1592	.3543
681-371	AM1256160	125	61	6.0	4.920	2.400	.2362	.1434	.3780
681-372	AM1256160-R	125	61	5.59	4.920	2.400	.2200	.1600	.3780
681-D16-1M	AM1256180	125	61	7.49	4.920	2.400	.2950	.1361	.4291
681-374	AM1256435	125	64	3.5	4.920	2.520	.1378	.1788	.3150

▲681-319YZ Yellow Zinc
■681-837 17-7PH Stainless Steel

Metric

Métrique

NOMENCLATURE

P = load in lbs.
σ = stress in (psi) lbs./sq. in. x 10^3
f = deflection in inches

Disc Springs (Washers) Part 2

Rondelles à ressort (Belleville) 2e partie

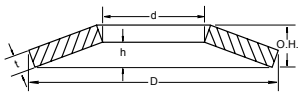
	f = .25h		f = .50h		f = .75h			f = h		
SPAENAUR No.	**P Load**	**f Deflection**	**P Load**	**f Deflection**	**P Load (in lbs.)**	**f Deflection (in inches)**	**Stress σ**	**P Load**	**f Deflection**	**PKG QTY.**
681-319	553	.0208	906	.0416	1125	.0624	160	1278	.0832	25
681-320	723	.0178	1287	.0357	1745	.0535	178	2150	.0713	25
681-321	1070	.0168	1979	.0337	2781	.0505	229	3528	.0674	25
681-323	1081	.0164	2006	.0328	2827	.0492	204	3596	.0656	25
681-324	828	.0179	1473	.0358	1995	.0538	199	2456	.0717	25
681-325	1228	.0169	2268	.0339	3184	.0508	210	4037	.0678	25
681-326	1599	.0150	3047	.0299	4393	.0449	232	5690	.0599	25
681-327	563	.0233	869	.0467	1004	.0700	206	1054	.0933	25
681-328	700	.0174	1252	.0348	1705	.0521	166	2108	.0695	25
681-329	1176	.0179	2155	.0359	3004	.0538	198	3786	.0717	25
681-330	1293	.0139	2479	.0278	3594	.0418	199	4672	.0557	25
681-331	570	.0248	890	.0495	1046	.0743	155	1118	.0990	25
681-332	892	.0238	1493	.0476	1900	.0714	187	2210	.0953	25
681-333	1114	.0209	1992	.0417	2714	.0626	175	3356	.0834	25
681-334	1201	.0209	2148	.0418	2924	.0627	201	3615	.0836	25
681-335	2106	.0179	3996	.0359	5742	.0538	229	7415	.0717	25
681-336	2024	.0160	3878	.0320	5619	.0480	216	7304	.0641	25
681-337	2786	.0120	5481	.0240	8117	.0360	227	10723	.0480	25
681-338	678	.0258	1048	.0517	1212	.0775	204	1273	.1033	25
681-339	685	.0199	1193	.0397	1585	.0596	160	1917	.0795	25
681-340	1766	.0159	3386	.0319	4907	.0478	204	6380	.0637	20
681-341	874	.0277	1407	.0555	1714	.0832	165	1906	.1110	20
681-342	1078	.0248	1864	.0495	2456	.0743	157	2950	.0990	20
681-343	1753	.0208	3272	.0417	4637	.0625	205	5923	.0833	10
681-344	1291	.0268	2194	.0536	2837	.0804	194	3351	.1072	20
681-345	1960	.0219	3637	.0437	5125	.0656	201	6520	.0875	10
681-346	878	.0293	1354	.0586	1562	.0879	208	1635	.1175	20
681-D04-1M	1058	.0229	1860	.0457	2491	.0686	174	3036	.0915	20
681-348	2097	.0219	3890	.0438	5480	.0658	203	6969	.0877	10
681-349	2844	.0170	5511	.0339	8062	.0509	224	10553	.0678	10
681-350	1007	.0318	1563	.0636	1818	.0953	196	1923	.1271	10
681-351	1392	.0248	2480	.0497	3366	.0745	171	4151	.0994	10
681-352	2709	.0199	5191	.0399	7524	.0598	199	9781	.0797	10
681-353	2077	.0317	3622	.0635	4812	.0952	175	5825	.1270	1
681-354	2951	.0273	5477	.0546	7719	.0819	206	9820	.1092	1
681-355	1132	.0347	1751	.0695	2028	.1042	187	2134	.1389	1
681-356	1331	.0278	2321	.0556	3084	.0834	159	3732	.1112	1
681-357	2071	.0298	3657	.0597	4918	.0895	193	6017	.1194	1
681-358	3351	.0279	6200	.0559	8715	.0838	207	11063	.1117	1
681-359	4099	.0219	7907	.0438	11520	.0657	218	15037	.0877	1
681-361	1381	.0387	2135	.0774	2470	.1161	185	2596	.1548	1
681-362	1813	.0318	3160	.0636	4197	.0954	166	5078	.1271	1
681-363	3775	.0249	7212	.0497	10424	.0746	190	13524	.0995	1
681-365	2023	.0415	3315	.0831	4119	.1246	144	4678	.1661	1
681-366	2404	.0446	3866	.0892	4701	.1337	180	5222	.1783	1
681-367	3120	.0387	5468	.0774	7302	.1161	169	8878	.1548	1
681-368	4078	.0337	7539	.0675	10589	.1012	194	13433	.1350	1
681-370	3500	.0398	6099	.0796	8097	.1194	202	9795	.1592	1
681-371	4760	.0359	8725	.0717	12160	.1076	200	15331	.1434	1
681-372	4775	.0400	8495	.0800	11513	.1200	225	14179	.1600	1
681-D16-1M	8356	.0340	15835	.0680	22728	.1021	263	29330	.1361	1
681-374	2027	.0447	3141	.0894	3648	.1341	201	3851	.1788	1

NOTE 1: Disc springs are tested only at f = .75h
DIN 2093

See Page D45-D47 for Technical Data

Disc Springs (Washers) Part 1

Rondelles à ressort (Belleville) 1re partie



Metric

Métrique

Chart continues across facing pages.

SPAENAUR No.	Cross-Reference AM Series Part No.	SPRING DIMENSIONS in Millimetres D O.D.	d I.D.	t Thick	INCH DIMENSIONS Subject to normal commercial tolerances. D	d	t	h	O.H.
681-375	AM1256450	125	64	5.0	4.920	2.520	.1968	.1392	.3346
681-376	AM1256480	125	64	**7.5**	4.920	2.520	.2950	.1241	.4173
681-377	AM1257160	125	71	6.0	4.920	2.800	.2362	.1319	.3661
681-379	AM1257180	125	71	**7.49**	4.920	2.800	.2950	.1165	.4094
681-380	AM1257110	125	71	**9.4**	4.920	2.800	.3700	.0964	.4646
681-381	AM1407238	140	72	3.8	5.510	2.830	.1496	.1945	.3425
681-382	AM1407250	140	72	5.0	5.510	2.830	.1968	.1590	.3543
681-383	AM1407280	140	72	**7.5**	5.510	2.830	.2950	.1480	.4409
681-384	AM1506150	150	61	5.0	5.910	2.400	.1968	.2102	.4055
681-385	AM1506160	150	61	6.0	5.910	2.400	.2362	.1905	.4252
681-386	AM1506160-R	150	61	5.59	5.910	2.400	.2200	.2069	.4252
681-387	AM1507160	150	71	6.0	5.910	2.800	.2362	.1909	.4252
681-D08-1Y	AM1507160-R	150	71	5.59	5.910	2.800	.2200	.2074	.4252
681-D17-1X	AM1507180	150	71	**7.49**	5.910	2.800	.2950	.1796	.4724
681-D18-1A	AM1508180	150	81	**7.49**	5.910	3.200	.2950	.1682	.4606
681-391	AM1508110	150	81	**9.4**	5.910	3.200	.3700	.1443	.5118
681-392	AM1608243	160	82	4.3	6.300	3.230	.1693	.2223	.3898
681-393	AM1608260	160	82	6.0	6.300	3.230	.2362	.1789	.4134
681-394	AM1608260-R	160	82	5.59	6.300	3.230	.2200	.1954	.4134
681-395	AM1608210	160	82	**9.4**	6.300	3.230	.3700	.1639	.5315
681-396	AM1809248	180	92	4.8	7.090	3.620	.1890	.2461	.4331
681-397	AM1809260	180	92	6.0	7.090	3.620	.2362	.2025	.4370
681-398	AM1809260-R	180	92	5.59	7.090	3.620	.2200	.2189	.4370
681-399	AM1809210	180	92	**9.4**	7.090	3.620	.3700	.1836	.5512
681-D19-1P	AM2008280	200	82	**7.49**	7.870	3.230	.2950	.2662	.5591
681-401	AM2008210	200	82	**9.4**	7.870	3.230	.3700	.2424	.6102
681-402	AM2008212	200	82	**11.25**	7.870	3.230	.4430	.2126	.6535
681-403	AM2009210	200	92	**9.4**	7.870	3.620	.3700	.2470	.6142
681-404	AM2009212	200	92	**11.25**	7.870	3.620	.4430	.2211	.6614
681-D12-1N	AM2009214	200	92	**13.11**	7.870	3.620	.5160	.1992	.7126
681-406	AM20010255	200	102	5.5	7.870	4.020	.2165	.2779	.4921
681-407	AM20010280	200	102	**7.5**	7.870	4.020	.2950	.2430	.5354
681-408	AM20010210	200	102	**9.4**	7.870	4.020	.3700	.2477	.6142
681-409	AM20010212	200	102	**11.4**	7.870	4.020	.4430	.1972	.6375
681-410	AM20010214	200	102	**13.11**	7.870	4.020	.5160	.2039	.7165
681-411	AM20011212	200	112	**11.25**	7.870	4.410	.4430	.1982	.6378
681-412	AM20011214	200	112	**13.11**	7.870	4.410	.5160	.1762	.6890
681-413	AM20011216	200	112	**15.01**	7.870	4.410	.5910	.1519	.7402
681-414	AM22511265	225	112	6.5	8.860	4.410	.2559	.2817	.5354
681-415	AM22511280	225	112	**7.5**	8.860	4.410	.2950	.2784	.5709
681-416	AM22511212	225	112	**11.3**	8.860	4.410	.4430	.2289	.6693
681-417	AM25010210	250	102	**9.4**	9.840	4.020	.3700	.3415	.7087
681-418	AM25010212	250	102	**11.25**	9.840	4.020	.4430	.3077	.7480
681-419	AM25012770	250	127	7.0	9.840	5.000	.2756	.3096	.5827
681-420	AM25012710	250	127	**9.4**	9.840	5.000	.3700	.3025	.6693
681-421	AM25012712	250	127	**11.25**	9.840	5.000	.4430	.3212	.7598
681-D06-1A	AM25012714	250	127	**13.1**	9.840	5.000	.5160	.2591	.7717
681-423	AM25012716	250	127	**15.01**	9.840	5.000	.5910	.2716	.8583

DIN 2093

Disc springs **7.49 mm and thicker** are made with a bearing flat at upper I.D. and lower O.D., as Standard. See Figure 6 on page D42.

See Page D45-D47 for Technical Data

Metric

Métrique

NOMENCLATURE

P = load in lbs.
σ = stress in (psi) lbs./sq. in. x 10^3
f = deflection in inches

Disc Springs (Washers) Part 2

Rondelles à ressort (Belleville) 2e partie

	f = .25h		f = .50h		f = .75h			f = h		
SPAENAUR No.	**P Load**	**f Deflection**	**P Load**	**f Deflection**	**P Load (in lbs.)**	**f Deflection (in inches)**	**Stress σ**	**P Load**	**f Deflection**	**PKG QTY.**
681-375	2919	.0348	5219	.0696	7107	.1044	176	8788	.1392	1
681-376	7662	.0310	14640	.0621	21163	.0931	246	27458	.1241	1
681-377	4721	.0330	8754	.0659	12330	.0989	212	15676	.1319	1
681-379	7682	.0291	14753	.0582	21417	.0874	239	27876	.1165	1
681-380	11965	.0241	23492	.0482	34727	.0723	274	45817	.0964	1
681-381	2256	.0486	3495	.0973	4055	.1459	190	4277	.1945	1
681-382	2853	.0397	4972	.0795	6603	.1192	168	7990	.1590	1
681-383	7588	.0370	14254	.0740	20306	.1110	219	26051	.1480	1
681-384	3634	.0525	5934	.1051	7346	.1576	179	8313	.2102	1
681-385	4663	.0476	8130	.0952	10801	.1428	174	13074	.1905	1
681-386	4650	.0517	7836	.1034	10047	.1551	192	11770	.2069	1
681-387	4953	.0477	8632	.0954	11462	.1432	196	13868	.1909	1
681-D08-1Y	4941	.0518	8322	.1037	10664	.1555	216	12486	.2074	1
681-D17-1X	8168	.0449	14967	.0898	20852	.1347	217	26281	.1796	1
681-D18-1A	8090	.0421	14960	.0841	21018	.1262	228	26669	.1682	1
681-391	12487	.0361	24003	.0721	34871	.1082	256	45416	.1443	1
681-392	2884	.0556	4456	.1112	5153	.1668	188	5412	.2223	1
681-393	4092	.0447	7225	.0894	9719	.1342	169	11892	.1789	1
681-394	4084	.0488	6974	.0977	9068	.1465	187	10765	.1954	1
681-395	12321	.0410	23437	.0820	33750	.1229	244	43660	.1639	1
681-396	3464	.0615	5365	.1230	6223	.1845	182	6560	.2461	1
681-397	3915	.0506	6738	.1012	8834	.1519	157	10565	.2025	1
681-398	3905	.0547	6491	.1095	8198	.1642	172	9467	.2189	1
681-399	11120	.0459	20914	.0918	29824	.1377	206	38293	.1836	1
681-D19-1P	7920	.0666	13475	.1331	17455	.1997	185	20646	.2662	1
681-401	11956	.0606	21660	.1212	29862	.1818	204	37313	.2424	1
681-402	16228	.0531	30631	.1063	43816	.1594	247	56392	.2126	1
681-403	12796	.0617	23110	.1235	31770	.1852	211	39602	.2470	1
681-404	17786	.0553	33430	.1160	47645	.1658	245	61147	.2211	1
681-D12-1N	23996	.0498	46160	.0996	67103	.1494	280	87434	.1992	1
681-406	4710	.0695	7322	.1390	8536	.2085	190	9051	.2779	1
681-407	7414	.0608	12974	.1215	17158	.1823	194	20684	.2430	1
681-408	13575	.0619	24507	.1238	33676	.1858	234	41963	.2477	1
681-409	16230	.0493	30859	.0986	44422	.1479	225	57451	.1972	1
681-410	26090	.0510	50101	.1019	72728	.1529	283	94662	.2039	1
681-411	17489	.0495	33237	.0991	47825	.1486	228	61833	.1982	1
681-412	23472	.0440	45514	.0881	66604	.1321	256	87217	.1762	1
681-413	29561	.0380	58068	.0760	85874	.1139	269	113328	.1519	1
681-414	5421	.0704	8784	.1409	10774	.2113	168	12078	.2817	1
681-415	7271	.0696	12243	.1392	15681	.2088	180	18353	.2784	1
681-416	15165	.0572	28392	.1145	40326	.1717	194	51613	.2289	1
681-417	13017	.0854	22034	.1707	28383	.2561	191	33399	.3415	1
681-418	17073	.0769	30627	.1539	41834	.2308	192	51868	.3077	1
681-419	6211	.0774	10010	.1548	12202	.2322	165	13590	.3096	1
681-420	11651	.0756	20257	.1513	26833	.2269	193	32393	.3025	1
681-421	20008	.0803	35617	.1606	48293	.2409	237	59503	.3212	1
681-D06-1A	22121	.0648	41550	.1295	59185	.1943	210	75924	.2591	1
681-423	34298	.0679	65017	.1358	93351	.2037	263	120492	.2716	1

DIN 2093

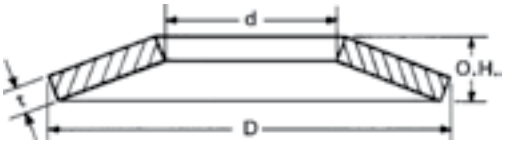
See Page D45-D47 for Technical Data

NOTE 1: Disc springs are tested only at f = .75h

High Quality Carbon Spring Steel (oil Finish) for locking bolts, screws and nuts

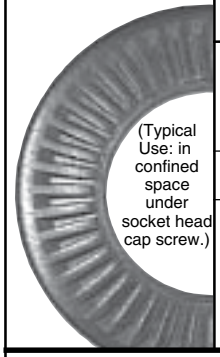
CONTACT Disc Springs combine two important features for improved bolt connections. Their conical shape provides a reactive force and a high elasticity of spring return to compensate for developed looseness, loss of bolt tension due to applied surface deterioration, or movement due to thermal expansion and contraction.

The hardened, serrated profile "grips" the lower surface of the bolt or nut to prevent the loss of tension that normally occurs during extreme vibration or severe shock.



PKG QTY. 100

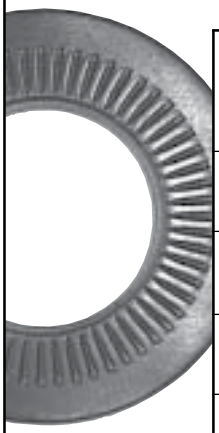
CONTACT "NARROW"



(Typical Use: in confined space under socket head cap screw.)

SPAENAUR No.	Use with Bolt Dia. Inch	Use with Bolt Dia. mm	D (O.D.) Inch	D (O.D.) mm	d (I.D.) Inch	d (I.D.) mm	t (thickness) Inch	t (thickness) mm	Max. O.H. (O/A height) inch	Max. O.H. (O/A height) mm	Calculated load at Flat lbs.	Calculated load at Flat Newton
680-010	-	M3	.236	6	.122	3.1	.020	.50	.035	.90	540	2400
680-011	#6	M3.5	.276	7	.142	3.6	.028	.70	.043	1.10	719	3200
680-013	#10	M5	.394	10	.201	5.1	.039	1	.059	1.50	1529	6800
680-B23-1N	-	M6	.472	12	.240	6.1	.047	1.20	.073	1.85	2136	9500
680-B19-1Y	9/32"	M7	.551	14	.284	7.2	.055	1.40	.081	2.05	3080	13700
680-016	5/16"	M8	.630	16	.323	8.2	.055	1.40	.087	2.20	3934	17500
680-017	3/8"	M10	.787	20	.402	10.2	.063	1.60	.102	2.60	6182	27500
680-018	7/16"	M12	.945	24	.488	12.4	.063	1.60	.102	2.60	10993	48900

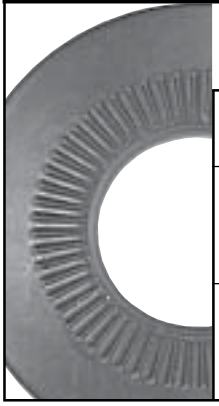
CONTACT "REGULAR" (For general use)



680-020	-	M3	.315	8	.122	3.1	.024	.6	.039	1	540	2400
680-021	#6	M3.5	.354	9	.142	3.6	.028	.7	.049	1.25	719	3200
680-022	#8	M4	.394	10	.161	4.1	.035	.9	.055	1.40	944	4200
680-023	#10	M5	.472	12	.201	5.1	.047	1.2	.073	1.85	1850	8230
680-024	-	M6	.551	14	.240	6.1	.051	1.3	.083	2.10	2136	9500
680-026	1/4"	-	.551	14	.254	6.45	.055	1.4	.087	2.20	2608	11600
680-027	5/16"	M8	.709	18	.323	8.2	.055	1.4	.093	2.35	3934	17500
680-030	3/8"	M10	.866	22	.402	10.2	.063	1.6	.108	2.75	6182	27500
680-031	7/16"	M12	1.063	27	.488	12.4	.071	1.8	.122	3.10	8992	40000
680-032	1/2"	-	1.063	27	.512	13	.071	1.8	.120	3.05	10993	48900
680-033	9/16"	M14	1.181	30	.567	14.4	.094	2.4	.146	3.70	12364	55000
680-034	5/8"	M16	1.260	32	.646	16.4	.098	2.5	.156	3.95	16860	75000

CONTACT "WIDE"

(Typical use: for oversize holes in sheet metal applications making use of wide bearing surface.)

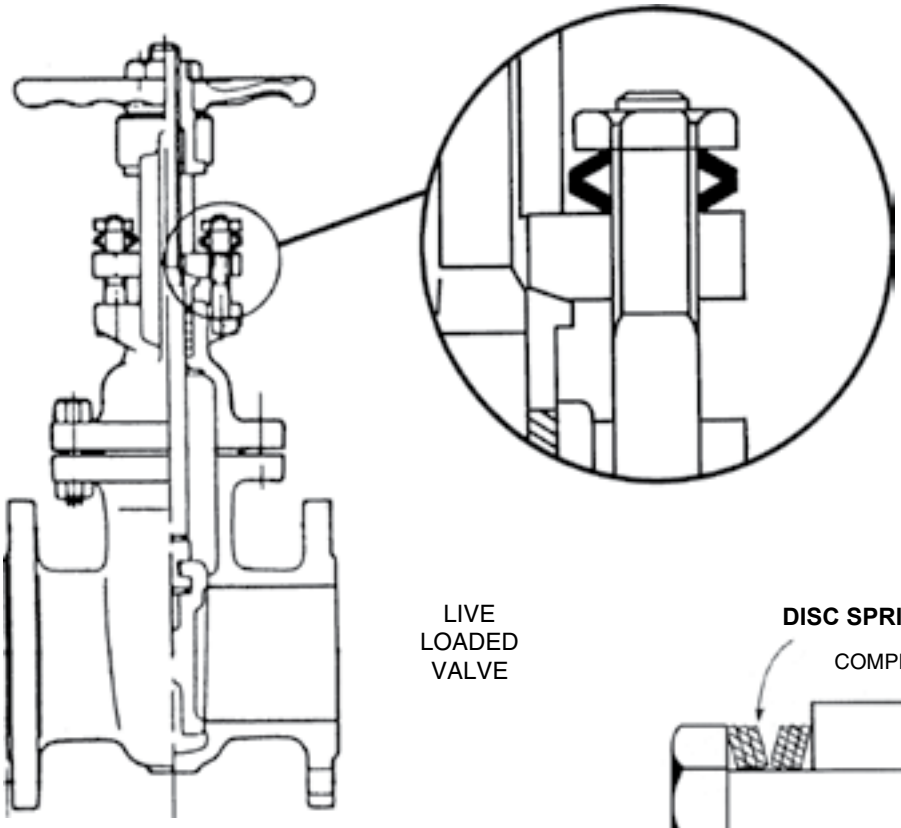


680-036	#8	M4	.551	14	.161	4.1	.039	1	.071	1.80	944	4200
680-037	#10	M5	.630	16	.201	5.1	.047	1.2	.083	2.10	1529	6800
680-B05-2A	-	M6	.709	18	.240	6.1	.055	1.4	.098	2.50	2136	9500
680-039	1/4"	-	.717	18.2	.254	6.4	.055	1.4	.100	2.55	2608	11600
680-040	5/16"	M8	.866	22	.323	8.2	.055	1.4	.094	2.40	4766	21200
680-041	3/8"	M10	1.063	27	.402	10.2	.063	1.6	.112	2.85	7576	33700
680-042	-	M12	1.260	32	.488	12.4	.071	1.8	.138	3.5	10993	48900
680-B24-1T	1/2"	-	1.260	32	.512	13	.071	1.8	.138	3.5	10993	48900

Disc Springs (Washers) - Gasket Assembly Applications

Rondelles à ressort (Belleville) – applications d'assemblage de joint d'étanchéité

Use the elastic properties of disc springs in the flange system to maintain a positive seal under varying thermal and mechanical operating conditions.

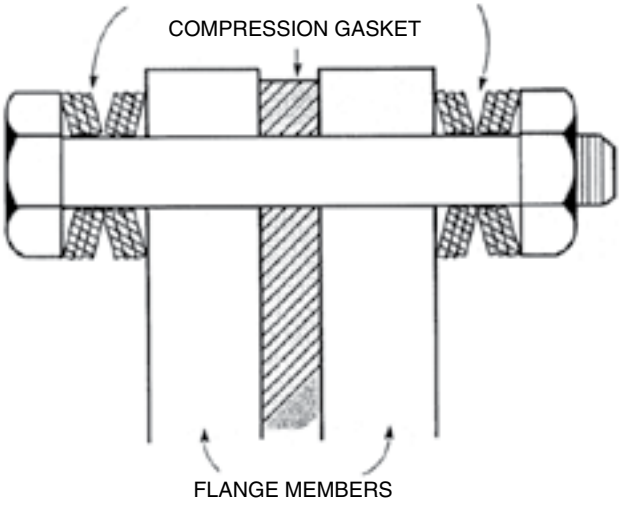


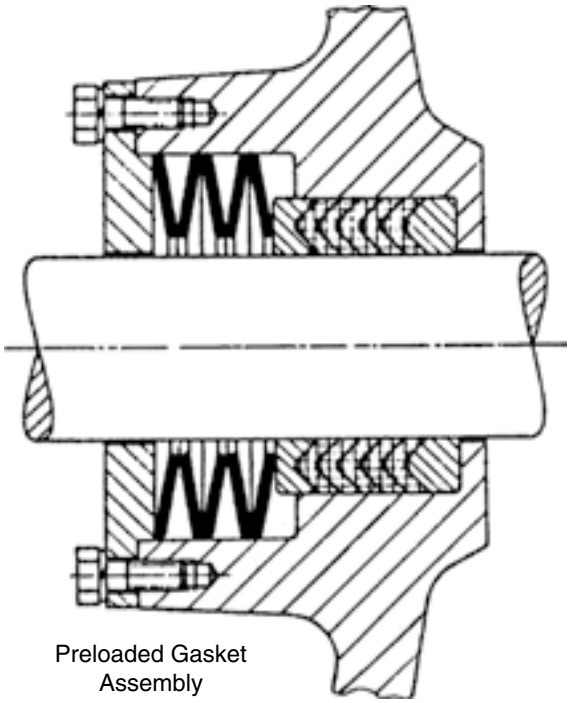
LIVE LOADED VALVE

Disc Springs help to eliminate gasket leakage by maintaining sufficient load under the following conditions:

- GASKET SET
- BOLT CREEP
- LOSS OF GASKET RESILIENCY
- VIBRATION
- SHOCK LOADING
- THERMAL EXPANSION
- PRESSURE VARIATIONS

TYPICAL DISC SPRING ARRANGEMENT





Preloaded Gasket Assembly

- Preload by torquing bolts to proper operating condition for gasket loading.
- As unit heats up, temperature differences occur between flange members and bolts, causing flange members to grow in relation to bolt.
- This growth further compresses disc springs, thereby not damaging bolts or compression gasket.
- As bolt temperature approaches that of flange members during stable operations, disc spring relaxes to original preload position, thereby producing the optimal gasket sealing force.

Independent tests have shown a “live loaded” valve can operate up to 100 times longer than a conventionally loaded valve.

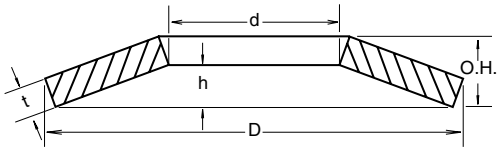
Stainless Steel 17-7PH Armco is available “Special to Order” on most common sizes.

STAINLESS STEEL for Flange Applications

Spring Discs are an elastic mechanical element. When used in bolt joints that are subject to thermal or mechanical shock, they deflect and move with the bolted joint. Hence, they compensate for developed looseness. The reactive power of the spring disc serves to keep the bolt joint tight under all conditions. Principal applications include piping construction, compression joints, steam piping joints, valve and pump connections, and others in the petrochemical field.

A principal cause of flange leakage is abnormally high loads produced by thermal expansion and contraction of a bolted joint. Generally, flanges are under static load conditions. However, in large piping systems, there may also be mechanical shock from compressor related piping. Thermal and mechanical shock differential can cause variation and yielding in bolt loads. To protect against these conditions, always use spring discs under the nut or bolt head.

Pre-stressing or torquing the bolt at factory installation is not sufficient to protect the flange joint under unexpected temperature variations and mechanical shock loads in the field. By absorbing peak stresses, spring discs prevent damage to the bolt, gasket, and joint.



SPAENAUR No.	Use with Bolt Dia. Inch	mm	INCH DIMENSIONS D	d	t (± 10%)	O.H.	*LOAD AT FLAT P (lbs.)	PKG QTY.
681-800	1/2"	M12	.900	.515	.089	.100	2100	50
681-801	5/8"	M16	1.145	.656	.125	.143	6000	50
681-802	3/4"	M20	1.365	.781	.131	.150	5100	50
681-803	7/8"	M22	1.585	.906	.160	.180	7100	50
681-804	1"	M26	1.805	1.032	.168	.195	8600	10
681-805	1-1/8"	M29	2.020	1.156	.187	.217	10600	10
681-806	1-1/4"	M32	2.240	1.281	.190	.225	10500	10
681-807	1-3/8"	M35	2.450	1.406	.250	.290	23000	10
681-808	1-1/2"	M38	2.680	1.531	.250	.290	19000	10
681-809	1-5/8"	M42	2.950	1.687	.262	.307	20000	1
681-810	1-3/4"	M45	3.170	1.812	.281	.329	23000	1
681-811	1-7/8"	M48	3.380	1.937	.300	.353	28000	1
681-812	2"	M52	3.600	2.062	.318	.375	32000	1
681-813	2-1/4"	M58	4.040	2.312	.356	.418	39000	1
681-814	2-1/2"	M64	4.470	2.562	.394	.464	48000	1

*For single spring disc; for higher loads, use parallel stacks.

2/parallel Cross-section

Series Stack

Note: Load calculated for 17-7PH stainless steel with large radii. R = $\frac{t}{4}$

MATERIAL:

STAINLESS: 17-7PH (Armco) precipitation hardened
Hardness: Rc 40-45
TEMPERATURE RANGE: -220°C to +300°C.
For higher temperatures, to +600°C, we can supply Inconel X-750 (non-standard). Prices on application.
Note: For normal operating temperatures, we can supply Chrome Vanadium SAE 6150. Prices on request.

TOLERANCE:

OD - Plus .000/Minus 1.5% x OD
(Designed for standard flange spot face diameter.)
ID - Minus .000/Plus 1.5% ID
THICKNESS - Tolerance may vary ±10% of nominal thickness shown.
LOAD - Plus/Minus 20% of nominal shown.
(When ordering, ALWAYS specify materials after part number.)

LOAD CHANGE (DECREASE) (▲P) VS. TEMPERATURE

For flanges subject to high temperature conditions, the relative load loss resultant is shown in the table below. Therefore, it may be necessary to use two discs in parallel to compensate and achieve adequate clamping load. (See illustration at upper right.)

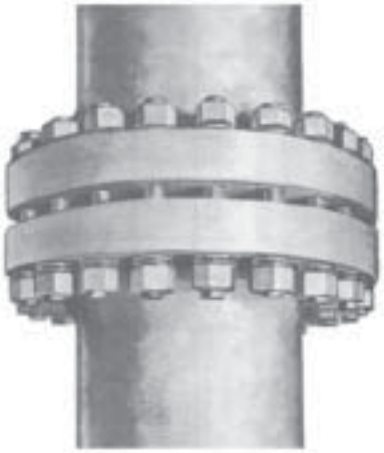
LOAD CHANGE (DECREASE) (▲P) VS. TEMPERATURE

Temperature	21°C (70°F)	205°C (400°F)		302°C (575°F)		399°C (750°F)		455°C (850°F)	
Material	E psi•10⁶	E psi•10⁶	▲P %	E psi•10⁶	▲P %	E psi•10⁶	▲P %	E psi•10⁶	▲P %
SAE6150	30	28.5	5	27.5	8.3	-	-	-	-
17-7PH	28	24.4	6.2	23.2	10.8	-	-	-	-
Temperature	**21°C (70°F)**	**121°C (250°F)**		**260°C (500°F)**		**538°C (1000°F)**		**649°C (1200°F)**	
Inconel X-750	31	30.8	.6	28.7	7.4	25	19.4	23	25.8

▲P = Load Change E = Modulus of Elasticity

Spring Discs make secure, reliable bolted connections and flanges, as used in:

- **Piping construction**
- **Compression joints**
- **Steam piping joints**
- **Petrochemical field applications**
- **Valve and pump connections**



Typical Application of Flanged (bolted) Piping