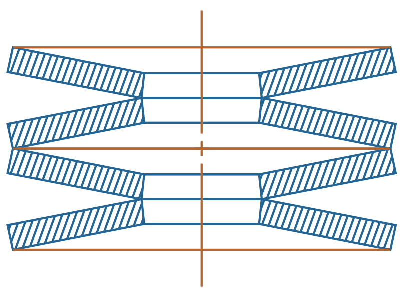
KAISER TECHNICAL MARKETING

Springs that travel

Disc Spring Stacking

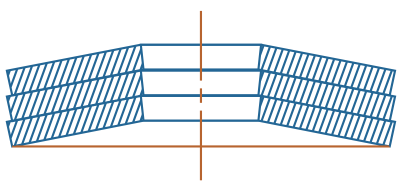
The conical shape of the disc spring, allows for stacking them in different ways:



Series: “face to face” whereby their deflections can be added together.

Deflection:
of single disc spring multiplied by number of disc springs in a column

Force:
as for single disc spring



Parallel: “same sense” whereby their forces can be added together.

This way of stacking induces increased friction, and suitable lubrication can reduce the effects of friction. No more than 2 or 3 disc springs should be stacked in parallel unless a large friction loss is desired.

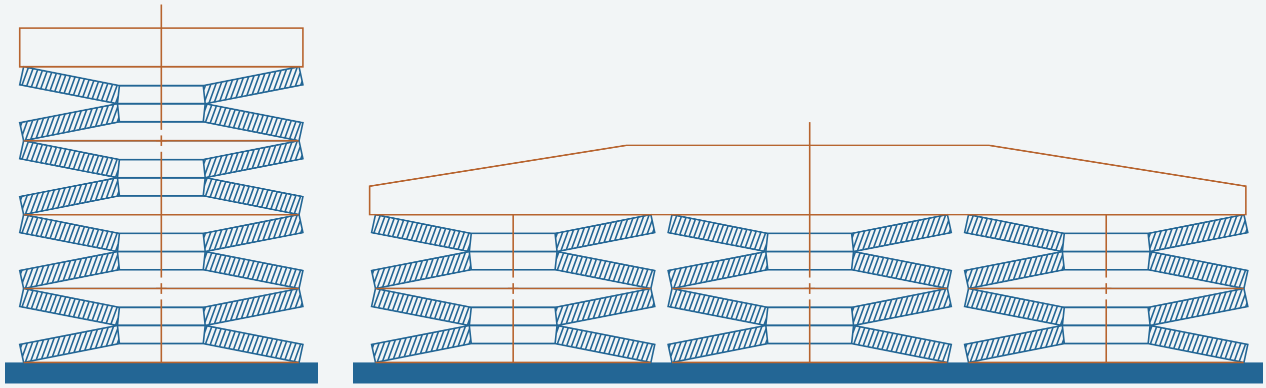
Deflection:
as for single disc spring

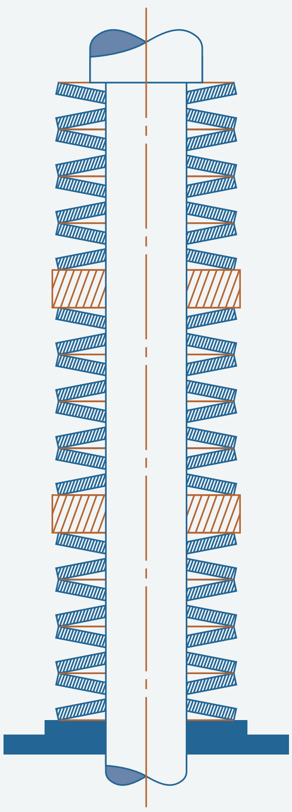
Force:
of single disc spring multiplied by number of disc springs

Notes:

As a series stack of disc springs becomes more slender, its tendency to tilt increases. Long stacks cause friction and uneven deflection of individual discs making it move unevenly. This possible significant rise in friction between the springs and guide is detrimental to the characteristic curve and lifespan of the stack of disc springs.

The best disc spring arrangement is one that uses the least number of individual springs. By using the largest outside diameter possible, it will automatically keep the stack length short. Stack lengths should not exceed three times the outer diameter.





▲

The figure above shows how a parallel stack can be converted into series stacks.

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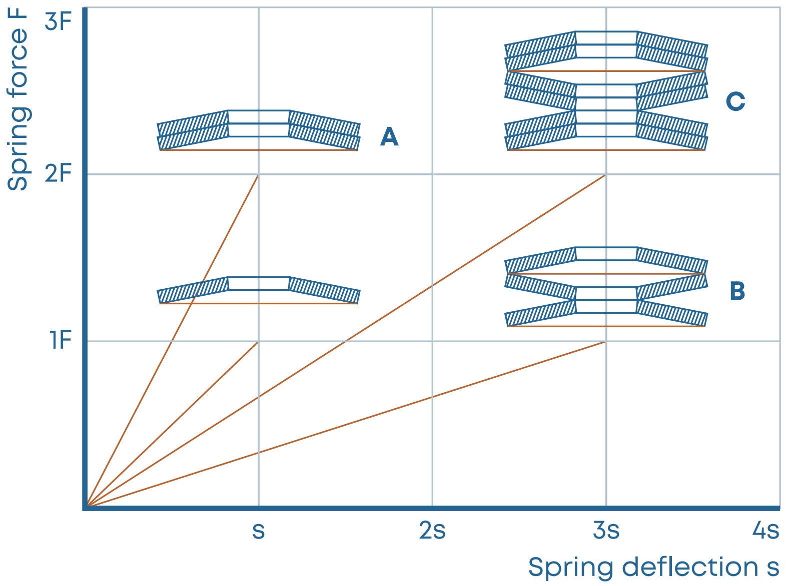
Stacks can be stabilized by adding guide washers.

Possible combinations:

Degressive to linear characteristic combinations:



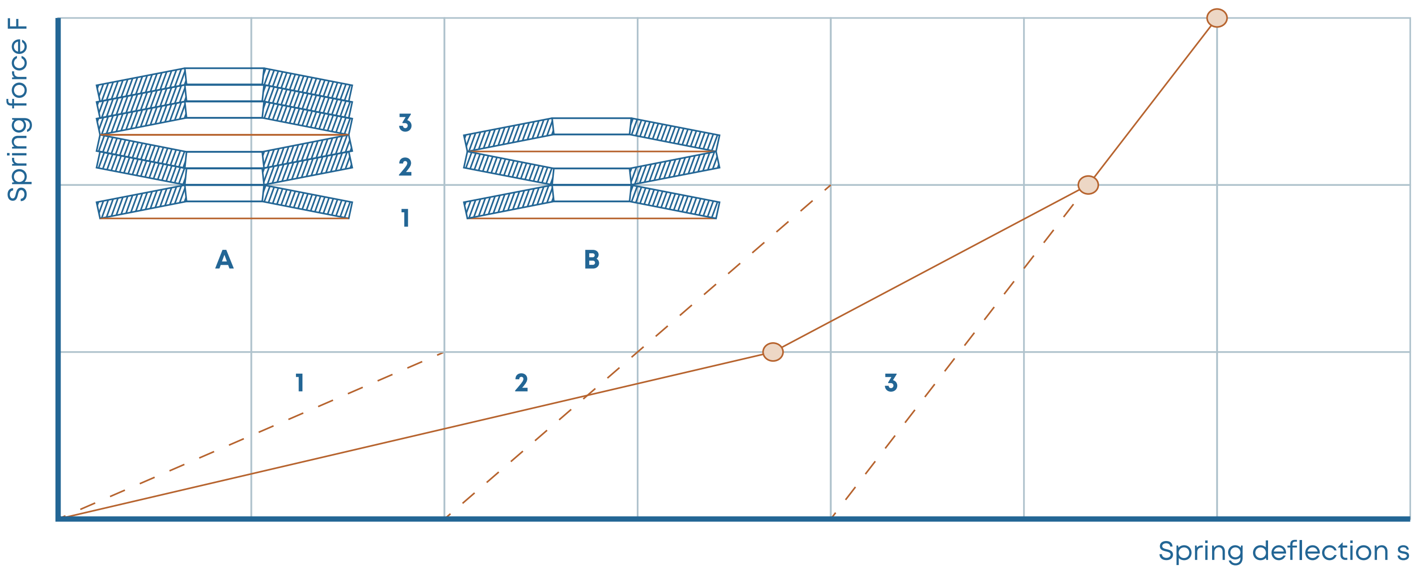
A. Stack of 2 disc springs in parallel: force x 2

B. Stack of 3 disc springs in series: deflection x 3

C. Series stack of 3 parallel stacks, each of 2 individual disc springs: deflection x 3; force x 2

Progressive characteristic combinations:

Progressive characteristic curves can be achieved when appropriately combining parallel stacks of different numbers or individual disc springs of varying thicknesses.



A. the disc springs of the 1, 2 and 3-fold layering will be flattened in sequence as a load is applied, resulting in in the addition of the individual characteristics.

B. the same result can be achieved by combining disc springs of different thicknesses.

However, it must be remembered that 1 and 2-fold- or thinner single disc springs are subjected to high stresses. Overloading can be prevented by adding spacer sleeves or rings that act as deflection limiters.

Guides:

Disc springs may be guided on a rod or in a tube, usually a rod is preferred. The mating surface to the disc spring must be hardened and smooth. In dynamic applications, the surface of the guide has to be harder than the disc springs. Adequate clearance between the disc springs and the guide must be allowed. Incorrect guide clearance can change the loading.

Standards:

With effect from 01.02.2017 the familiar DIN standards for disc springs ("DIN 2092-Calculation of Disc Springs" and "DIN 2093-Quality requirements, Dimensions") have been withdrawn.

These solely German standards have now been incorporated into European standards with the aim of securing the availability of high-quality standard disc springs for the whole world market.

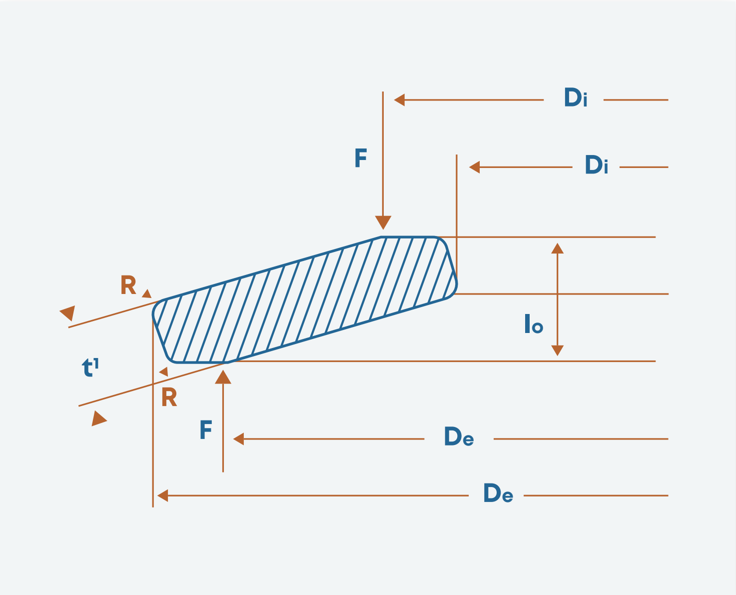
- DIN EN 16983 – Quality requirements, Dimensions
- DIN EN 16984 – Calculation

For disc springs, DIN EN 16983 (Formerly DIN 2093) is applicable. DIN EN 16983 contains three manufacturing methods, depending on relevant thickness and comprehensive quality requirements for type, dimensions, material, and permissible stresses.

Group 1:
t < 1.25mm, punching, cold forming, rounding off edges

Group 2:
1.25 ≤ t ≤ 6mm, punching, cold forming, rounding off edges or fine -blanking, cold forming, rounding off edges

Group 3:
> 6 < ≤ 14mm, cold or hot formed, turning all sides, rounding edges or punching, cold forming, turning and rounding off edges or fine- blanking, cold forming, rounding off edges.



Group 3 disc springs have turned bearing surfaces and reduced disc thickness. The bearing surface increases the force, which is compensated for by the reduced disc thickness t'.

Schnorr® disc springs are manufactured according to DIN EN 16983 as well as the company's internal standards.

Standard Materials:

C60S (1.1211):
This spring steel is a quality steel according to DIN EN 10132-4. We use this spring steel exclusively for our original SCHNORR® safety washers and load washers according to DIN 6796.

C67S (1.1231) and C75S (1.1248):
These stainless steel grades according to DIN EN 10132-4 are used as cold rolled strip for disc springs of group 1 according to DIN EN 16983 up to a thickness of t < 1.25 mm and for our disc springs of the "K" series.

51CrV4 (1.8159):
This chromium-vanadium alloyed stainless steel is used in rolled condition (according to DIN 10132-4 or acc. to DIN 10089) for disc springs with a thickness between 1.25 mm to 6 mm. Normally this stainless steel is processed in forged form for disk thicknesses of more than 6 mm.

Materials for special requirements

Corrosive, high temperature and other aggressive environments require the use of materials. These materials, in general, have lower tensile strength than standard materials and should only be specified if absolutely necessary. These springs have a lower overall height than comparable sizes made of standard materials, resulting in lower spring force. This must be taken into consideration when using these materials.

Corrosion-resistant materials

X10 CrNi 18-8 (1.4310):
This chromium-nickel alloyed steel according to DIN EN 10151 is the most commonly used material for disc springs up to a thickness of t = 3.0 mm. Unfortunately, the cold forming process makes in magnetic.

X7 CrNiAl 17-7 (1.4568):
This steel alloy according to DIN EN 10151 is a precipitation- hardened spring steel which is processed in cold-strained condition up to a thickness of approx. 2.5 mm. The cold forming process makes this material magnetic.

X5 CrNiMo 17-12-2 (1.4401):
With this steel according to DIN EN 10151, the strength is somewhat less than that of the previous two. However, it offers higher corrosion resistance and lower magnetism. Small amounts of this material are hard to procure, and it is thus rarely used.

High-temperature materials

X22 CrMoV 12-1 (1.4923):
This chromium-molybdenum-vanadium steel according to DIN EN 10269 that can be quenched and tempered has proved very well for the use of heat-resistant disc springs.

X39 CrMo 17-1 (1.4122):
This is a chromium-molybdenum alloyed steel according to DIN EN 10088-2 that can be quenched and tempered. This material grade has also proved very well for the use of heatresistant disc springs. Please bear in mind that both steel grades mentioned are not considered as corrosion-resistant steel grades.

Anti-magnetic and corrosion-resistant materials

CuSn 8 (2.1030):
Tin bronze according to DIN EN 1654 is an alloy consisting of copper and tin, maintaining its spring characteristics due to cold forming. Please bear in mind that the strength values and the spring forces resulting from it are considerably lower than with the standard material.

CuBe 2 (2.1247):
Copper-beryllium according to DIN EN 1654 is an excellent spring material grade which is suitable for extremely low temperatures up to the vicinity of the absolute zero point. These copper alloys are absolutely anti-magnetic, and they have a very good electric conductivity. Furthermore they show a high corrosion resistance against many media.

Heat-resistant special materials with a very good corrosion resistance

Due to their composition, these nickel-base alloys show an excellent resistance against a lot of media. Unfortunately, they are expensive and often hard to procure. As these material grades are often used under extreme operational conditions, a potential creeping under load might lead to a loss of installation height/loss of force of the disc spring. This creeping is a function of temperature, time and tension. A disc spring can be used at higher temperatures, for example, when either a low load is chosen or the exposure time is accordingly short. Thus a maximum working temperature cannot be stated. The values stated in the material grade overview table can therefore serve as a guiding value only.

NiCr 20 Co 18 Ti (NIMONIC 90) (2.4632):
This nickel-cobalt alloy shows very good high temperature strength characteristics and can be used for higher temperatures with corresponding dimensioning.

NiCr 15 Fe 7 TiAl (INCONEL X 750) (2.4669) and NiCr 19NbMo (INCONEL 718) (2.4668):
These nickel-chromium alloys are virtually cobalt-free and for this reason they are often used in nuclear reactor technology.

Surface protection:

Disc springs are used in many applications where corrosive media are common.

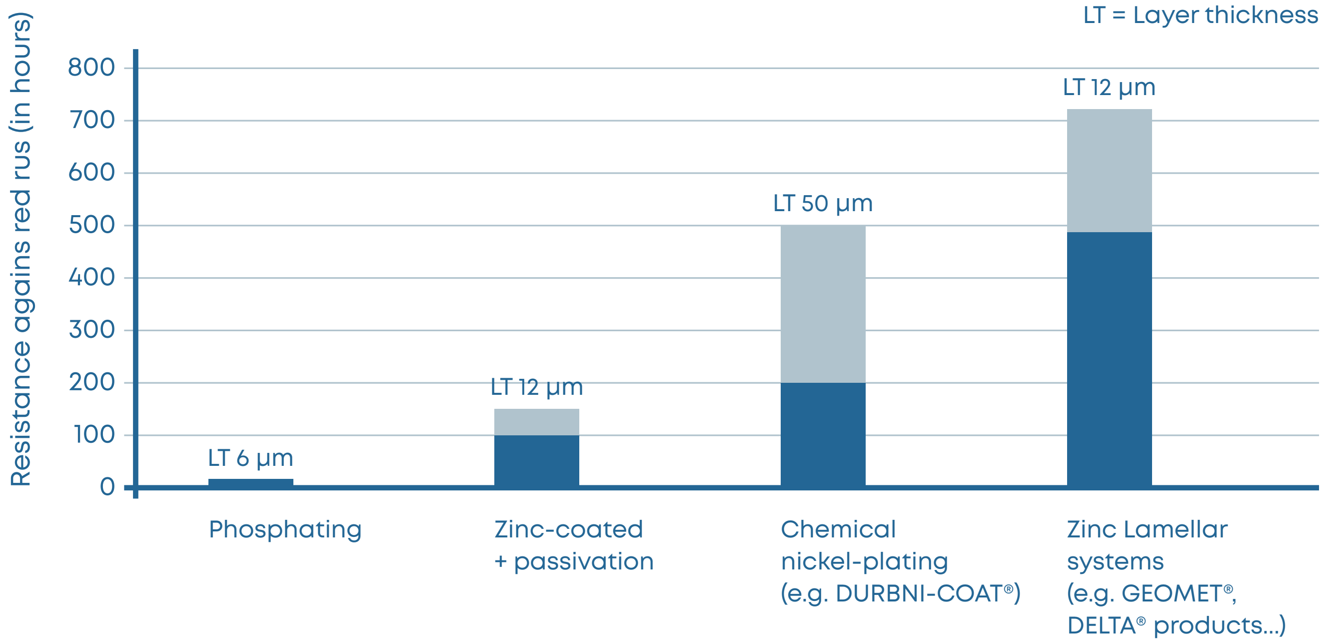
When used in outdoor areas, the spring steel is attacked by condensation, rain, river- and sea water. Further applications can be found in automotive building, the food industry, household appliances (e.g. washing machines), bridge building, the aerospace industry etc.

In such instances, watery or chloride-containing solutions, acids and etches in various concentrations may make contact with the disc springs.

In these cases, the standard spring steels do not provide sufficient protection and need specific surface treatment to have suitable protection for their working environments.

The criteria given in the following tables are intended to help you find the surface protection best suited for your applications.

Surfaces in the salt spray test in accordance with DIN EN ISO 9227



Browning:

Browning simply produces an oxidized surface; the springs are coated with corrosion resistant oil.

Herewith the corrosion resistance is not as good as with phosphating; therefore this treatment is mostly used where a phosphate coating or its abrasion poses a problem.

Phosphating:

Phosphating is the standard process generally applied for disc springs made of low-alloy steels unless otherwise agreed upon.

A zinc phosphate layer is produced on the surface, which is then impregnated with corrosion-protection oil.

In the vast majority of all cases, the protection achieved in this way suffices. For indoor or outdoor applications, no additional protection is required if the springs are installed with weather protection.

Galvanic zinc plating:

With electroplating, virtually any metal can be precipitated as a surface coating.

However, when treating high-tensile steels – like those always used for disc springs and bolt-locking devices – the danger of hydrogen embrittlement cannot be excluded under application of the current technological standards.

Thermal post-treatment is also no guarantee that this risk is completely eliminated.

Thus, this process is not recommended for disc springs.
Thus when safety is an issue, the use of corrosion-resistant materials should be preferred.

Mechanical zinc plating:

With the mechanical zinc plating process, the parts to be treated are moved in a barrel together with peening media, e.g. glass beads. A so-called promoter and the coating metal (preferably zinc) are added in powdered form.

This powder deposits on the surface and is compacted by the peening media.

A uniform, non-glare coating results, which can be subsequently chromatized in much the same way as electroplating.

The usual layer thickness is 8 μm, however, thicknesses of up to 40 μm are possible.

NOTE: It is of particular importance that hydrogen embrittlement is prevented by a correct performance of the process.

Zinc flake coatings:

Zinc flake coating is an inorganic, metallic silver-grey coating of zinc and aluminium flakes.

The parts are suitable as barrel or rack plating. Afterwards, the coating is baked into the surface.

Disc springs coated with this process feature excellent resistance in the salt spray test.

Under application of standard process technology, hydrogen embrittlement is completely ruled out.

Chemical nickel-plating:

Chemical nickel plating is also known as “electroless nickeling”. This is a process whereby a nickel-phosphor alloy is chemically precipitated onto the surface of the basic material.

This results in a thick, hard layer with sharp contours and outstanding corrosion and abrasion resistance. The coating is usually applied in layers with a thickness of 15- to 30 μm.