GUIDE TO
SPRING DESIGN

ENGINEERING SOLUTIONS ISO 9001

MID-WEST SPRING AND STAMPING

800-424-0244

www.mwspring.com

GUIDE TO SPRING DESIGN

How to use this guide

This Guide to Spring Design was developed to assist engineers and designers to plan, design and specify custom springs, wire forms and stampings. The data it summarizes is intended to help you avoid costly errors and omissions.

You can submit your request for a quote at www.mwspring.com or send us a fax to our quoting department at (574-807-6477)

About Mid-West Spring & Stamping
Established in 1928, Mid-West Spring and Stamping, Registered ISO 9001, is dedicated and experienced when it comes to springs, wire forms and metal stampings. Today, Mid-West Spring & Stamping is privileged to be a multi-plant spring manufacturer with a full-range of products and services.

We've established a strong foundation for our company, built on quality and reliability. You will not find a more dedicated and experienced custom spring manufacturer. All of our products are manufactured to the highest standards. We supply service-conscious customers coast-to-coast.

Our Difference
We are good people creating good products with good processes. We have experienced people that care. They are proud of their craft and seek continuous improvement.
We are an ISO 9001 registered company and take great pride knowing that it is our people and the process they develop that sustain our quality and repeatability.
It is that edge that we proudly offer.

Engineering & Design Assistance
Mid-West Spring & Stamping can also provide you with engineering and design assistance. We have a staff of product engineers who are ready to help you determine what spring design best fits your application.

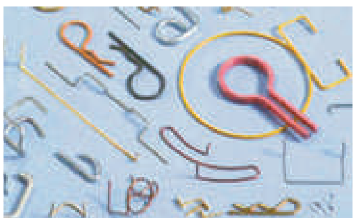
Feel free to speak with one of our engineers at
800-424-0244 (Fax 574-807-6477).

Nobody offers you more options.

At Mid-West Spring & Stamping, the custom compression, torsion and extension springs discussed in this guide are only the beginning of our capabilities. We are also your high quality certifiable source for many other types of springs, wire forms and stampings like those shown below.

Clock, die and special springs

Custom die springs are available in most lengths and deflections; we can produce flat spiral clock or motor springs for most design specifications.



Wire Forms

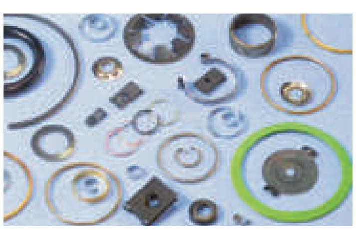
Mid-West Spring can supply virtually any form you require from .010" to .750" round, square or rectangular wire. Our specialized background and equipment allow for an unlimited range of possibilities from clips and clamps to the unusual in size, shape and application.

Precision Engineered Formed Parts

Mid-West Spring specializes in complex, precision custom designs. Professional, skilled and responsive engineers at Mid-West Spring offer unlimited options in the design and manufacture of high-precision parts. Competitively priced, Mid-West Spring supplies millions of these parts to meet industry needs each year.

Multi-Slide, Flat Springs & Stampings

Mid-West Spring supplies an array of multi-slide stampings and flat springs, which are produced from annealed materials hardened and tempered to your critical shape and form design. Applications include, but are not limited to: connectors, fasteners, hinges and holding brackets.



Springs, Washers & Snap Rings

These are available in slotted, curved, wave, Belleville disc and special in order to solve problems of high loads in limited spaces. SNAP RINGS are available in round, square or rectangular wire for retention of components.

Compression Springs

Materials: Most materials and alloys

Wire Sizes: 004" to .750" round (square or rectangular upon request)

Quantity: Any

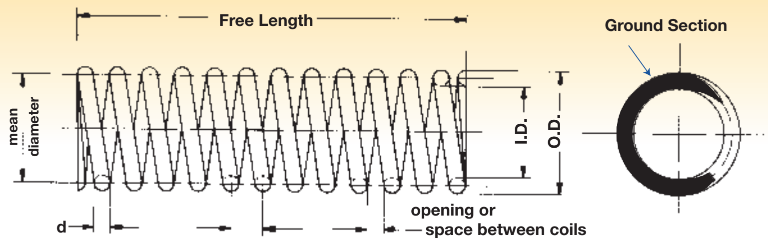
Typical Applications: Fluid/air controls, automotive, switches, off-road equipment, aerospace

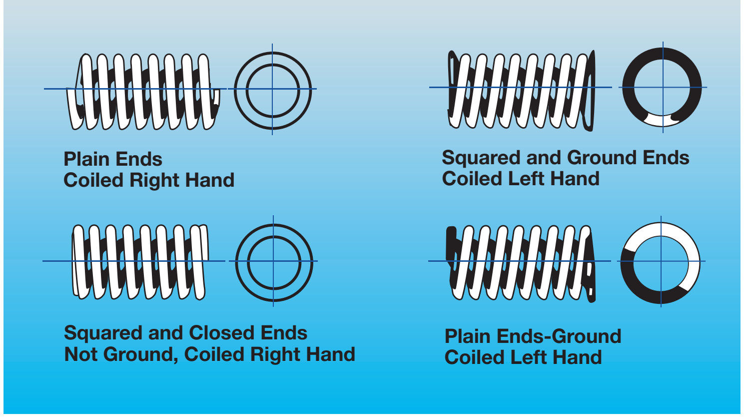
Premier Compression Spring Manufacturer

We produce custom compression springs for your unique applications. Most compression springs are manufactured as a straight cylindrical spring, made with a variety of sizes and types of wire. Other compression springs are designed in the form of a cone, allowing longer travel due to the individual coils not being forced against each other.

Some important factors to consider when ordering your custom compression springs:

End treatment - Custom springs can have open, open and ground, closed or closed and ground ends.
Free length – How long is the spring when fully extended?
Helix direction -The direction of coils is right or left-handed, depending on how the machine making them is set up. Handedness is important in very few applications.
Load at Solid Height – The force in pounds required to collapse the spring completely.
Solid height – What is the length of the spring when completely compressed?
Spring Rate – How much force in pounds per inch of deflection does it take to compress the spring? See calculating procedure below.
Total number of coils in the spring
Outside diameter of the spring
Wire diameter – Diameters of .007" to .750 are available in round, square or rectangular.
Wire material – Custom springs are available in a variety of steel and non-ferrous alloys.





Formlula Index

R = Rate	p = Pitch	d = Diameter of wire
P = Load in Pounds	M = Moment or torque, in lb	Pi = 3.14
S = Stress(uncorrected)	E = Modulus of Elasticity in bending	L = Length
SH = Solid Height	N_a= Active coils	D = Mean diameter of coil
G = Modulus of elasticity in torsion	N_t = Total Coils	S_k = Corrected Stress

MID-WEST SPRING AND STAMPING

Extension Springs

Materials: Most materials and alloys

Wire Sizes: 004” to .750” round (square or rectangular upon request)

Quantity: Any

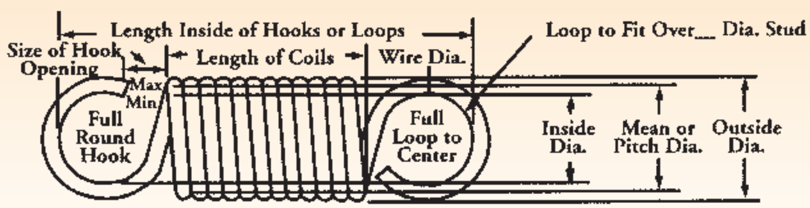
Typical Applications: Automotive, window components, lawn and garden equipment, and many other OEM applications - unlimited end styles are available.

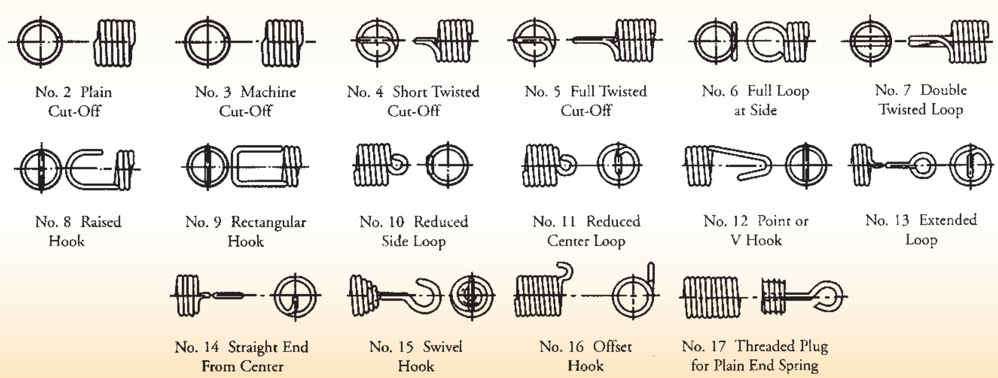
Premier Extension Spring Design

Rectangular wire springs and extension springs manufactured by MWS are engineered to exact customer specifications.

Some important factors to consider when ordering your custom extension springs:

End Style
Extension Spring Diameter – O.D. maximum, I.D minimum
Extension Spring Rate – What is the load in pounds per inch required to extend the spring?
Length of inside hooks
Load fully extended – For a specific application, you will need to know the total load at the maximum extended length
Total number of coils.
Winding direction – ***THE DIRECTION OF THE COIL*** is right-hand or left-hand winding. Handedness is important in very few applications.
Wire diameter – We can produce an extension spring in diameters from .007” to .625” round, up to .375” square and rectangular to specifications.
Wire material – We can furnish springs in most metals and alloys.





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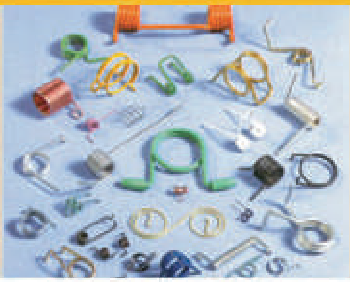
Torsional Modulus Elasticity

Steel . . . . 11.5 x 10^6	Chrome Silicon . . . . . . 11.5 x 10^6
Phosphor Bronze . . . . 6.25 x 10^6	Stainless Steel . . . . 10 x 10^6
Chrome Vanadium . . . . 11.5 x 10^6	Brass . . . . 5.5 x 10^6

Use Compression Rate and Stress Formulas for calculating extension springs.
1.75 x ID = Height of regular hooks (divided by 2 for one end)

MID-WEST SPRING AND STAMPING

Torsion Springs



Materials: Most materials and alloys

Wire Sizes: .004" to .750" round (square or rectangular upon request)

Quantity: Any

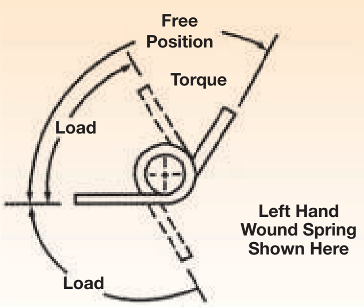
Typical Applications: Automotive, irrigation, heavy agriculture and construction equipment
Torsion springs generally require ample axial room, with the best designs working over an arbor or shaft.

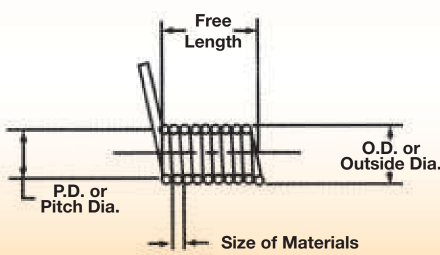
Expertly Engineered Torsional Springs

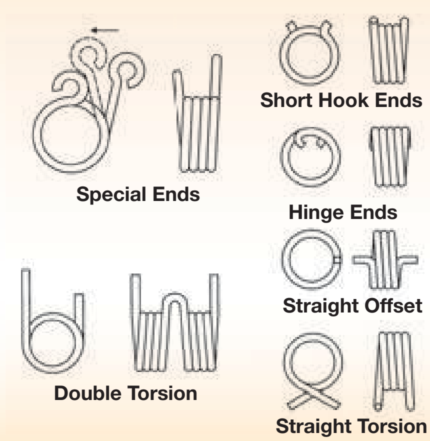
We offer torsion springs in a variety of wire diameters from .007" to .625". Square wire torsion springs are also available. Common torsion springs are found in clothes pins, clipboards, and garage doors. In addition, torsion springs are also used as hinges and counterbalances in a variety of applications.

Some important factors to consider when ordering your custom torsion springs:

Expected deflection in degrees
Free position of the ends in degrees
Frequency of rotation
Inside diameter of spring – See mandrel information below.
Length of leg ends – Torsion spring end style is straight legs.
Mandrel size – Usually torsion springs are used over a mandrel, shaft or arbor. Suggested mandrel diameter should leave 10% clearance within the inside diameter of the torsion spring for deflections. For greater deflections reduce mandrel size.
Maximum wound position in number of turns or degrees from free position
Range of operating temperature
Spring outside diameter – Maximum outside diameter is controlled by performance and space considerations.
Torque – Force of load as inch-pounds at stated deflection in degrees.
Winding direction – Helix direction is either right hand or left hand and since force is applied to torque and not deflection, right and left cannot be interchanged.
Wire diameter – MWS makes torsion springs from .007" to .625" round wire, square to .375" and rectangular to specification.
Wire material – Torsion springs can be made from most metals and alloys.







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SH = Solid Height	N_a= Active coils	T_1 = Torque (Load Point)
G = Modulus of elasticity in torsion	N_t = Total Coils	T_2 = Torque (Load Point)
	D = Mean diameter of coil	S_k = Corrected Stress

Torsional Modulus Elasticity

Steel . . . . 11.5 x 10^6	Chrome Silicon . . . . . . 11.5 x 10^6
Phosphor Bronze. . . . . 6.25 x 10^6	Stainless Steel . . . . 10 x 10^6
Chrome Vanadium . . . . 11.5 x 10^6	Brass. . . . . 5.5 x 10^6
Use Compression Rate and Stress Formulas for calculating extension springs. 1.75 x ID = Height of regular hooks (divided by 2 for one end)	

MID-WEST SPRING AND STAMPING

Material Selection

High carbon spring steels are the most commonly used of all materials. Try to use these materials in preference to others because they are least expensive, readily available, easy worked, and most popular. These materials are not satisfactory for high or low temperatures or for shock or impact loading.

	Material	Method of Manufacture • Chief Uses • Special Properties
High Carbon Wire	Music Wire ATSM 228	Cold drawn. High and uniform Tensile. High quality springs and wire forms
	Hard Drawn ASTM A 227	Cold drawn. Average stress applications. Lower cost springs and wire forms
	High Tensile Hard Drawn ASTM A 679	Cold drawn. Higher quality springs and wire forms.
	Oil Tempered ASTM A 229	Cold drawn and heat treated before fabrication. General purpose spring wire.
	Carbon Valve ASTM A 230	Cold drawn and heat treated before fabrication. Good surface condition and uniform tensile.

The alloy spring steels have a definite place in the field of spring materials. Try to use these materials, particularly for conditions involving high stress and for applications where shock or impact loading occurs. Alloy spring steels can also withstand higher and lower temperatures than the high-carbon steels and are obtainable in either the annealed or pre-tempered conditions.

	Material	Method of Manufacture • Chief Uses • Special Properties
Alloy Steel Wire	Chrome Vanadium ATSM A231	Cold drawn and heat treated before fabrication. Used for shock loads and moderately elevated temperatures.
	Chrome Silicon ASTM A401	Cold drawn and heat treated before fabrication. Used for shock loads and moderately elevated temperatures. (***Mid-West Spring recommends that Chrome Silicon never be electro-plated.)***

The use of stainless steels has increased considerably in recent years. Several new compositions are now available to withstand corrosion. All of these materials can be used for high temperatures up to 650°F.

	Material	Method of Manufacture • Chief Uses • Special Properties
Stainless Steel Wire	ASI 302-304 ATSM 313	Cold drawn. General purpose corrosion and heat resistant. Magnetic in spring temper.
	ASI 316 ASTM A313	Cold drawn. Heat resistant and better corrosion resistant than 302. Magnetic in spring temper.
	17-7 PH ASTM A313 (631)	Cold drawn & precipitation hardened after fabrication. High strength and general purpose corrosion resistance. Slightly magnetic in spring temper.

Copper-based alloys are important spring materials because of their good electrical properties combined with their excellent resistance to corrosion. Although these materials are more expensive than the high-carbon and alloy steels, they nevertheless are frequently used in electrical components and in subzero temperatures. All copperbased alloys are drawn to the American wire gage (same as Brown & Sharpe gage) and are magnetic.

	Material	Method of Manufacture • Chief Uses • Special Properties
Non-Ferrous Alloy Wire	Phosphor Bronze Grade A ASTM B159	Cold drawn. Good corrosion resistance and for electrical conductivity.
	Beryllium Cooper ASTM B197	Cold drawn and may be mill hardened before fabrication, good corrosion resistance and electrical conductivity. High physicals.
	Monel 400 AMS 7233	Cold drawn. Good corrosion resistance at moderately elevated temperatures.
	Monel K500 QQ-N-286	Excellent corrosion resistance at moderately elevated temperatures.

Nickel-based alloys are especially useful spring materials to combat corrosion and to withstand both elevated and below-zero temperature applications. Their magnetic characteristics are important for such devices as gyroscopes, chronoscopes and indicating instruments. These materials have high electrical resistance and should not be used for conductors of electric current.

	Material	Method of Manufacture • Chief Uses • Special Properties
High Temperature Alloy Wire	A286 Alloy	Cold drawn & precipitation hardened after fabrication. Good corrosion resistance at elevated temperatures.
	Inconel 600 QQ-W-390	Cold drawn. Good corrosion resistance at elevated temperatures.
	Inconel 718	Cold drawn & precipitation hardened after fabrication. Good corrosion resistance at elevated temperatures.
	Inconel X-750 AMS 5698, 5699	Cold drawn & precipitation hardened after fabrication. Good corrosion resistance at elevated temperatures.

Flat High-Carbon Spring Steels	Flat high-carbon Spring Steels General. Although several types of thin flat strip are available for specific applications in watches, clocks and certain instruments only two types are readily available. These two compositions are used for over 95% of all applications requiring flat high-carbon strip. Although these materials are frequently plated, sections under 0.015 in. having carbon content over 0.85 with hardness over Rockwell C47 are highly susceptible to hydrogen-embrittlement even though special plating and heating operations are employed.

Glossary of terms

Active coils (n)- Those coils free to deflect under load.

Closed ends - In compression springs, ends in which the pitch of the terminal coils is reduced so that they touch the adjacent coils.

Closed and ground ends - Closed ends ground to provide a flat plane.

Close-wound spring - coiled with adjacent coils touching.

Coils per inch - *See pitch.*

Deflection (F) - Motion of spring ends or arms under the application or removal of an external load (P).

Elastic limit - Maximum stress to which a material can be subjected without permanent set.

Free angle - In torsion springs, the angle formed by the spring's arms under no load.

Free length (L) - The overall length of a spring under no load.

Heat setting - Fixturing a spring at elevated temperature to minimize loss of load at high operating temperature. Helix the spiral form (open or closed) of compression, extension and torsion springs.

Hooks - The open loops or ends of an extension spring.

Hydrogen embrittlement - Condition in which hydrogen is absorbed into carbon steel causing brittleness and susceptibility to cracking, particularly under sustained loads. Often occurs during electroplating or pickling.

Initial tension (P) - The resistance that tends to keep the coils of an extension spring closed. This force must be overcome before those coils will begin to open.

Load (P) - Any force applied to a spring which, in sufficient degree, will cause deflection.

Loops - Coil-like wire shapes at the end of extension springs that provide for attachment and force application.

Mean coil diameter (D) - Outside spring diameter (OD) minus one wire diameter (d).

Modulus in shear or torsion (G) Coefficient or stiffness for extension and compression springs.

Moment (M) see torque.

Open ends - In compression springs, ends with a constant pitch for each coil. May be ground or un-ground.

Passivating - Acid treatment to remove contaminants and improve corrosion resistance in stainless steel.

Permanent set - Condition in which a material does not return to its original condition when a load is removed. Occurs when the material's elastic limit has been exceeded.

Pitch (p) - The center-to-center distance between adjacent active coils. (The recommended practice is to specify number of active coils rather than pitch).

Rate (R) - The change in load or unit of deflection. Most often given in lb/in.

Remove set - The process of closing to solid height a compression spring that has been coiled longer than the desired finish length, so as to increase the apparent elastic limit.

Residual stress - Stress induced by set removal, shot peening, cold working, forming or other operations. May be beneficial or detrimental, depending on the application.

Set - *See permanent set.*

Solid height (SH) - The length of a compression spring under load sufficient to bring each coil into contact with adjacent coils.

Spring index - Ratio of mean coil diameter (D) to wire (d).
Squared and ground ends.
See closed and ground end.
Squared ends
See closed ends.

Stress range - The difference in operating stress under minimum and maximum loads.

Stress relieve - To subject springs to low-temperature heat treatment to relieve residual stress.

Shot peening - A cold-working process in which the material surface is peened to induce compressive stresses, thereby improving fatigue life.

Torque (M) - In torsion springs, twisting action that tends to produce rotation. Equals load x distance (moment arm) from the load to the axis of the spring body. Most often expressed in-oz or ft-lb.

Total number of coils (Nt) - Number of active coils (Na) plus the coils forming the ends.

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