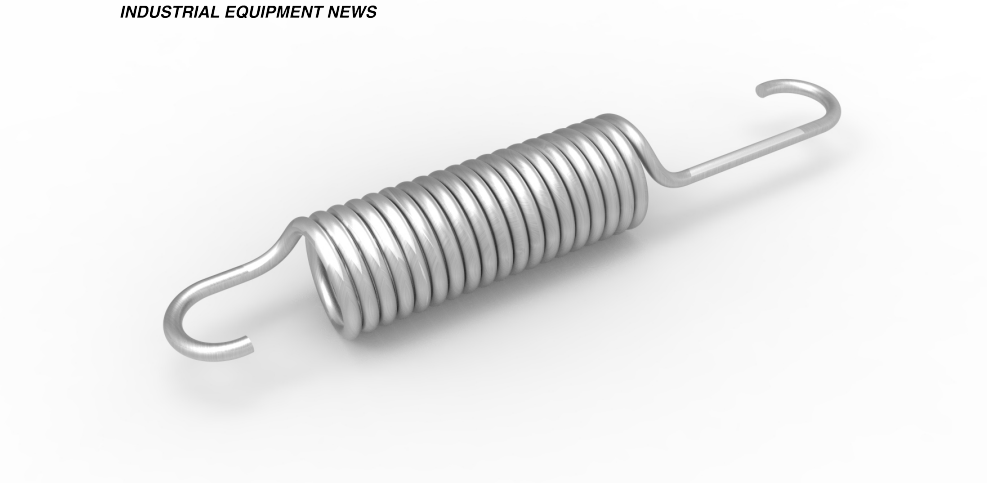
SPRINGS 101

MAKING ENDS MEET

How to design the right types of ends or mating components for the three most popular types of springs: extension springs, compression springs, and torsion springs.



EXTENSION SPRINGS

An extension spring is required any time the application calls for a spring that will work in tension. The spring body will be extended during use, so the most common type of ends are hooks.

HOOKS

Hooks come in many different shapes and sizes. Standard hooks are simple loops at each end. Hook size and length are important because the design can make the part more cost-effective as well as more durable.

Sometimes, a reduced hook can be used to decrease the bending moment (or bending stress). The maximum bending moment occurs close to the applied load. Reducing the hook decreases the distance between the applied load and the part of the wire that sees the highest moment.

Hooks can be found in most extension spring applications, they are made from the same wire as the spring body in one continuous manufacturing process. However some applications require end fittings or swivel hooks.

Wire size is the only limitation for extension springs, and at some point the wire becomes too large to bend the hooks — especially with 0.5” or larger wire.

When using larger wire, one solution to minimize hook failure is to design the hook and the body of the spring as separate components.

- **SWIVEL HOOK DESIGN**
  The swivel hook, like the attachments commonly found on dog leashes, enable a larger diameter wire to be used for the hook, and therefore reduce some stresses.

- **END FITTING**
  An end fitting is the most expensive solution, but also the best way to reduce failures. End fittings are screwed onto a spring and are typically used in mission critical applications, such as the landing gear spring for a jet airplane. For most industrial uses, an end fitting is not worth the expense, but they are used occasionally.

GAP

Also known as the loop opening, if the gap is too small, the spring won’t fit the assembly. If the gap is too big, the spring could come loose during operation. The best way to ensure the correct gap size is to plan ahead and design the components that the spring is hooking onto.

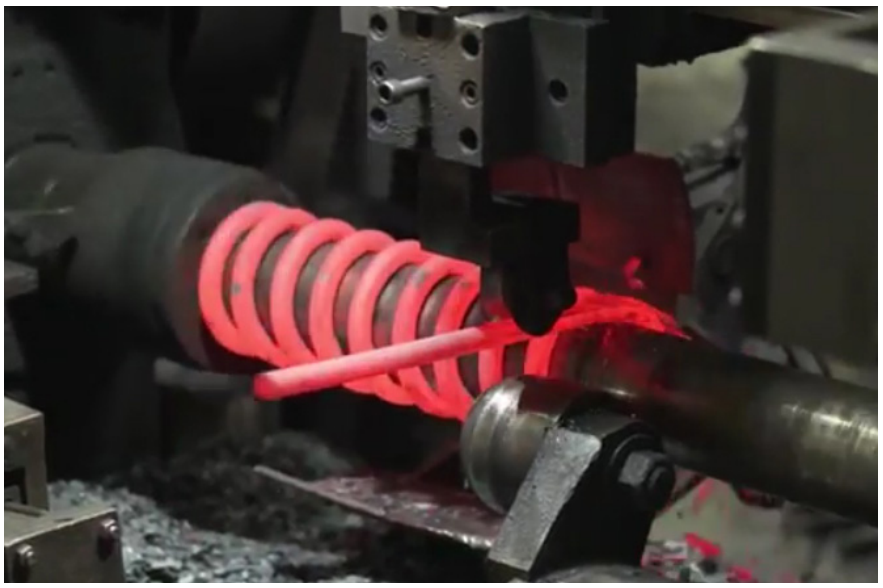
MATERIALS

The most common material is music wire, a high-carbon steel alloy. Music wire is cold drawn and has a uniform tensile strength, and is generally used for small springs less than ¼” in diameter.

Stainless steel is another common material used to manufacture springs, particularly 302 stainless steel. Stainless steel also gets its strength from the drawing process, but it doesn’t have the tensile strength of music wire. Stainless steel is a little bit more expensive, but it does provide some corrosion resistance that the music wire does not provide.

DESIGN TIPS

According to Bob Townley, senior engineer at Atlantic Spring, a MW Industries company, the majority of extension spring failures occur at the hooks and not the body. *“You want to design a hook that’s going to minimize failures. You do that by allowing generous radiuses,”* he says.



COMPRESSION SPRINGS

A compression spring decreases in length during use to provide a deflected force. Like extension springs, they come in all sizes, from little tiny springs that you might find inside of a pen, to huge hot-wound springs that you might find on a train.

MATE/MOUNT

A compression spring is typically sandwiched between two parts of an assembly that are being compressed. The ends of compression springs are typically ground flat (about half the wire is ground flat), which gives the spring a good bearing surface and lets it stand up essentially by itself without falling over.

HOW THEY ARE MADE

Compression springs (and extension springs) are coiled. The same machine will coil an extension spring or a compression spring, but there are two differences. One is that the compression spring obviously has to have a gap between the coils, because it needs to compress (also known as open-wound). In an extension spring, the coils can be touching each other because as the spring works, the coils are pulled away from each other.

Sometimes, an application calls for multiple compression springs in order to meet the force tolerances. In such applications, the springs are either assembled next to each other, or on top of one another. That is, they are either in parallel or in series.

Compression springs are ground so that the load is spread over the entire spring. Not grinding a spring can cause load problems, such as an off center load, which can lead to catastrophic failures.

Compression springs are usually fit into something, such as a groove, or work over a component, like a cylinder.

APPLICATIONS

Compression spring applications range from the aforementioned rail cars — which use hot wound springs, up to 3.0” or more bar diameter — to shutting valves and vibration isolation applications.

If the application calls for fairly small springs, for example less than .031” wire, the ends do not have to be ground in order to work properly. Grinding is usually the biggest cost of a compression spring.

DESIGN TIPS

Whenever possible, use a standard spring, especially in the research phase of a project.

Typically, off-the-shelf springs are used for research, but as an application heads into development, it is best to collaborate with a spring manufacturer. Spring manufacturers can spot common problems, fix critical problems, and help speed the application through development.

“We deal with a lot of companies that have a whole design completed before they say, ‘Okay, we’re going to put the spring in this spot,’” says Bob Townley, senior engineer at Atlantic Spring. *“By the time they get to us, they need a spring an inch in diameter and they need 500 pounds of force to compress a few inches. Many times, there just isn’t enough room.”*

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TORSION SPRINGS

A torsion spring is meant to twist, or torque. Instead of being compressed or extended, it's twisted. Some examples that call for a torsion spring include garage door springs, clothespins, and lift ramps.

The torsion spring can be the easiest spring to design for a piece of equipment because the torquing mechanism and spring ends can be very custom configured. The ends can fit over, into, and around anything needed for the application. Compression springs use a flat surface; extension springs use hooks, but torsion spring ends are nearly unlimited.

FASTENING OR MATING

The torsion spring must always deflect the way it's coiled — the spring should increase the number of coils during use, not decrease the number of coils.

NUMBER OF COILS

The number of coils is dependent on the amount of deflection required. The more deflection, the more coils.

For example, consider a torsion spring that holds up a copy machine cover. To prevent the cover from slamming down when the cover is closed, a torsion spring is installed at the hinge. As the cover is being closed and the weight of the cover is coming down, the torsion spring is deflecting the force. The more it's deflected, the more torque it is going to put out.

The spring design can be more complicated, because of the requisite. If the spring is too weak, the cover comes down on its own force (slams shut). If the spring is too strong, the cover may not shut at all. For this example, the ideal torsion spring will not only help close the cover, but also make it easier to open.

MATERIALS

Torsion springs use materials similar to compression and extension springs, primarily music wire and stainless steel. For heavier springs over ¼", applications typically use oil-tempered materials, which are heated and quenched during the drawing process.

Alloy steels such as chrome silicon make good spring materials. These materials have higher tensile strength (improved impact loading and shock resistance) and are better suited for higher temperature applications.

DESIGN TIPS

No matter the application, reach out to spring experts early in the design process to make sure that that part is not neglected. *"When you take a look at a spring initially, you want an idea of the spring's lifecycle,"* says Bob Townley, senior engineer at Atlantic Spring. *"Is it going to need hundreds of uses or millions? Or does it only need to be compressed once and then sit unused? These are the types of questions that a design engineer needs to ask, and a spring expert can help answer."*

GET STARTED

Don't wait until the final hour of your deadline. If your application calls for a spring, consult a spring expert, like the professionals at Atlantic Spring. It will save you design time and cost, as well as help prevent application failures.

For more information, visit:
www.mw-ind.com/brands/atlantic-spring/

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