

ROUND-WIRE WAVE SPRINGS ENABLE DESIGN EFFICIENCY



Wave springs manufactured from round wires take up less radial space and have a lower working height than other spring designs. Their precise load-deflection behavior combined with lower cost and near-zero-waste manufacturing add to their all-around design efficiency.

INTRODUCTION

Wave springs—wires shaped into sinusoidal waves—have a variety of uses across a broad spectrum of industries. They can be found in the oil and gas, automotive, aerospace, hydraulic, pneumatic, and electric industries, among others.

In these and other industries, the most common form of a wave spring is the single-turn, circular wave spring, a waved wire that traces one complete circle. Such springs provide mating forces in ball-valve seats, preload bearings, and enable efficient operation of clutches and other components.

Many wave spring designs start with a flat wire, but round-wire wave springs have several distinct advantages. The use of a round wire gives these wave springs unique attributes in geometry, performance, cost, and application.

GEOMETRY AND MECHANICS

The basic wave spring geometry sets these components apart from other spring types such as coiled or helical and disc springs. When load is applied to the sinusoidal wave forms, the spring compresses with a flattening of the crests. This flattening produces a bending load within the spring which is directed axially, so all the load is reacted by the spring itself.

In contrast, helical springs have a torsional reaction to compression that can lead to wasted energy, excessive heat, and fatigue. Disc springs also flatten, but the load is directed toward the outer edge of the discs into the mating surfaces of the application.

Standard Single Turn Wave Spring



PATENTED OPTIONAL END DESIGN

If a wave spring reacts its load through bending, then the spring's bending moment is of key importance. The circular cross-section of a round wire has a greater bending moment than of a flat wire of the same width. Designers can take advantage of this fact to simplify a complex stack of nested flat-wire wave springs into a single-turn round-wire wave spring. The simpler design saves money and may have a positive impact on space and weight, as well.

Round-wire single-turn wave springs have comparatively small free and working heights. For instance, Rotor Clip's standard line ranges from 0.062 in. to 0.268 in. of free height and 0.052 in. to 0.200 in. of working height. Wave springs take up about half the height of helical springs for the same spring force.

[Round Wire Single Turn Wave Spring](#)



Wave springs also save space radially compared to disc springs. The difference between the inner and outer diameters of a disc spring is usually at least twice as large as that of a wave spring. In fact, in a wave spring, this distance is only the diameter of the wire.

The increased space efficiency afforded by wave springs opens up design options. Designers can choose to shrink the bores needed around a standard shaft to save space and weight. Or, they may opt to boost shaft diameter within a fixed bore for more robust performance.

Standard round-wire wave springs can fit housings with inner diameters of 0.50 in. to 6.00 in. in 0.125 in. increments. The same range is true of shaft outer diameters, which can range from 0.408 in. to 5.644 in.

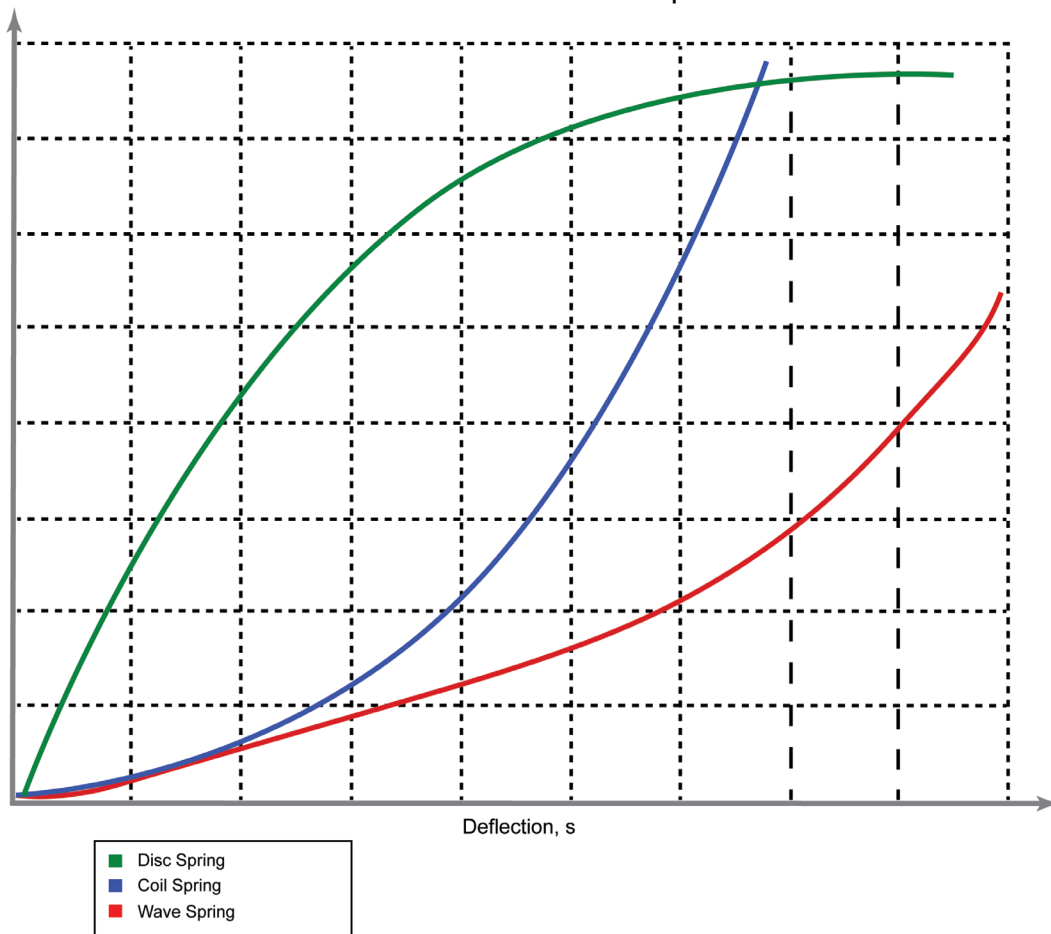
Using these wide product ranges, designers can choose which tolerances to focus on to improve ease of assembly. For instance, a round-wire single-turn wave spring can press fit into the inner diameter of a bore or onto the outer diameter of a shaft, depending on the dimensions chosen. Cling-to-shaft or cling-in-bore designs let installers pre-install the wave spring either on the shaft or in the housing prior to mating without fear of the spring becoming dislodged in the assembly process.

WAVE SPRING PERFORMANCE

The performance of a spring component is of equal importance to its geometry. When evaluating spring candidates, designers will first want to consider their spring rates.

Spring rate is a measure of how far the spring will deflect in inches for a given force. Each spring design has a different characteristic force-deflection curve. For example, disc springs have a steep slope—and a high spring rate—indicating that they show little deflection until relatively high loads are reached. This can be effective for designs where the goal is minimal dimensional change over a wide range of loads.

Load-Deflection Curves Compared

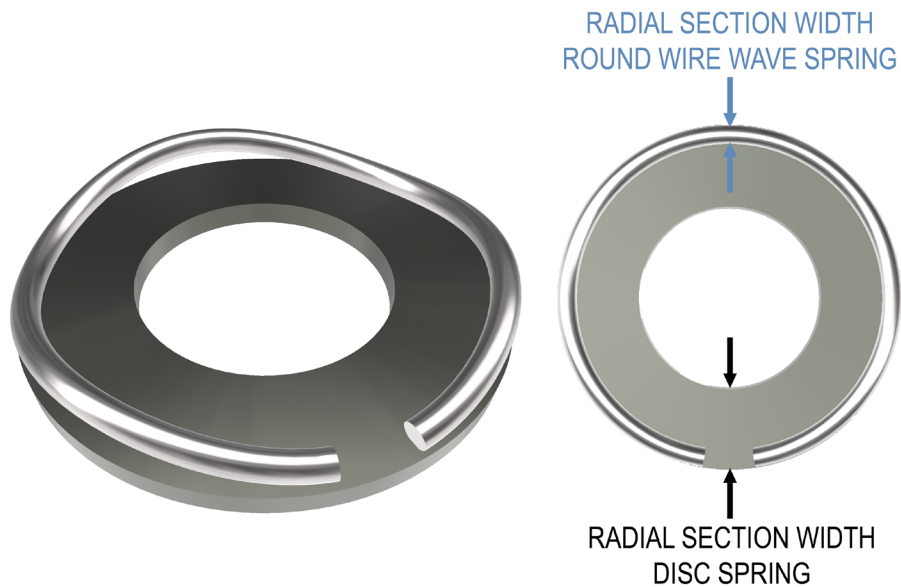


However, designers looking for more precise control of the deflection or of the reacted load may choose a lower spring rate, such as that found in round-wire single-turn wave springs. The spring rates of these springs range from approximately 3,500 lb/in. to 6,900 lb/in., depending on the section diameter and the number of waves around the spring's circumference.

Another key feature of round-wire single-turn wave spring performance is the length of the linear region of its force-deflection curve. Since the spring rate is the slope of this curve, a longer linear region indicates more predictable loading and unloading of the spring. At their working heights, round-wire single-turn wave springs can react 35 lb to 470 lb, depending on their geometry.

The linear behavior of these wave springs extends from 30% to 70% of their full deflection range and is due to the bending behavior described above.

Comparison of Round Wire Wave Spring to Disc Spring



Helical springs may start with a similar spring rate to round-wire wave springs, but they quickly depart from linearity due to their torsional response to applied load. Helical springs have a linear range about a third as long as that of wave springs.

One performance consideration not addressed by round-wire wave springs' force-deflection curve is their lifecycle. These wave springs are generally suited to static or low cycle applications, where they can function with no fatigue effects almost indefinitely.

In contrast, nested flat-wire wave springs do have a finite fatigue life, as the individual wires move and fret against each other during compression.

Disc springs, especially if not deburred, also cause wear as their outer diameters slide along their mating surface or the walls of the bore in which they sit.

MANUFACTURING ADVANTAGES

Round-wire single-turn wave springs' attributes are due, in part, to their geometry and manufacturing process. In particular, the way these springs are made contributes to their lower cost and longer life.

Standard round-wire single-turn wave springs are made from SAE 1070-1090 carbon steel or 17-7 stainless steel. The more commonly selected carbon-steel material is pre-hardened and less expensive. Designers choose the stainless-steel grade for high stress and fatigue applications and when more resistance to higher temperatures and corrosion is required.

For applications that see extremely high temperatures or corrosive environments, specialty materials are available.

These include AISI 302 and 316 stainless steel, A286 iron-nickel alloy, Inconel X-750, Elgiloy, Hastelloy C276, beryllium-copper, and phosphor-bronze.

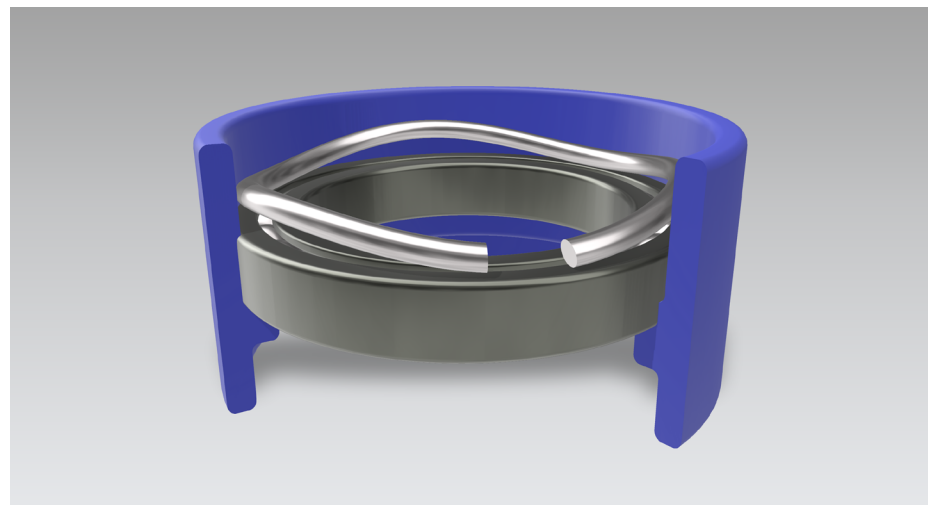
The process for creating a round-wire wave spring from any of these alloys is the same. The wire is formed by edge coiling rather than drawing. This results in microscopic metallic grains wrapping around the wire's circumference.

The wires are then formed into their circular shape as sinusoidal waves are formed simultaneously. The number of waves of the standard range varies from three to six, depending on the circumference of the circle. The process produces virtually zero material waste.

By contrast, disc springs are created by stamping two concentric circles from a metal sheet. The inner circle and some material around the outer circle become scrap. Especially for high-value alloys, this wasted material adds to the final cost of the spring.

The stamping and forming process also cuts through grain boundaries and imparts directionality to the grains, introducing strain on the microscopic level. Because stamping also creates sharp edges, disc springs must undergo an additional production step: deburring. If they are not deburred, the sharp edges can cause significant wear of the mating surface.

Pre-load Bearing



IN THE FIELD

The efficient size, precise tolerances, and lower costs of round-wire single-turn wave springs makes them attractive in a multitude of applications.

One such application is electrical quick connectors. Wave springs supply the pressure needed to ensure a secure connection with threaded or bayonet-style locking. The ability of wave springs to cling in the bore or to the shaft of one of the mating parts lets them ease the assembly of this type of connector, especially in military, aerospace, and industrial applications where the connection could be made at any angle.

Round-wire single-turn wave springs are also found in hydraulic and pneumatic power assemblies. They flexibly take up axial play and keep internal components aligned. They can also act as preloads on directional control valves to ensure smooth and error-free operation.

Wave springs constructed from specialty alloys can extend the life of downhole applications where they can withstand the hazards of corrosive conditions and extreme temperatures. They frequently contribute to the reliability of fluid-transfer systems in these rugged conditions.

Another common application is bearing pre-load. Round-wire single-turn wave springs can replace multi-turn wave springs in some applications at a lower cost and with a smaller working height. Their precise and predictable load-deflection behavior lets them reliably hold bearings in position, even in high-load, narrow-race applications.

Wave springs can be especially helpful for bearing preload in rotational applications like propellers and rotor blades. Their lightweight and space-saving design has minimal impact on the design's rotational characteristics.

Round-wire single-turn wave springs can replace flat-wire multi-turn wave springs or disc springs in heavy-duty clutches, as well.

Their precise behavior and long life help keep the frictional elements of the assembly in contact, even in extreme conditions.

CONSIDERING THE DESIGN OPTIONS

Round-wire single-turn wave springs combine a space-saving design with precise load-deflection behavior and a variety of common and exotic material choices. These attributes give designers more latitude to size shafts and bores, save weight, plan for easier assembly, and meet the challenges of extreme application environments. At the same time, round-wire single-turn wave springs use less material and can cost less than disc springs or nested flat-wire wave springs in certain applications.

Designers considering round-wire single-turn wave springs for their fluid power, bearing preload, valve seat, or other applications can learn more by contacting a wave spring manufacturer like Rotor Clip, which has engineers available by phone, online, or in person to help with wave spring design or selection.

Ready to use a Round Wire Wave Spring in your next application? **Connect with one of our Engineers.**

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