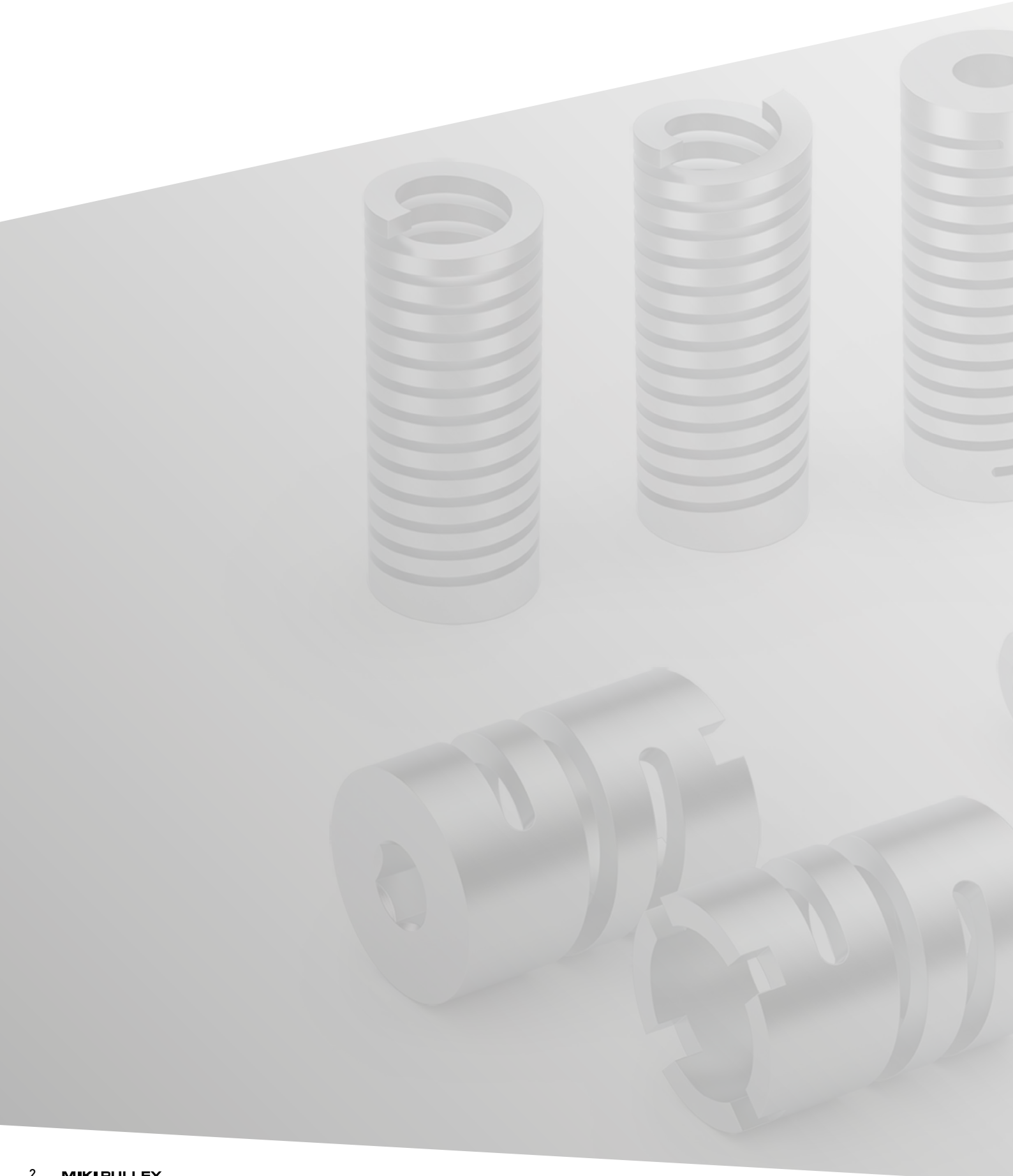


# Precision Springs



# Precision Springs





» **Content**

- 05 Technical Fundamentals
- 07 Materials and Design Features
- 10 Comparison: Standard Springs vs. Precision Springs

## Technical Fundamentals of Precision Springs

In engineering, springs are generally known as standard parts manufactured through cold or hot forming from alloyed or unalloyed spring steels with round, square, or rectangular cross-sections. Springs machined from a single piece of material, on the other hand, are less common.

These springs can absorb compressive, tensile, and torsional forces as well as bending stresses. Their particular advantage lies in the targeted combination of different spring characteristics within a single component.

Compared to coiled springs, they enable very precise and constant spring rates of up to  $\pm 0.1\%$  as well as a repeatability of up to 1%. They are manufactured from solid material, such as bars or tubes, into which a helical groove is cut.

Since machining does not create artificial internal stresses—only natural material stresses remain—the result is springs with a linear spring characteristic curve, high fatigue strength, and very good repeatability. Machined precision springs also offer numerous design advantages:

- Versatile mounting options without bent spring ends
- High strength and long service life
- Integration of additional functions into the component
- Wide selection of materials
- Multi-turn or counter-rotating helical designs to prevent buckling or rotation of free spring ends



Application Example: Custom Compression Spring

Original Solution (left): Compression spring consisting of three components

New solution (right): Precision spring consisting of a single component

Advantages of the new solution:

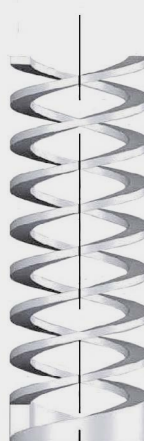
- Higher accuracy and operational reliability
- Only one component for the main “compression spring” function
- Minimization of procurement costs and inventory

## Force distribution

Single-coil compression spring



Precision spring



No unwanted lateral buckling with a double- or multi-coil precision spring.

Single-coil spring



Double-coil spring



In precision springs manufactured by machining, both left- and right-handed coils can be combined within a single spring. This effectively prevents unwanted twisting of the spring ends.



## Maximum Accuracy in Precision Springs

The machining process used to manufacture precision springs does not generate any additional internal stresses that must be overcome when the spring is loaded. Furthermore, due to the high manufacturing accuracy, all coil windings are active. As a result, the spring deforms uniformly under load and returns to its original shape once the load is removed. The result is a linear and precise spring characteristic curve.

For conventionally wound springs, the spring rate typically falls within a tolerance range of approximately  $\pm 10\%$ . Machined precision springs, on the other hand, achieve significantly lower deviations of about  $\pm 5\%$ . For custom solutions, tolerances as tight as  $\pm 1\%$  can even be achieved.

Particularly high precision with a nearly perfectly linear spring characteristic curve is required above all for very small stroke movements in high-precision control systems.

### Influence of the spring principle on the spring characteristic curve

Coiled spring



In coiled springs, the end coils are partially inactive due to their design. Consequently, a fully linear characteristic curve does not develop in the initial phase of deformation. To achieve a constant force curve, compression springs often need to be preloaded.

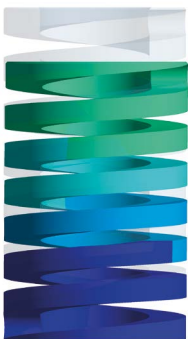
Precision springs



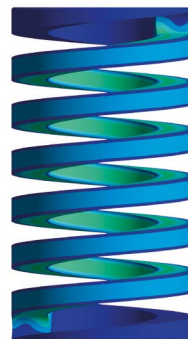
Since all coils are freely movable, the precision spring has a linear spring characteristic curve.

## Use of the Finite Element Method (FEM)

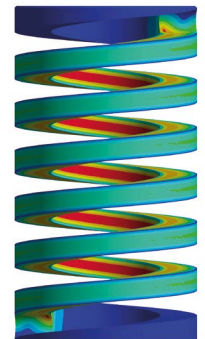
The Finite Element Method (FEM) is frequently used for the design and optimization of precision springs. This analysis allows for reliable predictions regarding strength, load-bearing capacity, and service life for specific applications.



Shifting



Torsion loading



# Materials and Design Features

## Wide Range of Materials for Precision Springs

Conventional coiled springs are usually made from spring steel wire in accordance with EN 10270-1. For machined precision springs, however, the choice of materials is significantly broader, since the material does not need to be formed but only needs to be machinable.

This allows, for example, the following materials to be used:

- Aluminum for particularly lightweight springs
- Plastics for electrically insulating applications
- Titanium for high-strength and corrosion-resistant precision springs

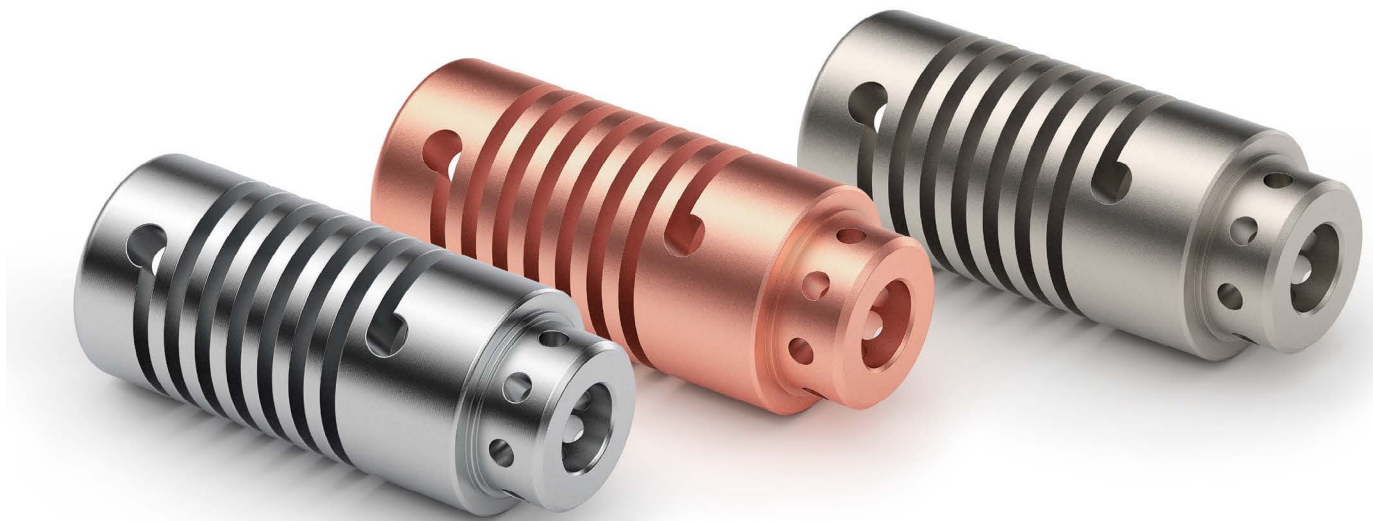
## Typical Applications and Dimensions

### Compression and Tension Springs

- Force range: 2 – 4500 N
- Outer diameter: 1.5 – 80 mm
- Lengths: 6 – 500 mm

### Torsion springs

- Torque: 5 – 225 Nm
- Twist angle: 1 – 360°
- Outer diameter: 1.5 – 80 mm
- Lengths: 6 – 500 mm



Compression springs made of stainless steel (left), copper (center), or titanium (right)

## Optimized Fastening for Precision Springs

In traditional coiled spiral springs, fastenings are often achieved using bent wire ends, hooks, rings, or ground spring ends. However, these small bend radii often result in high material stresses and can lead to premature component failure. Furthermore, these connection points can only transfer the torques generated in the spring to adjacent components to a limited extent.

Machined precision springs offer design advantages in this regard. Fasteners can be specifically integrated into the component and reinforced where forces need to be transmitted. Typical solutions include, for example:

- Double pins
- Cross slots
- Grooves
- Mounting flanges, and much more.
- 

Such integrated connections increase the service life and operational reliability of the spring. At the same time, installation space, production costs, and assembly costs can often be reduced.



Threaded pins



Pin holes



Hex socket



Grooves

Custom torsion spring,  
material C 300



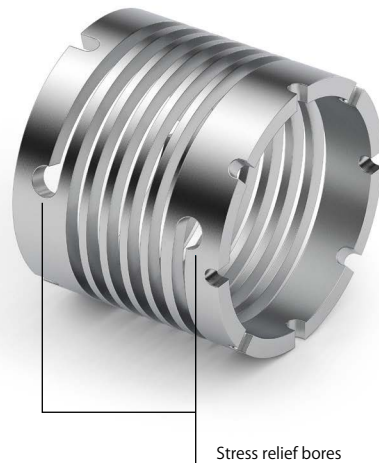
## Extending Service Life

The service life of precision springs can be extended through various design measures.

Typical optimizations include:

- Stress-relief holes at the coil end to reduce notch stress
- Material reinforcements in the critical area of the coil
- Surface coatings such as nickel plating to improve wear resistance and corrosion protection

These measures increase the number of possible load cycles and improve the spring's fatigue strength.



## Integrated functions to reduce the number of components

Thanks to the design possibilities of machined precision springs, fasteners and additional functions can be integrated directly into the component.

### The key advantages:

#### Cost reduction

- Fewer components per function
- Shorter assembly times
- Reduced procurement costs

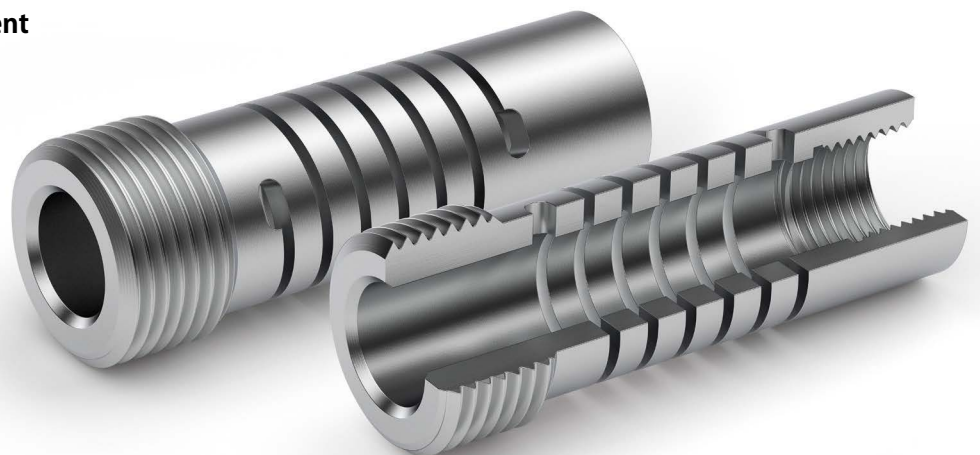
#### Increased system reliability

- Clear interfaces through a single component
- A single point of contact for multiple functions

#### Optimized inventory management

- Reduced inventory levels
- Fewer orders and suppliers

Industry: Printing machines  
Application: Helix coupling as compression spring in clamp coupling



# Comparison: Standard Springs vs. Precision Springs

## Standard Springs



- Usually available only in single-coil designs
- Mounting options are limited and can typically only be added after production
- Precise inner or outer diameters often require additional grinding processes
- Different spring types (compression, tension, or torsion springs) cannot be combined
- Material-related residual stresses affect performance
- Spring rates may vary within a single production batch
- Limited material selection
- Possible deviations in parallelism or buckling under load
- Integrated additional functions can only be achieved using multiple components

## Precision springs



- Single-, double-, or triple-coil designs possible
- Custom fasteners can be directly integrated
- Single-piece manufacturing enables very high dimensional accuracy
- Defined compression, tension, and torsion characteristics as well as combined load parameters can be achieved
- Minimal residual stresses in the coil
- Very consistent spring rates with repeatability of up to approximately 1%
- Wide selection of materials, e.g., steel, aluminum, titanium, or plastic
- High reliability due to precise parallelism and perpendicularity
- Complete function, including mounting parts, can be provided by a single manufacturer





[www.mikipulley.de](http://www.mikipulley.de)