



BRAKING SYSTEMS
ENERGY RECOVERY
SYSTEMS
BATTERY
CONNECTIONS

TMB-14



Connecting, Conducting and EMI/RFI Shielding Solutions for the Motorsports Industry

Custom components that drive tomorrow's technologies.®

 **BAL SEAL**
ENGINEERING, INC.



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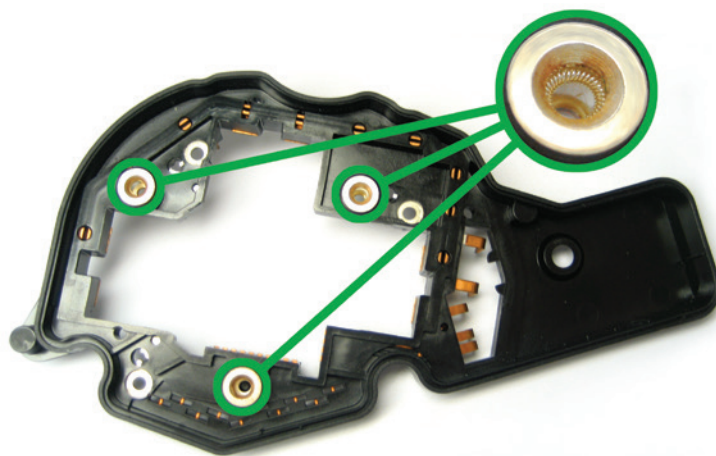
A Reputation for Innovation

When manufacturers of high-performance motorsports vehicles and systems need smart solutions to tough design challenges, they turn to Bal Seal Engineering.

Our products are custom-engineered to ensure reliable, consistent fastening, shielding, and delivery of current to and from vehicle systems, and they're already at work in many of today's top-performing platforms. For example, our Bal Spring® canted coil springs, with their unique mechanical and electrical properties, allow for the more efficient design of regenerative braking and energy recovery systems (ERS) that can increase power up to tenfold in high-performance electric and hybrid vehicles.



We're more than just a problem-solver—we're your innovation partner. With a vast application knowledge base, ISO 9001 and IATF 16949 certified processes, and advanced manufacturing capabilities, we can help you develop standard-setting breakthroughs that give you and your team a competitive edge.



The integration of Bal Spring® canted coil spring technology into this electronic steering system is just one example of how design engineers have leveraged our products and expertise to improve vehicle reliability and performance.

The Bal Spring® Simple, Efficient & Robust



The Bal Spring® canted coil spring is a versatile component that mechanically fastens, conducts electricity, and shields sensitive electronics from the harmful effects of electromagnetic interference (EMI), and radio-frequency interference (RFI). The spring's independent coils, which serve as multiple contact points for optimal current carrying capability in electrical and shielding applications, ensure consistent, reliable connection—even under shock and vibration.

The Bal Spring is robust enough to withstand thousands of insertion and removal cycles, and it can be precisely engineered to meet virtually any connector force requirement. Available in a broad range of wire materials, sizes, and finishes, the spring can be manufactured to inside diameters as small as 0.41 mm (0.016 in.), and can also be easily configured to serve as a “tamper-proof” connection. The spring's compact design and multi-function capabilities help reduce system complexity and weight without compromising performance.



Electrical Conducting

Bal Spring® Conducting Applications

- Regenerative braking systems
- Lithium-ion battery pack/harness connections
- Kinetic MGU, heat MGU, energy storage, and control electronics
- Electronic starter controls
- Steering systems

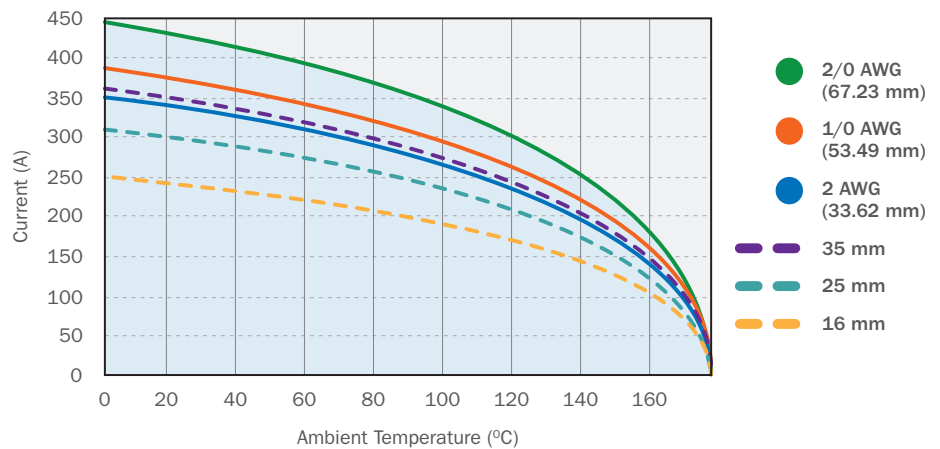
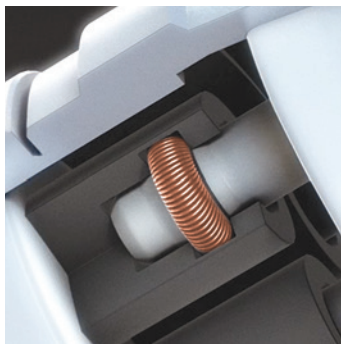


Figure 1. Derating curves for 8 mm Bal Spring® canted coil springs in electrical contact applications. Tests performed to DIN EN 60512-5-2 specifications. Solid line curves are based on actual test data. Cross-sectional cable areas in mm are included for comparison purposes against EU standard cable sizes. Dashed lines represent theoretical derating curves for the same 8 mm connector, using 35, 25 and 16 mm EU standard cables.



The Bal Spring® canted coil spring performs extremely well as an electrical contact element, enabling motorsports vehicle and system designers to effectively manage high, medium, and low current with minimal heat rise in a wide range of vehicle applications.

Each coil of the Bal Spring acts independently across the mating surface interface, compensating for large tolerances and surface irregularities. Figure 1 shows derating curves for an 8 mm connector using a Bal Spring made from copper alloy.

Mechanical Fastening

Bal Spring® Connecting Applications

- Driver communication systems
- Driver safety systems
- Body assembly

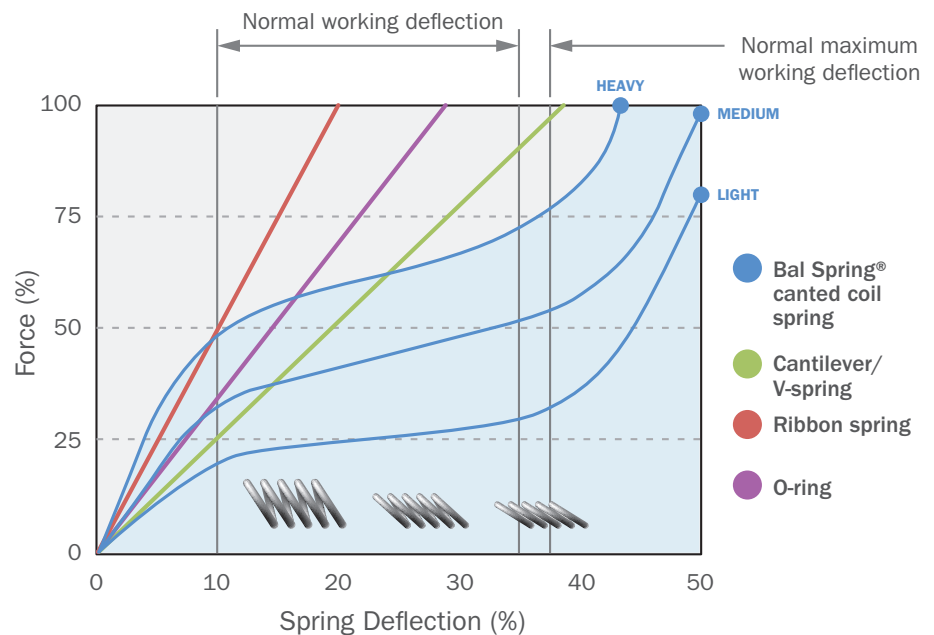
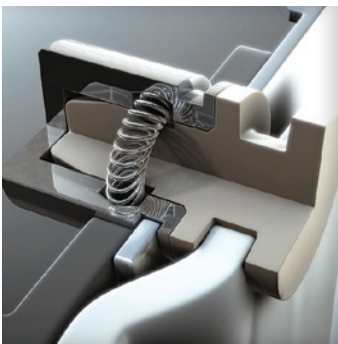


Figure 2. Unlike typical spring technologies, the Bal Spring® canted coil spring provides nearly constant force across the working deflection.



Our Bal Spring® canted coil springs for latching, locking, and holding applications are available in a variety of materials and surface finishes. In addition to fastening or latching, the spring can be designed to permanently lock two pieces together, or to perform a holding function.

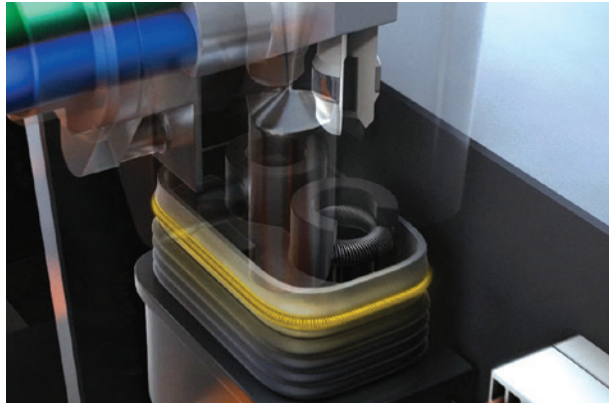
Depending on design requirements, a spring may be engineered to require as much as 900–1000 lb of tension load breakaway force. The spring can also be used to dampen vibration. Its resistance to compression set translates to consistent, repeatable service over thousands of cycles, and its controllable forces make it ideal for quick connect/disconnect applications.



EMI/RFI Shielding

Bal Spring® Shielding Applications

- Driver information & safety systems
- Radio, telephony & antennae
- Power management (battery packs, power converters & sensors)
- Vehicle performance monitoring



The Bal Spring® canted coil spring's highly conductive properties and unique design enable it to provide superior shielding against EMI/RFI, particularly in high-frequency, small-package applications. As an interface shielding component, the spring offers designers a simple, economical means to greatly reduce radiated emissions and conducted interference.

Figure 3 indicates the superior shielding effectiveness of the Bal Spring canted coil spring as compared with other shielding options. Summary testing data shows that the spring exhibits much lower transfer impedance than fingerstock, helical flat springs, or wire mesh over elastomer.

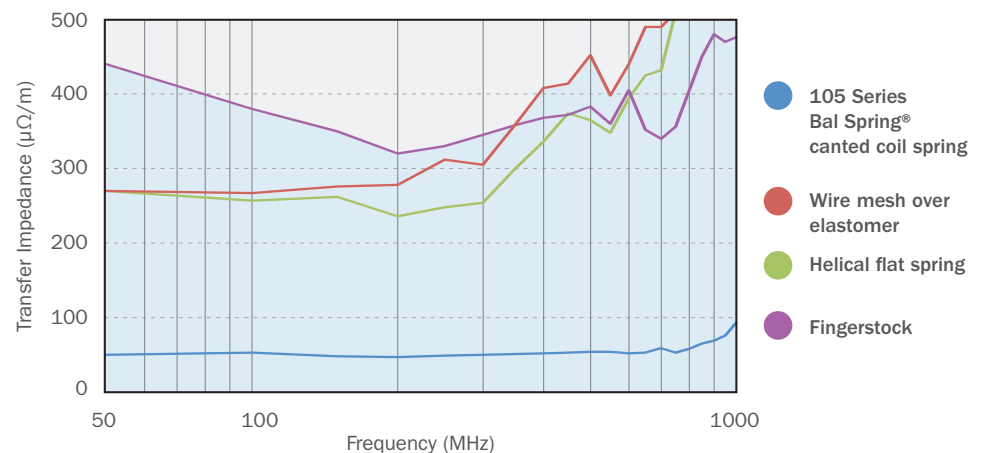


Figure 3. Transfer impedance of Bal Spring® canted coil spring vs. other shielding methods

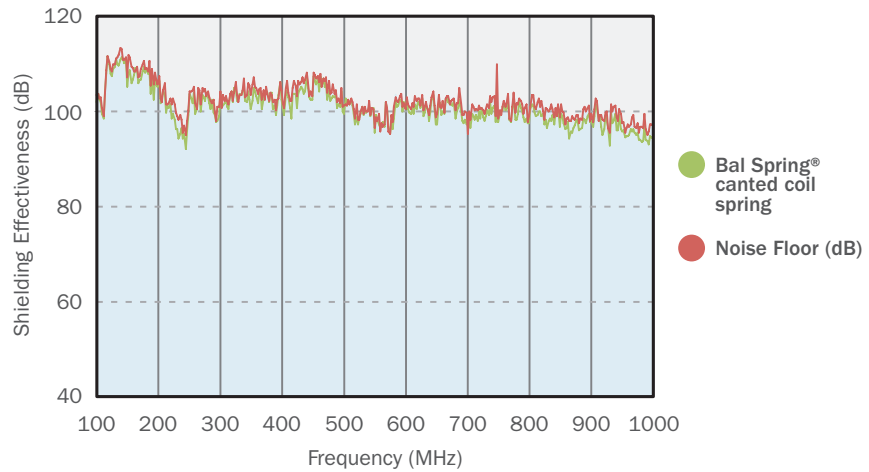


Figure 4. 100 MHz–1 GHz, shielding effectiveness vs. frequency

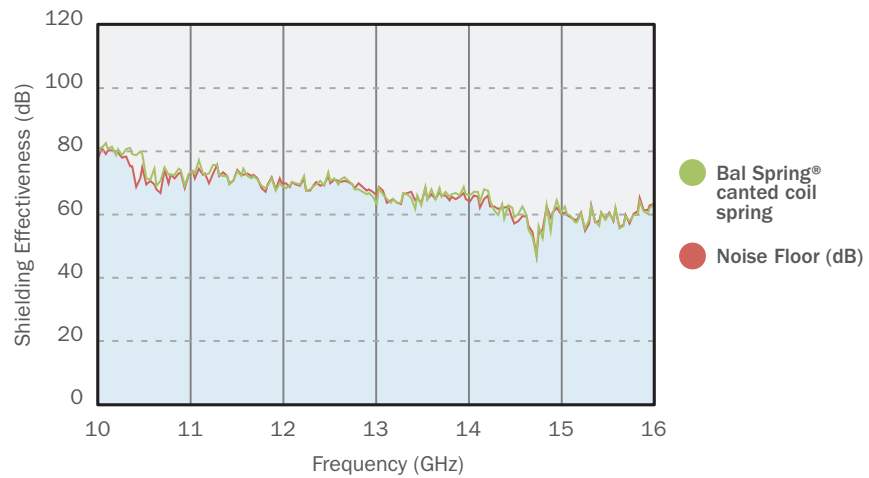


Figure 5. 10–16 GHz, shielding effectiveness vs. frequency



Figures 4 and 5 illustrate the Bal Spring's shielding effectiveness at frequency ranges of 100 MHz–1 GHz and 10–16 GHz. Each graph includes the noise floor data for comparison, showing how closely the Bal Spring matches the noise floor throughout the entire frequency range.

Following IEC 61726 Standard, the test procedure was conducted at an accredited third party EMC test lab, using a 50-Ω characteristic impedance coaxial connector with an overall diameter of Ø0.725.

Note: shielding effectiveness is highly dependent on the connector design and configuration.



Bal Spring® Applications in Formula 1 and Formula E

In radio, telephony & antennae

The Bal Spring® shields against EMI/RFI and prevents system “cross-talk.”

In power management systems

The Bal Spring® shields against EMI/RFI, ensuring the integrity of signal/data transfer between battery packs, power converters, and sensors.

In body assembly applications

The Bal Spring® can be custom-engineered to latch and lock panels and body components for fast removal/replacement.

In kinetic MGU, heat MGU, energy storage and control electronics

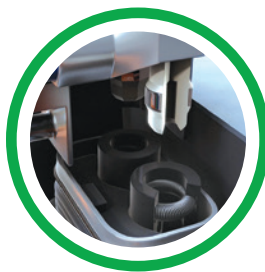
The Bal Spring® provides multi-point electrical contact, even in high vibration and shock load environments.

In regenerative braking systems

The Bal Spring® ensures consistent power transfer to the ERS.



EMI/RFI Shielding



Electrical Conducting



Mechanical Fastening/
Connecting

Important Information

CLEANING

Bal Seal Engineering products may require cleaning and/or sterilization before use, depending on the application.

TESTING

It is essential that the customer run evaluation tests to determine if the proposed, supplied, or purchased Bal Seal Engineering products are suitable for the intended purpose. Run tests under actual service conditions with an adequate safety factor.

Welded springs have an increased probability of breaking or failing at or near the weld. This probability is magnified if the spring is used in an application involving extension of the spring. In addition, temperature affects the properties of the spring (i.e., tensile strength, elongation, etc.) Failure of Bal Seal Engineering products can cause equipment failure, property damage, personal injury, or death. Equipment containing Bal Seal Engineering products must be designed to provide for any eventuality that may result from a partial or total failure of Bal Seal Engineering products.

Bal Seal Engineering products must be tested with a sufficient safety factor after installation and they must be subjected to a program of regular maintenance and inspection. The customer, through analysis and testing, is solely responsible for making the final selection of the products and for ensuring that all performance, safety, and other requirements of the application are met.

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PATENTS

The products described herein include those which are the subject of pending and issued patents, both foreign and domestic, including patents 8,167,285; 8,297,662; 8,375,543; 8,561,274; 9,267,526; 9,534,625; (LE-173 Rev. 0) (Report#621-7).

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We're more than just a component maker. In early development or existing product improvement stages, we combine our proven seals, springs, and contacts with engineering, material science, and precision manufacturing expertise to produce solutions that break down performance barriers.



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