Shielding Characteristics of Bal Spring® Canted Coil Springs and Other EMI Gaskets

Technical Report
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Bal Seal Engineering is certified to ISO 9001 and TS 16949

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1.0 INTRODUCTION

This report presents the results of transfer impedance measurement performed upon Bal Spring™ BG-series and gaskets produced by other EMI gasket manufacturers. The measurements of the various gaskets were performed by DNB Engineering, Inc., a fully certified EMC testing laboratory.

Bal Seal Engineering's BG-series gaskets are based upon a specific design optimization of its patented canted coil spring. These gaskets incorporate an all metallic spring design manufactured with specialized features to create a unique canting deflection.

2.0 PURPOSE OF TESTING

The purpose of the test was to show how the shielding capability of Bal Spring™ gaskets compares to other types of gaskets from other manufacturers. Testing was performed to the requirements of SAE ARP 1705, an established procedure for EMI gasket materials, the output of which consist of transfer impedance measurements.

3.0 SUMMARY

The results of the comparison indicate that Bal Spring™ gaskets provide a level of overall priorities which is superior to that of other gasket types, including wire mesh over elastomer, finger stock, conductive elastomer, and helical flat spring. The Bal Spring™ gasket yielded very low transfer impedance test measurements, signifying excellent shielding capability. A supplementary mechanical evaluation showed the Bal Spring™ gasket to possess strong resistance to compression set, a trait not common to many other types of EMI gaskets.

4.0 BAL SEAL EMI SPRING GASKETS

The Bal Spring™ BG-series is designed to provide superior overall properties, ensuring strong shielding performance with a high level of reliability. The gasket is of a unique canted spring design with the following benefits and features:

- Long term durability: high resistance to compression set provided by high deflection and resilience.
- High shielding effectiveness: conductivity across interfaces preserved by highly concentrated forces at numerous contact points.
- Consistent shielding despite surface irregularities and tolerance variations: conformance due to near constant force over a large compression range.
- Fits small package requirements: available in very small ring diameters and cross sections with various groove options.
- Easy installation: spring gaskets are self-retained in grooves; no adhesives required.
- Easy assembly: low closure forces from light spring gasket loads.

Typical forms of Bal Spring™ gaskets are shown in Figure 1.

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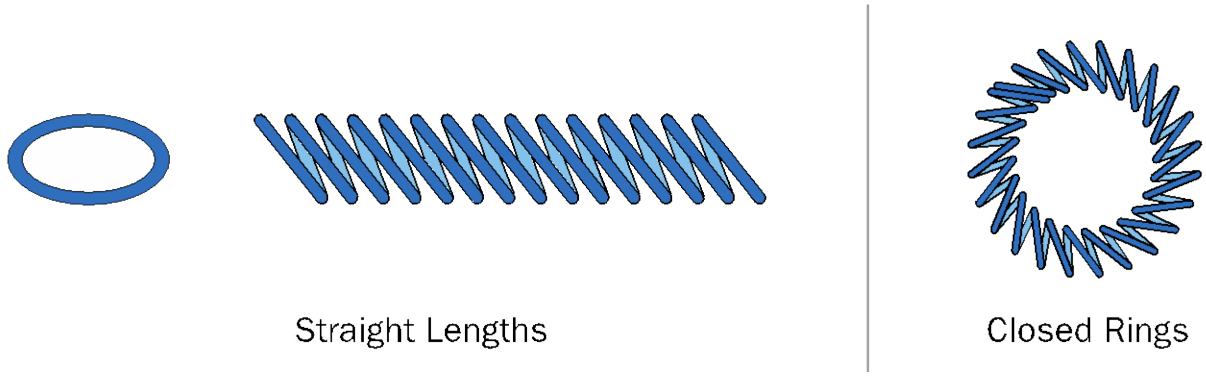

Figure 1
Typical Forms of Bal Seal Gaskets

5.0 OTHER EMI GASKET TYPES

Many types of EMI shielding gaskets are offered by other manufacturers. The gasket configurations used in the test were selected in order to provide a diversity of forms for a broad basis of comparison. The gasket types evaluated were: conductive elastomer, finger stock, helical flat spring, and wire mesh over elastomer. These parts are among the best offered by their manufacturers in terms of shielding data that was presented in catalogs and other test reports. The size of each type of gasket was selected to be on the same order as that of the Bal Spring™ gasket under test.

Conductive elastomer gaskets generally consist of a silicone based binder, within which metallic particles are distributed to provide conductivity. The particles are usually silver, or silver plated glass or copper. These gaskets have an environmental sealing capacity due to the elastomeric base. Available forms include strips, sheets, molded, and cut parts.

Finger stock gaskets are stamped or etched, usually from beryllium copper strip sheet, then formed to create a row of spring fingers. The spring fingers generally need to be of sufficient length and minimized thickness to have a force characteristic which is appropriate for users. Helical flat spring gaskets are similar to coils springs with the difference being that a continuous rectangular strip is used instead of wire. The appearance of these gaskets approaches that of a nearly continuous tube. These are made of beryllium copper or stainless steel, plated to improve galvanic compatibility or conductivity.

Wire mesh gaskets consist of woven or braided lengths of wire which are configured to create hollow or filled (with elastomers or other compliant materials) strips of round or rectangular cross sections .These wires may be comprised of any of a number of materials, with those possessing high conductivity preferably selected. Illustrations of the different gasket types are shown in Figure 2.

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Conductive Elastomer | Finger Stock | Helical Flat Spring | Wire Mesh over Elastomer

Figure 2
Other Gasket Types

6.0 TEST PROCEDURE

Transfer impedance measurements were performed to the requirements of SAE ARP 1705 “Coaxial Test Procedure to Measure the RF Shielding Characteristics of EMI gasket Materials.” ARP 1705 is a test procedure created by the Society of Automotive Engineers “to establish a technique using conducted methods for reliably and repeatably measuring the RF shielding characteristics of EMI gasket materials and to establish standard terminology.” The output of this test consists of transfer impedance measurements over a frequency range. Transfer impedance is inversely proportional to shielding capability.

The method is very repeatable, within 2 dB, making it an appropriate method for comparison testing.

The test method is intended to employ a conduction mode exclusively. A coaxial housing of ARP 1705-specified dimensions is used, and a signal is passed through the center conductor. Internal to the housing, in series with the center conductor, are a fixed impedance and a cover plate. The next plate, a test plate, is interchangeable for each gasket sample. Each gasket sample is assigned its own such plate, within which is machined a gasket mounting groove sized to the manufacturer’s recommendations. The plates are secured to the housing using fasteners.

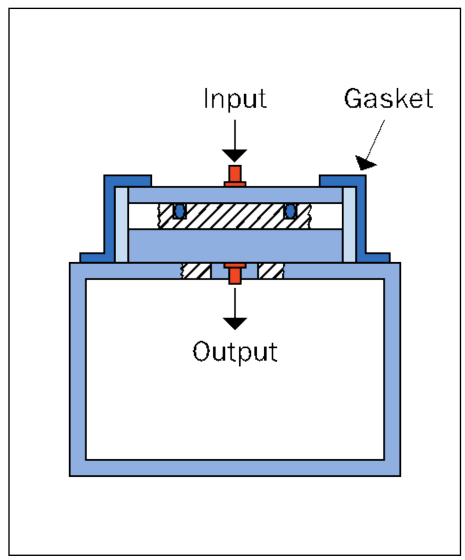

Figure 3
Transfer Impedance Test Fixture

The input signal is injected into the connector, then passes through the fixed impedance and gasket, and travels in a return path through the walls of the fixture. Measurements are taken with regard to the input power and voltage drop across the gasket. The power measurement is used to derive the current. The derived current and measured voltage drop are then taken to calculate the transfer impedance of the gasketed interface. This value is generally expressed in terms of ohms per unit length. The test fixture is depicted in Figure 3.

The fixture employed by the testing laboratory has a designed range of DC to 1 GHz. Measurements taken beyond 1 GHz may be distorted by resonances. The testing of the Bal Seal EMI spring gaskets and other gaskets was performed over the frequency range of 50 MHz to 1 GHz, in 50 MHz increments.

Bal Seal Engineering parts from the BG20 series were tested. These are of 0.094 in. (2.39 mm) nominal size. Different configurations of the gaskets were evaluated, including variations of base materials, plating materials, compression forces, and groove types.

The other gaskets were selected with the purpose of obtaining a diversity of forms with the same order of size. These included 0.094 in. (2.39 mm) conductive elastomeric strip, 0.28 in. (7.11 mm) beryllium copper finger stock, 0.094 in. (2.39 mm) helical flat spring, and 0.125 in. (3.17 mm) wire mesh over elastomer. The gaskets were tested in their manufacturer-recommended groove.

7.0 TEST RESULTS

Bal Spring™ gaskets of the BG20 series exhibited lower transfer impedance measurements than did the finger stock, wire mesh over elastomer, and helical flat spring gaskets over the frequency range of 50 MHz to 1 GHz.

The Bal Spring™ gasket with the lowest measurements was a BG20M5-SBB part in a tapered bottom groove, with measurements of approximately 40 μΩ/m, and wire mesh over elastomer at 260 to 1650 μΩ/m over the 50 MHz to 1 GHz frequency range. The BG20M5-SBB spring gasket is of 0.094 in. (2.39 mm) nominal size, medium compression force, beryllium copper base, and nickel plating. The other BG20-series spring gaskets included those of silver plated stainless steel and nickel plated beryllium copper, in a tapered bottom, dovetail and angled grooves. Transfer impedance measurements of the conductive elastomer gaskets were approximately 20–60 μΩ/m lower than the Bal Spring™ BG20M5-SBB gasket over the 50 MHz to 1 GHz range.

Shielding data is presented in Figure 4 displaying transfer impedance measurements for Bal Spring™ gaskets and other gaskets over the test range of 50 MHz to 1 GHz. The table in Figure 5 also contains descriptions and data for the purpose of comparing other properties between the different gasket types.

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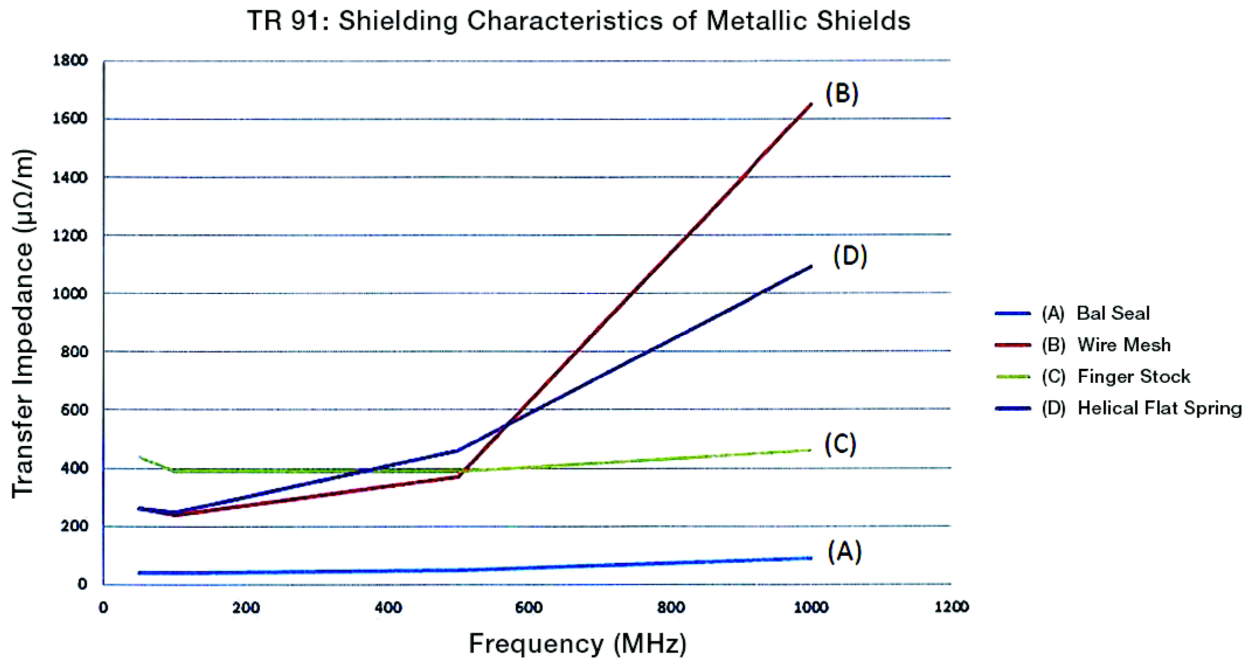

Figure 4
Transfer Impedance Measurements

8.0 CONCLUSIONS

The low transfer impedance measurements indicate that the Bal Spring™ gaskets possess strong EMI shielding properties. In comparing the results of the testing, the measurements show that the Bal Spring™ gaskets provide a level of EMI shielding which is superior to that of other types, including wire mesh over elastomer, finger stock, and helical flat spring. The transfer impedance measurements were approximately 10 times lower for the Bal Spring™ gasket than for these types. As compared with conductive elastomer gaskets, the Bal Spring™ gasket performs at the same order of transfer impedance.

The Bal Spring™ gasket also showed a consistency of shielding across the test frequency range. The transfer impedances were low and near constant. The rate of increase of transfer impedances at the frequencies approaching 1 GHz was distinctly lower for the Bal Spring™ gaskets than for the wire mesh over elastomer, finger stock, and helical flat spring gaskets.

A review of the material properties of the gasket yielded a number of pertinent items. The Bal Spring™ gaskets display negligible compression set over their working deflection range, an important trait common to all of the tested metallic gasket types. The compression set figures cited by the manufacturers of the conductive elastomer and wire mesh over elastomer gaskets indicate that there may be deformation occurring through compression. The compression set may affect the performance of the gasket in a number of ways. These include the reduction of contact force, resulting in reduced interface conductivity and shielding capability, and the reduction of preload at interface fasteners, again resulting in a reduction of contact force. The degradation will also lead to a need for replacement or careful examination of the gaskets if the assembly is

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reworked. The resistance to compression set indicates that the Bal Seal spring gaskets will provide for long-term durability and shielding performance.

The Bal Spring™ gaskets, as did the other metallic gasket types, have a working temperature range which extends significantly beyond those of conductive elastomer and wire mesh over elastomer gaskets. The increase of range applies to both the low and high temperature extremes, providing for a larger domain of thermal applications.

All applications should be reviewed carefully with regard to the criteria used in selecting the gasket and groove. The parameters include package, size, structure, materials, galvanic compatibility, usage environment, and manufacturing processes.

Properties of Tested Gaskets					
	Bal Spring™ Canted Coil Spring	**Wire Mesh over Elastomer**	**Conductive Elastomer**	**Finger Stock**	**Helical Flat Spring**
Tested Forms	Nickel plated beryllium copper closed ring	Monel mesh over solid silicone o-strip	Silver plated copper in solid silicone o-strip	Nickel plated beryllium copper strip	Tin plated beryllium copper strip
Gasket Size	0.094 in. (2.39 mm)	0.125 in. (3.17 mm)	0.094 in. (2.39 mm)	0.28 in. (7.11 mm)	0.094 in. (2.39 mm)
Conductive Material	Nickel plating, beryllium copper base	Monel Wire Mesh	Silver plated copper filler	Nickel plating, beryllium copper base	Tin plating, beryllium copper base
Binder or Core Material	N/A	Silicone	Silicone	N/A	N/A
Temperature Range	-200°F to 350°F (-129°C to 177°C)	-40°F to 225°F (-40°C to 107°C)	-85°F to 257°F (-65°C to 125°C)	-200°F to 350°F (-129°C to 177°C)	-200°F to 350°F (-129°C to 177°C)
Compression Force/Pressure	5.15 lb/in (0.92 kg/cm)	30 lb/in (5.37 kg/cm)	7.0 lb/in (1.25 kg/cm)	1.8 lb/in (0.32 kg/cm)	30 lb/in (5.37 kg/cm)
Compression Set	None at up to 35% compression	6% at 30% compression	8% at 25% compression	None at up to 25% compression	None at up to 25% compression
Transfer Impedance Measurements 50 MHz	40 µΩ/m	260 µΩ/m	24 µΩ/m	440 µΩ/m	260 µΩ/m
100 MHz	40	240	20	390	250
500 MHz	50	370	25	390	460
1 GHz	90	1650	27	460	1090

Figure 5
Table of Gasket Properties

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