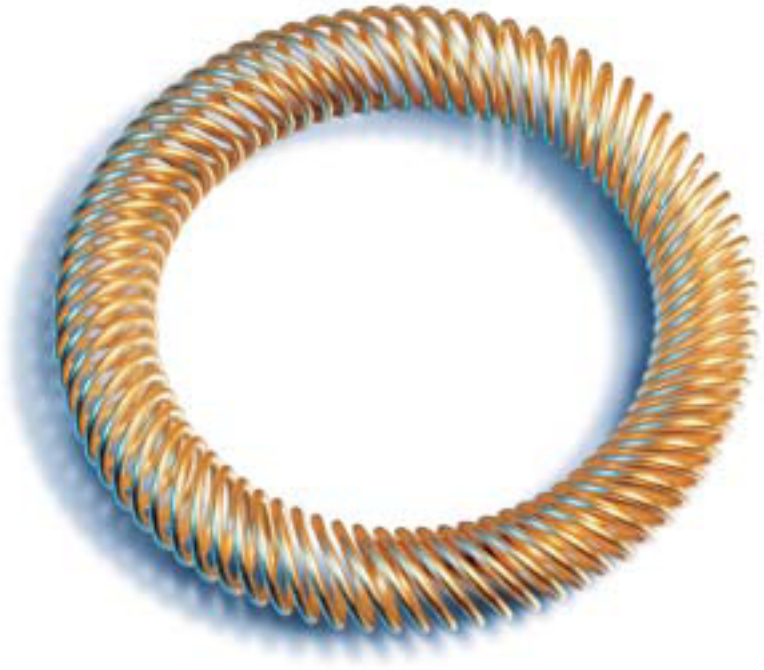
BAL SEAL ENGINEERING

EMI Gasket Catalog
DM8



BalShield™

Solutions for EMI Applications

- Simply better shielding

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Bal Seal Engineering Company Inc. is the leader in canted coil spring technology. Over 40 years of successful experience has earned Bal Seal an acknowledged worldwide distinction. Designs have been implemented successfully in many applications and environments. This catalog presents the EMI spring gasket product line. The BalShield™ EMI spring gasket has a unique configuration and properties, and a design which is flexible to meet your demanding shielding requirements. This performance is backed up by a high level of attentive technical support for fast, efficient solutions.

CANTED-COIL SPRING TECHNOLOGY.

The BalShield™ EMI spring gasket is based upon a specific design optimization of the patented Bal Seal canted-coil spring. The design possesses superior EMI shielding and spring properties, a compact configuration, and lasting reliability. No other spring gasket can match the BalShield™ EMI spring gasket for overall performance, especially in high frequency, small package requirements.

QUALITY TECHNICAL ASSISTANCE.

Bal Seal provides immediate technical support for our products and details on service conditions. We encourage you to talk with our technical support staff to assure that we provide you with the best spring gasket possible. You will promptly receive an EMI gasket design proposal, technical information, and samples to facilitate your selection.

Product Description

The control of electromagnetic and radio frequency interference is a key technology in today's world of extensive telecommunications, complex defense, sensitive medical electronics, and booming computer usage. The shielding to and from such interference is critical in light of the potential damage that may occur to systems and components.

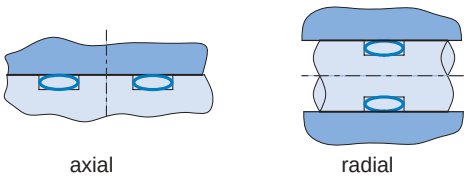
BalShield™ EMI spring gaskets have been tested and proven to be effective shielding elements in the packaging of electronic enclosures. As interface sealing components, these gaskets offer a simple, economical design which greatly contributes toward the reduction of radiated and conducted interference. BalShield™ spring gaskets offer the additional benefits afforded by their canted-coil design, including outstanding durability and reliability.

BalShield™ EMI spring gaskets are available in a variety of sizes and configurations:

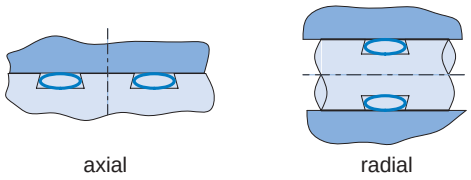
- sizes from 0.041 to 0.494 inch (1,04 to 12,55 mm)
- ring diameters from 0.062 inch (1,57 mm)
- base materials include beryllium copper and stainless steel
- platings available upon request
- forms include continuous lengths, cut lengths, and closed rings

Extensive design and testing has been performed by Bal Seal Engineering and an independent laboratory to create groove configurations which optimize the shielding performance of its spring gaskets. These groove configurations are readily adaptable to a multitude of hardware applications.

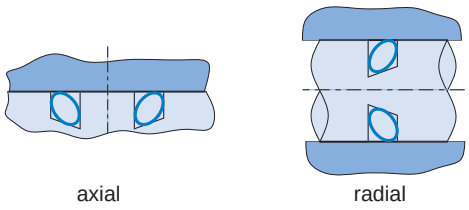
TYPICAL GROOVE CONFIGURATIONS



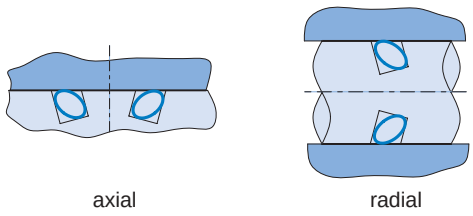
RECTANGULAR



DOVETAIL



TAPERED BOTTOM



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Patented Canted Coil Configuration

BalShield™ EMI spring gaskets are characterized by their canted coils, which exhibit a unique deflection and force behavior upon compression. The springs gaskets are available as closed rings or straight lengths, in a variety of sizes and materials to fill demanding shielding requirements.

PATENTED CANTED-COIL CONFIGURATION

Benefits of Canted-Coil Gasket Design

Long term durability: high resistance to compression set provided by high deflection and resilience.

High shielding effectiveness: conductivity across interface preserved by highly concentrated forces at numerous contact points.

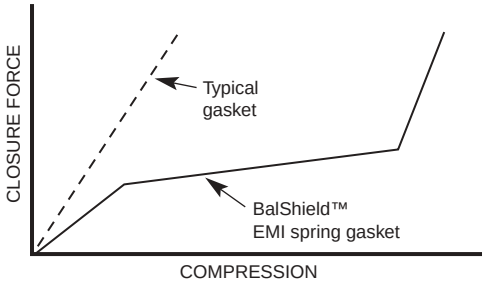
Consistent shielding despite surface irregularities and tolerance variations: conformance due to near constant force over a large compression range.

Fits small package requirements: available in very small ring diameters and cross sections, with various groove options.

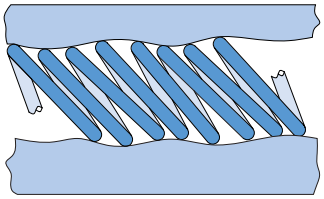
Easy installation: spring gaskets are self-retained in grooves; no adhesives required.

Easy assembly: low closure forces from light spring gasket loads.

NEAR CONSTANT FORCE OVER A LARGE COMPRESSION RANGE



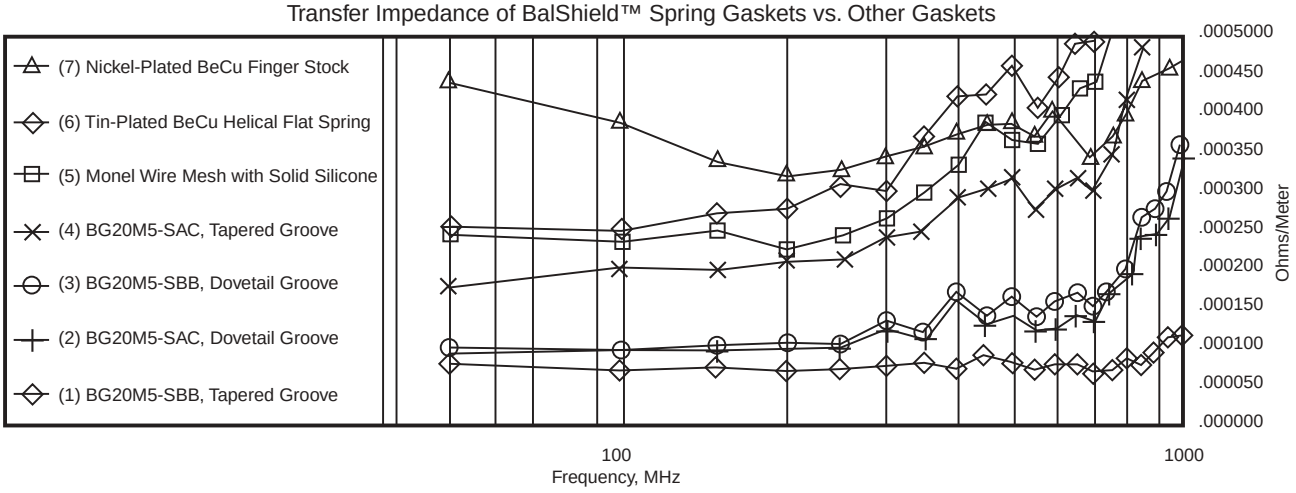
CONSISTENT SHIELDING DESPITE SURFACE IRREGULARITIES AND TOLERANCE VARIATIONS



Effective EMI Shielding

Summary data from Transfer Impedance (Z_T) testing displays the high EMI shielding performance capability of BalShield™ spring gaskets. The following EMI test data graph relates the performance of BalShield™ spring gaskets to other types of gaskets.

Transfer Impedance of BalShield™ Spring Gaskets vs. Other Gaskets



Applications

The versatile design of BalShield™ EMI spring gaskets allows them to be employed in a variety of applications. The set of recommended grooves optimizes the performance of the spring gaskets in various user geometries. The following are the most common assembly orientations, each accompanied by a typical example.

AXIAL LOAD ASSEMBLY

For applications involving flat, planar interfaces. The groove may be a linear or closed shape, with the spring gasket being provided as a free length or ring. Interference between the coils and walls retains the spring gasket in the groove through installation. The mating surface compresses and captivates the spring gasket as assembled.

RADIAL LOAD ASSEMBLY

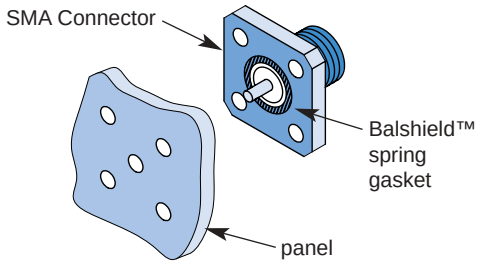
For plug and socket arrangements. The spring gasket in a closed ring form is mounted in the groove on the plug. Coil tension retains the part in the groove through installation. The mating housing compresses and captivates the spring gasket as assembled.

CONNECT/DISCONNECT ASSEMBLY

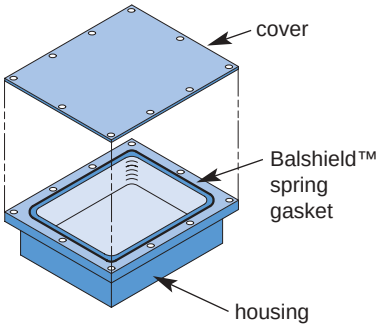
For applications requiring strong retention or locking between plug and socket parts. The spring gasket is mounted in the groove on the plug. Groove designs on both parts are available for different mating conditions, loading levels, and load sensitive release mechanisms. The mating housing compresses and captivates the spring gasket as assembled.

OTHER SAMPLE APPLICATIONS

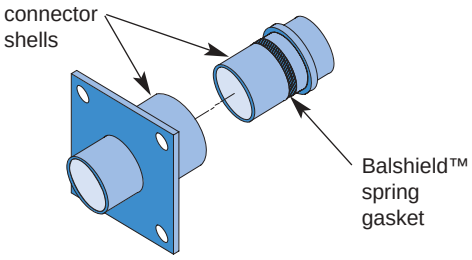
COAXIAL CONNECTOR



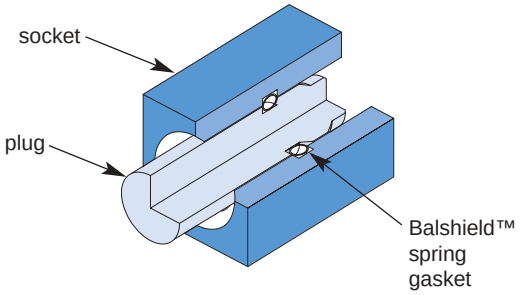
TYPICAL AXIAL APPLICATION ELECTRONIC ENCLOSURE



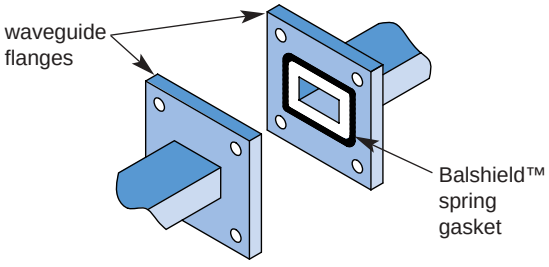
TYPICAL RADIAL APPLICATION ELECTRICAL CONNECTOR



TYPICAL CONNECT/DISCONNECT ASSEMBLY



WAVEGUIDE FLANGES



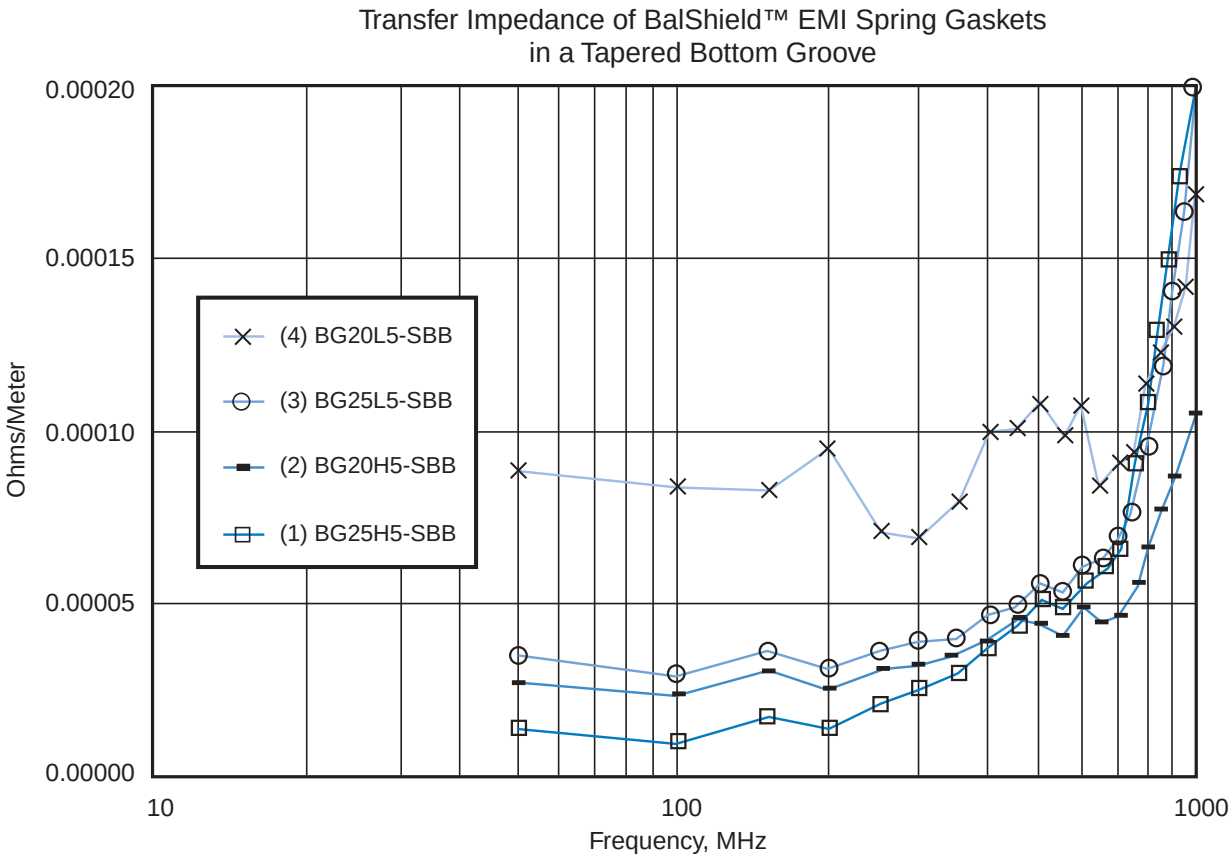
EMI Testing

Bal Seal Engineering (BSE) maintains a library of data of Transfer Impedance (Z_T) and Shielding Effectiveness (SE) measurements for spring gaskets.

This data is the product of extensive testing to the standards of MIL-G-83528, for Shielding Effectiveness, and SAE ARP 1705, for Transfer Impedance, conducted for BSE by an independent test laboratory. We have a series of Technical Reports covering this subject, including TR-91 "Shielding Quality of BalShield™ Spring Gaskets and other EMI Spring Gaskets," TR-92 "Shielding Effectiveness of BalShield™ Spring Gaskets," and TR-93 "EMI Gaskets Test Methods—Transfer Impedance vs. Radiated Shielding Effectiveness."

This graph relates the performance of a sampling of BalShield™ spring gaskets over a frequency range of 50 MHz to 1 GHz.

TRANSFER IMPEDANCE OF BalShield™ EMI SPRING GASKETS

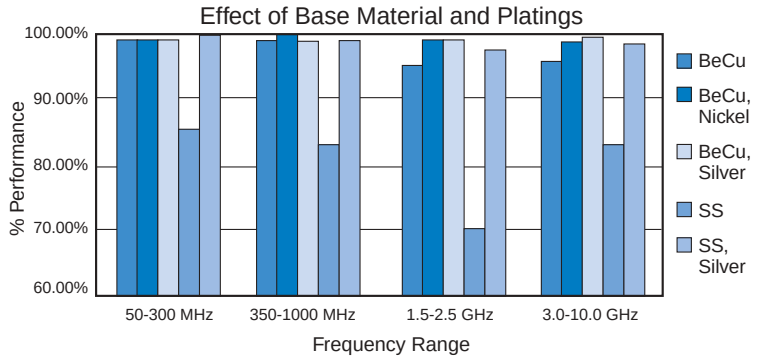


Note
Please give consideration to the fact that the Z_T values provided throughout this catalog, and other documents, are the product of specific test samples, hardware, and procedures. For these reasons, the data may be subject to variations with respect to our users' actual hardware and in-use conditions. The only verifiable method to determine the shielding performance is through actual testing of hardware under real or accurately simulated operating conditions.

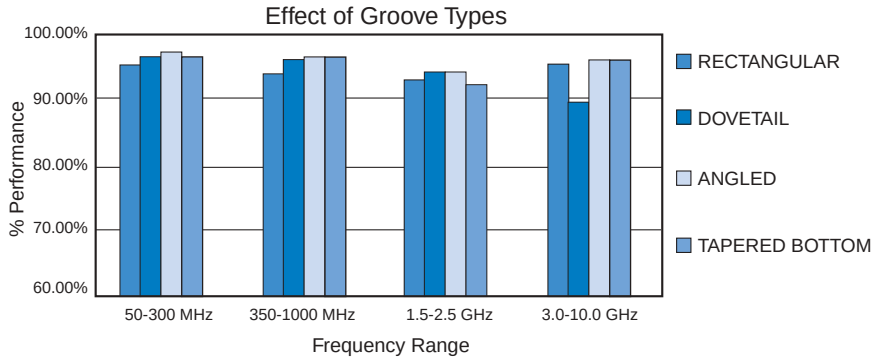
Shielding Performance for Varied Parameters

The following results were compiled from transfer impedance (SAE ARP 1705) measurements taken from over 150 different configurations. Each graph presents its data in terms of a specific parameter—materials and platings, groove types, and gasket forces. The data is averaged for each type within the parameter groupings. Comparative performance between the different types within a graph is expressed in terms of percentage.

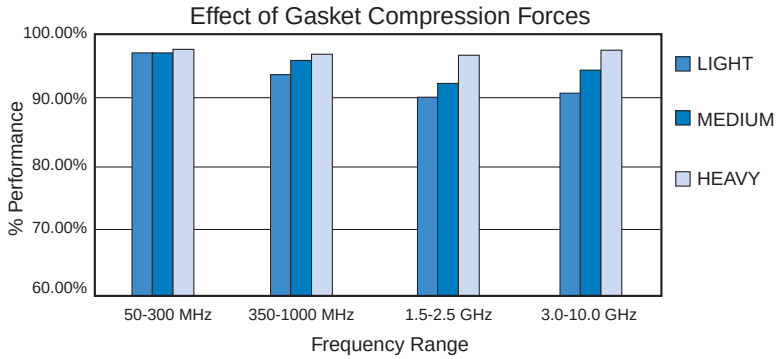
Gaskets comprised of stainless steel and beryllium copper base materials were plated with nickel and silver. This graph shows their effect upon Z_T measurements.



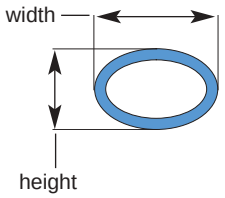
Four groove types were evaluated: rectangular, dovetail, tapered bottom, and angled. This graph shows their effect upon Z_T measurements.

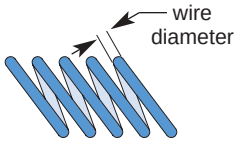


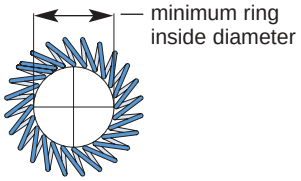
Three different compression forces per gasket size were evaluated: light, medium, and heavy. Z_T performance was gained with increased force.



Spring Gasket Dimensions







SPRING GASKET DIMENSIONS (for reference only)

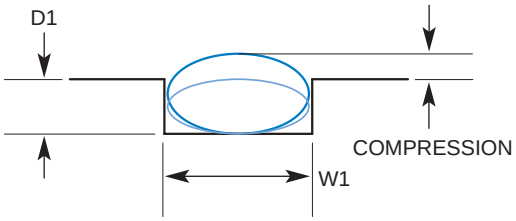
Series	Deflected Height in *(mm)*	Free Height in *(mm)*	Width in *(mm)*	Wire Diameter in *(mm)*	Minimum Ring Inside Diameter in *(mm)*
BG 10 L5	0.031 *(0,79)*	0.041 *(1,04)*	0.047 *(1,19)*	0.004 *(0,10)*	0.062 *(1,56)*
BG 10 M5	0.031 *(0,79)*	0.041 *(1,04)*	0.047 *(1,19)*	0.0045 *(0,11)*	0.062 *(1,56)*
BG 10 H5	0.031 *(0,79)*	0.041 *(1,04)*	0.047 *(1,19)*	0.006 *(0,15)*	0.062 *(1,56)*
BG 15 L5	0.063 *(1,60)*	0.082 *(2,08)*	0.094 *(2,39)*	0.008 *(0,20)*	0.124 *(3,12)*
BG 15 M5	0.063 *(1,60)*	0.082 *(2,08)*	0.093 *(2,36)*	0.009 *(0,23)*	0.124 *(3,12)*
BG 15 H5	0.063 *(1,60)*	0.082 *(2,08)*	0.093 (2,36)	0.012 *(0,31)*	0.124 *(3,12)*
BG 20 L5	0.094 *(2,39)*	0.124 *(3,15)*	0.140 *(3,56)*	0.012 *(0,31)*	0.187 *(4,72)*
BG 20 M5	0.094 *(2,39)*	0.124 *(3,15)*	0.140 *(3,56)*	0.014 *(0,36)*	0.187 *(4,72)*
BG 20 H5	0.094 *(2,39)*	0.124 *(3,15)*	0.140 *(3,56)*	0.016 *(0,41)*	0.187 *(4,72)*
BG 25 L5	0.125 *(3,18)*	0.165 *(4,19)*	0.187 *(4,75)*	0.016 *(0,41)*	0.248 *(6,29)*
BG 25 M5	0.125 *(3,18)*	0.165 *(4,19)*	0.187 *(4,75)*	0.018 *(0,46)*	0.248 *(6,29)*
BG 25 H5	0.125 *(3,18)*	0.165 *(4,19)*	0.186 *(4,72)*	0.022 *(0,56)*	0.248 *(6,29)*
BG 30 L5	0.156 *(3,96)*	0.206 *(5,23)*	0.234 *(5,94)*	0.019 *(0,48)*	0.309 *(7,85)*
BG 30 M5	0.156 *(3,96)*	0.206 *(5,23)*	0.234 *(5,94)*	0.022 *(0,56)*	0.309 *(7,85)*
BG 30 H5	0.156 *(3,96)*	0.206 *(5,23)*	0.233 *(5,92)*	0.027 *(0,69)*	0.309 *(7,85)*
BG 35 L5	0.188 *(4,78)*	0.247 *(6,27)*	0.281 *(7,14)*	0.022 *(0,56)*	0.371 *(9,41)*
BG 35 M5	0.188 *(4,78)*	0.247 *(6,27)*	0.280 *(7,11)*	0.026 *(0,66)*	0.371 *(9,41)*
BG 35 H5	0.188 *(4,78)*	0.247 *(6,27)*	0.280 *(7,11)*	0.032 *(0,81)*	0.371 *(9,41)*
BG 40 L5	0.250 *(6,35)*	0.330 *(8,38)*	0.375 *(9,53)*	0.030 *(0,76)*	0.495 *(12,57)*
BG 40 M5	0.250 *(6,35)*	0.330 *(8,38)*	0.374 *(9,50)*	0.034 *(0,86)*	0.495 *(12,57)*
BG 40 H5	0.250 *(6,35)*	0.330 *(8,38)*	0.373 *(9,47)*	0.041 *(1,04)*	0.495 *(12,57)*
BG 45 L5	0.313 *(7,95)*	0.412 *(10,47)*	0.469 *(11.91)*	0.036 *(0,91)*	0.618 *(15,70)*
BG 45 M5	0.313 *(7,95)*	0.412 *(10,47)*	0.468 *(11,89)*	0.041 *(1,04)*	0.618 *(15,70)*
BG 45 H5	0.313 *(7,95)*	0.412 *(10,47)*	0.467 *(11,86)*	0.049 *(1,25)*	0.618 *(15,70)*
BG 50 L5	0.375 *(9,53)*	0.494 *(12,55)*	0.562 *(14,28)*	0.043 *(1,09)*	0.741 *(18,82)*
BG 50 M5	0.375 *(9,53)*	0.494 *(12,55)*	0.562 *(14,28)*	0.049 *(1,25)*	0.741 *(18,82)*
BG 50 H5	0.375 *(9,53)*	0.494 *(12,55)*	0.560 *(14,22)*	0.058 *(1,47)*	0.741 *(18,82)*

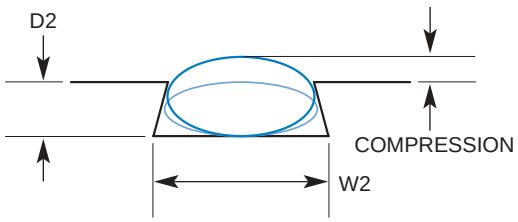
Groove Dimensions

GROOVE DIMENSIONS, in *(mm)* **(for reference only)**

Series	Nominal Size in *(mm)*	Rectangular		Dovetail	
		D1 depth	W1 width	D2 depth	W2 width
BG 10	0.031 *(0,79)*	0.028 *(0,71)*	0.047 *(1,19)*	NR	NR
BG 15	0.63 *(1,60)*	0.056 *(1,42)*	0.095 *(2,41)*	NR	NR
BG 20	0.094 *(2,39)*	0.084 *(2,13)*	0.142 *(3,61)*	0.084 *(2,13)*	0.169 *(4,29)*
BG 25	0.125 *(3,18)*	0.113 *(2,87)*	0.189 *(4,80)*	0.113 *(2,87)*	0.225 *(5,72)*
BG 30	0.156 *(3,96)*	0.141 *(3,58)*	0.236 *(5,99)*	0.141 *(3,58)*	0.281 *(7,14)*
BG 35	0.188 *(4,78)*	0.169 *(4,29)*	0.284 *(7,21)*	0.169 *(4,29)*	0.337 *(8,56)*
BG 40	0.250 *(6,35)*	0.225 *(5,72)*	0.378 *(9,60)*	0.225 *(5,72)*	0.449 *(11,41)*
BG 45	0.313 *(7,95)*	0.281 *(7,14)*	0.474 *(12,04)*	0.281 *(7,14)*	0.561 *(14,25)*
BG 50	0.375 *(9,53)*	0.338 *(8,59)*	0.568 *(14,43)*	0.338 *(8,59)*	0.672 *(17,07)*

NR – Not recommended, please consult the factory.
Note: Complete dimensions available upon request.





RECTANGULAR

Axial applications use a 'T' type spring configuration
Radial applications use an 'S' type spring configuration

Advantages:

- Easy to machine or mold
- Well suited for radial applications
- Shallow grooves

Disadvantages:

- Does not retain spring gasket in axial applications

DOVETAIL

Axial applications use a 'T' type spring configuration
Radial applications use an 'S' type spring configuration

Advantages:

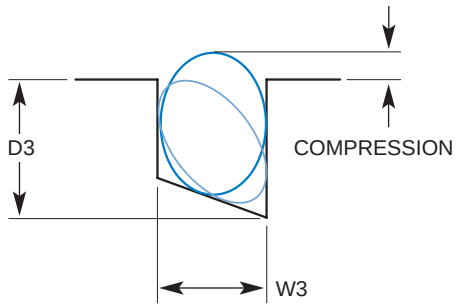
- Machinable in lengths or corners
- Retains spring gasket in axial and radial applications
- Shallow grooves

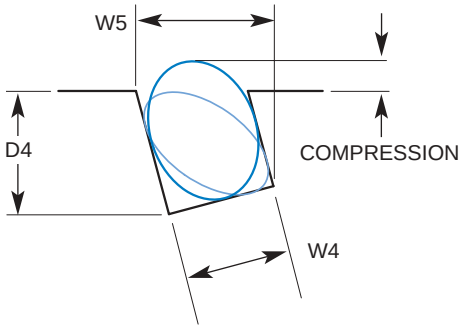
Disadvantages:

- Requires tight tolerance due to limited use of gasket compression
- Smallest sizes may be difficult to machine

GROOVE DIMENSIONS, in *(mm)* (for reference only)						
Series	Nominal Size in *(mm)*	Tapered Bottom		Angled		
		D3 depth	W3 width	D4 depth	W4 groove width	W5 max width
BG 10	0.031 *(0,79)*	NR	NR	0.043 *(1,09)*	0.039 *(0.99)*	0.052 *(1,32)*
BG 15	0.63 *(1, 60)*	NR	NR	0.083 *(2,11)*	0.078 *(1,98)*	0.104 *(2,64)*
BG 20	0.094 *(2,39)*	NR	NR	0.124 *(3,15)*	0.117 *(2,97)*	0.155 *(3,94)*
BG 25	0.125 *(3,18)*	0.175 *(4,45)*	0.156 *(3,96)*	0.164 *(4,17)*	0.156 *(3,96)*	0.207 *(5,26)*
BG 30	0.156 *(3,96)*	0.218 *(5,54)*	0.196 *(4,98)*	0.205 *(5,21)*	0.196 *(4,98)*	0.258 *(6,55)*
BG 35	0.188 *(4,78)*	0.261 *(6,63)*	0.235 *(5,97)*	0.245 *(6,22)*	0.235 *(5,97)*	0.310 *(7,87)*
BG 40	0.250 *(6,35)*	0.347 *(8,81)*	0.313 *(7,95)*	0.326 *(8,28)*	0.313 *(7,95)*	0.413 *(10,49)*
BG 45	0.313 *(7,95)*	0.433 *(11,00)*	0.391 *(9,93)*	0.407 *(10,34)*	0.391 *(9,93)*	0.516 *(13,11)*
BG 50	0.375 *(9,53)*	0.520 *(13,21)*	0.469 *(11,91)*	0.488 *(12,40)*	0.469 *(11,91)*	0.619 *(15,72)*

NR – Not recommended, please consult the factory.
Note: Complete dimensions available upon request.





TAPERED BOTTOM

Axial applications use an 'S' type configuration
Radial applications use a 'T' type spring configuration

Advantages:

- Can be in lengths or corners
- Retains spring gasket in axial and radial applications
- Narrow grooves
- Machinable in diameters
- Enhances electrical performance

Disadvantages:

- Corners are impossible to machine on corners of flat plates

ANGLED

Axial applications use an 'S' type configuration
Radial applications use a 'T' type spring configuration

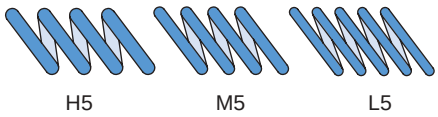
Advantages:

- Machinable in lengths or corners
- Retains spring gasket in axial and radial applications
- Narrow grooves
- Enhances electrical performance

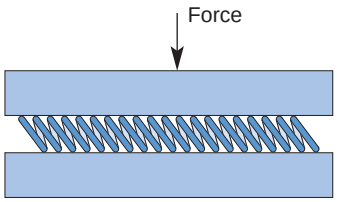
Disadvantages:

- Cannot be easily molded

Spring Gasket Compression Forces



RELATIVE SPRING GASKET PROFILES



FORCE ORIENTATION

GASKET COMPRESSION FORCES (for reference only)

Series	Nominal Size in *(mm)*	Stainless Steel		Beryllium Copper	
		Rectangular and Dovetail Grooves lb/in (g/cm)	Tapered Bottom and Angled Grooves lb/in (g/cm)	Rectangular and Dovetail Grooves lb/in (g/cm)	Tapered Bottom and Angled Grooves lb/in (g/cm)
BG 10 L5	0.031 *(0,79)*	0.66 *(118)*	1.06 *(189)*	0.39 *(70)*	0.42 *(75)*
BG 20 L5	0.094 *(2,39)*	2.24 *(400)*	2.95 *(530)*	1.43 *(255)*	1.90 *(340)*
BG 20 M5	0.094 *(2,39)*	5.15 *(920)*	6.55 *(1170)*	3.27 *(585)*	4.18 *(750)*
BG 20 H5	0.094 *(2,39)*	9.94 *(1780)*	12.89 *(2305)*	5.76 *(1030)*	7.70 *(1380)*
BG 25 L5	0.125 *(3,18)*	3.13 *(560)*	3.50 *(625)*	1.93 *(345)*	2.16 *(385)*
BG 25 M5	0.125 *(3,18)*	5.85 *(1045)*	6.64 *(1190)*	3.73 *(670)*	4.29 *(770)*
BG 25 H5	0.125 *(3,18)*	16.14 *(2890)*	19.95 *(3570)*	11.06 *(1980)*	11.96 *(2140)*
BG 45 L5	0.313 *(7,95)*	3.89 *(695)*	5.06 *(905)*	2.37 *(425)*	3.13 *(560)*

Standard Materials

Beryllium Copper and Stainless Steel are the standard base materials for BalShield™ spring gaskets. These materials possess an excellent combination of mechanical, electrical, and manufacturing properties for producing gaskets of highest performance and reliability.

Beryllium copper is sufficiently conductive to be used unplated in many applications; stainless steel will benefit by being plated with a more conductive metal. Type 316 stainless steel is used for wire diameters between 0.004 in. (0,10 mm) and 0.016 in. (0,41 mm), and type 302 is used for wire diameters greater than 0.016 (0,41 mm).

A spring gasket composed of stainless steel will have a higher force per unit compression than one of identical dimensions made from beryllium copper.

Material	Conductivity, IACS	Resistivity, μΩ-cm	Comments
Beryllium Copper Alloy 25	17%	10	High conductivity Susceptible to oxidation
Stainless Steel Type 302	3%	72	High conductivity when plated Good corrosion resistance
Stainless Steel Type 316	2.9%	74	High conductivity when plated Excellent corro-sion resistance

Platings

BalShield™ spring gaskets are available with electronic grade platings for such applications as in humid, corrosion-inducing environments, or where higher conductivity is desired. The platings may be ordered to MIL standards or other specifications.

Silver plating will generally provide the surfaces of highest conductivity, but, as with all finishes, will need to be evaluated with respect to other concerns, such as corrosion potential and wear characteristics.

The galvanic compatibility entries in the table are intended as a reference to materials which are in an environment of harsh temperature, humidity, and ionic conductors.

Other materials and platings are available upon request.

Plating Material	Conductivity, IACS	Resistivity, μΩ-cm	Galvanic Compatibility
Gold	74%	2.35	Silver, Titanium, Platinum
Silver	105%	1.59	Nickel, Titanium, AISI 300 steels
Nickel	19%	7.98	Copper, Brass, Beryllium Copper, Tungsten
Tin	15%	11.0	Chromium plating, Aluminum alloys, Galvanized steel series, Brass

Conductivity values are percentages of standard copper conductivity.
References: Metals Handbook, American Society for Metals, 1961
TR-85, Galvanic Compatibility for Spring Materials,
BAL Seal Engineering Co., 1992

Technical Support

At Bal Seal Engineering, we provide expert technical support to our customers to ensure a high level of product reliability. BSE employs the latest technology and remains intimately involved with all major advances in canted-coil spring applications. Through intense research and development, we have compiled a large applications library. Typical spring gasket applications include EMI/RFI shielding, connect/disconnect interfaces, and electrical contacts.

Technical Sales Staff: Our experienced technical staff is ready to answer questions regarding engineering details and service capabilities of all BAL products. Our company provides substantial technical support complemented by customized design proposals, technical reports, and other product information. Please contact the technical sales staff or local representative for up-to-date solutions to your application needs.

Proposals and Data Sheets: Bal Seal Engineering provides design proposal drawings which consist of important spring gasket dimensions and suggested groove dimensions and deflections. Upon request, our sales staff will supply a data sheet.

Samples: A small quantity of sample spring gaskets may be supplied for potential applications. Such evaluation samples can be provided at no cost for standard designs in most diameters and lengths. Where custom parts or larger quantities are needed, a nominal charge may be required.

Part Numbering System

Callout:	BG	XX	XX	-	XXX.XXX	-	X	X	X
Step No.:		1	2		3		4	5	6

1 Nominal Gasket Height

10	0.031 in	(0,79mm)
15	0.063	(1,60)
20	0.094	(2,39)
25	0.125	(3,18)
30	0.156	(3,96)
35	0.188	(4,78)
40	0.250	(6,35)
45	0.313	(7,95)
50	0.375	(9,53)

2 Force

L5	Light
M5	Medium
H5	Heavy

3 Size

XXX.XXX	Inches
XXX,XXM	Millimeters
000	Continuous Length

4 Configuration

S	Closed Ring Type S
T	Closed Ring Type T
L	Continuous Length
C	Cut Length

5 Material

A	Stainless Steel
B	Beryllium Copper Alloy 25

6 Plating Material

A	None
B	Nickel
C	Silver
D	Gold
E	Tin

Sample Part Number

BG 25 M5 – 1.375 – S B B: 0.125 in. (3,18 mm) nominal, medium force, 1.375 in. (34.9 mm) diameter closed ring type S, beryllium copper base material, nickel plating

Important Information

WARNING
IT IS ESSENTIAL THE END USER RUN EVALUATION TESTING UNDER ACTUAL SERVICE CONDITIONS WITH A SUFFICIENT SAFETY FACTOR TO DETERMINE IF THE PROPOSED, SUPPLIED, OR PURCHASED, BAL SEAL PRODUCTS ARE SUITABLE FOR THE INTENDED PURPOSE.

Welded springs have an increased probability of breaking or failing at or adjacent to the weld as opposed to other areas of the spring. This probability is increased further if the spring is used in an application involving extension of the spring. Temperature affects the properties (i.e. tensile, elongation, etc.) of the spring. Failure of BAL Seal Engineering Company, Inc. products can cause greater leakage, equipment failure, property damage, personal injury, and/or death. Equipment containing BAL Seal products must be designed to provide for the safe handling of any eventuality that may result from a partial or total failure of said BAL Seal products. BAL Seal products must be tested with a sufficient safety factor after installation. A program of regular maintenance and inspection must be performed. The User, through its own analysis and testing, is solely responsible for making the final selection of the products and for assuring that all performance, safety, and warning requirements of the application are met.

CLEANING
CUSTOMER/END USER IS ADVISED THAT BAL SEAL PRODUCTS MAY REQUIRE CLEANING AND/OR STERILIZATION PRIOR TO USAGE, DEPENDING ON THE APPLICATION.

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*Products described herein may be covered by one or more of the following U.S. Patents: 4,934,666; 4,655,462; 4,826,144; 4,876,781; 4,915,366; 4,830,344; 5,072,070; 5,108,078; 5,117,066; 5,134,244; 5,139,276; 5,474,309.
(LE-88C Rev. E)

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