EMI GASKET TEST METHODS

Transfer Impedance vs. Radiated Shielding Effectiveness

Technical Report
TR-93 (Rev. NC; 9-5-14)
(100-86)

Bal Seal Engineering
19650 Pauling
Foothill Ranch CA 92610
Toll Free (800) 366-1006
Tel (949) 460-2100
Fax (949) 460-2300
Email: sales@balseal.com

Bal Seal Engineering Europe B.V.
VIDA Building, 1st Floor
Kabelweg 57
1014 BA Amsterdam
The Netherlands
Tel +31 20 638 6523
Fax +31 20 625 6018
Email: info@balseal.nl

Bal Seal Asia Limited
Suite 901, Chinachem Century Tower
178 Gloucester Road
Wanchai, Hong Kong
Tel +(852)-28681869
Fax +(852)-22956753
Email: sales@balseal.com.hk

Bal Seal Engineering is certified to ISO 9001 and TS 16949

Table of Contents

1.0 INTRODUCTION 3

2.0 SUMMARY 3

3.0 MIL-G-83528 (RADIATIVE METHOD) 3

4.0 ARP 1705 (CONDUCTIVE METHOD) 5

5.0 ADVANTAGES AND DISADVANTAGES OF THE TEST METHODS 5

6.0 CONCLUSIONS 6

7.0 REFERENCES 7

TR-93 Rev.NC, 9-5-14 (RR# 100-86)

Bal Seal Engineering: 19650 Pauling • Foothill Ranch, CA 92610-2610 • Tel: (949) 460-2100 • Fax: (949) 460-2300
Bal Seal Engineering Europe B.V.: VIDA Building, 1st floor • Kabelweg 57 • 1014 BA Amsterdam • The Netherlands • Telephone: 31 20 638 65 23 • Telefax: 31 20 625 60 18
Bal Seal Asia Limited: Suite 901, Chinachem Century Tower 178 Gloucester Road, Wanchai, Hong Kong • Telephone: +(852) 28681860 • Telefax: +(852) 22956753

1.0 INTRODUCTION

Bal Seal Engineering manufactures a series of EMI shielding spring gaskets, and has had a significant amount of testing performed as a means of establishing a representative, functional database.

Two test methods are predominantly used by the EMI gasket industry. One is a military specification based upon a radiative method, MIL-G-83528, "Gasketing Material, Conductive, Shielding Gasket, Electronic, Elastomer, EMI/RFI". The other is a conductive method, Society of Automotive Engineers (SAE) specification ARP 1705, "Coaxial Test Procedure to Measure the RF Shielding Characteristics of EMI Gasket Materials."

By its title and scope, MIL-G-83528 may be considered to be solely for the purpose of evaluating conductive elastomeric gaskets, the type of which is a subset of available EMI shielding gaskets. The purpose of ARP 1705, as stated within the specification, is "to establish a technique using conducted methods for reliably and repeatably measuring the RF shielding characteristics of EMI Gasket Materials."

As viewed by the industry, each method has a set of actual and perceived strengths and weaknesses. The purpose of this technical report is to objectively present both of the methods, outlining the basic features of each, and discussing the differences between them.

2.0 SUMMARY

The two most commonly employed EMI gasket testing specifications, MIL-G-83528 and ARP 1705, differ in terms of the test modes used and results produced. Each has its strengths and drawbacks. Only MIL-G-83528 measurements may be used directly in shielding calculations. Both methods may be used to produce data, which is useful in terms of comparing the shielding performance of different gaskets. Testing experience has shown that MIL-G-83528, a radiative test, may be the more difficult method to maintain repeatability.

3.0 MIL-G-83528 (RADIATIVE METHOD)

MIL-G-83528 is a military specification for electrically conductive elastomeric EMI/RFI shielding gaskets. In terms of its scope, it would appear to cover all conductive shielding gaskets; however, by its title and range of types specified, it includes only elastomer-based materials. Each material type is assigned a letter, and is described in terms of its composition, plane wave shielding effectiveness capability in dB, continuous use temperature range, and chemical tolerance to fluids.

The MIL-G-83528 method specifies testing in a radiation configuration, in a modified version of MIL-STD-285, "Military Standard Attenuation Measurements for Enclosures, Electromagnetic Shielding, for Electronic Test Purposes, Method of". The test configuration for MIL-STD-285 is basically that of an enclosure within which is a receiving antenna, and external to it, a transmitting

Bal Seal Engineering: 19650 Pauling • Foothill Ranch, CA 92610-2610 • Tel: (949) 460-2100 • Fax: (949) 460-2300
Bal Seal Engineering Europe B.V.: VIDA Building, 1st floor • Kabelweg 57 • 1014 BA Amsterdam • The Netherlands • Telephone: 31 20 638 65 23 • Telefax: 31 20 625 60 18
Bal Seal Asia Limited: Suite 901, Chinachem Century Tower 178 Gloucester Road, Wanchai, Hong Kong • Telephone: +(852) 28681860 • Telefax: +(852) 22956753

antenna. The shielding effectiveness is determined by taking measurements with and without the enclosure. As MIL-G-83528 is focused upon the shielding characteristics of gasket samples, the enclosure is altered to accommodate a gasket mounting site. Located on one of the enclosure walls is an opening, upon which a plate is bolted; this interface is sealed with the gasket specimen. The opening is a square shape, two feet per edge. The enclosure is generally cubic in shape; the overall dimensions are not fixed by the specification. The antennas are aligned and each located one meter away from the opening. Measurements are taken between the antennas, first through the opening, and then with the gasketed plate bolted in place. The ratio between the measurements, expressed in dB, is the "shielding effectiveness" of the gasketed interface. As such, shielding effectiveness increases as the ratio, in dB, increases. The specification cites a test frequency range of 20 MHz to 10 GHz, which makes a portion of the results susceptible to resonances; resonant modes may occur within the enclosure and opening beyond approximately 175 MHz due to their dimensional relationship with test wavelengths. The basic test configuration is shown in Figure 1.

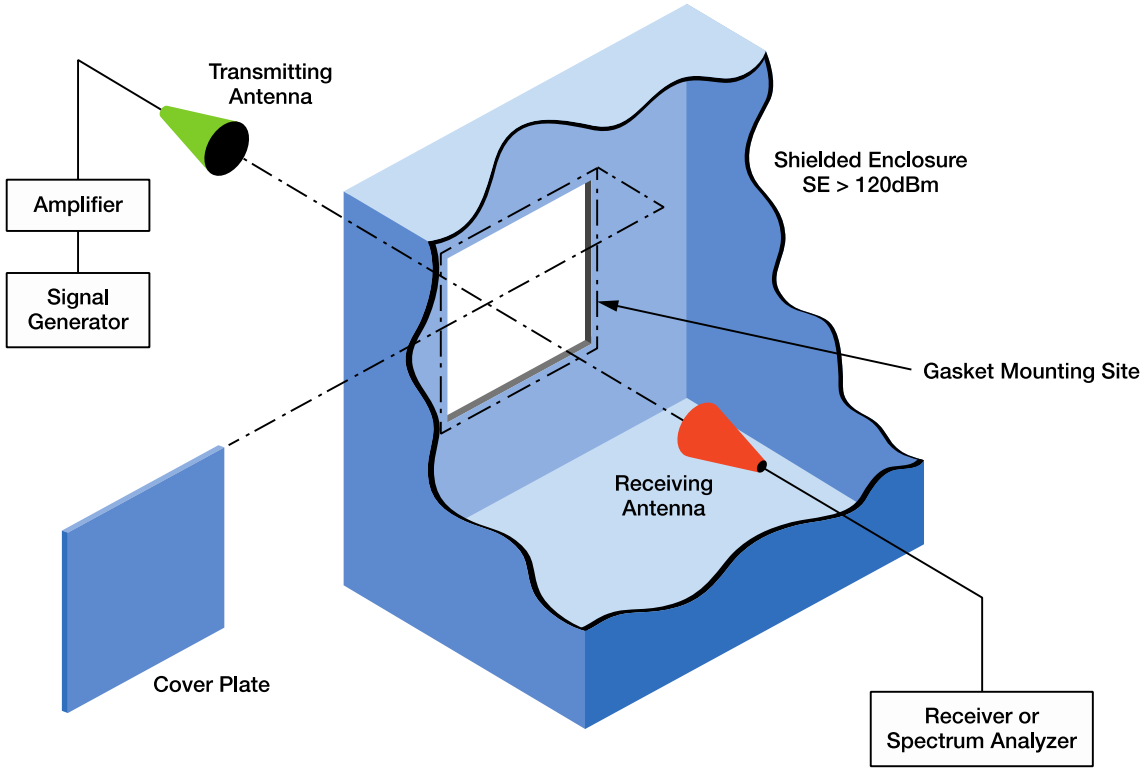

Figure 1
MIL-G-83528 Test Fixture

As a general specification, MIL-G-83528 also includes a comprehensive list of quality assurance tests to qualify material lots of the gaskets. These include operating temperature range, hardness, tensile strength, stability through vibration, volume resistivity after life testing, and fluid immersion, among others.

Bal Seal Engineering: 19650 Pauling • Foothill Ranch, CA 92610-2610 • Tel: (949) 460-2100 • Fax: (949) 460-2300
Bal Seal Engineering Europe B.V.: VIDA Building, 1st floor • Kabelweg 57 • 1014 BA Amsterdam • The Netherlands • Telephone: 31 20 638 65 23 • Telefax: 31 20 625 60 18
Bal Seal Asia Limited: Suite 901, Chinachem Century Tower 178 Gloucester Road, Wanchai, Hong Kong • Telephone: +(852) 28681860 • Telefax: +(852) 22956753

4.0 ARP 1705 (CONDUCTIVE METHOD)

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 test method is intended to employ a conduction mode exclusively. A coaxial housing of specified dimensions is used, the center conductor through which is passed an input signal. Internal to the housing, in series with the center conductor are a fixed impedance and a plate. The gasket is placed between this plate and the housing, clamped with fasteners. The input signal is injected into the input connector, through the impedance and gasket, and travels in a return path through the walls of the fixture. There is a return current which passes through this gasket, and a voltage drop across it. The magnitude of the current is calculated by using the input power and impedance. The voltage drop across the gasket is obtained through measurement. These terms are used to calculate the "transfer impedance" of the gasketed interface. This value may be expressed in terms of dB of attenuation between input and output voltages, or resistance per unit length. An increasing voltage attenuation, or decreasing resistance per unit length indicates improving shielding characteristics. The test fixture described in the specification has a designed range of DC to 700 MHz, beyond which resonant conditions may occur; measurements taken beyond 700 MHz may be distorted by these resonances. The basic test configuration is shown in Figure 2.

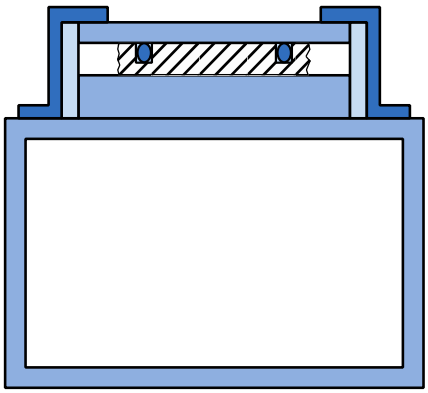

Figure 2

ARP 1705 Test Fixture

5.0 ADVANTAGES AND DISADVANTAGES OF THE TEST METHODS

Each test method is well suited to produce results that may be regarded as valid, valuable results. Alternatively, each method has traits which may be considered to be drawbacks.

Bal Seal Engineering: 19650 Pauling • Foothill Ranch, CA 92610-2610 • Tel: (949) 460-2100 • Fax: (949) 460-2300
Bal Seal Engineering Europe B.V.: VIDA Building, 1st floor • Kabelweg 57 • 1014 BA Amsterdam • The Netherlands • Telephone: 31 20 638 65 23 • Telefax: 31 20 625 60 18
Bal Seal Asia Limited: Suite 901, Chinachem Century Tower 178 Gloucester Road, Wanchai, Hong Kong • Telephone: +(852) 28681860 • Telefax: +(852) 22956753

The measurements obtained through using MIL-G-83528 are in units of dB of shielding, and may be directly insertable to shielding analyses. The results are therefore very user friendly, as translations or other conversions are not required. In the case of ARP 1705, the measurements are in units of resistance per unit length or voltage attenuation, which cannot be readily incorporated into traditional shielding calculations. There is also no consensual translation of transfer impedance measurements into equivalent shielding effectiveness values, although several methods have been proposed.

The ARP 1705 method has been shown through industry-wide usage to be capable of very high repeatability. This is due to the conductive medium of the test configuration, which incorporates cables, connectors, and other such rigid components which are relatively stable. This feature makes it an excellent method for comparison testing of different gasket types. Testing experience has shown that MIL-G-83528 is potentially susceptible to measurement inconsistencies due to the sensitivity of the procedure to the test configuration and nature of the medium. As the test is based upon radiative techniques, the measured results are very dependent upon the positioning of the fixtures and antennas.

Both specifications define the fixturing configurations; these place physical restrictions upon the test frequency ranges with respect to resonant modes. The opening in the MIL-G-83528 fixture creates an aperture which corresponds to the wavelength of approximately 175 MHz, which becomes the cutoff frequency. MIL-G-83528, in its material specifications, cites gasket shielding performances at 10 GHz, so the test set-up and results must be evaluated for the effects of resonances. The ARP 1705 specification states that the fixture cuts off at 700 MHz and that testing beyond this frequency will yield invalid results.

Both specifications point out that their results are the product of the specific test set-up and conditions, and that these measurements may not exactly predict the performance that will be obtained in the users' application. The tests are designed to create conditions which are as repeatable as possible. However, the sensitive mature of high frequency electromagnetic waves to the finite tolerances of the fixturing and test equipment, and the administration of the test, combine to introduce the chance of measurement inconsistencies.

6.0 CONCLUSIONS

The two most commonly employed EMI gasket testing specifications, MIL-G-83528 and Arp 1705, use different techniques and produce different forms of results. Each has its strengths and drawbacks relative to these differences.

Only MIL-G-83528 measurements may be used directly in shielding calculations, as the test simulates a radiative environment and measures shielding effectiveness in units of dB.

ARP 1705 measurements are in units of resistance per unit length or voltage attenuation, which are not convertible to traditional shielding units in a universally acceptable manner. Both methods may be used to produce data which is useful in terms of comparing the shielding performance of different gaskets.

Bal Seal Engineering: 19650 Pauling • Foothill Ranch, CA 92610-2610 • Tel: (949) 460-2100 • Fax: (949) 460-2300
Bal Seal Engineering Europe B.V.: VIDA Building, 1st floor • Kabelweg 57 • 1014 BA Amsterdam • The Netherlands • Telephone: 31 20 638 65 23 • Telefax: 31 20 625 60 18
Bal Seal Asia Limited: Suite 901, Chinachem Century Tower 178 Gloucester Road, Wanchai, Hong Kong • Telephone: +(852) 28681860 • Telefax: +(852) 22956753

Testing experience has shown that MIL-G-83528, a radiative test, which is generally sensitive to variations in the test setup, fixturing, and instrumentation. The specified enclosure and its gasketed opening are of such dimensions as to make the test susceptible to resonances at frequencies below 200 MHz.

Testing experience with ARP 1705 has shown the method to be capable of a high degree of repeatability. This characteristic is consistent with the method and the test configuration. The fixturing and instrumentation for this conductive test consists of rigid hardware, including cables and connectors. The high repeatability makes the method a good one for comparing the relative performance of different types of gaskets. The frequency range of the test is limited by the dimensions of the test housing, cited by the specification at 700 MHz.

A document review has shown that there are no military specifications which address gasket types other than the conductive elastomers. As MIL-G-83528 address elastomeric gaskets only, an approach to qualifying non-elastomeric gaskets with a radiative method would be to test them to the MIL-STD-285 procedure, and to the manufacturers' qualifiable material specifications. This would yield measurements in which shielding effectiveness of the gasket could be used in overall shielding calculations.

Alternatively, the translation methodologies for converting transfer impedance measurements to shielding units may be evaluated. While there is no standard method for doing so, it may be determined through analytical and empirical evaluation that there may be one which is appropriate for a particular usage.

7.0 REFERENCES

1. SAE ARP 1705 – "Coaxial Test Procedure to Measure the RF Shielding Characteristics of EMI Gasket Materials", 1 June 1981, Society of Automotive Engineers, Inc.
2. MIL-G-83528 – "Gasketing Material, Conductive, Shielding Gasket, Electronic, Elastomer, EMI/RFI", 4 June 1993, United States Department of Defense
3. MIL-STD-285 – "Attenuation Measurements for Enclosures, Electromagnetic Shielding, for Electronic Test Purposes, Method of", 25 June 1956, United States Department of Defense

Bal Seal Engineering: 19650 Pauling • Foothill Ranch, CA 92610-2610 • Tel: (949) 460-2100 • Fax: (949) 460-2300
Bal Seal Engineering Europe B.V.: VIDA Building, 1st floor • Kabelweg 57 • 1014 BA Amsterdam • The Netherlands • Telephone: 31 20 638 65 23 • Telefax: 31 20 625 60 18
Bal Seal Asia Limited: Suite 901, Chinachem Century Tower 178 Gloucester Road, Wanchai, Hong Kong • Telephone: +(852) 28681860 • Telefax: +(852) 22956753