Testing EMI Gaskets and Gasketed Joints

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INTRODUCTION

EMI gaskets are used extensively by the electrical/electronic industry to provide an electromagnetic (EM) bond between a pair of joint surfaces, where the materials which make up the joint surfaces are used as an EM shield. The gaskets provide a low impedance path across the joint. The recommended method used to measure the EM bond of the gasketed joint surface is known as transfer impedance, and describes how the energy penetrating through the gasketed joint (i.e., the shielding effectiveness of the joint) is inversely proportional to the transfer impedance of the joint.

Variables which can inhibit the effectiveness and/or the life of EMI gaskets are the material and finish of the joint surfaces, the environment in which the gasket is stored, the environment in which the gasketed joint is to be used, and the available force on the gasketed joint.

This article describes a low-cost method which can be used to test the salient aspects of EMI gaskets and gasketed joints. It consists of three specific tests which measure the shielding quality of EMI gaskets, the shielding quality of EMI gasketed joints, and the shielding quality of EMI gaskets and gasketed joints as a function of the applied force exerted on a gasket.

The data obtained by testing the shielding quality of EMI gaskets and gasketed joints yield the intrinsic impedances of a gasket and the intrinsic impedance of gasketed joints.

Tests are available to ensure that EMI gaskets are effective in their end environment.

This data can be used to accurately predict the penetration of an electromagnetic field through a gasketed joint.

The tests are designed to be used by EMI gasket manufacturers and users to verify the shielding quality of various gaskets, to test the shelf life of gaskets, to test EMI gaskets in various environments and to test the shielding quality of EMI gaskets and/or gasketed joint surfaces under force.

The test variables of concern include:

- The shielding quality of a gasket when the gasket is compressed a given amount. The testing is performed in as-delivered condition and after the gasket has been stored in transportation/storage environments of concern.
- The shielding quality of a gasketed joint when the gasket is compressed a given amount. The testing is performed in as-delivered condition and after the gasketed joints are subjected to various hostile environments of concern.
- The shielding quality of an EMI gasket and/or a gasketed joint surface as a function of the force exerted on the gasket by the joint surface.
- The shielding quality of an EMI gasket and/or gasketed joint surface as a function of the force exerted on the gasket where the joint surfaces are not parallel (i.e., representing a joint surface condition that is uneven).

TEST PURPOSE

In testing for the shielding quality of an EMI gasket, the gasket is placed between two flat parallel gold-plated plates and is compressed a given amount. The purpose of the test is to evaluate the salient aspects of the gasket such as the surface contact resistance and internal resistance of the gasket. It is designed to be used by manufacturers and users of EMI gaskets to grade the various gaskets of concern and to test (QC test) a gasket lot to verify the shielding quality of the lot. Since many of the EMI gaskets on the market possess a shelf life in the presence of hostile storage and/or transportation environments, the test can be used to determine the shielding quality of various EMI gaskets after being subjected to hostile environments such as moisture, salt fog, temperature, etc.

In testing the shielding quality of an EMI gasketed joint, the gasket is placed between two flat parallel plates and compressed a given amount. The plates are fabricated and finished from specific materials of concern (e.g., chemical film-plated aluminum). The purpose of the test is to select a gasketed joint combination that fulfills the require-

*See Advertisement on Page 2.

ments of a specific system or set of systems. These requirements can include survival in specific hostile environments such as moisture, salt fog, temperature, dust, etc.

In testing for the shielding quality of an EMI gasket or gasketed joint as a function of the force exerted on the gasket, the gasket is placed between two flat parallel plates. The shielding quality is measured at specific forces which are exerted on the plates, i.e., from measurements taken as the force is gradually increased. The plates can be gold-plated which will yield a shielding quality of the gasket as a function of force, or fabricated and plated to a specific requirement, yielding a shielding quality of the gasketed joint as a function of the force on the gasket.

In testing for the shielding quality of the EMI gasket or gasketed joint as a function of the unevenness of the joint and the force exerted on the gasket, the gasket is placed between two plates where the parallelism of the plates is offset a given amount. The shielding quality of the gasket is then measured as a function of the force exerted on the gasket at specific predetermined levels. Such testing can be for the shielding quality of the gasket (using gold-plated joint surfaces) or the shielding quality of a gasketed joint (using specific joint surfaces of concern). This is a very valuable test when the force on the gasketed joint is relatively small and the joint surfaces are uneven.

TEST REQUIREMENTS

The gasket materials under test are placed between a set of test plates. The size of the sample and placement of the sample are specified by the manufacturer of the test fixture under use.

The testing is performed using receivers, spectrum analyzers or network analyzers in a sweep mode. If possible, a tracking generator is used to obtain a continuous sweep of data over the frequency range of interest. If a continuous sweep is not possible, the data is obtained at randomly selected frequencies with a minimum of 10 frequencies per octave. This is performed by having the receiver and signal generator sweep over a given frequency range at different speeds, and detecting and recording a minimum of 10 readings within each given octave. In performing this testing, care must be used to insure that the dwell time of the receiver is of sufficient length (i.e., sweep rate) to capture the signal generated by the signal generator.

The data obtained by testing the shielding quality of EMI gaskets and gasketed joints yield the intrinsic impedances.

In testing for the shielding quality of EMI gaskets, the test plates are to be gold-plated. In testing for the shielding quality of gasketed joints, the test plates are to be manufactured and plated from the same materials and in a manner identical to that used during actual application of the system of concern.

TEST PROCEDURE

The testing is performed on sample coupons. During the performance of the test, the following requirements are necessary. The joint test surfaces are to be gold-plated 6061-T6 aluminum (or equivalent). In performing the engineering evaluation testing on gasketed joints, the joint surfaces are to be of the same material and finish as those used during normal operation.

In performing the dynamic pressure testing, the joint surfaces are to be gold-plated for testing the shielding quality of EMI gaskets and formed from the materials and finishes of concern for testing the shielding quality of EMI gasketed joints, e.g., 6061-T6 aluminum, tin-plated per MIL-T-10727. Prior to the start of testing, the joint surfaces are to be cleaned of all contaminants with appropriate solvents.

Steps for Specific Testing

Obtain a current amplitude spectrum in the following manner (required for all testing). Set up the test fixture as described by the manufacturer of the fixture. Place a 1-ohm calibration assembly in the Z_T test fixture, and observe and record readings over the frequency range of interest.

Transfer Impedance Test of EMI Gaskets

Conduct a transfer impedance test for EMI gaskets. This testing can be performed on production quality gaskets or on gaskets after being subjected to the applicable transportation/storage environments of Table 1.

- Place the gasket coupon under test between gold-plated joint surface plates and compress the gasket material to the deflection amount specified by the manufacturer of the gasket under test. Note that care must be exercised to insure that the conductivity between the plates is only through the gasket.
- Set up the test fixture as described by the manufacturer of the fixture with the signal generator connected to the input port and the receiver connected to the output port.
- Set the output power level of the signal source to the same level as used to determine a current amplitude spectrum, and scan over the

frequency range of interest. Observe the voltage amplitude spectrum obtained by the receiver, and record a minimum of 10 readings per octave where the frequencies are to be randomly selected.
- Convert the reading to ohm-meters (or dB ohm-meters) using the methodology given below.

Transfer Impedance Testing of EMI Gasketed Joints

This test can be performed on production quality gaskets using the joint material and surface finishes of concern or on the gasketed joints after being subjected to the applicable mission/sortie environments of Table 2.

- Place the gasket coupon under test between the joint plates, where the material and surface preparation of the plates are identical to that to be used in normal operation.
- Set up the test fixture as described by the manufacturer of the fixture with the signal generator connected to the input port, and the receiver connected to the output port.
- Set the output power level of the signal source at the same level as used to obtain a current amplitude spectrum, and scan over the frequency range of interest. Observe the voltage amplitude spectrum obtained by the receiver, and record a minimum of 10 readings per octave. Note that the frequencies are to be randomly selected.
- Convert the reading to ohm-meters (or dB ohm-meters using transfer impedance calculations).

Transfer Impedance Testing vs. Applied Force

The testing can be performed on gaskets using joint surfaces parallel to each other or with the parallelism offset a specific amount.

- Place the gasket coupon under test between gold-plated transfer impedance test fixture joint surface plates for testing the shielding quality of EMI gaskets, or between joint surfaces where the material and finish of the plates are identical to that to be used in normal operation for testing the shielding quality of EMI gasketed joint surfaces.
- Set up the test fixture with the signal generator connected to the input port and the receiver connected to the output port.
- Apply the minimum force on the set of contact plates as recommended by the manufacturer of the test fixture.
- Set the output power level of the signal source to the same level as used to obtain a current amplitude spectrum and scan over the frequency range of interest. Observe the voltage amplitude spectrum obtained by the receiver, and record a minimum of 10 readings per octave.

Environmental Stress Condition	Test Method/ Procedure (MIL-STD-810D)	Duration/ Stress
High Temperature (Dry Humid)	Method 501.2	TBD
Low Temperature (Rain/Hail/Freezing)	Method 502.2	TBD
Thermal Shock	Method 503.2	TBD
Solar Radiation	Method 505.2	TBD
Fungus Growth	Method 508.3	TBD
Rain	Method 506.2	TBD
Humidity	Method 507.2	TBD
Salt Fog	Method 509.2	TBD

Table 1. *Transportation/Storage Environments.*

Environmental Stress Condition	Test Method/ Procedure (MIL-STD-810D)	Duration/ Stress
High Temperature	Method 501.2	TBD
Salt Fog	Method 509.2	TBD
Explosive Atmosphere	Method 511.2	TBD
Rain	Method 506.2	TBD
Immersion	Method 512.2	TBD
EMP/Lightning	MIL-STD-461 Req. CS12	TBD

Table 2. *Mission/Sortie Environments.*

- Convert the readings to ohm-meters (or dB ohm-meters) using the methodology given within the transfer impedance calculations section above.
- Repeat the preceding three steps with an increase in force. A minimum of 4 forces, with the force differential between the force evenly spaced, are to be recorded.

TRANSFER IMPEDANCE CALCULATIONS

The impedance of a gasket is the voltage across joint (faying) surfaces as a function of the current in amperes flowing across the gasket under test, i.e.,

$$Z(\text{Impedance}) = \frac{E\ (\text{volts})}{I\ (\text{amps})}\ (\text{ohm})$$

To convert the impedance, to transfer impedance the impedance is multiplied by the circumference of the gasket sample in meters, i.e.,

$$Z_T = \frac{E}{I} \times C_m\ (\text{ohm-meters})$$

$$Z_T(dB) = E(dB) - I(dB) + C_m(dB)$$

Where

Z_T = Transfer Impedance

E = Recorded Voltage Reading (V)

I = Recorded Amperage Reading (A)

C_m = Circumference of gasket in meters

Example (See Figure 1 @ 500 MHz)

E(dB) = -70 dBm (V)

I(dB) = -36 dBm (A)

C_m(dB) = 20 log 0.05 = -26 (m)

Z_T (dB) = -70 - (-36) + (-26)

= -60 dB ohm-meters or 0.001 ohm-meters

Using absolute values

-70 dBm = 3.2×10^{-4} mV

-36 dBm = 0.016 mA

C_m = 0.015 meters

$$Z_T = \frac{3.2 \times 10^{-4}}{0.016} \times .05$$

= 0.001 ohm-meters

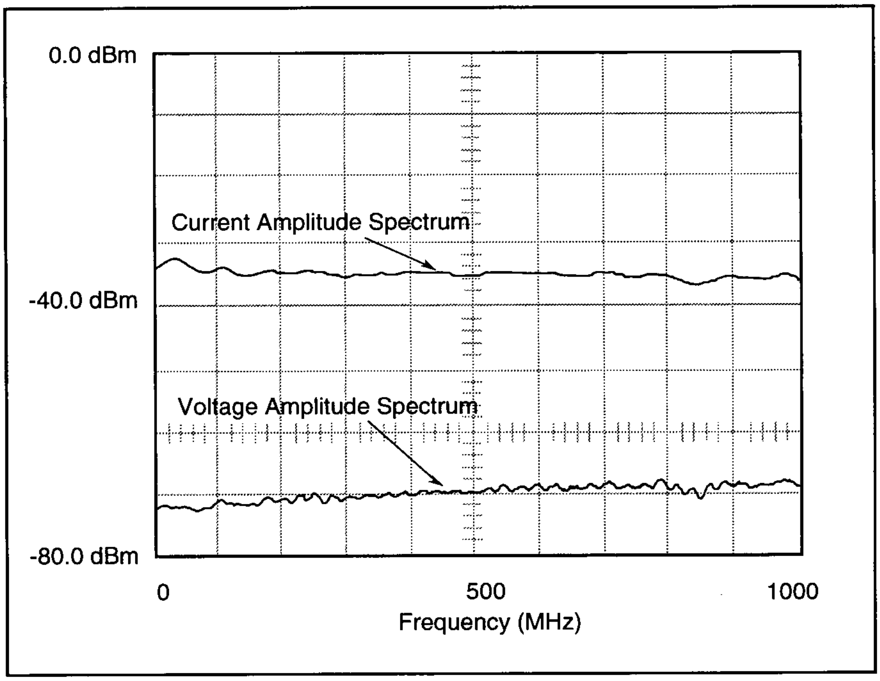


Figure 1. *Results of Transfer Impedance Testing on 2.0-inch (0.05 meter) Long Gasket Using Z_T-300 Test Fixture. Note: A spectrum analyzer with tracking generator was used in the performance of this test. This results in a continuous reading over the frequency range of interest.*

Z_T (dB) = 20 log 0.001

= -60 dB ohm-meters

ENVIRONMENTAL TEST CONSTRAINTS

The exposure of EMI gaskets to various environmental conditions can significantly reduce the gasket's effectiveness as well as greatly limit the life of a gasketed joint. The following section describes environments which have been known to degrade the effectiveness of various types of gaskets, and/or degrade the effectiveness of EMI gasketed joints.

Transportation/Storage Environments

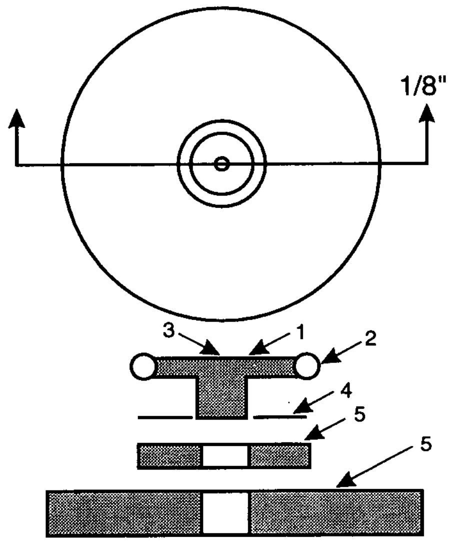
When specified, the gaskets are subjected to hostile environments prior to transfer impedance testing. The specific environments to which the gaskets are to be subjected are tailored to the conditions expected during the transportation and/or storage of the gaskets. The specific environments of concern are given in Table 2.

While subjecting the gaskets to the specific environments, the gaskets are placed in a commercial-grade corrugated carton. If special packaging is needed to comply with the requirements, such instructions are stipulated with the shipment of the product.

Mission/ Sortie Environments

When specified, the gasketed joints are to be subjected to hostile environments prior to performing transfer impedance testing. The specific environments to which the gasketed joints are subjected are determined by the environments to which the end-use equipment will be subjected during the equipment life.

In performing the environmental testing, the gasketed joints are to be placed in commercial-grade corrugated cartons.



NOTES
1. 1-ohm disk resistor
2. EMI gasket
3. 1/8-inch diameter brass rod
4. 0.010-inch thick nylon spacer
5. Contact plate with following dimensions

Z_T Fixture	Diameter	Thickness
300	0.75	0.125
1000	4.00	0.250
2000	7.00	0.250

6. The EMI gasket (2) and brass rod (3) are soldered to resistor (1). Soldering is to provide a continuous electrical joint.
7. The brass rod (3) is to be inserted completely into contact plate (5) and soldered, fused or otherwise made electrically continuous with plate.

Figure 2. *Design of Calibration Fixtures.*

CALIBRATION FIXTURE

The calibration fixture is used for two purposes. These are to measure the current being delivered to the test fixture by the signal source and to calibrate the fixture. The voltage across a 1-ohm resistor measures the current through the resistor (i.e., that which is delivered to the fixture).

Calibration of the Fixture

There are several transfer impedance test fixtures on the market today. The plates and assemblies making up the fixtures limit the frequency range of the testing. Any resonance (which causes the frequency range limitation) will be observed in performing the testing as follows:

- Set up the test sample as described above. Observe and record the current amplitude spectrum over the frequency range of concern.
- Replace the test fixture with an appropriate coaxial connector (e.g., type N, UG291) and observe and record the current amplitude spectrum.
- Compare the two readings. The results indicate the following:
  - A 34±2 dB difference between the readings indicates the test fixture will provide accurate transfer impedance data. Such data can be used to predict the field strength emanating from the joint.
  - A slight deviation from the 34±2 dB difference indicates that the transfer impedance data cannot be used to accurately predict the field strength penetrating the resultant gasketed joint but can be used to grade gaskets or gasketed joints.
  - A significant deviation at any frequency indicates that the fixture cannot be used at that or a higher frequency.

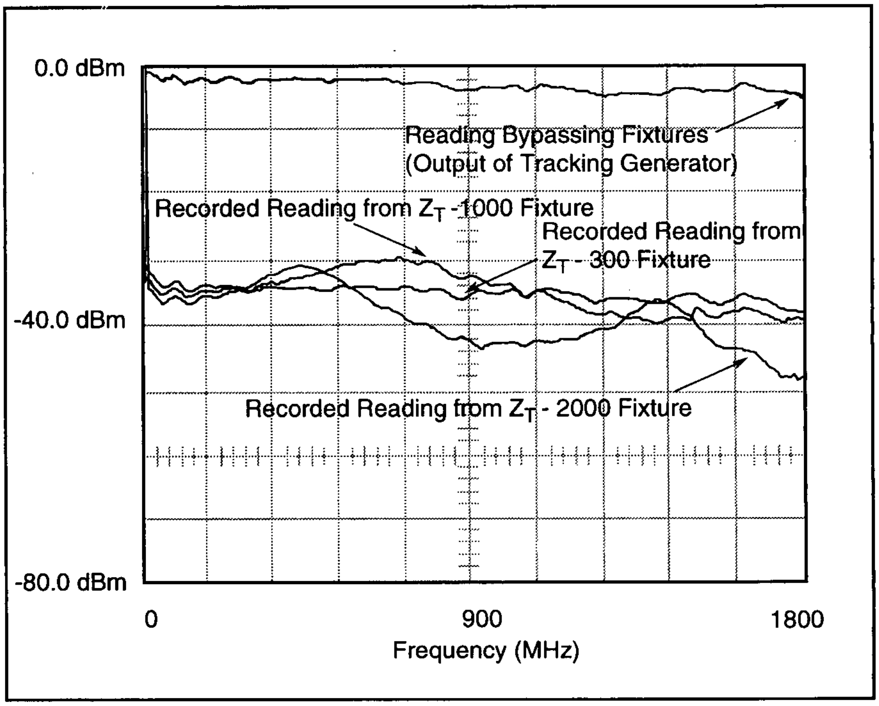


Figure 3. *Measured Impedance of 1-ohm Calibration Assemblies Using Three Different Test Fixtures.*

Figure 2 illustrates the design of the calibration fixtures.

Figure 3 illustrates the results of testing on the three transfer impedance test fixtures. The results of the test indicate the following:

- The difference in the reading between the output of the tracking generator and the voltage across the 1-ohm resistor of the ZT-300 fixture varies from 32.5 to 34 dB. This means that the data obtained from the fixture is accurate through 1.8 GHz.

- The difference in the reading between the output of the tracking generator and the voltage across the 1-ohm resistor of the ZT-1000 fixture varies from the 34±2 dB above 400 MHz by as much as 6 dB. This implies that the transfer impedance measures above 400 MHz can be off by as much as 6 dB.
- The difference in the reading between the output of the tracking generator and the voltage across the 1-ohm resistor of the ZT-2000 fixture varies from the 34±2 dB above 200 MHz by as much as 7 dB. This implies that the fixture can be used to accurately measure the transfer impedance of gaskets up to 250 MHz, the transfer impedance of gaskets or gasketed joints can be off by as much as 7 dB over the frequency range of 250 MHz to 1.8 GHz, and the fixture can be used to grade gaskets and gasketed joints up to 1.8 GHz.

CONCLUSION

The procedure described here is a low cost method which can be used by manufacturers and users of EMI gaskets to test the salient aspects of EMI gaskets and gasketed joints. The test variables include the compression set, environmental exposure, and exposure exerted by joint surfaces under parallel and nonparallel conditions.

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