

A Practical Shielding Effectiveness Evaluation of EcE Gaskets Incorporating Accelerated Aging

Douglas S. McBain, Tam Chau, Shelby Ball, and Robert Antonio
Laird Technologies
4707 Detroit Avenue
Cleveland, Ohio, 44102
USA

216-939-2300 (Phone), 216-939-2310 (Fax), doug.mcbain@lairdtech.com

Abstract

A practical radiating Shielding Effectiveness test fixture is described for evaluating Electrically Conductive Elastomer (EcE) gaskets of the type used to provide protection against electromagnetic interference (EMI). The fixture itself consists of two compartments, each fitted with a broadband antenna. A perimeter gasket of EcE extrusion seals the fixture compartments against a common back-plate. The frequency range of interest is 0.8 to 3.0 GHz. The test fixture is used to generate comparable data describing gasket performance under compression and conditions of accelerated aging, such as elevated temperature and high relative humidity. Measurements of Shielding Effectiveness of several conductive elastomer compositions are described, along with a summary of the advantages and limitations of this type of testing.

Keywords: Shielding Effectiveness, Electrically conductive Elastomer, Accelerated Aging

Introduction

Shielding Effectiveness testing is performed to indicate the ability of a material to attenuate electromagnetic radiation of a given frequency or range of frequencies. Test methods and standards vary by material, application, and measurement equipment. Three of the more widely used standards include that described in MIL-DTL-83528 [1] or ASTM D4935 (withdrawn) [2], for radiated Shielding Effectiveness, and SAE-ARP-1705 [2], a transfer impedance method. The MIL-DTL test is used for frequencies from 20 MHz to 10 GHz, while the transfer impedance method is useful at frequencies less than 1 GHz.

Several electronics original equipment manufacturers and designers have developed in-house enclosure-level test devices which they believe to have utility over frequency ranges of interest to the OEM themselves. A driving factor behind the interest in such limited testing is a desire to predict service life-times which are relevant to the device itself. In particular, there is an interest in the effect of accelerated aging

tests on the Shielding Effectiveness of conductive materials used as gaskets.

Methods

Measurements of Shielding Effectiveness were made with a two-chamber fixture, as shown in Figure 1. The fixture dimensions were 24 cm. in length, so each cavity is approximately 12 cm. X 24 cm, and 1 cm. in depth. The fixtures were machined from aluminum and coated with electroless-nickel. The fixture has a one-piece common back-plate which is sealed against the gasket with screws. Gasket compression is controlled by the use of shims which are removed prior to testing.

The perimeter gasket of the fixture was a hollow-sprocket of electrically conductive elastomer (EcE), with dimensions as shown in Figure 2. The center-line gasket of the fixture was a conductive Form-In-Place (FIP) gasket which was a composition common to all of the test fixtures, while the composition of the EcE gasket varied. Broad-band antennas [4] were a commercially available design manufactured by Laird Technologies and were held in position by

double-sided adhesive foam tape. An Agilent Model E5701C Virtual Network Analyzer was used for testing.

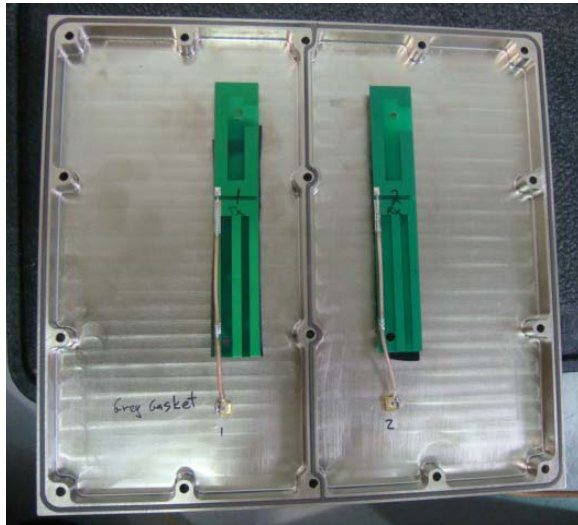


Figure 1. Two-chamber test fixture with strip antennas, perimeter and central gaskets installed for testing.

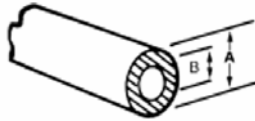


Figure 2. Hollow-Sprocket O-Strip Extrusion used as the Perimeter Gasket. Nominal dimensions OD (A) of 2.4 mm, and ID (B) of 1.2 mm.

The EcE gaskets, all items of commerce, used for the study were fabricated from two base elastomer compositions, which were a silicone-based material or an EPDM-based material. The base elastomer compositions in each case were filled with nickel-coated graphite particles to obtain a volume resistivity of 0.100 Ω -cm. or less.

Following installation of the gasket materials, each antenna was verified to be operational by open-air testing. The back-plate was then fastened to the test-fixture and carefully compressed to obtain a gasket compression of 25% of the original gasket height. The Network Analyzer was calibrated, and background contribution of the cables and fixtures themselves was also removed by calibration. A signal measurement was obtained with the Network Analyzer by using one antenna in a radiating mode and the other antenna in

receiving mode. The antenna modes were subsequently reversed and the two datasets compared. Dissimilar data indicates leakage of the perimeter gasket or antenna malfunction. The signal was measured at 200 points between 0.8 GHz and 3.0 GHz. Signal response for the test fixture fitted with gaskets and back-plate is shown in Figure 3.

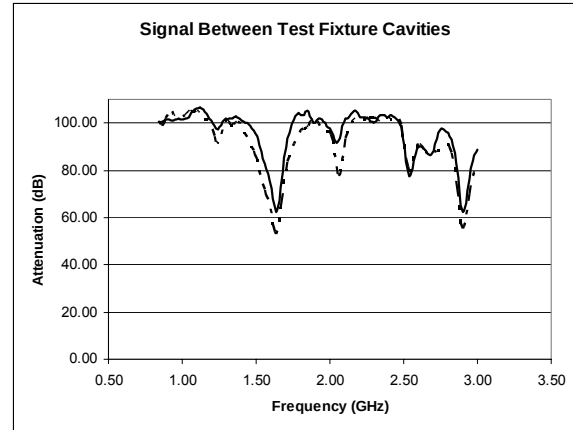


Figure 3.
Solid Line, Silicone-Type Gasket;
Dashed Line, EPDM-Type Gasket

A comparable measurement of the signal strength of the fixture, back-plate (at the working height used for gasket compression) and antennas, but without central or perimeter gaskets, was previously made. This measurement represents what each antenna receives if no gasket is present. The Shielding Effectiveness (in dB) of the gaskets, then, represents the measurement of the loss in field strength (in dB) from the measurements with and without the gasket interposed. The Dynamic Range, or maximum Shielding Effectiveness which can be measured, is estimated to be 110 dB for the test fixture based on work with more conductive gaskets.

The assembled fixtures were measured initially and then subjected to accelerated aging. Replicate fixtures were prepared, measured, and aged simultaneously. The test conditions were chosen to represent protocols typical of qualification testing, namely 85°C and 85%RH, and cycling temperature between extremes of 85°C and -45°C. The cycling temperature profile was comprised of one hour ramp and one hour hold periods, or four hours, respectively, for a complete hot-cold cycle.

After aging the fixtures were re-measured without opening. The difference between the initial and final datasets represents

the loss of Shielding Effectiveness with aging. The data was smoothed using a 5 point forward averaging algorithm to derive the plots reported below.

One set of fixtures, of each gasket type, was measured and kept at room temperature during the duration of the accelerated aging of the experimental fixtures. This fixture was re-measured along with the experimental fixtures. The performance of the control fixture was expected to change little over the time-frame of the study, and could be contrasted to the

performance of those fixtures which were more aggressively aged.

Results

Figures 4. and 5. show the change in the control fixture for both the silicone-type and the EPDM-type gaskets, respectively. Only small changes are observed in Shielding Effectiveness between the initial and final measurements over the experimental time-frame.

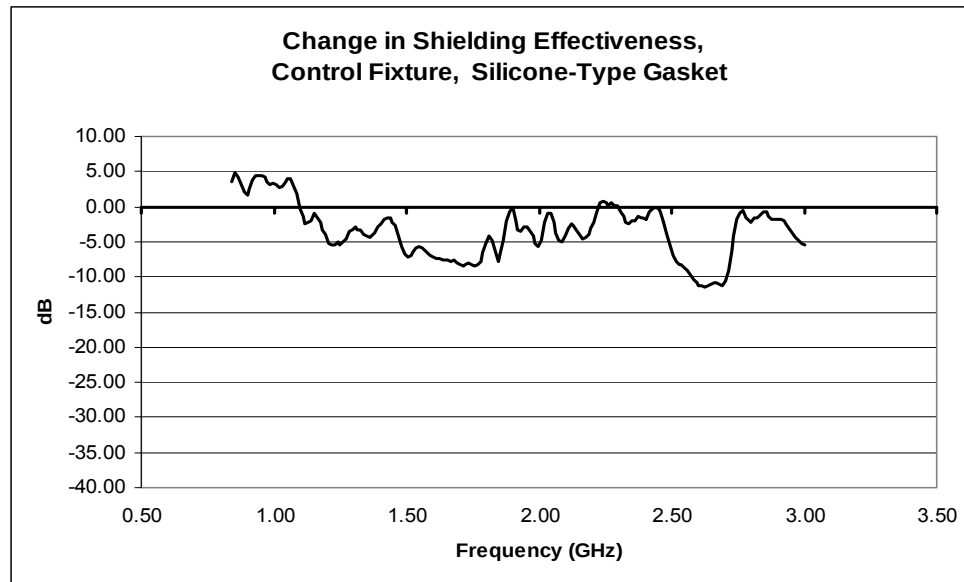


Figure 4.

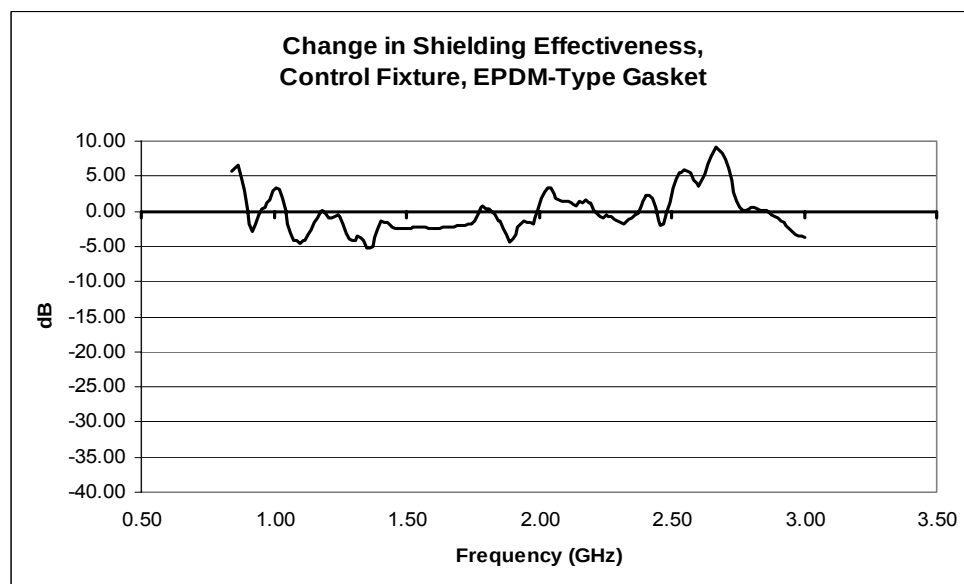


Figure 5.

The control fixtures were aged at room temperature and approximately 50% RH, and treated similarly to the experimental fixtures. The experimental time period was that necessary to complete all the aging exposures of the experimental fixtures.

Figures 6. and 7. show the results for fixtures which were aged for 240 hours at 85°C with 85%RH. Both the silicone-type gasket and the EPDM-type gasket displayed a significant loss of Shielding Effectiveness following accelerated aging. The EPDM-type gasket was affected more by this type of aging condition than the silicone-type material.

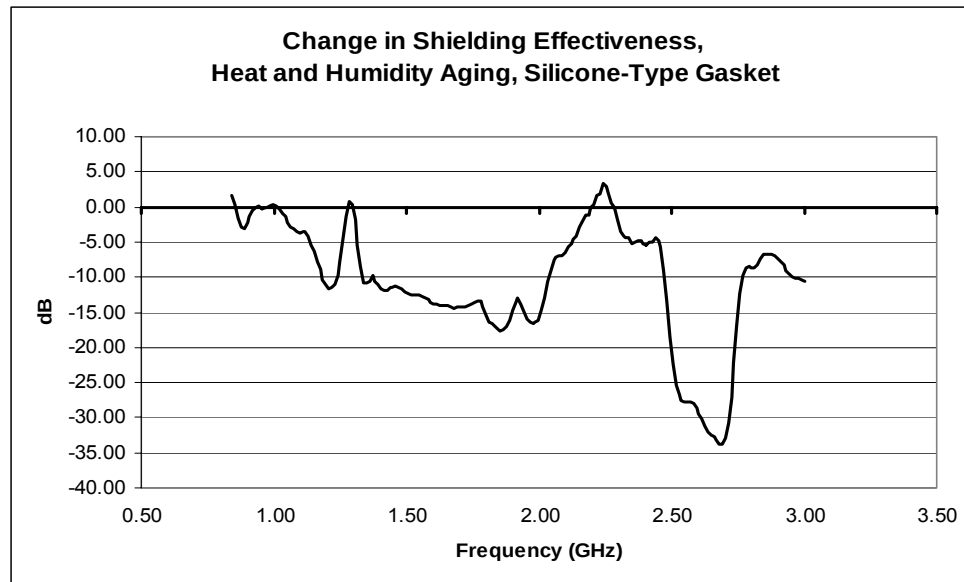


Figure 6. Silicone-Type Gasket aged 240 Hours at 85°C/85%RH.

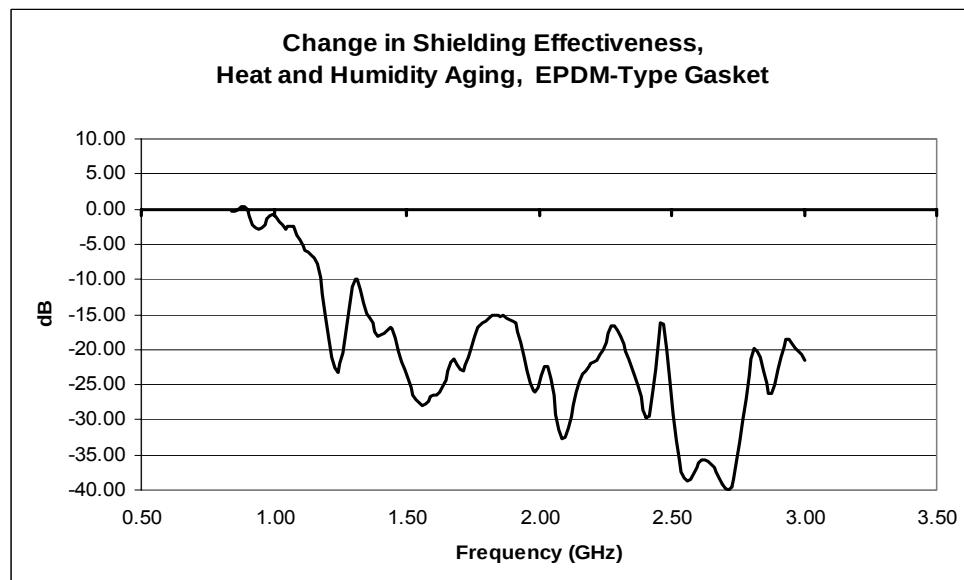


Figure 7. EPDM-Type Gasket aged 240 Hours at 85°C/85%RH.

The experimental fixtures aged for 240 hours at high heat and humidity displayed a loss of Shielding Effectiveness significantly different from the control samples. Although the silicone-type gasket control fixture had slight changes in Shielding Effectiveness at room temperature over the experimental time-frame, the gasket fared better on aging than the EPDM-type gasket.

Figures 8. and 9. show the results for fixtures which were aged for 40 cycles of exposure between temperature extremes of 85°C and -45°C. Both the silicone-type gasket and the EPDM-type gasket displayed a significant loss of Shielding Effectiveness following the cyclic temperature accelerated aging protocol. The EPDM-type gasket was again affected more by this type of aging condition than the silicone-type material.

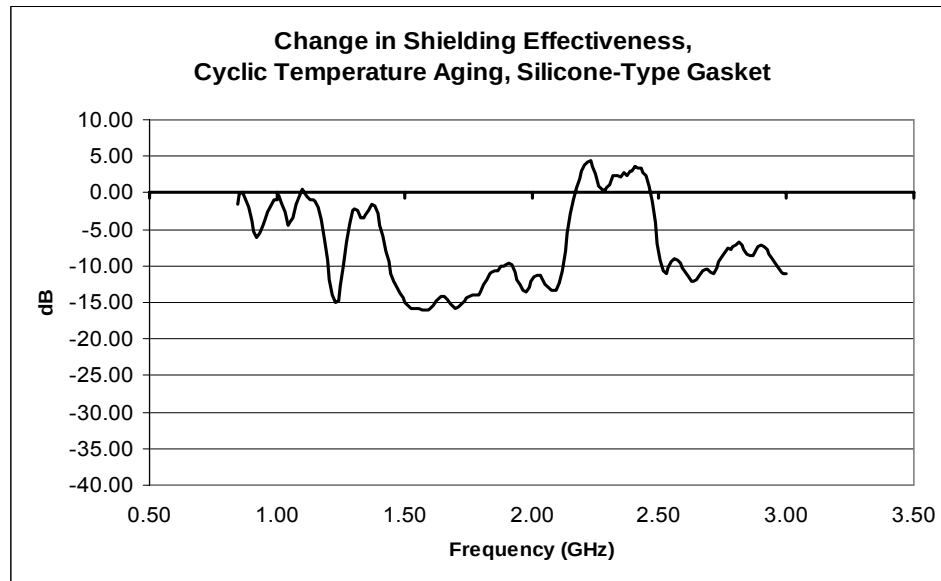


Figure 8. Silicone-Type Gasket aged 40 Cycles at 85°C/-45°C.

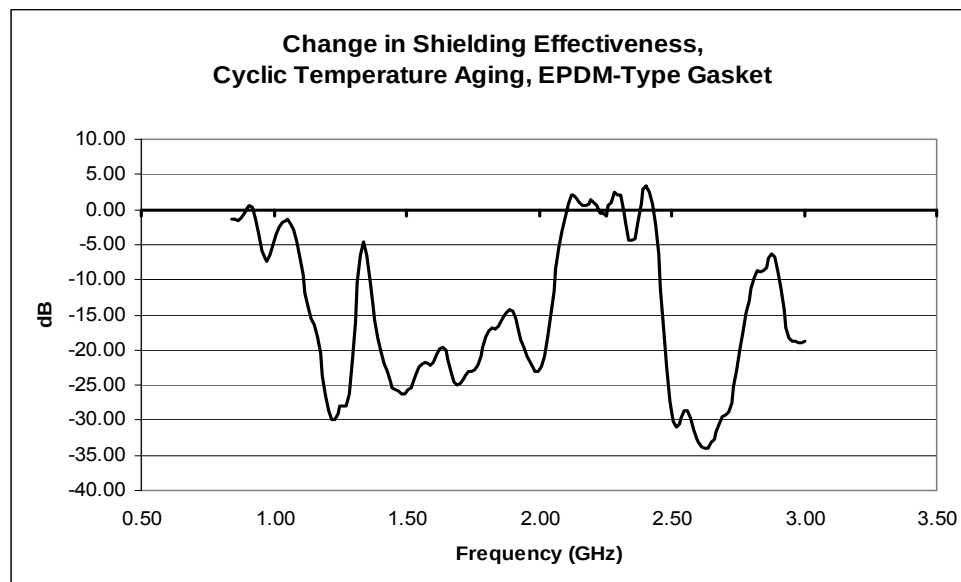


Figure 9. EPDM-Type Gasket aged 40 Cycles at 85°C/-45°C.

The experimental fixtures aged for 40 extreme temperature cycles displayed a loss of Shielding Effectiveness significantly greater than the control samples, and different from the fixtures aged at high temperature and high humidity alone. Again, the silicone-type gasket fared better on aging than the EPDM-type gasket.

Overall, the results indicate that cyclic temperature accelerated aging and high temperature and high humidity aging may be expected to yield different results for a given exposure time.

Discussion

First, the amount of accelerated aging and the relationship of exposure-time to service lifetime needs to be evaluated in a material and application relevant manner. Accelerated aging testing, although certainly useful, must be correlated to actual lifetime data before any specific conclusions can be made. Generally, however, relative comparisons between materials can be valuable during the project phases representing material development, material selection, and application or equipment design.

Second, the results shown above clearly demonstrate the utility of this approach to Shielding Effectiveness measurements. The fixture and antenna design lead to cavity resonances and “noisy” data, but certainly the relative conclusions are evident. Useful distinctions between gasket material performance and aging conditions can be drawn.

Finally, although this type of testing is shown to be useful, the fixture design is non-standard and the antenna choice is not optimized. Results obtained may not correlate with other designs or test protocols.

Recommendation

An improved fixture design, optimized for a given antenna performance and for gasket placement, needs to be derived and this type of testing. A standard design would be of benefit for materials development, engineering specifications, and of assistance to those individuals involved in application design.

References

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2. “Standard Test Method for Measuring the Electromagnetic Shielding Effectiveness of Planar Materials”, ASTM D4935-99 (Withdrawn).
3. “Coaxial Test Procedure to Measure the RF Shielding Characteristics of EMI Gasket Materials”, SAE ARP1705 Rev. A, 2006-04.
4. Laird Technologies, “Heptaband” Quadband GSM+ UMTS/3G Antenna.