A new technique to improve gasket performance that uses elastomer or rubber material

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ABSTRACT:
Elastomer material loaded with conductive metal powder is frequently used as EMI (electromagnetic interference) gaskets, and open or closed cell polymer or rubber is used as the core material of wire-mesh gasket or conductive fabric. Reported and well documented, and many shielding effectiveness test personnel know that, especially on some applications requiring very high level of shielding, these gaskets frequently fail to meet performance requirements because of compression set [1]. New test results reveal ways to circumvent this kind of failure, and we suggest a new test procedure in choosing the polymer material to address the existing problem.

I. INTRODUCTION
ASTM International standard D1056 [2] and D395 [3] are used to specify/test a compression set of sponge or re-expanded rubber material, and it appears that EMI gasket manufacturers simply use available compression set data from the elastomer/rubber manufacturer. Elastomer manufacturers exclusively use the ASTM International standard D1056 and/or D395 to measure compression set. But it turned out that their test procedures are not well suited for EMI gasket applications.

To reduce exposure of sensitive electronic equipment from harmful EMI signals or to protect sensitive RF signals from radiating out to an open field, we need elastomer/rubber to expand to its original or close to its original height as soon as possible so that the necessary contact pressure can be maintained. It turned out that door gaskets are frequently failing to meet performance requirements [1]. The door gasket failure is well known to the military shelter community, and a few organizations have tried to address the problem with minimal success. The door gasket problem has not been highly publicized, because most of the users are not aware of the problem. There are few maintenance programs to periodically inspect, replace or verify integrity of gaskets, but effectiveness of the program is hardly known to the EMI community.

A potential user of a system usually requires that a shielding effectiveness test be done on a basic, unmodified shelter before any subsequent modifications. Then, following modifications such as installations of air conditioning, panels, etc., further tests must be conducted to ensure shielding effectiveness. Previous experiences have shown that a brand new shelter delivered from a warehouse does not meet a required shielding effectiveness [4]. Usually, it turned out that the problem was caused by compression set of door gasket. To restore its shielding effectiveness, the gasket is replaced before its lifecycle has ended, or shims are added, or appropriate repair work is done to increase contact pressure [5]. Adding shims or other repair work to increase shielding effectiveness is a very time consuming procedure because it requires skilled test personnel to test shielded enclosures during and/or after adding shims to monitor the shielding effectiveness values around a door or a panel. However, as will be seen later, this problem can be circumvented or prevented.

II. VERIFICATION METHOD
To verify performance of radio frequency (RF) or EMI gaskets, shielding effectiveness tests are usually conducted by following a standard test procedure. However, at present, there is quite a bit of controversy on the test procedures because there are few applicable standards and they provide different results [6-13].

For gaskets that rely on gasket core material to provide necessary contact pressure and resiliency, we need to make sure that the core material works well. Apparently, many researchers have overlooked the performance of the gasket core material. This paper points out the important role of the gasket core material in providing adequate shielding effectiveness. The test approach presented in this paper does not rely on shielding effectiveness, but use the following simple test approach: A U-shaped groove is cut on plywood, where depth of the groove is approximately 50% of a gasket core material’s height to be tested. Gasket core material was cut in two inch lengths and placed in the groove. For stability, two identical samples were placed parallel to each other, and a weighted metal plate was placed on top of the gasket core materials. Subsequently, the weight was
removed at a predetermined time and the gasket core height was measured at given time intervals.

III. SHORT TERM MEMORY

Without any existing standard that defines operating condition, it is arbitrary to pick a time interval to compress gasket core material for evaluation of compression set. However, seven randomly chosen polymer and rubber gasket core materials, which are presently used by various vendors, were compressed for 15 minutes for short term memory test. After removal of the weight, heights of the polymer/rubber materials were measured every 10 seconds for one minute. The 10 second interval was primarily chosen through trial and error so that height of the polymer can be measured without rushing, which can lead to measurement errors.

It was a challenge to measure height of the polymer or rubber material as they expand without sophisticated equipment. Actually the measurement was made using a caliper at the center section of the two inch long gasket core material. Since polymer and rubber sponge materials cannot be cut smoothly and accurately like solid material, one should expect some errors or small variations associated with the measurement. Two solid rubber core materials were tested, but their dimensions are not uniform along the two inch section of their samples due to warping and lose tolerance. However, we believe, these variations are not significant and measurement errors are fairly small, perhaps plus or minus five mils.

Initial set of measurement was taken without wire mesh gaskets over the polymer. As shown in figure 1, the measurement shows that recovery of their height at 10 seconds varied approximately from 80% to 100%, and after 60 seconds their height improvement ranged from 85% to 100%, respectively. Clear winners are the hollow-circular solid silicone rubber. Overall they all show pretty good responses of better than 90% except G07.

G01 is a firm rectangular open cell and its cross section size is 0.375” by 0.5”, approximately. G07 is Ethylene-Propylene-Diene-Monomer (EPDM) with semicircular shape and has a round-top cone shape hole in the middle and its size is 0.375” high and 0.5” wide. G08 is a hollow circular silicon rubber, but its shape is warped, kind of oval (0.56” by 0.42”). G09 is the proprietary material and its cross section is identical to G07. G10 is silicone sponge and its cross section is 0.25” by 0.25” square. G12 is rectangular neoprene sponge whose cross section size is 0.5” by 0.75”. G14 is a hollow-circular silicone rubber whose diameter is 0.5”.

To observe effects of wire mesh gasket upon a core material, the aforementioned experiment was repeated with wire mesh gaskets on them. All have two layers of wire mesh gaskets on them except G01 and G09 with three layers of wire mesh gaskets. Effects of wire mesh gasket upon the gasket core material were mixed as shown in figure 2. Close observations revealed that they are depend on how tightly wound around the gasket core material. In addition, wire mesh gasket has some resiliency, and the wire mesh gaskets tend to bulge in some places when they are not tightly wound around the gasket core material, making measurements very difficult and inaccurate, which was more pronounced when working with two inch samples.

To probe further on inconsistencies, materials shown in figure 2 were compressed for 30 minutes, and their recovery trend is plotted in figure 3. One would expect that materials compressed for 30 minutes will show more compression set compare to those compressed for 15 minutes. However, there were some surprises on gaskets G01 and G14, which showed consistently higher recovery rate. G11, silicone sponge, showed better recovery at 10 second measurement only, which could be measurement uncertainty caused by minor resiliency of wire mesh gasket. Results of comparison on gaskets G10, G12, and G13 show what was expected, exhibiting more compression set when the duration of compression time was doubled. However, Gasket G09 showed consistent resiliency regardless of the compression time duration, though not a lot. In addition, three layers of wire mesh gasket were wound around it fairly tight.

IV. LONG TERM MEMORY

Another group of four gasket core of open cell polymer materials was tested over 180 days, but their test method was changed after 60 days to simulate other operational situations. Significant differences in recovery of their height became apparent in just a few days (see figure 4), but their behavior became fairly consistent in about two weeks. Two materials (G04 and G05) maintained their height over 90% during the test period of about 60 days. G04 and G05 maintained about 97% of their height on first day, dropped down to about 93% in 13 days, and gradually dropped down to about 92% to 90% for rest of the test period. G04 is an extra firm open cell sponge and G05 is commonly called M100 sponge. Another open cell sponge (G06) was unstable, showing continuous change of its height for about 30 days, and its height was down to about 71% of its original height after 30 days. However, subsequent data reveals that its height fluctuated from 77% to 69%, approximately. G02, called ester open cell, took about 14 days to settle down, and managed to maintain about 53% of its height, but its height fluctuated about 5% for rest of the test period. For the above long term test, weight was placed on 24 hour intervals except during the measurement period of about five minutes.

The results clearly show that a minimum of 30 day testing is required to find a stable height or percentage of compression set for this group of open cell sponge. In addition, it also shows that an open cell can be used as a gasket core material.
in contrary to common belief if seeking resiliency is the sole purpose. Obviously, it is very easy to choose a material showing good resiliency using this test.

The same gaskets were tested continuously at the conclusion of aforementioned test for over 180 days, but the test samples were allowed to expand by which measurements were made 30 minutes after removal of weight. G04 and G05 improved their compression set about 5% more during the 30 minute waiting period. G06, unstable polymer, compression set improved, but varied widely from 8% to about 17%. G02 exhibited the worst compression set from previous test, but now shows up to 10% improvement. Though, on average the G02 shows about 3% improvement during the 30 minute period.

The tests involving 30 minute waiting period were conducted to gain data in reference to ASTM International standard D395 or ASTM International standard D1056. Test results show that improvements made during the 30 minutes are not very significant for G04 and G05 simply because they do not have whole lot of compression set to recover. The G06 and G02 show more improvement than G04 and G05. However, no one would choose G06 and G02 because of their poor reliability and resiliency or high percentage of compression set.

V. CONCLUSION

The evaluation of gasket-core performance using these new tests, presented in this paper, is essential in weeding out materials that have poor or unreliable resiliency. These new tests should be done by gasket manufacturers and provided to customers for when they choose or replace their materials for a design. For polymer material, higher density materials tend to have greater resiliency, but solid rubber materials clearly performed better than polymer materials at 10 second measurement time, which is crucial in terms of protecting sensitive equipment. It is important not only to look at short term response, but also long term response as well. In addition, a gasket which relies on polymer/rubber core for its performance needs a new standard test method based on realistic operational conditions that includes environmental effects such as temperature.

REFERENCES


Figure 1. Polymer or rubber core, two inch long, were compressed about 50% of its height for 15 minutes, and then released. Recovery trend is plotted as a function of time. H is the height of the polymer or rubber in percentage. G01 is a firm rectangular open cell and its cross section size is 0.375” by 0.5”, approximately. G07 is Ethylene-Propylene-Diene-Monomer (EPDM) with a semicircular shape and has a round-top cone shape hole in the middle measuring 0.375” high and 0.5” wide. G08 is hollow circular silicon rubber, but its shape is warped, kind of oval (0.56” by 0.42”). G09 is the proprietary material and its cross section is identical to G07. G10 is silicone sponge and its cross section is 0.25” by 0.25” square. G12 is rectangular neoprene sponge whose cross section size is 0.5” by 0.75”. G14 is a hollow-circular silicone rubber whose diameter is 0.5”.

Figure 2. The recovery trends of polymer or rubber material with wire mesh gaskets over them. Materials were compressed about 50% of its height for 15 minutes, and then released. G01 and G09 have three layers of wire mesh, and the rest of the materials have two layers of wire mesh. G11 is a 0.25” by 0.5” rectangular silicone sponge. G13 is the rectangular shape closed cell EPDM, and it is 0.375” high and 0.75” wide. See caption of figure 1 for rest of the gasket description.
Figure 3. Recovery trend of rubber or polymer core with wire mesh gaskets over them. They were compressed about 50% of their height for 30 minutes. See figure captions 1 and 2 for descriptions of gaskets.

Figure 4. Sponge compression set trend. Materials were continuously compressed on a flat surface to about 50% of their original height except during measurement time of about five minutes. G02 is called ester open cell, and G04 is an extra firm open cell sponge. G05 is commonly called M100 sponge, and G06 is another open cell sponge. Sponge size: 0.5” (W) by 0.75” (H) by 2” (L).
Figure 5. Open cell polymer compression set results shown in figure 4 were continuously tested, but each material was allowed to re-expand for 30 minutes before taking measurements.