

A Study of the Influence of FIP Bead Shape on Compression Force in PCB/Shield Assemblies

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Abstract

Electrically conductive elastomers are used on electronic equipments to provide shielding against electromagnetic interference (EMI) as well as protect the enclosure against external environmental conditions. The gasket is rendered electrically conductive through the use of metal fillers embedded in a base polymer matrix. Typically, they are prepared either by compression molding or extrusion. One of the most economical and convenient ways of preparing EMI gaskets, however, is by dispensing the material directly on a shield assembly and allowing it to cure and form in place (FIP). The amount of force needed to compress an elastomer gasket is critical to its shielding effectiveness. A typical Form-in-Place (FIP) gasket should have low compression force to deflect the gasket sufficiently to ensure proper electrical continuity between two adjacent substrates. This study presents the evaluation of the effect of varying bead shapes on the compression force of FIP gaskets. The samples tested were heat- and moisture-cured silicone elastomers with Ag/ Cu and Ag/Al fillers, dispensed on shield assemblies. The gaskets were dispensed in different shapes: single- (S) and double-layered (D) D-shaped beads, as well as single-layered triangular (T) beads. Compression forces were measured under dynamic and static conditions.

Keywords: Electromagnetic interference, Form-in-place gasket, compression force, shielding effectiveness, bead shape

Introduction

An important property of an FIP gasket is its compression force. Compression force is the amount of force required to cause a specific deflection in a material. Ideally, low compression force is desired. Highly compressible materials conform well to mating surfaces, and require low forces to deflect the gasket and effectively seal an enclosure. This ensures proper electrical continuity (low resistivity) between the two adjacent substrates and therefore good shielding effectiveness[1].

The compression force of an FIP bead is affected by a number of factors. Specific to the FIP itself are the materials chosen for the formulation, namely silicone, additives, and

metal filler. Irrespective of the FIP itself, the dimensions of the bead, the shape and the geometry of the gasket can also play a significant role in gasket compression force.

This study presents the evaluation of the influence of varying FIP bead shape on compression force in PCB/ shield assemblies.

Methods

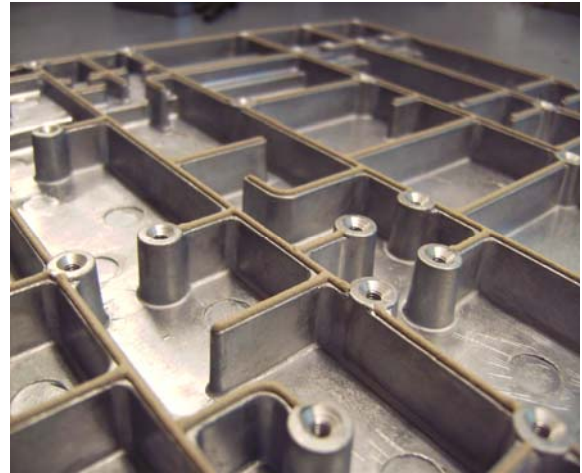
The samples tested were heat- and moisture-cured silicone gaskets incorporated with either silver-aluminum or silver-copper metal filler, dispensed on aluminum shield assemblies (refer to Figure 1) through the use of

an automated dispensing robot. The samples were dispensed in varying bead shapes (as shown in Figure 2): single- and double- layered D-shaped beads, as well as single-layered

triangular (T) beads, with dimensions shown in Table 1. The shape of the gasket was determined by the type of needle used.

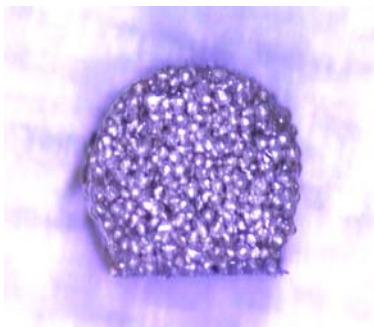


(a)



(b)

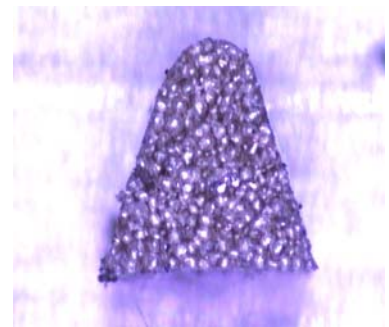
Figure1. (a) An image of the FIP gasket dispensed on the aluminum shield, (b) a closer view of the shield.



(a)



(b)



(c)

Figure 2. Cross-sectional images of heat cured Ag/Al-filled gaskets from an optical microscope showing varying shapes: (a) single D-shaped, (b) double D-shaped and (c) triangular-shaped.

For the FIP Beads shown in Table 1, the moisture-cured gaskets (A and B) were cured at room temperature for a minimum of seven days,

while the heat-cured products (C and D) were cured at 125°C for approximately two hours.

Table 1. Properties and Dimensions of the FIP Beads

FIP		A	B	C	D
Type		Moisture-cured	Moisture-cured	Heat-cured	Heat-cured
Filler		Ag/ Al	Ag/Cu	Ag/Al	Ag/Cu
Bead Dimensions (H x W) (mm)	Single	1.02 x 1.52	1.00 x 1.25	1.12 x 1.47	1.08 x 1.68
	Double	1.17 x 0.86	-	1.19 x 0.76	1.06 x 1.01
	Triangular	1.04 x 1.16	1.00 x 1.03	1.00 x 1.15	1.00 x 1.24

Six cured samples of 1.0 +/- 0.2 inches in length were cut off from different sides of each alu aluminum substrate. Three of the samples were used for static compression force measurement while the other three for the dynamic compression force.

A Digital Force Gauge was used to measure the static compression force of the gaskets. The sample was placed in between the platens, and the upper platen was lowered until it reaches the free height of the gasket. The compression force, as well as the height was zeroed initially. The upper platen was then lowered by 0.02 mm. Compression force reading was allowed to stabilize for 30 seconds before measurement was taken. The upper platen was then continuously lowered in 0.02 mm increments until the desired maximum percent deflection was reached.

Dynamic compression force measurements, on the other hand, were done using an MTS machine with a 1000N load cell. In this method [2], the sample was compressed continuously at a rate of 0.25 inch per minute until the desired maximum % deflection was obtained.

The volume resistivities of the samples at 25% deflection were also measured. Three samples of 5.0 +/- 0.1 mm in length were cut off from the cured gaskets in the PCB shield. The bead was then placed in between gold-plated electrodes attached to a micro-ohmmeter, and compressed by 25%. The value was allowed to stabilize for 30 sec before measurement was taken.

Results and Discussion

Figure 3. shows a representative curve of the static compression force vs. percent deflection of one of the FIP gaskets (the heat-cured Ag/Al-filled silicone elastomer), with varying bead shape. Results showed that triangular-shaped beads exhibit the lowest amount of force needed to compress the gaskets, while single D-shaped beads required the largest compression force. Upon application of force, the gasket tends to deflect and spread in a lateral direction, increasing the area in contact with the force gauge platens. The larger the contact area, the greater the force required to deflect it. Compared to the other two, single layered D-shaped beads are wider and have larger contact area, thereby requiring greater compression force.

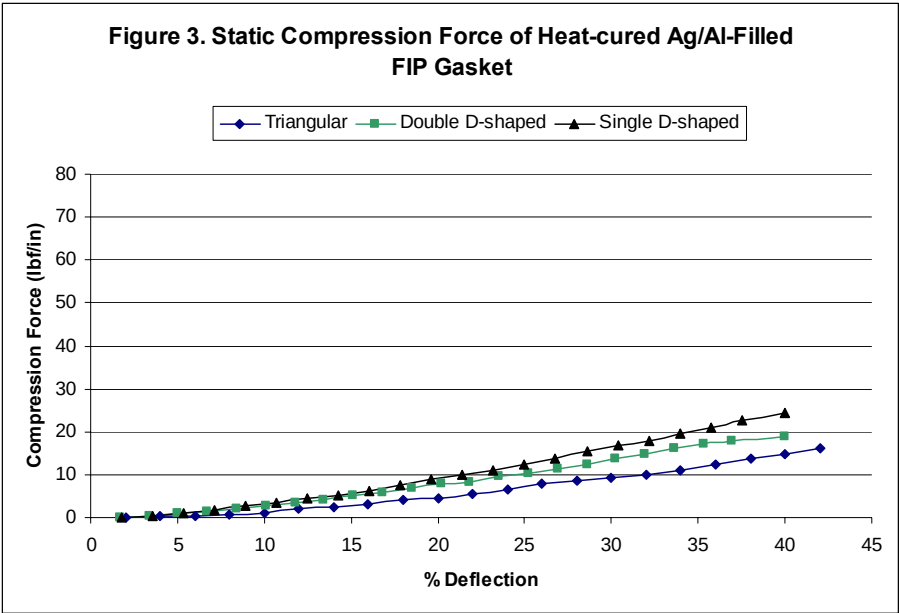
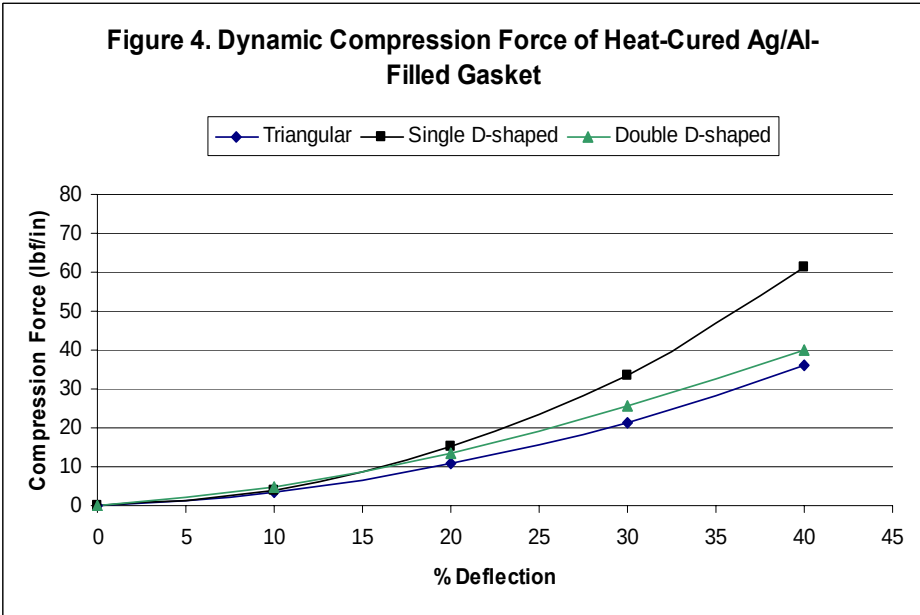


Figure 4 shows a representative curve for the dynamic compression force measurements. Although the same trend for compression force is observed for the three different shapes, it is evident that the compression force values are larger, compared to the ones measured under static conditions.

The dynamic forces also showed steeper slopes in the trend line. Such results are expected, since under dynamic conditions, the gaskets were not given time to relax and equilibrate.



Figures 5 and 6 show graphs of the relative compression force of the two moisture-cured FIP gaskets at 20% and 40% deflection. Both gaskets showed similar trend in compression force, with single D-shaped bead exhibiting the highest compression force. The Ag/Al-filled silicone gaskets, however, showed

higher compression forces than the Ag/Cu- filled beads. This can be attributed to greater Ag/Al filler loading of the gaskets which were added to increase the materials' conductivity (or lower their resistivity). In addition, Ag/Al particles are larger in size than the Ag/Cu fillers, decreasing its compressibility.

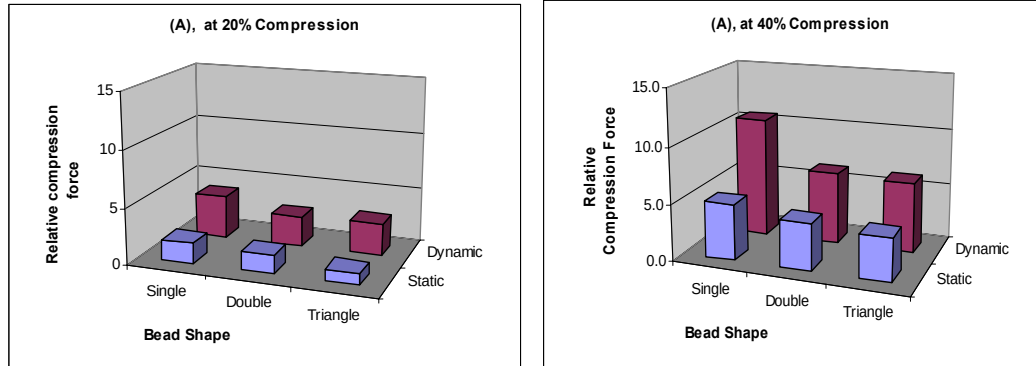


Figure 5a and b. Relative compression force of Moisture Cured Ag/ Al-Filled Gasket

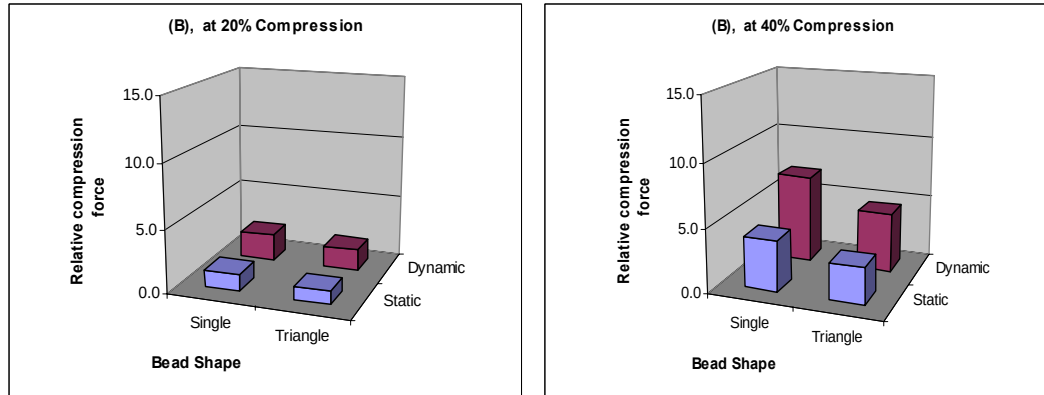


Figure 6a and b. Relative compression force of Moisture Cured Ag/Cu-Filled Gasket

The relative compression forces of the two heat-cured products are shown in Figures 7 and 8. Compared to the moisture-cured beads, these gaskets have higher compression forces.

This can be attributed to the type of silicone used, and the physical properties (e.g. hardness) of the cured product.

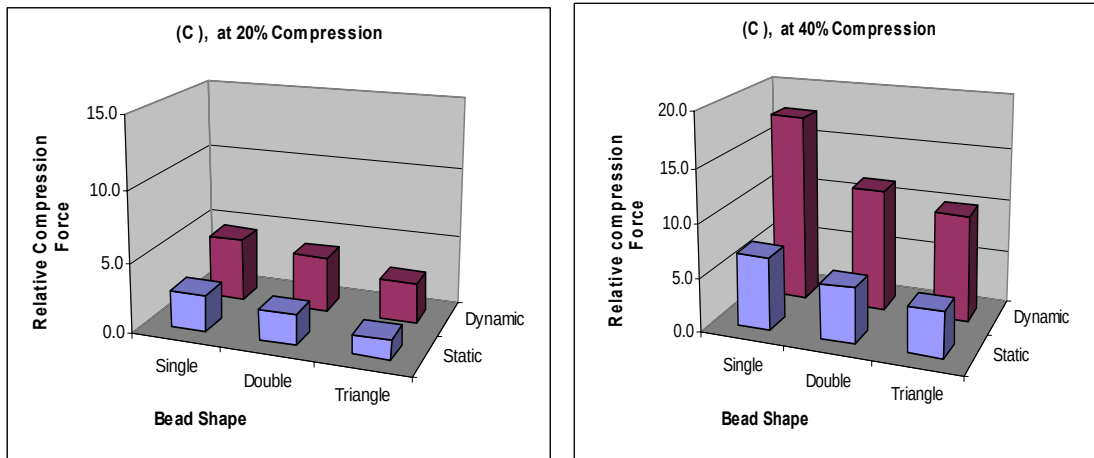


Figure 7a and b. Relative compression force of Heat Cured Ag/Al-Filled Gasket

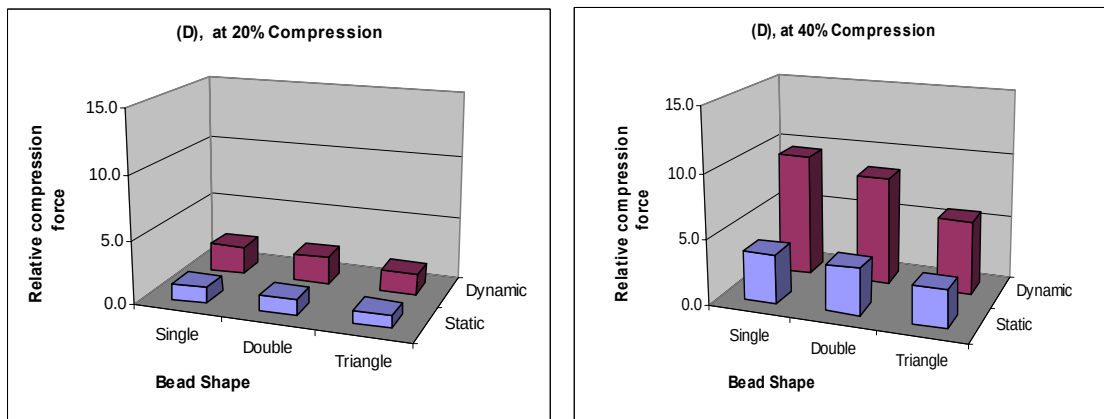


Figure 8a and b. Relative Compression Force of Heat-Cured Ag/Cu-Filled Gasket

Table 2 shows the volume resistivities of the gaskets at 25% compression. The resistivities, when measured at the same % deflection, showed no significant difference with varying shapes. Since volume resistivity

decreases with increasing % deflection, this indicates that for more compressible bead shapes, (as well as for more compressible materials), it takes lower amount of compression force to attain the percent deflection with the desired conductivity.

Table 2. Volume Resistivities of the Four FIP Gaskets

FIP	Volume Resistivity (mΩ-cm)		
	Single	Double	Triangular
A	2	3	2
B	2	-	2
C	5	4	6
D	10	8	9

A summary of the results of the compression force of the four FIP products at 20% and 40% compression, under the static and dynamic conditions are shown in the table

below. From these results, it is clear that the shape of the bead affects the compression forces of gaskets.

Table 3. Summary of the Compression Forces of the FIP Products, Per Linear Inch of Bead

FIP	Bead Shape	Static Compression Force (lbf)		Dynamic Compression Force (lbf)	
		20%	40%	20%	40%
A	Single	6.6	17.8	14.2	38.2
	Double	6.1	14.8	9.74	22.9
	Triangular	3.6	13.6	10.4	22.4
B	Single	5.0	14.6	7.8	25.3
	Double	3.7	10.5	6.3	16.9
	Triangular				
C	Single	9.5	24.5	16.2	63.3
	Double	7.7	18.6	13.9	41.2
	Triangular	4.8	15.2	10.2	35.7
D	Single	4.5	13.6	8.0	34.3
	Double	4.3	12.9	7.9	30.4
	Triangular	3.5	10.4	5.9	20.6

Conclusion

The amount of force required to compress a gasket is affected by a number of factors. One such factor is the bead shape of the gasket.

Triangular- shaped gaskets exhibit the lowest compression force, under both the static and dynamic measurements, compared with single- layered D-shaped beads.

Double-beads require comparable, but typically slightly less, force compared to single D-shaped gaskets.

Dynamic compression force values are greater than static compression forces. This is because under dynamic conditions, the materials are not allowed to relax and equilibrate.

The particle size and shape of the filler as well as the amount of filler loading, also affect compression force measurements. Larger particles and higher filler loading typically increase the values.

References

1. "Elastomeric EMI Shielding Solutions", Laird Technologies, Product Catalogue, 2002.
2. "Standard Test Methods for Rubber Properties in Compression", ASTM D 575-91, 2001