# Costs Associated With the Use of EMI Gaskets

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## INTRODUCTION

EMI gaskets are used extensively in the design of electrical and electronic equipment. The proper selection and use of gaskets can increase the likelihood that radiated emission and susceptibility requirements can be met. The use of the proper gasket can also reduce the cost of agency compliance with these requirements. However, there are significant hidden costs associated with the use of EMI gaskets that must be understood to properly appreciate the advantages of using them. These costs are based on: the shelf life of some gaskets on the market; the useful life of gasketed joints; the methods of holding the gaskets in place; and the methods used to control the forces required to appreciate the shielding quality offered by the gasket.

*The use of the proper gasket can reduce the cost of agency compliance.*

## SHELF LIFE CONSIDERATIONS

Many of the gaskets on the market have a shelf life which requires special packaging considerations and/or storage environments to maintain the conductivity of the gasket. An act as innocent as opening the package of a gasket that contains silver by incoming quality control in order to confirm the dimensions of the product, and then inserting a paper (QC) tag, can have a detrimental effect on the shelf life of the gasket. The sulfide in the paper can join with the silver to produce a silver sulfide coating on the silver particles. This can significantly increase the contact resistance of the particles and reduce the shielding quality of the gasket to unacceptable levels.

Table 1 illustrates transportation/storage environments to which military components can be subjected. These environments have been known to reduce the conductivity of some gaskets on the market. It is strongly recommended that gaskets be tested to the applicable environments illustrated in Table 1 prior to selection of a gasket for a specific application. If the gasket of choice cannot adequately survive the environments, then the gasket must be protected during transportation and storage. Alternatively, a gasket that can survive those environments can be selected.

## USEFUL LIFE CONSIDERATIONS

The impedances of all EMI gasketed joints increase with time. This means that the shielding quality of the joint will decrease with time. The increase in the impedance is due to: a change in the contact resistance (surface resistance) of the joint surfaces; a change in the contact resistance of the gasket; and/or a change in the conductivity of the gasket material. These changes can be due to a buildup of oxides on the surface of the joints, a buildup of oxides on the surface of the gaskets and/or a buildup of oxides (or silver sulfide) on particles that make up the gaskets on the market. Table 2 illustrates mission/sortie environments to which military components and systems can be subjected. It is strongly recommended that gasket joints be tested to the applicable environments illustrated in Table 2 prior to selection of the gasket or joint surface of choice. A loss of the shielding quality of a joint can significantly increase the cost of using the gasket. If the loss of conductivity forces a redesign and subsequent field retrofit, such costs can be catastrophic. Since all gasketed joints lose conductivity with time, one should be very conservative in selecting the gasket and joint surfaces to be used.

## COST-EFFECTIVE APPLICATION OF EMI GASKETS

EMI gaskets are used to provide a conductive path across the joints of electrical/electronic equipment chassis. These gaskets are either groove or flange mounted. Each of these methods of mounting the gaskets have costs associated with their use. The proper understanding of these costs can significantly increase the cost-effectiveness of using a gasket for a specific application.

### GROOVE MOUNTED GASKETS

There are several recommended methods of designing and manufacturing grooves to secure and/

| ENVIRONMENTAL STRESS CONDITION | TEST METHOD/PROCEDURE (MIL-STD-810D) |
|---|---|
| High Temperature (Dry/Humid) | Method 501.2 |
| Low Temperature (Rain/Hail/Freezing) | Method 502.2 |
| Thermal Shock | Method 503.2 |
| Solar Radiation | Method 505.2 |
| Fungus Growth | Method 508.3 |
| Rain | Method 506.2 |
| Humidity | Method 507.2 |
| Salt Fog | Method 509.2 |

***TABLE 1.*** *Transportation/Storage Environments.*

| ENVIRONMENTAL STRESS CONDITION | TEST METHOD/PROCEDURE (MIL-STD-810D) |
|---|---|
| High Temperature | Method 501.2 |
| Salt Fog | Method 509.2 |
| Explosive Atmosphere | Method 511.2 |
| Rain | Method 506.2 |
| Emersion | Method 512.2 |
| EMP/Lightning | MIL-STD-461 Req CS12 |

***TABLE 2.*** *Mission/Sortie Environments.*

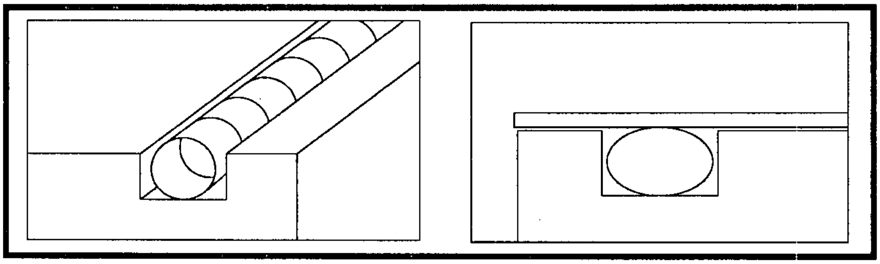

***FIGURE 1.*** *Gasket in O-Ring Groove.*

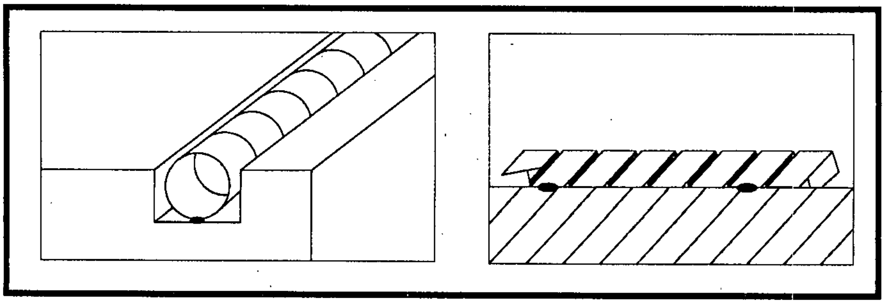

***FIGURE 2.*** *Gasket Held in O-Ring Groove with Adhesive.*

or protect the selected EMI gaskets. Gaskets can be: groove mounted where the width of the groove is wider than the diameter (or width) of the gasket; groove mounted where the width of the groove is the same or slightly narrower than the diameter (or width) of the gasket; and mounted in a dovetailed groove.

The use of a groove which is wider than the diameter of the gasket is the most cost-effective means of securing and/or protecting the gasket. These grooves can be die cast (or molded) into an equipment case or chassis or cut in with an end mill. The recommended groove is illustrated in Figure 1. When compressed, the gasket does not touch the sides of the groove. The fastener or screw spacing can be calculated relatively closely by preventing constriction of the gasket by the sides of the groove. A reduction in the number of fasteners offsets the cost of the gasket and groove. If the gasket needs to be held in place, one can use a nonconductive adhesive (RTV or epoxy) to secure the gasket (Figure 2). Conductive adhesives are not recommended because they provide a level of conductivity that will deteriorate with time. Pinch bosses can also be used (Figure 3). The use of adhesive or pinch bosses to hold a gasket in a groove will degrade the shielding quality of a gasketed joint. This degradation is a function of the conductivity of the gasket as well as the surface conductivity of the joint material. Figure 4 illustrates the shielding quality of a tin-plated (military grade) gasket when tested against gold-plated and bare aluminum joint surfaces with and without pinch bosses. Figure 5 illustrates the shielding quality of a stainless steel (commercial grade) gasket when tested against gold-plated and bare aluminum joint surfaces with and without pinch

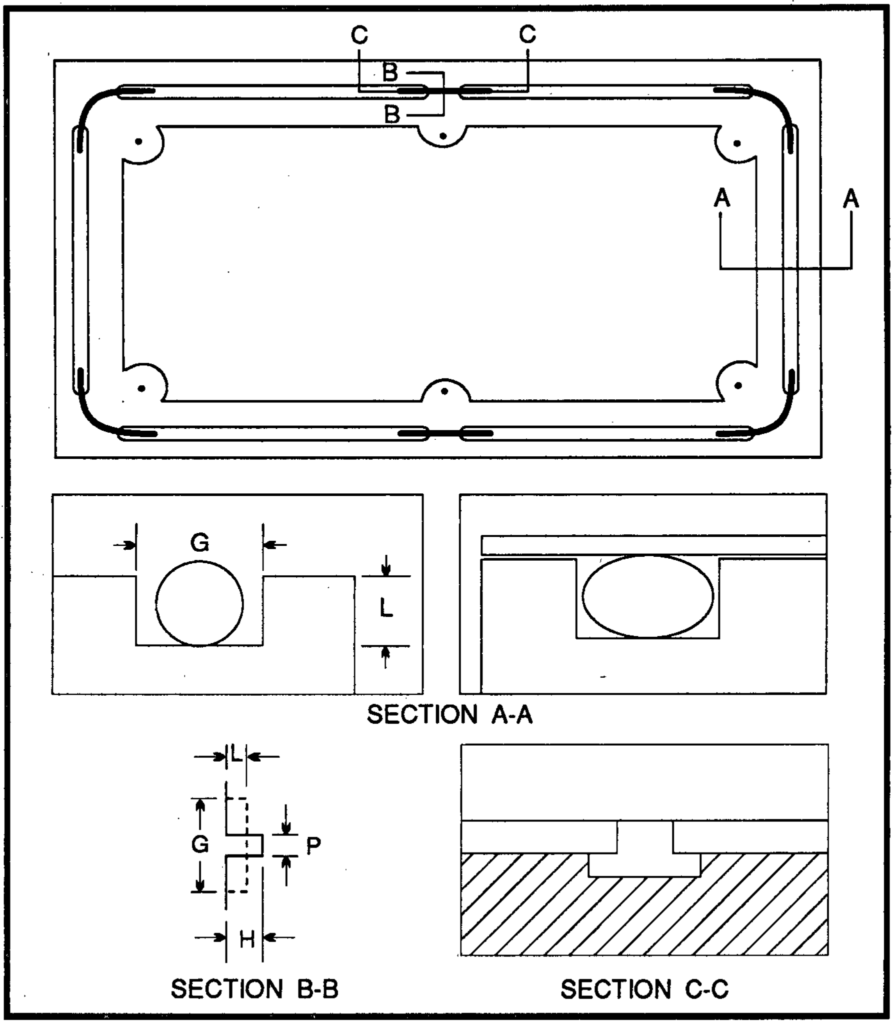


***FIGURE 3.*** *Pinch Boss Groove Detail.*

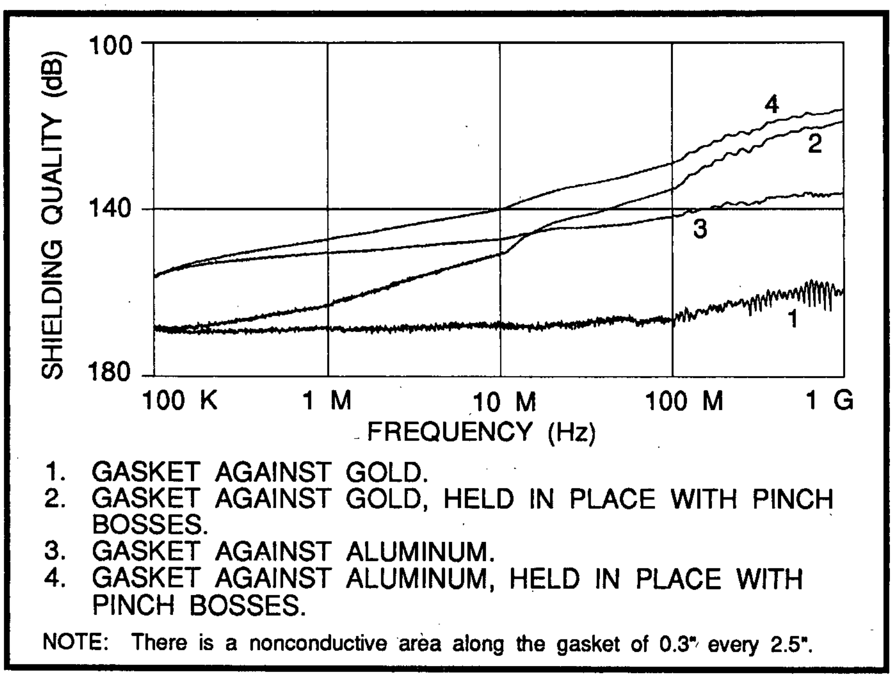


***FIGURE 4.*** *Shielding Quality of Tin-plated Shield Gasket Material.*

bosses. Table 3 illustrates the difference in the shielding quality of the gasketed joints at 1 GHz as a function of the gasket and joint surface with and without pinch bosses (or adhesive) to hold the gasket in place. As illustrated, there is a significant loss in shielding quality by using pinch bosses or adhesive to hold the gasket in place when the gasket and joint surface are very highly conductive. However, the loss is negligible when the stainless steel gasket and bare aluminum joint surfaces are used.

The dovetailed groove illustrated in Figure 6 provides a groove which holds the gasket in place while allowing the gasket to expand laterally without being constrained by the sides of the groove. This groove will allow fairly wide screw spacing. This offsets the cost of the gasket and groove, because easy replacement of the gasket is also facilitated.

A groove which is the same width as the diameter of the gasket is the least cost-effective means of securing/protecting the gasket (Figure 7). This groove is the most commonly used, since it is inexpensive to manufacture, facilitates maintenance and is recommended by numerous gasket manufacturers. Because the sides of the groove constrain the lateral movement of the gasket as it is compressed, the force required to compress the gasket is very high and cannot be predicted within close tolerances. As such, the fastener spacing must be very close (i.e., many of the EMI gasket manufacturers recommend 3/4-inch fastener spacing for sheet metal joint flanges) where fastener spacing of 12 to 16 inches can be achieved using the groove configuration of Figures 1, 2 or 6 along with a properly chosen gasket and cover thickness.

| GASKET* | JOINT SURFACES | HOLDING METHOD | | Δ (dB) |
|---|---|---|---|---|
| | | NONE | PINCH BOSSES | |
| 1 | Gold | 159 dB | 119 dB | 40 |
| 1 | Aluminum | 136 dB | 116 dB | 20 |
| 2 | Gold | 123 dB | 115 dB | 8 |
| 2 | Aluminum | 116 dB | 110 dB | 6 |

*(1) Tin-plated gasket.
(2) Stainless steel gasket.
Δ Difference in shielding quality at 1 GHz due to using pinch bosses (or adhesive) to hold gasket in place.

***TABLE 3.*** *Shielding Quality at 1 GHz.*

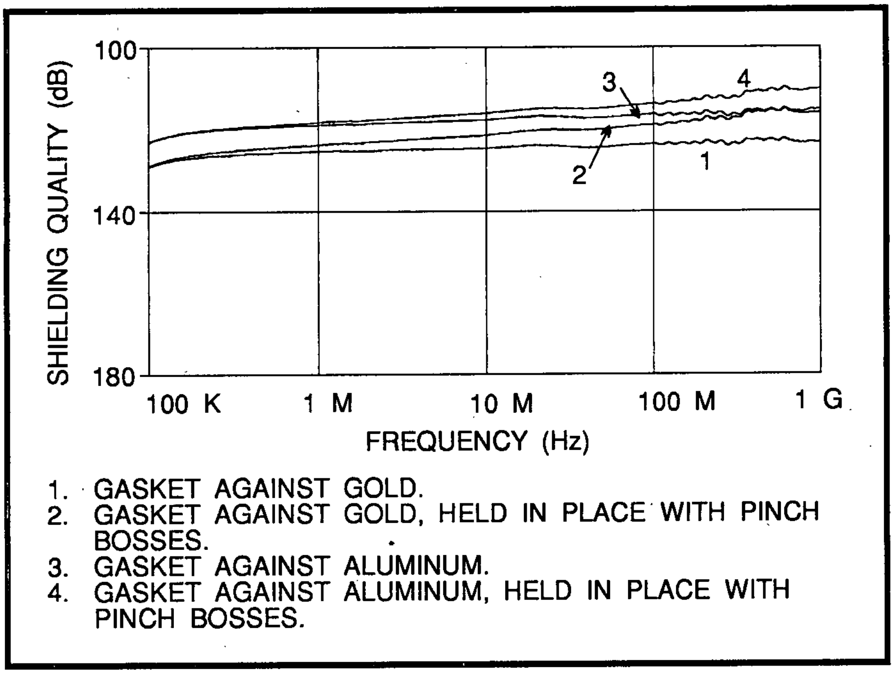


***FIGURE 5.*** *Shielding Quality of Stainless Steel Shield Gasket Material.*

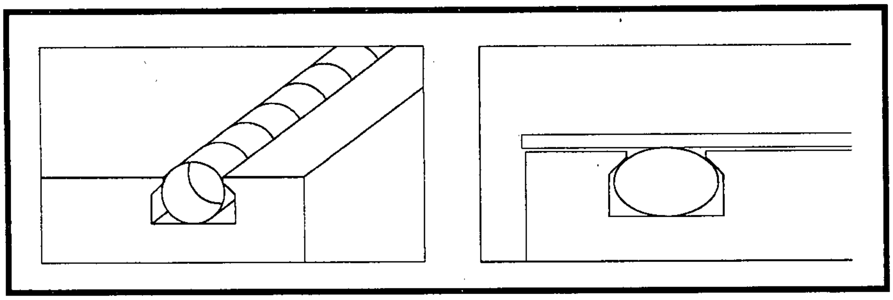

***FIGURE 6.*** *Gasket in Dovetailed Groove.*

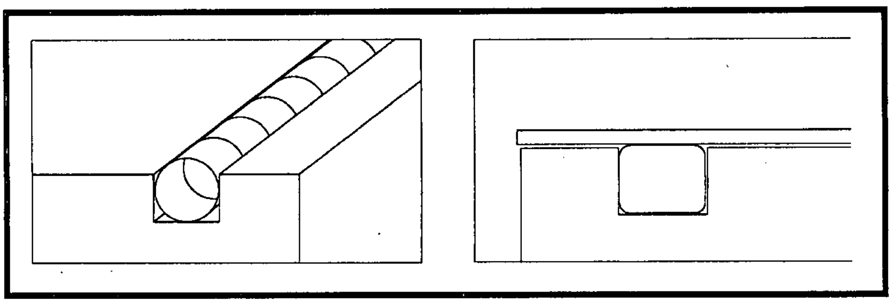

***FIGURE 7.*** *Gasket in Narrow O-Ring Groove.*

**FLANGE MOUNTED GASKETS**

The flange mounted gaskets are thin and wide. Rubber is often used to hold the EMI conductive gasket material in place. The rubber can also be used to provide a positive environmental seal. Figures 8 and 9 illustrate gaskets designed to be used for flange mounted applications. When using the flange mounted gaskets, the force to compress the rubber is of critical concern. As an example, the maximum fastener spacing which is required to provide an EMI seal where the cover just touches the rubber of Figure 8 (using an EMI gasket diameter of 0.125, a cover thickness of 0.125 inches and a resiliency of 2 pounds per linear inch) is 11.5 inches. If the rubber rates 60 on a durometer and is compressed 5 percent, the maximum fastener spacing will be 4.5 inches. A compression of 10 percent reduces the maximum fastener spacing to 3.5 inches. This means that the force of the cover on the gasket must be carefully maintained. If it is not, then many more fasteners must be used or a significant level of shielding will be lost. Figure 10 illustrates an optimal gasketed joint, where the gasket makes positive contact with the cover and chassis along the entire joint. Figure 11 illustrates a case where the fastener spacing is too large. The result will be the loss of a significant level of shielding. If the gap is a quarter wavelength long, then the shielding quality of the gasketed joint can approach zero.

Positive stops can be used to prevent the excessive bowing due to the rubber compression illustrated in Figure 11. This type of stop is illustrated in Figures 12 and 13. A concern when using stops is that the stop should be higher than the rubber thickness. The excessive bowing is caused by the force of the rubber on the cover. If the stop is lower

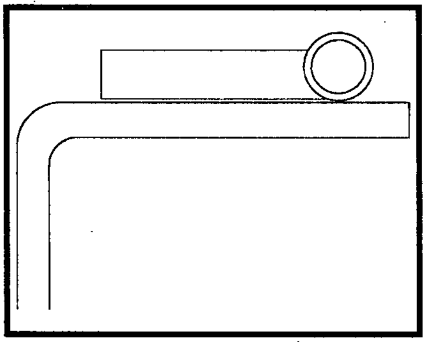

***FIGURE 8.*** *Flange Mounted Gasket.*

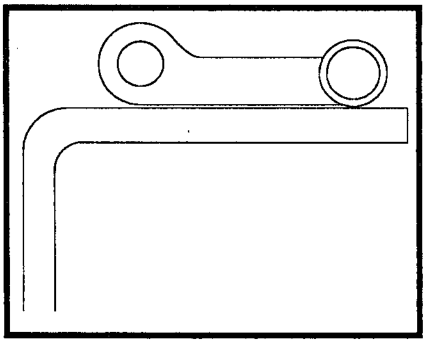

***FIGURE 9.*** *Alternative Flange Mounted Application.*

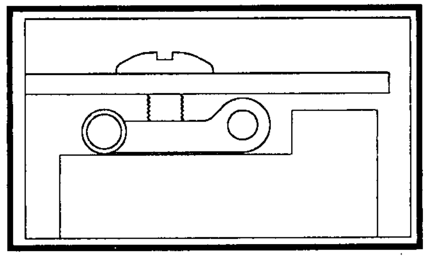

***FIGURE 12.*** *Step Acts as Compression Stop.*

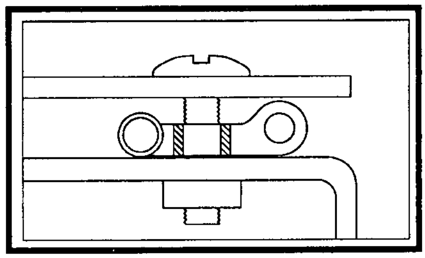

***FIGURE 13.*** *Washer Acts as Compression Stop.*

than the height of the rubber, then the force of the rubber on the cover can cause excessive bowing. The trade-off between using stops or more fasteners is cost, since it may cost more to provide the stops than it costs for extra fasteners. Another consideration is the confidence level associated with providing the proper torque on the fastener. If during maintenance procedures the fasteners are tightened when the elastomer is compressed 15 percent, and the joint is designed for a maximum elastomer compression of 5 percent, the increased bowing of the cover due to the over compression can result in a significant loss of the shielding quality of the joint.

## CONCLUSION

EMI gaskets are used by the electrical/electronic engineering community to assist in complying with required EMI radiated emissions and susceptibility requirements. Gaskets are used to ensure that the radiated emissions and/or susceptibility requirements of a system will be met. They can also be used to significantly reduce the cost of complying with agency requirements. However, to obtain the benefits of using EMI gaskets, a design engineer must understand the hidden costs. These are costs associated with the shelf life of many of the gaskets on the market, their useful life, a loss of shielding quality of gasketed joints, and designs which can jeopardize compliance with the radiated emissions and/or susceptibility requirement limits.

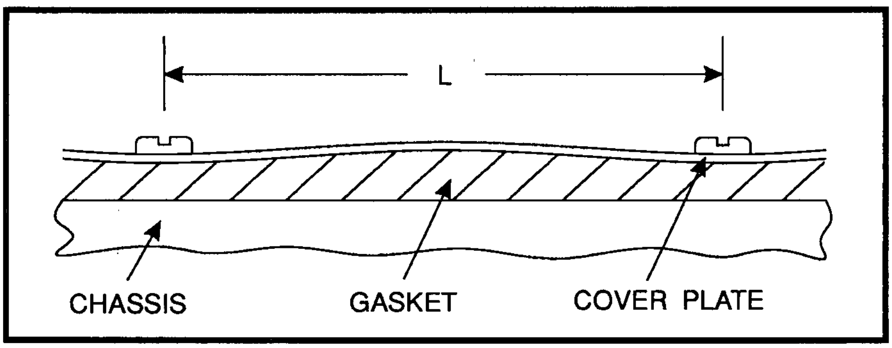


***FIGURE 10.*** *Optimal Gasketed Joint.*

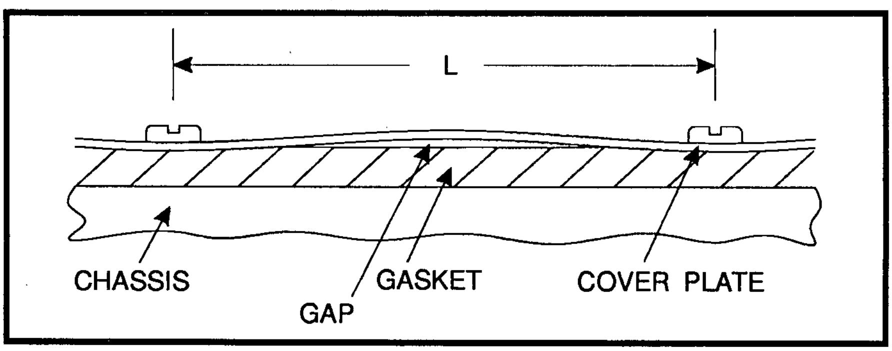


***FIGURE 11.*** *Gasketed Joint with Improper Contact.*

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