10-500-11
Conductive Sealing Gaskets

Techtest Limited

An introduction to the problems of Radio Frequency bonding and the prevention of corrosion in bonded joints

Introduction

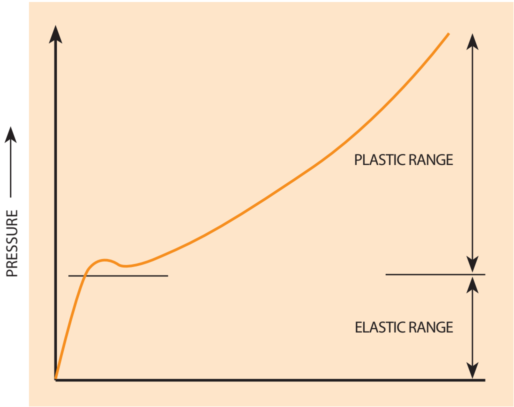
To achieve efficient operation from antennas mounted on aircraft, it is essential to have the base of the antenna bonded to the airframe, which, in turn, must be adequately bonded to provide an effective ground plane. It is not sufficient for the resistance between the antenna base and airframe to meet some arbitrary limit. This could probably be achieved by a single point of contact which would not however suppress RF circulating currents. To ensure suppression of these circulating currents, it is important that the base should be in contact over a substantial amount of its surface area. A similar restriction applies to the bonding of aircraft skins, where, as with antennas, a high degree of contact is required, thereby removing the possibility of the formation of resonant slots at the operating frequencies being used.

It is not only with antennas that effective bonding is required. In the construction of racks to hold avionic or electronic equipment, bonding of the structural members is of great importance in the control of electromagnetic interference. In fact, wherever current is being carried across a metal to metal joint, bonding integrity must be effectively established.

When two metal surfaces must be bonded together and either brazing or welding cannot be used, then consideration must be give to the use of some form of conductive gasket to ensure adequate contact area and prevent the ingress of moisture. The HR Smith range of Conductive Sealing Gaskets have been specifically designed to combat the problems of both inadequate contact surface area and corrosion as described.

Contact Surface Area and Bearing Pressure

To produce an effective bond between two metal surfaces, the faces must be clean, untreated and flat. The removal of any protective treatment and cleaning of the faces can be readily accomplished, but the provision of flat surfaces cannot be assured.



If we consider two perfectly flat surfaces brought together in a vacuum, contact is made over the total area with zero load. When the surfaces are not perfectly flat, then with zero pressure contact will only be made between those points which are necessary for stability. This will be three points of micro area, plus any other points which happen, coincidently, to just touch when the three primary points are in contact. The probability of any of these secondary points occurring under zero pressure is small. An increase load is applied to bring the surfaces together, the primary contact points crush to form a finite contact area which can be calculated from the load, and the elastic and plastic distortion characteristics of the material. A normal stress/strain curve is show Figure 1 and indicates the characteristics of the material used.

As the primary contact points crush, the two surfaces move into closer proximity and more points make contact and crush according to their own particular position on the material stress/strain curve. Therefore, under load the contact area will consist of multiple discrete areas, each with a different pressure according to the amount of distortion present, and the load will be reacted by the summation of the product of pressure and area for each contact surface i.e.

$$L=\Sigma pa$$

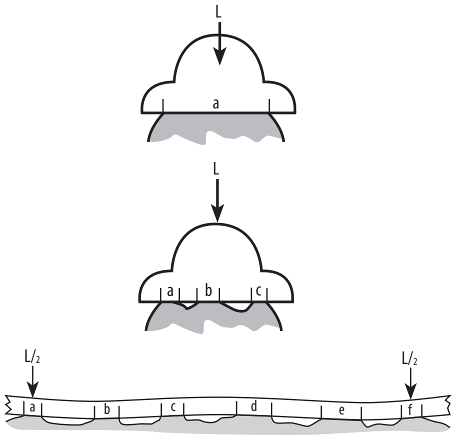


Figure 2 - Uniform and distributed loading

In perfectly elastic material all the contact areas can be determined by consideration of the modulus of elasticity; while in a plastic material, the plastic characteristics must be taken into account. The latter also applies when a material is worked beyond its elastic limit and compressed until the discrete points merge into a total contact surface. Regardless of the number of discrete points, it follows that within the constraints of elastic/plastic deformation; a particular load requires a particular bearing surface area to react it. In practical terms, regardless of whether the load is applied uniformly or at discrete points, the contact surface area is the same, with the load being shared between the incremental areas a, b, c, etc., as illustrated in Figure 2.

Bond Impedance

In general terms, the d.c. resistance of a bonded assembly is inversely proportional to contact area, with the two important parameters being the total applied load and the elastic/plastic modulus of the material used. When the RF impedance is also considered, a third parameter becomes important and that is the distribution of contact areas.

From what has already been stated, it can be seen that for practical flat surfaces contact is only made at discrete points. Both the distribution and size of these areas are critically dependent on the flatness of the surface and the method of applying the clamping load; assuming of course, a practical case where the clamping loads are low compared with the material hardness, e.g. A typical aircraft antenna mounting. For a given clamping load, as roughness of the mating surfaces increases, the contact area will remain substantially constant. This will give constant bearing stress but because the local distortion at the contact points will be greater, a more even distribution of contact areas will be achieved; this is illustrated in Figure 3. In the limit, a 'smooth' surface will be in contact at only three points and although the d.c. resistance may be identical to that achieved with a 'rough' surface of the same contact area, the large gaps between the contact areas may increase the RF impedance of the bonded assembly. This situation could occur with antennas fitted to an aircraft, where the curvature of the airframe means that contact can only be expected along the fore and aft axis and where, even when the contacting surfaces are notionally flat, the areas of contact may be very small. The RF impedance of the antenna base to airframe bond will appear as part of the antenna load and could adversely affect the performance of the system.

Corrosion

Having resolved the problem of contact surface area, the integrity of the bonded joint will be reduced in the event that corrosion occurs. When two metal surfaces are bonded together, corrosion can be initiated by the introduction of contaminated moisture, which acts an an electrolyte.

For electrolytic action to take place, d.c. Must flow between the two metals, which can be chemically similar. Corrosion being dependent on the presence of contaminated moisture and the current flowing in the circuit; a situation which could readily exist with bonds that form part of the system earth return. Galvanic corrosion can also occur when dissimilar metals are used. However, both form of corrosion are eliminated when an electrolyte is not present. Therefore moisture must be eliminated from the metallic junction to prevent corrosion.

Gasket Requirements

From the foregoing discussions, it follows that if the material modulus is reduced, i.e. Softer materials are used, then more contact area will be established and the impedance of the bonded joint will be reduced. It has also been established that a rough surface finish of low hardness provides a superior distribution of contact areas. This, of course, applies on nominally flat mating surfaces and presupposes that the spikes in the surface are high enough to span the interface gap. If the surfaces were roughened sufficiently to meet this requirement, then the following problems could arise where, for example, a flat based antenna is fitted to a circular fuselage:

- Machining the antenna would be expensive.
- Cavities would exist between the contact spikes which could trap moisture and probably create the corrosion problems already discussed.
- If the spikes on the antenna base were harder than the aircraft skin, stress raising marks would result which might affect fatigue life.

It is obvious that some form of gasket capable of bridging the gaps between the metal surfaces must make bonding preparations easier and also create a more effective and efficient bond. It can also be seen that if moisture can be excluded from between the surfaces, then the use of dissimilar metals or the flow of d.c. will not cause corrosion.

To meet these requirements, the gasket must be capable of providing adequate contact areas to ensure an acceptable RF and d.c. bond and also ensuring the continued function of that bond when the area is subjected to an environment which would normally create corrosion problems.

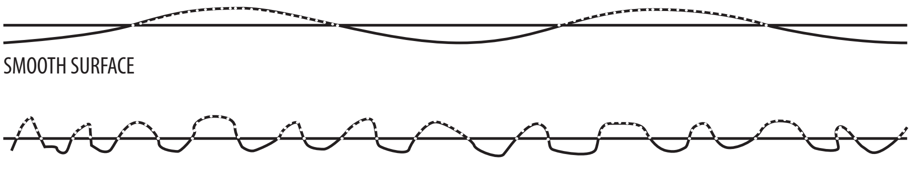
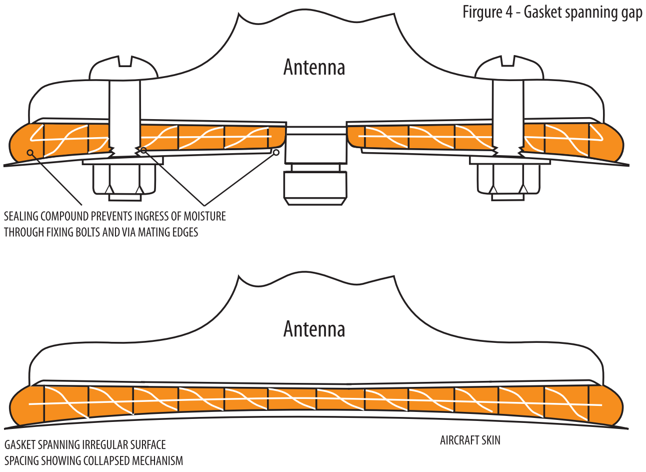


Figure 3

Gasket Types

Various approaches to solving the problem of non-flat surfaces and corrosion inhibition have been made and these were evaluated before the current range of H.R. Smith Conductive Sealing Gaskets were designed.
The different types of gasket were:



Firgure 4 - Gasket spanning gap

1 - LOADED GREASES

Various greases had been devised, which were loaded with conductive particles of graphite or various metals. This approach was considered to be of doubtful value for use with aircraft antennas, because cabin pressure could bleed through the grease when gaps due to airframe curvature had to be accommodated. Once this had occurred, moisture could enter the joint and corrosion start to form.

2 - LOADED ELASTOMERS

Elastomers loaded with conductive particles and formed into flat gaskets had been manufactured, but since an insulated base material was used, it was essential that sufficient conductive particles were included to ensure contact. This produced a gasket without the required flexibility to make it suitable for use with aircraft antennas. The high compressive force required to distort the gasket enough to bridge and seal the gap between the base of the antenna and airframe was not available from the fixing screws. The exposed conductive particles - sometimes silver - then are capable of actually encouraging the onset of corrosion.

3 - METAL SPRINGS

Metal springs or other means of providing metal point contacts were available, but while possibly improving contact between surfaces, did nothing to prevent corrosion.

4 - METAL MESH/ELASTOMER COMBINATION

Metal mesh of various forms had been enclosed in elastomer sheets with the surface abraded away to expose the metal. The resultant gasket had the same problems as the loaded elastomers and was obviously too inflexible for use on aircraft installations.

Conclusions

The evaluation of the different approaches to producing a conductive sealing gasket suggested that none provided the basis for a stable gasket, capable of bridging the gap between the two metal surfaces and at the same time hermetically sealing the joint. The H.R.SMITH (TECHNICAL DEVELOPMENTS) LTD CONDUCTIVE SEALING GASKETS TYPE 10-500-11 were designed to combat the problems described and to meet all practical problems.

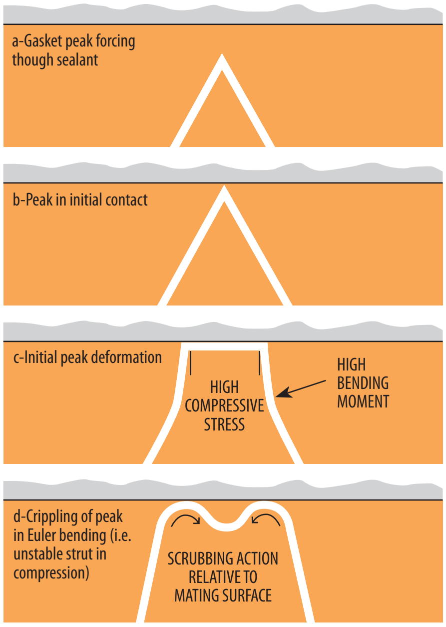
HR Smith Type 10-500-11 Gaskets

The gaskets are produced from 0.002" thick pure aluminium sheet with pierced, opposed projections, designed to collapse under the loads available from fixing screws. The form of the projections is such that the small contact areas produce substantial contact pressure to penetrate the sealing compounds used with the gaskets. In theory the gap between the mating surface is spanned as shown in Figure 4.
When the peaks of the projections are force into contact with the mating surface, a 'scrubbing' action occurs which expels the sealant and abrades the contact surfaces thus ensuring good electrical continuity. The sequence is shown in Figure 5, with the deformation exaggerated for the purpose of illustration.
When the sealant sets it becomes resilient and supports the gasket with a 'backing spring', thus retaining the contact even in the presence of small movements between the mating surfaces.

Application of the Type 10-500-11 Gaskets

With the ability to bridge gaps of up to 0.035" and to be compressed down to 0.004", the gasket enables large irregularities to be accommodated. This, combined with the flow of sealant through the pierced holes and across the faces of the gasket and mating surfaces, produces a gasket that is tailored to match the irregularities of the joint.

Sealing compounds are chosen to meet the mechanical, chemical and environmental conditions under which the bonded assembly will operate. Where joints may need to be broken down for maintenance, a sealant with a low adhesive value would be used, but on permanent bonds a high adhesive compound can be used instead. Although originally intended to meet the requirements of mounting antennas on aircraft, where the curvature of the airframe has to be compensated for, the gaskets are eminently suitable for improving or protecting the integrity of most non-brazed or non-welded assemblies. Under the collective type number 10-500-11, some five hundred different gasket kits are available to meet specific requirements for antennas, where a preformed gasket is supplied, and also in strips of different widths for use on equipment crates etc. Where existing kits do not meet the requirements of a specific installation, gaskets can be produced to match the requirement.



Firgure 5 - Deformation of gasket