Corrosion Effects on Field Penetration Through Apertures

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SUMMARY

The penetration of electromagnetic fields through an aperture caused by the faying join of a door or cover in a shielded barrier is dependent upon the conductivity of the join and the size of the aperture. It is common practice to plate the faying surfaces and place an EMI gasket between the joining surfaces to increase the conductivity and reduce the effective aperture of the join. In selecting the plating and gasket materials, corrosion control is usually of utmost concern, where the corrosion of concern is usually that which causes deterioration of the structure (i.e., oxidation of the base material). Oxidation of the plating and gasket material can, however, cause the conductivity of the join to increase significantly. As a result, the penetration of electromagnetic fields through the aperture can increase with time as oxidation of the platings and gasket material take place.

INTRODUCTION

Shielding theory as proposed for use by the various EMI design handbooks assumes that the electromagnetic shields are infinite in size, homogeneous and flat. The homogeneous assumption nullifies the use of the theory when apertures such as covers and doors are employed in the shield. To circumvent this problem, the super position theorem is utilized where the effective penetration of the field is measured utilizing MIL-STD-285 type "shielding effectiveness" tests. It has been shown[1] that the MIL-STD-285 type tests can produce erroneous results of as much as 80 dB. Additionally, errors due to uncontrolled variables leave such test results nearly invalid. One of the uncontrolled variables not considered in such testing is the degradation of the conductivity of the join due to corrosion. The obvious corrosion which is basically considered in design is the degradation of the structural strength of the shield due to oxides attacking the base materials such as iron rust and aluminum oxide. However, the platings used to protect the base material are effective by virtue of the forming of an oxide on the plating, where this oxide protects the plating structure. Most of these oxides are relatively poor conductors. As a result, the penetration of electromagnetic fields through an aperture as a result of the use of doors and covers will vary as a function of the platings used on the faying surfaces and the material used in the manufacture of EMI gaskets utilized. Such penetration can significantly increase in time due to corrosion (oxidation) of the EMI gaskets and shielded surface platings.

RELATIVE FIELD PENETRATION TESTS

The data obtained from the performance of two sets of tests are evaluated herein. These are:

1. RF Transfer Impedance Tests
2. DC Contact Resistance Tests

It has been shown[2], that transfer impedance test data can be used to accurately predict the relative radiated field penetration through a discontinuity (aperture) in a shield as a function of the variables under test. It has been argued that dc contact resistance tests can be used in lieu of the transfer impedance tests to obtain a predicted relative level of field penetration through the discontinuity of a join.

The results of a significant number of transfer impedance tests are illustrated where the variables are: (1) platings on aluminum shields and cover plate; (2) configuration of EMI gaskets; (3) materials used in the manufacture of EMI gaskets; and (4) the effect of aging. The variables used in the dc contact resistance testing were: (1) the base materials used; (2) platings on the base materials; and (3) the effect of aging.

Aging on the materials used in the performance of the dc contact resistance test was very highly controlled and consisted of subjecting the plates to a relative humidity of 95 percent at 40°C for 400 and 1000 hours. Aging on the materials used in the transfer impedance tests was not well controlled and consisted of subjecting the materials to a one-year shelf life where neither the temperature or relative humidity were controlled.

DC Resistance Testing

Earl Groshart of the Boeing Aerospace Company has performed a series of dc contact resistance measurements on aluminum, steel, copper and stainless steel where the results have been documented in previously published reports[3,4] and is illustrated in Table I herein.

The testing consisted of measuring the contact resistance of the materials using different finishes, where the measurements were taken with initial clean surfaces and after the materials were subjected to aging at 40° C in a relative humidity environment of 95 percent for 400 hours and 1000 hours.

In obtaining the measurements, the individual samples were subjected to a constant force. The force used in most of the tests were 20 pounds per square inch. The more recent test results used 100 pounds per square inch. The change in applied force was instituted due to the realization that the contact resistance is dependent upon the applied force, and it was felt that 100 pounds per square inch is more consistent with the force applied by screw fasteners than was the 20 pounds originally used in the testing.

RF Transfer Impedance Testing

It has been shown[2], that transfer impedance measurements can be used to accurately predict the relative penetration of radiated fields through an aperture in a shield as a function of the variables under test. As such, a significant number of transfer impedance tests were performed. The variables under test were:

1. Platings used on aluminum shield and cover plate.
2. Configuration of EMI gaskets.