CONNECTOR INTERFACE AND SHIELDING PERFORMANCE

The care taken to design a shielded cable is often compromised when connectors are not properly selected to support the required shielding effectiveness.

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INTRODUCTION

When designing shielded cable and conduit assemblies, a great deal of attention must be given to the election of a connector that will not degrade expected shielding performance.

The care taken to design a shielded cable is often compromised when connectors are not properly selected to support the required shielding effectiveness. This article investigates the degradation experienced in shielded conduit assemblies designed for a military radar system. Since the radar had passed full-up systems tests for many years, personnel had become complacent concerning the shielding of the assemblies in the radar system. However, when testing the individual assemblies, none of the 12 types passed the shielding requirements.

This article considers all of the various components of the shielded conduit assemblies and their contributions to the shielding effectiveness. Measurements of shielding effectiveness are introduced, as well as the reasons for any deviation from the requirements.

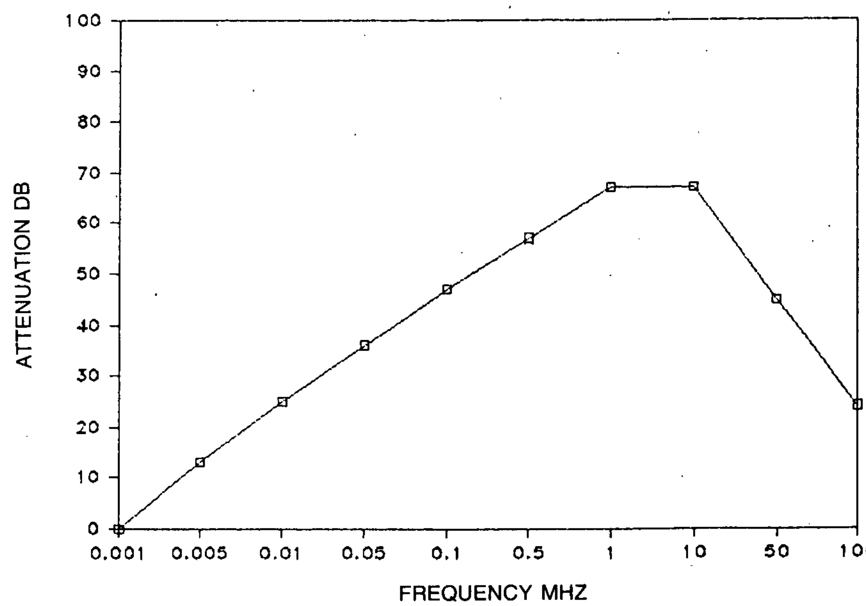

Figure 1. Magnetic Specification.

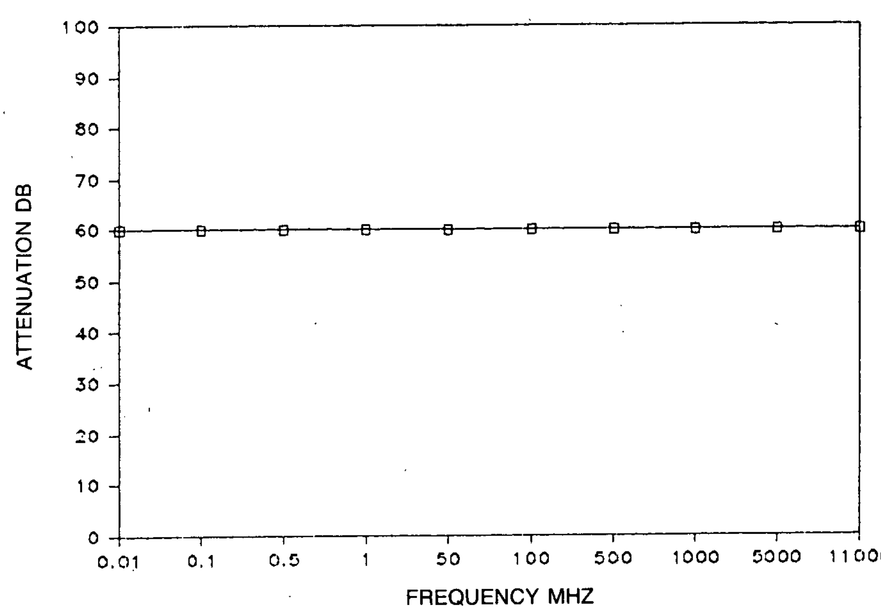

Figure 2. Electric Specification.

ORIGINAL SHIELDING SPECIFICATIONS

Since radar systems produce electromagnetic waves of a broad spectrum, specifications were developed to guard against both magnetic and electric fields. Figure 1 illustrates the magnetic specification. The electric specification is shown in Figure 2.

CONDUIT ASSEMBLY DESIGN

In order to meet the original shielding specifications discussed above, a conduit was designed with the following multiple layers:

1. A helical, corrugated core of nickel iron alloy.
2. A second layer of an outer braid of corrosion resistant steel.

Adaptors were designed to be manufactured from Aluminum Alloy 6061-T6 and tin or electroless nickel plated. The adaptors were soldered directly to the braided conduit. The adaptors were attached to the connector by means of a captivated, threaded coupling nut. MS-5015 type and MS-38999 Series 2 connectors were selected to mate with existing connectors on the interface equipment.

TEST RESULTS

The test setup shown in Figure 3 was employed to test the cables. The test setup shows a biconical antenna, used for mid-range frequency measurements of the electric field. A horn antenna was used for high frequencies (1 GHz and up), and for low frequencies (below 10 MHz) a dipole and flat plate were used. All magnetic measurements were made with a pickup coil placed around the conduit. Test results fell into two broad categories, labeled A and B. Figures 4 and 5, respectively, show the magnetic and electric results for category A. Figures 6 and 7 show the magnetic and electric results, respectively, for Category B.

A comparison with the requirements shows that each category has its own area where it falls out of specification. The purpose of this analysis is to discover the reason for non-compliance.

EVALUATION

Shielding for the conduit assemblies can be split into three contributors as follows:

Conduit. Calculation of the shielding specifications for the corrugated nickel-iron conduit covered with a braid of corrosion-resistant steel indicates that, if properly constructed, this should provide more than adequate shielding to meet the requirements.

Nickel-Iron. Iron with steel overbraid of the thickness used in this particular design has a shielding effectiveness that begins to show at 500 Hz, and reaches in excess of 80dB near 20 kHz, and increases to nearly 100dB at 10 MHz, and stays constant to over one GHz, falling to approximately 70dB at 10 GHz.

Adaptors. The aluminum adaptors are made with a minimum material thickness of 3/16-inch. Due mainly to material thickness, the shielding

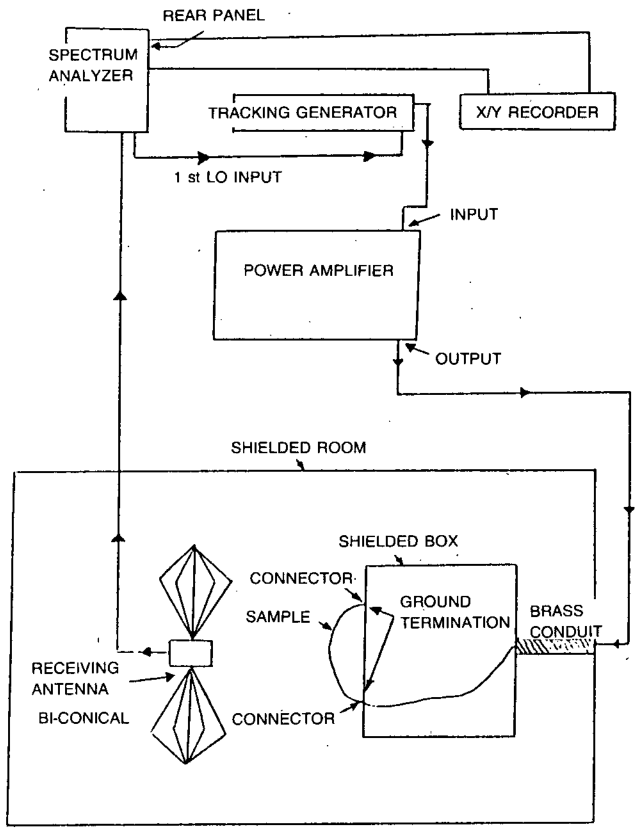

Figure 3. Test Setup.

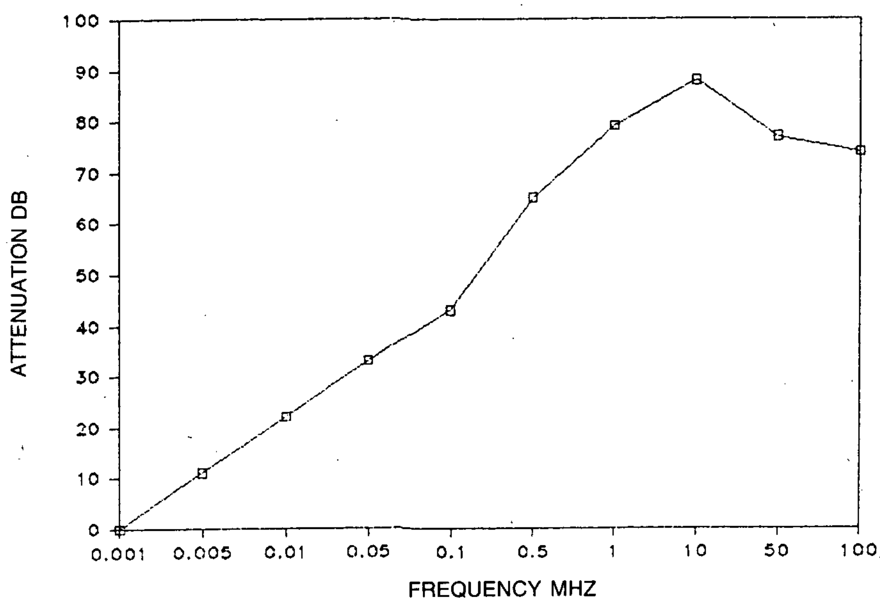

Figure 4. Category A Magnetic Field.

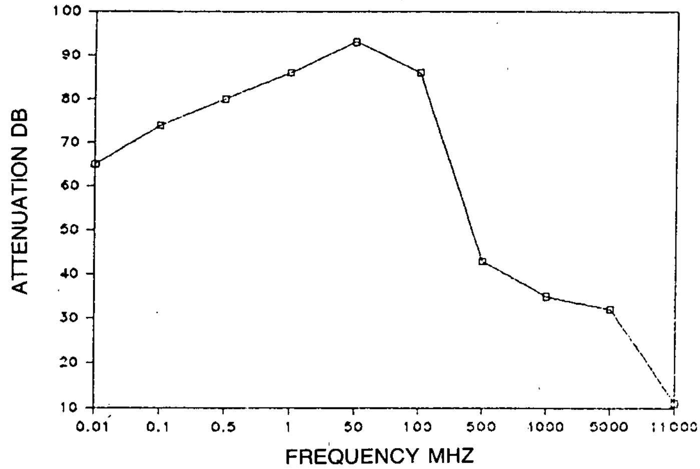

Figure 5. Category A Electric Field.

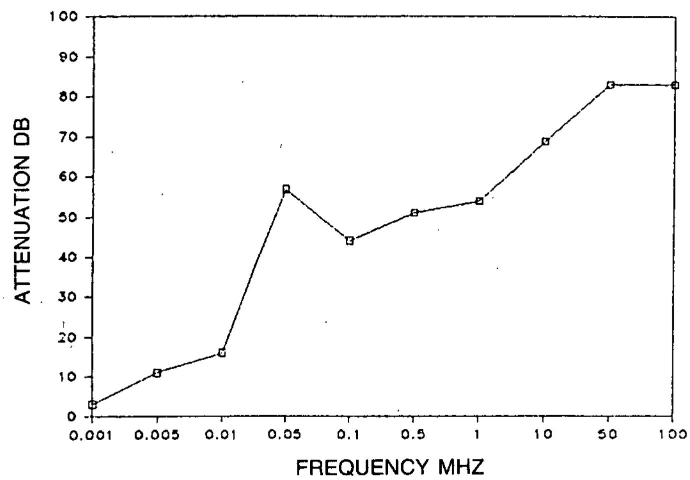

Figure 6. Category B Magnetic Field.

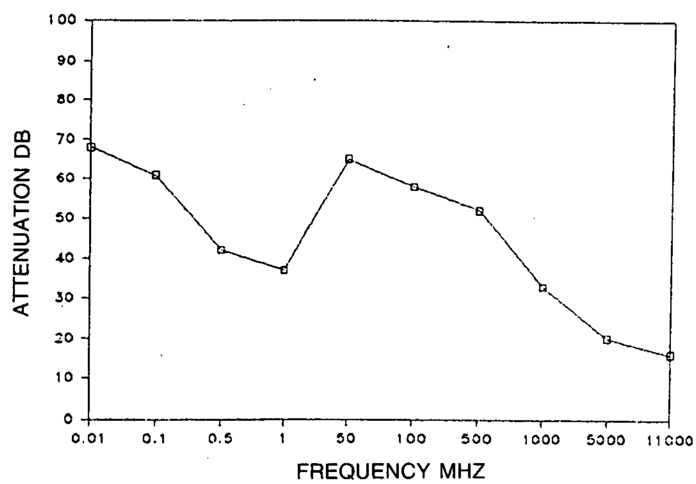

Figure 7. Category B Electric Field.

effectiveness of the adaptors is better than the conduit at high frequencies and only slightly worse at frequencies below one MHz, with the magnetic shielding effectiveness beginning to roll up at approximately 800 Hz, rising to 70dB at 50 kHz and 90dB at 10 MHz, then rising to track slightly above the conduit to frequencies over 10 GHz.

Connectors. The two types of connectors used each have their own characteristic shielding signature. Figure 8 shows the measured shielding effectiveness for the MS-5015 type connector, while Figure 9 shows the MS-38999 shielding effectiveness. The MS-38999 shielding compares well with the specification for the connector.

CONTRIBUTION OF MAGNETIC FIELD

Since the shielding contribution of the magnetic field is not well represented by the combination of materials, the specification was rewritten as is shown in Figure 10.

This rewritten specification is more in line with the actual system requirements and actually better represents the harmful fields that could be seen by the conduit assemblies in use.

CONCLUSIONS

When a composite of materials is chosen for a shielded assembly, care must be exercised in the selection of each component. In the case demonstrated here, the shielding effectiveness of the entire conduit system was compromised because one component was not selected with an eye toward the total shielding requirements. In this case, once the culprit was recognized, a rewrite of the specification allowing all of the various components to be limit-driven was undertaken.

It is apparent that the single component failure in this case is not responsible for all of the shielding loss and the total can best be explained by some leakage around the adaptor connector interface as well as connector-connector leakage.

If one were to thoroughly study Categories A and B shielded conduits with relation to the initial specification, it is easy to see that none of the items fall within specifications. However, when the same comparison is made against the new specifi-

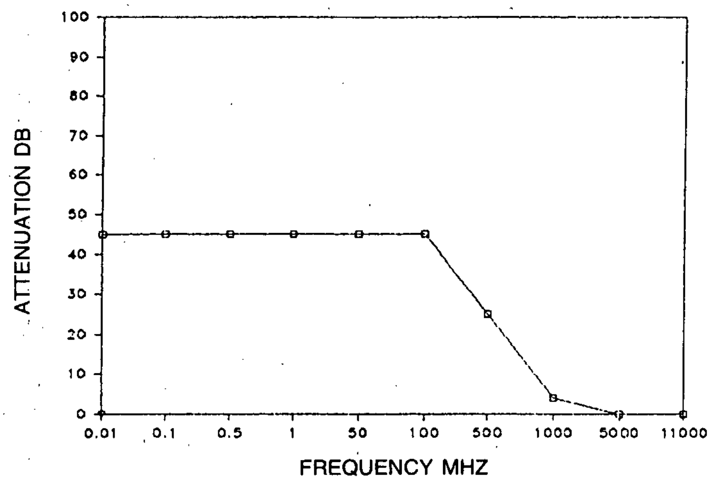

Figure 8. MS-5015 Electric Field.

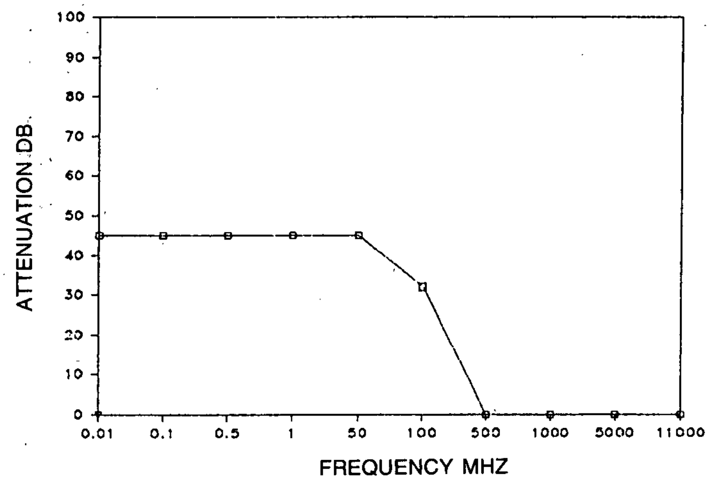

Figure 9. MS-38999 Electric Field.

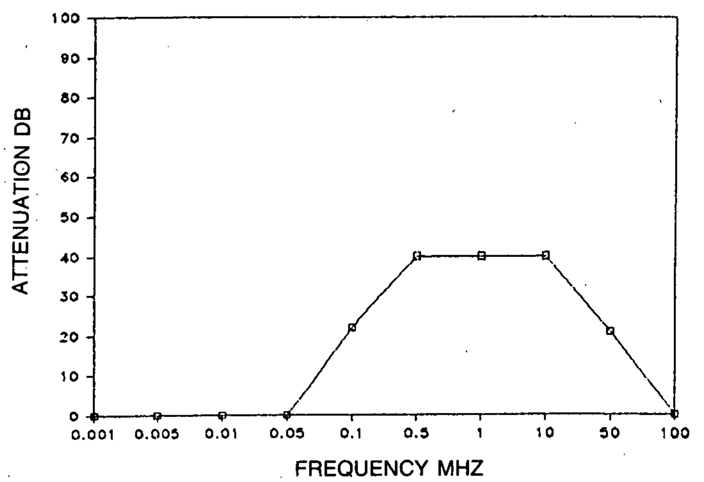

Figure 10. Magnetic Field Specification.

cation, both types fall well within the requirements.

A very valuable lesson for the designer can be learned from this experience. Exhaustive testing of the exact configuration to be used must be performed before final specifications are written. It is not enough to examine each item separately; each must be integrated and tested as a total system. Each system constructed will have its own point of possible failure, whether it be connector, connector-to-connector, interface, or any other point on the assembly. ■

ACKNOWLEDGEMENT

The author wishes to express thanks to Tony Genova of Chomerics and John Novak of Raytheon for cooperation in making measurements.