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Subject: Glenair MIL-PRF 24758 Conduit Surface Transfer Impedance Test

Reference: P.O. E60272-1211

Glenair
1211 Air Way
Glendale, CA 91201

Dear Sirs:

The surface transfer impedance of a MIL-PRF 24758 Conduit Assembly, furnished by Glenair, has been measured.

Test Method

All measurements were made using the line injection method of IEC 600096-1, Amendment 2. This method allows credible measurements to be made to very high frequencies and can be performed with reasonably simple test accessories. This method is described in detail in references 1, 2, and 3. Reference 4 compares the line injection method with more conventional test techniques which use cylindrical drives lines (quadraxial and triaxial test fixtures). In the line injection method, current is injected on the exterior of the conduit shield by installing a strip line on the exterior of the jacket. The termination of the drive line is connected to the reference or current measuring port of a network analyzer. Assuming that the drive line is match terminated, the drive current can be obtained by measuring the voltage on the drive line and dividing by the characteristic impedance.

The voltage on the inside of the conduit sample is measured with the aid of a sense line or core. Both ends are match terminated to eliminate standing waves. The sense line voltage is measured at the opposite end from where the current is injected. The transfer impedance of the sample is the voltage on the inside of the shield (twice the voltage at the measurement end) divided by the drive current. The transfer impedance per unit length is obtained by dividing this impedance by the length of the sample.

If the geometry is ideal, the drive and sense lines match terminated and the phase velocities exactly matched, this method can be used to measure transfer impedance up to frequencies where the transverse dimensions of the sample approach a half wavelength. Unfortunately, these ideal conditions cannot usually be found in practical cables or conduits such as are being measured in the present test. However, by adjusting the insulation in order to control the phase velocity, keeping all connections short and properly terminating all the instrumentation, sense and drive lines, credible measurements were able to be made to frequencies of 1 GHz and above. The most significant measurement artifact in the present measurements was high frequency cross-talk between the drive and measurement cables and connectors.

Test Samples

The test conduit assembly consisted of a 1 meter (40") length of M24758-C 3/4 " I.D. conduit with one end terminated to a M24758-2CC fitting. A 5/16" brass tube was installed in the center of conduit assembly, held in place by low density Styrofoam spacers. This served as the sense wire and allowed the measurement of the voltage on the inside surface of conduit. Two 100 W resistors were connected between the center conductor or sense wire and the inside of the conduit at the drive end of the sample. This was insulated and covered with copper tape. All seams were sealed with solder and the tape was soldered to the outer surface of conduit. A small aluminum box was installed on the measurement end of the conduit assembly. An N-type connector on the wall of the box was connected to the sense wire/center conductor. Thus the interior of the test sample was completely shielded.

A drive line, consisting of a 5/8"wide strip of copper tape was fastened to the length of the sample over the jacket. The center conductor of appropriate lengths of RG-58 cable was soldered to the drive line. The shield of the instrumentation cables was attached to the outer surface of the conduit with hose clamps. In all cases, the conductive portion of the drive line was made of copper tape. This formed one plate of a 50 W parallel plate transmission line. The metal surface of the conduit formed the other plate. The drive line was applied only over the jacket portion of the samples.

The test assembly is shown in Figure1. Figures 2 and 3 show the details of the drive and measurement ends of the test assembly.

Figure 1. Glenair M24758 Conduit Assembly, with IEC 600096-1, Amendment 2 Test Apparatus Installed. A 1-m scale is included.

Figure 2. Drive End of Glenair M24758 Conduit, with IEC 600096-1, Amendment 2 Test Apparatus Installed.

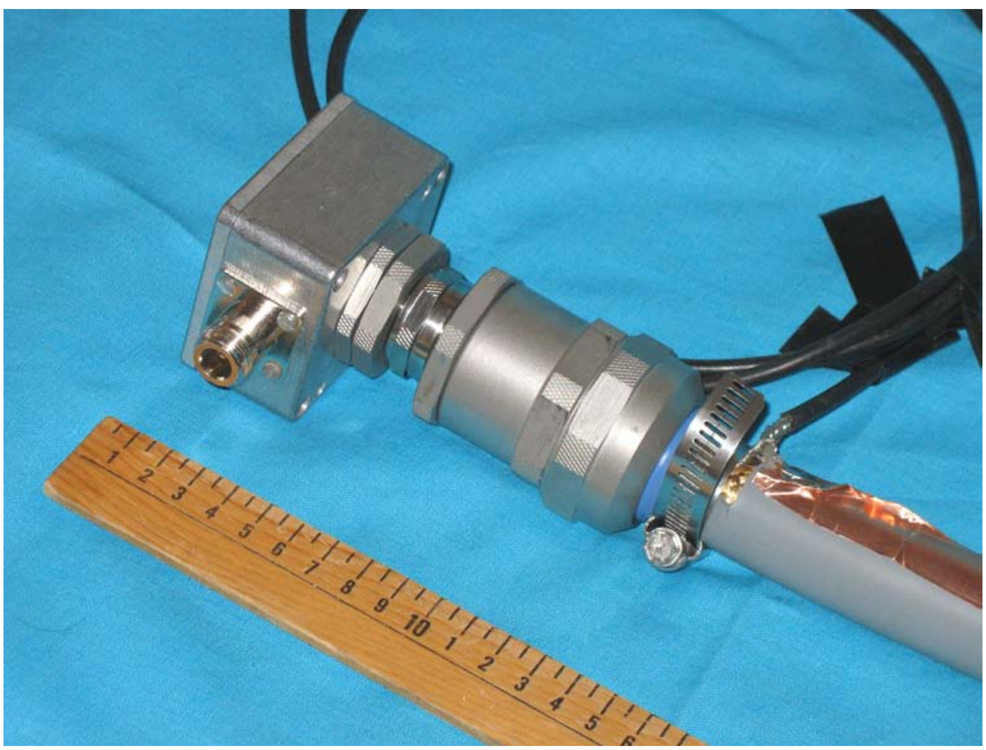


Figure 3. Measurement End of Glenair M24758 Conduit, with IEC 600096-1, Amendment 2 Test Apparatus Installed.

Instrumentation

The magnitude and phase of the complex ratio of the test channel voltage (sense line) to the reference channel voltage, which is proportional to current, was measured using two network analyzers. Low frequency measurements (1 kHz to 200 MHz) were made using a computer controlled HP 3577A network analyzer. High frequency measurements (300 kHz to 3 GHz) were made with a computer controlled HP5783C network analyzer. Th HP3577A network analyzer produced 15 dBm of power while the HP8573C produced 25 dBm. Both used a bandwidth of 10 Hz.

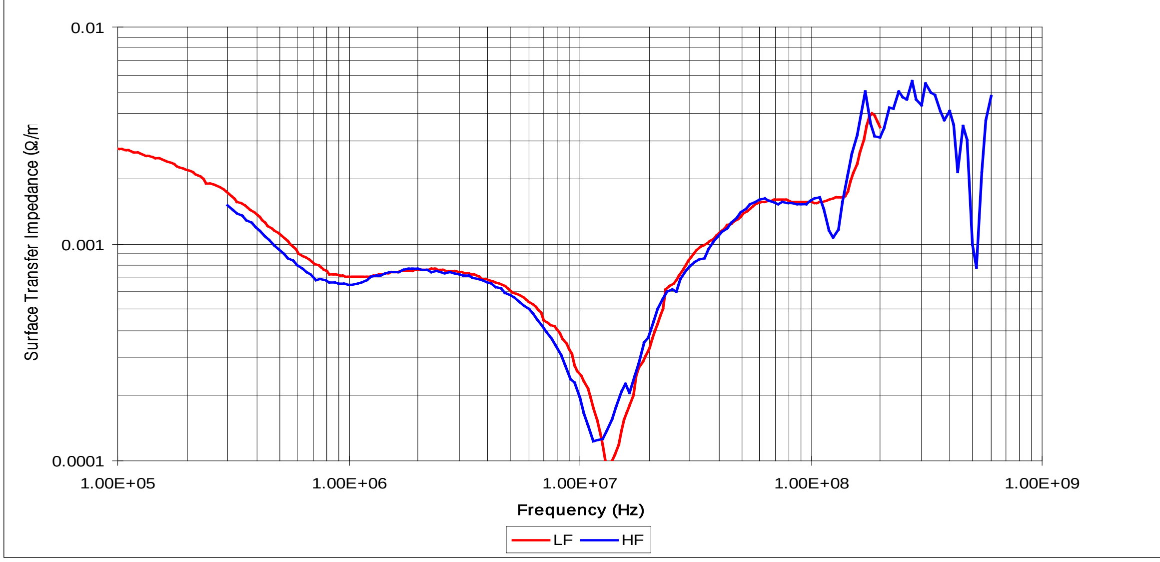
Ferrite beads were placed on the instrumentation cable from the analyzer output to the drive line and a short low transfer impedance cable was used to connect the sample to the network analyzer test channel in order to reduce the effect of ground loop coupling cross talk.

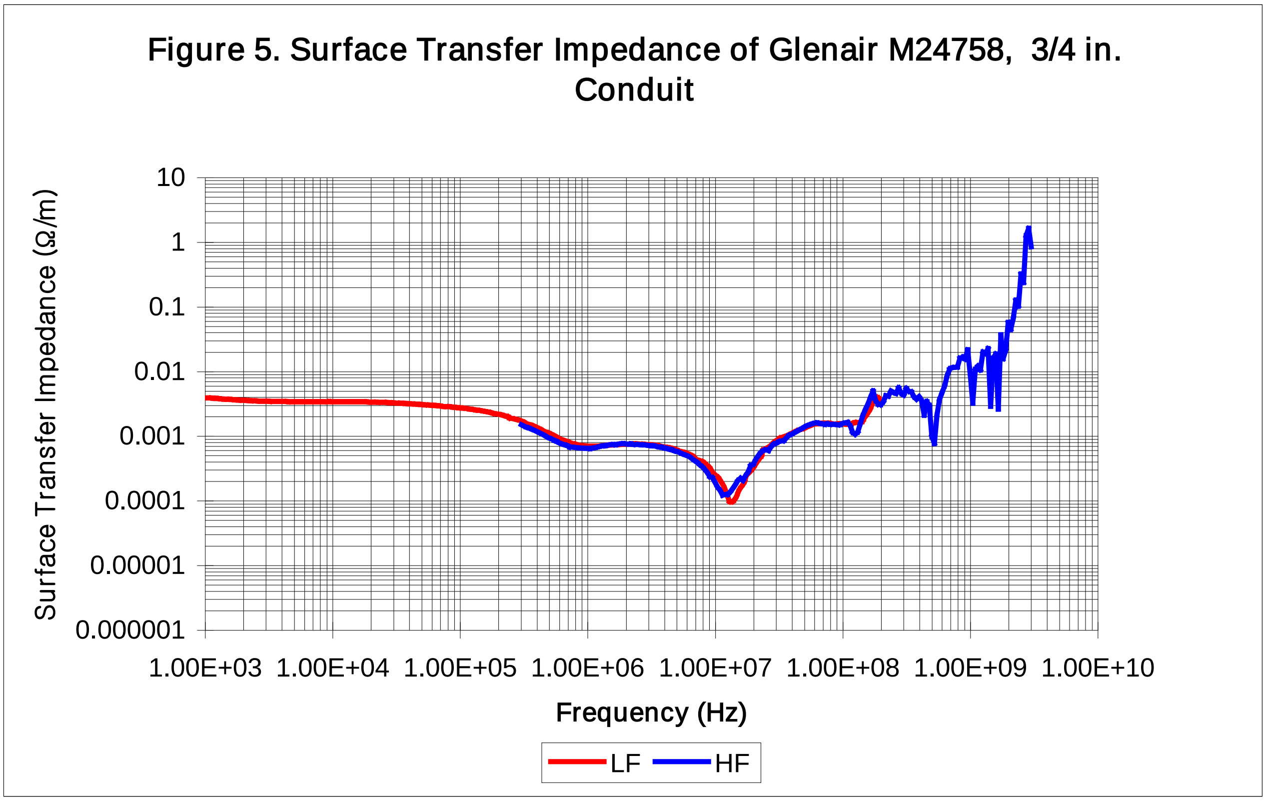
All data was initially recorded on the computer's hard disk and then transferred to floppy disks. Final analysis and plotting was performed using the Excel spreadsheet program.

Results

The measured transfer impedance of the Glenair M24758 conduit assembly over the frequency range of the specification is presented in Figure 4. Figure 5 presents the data obtained in this test over the entire frequency range the measurements. These measurements are similar to those presented in Figure 10 of reference 5 which were made over 20 years ago using a slightly bigger conduit of similar construction. The transition at about 1 MHz is probably due to the inductance of the region between the braid and the convolute. Above 10 MHz, the increase in the measured surface transfer impedance may be due to crosstalk between the drive and measurement cables and connectors. The true surface transfer impedance is probably less (better) than the data presented here.

Figure 4. Surface Transfer Impedance of Glenair M24758, 3/4 in. Conduit





Shielding Effectiveness

The ratio of currents shielding effectiveness was calculated from the measured surface transfer impedance and the termination impedances of the sense line using the following equation [5].

$$\text{Shielding Effectiveness} = 20 \text{ Log } (I_s/I_c) = 20 \text{ Log } ((R_1 + R_2)/Z_t) = 20 \text{ Log } (100/Z_t\, l\,)$$

where I_s and I_c are the shield and core currents, R_1 and R_2 are the termination resistors at the ends of the sense line, Z_t is the measured transfer impedance, and l is the length of the sample. Note that Shielding Effectiveness is usually a positive number in this calculation.

Figure 6 and 7 present the calculated ratio of currents shielding effectiveness for the Glenair M24758 Conduit Assembly. These figures correspond to Figures 4 and 5.

Figure 6. Shielding Effectiveness of Glenair M24758 Conduit

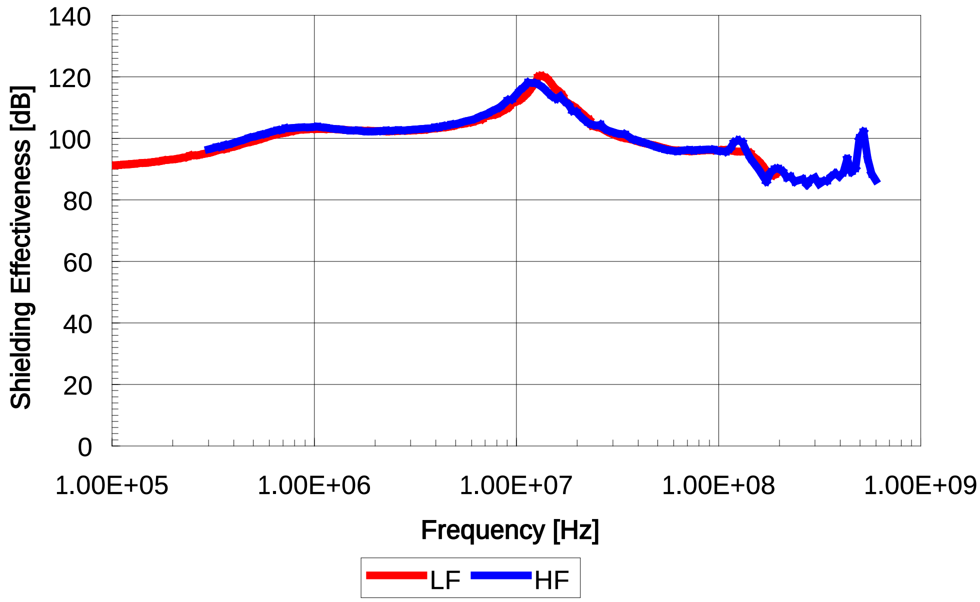
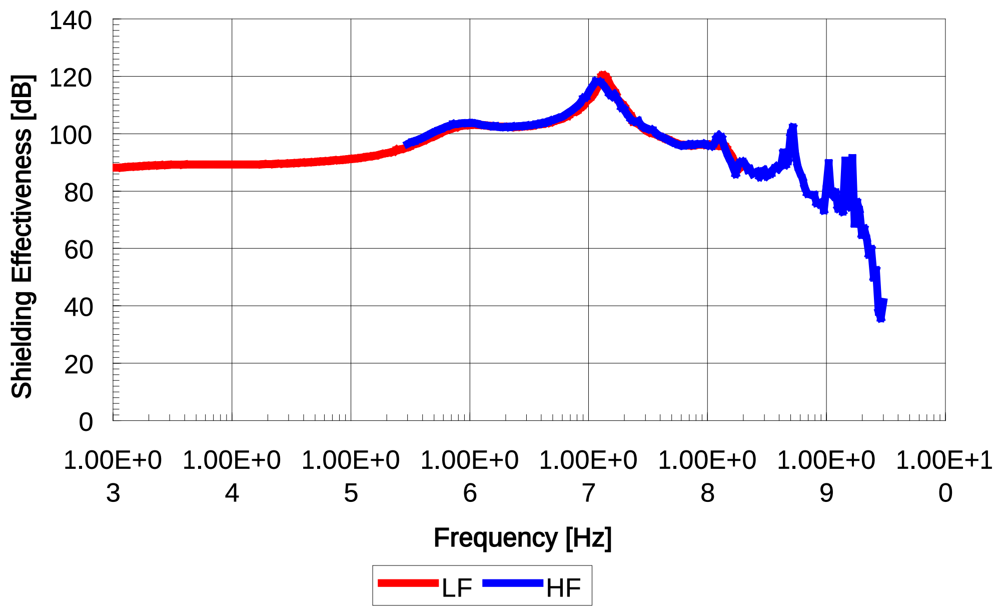


Figure 7. Shielding Effectiveness of Glenair M24758 Conduit



This completes the measurements required by the referenced purchase order. Electronic files (PC format) are being sent by e-mail. If you have any questions, please feel free to contact me. Please accept my thanks for being able to serve you on this project.

Yours truly,

Lothar O. Hoeft, PhD

References

1. B. T. Szentkuti, "Shielding Quality of Cables and Connectors: Some Basics," *Record of the 1992 IEEE International Symposium on Electromagnetic Compatibility*, Anaheim, CA, August 1992, pp. 294-301.
2. B. Eicher and L. Boillot, "Very Low Frequency to 40 GHz Screening Measurements on Cables and Connectors: Line Injection Method and Mode Stirred Chamber," *Record of the 1992 IEEE International Symposium on Electromagnetic Compatibility*, Anaheim, CA, August 1992, pp. 302-307.
3. L. Halme, "Development of IEC Cable Shielding Effectiveness Standards," *Record of the 1992 IEEE International Symposium on Electromagnetic Compatibility*, Anaheim, CA, August 1992, pp. 321-328.
4. L. O. Hoeft, T. M. Salas, and W. D. Prather, "Comments on the Line Injection Method for Measuring Surface Transfer Impedance of Cables," *Record of the 12th International Zurick Symposium on Electromagnetic Compatibility*, Zurick, Switzerland, February 1997, pp. 263-268.
5. L. O. Hoeft and Joseph S. Hofstra, "Measured Electromagnetic Shielding Performance of Commonly Used Cables and Connectors," *IEEE Transactions on EMC*, Vol. 30, No. 3, August 1988, pp 260-275.