A short history and review of shielded cables

Effective shielding prevents interference from entering or emanating from a cable.

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HISTORY

In the late 1800s, as the use of electricity was first being used for communications, interference reared its ugly head. The imperative for some form of mitigation became apparent. The first attempts involved wire spacing. Bare wires on wooden poles were simply spaced farther apart to reduce interference. When the wires entered buildings and were forced closer to each other, twisting the pair was the preferred technique for reducing interference. Look at early pictures of New York City; the sky is dark with thousands of wires for telegraph and telephone wires. Then radio came along, and radio broadcasts could be heard coming from the telephone wires. The need for shields became a problem begging for a solution.

Wrapping the cable with grounding wires (a simple served shield), worked for fixed installations; but when the cable was subjected to flexing, the wrapped wires separated and interference returned.

Enter the braider. Braiders were invented in the mid-1800's to manufacture shoe laces and other textile items. Tinsel wire, a flattened wire wrapped around a cotton or flax yarn, was used for the epaulettes on military uniforms. Early telephone engineers discovered that this was a great, very flexible conductor for telephone earpiece cords. The tinsel wire could also be braided over the conductors in the earpiece cords to reduce radio interference. When the cable was not subjected to the high flexing conditions of a telephone cord, tinsel wire could be replaced by simple strands of wire.

TODAY

The purpose of a shield is to prevent interference from entering or emanating from a cable. The three types of interference are: radio frequency interference (RFI), electromagnetic interference (EMI), and electromagnetic pulse (EMP). RFI was the earliest type of interference that engineers had to deal with. Early radio signals easily found their way into devices. Coaxial cables and shielded twisted pairs using copper eliminated most of this type of interference.

Today, EMI has become more problematic because of high power transmission lines; higher magnetic fields, such as MRI machines in hospitals; and other high power applications. Copper may not offer much resistance to higher magnetic fields; therefore, the use of magnetic materials such as high permeable irons may be required.

EMP is produced by the detonation of nuclear devices. When the hydrogen bombs were tested in the 1950s at Bimini Atoll in the South Pacific, circuit breakers at power stations in Hawaii were tripped by the EMP wave from the detonation. Critical military and civilian circuits must be protected from an EMP condition. These shields require the use of both high and low permeable materials to reduce the effect of an EMP.

TYPES OF SHIELDS

The simplest type of shield in use today is a plated plastic film (aluminized Mylar) wrapped around a cable or twisted pair. A drain wire contacts the foil along the cable to maintain a low resistance. For increased shield effectiveness, a loose braid may be placed over the tape. Many CATV cables use this technique. This method works well as long as the cables are flexed only during installation and maintenance. A served shield offers higher shielding effectiveness than the film shield (Figure 1). It can be used when the cable is subjected to moderate flexing.

When the cable is subjected to flexing, a braid shield becomes the best choice (Figure 2). By choosing the right wire size, the braid offers the best shield method.

Calculating the size of the shield material used to be a chore. The formulas for calculating the braid construction form an Eigen value problem, for which is there is no finite answer to the calculation. Early engineers created tables of shield constructions and used them as a guide to designing the braid. Today computers can quickly make the calculation. The formulas can be found in cable design handbooks and military specifications.

The materials commonly used for

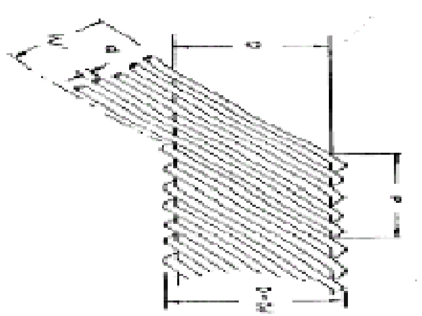

Figure 1. *A served shield.*

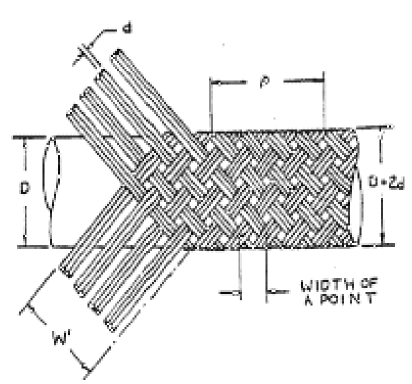

Figure 2. *A braided shield.*

shields are: copper, tin-plated copper, silver-plated copper, nickel-plated copper, high and low permeable irons, carbon fibers, tinsel wire and aluminum.

The choice of materials for the shield and the choice of insulation and conductor materials depend upon the environmental conditions to which the cable will be subjected.

Calculating the shield coverage and braid angle

Simple formulas can be used to calculate shield coverage and braid angle. The shield should consist of a woven braid using strand material specified in the cable specification. Coverage should not be less than 85% for most cables, but may be increased to 90%. The angle of the braid with the axis of the cable should lie between 20° and 40° for diameters up to .600 inch (15.2 mm). For diameters larger than .600 inch (15.2 mm), the braid angle may be greater than 40°. Percent coverage, K, and angle of braid, a, should be calculated as follows:

K = (2F - F2) x 100
F = NPd/Sin a
a = Tan -1 (2π(D +2d) P/C)

where

F = Fill or space factor
K = Percent coverage
N = Number of wires per carrier
P = Picks per inch of cable length
d = Diameter of individual braid wire in inches
a = Angle of braid with axis of cable
D = Diameter of cable under the shield in inches
C = Number of carriers

BRAIDERS

The vocabulary for the braider comes from the early textile industry. A bobbin is the small spool that holds the number of wires needed. The number of carriers is the count of the bobbin holders on the braider; common numbers are 12, 16, 24, 36, 48 and 96. Ends are the number of strands of wire wound on a bobbin. Pick is the number of times that the wires coming from a bobbin occur in one inch.

When using yarn for the braid, another common unit for the yarn is Denier. A Denier is the weight in grams of 9,000 yards of the yarn. Often you may see the length as meters, which is not the unit Mr. Denier defined. The reason for the mismatch of units is that in the early textile mills, gram scales were used for small weights. The common linear quantity was 9,000 yards. Calculators did not exist in the mid-1800's so Mr. Denier chose his unit to use readily available units, *i.e.*, grams and yards.

Shield effectiveness is expressed in decibels or dB. For a single copper shield, the value is around 40 dB for 85% coverage and only climbs to 45 dB for 90% coverage. By using two copper shields, the value rises to around 60 dB. To go higher in effectiveness requires the use of high and low permeable irons.

CONCLUSION

Cable shields have come a long way since the inceptions of radio and telephones. Today with the wide range of transmitters from cellphones, AM and FM radios, high definition TV, and a multitude of other consumer electronics, it is important to consider the proper shields for any new cable. Shielding of the cases for a device is a reason for another article.

For more information on shields see:

MIL-DTL-27500
Rome Wire and Cable Handbook
Wire Association Electrical Wire Handbook.

Don Dodge *has been with Calmont Wire and Cable for 28 years, starting as Chief Engineer and is now the Vice President of Research. Don started in the wire and cable industry after leaving the Army in 1969, first as Quality Control Laboratory Supervisor at Pacific Electricord, then moved to Quality Control Manager, and finally as Chief Engineer.He was Chairman of the Flexible Cords Technical Committee of NEMA and Chairman of the US Delegation for IEC SC20B for Wires and Cables. He was involved with ribbon cable while at T&B Ansley. He has designed many ultra-flexible cables for Military, Medical and Aerospace applications. Don holds a Bachelors degree in Physics and a Masters degree in Business Administration.*