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Technical Paper

Understanding Shielded Cable

Industrial applications such as the factory floor are typically electrically noisy environments. Electrical noise, either radiated or conducted as electromagnetic interference (EMI), can seriously disrupt the proper operation of other equipment. Insulation protects a cable mechanically from scraps and abrasion and environmentally from moisture and spills. But insulation is transparent to electromagnetic energy and offers no protection. Shielding is needed to combat the effects of EMI.

EMI and its role in shielding

Cables can be a main source of transfer for EMI, both as a source and receiver. As a source, the cable can either conduct noise to other equipment or act as an antenna radiating noise. As a receiver, the cable can pick up EMI radiated from other sources. A shield works on both.

Table 1 below gives general guidelines as to the areas which are subject to these generalized noise levels. Notice that switching heavy loads, inductive heaters, and large transformers can all present high levels of both conducted and radiated EMI.

Placing signal cables next to power cables can also allow power-line noise to couple onto the signal lines.

Noise Level	Noise Source	Typical Locations
High	Electrolytic processes, heavy monitors, generators, transformers, induction heating, relay controls, power lines, and control wire in close proximity	Heavy processing plants such as steel mills and foundries
Medium	Wiring near medium- sized motors, control relays	Average manufacturing plants
Low	Wiring located far from power lines, motors; motors	Storage areas, labs, offices, and light assembly operations

Table 1. Noise levels and location

Combatting EMI

The primary way to combat EMI in cables is through the use of shielding. The shield surrounds the inner signal- or power-carrying conductors. The shield can act on EMI in two ways. First, it can reflect the energy. Second, it can pick up the noise and conduct it to ground. In either case, the EMI can barely reach the conductors. In either case, some energy still passes through the shield, but it is so highly attenuated that it doesn't cause interference.

Cables come with various degrees of shielding and offer varying degrees of shielding effectiveness. The amount of shielding required depends on several factors, including the electrical environment in which the cable is used, the cost of the cable—why pay for more shielding than you need?—and issues like cable diameter, weight, and flexibility.

An unshielded cable for industrial applications typically is used in a controlled environment—inside a metal cabinet or a conduit, where it is protected from ambient EMI. The metal of the enclosure shields the electronics inside.

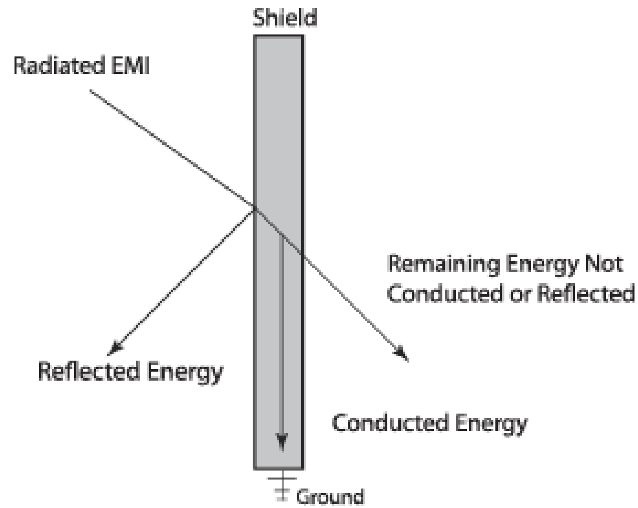

Figure 1. A shield will reflect some energy, conduct some energy to ground, and pass some energy

Typically, two types of shielding are used for cables: foil and braid.

Foil shielding used a thin layer of aluminum, typically attached to a carrier of the conductors it surrounds, which is good. It is thin, which makes it harder to work with, especially when applying a connector. Usually, rather than attempting to ground the entire shield, the drain wire is used to terminate and ground the shield.

A braid is a woven mesh of bare or tinned copper wires. The braid provides a low-resistance path to ground and is much easier to termination by crimping or soldering when attaching a connector. Nevertheless, braided shields do not provide 100% coverage, allowing small gaps in coverage. Depending on the tightness of the weave, braids typically provide between 70% and 95% coverage. When the cable is stationary, 70% is usually sufficient. In fact, you won't see an increase in shielding effectiveness with higher percentages of coverage. As copper has higher conductivity than aluminum and the braid has more bulk for conducting noise, the braid is more effective as a shield. Still, it adds size and cost to the cable.

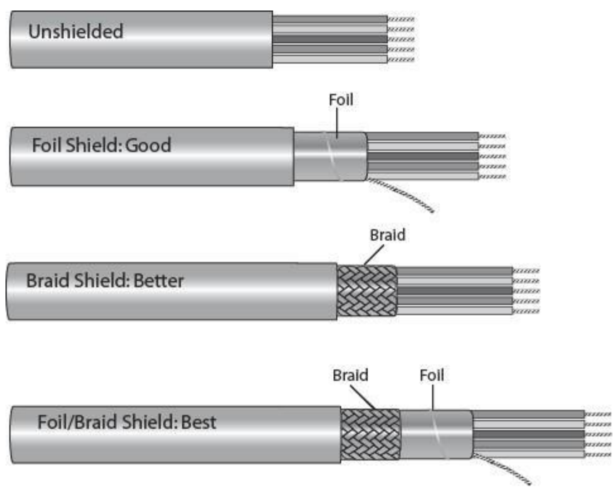

Figure 2. Typical shielding configurations

For very noisy environments, multiple shielding layers are often used. The most common is a combination of both a foil and a braid. In multiconductor cables, individual pairs are sometimes shielded with foil to provide crosstalk protection between the pairs, while the overall cable is shielded with foil, braid, or both. Cables can also use two layers of either foil or braid.

A third approach combines both foil and braid shields in protecting the cable. Each supports the other, overcoming the limitations of one with its own compensating strengths. As shown in Figure 2, this presents shielding effectiveness superior to either approach alone. Increasing the performance of the foil/braid design is the unique triple laminate aluminum/polyester/aluminum foil tape. This tape increases shielding effectiveness through reduced shield resistance and is in contact with a drain wire to facilitate quick and reliable termination.

In practice, the purpose the shield is to conduct to ground any of the noise it has picked up. The importance of this cannot be overstated—and failure to understand the implications can mean ineffective shielding. The cable shielding and its termination must provide a low-impedance path to ground. A shielded cable that is not grounded does not work effectively. Any disruptions in the path can raise the impedance and lower the shielding effectiveness.

Practical guidelines for effective shielding

1. Make sure you have a cable with sufficient shielding for the application's needs. In moderately noisy environments, a foil alone may provide adequate protection. In noisier environments, consider braids or foil-braid combinations.
2. Use a cable suited to the application. Cables that experience repeated flexing usually use a spirally wrapped shield rather than a braid. Avoid foil-only shielding on flex cables since continuous flexing can tear the foil.
3. Make sure the equipment that the cable is connected is properly grounded. Use an earth ground wherever possible and check the connection between the ground point and the equipment. Eliminating noise depends on a low resistance path to ground.
4. Most connector designs allow full 360° termination of the shield. Make sure the connector offers shielding effectiveness equal to that of the cable. For example, many common connectors are offered with metal-coated plastic, cast zinc, or aluminum backshells. Avoid both over-specifying and paying for more than you need or under-specifying and getting poor shielding performance.
5. Ground the cable at one end. This eliminates the potential for noise inducing ground loops.

A shielded system is only as good as its weakest component. A high-quality cable is defeated by a low-quality connector. Similarly, a great connector can't do anything to improve a poor cable.

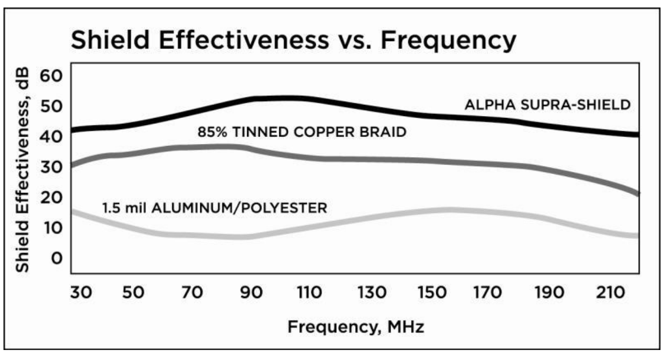

Figure 3. Foil-braid shielding yields the highest Shield Effectiveness