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Factors to Consider for High Performance Coaxial Cables

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This month's tutorial looks at some key issues in high performance cables, featuring a comparison of the various jacket and dielectric materials from a recently-published paper

High performance cables and cable assemblies are typically well-controlled in their loss and VSWR performance, shielding (EMI) performance and especially, mechanical and environmental performance. The manufacturer's choice of construction materials, in combination with the method of fabrication, determines the overall performance. As might be expected, there is a wide range of materials and construction techniques that are used to make cables for various high performance applications.

Many cables have specific electrical and operational specifications that place limits on their mechanical construction. The use of a specific connector type typically places restrictions on the size of the cable. The required frequency range of operation and maximum insertion loss will also limit the choice of cable size and type.

Once these practical factors are considered, the term *high performance* in coaxial cables and cable assemblies typically means stable, predictable electrical performance under mechanical and environmental conditions that exceed those found in typical laboratory or user facilities. These conditions may include:

- Repeated mating/unmating cycles, as in test systems, or for regular maintenance
- Repeated flexing, or small-radius bends
- Mechanical abuse, such as abrasion, vibration, crush pressure or pulling force
- Other mechanical forces, perhaps for trenching or for pulling through conduit

High performance cables rely on quality materials and construction methods to maintain RF, mechanical and environmental performance under demanding conditions. ***Photo: W. L. Gore & Associates***

- Operation at extreme temperatures, pressures or vacuum, as might be found in space applications and some industrial processes
- Exposure to chemicals or radiation that are capable of degrading many materials

In addition to these typical factors, special requirements may be specified for such things as flammability, outgassing or high voltage breakdown.

Achieving the required performance requires the right materials and construction. For example, maximum shielding effectiveness will require a double shield, perhaps with one layer being a flat conductor to reduce the cable diameter. High flexibility requires attention to all components: inner conductor, dielectric material, shield and jacket.

The cable jacket and dielectric are non-metallic and are often the key to overall mechanical and environmental performance. A recent publication on cable performance [1] provides a valuable comparison of materials commonly used in coaxial cables. Tables 1-4 from that reference list the advantages and disadvantages of four types of materials. This side-by-side comparison should clarify the range of choices available, particularly for selecting the proper cable jacket type.

In [1] an additional table lists the additional advantages that can be had using engineered fluoropolymers, including enhanced flexibility and strength, as well as improved resistance to the various environmental conditions.

An important high performance application is phased array antenna systems, which require multiple cables with performance that tracks over temperature and time. This type of performance adds the requirement for superior consistency, which can be achieved with tight manufacturing tolerances and uniform, repeatable material characteristics.

	Advantages	Disadvantages
Electrical	Dielectric constant	
Mechanical	Flexible at low temperatures	Low cut-through resistance
	High coefficient of friction	
	High specific gravity	
Environmental	Radiation resistance to 108 RADs	Outgases silicone oil
	Tacky texture	Low resistance to oil
Application-Specific	Low-profile packaging	Weight
		Thick insulation needed, leading to large outer diameter

Table 1 · Properties of silicone (1).

	Advantages	Disadvantages
Electrical	Overall electrical performance	Dielectric withstanding voltage
Mechanical	Cut-through resistance	Tacky in high-flexibility grades
	Abrasion resistance	
	Flexibility	
	Flame treatment doesn't reduce flexibility	
Environmental	Solvent resistance	Temperature resistance
	UV resistance	Contaminant resistance
	Radiation resistance	
	Fungus resistance	
	Halogen-free	
Application-Specific	Primarily used for jacketing	

Table 2 · Properties of polyurethane (1).

	Advantages	Disadvantages
Electrical	Dielectric constant	
Mechanical	Abrasion resistance	Stiff in abrasion-resistant grades
	Wide range of grades	
Environmental	Chemical resistance	Temperature resistance
	Coefficient of friction	Adhesion
	Radiation resistance	Flame retardance
Application-Specific	Used for conductors and jacketing	Flexibility

Table 3 · Properties of polyethylene (1).

	Advantages	Disadvantages
Electrical	Dielectric constant	
Mechanical	Flexibility	Abrasion and cut-through resistance
	Tensile strength	
Environmental	Liquid and gas resistance	Radiation resistance
	Temperature resistance	
	UV resistance	
	No outgassing	
	Coefficient of friction	
Application-Specific	Used as dielectric and jacketing	Additional processing required
	Flame resistance	
	Performance standards	

Table 4 · Properties of fluoropolymers (1).

Testing Assures High Performance

Perhaps the most important part of a high performance cable specification is the requirement for a manufacturer to verify compliance through testing. The test methodology and rigor will also provide insight into the manfacturer's commitment to product quality.

Investment in test fixturing for mechanical testing (pull, crush, flex, shock, vibration etc.) and for environmental testing (temperature, chemical resistance, corrosion, UV and ionizing radiation, etc.) represents a significant investment. Reputable companies recognize that such an investment is necessary. And the best companies usually have exceptional test methods along with the proper test facilities. Such capabilities assure that customer performance specs are met, and provide quality assurance for standard products.

References

1. "Impact of Materials on Microwave Cable Performance," W.L. Gore & Associates, white paper published June 2011.

2. G. Breed, "Notes on the Selection Criteria for Coaxial Cable," *High Frequency Electronics*, Sep. 2010.

We recommend that readers review the technical resources available from cable manufacturers and vendors.