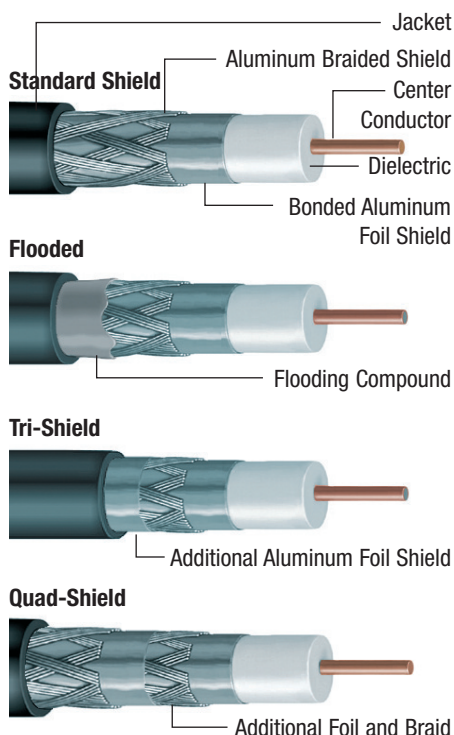


COAX 101

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Structured cable systems have very thorough standards for fiber optic and twisted pair installations. The cabling components and installed systems have test requirements spelled out clearly so that end users have assurance that the installation meets industry requirements. Test tools are readily available and user friendly. Unfortunately, for coaxial installations the standards are not as comprehensive, particularly for field-testing. TIA/EIA 570 "Residential Cabling" specifies that RG6 type coaxial cable be used and that the cabling components meet Society of Cable Television Engineers (SCTE) standards. There are not field testing requirements spelled out so the end user is dependant on the contractor's selection of connectors, cable and installation practices. From what CommScope has observed during random testing of competitive products there are large amounts of deficient materials used and not detected due to limited field-testing.



CONSTRUCTION BASICS

Coaxial cable consists of a center conductor surrounded by a dielectric core material. The dielectric core separates the center conductor from the outer conductor.

Ideally, the center conductor and outer conductor are perfectly concentric. A protective jacket is extruded over the outer conductor. The center conductor is made of copper, copper clad steel (CCS) or copper clad aluminum (CCA). Most flexible coaxial cables use bare copper or CCS. CCA is used on larger semi rigid cables such as CommScope P3 or QR products. Clad metals are used because at higher frequencies the signal is almost totally transmitted in the outer skin of the center conductor. CCS provides higher strength than copper at a lower cost. CCA is much lighter in weight than copper and has better conductivity than steel. This is why it is the material of choice for larger cables.

The dielectric material must have low loss characteristics and is manufactured from polyethylene, or for plenum applications, a low loss fluoropolymer such as FEP, PTFE or PFA. Typically it is a foamed, cellular construction, which improves electrical properties and reduces the size and cost of the cable.

The outer conductor provides electrical shielding for the cable. The shield construction depends upon the frequency range, mechanical requirements and required shielding for the application. For most products used in a structured cabling environment, a combination of shielding tape and braid is used. If optimum shielding is desired, for example in a high noise environment, a quad shield consisting of two tapes and two braids may be deployed. The braid may be aluminum or tinned copper. Tinned copper is more costly but provides slightly better shielding and lower resistance than aluminum, particularly at lower frequencies. For low frequency baseband applications such as for security cameras a copper braid alone may suffice. Figure 1 shows some typical cable configurations.

CABLE REQUIREMENTS

Coaxial cable is subject to many of the same requirements as twisted pair. Attenuation, Impedance, Return Loss, Capacitance and DC Resistance (DCR) all specified. In addition, since coaxial cable is by definition shielded it is subject to specifications for minimum braid coverage and shielding tape thickness. Bonding of the center conductor and tape to the dielectric are important for optimum electrical performance and ease of connectorization.

SCTE specifications for flexible coaxial cable are listed in Chart A. construction of the cable and the size of the cable. To significantly lower attenuation in a coaxial cable, it is necessary to increase the size of the product. If two cables are an equivalent size and construction, the cable with the higher impedance will have the lower attenuation. Assuming size and cable impedance are equivalent, the other key factor is the dielectric material used in the core. The dissipation factor, proportional to the amount of heat generated by signals traveling through the cable, is a key parameter. Adding air to the dielectric material via "foaming" improves the dissipation factor and the attenuation. This is particularly true at higher frequencies. Additives such as flameretardants typically increase the dissipation factor and therefore the attenuation of the cable. Listed below is the formula for attenuation in a coaxial cable.

$$\text{Attenuation}(\alpha) = C_1 \frac{\sqrt{\rho_i f}}{d_i} + C_2 \frac{\sqrt{\rho_o f}}{d_o} + C_3 \frac{d k f}{\log \frac{d_o}{d_i}}$$

ρ_i = resistivity of center conductor
 C = constant
 ρ_o = resistivity of outer conductor
 d = dissipation factor of core
 f = frequency (MHz)
 k = dielectric constant of core
 d_i = diameter of inner conductor
 d_o = diameter of outer conductor

Chart A: SCTE Specifications

	DOCC	DOC	DIMENSIONS		DOJ
			TAPE Min.	TAPE Max.	
Series F6	.0418"	.180"	0.0019"	0.0032"	.273 +/- .008"
Series F11	.0634"	.280"	0.0019"	0.0032"	.400 +/- .010"

	ELECTRICAL REQUIREMENTS				Impedance
	Attenuation (Max) dB/100'			SRL	
	55 MHz	500 MHz	1000 MHz	5-1000 MHz	
Series F6	1.60	4.84	7.00	-20 dB	75 +/- 3Ω
Series F11	1.03	3.19	4.67	-20dB	75 +/- 3Ω

Return Loss (RL) is a measure of how much signal is reflected back to the source relative to the initial signal strength. It is typically expressed in terms of dB's. Since these are negative values, 35 dB is better than 15 dB. RL loss is typically reported as a worst case over a frequency band. RL is essentially a measurement of the impedance variations over the length of a cable. These variations can be random or in the worst case periodic, causing large reflections in a narrow frequency band. The formula for impedance is listed below.

$$Z = \frac{138.2}{\sqrt{k}} \left[\log \left(\frac{do}{di} \right) \right]$$

Z = impedance(ohms)
k = dielectric constant
do = diameter of outer conductor
di = diameter of center conductor

diameter, dielectric properties of the core or outer conductor size will affect impedance. It is a very challenging task for a manufacturer to provide consistently good return loss values over wide frequency bands. SCTE specifies a bandwidth of 5-1000 MHz. By comparison the specification for Category 6 UTP cable only extends to 250 MHz and the latest Cat 6A cabling 500 MHz. To supply consistent RL values CommScope combines process control technology with high levels of Quality Assurance testing. On line Fast Fourier analysis compares events in the time and frequency domain to make sure nothing in the extrusion process is causing periodicities in dimensions or capacitance that can cause RL peaks. The braiding process is carefully monitored to ensure even tape application and braid uniformity. During the jacketing process

conditions are controlled to optimize shielding tape bonding. Quality Assurance monitors the statistical performance of test reels to ensure quality is built into every reel. Listed below is the performance of competitive plenum products and CommScope cable selected at random. As you can see in Chart B the competition leaves something to be desired. Poor RL performance can cause problems with a video signal, potentially causing the total loss of a picture in the case of digital transmission.

SHIELDING

Shielding is critical to the performance of a coaxial cable. RF shielding effectiveness is a measure of how well Radio Frequency (RF) energy is blocked from entering or exiting a device. It is expressed in decibels (dB). Without proper shield construction noise ingress can seriously degrade the signal transmitted in the cable. Egress from the cable can interfere with other nearby signals or electrical components as well.

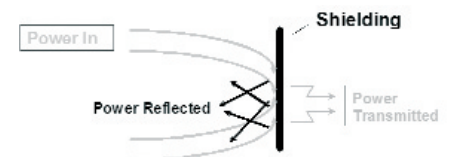


Chart B: Plenum RG6 Comparison

Product	DOD	DOJ	Impedance (Ω)	RL (dB)	Attn @ 1,000 MHz
CommScope 2275V	.172"	.239"	75.9	25.6	7.34
Company A	.163"	.233"	76.6	13.1	7.75
Company B	.172"	.239"	77.4	14.2	7.66
Company C	.171"	.241"	81.2	12.5	7.50
Company D	.172"	.237"	74.3	17.2	7.75

all electrical values tested from 5-1000 MHz

Factors influencing the shielding effectiveness of a flexible coaxial cable include the braid coverage, tape thickness and material, and the number of shields utilized in the cable.

Standard constructions include single tape and braid (standard), two tapes and braid (trishield), and two tapes and two braids (quad shield).

The robustness of a shield's construction is measured by subjecting the cable to a 10,000 cycle flex test and comparing the before and after shielding effectiveness. Chart C shows the shielding effectiveness results measured in CommScope's GTEM chamber.

As you can see from the results of the flex testing analysis there are significant performance differences between vendors. At first glance the impostors may look like CommScope cable but they aren't engineered to deliver the same shielding levels, for the life of the installation. Corrosion will negatively affect shielding effectiveness. For outdoor applications a flooding compound or dry anti-corrosion package such as BrightWire should be used.

Chart C: Shielding Effectiveness

Product	Shield Construction	Shielding Effectiveness (dB)	
		Before Flex	After 10k Cycles
CommScope	Foil + 60% Al Braid	108	72
CommScope	2 Foil + 40/60% Al Braid	115	85
Company A	Foil + 55% Al Braid	103	46
Company B	2 Foil + 56% Al Braid	109	60
Company C	2 Foil + 75% Al Braid	108	72

JACKET CONSTRUCTION

The cable jacket is designed to match the application. Poly Vinyl Chloride (PVC) is typically used for indoor and, with additional UV stabilizers, some outdoor applications. It is naturally flame retardant and with additional flame retardant additives can be made to conform to CMR, riser ratings. If FEP core material is used it is possible to meet CMP, plenum, requirements. Fluoropolymer jackets such as PVDF or FEP may also be used for certain plenum cable constructions. Polyethylene is used for many outdoor applications as it provides the best combination of low cost, UV resistance and toughness.

As we saw with the shield construction, there are differences in material performance. After temperature aging many jacket compounds lose significant elongation capability and are more prone to cracking. CommScope carefully selects materials and through thorough qualification insures long-term reliability. Proper dimensions are also critical for proper termination. The jacket and core dimensions must be within tolerances or the connector will not stay on properly. Connector pull off testing gives a good indication of proper dimensions and braid construction. Some plenum cables in particular are built undersized to save on expensive FEP core material. Higher braid coverage will typically provide better connector pullout performance as well.

CONCLUSION

CommScope is the largest producer of coaxial cable in the world. The technology we have developed over the past 25 years gives us a significant advantage in the production of product that is of consistently superior quality. While other cables may look similar, the similarity is only skin deep. The cable's performance will typically not measure up to its appearance.

Before making a purchase decision make sure that key electrical parameters such as attenuation, impedance tolerance and RL are specified and backed up by the manufacturer. Shielding characteristics should be clearly specified. In some cases excessive RF leakage will cause problems with broadband service activation due to Cumulative Leakage Index (CLI) requirements. If the cable is to be used outdoors a UV stabilized jacket and anti-corrosion construction should be used. A few extra dollars spent on a quality product today will ensure many years of trouble free performance. Think CommScope for your coaxial cable requirements.

