CommScope Smooth-Wall Transmission Line System Survives Extreme Testing Without Secondary Waterproofing

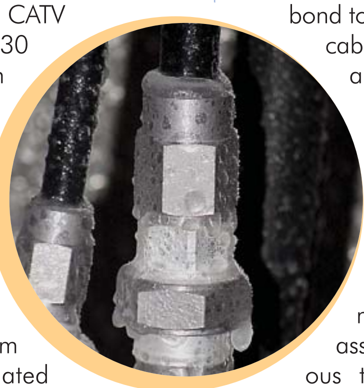
Over the last seven years, the wireless industry has installed over 24 million feet of CommScope smooth-wall cable, including more than 2 million connectors. Many of the locations are in the harshest climates in the world. Yet, not a single cable or connection has failed when installed properly. This fact has led many in the industry to wonder just what it would take to push the smooth-wall cable to the breaking point.

In 2004, a major infrastructure vendor challenged CommScope engineers to subject their smooth-wall cable assembly to the most extreme environmental tests ever developed. The battery of tests, devised by a joint team of OEM and CommScope engineers, included the following extreme testing: extreme thermal cycling and icing, monsoon-like rainfall and thermal stress cycling with the cable assembly having a damaged outer jacket.

During the tests, every effort was made, every measure taken, to force the smooth-wall cable assembly to fail. In the end, however, the tests failed to push the CommScope Transmission System to the breaking point.

New Smooth-Wall Technology Makes A Big Impression

In 1998, CommScope Wireless introduced a smooth-wall coaxial cable assembly into the wireless market. Similar cable and connector assemblies have been used in the CATV industry for more than 30 years and deployed in over 90% of the broadband networks throughout the world. For wireless transmission line applications, however, the smooth wall cable was seen as a radical departure from the standard corrugated copper assemblies typically used in the wireless industry.



The cable itself features a triple-bonded configuration in which a solid center conductor is physically bonded to a closed cell foam dielectric. The dielectric, in turn, is bonded to a smooth, outer conductor. The outer conductor shares a physical bond to the polyethylene sheath. The cable is manufactured with either aluminum or copper outer conductors.

The smooth-wall, non-corrugated structure also enables more accurate and consistent termination. As a result, CommScope engineers claim that the entire assemblies are virtually impervious to environmental conditions such as water migration, humidity, and thermal cycling.

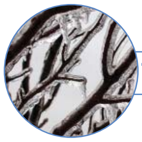
Prior to its introduction the CommScope smooth-wall cable assemblies easily passed the standard battery of industry-accepted tests such as IEC's IP68. More important, however, is the product's performance in the field. In the last seven years, the wireless industry has installed more than 24 million feet of the CommScope smooth wall cable and connector assemblies. CommScope Transmission Line Systems are located in many of the most severe environmental conditions throughout the world. In that time, not a single assembly has failed when installed properly.

When compared to similar corrugated assemblies, whose failure rates reach as high as 25%, the performance and reliability of the CommScope smooth wall cable assemblies is an anomaly. (For details, see article CommScope® *Smooth-Wall Replacing Corrugated As Cable Of Choice)*

Challenging the Results

In 2004, CommScope presented its smooth-wall cable technology to engineers of a prominent wireless infrastructure vendor. After several presentations during which test data and anecdotal evidence were presented, the vendor's engineers remained skeptical that any cable assembly could be as durable as the field and lab results indicated. When asked what it would take to convince them, the engineers suggested a series of tests designed to go beyond the most extreme environmental conditions and find a weakness that traditional testing would not expose.

The test development team consisted of engineers from the vendor and CommScope. The team decided to test CommScope's smooth-wall 50-ohm aluminum-based cable; thereby challenging CommScope's claim that aluminum is as effective as the industry standard copper-based cable. Other decisions, as described in this paper, were also made in an attempt to stack the odds against the success of the CommScope cable assembly. The tests were conducted at CommScope's facilities and the vendor had unrestricted access to all phases of the tests and the resulting data.



Test #1: Extreme Thermal Cycling and Icing

The most extensive and heavily controlled test involved prolonged and extreme thermal cycling in addition to heavy icing. The tests involved four groups of 24 CommScope FXL aluminum smooth-wall cable assemblies. Each assembly consisted of a 2-foot section of 50-ohm main line transmission cable connected on either end to two 2-foot long jumper cables. The free ends of the jumper cables were then terminated and fitted with connectors and connected to the test equipment.

The preparation of the samples, however, did not take place in the lab under ideal conditions. In an attempt to duplicate extreme environmental conditions, the technicians were required to prepare the cable ends and connect the assemblies in a thermal chamber where temperatures were held steady at -30°C (-22°F). Even with heavy gloves and appropriate clothing, the maximum length of time an individual technician could endure such conditions was 10 to 15 minutes. During that time, each technician prepared and connected eight cable assemblies.

To further induce failure, the test team prepared the assemblies without the benefit of any secondary waterproofing. While this is contrary to standard industry practice, vendor engineers were eager to challenge CommScope's claim that, when prepared and connected properly, the smooth-wall cable assembly requires no secondary waterproofing.

Once connected, the assemblies were allowed to return to room temperature. After the temperature had stabilized at 20°C (68°F), each assembly was tested for Return Loss and DTF (Distance to Fault). (See diagram 1)

Diagram 1 Side-by-side comparison of pre-and-post test analysis

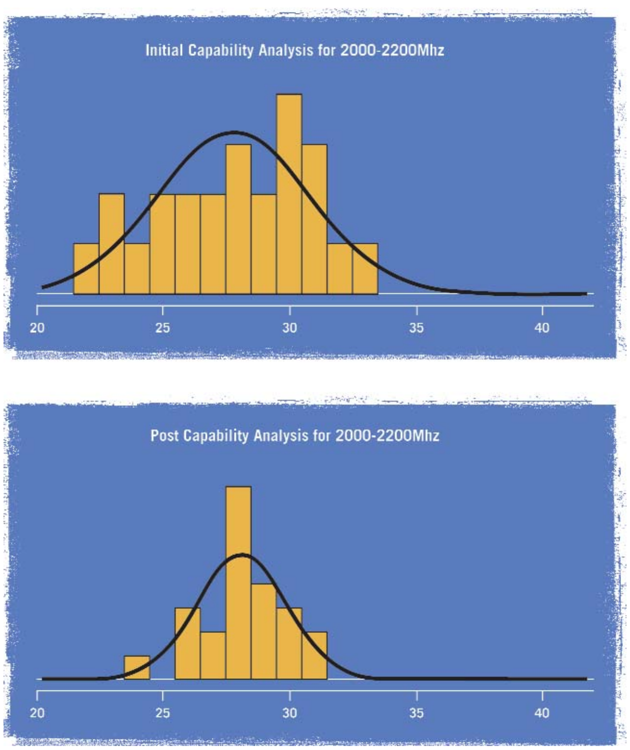
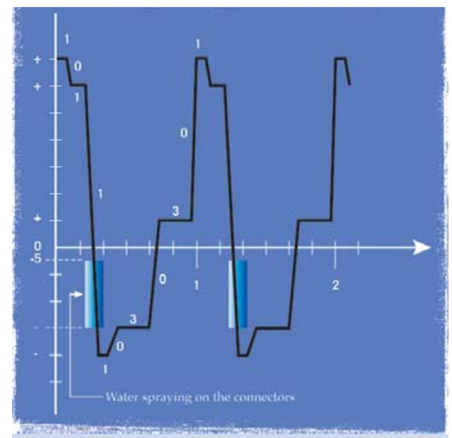
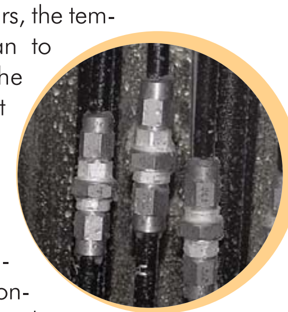


Diagram 2 Thermocycling profile



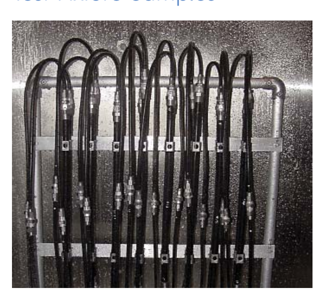
After benchmarking, the 24 samples were returned to the thermal chamber and subjected to prolonged extreme thermal cycling (See diagram 2). Each cycle ranged from -40°C (-40°F) to 60°C (140°F) and lasted approximately 12 hours. During the cycle, the temperature was held at the highest and lowest point for sixty minutes.

As the temperature passed from -5°C (23°F) to -40°C (-40°F) during each cooling cycle technicians entered the chamber to spray a cold water mist directly onto the cable-connector assembly. Numerous cold-water mist applications were made during each cycle in an attempt to build up an ice coating of at least 1/16 inch (1.6mm) thick. The ice layer remained for three hours as the temperature rose slightly to -30°C (-22°F). After three hours, the temperature began to rise past the freezing point and the water had a chance to migrate into any openings within the cable-connector interface that may have formed during the severe thermal contraction and expansion. The chamber was also programmed so that the temperature rose and fell rapidly in order to apply as much stress on the cable-connector assemblies as possible.



After 28 continuous cycles lasting 336 hours, the test was completed.

Test Fixture Samples

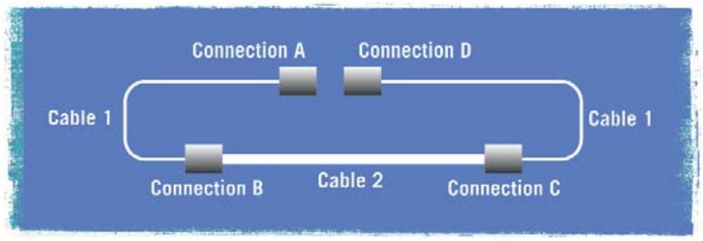


Test #1 Results:

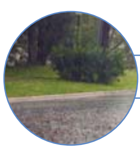
At the completion of the final cycle of environmental tests, each assembly was tested once again for Return Loss and DTF (Distance to Fault).
(See Diagram 1)
Of the 138 individual cable/connector assemblies (four groups of 24 samples), only one assembly showed signs of degradation. When studying this assembly, only one failed connector was found. The failed connection involved a 3/8-inch connector, the smallest size used in the tests. Closer analysis of the failed connector assembly revealed a damaged o-ring caused when a technician, working with heavy, bulky gloves in sub-zero temperatures, failed to connect the assembly properly. Considering the extreme conditions, the fact that only one assembly failed speaks not only to the integrity of the technology but to the ease and simplicity of the installation.

An example of the sample schematic is illustrated in Diagram 3.

Diagram 3 Sample schematic and description



Sample #	Connection A	Cable 1	Connection B	Cable 2	Connection C	Cable 3	Connection D
1	540ADM	FXL540	1070540ATSBN	FXL1070	1070540ATSBN	FXL540	540ADF
2	540ADM	FXL540	1070ADF/540ADM	FXL1070	1070ADF/540ADM	FXL540	540ADF
3	SFXADM	SFX500	1070ADF/SFXADM	CR1070	1070ADF/SFXADM	SFX500	SFXADF
4	SFXADM	SFX500	1070ADF/SFXADM	FXL1070	1070ADF/SFXADM	SFX500	SFXADF



Test #2: Extreme Rain Simulation

The second test involved subjecting the assemblies to monsoon-like conditions that prevail in many parts of the world. With water migration as a major cause of transmission line failure, the vendor required that the test conditions far exceed anything that may occur in temperate regions.

Technicians prepared 96 individual cable/connector assemblies (eight groups of 4 samples) identical to those used in the extreme thermal cycling and icing tests. The assemblies were prepared in a thermal chamber at -15°C (5°F). To encourage failure, no secondary waterproofing was applied to any sample. In one-third of these samples, each connector was hand-tightened only. While installation guidelines require wrenches for final tightening, installers may overlook tool tightening in the field. The test team wanted to know what the outcome might be if connectors were only hand-tightened.

The test team conducted pre-test benchmarking as before. The samples were then placed in the test chamber where multiple showerheads were situated a few inches away from the assemblies and aimed directly on the cable-connector junction. Water spray from the showerheads exposed the cable-connector assemblies to the equivalent of 27 inches of rain.

The samples were then immediately subjected to thermal cycling during which temperatures ranged from -20°C (-4°F) to 27°C (80.6°F). When the temperature dropped to the freezing point, the samples were sprayed with a cold-water mist to build an ice layer. As the ice melted, the water had the opportunity to migrate into any gaps between the cable-connector interface that may have developed. Each cycle lasted 6 hours. The test concluded at the end of 8 cycles; at which time, the assemblies underwent post-test electrical analysis.

Text #2 Results:

Of the 32 individual cable-connector assemblies in the eight test samples, not a single connection failed.

Test 3: Extreme Thermal Stress Cycling:

A key to a transmission cable's durability and value is how it performs if the protective polyethylene jacket is abraded, cut or torn. The inherent design of corrugated copper cable allows gaps between the outer conductor and polyethylene jacket that encourage water migration and ultimately leads to failure. This final test was designed to challenge CommScope's assertion that the adhesive bond between the jacket and the outer conductor protects the smooth-wall cable from water migration if the outer jacket is damaged or torn. Prior to the test 10 aluminum cable-connector assemblies were prepared as before at room temperature. Each assembly was electrically tested for return loss and passive inter-modulation.

Removed portion of cables polyethylene jacket.

After benchmarking, technicians removed a portion of the cable's polyethylene jacket, directly behind the connector, from five of the samples. All ten samples were then placed in the thermal chamber where the relative humidity was raised to 80%. The samples were thermal cycled from -40°C (-40°F) to 50°C (122°F). Each cycle lasted two hours with this portion of the test involving six cycles.

After the first phase of thermal cycling, the ten samples with the damaged polyethylene jacket were removed from the thermal chamber and subjected to IP68 water immersion testing for 24-hours.

The ten samples were removed from the water, dried then re-tested for return loss and passive intermodulation.

Text #3 Results:

Of the ten samples, consisting of 20 connector/cable interfaces, not one showed signs of electrical degradation.

Conclusion:

In the field, it is unlikely that a wireless transmission cable system will be subjected to the extreme environmental conditions and installation hardships experienced by the CommScope System during these tests. The value of such tests is what they show in terms of the robust quality and reliability of the smooth-wall cable system.

Under extreme environmental conditions, the CommScope cable and connector system has demonstrated, to the satisfaction of one of its most demanding customers, the ability to support the long-term reliability needs of today's wireless networks. Additionally, these tests prove that the CommScope System is reliable even without the benefit of secondary weatherproofing.

This type of evidence further substantiates CommScope's belief that the smooth-wall cable and connector design indeed delivers the lowest life cycle cost in the industry.

TL 9000

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CommScope is committed to Manufacturing Excellence in all aspects of its operations. Our policy is to design, manufacture and deliver products and services which conform to specifications and satisfy customer requirements and expectations in every way.

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