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Applications
Engineering Note

Loose Tube Cable vs. Tight Buffered Cable in Outdoor Applications

AEN 26, Revision: 9

Optical cables are designed to protect the optical fibers from damage due to the rigors of installation and from the demands of the surrounding environment. No single optical cable design is universally superior in all applications, however. In order to meet the application-specific requirements, outside plant (outdoor), indoor/outdoor cables, and inside plant (indoor) cables are designed for their intended installation environment. The consequences of optimizing a cable design for outdoor use can prove counterproductive to meeting the requirements for indoor placement and vice versa. For example, the most popular cable jacket material for outdoor use will not pass flame resistance tests required for placement indoors. In general, optical fiber cables installed in an outdoor environment are exposed to more severe mechanical and environmental conditions than are experienced in the protected, climate-controlled, indoor environment. Outdoor installations (usually lashed aerially, pulled through duct, or direct buried in the ground) are subjected to combinations of ultraviolet (UV) radiation, standing water, cable-gnawing rodents, temperature extremes and other outdoor-specific hazards. Outdoor loose tube optical cable designs and indoor/outdoor optical cable designs are optimized for outside plant applications. Specific considerations for outside plant applications, with respect to the selection of cable designs (loose tube vs. tight buffered), will now be considered.

Performance at Extreme Temperatures

The major constituents of an optical cable structure are silica glass and polymeric plastics. For a given temperature change, the rate/magnitude of material expansion and contraction will be different because each material possesses a different coefficient of thermal expansion. The loose tube cable establishes a strain-free environment for the optical fiber by mitigating the influences of this effect. Loose tube cable manufacturing processes ensure that the optical fiber to buffer tube length ratio is controlled such that no optical fiber is compressed against the tube wall when the tubes expands or contracts with changes in temperature. The strain-free environment established in the loose tube cable design compensates for movement in the cable structure without inducing mechanical forces on the fiber. This characteristic enhances the operating temperature range of the loose tube design. Tight-buffered cables are typically more sensitive to temperature extremes and mechanical disturbances than are loose tube cables.

Protection from Ice Crush Effects (Water-blocking Requirement)

Ice crush hazards affect optical cables in locations where standing water and freezing temperatures coexist. In a confined space, significant tensile and compressive forces can be

Published: 04/16/15

generated from the expansion of water as it transitions to a solid state under cold conditions. In optical fiber cable applications, this effect can occur in water-filled outdoor conduits or within the cable core itself. Both loose tube and tight-buffered cable structures are designed to withstand compressive forces applied from outside the cable jacket, but forces applied directly inside the cable core can degrade performance. Water migration inside the cables outer jacket can result in the formation of ice crystals within the optical fiber cable core. The ice will impart stresses in close proximity to the optical fibers and may result in an unacceptable increase in attenuation or even fiber breakage. Therefore, it is essential to prevent the intrusion and uncontrolled movement of water inside the cable.

A loose tube cable is designed to provide maximum protection against water penetration and water migration by utilizing intrusion preventative measures in both the cable core and the buffer tubes. Water-blocking protection of the cable core is accomplished by surrounding it with a dry water-swellable tape and yarns, powder, or with a gel, to stop the entry and migration of water should the cable's outer jacket be breached. This protective measure is included primarily to maintain the mechanical integrity of the cable itself, (e.g. prevent ice crush from within the cable, fungus growth, or corrosive metallic cable members when present). The water-blocking protection, water-swellable yarn, powder, or gel, is placed in the buffer tubes with the optical fiber during manufacture of the cable.

Standard tight-buffered cables may not have water-blocking protection, making them susceptible to damage caused by water penetration and migration. Even if the core were to be water-blocked, no plastic material is impervious to water, and a tight-buffer material alone cannot permanently isolate an optical fiber from the influence of moisture. If water penetrates the cable jacket and buffer material, the individual tight-buffered fibers will be subjected to increased attenuation or damage due to microbending, as freezing operating temperatures can cause water molecules to crystallize along the optical fibers surface.

Mechanical Protection

As stated previously, loose tube cables establish a strain-free environment for the optical fiber by mitigating the influences of external effects. In addition to the benefit provided at extreme temperatures, this attribute also enhances the performance of the loose tube cable design under a variety of mechanical forces. Installation practices and installed system conditions can subject the cable to tensile, flexure, twisting, crush, impact and bending forces. By isolating the fiber from these external forces, the loose tube design ensures maximum cable life in an outdoor environment.

UV Protection

The optical fiber cable must also be able to withstand direct exposure to ultraviolet sunlight in aerial installations. In the outdoor environment, light, heat and moisture combine to cause optical, mechanical and chemical changes in materials. The first line of protection of any optical fiber cable is the cable outer jacket. Carbon black, which is compounded into the jacket material to provide maximum ultraviolet protection, is the best defense against ultraviolet degradation. Standard indoor tight-buffered cables use a colored outer jacket material, which does not contain carbon black and should therefore not be used in

Published: 04/16/15

applications that involve exposure to direct sunlight. Cables labeled as indoor/outdoor, or outdoor will contain the carbon black compound for UV protection.

Standards

The predominant users of outside plant cable continue to specify loose tube cables in outdoor environments. Loose tube cables must pass rigorous mechanical, environmental and optical tests in accordance with accepted Electronic Industries Association/Telecommunications Industry Association (EIA/TIA) fiber optic test procedures (FOTPs). The American National Standards Institute/Telecommunications Industry Association/Electronic Industry Alliance – Commercial Building Telecommunications Cabling Standard Part 3 (ANSI/TIA/EIA–568–B.3). Optical Fiber Cabling Components Standard recognizes that the outside environment is much more demanding on the cable than typical indoor environments. Therefore, ANSI/TIA/EIA-568-B.3, Section 4.32 states that outside plant optical fiber cable shall comply with the mechanical, environmental and water penetration requirements of ANSI/ICEA S-87-640, “Standard for Optical Fiber Outside Plant Communications Cable.” Corning Optical Communications’ loose tube cables meet the stringent requirements of the Insulated Cable Engineers Association (ICEA) Standard. Section 3.1 of this standard states that it does not address tight-buffered cable, but tight-buffered cable criteria can be found in ANSI/ICEA S-83-596, “Standard for Fiber Optic Premises Distribution Cable.” Corning Optical Communications manufactures loose tube cables which are accepted products of the United States Department of Agriculture and Rural Utilities Service (RUS) as meeting the requirement of 7 CFR 1755.900 (PE-90).

ICEA S-104-696, “Standard for Indoor – Outdoor Optical cables” was developed to address the need for an inter-building and/or intra-building cable. These cables can be loose tube or tight-buffered for the ease of termination such as premises cable, but must offer the tensile strength, water blocking protection, and UV protection of an outside plant cable. These inter/intrabuilding cables are typically used for short runs to connect to another building and some limited premises applications. Corning Optical Communications indoor/outdoor cables protect the optical fiber from mechanical and environmental stresses by decoupling the fiber from the cable. Corning Optical Communications indoor/outdoor cables meet or exceed the requirements of ICEA 696.

Conclusion

The uses of tight-buffered cable in outdoor environments are limited when compared to the advantages of loose tube cable designs. Loose tube cables are specifically designed to perform in harsh outdoor environments with minimal performance degradation. This comparison is not intended to depreciate the proper uses of tight buffered cable in many applications, but to point out the advantages of loose tube cables in outdoor applications.

Published: 04/16/15

References:

1) United States Department of Agriculture, Rural Utilities Service, 7 CFR 1755.900, (formerly REA PE-90).

2) *Modern Plastics Encyclopedia*, Mid-October 1991, Volume 68, Number 11.

3) ICEA Standard for Optical Fiber Outside Plant Communications Cable, ANSI/ICEA S-87-640-XXXX.

Published: 04/16/15