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Applications Engineering Note

Optical Cables for Shallow Water Applications

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Applications

In addition to true submarine cables designed for deep-water, long-haul systems, Corning Cable Systems also offers a family of cables designed for short-length, shallow water applications, such as might be encountered when crossing small lakes, reservoirs, rivers or channels. These cables serve as an extension of those employed in terrestrial systems where the application necessitates crossing one or more shallow bodies of water, and where other options are not possible (i.e., bridge or utility line crossing) or are cost prohibitive. They are not intended for trans-oceanic links, island hopping, or coastal festooning. The cable design addressed herein is limited to water depths of no more than 300 feet.

The major difference between these cables and true submarine cable lies in the construction of the cable cores. Like their terrestrial counterparts, the core of shallow-water submarine cable typically consists of a standard, all-dielectric, stranded loose tube cable[1]. Conversely, traditional deep-water submarine cables employ a special hermetically sealed copper tube to protect the fibers from the effects of deep-water environments. Special submarine fiber may also be required depending on the specific application.

The biggest advantage of a shallow-water submarine cable design is that, aside from the armor casing, the core cable can be handled and used like the more familiar loose-tube terrestrial cable designs, because it is a standard terrestrial design. Therefore, the characteristics of the cable will be familiar to the craftspeople and the enclosed fibers can be accessed and terminated using standard tools and procedures, once the submarine armoring has been removed.

Construction

Around the core loose tube cable is a layer of helically stranded galvanized steel wires (see Figure 1); two layers are available as a dual-layer design for added protection. The purpose of the wires is to give the cable added mechanical performance in terms of tensile strength and durability, making the cable design much more resistant to the types of external forces found in the submarine environment. This is particularly important where such environments may include rocky terrain and/or other potential hazards such as boat anchors, dredges, trawlers, large pieces of debris, etc. In addition, the submarine armoring provides the overall density needed to prevent the cable from floating, or from drifting in low currents, when the cable is not buried in the sediment or soil. The entire armored cable is then covered with an outer serving yarn and an asphaltic compound to fill interstitial spaces and add negative buoyancy.

1) Refer to specification sheet, "ALTOS® All-Dielectric Cables, 2-288 Fibers," CLT-54, for additional information

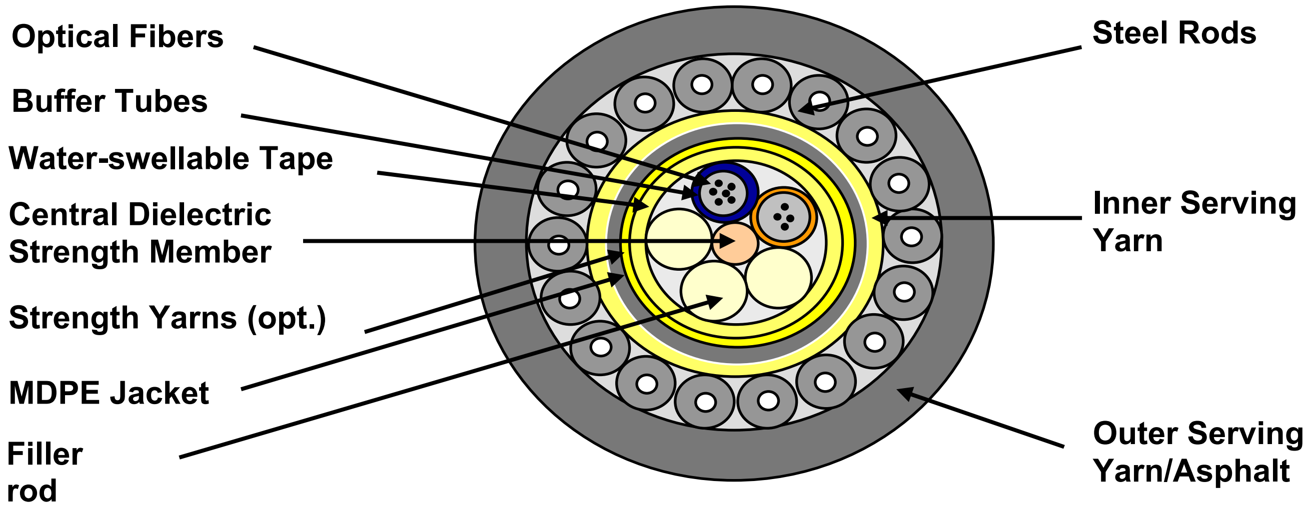

Figure 1: Typical Submarine Cable Cross Section – Single Armor

Hydrogen Effects

In addition to the significant external physical forces that may be encountered in a submarine environment, the other major concern is the effect of hydrogen on the performance of the optical fiber in cables used in such applications. The effect of hydrogen on fiber performance depends on specific system characteristics. System attributes such as fiber type, system operating wavelength, and cable design and installation method, all factor into the impact that hydrogen will have on a particular installation.

Chemical Hydrogen: Hydrogen can chemically react with dopants such as phosphorus to produce irreversible absorption peaks, resulting in a significant increase in the attenuation coefficient across various wavelength ranges. This phenomenon, also known as Type 1 hydrogen effect, occurred primarily in early optical fiber designs using a phosphorus dopant. Current fibers employing germania dopants are not susceptible to Type 1 hydrogen effects, as were early phosphorus fibers.

Interstitial Hydrogen: The second hydrogen effect arises from the propensity for molecular hydrogen to diffuse readily through most other materials. When diffused into glass optical fiber, hydrogen creates distinct absorption peaks at certain wavelengths. The most predominant of these occurs at 1240 nm and 1380 nm. The tails of these peaks may extend out, depending on the hydrogen concentration, affecting the optical performance at 1310 nm and 1550 nm. Unlike the Type 1 effect, the effect created by molecular hydrogen is reversible and is known as the Type 2 hydrogen effect.

While the major source of the hydrogen is a disputed topic, many sources of hydrogen can exist in a submarine environment. These include byproducts from the corrosion of the metal armoring, organic sources such as bacterium contained naturally in the water and sediment, and outgassing from certain cable materials. The major sources are typically understood to be the corrosion of the metal armoring and the presence of bacteria.

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Corning Cable Systems has developed guidelines to predict the possible attenuation increase for submarine cables, based on a worst-case 100% hydrogen environment. Because the concentration of hydrogen is a key factor the depth of the water the cable is in plays a significant role. As depth increases the partial pressure of hydrogen increases, resulting in an increase in the amount of interstitial hydrogen that can be present in the fiber.

Table 1 gives some examples of attenuation increases due to interstitial hydrogen based on various depths. The amount that the fiber attenuation may increase, above the baseline intrinsic fiber attenuation, is listed for several deployment depths. Therefore, the overall attenuation coefficient for the cabled fiber is the sum of the baseline attenuation coefficient of the cable and the attenuation increase due to Type 1 hydrogen effect.

SUBMARINE CABLE ATTENUATION INCREASES				
	MULTIMODE FIBER		SINGLE-MODE FIBER	
DEPTH (ft)	**850 nm**	**1300 nm**	**1310 nm**	**1550 nm**
30	0.30 dB/km	0.46 dB/km	0.30 dB/km	0.9 dB/km
100	1.0 dB/km	1.52 dB/km	1.0 dB/km	3.0 dB/km
300	3.0 dB/km	4.56 dB/km	3.0 dB/km	9.0 dB/km

Table 1: Possible Attenuation Increase at various deployment depths

Note that the table indicates worst-case attenuation increases that may be observed in the installed submarine cable. Actual increases experienced will typically be less than those listed. Even then, these guidelines only apply to the section of the cable that is submerged, which is typically a relatively small portion of an entire system. However, by estimating a worst case value, a system can be properly designed to ensure satisfactory performance for the intended lifetime.

Additional information on hydrogen effects can be found in the following.:

W.T. Anderson, A.J. Johnson, J.P. Kilmer, and R.M. Kanen, *Hydrogen Gas Effects on Installed Submarine Single-Mode Fiber Cables,* Proceedings of the Thirty-Seventh International Wire and Cable Symposium, pp 188-199.

W.T. Anderson, A.J. Johnson, and A. DeVito, *Field Measurements of the Effects of Hydrogen Gas on Installed Submarine Single-Mode Fiber Cables*, Proceedings of the Thirty-Eighth International Wire and Cable Symposium, pp 675-683.

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