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Applications Engineering Note

Optical Cables for Shallow Water Applications

AEN 2, Revision: 7

Applications

This Applications Engineering Note (AE Note) addresses deployment considerations for Marinized Terrestrial Cables (MTCs). MTCs are used for short-length, shallow-water crossings where other options are impractical, e.g. bridge or overhead line crossings. These cables are not suitable for trans-oceanic links, island hopping, or coastal festooning. Further, Corning Optical Communications' recommends limiting their deployment to water depths of no more than 300 feet.

MTCs differ from true submarine cables in core construction. They are typically built around standard loose tube cables (but may use other terrestrial designs). Submarine cables, however, are built around hermetically sealed cores to protect fibers from the drastic and permanent effects of high pressure hydrogen diffusion. Further, submarine cables sometimes include specialty fibers for specific applications. MTC cores (i.e. the standard cable) can be handled and terminated by technicians experienced with standard field practices, once the submarine armor has been removed.

Construction

MTCs surround the core (loose tube cable) in one or two layers of helically stranded galvanized steel wires (Figure A). The wires increase cable tensile strength and durability as well as density (non-marinized terrestrial fiber optic cables typically float). The entire armored cable is typically covered with additional yarns and then covered in a jacket of asphaltic compound or polyolefin. These changes make the cable more suitable for marine environments, e.g. rocky cable landings, boat anchors, dredges, trawlers, large debris.

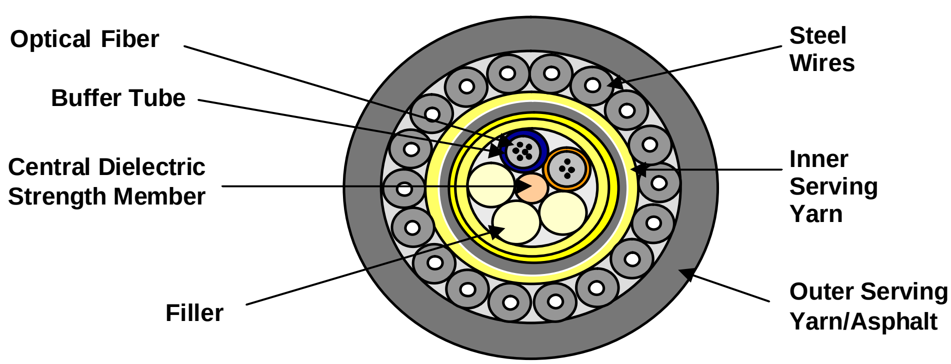

Figure A: Typical Submarine Cable Cross Section

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Published: 11/1/2016

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Hydrogen Effects

In addition to significant physical hazards in a submarine environment, hydrogen adversely affects submerged optical fiber cables. System attributes such as fiber type, system operating wavelength, and cable design as well as installation method all factor into the effects that hydrogen will have on a particular installation.

> Chemical Hydrogen: Hydrogen can chemically react with some dopants to produce irreversible attenuation increases across various wavelength ranges. This phenomenon, known as Type 1 hydrogen effect, occurred primarily in early optical fiber designs using a phosphorus dopant. Fibers employing germania core 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 sources of hydrogen vary, many are possible submarine environments. These most commonly include byproducts from the corrosion of the metal armoring and from bacterial decomposition of organic materials.

Corning Optical Communications' has developed guidelines to predict possible attenuation increases for underwater cables. Because the concentration of hydrogen is a key factor, the depth of water is significant. As depth increases the partial pressure of hydrogen increases, resulting in an increase in the amount of interstitial hydrogen that could be present in the fiber.

Table 1 gives examples of expected attenuation increases due to interstitial hydrogen. The overall attenuation for cabled fiber is the sum of the baseline attenuation these increases.

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

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Published: 11/1/2016

Note that the table indicates typical poor-case attenuation increases in the installed submarine cable. Actual increases experienced are typically 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.

Note that under rare circumstances, such as plowing in estuarine marshes, cables can sustain hydrogen concentrations considerably higher than predicted by water depth. This is often due to anaerobic decomposition of organic materials. In such circumstances, a local assessment of hydrogen concentrations should be undertaken prior to deploying MTC. If doubt exists, a true submarine (i.e. hermetically sealed) cable is a better choice.

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.

Published: 11/1/2016