Comparison of Low-Temperature Resistance and Performance of Special Optical Cables

Article Overview

Special optical cables exhibit varying low-temperature resistance and performance depending on fiber type, coating, buffer tube material, and filling compounds, with optimized designs significantly reducing optical loss and mechanical stress in extreme cold.

Low-Temperature Optical Loss

Studies on OPGW cables in extreme cold (-70? to -55?) show that optical fibers experience increased loss as temperature drops, particularly below -60?, though this loss is largely reversible upon warming . Among G.652 fibers, some types show abrupt loss increases during cooling, while others remain relatively stable, highlighting the importance of fiber selection for low-temperature applications . Ultra-low temperature-sensitivity cables using negative expansion coefficient materials like liquid crystal polymer (LCP) achieve temperature delay coefficients as low as -4.1 to 2.0 ps/km/?, offering an order-of-magnitude improvement over conventional fibers .

Mechanical Stability and Coating Effects

Mechanical reliability is influenced by buffer tube materials and coatings. Loose tube cables can suffer microbending due to axial shrinkage of buffer tubes at low temperatures, causing additional optical loss . Coatings such as acrylate or polyimide provide protection, but mismatched thermal expansion coefficients can induce microbends or cracks, increasing loss . Polyimide coatings are particularly effective in cryogenic environments, maintaining mechanical integrity and minimizing optical degradation .

Cable Design and Filling Compounds

The choice of filling compounds and cable structure significantly affects low-temperature performance. Gel-filled cables can experience higher loss in extreme cold, whereas hydrophobic or low-temperature-resistant optical greases improve performance . Optimized OPGW designs incorporate additional fiber length and stainless steel reinforcement to accommodate thermal contraction and reduce stress-induced loss . Armored cables like GYTA53 or dielectric ADSS variants provide mechanical protection and corrosion resistance, suitable for harsh outdoor conditions with large temperature fluctuations .

Practical Applications

o High-altitude and cold regions: OPGW lines in the Qinghai-Tibet Plateau operate reliably between -55? and +60? using low-temperature-resistant fibers and greases .

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o Cryogenic sensing and research: Polyimide-coated fibers maintain optical and mechanical performance down to 4 K, suitable for high-vacuum and cryogenic applications .
o Harsh outdoor environments: Armored and anti-corrosion cables resist mechanical stress, UV exposure, and chemical degradation while maintaining low optical loss .

Summary

The performance of special optical cables at low temperatures depends on a combination of fiber type, coating, buffer tube material, filling compounds, and cable design. Optimized solutions, such as ultra-low temperature-sensitivity fibers, polyimide coatings, and hydrophobic filling compounds, can minimize optical loss, maintain mechanical integrity, and ensure reliable operation in extreme cold, making them suitable for high-altitude, cryogenic, and harsh environmental applications .

After the temperature changes from low temperature to high temperature, the transmission loss of optical fiber

A series of service-affecting field failures in cold weather (-40°C to 0°C) initially and in more moderate conditions (up

This paper aims to provide a thorough comparison between optical and conventional thermal sensors, analyzing their performance

Learn the temperature limits of optical fiber (standard, high-temperature, low-temperature), how heat/cold affects

This chapter gives an overview and introduces application scenarios for optical fibers and cables in optical communications. The use

The conceptual assessment of the rating conditions of power cables was addressed over one century ago, with

Outdoor Fiber Optic Cables: Classification, Applications, and Technical Comparison Outdoor fiber optic cables are

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Comparison of Low-Temperature Resistance and Performance of Special Optical Cables

The analysis and computation are carried out in a main subject which is the thermal effects

The cable construction incorporates a variety of packaging technologies that allow for operation in

Explore how to select the right fiber optic cable for challenging environments including high temperatures, extreme

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The objective of this article is to examine the problems of reliability optical cable during construction and operation at

Some recent service-affecting field failures in cold weather raised concerns about the low- temperature performance of

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