Indoor-Outdoor Air Blown Optical Cable

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As network traffic increases, optical cables for connecting buildings in data center require more economical and efficient cable installation method, such as air-blown installation. We have successfully developed the 288-fiber Indoor-Outdoor Air Blown Optical Cable with two different flame-retardant grades for Europe and North America. Since this cable is applicable to both indoor and outdoor environments, this cable covers both indoor and outdoor areas by a piece of this cable. This cable complies with ICEA S-122-744 for mechanical characteristics and ICEA S-104-696 for environmental characteristics, having over 1000 Ft jetting characteristics.

1. Introduction

As network traffic increases and data storage services expand, efficient and economical installation of optical cables between buildings in data center is highly required. One of the cable installation methods that meets this demand is the jetting, in which cables are fed into existing microducts with compressed air [1)].

Conventional microduct cables, so-called air blown optical cables are limited to outdoor usage, and high-density polyethylene is generally used as their outer sheath to withstand crush force added during jetting process. On the other hand, flame-retardant properties are required in optical cables for indoor usage such as in data centers. Since it is difficult to ensure lateral pressure resistance with flame-retardant resin, air blown optical cables between buildings in data center had to be relayed to indoor-outdoor cables and connected to indoor cables in the building through closures as shown in Fig. 1 [2)].

This time, we have developed a 288-fiber Indoor-Outdoor Air Blown Optical Cable that can be used not only for conventional outdoor applications, but also for indoor ones with flame retardancy. The resin used for the outer sheath was newly developed, and this cable has been confirmed to meet two types of flame-retardant grades: UL 1666 [3)] and B2ca-s1 (Construction Products Regulation grade, B2ca: flammability, s1: smoke production) of the European Construction Products Regulation [4)5)] (CPR). Comparing Fig. 1 and Fig. 2, our developed cable can contribute to reducing not only the person-hour required for closure connections, but also the number of network components and the number of product type in stock.

We have applied two technologies of the "Spider Web Ribbon" (SWR®) and the “Wrapping Tube Cable” (WTC®) to this newly developed Indoor-Outdoor Air Blown Wrapping Tube Cable (IO AB-WTC). SWR is a fiber ribbon intermittently fixed adjacent optical fiber and can be spliced by mass fusion splicer in fiber ribbon units. WTC is a cable with the core covered in tape and embedded with tensile strength members. These technologies realize small diameter and high-density mounting of fibers in the cable core.

This cable showed its jetting characteristics over 1000 Ft in third-party’s test, confirming that it is sufficient for connecting buildings in the data center.

This paper introduces the development of the 288-fiber IO AB-WTC.

2. Cable Design

2.1 Optical fiber

SWR consisting of 12 fibers with 200 μm coating diameter was applied. Figure 3 shows the structure of the 12-fiber SWR. SWR has a structure in which adjacent optical fibers are intermittently fixed while maintaining their arrangement, allowing the shape of the SWR to be changed flexibly and the fiber to be mounted high-density in a cable. It is also possible to separate a fiber ribbon into 12 fibers without using special tools [6)].

To identify optical fiber accurately and easily, stripe ring marks are printed on SWRs. SWR is easy to identify both in fiber ribbon state and after separated into individual fiber.

2.2 Cable Outer Diameter

To improve the jetting characteristics, the outer sheath of the conventional AB-WTC has a concave-convex structure to reduce the frictional resistance between the cable and the inner surface of the duct, as shown in Fig. 4. The same structure was applied to IO AB-WTC. The IO AB-WTC was developed for the European and for the North American markets and was designed to have an outer diameter of approximately 9.5 mm, assuming the use of ducts with inner diameters of 12 mm (for Europe) and 13 mm (for North America). The design is considered the fill ratio to the duct to ensure jetting characteristics.

1 : Optical Cable Development Dept.

2 : Optical Cable Manufacturing Dept.

Abbreviations, Acronyms, and Terms.

ICEA—Insulated Cable Engineers Association
The Insulated Cable Engineers Association is a professional organization dedicated to developing cable standards for electric power, control, and telecommunications industries.

Jetting—Air-Blown installation / Jetting installation
A method of feeding cables into existing microducts with compressed air

UL—Underwriters Laboratories Limited Liability Company
Standards and Certification issued by UL

Closure—Closure
A device for accommodating connection points when connecting, branching, and pulling down optical cables.

Fusion splice—Fusion splice
A method of connecting multiple optical fibers at once by fusing the end of the optical fibers using the discharge of a fusion splicer after aligning the axes of the end of the optical fibers.

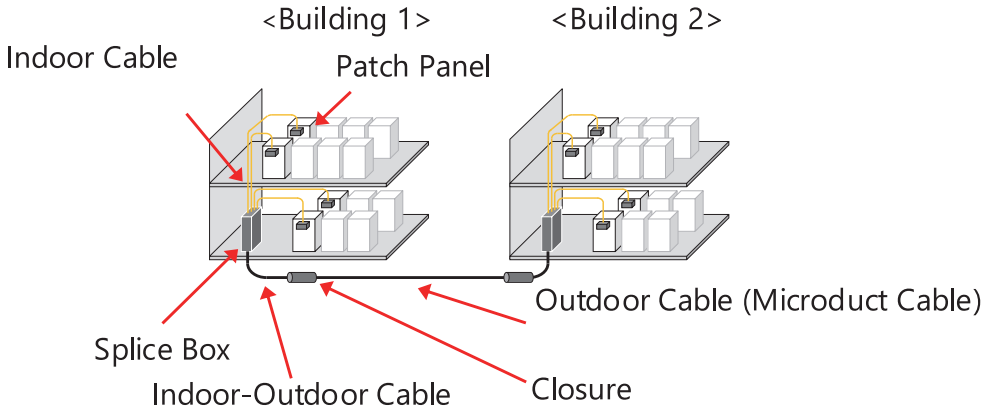


Fig. 1. Wiring diagram of conventional cables in a data center.

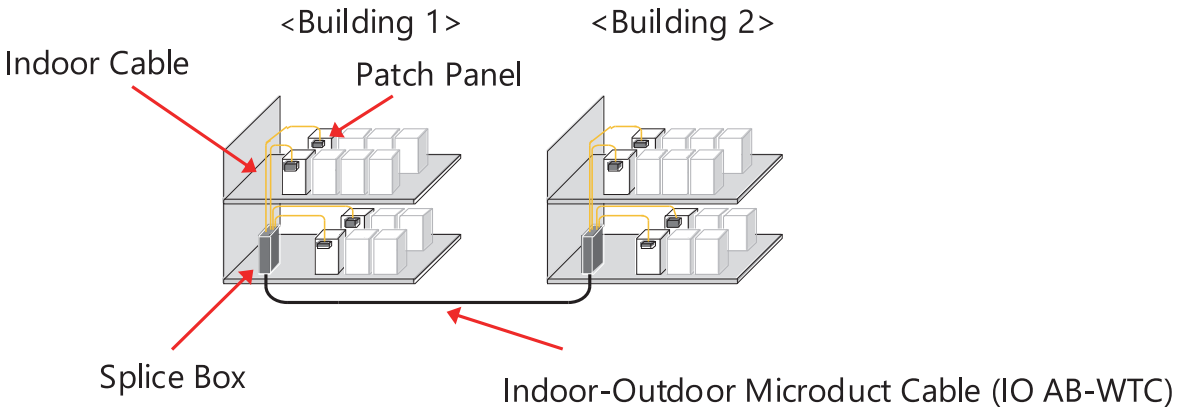


Fig. 2. Wiring diagram of cables in a data center applied IO AB-WTC.

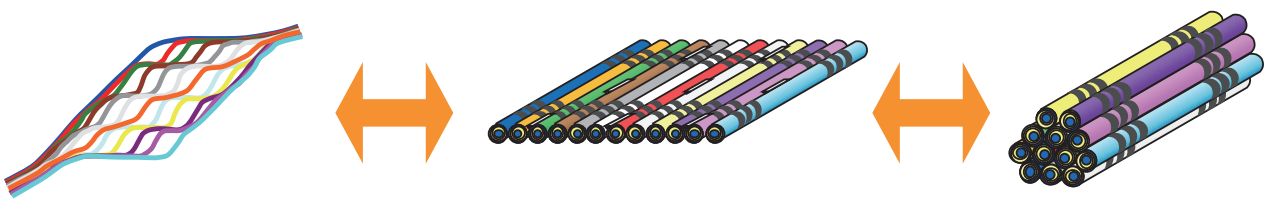


Fig. 3. Structure of 12-fiber SWR.

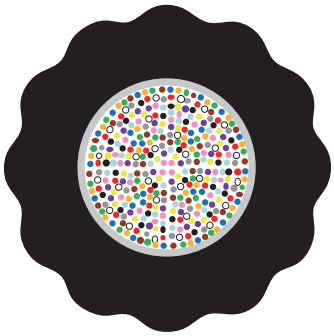


Fig. 4. AB-WTC cross section.

Table 1. Comparison of IO-WTC and IO AB-WTC.

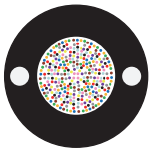
Item	IO-WTC	IO AB-WTC
Cross Section		
Fiber count	288	288
Outer Diameter (mm)	12.5	9.5
Weight (kg/km)	180	100

Table 2. Mechanical characteristics of IO AB-WTC.

Item	Test conditions	Result
Cable low and high temperature bend test	Bending diameter: 40D (D: cable outer diameter) Temperature: -30/+60 (°C) Number of turns: 3	< 0.15 (dB) No damage to the cable jacket
Cyclic flexing test	Bending diameter: 40D (D: cable outer diameter) Angle : ±90 (°) Number of cycles: 25	< 0.15 (dB) No damage to the cable jacket
Cable impact test	Striking surface R12.5 (mm) 1.0 (J)	< 0.15 (dB) No damage to the cable jacket
Cable tensile loading and fiber strain test	1×W (W: cable weight (kg/km)) 1 hour	< 0.9 (%)
	0.3×W, 10 minutes	< 0.266 (%), < 0.15 (dB)
	After 5 minutes of load release	< 0.15 (dB)
Cable compressive test	50 (N/cm) 1 minute later Speed: 2.5 (mm/minute)	< 0.15 (dB)
Cable twist test	Test length: 2 (m) Angle: ±180 (°), Number of cycles: 10	< 0.15 (dB) No damage to the cable jacket
Cable kink test	Loop diameter: 40D (D: cable outer diameter)	No kink

2.3 Flame retardant sheath

A new resin with flame retardant properties and mechanical strength was blended and applied to IO AB-WTC.

This cable is classified UL1666/1685[7] (US) and Cca-s1b, d1, a1 (EU / CPR) (CPR grades, Cca: flammability, s1b: smoke production, d1: flaming droplets, a1: acidity).

3. Comparison with conventional cables

Comparing the conventional IO-WTC and IO AB-WTC that are commercially available, IO AB-WTC has a lighter weight and smaller diameter structure, as shown in Table 1.

4. Cable characteristics

4.1 Mechanical and environmental characteristics

The test results of the mechanical and environmental characteristics of IO AB-WTC are shown in Tables 2 and 3. Regarding test methods, mechanical tests were evaluated in accordance with ICEA S-122-744[8] (Standard for optical fiber outside plant microduct cables), and environmental characteristics were evaluated in accordance with ICEA S-104-696[9] (Standard for indoor-outdoor optical fiber cable), except for some tests. The measurement wavelength was 1550 nm. Good characteristics were confirmed in all tests.

Table 3. Environmental characteristics of IO AB-WTC.

Item	Test conditions	Result
Environmental stress crack resistance	Bending diameter: < 10D (D: cable outer diameter) Angle: 180 (°) Temperature : 50 (°C) Soak time: 48 hours	No damage to the cable jacket
Cable external freezing test	Freezing temperature : -10 or -40 (℃) Temperature rise to -2 (°C)	< 0.40 (dB/km) No damage to the cable jacket
Cable temperature cycling test	-40/+70 (°C) Number of cycles: 2	< 0.40 (dB/km)
Water penetration*	Height of water: 1 (m) Test length: 40 (m)	No water leaking from the exposed end of the cable

*IEC60794-1-22 Method F5C

4.2 Jetting characteristics

This cable achieves well over our blowing distance target of 1000 Ft.

5. Conclusion

We have successfully developed thin and high-density 288-fiber IO AB-WTC with two flame-retardant grades, UL 1666 and CPR B2ca-s1. This cable meets mechanical characteristics in accordance with ICEA S-122-744 and environmental characteristics in accordance with ICEA S-104-696, and achieves a jetting characteristic over 1000 Ft. This performance enables easy connection between buildings in a data center and contributes to efficient network construction.

Reference

1) S. Shimizu, et al. "Air-blown Fiber Optic Cable with SWR and WTC Technologies," Proceedings of 67th IWCS, 2018.
2) S. Kaneko, et al. "Development of Indoor/Outdoor cables with high-flame retardant", Proceedings of 70th IWCS, 2021.
3) UL 1666, "Standard for Safety: Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts (Ed.5)", (2007).
4) BS EN 50399:2011+A1:2016, "Common test methods for cables under fire conditions - Heat release and smoke production measurement on cables during flame spread test - Test apparatus, procedures, results".
5) BS EN 60332-1-2 +A 12 - Tests on electric and optical fibre cables under fire conditions - Part 1-2: Test for vertical flame propagation for a single insulated wire or cable - Procedure for 1 kW pre-mixed flame - AMD.
6) T. Kaji, et al. "Development of Wrapping Tube Cable with Spider Web Ribbon using fiber based on ITU-T G652 D", Proceedings of 65th IWCS, 2016.
7) UL 1685, "Standard for Safety: Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables (Ed.4)", (2015).
8) ICEA S-122-744-2022, "Standard for Optical Fiber Outside Plant Microduct Cables", (2022).
9) ICEA S-104-696-2019, "Standard for Indoor-Outdoor Optical Fiber Cable", (2019).