Ultra-High Fiber Count I/O WTC for Jetting Installation

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To reduce fusion splice cost, there has been an increasing demand for indoor-outdoor (I/O) cables that combine the flame-retardant properties of inside plant (ISP) cables for indoor use and weather-resistant outside plant (OSP) cables for outdoor use. However, I/O cables in general are weaker than OSP cables, which limit the cable installation methods available. By developing Robust I/O (RIO) cables with superior mechanical strength, it has become possible to adopt the jetting installation method, which offers superior workability.

1. Introduction

The demand for optical cables for the data center (DC) has increased exponentially in recent years. As shown in Fig.1, the DC cabling uses an ISP cable with flame retardant properties that prevents the spread of fire through the cable in the event of a fire in the building, and an OSP cable designed with a small diameter by increasing the fiber mounting density while installing more fibers to connect DC buildings where the installation space is limited. Traditionally, ISP and OSP cables have been installed separately and then connected to each other. Recently, there has been increasing demand for I/O cables that combine the characteristics of ISP and OSP, with the aim of reducing connection and installation costs. We have already developed I/O cables ranging from 144 F to 6912 F[1)] and realize a cable structure suitable for data centers. However, due to the formulation required to achieve high flame retardancy, the jacket material used in I/O cables is mechanically inferior to that of OSP cables, and it was necessary to choose the pulling installation method shown in Fig. 2. This method is connecting a cable to a pulling rope installed in advance in the underground duct and winding it up at the other side. On the other hand, as shown in Fig. 3, the jetting installation method involves applying pressure while using a caterpillar to feed the cable into underground ducts. This method saves time and money by eliminating the need to install a pulling rope in advance, but requires robustness with both pressure resistance and durability to withstand the caterpillar. To solve this problem, we developed RIO cables.

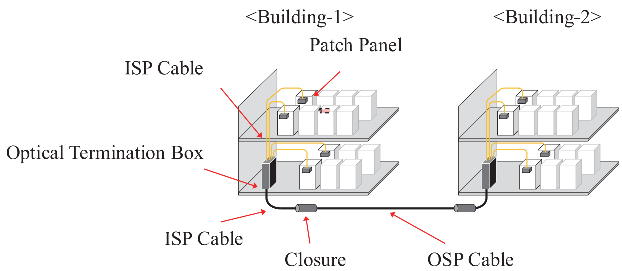


Fig.1. DC wiring diagram.

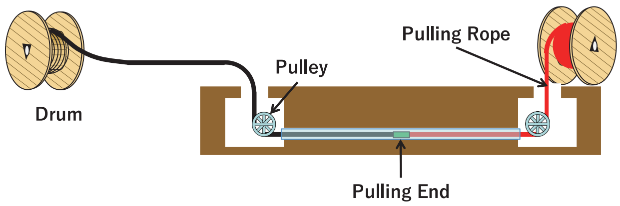


Fig.2. Pulling installation method.

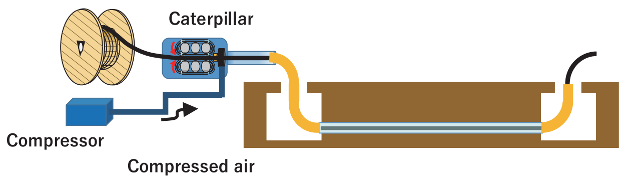


Fig.3. Jetting installation method.

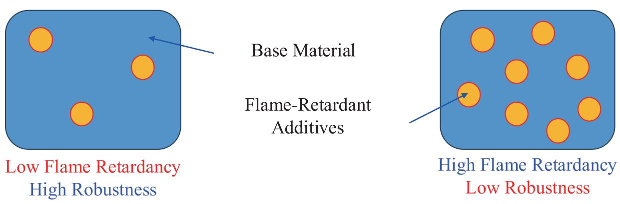


Fig.4. Overview of jacket material with frame retardancy.

1 : Optical Cable Development Department

Abbreviations, Acronyms, and Terms.

Fusion splice—Same as left
This is a fusion splicing technique where the end faces of optical fibers are precisely aligned, and then fused together by melting the fiber ends through an electric arc discharge generated by a fusion splicing machine.

Closure—Same as left
A optical cable splice closure or termination box designed to accommodate splicing, branching, and drop cable connections in optical cable networks.

Jetting installation method—Same as left
A cable installation method in which the cable is fed into existing ducts using compressed air.

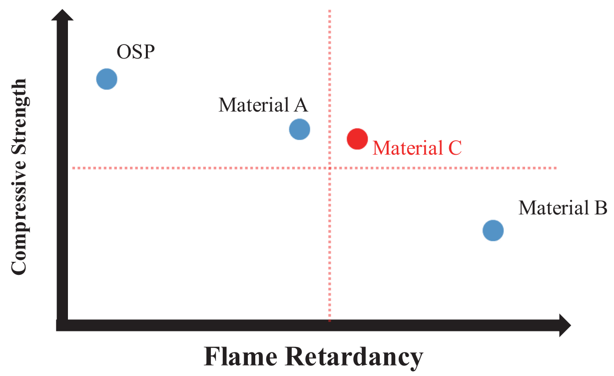


Fig.5. Comparison of jacket material.

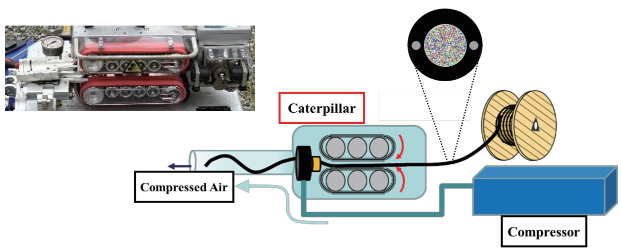


Fig.6. Overview of jetting installation test.

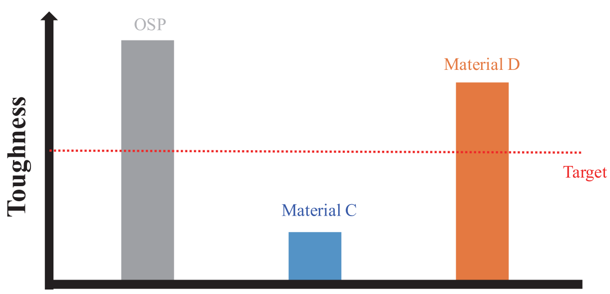


Fig.7. Result of jetting installation test.

2. RIO Cable Design

2.1. Selection of Jacket Material

When RIO cables are designed, as shown in Fig. 4, the flame-retardant properties of the jacket material are achieved by incorporating flame-retardant additives into the base compound. However, careful optimization of this formulation is essential, as increasing the quantity of additives tends to compromise the mechanical strength of the material. As shown in Fig. 5, based on the results of the basic physical property evaluation of jacket materials A and B, it was assumed that jacket material C had appropriate properties, so we moved on to the evaluation as a cable. However, as shown in Fig. 6 and Fig. 7, when a test simulating jetting installation was conducted, it was found that there was a problem with durability, so the material was selected again, and it was confirmed that all the required properties were satisfied by using jacket material D as shown in Table 1.

Table 1. Comparison of jacket material.

		A	B	C	D
Flame Retardancy		Low	High	High	High
Robustness	Compressive Strength	High	Low	High	High
	Toughness	N/A	N/A	Low	High
Judgement		Bad	Bad	Bad	Good

2.2. Cable Structure Selection

For the small diameter and high-density structure required for optical cables for DC, we adopted Spider Web Ribbon® (SWR®) & Wrapping Tube Cable® (WTC®) as shown in Fig. 8 and Fig. 9. As shown in Fig. 10, the deformation rate of the cable during compressive strength test was simulated and designed to be equivalent to OSP WTC. It achieves an outer diameter equivalent to that of WTC.

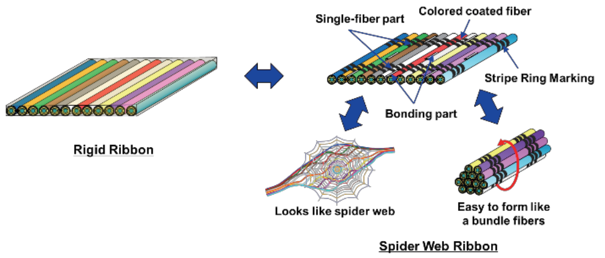


Fig.8. Overview of SWR structure.

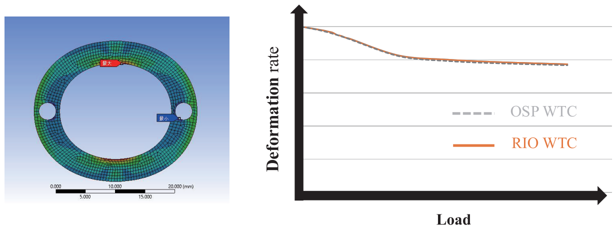


Fig.10. Simulation result of RIO WTC.

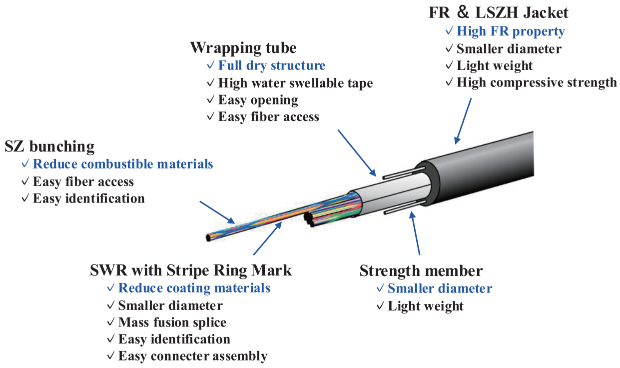


Fig.9. Overview of WTC structure.

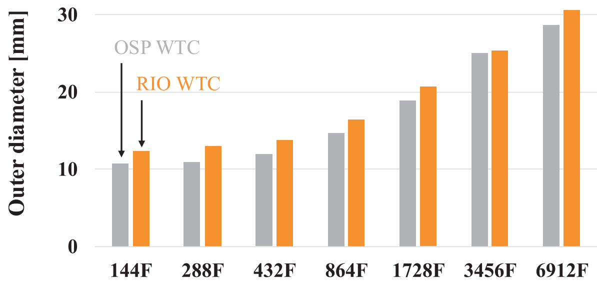


Fig.11. Comparison of outer diameter of RIO WTC and OSP WTC.

3. Test Results for RIO WTC

3.1. Flame Retardant Properties

The requirements and test methods for flame retardant properties of optical cables vary depending on country and region, but the main ones are Optical Fiber Non-Conductive Risers (OFNR)[2] adopted in North America and Construction Products Regulations (CPR)[3] adopted in Europe. As shown in Table 2, the results satisfied both requirements for RIO WTC lineup.

Table 2. Flame retardant test result.

	Flame Retardant Test	
	OFNR(UL)	CPR(EN)
144F-WTC		
288F-WTC		
432F-WTC		
864F-WTC	Pass	Cca-s1 or higher
1728F-WTC		
3456F-WTC		
6912F-WTC		

3.2. Mechanical Properties

The requirements and test methods for mechanical properties of optical cables vary depending on the application, however this product complies with ICEA S-104-696-2019[4], which is widely recognized as the standard for I/O cables. Additionally, for certain items, the required properties of ICEA S-83-596-2016[5], a standard for ISP cables, are more stringent, so the evaluations were conducted based on those standards. As shown in Table 3, the results satisfied all requirements for RIO WTC lineup.

3.3. Environmental Properties

The requirements and test methods for environmental properties of optical cables were conducted based on ICEA S-104-696-2019. As shown in Table 4, the results satisfied the requirements for RIO WTC lineup.

Table 3. Mechanical test result.

Item	Condition	Result
Low-high Temperature Bend (*1)	Bending radius: 10D（D:Cable Diameter） Temperature: -10, +60 degree C Turns: 4, Cycle: 3	Pass
Cable Cyclic Flexing	Bending radius: 20D（D:Cable Diameter） Cycle: 25	Pass
Impact	Striking surface: 12.5 mm Impact energy: 4.4 N・m Striking count: twice at the same place	Pass
Tensile Strength	Load: 2700 N 1 h（Short Term）	Pass
	Load: 810 N（Long Term）	Pass
Compressive Strength	110 N/cm 10 minutes after 220 N/cm 1minute	Pass
Cable Twist (*1)	Sample length: 1 m Test angle: ±180 degrees, Cycle: 10	Pass

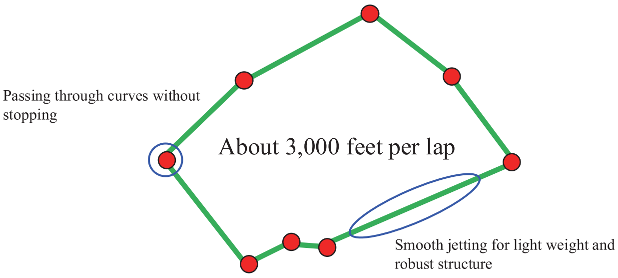
*1 : Tested by ICEA S-83-596-2016 for indoor because it is a stricter test condition.

Table 4. Environmental test result.

Item	Condition	Result
Temperature Cycling	-40 to +70 degree C　Cycle : 2	Pass
Water Penetration	Height of water : 1 m Sample length : 40 m	Pass
Weathering Test	Exposure Time : 720h	Pass
Cable Aging Test	Temperature : 85 degree C Aging Time : 720h	Pass

3.4. Jetting Installation Test

As shown in Fig. 12, jetting installation tests were carried out using 864 F-WTC and 1728 F-WTC, at a test site simulated actual field conditions. Both cables were successfully and smoothly jetted over the entire length of the duct trajectory in good condition, confirmed their excellent workability in DC installation methods.



Item	Property	Result
864F-WTC	Duct size : 1.25 inch	3,322 feet
1728F-WTC	Duct size : 1.50 inch	3,700 feet

Fig.12. Jetting installation test for RIO WTC.

4. Conclusion

As shown in this report, we have developed an Ultra-High Fiber Count I/O WTC suitable for Jetting Installation. By carefully selecting the jacket material and conducting thorough evaluation and analysis, we have successfully achieved a structure that meets the target performance requirements.

References

1) S. Kaneko, et al.: "Development of Indoor / Outdoor cables with high-flame retardant,"
Proceedings of IWCS 70, pp. 354-358, 2021
2) UL 1666: "Safety Standard: Test for Flame Propagation Height of Electrical and Fiber Optic Cables Insulated Perpendicular to the Shaft (Ed.5)," 2007
3) BS EN 50399: "General test methods for cables under fire conditions – Heat emission and smoke formation measurements of cables during flame propagation tests – Test apparatus procedures and results," 2016
4) ICEA S-104-696-2019: "Standard for Indoor-Outdoor Fiber Optic Cables," 2019
5) ICEA S-83-596-2016: "Standard for Indoor Fiber Optic Cables," 2016