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FEATURED TOPIC

Corrosion-Resistant Aluminum-Covered Stainless Steel Tube Composite Fiber Optic Overhead Ground Wire

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In recent years, corrosion-related communication failures in Optical Fiber Composite Overhead Ground Wire (OPGW) have become a significant issue. To address this problem, we have been working on applying an optical unit of aluminum-covered stainless steel tube-type (SUS/AL unit) instead of the optical unit of the conventional aluminum tube-type, aiming to reduce communication disruptions and minimize maintenance costs.

We collaborated with eight domestic transmission system operators (TSOs) to produce OPGWs utilizing the SUS/AL unit and evaluated their performance. The results demonstrated excellent corrosion resistance and positive outcomes in other performance aspects as well. These OPGWs have been supplied to several TSOs for extra-high voltage overhead transmission lines.

Keywords: OPGW, corrosion, freezing, corrosion resistance, SUS/AL unit

1. Introduction

The Optical Fiber Composite Overhead Ground Wire (OPGW) is a ground wire that incorporates an optical unit*1 into the overhead ground wire installed atop of transmission towers. It was launched for practical use in Japan in 1981. Since then, various types of OPGW have been supplied to transmission system operators (TSOs) and widely used nationwide.

However, over time, communication failures in OPGW (increased attenuation loss in optical fibers and fiber breaks) have gradually increased, becoming a significant issue in recent years.

The primary cause, particularly for OPGW installed near coastlines, is that sea salt particles carried by wind and rain enter the gap between the OPGW's aluminum-clad steel wires (AC wires) and the aluminum tube. Corrosion products from "crevice corrosion" then either crush the aluminum tube or, in case of pitting corrosion, invade its interior. This can compress the optical fibers, leading to fiber breaks in the worst case (see Fig. 1).

Additionally, cracks in the aluminum tube caused by vibration fatigue at bolted or jumper clamps have been reported. Rainwater entering through these cracks can accumulate at the lowest sag point of the OPGW span, and ice formed during freezing in winter can compress the optical fibers.

Communication failures from these two factors account for approximately 80% of all incidents.

To resolve these issues, the optical unit will not use the conventional aluminum tube-type. Instead, it will adopt an aluminum-covered stainless steel tube-type (SUS/AL unit), which Sumitomo Electric Industries, Ltd. has primarily developed and applied for overseas markets.

This paper first describes the previous efforts of Sumitomo Electric and the development process leading to the application of SUS/AL units (including bare stainless steel units for reference) for OPGW. Subsequently, we present notable results from the evaluation of an Aluminum-Covered Stainless Steel tube OPGW (SUS/AL tube OPGW) manufactured and evaluated using SUS/AL units, developed jointly with eight TSOs.

This OPGW is currently being supplied for extra-high-voltage overhead transmission lines of several TSOs.

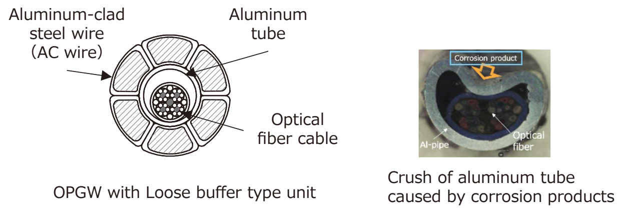


Fig. 1. Examples of OPGW corrosion in Japan(1)

2. Background of SUS/AL Unit Application

From the late 1990s to the 2000s, the overseas OPGW market experienced advancements toward smaller diameters using bare stainless steel tube-types (SUS units) and a shift to multiplexed transmission utilizing Wavelength Division Multiplexing (WDM) fibers. In particular, European manufacturers began actively marketing low-cost OPGW products with UV fibers,*2 which are standard in communication cables, incorporated into stainless steel tubes (SUS tubes) and jelly compound (filler) filled in them (see Fig. 2).

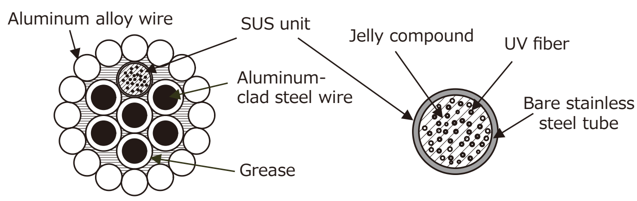


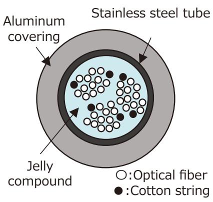
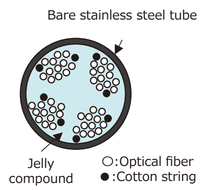
Fig. 2. Representative bare SUS tube OPGW at the time

In 2001, J-Power Systems Corporation was established. To respond to these changes in the market environment, J-Power Systems flexibly addressed diverse customer needs by offering two product types: SUS/AL tube OPGW (developed and commercialized by former Hitachi Cable, Ltd. around that time) and bare stainless steel tube greased OPGW (previously commercialized by Sumitomo Electric).

The aluminum-covered stainless steel tube, in particular, effectively eliminates concerns about "galvanic corrosion" caused by different metal contact between the bare SUS tube and the aluminum layer on the AC wires.

Since 2005, SUS/AL tube OPGW has been primarily supplied to overseas customers (see Table 1).

Table 1. Specifications for the SUS/AL and SUS units

Item		SUS/AL unit	SUS unit†2
Structure			
Unit diameter (mm)	Aluminum covering	5.2, 6.5	-
	Stainless steel tube	3.6	2.6 to 4.1
Type of optical fiber		UV Resin / Single Mode	UV Resin / Single Mode
Max. number of optical fiber		36	12 to 48
Fiber Identification (Max.)		12 colors of fibers + 3 colors of strings†1	12 colors of fibers + 4 colors of strings

†1 Initially, colored ring mark identification of fibers was adopted instead of colored cotton strings.
†2 There is a supply record for unit types without jelly compound.

Meanwhile, in Japan, two types of OPGW based on SUS tube have been supplied to some TSOs.

One type uses a SUS unit containing 60 cores of silicone fiber*3 which is standard for domestic OPGW. The other type is a SUS/AL unit containing 24 cores of UV fiber.

The SUS unit employs a thin-walled bare SUS tube to accommodate silicone fiber (diameter: 400 µm), which is larger than UV fiber (diameter: 250 µm). It can house a cable with the domestic maximum core count of 60 cores, resulting in an outer diameter of 6.5 mm (see Fig. 3).

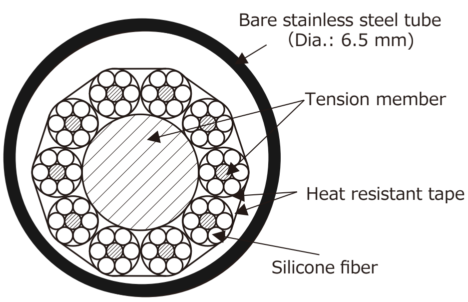
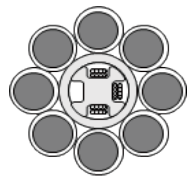
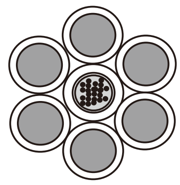


Fig. 3. SUS unit with a 60-core cable (However, this is no longer supplied)

On the other hand, the SUS/AL unit is an optical one housing 24-core UV fibers. To provide lightning resistance within the small size of OPGW 60 mm^2, the AC wire diameter was increased from 3.2 mm to 3.8 mm. Consequently, the unit diameter was also set to 3.8 mm, matching the wire diameter. While aluminum tube-type units previously had diameters ranging from 5 mm to 6.5 mm, applying the SUS/AL unit with its corrosion countermeasures was the optimal solution to achieve this 3.8 mm slim-diameter unit (see Table 2).

Table 2. Specification comparison between the conventional type and the lightning-resistant LP-OPGW 60 mm^2

Item	Conventional Type (Tape-shaped fibers) OPGW 60 mm^2	Lightning Protection Type LP†1-OPGW 60 mm^2
Structure		
Type of optical fiber	UV Resin / Single Mode	UV Resin / Single Mode
Standard number of optical fiber	20 + 4 (dummy)	24
Max. number of optical fiber	32	24
Configuration	8/3.2 mm-23AC +1/5 mm-OP unit	6/3.8 mm-14AC +1/3.8 mm-OP unit
Min.Ultimate tensile strength (kN)	73.5	96.1
OPGW Diameter (mm)	11.4	Same as left

†1 LP stands for Lightning Protection

Regarding fiber identification, while cotton string identification was common for overseas customers, ring-marked fibers were adopted for this slim unit due to the lack of space to store the string.

The above outlines the background of OPGW using SUS/AL units, which have been supplied to overseas and some domestic TSOs to date.

3. Aluminum-Covered Stainless Steel Tube OPGW

3-1 Background of development research

Over 30 years have passed since OPGW was introduced extensively, during which time issues such as communication failures have increased. The cause lies in deformation or damage to the aluminum tube-type unit due to corrosion, cracking, freezing, and other factors, leading to compression or fiber breaks inside the tube.

To address this, we focused on applying SUS/AL units, which already have a proven supply record overseas. This unit features a robust construction with a SUS tube placed inside and covered with thick aluminum. Furthermore, even if the aluminum covering becomes thin and exposes the inner stainless steel, it will act as a sacrificial anode, protecting the SUS tube from corrosion.

Additionally, we believed that even if the SUS tube were damaged and rainwater entered the tube cavity, the jelly compound filling inside would mitigate rainwater penetration and freezing.

However, since the SUS/AL unit requires UV fibers which lack the 300°C heat resistance of silicone fibers, it was intended for small-sized OPGW (single-layer stranded ground wire) for extra-high voltage (154 kV or below) lines.

Thus, starting in 2016, joint development research on OPGW incorporating the SUS/AL unit commenced with eight domestic TSOs. Over approximately two and a half years, demonstration tests including corrosion tests were conducted.

3-2 Selection of OPGW size and specifications of SUS/AL unit

After consultation with the eight TSOs, four types of single-layer SUS/AL tube OPGW, as shown in Table 3, were manufactured for evaluation. For the SUS/AL units, to maintain the same surrounding stranded wire structure as conventional products, 5 mm and 6 mm diameters were applied to match existing sizes. Size designations conform to the power industry standard A401: "Optical Fiber Composite Overhead Ground Wire" (published by the Japan Electrical Association, 2022).

Table 3. Manufactured and evaluated SUS/AL tube OPGW

Size (mm^2)	50	60	70	85a
Shape of outer wires	Trapezoid			Round
OPGW diameter (mm)	9.6	10.5	11.5	12.8
Unit diameter (mm)	5	5	6	5

For the 5 mm diameter SUS/AL unit, it was considered that it can accommodate up to 36 optical fibers, and the thickness of the aluminum covering should be at least as thick as that of conventional aluminum tubes (approximately 0.6 mm) to ensure corrosion resistance. The SUS tube inside was adopted with a diameter of 3.6 mm, consistent with our overseas specifications.

For the 6 mm diameter SUS/AL unit, however, a 4.3 mm diameter SUS tube was adopted to ensure sufficient space, as it can accommodate up to 48 optical fibers and requires a certain amount of slack (the fibers are several millimeters longer per meter of tube). The reason for providing this excess length is to minimize stress on the optical fibers by accounting for elongation that occurs during OPGW overload conditions, such as those caused by Japan's characteristic heavy snow accumulation. The specifications of the SUS/AL unit are shown in Table 4.

Furthermore, representative specifications of the OPGW manufactured and evaluated this time are shown in Tables 5 and 6, comparing them with conventional products.

Table 4. Specifications of 5 mm and 6 mm diameter SUS/AL units

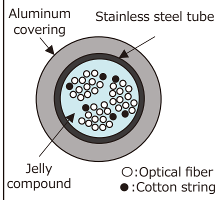
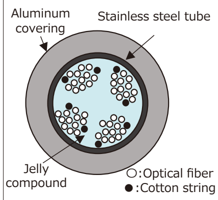
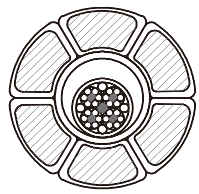
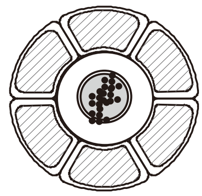
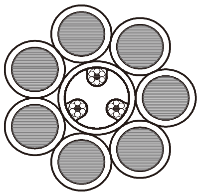
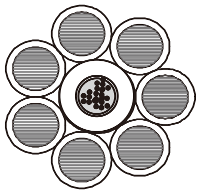
<table>
<tr><th colspan="2">Item</th><th>SUS/AL Unit: 5 mm</th><th>SUS/AL Unit: 6 mm</th></tr>
<tr><td colspan="2">Structure</td><td>
</td><td>
</td></tr>
<tr><td rowspan="3">Unit diameter (mm)</td><td>Aluminum covering</td><td>5</td><td>6</td></tr>
<tr><td>Thickness of aluminum covering</td><td>0.7</td><td>0.85</td></tr>
<tr><td>Stainless steel tube</td><td>3.6</td><td>4.3</td></tr>
<tr><td colspan="2">Type of optical fiber</td><td>UV Resin / Single Mode</td><td>UV Resin / Single Mode</td></tr>
<tr><td colspan="2">Number of optical fiber</td><td>12, 24, 36</td><td>12, 24, 36, 48</td></tr>
<tr><td colspan="2">Fiber Identification (Max.)</td><td>12 colors of fibers + 3 colors of strings</td><td>12 colors of fibers + 4 colors of strings</td></tr>
</table>

Table 5. Comparison of conventional and SUS/AL tube trapezoid-shaped wire OPGWs(2)

<table>
<tr><th colspan="2" rowspan="2">Item</th><th colspan="2">Conventional loose buffer type</th><th>SUS/AL tube</th></tr>
<tr><th colspan="3">OPGW 70 mm²</th></tr>
<tr><td colspan="2">Structure</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Type of optical fiber</td><td colspan="2">Silicone Resin / Single Mode</td><td>UV Resin / Single Mode</td></tr>
<tr><td colspan="2">Standard number of optical fiber</td><td colspan="2">24</td><td>24, 36, 48</td></tr>
<tr><td colspan="2">Max. number of optical fiber</td><td colspan="2">24</td><td>48</td></tr>
<tr><td colspan="2">Configuration</td><td colspan="2">6/(3.86 mm)-23AC +1/6 mm-OP unit</td><td>6/(3.86 mm)-23AC +1/6 mm-OP unit</td></tr>
<tr><td colspan="2">Min.Ultimate tensile strength (kN)</td><td colspan="2">80.2</td><td>Same as left</td></tr>
<tr><td colspan="2">OPGW Diameter (mm)</td><td colspan="2">11.5</td><td>Same as left</td></tr>
<tr><td rowspan="3">Calculated cross sectional area†3 (mm²)</td><td>AC wires</td><td colspan="2">70.2</td><td>Same as left</td></tr>
<tr><td>OP unit</td><td>10.18</td><td>11.66</td><td>16.33</td></tr>
<tr><td>Total</td><td>80.38</td><td>81.86</td><td>86.53</td></tr>
<tr><td rowspan="3">Mass†3 (kg/km)</td><td>AC wires</td><td colspan="2">445.4</td><td>Same as left</td></tr>
<tr><td>OP unit</td><td>50.49</td><td>46.48</td><td>66.94†1</td></tr>
<tr><td>Total</td><td>495.9</td><td>491.9</td><td>512.3</td></tr>
<tr><td colspan="2">D.C. Resistance at 20°C (Ω/km)†2</td><td colspan="2">1.08</td><td>Same as left</td></tr>
</table>

†1 Mass for the 48-fiber case
†2 Value excluding the resistance of the unit
†3 Two values of conventional type for OP unit and total due to varying customer specifications

Table 6. Comparison of conventional and SUS/AL tube round-shaped wire OPGWs

Item		Conventional tight buffer type	SUS/AL tube
		OPGW 80 mm²	OPGW 85a mm²
Structure			
Types of optical fiber		Silicone Resin / Single Mode	UV Resin / Single Mode
Standard number of optical fiber		18	12, 24, 36
Max. number of optical fiber		18	36
Configuration		7/3.9 mm-23AC +1/5 mm-OP unit	7/3.9 mm-23AC +1/5 mm-OP unit
Min.Ultimate tensile strength (kN)		95.6	Same as left
OPGW Diameter (mm)		12.8	Same as left
Calculated cross sectional area (mm²)	AC wires	83.65	Same as left
	OP unit	13.55	11.59
	Total	97.20	95.24
Mass (kg/km)	AC wires	535.0	Same as left
	OP unit	42.60†1	48.93†2
	Total	577.6	583.9
DC Resistance at 20°C (Ω/km)†3		0.647	0.914

†1 Mass for the 18-fiber case
†2 Mass for the 36-fiber case
†3 Conventional type includes unit resistance values. SUS/AL tube type excludes unit resistance values

3-3 Evaluation of SUS/AL tube OPGW

(1) Test items for evaluation

For the evaluation of SUS/AL tube OPGW, type test items common to all eight TSOs were tested in consultation with them. Furthermore, to confirm the reliability of this OPGW, tests were performed including accelerated corrosion testing tailored to the development objectives, freezing tests inside the SUS unit, and steep slope vibration tests raised as concerns during the consultation process. The results of these tests are introduced below.

(2) Results of accelerated corrosion testing

To confirm the corrosion resistance of the SUS/AL tube OPGW, an accelerated corrosion testing was conducted over 19 months using our accelerated corrosion testing apparatus (capable of inducing corrosion in a short period), as shown in Fig. 4. Table 7 details the six OPGW types tested (including a conventional product for comparison), while Table 8 shows the conditions and measurement items for accelerated corrosion testing.

Regarding the tested OPGW types, we also evaluated the conventional aluminum tube greased OPGW and the OPGW of the SUS/AL unit with V-groove scratches on the aluminum covering. This assessment assumes a scenario where corrosion causes wall thinning in the aluminum covering of the SUS/AL unit, exposing the underlying stainless steel.

Table 9 shows the results of the accelerated corrosion testing, including the increase in attenuation loss of the

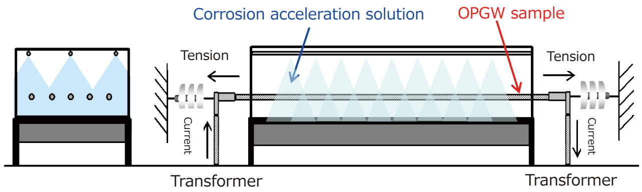


Fig. 4. Schematic diagram of accelerated corrosion testing apparatus

Table 7. Six types of OPGW subjected to accelerated corrosion testing

Size (mm²)	Shape of outer wires	Unit type	Number of fibers	Remarks
70	Trapezoid	Conventional loose buffer type	24	Refer to the left diagram in Table 5
		Conventional loose buffer type (Unit-greased)		Unit type: 4-groove spacer included Unit Surroundings: Greased (Light Corrosion Resistance)
		SUS/AL tube	48	Refer to the right diagram in Table 5
		SUS/AL tube (V-groove scratches on the unit)		Aluminum covering of the SUS/AL unit has circumferential V-groove scratches (Scratches reach the surface of the SUS tube)
85a	Round	Conventional tight buffer type (Spacer type)	18	Refer to the left diagram in Table 6
		SUS/AL tube	36	Refer to the right diagram in Table 6

Table 8. Conditions and measurement items for accelerated corrosion testing

Method	Dry-Wet Cycle
Corrosive Solution	NaCl, H_2SO_4
Max. Test Duration	19 months†1
Measurement items	• Attenuation loss • Appearance, Cross-sectional observation, Pitting depth, etc.

†1 The test will terminate when attenuation loss indicates fiber break

Table 9. Results of accelerated corrosion testing

Size (mm²)	Shape of outer wires	Unit type	Duration (months)			Life span multiplier†1	Appearance of the unit
			Increase in attenuation loss (loss increase)	Fiber break	No loss increase / No fiber break		
70	Trapezoid	Conventional loose buffer type	11	16.5	-	1	• Aluminum tube with dents, but without pitting through the tube
		Conventional loose buffer type (Unit-greased)	13.5	13.5	-	1.2	• Aluminum tube with dents and with pitting through the tube
		SUS/AL tube	-	-	19	1.7	• Aluminum covering without dents and without pitting through the covering • SUS tube without pitting through the tube
		SUS/AL tube (V-groove scratches on the unit)	-	-	19	1.7	• SUS tube without pitting through the tube
85a	Round	Conventional tight buffer type (Spacer)	14.5	15	-	1	• Aluminum tube with damage and with pitting through the tube
		SUS/AL tube	-	-	19	1.3	• Aluminum covering without dents, but with pitting through the covering • SUS tube without pitting through the tube

†1 The duration at which loss increases for conventional loose and tight buffer types is defined as 1

optical fibers, the duration until fiber breaks, and the appearance of the unit.

Regarding attenuation loss, the conventional loose buffer type OPGW 70 mm² showed an increase in attenuation loss 11 months after the start of the test, and the optical fiber broke after 16.5 months. Furthermore, the conventional tight buffer type OPGW 85a mm² exhibited an increase in attenuation loss 14.5 months after the start of the test, and the optical fiber broke after 15 months as well. In contrast, the SUS/AL tube OPGWs showed no increase in attenuation loss even after 19 months of testing.

These results confirm that, compared to the conventional types in terms of corrosion resistance, the SUS/AL tube OPGWs have a lifespan at least 1.3 to 1.7 times longer until attenuation loss increases.

Furthermore, even in the unit with V-groove scratches on the aluminum covering for OPGW 70 mm², no increase in attenuation loss or damage to the SUS tube was observed after 19 months. This indicates that the protective function of the SUS tube via the sacrificial anode in the aluminum covering is reliably effective.

Based on these test results, the SUS/AL tube OPGW is highly safe with dual protective functions, and further extended service life is anticipated.

Figure 5 shows post-test cross-sectional photographs of the conventional loose buffer type and the SUS/AL tube-type for OPGW 70 mm². Figure 6 shows post-test cross-sectional photographs of the conventional tight buffer type and the SUS/AL tube-type for OPGW 85a mm².

In both OPGW types, the inner surface of the AC wires at the corrosion sites revealed exposed steel, albeit to varying degrees. This indicates that galvanic corrosion between the steel and aluminum accelerated the corrosion of the unit.

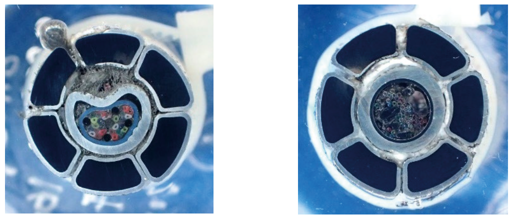
In the conventional loose buffer type OPGW 70 mm², corrosion products formed between the AC wires and aluminum tube crushed the tube, compressing the internal optical fibers. In contrast, the SUS/AL tube OPGW showed some corrosion-induced thinning of the aluminum covering, but no dents or damage to the SUS tube were observed.

In the conventional tight buffer type OPGW 85a mm², corrosion products were observed between the AC wires and aluminum tube, and damage to the aluminum tube was confirmed, extending to the groove of the spacer inside. In contrast, the SUS/AL tube OPGW showed only slight corrosion-induced thinning of the aluminum covering, but, similar to the 70 mm² case, no dents or damage to the SUS tube were observed.

These observations indicate two reasons for the superiority of the SUS/AL unit: first, its dual-layer structure comprising a thick aluminum covering and a robust inner SUS tube, and second, the protective function of the SUS tube described earlier.

Supporting the latter point, as shown in Table 9, although pitting reached the surface of the SUS tube in the SUS/AL unit (with penetration of the aluminum covering) for OPGW 85a mm², no further significant corrosion progression or damage to the SUS tube was observed.

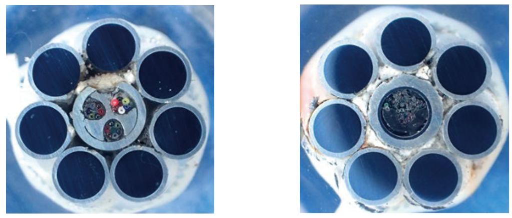
Based on the above, the SUS/AL tube OPGW demonstrated excellent corrosion resistance in the 19-month accelerated corrosion testing.



(a) After 16.5 months for conventional loose buffer type

(b) After 19 months for SUS/AL tube

Fig. 5. Cross-sectional photo after testing OPGW 70 mm²



(a) After 15 Months for Conventional tight Buffer type (Spacer type)

(b) After 19 Months for SUS/AL tube

Fig. 6. Cross-sectional photo after testing OPGW 85a mm²

(3) Freezing test results for SUS units

As described in Chapter 1, conventional aluminum tube OPGW suffers from the problem of cracks in the aluminum tube due to vibration fatigue at the bolted or jumper clamps. Rainwater entering through these cracks then freezes, causing communication failures.

However, as noted in Section 3-1, the SUS/AL unit has a robust structure. Considering this, even if cracks were to form in the SUS tube, the jelly compound filling inside would mitigate attenuation loss and fiber breaks by frozen rainwater, potentially extending the operational lifespan of the OPGW.

Therefore, to confirm the behavior when rainwater infiltrates and freezes, water was forcibly injected into the interior of the SUS unit (before aluminum covering) and a freezing test was conducted. The test setup is shown in Fig. 7, and the test conditions and measurement items are listed in Table 10. The test conditions were set to the most severe level after consultation with eight TSOs. Additionally, for the SUS unit with a diameter of 3.6 mm (φ3.6), tests were conducted on both the normal jelly compound-filled type (normal filling rate of jelly: 55%) and the highly-filled type (high filling rate of jelly: 75%).

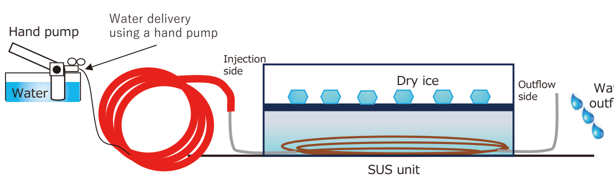


Fig. 7. Freezing test setup for SUS unit

Table 10. Freezing test conditions and measurement items

Items	Freezing test conditions	Remarks
SUS unit type†1	• SUS unit, 3.6 mm dia. (Normal filling rate of jelly compound) • SUS unit, 3.6 mm dia. (High filling rate of jelly compound)	SUS/AL unit dia.: 5 mm
	• SUS unit, 4.3 mm dia. (Normal filling rate of jelly compound)	SUS/AL unit dia.: 6 mm
SUS unit length	Each 20m	-
Unit temperature	≤ −35°C	-
Measurement time	1 hour (at ≤ −35°C)	-
Measurement items	• Attenuation loss • Photo of freezing conditions	-

†1 Normal filling rate of jelly compound:55%, High filling rate of jelly compound:75%

Figure 8 shows the measured increase in attenuation loss versus temperature change for the SUS tube. Furthermore, Fig. 9 presents the results observed after cutting the SUS tube during the test at or below −35°C to examine the internal freezing condition.

Figure 8 shows that all SUS units met the specification of attenuation loss increase ≤ 0.1 dB when the temperature was ≥ −35°C. Notably, the 3.6 mm diameter SUS unit with high jelly compound filling did not exhibit the sharp loss increase seen in other units even around −55°C, continuing to meet ≤ 0.1 dB. Furthermore, no residual loss increase was observed in any unit after returning to room temperature.

Figure 9 confirms that the jelly compound did not freeze; only the water component froze.

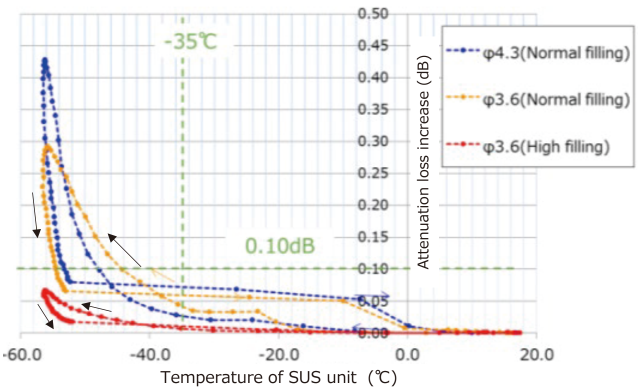


Fig. 8. Relationship between SUS tube temperature and increase in attenuation loss (φ denotes the diameter)

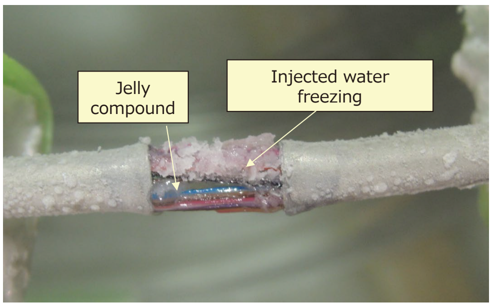


Fig. 9. Internal freezing conditions of SUS unit (φ4.3) at ≤ −35°C

Based on these results, the presence of jelly compound filling within the SUS/AL unit mitigates water ingress, thereby suppressing freezing. Moreover, the internal optical fibers are not tightly constrained by the jelly compound, allowing them to shift slightly to avoid partially frozen water (ice), which likely minimized loss increase. Indeed, the unit with a high filling rate of jelly compound demonstrated improved freeze resistance.

(4) Steep-slope vibration test results

The SUS tube OPGW, where jelly compound is filled and each optical fiber is simply arranged in parallel within the tube, is widely used overseas and has proven performance. However, in Japan, it is often applied in rugged mountainous terrain. Concerns arose that, on spans with large elevation differences between OPGW's support points at the towers, jelly compound and optical fibers might shift toward the lower point during operation, potentially affecting performance. Therefore, an approximately 10-meter OPGW was strung at an inclination angle of about 45 degrees in our testing facility, and a vibration test for 10^7 cycles was conducted.

The results confirmed no displacement of the jelly compound and no optical fibers, and no protrusion or retraction of the optical fibers at either end of the unit.

4. Conclusion

The SUS/AL tube OPGW was developed primarily for overseas markets. This unit eliminates concerns about galvanic corrosion by applying an aluminum covering on the SUS tube, resulting in a robust double-layer structure.

In this joint development research with eight TSOs, this OPGW was manufactured and subjected to accelerated corrosion testing. The results demonstrated corrosion resistance of 1.3 to 1.7 times greater than that of conventional aluminum tube OPGW. Other test results also confirmed beneficial characteristics.

Based on these findings, the SUS/AL tube OPGW is expected to achieve broader domestic adoption as a highly reliable product offering superior corrosion resistance compared with conventional designs.

5. Acknowledgments

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Technical Terms

∗1 Optical Unit or Unit: An integrated unit comprising a protective tube (such as aluminum or stainless steel tube) and the optical fibers and other components contained within it.

∗2 UV Fiber: An optical fiber coated with ultraviolet-cured resin.

∗3 Silicone Fiber: An optical fiber coated with silicone resin. It has high heat resistance.

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