

Test items and Conclusion

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9	Attenuation coefficient	6	Qualified
10	Attenuation uniformity	6	Qualified
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Main Test equipments

No.	Test equipments	Model	Serial number
1	Tension tester	1000kN	TX1-0008
2	Fiber optic measurement system	CD400	TX1-0032
3	Vibration measurement system	DH-5937	TX1-0004
4	Electromagnetic shaker	D-300-3	TX1-0001
5	Mode field analyzer	2200	TX1-0036
6	Optical dimension apparatus	2400	TX1-0037
7	OTDR	PK-8000	TX1-0038
8	Temperature test system for Short-Circuit Tes	OTM-03	TX1-0043
9	Lightning test system	--	TX1-0040
10	Creep test system	--	TX1-0023



Test Report

NO.	Test Item	Requirements	Test Result	Conclusion
1	Structure integrity and visual inspection	Eyesight to inspect. The Structure should be integrity.	Central tube type , Integrity	Qualified
2	Fiber color coding	Full spectrum, no depigment.	Full spectrum, no depigment.	Qualified
3	Fiber-optic tube color coding	When the number of stainless steel pipes is greater than one, the color faded and non migratory marks should be used.	Stainless steel tubes:1	Qualified
4	Length of lay of OPGW	$10 \leq A \leq 14$	12.93 Right strand	Qualified
5	diameter	$\Phi 12.30\text{mm}$	$\Phi 12.31\text{mm}$	Qualified



NO.	Test Item	Requirements	Test Result				Conclusion
			1	2	3	4	
6	Model field diameter	B1: (8.6~9.5) ±0.6 μm	1	8.98	2	9.10	Qualified
			3	9.09	4	9.12	
7	Non circularity of cladding	≤1.0%	1	0.25	2	0.18	Qualified
			3	0.26	4	0.13	
	Core/cladding concentricity error	≤0.6μm	1	0.14	2	0.12	Qualified
			3	0.08	4	0.10	
	Cladding diameter	125.0±1μm	1	124.96	2	124.99	Qualified
			3	125.03	4	125.06	
Coating geometry diameter	250±15μm	1	254.79	2	255.42	Qualified	
		3	256.58	4	259.44		
Cladding/ Coating geometry concentricity error	≤12.5μm	1	4.89	2	3.94	Qualified	
		3	6.27	4	7.32		
8	Cutoff wavelength	B1: $\lambda_{cc} \leq 1260$	1	1212.79	2	1214.81	Qualified
			3	1213.82	4	1212.73	



NO.	Test Item	Requirements	Test Result				Conclusion	
				α_{1310}		α_{1310}		
9	Attenuation coefficient	B1: @1550nm : ≤ 0.35 dB/km	1	0.325	7	0.323	Qualified	
			2	0.316	8	0.331		
			3	0.322	9	0.317		
			4	0.326	10	0.325		
			5	0.313	11	0.324		
			6	0.318	12	0.329		
		B1: @1550nm : ≤ 0.19 dB/km		α_{1310}		α_{1310}		
			1	0.186	7	0.186		
			2	0.181	8	0.194		
			3	0.194	9	0.183		
			4	0.191	10	0.191		
			5	0.193	11	0.198		
10	Attenuation uniformity	There are no point discontinuities in excess of 0.10dB for single-mode fiber at 1310nm and 1550nm.	There are no point discontinuities in excess of 0.001dB for single-mode fiber at 1310nm and 1550nm.				Qualified	
11	Attenuation coefficient for wavelengths	①1285nm-1330nm @1310nm, ≤ 0.04 dB/km。 ②1525nm-1575nm @1550nm, ≤ 0.03 dB/km。	①1285nm-1330nm @1310nm, ≤ 0.002 dB/km。 ②1525nm-1575nm @1550nm, ≤ 0.001 dB/km。				Qualified	



NO.	Test Item	Requirements	Test Result				Conclusion	
12	Chromatic dispersion (B1.1)						Qualified	
	Zero-dispersion wavelength	$1300\text{nm} \leq \lambda_0 \leq 1324\text{nm}$	Fiber	λ_0	Fiber	λ_0		
			1	1318.11	3	1314.65		
			2	1318.04	4	1320.18		
	The maximum value of dispersion slope	$\leq 0.092\text{ps}/(\text{nm}^2 \cdot \text{km})$	Fiber	S_0	Fiber	S_0		
			1	0.0831	3	0.0843		
			2	0.0830	4	0.0820		
	The maximum absolute value of the dispersion coefficient $ D _{\text{max}}$ @1310nm	$1288 \sim 1339\text{nm}$ $\leq 3.5\text{ps}/(\text{nm} \cdot \text{km})$	Fiber	$ D _{\text{max}}$	Fiber	$ D _{\text{max}}$		
			1	2.747	3	2.440		
			2	2.721	4	2.936		
		$1271 \sim 1360\text{nm}$ $\leq 5.3\text{ps}/(\text{nm} \cdot \text{km})$	Fiber	$ D _{\text{max}}$	Fiber	$ D _{\text{max}}$		
			1	4.371	3	4.053		
			2	4.309	4	4.481		
	$ D _{\text{max}}$ @1550nm	$\leq 18\text{ps}/(\text{nm} \cdot \text{km})$	Fiber	$ D _{\text{max}}$	Fiber	$ D _{\text{max}}$		
			1	16.546	3	16.782		
2			16.557	4	16.271			



NO.	Test Item	Requirements	Test Result	Conclusion
13	Rated strength test	$\geq 100\text{RTS}(88.8\text{kN})$	The cable was broken at 94.95kN.	Qualified
14	Tensile performance test	40%RTS: no visible increase in optical attenuation and fiber strain.	No increase in optical attenuation and fiber strain.	Qualified
		60%RTS: fiber strain $\leq 0.25\%$, temporary increase of optical attenuation $\leq 0.05\text{dB}$.	No increase in optical attenuation and fiber strain.	
		After the test, there is no visual damage to the OPGW and no permanent increase in optical attenuation.	After the test, there was no visual damage to the OPGW and no permanent increase in optical attenuation. Detail results see Appendix 1.	
15	Stress-strain	Cable tension should reach to 30%、50%、70%and 85% and holding. After the test, there is no visual damage to the OPGW.	Detail results see Appendix 1.	Qualified
16	Sheave test	Tensile: 15%RTS Cycles: 15 Angle: $30^{\circ}\pm 2^{\circ}$ There is no visual damage to the OPGW. The allowable temporary / permanent attenuation: $\leq 0.1\text{dB/km}(1550\text{nm})$.	Tensile load: 13.5kN The temporary attenuation: $\leq 0.09\text{dB/km}(1550\text{nm})$. There was no visual damage to the OPGW and no permanent attenuation.	Qualified
17	Crush	The load: 2200N/100mm Duration time: 10min Cycles: 3 There is no visual damage to the OPGW. The allowable temporary/ permanent attenuation $\leq 0.05\text{dB/fiber}(1550\text{nm})$	The temporary attenuation: $\leq 0.022\text{dB/fiber}(1550\text{nm})$. There was no visual damage to the OPGW and no permanent attenuation.	Qualified



NO.	Test Item	Requirements	Test Result	Conclusion
18	Bend	Radius:15-20*Cable Diameter Two circles There is no visual damage to the OPGW. The allowable temporary or permanent attenuation: $\leq 0.05\text{dB}/\text{fiber}(1550\text{nm})$.	Radius:200mm The temporary attenuation: $\leq 0.026\text{dB}/\text{fiber}(1550\text{nm})$. There was no visual damage to the OPGW and no permanent attenuation.	Qualified
19	Twist	Load: 20%RTS Twist :90/m Cycles:2 Fiber length: $\geq 100\text{m}$ There is no visual damage to the OPGW. The allowable temporary or permanent attenuation: $\leq 0.1\text{dB}/\text{km}(1550\text{nm})$.	The temporary attenuation: $\leq 0.031\text{dB}/\text{km}(1550\text{nm})$. There was no visual damage to the OPGW.	Qualified
20	Aeolian vibration test	Tensile load: 20%RTS Cycles: $\geq 1 \times 10^7$ Frequency: $(830/d \pm 10)$ Hz There is no visual damage to the OPGW. The allowable temporary or permanent attenuation $\leq 1.0\text{dB}/\text{km}(1550\text{nm})$.	Tensile load: 17.8kN Frequency: (66-68)Hz Amplitude: (4.1 ± 0.3) mm The temporary attenuation: $\leq 0.029\text{dB}/\text{km}(1550\text{nm})$ There was no visual damage to the OPGW and no permanent attenuation.	Qualified
21	Galloping test	Tensile load: 2%RTS Vibration cycles: $\geq 1 \times 10^5$ Frequency: (1~4) Hz There is no visual damage to the OPGW. The allowable temporary or permanent attenuation: $\leq 1.0\text{dB}/\text{km}(1550\text{nm})$.	Tensile load: 1.8kN Frequency: (1.7-1.9) Hz Amplitude: 1.0m The temporary attenuation: $\leq 0.06\text{dB}/\text{km}(1550\text{nm})$. There was no visual damage to the OPGW and no permanent attenuation.	Qualified



NO.	Test Item	Requirements	Test Result	Conclusion
22	Creep test	Temperature: $22^{\circ}\text{C}\pm 2^{\circ}\text{C}$ Tensile load: $(25\%\pm 1\%)$ RTS Duration time:1000h	Detail results see Appendix 4.	Qualified
23	Short circuit test	Tensile load: $(15\sim 20)\%$ RTS Designed short-circuit capacity: $29.4\text{ kA}^2\cdot\text{s}$ (0.25s 40°C - 200°C) The allowable temporary or permanent attenuation: $\leq 0.05\text{dB}/\text{fiber}$ (1550nm). The temperature of any metallic component shall not exceed requirement. The temperature of the optical core $\leq 180^{\circ}\text{C}$. The residue tension: $\geq 75\%$ RTS.	Tensile load: 13.4kN Test short-circuit capacity $29.4\text{ kA}^2\cdot\text{s}$ $30.9\text{ kA}^2\cdot\text{s}$ $29.7\text{ kA}^2\cdot\text{s}$ The temperature of the optical core $\leq 84.8^{\circ}\text{C}$. Attenuation: $\leq 0.009\text{dB}/\text{fiber}$ (1550nm) The change of temperature during the test met the requirement of design. The residue tension: $\geq 75\%$ RTS. (See appendix 2).	Qualified
24	Lighting test	Tensile load: $(15\sim 20)\%$ RTS Lightning-level: I class (200A, 0.5s) The allowable temporary or permanent attenuation: $\leq 0.05\text{dB}/\text{fiber}$ (1550nm). The calculated residue tension: $\geq 83\%$ RTS.	Tensile load: 13.5kN There was no temporary or permanent attenuation ($0.005\text{dB}/\text{fiber}$) at 1550nm. There was no breakage in the outer layer. (See appendix 3).	Qualified
25	DC Resistance test	The calculated DC resistance of the OPGW is 1.085 Ohms/km at 20°C .	$1.060\Omega/\text{km}$ (at 20°C)	Qualified



NO.	Test Item	Standard & Request	Test Result				Conclusion		
			Cycle1		cycle 2				
			$\Delta\alpha_{1310}$	$\Delta\alpha_{1550}$	$\Delta\alpha_{1310}$	$\Delta\alpha_{1550}$			
26	Temperature cycling test	Temperature: -40°C ~ +65°C; Attenuation: ≤ 0.1 dB/km (1310/ 1550nm, based on 20°C).	-40 °C	1	0.001	0.002	0.001	0.002	Qualified
				2	0.002	0.001	0.003	0.001	
				3	0.001	0.001	0.002	0.001	
				4	0.003	0.003	0.002	0.001	
				5	0.002	0.001	0.001	0.002	
				6	0.003	0.001	0.001	0.000	
				7	0.004	0.001	0.002	0.002	
				8	0.003	0.001	0.001	0.001	
				9	0.002	0.002	0.001	0.001	
				10	0.001	0.001	0.000	0.002	
				11	0.002	0.001	0.002	0.001	
				12	0.000	0.001	0.001	0.002	
			+65 °C	1	0.001	0.001	0.001	0.001	
				2	0.001	0.001	0.002	0.001	
				3	0.000	0.001	0.001	0.002	
				4	0.001	0.001	0.001	0.001	
				5	0.001	0.000	0.000	0.002	
				6	0.000	0.001	0.002	0.000	
				7	0.001	0.001	0.001	0.001	
				8	0.001	0.002	0.001	0.002	
				9	0.002	0.001	0.002	0.002	
				10	0.001	0.001	0.001	0.001	
				11	0.001	0.001	0.001	0.001	
				12	0.002	0.001	0.001	0.002	
27	Water ingress test	The water should maintained at 0.5m high for 1h. No water is allowed to leak through.	No water is allowed to leak through.				Qualified		
28	Seepage of flooding compound	The flooding compound should not flow at 70°C for 24h.	There was no flooding compound flow.				Qualified		



Appendix 1 :

Results of Stress-strain & Tensile performance test

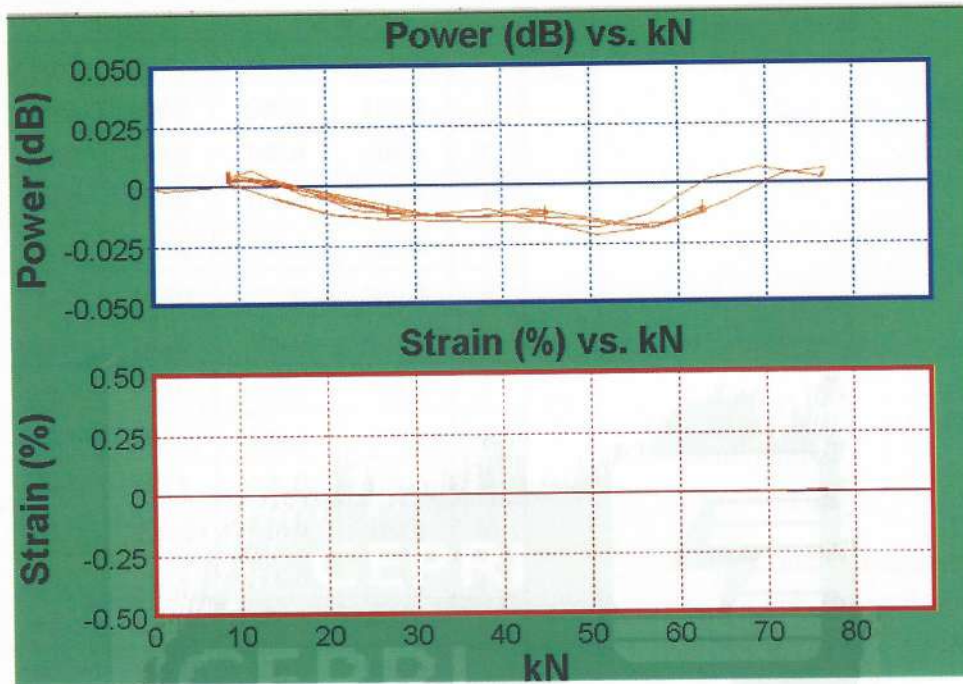


Figure 1-1: Optical Attenuation and Fiber Strain curve



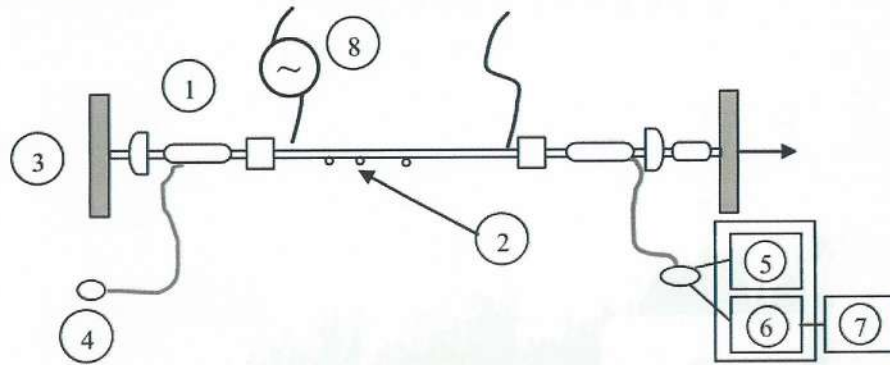
Figure 1-2: Stress-strain



Appendix 2:

Results of Short-circuit current test

1. Short-circuit current test setup figure



1. OPGW sample 2. thermocouple 3. Anchoring clamps 4. Fiber loop 5. light Source 6. Optical power meter
7. Data record meter 8. External power source line

Figure 2-1 Short-circuit current test setup

2. Thermocouple placement description

光缆型号: OPGW-48B1-79 [88.8;29.4]

光缆结构

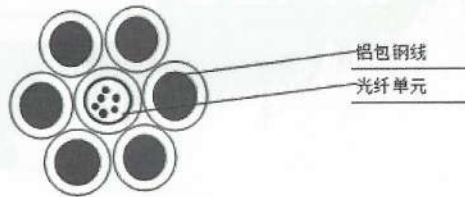


Figure 2-2 Figure for the thermocouple position

Thermocouple #1 – The OPGW cable surface

Thermocouple #2 –optical tube

Thermocouple #3 –Between AS wires and Optical tube



3. Test results

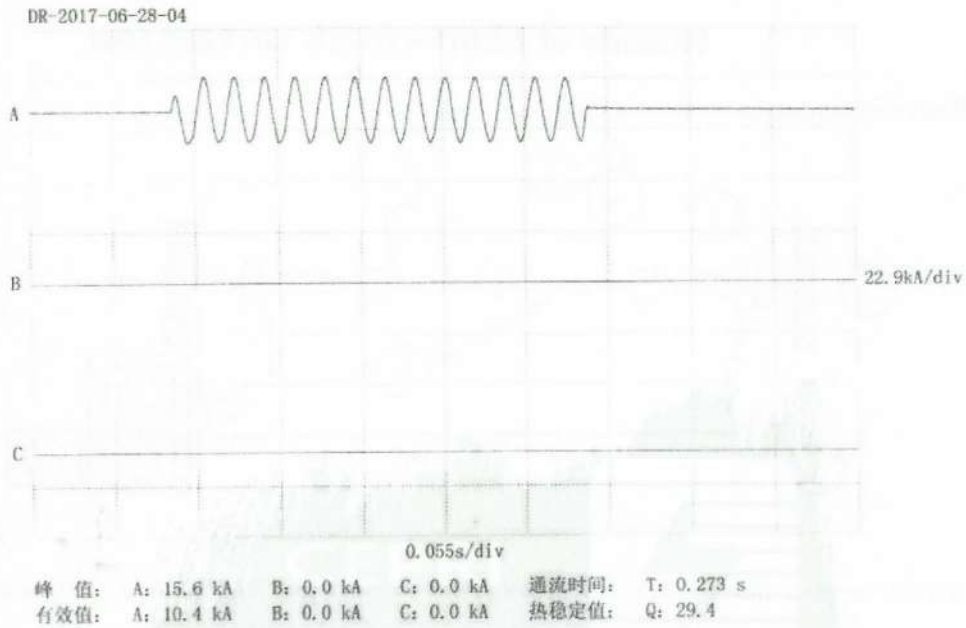
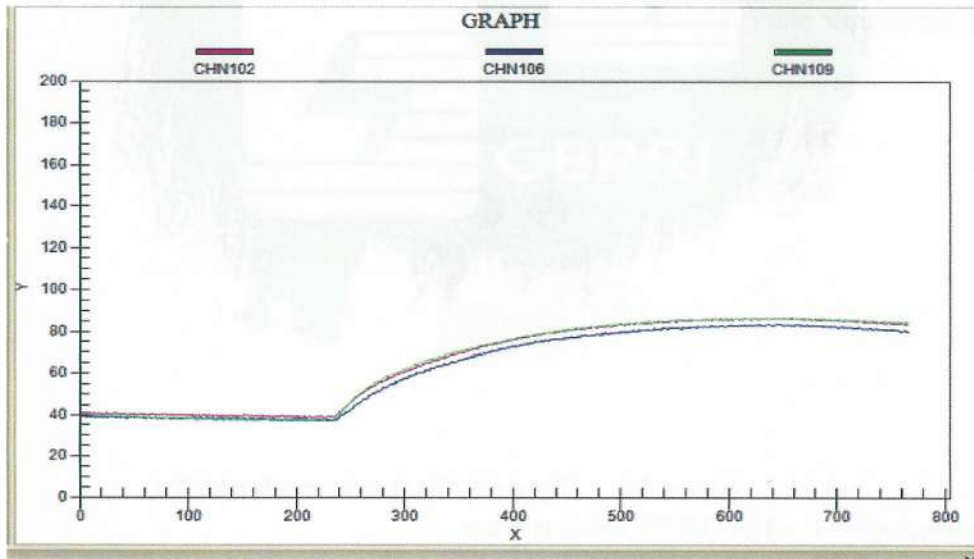


Figure 2-3 Waveform of pulse



The OPGW cable surface

80.4 °C (Blue)

optical tube

84.6°C (Green)

Between AS wires and Optical tube

83.7°C (Purple)

Figure 2-4 Temperature rise curve



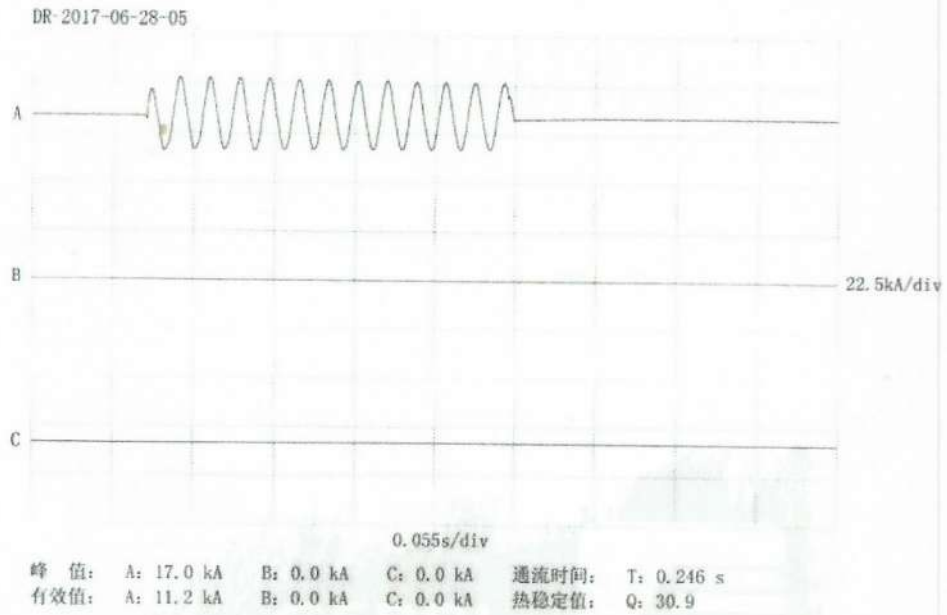
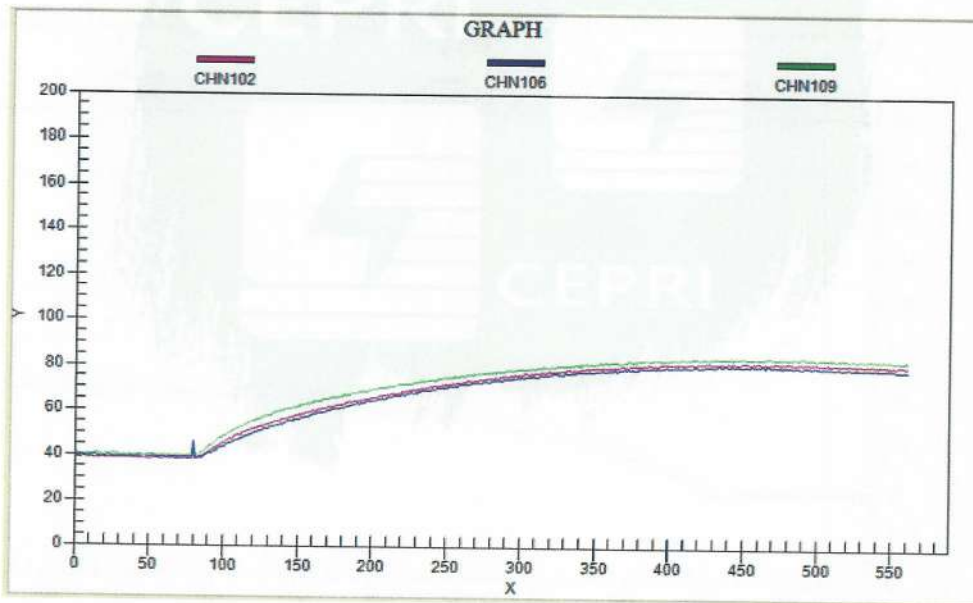


Figure 2-5 Waveform of pulse



The OPGW cable surface	79.1 °C (Blue)
optical tube	83.3 °C (Green)
Between AS wires and Optical tube	80.7 °C (Purple)

Figure 2-6 Temperature rise curve



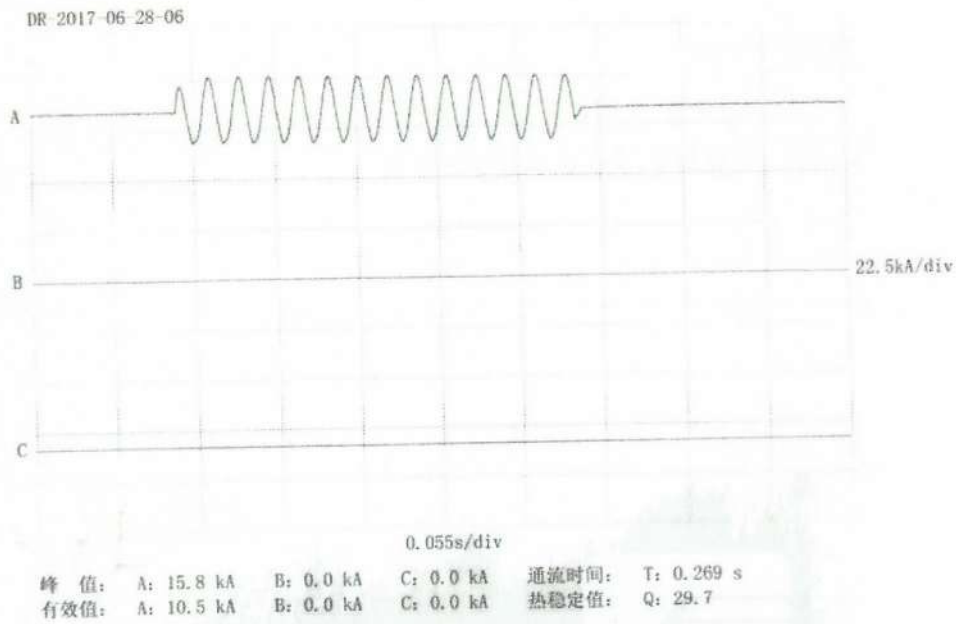
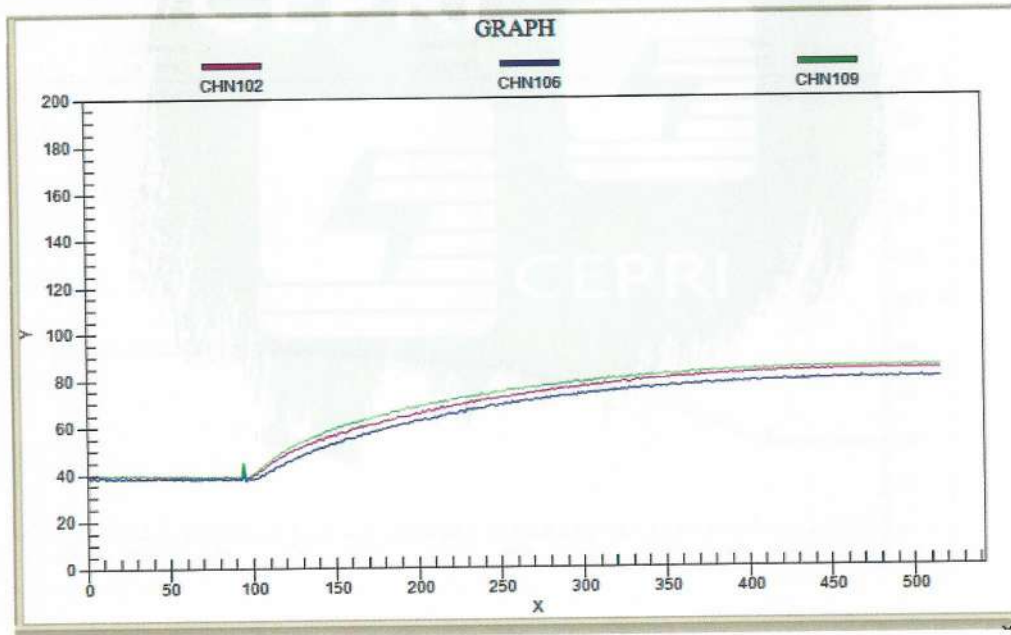


Figure 2-7 Waveform of pulse



The OPGW cable surface
optical tube

79.8°C (Blue)

84.8°C (Green)

Between AS wires and Optical tube

83.5°C (Purple)

Figure 2-8 Temperature rise curve



Appendix 3:**Results of Lightning test**

1. Test conditions:

Initial temperature: 25°C

Number of tests: 5

2. Sample Description:

RTS: 88.8kN

Outer diameter of OPGW: 12.30mm

OPGW structure: Outside layer 6×Φ4.10mm (AS)

Outer layer single wire material: 20.3%AS wires

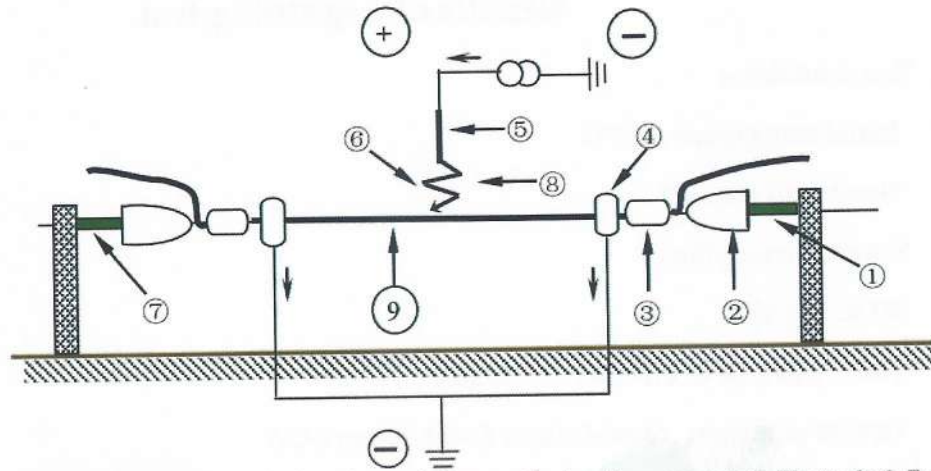
3. Test Results:

Table 3-1 Test result of lightning test

Cycle	Current	Duration time	Charge	Number of broken wires	Attenuation	Calculated residue tension
1st	200A	564ms	111.8C	0	0.003 dB/纤	100%RTS
2nd	200A	576ms	117.2C	0	0.005 dB/纤	100%RTS
3rd	200A	568ms	108.9C	0	0.003 dB/纤	100%RTS
4th	200A	548ms	103.8C	0	0.004 dB/纤	100%RTS
5th	200A	544ms	103.0C	0	0.005dB/纤	100%RTS



Figures:



1. Turnbuckle 2. Insulator 3. Anchoring clamps 4. Symmetrical earth connectors 5. Electrode 6. Fuse 7. Tension meter 8. Gap between electrode and cable surface 9. OPGW test sample

Figure3-1 Lightning test setup

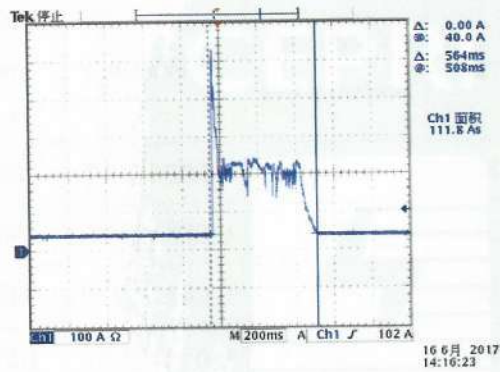


Figure 3-2 1st lightning result

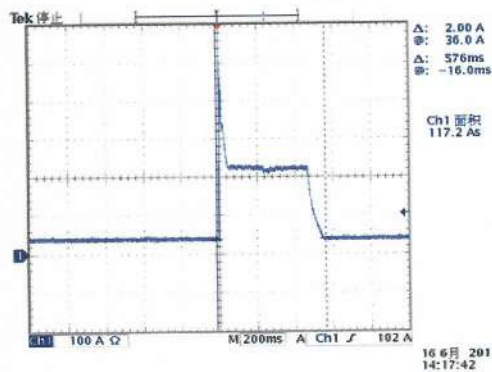


Figure 3-3 2nd lightning result



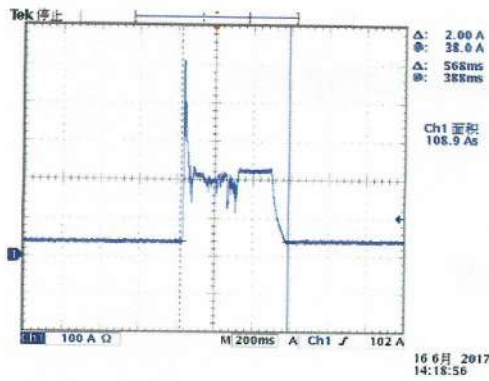


Figure 3-4 3rd lighting result

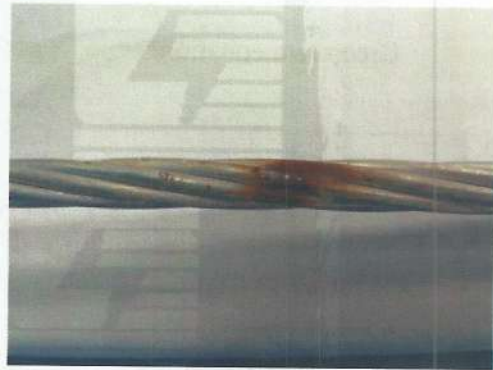
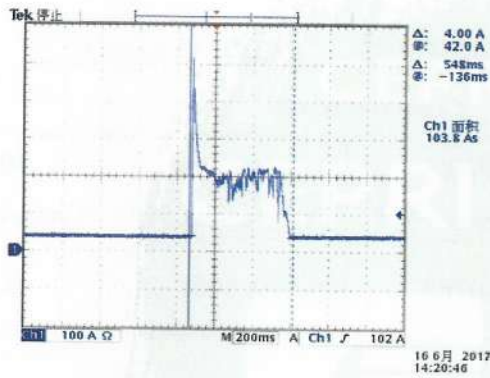


Figure 3-5 4th lighting result

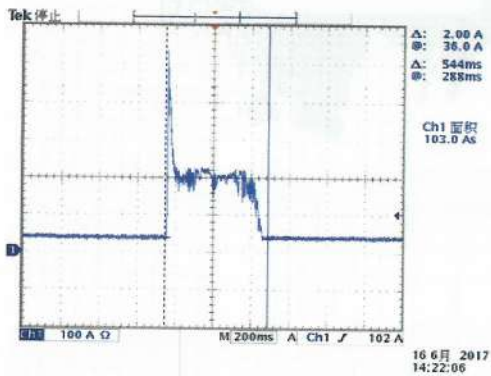


Figure 3-6 5th lighting result



Appendix 4:

Results of Creep test

1. Test conditions:

Outer diameter of OPGW: 12.3mm

Rated tensile strength (RTS): 88.8kN

Duration time: 1000 hours

Effective length of OPGW: 16m

Test tension: 22.2kN (25%RTS)

Test temperature: 20.0±2.0°C

2. Test result:

Creep rate equation: $\epsilon = 0.0422T^{0.0765}$ (Where T: hours)

Table4-1 Creep test result

Tension	Creep rate equation (%)	1000h Creep rate (%)	10 years Creep rate (%)	30 years Creep rate (%)
25%RTS	$0.0422T^{0.0765}$	0.0750	0.1056	0.1148

T: time (Unit: hours)

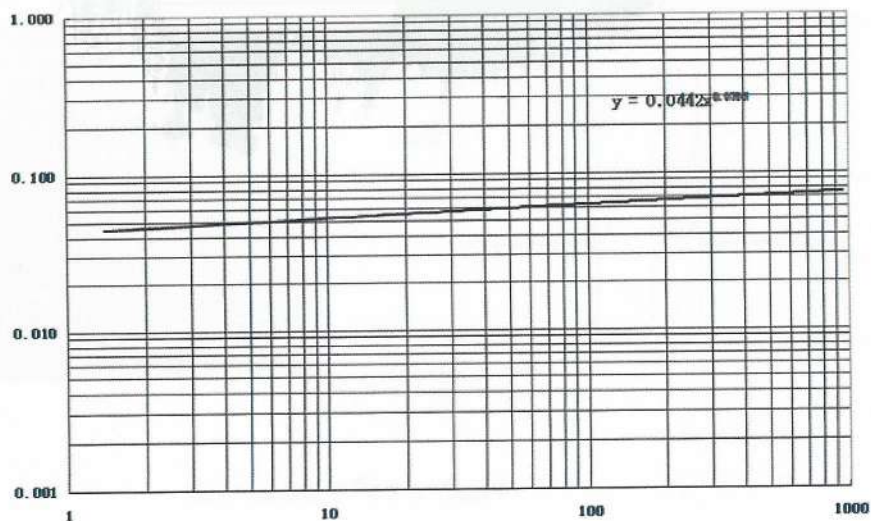


Figure 4-1 Fitting curve of creep test

