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RAW MATERIAL STANDARD OF OPTICAL FIBRE AND OPTICAL CABLE

UV-LED Curing Coating for
Optical Fibre Rev: 1.0 (2019)

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Asian-Pacific Optical Fiber and
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RAW MATERIAL STANDARD OF OPTICAL FIBRE AND OPTICAL CABLE

UV-LED Curing Coating for Optical Fibre

Rev:1.0(2019)

Issued by：
Asian-Pacific Optical Fiber and Cable Industry Association(APC)

Preface

Abstract: This standard specifies the classifications, technical requirements, methods of inspection, rules of inspection, identifications, packaging, transportations, storages and etcetera of UV-LED curing coating for optical fiber (LED coating for short).

Keywords: Coating, Fiber Drawing, Curing, UV-LED

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Contents

UV-LED Curing Coating for Optical Fiber

1 Scope

This standard specifies the classifications, technical requirements, methods of inspection, rules of inspection, identifications, packaging, transportations, storage and etcetera of UV-LED curing coating for optical fiber (LED coating for short).

Single coating, colored coating and special optical fiber coating are not applicable to this standard.

2 References

The following documents are essential for the application of this document. For dated references, only the dated version applies to this document. For undated references, the latest version (including all amendments) is applicable to this document.

Chinese National Standard GB / T 191-2008 Packing-pictorial Marking for Handling of Goods

Chinese National Standard GB / T 4472-2011 Determination of Density and Relative Density of Chemical Products

Chinese National Standard GB / T 1034-2008 Plastics-Determination of Water Absorption

Chinese National Standard GB / T 1040.1-2006 Plastics-Determination of Tensile Properties-Part 1: General Principles

Chinese National Standard GB / T 1040.2-2006 Plastics -Determination of Tensile Properties - Part 2: Test Conditions for Molding and Extrusion Plastics

Chinese National Standard GB / T 1040.3-2006 Plastics -Determination of Tensile Properties - Part 3: Test Conditions for Films and Sheets

Chinese National Standard GB 10006-88 Plastics-Film and Sheeting -Determination of the Coefficients of Friction

Chinese national Standard GB / T 6541-1986 Petroleum Products - Mineral Oils - Determination of Interfacial Tension of Oil against Water - Ring Method

Chinese National Standard GB / T 8170 Rules of Rounding off for Numerical Values & Expression and Judgment of Limiting Values

Chinese National Standard GB / T 22567-2008 Electrical Insulating Materials - Method of Test for the Determination of the Glass Transition Temperature

Chinese Communication Industrial Standard YD / T 839.1-2015 Filling Compounds and Flooding Compounds for Telecommunication Cable and Optical Fibre Cable Part 1: Test Methods

ASTM e831-2014 Standard Test Method for Linear Thermal Expansion of Solid Materials by Thermo Mechanical Analysis

ISO / IEC 11801-1 Information Technology - Generic Cabling for Customer Premises - Part1: General Requirements

ITU-T G.652 Characteristics of a Single -Mode Optical Fibre and Cable

ITU-T G.654 Characteristics of a Cut -off Shifted, Single -mode Optical Fibre and Cable

ITU-T G.655 Characteristics of a Non -zero Dispersion -shifted Single -mode Optical Fibre and Cable

ITU-T G.657 Characteristics of a Bending Loss Insensitive Single Mode Fiber and Cable for the Access Network

3 Terms and Definitions

The following terms and definitions are applicable to this document.

3.1 Granularity

It refers to the quantity of each type of particles per liquid coating, and the unit is piece/g.

3.2 Viscosity

In the two liquid layers separated by unit distance, the tangential force required to maintain unit velocity difference in the liquid layer per unit area.

3.3 Density

It is a measure of the mass in a specific volume. Density is equal to the mass of the object divided by the volume, which is represented by the symbol ρ .

3.4 Refractive Index

The ratio of the velocity of light in a vacuum to the velocity of light in the material.

3.5 Surface Tension

It refers to the surface tension of a gas or liquid layer acting on any boundary line along the surface due to the unbalanced molecular gravity.

3.6 Liquid Coating Stability

It refers to the ratio of change of viscosity of liquid coating after a test to that before a test.

3.7 Glass Transition Temperature

It refers to the temperature corresponding to the transition from high elastic state to glass state or from glass state to high elastic state.

3.8 Special Module

It refers to the result of Young's modulus when the strain of a material is at 2.5%.

3.9 Elongation at Break

It refers to the ratio of the length change before and after stretching to the original length when the material is broken by external force.

3.10 Tensile Strength

It refers to the maximum tensile load per unit of original cross section within the gauge length of the material sample, and the unit is MPa.

3.11 Cure Rate

The cure rate of the coating is characterized by the radiation dose when the maximum specific modulus reaches 95%, and the maximum specific modulus is obtained by fitting the growth curve of the modulus.

3.12 Water Extraction Rate

Under normal atmospheric pressure, the amount of mass change of an object in a specified size after immersion in water or water absorption under certain humidity and then dry it under certain conditions within a certain period of time, expressed in percentage.

3.13 Water Absorption Rate

Under normal atmospheric pressure, the amount of water absorbed by an object in a specified size immersed in water within a certain period of time or under a certain humidity, expressed in percentage.

3.14 Hydrogen Evolution

It refers to the phenomenon of hydrogen produced by materials under certain thermal aging conditions, expressed by the amount of hydrogen evolution, and the unit is μL/g.

3.15 Linear Expansion Coefficient

It refers to the elongation per unit length of an object when the temperature is increased by 1 ℃, and the unit is 10^{-6}/ ℃.

3.16 Peel Strength

It refers to the bonding strength between the inner coating and the glass plate after curing under certain conditions, and the unit is N/m.

3.17 Frictional Coefficient

It refers to that after the outer coating is cured into a film under certain conditions, the surfaces of the two cured films are placed flat together to have relative movement under certain contact pressure, which is generally characterized by dynamic friction coefficient.

4 Abbreviations

None

5 Rules of Revisions

When determining whether the value meets the requirements of the standard, the comparative method of rounding value specified in GB/T 8170 shall be used. The measured value shall be rounded to an even number first, and then compared with the standard value.

6 Classifications

Quartz glass fiber UV-LED optical fiber coating products are divided into inner layer optical fiber coating and outer layer optical fiber coating according to the use; single-mode optical fiber coating for G.652, G.654, G.655 and G.657, and multi-mode optical fiber coating for 50 / 125 and 62.5 / 125 according to the category of fiber; optical fiber coating for 250m and 200m according to the fiber diameter; optical fiber coating for communication and optical fiber coating for devices according to the use of optical fiber.

7 Names of Product Models

The product model and name shall fully reflect the classification information in Chapter 6. The manufacturer of the specific model can consult with the user.

8 Requirements

8.1 General Requirements

LED coating is generally a liquid material and which is mainly composed of acrylic resin (prepolymer and monomer), photo initiators and additives (including inhibitor, adhesion promoter, lubricant, active diluents, etc).

The typical working wavelengths of LED coating are 395 nm, 385 nm, 365 nm, etc.

8.2 Technical Requirements of Optical Fiber LED Coating for Communication

8.2.1 The performance parameters of LED coating for G.652 and G.657 single-mode optical fiber for 250μm communication should meet the requirements of Table 1.

Table 1. Technical requirements of LED coating for G.652 and G.657 single-mode optical fiber for 250 μm communication

Performance	Unit	Technical Requirements	
		Inner Layer	Outer Layer
Before Curing			
1.Apperance	-	Transparent Liquid	Transparent Liquid
2. Granularity（>2 μm concentration of granularity）	/g	≤100	≤100
3.Viscosity (25 ℃)	mPa.s	1000～10000	1000～10000
4.Density (20 ℃)	g/cm^3	0.90～1.20	1.00～1.20
5.Refractive Index (23 ℃)	-	1.46～1.50	1.48～1.55
6. Surface Tension (23 ℃)	mN/m	≤50	≤50
7. Liquid Coating Stability (7×24 h, 60 ℃ viscosity rise ratio)	%	≤10	≤10
After Curing			
8. Glass Transition Temperature	℃	≤-20	≥50
9. Special Module (23 ℃)	MPa	0.3～2	500～1500
10. Elongation at Break (23 ℃)	%	≥80	≥10
11. Tensile Strength (23 ℃)	MPa	≥0.2	≥30
12. Cure Rate	J/cm^2	≤0.8	≤0.5
13. Water Extraction Rate	%	≤4	≤4
14. Water Absorption Rate	%	≤6	≤4
15. Refractive Index (23 ℃)	-	1.47～1.51	1.50～1.57
16. Hydrogen Evolution (24h,80℃, inert gas protection)	μL/g	≤1	≤1
17. Curing Shrinkage (23 ℃)	%	≤10	≤10
18. Linear Expansion Coefficient Glass State High Elastic State	10^{-6}/℃	- ≤800	≤800 -
19. Peel Strength (23 ℃, 50% R.H)	$N/cm\times10^{-1}$	0.5～5.0	-
20. Frictional Coefficient (23 ℃, 50% R.H)	-	—	≤1.0
21. Thermogravimetric Change (aging 56×24 h, 85 ℃)	%	≤8	≤8

Note 1 – "After curing" refers to the curing state when the liquid coating with a certain film thickness is exposed under the UV light source, and its curing degree (% RAU) is as close as possible to 100%.
Note 2 – The glass transition temperature is only for the coating curing film, which should meet the temperature range of optical fiber specified in the national standard of practical applications.

8.2.2 The performance parameters of LED coating for G.654.x and G.655 single-mode optical fiber for communication should meet the requirements of Table 2.

Table 2. Technical requirements of G.654.x and G.655 for single-mode optical fiber for communication

Performance	Unit	Technical Requirements	
		Inner Layer	Outer Layer
Before Curing			
1.Apperance	-	Transparent Liquid	Transparent Liquid
2. Granularity（>2 μm concentration of granularity）	/g	≤100	≤100
3.Viscosity (25 ℃)	mPa.s	1000～10000	1000～10000
4.Density (20 ℃)	g/cm^3	0. 90～1. 20	1. 00～1. 20
5.Refractive Index (23 ℃)	-	1. 46～1. 50	1. 48～1. 55
6. Surface Tension (23 ℃)	mN/m	≤50	≤50
7. Liquid Coating Stability (7×24 h, 60 ℃ viscosity rise ratio)	%	≤10	≤10
After Curing			
8. Glass Transition Temperature	℃	≤-30	≥50
9. Special Module (23 ℃)	MPa	0. 1～1. 5	500～1500
10. Elongation at Break (23 ℃)	%	≥80	≥10
11. Tensile Strength (23 ℃)	MPa	≥0. 2	≥30
12. Cure Rate	J/cm^2	≤0. 8	≤0. 5
13. Water Extraction Rate	%	≤4	≤4
14. Water Absorption Rate	%	≤6	≤4
15. Refractive Index (23 ℃)	-	1. 47～1. 51	1. 50～1. 57
16. Hydrogen Evolution (24h,80℃, inert gas protection)	μL/g	≤1	≤1

17. Curing shrinkage (23 ℃)	%	≤10	≤10
18. Linear Expansion Coefficient Glass State High Elastic State	10^{-6}/℃	– ≤800	≤800 –
19. Peel Strength (23 ℃, 50% R.H)	N/cm×10^{-1}	0. 5～5. 0	–
20. Frictional Coefficient (23℃, 50% R.H)	-	—	≤1. 0
21. Thermogravimetric Change (aging 56×24 h, 85 ℃)	%	≤8	≤8
Note 1 – x in G.654x represents Class A, B, C and D in G.654's standard. Note 2 – "After curing" refers to the curing state when the liquid coating with a certain film thickness is exposed under the UV light source, and its curing degree (% RAU) is as close as possible to 100%. Note 3 – The glass transition temperature is only for the coating curing film, which should meet the temperature range of optical fiber specified in the national standard of practical applications.			

8.2.3 The performance parameters of LED coating for G.654E single-mode optical fiber for communication should meet the requirements of Table 3.

Table 3. Technical requirements of LED coating for G.654E single-mode optical fiber for communication

Performance	Unit	Technical Requirements	
		Inner Layer	Outer Layer
Before Curing			
1.Apperance	-	Transparent Liquid	Transparent Liquid
2. Granularity（>2 μm concentration of granularity）	/g	≤100	≤100
3.Viscosity (25 ℃)	mPa.s	1000～10000	1000～10000
4.Density (20 ℃)	g/cm^3	0. 90～1. 20	1. 00～1. 20
5.Refractive Index (23 ℃)	-	1. 46～1. 50	1. 48～1. 55
6. Surface Tension (23 ℃)	mN/m	≤50	≤50
7. Liquid Coating Stability (7×24 h, 60 ℃ viscosity rise ratio)	%	≤10	≤10
After Curing			
8. Glass Transition Temperature	℃	≤-30	≥50

9. Special Module (23 ℃)	MPa	0.1～1.2	800～1500
10. Elongation at Break (23 ℃)	%	≥80	≥10
11. Tensile Strength (23 ℃)	MPa	≥0.2	≥30
12. Cure Rate	J/cm^2	≤0.8	≤0.5
13. Water Extraction Rate	%	≤4	≤4
14. Water Absorption Rate	%	≤6	≤4
15. Refractive Index (23 ℃)	-	1.47～1.51	1.50～1.57
16. Hydrogen Evolution (24h,80℃, inert gas protection)	μL/g	≤1	≤1
17. Curing Shrinkage (23 ℃)	%	≤10	≤10
18. Linear Expansion Coefficient Glass State High Elastic State	10^{-6}/℃	– ≤800	≤800 –
19. Peel Srength (23 ℃, 50% R.H)	N/cm×10^{-1}	0.5～5.0	–
20. Frictional Coefficient (23 ℃, 50% R.H)	-	—	≤1.0
21. Thermogravimetric Change (aging 56×24 h, 85 ℃)	%	≤8	≤8
Note 1 – "After curing" refers to the curing state when the liquid coating with a certain film thickness is exposed under the UV light source, and its curing degree (% RAU) is as close as possible to 100%. Note 2 – The glass transition temperature is only for the coating curing film, which should meet the temperature range of optical fiber specified in the national standard of practical applications. Note 3 – G.652 and G.657 single-mode fibers with 180um diameter can also be used for reference.			

8.2.4 The performance parameters of LED coating for G.652 and G.657 single-mode optical fiber for 200 μm communication should meet the requirements of Table 4.

Table 4. Technical requirements of LED coating for G.652 and G.657 single-mode optical fiber for 200 μm communication

Performance	Unit	Technical Requirements	
		Inner Layer	Outer Layer
Before Curing			
1.Apperance	-	Transparent Liquid	Transparent Liquid
2. Granularity（>2 μm concentration of granularity）	/g	≤100	≤100
3.Viscosity (25 ℃)	mPa.s	1000～10000	1000～10000

4.Density (20 ℃)	g/cm^3	0. 90～1. 20	1. 00～1. 20
5.Refractive Index (23 ℃)	-	1. 46～1. 50	1. 48～1. 55
6. Surface Tension (23 ℃)	mN/m	≤50	≤50
7. Liquid Coating Stability (7×24 h, 60 ℃ viscosity rise ratio)	%	≤10	≤10
After Curing			
8. Glass Transition Temperature	℃	≤-30	≥50
9. Special Module (23 ℃)	MPa	0. 1～1. 5	500～1500
10. Elongation at Break (23 ℃)	%	≥80	≥10
11. Tensile Strength (23 ℃)	MPa	≥0. 2	≥30
12. Cure Rate	J/cm^2	≤0. 8	≤0. 5
13. Water Extraction Rate	%	≤4	≤4
14. Water Absorption Rate	%	≤6	≤4
15. Refractive Index (23 ℃)	-	1. 47～1. 51	1. 50～1. 57
16. Hydrogen Evolution (24 h,80 ℃, inert gas protection)	μL/g	≤1	≤1
17. Curing Shrinkage (23 ℃)	%	≤10	≤10
18. Linear Expansion Coefficient Glass State High Elastic State	10^{-6}/℃	- ≤800	≤800 -
19. Peel strength (23 ℃, 50% R.H)	$N/cm\times10^{-1}$	0. 5～5. 0	-
20. Frictional coefficient (23 ℃, 50% R.H)	-	—	≤1. 0
21. Thermogravimetric Change (aging 56×24 h, 85 ℃)	%	≤8	≤8
Note 1 – "After curing" refers to the curing state when the liquid coating with a certain film thickness is exposed under the UV light source, and its curing degree (% RAU) is as close as possible to 100%. Note 2 – The glass transition temperature is only for the coating curing film, which should meet the temperature range of optical fiber specified in the national standard of practical applications.			

8.2.5 The performance parameters of LED coating for multi-mode optical fiber (50/125 and 62.5/125) for communication should meet the requirements of Table 5.

Table 5. Technical requirements of LED coating for multi-mode optical fiber (50/125 and 62.5/125) for communication

Performance	Unit	Technical Requirements	
		Inner Layer	Outer Layer
Before Curing			
1.Apperance	-	Transparent Liquid	Transparent Liquid
2. Granularity（>2 μm concentration of granularity）	/g	≤100	≤100
3.Viscosity (25 ℃)	mPa.s	1000～10000	1000～10000
4.Density (20 ℃)	g/cm^3	0. 90～1. 20	1. 00～1. 20
5.Refractive Index (23 ℃)	-	1. 46～1. 50	1. 48～1. 55
6. Surface Tension (23 ℃)	mN/m	≤50	≤50
7. Liquid Coating Stability (7×24 h, 60 ℃ viscosity rise ratio)	%	≤10	≤10
After Curing			
8. Glass Transition Temperature	℃	≤-30	≥50
9. Special Module (23 ℃)	MPa	0. 1～1. 5	500～1500
10. Elongation at Break (23 ℃)	%	≥80	≥10
11. Tensile Strength (23 ℃)	MPa	≥0. 2	≥30
12. Cure Rate	J/cm^2	≤0. 8	≤0. 5
13. Water Extraction Rate	%	≤4	≤4
14. Water Absorption Rate	%	≤6	≤4
15. Refractive Index (23 ℃)	-	1. 47～1. 51	1. 50～1. 57
16. Hydrogen Evolution (24 h,80 ℃, inert gas protection)	μL/g	≤1	≤1
17. Curing Shrinkage (23 ℃)	%	≤10	≤10
18. Linear Expansion Coefficient Glass State High Elastic State	10^{-6}/℃	- ≤800	≤800 -
19. Peel Strength (23 ℃, 50% R.H)	$N/cm\times10^{-1}$	0. 5～5. 0	-
20. Frictional Coefficient (23 ℃, 50% R.H)	-	—	≤1. 0
21. Thermogravimetric Change (aging 56×24 h, 85 ℃)	%	≤8	≤8

Note 1 – "After curing" refers to the curing state when the liquid coating with a certain film thickness is exposed under the UV light source, and its curing degree (% RAU) is as close as possible to 100%.
Note 2 – The glass transition temperature is only for the coating curing film, which should meet the temperature range of optical fiber specified in the national standard of practical applications.

8.3 Technical Requirements of UV-LED Curing Coating for Optical Fiber Used in Devices

8.3.1 The performance parameters of LED coating for 250 μm and 200 μm single-mode optical fiber of G.652 and G.657 for devices should meet the requirements of Table 6.

Table 6. Technical requirements of LED coating for G.652 and G.657 single-mode optical fiber for devices

Performance	Unit	Technical Requirements	
		Inner Layer	Outer Layer
Before Curing			
1.Apperance	-	Transparent Liquid	Transparent Liquid
2. Granularity（>2 μm concentration of granularity）	/g	≤100	≤100
3.Viscosity (25 ℃)	mPa.s	1000～10000	1000～10000
4.Density (20 ℃)	g/cm^3	0.90～1.20	1.00～1.20
5.Refractive Index (23 ℃)	-	1.46～1.50	1.48～1.55
6. Surface Tension (23 ℃)	mN/m	≤50	≤50
7. Liquid Coating Stability (7×24 h, 60 ℃ viscosity rise ratio)	%	≤10	≤10
After Curing			
8. Glass Transition Temperature	℃	⩽-20	⩾50
9. Special Module (23 ℃)	MPa	changed to 0.1-1.5	500～1500
10. Elongation at Break (23 ℃)	%	⩾80	⩾10
11. Tensile Strength (23 ℃)	MPa	＞0.2	⩾30
12. Cure Rate	J/cm^2	⩽0.8	⩽0.5
13. Water Extraction Rate	%	⩽4	⩽4
14. Water Absorption Rate	%	⩽6	⩽4
15. Refractive Index (23 ℃)	-	1.47～1.51	1.50～1.57

16. Hydrogen Evolution (24h,80℃, inert gas protection)	μL/g	≤1	≤1
17. Curing Shrinkage (23 ℃)	%	≤10	≤10
18. Linear Expansion Coefficient Glass State High Elastic State	10^{-6}/℃	– ≤800	≤800 –
19. Peel strength (23 ℃, 50% R.H)	N/cm×10^{-1}	0. 5～5. 0	–
20. Frictional coefficient (23 ℃, 50% R.H)	-	—	≤1. 0
21. Thermogravimetric Change (aging 56×24 h, 85 ℃)	%	≤8	≤8
Note 1 – "After curing" refers to the curing state when the liquid coating with a certain film thickness is exposed under the UV light source, and its curing degree is as close as possible to 100%. Note 2 – The glass transition temperature is only for the coating curing film, which should meet the temperature range of optical fiber specified in the national standard of practical applications.			

8.3.2 The performance parameters of LED coating for multi-mode optical fiber (50/125 and 62.5/125) for devices should meet the requirements of Table 7.

Table 7. Technical requirements for multi-mode optical fiber (50/125 and 62.5/125) LED coatings for devices

Performance	Unit	Technical Requirements	
		Inner Layer	Outer Layer
Before Curing			
1.Apperance	-	Transparent Liquid	Transparent Liquid
2. Granularity（>2 μm concentration of granularity）	/g	≤100	≤100
3.Viscosity (25 ℃)	mPa.s	1000～10000	1000～10000
4.Density (20 ℃)	g/cm^3	0.90～1.20	1.00～1.20
5.Refractive Index (23 ℃)	-	1.46～1.50	1.48～1.55
6. Surface Tension (23 ℃)	mN/m	≤50	≤50
7. Liquid Coating Stability (7×24 h, 60 ℃ viscosity rise ratio)	%	≤10	≤10
After Curing			
8. Glass Transition Temperature	℃	≤-30	≥50

9. Special Module (23 ℃)	MPa	0.1-1.5	500～1500
10. Elongation at Break (23 ℃)	%	≥80	≥10
11. Tensile Strength (23 ℃)	MPa	＞0.2	≥30
12. Cure Rate	J/cm^2	≤1.0	≤0.8
13. Water Extraction Rate	%	≤4	≤4
14. Water Absorption Rate	%	≤6	≤4
15. Refractive Index (23 ℃)	-	1.47～1.51	1.50～1.57
16. Hydrogen Evolution (24 h,80 ℃, inert gas protection)	μL/g	≤1	≤1
17. Curing Shrinkage (23 ℃)	%	≤10	≤10
18. Linear Expansion Coefficient Glass State High Elastic State	10^{-6}/℃	- ≤800	≤800 -
19. Peel Strength (23 ℃, 50% R.H)	$N/cm\times10^{-1}$	0.5～5.0	-
20. Frictional Coefficient (23 ℃, 50% R.H)	-	—	≤1.0
21. Thermogravimetric Change (aging 56×24 h, 85 ℃)	%	≤8	≤8
Note 1 – "After curing" refers to the curing state when the liquid coating with a certain film thickness is exposed under the UV light source, and its curing degree (% RAU) is as close as possible to 100%. Note 2 – The glass transition temperature is only for the coating curing film, which should meet the temperature range of optical fiber specified in the national standard of practical applications.			

9 Methods of Inspection

9.1 General Principles

Alternative methods of inspection (to be studied) are allowed for performance inspection of coatings. In case of disputes, the test methods of inspection specified in this standard shall be as benchmark test methods.

9.2 Appearance and Granularity

Take the coating liquid sample and put it into a colorless transparent jar, and put it in the backlight environment. After the bubbles are completely eliminated naturally, move it to the natural light, and visually observe and record the results of inspection within 5minutes.

The granularity of the liquid coating shall be measured in accordance with Appendix A.

9.3 Viscosity

Measurement of viscosity of the liquid coating shall be measured in accordance with Appendix B.

9.4 Density

Determine the density of the liquid coating and solid coating respectively in accordance with the method of GB / T 4472-2011.

9.5 Refractive Index

Determine the refractive index of the liquid coating and coating curing film in accordance with the details specified in Appendix C.

9.6 Surface Tension

Determine the surface tension of the liquid coating in accordance with the details specified in Appendix D.

9.7 Liquid Coating Stability

The test shall be carried out in accordance with the provisions of Appendix B. The test temperature is 60 ℃ and the test period is 7 days. The rate of change of viscosity before and after the test shall be calculated.

9.8 Glass Transition Temperature

The glass transition temperature of the coating curing film shall be measured in accordance with Appendix E.

9.9 Special Module, Elongation at Break, Tensile Strength

The specific module, elongation at break and tensile strength of the cured film shall be determined in accordance with the details specified in GB / T1040.1-2006, GB / T1040.2-2006, GB / T1040.3-2006 and Appendix F.

9.10 Cure Degree

The cure degree of the cured coating shall be measured in accordance with Appendix G.

9.11 Cure rate

The cure rate of the liquid coating shall be measured in accordance with Appendix H.

9.12 Water Extraction Rate and Water Absorption Rate

Determine the water extraction rate and water absorption rate of the coating curing membrane in accordance with the details specified in GB / T 1034-2008 and Appendix I.

9.13 Hydrogen Evolution

According to YD / T 839.1-2015 Filling compounds and flooding compounds for telecommunication cable and optical fibre cable Part 1: Test methods: test hydrogen evolution of the inner coating and outer coating curing film respectively.

9.14 Curing Shrinkage

According to the method of GB / T4472-2011, determine the density of liquid coating and solid coating respectively, and calculate the curing shrinkage Sc of the sample according to formula (1):

$$Sc=(\rho_{solid}-\rho_{liquid})/\rho_{liquid}\times 100\% \quad \text{……(1)}$$

In the formula:

ρ_{solid} —— Density of cured material, unit is grams per cubic centimeters (g/cm^3).

ρ_{liquid} —— Density of liquefied coating, unit is grams per cubic centimeters (g/cm^3).

Measure three times in parallel, take the arithmetic mean value as the measurement result, and round to one decimal place.

9.15 Linear Expansion Coefficient

Test the linear expansion coefficient of coating curing film according to ASTM E831-2014 Standard Test Method for Linear Thermal Expansion of Solid Materials.

9.16 Peel Strength

The peel strength between the curing film of the inner coating and the glass shall be measured in accordance with Appendix J.

9.17 Frictional Coefficient

Determine the surface frictional coefficient of the curing film of the outer coating in accordance with the details specified in GB 10006-88 and Appendix K.

9.18 Thermogravimetric Changes

The thermogravimetric measurement of the cured film of the coating shall be carried out in accordance with the provisions of Appendix L.

10 Inspection

10.1 Classifications of Inspection

The inspection specified in this standard is divided into:

a) Output products inspection;

b) Type inspection.

10.2 Output Products Inspection

10.2.1 Production Batch

Under basically the same conditions, products produced with the same raw materials, process, equipment and time are adopted.

10.2.2 Inspection Lot

The same production batch is a batch of inspection.

10.2.3 Items of Inspection Procedure

Items of inspection for output products, technical requirements and test methods shall be carried out according to Table 8.

Table 8. Items of inspection for output products, technical requirements and test methods

Items of Inspection	Requirement Seal No.	Methods of Inspection Seal No.
Appearance	8	9.2
Granularity	8	9.2
Viscosity	8	9.3
Special Module	8	9.9
Elongation at Break	8	9.9
Tensile Strength	8	9.9

10.2.4 Sampling Plan

Three samples shall be randomly selected from the same batch of filled containers, and the capacity of each sample shall meet the total amount required for factory inspection.

10.2.5 Preparation of Cured Samples

10.2.5.1 Test Instruments and Materials

Test instruments and materials are as follows:

a) Light source: UV-LED light source that matches with the UV absorption wavelength of the coating, the radiation intensity of the light source is more than or equal to 5 W/cm^2, the wavelength range of the light source is 200 nm to 400 nm, and the setting for the amount of radiation shall ensure that the curing degree is as close as possible to 100%, such as 1 J/cm^2

b) Meter of UV illuminance: measure the energy of UV wavelength area of UV-LED light source

c) Facilities of nitrogen atmosphere

d) Base material: the glass plate is used for the inner coating; the outer coating shall be made of polyester film on top of the glass plate, and the middle part shall be padded to prevent the thermal conductivity effect of the glass

e) Coating applicator

10.2.5.2 Operation Steps

The operation steps are as follows:

a) Turn on the UV-LED light source according to the operation instructions of the instrument, turn on the nitrogen facilities, and set the appropriate flow rate, such as 0.2 m^3/min. After sufficient preheating and stable nitrogen atmosphere, the ultraviolet irradiance meter is placed in the middle of the conveyor belt to measure the amount of UV light. When the difference between the three test values of light measurement and the average value is less than 5%, the measurement results are effective, and the average value is taken as the measurement result. Adjust the conveyor belt speed to achieve the predetermined value of amount of radiation.

b) Place the applicator on the clean glass plate or polyester film for the outer coating, add a proper amount of liquid coating sample without bubbles, use the applicator and scrape the film. The

recommended range of film thickness is 0.050 - 0.150 mm.

c) Place the glass plate with the sample film of liquid paint in the center of the conveyor belt, and cure it with UV light source to prepare the cured sample.

10.2.6 Rules of Determination

10.2.6.1 Qualified

Three samples are tested according to the items specified in Table 8. If all the test results meet the requirements of Table 8, the batch of products will be determined as qualified.

10.2.6.2 Unqualified

If any one or more test results of any one of the three samples does not meet the requirements of Table 8, re-sampling is allowed for retest. If the retest results meet the requirements of 10.2.6.1, the batch of products is qualified. If any item is still unqualified, the batch is determined as unqualified.

10.2.7 Inspection Report

The qualified batch shall be issued with the output products inspection report.

10.3 Type Inspection

10.3.1 General Rules

Normally once a year. Type inspection shall be carried out under any of the following circumstances:

a) Identification of trial production of new products or products transferred to other factories;

b) After the formal production, if the structure, material and process are greatly changed, and the impact on product performance is assessed;

c) In the normal production process, after a certain amount period of production or after a period of accumulated production, a periodic inspection is carried out to check the stability of products' qualities;

d) The results of output products inspection are quite different from the previous results of type inspection;

e) The production is resumed after the production is stopped for more than three months;

f) When required by users.

10.3.2 Items of Inspection Procedure

The items inspection of type inspection are all the items of coating characteristics specified in Chapter 8. Carry out corresponding inspection and verification according to the corresponding inspection methods of optical fiber coating characteristics specified in Chapter 9.

10.3.3 Sampling Plan

One sample shall be randomly selected from the inspection batch during the output products inspection.

10.3.5 Rules of Determination

10.3.5.1 Qualified

If any test result of the sample meets the technical requirements of the corresponding products in chapter 8, the type inspection is qualified.

10.3.5.2 Unqualified

If one or more inspection results of the samples does not meet the requirements of Table 8, the preserved samples shall be retested. If the retest is still unqualified, the type inspection is unqualified.

10.3.6 Type Inspection Report

Issue type inspection of all the test items according to the technical requirements of the corresponding products in chapter 8.

11 Packaging, LOGO, Transportation and Storage

11.1 Packaging

The containers of packaged products shall be brown, gray or black polyethylene or polypropylene plastic bottles that are impervious to visible light and ultraviolet light and can be ventilated, with a standard capacity of 10 L. Other containers and capacity can also be used according to the user's requirements.

One or more of the following methods shall be used to distinguish the inner optical fiber coating and the outer optical fiber coating on the containers of packaged products:
a) Use two different colors of fonts for identification;
b) The border of the sign shall be marked with two different colors;
c) The background of the sign is marked with two different colors;
d) Other identification methods agreed between manufacturer and user.

11.2 Logo

Packages' logo shall include identifications of outer packaging papers (only for standard capacity packages, other non-standard capacity packages can be used or not used according to actual demand) and identifications of bottles. The product name, model and specification, batch number, production date or validity period, manufacturer's trademark, manufacturer's name, address, telephone number and postcode shall be indicated on the logos of outer packaging papers and bottles. The outer packaging box shall also be marked with "handle with care", "free from exposure to rain", "avoid sun exposure", "keep away from heat source" or other words or marks according to the provisions of GB /T191-2008. According to the user's requirements, other logos can also be used, such as typical working wavelength.

11.3 Transportation and Storage

Products shall be heat-proof, light-proof and water-proof during transportation, and extrusion and collision shall be prevented during transportation.

The product shall be stored in a dry room. The storage temperature is 0 ℃ - 40 ℃, dark.
For the product storage period, usually inner coating should not exceed 12 months from production date, outer coating should not exceed 18 months from production date.

11.4 Use Methods and Safety Precautions

Refer to Appendix M for the use method and safety precautions of the product.

Appendix A

(Standard Appendix)

Measuring Method of Granularity of Liquid Coatings

A.1 Overview

Measurement of granularity uses laser particle counter to detect the size and quantity of various particles in the liquid coating according to the scattering principle of light.

A.2 Instruments and Materials

The instruments needed for measurement are:

a) Laser particle counter;

b) Incubator;

c) Clean beaker.

A.3 Sample Preparation

Pour 15 g - 20 g of the coating sample into a clean beaker through the blank experiment (the granularity measured by the laser particle counter is 0), add the acetone solvent filtered through the 0.2 μm filter screen, which is nine times the weight of the coating sample, and wrap it with a dust-free cloth to prevent the particles from entering and affecting the experimental results.

A.4 Steps of Measurement

Place the pre-processing sample in the sample cell corresponding to the laser particle counter, and turn on the instrument for testing.

A.5 Results of Measurement

Measure twice in parallel according to the measurement procedure, record the results of measurement and calculate the average value. Obtain the value of particle concentration in the original coating by multiplying the value of particle concentration obtained from the solution sample by 10.

Appendix B
(Standard Appendix)
Measuring Method of Viscosity of Liquid Coatings

B.1 Overview

This method is suitable for measuring the viscosity of UV-LED curing coating.

B.2 Instruments

The instruments needed for measurements are:

a) Rotational viscometer;

b) Constant temperature water bath.

B.3 Sample Preparation

A proper amount of samples shall be taken and placed in the backlight environment to eliminate bubbles completely.

B.4 Steps of Measurement

Open the constant temperature water bath, when the water bath temperature is stable at 25 ℃± 0.2 ℃. Test the viscosity of the sample according to the instruction manual of the instrument, and record the displayed readings.

B.5 Results of Measurement

Measure twice according to the steps of measurement. The second measurement is effective when the difference between the value of the second test and the average value is less than 3%. Take the average value as the result of measurement.

Appendix C
(Standard Appendix)
Measuring Method of Refractive Index

C.1 Overview

This method is suitable for the measurement of refractive index of UV-LED curing fiber coating liquid and curing film.

C.2 Instruments and Materials

The instruments and materials required for measurement are as follows:

a) Refractometer: refractive index measurement range: 1.3000-1.7000, accuracy: ± 0.0002;

b) Constant temperature water bath;

c) Naphthalene bromide.

C.3 Sample Preparation

The samples are liquid coating and cut into a bright, clean transparent cured film with the length, width and thickness respectively are 1.0 cm ± 0.1 cm,1.0 cm ± 0.1 cm, 75 μ m ± 5 μm, with bright and clean transparent curing film on the surface. The curing membrane shall be prepared according to 10.2.5.

C.4 Steps of Measurement

The steps of measurement are as follows:

a) Place the calibrated refractometer in a place with sufficient light, open the constant temperature water bath, and make the water bath temperature stable at 23 ℃±0.2 ℃;

b) Separate the two prisms and drop a drop of liquid paint; or drop several drops of bromonaphthalene, stick the solid film sample on the prism with bromonaphthalene, close the prism, take off the protective cover as the light inlet surface, and use the reflected light to measure;

c) Record the reading according to the scale, and the reading shall be account to fourth decimal places.

C.5 Results of Measurement

Repeat the measurement twice according to the steps of measurement. When the difference between the two test values is not more than 0.0005, the result of measurement is valid. Take the average value as the result of measurement.

Appendix D
(Standard Appendix)
Measuring Method of Surface Tension of Liquid Coatings

D.1 Overview

This method is suitable for measuring the surface tension of liquid coating for UV curable optical fiber.

D.2 Summary

Proceed as GB / T 6541-1986 and the following details.

D.3 Instruments and Materials

Interfacial tensiometer (ring method - platinum ring method, or platinum plate method)

D.4 Sample Preparation

A proper amount of samples shall be taken and placed in the backlight environment to eliminate bubbles completely.

D.5 Steps of Measurement

The steps of measurement are as follows:

a) Wash the platinum ring or platinum plate and glass dish;

b) Turn on the power supply of the instrument and carry out the calibration according to the specified steps of the instrument;

c) Pour the sample that has adjusted to 23℃±0.2℃ into the glass dish. The platinum ring method needs to be 20 mm - 25 mm high. Place the glass cup in the middle of the tray, adjust the zero point and press the up key. The platinum ring will contact the sample to be tested, so that the platinum ring can penetrate into the liquid for 5 mm - 7 mm, press the stop key and read. The platinum plate method program sets the platinum plate immersion depth of 2 mm. Start the test, and record the surface tension value.

D.6 Results of Measurement

Repeat the measurement twice according to the steps of measurement. When the difference between the value of the second test and the average value is less than 5%, the result of measurement is valid. Take the average value as the result of measurement.

Appendix E
(Standard Appendix)
Measuring Method of Glass Transition Temperature of Coating Curing Film

E.1 Overview

The glass transition temperature can be measured by dynamic mechanical analyzer or thermomechanical analyzer. This standard takes the dynamic mechanical analyzer method as the standard test method and method of arbitration.

E.2 Instruments and Materials

The instruments and materials required for measurement are as follows:

A) Equipped with computer and dynamic mechanical analyzer of liquid nitrogen control system;

B) Caliper: accuracy 0.1 mm;

C) Flat head micrometer: accuracy 0.002 mm.

E.3 Sample Preparation

Due to the variety of dynamic mechanical instruments, the length and width of the sample are not specified, and the instrument manufacturer's recommendation is preferred; the solidified sample film with the recommended sample thickness range of 0.050 - 0.150 mm can be applied.

E.4 Conditions of Measurement

The conditions of measurement are as follows:

a) Measure the width and thickness of the sample, and the result shall be account to ± 5%;

b) The setting range of vibration frequency is 0.1Hz-1.0 Hz, and the amplitude should be within the linear visco-elastic range of the material (the recommended strain is less than 1%);

c) Temperature range: depending on the sample type, from the glassy area to the high elastic area of the sample;

d) Test at a sufficiently slow heating rate over the entire temperature range.

E.5 Steps of Measurement

The steps of measurement are as follows:

a) Enter the size of the sample into the computer software to measure the elastic modulus and viscosity modulus;

b) Mount the sample on the measuring fixture;

c) Enter the initial temperature, final temperature and the strain used in the starting stage of the test;

d) Conduct temperature scanning on the sample from low temperature to high temperature, and analyze the sample within the required measurement temperature range.

E.6 Results of Measurement

The highest point of the recorded loss factor tan δ - temperature curve is the glass transition temperature.

Appendix F
(Standard Appendix)
Measuring Method of Special Module, Elongation at Break and Tensile Strength of Coating Cured Samples

F.1 Overview

This method can be used to measure the special module, elongation at break and tensile strength of the curing film of UV cured optical fiber coating.

F.2 Summary

The special module, elongation at break and tensile strength of the coating cured samples shall be measured in accordance with GB / T1040.1-2006, GB / T1040.2-2006, GB / T1040.3-2006 and the following details.

F.3 Instruments and Materials

Instruments and materials for testing are as follows:

a) Electronic tensile machine; when measuring the outer coating, the application range of the sensor is 100 N – 200 N, the tensile speed range is 20 mm / min -100 mm / min, when measuring the inner coating, the sensor is 10 N - 50 N, and the tensile speed is 20 mm / min -100 mm / min;

b) Light source: meet the requirements of 10.2.5.1);

c) Sample fixture;

d) Base material: glass plate;

e) Coating applicator;

F.4 Sample Preparation

F.4.1 Inner Coating Film Sample

Prepare the rectangular curing sample film of inner coating on the clean glass plate according to the provisions of 10.2.5. The length and width of the sample are not specified, and the instrument manufacturer's recommendation is preferred; the recommended range of sample thickness is 0.050 mm-0.150 mm. The surface shall be flat, free of bubbles and cracks, with at least 3 samples in each group.

F.4.2 Cylindrical Sample of Outer Coating

The elongation at break and tensile strength of the coating film cannot represent the intrinsic value of the material. This method suggests that the outer coating be made into a cylindrical sample to obtain accurate elongation at break and tensile strength of the material. A pressure injection pump is used to inject the outer coating into the silica gel hose through the syringe. Suitable hoses with size such as 0.76 mm inner diameter and 1.65 mm outer diameter can be used. Bubble formation should be avoided during injection. Cut the silicone hose that needs to be injected with paint into proper length, for example 10cm. According to the provisions of 10.2.5, aluminum foil paper is pasted on the clean glass plate to reflect the light as well. The silica gel hose with coating is placed on the aluminum foil paper. After the curing step is completed, the cured cylindrical coating sample is extracted from the silica gel hose.

F.5 Conditions of Measurement

The measurement conditions are as follows:

a) Temperature: 23 ℃ ± 1 ℃;

b) Relative humidity (R.H.): 50% ± 5%;

c) Tensile speed: when measuring the outer coating, the applicable range of the sensor is 100 N – 200 N, the tensile speed range is 20 mm / min -100 mm / min, when measuring the inner coating, the sensor is 10 N -50 N, and the tensile speed is 20 mm / min -100 mm / min.

F.6 Steps of Measurement

The measurement shall be carried out as follows:

a) Measure the thickness and width of the sample, or the diameter of the coated cylindrical sample, and enter it into the control program;

b) Fix the sample on both ends of the position of sample of the electronic tensile machine and clamp it;

c) Turn on the test software to measure data and record.

F.7 Results of Measurement

Test three times in parallel, when the difference between the three test values and the average value is less than 5%, the measurement result is valid, take the average value as the measurement result.

Appendix G
(Standard Appendix)
Measuring Method for Cure Degree of Cured Coatings

G.1 Overview

The cure degree of the coating after curing is characterized by comparing the relative reduction of C = C bond of acrylic resin olefin in the coating before and after curing with the scanning of infrared spectrometer.

G.2 Instruments and Materials

Infrared spectrometer.

G.3 Sample Preparation

Samples of cured inner or outer coating films shall be prepared in accordance with 10.2.5.

G.4 Conditions of Measurement

Temperature: 23 ℃±1 ℃;

G.5 Steps of Measurement

The measurement steps are as follows:

a) Turn on the infrared spectrometer;

b) Measure the background spectrum;

c) Put a proper amount of liquid coating on the crystal surface and measure the infrared spectrum of the sample;

d) In the absorption peaks (810 nm, 1410 nm, 1635 nm) of acrylic resin olefin double bond, select the appropriate absorption peak integral which is not interfered by other chemical bonds, then set the standard absorption peak integral (select the appropriate constant absorption peak as the standard), the area SAL/ SRL integral ratio of the two absorption peaks is set as AU liquid;

e) Remove the curing film with the blade, and measure the infrared spectrum of the contact surface between the curing film and the glass plate with the infrared spectrometer;

f) Repeat step 6.7, the integral ratio of the areas of two absorption peaks of S_{AC} / S_{RC0} is determined as AU_{sample}.

G.6 Results of Measurement

The absolute cure rate is calculated according to Formula G.1:

$$\%RAU = \frac{AU_{liquid} - AU_{sample}}{AU_{liquid}} \times 100\% \quad \text{(G.1)}$$

In the formula:

%RAU —— cure degree (%RAU – Percentage Reacted Acrylate Unsaturation);

AU_{liquid} —— the ratio of the peak areas of two absorption peaks of AU_{liquid};

AU_{sample} —— the ratio of the peak areas of two absorption peaks of AU_{sample}.

Appendix H
(Standard Appendix)
Measuring Method for Cure Rate of Cured Coatings

H.1 Overview

The cure rate of the coatings is characterized by the amount of radiation when the maximum special module reaches 95%. The maximum special module is obtained by fitting the module's growth curve.

H.2 Instruments and Materials

The instruments and materials required for measurement are as follows:
A) Ultraviolet illuminance meter;
B) Light source: meet the requirements of 10.2.5.1.a);
C) Base material: glass plate;
D) Coating applicator;
E) Infrared spectrometer.

H.3 Sample Preparation

Prepare the liquid film of inner coating or outer coating as specified in 10.2.5.1.

H.4 Conditions of Measurement

The conditions of measurement are as follows:
a) Temperature: 23 ℃ ± 1 ℃;
b) Film thickness: the recommended range of sample thickness is 0.050 nm-0.150 mm.

H.5 Steps of Measurement

The steps of measurement are as follows:

a) Turn on the UV light source according to the operation instructions of the instrument, turn on the nitrogen facilities, and set the appropriate flow rate, such as 0.2 m^3 / min;
b) After sufficient preheating and stable nitrogen environment, place the ultraviolet irradiance meter in the middle of the conveyor belt to measure the amount of ultraviolet radiation (energy density). When the difference between the three test values of the amount of light and the average value is less than 5%, the measurement results are effective, and the average value is taken as the measurement result;
c) In the energy density range of 0 J / cm^2 - 1.0 J / cm^2, take at least 5 points from small to large for curing to obtain the cured sample film. For example, solidify at the energy density of 0.2 J/cm^2, 0.3 J/cm^2, 0.5J/cm^2, 0.75 J/cm^2, 1.0 J/cm^2, the target energy density shall be achieved by adjusting the conveyor belt speed under the condition of ensuring constant light intensity;
d) Obtain coating film samples cured at different energy densities and measure specific modulus in accordance with Appendix F. (since there is no need to obtain the elongation at break and tensile strength, the outer coating sample does not need to be cylindrical.);
e) Take the special module E as the Y-ordinate and the amount of UV radiation D as the X-ordinate, and fit the cure rate curve characterized by the module's growth according to the following Formula H.1 by the least square regression method.

$$E = E_{max}(1 - e^{-k(d - d_0)}) \quad \cdots\cdots (H.1)$$

In the formula:
E_{max} —— maximum special module;
K —— rate constant;
D_0 —— induced amount.

The above three parameters in the formula are obtained by the fitting curve. According to the fitting curve, the amount of UV radiation d when the maximum special module reaches 95% is taken as the characterizd index of cure rate.

Appendix I
(Standard Appendix)
Measuring Method for Water Extraction Rate and Maximum Water Absorption Rate of Cured Coatings

I.1 Overview

According to GB / T 1034-2008 and the following details.

I.2 Instruments

The instruments required for the test are as follows

a) Analytical balance: graduation value 0.0001 g;

b) Incubator;

c) Constant temperature water bath.

I.3 Sample Preparation

According to 10.2.5, prepare rectangular solidified sample films with length, width and thickness of 40 mm ± 1mm, 40 mm ± 1mm and 0.16 mm ± 0.05 mm respectively. The surface is flat, free of bubbles and cracks. Each group has 3 samples. Then dry the sample in a 50 ℃ incubator for 24 hours, cool it in a dryer to room temperature, and repeat this step until the weight change is less than 0.1 mg.

I.4 Conditions of Measurement

The measurement conditions are as follows:

a) Water temperature: 23 ℃ ± 2 ℃;

b) The water consumption of each group of test shall not be less than 150ml.

I.5 Steps of Measurement

The measurement steps are as follows:

a) Weigh the dried sample weight (m1), accurate to 0.1mg, one group for each 3 pieces of sample, put it into a container filled with distilled water, and soak it for 24 h at 23 ℃± 2 ℃;

b) After soaking for 24 hours, take out the sample, wipe off the water on the sample surface with clean filter paper, weigh the sample weight (m2), be precise to 0.1mg (take out the sample from the water for 1min to complete the weighing);

c) Dry the weighed sample in a 50℃ incubator for 24 hours, take it out and cool it to room temperature in a dryer, weigh the sample (m3), be precise to 0.1 mg, and repeat this step until the weight change is less than 0.1mg.

I.6 Results of Measurement

The water extraction rate is calculated according to formula I.1:

$$\text{water extraction rate} = (m1-m3) / m1 \times 100\% \quad \cdots\cdots (I.1)$$

The water absorption rate is calculated according to formula I.2:

$$\text{water absorption rate} = (m2-m3) / m1 \times 100\% \quad \cdots\cdots (I.2)$$

Appendix J
(Standard Appendix)
Measuring Method for Peel Strength between Curing Film and Glass of Inner Coating

J.1 Overview
By measuring the peel strength between the coating and the glass plate, the peel strength of the coating on the fiber glass core can be indirectly reflected.

J.2 Instruments and Materials
The instruments and materials required for measurement are as follows:
a) Electronic tensile machine;
b) Light source: UV light source matching the UV absorption wavelength of the coating;
c) Sample fixture;
d) Base material: clean glass plate (e.g. length × width × height = 120 mm × 50 mm × 4.5 mm).

J.3 Sample Preparation
Prepare liquid coating film with length, width and thickness of 90 mm ± 1 mm, 30 mm ± 1 mm and 160 μm ± 20 μm respectively on clean glass plate; use UV light source to match with UV absorption wavelength of coating to cure, radiation intensity of light source is more than 5 W / cm^2; curing degree (% RAU) is as close as possible to 100%, such as 1J/cm. Place the prepared sample in dark for 16-24 hours.

J.4 Conditions of Measurement
The measurement conditions are as follows:
a) Temperature: 23 ℃ ± 1 ℃;
b) Relative humidity (R.H.): 50% ± 5%;
c) Sensor: 50 N;
d) Test speed: 25 cm / min.

J.5 Steps of Measurement
The steps of measurement are as follows:
a) Take the peel strength test fixture and install it on the electronic tensile machine;
b) Remove one end of the sample for about 30 mm as the free end;
c) 90 ° angle peeling method or 180 ° angle peeling method can be used for the test. When the 90 ° angle peeling method is used, the free end of the sample is fixed to make the sample film peel vertically from the surface of the glass plate, and the glass plate is moved horizontally to ensure that the glass plate and the sample film always maintain a 90 ° angle; when the 180 ° angle peeling method is used, the glass plate is fixed, and the leading traction fixture is fixed on the upper sample clamp through the pulley, and the peeling angle of the sample film is close to 180°. Talcum powder shall be coated on the surface of solidified sample to avoid the interference of frictional force caused by traction clamp sliding on the mold of the sample.
d) The test length is 10 mm, read and record the peel strength data through the testing software.

J.6 Results of Measurement
Test three times in parallel, when the difference between the three test values and the average value is less than 10%, the measurement result is valid, take the average value as the measurement result.

Appendix K
(Standard Appendix)
Measuring Method for Frictional Coefficient of Outer Cured Coating

K.1 Overview

Proceed as GB 10006 and the following details.

K.2 Instruments and Materials

The instruments and materials required for measurement are as follows:

a) Electronic tensile machine;

b) Slide 63 mm × 63 mm, weight 200 g ± 2 g.

K.3 Sample Preparation

Prepare two kinds of liquid film on the clean glass plate with length, width and thickness of 20 cm ± 1 cm, 8 cm ± 0.5 cm, 160 μm ± 20 μm (sample 1) and length, width and thickness of 63 mm ± 1 mm, 63 mm ± 1 mm, 160 μm ± 20 μm (sample 2) respectively, and prepare the sample curing film according to 6.2.5. The sample film shall be flat, free of wrinkles and scars that may change the properties of friction, and the edge shall be smooth; the test is that the surface of the sample film shall be free of dust, fingerprints and any foreign substances that may change the properties of surface.

K.4 Conditions of Measurement

The conditions of measurement are as follows:

a) Temperature: 23 ℃ ± 2 ℃;

b) Relative humidity (R.H.): 50% ± 5%;

c) Sensor: 200 N;

d) Test speed: 100mm / min.

K.5 Steps of Measurement

The steps of measurement are as follows:

a) Fix the non-experimental surface of the cured film of sample 2 to the sliding block with double-sided tape;

b) The test surface of the curing film of sample 1 shall be upward and fixed on the horizontal test bench in a flat position;

c) Place the sliding block fixed with the sample in the center of the curing film of sample 1 without impact, and make the test direction of the two samples parallel to the sliding direction, and the force measuring system is just free of force;

d) Keep the two samples in contact for 15 seconds, and start the instrument to move the two samples relative to each other;

e) The average value of the force (excluding static friction) within 6 cm of relative movement of the two samples is the dynamic frictional force F.

K.6 Results of Measurement

The dynamic friction coefficient (μ_d) of the sample is calculated according to formula K.1:

$$\mu_d = F_d / F_p \quad \text{(K.1)}$$

In the formula:

μ_d —— dynamic friction coefficient;

F_d —— dynamic friction, N;

F_p —— normal force, N.

Test three times in parallel, when the difference between the three test values and the average value is less than 10%, the measurement result is valid, take the average value as the measurement result.

Appendix L
(Standard Appendix)
Measuring Method for Thermogravimetric Change of Cured Films

L.1 Overview

When the sample is heated, some small molecules will volatilize from the curing film, resulting in the weight change of the curing film. By weighing the mass of the sample before and after the heat, the change of the sample's thermal weight can be detected.

L.2 Instruments and Materials

The instruments and materials required for measurement are as follows:

a) Analytical balance: accuracy 0.0001 g;

b) Incubator;

c) Weighing bottle: φ 100 mm × 20 mm.

L.3 Sample Preparation

Prepare the liquid film with length, width and thickness of 10 cm ± 0.5 cm, 5 cm ± 0.5 cm and 150 μm ±10 μm respectively on the clean glass plate, and prepare the sample curing film according to 6.2.5. The film is placed in a constant temperature oven at 60℃ for 1 h and then in a dryer for 15 min.

L.4 Conditions of Measurement

The measurement conditions are as follows:

a) Heating temperature: 85 ℃± 2℃;

b) Heating time: (56 × 24) h.

L.5 Steps of Measurement

After weighing the sample, put it into the constant temperature box with a specified temperature, 56 × 24h later, take out the sample and place it in the dryer to cool it to the room temperature, and then weigh it.

L.6 Results of Measurement

The thermal weight loss of the sample, L_H (%) is calculated according to formula L.1:

$$L_H=（m_1-m_2）/m_1\times100\%\cdots\cdots \quad (L.1)$$

In the formula:

L_H —— thermal weight loss, %;

m_1 —— mass of sample before test, unit is g;

m_2 —— mass of sample after test, unit is g.

Test three times in parallel, when the difference between the three test values and the average value is less than 5%, the measurement result is valid, and the average value is taken as the measurement result.

Appendix M
(Standard Appendix)
Methods of Application and Safety Precautions of Coatings

M.1 Methods of Application

In the process of transportation or storage at low temperature of optical fiber coatings, phase separation may occur. At the same time, it is easy to produce bubbles during transportation. In order to avoid abnormalities, it is recommended to heat for several hours at a proper temperature before use to eliminate bubbles.

M.2 Safety Precautions

M.2.1 Overview of Risks

M.2.1.1 Category of Hazard

There are usually several items listed in Table M.1 according to the category of hazard of coatings.

Table M.1 Common Categories of Hazard of Coatings

Categories of Risks GHS	Possible Hazards
skin corrosion / category of irritation 2	Cause skin irritation
category of skin sensitizer 1	may cause allergic reaction of skins
Severe eye injury / category of eye irritation 2	cause serious eye irritation

M.2.2 Protective Measures

Protective measures usually include:

- Respiratory protection: generally, personal respiratory protection equipment is not required. Eye protection: wear safety goggles.
- Skin and body protection: wear protective clothing.
- Hand protection: wear protective gloves.
- Other protection: smoking, eating and drinking are prohibited at the work site. After work, shower and change clothes. Keep good hygiene habits.

M.2.3 First Aid Measures

First aid measures usually include:

- Quickly leave the site to the place with fresh air; keep respiratory tract unobstructed; get medical attention immediately.
- Rinse and drink water; get medical attention immediately.
- Immediately remove the contaminated clothes and wash with a large amount of flowing water for at least 15 minutes; get medical attention immediately.
- Wash eyes carefully with water for at least 15 minutes; if wearing contact lenses and it is easy to take them out, take them out and continue to wash the eyes; get medical attention immediately.

M.2.4 Fire Fighting Measures

M.2.4.1 Fire Extinguishing Media

Use dry powder, carbon dioxide and foam extinguisher to extinguish fire.

M.2.4.2 Harmful Combustive Products
Carbon monoxide, carbon dioxide.

M.2.4.3 Precautions and Protective Measures for Fire Fighting
Isolate the accident site and forbid irrelevant personnel to enter; fire fighters shall put out the fire in the upwind direction; firefighters and other people in contact shall bring their own air breathing devices, wear complete fire-proof clothing and use fire-fighting equipments matching with the site and surrounding environment.

M.2.5 Leakage Emergency Treatment
M.2.5.1 Personnel Protection Measures, Protective Equipments and Emergency Response Procedures
Evacuate irrelevant personnel and isolate the leakage pollution area. It is recommended that emergency treatment personnel wear protective masks and protective clothing, and do not contact with the leakage directly.

M.2.5.2 Environmental Protection Measures
This product will cause water pollution and prevent it from entering sewers, surface water and groundwater.

M.2.5.3 Storage, Removal Methods and Disposal Materials of Leaked Chemicals
In case of a small amount of leakage, inert adsorptive materials can be used to absorb the leakage, and in case of a large amount of leakage, embankment shall be built for control. The attachment or collection can be stored in a suitable closed container and discarded according to the relevant local laws and regulations. Remove all sources of ignition and use fire flower-proof tools and anti-explosion equipment.

M.2.6 Handling and Storage
M.2.6.1 Operation Precautions
Maintain adequate ventilation, especially in closed areas. Eye wash and shower facilities shall be set near the workplace. Equip with leakage emergency treatment equipment. Use explosion-proof electrical appliances, ventilation, lightings and other equipments. Keep away from sources of fire and heat. Smoking is strictly prohibited in the workplace. Operators shall wear goggles, protective clothing and gloves.

M.2.6.2 Storage Precautions
Containers should be sealed and be placed in dry, well ventilated positions. The opened container must be closed again and kept upright to prevent leakage. Store in a cool and ventilated warehouse. Keep away from fire and heat. Keep away from light and prevent ultraviolet light. Packages should be sealed. The area of storage shall be equipped with appropriate materials to contain the leakage.

From the date of production, the period of storage of inner coating is 12 months, and that of outer coating is 18 months. If the coating is beyond the storage validity, it is recommended to contact the manufacturer for retest, and determine whether it can continue to be used according to the test results.