Fujikura

**Reliability test report for SR15-9/125-ACL**
**(SM Fiber with high temperature resistant acrylate coating)**

## Introduction

This document describes the reliability test results on Fujikura's SR15-9/125-ACL.

## 1. Product specification

| | |
|---|---|
| Operating Wavelength | 1550 nm |
| Mode Field Diameter | 9.8±0.7 μm at 1550nm |
| Core concentricity error | ≤0.7 μm |
| Cladding diameter | 125.0±1.0 μm |
| Cladding non-circularity | ≤1 % |
| Coating diameter | 245±10 μm |
| Attenuation | ≤0.25 dB/km at 1550 nm |
| Fiber cutoff wavelength | ≤1.3 μm |
| Maximum operating temperature | 200 °C |
| Proof level | ≥1 % (≥100 kpsi) |

## 2. Test items and results

The following tests are performed to confirm the quality of SR15-9/125-ACL.

2-1. Environmental tests at high temperature

1. Attenuation changing (200°C, 150 °C)
2. Coating diameter changing (200 °C, 150 °C)
3. Thermo Gravimetry and Differential thermal analysis (30 °C up to 400 °C)

2-2. Mechanical tests at high temperature

1. Tensile strength on short-length fiber (200 °C, 150 °C)
2. Dynamic fatigue value ($n_d$) (200 °C, 150 °C)

The following sheets contain the purposes, procedures and results of the tests.

| Item No. | Test Item |
|---|---|
| 2-1-1 | Attenuation changing (200 °C , 150 °C ) |

## Introduction

This test is performed to evaluate the stability of attenuation of SR15-9/125-ACL by using a loss measurement system.

## Procedure

Method ; Backscattering technique (ITU-T G650)

Specimen ; 1000 m length fiber to each condition.

Apparatus ; Optical time domain refract meter

Wavelength ; 1310 nm or 1550 nm

Test condition ; 200 °C 7days, 150 °C 30days/100days

## Results

Table1. Attenuation variation at operating wavelength 1310nm.

| | Condition | Duration | Attenuation variation (dB/km, @1310 nm) |
|---|---|---|---|
| Attenuation changing | 200 °C | 7 days | ≦0.01 |
| | 150 °C | 30 days/100days | |

Table2. Attenuation variation at operating wavelength 1550nm.

| | Condition | Duration | Attenuation variation (dB/km, @1550 nm) |
|---|---|---|---|
| Attenuation changing | 200 °C | 7 days | ≦0.01 |
| | 150 °C | 30 days/100days | |

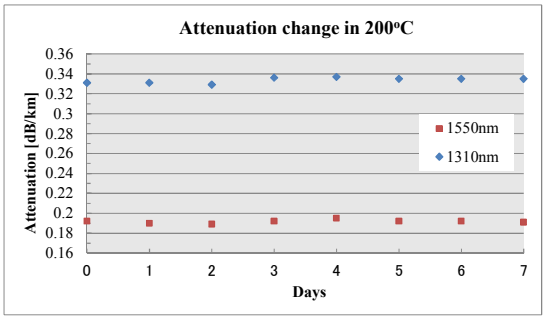


Fig. 1 Attenuation change in 200 °C

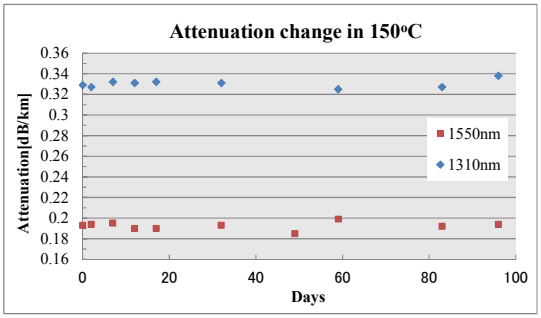


Fig. 2 Attenuation change in 150 °C

Table 1, 2 and Fig.1, 2 shows the results of attenuation variation. We obtained not more than 0.01dB/km variation at both 1310 nm and 1550 nm.

| Item No. | Test Item |
|---|---|
| 2-1-2 | Coating resin diameter changing (200°C , 150°C ) |

## Introduction

This test is performed to evaluate the coating resin stability of SR15-9/125-ACL.

## Procedure

Specimen ; 0.1 m length fiber to each condition.
; Diameter of 125 μm clad and 240 μm coating

Test condition ; 200°C 7days, 150 °C 30days

## Results

Table3. Coating resin decrement.

| | Condition | Duration | Coating resin decrement (μm) |
|---|---|---|---|
| Coating resin diameter changing | 200 °C | 7 days | 25 |
| | 150 °C | 30 days | 10 |

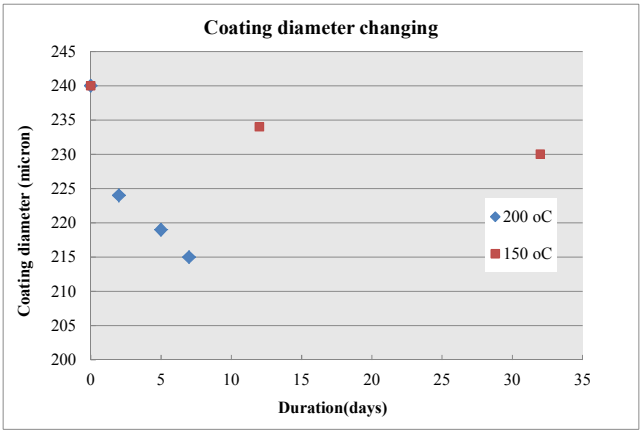


Fig. 3. Coating resin diameter changing.

Table 3 and Fig.3 shows the results of coating resin decrement. We obtained only 25 μm coating resin decrement and it shows good coating stability.

| Item No. | Test Item |
|---|---|
| 2-1-3 | Thermo Gravimetry and Differential thermal analysis |

## Introduction

This test is performed to evaluate the coating resin stability of SR15-9/125-ACL.

### Thermo Gravimetry(TG)

A technique in which the mass of the sample is monitored against time or temperature while the temperature of the sample, in a specified atmosphere, is programmed.

### Differential thermal analysis(DTA)

A technique in which the difference in temperature between the sample and a reference material is monitored against time or temperature while the temperature of the sample, in a specified atmosphere, is programmed.

## Procedure

Specimen ; Coating resin of SR15-9/125-ACL.

Test condition ; 30 °C up to 400 °C, 2 °C /min, at air

## Results

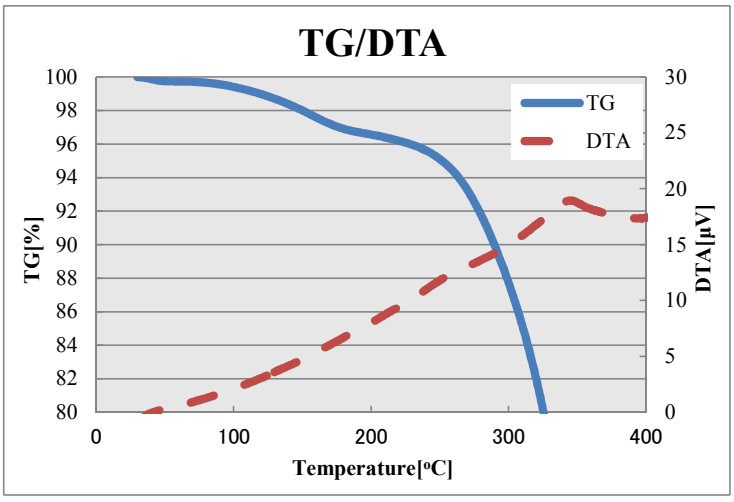


Fig. 4. TG/DTA.

Fig.4 shows the coating resin is stable until around 250 °C. In the condition under 200 °C, we use the fiber without problem.

| Item No. | Test Item |
|---|---|
| 2-2-1 | **Tensile strength on short length fiber** |

## Introduction

This test is performed in accordance with IEC and GR-20 to evaluate the tensile strength of unaged/aged fibers.

## Procedure

Method ; Tensile strength of optical fibers (IEC60793-1-B2)

Specimen ; 0.5 m length of fiber per test

Strain rate ; 10 %/min.

Number of test ; 10 times

Aging condition ; Aging conditions are listed below.

| | Condition | Duration |
|---|---|---|
| Origin | 23 +/- 5 °C | NA |
| High temperature aging | 200 °C | 7 days |
| | 150 °C | 30 days/100days |

## Criteria

Unaged fiber : Not less than 3.8 GPa at F(50) value. (GR20 recommended)

Aged fiber :Not less than 3.03 GPa at F(50) value. (GR20 recommended)

## Results

Table4. Tensile strength.

| | Condition | Duration | F(50) value(GPa) |
|---|---|---|---|
| Origin | 23+/- 5 °C, | NA | 5.1 |
| High temperature aging | 200 °C | 7 days | 5.3 |
| | 150 °C | 30 days / 100days | 5.1 / 5.2 |

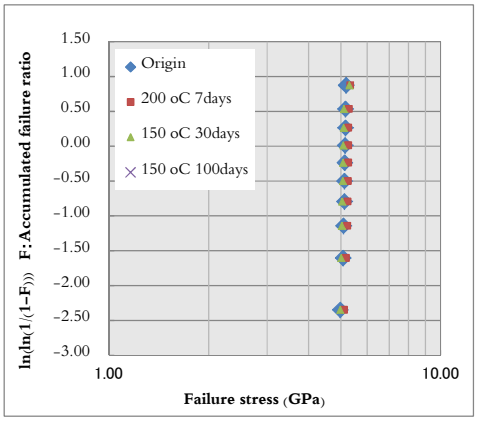


Fig. 5. Weibull distribution of tensile strength.

Weibull plot parameter of tensile strength is shown in Table 4. The origin has 5.1GPa, on the other hand, the aged (150 °C, 100days) has 5.2 GPa. It is found that the fiber has a good tensile strength.

| Item No. | Test Item |
|---|---|
| 2-2-2 | Dynamic fatigue value ($n_d$) |

## Introduction

This test is performed in accordance with IEC and GR-20 to get the dynamic stress corrosion susceptibility parameter of unaged/aged fibers.

## Procedure

Method ; Dynamic fatigue by axial tension (IEC60793-B7A)

Specimen ; 0.5 m length of fiber per test

Strain rate ; 100 %/min., 10 %/min., 1 %/min., 0.1 %/min.

Number of test ; 10 times

## Criteria

The dynamic stress corrosion susceptibility parameters, $n_d$, should be ≧ 18. (GR20 recommended)

## Results

Table5. Dynamic fatigue value($n_d$).

| | Condition | Duration | $n_d$ |
|---|---|---|---|
| Origin | 23+/- 5 °C, | NA | 20 |
| High temperature aging | 200 °C | 7 days | 20 |
| | 150 °C | 30 days / 100days | 20 / 21 |

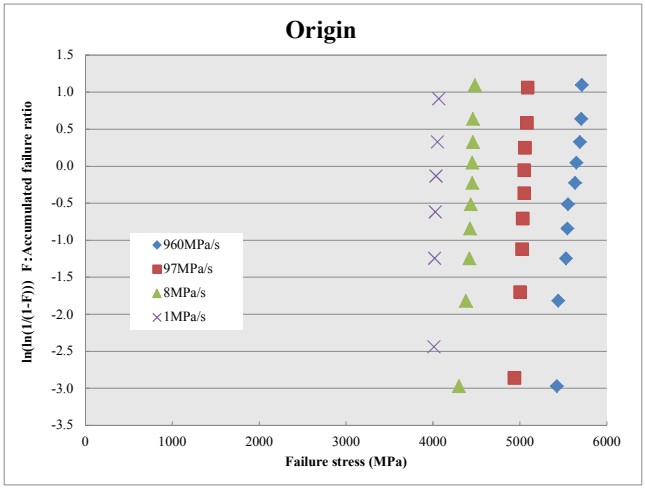


Fig. 6. Weibull distribution (origin, $n_d$ =20).

The origin has 20, on the other hand, the aged (150 °C, 100days) has 21.

It is found that our fiber's $n_d$ is upper GR20 recommended one, even if the fiber is aged.

## 3. Conclusion

We developed single-mode fiber with high temperature resistance coating. It was confirmed that this fiber has small attenuation variation (≦0.01dB/km) in 150°C or 200°C and good coating stability. The tensile strength is 5.1GPa (aged) and dynamic fatigue value ($n_d$) is 20(aged). It will be applied to a harsh environment like Oil & Gas industry.