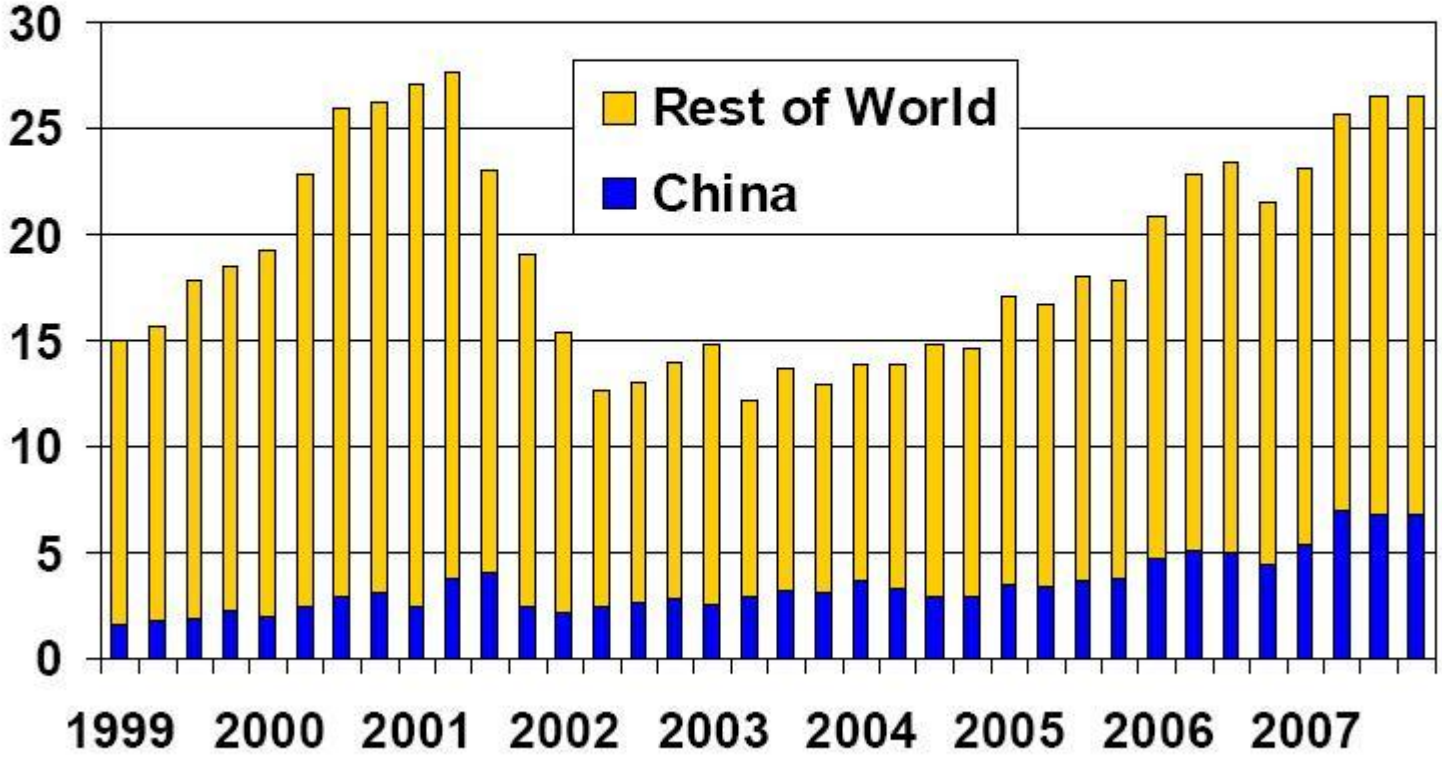
A Small Company's Mission-Oriented Research in the Changing World of Optical Fiber Communication

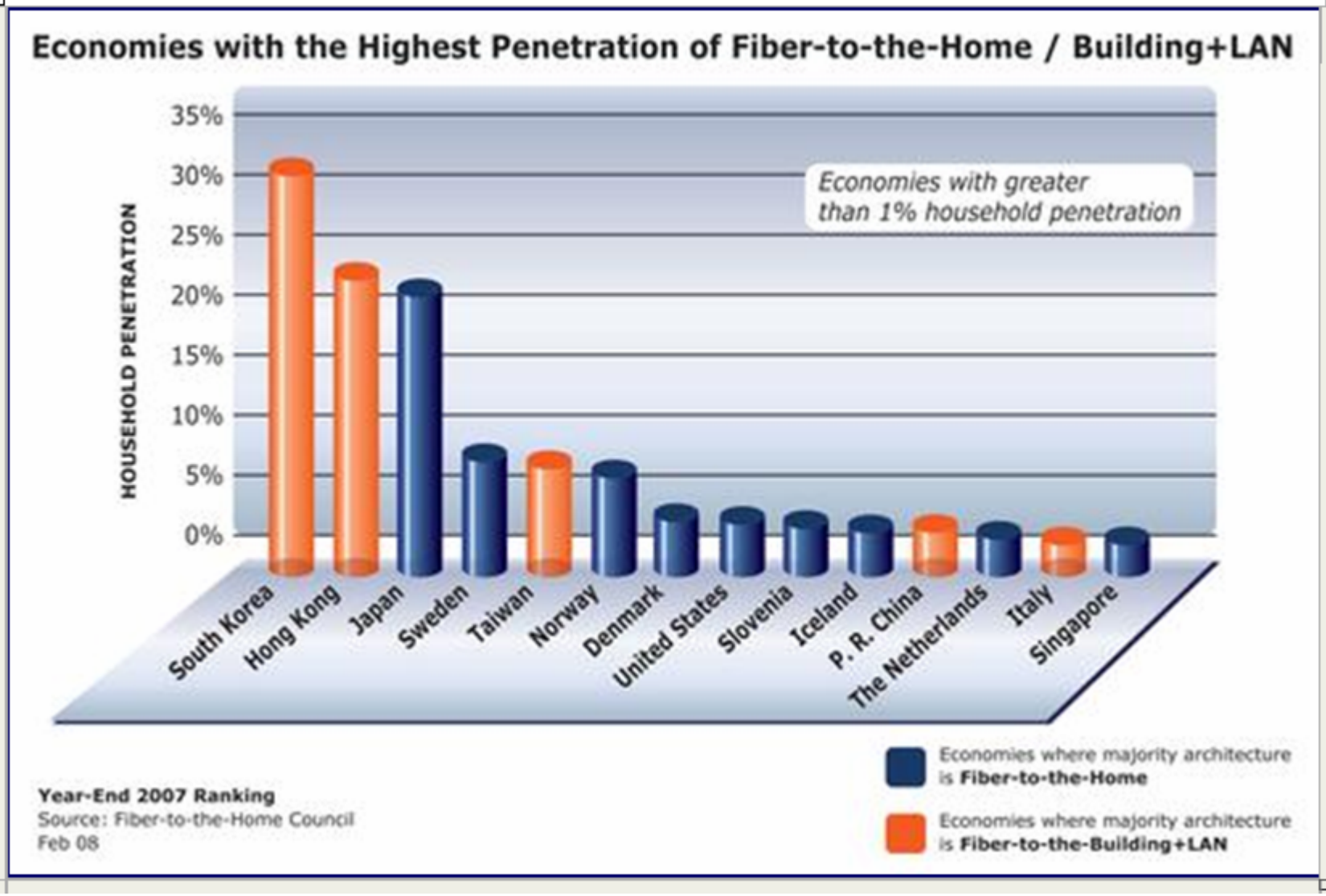
Hen-Tai Shang Prime Optical Fiber Corporation

向亨台 卓越光纖（POFC）2008/4/23

Cabled Fibre Demand by Quarter

(Million Fibre-km)




Economies with the Highest Penetration of Fiber-to-the-Home / Building+LAN
HOUSEHOLD PENETRATION
35%
30%
25%
20%
15%
10%
5%
0%
Economies with greater than 1% household penetration
South Korea
Hong Kong
Japan
Sweden
Taiwan
Norway
Denmark
United States
Slovenia
Iceland
P. R. China
The Netherlands
Italy
Singapore
Year-End 2007 Ranking
Source: Fiber-to-the-Home Council
Feb 08
Economies where majority architecture is Fiber-to-the-Home
Economies where majority architecture is Fiber-to-the-Building+LAN

Prime Optical Fiber Corporation (POFC)

1991,6/15 established

New Factory Space: 18,000 square meter

Current Employee: 50

1996 received ISO 9002 certification

2002 received ISO 9001-2000 certification

2002,3/8 public listed on Taiwan Stock Exchange

2005,6 became 3M's FTTx GGP fiber Patents licensee and supplier; POFC produces not only standard telecom fiber but also GGP Fibers; (GGPR15 & GGPR7 SMF, GGP625, GGPOM3 fiber), and BendSafe™ Cable & **Patch Cord**, which use low bending loss and high bending strength GGP fiber, for FTTx-MDU deployment.

POFC = Solution provider in the FTTx markets.

POFC

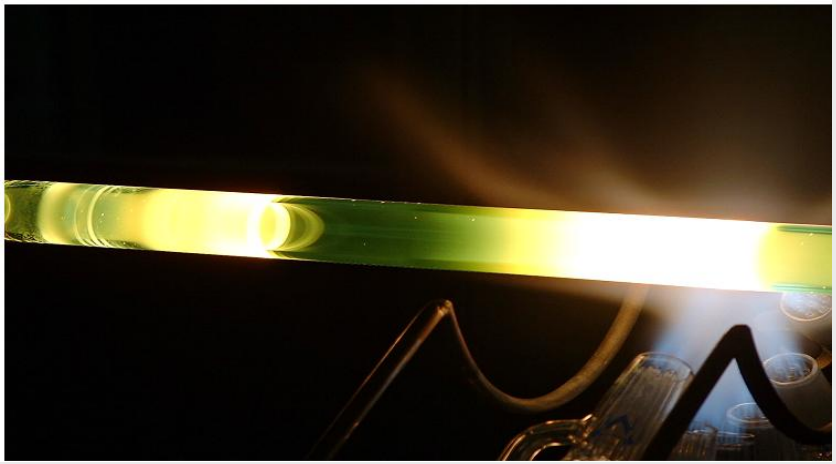
Preform Facility

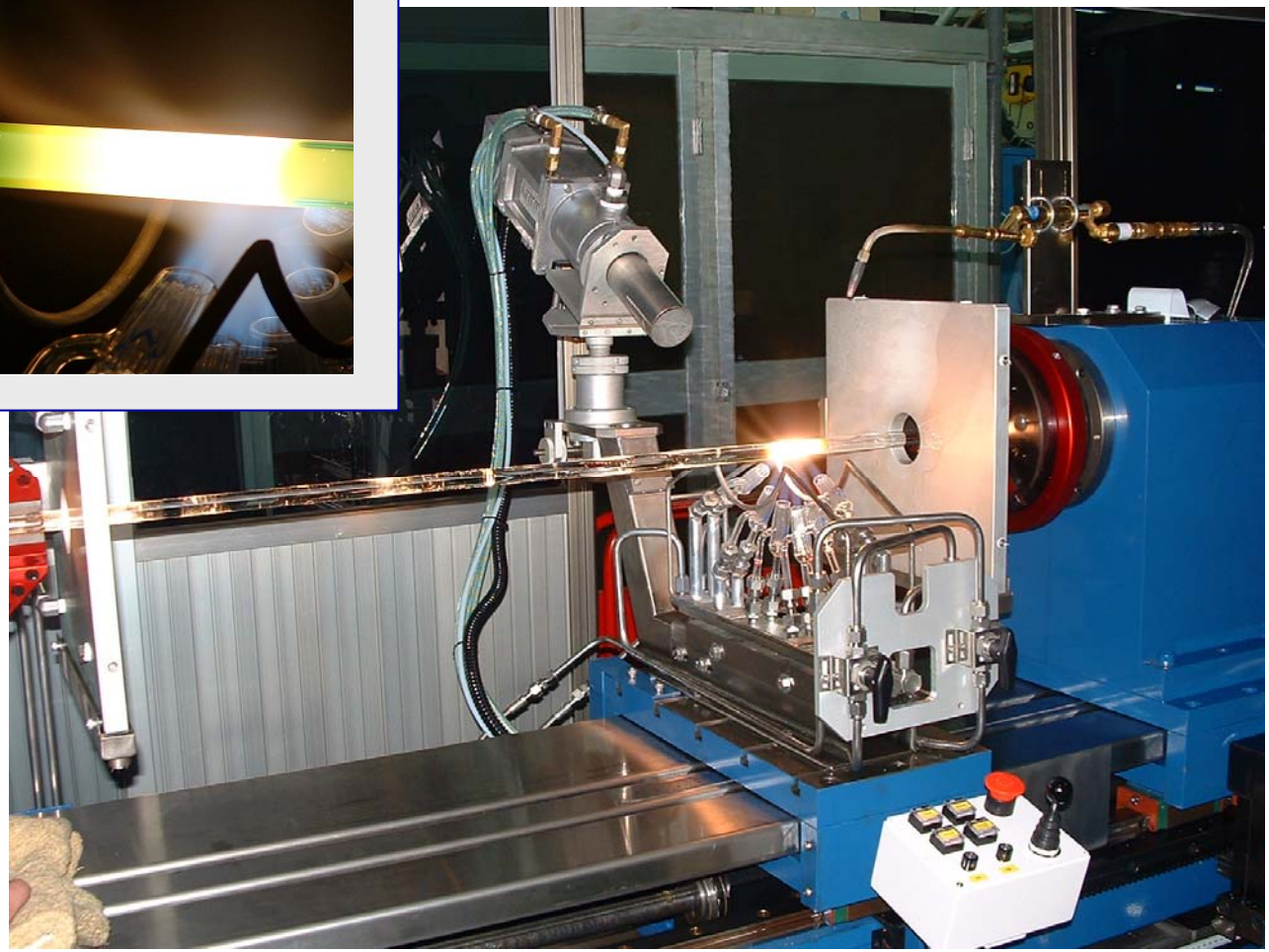
DOFC

Preform Core Process
(Standard Telecom Fiber)

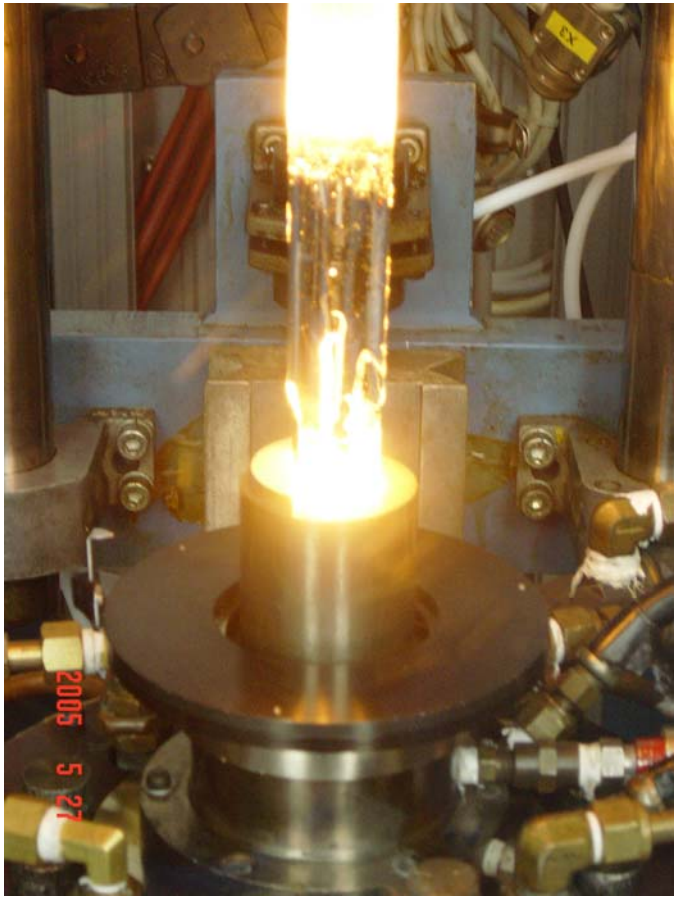
DOFC

Preform Manufacturing Process (Special Er or Yb doped Fiber)





Draw Tower



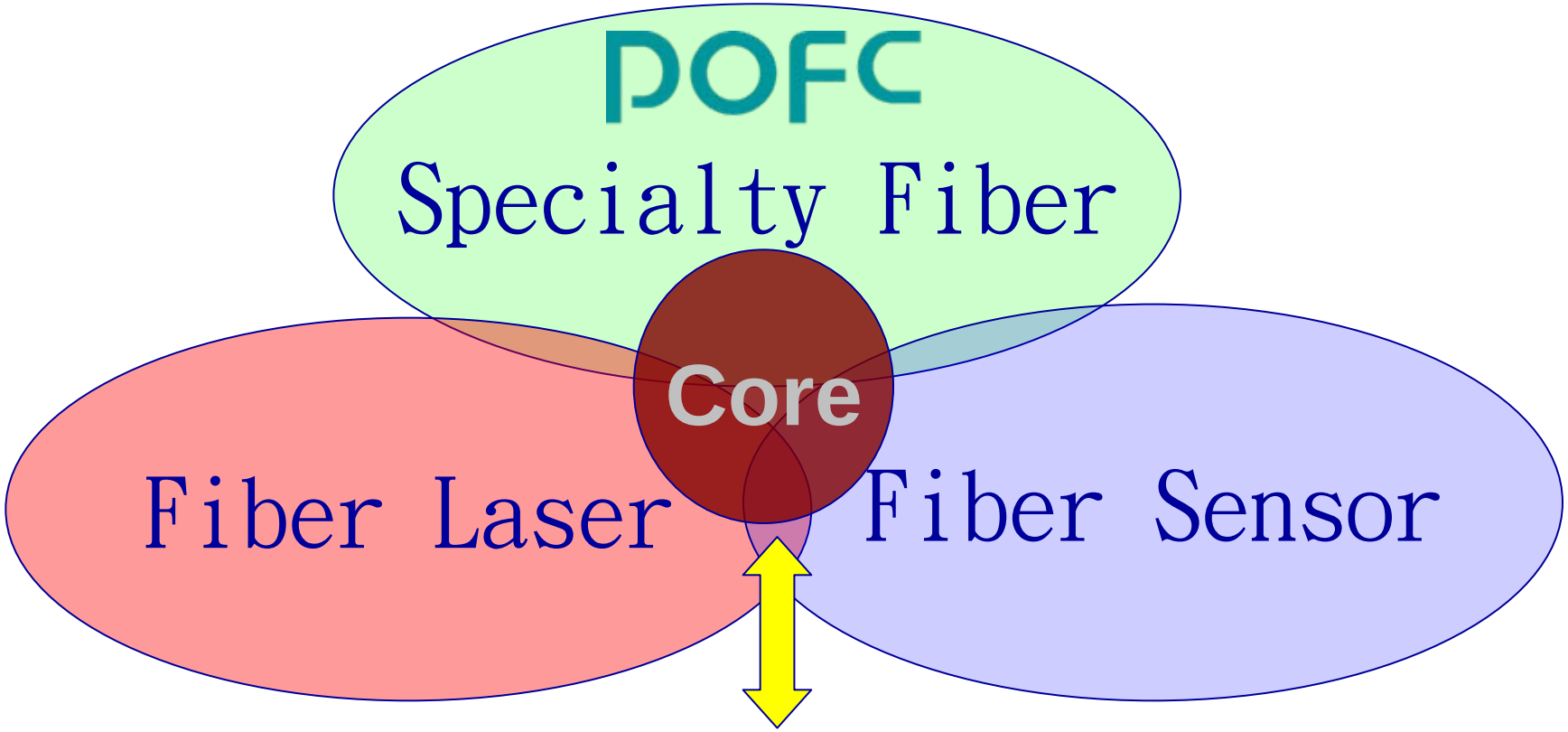
Fiber Characterization

Pk2500

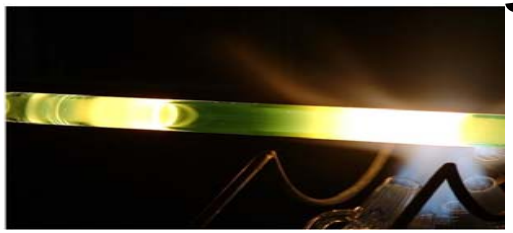
Pk2400

POFC

R/D Interest



MCVD Preform Manufacturing Technology



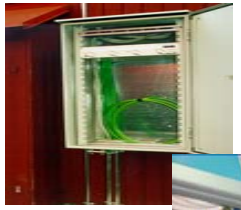
DOFC

FTTH need more robust Fiber/Cable

Distributed Closure

Challenge

FTTH



Panel-to-Panel cross-connect

FTTD

Equipment Back Planes

Requirements:

Tight Bend , Durability ,Reliability and Ruggedness

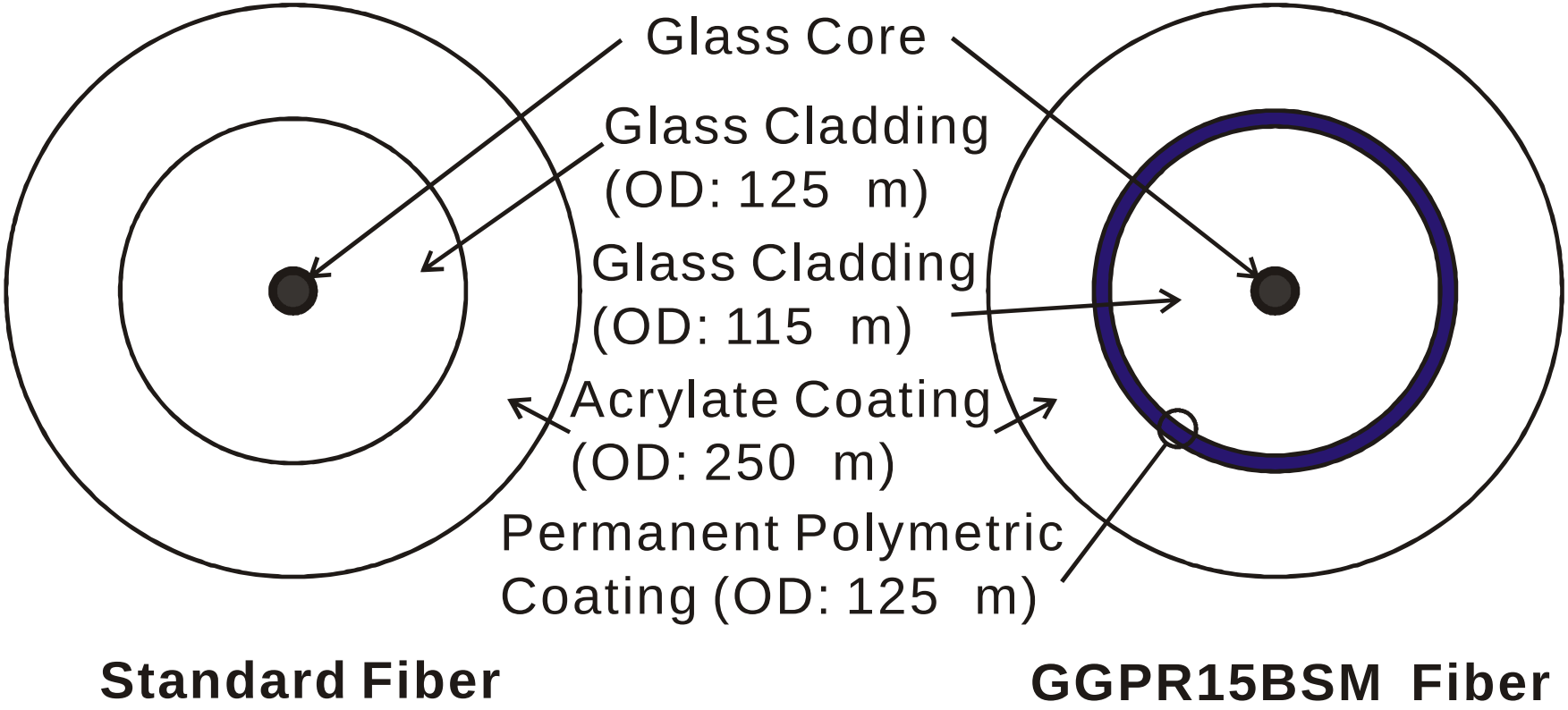
Application :

- FTTHome
- FTTDesktop
- Requiring Tight Bends, Durability and Dependability
- Panel-to-Panel Cross Connects
- Equipment Back Planes

Solution

POFC

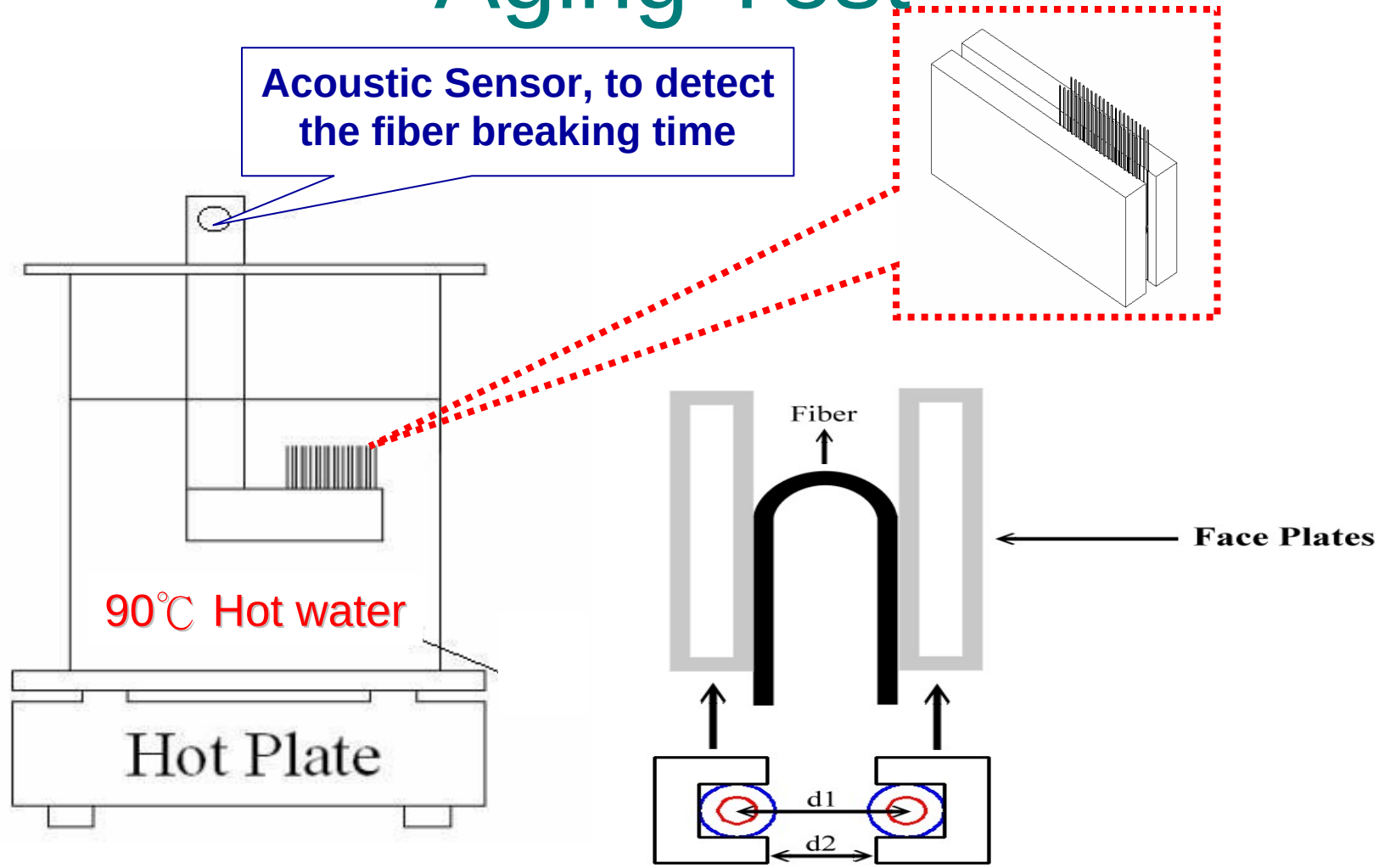
High Bending Strength GGP thin p-coat Fiber & Standard SMF



Standard Fiber **GGPR15BSM Fiber**

*** Licenses granted by 3M IPC**

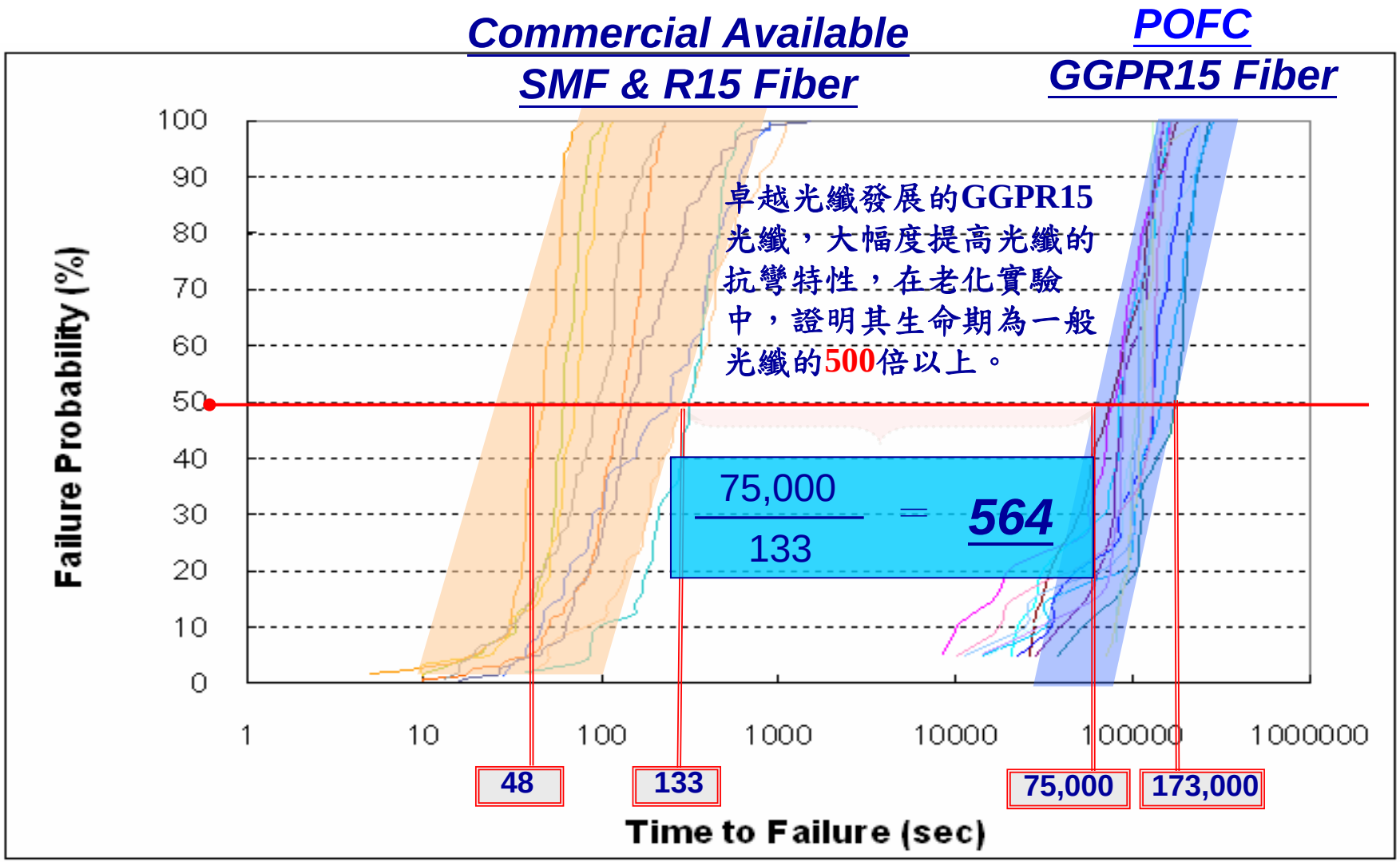
Aging Test



Gap between two plates: d1= 3.5mm (for OD:125μm cladding fiber)

Aging Test Results

（Test Conditions: 1.Bending Gap 3.5mm. 2.All specimens are immersed in 90±0.2℃ de-ionized water during the test period. 3.Issued Date 2007/12）



Storage fiber life time vs. n-Value

傳統n=18的要求滿足FTTH G.657的壽命要求?

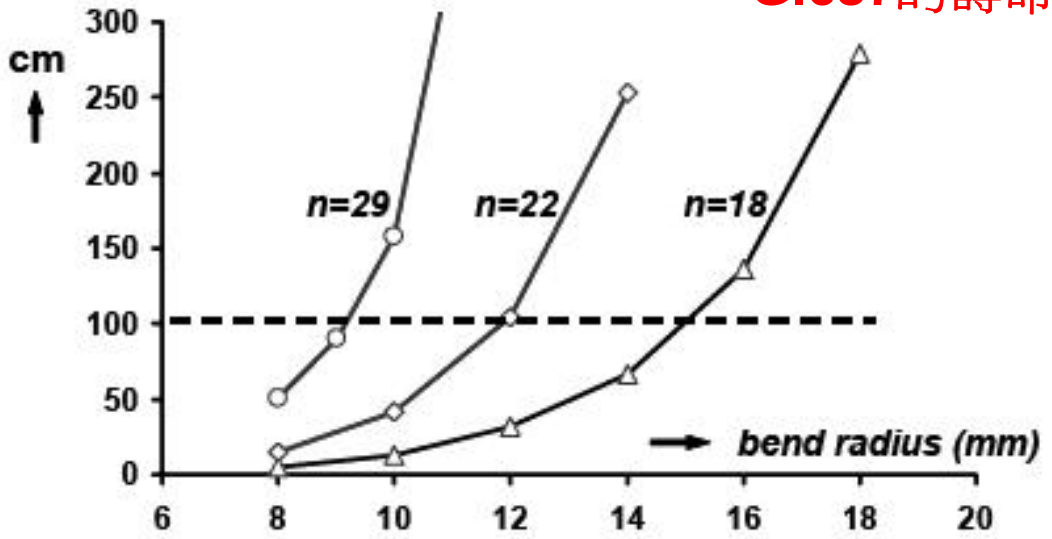


Fig. AI-2 Maximum storage length for a bent fibre and different values of the fatigue parameter n

ITU-T G.657 Appendix 1: 20年壽命要求下之n-Value與儲存半徑之關係

Dynamic fatigue parameter n-Value Measurement

Spec: IEC-60793-1-33

Use Fiber Sigma Co.'s two-point bender test set

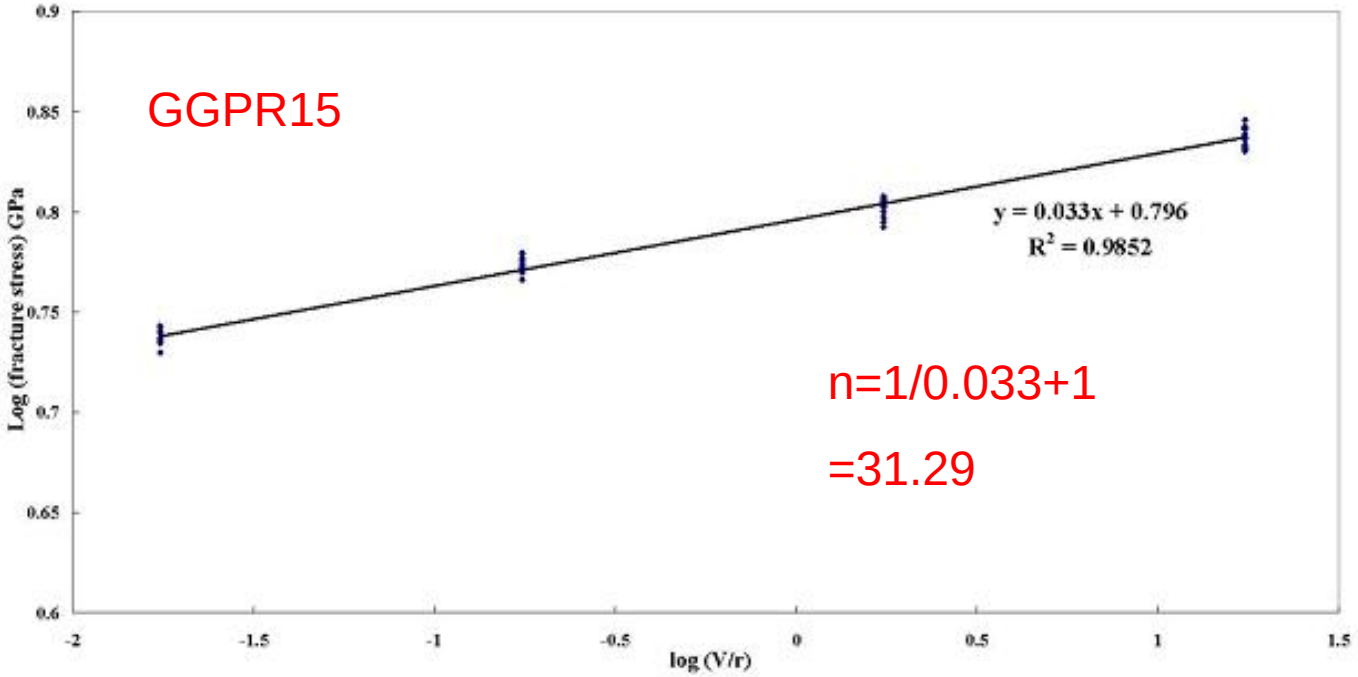
Isolated experimental region to control its temperature = 22C ~ 24C，RH 44% ~ 48%。

4 test speed: 1000um/s,100um/s,10um/s, 1um/s . Record time to break.

Measured n-Value

Dynamic fatigue data

Date	: 2008/2/26	Platen Velocity = 1000μm/s,100μm/s,10μm/s,1μm/s		X-Bar	= -0.259
Fiber ID	: POFC GGPR15 G008B7B15F1DY	Sample Size for each platen velocity = 16		Y-Bar	= 0.787
Cladding OD	: 114.7 μm	Temperature = 23 ± 1 ℃		Nd	= 31.29
Coating OD	: 246.8 μm	Humidity = 46 ± 2 %RH		Ndu	= 32.24
Operator	: 370	Pre-Conditioning time >12 Hours		Ndl	= 30.39



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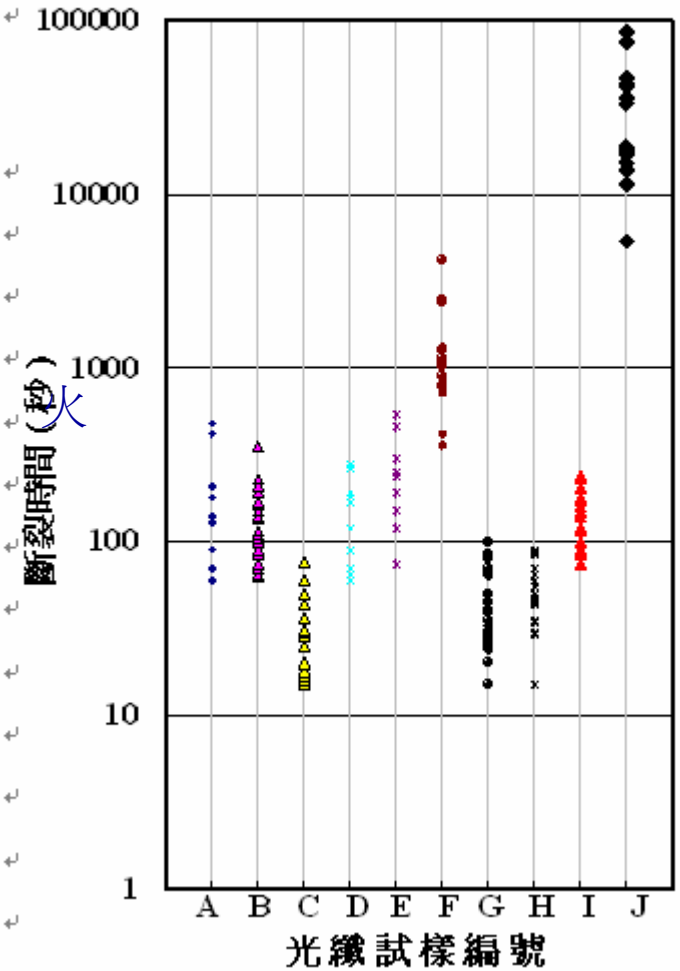
中華電信研究所
單模光纖耐彎曲特性研究

Life time for fiber samples wraps
10 turns on 3 mm diameter rod

圖 14 爲光纖試樣在捲繞直徑 3mm 時的斷裂時間分布圖。



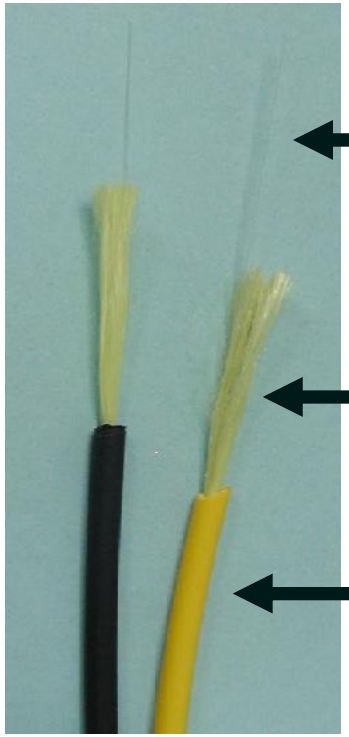
光纖進化三部曲

好 還要更好!

	標準 單模光纖	R15 耐彎曲光纖	GGPR15高強度 耐彎曲光纖
進化特性	光學特性 G.652D	G.652D + G.657彎曲低損耗	G.652D + G.657彎曲低損耗 + 高強度又耐用

爲什麼不一次使用最好的?

BendSafe™ 引接光纜 (Drop Cable)



250 um GGPR15

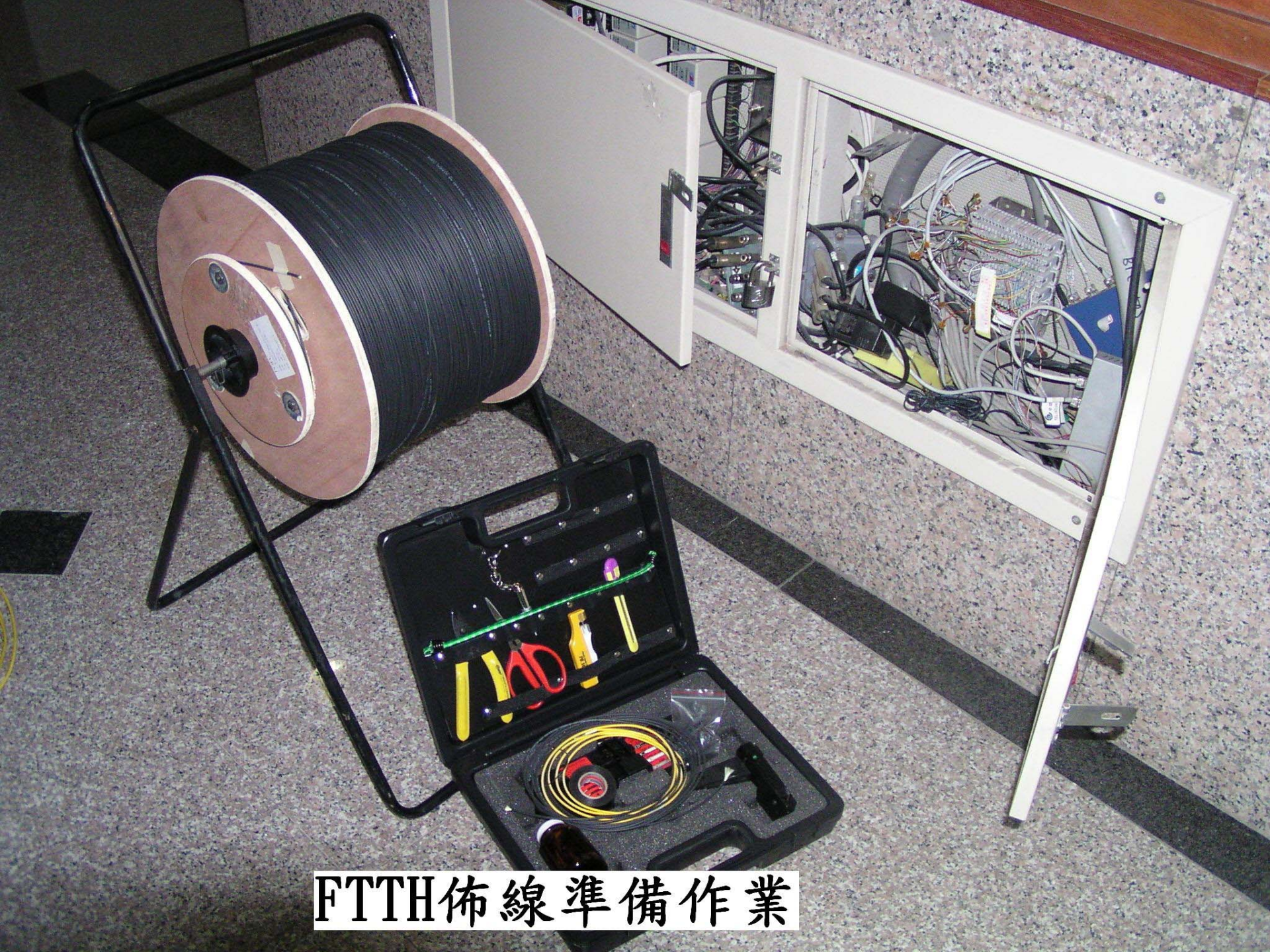
SM Fiber

Kevlar

3.0 mm FRPE Jacket or PVC (OFNR)

- **GGPR15**光纖的高強度以更耐彎、更防潮、更耐溫的特色實現戶外戶內通用的引接光纜
- 結構更簡單、外徑更小、更柔軟。不受環境影響，施工更便捷、更經濟
- 直角彎曲壽命超過**40**年

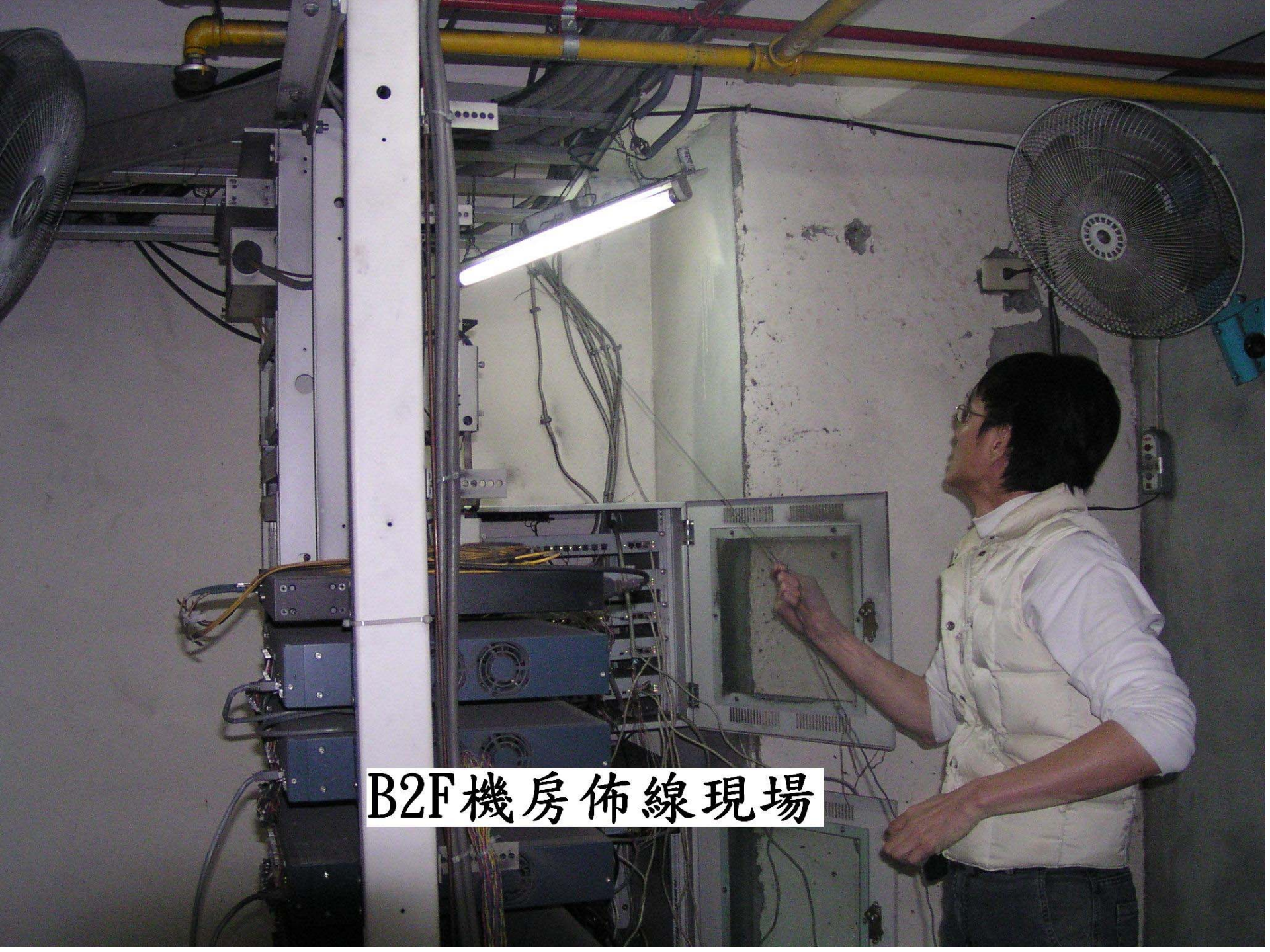
結構簡單、施工方便、經濟又可靠



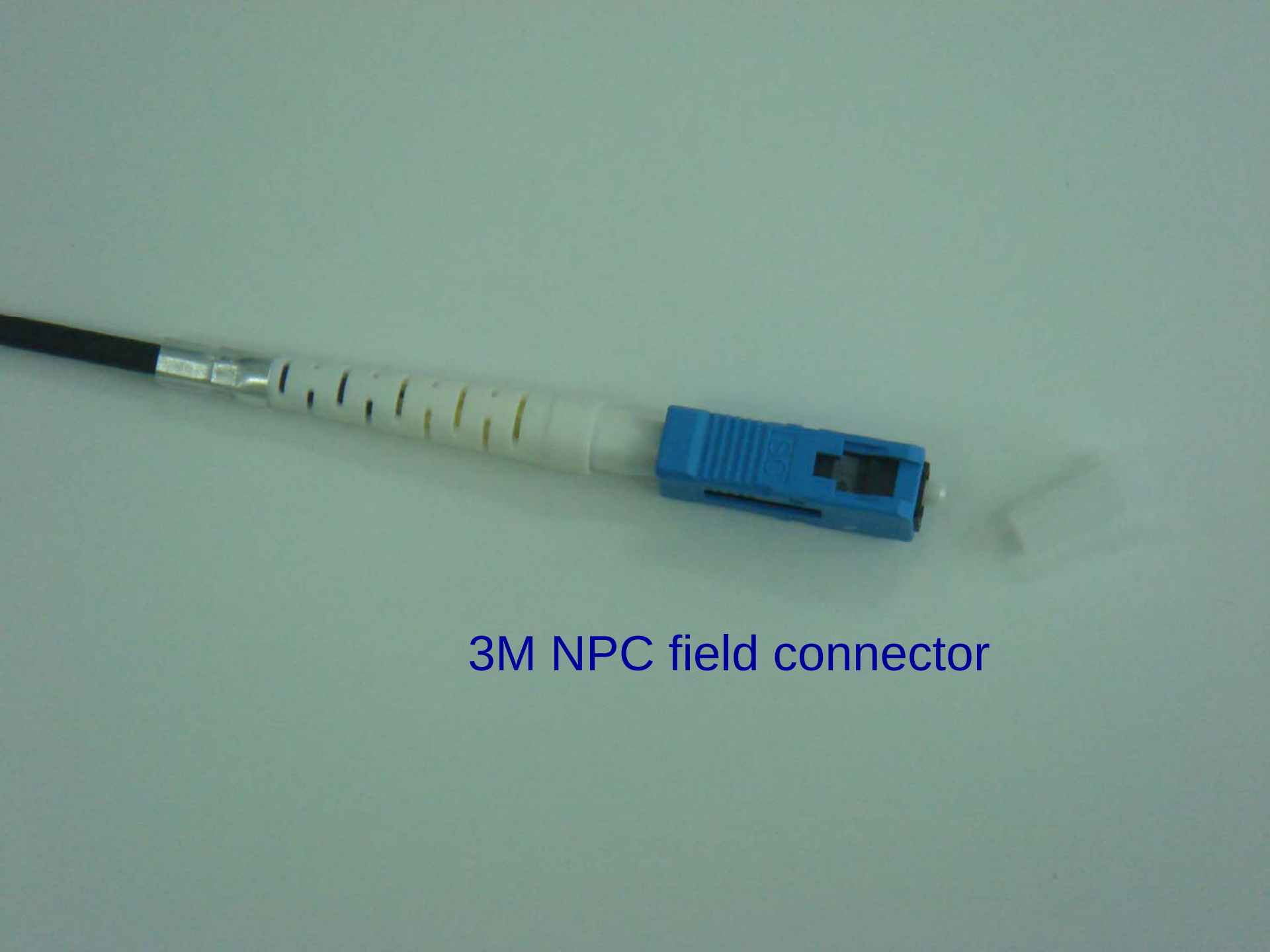
FTTH佈線準備作業

宅配箱實景

自頂層開始佈放光纜


B2F機房佈線現場

FTTH佈線完成



3M NPC field connector

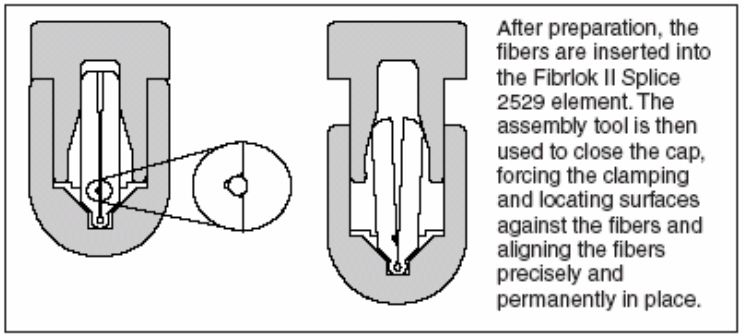
100BASE-TX
Link/Act 10/100 FDX
PWR Link/Act SD FE-Flt
TP
FX
100BASE-FX
MN

系統連線測試完成

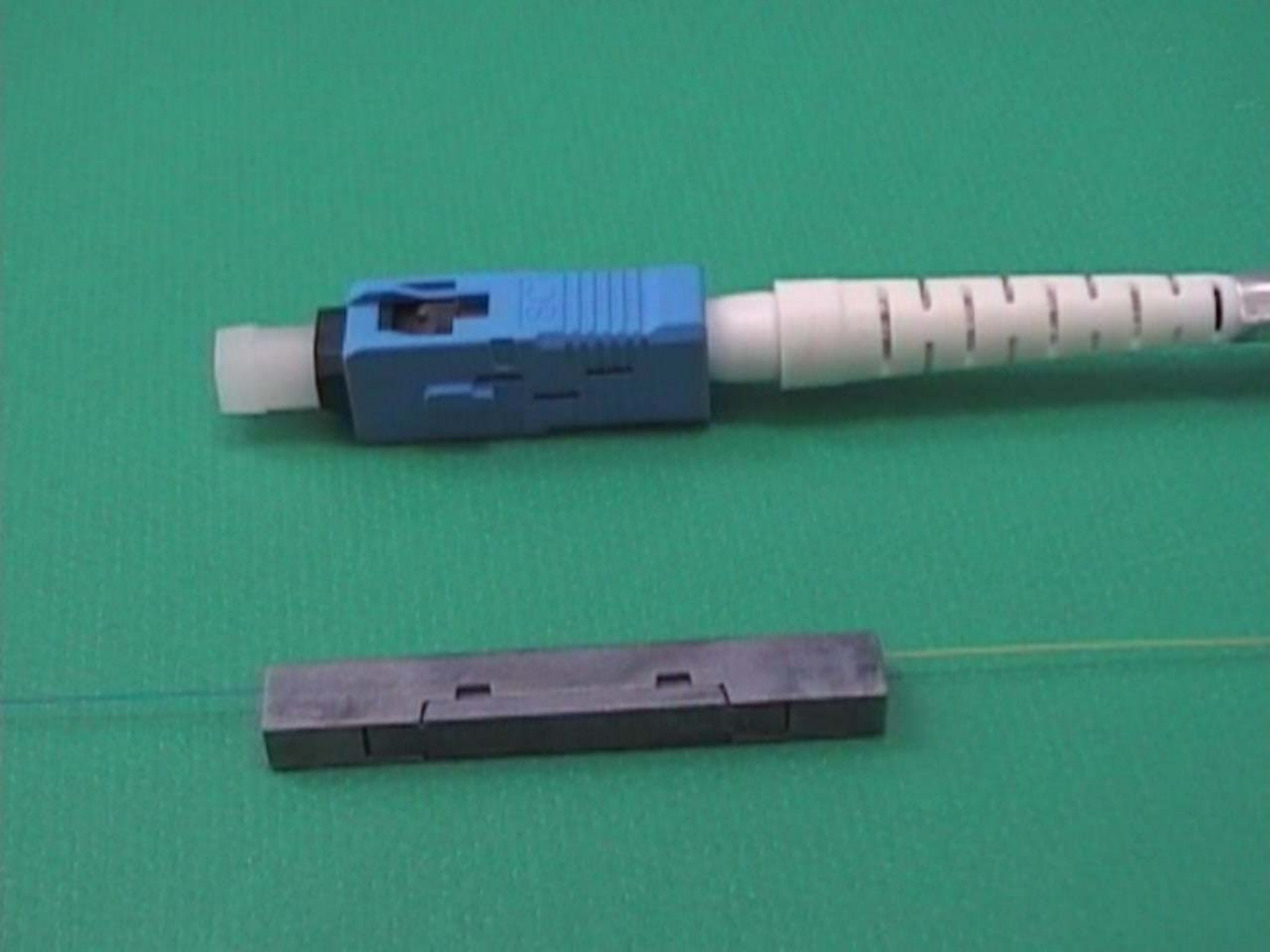
3 FibrLok™ Splice

Over 4.0 Million Deployed In Japan FTTH Market Without Any Field Trouble

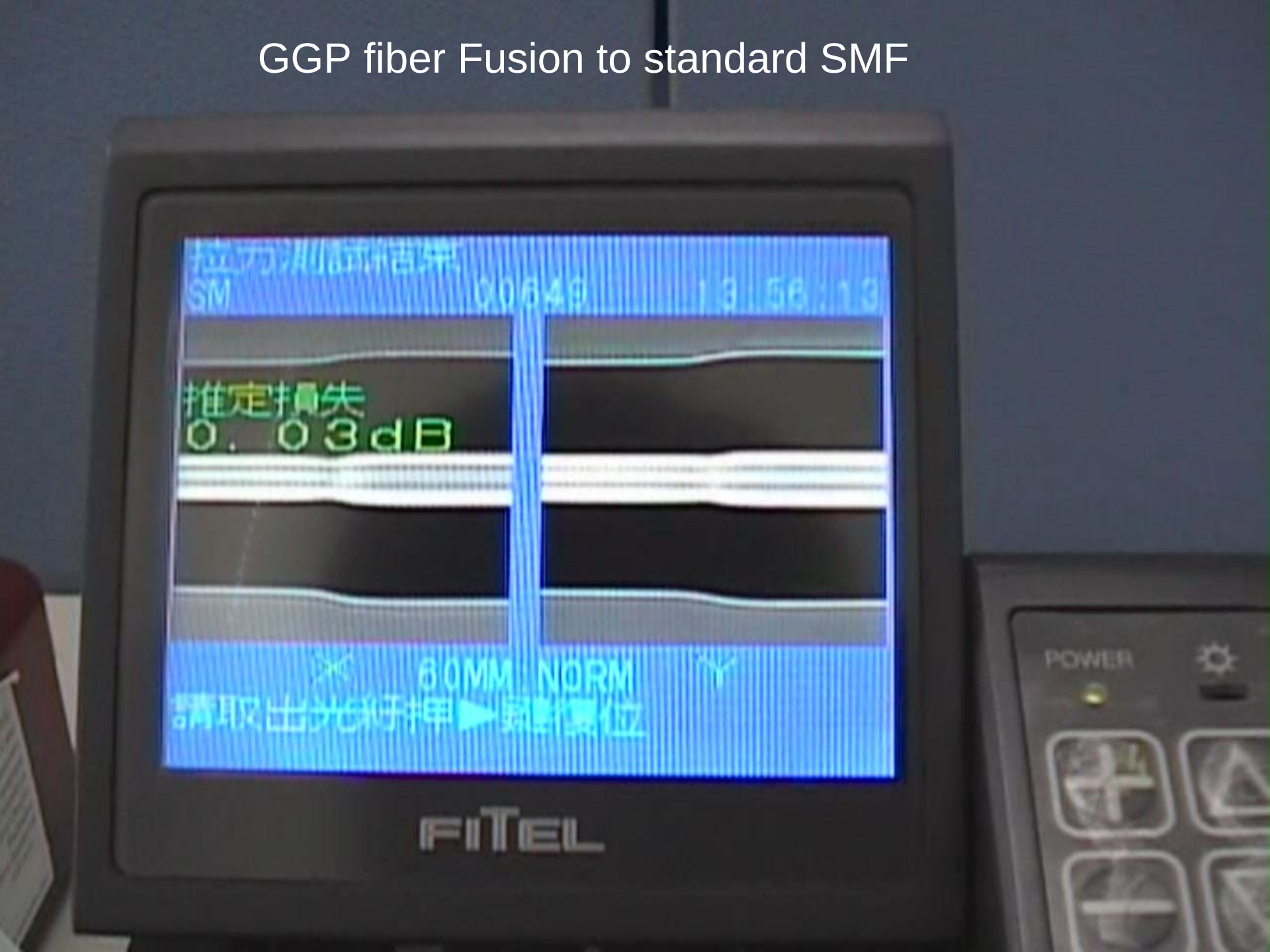
Cross-sectional view of open and actuated Fibrlok II Splice 2529



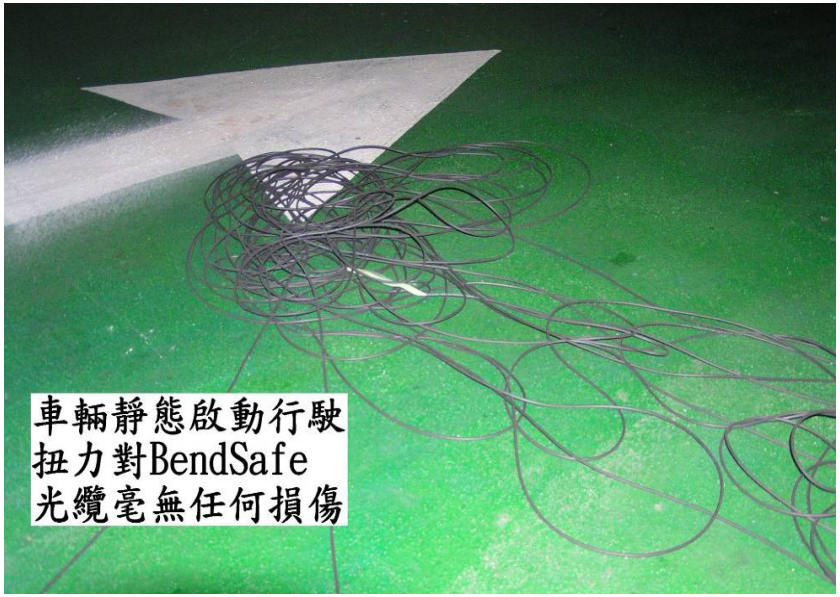
Features	Benefits
<0.1dB insertion loss	High performance
30 second installation time	Increased productivity
Minimum tooling requirements	Low capital cost
No epoxy or electricity required	Easy on-site installation
Simple, easy to use	Minimal training, lower installed cost



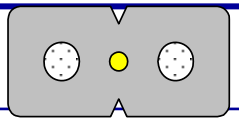
GGP fiber Fusion to standard SMF



BendSafe™ Cable Field Test



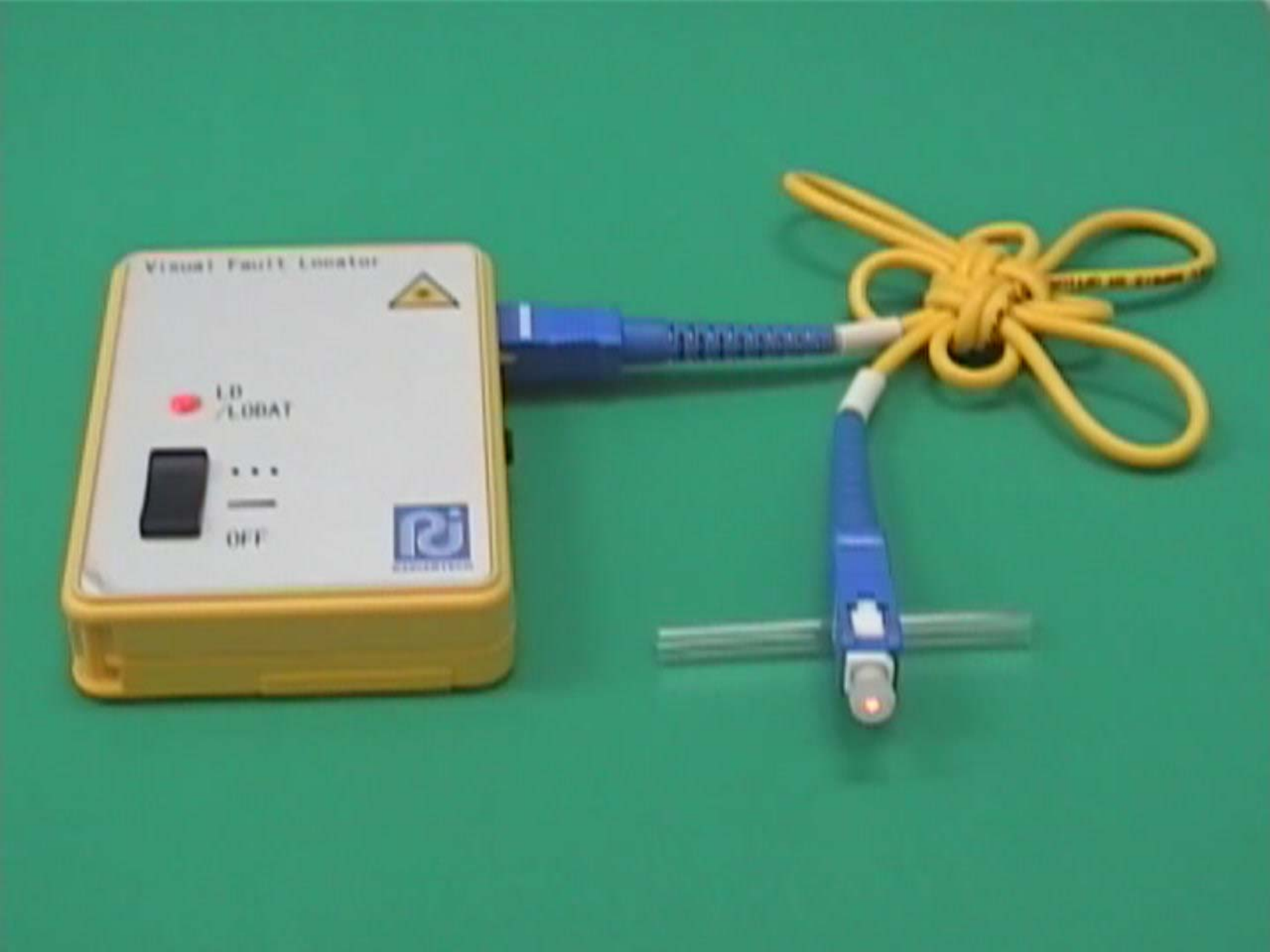
引接光纜比較

	日式扁平光纜 	BendSafe™Cable
尺寸	**1.5mm*3mm**	**3 mm round**
抗張體	**FRP**	止水**Kevlar** **1500**丹***4**
光纖	**G652D or G.657A** 單模光纖	**G.657A +**高強度 **GGPR15**單模光纖
n-Value	**18~20**	**> 30**
Loop in 3.0mm ID Tube Lifetime	**< 5 min**	**> 1000 min**
現場施工	**?**	**Easy**
現場接頭	**FA Socket**	**NPC 8022**

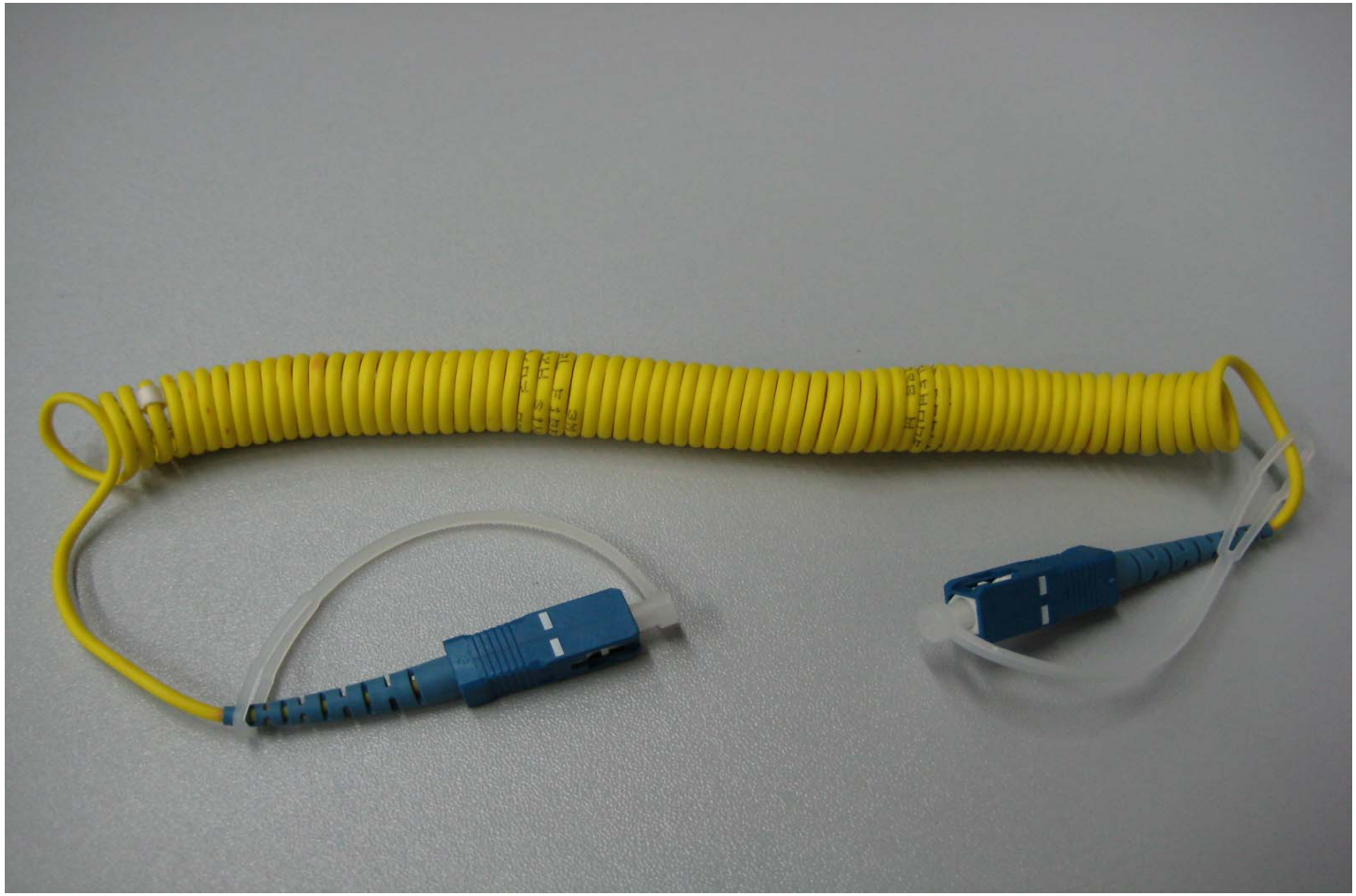
BendSafe™ GGP 高強度耐彎曲光纖跳接線

- 符合標準光纖跳接線要求，可全面取代標準跳接線
- **GGP**光纖的鍍膜強度使跳接線更耐彎、更耐久更可靠
- 耐溫特性，更適合機房的高溫環境**(-40 - +85 C)**
- 尺寸更小，強度更高，機櫃收納更容易；直角彎曲也不怕

更小外徑：**2.0 mm**


Visual Fault Locator
LD
/LOBAT
OFF

New GGP Coiled Patch Cord



Summary

- Reliable FTTH network can be established quickly using BendSafe™ Drop Cable, Patch Cord and Mechanical Splice
- Commercial fiber Cleavers and Fusion Splice Machines can still be used to cleave GGP fiber and make fusion splice
- Simple Installation Tools, Time saved, Easy Maintenance, Worry Free!

FBG Sensor

DOFC

Optical Strain Gage

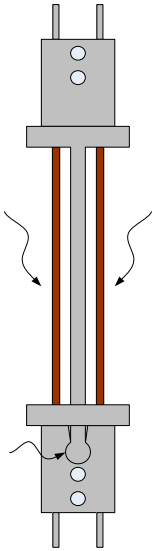
FBG Inclinometer

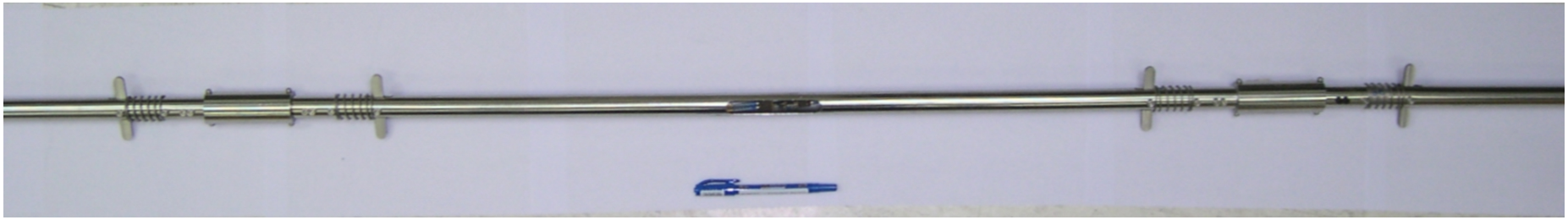
FBG Temperature Sensor

Rugged Strain Gage

DOFC

Optical Fiber Inclinometer





US007200292B2

(12) **United States Patent**
Shang et al.

(10) **Patent No.: US 7,200,292 B2**
(45) **Date of Patent: Apr. 3, 2007**

(54) **OPTICAL FIBER INCLINOMETER**

(75) Inventors: **Hen-Tai Shang**, Hsinchu (CN); **I-Wen Wu**, Tainan (CN); **Chun-Chu Yang**, Kaohsiung (CN); **Chih-Pi Cheng**, Changhua (CN)

(73) Assignee: **Prime Optical Fiber Corporation**, Miao-Li (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/996,474**

(22) Filed: **Nov. 26, 2004**

(65) **Prior Publication Data**

US 2005/0169568 A1 Aug. 4, 2005

(30) **Foreign Application Priority Data**

Nov. 28, 2003 (TW) 92133637

(51) **Int. Cl.**
G02B 6/00 (2006.01)
G02B 6/34 (2006.01)

(52) **U.S. Cl.** **385/13**; 385/12; 385/37

(58) **Field of Classification Search** 385/12, 385/13, 37

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,999,671 A * 12/1999 Jin et al. 385/37
6,327,405 B1 * 12/2001 Leyva et al. 385/37
6,493,486 B1 * 12/2002 Chen 385/37
6,665,062 B2 * 12/2003 Ferdinand et al. 356/139.1
6,785,443 B2 * 8/2004 Mendez et al. 385/37

FOREIGN PATENT DOCUMENTS

JP 2003287411 A * 10/2003

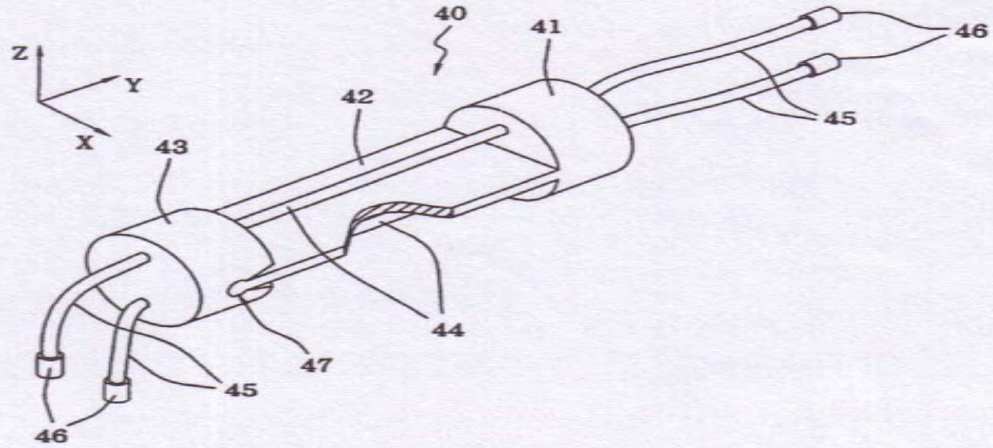
* cited by examiner

Primary Examiner—Sung Pak
Assistant Examiner—Daniel Petkovsek
(74) *Attorney, Agent, or Firm*—Oliff & Berridge, PLC

(57) **ABSTRACT**

An optical fiber inclinometer comprises a pair of fiber Bragg grating devices, a fixed base, a connection plate, and a rotatable base. One end of the connection plate is fixed to the fixed base, whereas the other end of the connection plate is connected to the rotatable base through the joint of a turning pair mechanism between them. The two ends of each fiber Bragg grating device are installed onto the fixed base and the rotatable base respectively, and the two devices are mounted on the opposite side of the connection plate. Once the rotatable base rotates around the joint of the connection plate, axial tensile elongation occurs in one of the fiber Bragg grating devices, whereas axial compressive deformation occurs in the other device. The rotation angle of the rotatable base relative to the connection plate can be obtained by measuring and calculating the Bragg wavelength drifts of the pair of fiber Bragg grating devices respectively.

14 Claims, 7 Drawing Sheets



台灣光通訊產業聯盟
Taiwan Optical Communication Industry Alliance

2005年台灣光通訊菁英獎

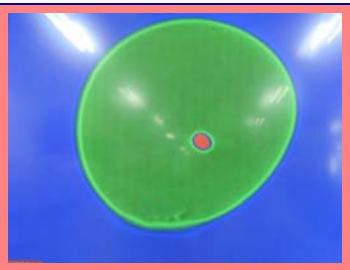
賀　卓越光纖股份有限公司研發之「光纖測彎計」，績效卓著，獲第三屆台灣光通訊菁英獎之「傑出產品獎」　佳作，特此表揚，以資鼓勵。

台灣光通訊產業聯盟
會長 [illegible]

中華民國九十四年四月七日

Fiber Laser

DOFC



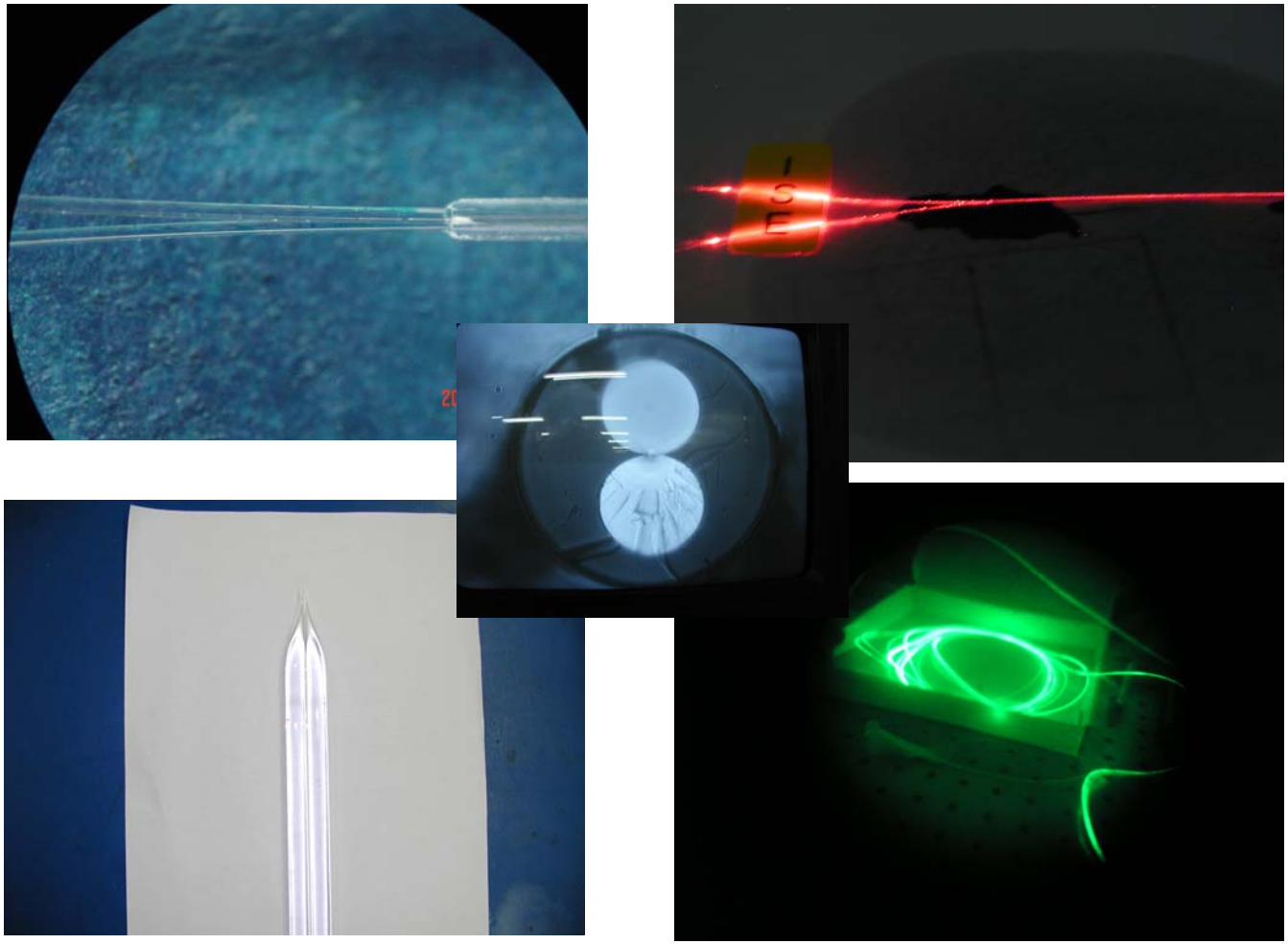
D-Shape Fiber

Twin-core Fiber

Laser module

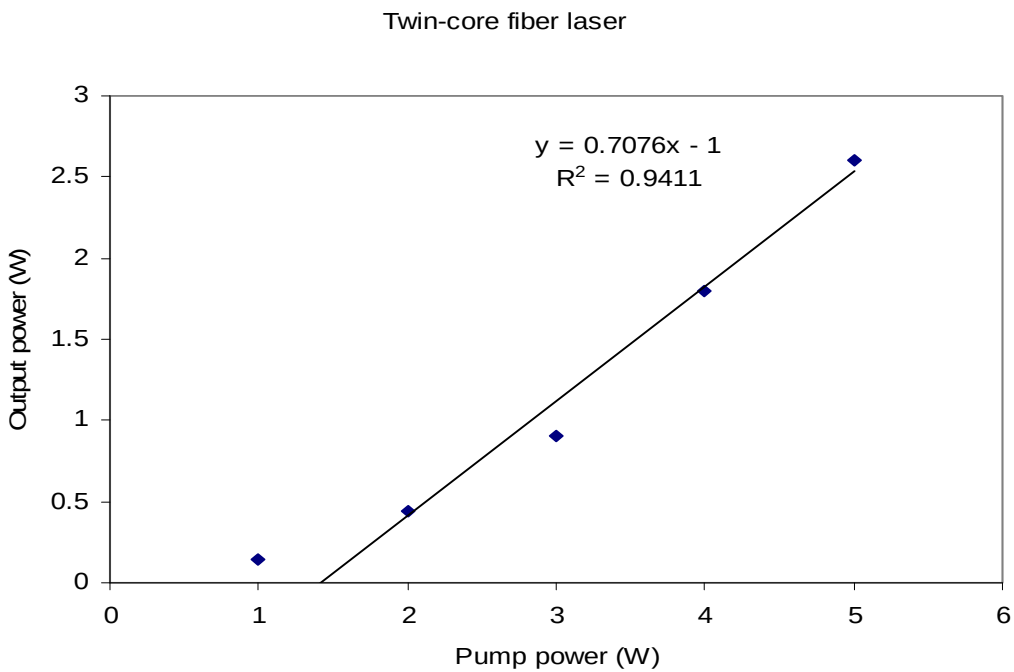
Yb-doped Fiber

DOFC



DOFC

POFC's Twin Core Yb-doped Fiber
- Test result from third party



Reference: Dr.Xijia Gu,
Ryerson university, Toronto, Canada

Pump laser: 975 nm, multimode coupled, forward pumping
Fiber length: 10 m (it should be longer since 0.4 W left at the other end of pump MMF)
High reflection FBG: 1063.4 nm, 0.58 nm@-3 dB
Output coupler: cleaved end, (4%, broadband)

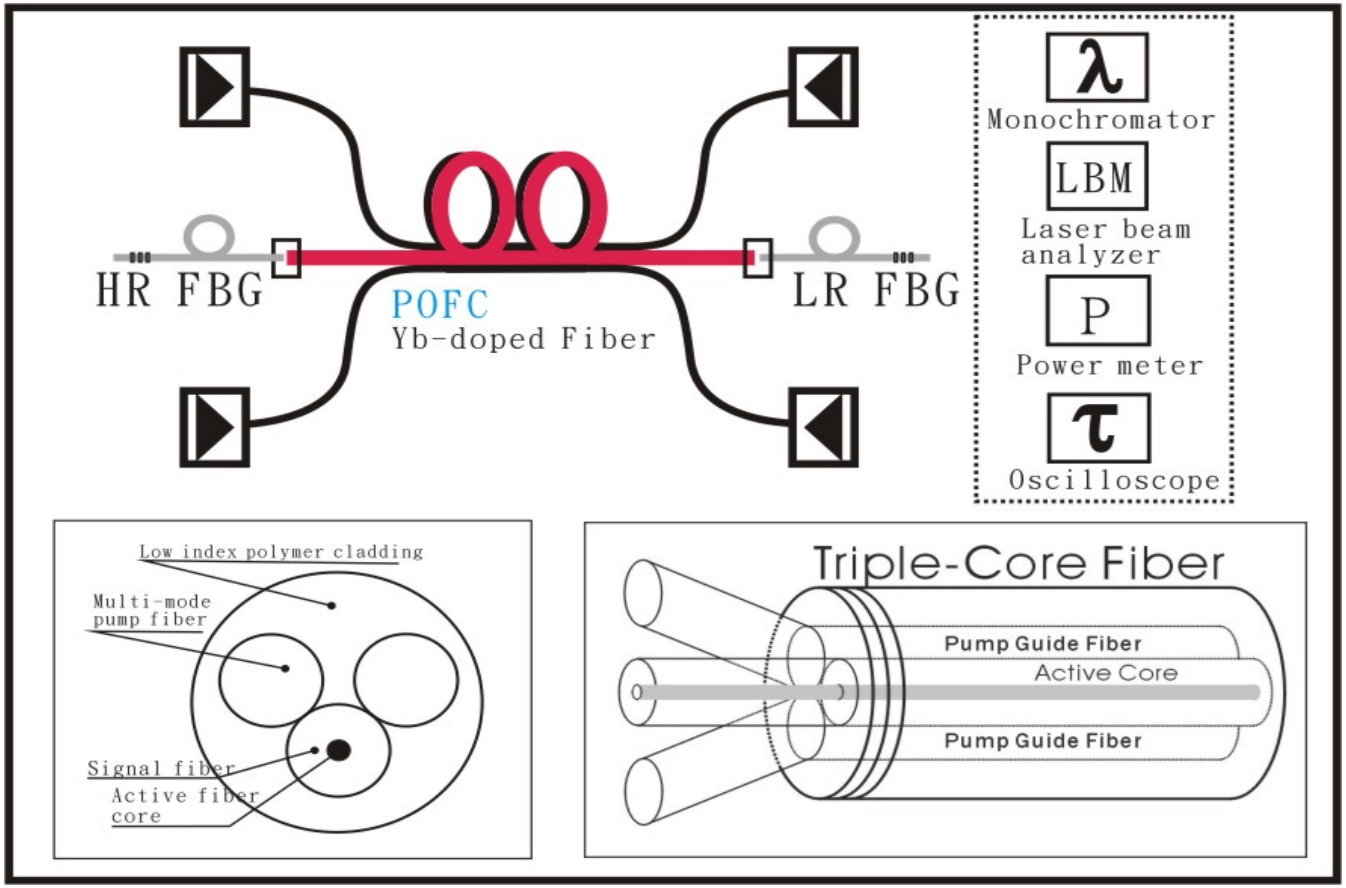
Overall efficiency: 52%

Slop efficiency: 70%

POFC

POFC Fiber Laser System

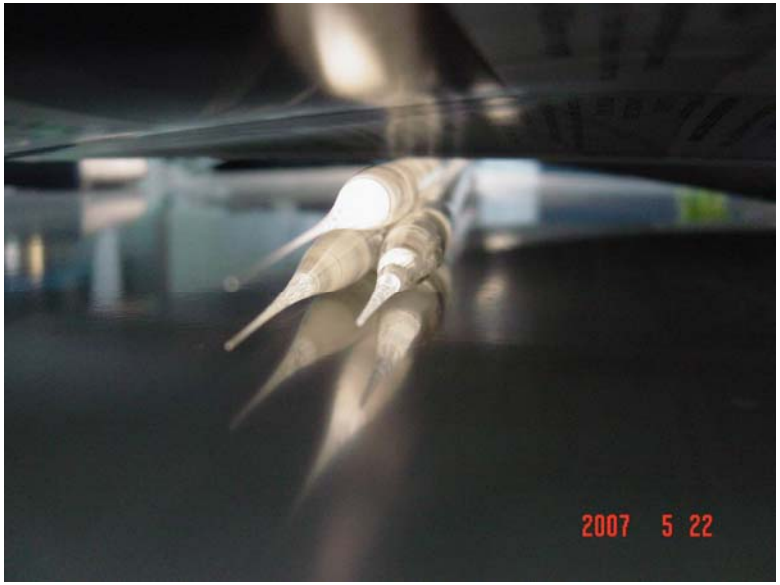
Ongoing Triple Core Yb-doped Fiber Laser Experiment



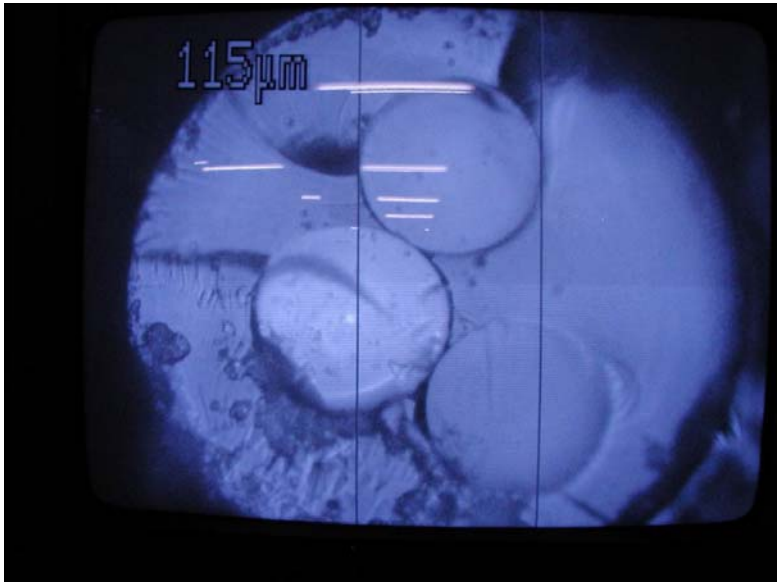
POFC

Higher Power Fiber Laser Design

- Triple Core Yb-doped Fiber



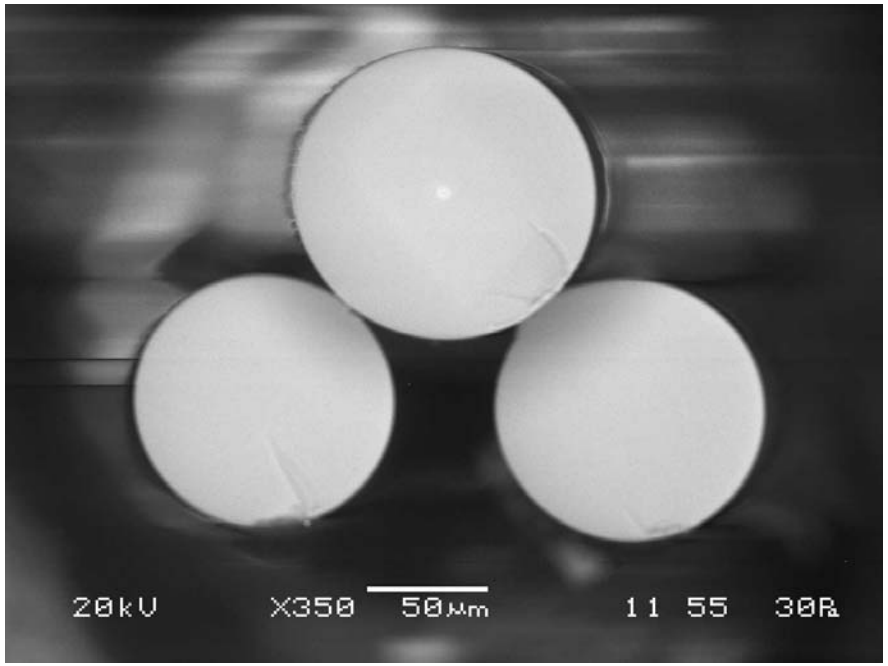
Triple Core Preform



Triple Core Cross Section

DOFC

Triple Core Yb-doped Fiber SEM picture



DOFC

POFC Triple-core Ytterbium-doped Double Clad Optical Fiber

Product Information

Issue Date : 2007/06

INTRODUCTION

Triple-core Yb-doped double clad fiber can let high-power multi-mode pump diode couple energy into the active core without additional complex optical components and without interrupt the laser output path.

APPLICATIONS

The YBDCTC125 is a single mode Yb-doped core fiber with two pump core in a Double Clad structure for lasers operating in 1-100 W output power range. It can be economically pumped by 915 & 975 nm diode laser. Typical operating wavelength is at 1060~1100 nm.

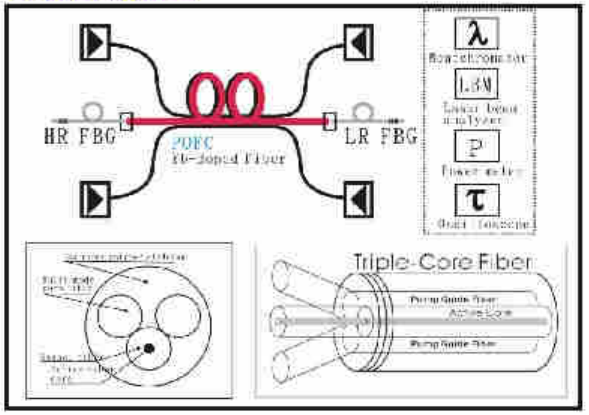
SPECIFICATIONS

Product Name	YBDCTC125	
Core	**Value**	**Units**
Absorption Coefficient @ 915 nm	220 ± 5	dB/m
Absorption Coefficient @ 975 nm	285 ± 5	dB/m
Absorption Coefficient @ 1200 nm	14.5 ± 1	dB/km
Core Diameter	3.1 ± 0.3	μm
Cut-off Wavelength	909 ± 20	nm
Numerical Aperture	0.13 ± 0.02	

Pump cladding		
MM Pump Absorption @ 915 nm	0.29 ± 0.5	dB/m
MM Pump Absorption @ 975 nm	0.58 ± 0.5	dB/m
Cladding Diameter (each guiding core)	120 ± 10	μm
Outer Coating Diameter	404 ± 10	μm
Primary Coating Type	Low index polymer	
Numerical Aperture	0.37 ± 0.05	
Length	Customized	

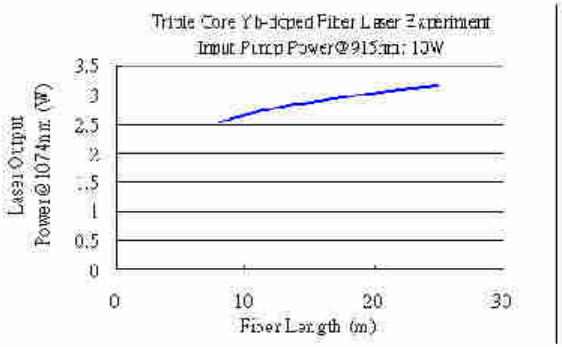
Prime Optical Fiber Corporation
No.11, Ke Jung Rd.
Science-Based Industrial Park
Chu-Nan, 350, Miao-Li County, Taiwan, R.O.C.
Tel: 886-37-586999 Fax: 886-37-586899
E-mail: sales@pofc.com.tw

SCHEMATICS



Allowed 4 single stripe diode laser with 100/125 μm guiding fiber spliced to each pump laser guiding fibers.

Test Result



Self-generated fiber laser experiment test result.

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FTTH 示意圖

POFC 卓越光纖

台灣新竹科學工業園區苗栗縣竹南鎮科中路11號
TEL:886-37-586999 FAX:886-37-586899

ndSafe BendSafe BendSafe BendSaf

End of Presentation

Thank you !!

Q & A

Cut GGPR15 Fiber - 切割刀調整

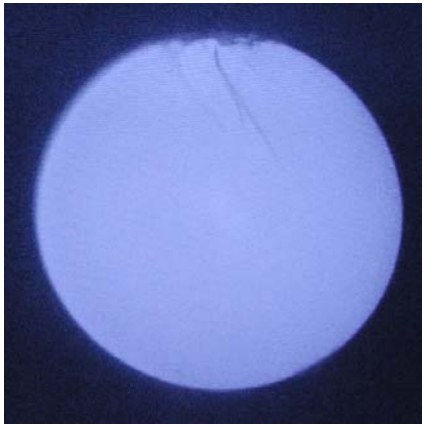
由**POFC** 網頁可以下載不同廠牌切割刀調整方式

http://www.pofc.com/chinese/product/fttx.htm

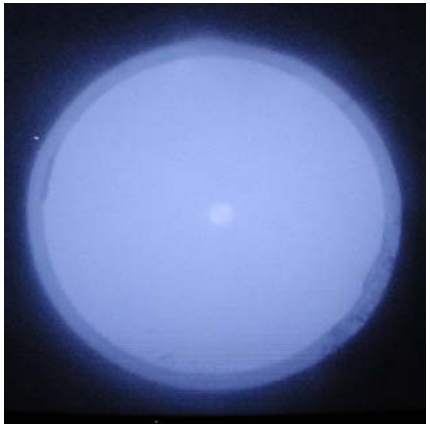
調整切割刀
可同時切割GGPR15光纖與標準光纖

CT-04

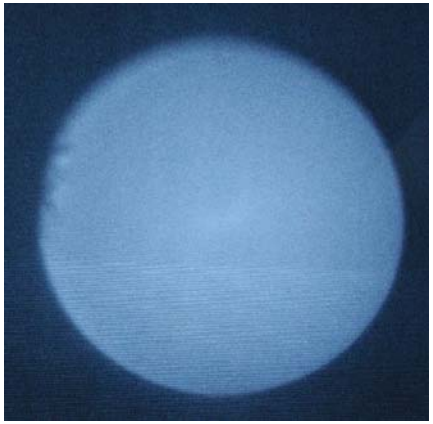
CT-30



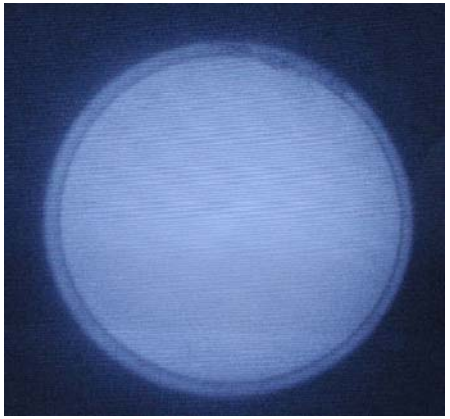
Standard
SM Fiber



GGPR15
Fiber



Standard
SM Fiber



GGPR15
Fiber

*After adjustment of cutter Position

更多切割端面

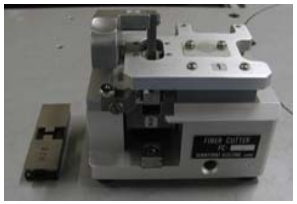
*all commercial cleavers can work with both type of fiber

S323RT

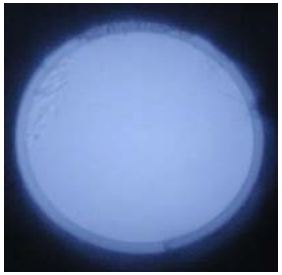
S323

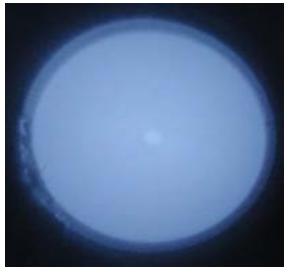
A8

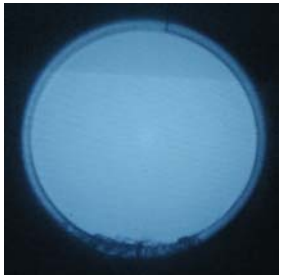
FC-04

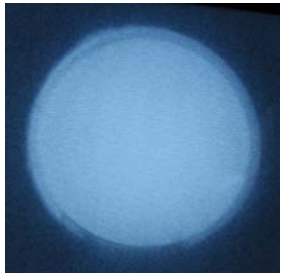


CI-01

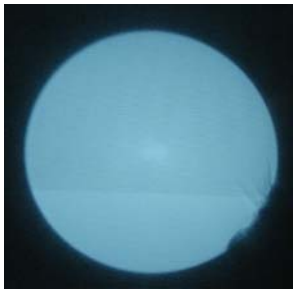


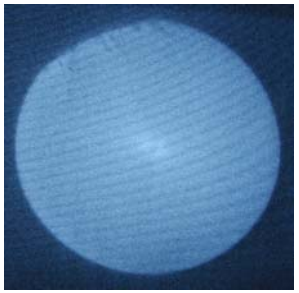


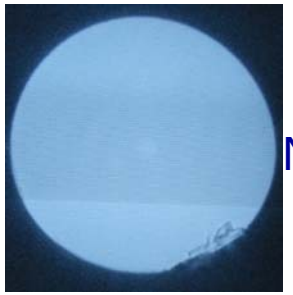




GGPR15







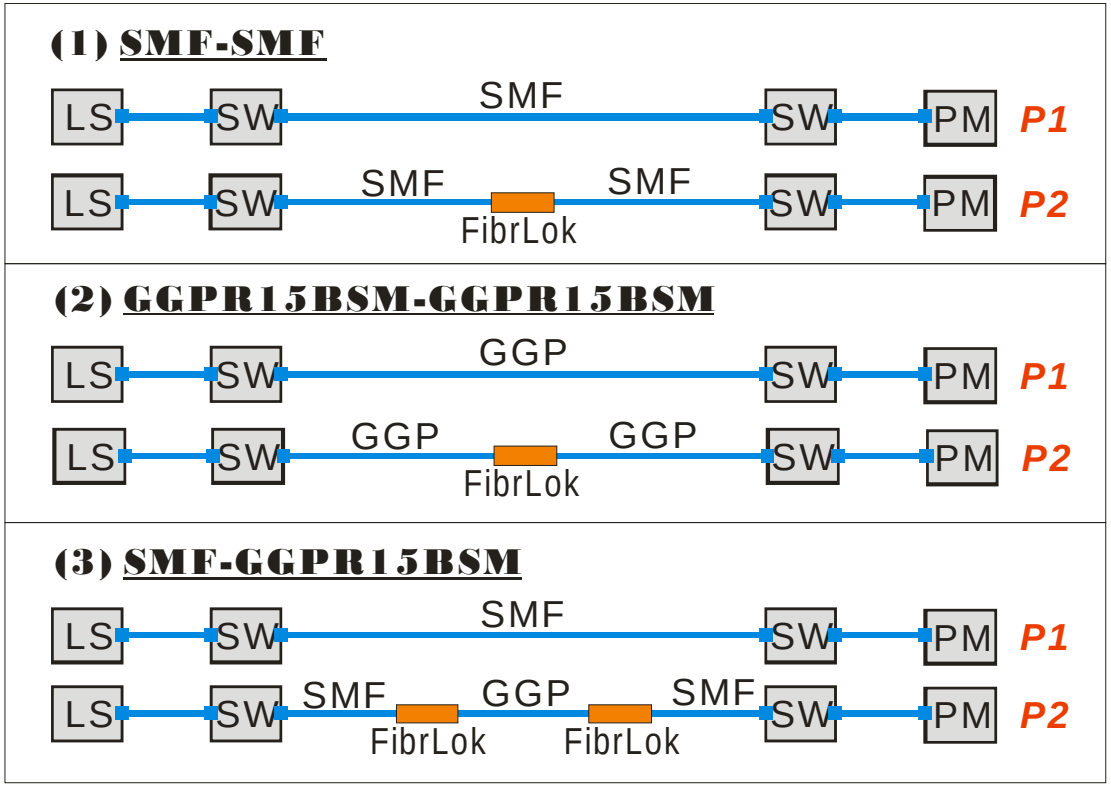
Normal SM

POFC

GGPR15/FibrLok™ Performance Test Results

1. Splice Loss Test
2. Temperature Cycling
3. Mechanical Property Test

GGPR15 & SMF Splice (FibrLok™) Loss Test Setup



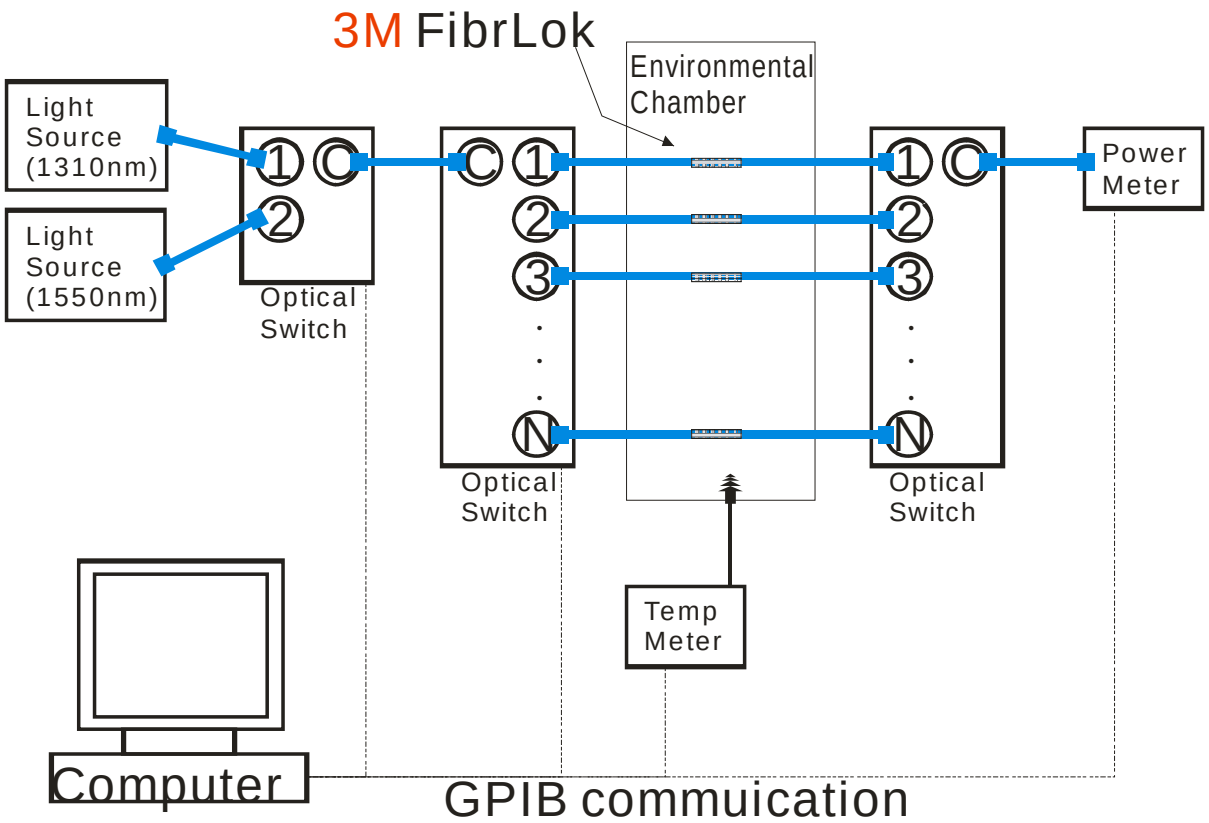
Type	Test Terms	Criteria
A-MS-250	250 μm SMF & 250 μm SMF	Insertion Loss < **0.5 dB** @1310nm&1550nm)

GGPR15 & SMF Splice Loss (FibrLok™) Results

FibrLok™	SMF-SMF Loss (dB)		GGP-GGP Loss (dB)		SMF-GGP-SMF Loss (dB)	
Sample #	1310nm	1550nm	1310nm	1550nm	1310nm	1550nm
1	0.04	0.054	0.11	0.123	0.105	0.099
2	0.06	0.047	0.08	0.091	0.095	0.120
3	0.05	0.056	0.07	0.072	0.105	0.100
4	0.07	0.106	0.09	0.095	0.110	0.127
5	0.05	0.074	0.12	0.121	0.100	0.106
Average	***0.054***	***0.0674***	***0.094***	***0.1004***	***0.103***	***0.1104***

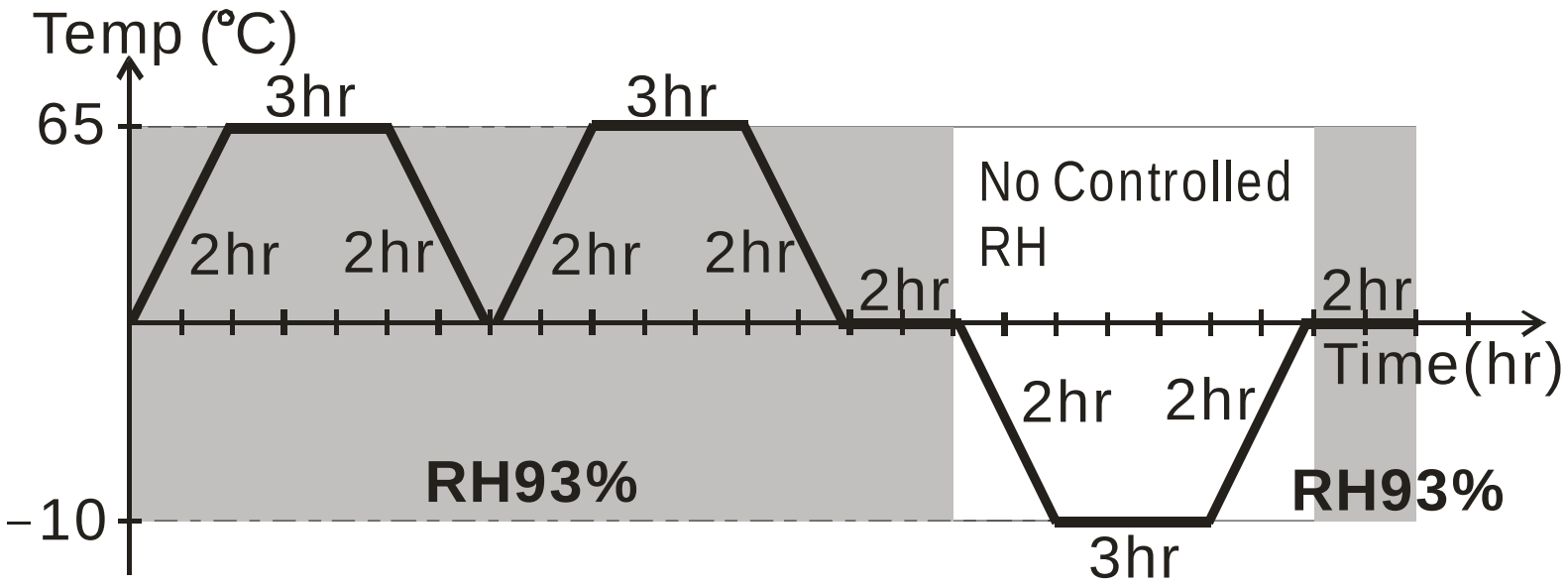
All have similar low loss ~ 0.1 dB

Temperature Cycling Test Setup



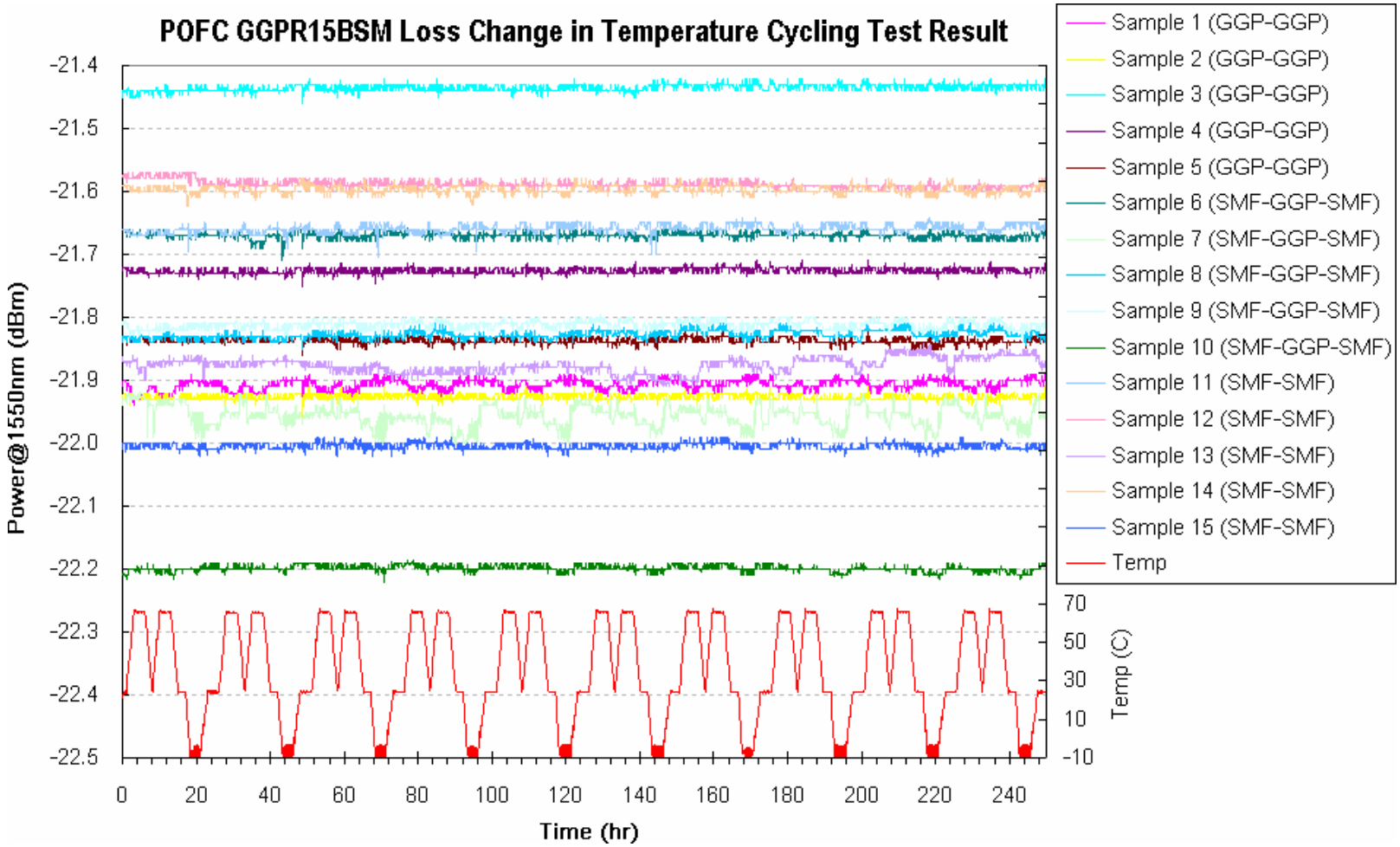
Channel 1-5: GGP5-GGP5
Channel 6-10: SM-GGP5-SM
Channel 11: Blank (SM patchcord)
Channel 12-14: SM-SM
Channel 15: None
Channel 16-17: SM-SM
Channel 18: GGP5 Patchcord

Temperature Cycle



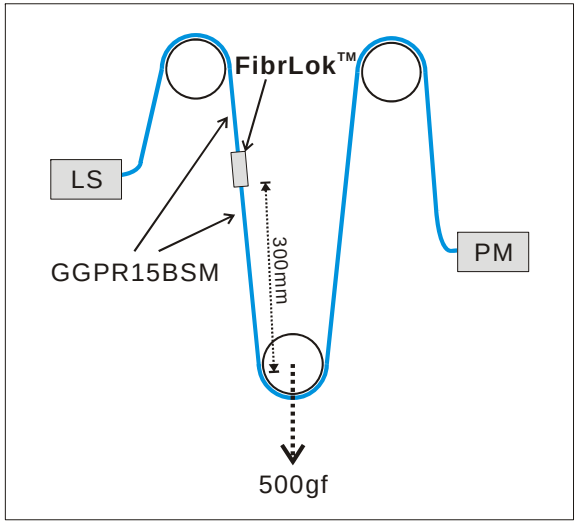
Item	Test Conditions	Criteria
Temperature Cycling Test	Reference:IEC-61300-2-21 Humidity:93±3% RH. Temperature:-10～25～65℃, 10Cycles. (Taiwan Chung Hwa Telecom Temperature Range)	The FibrLok™ loss variation requirement of 0.3dB.

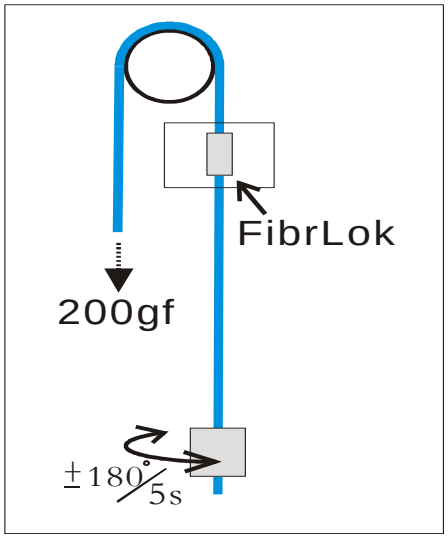
GGPR15 Fiber Splice using FibrLok™ Temperature Cycling Test Results



Maximum Loss Change < 0.1 dB

Mechanical Property Test





Items	Reference	Test conditions	Criteria
Pull Strength	IEC 61300-2-4	Applied 500gf load to FibrLok™ connectors with GGPR15 fiber for 1 minutes.	The FibrLok™ loss variation requirement of 0.2dB.
Twist	IEC 61300-2-5	Applied 200gf load to FibrLok™ connectors with GGPR15 fiber. Rotate the angle of the test fixture through the following cycle: 0°, 90°, 0°, -90°, 0°.	
Vibration	IEC 61300-2-1	Amplitude：1.5mm p-p Frequency：10-55Hz Vibrate the connector for 2 hours.	

Mechanical Properties Test Results

Test Items	3M FibrLok™ (GGPR15-GGPR15)			3M FibrLok™ (SMF-GGPR15-SMF)		
	Sample #	1310nm	1550nm	Sample #	1310nm	1550nm
Pull Strength	1	0.009	0	1	0.025	0
	2	0	0.008	2	0	0.004
	3	0	0.009	3	0.013	0.004
	Average	***0.003***	***0.0057***	***Average***	***0.0127***	***0.0027***
Twist	1	0	0.001	1	0	0.004
	2	0.002	0.001	2	0	0.002
	3	0.001	0.002	3	0.002	0.001
	Average	***0.001***	***0.0013***	***Average***	***0.0006***	***0.0023***
Vibration	1	0.001	0.001	1	0.001	0.002
	2	0	0.001	2	0	0.001
	3	0.002	0	3	0.002	0.002
	Average	***0.001***	***0.0007***	***Average***	***0.001***	***0.0017***

Basically NO Change During Test