Prysmian Group

Optical Fibre Division & Aerospace

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Intra-satellite Fibre Optic Links Workshop
ESA/ESTEC, Noordwijk
10 + 11 Dec. 2015

WORLDWIDE LEADER IN RENEWAB

ARTER AND GREENER POWER GRIDS **LINKING THE FUTURE** SUPPORTING GLOBA

STRONGER PLATFORM TO ENHANCE CUSTOME

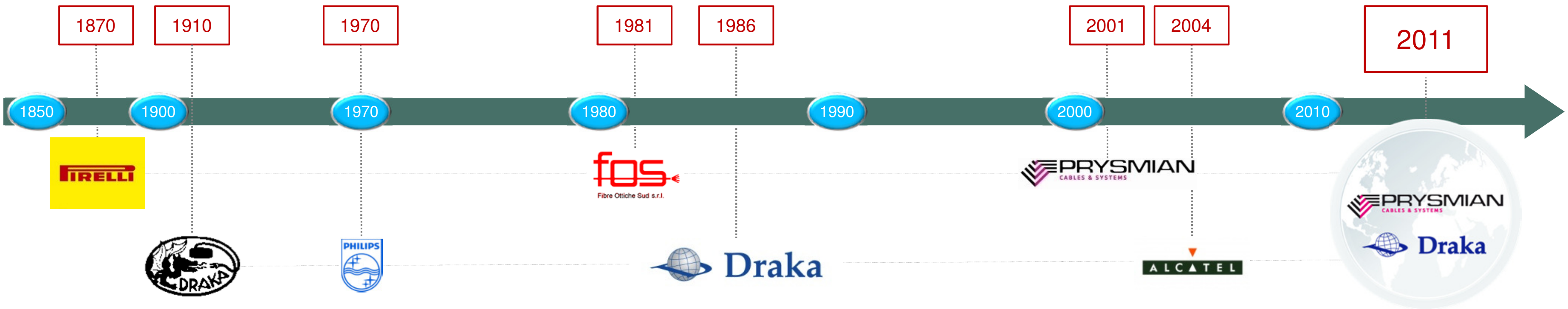
Prysmian Group

No1 in cable solutions for the energy and telecommunication business

PRYSMIAN

Draka

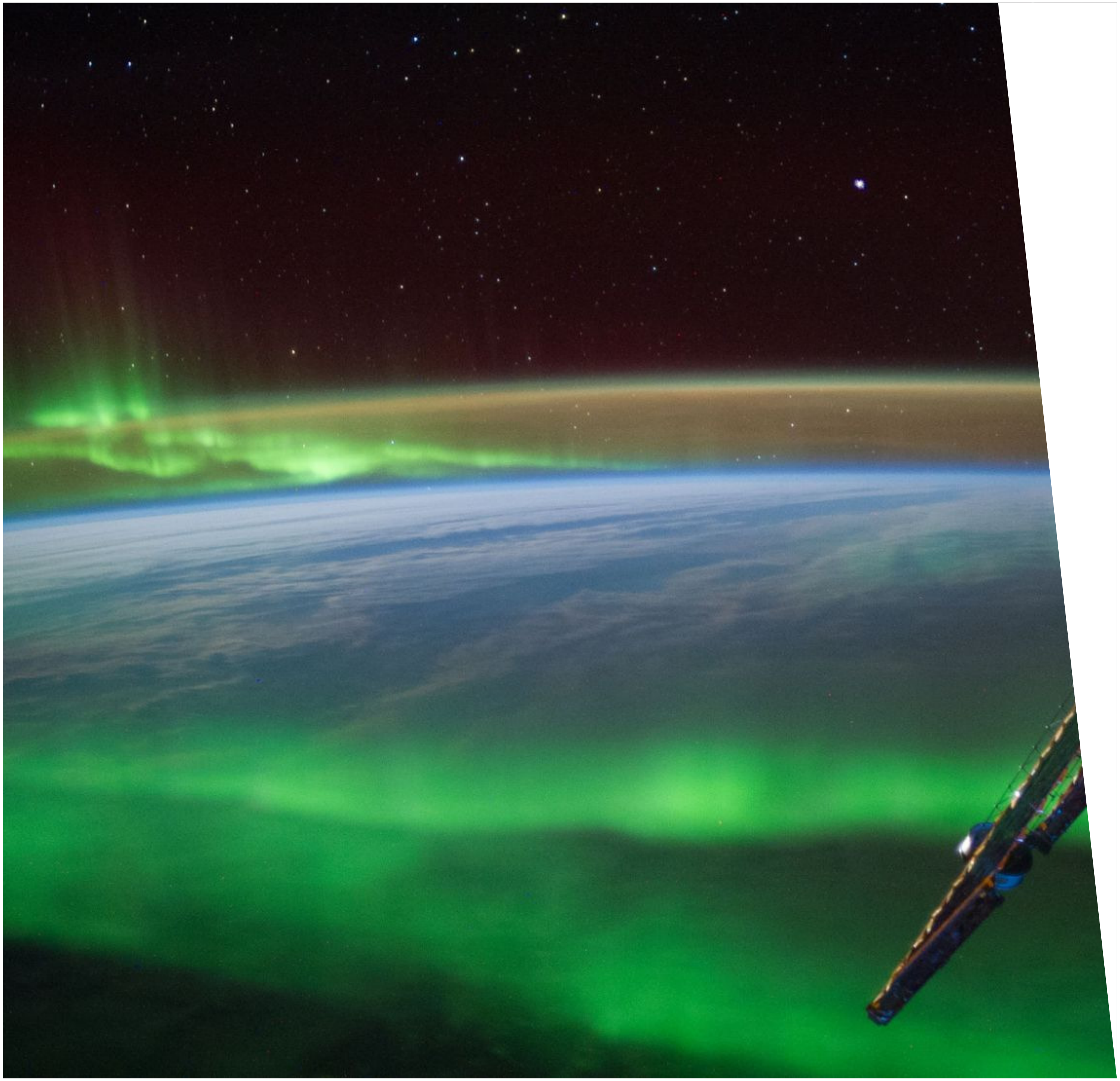
FIBRE PRODUCTION HISTORY



Prysmian Group aggregates industrial assets and technologies developed from:

Draka	=	Philips (PCVD)
Alcatel	=	(FCVD – APVD)
Pirelli	=	(OVD)

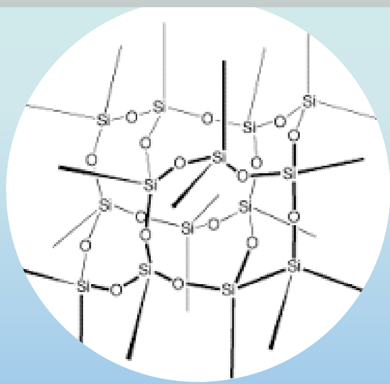
- **PCVD** & **FCVD** manufacturing platform combined with **APVD** overcladding technology deliver optical fibre of same specifications and optical qualities (100% proprietary technologies)
- **OVD** manufacturing platform is operated under Corning's license
- Prysmian Group is the only optical fibre manufacturer operating several manufacturing platforms enabling optimization of optical fibre manufacturing processes allowing unprecedented opportunities in term of product innovation and development.



RADIATION-
HARNEDED
&
SUPER RADIATION
HARDENED

Physical Mechanisms in Silica-based optical fibre

IRRADIATION



SILICA GLASS MATRIX

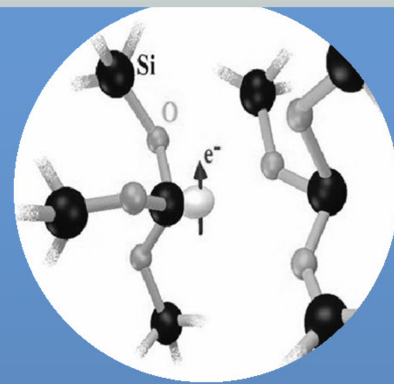
Si-O-Si-O

Si-O-Ge-O

Si-O-P=O

Si-O-Si-F

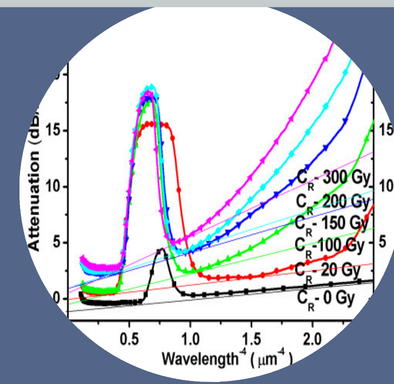
Impurities



MICRO-scopic scale

Broken bonds, trapped charges:
Si°, Si-O°, Si-O° -Si …

- **Creation of Local Defects**
- **Absorption Bands**
  λ_{max} (UV-Visible)
  bandwidth
  Intensity peak
- **Kinetics**
  growth / annealing = lifetime



MACRO-scopic scale

Radiation-Induced Attenuation

- **Wavelength**
- **Glass composition** (Ge, P, F,…)
- **Total dose**
- Dose-rate (defects' lifetime)
- Temperature (thermal bleaching)
- Injected power (photobleaching)

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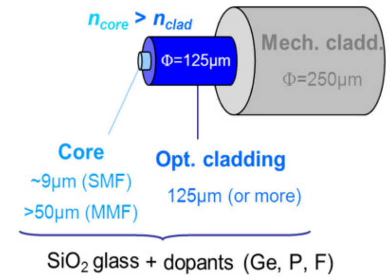
Material Purity & Manufacturing requirements



RIA is dependent on the

Core chemical composition

SiO2 doped with Phosphorus, Bore, Aluminum…

SiO2 doped with Germanium

Pure SiO_2

SiO_2 *doped with F*

RIA ↘

Cladding chemical composition

Synthetic SiO_2

RIA ↘

Impurities content

RIA ↘ when impurity level ↘ (*e.g.* Alcaline, metallic)

Coating properties

Polyimide, acrylate, hermetic coating… Radiation can cause crosslinking resulting in microbending.

Manufacturing parameters

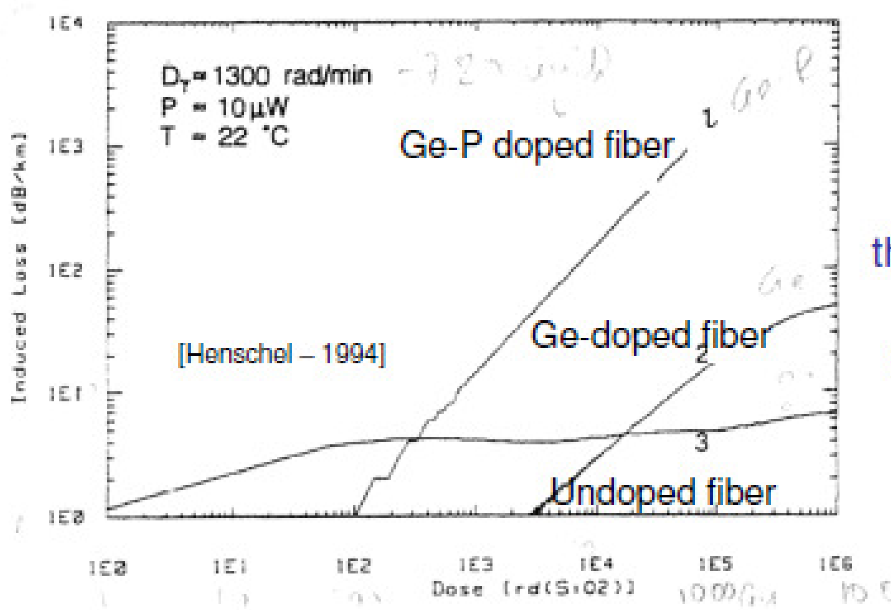
Glass fictive temperature[1] (T_f) at draw as low as possible (less defects)

[1] used to define the structural state of the glass

Impacting parameters for RadHard applications

Fiber composition is the first order parameter regarding radiation resistance

Fibers' performance depends on radiation conditions => a given fiber composition can be good at low doses, but bad at high doses, and vice versa.



To our knowledge, there is no fiber that is perfect for all radiation conditions.

1Gy = 100 Rad

- P is to avoid as dopant, even at low contents in core and fiber cladding
- At very high dose, Ge free fibers are the most radiation-resistant

DRAKA's solutions for RadHard and SRH SMF/MMF

Draka's history in RadHard fibers

- Draka has been involved in RadHard fibers for a long time
- Based on its Plasma-activated Chemical Vapor Deposition (PCVD) process, phosphorous free fibers are produced
- For more then 10 years Draka's RadHard fibers are qualified by USA DoD (MIL-49291 series):
  - ✓ Plant in EINDHOVEN (Netherlands) is qualified by MIL-790 quality system
  - ✓ A dedicated product line is used for manufacturing in order to guarantee the reproducibility of the fiber performance
- Draka also delivered RadHard multimode fibers via other cable manufacturers for the CERN ATLAS detector
- Draka participated in a CERN/Fraunhofer investigation for improved radiation performance (start of super RadHard project)

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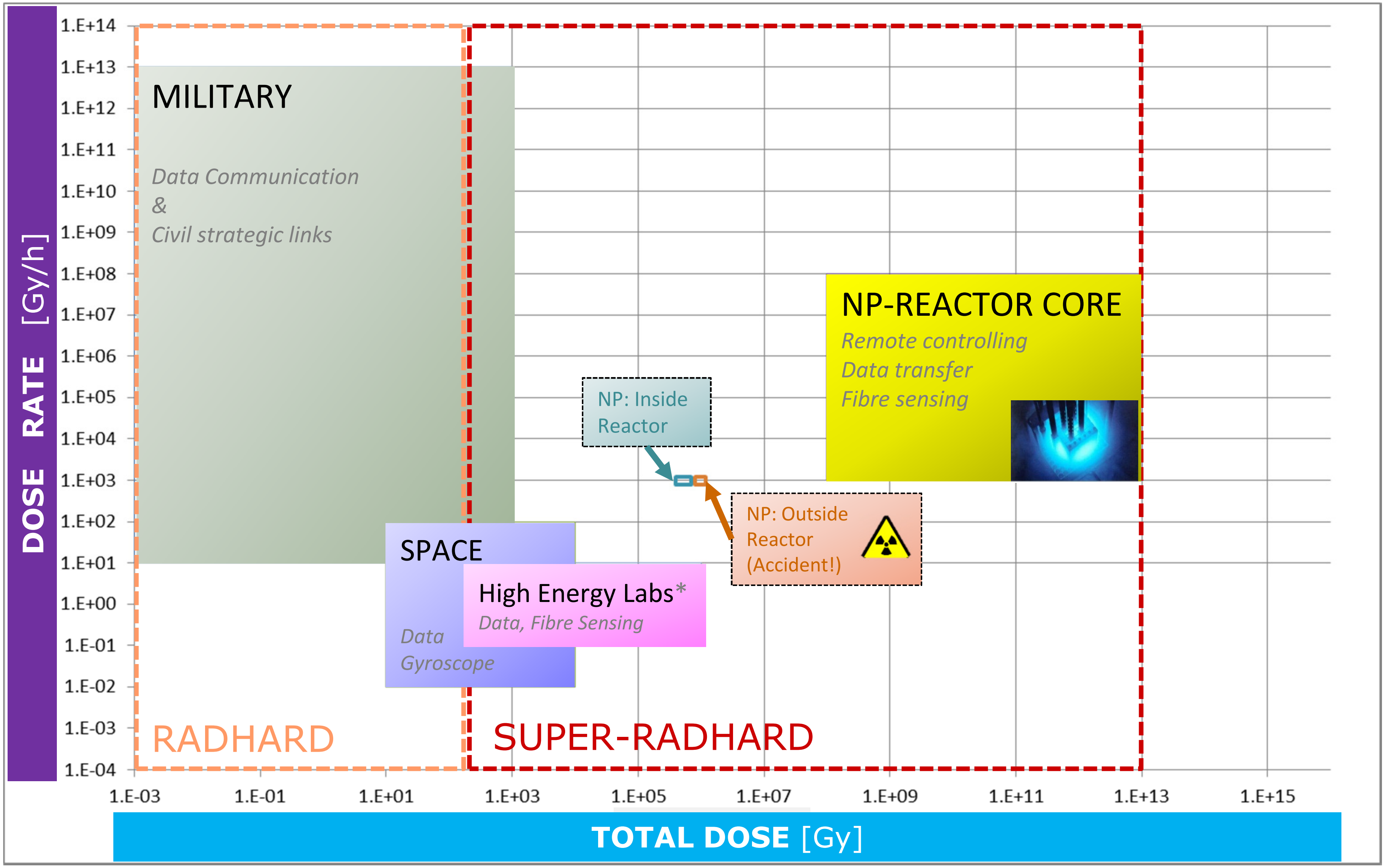
APPLICATION MATRIX



*: Total Annual Dose. CERN / Fermi National Accelerator Laboratory (USA)

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DRAKA's RADHARD & SUPER-RADHARD SERIES

Prysmian Group has developed a wide family of DrakaElite™ specialty multimode and single-mode fibres optimized for use in irradiative environments, thanks to its proprietary PCVD glass deposition process, allowing phosphorous-free operation.

	Single-mode	Multimode
RADHARD Dose < 100 Gy	Germanium-doped core G.652.B type	Germanium doped core GI-MMF OM1, OM2, OM3 & OM4
SUPER-RADHARD Dose > 100 Gy	Depressed-clad Fluorine-doped G.652.B type	Depressed-clad Fluorine doped core GI-MMF OM2

Prysmian Group maintains a dedicated production line, optimized for these RadHard products. Guaranteeing sustainable performances over the lifetime, and traceability – a pre-requisite for both Nuclear Power Plant and Military Applications.

DRAKA's RADHARD MIL-49291 Series

- A wide product range of Germanium-doped fibres has been developed for nuclear performance in US military and space applications, and type approvals have been obtained. (MIL-PRF 49291 series).
- Qualified products can be viewed at DLA/DSCC qualified products list (QPL).
- Draka Fibers are **dual-coated** with high resistant to micro-bending acrylate coating
- High temperature coating can also be applied on request

245 µm diameter coating

RadHard	9/125/245µm	Single-mode	MIL-PRF-49291/7-01
RadHard	62.5/125/245µm	Multimode	MIL-PRF-49291/6-03
RadHard	50/125/245µm[1,2]	Multimode	MIL-PRF-49291/1-01

500 µm diameter coating

RadHard	9/125/500µm	Single-mode	MIL-PRF-49291/7-02
RadHard	62.5/125/500µm	Multimode	MIL-PRF-49291/6-05
RadHard	50/125/500µm[1,2]	Multimode	MIL-PRF-49291/1-02

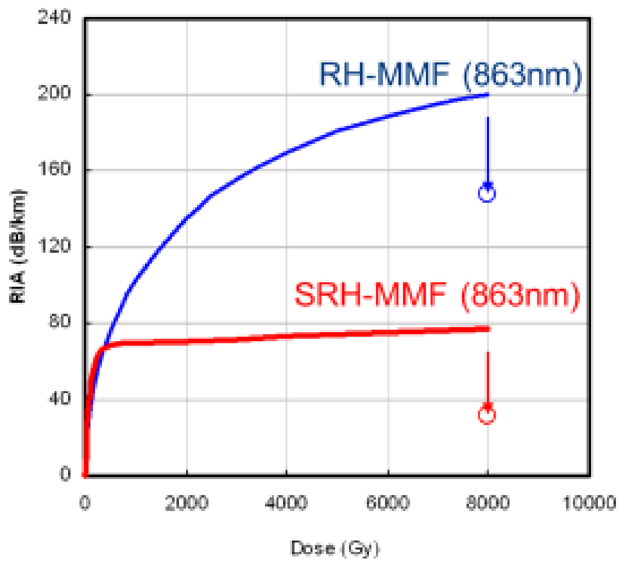
[1] *With or without Bend-Insensitivity performance for 50/125 MMF*

[2] *Available in OM2, MaxCap-OM3 & OM4 quality.*

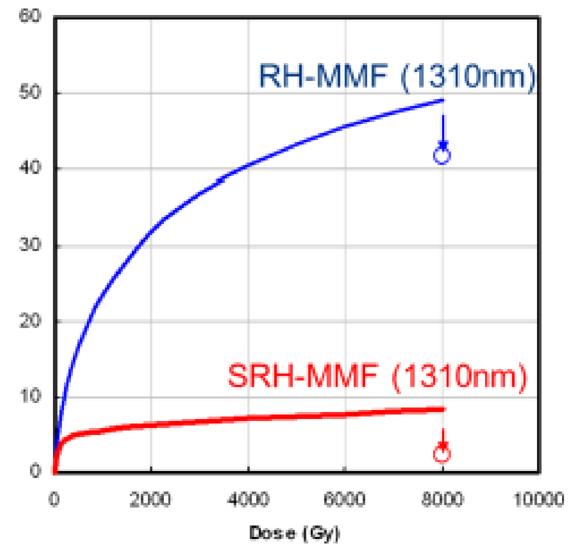
Radiation resistance of Draka's RadHard and Super RadHard MMF

Co^{60} irradiation at a dose rate of 0.125 Gy/s at room temperature

Fiber type : 50 / 125 / 245



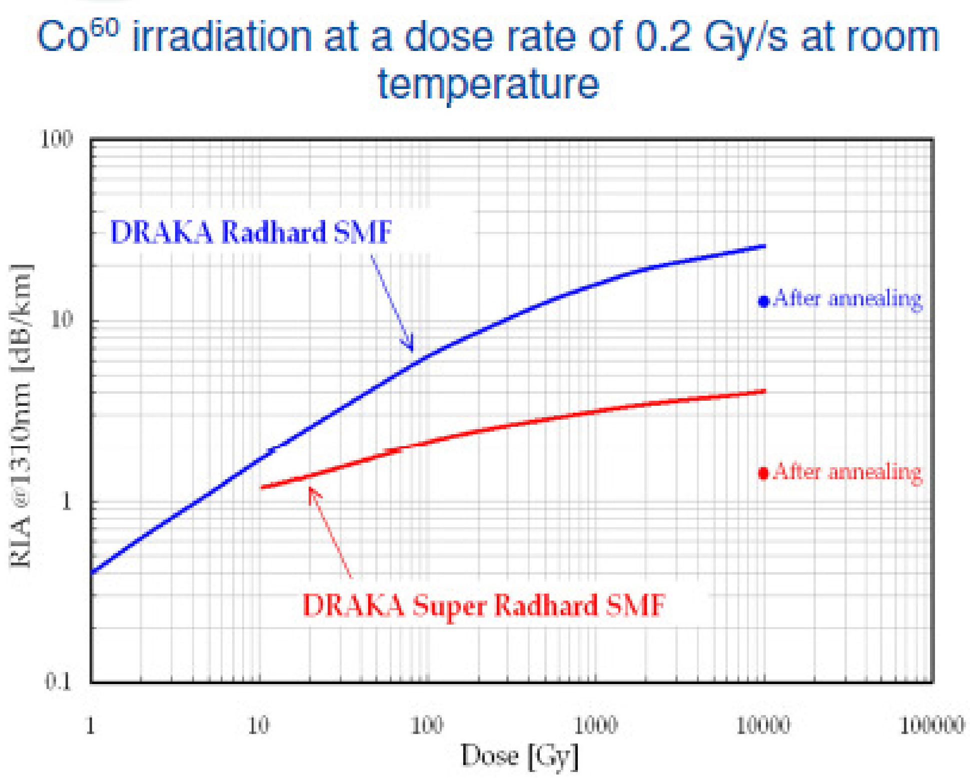
Typical RIA for 10KGy and 0,125Gy/s at 25 C



* **Draka's Super RadHard MMF exhibit very good behavior both under and after radiation exposure ➔ Particularly well suited for <u>high dose applications</u>**

* **Behavior at 850nm / 1300nm has been tested up to 2MGy @1Gy/s and @45C ➔ Typical RIA remains below 20 dB/km at 1300nm and 40 dB/km at 850nm**

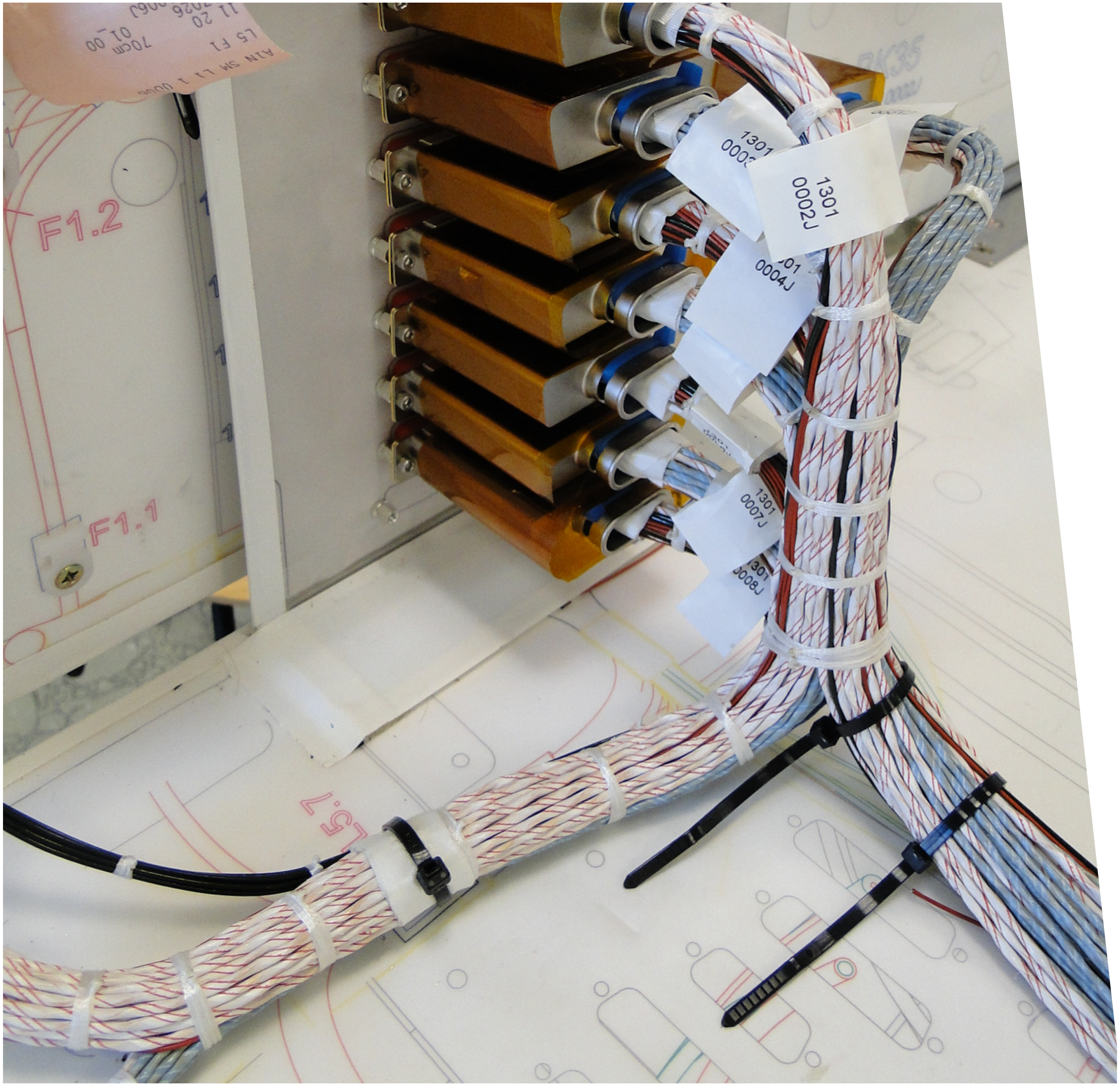
Radiation resistance of Draka's RadHard and Super RadHard SMF



Typical RIA **1310 nm**

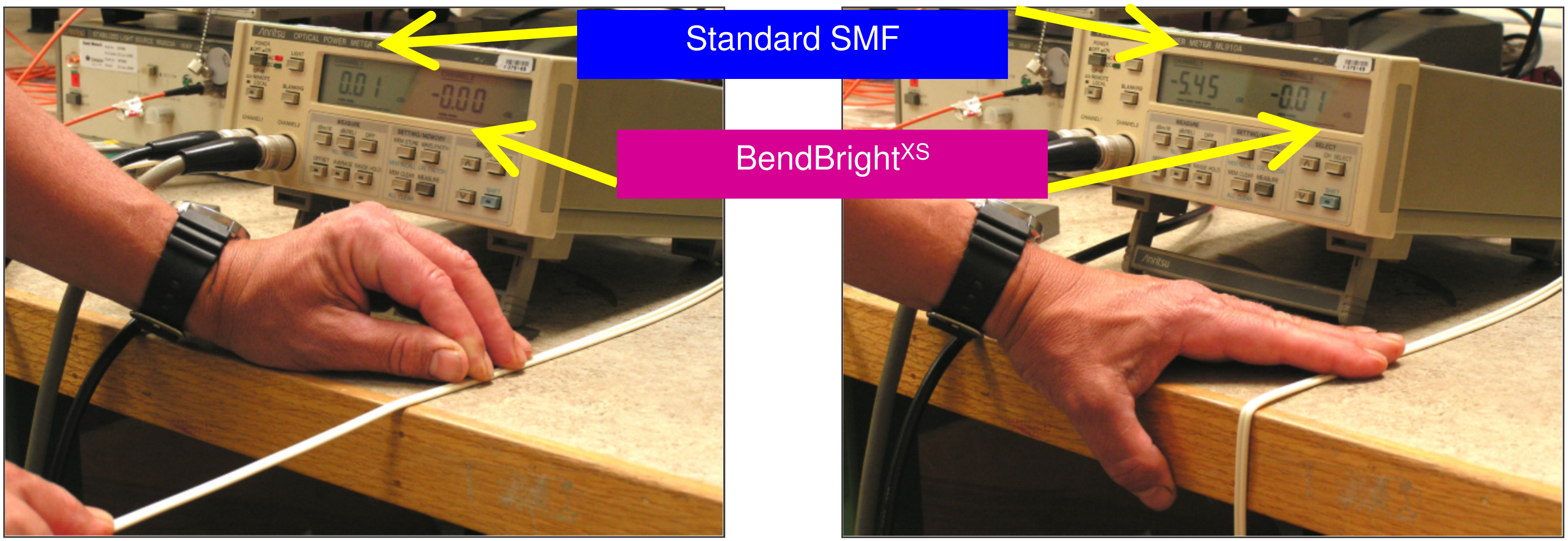
Total dose ; dose rate ; T°C	RIA
10 kGy ; 0,2 Gy/s ; 24°C	~2,5 dB/km
100 kGy ; 1,6 Gy/s ; 24°C	~5 dB/km
2 MGy ; 1,,52 Gy/s ; 45°C	~10 dB/km

*** Draka's Super RadHard SMF exhibit very good behavior both under and after radiation exposure → Particularly well suited for high dose applications**



BENDBRIGHT TECHNOLOGY

BendBright-XS (G.657.A2); 100x more bend resistant than SMF



BendBright-XS

ITU-T G.657.A2, G.652.D

Corner turn r<5mm

PATCHCORD QUALITY

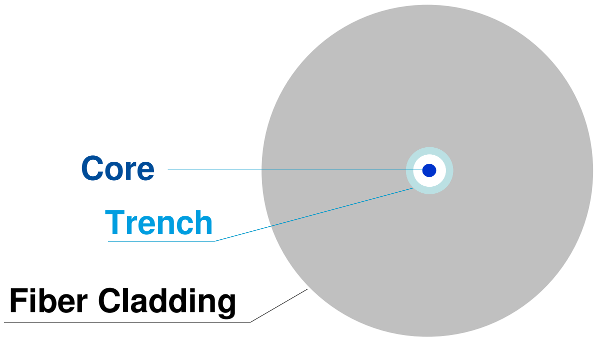
Products for advanced performances in Pigtails, Patchcords and Components

- **Bend insensitive and Ultra bend insensitive**
  - BendBright-XS (ITU-T G.657A2/B2)
  - BendBright-Elite (ITU-T G.657B3)

- **Mechanical Constraint Resistant**
  - High Reliability and Durability in confined environments

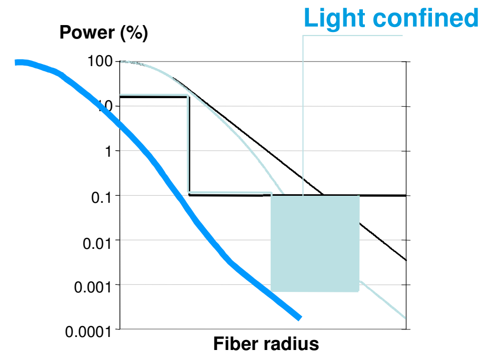
- **Tight geometrical specification for Optical Connections and Connectors**
  - Save on Optical Budget by minimizing Insertion Loss
  - Tighter geometry for more reproducibility

BendBright Technology allows fiber innovation



BendBright Technology

New range of innovative performance and fiber designs



1. BendBright-XS *(2006)*

G.657.A2

G.652.D compliant

All solid-glass design

BIF for indoor/outdoor

> 5Mfiber-km worldwide

2. BendBright-Elite *(2008)*

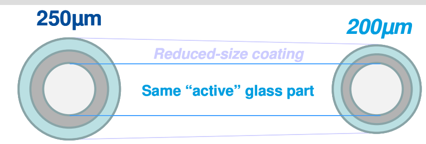
G.657. B3 & G.652.D

G.652.D compliant

All solid-glass design

UBIF for extreme indoor including MDU

3. BendBright-XS 200µm *(2009)*

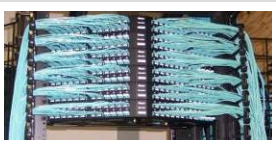


G.657.A2

BIF and ColorLock-XS

High fiber count cables

4. BendBright OM3&4 *(2010)*



Bend-insensitive high-rate multimodes

Support 10, 40, 100 Gb Ethernet

New generation of data centers

5. ezDistance *(2010)*

G.652.D

ULTRA-LOW LOSS

G.652.D, very low cabled attenuation in all bands

ultra-low loss not at the expenses of water peak or L-band

6. LongLine *(2010)*

G.654

Record eff

Longer distances

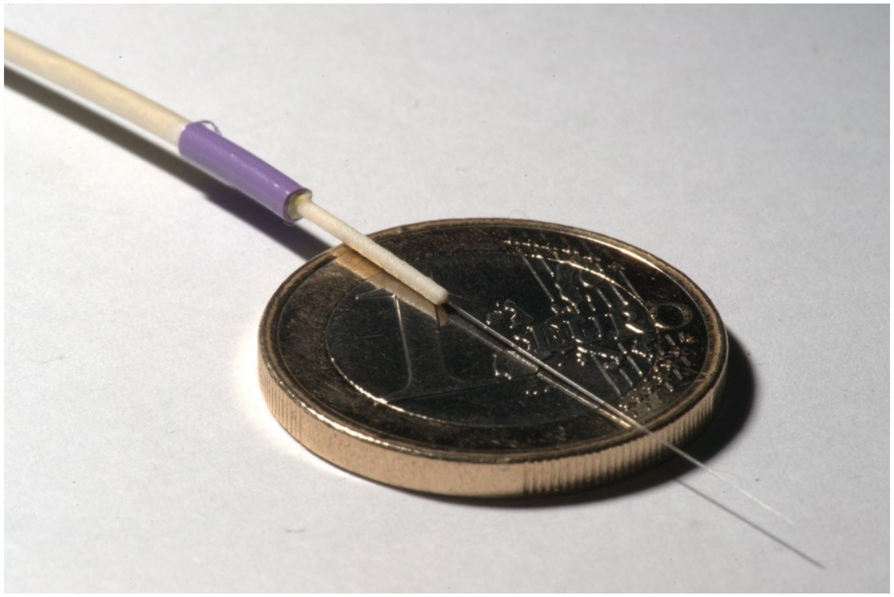
CABLES
&
BENDING RADIUS

Aeronautics experience

More than 20 years experience of FO cables in aeronautics, starting with Eurofighter program.

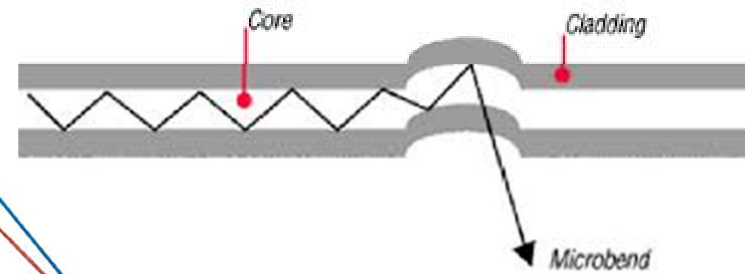
Challenges to fiber optic implementation:

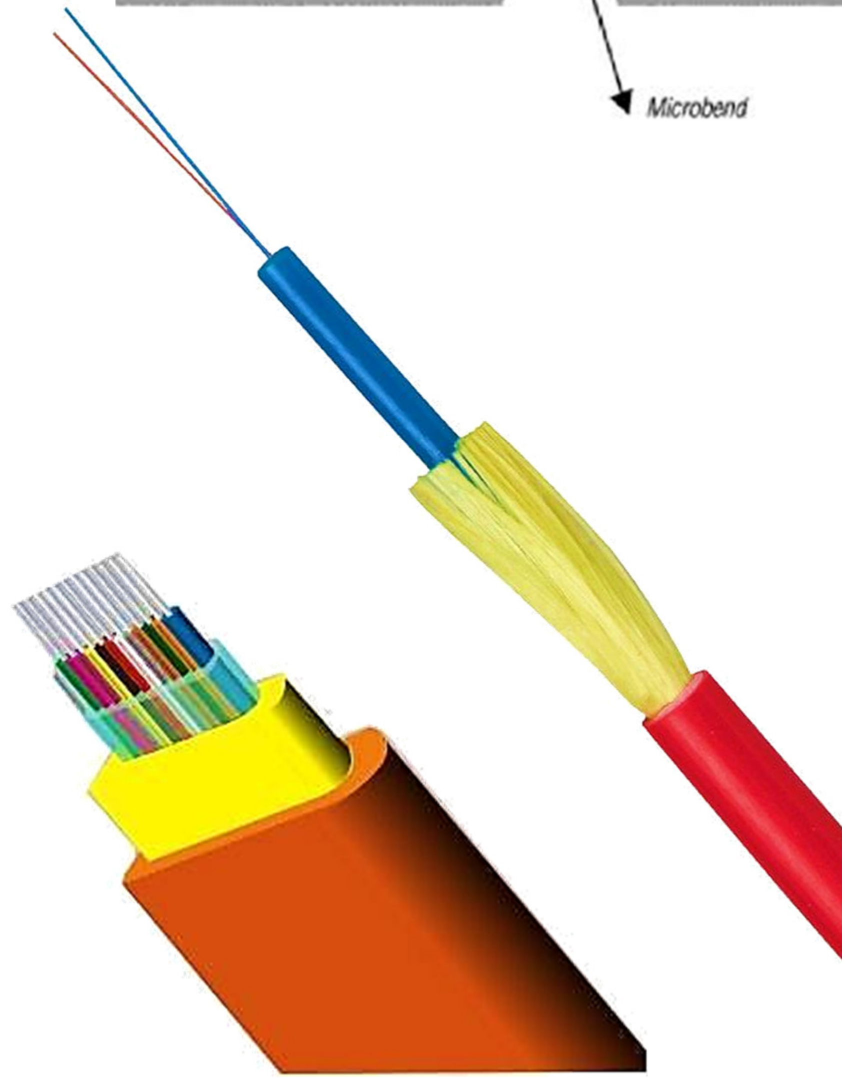
- Extreme temperatures might be down to -60° C and up to +125° C
- Outgassing
- Radiations
- Mechanical shocks & vibrations
- Bending



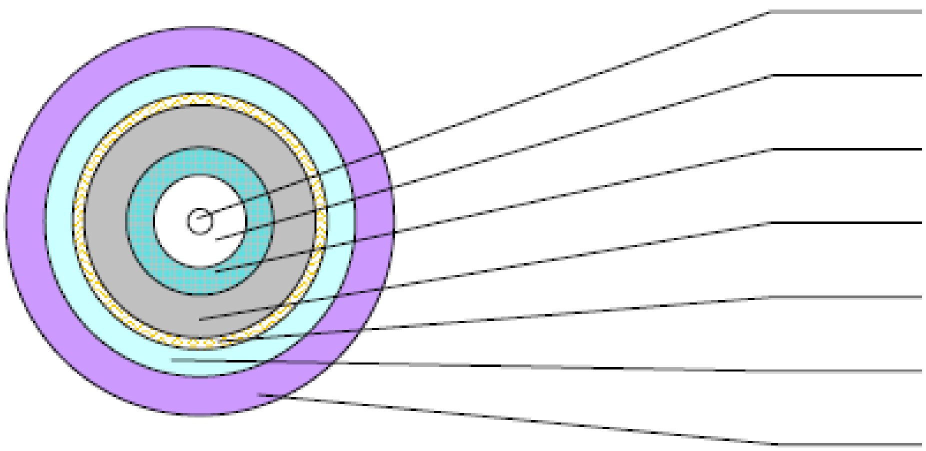
Cables - functions

- Cable Functions
  - Limit micro bending
    - Under acceleration
    - Installation
  - Mechanical protection
    - Abrasion
    - Traction
    - Chocks protection
  - Chemical protection
    - On-board fluids
  - Reduce out gazing
  - Longitudinal stability
    - Under temp variation
    - Dilatation
  - Assembly
    - Ribbon
    - Single





FO CABLES



Item	Designation
1	Core (fibre)
2	Cladding (fibre)
3	Primary buffer
4	Secondary buffer
5	Strength member
6	Jacket
7	

Buffer and jacket materials

	Unit	PTFE	FEP	PFA	Polyimide	PEEK
Temp max	° C	-200 / +260	-200 / +205	-200 / +260	-200 / +260	-60 / +260
Radiation	Gy	10^3	10^4	10^4	10^7	10^8
Hardness	Shore D	58	55	60	75	85

Based on customer requirement, aerospace BU of Prysmian Group defines the construction of the raw material of the cable to optimize and protect the characteristics of the optical fiber.

Thank you

Any questions?

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Draka