AllWave® Fiber

Zero Water Peak

ofs

Leading Optical Innovations

The New Standard for Single-Mode Fiber

Product Description

OFS' AllWave® Zero Water Peak (ZWP) single-mode optical fiber is the industry's first full-spectrum fiber designed for optical transmission systems operating over the entire wavelength range from 1260 nm to 1625 nm. Since 1998, OFS has shipped billions of meters of AllWave ZWP fiber to satisfied customers all over the world. AllWave ZWP fiber is OFS' standard single-mode fiber. This fiber offers customers industry leading performance specifications, reliability, and unsurpassed quality. AllWave ZWP fiber sets the benchmark and maintains leadership with specifications that are fully compliant with ITU-T G.652 standards for single-mode optical fiber and even exceed requirements of the latest ITU-T G.652.D low water peak (LWP) fiber standard.

Before AllWave ZWP fiber was introduced, systems were limited to operating in either the O-band (1310 nm window) or the C- and L-bands (1530 nm to 1625 nm). Since the commercialization of AllWave ZWP fiber in 1998, the E-band (1400 nm window) is available to inexpensively expand the capacity of optical networks. This is due to an OFS patented manufacturing process that ***permanently*** removes the water peak defect to ensure low and stable loss performance in the 1400 nm band and over the lifetime of the cable. AllWave ZWP fiber offers the lowest loss of all commercial LWP fibers in the industry.

Why AllWave ZWP Fiber for Metro and Access Networks?

AllWave ZWP fiber is the fiber of choice for metropolitan, local and the fast evolving access networks due to its superior specifications - low optical loss across the entire wavelength range from 1260 to 1625 nm, tightest available geometry, low splice loss and low PMD. These features, combined with complete compatibility with embedded fiber base, provide ultimate network design flexibility and enable cost effective solutions to help maximize return on investment. AllWave ZWP fiber is protected under OFS US Patent No 6205,268 and world wide counterparts for use in wavelength division multiplexing (WDM) system operation in the water peak region.

AllWave ZWP Fiber supports the most demanding applications, including 10 Gigabit Ethernet, Asynchronous Transfer Mode (ATM), 10 and 40 Gb/s Synchronous Optical Network (SONET), and Synchronous Digital Hierarchy (SDH), using single channel, Dense Wavelength Division Multiplexing

US Patent 6,131,415, 6,205,268, 5,298,047, 5,418,881 and world wide counterparts

Features of the World's Best Single-Mode Fiber:

- **Fully Compatible** with all conventional single-mode fiber international standards. The addition of AllWave ZWP to an existing network will maximize the extended network performance.
- Best in class, **Low Optical Loss** across the entire spectrum from 1260 to 1625 nm (See Figure 1)
- Absence of hydrogen aging defects and using high purity synthetic silica ensures **Long-Term Attenuation Reliability** across the entire wavelength range (1260-1625 nm)
- A **50% Increase in Usable Optical Spectrum** enabling 16- channel CWDM and DWDM support
- Best in class, tightest geometry control for **Lowest Splice Loss** and improved connectorization performance
- Best in class, **Ultra Low Fiber PMD** enables speed and distance upgrades
- **Outstanding Reliability**, environmental performance, and strippability provided by industry leading DLux® Coating
- Provides network designer maximum flexibility to meet todays demanding requirements while best supporting unknown future demands
- Protected by OFS U.S. **patents** and world wide counterparts.

(DWDM) and/or multi-channel Coarse Wavelength Division Multiplexing (CWDM) transmission.

To extend today's network or design tomorrow's emerging networks, look for AllWave ZWP fiber to provide you the greatest capacity and flexibility at the lowest cost.

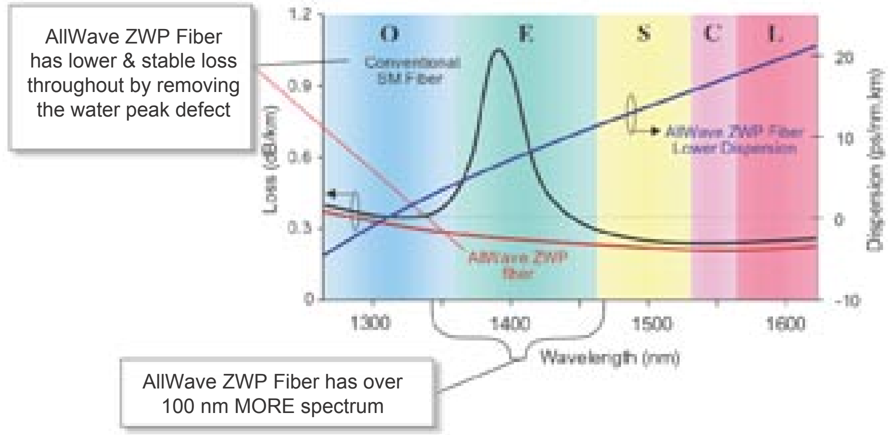


Figure 1. *AllWave ZWP Fiber – Compatible with Conventional Single-Mode Fiber, but with More Available Spectrum*

CWDM and High-Speed Applications in the E-band

Service requirements of metropolitan area networks demand that multiple service platforms be available over network architectures at low cost. CWDM is now a real economic choice as it allows the use of low-cost, uncooled lasers with direct modulation technology and lower cost multiplexers. AllWave ZWP fiber provides 50% more (>100 nm) usable wavelengths than conventional single-mode fiber (G.652.A or G.652.B).

Deploying CWDM over AllWave ZWP fiber, using commercially available equipment from multiple systems vendors, can reduce system costs by 35% or more relative to a DWDM system over conventional single-mode fiber!

AllWave ZWP fiber also supports higher transmission rates without dispersion compensation in the E-band further lowering network cost while leaving room for future upgrades and longer distances.

AllWave ZWP Fiber in HFC Networks and FTTX

Traditionally, with the network being largely unidirectional, Hybrid Fiber Coax (HFC) has provided distributed video service from cable head-ends to residential homes. With the growth of Internet traffic, IP telephony, and video on demand services, up-stream traffic is now evolving to AllWave ZWP fiber based Fiber-to-the-X (FTTX) network. The typical unavailability of low cost upstream optical paths limits the scope of these bi-directional networks. AllWave ZWP fiber solves the problem by providing more upstream paths with low cost CWDM technology.

In addition, AllWave ZWP fiber enables low cost CWDM overlays on spectrum-challenged Passive Optical Networks (PONs) to provide premium point-to-point services for high bandwidth business customers. AllWave ZWP fiber based PONs can also enable low cost CWDM upgrade capacity for instant on-demand HDTV services. Finally, the AllWave ZWP fiber based FTTX network extends the reach of both PON and point-to-point systems by minimizing channel insertion loss through lower attenuation, splice, and connection loss.

OFS is now specifying loss at 1490nm, a standard FTTX wavelength as well as uniformity across the entire spectrum. The standard variation across 1285-1330nm and 1525-1585nm windows have been enhanced to cover the water peak region, as well as the attenuation to 1625nm. OFS specifies maxium loss across the 1400nm band (1360 to 1480nm) relative to the AllWave ZWP fiber benchmark loss of 0.31dB/km at 1383nm. The attenuation in the region from 1460 to 1625 nm is compared to the 1550 nm loss.

Low System PMD

OFS was the first to adopt specifications for Polarization Mode Dispersion (PMD) in single-mode fibers. Manufactured using both a patented fiber drawing process and unsurpassed quality control, AllWave ZWP fiber is specified at levels that improve upon even the most recent PMD specifications in that further improve ITU G.652.D.

OFS understands that PMD is a statistical value that is dependent on the properties of the fiber as well as the mechanical condition of the fiber in cable. OFS uses a low mode coupled (LMC) measurement to ensure fiber performance. Spooled fiber PMD measurements are not indicative of final cabled performance. OFS' AllWave ZWP fiber PMD is specified in fiber form with a best in class Link Design Value (LDV) and a Maximum Individual Fiber Value to support customer validation of system performance as well as individual product performance.

Note: Spool PMD does NOT infer good cabled or field performance.

Choose AllWave ZWP Fiber for Long-Term Reliability

- AllWave ZWP fiber is manufactured using a patented process that helps ensure that the full spectrum attenuation will remain stable throughout the life of the cable, even when exposed to hydrogen.
- AllWave ZWP fiber has stable loss over its lifetime by using high purity synthetic silica glass minimizing alkali impurities and guarding against long-wavelength (LWL, >1360 nm) hydrogen aging loss.
- AllWave ZWP fiber features OFS' high performance DLux coating for excellent environmental performance and long-term reliability. This robust dual coating system is applied over the cladding to protect the fiber but can be easily removed for splicing and connectorization.
- Each fiber is proof-tested to at least 0.7 GPa (100 kpsi) to ensure durable installation and long-term reliability.
- OFS ultra-low & stable PMD performance supports future high speed upgrades.

Geometrical Characteristics:

Glass Geometry:	
Cladding Diameter	125.0 ± 0.7 µm
Core/Clad Concentricity Error	≤ 0.5 µm, < 0.2 µm typically
Cladding Non-circularity	≤ 1.0%
Typical Splice Loss (AllWave ZWP fiber to AllWave ZWP fiber)	< 0.02 dB
DLux Coating Geometry:	
Coating Diameter (colored)	245 – 260 µm
Coating/Cladding Concentricity Error	≤ 12 µm
Length:	
Lengths can be cut to specific customer specifications	
12.6, 25.2, 37.8 and 50.4 km	12.6, 25.2, 37.8 and 50.4 km

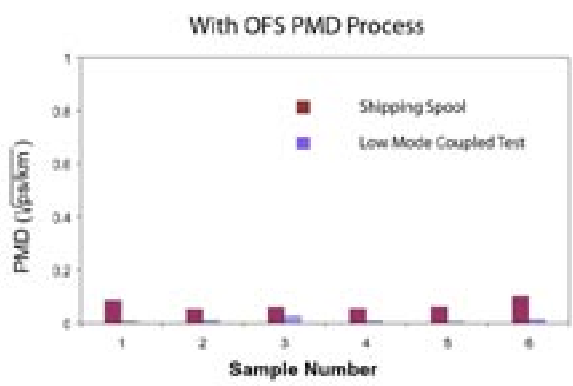
PMD:

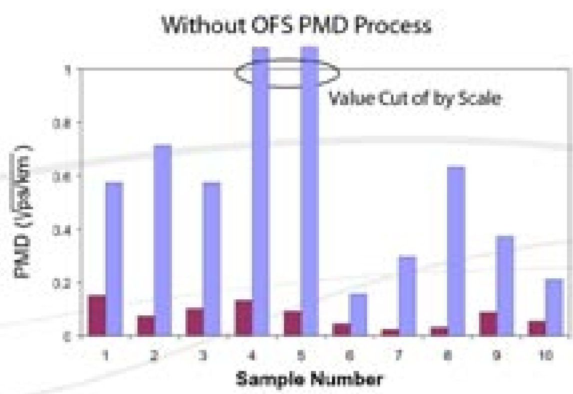
Fiber Polarization Mode Dispersion[1]	
Fiber PMD Link Design Value (LDV)[2]	≤ 0.06 ps/√km
Maximum Individual Fiber	≤ 0.1 ps/√km
Typical Fiber LMC PMD	≤ 0.1 ps/√km

[1] As measured with low mode coupling(LMC) technique in fiber form, value may change when cabled. Check with your cable manufacturer for specific PMD limits in cable form.

[2] The PMD Link Design Value complies with IEC 60794-3 , September 2001 (N=24, Q=0.1%). Details are described in IEC 61282-3 TR Ed1.0, October 27, 2000.

OFS Fiber Has Best in Class PMD





Transmission Characteristics:

Attenuation (uncabled fiber):

The maximum attenuation coefficient (loss) may be specified as follows:

Wavelength (nm)	Attenuation (dB/km)	
	Maximum	Typical
1310	0.34	0.32
1383	0.31	0.28
1490	0.24	0.21
1550	0.21	0.19
1625	0.24	0.20

Attenuation vs. Wavelength:

Range (nm)	Reference(nm) λ	α
1285 – 1330	1310	0.03
1360 – 1480	1385	± 0.04
1525 – 1575	1550	0.02
1460 – 1625	1550	0.04

The attenuation in a given wavelength range does not exceed the attentuation of the reference wavelength(λ)by more than the value α .

Change in Attenuation at Water Peak:

The uncabled fiber attenuation coefficient at the OH^- absorption peak (1383 ± 3 nm) after exposure to hydrogen is ≤ 0.31 dB/km and ≤ 0.28 dB/km typically. This test simulates long-term hydrogen aging in installed cables.

Macrobending Attenuation:

The maximum attenuation with bending does not exceed the specified values under the following deployment conditions:

Deployment Condition	Wavelength	Induced Attenuation
1 turn, 32 mm (1.2 inch) diameter	1550 nm	≤ 0.05 dB
100 turns, 50 mm (2 inch) diameter	1310 nm 1550 nm	≤ 0.05 dB ≤ 0.05 dB
100 turns, 60 mm (2.4 inch) diameter	1550 nm 1625 nm	≤ 0.05 dB ≤ 0.05 dB

Point Discontinuities:

No attenuation discontinuities greater than 0.05 dB at 1310 nm or 1550 nm.

Chromatic Dispersion:

Zero dispersion wavelength (λ_0):	1302 – 1322nm
Typical zero dispersion wavelength:	1312 nm
The maximum dispersion slope (S_0) at λ_0:	0.090 ps/nm² -km
Typical dispersion slope:	0.087 ps/nm² -km

Mode Field Diameter:

at 1310 nm	9.2 ± 0.4 µm
at 1550 nm	10.4 ± 0.5 µm

Cutoff Wavelength:

Cable Cutoff Wavelength (λ_{cc}):	≤ 1260 nm

Environmental Characteristics:

Operating Temperature:	-60º C to +85º C
Temperature Dependence of Attenuation	
Induced attenuation at 1310, 1550 & 1625 nm at -60º C to +85º C	≤ 0.05 dB/km
Temperature – Humidity Cycling	
Induced attenuation at 1310, 1550 & 1625 nm at -10º C to +85º C and 95% relative humidity	≤ 0.05 dB/km
Water Immersion, 23º C	
Induced attenuation at 1310, 1550 & 1625 nm due to water immersion at 23 ± 2º C	≤ 0.05 dB/km
Accelerated Aging (Temperature), 85º C	
Induced attenuation at 1310, 1550 & 1625 nm due to temperature aging at 85 ± 2º C	≤ 0.05 dB/km
Full Spectrum Testing & Performance Assurance	

Mechanical Characteristics:

Proof Test Level:	0.7 GPa (100 kpsi)
Dynamic Tensile Strength:	
The median tensile strength of unaged samples with a 0.5 meter gauge length is:	≥ 3.8 GPa (550 kpsi)
Coating Strip Force:	
The force to mechanically strip the dual coating is:	≥ 1.3 N (0.3 lbf.) and < 8.9 N (2.0 lbf.)
Pullout Force (Adhesion of DLux Coating to Glass Surface):	
The pullout force is:	> 6.2 N (1.4 lbf.) and < 22.2 N (4.9 lbf.)

Other Performance Characteristics:

Effective Group Index of Refraction:	
1310 nm	1.467
1383 nm	1.468
1550 nm	1.468
Dynamic Fatigue Parameter (N_d):	> 20
Rayleigh Backscattering Coefficient (for 1 ns pulse width):	
1310 nm	-79.6 dB
1550 nm	-82.1 dB
Weight per unit length:	64 grams/km

Full backward compatibality with Legacy Equipment and Other Industry Standard Single-Mode Fibers

With the similar dispersion characteristics at 1310 nm and 1550 nm as conventional single-mode fiber, AllWave ZWP fiber is compliant to the latest ITU -T G.652 A through D requirements. As shown in the table below AllWave ZWP fiber has dramatically improved performance in almost every characteristics for conventional single-mode fiber , and thus is clearly fully backward compliant to any G652 single mode fiber.

Best-in-Class Splice Performance

The excellent geometrical properties and tight mode field control of AllWave ZWP fiber enable consistent low loss splices when matched to either AllWave ZWP fiber or other leading G.652 fibers. This helps eliminate splice remakes in the field, lowering the cost of deploying fiber.

Comparison to Standards:

Fiber Attributes

Attribute	G.652.A Value	G.652.B Value	G.652.C Value	G.652.D Value	AllWave ZWP Fiber Value
Mode field diameter at 1310 nm	Nominal: 8.6 – 9.5 µm, Tolerance: ± 0.7 µm				Better by > 40%
Mode field diameter at 1550 nm	No Recommendation				—
Cladding diameter	125 ± 1.0 µm				Better by > 30%
Core concentricity error	≤ 0.8 µm				Better by > 35%
Cladding noncircularity	≤ 2.0%				Better by > 50%
Cable cut-off wavelength	≤ 1260 nm				Meets
Macrobend loss at 1310	No Recommendation				—
Macrobend loss at 1550	≤ 0.5 dB			≤ 0.5 dB	Better by > 95%
Macrobend loss at 1625		≤ 0.5 dB	≤ 0.5 dB		Better by > 60%
Proof stress	≥ 0.69 GPa				Meets
Zero dispersion wavelength	1300 – 1324 nm				Better by > 15%
Zero dispersion slope	≤ 0.093 ps/nm²/km				Exceeds

Cable Attributes

Attribute	G.652.A Value	G.652.B Value	G.652.C Value	G.652.D Value	AllWave® ZWP Fiber Value for Cable Margin G652A- G652D
Attenuation at 1310 nm	≤ 0 .5 dB/km	≤ 0.4 dB/km	≤ 0.4 dB/km	≤ 0.4 dB/km	Better by > 32% – 15%
Attenuation at 1383 nm ± 3 nm (post H_2 aging)			≤ 1310 nm value	≤ 1310 nm value	Better by > 23%
Attenuation at 1550 nm	≤ 0.4 dB/km	≤ 0.35 dB/km	≤ 0.3 dB/km	≤ 0.3 dB/km	Better by > 48% – 30%
Attenuation at 1625 nm		≤ 0.4 dB/km	≤ 0.4 dB/km	≤ 0.4 dB/km	Better by > 40%
Maximum PMD_Q	≤ 0.5 ps/√km	≤ 0.2 ps/√km	≤ 0.5 ps/√km	≤ 0.2 ps/√km	Better by > 88% – 70%