

# TrueWave® *REACH* Fiber

## Low Water Peak



A Furukawa Company

Optimized for 40+ Gb/s transmission, Raman pumping, long span length and economical upgrades of transmission equipment.

### Overview

TrueWave® *REACH* Fiber provides maximum performance for optically amplified systems over longer distances with higher capacity. TrueWave *REACH* Fiber meets and exceeds both the ITU-T G.655 C and E and G.656 standards. Optimized for Raman amplification, the fiber minimizes the need for complex dispersion and dispersion slope compensators and additional amplification. With fully matched dispersion compensation modules available in the C-, L-, and S-bands, TrueWave *REACH* Fiber enables the highest performance and minimal system cost for 10 and 40 Gb/s transmission and beyond.

### Product Description

TrueWave *REACH* Fiber, a low water peak product, has been engineered for today's high capacity optically amplified systems – and tomorrow's. It is fully compliant with both ITU-T G.655.C and E and G.656 recommendations for Non-Zero Dispersion Fiber (NZDF), but its engineering goes well beyond those specifications.

TrueWave *REACH* Fiber allows Dense Wavelength Division Multiplexing (DWDM) transmission channels to be used over the full S, C, and L-bands (1460 to 1625 nm). Not only is the fiber fully compatible with erbium doped fiber amplifiers (EDFAs), it is also optimized for the fast emerging distributed Raman amplification technology:

- Its high Raman efficiency enables more effective coupling of the Raman pump power into the optical signal – substantially better than fibers with a larger effective area
- Its low water peak provides low attenuation at the critical pump wavelengths near 1383 nm
- It features a zero dispersion wavelength (ZDW) below 1405 nm, preventing four wave mixing between the Raman pump source and the transmission signal.

### Applications

TrueWave *REACH* Fiber provides full-spectrum optical performance. Its typical attenuation at 1383 nm is less than 0.35 dB/km (this value is maintained after exposure to hydrogen, according to tests defined in IEC 60793-2-500). Its low water peak attenuation enables the use of the entire wavelength range from 1310 to 1625 nm.

### Features/Benefits:

- Low and stable full spectrum performance to maximize transmission distance and minimize transmitter power
- Ultra-low and stable PMD to support the highest data rates with lower electronics costs
- Low dispersion slope to provide more DWDM channels and lower residual dispersion as well as less temperature variation
- Optimized for both EDFA and Raman amplification to maximize system design options.

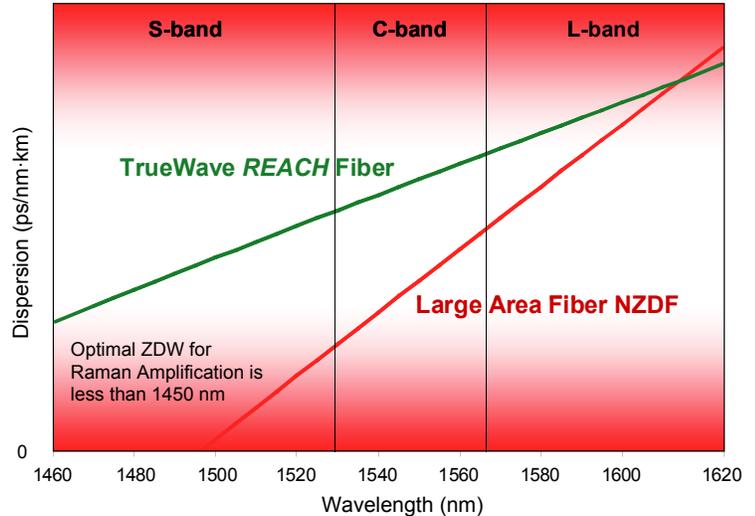
### Transmission examples using TrueWave *REACH* Fiber with 100 km spans, consistent with many terrestrial deployments:

- 3200 km transmission of 80 wavelength channels operating in the C-band alone, at 10 Gb/s each
- Greater than 3 Tb/s per second transmission over 1200 km of TrueWave *REACH* Fiber, with 77 wavelength channels operating in both the C- and L-bands, each at 40 Gb/s
- S-band transmission of 40 wavelength channels at 10 Gb/s each, over 1200 km, with a Raman amplified system.
- 2000 km transmission of 80 wavelength channels, each at 40 Gb/s, with wideband Raman amplification and RightWave DCMs that simultaneously compensate both the C- and L-bands.

## Wide Operating Band

Ideally, the chromatic dispersion of an optical fiber should have a constant, moderate value over the entire operating wavelength region. However, the dispersion of all fibers changes with wavelength, as determined by the dispersion slope. The smaller the slope, the less the dispersion changes with wavelength. For optimum performance over the C-, L-, and S-bands, dispersion slope should be minimized. TrueWave *REACH* Fiber fulfills the G.656 requirement based on its low dispersion slope.

The small dispersion slope of TrueWave *REACH* Fiber allows its minimum dispersion to be increased to better suppress the four wave mixing (FWM) nonlinearity. At the same time, this keeps the fiber's maximum dispersion small enough for signals to travel over long distances with minimum need for dispersion and dispersion slope compensation over the C-, L-, and S-bands. Finally, TrueWave *REACH* Fiber keeps the ZDW below 1450 nm in order to avoid FWM between Raman pump source and transmission signal for optimum distributed Raman amplification.

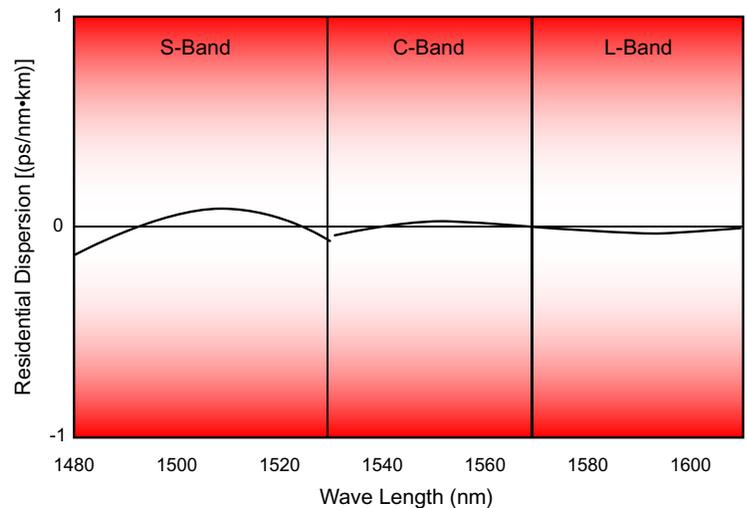


**TrueWave *REACH* Has Optimal Dispersion Across All Three Bands**

## Precise Dispersion Compensation

The highest capacity systems today use the wide spectral bands available in optical fibers. To achieve long distance transmission for 10 Gb/s systems, and especially for 40 Gb/s systems, precise dispersion compensation over the full extent of these bands is required.

TrueWave *REACH* Fiber is optimized to achieve precise wideband dispersion over the C-, L-, and S-bands. TrueWave *REACH* Fiber's dispersion properties result in a low relative dispersion slope across all three bands. This makes it easier to create the precise wideband compensating modules needed for high capacity systems. Coupled with OFS' RightWave™ Dispersion Compensating Modules (DCM), TrueWave *REACH* Fiber provides unsurpassed system performance compared with other NZDF products.



**RightWave DCM with TrueWave *REACH* LWP Delivers Unsurpassed Residual Dispersion**

## Flexible Amplification

TrueWave *REACH* Fiber allows DWDM transmission channels to be used over the full S, C and L-bands (1460 to 1625 nm). Amplifier technologies used may be both EDFAs and the fast emerging distributed Raman amplification technology.

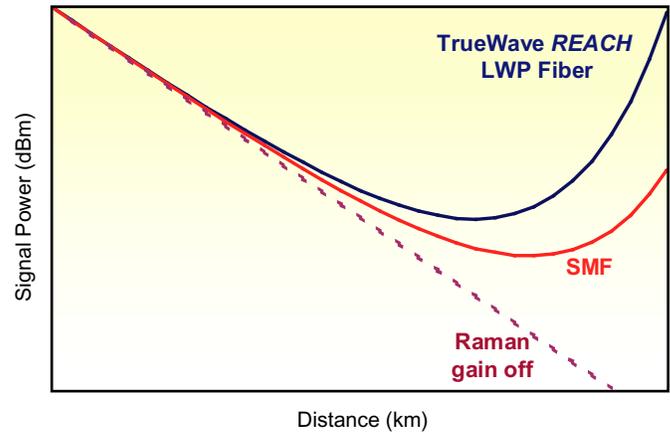
Distributed Raman amplification technology shows advantages in reducing system noise and enabling wideband amplification as compared to today's EDFAs. How well the transmission fiber can utilize this new amplifier technology is defined by the Raman Gain Efficiency (see below).

## Optimal Raman Gain Efficiency

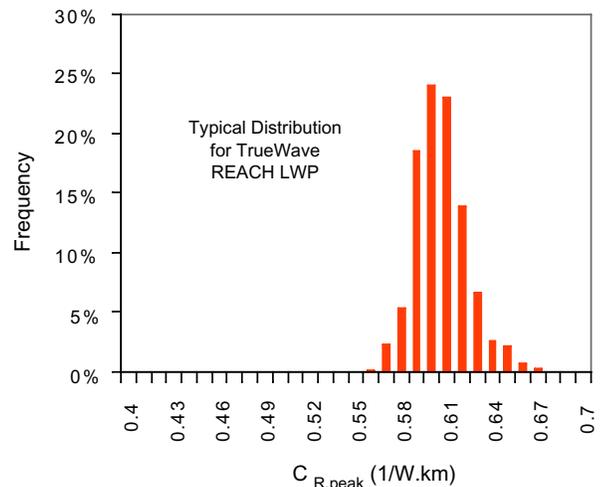
TrueWave *REACH* Fiber has been optimized to have one of the best Raman gain efficiencies compared to other transmission fibers due to the optimized effective area of the fiber. A typical value for TrueWave *REACH* Fiber is 0.60 W<sup>-1</sup> km<sup>-1</sup> compared to 0.40 – 0.45 for Standard Single-Mode Fiber and Large Effective Area NZDF respectively.

## Manufacturing and Quality Control

OFS was the first to adopt specifications for Polarization Mode Dispersion (PMD) in single-mode fibers. Manufactured using both a fiber drawing process patented by OFS and extensive process control, TrueWave *REACH* Fiber is specified at levels much lower than the minimum requirements defined by ITU-T G.655 and G.656. OFS understands the fundamental statistical behavior of PMD and its measurement to develop a process that provides an ultra low PMD in the optical fiber that can be preserved with proper cable design. Proven in a large number of installations, our Link Design Value of less than 0.04 ps/sqrt(km) can be preserved in the field. OFS engineers are ready to support customer validation of system performance as well as individual product performance.



**Raman Amplification Performance**



**Raman Gain Efficiency ( $C_{R,Peak}$ )**

## Product Specifications

### Physical Characteristics

Clad Diameter	125.0 ± 0.7 μm
Clad Non-Circularity	≤ 0.7 %
Core/Clad Concentricity Error (Offset)	≤ 0.5 μm, ≤ 0.2 μm typically
Coating Diameter (Uncolored)	245 ± 5 μm
Coating-Clad Concentricity Error (Offset)	≤ 10 μm
Tensile Proof Test	100 kpsi (0.69 GPa)
Coating Strip Force	Range: ≥ 1.3 N ≤ 8.9 N (≥ 0.3 lbf ≤ 2.0 lbf)
Fiber Curl Radius	≥ 4 m
Dynamic Fatigue Parameter (N <sub>d</sub> )	≥ 20
Reel Lengths	Standard as well as customer specific lengths are available up to 50.4 km

### Optical Characteristics (after hydrogen aging)

Attenuation	Maximum	Typical
at 1310 nm	≤ 0.4 dB/km	≤ 0.35 dB/km
at 1383 nm	≤ 0.4 dB/km	≤ 0.35 dB/km
at 1450 nm	≤ 0.26 dB/km	≤ 0.25 dB/km
at 1550 nm	≤ 0.22 dB/km	≤ 0.20 dB/km
at 1625 nm	≤ 0.24 dB/km	≤ 0.21 dB/km

Attenuation Uniformity at 1550 nm ≤ 0.05 dB

#### 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	≤ 0.5 dB
	1625 nm	≤ 0.5 dB
100 turns, 60 mm (2.4 inch) diameter	1550 nm	≤ 0.05 dB
	1625 nm	≤ 0.05 dB

#### Chromatic Dispersion

C-Band 1530-1565 nm	5.5 – 8.9 ps/nm-km
L-Band 1565-1625 nm	6.9 – 11.4 ps/nm-km
Dispersion Slope at 1550 nm	≤ 0.045 ps/nm <sup>2</sup> -km
S - L bands 1460 - 1625 nm	2.0 – 11.4 ps/nm-km
Zero Dispersion Wavelength	≤ 1405 nm

Chromatic Dispersion at 1310 nm -5 ps/nm-km (typical)

#### Group Refractive Index

at 1310 nm	1.471
at 1550 nm	1.470
at 1625 nm	1.470

Mode Field Diameter	8.6 ± 0.4 μm @ 1550 nm
Effective Area	55 μm <sup>2</sup> (typical) @ 1550 nm

Cut-off Wavelength (λ<sub>cc</sub>) ≤ 1330 nm

#### Polarization Mode Dispersion (PMD)<sup>1</sup>

Fiber PMD Link Design Value (LDV) <sup>2</sup>	≤ 0.04 ps/√km
Maximum Individual Fiber	≤ 0.1 ps/√km
Typical Fiber LMC PMD	≤ 0.02 ps/√km

<sup>1</sup> 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.

<sup>2</sup> The PMD Link Design Value complies with IEC 60794-3, September 2001 (N = 20, Q = 0.01%). Details are described in IEC 61282-3 TR Ed 2, October 2006.

Typical Raman Gain Efficiency ≥ 0.6 (1/W.km) using 1450 nm pump source

### Environmental Characteristics (at 1550 & 1625 nm)

Temperature Cycling (-60° + 85° C)	≤ 0.05 dB/km
High Temperature Aging (85 ± 2° C)	≤ 0.05 dB/km
Temperature & Humidity Cycling (at -10° C to +85° C and 95% RH)	≤ 0.05 dB/km
Water Immersion (23 ± 2° C)	≤ 0.05 dB/km

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1-888-fiberhelp (from inside the USA).

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