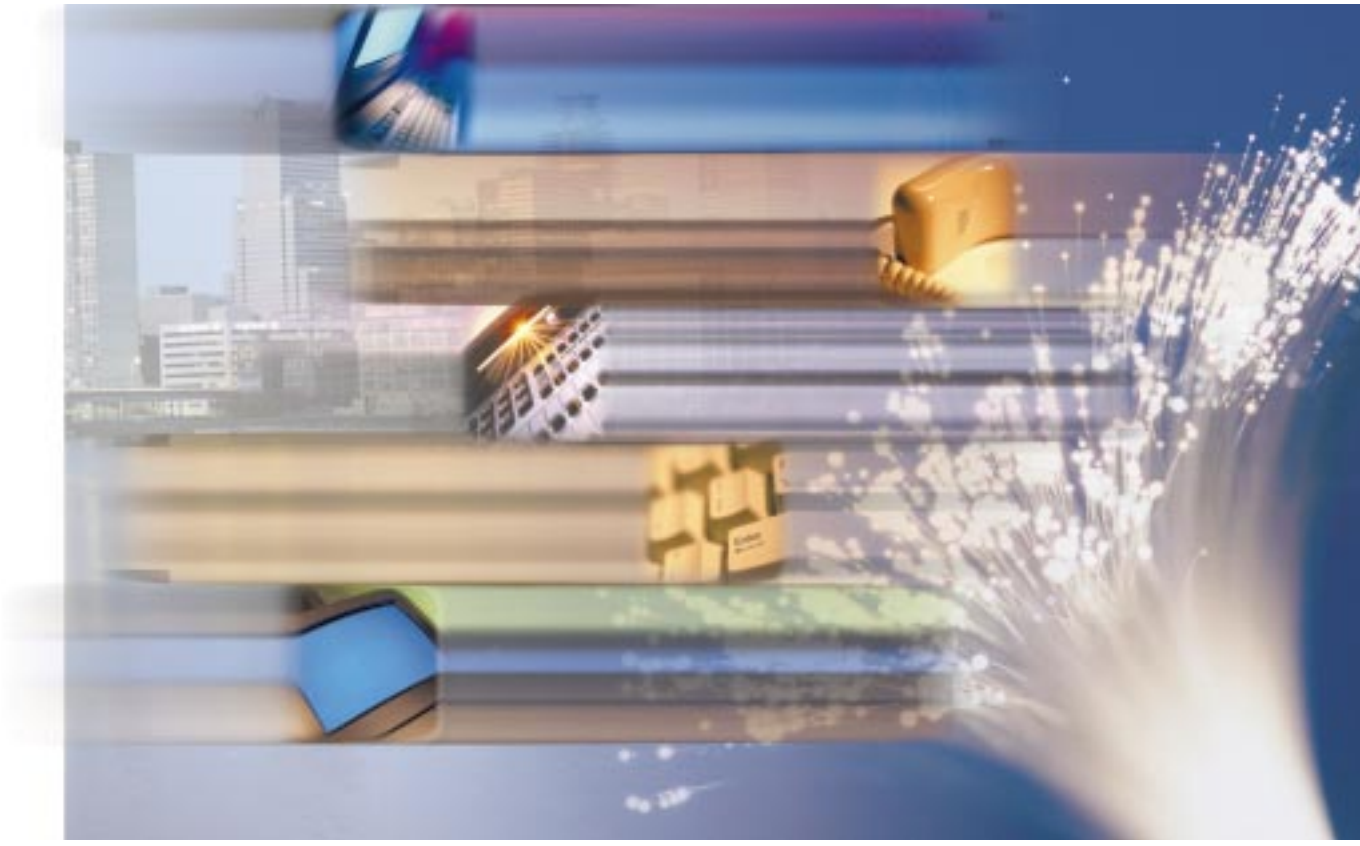
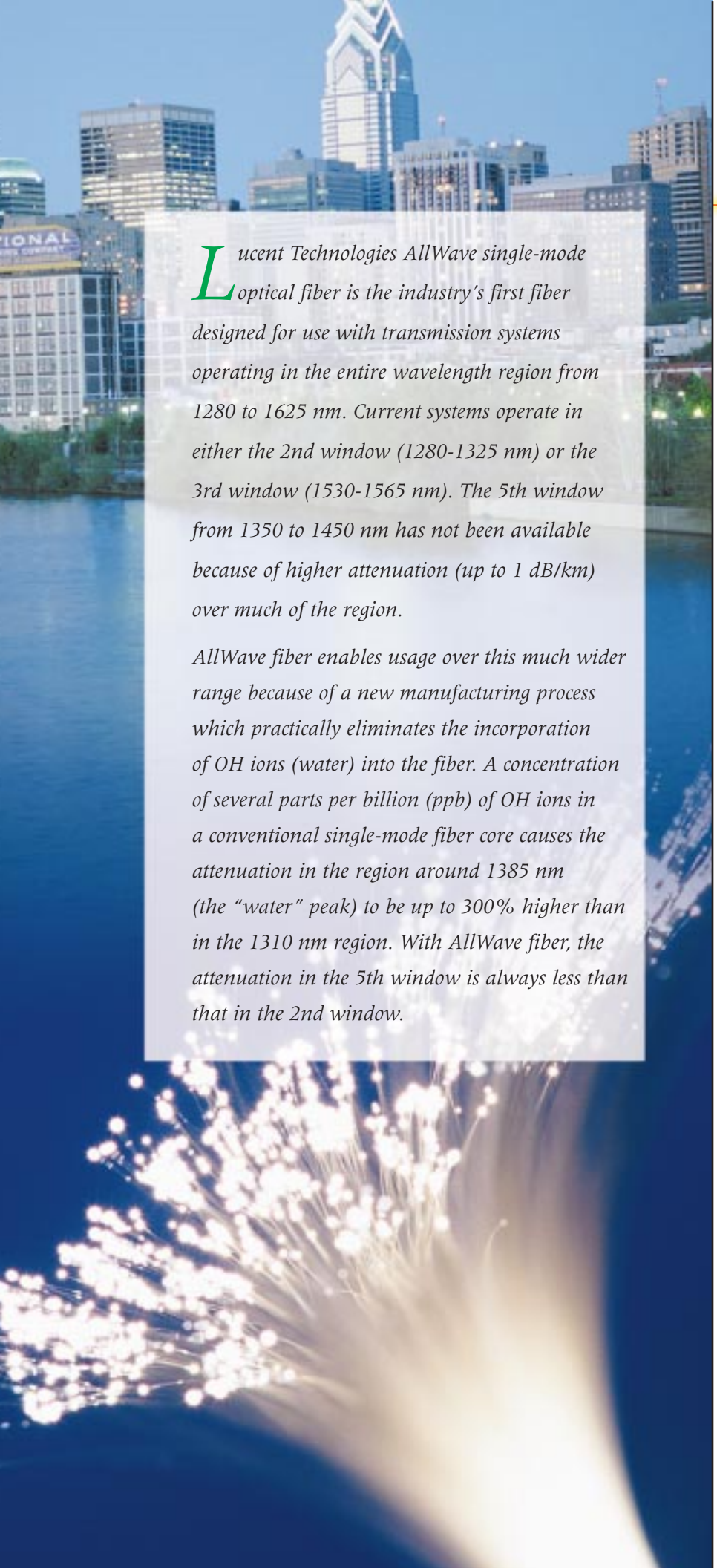
Lucent Technologies
Bell Labs Innovations

AllWave™
Single-Mode Optical Fiber



Opening the Fifth Operating Wavelength Window!



Lucent Technologies AllWave single-mode optical fiber is the industry's first fiber designed for use with transmission systems operating in the entire wavelength region from 1280 to 1625 nm. Current systems operate in either the 2nd window (1280-1325 nm) or the 3rd window (1530-1565 nm). The 5th window from 1350 to 1450 nm has not been available because of higher attenuation (up to 1 dB/km) over much of the region.

AllWave fiber enables usage over this much wider range because of a new manufacturing process which practically eliminates the incorporation of OH ions (water) into the fiber. A concentration of several parts per billion (ppb) of OH ions in a conventional single-mode fiber core causes the attenuation in the region around 1385 nm (the "water" peak) to be up to 300% higher than in the 1310 nm region. With AllWave fiber, the attenuation in the 5th window is always less than that in the 2nd window.

With AllWave fiber, Lucent Technologies continues the technology innovation Wave to provide increased service capabilities. Compared to conventional single-mode fiber, AllWave fiber offers:

- up to 200% lower attenuation in the 1400 nm window
- a 50% increase in usable wavelength range (300 nm vs. 200 nm)

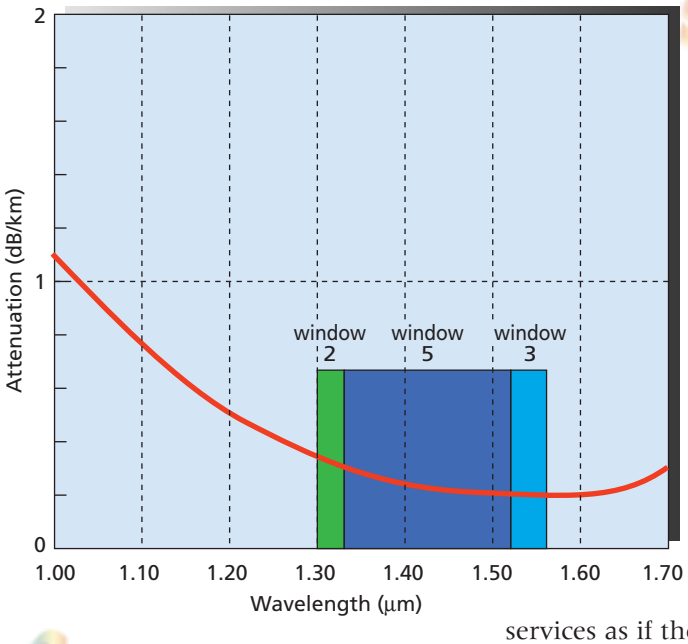
AllWave fiber's advantages in the 5th window can be used to achieve:

- longer distances without regeneration or amplification
- longer distances without regeneration or dispersion compensation for high bit rate (10 Gb/s) systems
- flexible configuration of systems for multiple services on each fiber

These advantages translate into greater information capacity than is available with conventional single-mode fiber. When designing today's network, look for the fiber that will provide you the greatest capability and flexibility both now and in the future!

More Wavelength Capability

AllWave fiber provides 100 nm more usable optical bandwidth than conventional single-mode fiber. By opening the fifth window available (1350 to 1450 nm) as shown in the figure below, AllWave fiber makes 120 or more channels available for wavelength-intensive applications such as metropolitan or regional networks.



Increased Service Capabilities

The new window opened by AllWave fiber has exciting system-enabling characteristics. With its lower loss than conventional single-mode fiber in the fifth window, longer distances without amplification or regeneration are possible. Similarly, by using the fifth window instead of the third window, high-bit rate (10 Gb/s) transmission is possible over twice the distance without dispersion compensation being required. In combination, these characteristics make AllWave a simpler and less costly choice for many applications.

AllWave fiber gives system designers and operators increased flexibility in providing a wide range of services on a single fiber. For example, the same fiber could be used for WDM analog video in the 2nd window, high-bit rate data (up to 10 Gb/s) in the 1350 to 1450 nm region, and DWDM traffic at up to 2.5 Gb/s in the region above 1450 nm.

New Network Management Capabilities

With the additional spectrum available, new options for network management are readily available. Different service types can be grouped together and allocated to certain wavelength bands where they are best suited. Management systems can be tailored to the specific services as if they were operating on separate fiber systems while gaining the economies provided by using a single fiber to provide the services.

Reduce System Cost With AllWave Fiber

With more wavelengths available, DWDM signals can be spread over a broader range, allowing use of less expensive lasers. Other components such as multiplexers, demultiplexers and wavelength add/drop devices can also be designed to take advantage of the increased wavelengths available.

Compatibility with Existing Equipment

Since AllWave fiber has loss and dispersion similar to conventional single-mode fibers, existing transmission equipment can be used today. In the future, new equipment designed for conventional fiber will also be compatible with AllWave fiber.

Lower PMD

Manufactured using a patented fiber drawing process, AllWave fibers have low Polarization Mode Dispersion (PMD). The PMD Link Design Value (a value used to compute a statistical upper limit on the PMD of a concatenated link) of fibers in an AllWave cable is less than 0.1 ps/$\sqrt{\text{km}}$. Furthermore, individual fibers in a cable typically do not exceed 0.05 ps/$\sqrt{\text{km}}$.

Because the PMD of a fiber can depend on its geometrical and mechanical condition, the best indicator of true PMD is the PMD of the fiber in the finished cable — before it is shipped from the factory. This arises because the fiber's bend diameter and back tension on a spool can mask its true PMD. Low values of PMD measured when the fiber is wound on a spool do not guarantee consistently low PMD in finished cable.

With AllWave fiber, Lucent Technologies is the first manufacturer to specify a new product parameter — the PMD Link Design Value. This parameter complies with the U.S. contribution to the IEC standards body, and gives network designers a useful tool for computing the PMD of concatenated cables. For example, the 0.1 ps/$\sqrt{\text{km}}$ PMD LDV for AllWave cabled fiber produces a 2 ps value for a 400 km long route. This excellent PMD performance is sufficiently small to enable 40 Gb/s transmission at each of multiple wavelengths!

Improved Core/Cladding Eccentricity

Accurate centering of the core in its cladding makes it easier to achieve low loss fusion splicing using standard techniques and equipment. At ≤ 0.6 µm, the core/cladding concentricity error of AllWave fiber is among the best.

Choose AllWave Fiber For Long-term Reliability

AllWave fiber features D-LUX® coating for excellent environmental performance and long-term reliability. This dual coating is applied over the cladding to protect the fiber. Each fiber is proof tested to at least 100 kpsi to ensure that it will survive installation loads and associated long-term stresses, even under extreme environmental conditions.

Stay in the Vanguard with Lucent Technologies

Lucent's family of single-mode fiber cables represent the most complete product line in the industry for building high capacity transport systems. AllWave fiber is the latest Wave from Bell Laboratories!

Transmission Characteristics

Attenuation

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

Wavelength (nm)	Maximum Attenuation (dB/km)
1310	0.35-0.40
1385	0.31
1550	0.21-0.25

Attenuation vs. Wavelength

The maximum attenuation in the wavelength range from 1285 to 1330 nm is no more than 0.10 dB/km greater than the attenuation at 1310 nm.

The maximum attenuation in the wavelength range from 1525 to 1575 nm is no more than 0.05 dB/km greater than the attenuation at 1550 nm.

Attenuation at Water Peak

The attenuation coefficient at the OH^- absorption peak (1383±3 nm) is less than or equal to 0.31 dB/km.

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
100 turns, 75 mm (3 inch) diameter	1310 nm	≤ 0.05 dB
	1550 nm	≤ 0.10 dB

Point Discontinuities

There are no attenuation discontinuities greater than 0.10 dB at 1310 nm or at 1550 nm.

Chromatic Dispersion

Zero dispersion wavelength (λ_0):	1300-1322 nm
The maximum dispersion slope (S_0) at λ_0:	0.092 ps/nm²-km

Mode Field Diameter

at 1310 nm	9.3 ± 0.5 µm
at 1550 nm	10.5 ± 1.0 µm

Cutoff Wavelength

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

Cabled Fiber Polarization Mode Dispersion[1]

PMD link design value[2]	≤ 0.1 ps/$\sqrt{km}$

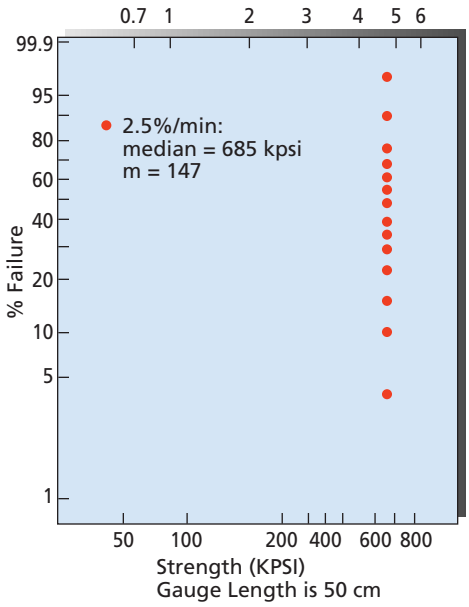
[1] In Lucent Technologies Cables. Check with your cable manufacturer for specific PMD limits in cable form.
[2] The PMD Link Design Value complies with the U.S. contribution to IEC SC 86A/WG1, Method 1, September 1997.

AllWave Fiber for Maximum Network Capability

AllWave fiber provides all of the capability available today with conventional single-mode fiber while offering the potential of:

- providing significantly more capacity per fiber
- supporting longer distances and higher transmission rates
- enabling new network management approaches
- creating a more economical end-to-end solution

AllWave fiber provides exciting growth capabilities in a world where bandwidth demand continues to grow at an exponential rate.



Geometrical Characteristics

Glass Geometry	
Cladding Diameter	125.0 ± 1.0 µm
Core/Clad Concentricity Error	≤ 0.6 µm
Cladding Non-circularity	≤ 1.0%
Coating Geometry	
Coating Diameter (uncolored)	245 ± 10 µm
Coating/Cladding Concentricity Error	≤ 12 µm
Length	
Lengths can be cut to specific customer specifications	
Standard spool lengths	4.4, 6.4, 12.6, 19.2, 25 km

Mechanical Characteristics

Proof Test Level	100 kpsi (0.7 Gpa)*
Dynamic Tensile Strength	
The median tensile strength of unaged samples with a 0.5 meter gauge length is (see illustration at left):	≥ 550 kpsi (38 Gpa)
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.)
Coating Appearance	
The dual coating layers are free of voids or entrapped bubbles.	
Pullout Force (Adhesion of Coating to Glass Surface)	
The pullout force is	> 6.2 N (1.4 lbf.) and < 22.2 N (4.9 lbf.)
Fiber Curl	≥ 4 m

Fiber Shipping Spool Mechanical Specifications

	A (for lengths < 15 km)	B (for lengths > 15 km)
Flange diameter	9.25 in (23.50 cm)	9.25 in (23.50 cm)
Barrel Diameter	6.00 in (15.24 cm)	6.00 in (15.24 cm)
Traverse Width	3.39 in (8.61 cm)	4.70 in (11.94 cm)
Weight	1.22 lbs (0.46 kg)	1.36 lbs (0.51 kg)

* Higher proof test levels are available upon request.

Environmental Characteristics

Operating Temperature	-60° C to +85° C
Temperature Dependence of Attenuation	
Induced Attenuation at 1310 & 1550 nm at -60° C to +85° C	≤ 0.05 dB/km
Temperature — Humidity Cycling	
Induced Attenuation at 1310 & 1550 nm at -10° C to +85° C and 95% relative humidity	≤ 0.05 dB/km
Water Immersion, 23° C	
Induced Attenuation at 1310 & 1550 nm due to Water Immersion at 23 ± 2° C	≤ 0.05 dB/km
Accelerated Aging (Temperature), 85° C	
Induced Attenuation at 1310 & 1550 nm due to Temperature Aging at 85 ± 2° C	≤ 0.05 dB/km
Retention of Coating Color	
D-LUX coated fiber shows no discernible change in color when aged for: • 30 days at 95° C and 95% relative humidity • 20 days in dry 125° C heat	

Other Performance Characteristics (Typical Values)

Nominal Zero Dispersion Wavelength (λ_0)	1312 nm
Nominal dispersion slope at λ_0	0.088 ps/nm^2-km
Effective Group Index of Refraction	
1310 nm	1.466
1550 nm	1.467
Rayleigh Backscattering Coefficient (for 1 µs pulse width)	
1310 nm	-49.6 dB
1550 nm	-52.1 dB
Dynamic Fatigue Parameter (N_d)	> 20
Static Fatigue Parameter (N_s)	> 20
Weight per unit length	64 grams/km
Cabled Polarization Mode Dispersion[1]	≤ 0.05 ps/$\sqrt{\text{km}}$

[1] In Lucent Technologies Cables. Check with your cable manufacturer for specific PMD limits in cable form.

For more information about this and other Lucent Technologies products and services, please contact your Lucent Technologies Sales Representative.

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