Verizon NEBS™ Compliance: Optical Fiber and Optical Fiber Cable

Verizon Technical Purchasing Requirements

VZ.TPR.9430

Issue 4, April 2010

CHANGE CONTROL RECORD:

Version	Date	Action*	Reason for Revision
1	11/2/2007	New	New Document.
2	4/3/2008	Change	Modified document from stating 3% seawater to stating 3% Salinity by volume
3	*4/21/2008*	Change	5.1.2 Ribbon Dimensions – changed to 5 samples 5.2.3 Ribbon Residual Twist – changed to 5 @ Pitch ≥ 400 mm 6.3.1 Filling Compound – changed to 1 sample 6.3.2 Water Blocking – changed to 1 sample 6.3.3 Filling Material Flow – changed to 70C for 24 hours 6.5.1 Optical Measurement – changed ref. to VZ.TPR.9413 6.5.4 Impact Resistance – removed 5X magnification 6.6.1 Optical Measurements – changed ref. to VZ.TPR.9413 6.6.4 Cable Aging – changed to measurements B/A
4	*4/09/2010*	Add	Added Rodent-resistant requirement
* **New, Add, Delete, Change, Reissue**			

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Table of Contents

1.0 PURPOSE

The purpose of this Verizon Technical Purchasing Requirement (VZ.TPR) document is to provide additional and/or overriding FOC testing requirements to those specified in GR-20: Generic Requirements for Optical Fiber and Optical Fiber Cable.

2.0 SCOPE

Optical Fiber and Optical Fiber Cables

3.0 REFERENCES

ASTM D3895	ASTM D3895-07 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
ASTM D4565	Standard Test Methods for Physical and Environmental Performance Properties of Insulations and Jackets for Telecommunications Wire and Cable
ASTM G21	Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
GR-20-CORE, Issue 2, July 1998	Generic Requirements for Optical Fiber and Optical Fiber Cable
FOC Memo # 29	Applicable to Fiber Ribbons
FOC Memo # 30	Applicable to Ribbon Cables with Gel Free Construction
FOC Memo # 36	Applicable to GR-20 Sample Sizes
FOC Memo # 41	Applicable to Bend Insensitive Fibers
FOC Memo # 46	Applicable to 3 x 4 Splittable Ribbons
VZ.TPR.9405	Generic Reliability Assurance Requirements for Passive Optical Components

4.0 ACRONYMS

A	After
B	Before
D	During
FOC	Fiber Optic Components
ITL	Independent Test Laboratory
TPR	Technical Purchasing Requirement

5.0 TEST REQUIREMENTS FOR OPTICAL FIBER AND OPTICAL FIBER CABLE

Verizon purchases Optical Fibers and Optical Fiber Cables as required for the network. The following are the test requirements for qualifying Optical Fiber and Optical Fiber Cables. All the testing must be completed by a Verizon approved ITL.

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
3.0 Product Qualification Requirements				
3.1 Optical Fiber Product Qualification	R3-1			Product qualified prior to product offering (per GR-20 - Table 1), requalification periodically. If a change to form, fit or function of the product is made, it must be requallified to the applicable sections of the standard.
3.2 Fiber Ribbon Product Qualification	R3-2			Product qualified prior to product offering (per GR-20 - Table 2), requalification periodically
	R3-3			If a change to form, fit or function of the product is made, it must be requallified to the applicable sections of the standard.
3.3 Optical Fiber Cable Product Qualification	R3-4			Product qualified prior to product offering (per GR-20 - Table 3), requalification periodically
	R3-5			If a change to form, fit or function of the product is made, it must be requallified to the applicable sections of the standard.
	R3-6			Do not ship any cable, which has gone through testing to a customer.
	R3-7			Sample size - Section 6.5 and 6.6: no less than 1 per cable design family. Min 10 fibers (or all if less then 10) per cable measured for attenuation change
	R3-8			Per GR-20
4.0 Requirements for Single-Mode Optical Fibers				
4.1 Fiber Materials				Requirements of GR-20, Section 4 shall be meet with the exceptions, additions and modifications described in Section 4.1 of this document

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
4.1.1 Glass Composition	R4-1			See GR-20, section 4.1.1
	R4-2			See GR-20, section 4.1.1
4.2 Requirements for Multimode Fiber				
4.2.1 Attenuation Coefficient	R4-3			Agreed upon between fiber manufacturer and cable manufacturer
4.2.2 Point Discontinuities	R4-4	1@500 meters		No discontinuities with loss greater then 0.1 dB or reflectance greater than -40dB
4.2.3 Chromatic Dispersion				
Dispersion-Unshifted (Class IVa)	R4-5			1300 nm ≤ λ_0 ≤ 1324 nm
	R4-6			S_{0max}: ≤ 0.093 ps/(km.nm^2)_
Dispersion-Shifted (Class IVb)	R4-7			1535 nm ≤ λ_0 ≤ 1565 nm
	R4-8			S_{0max}: ≤ 0.085 ps/(km.nm^2)_
Nonzero-Dispersion (Class IVd)	R4-9			The Chromatic Dispersion coefficient, D shall conform to 0.1 ≤ D_{min} ≤|D| ≤ D_{max} ≤ 8.0 ps/(nm.km) over the wavelength range 1530nm ≤ λ_{min} ≤ λ ≤ λ_{max} ≤ 1565 nm.
	R4-10			The Chromatic Dispersion coefficient, D shall be stated as all positive or as all negative over the wavelength range from λ_{min} to λ_{max}.
4.2.4 Cutoff Wavelength				
Dispersion-Unshifted (Class IVa)	R4-11			λ_{cc} ≤ 1260 nm

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
Dispersion-Shifted and Non-Zero Dispersion (Class IVb and IVd)	R4-12			$\lambda_{cc} \leq 1480$ nm
	R4-13			For systems specified to operate at 1310nm, $\lambda_{cc} \leq$ 1260 nm
4.2.5 Mode Field Diameter	R4-14			Dispersion-unshifted fiber @ 1310 nm, MFD 8.6 um ≤ nominal MFD ≤ 9.5 um.
	R4-15			Dispersion-unshifted fiber tolerance: ± 0.5 um.
	R4-16			Dispersion-Shifted fibers @ 1550 nm, MFD 7.8 um ≤ nominal MFD ≤ 8.5 um.
	R4-17			Dispersion-unshifted fiber tolerance: ± 0.7 um.
	R4-18			Nonzero-Dispersion fibers @ 1550 nm, MFD 7.2 um ≤ nominal MFD ≤ 11.0 um.
	R4-19			Dispersion-unshifted fiber tolerance: ± 0.7 um.
4.2.6 Fiber Macrobend	R4-20			100 turns fiber @ 75 mm ± 2 mm in dia. Not to exceed 0.50dB @ 1550 nm including intrinsic attenuation of the 23.6 meters of fiber.
	R4-21			1 turn of fiber @ 32 nm ± 0.5 diameter mandrel: not to exceed 0.50 dB @ 1550 nm.
4.3 Geometrical Requirements				
Cladding Diameter	R4-22			Cladding Outside Diameter = 125.0 um ± 1.0 um
Cladding Noncircularity	R4-23			Cladding noncircularity ≤ 1.0 %
Core/Cladding Concentricity Error	R4-24			Offset between center of the core and center of the cladding ≤ 0.8 um
Colored Fiber Outside Diameter	R4-25			Nominal outside diameter of colored fiber: 240 um ≤ nominal OD ≤ 260 um

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
	R4-26			Tolerance about the nominal: ± 15um
Fiber Curl	R4-27			Radius of curvature of an optical fiber: ≥ 2.0 meters
4.4 Mechanical Requirements				
4.4.1 Tensile Proof Strength	R4-28			0.69 Gpa (100 kpsi)
4.4.2 Coating Strip Force	R4-29			Remove 30 mm + 3mm of unaged coating @ 0ºC & 45ºC; ≤9.0 N and ≥ 1.0 N
	R4-30			Remove 30 mm + 3mm of temperature/humidity aged coating @ 0ºC & 45ºC; ≤9.0 N and ≥ 1.0 N
	R4-31			Remove 30 mm + 3mm of water-aged fiber coating @ 0ºC & 45ºC; ≤9.0 N and ≥ 1.0 N
4.4.3 Dynamic Tensile Strength	R4-32			Per Table 4, GR-20
	R4-33			Per Table 5, GR-20
4.4.4 Stress Corrosion Parameter	R4-34			Dynamic stress corrosion parameter, n_d of unaged and aged fibers shall be ≥ 18
4.5 Fiber Cleavability and Fusibility				
4.5.4 Fiber Cleavability	R4-35			End face cleave angel shall not be greater then 1º for 90% and 2º for 100% of fibers
4.5 Fiber Fusibility	R4-36			Shall be fusible with commercially available splicers with a mean splice loss > 0.10 dB.
5.0 Requirements for Fiber Ribbons				
5.1 Geometrical Requirements				
5.1.1 Ribbon Structure	R5-1			No crossovers
5.1.2 Ribbon Dimensions	R5-2	5@min 2 inches		Ribbon dimensions - GR-20, Table 6: measure as specified: (12 fiber ribbon dimensions apply to the

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
				3 x 4 fiber splittable ribbon)
5.2 Mechanical Requirements				
5.2.1 Resistance to Twist (Robustness)	R5-3	20@2 meters (10 aged, 10 unaged)		No visible separation (5X magnification) for unaged and aged (per 6.3.4) ribbon - Per FOTP-141: Perform on 12-fiber ribbon and 4 fiber sub-ribbons as required.
5.2.2 Ribbon Separation (see procedure after - Ribbon Separation Modified after punch list)	R5-4	10@2 meters for mid-span; 10@560 mm for End Separation; 10@560mm for Individual Separation		For Unaged ribbon: 0.3 meter length - individual fiber or of a six or 12 fiber subgroup shall be separable from ribbon with out breaking or damaging fiber coating. Separation forces > 4.4N. (5X magnification) - See Note * - End Separation: All fibers to be separated one at a time to edge of the fiber. - Individual Fiber Separation: All fibers to be separated one at a time. - Mid-span Separation: separate close to middle for 0.5 meters
	R5-5			Remove ribbon matrix with out damaging individual fiber coating
	R5-6			Fibers separated from ribbon shall retain sufficient colorant that any 2.5 cm length is readily identifiable. (Per sections 6.25 and 6.6.6)

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
	R5-7			Any single fiber or a multi-fiber subgroup shall be separable by a tool or by hand from the ribbon for a length of more that 1 meter. Four different setups: • Pulling individual fibers out of the ribbon at an end • Pulling individual fiber out of the ribbon in a mid-span. • Pulling 4-fiber sub-ribbon out of the 12-fiber ribbon at an end. • Pulling a 4-fiber sub-ribbon out of the 12-fiber ribbon in a mid-span.
5.2.3 Ribbon Residual Twist	R5-8	5@ pitch ≥ 400mm		Aged (per 6.3.4) Ribbon: pitch ≥ 400 mm: Perform on 12 fiber ribbon and 4 fiber sub-ribbon
5.2.4 Ribbon Strippability	R5-9	30@6 inches; 10 per condition		Strip 25 mm of matrix material and fibers protective coating @ Unaged, Temp/Hum: 85ºC 85% RH - 30 days, Water Aged: soaked in Di (or distilled) water - 23ºC -14 days. No breakage, coating residue removable with 1 isopropyl alcohol wipe. Perform on 12-fiber ribbon and 4-fiber sub-ribbon.
6.0 Requirements for Optical Cables				
6.1 Cable Construction				
6.1.1 Continuity of Metallic Members	R6-1	1 sample, minimum of 500 meters		Metallic elements used in cables shall be electrically continuous.
6.1.2 Cable Core	-			Cable core shall be dielectric
6.1.3 Anti-buckling and Strength Elements Splicing	R6-2			150% strain value@rated installation load

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
				- Unaged - Aged: 85ºC - 7 days in mineral oil #33088-9[1]; remove, wipe with water followed by Temp/Humidity 85ºC 85%RH - 7 days
6.1.4 Pulling Tension	R6-3			Rated installation load - 2670 N (600 lfb)
	R6-4			1335 N (300 lbf) or 4000 N (900 lbf) rated installation load acceptable for specific applications.
6.1.5 Spare Fibers in Cable	R6-5			No Spare Fibers
6.1.6 Number of Fibers per Unit/Binder	R6-6			Unit shall consist of 4,6,8,12 or 24 fibers, identified per coloring method (Section 6.2.5). May be made up of 2 or more sub-units.
	R6-7			Cables containing 48 fiber or less shall have 4,6,8 or 12 fibers per unit
	R6-8			Cables containing greater then 48 fibers shall have 12 or 24 fibers per unit.
6.1.7 Unit Stranding	R6-9			All multiple buffer tubes that are stranded around a rigid central element within a cable shall be stranded using the SZ lay method.
6.1.8 Spliced and Defective Fibers	R6-10			Splices no less then 5 Km apart, must meet section 4 for unspliced fibers
	R6-11			No defective fibers
6.1.9 Ripcords	R6-12	3 samples - 5 meters minimum length		1 ripcord per single sheath cable, 2 for armored - 180º apart
	R6-13			Capable of slitting the jacket/armor without breaking for 1 meter @ install temps.

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
	R6-14			Readily distinguishable from other components.
6.2 Cable Marking, Packaging and Shipping				
6.2.1 Cable Marking	R6-15			Cable markings printed, preferably with white characters, on the outer cable jacket
	R6-16			Insoluble in water - in tap water for 24 hours followed by marking durability test (Section 6.6.6)
	R6-17			Character height and spacing per standard commercial practices
	R6-18			Printed @ no more than two feed for cables marked in feet and one meter for cable marked in meters.
6.2.2 Cable Re-marking	R6-19			Re-marking printed, preferably in yellow characters, on the outer cable jacket. (If more then two sets of markings, correct marking must be identified)
6.2.3 Identification Marking	R6-20			Manufacturer, Month/year, trade name and Optical Cable code per SR-NWT-002014
	R6-21			NEC marking
6.2.4 Cable Length and Length Markings	R6-22			Cable length +1, -0% of length markings
	R6-23			Sequential cable length markings along cable, not reset along length of cable (interconnect cables excluded)
	R6-24			Cable length markings verified at 10-foot increments with NIST traceable device.
6.2.5 Fiber and Unit Identification	R6-25			Individual fiber color per TIA/EIA-598
	R6-26			Centroid Color and tolerances

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
6.26 Packaging	R6-27 - R6-29			Per GR-20
6.2.7 Shipping	R6-30			Per GR-410
6.2.8 Cable Reel	R6-31			Shipped on reels, designed to prevent damage. Less that 150 meters may be coiled and packaged for shipping.
	R6-32			Arbor holes - min: 68 mm and max 101 mm. (lined with a metal bushing or reinforced with a bearing plate.
	R6-33			Reel shall be plainly and permanently marked indicating direction reel can be rolled to prevent loosening the cable on the reel.
6.3 Cable Materials				
6.3.1 Filling Compound Material (if used)	R6-34	Fungus - 1 samples min; Cleaning - 1 samples min; OIT - 1 samples min		ASTM-G21-70. Rating of 0; Nonconductive, Homogeneous and free from dirt and foreign matter.
	R6-35			Cleanable using conventional cleaning agents.
	R6-36			OIT (20 minutes) per ASTM D 3895; aluminum pan, no screens, no torque rheometer, max temp 190ºC, heating rate - 10ºC/min
6.3.2 Water-Blocking Material	R6-37	Fungus - 1 samples min; Cleaning - 1 samples min; OIT - 1 samples min		Meet Water Penetration - Section 6.6.7; Oil based must meet Section 6.3.1
	R6-38			ASTM-G21-70. Rating of 0; Nonconductive, Homogeneous and free from dirt and foreign matter.
	R6-39			Shall not adversely affect the ability to handle the cable and shall be readily removable by conventional methods.

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
6.3.3 Filling and Water-Blocking Material Flow	R6-40	5 samples @ 6 inches		70ºC – 24 Hours; no filling and water-blocking materials shall flow (per FOTP-81)
6.3.4 Cable Material Compatibility	R6-41	Sample prep and testing per GR-20 Section 6.3.4		Force to Remove 30 mm of fiber's protective coating from aged sample shall be ≤ 9.0 N and ≥ 1.0 N.
	R6-42			Strip 25 mm of matrix material and fibers protective coating from aged samples. No breakage, coating residue removable with 1 isopropyl alcohol wipe.
	R6-43			Aged fibers and ribbons shall not exhibit cracking, splitting, or matrix material delamination when observed under normal, corrected vision.
	R6-44			Aged tubes shall not exhibit cracking or splitting when wrapped around an appropriate mandrel and examined under 5X magnification.
6.4 Jacket Requirements				
6.4.1 Jacket Material	R6-45 - R6-48			per GR-20, included OIT
6.4.2 Cable Outer Diameter and Jacket Thickness	R6-49	5 Samples - per ASTM D 4565 Sections 6 and 7		Average diameter of cable shall not exceed the manufacturer's stated maximum.
	R6-50			Min outer jacket thickness ≥ 1.0mm - single-jacket cables. ≥ 0.8 mm - multiple jackets not in direct contact with outer jacket.
	R6-51			Embedded anti-buckling/strength members ≥ 0.7 mm
6.4.3 Cable Jacket Yield Strength and Ultimate Elongation	R6-52	10 Samples; 5 aged and 5 unaged		Per GR-20, Section 6.4.3 - Table 8; Unaged and Aged (100C -120 hrs), crosshead speed 50 mm per minute.

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
6.4.4 Cable Jacket Adherence	R6-53	5 samples		Per ASTM D 4565. Section 31; slippage between outer jacket and underlying steel tape > 14.0 N.
6.5 Mechanical Requirements				
6.5.1 Optical Measurements	R6-54 - R6-55		Attenuation @ 1310, 1480, 1550 & 1625 nm	Per VZ.TPR.9413 and GR-20
6.5.2 Cable Testing	R6-56			Measured attenuation increase shall be ≤ 0.05 dB for 90% of test fibers and ≤ 0.15 dB for 100% of the test fibers
6.5.3 Low and High Temperature Cable Bend	R6-57	1 @ min 10 meters	B/D	Low temp: -30º - 4 turns around mandrel (20 times dia. of cable.), no damage @ 5X
				High temp: 60º - 4 turns around mandrel (20 times dia. of cable.), no damage @ 5X
6.5.4 Impact Resistance	R6-58	1 @ min 4 meters	B/A	Impact 3 different locations of fiber per FOTP-25. No damage
6.5.5 Compressive Strength	R6-59	1 @ min 4 meters	B/D*	Incidental load: rate of 3 mm - 20 mm per minute, 1 min@220 N and 10 min@110N. Superior armored cable 1 min@440N and 10min@220N.
6.5.6 Tensile Strength of Cable	R6-60	1 @ FOTP specification	B/D/A	Subject cable to rated installation load for 1 hour, fiber tensile strain ≤ 60% of fiber proof strain.
	R6-61			W/Rated installation load applied, 360º twist over < 3 meters w/o armor zippering or jacket splitting.
	R6-62			Cable residual load for long-term operation: 30% of rated installation load, fiber tensile strain at the cable's residual load ≤ 20% of the fiber proof strain.

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
	R6-63			Measured attenuation increase shall be < 0.05 dB for 90% of test fibers and < 0.15 dB for 100% of the test fibers
6.5.7 Cable Twist	R6-64	1@ min 2 meters	B/A	Test per FOTP-85; No damage @ 5X
6.5.8 Cable Cyclic Flexing	R6-65	1@ min 6 meters	B/A	Test per FOTP-104 - 25 cycles total; No damage @ 5X
6.5.9 Cable Termination	R6-66	1 @ min 18 meters	B/A	Per GR-20
6.6 Environmental Requirements				
6.6.1 Optical Measurement Equipment	R6-67 thruR6-68		N/A	Measurements to be performed at all four wavelengths; Equipment must meet VZ.TPR.9413
6.6.2 In-Service Cable Performance - Environmental Testing				
6.6.3 Temperature Cycling	R6-69	1 sample, minimum of 500 meters	B/D/A	Precondition- 24hrs@ 23ºC +/- 5ºC - take baseline
				Go to -40ºC, maintain 24hrs
				Go to 70ºC, maintain 24hrs
				Go to -40ºC, maintain 24hrs: Measure attenuation
				Go to 70ºC, maintain 24hrs: Measure attenuation
				(continue into Cable Aging if desired)
6.6.4 Cable Aging	R6-70	1 sample, minimum of 500 meters	B/A	85ºC +/-2ºC for 168 hours;
				Go to -40ºC, maintain 24hrs
				Go to 70ºC, maintain 24hrs
				Go to -40ºC, maintain 24hrs: Measure attenuation

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
				Go to 70ºC, maintain 24hrs: Measure attenuation
				Go to 23ºC, maintain 24hrs: Measure attenuation
6.6.5 Cable Freezing		1 sample, minimum of 50 meters	B/D/A	Per FOTP-98, method A
	R6-71			Average attenuation increase < 0.05dB, Max attenuation < 0.15dB
	R6-72			No cracking or splitting of jacket
6.6.6 Color Permanence and Marking Durability	R6-73	1 meter section	N/A	Age fibers per Section 6.3.4 or 6.6.4 Verify compliant to TIA-598
	R6-74			Age per Section 6.6.4, should remain legible after marking durability test.
6.6.7 Water Penetration	R6-75	3 samples, 1 meter		1 meter static head, 24 hrs, no water leak
6.6.8 Wasp Spray Exposure		1 two meter length / type or color	N/A	Per GR-20
	R6-76			Inspect tubes, no cracking/splitting/collapse
	R6-77			Inspect ribbons, no delamination or fiber separation
	R6-78			Inspect fiber coatings, no swelling or separation from fiber
	R6-79			All must meet TIA-598
	R6-80	10 colored fibers, 1 meter		Must meet coating strip force (R4-29)
	R6-81	30 samples, 2 meters (colored fibers)		Must meet tensile strength (R4-33)
6.6.9 Hydrogen in Cables	R6-82		N/A	Per FOTP - 183 (not required)
6.7 Electrical Protection Requirements				

FOC Test Plan for Optical Fiber and Optical Fiber Cable (Based on GR-20)				
Task	**Reference Spec.**	**Samples**	**Optical Monitor**	**Comments**
6.7.1 Lightning Damage Susceptibility	R6-83	3 samples (length as required by standard)	N/A	Per FOTP -181, define Category passed
6.7.2 Current Carrying Capability of Metallic Members	R6-84	1 sample, I meter		45-A (RMS), 60-HZ for 15 minutes, no loss of optical or metallic continuity
6.8 Cable Optical Requirements				
6.8.1 Attenuation Coefficient	R6-85	1 sample, minimum of 500 meters		Per FOTP-78 or FOTP-61
6.8.2 Point Discontinuity	R6-86	1 sample, minimum of 500 meters		Per FOTP-59 or FOTP-8, no point discontinuity > 0.10dB with RL > -40dB
Rodent resistance	Appendix	3 samples		Rodent-resistant cable shall meet a material hardness of Rockwell R87 or equivalent.

Sample Configuration:

Fiber count to be tested for cable qualification is as specified in GR20. In addition, for fiber qualification, it is permissible to test one sample that is greater than or equal to 2 km instead of 4 samples of 500 m each for attenuation coefficient, point discontinuity, chromatic dispersion and other similar tests.

New Test Procedures for Ribbon Separation - Section 5.2.2:

Current Section 5.2.2:

GR-20 section 5 contains the required ribbon tests. Section 5.2.2 covers ribbon separation. To briefly summarize the test, there are 4 variations of the test.

First, an edge fiber (blue or aqua) is pulled out of the ribbon starting at an end by using an Instron machine that measures force. One grip is placed on the end of the edge fiber being pulled out; a second grip is placed on the remainder of the ribbon. The machine moves the grips in opposite directions resulting in the edge fiber being pulled out of the ribbon perpendicular to the long axis of the ribbon.

Second, the test is repeated again at the end of the ribbon with one grip pulling on a 6-fiber sub ribbon and the second grip pulling on the other 6-fiber sub ribbon.

Third, the edge fiber test is repeated in a mid-span application.

Fourth, the 6-fiber ribbon/6-fiber ribbon test is repeated in a mid-span application.

To pass, the test requires that the force be below 4.4 N (1 lbf.) to accomplish the separation, that the ribbon matrix material can be removed, that enough ink is left in every 1 inch section to ensure fiber identification, and that the underlying fiber coating is not damaged.

Specific Changes and Additions to Section 5.2.2:

1. All fibers are to be separated from the ribbon, one at a time, using current test set up and equipment.
2. All fibers to be separated, one at a time, through the edge of the ribbon to reflect typical field practices.
3. If the cable under evaluation contains six ribbons or less then perform items 1 & 2 on all ribbons. If more than six ribbons then perform items 1 & 2 on six ribbons.
4. Pull six ribbon samples (less if less than a six ribbon cable) from six different lots, i.e. each sample from a different machine line up, or a different shift, etc. Document pedigree and rationale of each sample.

Perform section 5.2.2 with the changes identified in items 1-4.

New Test Procedures for Gel Free Ribbon Cable:

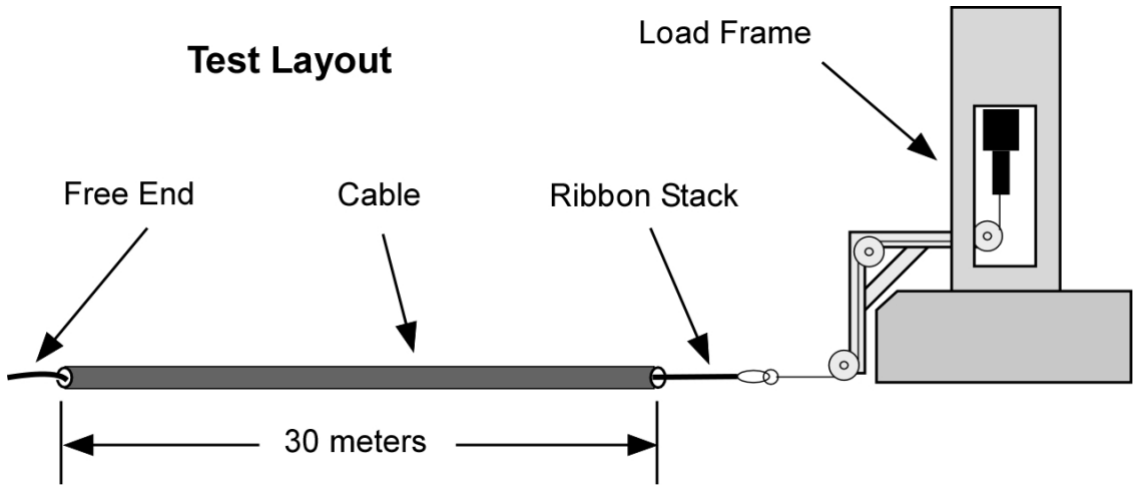
1.0 Ribbon Coupling/Pullout: meaning that the ribbons and surrounding cable act as one unit or are "coupled" together. If the ribbons are not adequately coupled to the cable in a gel-free cable design, the ribbons may slide relative to the surrounding cable structure, causing potential attenuation issues during or after installation. A test called the Ribbon Pullout Test has been developed to address this concern as follows:

Ribbon Pullout Test Procedure:

1. Lay out 31 to 32 meters of cable straight on a level surface as shown in Figure 1 below. Remove 1 meter of cable sheath, tube, and any water blocking components on the load frame end of the cable, allowing access to the ribbon stack. Do the same on the free end, leaving approximately 5 cm of ribbon stack and ensuring that 30 meters of cable sheath remains.

2. Secure the cable to the surface (floor or other suitable fixed surface) periodically using duct tape or equivalent. Ensure the cable is as straight as possible.

Figure 1



3. At the pulling end, tape or glue the ribbons together so that they act as one unit. Attach the ribbon stack to a load frame or other suitable apparatus for applying tension. A fixture or pulley system may be required to pull the ribbon stack straight from the cable sheath.

4. Activate the load frame to pull the ribbon stack at a rate of 100 ± 25 mm per minute. Note the force at which the ribbon stack begins to move. Continue pulling until the load stops increasing.

Note: A mark may be placed on the surface at the end of the ribbon stack to aid in determining when the stack begins to move.

5. The force required to begin movement of the ribbon stack shall be more than 0.1625 N (0.036 lbf) times the number of fibers in the ribbon stack. For example, the passing force for a 24-fiber ribbon cable is 3.9 N (0.87 lbf). The passing force for a 216-fiber ribbon cable is 35.1 N (7.80 lbf). Note: the supplier can change the pull out force suggested here provided the rationale is included with the test.

6. After the pull test is done, wrap the cable on the biggest supported reel and place the cable reel in the chamber and conduct GR-20, section 6.6.3 temperature cycling test. Cable reel shall be placed such that cable is vertically suspended (lying on both the flanges). Entire 30 meters length of the cable must be in the chamber.

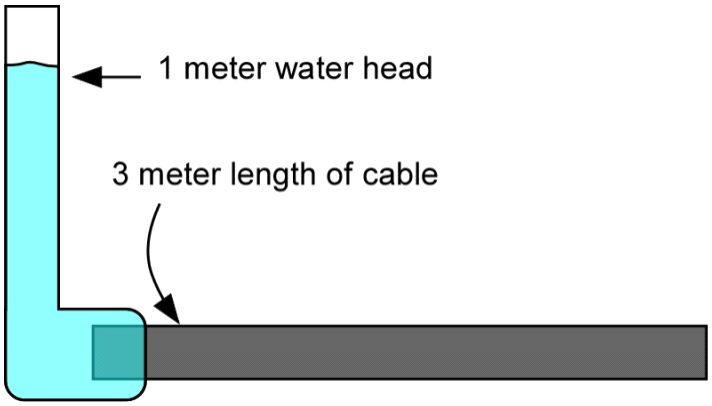
7. After completing the temp cycling, remove the cable from the cable reel and perform the ribbon pull test Step 1-5.
8. The pull force must be the same as measured before the temperature cycling test.

2.0 Ionic Water Penetration: the most likely way for water to enter into the central buffer tube and activate the water-blocking material is through a leaking closure or terminal. Since this scenario would typically involve a closure or terminal in a manhole or handhole, a study was performed on the ionic concentration of manhole water throughout the USA. As a result an additional water penetration test using ionic water at a concentration consistent with manhole water to ensure that water would not travel a significant distance through the cable via the central tube was developed and is provided here:

Ionic Water Penetration Test Procedure:

1. Conduct the test following FOTP-82 (Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable), cited in Section 6.6.7 (Water Penetration) of GR-20 CORE Issue 2, Requirement R6-75 with the following changes.
   - The cable test length shall be 3 meters.
   - The fluid used shall be 3% salinity by volume. This is artificial seawater mixed with distilled water. Aquamarin™ or equivalent is preferred. Aquamarin™ replicates seawater and impedes swelling of super absorbent polymers more than typical aquarium mixes that typically contain only some of the salts found in seawater.
2. Requirement: When a 1-meter static head or equivalent continuous pressure is applied at one end of the cable test length of unaged cable for 24 hours, no water shall leak through the open cable end.

Test Setup

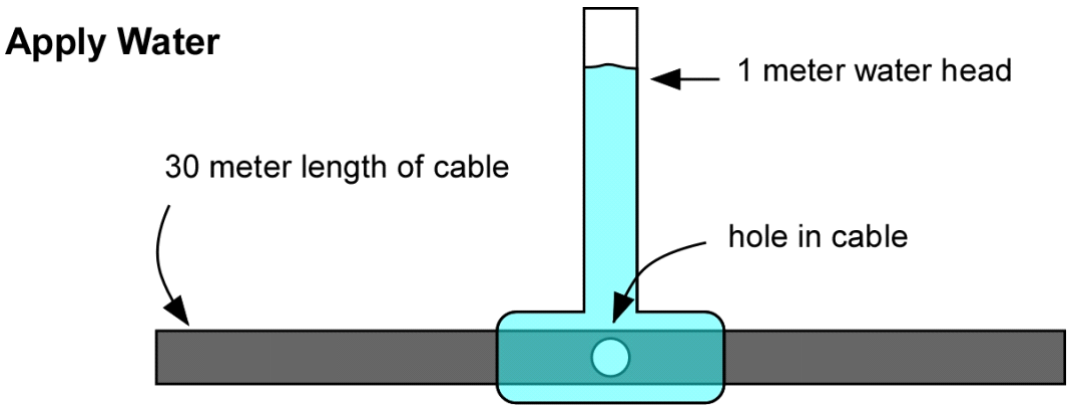


3.0 Cable Internal Freezing Test: the question was raised on what happens if water gets inside the central tube near the fibers, activates the water-blocking material, and subsequently freezes. A test was developed that forces water into the cable under pressure to fill a specified amount of the tube, specifies a freezing cycle, and checks for any attenuation impact.

Freezing Water Inside of Buffer Tube Test Procedure:

1. Obtain the test cable, which must be at least 30 m long. Drill approximately a 10 mm diameter hole in the middle of the length of cable through the cable jacket and buffer tube to expose the fibers. It is recommended to use a blunt-ended drill bit or end mill bit to accomplish this task. The water-blocking materials should provide some separation between the fibers and drill bit.
2. Apply water into cable through hole using 1-meter head of saltwater (3% salinity by volume) * for 1 hour (Figure 1). The pressure and set-up requirements are the same as the requirements of Section 6.6.7 (Water Penetration) in GR-20 CORE Issue 2, R6-75.

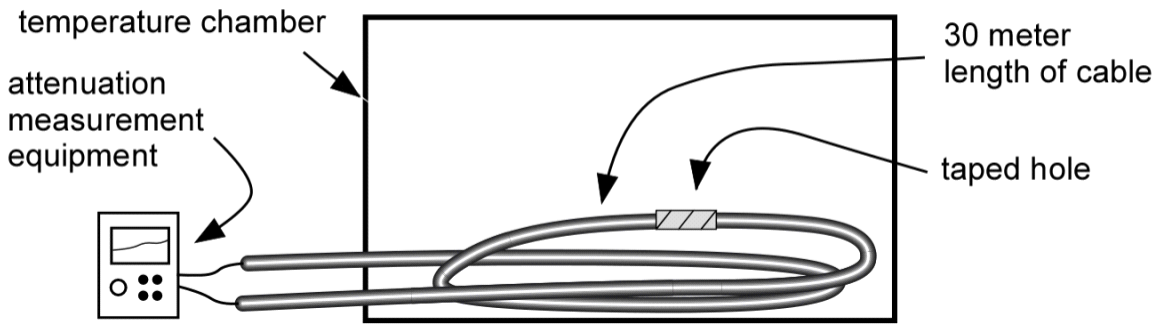
Figure 1 – Water Insertion



3. After applying the water, seal the hole in the cable with duct tape or equivalent. Coil at least 10 meters of cable in a temperature chamber ensuring there is at least 5 meters of cable length on each side of the hole inside the chamber (Figure 2).

Figure 2 – Test Setup

Freeze Cable and Measure Attenuation Change



4. Measure the attenuation of at least 24 fibers with the chamber at room temperature.

5. Transition the temperature chamber to -40°C within 12 hours and hold the chamber at -40°C for 4 hours. Measure the attenuation at -40°C. The allowable attenuation values shall be per the optical requirements of Section 6.6.5 (Cable Freezing) of GR-20 CORE Issue 2, requirement R6-71. The average attenuation increase shall not be greater than 0.05 dB and the maximum attenuation increase of an individual fiber shall not be greater than 0.15 dB.

6. Conduct 10 cycles.

New Test Procedures for 3x4F Splittable Ribbon

General Requirements

1. The ribbon must be splittable by hand into three 4-fiber ribbons when split at the end of a ribbon without generating any stray fibers or causing excessive overhanging ribbon matrix, defined as less than or equal to 1-fiber width (250 micron).
2. The ribbon must by splittable by hand or with the assistance of a ribbon splitting tool when split in the middle of the ribbon without generating any stray fibers or causing excessive overhanging ribbon matrix, defined as less than or equal to 1-fiber width.
3. The 12-fiber ribbon must be printed so that each 12-fiber ribbon within the cable can be individually identified. No print is required for the 4-fiber sub-ribbons.
4. The 12-fiber ribbons must be compatible with Verizon-approved mass-fusion splicers manufactured by Sumitomo and AFL without making modifications to the machines.

Test requirements (Modified From GR-20 Section 5)

Ribbon Structure

R5-1 Fibers in the ribbon structure shall be parallel and shall not crossover each other for the entire length of the ribbon.

Modifications: None

Ribbon Dimensions

R5-2 The dimensions of the fiber ribbon shall not exceed the maximum ribbon dimensions listed in Table 6 and described in Figure 1.

Modifications: The 12-fiber ribbon dimensions apply to the 3x4F splittable ribbon.

Resistance to Twist (Robustness)

R5-3 The unaged and aged completed ribbon shall not show any separation of individual fibers from the ribbon structure after completion of the twist test when observed under 5x magnification.

Modification: The twist test must be done on each 4-fiber sub-ribbon and on the 12-fiber ribbon. For the 12-fiber ribbon, the unaged and aged completed ribbon shall not show any separation of either individual fibers or 4-fiber sub-ribbons after completion of the twist test when observed under 5x magnification.

Ribbon Separation

R5-4 For unaged ribbon, a minimum of 0.3 (1.0 foot) length of an individual fiber or of a six or 12-fiber subgroup (in a 12-fiber or 24-fiber ribbon) shall be separable from the

ribbon without breaking fiber(s) or damaging the coating. The force required to perform the separation shall not exceed 4.4N (1 lbf). The area at the separation shall not show damage to the fiber coating when examined under 5x magnification.

R5-5 Ribbon matrix material shall be removable to access individual fibers without damaging the fiber coating.

R5-6 Fibers individually separated from the ribbon shall retain sufficient colorant that any 2.5 cm (1 inch) length is readily identifiable.

R5-7 Any single fiber or a multi-fiber subgroup shall be separable by a tool or by hand from the ribbon for a length of more than 1 meter.

Modification 1: Verizon FOC memo 29 had additional requirements for this procedure. The test has four set-ups:

Pulling individual fibers out of the ribbon at an end.
Pulling individual fibers out of the ribbon in a mid-span.
Pulling a 4-fiber sub-ribbon out of the 12-fiber ribbon at an end.
Pulling a 4-fiber sub-ribbon out of the 12-fiber ribbon in a mid-span.

Memo 29 requires that for the individual fiber portions of the test, all fibers (not just the edge fiber) are pulled out of the ribbon, one at a time. Additionally, Memo 29 increases the sample size to a minimum of 6 ribbons from different manufacturing lots.

Modification 2: In the past the sub-ribbon pulled out for the last two set-ups was a 6-fiber ribbon. Since these ribbons are specified to split into 4-fiber subribbons, the two set-ups involving pulling sub-ribbons out of the ribbon will be done with 4-fiber sub-ribbons instead.

Ribbon Residual Twist

R5-8 The aged ribbon's residual twist (if any) shall have a pitch $\geq$ 400 mm (15.7 inches)

Modification: This test must be done on each 4-fiber sub-ribbon and on the 12-fiber splittable ribbon.

Ribbon Strippability

R5-9 At least 25 mm (1.0 in) of the matrix material and the fibers' protective coatings shall be mechanically removable with commercial stripping tools from aged and unaged ribbons. There shall be no fiber breakage, and any coating residue shall be removable with a single isopropyl alcohol wipe.

Modification: This test must be done on each 4-fiber sub-ribbon and on the 12-fiber splittable ribbon.

Additional Test Requirements (Splicing)

1. Perform a minimum of 6 splices on an AFL mass-fusion splicer splicing 3x4F splittable ribbon to 3x4F splittable ribbon.
2. Perform a minimum of 6 splices on an AFL mass-fusion splicer splicing 3x4F splittable ribbon to standard (non-splittable) 12-fiber ribbon.
3. Perform a minimum of 6 splices on the Sumitomo mass-fusion splicer splicing 3x4F splittable ribbon to 3x4F splittable ribbon.
4. Perform a minimum of 6 splices on the Sumitomo mass-fusion splicer splicing 3x4F splittable ribbon to standard (non-splittable) 12-fiber ribbon.

For these splicing operations, the mass-fusion splicer must use the same set-up as would be used for splicing standard 12-fiber ribbon to standard 12-fiber ribbon and with the same accessories (i.e. thermal stripper, multi-fiber cleaver, and handlers) as used for standard 12-fiber ribbon.

Passing criteria: all splices must be completed satisfactorily, meaning:

(a) without excessive splice loss defined as all individual fiber splice losses are less than 0.15 dB as estimated by the mass-fusion splicer, and

(b) without error messages given by the machine that are attributable to the design of the 3x4F splittable ribbon (i.e. x-y offset errors may be indicative of excessive spacing between fibers and would be a concern).

Additional Test Requirements (Ribbon Splitting Tools)

1. Using a 3x4F splittable ribbon and the suppliers ribbon splitting tool (if any), split the ribbon at a mid-span location for a minimum length of 0.3 meter (1.0 ft) into one 4-fiber sub-ribbon and one 8-fiber sub-ribbon in accordance with the tool's operating instructions. Repeat this procedure six times.
2. Using a 3x4F splittable ribbon and the AFL ribbon splitting tool, split the ribbon at a mid-span location for a minimum length of 0.3 meter (1.0 ft) into one 4-fiber sub-ribbon and one 8-fiber sub-ribbon in accordance with the tool's operating instructions. Repeat this procedure six times.

Passing criteria: all twelve of the splitting operations must be completed satisfactorily, meaning:

(a) that each of the sub-ribbons is intact with no stray fibers generated.

(b) that overhanging matrix material on either side of the separation point is less than or equal to one fiber width for the entire length of the separation.

(c) that there is no damage to the fiber coating and that individual fibers retain sufficient colorant that any 2.5 cm (1 inch) length is readily identifiable, when examined using 5X magnification.