

A NEW FAMILY OF TOTALLY DRY OUTSIDE PLANT CABLES

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1. INTRODUCTION

In the current telecommunications market, service providers face continued growth in bandwidth usage despite a slow economy. As a result, service providers must find ways to provide increased bandwidth while minimizing cost and capital expenditure. One way to remove cost from the construction of outside plant fiber-optic cable routes is through use of craft-friendly optical cables that minimize the time, labor, and expense required for installation.

Complete elimination of filling compounds is one means of improving the craft-friendliness of outside plant optical cables. Filling compounds are hydrophobic, oil-based gels that occupy void spaces directly surrounding optical fibers or ribbons. As such, filling compounds are an effective means for blocking water penetration in cables. Unfortunately, installers must incur considerable costs in order to work with filling compounds in the field. The largest expense is associated with removal of filling compounds prior to fiber splicing. Filling compounds are typically sticky and greasy, and must be carefully removed using special solvents. Consequently, in order to prepare cable ends for splicing, skilled craft must spend a great deal of time removing filling compound. In addition, incomplete removal of filling compound can affect splice yields, leading to further increases in splicing time and cost. Sticky filling compounds also easily contaminate closures, tools, and test equipment. Finally, filling compounds are typically a substantial component of the overall weight of an outside plant cable, affecting handling and installation performance.

OFS has recently developed a new family of dry central-core optical cables that addresses these shortcomings through total elimination of filling compound. These cables are fully compliant with all requirements of Telcordia GR-20-CORE, Issue 2 [1]. In this new family of cables, the filling compound has been replaced by superabsorbent materials that block water penetration in compliance with industry standards. However, unlike filling compounds, the superabsorbent materials are clean and dry, and are easily removed from the cable during installation operations. As a result, this new family of cables can significantly reduce installation costs for service providers.

2. CURRENT TOTALLY DRY CABLE DESIGNS

Current OFS commercial offerings of completely dry cables include central-core ribbon cables and outdoor/indoor ribbon cables. Ongoing work is focused on development of a comprehensive product line of dry cables free of filling compound, including stranded loose tube cables, microcables, and drop cables.

2.1 Central Core Ribbon Cables

OFS' family of dry outside plant ribbon cables is marketed under the AccuRibbon[®] DC Cable trade name. These cables use a new patented cable core design [2], and are commercially available in fiber counts ranging from 12 to 432. As shown by the schematics in Figure 1, an engineered superabsorbent "core tape" replaces the traditional filling compound. This core tape is wrapped around the ribbons, and acts to block water propagation along the core of the cable. The fibers are organized in ribbons, providing for inherently high packing density. Use of ribbons also allows for increased field productivity through use of mass fusion splicing.

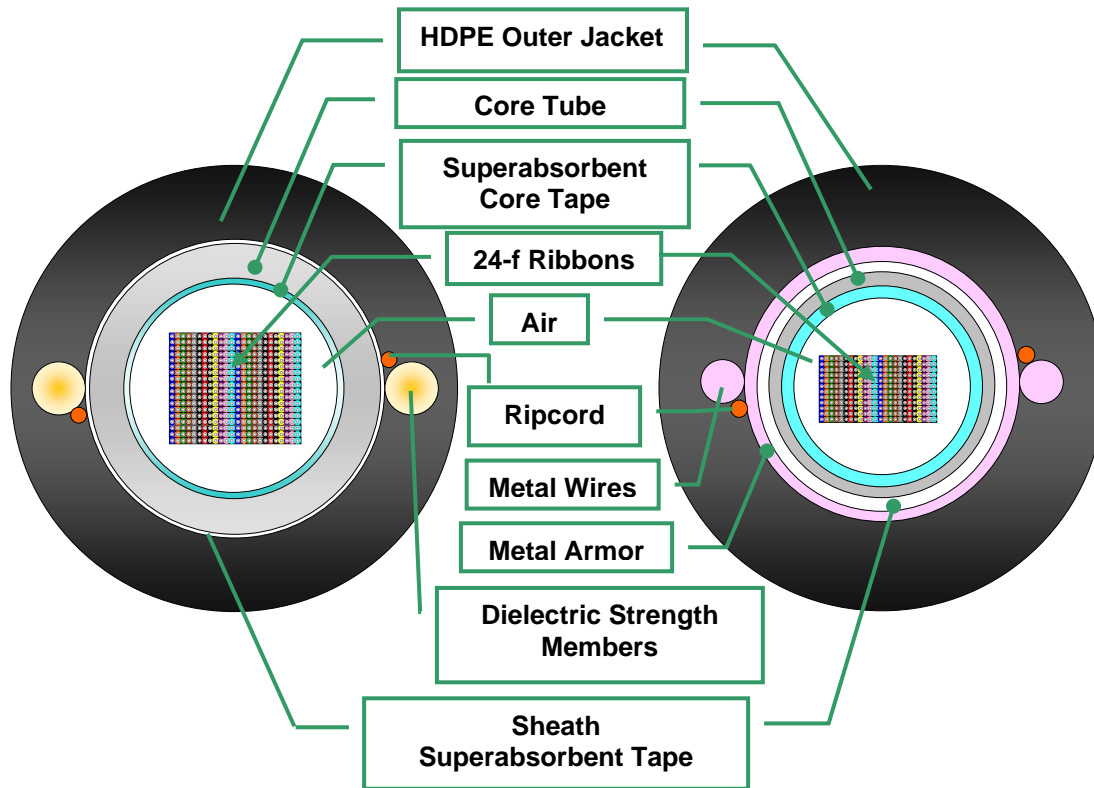


Figure 1 – Schematics of 432-Fiber Dielectric (left) and 288-Fiber Metallic (right) Dry Central Core Cables

These central-core cables are available in both armored metallic and dielectric sheaths, each using two linearly-applied strength members and a rugged high-density polyethylene (HDPE) jacket. The dielectric cables utilize a novel two-rod sheath design with significantly reduced preferential bending that provides improved handling and installation performance. [3]

A previous publication [4] introduced AccuRibbon[®] DC cables based on 12-fiber ribbons, available in fiber counts ranging from 12 to 216. In this paper, we present the qualification of high fiber count central core cables, based on 24-fiber ribbons. These new cables extend the maximum available fiber count to 432. Schematics of a dielectric 432-fiber cable, as well as a 288-fiber metallic cable, are shown in Figure 1. Details on the complete product line are summarized in Table 1.

Table 1 – Sizes and Fiber Counts of Commercially Available Dry Central Core Cables

Fiber Count	Number of Fibers per Ribbon	Ribbon Count	Cable OD mm(in)
12 to 48	12	1 to 4	13.0 (0.510)
60 to 144	12	5 to 12	15.5 (0.610)
156 to 216	12	13 to 18	18.0 (0.710)
288 to 432	24	12 to 18	21.6 (0.850)

2.2 Central-Core Outdoor/Indoor Ribbon Cables

OFS also offers completely dry outdoor/indoor cables, based on the dry waterblocked central core design described above. These dielectric ribbon cables are available with 12 to 432 fibers, and have dimensions identical to those of the outside plant cables (Table 1). The outdoor/indoor designs utilize a halogen-free, low smoke flame-retardant jacketing material. As a result, all of the outdoor/indoor dry ribbon cables are listed as passing the requirements of

the UL 1666 riser test [5] as well as the UL 1685 smoke generation test [6]. Deployment of the outdoor/indoor cables can significantly reduce cost when connecting central offices or high-bandwidth customers. Outdoor/indoor cables may be routed directly into an office from the “last manhole” in an outside plant cable network, eliminating the costly splice to an indoor cable at the building entrance.

3. COST SAVINGS THROUGH DEPLOYMENT OF TOTALLY DRY CABLES

To quantify the installation time savings that can be realized from use of the new family of dry cables, a series of time studies has been completed. In these experiments, the time required to fully prepare equivalent dry and traditional filled cables for splicing was measured. In a previous publication [4], time study results were presented comparing totally dry and filled 108-fiber metallic central core cables, using 12-fiber ribbons. That study found that end preparation of the dry central-core cable took only 4.25 minutes, as opposed to 30.25 minutes for the equivalent filled cable.

For this paper, 432-fiber dielectric and metallic cables with 24-fiber ribbon cores have been compared. Qualified installation trainers in a controlled environment performed the study. Results of the trials are presented below in Figure 2. The full end preparation time for the 432-fiber dry armored metallic cable was approximately 7.5 minutes, as compared to approximately 76.5 minutes for the equivalent filled cable. Similarly, only 5.0 minutes was required to prepare the dry dielectric 432-fiber cable for splicing, as compared with 74.0 minutes for the corresponding filled cable. Use of the dry cable design led to time savings of 90% for the metallic design, and 93% for the dielectric. As shown in Figure 2, the time difference is due to the time required to remove filling compound from the ribbons of the filled cables.

The reduced end preparation time afforded through use of the dry cables translates into significant time and cost savings in the deployment of cable routes. For example, in the case of a high density, 20-kilometer route using ten 2-kilometer 432-fiber dielectric cables, twenty different cable end preparation steps are required. Based on the time study results presented in Figure 2, installation crews would save over an hour during each end preparation, for a total time savings of 23 crew-hours for the route.

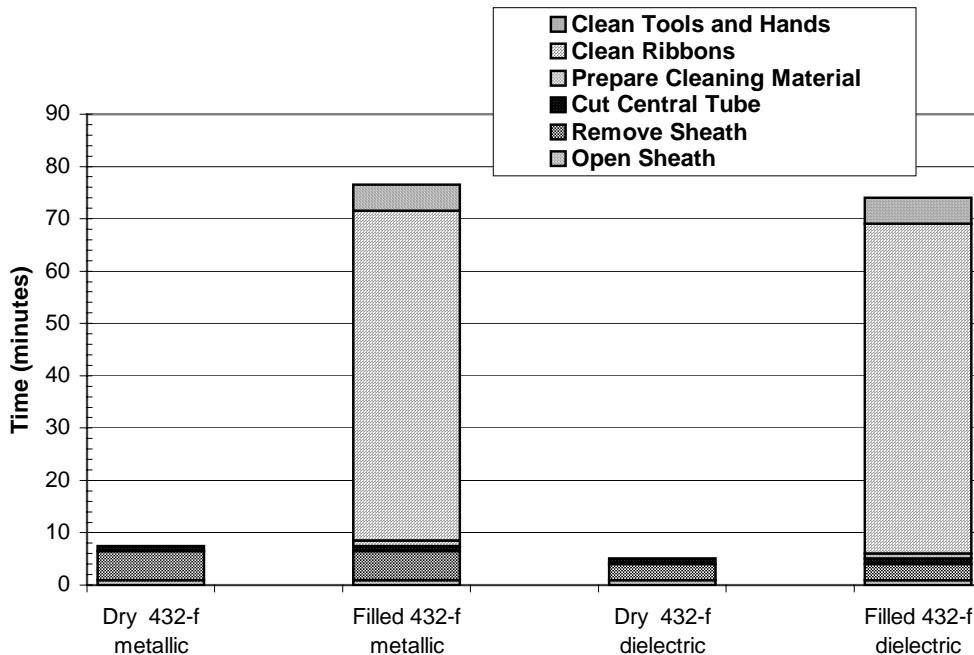


Figure 2 – Results of Time Study of Cable End Preparation of 432-Fiber Cables

4. QUALIFICATION TESTING OF DRY CENTRAL CORE CABLES

The entire family of dry central-core ribbon cables has been qualified to the requirements of Issue 2 of Telcordia GR-20 [1]. Qualification data for dry central core, 12-fiber ribbon cables was presented in a previous publication [4]. In this paper, qualification results are presented for high fiber count, dry central core ribbon cables using 24-fiber ribbons. Three cables were tested: a 288-fiber armored metallic cable, as well as 288-fiber and 432-fiber dielectric cables.

4.1 Mechanical Testing of High Fiber Count Dry Central Core Cables

Both metallic and dielectric high fiber count qualification cables comfortably pass all mechanical requirements of Telcordia GR-20 [1]. Table 2 presents representative results for the 432-fiber dielectric cable. This summary clearly shows that the actual median and maximum added losses for this cable are much lower than what is allowed under the GR-20 standard requirements.

Table 2 – GR-20 Mechanical Qualification Results for 432-Fiber Dry Dielectric Cable

Cable Test	Test Level	Requirement: Maximum Δ Loss	Measured Maximum Δ Loss (dB)	Requirement: Median Δ Loss	Measured Median Δ Loss (dB)
Impact	4 kg	< 0.15	0.012	< 0.05	-0.001
Tensile Load & Bend	801 N	< 0.15	0.059	< 0.05	0.005
High Temperature Bend	60°C, 356 mm	< 0.15	0.014	< 0.05	0.000
Low Temperature Bend	-30°C, 356mm	< 0.15	0.005	< 0.05	-0.007
Compression	1112 N	< 0.15	0.023	< 0.05	0.001
Twist	2 m, 180°	< 0.15	0.024	< 0.05	0.001
Cyclic Flex	356 mm	< 0.15	0.014	< 0.15	0.004
External Freezing	-1°C	< 0.15	0.020	< 0.15	0.002

4.2 Environmental Testing of High Fiber Count Dry Central Core Cables

For each of the three high fiber count cables, 2-kilometer lengths were tested to the environmental performance requirements of Telcordia GR-20 [1]. All three cables passed the requirements by a wide margin. Environmental cycling and aging results for the 432-fiber dielectric cable are summarized below in Figure 3. For both the cycling and aging tests, Figure 3 shows the *maximum* added attenuation measured at each temperature during the test. As indicated by these data, this dry 432-fiber central core cable passes the requirements of GR-20 by a wide margin.

4.3 Water Penetration Performance of High Fiber Count Central Core Cables

The engineered superabsorbent core tape must block water penetration within the core tube per Telcordia GR-20 and FOTP-82. All qualification cables have passed this standards requirement. Additionally, an extended series of tests was performed on core tubes extracted from cables to further verify waterblocking performance. A pressure-head manifold was designed to allow testing of multiple core tube samples to FOTP-82 by continuous exposure of the samples to the equivalent of a 1-meter pressure head. For 12-fiber ribbon cables with fiber counts from 12 to 216, results of extended studies were presented in a previous publication [4]. Results of water penetration tests for 288-fiber and 432-fiber cables are given in Table 3.

Table 3 – Water Penetration Results for the High Fiber Count Dry Central Core Design

Core Tube OD mm (in.)	Fiber Count	Number of Samples Tested	Results per FOTP-82
14.0 (0.550)	288	110	All pass
14.0 (0.550)	432	126	All pass

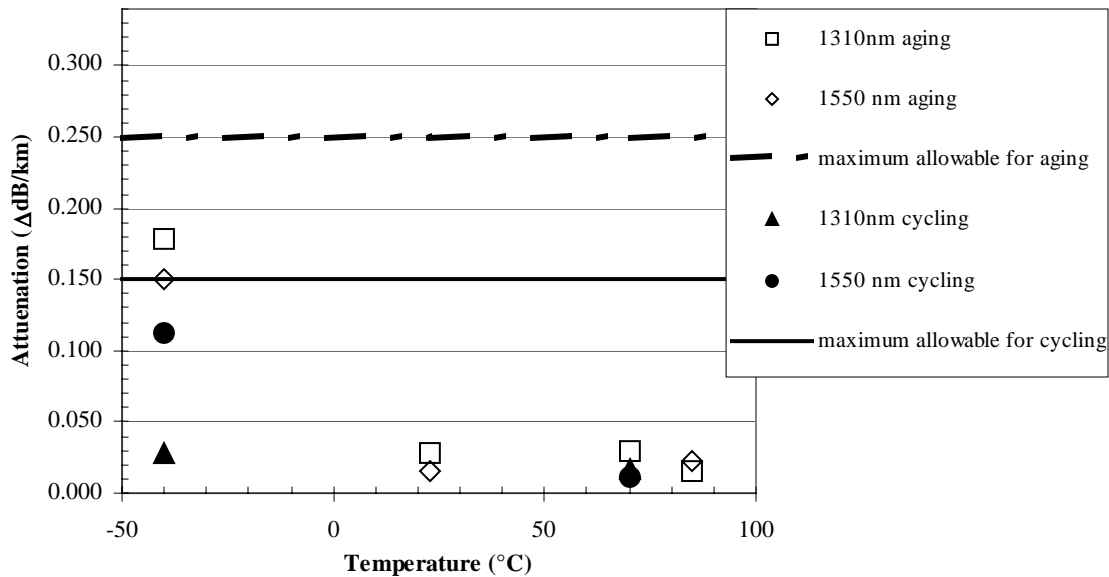


Figure 3 – Temperature Cycling and Cable Aging Data for 432-Fiber Dielectric Qualification Cable

5. PROTECTION AGAINST WATER INGRESS IN DRY CENTRAL-CORE CABLES

The new family of dry cables has multiple lines of defense against the ingress of both gaseous and liquid water. Coupled with the dry superabsorbent materials used in the cable interior, an undamaged cable sheath provides an effective barrier to permeation of liquid water or water vapor¹. As part of standard field procedures, the exposed ends of a cable are plugged with a silicone sealant and sealed inside watertight closures (see Section 6 below). If these seals fail, or if the cable sheath is damaged, the superabsorbent materials in the cable core will swell and prevent propagation of water along the cable core.

When exposed to water, the superabsorbent material in the core tape will swell, forming a soft gel. The swollen gel acts as a physical block to prevent water propagation in the core of the cable, identical to how filling or flooding compound physically blocks water. This swollen gel is thermodynamically stable, and water will not phase-separate from it. Water can slowly evaporate from the gel in hot conditions; however, after the water evaporates, the dehydrated superabsorbent material can re-swell to its full absorbency.

The presence of swollen superabsorbent gel in the core has a negligible effect on the transmission performance of the cable, regardless of temperature, as demonstrated in two model experiments. In a “flooding and aging” test, summarized below in Table 4, water was deliberately introduced into a 7.6-meter long section of a 48-fiber dielectric cable using a hypodermic syringe (note that 7.6 meters of flooding is substantially more than would be expected from a single incident of damage to the cable). The cable was then aged 28 days at 85°C and 85% relative humidity. As shown in Table 4, this deliberate flooding of the core has a negligible effect on attenuation.

A “flooding and freezing” test demonstrated that exposure of a flooded section of the core to subambient temperatures does not impact transmission performance. Ribbons in 100-foot lengths of two 144-fiber core tubes (one dry, one filled) were concatenated to create a 1200-foot fiber path. Each core tube was wrapped around an 18-inch diameter mandrel, and water was deliberately introduced into the dry, waterblocked core tube to form a gel. The two samples were then cycled from 23°C to -40°C over a period of 5 days with intermediate holds at 0°C, -10°C, and -20°C. At subfreezing temperatures, the swollen gel formed a benign frozen slush, as the superabsorbent material in the gel prevents the formation of large ice crystals. At each temperature, the added loss reading was

¹ Although water vapor can diffuse through the sheath of these cables, dry superabsorbent tapes inside both the jacket and core act as desiccants to prevent condensation of liquid water. A previously published study [7] of water diffusion into dry central core cables found that, even when the cable is completely immersed, relative humidity within the core remains below 100% for over 20 years at 25°C.

Table 4 – Results of “Flooding and Aging” Experiment for Dry Central Core Cable

Cable Type	48-fiber dielectric, 12-fiber ribbons
Cable Length	1.5 kilometers
Section Deliberately Flooded	7.6 meters long
Location of Flooded Section	150 meters from outside end of cable
Environmental Chamber Aging Conditions	28 days, 85°C, 85% relative humidity
Mean Cable Added Loss After Aging	0.004 dB/km
Maximum Cable Added Loss After Aging	0.008 dB/km

taken with a power meter. For the filled sample, the maximum attenuation measured during the cycle was 0.025 dB; the maximum attenuation measured for the flooded, frozen “dry” sample was 0.032 dB.

6. INSTALLATION SIMULATION TESTING OF DRY CENTRAL-CORE CABLES

The new dry central core cables have also been subjected to a rigorous battery of installation-simulation testing beyond the requirements of the Telcordia GR-20 standard. As discussed in a previous publication [4], metallic and dielectric dry central-core cables have been tested using procedures that model both standard and abusive installation practices, including: aerial coiling; direct burial; and installation in underground duct by both capstan pulling and blowing. Performance of the dry cables was identical to or better than that of traditional filled cable. In this paper, a new detailed study of aerial installation practice for the family of dry central-core cables is presented.

6.1 Aerial Installation of Central Core Ribbon Cable

6.1.1 Maximum span lengths

In accordance with widely accepted industry standards, all of these dry central-core cables have a 2700 N (600 lb) tensile load rating. This rating is intended to provide end users with robust cables while minimizing fiber strain during installation. During underground installation, cables may be exposed to high loads for brief periods. In this condition, static fatigue considerations require that the cable design limit fiber strain to 0.33%. Once the cable is placed, underground cables rarely see any additional loading throughout their life cycle.

Unlike underground cables, aerial cables are generally installed with low force, but will likely be exposed to repeated cycles of ice, wind, and thermal loading throughout their life cycle. Optical fibers may be exposed to many days or weeks of repeated load cycles. As a result, static fatigue considerations limit the maximum allowable fiber strain to 0.125%. Maximum storm-load strain may be limited by restricting the maximum permissible span length for aerial installation. Guidelines for aerial installation of 2700 N (600 lb) rated central-core ribbon cables are presented below in Table 5. Note that these guidelines are universal for both filled *and* dry cables. These guidelines were developed as the result of calculations of fiber strain at various loading conditions specified by the National Electric Safety Code.

Table 5. Maximum Permissible Span Lengths for Central Core Ribbon Cables

Strand Designation	NESC Storm Load District		
	Heavy m(ft)	Medium m(ft)	Light m(ft)
6.6M (6.4mm[0.25 in]EHS)	70 (225)	115 (375)	115 (375)
6M (7.9 mm[0.3125 in])	105 (350)	175 (575)	175 (575)
10M (9.5mm[0.375 in])	135 (450)	235 (775)	235 (775)

6.1.2 Controlling fiber movement

Both filled and dry central core ribbon cables manufactured by OFS allow longitudinal fiber movement within the core tube of the cable. This permits necessary relaxation of the ribbons in response to external loads. However, since the ribbons are free to move longitudinally, they may retract from an aerial splice closure under storm loading. Therefore, for both filled *and* dry cables, a few standard procedures can be used to limit fiber movement within the closure. These procedures include use of slack storage coils; use of a silicone core tube sealant at the closure

entrance; and excess fiber length in the closure. For the new dry core cables, the following installation procedures are required:

- 1. Slack Storage Coils.** As shown below in Figure 4a, five coils of slack cable are required adjacent to the splice closure. For 12-fiber ribbon cables, 46 cm (18 in.) is the minimum recommended coil diameter; 86 cm (34 in.) is the minimum coil diameter for 24-fiber ribbon cables. Alternatively, the slack cable can be stored in a “double snowshoe” configuration, as shown below in Figure 4b. The recommended snowshoe diameters are 20 times the cable diameter for 12-fiber ribbon cables, and 30 times the cable diameter for 24-fiber ribbon cables.
- 2. Core Tube Sealant.** The core tube seal is formed directly around the ribbons by injection of silicone adhesive sealant. A 5 cm (2 in.) length of tubing is placed over the end of the core tube to contain the silicone as it cures.
- 3. Slack Ribbon.** A minimum of 25.4 cm (10 in.) of slack ribbon is required in the splice closure. The slack ribbon must be free to move in the slack storage area of the closure and cannot be tie-wrapped or fastened.

Generally, these required procedures are already part of standard aerial procedures for central core optical cables. Since most aerial cables are spliced at street level, the needed slack loops are already created when the cable is returned to the support strand and the excess cable length is coiled adjacent to the aerial closure. The silicone core tube sealant at the closure entrance provides additional coupling to minimize fiber movement. The silicone sealant also beneficially acts as a barrier between the closure and the cable. For filled cables, the sealant prevents seepage of filling compound into the closure; for dry core cables, the plug acts to block water seepage into the cable from the closure. Finally, excess fiber length in the aerial closure eases splicing and accommodates any ribbon movement that may occur.

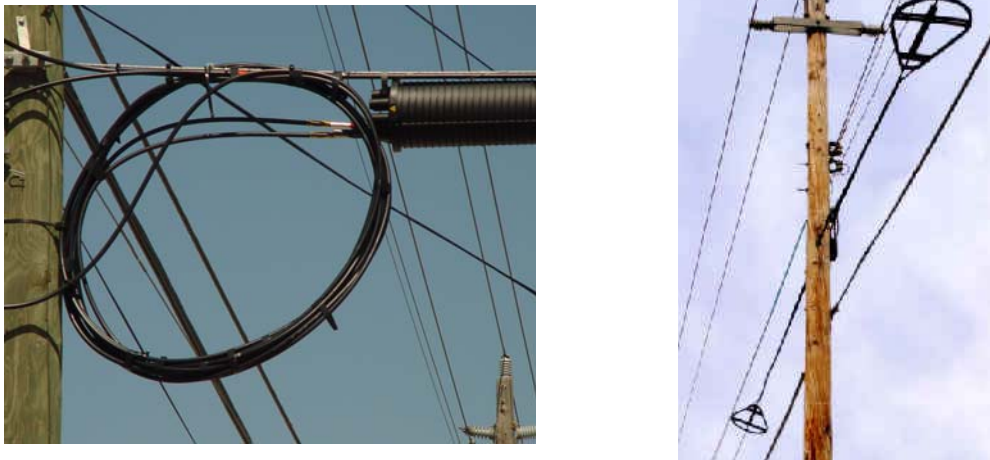


Figure 4 – (a) Picture of Cable in Slack Coils Adjacent to Aerial Closure; (b) Picture of “Double Snowshoe” Slack Storage on Telephone Pole

6.2 Simulated Storm-Loading Tests of Dry Central-Core Ribbon Cables

In order to confirm the fitness of these standard practices for the new dry central core cables, three cables were installed on an aerial pole line at an outdoor test facility. Total length of the line was 675m (2215 ft), and span lengths varied from 40 to 138m (132 to 454 ft). In each case, one end of the cable was terminated in a building, and the other end was terminated in an aerial closure. Simulated storm loading was provided by suspending two additional cables from the support strand. Fiber movement in the closure was monitored by measuring the free end of the fibers before and after application of the load. Details and results of the tests are given below in Table 6. Ribbon movement did occur in a 216-fiber “control” cable, which used neither sealant nor slack loops. In contrast,

no fiber movement occurred in 60-fiber and 156-fiber cables that used the recommended procedures. Note that the 60-fiber cable and the 156-fiber cable represent the lowest fiber packing density in their respective cable size.

Table 6 – Summary of Simulated Aerial Storm Load Tests of Dry Central Core Cables

Cable	Dry 216-Fiber Dielectric	Dry 156-Fiber Metallic	Dry 60-Fiber Metallic
Strand Type	10M	6.6M	6.6M
Theoretical Fiber Strain, 16°C (60°F)	0.04% – 0.08%	0.04% – 0.09%	0.04% – 0.09%
Theoretical Fiber Strain, 49°C (120°F)	0.06% – 0.10%	0.06% – 0.11%	0.06% – 0.11%
Duration of Test	3 months	1.5 months	1.5 months
Air Temperature During Test	10–35°C (50–95°F)	10–23°C (50–75°F)	10–23°C (50–75°F)
Slack Loops and Sealant Used?	No	Yes	Yes
Fiber Movement in Closure	25 mm (1 inch)	None	None

6.3 Laboratory Simulations of Aerial Installation of Dry Central Core Cables

As noted previously, the maximum-permissible fiber strain in the aerial environment is limited to 0.125%. Since the aerial installation tests described above did not achieve the maximum strain, additional laboratory tests were conducted to evaluate fiber movement at higher strain levels. In these tests, one free end of a 30.5 m (100 ft) length of cable was prepared using various combinations of a core tube sealant and/or slack coils. At the other end of the cable, the ribbon stack was exposed and wrapped around a capstan grip in a tensile testing machine. The ribbons were then pulled with a controlled level of force to simulate ribbon strain during storm loading. Repetitive testing with 216-fiber cable showed that a minimum of four slack coils with a diameter of 46 cm (18 in), plus sealant, were required to consistently restrict ribbon movement under high loads. With five slack coils, no ribbon movement occurred. Therefore, the use of five slack coils is specified as the configuration that best restricts ribbon movement, and also provides sufficient cable length to allow closure maintenance from the ground. A picture of a 216-fiber cable coiled at an aerial closure is shown above in Figure 4a.

For a set of 288-fiber cables, similar testing was conducted using two commercially available devices for the storage of cable slack in aerial installations. These were a “racetrack loop” consisting of two 86 cm (34 in.) plastic loops in a figure-eight arrangement, and a “double snowshoe” configuration in which the cable was wrapped around two 53 cm (21 in.) diameter plastic snowshoes. A picture of a “double snowshoe” installed on a telephone pole is shown in Figure 4b. For the racetrack loops, significant fiber movement occurred, even if a core tube sealant was used. When the core tube sealant was used with the snowshoe configuration, minimal ribbon retraction occurred.

7. FIELD DATA: INSTALLATION OF AN INTEROFFICE ROUTE USING DRY CENTRAL-CORE RIBBON CABLE

BellSouth recently installed approximately 19.2 km (63,000 ft) of AccuRibbon® DC cable between two central offices in Pensacola, Florida. This route included both 216-fiber and 288-fiber cables. Fibers 217 – 288 were terminated roughly midway between the two offices at a remote terminal location. Cable placing methods included direct burial, underground placement, and aerial installation. The direct buried portions of the route were installed by plowing, trenching, and directional boring techniques. Aerial placing methods included both stationary and moving reel methods, and the underground cables were pulled into innerduct. Metallic cables were installed in the direct buried portions of the route and dielectric cables were deployed in the underground and aerial sections. Several short lengths of dielectric cable were direct buried at transitions between the aerial and buried sections. Table 7 summarizes the various cable types and placing methods that were used during the installation.

During cable installation, about 23 m (75 ft) of slack cable was provided at each aerial splice location to accommodate slack coils and provide slack cable to reach the splicing vehicle. The slack coils were formed and positioned on the strand prior to the splicing operation. Subsequently, the two cable ends were dressed together and cut to length as required for the butt splice. During cable preparation, the splicing technicians appreciated the

absence of cable gel and commented that the dry core cables reduced cable preparation time on the order of 30 to 45 minutes per cable end. After positioning the cable ends in the splice closure, core tube seals were installed using plastic tubing and silicone adhesive sealant. Next, about 46 cm (18 in) of slack ribbon was positioned in the storage area of the closure, and the ribbons were routed into the splicing trays. No procedural differences were required between the 216-fiber and 288-fiber cables, other than splitting the 24-fiber ribbons in the 288-fiber cables into 12-fiber sub-groups. The 12-fiber ribbons were then trimmed to their required length and spliced using standard mass fusion techniques.

Table 7. Summary of Cable Types and Installation Methods in Pensacola, Florida Interoffice Route

Cable Type	216 Fiber-Count	288 Fiber-Count	Total Length
Metallic	0.88 km (2,875 ft)	4.70 km (15,425 ft)	5.58 km (18,300 ft)
Dielectric	7.44 km (24,400 ft)	6.23 km (20,435 ft)	13.67 km (44,835 ft)
Total	8.32 km (27,275 ft)	10.93 km (35,860 ft)	19.25 km (63,135 ft)
Installation Method			
Direct Buried	1.47 km (4,825 ft)	5.04 km (16,525 ft)	6.51 km (21,350 ft)
Underground	1.88 km (6,150 ft)	1.02 km (3,350 ft)	2.90 km (9,500 ft)
Aerial	4.97 km (16,300 ft)	4.87 km (15,985 ft)	9.84 km (32,285 ft)
Total	8.32 km (27,275 ft)	10.93 km (35,860 ft)	19.25 km (63,135 ft)

After the splicing operations were complete, bi-directional OTDR measurements were performed on 72 fibers. In the 216-fiber cable, the measured fibers were located in ribbons 1, 2, 9, 10, 17, and 18. In the 288-fiber cables, these fibers coincided with ribbons 1, 5, and 9. The OTDR measurements were used to compare *cabled fiber attenuation* to *installed fiber attenuation*. For the cabled attenuation, the total concatenated fiber loss in dB was determined from factory measurements, and the average fiber loss was determined from the total length of the concatenated cables. For the installed cable, the bi-directional OTDR traces were analyzed, and any high losses attributable to fiber connectors or splices (attenuation greater or equal to 0.1 dB) were subtracted from the total attenuation. Average fiber loss was then determined from the end-to-end measurement. As shown in Table 8, the average installed fiber attenuation is only 0.012 dB/Km higher than the cabled fiber attenuation. Given that the installed fiber attenuation includes all splice losses less than 0.1 dB, these results demonstrate excellent fiber attenuation performance.

Table 8. Comparison of Cabled Fiber Attenuation and Installed Fiber Attenuation

	Route Average (1550 nm)	Standard Deviation
Cabled Fiber Attenuation	0.192 dB/Km	0.004 dB/Km
Installed Fiber Attenuation	0.204 dB/Km	0.013 dB/Km

8. ONGOING WORK: QUALIFICATION OF DRY LOOSE TUBE CABLES

OFS has recently qualified a totally dry 72-fiber stranded loose tube cable to the full requirements of Telcordia GR-20. A schematic of the cable is shown in Figure 5. Twelve loose fibers are contained within each buffer tube. Within each of the buffer tubes, filling compound has been replaced by a single piece of engineered superabsorbent yarn, which blocks water propagation within each tube. Waterswellable elements in the DryBlock[®] core prevent water propagation outside the buffer tubes. Fiberglass strength elements supply additional tensile strength, and the cable is jacketed with tough medium-density polyethylene (MDPE). Work is ongoing to extend this dry loose tube cable concept to higher fiber counts.

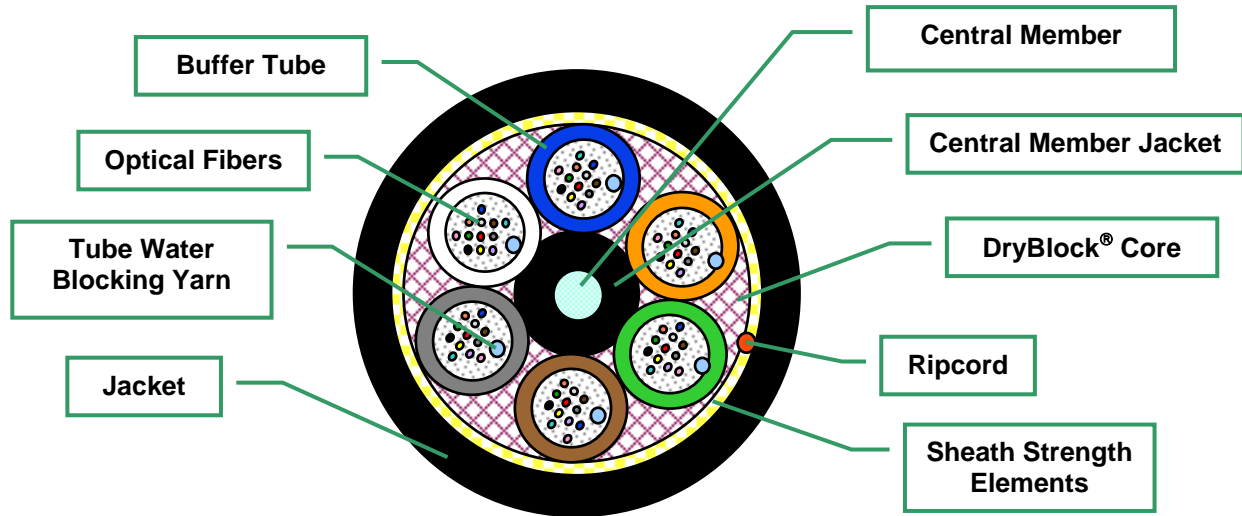


Figure 5 – Schematic of 72-Fiber Dry Loose Tube Cable

10. ACKNOWLEDGEMENTS

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11. REFERENCES

- [1] Telcordia GR-20-CORE, “Generic Requirements for Optical Fiber and Fiber Optic Cable - Issue 2” (1998).
- [2] U.S. Patent 6,504,979, “Water Blocking Optical Fiber Cable”, (2003)
- [3] R.H. Norris, P.A. Weimann, and H.M. Kemp, Proceedings of the 51st International Wire and Cable Symposium, pp. 192-201 (2002).
- [4] R.H. Norris and P.A. Weimann, Proceedings of the 51st International Wire and Cable Symposium, pp. 202-210 (2002).
- [5] Underwriters’ Laboratories 1666, “Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts”, Issue 4 (2000).
- [6] Underwriters’ Laboratories 1685, “Vertical-Tray Fire Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables”, Issue 2 (1997).
- [7] C.R. Taylor, K. Konstadinidis, R.D. Small, Jr., R.H. Norris, M.R. Santana and R.P. DeFabritis, Proceedings of the 50th International Wire and Cable Symposium, pp. 518-525. (2001)