A Furukawa Company

Aerial Installation Guidelines for Fiber Optic Cable

Contents **Section**

1. Scope

1.1 This practice covers the basic guidelines for installation of aerial fiber-optic cable. It is intended for personnel with prior experience in planning, engineering, or placement of aerial cable. A working familiarity with aerial cable requirements, practices, and work operations is necessary as this guide does not cover all aspects of aerial construction work. This practice assumes that the fiber optic cable will be attached to an existing support strand. Pole line construction and strand installation are not covered in this document.

1.2 OFS fiber optic cable can be placed using either the moving reel or stationary reel method. The choice depends on vehicle access to the pole line, the type of equipment available to the installer, and whether the cable must be pulled into position over existing facilities. Cable installation in aerial innerduct is permitted in certain circumstances as discussed in Section 10. Installation of pre-lashed cable is not permitted under any circumstance.

2. General Description of OFS Cables

2.1 OFS offers both central-tube and loose-tube fiber optic cables which are available in a variety of sheath and core configurations. OFS fiber optic cables are easy to handle and are designed to meet the conventional rigors of underground, buried, and aerial environments. Most OFS cables have a maximum rated cable load (MRCL) of 600 pounds and care must be taken during installation to avoid over tensioning the cable. Also, minimum bend diameters are specified for both static and dynamic conditions. Minimum bend diameters are expressed as a multiple of the cable outside diameter (OD) and are dependent on the cable construction and fiber count. Additional information is included in Section 6 of this document.

3. Aerial Design Information

3.1 In aerial plant, changes in environmental conditions occur throughout the service life of the cable. Wind and ice loads, as well as seasonal temperature variations cause the cable and strand to expand and contract applying variable forces to the fibers. This is in marked contrast to buried and underground cables where the most severe load a cable is likely to experience is usually applied during installation.

3.2 The design of overhead lines begins with material contained in Section 25 of the National Electric Safety Code (NESC). This standard is approved by the American National Standards Institute and is published by the Institute of Electrical and Electronic Engineers, Inc. Figure 1 shows the three storm-load districts — heavy, medium, and light — that are defined for the United States. The districts are delineated based on the expected ice, wind, and thermal loads on aerial cables. Storm loads for the three districts are shown in Table A. The NESC rules are intended to safeguard the public. In the simplest terms, aerial plant designed to meet the NESC storm load conditions is not supposed to fall. Such designs are based on a criterion of strength. However, an important characteristic of optical fiber that must be considered is its susceptibility to static fatigue, i.e., the growth of cracks under constant load in the presence of moisture, such as water vapor. Strains large enough to damage the fibers can occur without any apparent damage to the cable or it's supporting structure. Because the aerial environment is so variable and unpredictable, such events may take place months or even years after installation. Consequently, a stiffness design is required to minimize the fiber stress under storm load conditions.

3.3 High fiber-stress in aerial cable is associated with high temperatures and heavy transverse loading. In the medium and heavy loading districts, the heaviest transverse load is caused by ice accompanied by wind. The highest temperature at which this combination can exist is 32ºF. At higher temperatures, wind loading may be present but without the ice. In this case, the maximum air temperature accompanied by wind is assumed to be 100ºF. This loading requirement is applied to all three storm-load districts. Finally, in the absence of wind load, even warmer temperatures can be expected. In this case, the maximum cable temperature is assumed to be 170ºF.

3.4 Table B contains the specific ice, wind, and temperature conditions that are used to determine fiber stress in aerial optical-fiber cable. The maximum fiber stress under these conditions is limited to 12,500 psi. This limitation is necessary to help ensure a long service life in the presence of static fatigue.

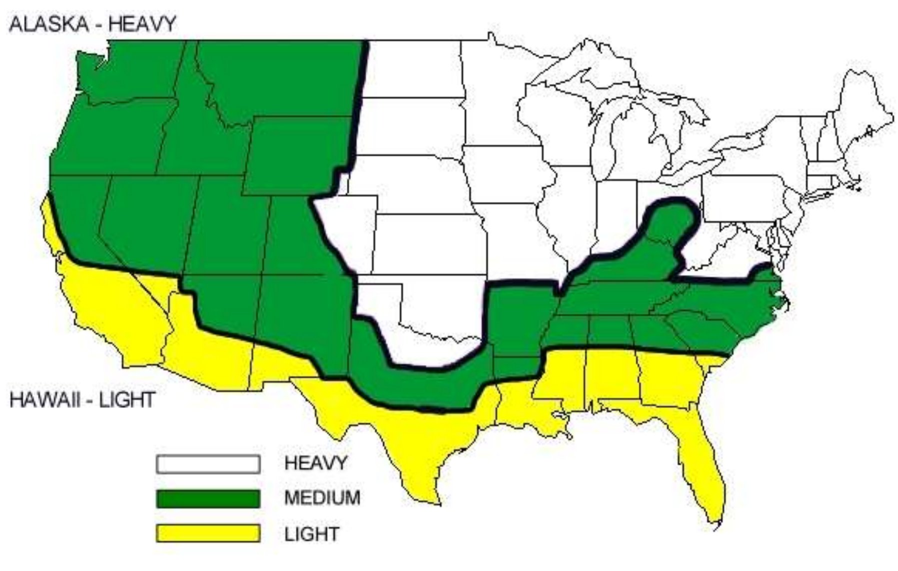

Figure 1 – NESC Loading Map of the United States

Table A - NESC Ice, Wind, and Temperature Load Conditions			
ENVIRONMENTAL CONDITION	STORM-LOAD DISTRICT		
	HEAVY	MEDIUM	LIGHT
Radial Thickness of Ice	0.5 inch	0.25 inch	0
Horizontal Wind Pressure	4 lb/sq-ft	4 lb/sq-ft	9 lb/sq-ft
Temperature	0 °F	+15 °F	+30 °F
Constant to be added	0.3 lb/ft	0.2 lb/ft	0.05 lb/ft

Table B - Ice, Wind and Temperature Conditions Used for the Stiffness Design of Aerial Fiber-Optic Cable				
ENVIRONMENTAL CONDITION	STORM-LOAD DISTRICT			
	HEAVY	MEDIUM	ALL	ALL
Radial Thickness of Ice	0.5 inch	0.25 inch	0	0
Horizontal Wind Pressure	4 lb/sq-ft	4 lb/sq-ft	9 lb/sq-ft	0
Temperature	+32 ºF	+32 ºF	+100 ºF	+170 ºF

4. Span Rules

4.1 Aerial fiber-optic cable plant must be stiff enough to keep the fiber stress within acceptable limits under the loads given in Table B. It must also be strong enough to meet the NESC requirements and support the loads given in Table A without exceeding 60 percent of the rated breaking strength of the support strand. Table C contains the maximum recommended span-lengths for OFS cables based on both criteria. The span length recommendations listed in Table C assume an initial installation sag of 1-1/2% for the strand and cable.

Table C - Maximum Recommended Span Lengths (ft)			
SUPPORT STRAND	STORM LOAD DISTRICT		
	HEAVY	MEDIUM	LIGHT
AccuRibbon® and AccuRibbon® DC Cables			
6.6M	225	375	375
6M	350	575	575
10M	450	775	775
LightPack® Cables			
6.6M	275	450	450
6M	400	725	725
10M	525	925	925
Mini C2™ DT Cable			
6.6M	300	575	575
Fortex™ and Fortex™ DT Loose Tube Cables			
6.6M	400	800	900
432f AccuTube® (Ribbon-In-Loose-Tube) Cable			
6.6M	225	350	350
6M	325	575	650

5. Overlashing

5.1 Overlashing a fiber optic cable onto an existing aerial cable requires special consideration. The presence of a second cable increases the environmental load on the existing cable and strand without adding much strength to it. In general, increased fiber stress on the existing cable, rather than the new cable, is the limiting condition.

5.2 If a fiber optic cable is overlashed to an existing fiber cable, the aerial span should not exceed 50% of the recommended length given in Table C. Alternatively, a fiber cable can be overlashed to an existing fiber cable if the support strand is one size larger than recommended in Table C.

5.3 The criteria for overlashing an optical fiber cable onto an existing twisted-pair copper cable are the same as those used for lashing to a strand alone, that is, the aerial span should not exceed the maximum recommended length given in Table C.

6. General Precautions

6.1 OFS fiber optic cables are designed to meet the rigors of conventional aerial, direct buried, and underground duct environments. However, special care must be taken during installation to observe the minimum recommended bend-diameter and the maximum rated cable load (MRCL) of the cable.

6.2 Cable minimum bend-diameters[1] are expressed as a multiple of the cable outside diameter (OD) for both static and dynamic conditions. The dynamic condition represents a cable during installation that may be exposed to the MRCL (typically 600 lb). The static condition applies during low-tension handling operations or long-term residual loads. Under static conditions, the maximum allowable cable tension is 30% of the MRCL (typically 180 lb). Minimum bend diameters for OFS cables are summarized in Table D.

6.3 For LightPack and AccuRibbon cables containing 216 fibers or less, an 18" minimum coil diameter is recommended for long-term slack cable storage. For loose-tube cables, Mini C2 DT cable, and AccuRibbon cables containing more than 216 fibers, the minimum storage coil diameters are expressed as a multiple of the cable OD as shown in Table D.

Table D - Minimum Bend-Diameters

Cable Type	Static*	Dynamic	Storage Coil
Loose Tube Cables			
Fortex and Fortex DT	20 × OD	30 × OD	20 × OD (but no less than 12”)
AccuTube	30 × OD	30 × OD	30 × OD
Central Core Cables			
Mini C2 DT	20 × OD	30 × OD	30 × OD
LightPack	20 × OD	40 × OD	18"
AccuRibbon & AccuRibbon DC (≤ 216 fibers)	20 × OD	40 × OD	18"
AccuRibbon & AccuRibbon DC (> 216 fibers)	30 × OD	40 × OD	40 × OD

* Includes minimum snow-shoe diameter.

[1] Some cable manufacturers express their cable-bending recommendations as a function of bend radius rather than bend diameter. For comparison to other cable manufacturers, the OFS minimum bend-diameter can be converted to bend radius by dividing the bend diameter by two. For example, the minimum recommended bend radii of OFS Fortex DT cable are 10 × OD and 15 × OD, respectively, for static and dynamic conditions.

6.4 To assure that the cable installation tension does not exceed the tensile-load rating of the cable, a breakaway pulling swivel, a winch line dynamometer, or tension-limiting winch must be used during cable installation. The breakaway swivel is attached between the cable pulling-grip and the winch line or pull rope. The load rating of the breakaway swivel must not exceed the MRCL of the cable. Cable winches must be calibrated so that the maximum pulling force does not exceed the MRCL of the cable. Cable winches must be calibrated on a regular basis as required by the manufacturer. A dynamometer can be used to monitor cable installation tension, but the dynamometer alone is not sufficient to protect the cable. A breakaway swivel or tension-limited cable winch should also be used to protect the cable from excessive tension.

7. Cable Installation - Stationary Reel Method

7.1 The stationary reel placing method is generally used when the cable is installed above existing lateral cables or other obstructions. The choice may also depend on the type of vehicles and placing equipment that are available to the installer. Using this method, a series of temporary cable blocks are first installed on the strand. Next, a pull line is threaded through the cable blocks and attached to the outside end of the cable using a breakaway swivel and a cable pulling-grip. The pull line is then used to pull the cable through the cable blocks into position below the support strand as shown in Figure 2. Finally, the cable is lashed to the strand. The lashing process begins at the outside end of the cable and proceeds towards the cable reel. The following steps outline the stationary reel placing method.

- Attach cable blocks to the strand to support the pulling line and cable during the placing operations. Place a sufficient number of cable blocks to support the weight of the cable. An insufficient number of cable blocks may result in excessive cable sag during the lashing operation. Additional cable blocks may be required where minimum vertical clearance must be maintained, e.g., over roads and driveways. Cable blocks should be distributed along the line prior to cable placing.

- Adequately sized cable blocks must be used at corner poles to support the cable's minimum bend radius. Note that equipment manufacturers commonly specify the overall diameter rather than the bottom-groove diameter (root-diameter) of the cable block. Because the cable rides in the bottom groove, the bottom-groove diameter must meet the minimum bend-diameter of the cable. OFS minimum bend diameters are summarized in Table D.

  Central Tube Cable Only: Quadrant blocks may be used in lieu of cable blocks to support the cable's minimum bend diameter at corner poles. The quadrant block must be designed for use with fiber optic cable and contain multiple rollers to support the cable's minimum bend diameter.

- If the cable will be pulled with a winch, the pulling rope or winch line must be installed through the cable blocks. A non-metallic rope or winch line should be used pull the cable.

- Position the cable reel directly in line with the strand. The distance between the cable reel and the pole should be approximately twice the height of the strand. Mount the cable reel on the reel carrier so that the cable pays off from the top of the reel.

- Secure a cable guide to the strand to support the minimum bend diameter as the cable transitions to the strand.

- Attach a pulling grip to the end of the cable and attach a 600-pound breakaway swivel between the pulling grip and winch line. A safety sling should be attached between the pulling grip and winch line to prevent the cable and pull rope from falling to the ground in the event that the swivel breaks. The safety sling must not support any load during normal pulling operations (the safety sling must be slack).

- A tension-limiting winch should be used to pull the cable. The winch must be calibrated to stop the pulling operation when the installation tension exceeds the MRCL (typically 600 pounds). Alternatively, a dynamometer can be used to monitor installation tension. The dynamometer must be equipped with an audible alarm or visual display and the pulling operation must be stopped when the installation tension reaches the MRCL.

- To minimize the installation tension, the cable should be payed off the reel by hand during the pull.

- Maintain communications at all times between the cable reel, winch operator, and all members of the installation crew so that the cable pull can be stopped instantly if necessary.

- Pull the cable at a safe and appropriate speed to minimize swinging and surging of the cable and to maintain complete control of the cable reel.

- After the cable has been pulled into its final position with slack for building access or for splicing, both ends of the cable should be secured to maintain sufficient tension in the cable to prevent excessive sag in the unlashed portion of the cable.

- The cable lashing operation begins at the cable winch and proceeds towards the cable reel.

- Slack cable that develops during the lashing operation should be taken up at the cable reel.

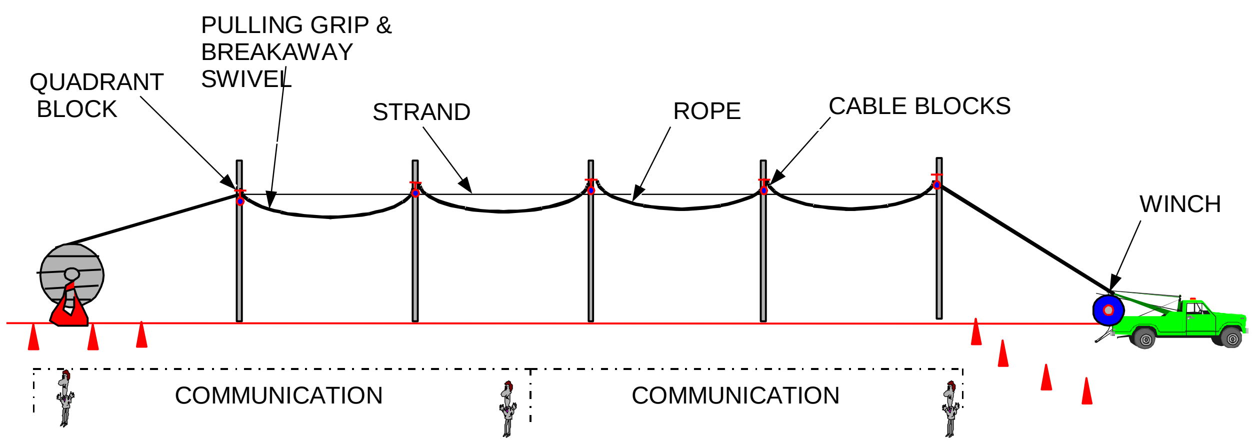

Figure 2 – Stationary Reel Method

- The poles may be "lashed by" by securing the lashing wire to the strand with a temporary clamp, transferring the lasher around the pole, and then continuing the lashing operation in the next span.

- Cable guards must be installed on the cable at all pole locations to prevent chafing against the strand suspension clamps. Cable spacers and lashing wire clamps should be installed as required during the lashing operation.

- Cable storage coils must meet the minimum bend-diameter requirements shown in Table D.

8. Cable Installation - Moving Reel Method

8.1 The moving reel method can be used in situations where a cable reel trailer or aerial lift truck can be moved along the pole line and there are no obstructions to prevent raising the cable to the suspension strand. The moving reel method has advantages over the stationary reel method in that temporary cable blocks and pulling lines are not required. Whenever possible, the moving reel method should be used to improve the efficiency of the placing operation. If trees or other obstructions prevent the use of the moving reel method for a portion of the route, a combination of stationary-reel and moving-reel methods can be used to install the cable. First, the stationary reel method is used to pull the cable past the obstruction to the end of the run. After that portion of the cable is lashed to the support strand, the remainder of the cable can be installed using the moving reel method.

8.2 For the moving reel method, the cable reel is mounted on a reel carrier of a cable trailer or aerial line truck. While the reel carrier is driven along the cable route, cable is payed off the reel with no back tension on the reel, guided to the support strand, and immediately lashed to the support strand. Depending on the available equipment, a craftsman may "ride the bucket" for quick access to the cable lasher as required to transfer the lasher around the poles. The moving reel method is a one-pass operation and does not require the use of cable blocks or pull lines. The following steps outline the placing operations for moving reel method.

- Mount the cable reel on the strand side of the aerial line truck or reel trailer. This will help maintain proper alignment of the cable and strand. A reel brake must not be used.

- Position the aerial line truck or cable trailer about 30 – 50 feet ahead of the cable splice point. The line truck or cable trailer must maintain this spacing in front of the lasher to assure a smooth transition of the cable to the support strand.

- If using an aerial line truck, feed the cable off the bottom of the reel through the cable guides and quadrant blocks up to the strand level. In general, the cable should not pass through the cable fairlead on the aerial bucket. The small-diameter rollers of the cable fairlead are not of sufficient size to meet the cable minimum bend diameter requirements. However, they may be used in certain circumstances so long as the cable reel, aerial bucket, and strand remain in good alignment and there is no back tension on the cable payoff. If at any time the line truck or aerial bucket is offset from the strand, the cable must be removed from the cable fairlead.

- Raise the cable end to strand level. Pull slack cable up to the strand as required for splicing and slack storage. Refer to the construction drawings to determine the amount of slack cable that is required. Slack cable is generally stored in a strand-mounted storage coil, a snowshoe-type storage system, or in an adjacent underground splice vault. Secure the slack cable to the strand with cable ties.

- Place the lasher and the cable guide on the strand. The cable guide is recommended to maintain the minimum cable bend-diameter as the cable approaches to the strand.

- Use a lashing wire clamp to attach the lashing wire to the strand about 16 inches from the pole centerline.

- Attach the cable to the strand using a cable-tie and spacer mounted about 14 inches from the centerline of the pole. Install cable guards as required to prevent chafing against the strand suspension clamps.

- Position the cable in the cable guide and lasher. Adjust the lasher per manufacturer's instructions.

- Attach separate pulling lines to the lasher and cable guide. Tie the pulling lines to the body of the aerial line truck. Do not attach the pulling lines to the boom or basket. The pulling lines should be adjusted so that the technician in the basket can ride alongside the lasher. The technician should be able to reach the strand from a point about four feet in front of the lasher to a point about four feet behind the lasher.

- Maintain constant communication between the craftsman in the bucket and the driver of the placing vehicle.
- Drive the placing vehicle parallel to and as close to the pole line as possible. Maintain constant speed and tension on the cable guide and lasher. The placing vehicle should be spaced about 30 – 50 feet in front of the cable lasher.
- The cable pay-off must be surge free. A reel brake should not be used. Reel rotation should be monitored to prevent free running or too slow a pay-off.
- Upon reaching a pole, stop the vehicle so that the cable guide and cable lasher may be transferred around the pole.
- Temporarily clamp the lashing wire to the strand.
- Transfer the cable guide and lasher around the pole to the next span.
- Attach cable guards and spacers as required at the pole
- If required, make permanent lashing wire terminations to the strand before moving to the next pole.
- Continue the cable installation span by span until the entire run is permanently lashed to the support strand.

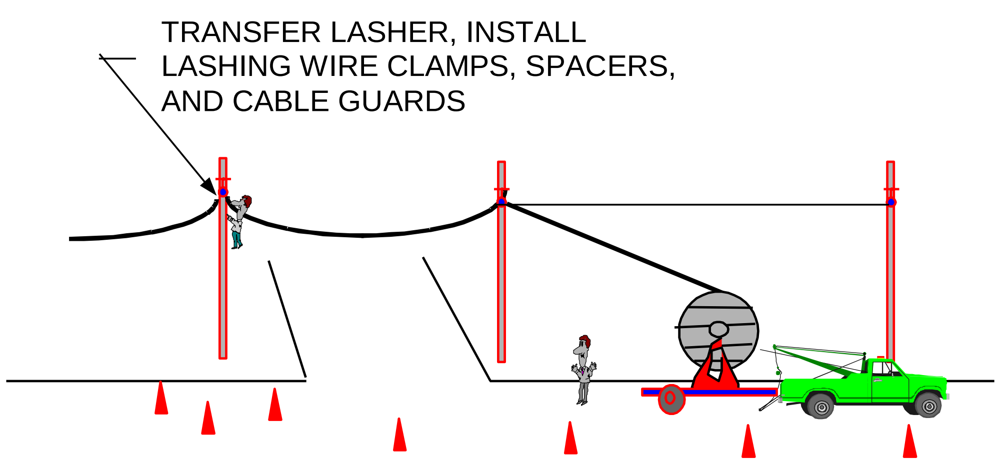

Figure 3 – Moving Reel Method

9. Termination of Central Core Cable

9.1 ***Slack Storage:*** OFS recommends that slack cable be stored adjacent to the aerial splice closure. The slack cable is used to lower the splice closure to the ground for splicing and maintenance activities. The slack cable may be stored using storage coils or a “snowshoe” storage system. These storage techniques also assist in coupling the fibers to the central core tube and restrict potential fiber movement when the cable is subjected to storm loads.

9.2 The minimum diameter of the storage coil is dependent on the cable design, fiber count, and cable OD as specified in Table D. The required cable length is dependent on local conditions such as the cable attachment height and accessibility to the splicing vehicle; however, at least five coils of slack cable are recommended to couple the fibers to the core tube and minimize potential fiber movement. Figure 4 shows a typical storage coil in an aerial application of AccuRibbon DC cable.

Figure 4 – Slack Storage Coil

9.3 For snowshoe applications, a minimum of one complete revolution around a pair of snowshoes is recommended. Figure 5 shows cable storage using a pair of snowshoes in a typical strand storage system. The snowshoes are available in various sizes and are available from equipment suppliers such as Preformed Line Products, Fiber and Cable Accessories, Inc., or Multilink, Inc. The minimum cable bend diameters for snowshoe applications are shown in Table D.

Figure 5 – Cable storage using snowshoes.

9.4 ***Core Tube Plug:*** OFS recommends that central core cables installed in aerial applications be terminated using a core tube plug as shown in Figure 6. The core tube plug serves several purposes – (1) to minimize fiber movement by coupling the fibers to the central core tube, (2) to minimize the possible entry of water into the cable from the closure, and (3) to prevent cable filling compound from flowing into the splice closure. The core tube plug is formed by injecting a one-inch (2.5 cm) long section of RTV silicone sealant into the core tube. For small diameter core tubes, a disposable syringe[2] is recommended

[2] McMaster-Carr, plastic syringe with taper tip, part# 7510A661, or equivalent.

for injecting the RTV into the core tube. OFS recommends RTV 108 silicone rubber adhesive sealant[3] for this application***.*** The RTV sealant becomes tacky after about 30 minutes and reaches full cure in about 10 hrs.

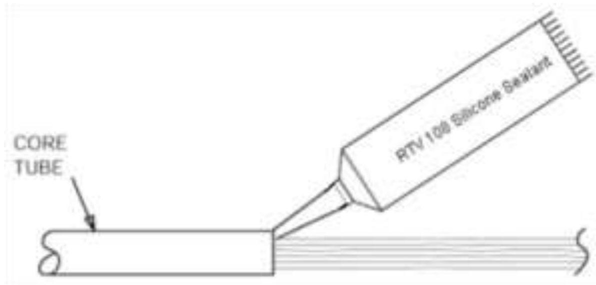

Figure 6 – Forming a core tube plug for central core cable.

9.5 ***Fiber and Ribbon Storage in Splice Closures:*** When the cable is exposed to storm loads, axial fiber strain may cause fiber movement at the ends and mid-span openings of the cable. Consequently, precautions should be taken at the splice closure to accommodate potential fiber movement. Specifically, a minimum of 10 inches (25 cm) of excess fiber or ribbon slack should be provided in the splice closure. The excess fiber slack should be free to move within the closure. Some closure manufacturers offer slack storage trays for this purpose. Alternatively, slack fiber may be stored in a slack storage area of the closure as shown in Figure 7.

9.6 The fiber or ribbon slack should be free to move in the slack storage area. The fiber should not be tie-wrapped or fastened in the slack storage area, and the fiber should not be routed around any guide pins or sharp corners in the slack storage area.

9.7 For Mini C2 DT cable, the buffer tube may be routed directly to the splice organizer tray and fiber slack stored within the organizer tray. If the splice closure allows for slack buffer tube storage, coil one-half to one full wrap of buffer tube before routing the buffer tube to the splice tray organizer.

Figure 7 – 2600LG closure with slack fiber stored in the fiber storage area.

10. Fiber Optic Cable in Aerial Innerduct

10.1 As discussed in Section 3, the storm load conditions for aerial fiber optic cables are a combination of the ice, wind, and thermal loads summarized in Tables A and B. For example, in the heavy load region, the NESC specifies that a cable and strand must support the load resulting from 0.5”

[3] Available from McMaster-Carr, part #7545A471.

of radial ice thickness and a horizontal wind pressure of 4 lb/ft^2. The actual load is a function of the cable diameter, i.e., the transverse load on a large diameter cable will be higher than that on a small diameter cable. In the heavy load region, the transverse load on a 0.5" diameter cable lashed to a 6.6M strand is 0.91 lb/ft. Under the same conditions, the transverse load on a 1.0" nominal-diameter aerial innerduct is 1.48 lb/ft. The storm load on the aerial innerduct is about 60% higher than the storm load on cable lashed directly to the strand. Since the innerduct does not add much tensile stiffness to the supporting structure, the axial strain of the strand/innerduct/cable composite will be significantly higher than that of the cable lashed directly to the strand. Consequently, the maximum allowable span lengths for fiber optic cable in aerial innerduct will be less than those permitted for cable lashed directly to the strand.

10.2 In addition to the ice and wind load, aerial innerduct will also be subjected to the weight of water that may accumulate in the innerduct. Assuming the space between the cable and innerduct is full of water, the additional vertical load is 0.33 lb/ft for a 0.5" diameter cable in the 1.0" nominal diameter innerduct. Adding the weight of water in the storm load calculation increases the total transverse load to 1.76 lb/ft.

10.3 Based on the above mentioned load criteria, maximum permissible span lengths for OFS cable installed in 1-inch and 1.25-inch nominal-diameter innerducts are given in Tables E and F. Note that in some cases, longer spans are allowed on 6.6M strand than allowed on 6M strand. This result arises from the fact that 6.6M strand has a higher breaking strength compared to 6M strand. Consequently, when the maximum permissible span is limited by the NESC strength criteria, a longer span length is achieved using 6.6M strand[4].

Table E - Maximum Recommended Span Lengths (ft) for Cable in 1" Nominal-Diameter Aerial Innerduct

Strand Designation	Storm-Load District		
	Heavy	Medium	Light
Central Tube Cable			
6.6M (1/4" EHS)	150	150	150
6M (5/16")	225	225	225
10M (3/8")	300	300	300
Loose Tube Cable			
6.6M (1/4" EHS)	200	600	600
6M (5/16")	250	400	400
10M (3/8")	300	800	800

Table F - Maximum Recommended Span Lengths (ft) for Cable in 1.25" Nominal-Diameter Aerial Innerduct

Strand Designation	Storm-Load District		
	Heavy	Medium	Light
Central Tube Cable			
6.6M (1/4" EHS)	100	100	100
6M (5/16")	175	175	175
10M (3/8")	225	225	225
Loose Tube Cable			
6.6M (1/4" EHS)	125	400	500
6M (5/16")	175	350	375
10M (3/8")	200	700	700

[4] In most cases, the maximum permissible span length is limited by the stiffness design. Since 6M strand has a higher tensile stiffness compared to 6.6M strand, 6M strand provides longer span lengths in these cases.

For additional information please contact your sales representative. You can also visit our website at www.ofsoptics.com or call 1-888-FIBERHELP (1-888-342-3743) from inside the USA or 1-770-798-5555 from outside the USA.

AccuRibbon, AccuTube, and LightPack are registered trademarks, and Fortex and Mini C2 are trademarks of OFS FITEL, LLC.

OFS reserves the right to make changes to the document at any time without notice. This document is for informational purposes only and is not intended to modify or supplement any OFS warranties or specifications relating to any of its products or services. OFS makes no warranty or representation with respect to the non-OFS products or non-OFS companies mentioned in this document.