CORNING

Installation of Solo® ADSS All-Dielectric Self-Supporting Fiber Optic Cables

p/n 005-038, Issue 6

1. GENERAL

1.1. This procedure provides general information for installing all Corning Cable Systems' Solo® ADSS All-Dielectric Self-Supporting fiber optic cables from 2-288 fibers. Each installation will be influenced by local conditions.The reader should be experienced in aerial fiber optic cable installation.

1.2. This procedure contains references to specific tools and materials in order to illustrate a particular method. Such references are not intended as product endorsements.

2. SAFETY PRECAUTIONS

CAUTION: Before starting any aerial cable installation, all personnel must be thoroughly familiar with all applicable Occupational Safety and Health Act (OSHA) regulations, the National Electrical Safety Code (NESC), state and local regulations, and company safety practices and policies. Failure to do so can result in life-threatening injury to employees or the general public.

WARNING: To reduce the chance of accidental injury:

a. Use protective leather gloves and, if necessary, lineman's rubber gloves. Use the leather gloves when climbing or descending a pole, and when working with sharp instruments or materials. Wear rubber gloves when working near exposed electrical circuits.

b. Use a safety harness on all bucket trucks and aerial lifts. A body belt and safety strap for the bucket or platform must be used when the equipment is in operation to minimize the chance of injury.

c. Before climbing a pole, inspect it for significant deterioration and safety hazards splintering, insect nests, sharp protrusions, etc.).

d. Position all motorized equipment so that exhausts are directed away from the location where most work will be done.

e. Personnel normally should not remain in an area where a cable is being pulled around a piece of hardware under tension. The installer can remain in such an area (for example, to observe the alignment of a cable around corner block), if he or she stays clear of the hardware under tension and has a clear path to safety.

f. Always lower cable blocks and other equipment from strand level with a handline.

g. Keep hands free of tools or materials when climbing or descending a pole or ladder. Do not step on cables, cable enclosures, or suspended equipment which might provide unsafe footholds.

h. Read the entire procedure before starting a Solo® cable installation. Thoroughly understand the procedure, its precautions, and the tools and equipment required before starting work.

2.1. Laser Handling Precautions

WARNING: Never look directly into the end of a fiber that may be carrying laser light. Laser light can be invisible and can damage your eyes. Viewing it directly does not cause pain. The iris of the eye will not close involuntarily as when viewing a bright light. Consequently, serious damage to the retina of the eye is possible. Should accidental eye exposure to laser light be suspected, arrange for an eye examination immediately.

3. CABLE HANDLING PRECAUTIONS

⚠	**CAUTION:** Fiber optic cable is sensitive to excessive pulling, bending, and crushing forces. Consult the cable specification sheet for the cable you are installing. Do not bend the cable more sharply than the minimum recommended bend radius. Do not apply more pulling force to the cable than specified. Do not crush the cable or allow it to kink. Doing so may cause damage that can alter the transmission characteristics of the cable; the cable may have to be replaced.

Maximum Pulling Tension

3.1. There are two different tensions to keep in mind during installation of ADSS cables. One is the maximum pulling tension during installation; the other is the span tension.

The maximum tension during installation should not exceed 600 lb_F (2700 N). Typically tensions for aerial installations are lower, but may approach 600 lb_F when using the stationary reel method of installation and the route is characterized by numerous elevation changes and routes.

3.2. After the cable is pulled in, it is placed in the pole hardware under tension. This tension, referred to as the span tension, is calculated for each cable to achieve a 1% installation sag. The span tension is calculated to accommodate the maximum wind and ice loads the cable should experience.

3.3. Please call Corning Cable Systems Engineering Services 1-800-743-2671 to assure that the proper tension is applied to achieve the correct sag for any given span. The following information is needed to calculate span tensions:

- Span length
- NESC loading conditions
- Installation temperature
- Fiber count
- Nominal outside diameter (OD) of the cable
- Height from ground to pole attachments
- Elevation changes
- Installation Sag (other than 1%)

Minimum Bend Radius

3.4. Corning Cable Systems cable specification sheets also list the minimum cable bend radius both “Loaded” (during installation) and “ Installed” (after installation). If these sheets are not available on the job-site, the following formulas may be used to determine general guidelines for installing Corning Cable Systems fiber optic cable:

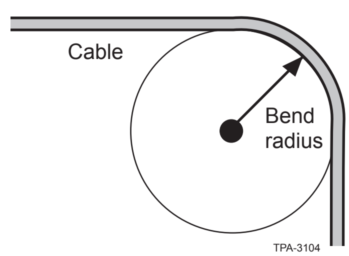
To arrive at a working bend radius for cable installation, multiply 15 times (15 x) the cable outside diameter.

Example:

Cable Diameter = 0.46 in (11.8 mm)

15 x 0.46 in = 6.9 in (177 mm)

Minimum Working Bend Radius = 6.9 in (17.7 cm)



2 x 6.9 in cm=
13.8 in (35.4 cm)

To find the minimum diameter requirement for pull wheels or rollers, simply double the minimum working bend radius:

3.5. If the cable must be unreeled during installation, use the figure-eight configuration to prevent kinking or twisting. Fiber optic cable should not be coiled in a continuous direction except for lengths of 100 ft (30 m) or less. The preferred size of the “figure-eight” is about 15 ft (4.5 m) in length, with each loop about 5 ft (1.5 m) to 8 ft (2.4 m) in diameter. Traffic cones spaced 7 - 8 feet apart are useful as guides during “figure-eighting.”

NOTE: When “figure-eighting” long lengths of cable, take steps to relieve pressure on the cable at the crossover of the eight. This can be done by placing cardboard shims at the crossover, or by forming a second “figure-eight.” If the “figure-eight” must be flipped over to obtain the pulling eye, it can be easily accomplished by three men, one at each end and one in the center. The cable can then be pulled off the “figure-eight” the remaining distance.

Uncontrolled Twisting

3.6. Uncontrolled twisting can damage any fiber optic cable. To prevent such damage during a pull, place a pulling swivel between the pulling line and the pulling grip (see Step 6.7). Whenever a cable is unreeled for subsequent pulling, Figure-eight the cable as outlined in Steps 5.2 through 5.5.

Equipment Inspection

3.7. All equipment to be used during handling and installation should be inspected for features which might damage the cable. Examples of dangerous features are nails, broken flanges on cable reels, and damaged blocks.

Cable Care And Inspection

3.8. Leave cable reel lagging, the protective boards nailed between the flanges of the reel, intact until the reel arrives at the installation site. Upon removal of the lagging, inspect the cable jacket for signs of damage. If the lagging has been previously removed, secure the cable end(s) during transit to prevent damage. Cable reels should be stored vertically on their flanges and chocked to prevent rolling.

3.9. Determine if your company requires that the cable be tested for optical continuity prior to installation. These tests can be done with an Optical Time Domain Reflectometer (OTDR).

3.10. Do not, under any circumstances, make unplanned cuts in the cable. Unplanned cuts mean additional splices, which are costly in monetary and attenuation terms. Any departure from the planned installation should be approved by the construction supervisor.

4. PLANNING AND PREPARATION

4.1. Prior to beginning an aerial cable installation, careful planning and preparation are necessary. Representatives of each organization potentially affected by the installation (utilities, street department, police, etc.) should be present during the route survey. Approval by all necessary parties should be secured before detailed planning begins. A few of the issues to be considered are listed in the following paragraphs. Planning should be undertaken jointly by construction and engineering personnel. Hardware requirements should also be considered at the planning stage.

Route Selection And Planning

4.2. Installation costs will be minimized by using existing poles whenever possible. The ability of existing poles to accept new fiber optic cable and the need for modification should be determined using your company’s normal criteria for installing an additional cable. Ideally, the guying of the cable plant should remove all lateral stress, leaving the poles to support only the weight of the cable and associated hardware. Sufficient clearance for new cable along the right-of-way should be confirmed during the route survey.

Cable Placement

4.3. Several factors should be considered when deciding where on a pole to place ADSS cable. Like other fiber optic cables, ADSS cable weighs less than equivalent copper cables and will tend to sag less over a given aerial span. Because of this, it should occupy the uppermost available communications space on a pole in order to maintain adequate clearance.

4.4. On joint-use poles, care must be taken to ensure sufficient clearances between ADSS cable and electrical power and other cables. The necessary clearance should be determined on a case-by-case basis by referring to the current National Electrical Safety Code (NESC), appropriate local codes and your company's standards.

Installation Planning

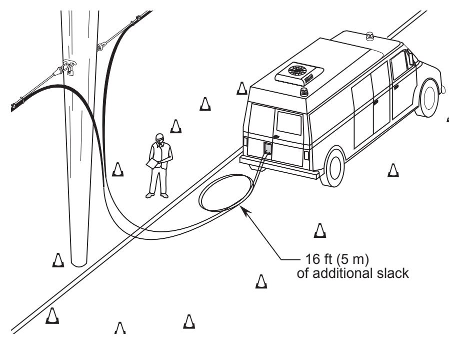
4.5. Planning the actual installation should take place only after a thorough route survey. The installation method to be used will be largely dictated by the cable route. Both the moving reel (drive-off) and stationary reel methods of aerial cable installation are outlined in this procedure, as well as conditions requiring use of one, the other, or both. Duct and direct burial placement are also discussed. With the proper installation hardware, any of these methods can be used to install Solo® ADSS cable.

4.6. Examine the ability of existing dead-end poles to withstand the temporary stresses of installation. Because it is impossible to tension each of the messenger spans along the route simultaneously, a dead-end pole will be subjected to an unbalanced load as the messenger is tensioned on one end of the cable run before the other. This temporary unbalanced loading can be relieved by temporary guy wires where required. Determine whether temporary guying is needed according to your company's standard route engineering guidelines.

Splice Locations And Cable Slack Requirements

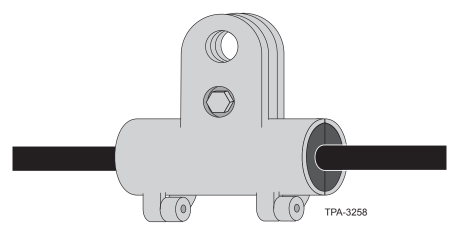
4.7. Select splice locations during the route survey and make plans for slack and splice closure storage. Splice locations should be placed to allow for the longest possible continuous cable spans and a minimum number of splices. The splice points should be chosen to facilitate the later splicing operation and should be easily and conveniently accessible to a splicing vehicle.

4.8. The amount of slack cable component at each splice point must be sufficient to reach from the pole's height to the planned splicing vehicle location on the ground. An additional 16 ft (5 m) should be added onto this figure to allow for closure requirements. This slack should be allowed for when planning the route and ordering cable. Leave sufficient slack at each future drop point to allow for splicing.



Pole Hardware

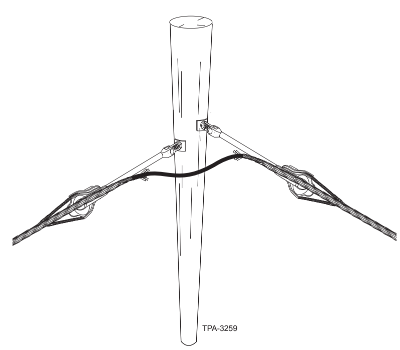
4.9. Solo® ADSS cable installations require a special tangent assembly or a mechanical dead-end at each pole. Use the following guidelines to identify the hardware needs of each pole:



Line offset of 0 to 20° (horizontal or vertical):
fiber optic tangent assembly.

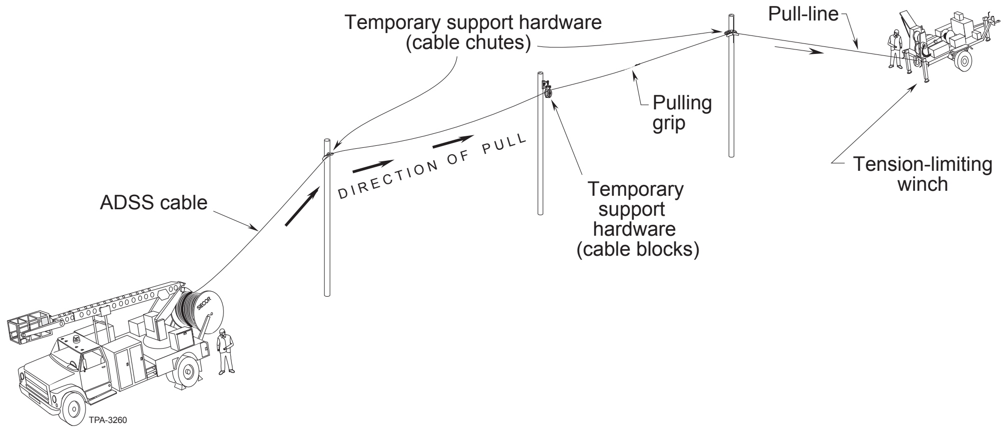
Line offset >20° (horizontal or vertical) or at the ends of the cable:
fiber optic dead-end.

The cable must be properly tensioned as described in Section 7 before it is permanently secured into the tangent assemblies and dead-end fixtures. Section 8, ADSS Cable Hardware, provides guidance on installation of pole hardware.



NOTE: If the cable end is secured, it is a dead-end. If the span continues, the fiber optic cable is not cut and is called a "false dead-end."

5. STATIONARY REEL INSTALLATION METHOD



5.1. In the stationary reel method of aerial cable installation, the cable is pulled along the cable route through temporary support hardware installed for this purpose as shown in the illustration above. When the cable is in place between splice points, the cable is tensioned and terminated at each dead-end pole along the route. The cable spans are then lifted out of the temporary support hardware and placed in tangent clamps at each intermediate pole.

5.2. The stationary reel method is generally slower and more costly than the moving reel method, but can be used anywhere since it does not require an unobstructed right-of-way or vehicular access to the pole line. Higher costs are imposed by the difficulty of coordinating the pulling operation over the length of the route.

5.3. Determine the cable reel and pull locations, each of which can be at any point along the route. The location of the cable reel and any subsequent intermediate pull points must be determined during the route survey. Some of the factors to consider are:

a. Where significant elevation change occurs along the route, it is usually best to pull downhill.

b. The cable reel location should be accessible by the reel-carrying truck, but removed from vehicle and pedestrian traffic.

c. By using the figure-eight coiling procedure, cable from one reel can be pulled in both directions from a central point. The route can be subdivided into shorter pulls to:
   - Keep the pulling tension below the cable's rated strength.
   - Avoid pulling across sharp turns.
   - Provide cable slack at designated points to allow for future drops.
   - Compensate for insufficient temporary support hardware or personnel to cover the entire route.

d. Installation time will be minimized if reels can be set up for continuous pulls in both directions from a splice point.

e. To prevent damage to the cable during payoff:
   - Keep the cable reel level to avoid cable rubbing against the reel flanges.
   - Orient the cable reel so that the natural payoff direction is directly towards the first pole.
   - Pay out the cable from the top of the reel as shown in the figure above to eliminate possible cable contact with the ground.

Temporary Support Hardware

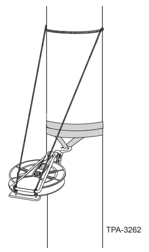
5.4. Temporary support hardware must be selected and placed so as to maintain the cable's minimum bend radius throughout the route and to prevent the cable's entanglement on obstructions in the right-of-way.

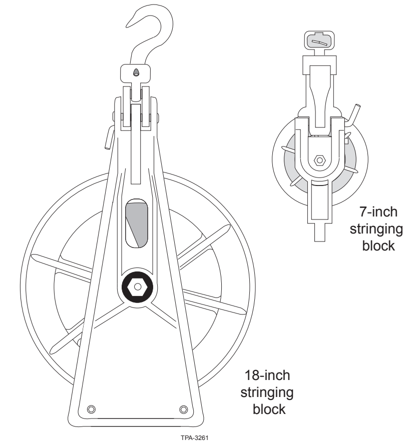
NOTE: Careful selection should be made when choosing equipment that maintains cable bend radius. Not all equipment is well suited for fiber optic cable installation.

Stringing Block Placement

5.5. Hang the proper stringing block on each pole or support structure. 18-inch (or greater) blocks should be used for any offset poles ≥ 10° and 7-inch blocks utilized for straight line poles.

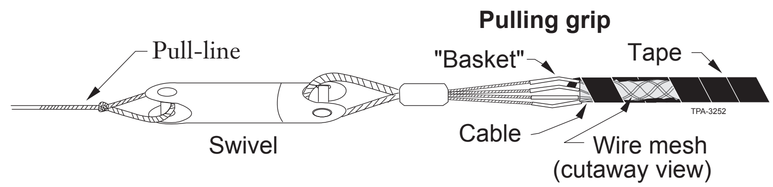
5.6. On poles with an offset greater than 10°, elevate the block by securing a rope to the shackle to ensure proper retention of the cable in the block. Attach the rope to one bottom pin of the shackle, bring the rope above the attachment point and back down to the opposite shackle pin.





Pulling Operation

5.7. The pull can be accomplished by using a cable pulling winch. Care must be taken not to exceed the cable's rated pulling strength. Use a tension-monitoring or -limiting winch or install a break-away swivel properly rated for the cable between the pull-line and the cable.



5.8. For installing a wire mesh pulling grip on Solo® ADSS cable, follow Corning Cable Systems SRP 004-137, Installing Wire Mesh Pulling Grips.

5.9. During the pull, sufficient personnel should be on hand to monitor the entire pull route. Two-way communication, should be established between the pull point, the cable reel location, and each of the route observers.

5.10. Start the pull very slowly as the cable is drawn from the reel at ground level up through the temporary support hardware located atop the first pole. Once the cable end is past the first pole, the pulling speed can be gradually and steadily increased. If sufficient support hardware is in place, pulling speeds on the order of 150 ft (45 m) per minute are typical.

5.11. Observers at the pull point, reel location and along the pull route must be alert for any condition which might cause cable damage and be able to stop the pull immediately if any damaging conditions are observed:

a. Avoid exceeding the cable's rated pulling strength and bending the cable beyond its minimum bend radius.

b. Control the unreeling of the cable either by hand or with a cable reel brake in order to prevent free-running or jerking of the cable.

c. At the pull point, winch the cable so as to prevent either free-running or jerking of the cable. If either is observed, the pull must be halted until the cause is eliminated.

d. Excessive oscillation or surging of the cable can be damaging. Reduce the pulling speed or add additional temporary support hardware to minimize these conditions.

5.12. When the cable reaches the pull point, do not allow it to engage the winch unless the winch maintains the cable's minimum bend radius.

5.13. Pull the amount of cable specified in the route plan and pull plan. This amount should include all slack requirements as outlined in Step 4.8.

5.14. When the cable has been pulled into place as specified by the route plan:

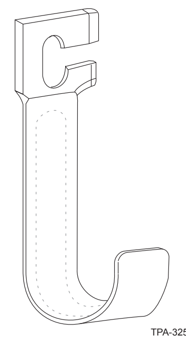
a. Install a dead-end on one end of the cable span at the cable reel end as outlined in Section 8.

b. Complete any pole modifications or additional temporary/permanent guying, as well as the installation of the dead-end and tangent clamp pole fixtures (see Section 8).

c. Proceed to Section 7 for instructions on tensioning and terminating the cable.

⚠	**CAUTION:** Proper measuring of tension is critical for a safe installation of aerial plant. Please read and understand all of Section 7 before attempting to apply tension to the cable.

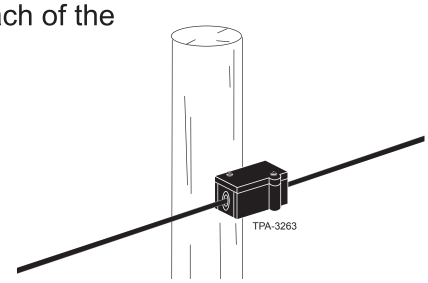
6. MOVING REEL INSTALLATION METHOD



6.1. In the moving reel or drive-off method, the cable is payed off of a moving vehicle as it drives along the pole line.

As the vehicle passes each pole, the cable is raised into place and into a J-hook or block fitting for temporary support. This procedure progresses down the pole line until a dead-end pole is reached.

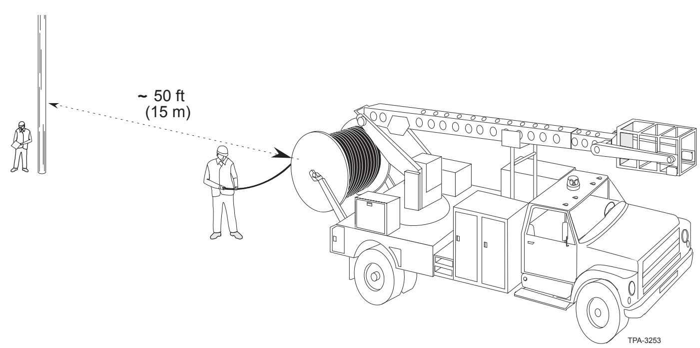
At this point the cable is tensioned and terminated into dead-end fittings.The cable between dead-ends is then lifted out of the temporary fittings at each of the intermediate poles and placed in permanent tangent assemblies.



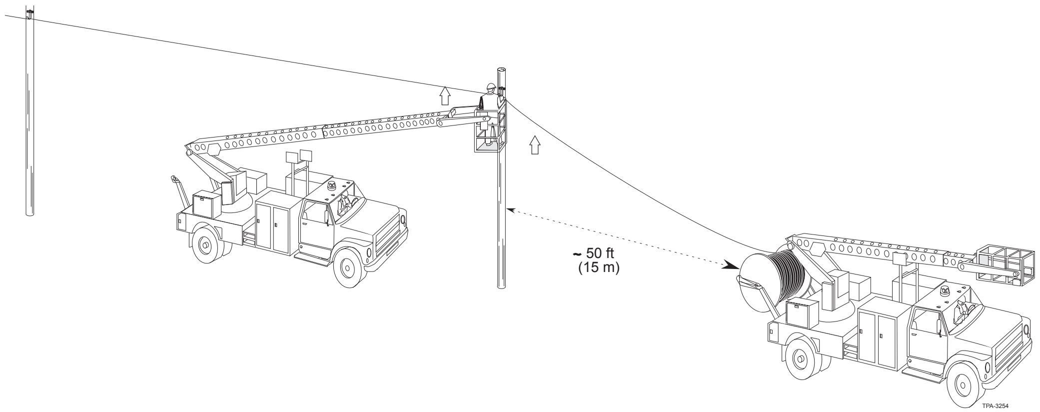
NOTE: Some tangent assemblies are designed to allow a cable to be placed in them during the moving reel method. After the cable is span tensioned, an insert is placed in the assembly to secure it.

6.2. In most cases, the drive-off method is the fastest and least expensive method of installing aerial cable. Pole-mounted hooks are the only temporary support devices required and fewer personnel are required than by other methods. It does require vehicular access to the placement side of the pole line and a right-of-way clear of tree limbs, guy wires, and other obstructions.

6.3. Begin the installation with the reel-carrying vehicle about 50 ft (15 m) from the pole and facing away from it down the pole line. The cable must pay off the top of the reel towards the rear of the vehicle.



6.4. Pull off the necessary amount of slack as specified in Step 4.8. Prepare the cable and install the dead-end as specified in Section 8.



6.5. Lift the dead-end to the top of the pole and mount on the pole fixture. It may also be necessary to pay out additional length as the cable is lifted.

6.6. Slowly drive the reel-carrying vehicle down the placement side of the pole line, paying out cable off the back of the truck. Once the reel is approximately 50 ft (15 m) past each pole, lift the cable up the pole and place it in a J-hook or block fitting.

6.7. Once the cable reel reaches the end of the span, lift the cable to its assigned position on the dead-end pole.

6.8. Complete any pole modifications or additional temporary/permanent guying.

6.9. Proceed to Section 7 for instructions on tensioning and terminating the cable. The sequence in which the cable sections are tensioned and dead-ended is unimportant as long as a central pole is not converged upon from both directions.

6.10. After the cable sections are properly tensioned and secured into dead-ends at both ends of the cable span:

a. Lift the cable out of the hooks/blocks at each intermediate pole.

b. Secure the cable in a tangent assembly on each pole as described in Section 7.

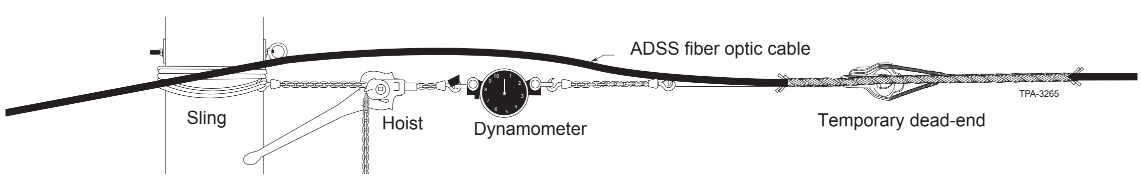
> ⚠ **CAUTION:** Proper measuring of tension is critical for a safe installation of aerial plant. Please read and understand all of Section 7 before attempting to apply tension to the cable.

7. CABLE TENSIONING

General

7.1. After the proper amount of cable has been placed in temporary support hardware between the dead-end poles, the cable must be properly tensioned before it is permanently secured into tangent assemblies.

7.2. With a dead-end fitting already in place on one end of the span, the cable is tensioned by pulling on its opposite “free” end with a chain hoist (come-along), using the set up shown below.



7.3. Once the cable sections are under the required tension, the “free” end of the cable is terminated into a dead-end described in Section 8.

Tensioning Operation

NOTE: Before beginning this stage of the installation, any pole modifications or additional temporary/ permanent guying must be completed.

7.4. Proceed to the end of the cable section which does not have a dead-end fitting already in place from the cable installation procedure. Pull out all cable slack between the dead-end poles.

7.5. Install a temporary dead-end (as described in Section 8) approximately 10 to 13 ft (3 to 4 m) away from the pole.

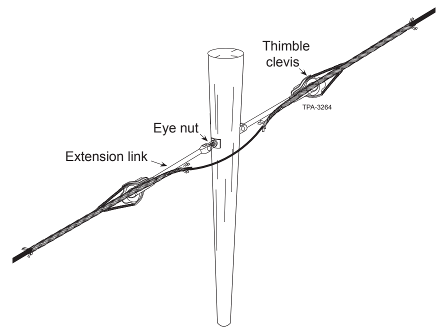
7.6. Set up the temporary dead-end, a chain hoist, an in-line dynamometer, and other hardware as shown. Typically, the chain hoist is strapped to the dead-end pole. Specific operation of the chain hoist should follow manufacturer's recommendations.

7.7. Apply tension to the cable with the chain hoist. During the tensioning operation, stay within the limits of maximum pulling tension for the cable and the strength of the poles themselves.

For long spans under high tension, it may be necessary to use two chain hoist temporary dead-end set-ups in succession to take out the slack and achieve the necessary tension.

WARNING: As the cable is placed under tension, weaknesses in the cable plant can cause failure of pole fittings, support hardware or even the poles themselves. The risk of death or injury due to such failures is best minimized by keeping all but essential personnel clear of the tensioning operation. Nobody should be allowed to climb intermediate poles as the span they support is being placed under tension. If possible, passersby on the ground should be kept away from the poles during this operation.

7.8. The tension can be initially monitored at the dead-end pole with the dynamometer shown. When tensioning several straight spans (with few offsets), it may be necessary to false dead-end the cable despite the pole offset being less than 20 degrees. This may be necessary to ensure that a 1% installation sag is maintained for all spans. Friction built up on some of the blocks or J-hooks on the far end of the tensioning operation may cause greater than 1% sag in those spans.



The number of spans between false dead-ends will vary, depending on the route and span lengths, but up to 20 straight pole spans are typical before false dead-ending is necessary.

CAUTION: Intermediate poles generally are not configured for lateral stress. If significant inter mediate tensioning is required, perform it in gradual steps, repeating the process until the required tension is reached.

7.9. Once the cable section is under the required tension, terminate the cable into a dead-end as described in Section 8. The dead-end should be placed on the cable where it reaches the pole fixture, unless allowances are being made for grade changes or turns.

Tensioning Across Turns And Grade Changes

7.10. Within the cable bend radius and limitations discussed in Section 3, the cable section may extend across turns and grade changes in the pole line. Since Solo® ADSS cable is normally placed in the permanent support hardware after tensioning, any change in pole line direction complicates the process. Two possible cases are discussed below.

a. Cable on inside of turn:

As the cable in this situation is tensioned, the cable will naturally tend to pull inside of the corner pole. A horizontally mounted stringing block will keep separation to a minimum.

⚠	**CAUTION:** Temporary support hardware used to restrain a cable being tensioned will be subjected to a significant portion of the cable's tensile loading and must be mounted accordingly.

Tension the cable in stages:

- Tension the cable to the degree planned from the dead-end pole.
- While monitoring the tension, move the cable from the temporary support hardware at the inside turn to the cable's permanent support hardware on the pole.
- As the cable is pulled out to the pole, tension will increase. Take care not to exceed the maximum pulling tension of the cable or the capacity of the poles and hardware. It may be necessary to relieve tension by backing off with the chain hoist at the dead-end pole. Continue this process until the cable is in place on the pole at the inside turn.

⚠	**CAUTION:** Do not allow personnel on the inside turn pole while tension is being increased at the dead-end pole. If personnel are sent up the inside turn pole, they must stay on the pole side opposite the cable.

b. Cable on the pole at a grade change:

The procedure used to tension the cable across a change of grade is similar to that used on an inside turn. The cable will pull up or down, depending on the direction of the grade change, rather than horizontally as is the case on an inside turn. Temporary support hardware must be mounted accordingly.

8. HARDWARE

8.1. Corning Cable Systems recommends the use of cable hardware designed for Solo ADSS cable applications manufactured by Dulmison or Preformed Line Products. Because of the different types of fiber optic dead-ends and tangent assemblies available, it is necessary to select the proper one for the cable design and route. In order to select the proper product the installer must know the following:

- nominal OD of the cable
- degree of offset from one pole to the next
- maximum cable tension under NESC loaded conditions

When ordering dead-ends, it is important to ensure that all other necessary pole hardware is ordered. These items include:

- thimble clevis
- eye nuts
- extension links (to maintain cable minimum bend radius)

Corning Cable Systems Field Engineering can assist customers with selection of the proper product (1-800-743-2671).

8.2. Determine the proper attachment location of the cable on the poles. Mark the location of the attachment point on the cable with a wrap of tape.

8.3. Drill the appropriate holes in wooden poles or apply band attachments to concrete or metal poles and mount supporting hardware accordingly.

8.4. Refer to the manufacturer's recommended procedures for installation.

8.5. For those applications where the cable may be subjected to wind-induced vibrations, special dampeners can be used to minimize these effects. Corning Cable Systems' Field Engineering can assist customers with selection of the proper hardware.

9. ROUTE RECONFIGURATION

9.1. If changes must be made to an existing cable aerial plant (i.e. due to highway widening, etc.) "repair slack" can be used to reconfigure a cable route without introducing additional fiber splice points. Shift the slack as needed while rerouting the cable.

10. SPECIAL APPLICATIONS OF ADSS CABLE

Duct Installation

10.1. Although Solo® ADSS cable is intended for aerial placement, it can easily be pulled into ducts where required. The procedures to be used follow closely those outlined in SRP 005-011, Duct Installation of Fiber Optic Cable, with the following stipulations:

a. Standard ADSS cable has a rated pulling strength of 600 lb_F (2700 N). This figure must not be exceeded (see Step 3.1). Use a wire mesh pulling grip on the separated cable component as described in SRP 004-137, Installing Wire Mesh Pulling Grips.

b. To calculate a fill ratio, use the following formulas from the chart. For a quick calculator, see www.corning.com/cablesystems/fillratio.

Formulas Used to Calculate Fill Ratio

First Cable	Second Cable	Third Cable
$\frac{d^2}{D^2} < 65\%$	$\frac{d_1^2 + d_2^2}{D^2} \leq 31\%$	$\frac{d_1^2 + d_2^2 + d_3^2}{D^2} \leq 40\%$

Legend
- d = Cable Diameter
- d_1 = First Cable Diameter
- d_2 = Second Cable Diameter
- d_3 = Third Cable Diameter
- D = Innerduct Diameter

TPA-3257

Direct Burial

10.2. Where required, cable can be buried as discussed in SRP 005-012, Direct Buried Installation of Fiber Optic Cable.

Corning Cable Systems LLC • PO Box 489 • Hickory, NC 28603-0489 USA
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ALTOS® All-Dielectric Gel-Free Cables, 6-432 Fibers

CORNING

Features and Benefits

Fully waterblocked loose tube, gel-free design
Simple access and no clean up

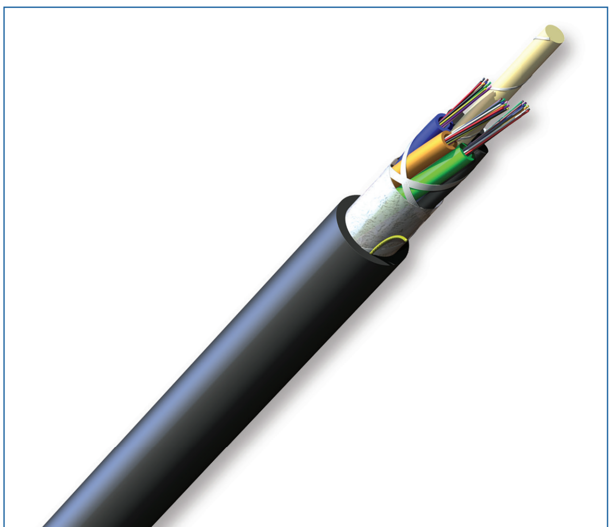
Polyethylene jacket
Rugged, durable and easy to strip (while providing superior protection against UV radiation, fungus, abrasion and other environmental factors)

All-dielectric cable construction
Requires no grounding or bonding

Available in 62.5 µm, 50 µm, single-mode (including bend-insensitive and non-zero dispersion-shifted (NZ-DSF) fiber options) and hybrid versions
Ready for any application including Gigabit Ethernet and 10 Gigabit Ethernet

Standards

Common Installations	Outdoor lashed aerial and duct; indoor when installed according to National Electrical Code® (NEC®) Article 770
Design and Test Criteria	ANSI/ICEA S-87-640, Telcordia GR-20, RDUP PE-90



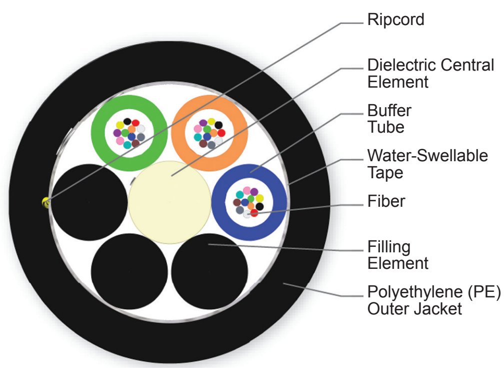
ALTOS All-Dielectric, Gel-Free Cables, 36 Fibers | Photo PIM2426

Corning ALTOS® all-dielectric gel-free cables are designed for outdoor and limited indoor use for backbones in lashed aerial and duct installations. The loose tube gel-free design is fully waterblocked using craft-friendly, water-swellable materials, which means cable access is simple and no clean up is required. The flexible craft-friendly buffer tubes are easy to route in closures, and the SZ-stranded, loose tube design isolates fibers from installation and environmental rigors while allowing easy mid-span access. The all-dielectric cable construction requires no bonding or grounding, and these cables have a polyethylene jacket that is rugged, durable and easy to strip.

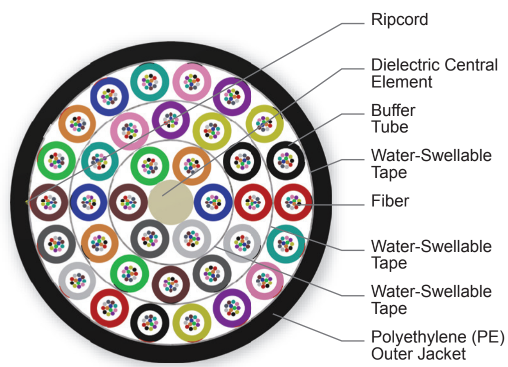
EXHIBIT 4

ALTOS® All-Dielectric Gel-Free Cables, 6-432 Fibers

CORNING



ALTOS All-Dielectric, Gel-Free Cables, 36 Fibers | Photo PIM2326



ALTOS All-Dielectric, Gel-Free Cables, 432 Fibers

Specifications

Temperature Range	
Storage	-40 °C to 70 °C (-40 °F to 158 °F)
Installation	-30 °C to 70 °C (-22 °F to 158 °F)
Operation	-40 °C to 70 °C (-40 °F to 158 °F)

** Note: Corning recommends storing cable in a proper temperature environment prior to installation to allow the cable temperature to meet installation temperature range specifications for best installation results.*

Mechanical Characteristics Cable	
Max. Tensile Strength, Short-Term	2700 N (600 lbf)
Max. Tensile Strength, Long-Term	890 N (200 lbf)

Fiber Count	Number of Tube Positions	Number of Active Tubes	Weight	Nominal Outer Diameter	Min. Bend Radius Installation	Min. Bend Radius Operation
6 - 72	6	1 - 6	73 kg/km (49 lb/1000 ft)	10.5 mm (0.41 in)	158 mm (6.2 in)	105 mm (4.1 in)
84 - 96	8	7 - 8	98 kg/km (66 lb/1000 ft)	12.2 mm (0.48 in)	183 mm (7.2 in)	122 mm (4.8 in)
108 - 144	12	9 - 12	162 kg/km (109 lb/1000 ft)	15.8 mm (0.62 in)	237 mm (9.3 in)	158 mm (6.2 in)
156 - 216	18	13 - 18	147 kg/km (99 lb/1000 ft)	16 mm (0.63 in)	240 mm (9.4 in)	160 mm (6.3 in)

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EXHIBIT 4

ALTOS® All-Dielectric Gel-Free Cables, 6-432 Fibers

CORNING

Fiber Count	Number of Tube Positions	Number of Active Tubes	Weight	Nominal Outer Diameter	Min. Bend Radius Instal-lation	Min. Bend Radius Ope-ration
228 - 288	24	19 - 24	196 kg/km (131 lb/1000 ft)	18.2 mm (0.72 in)	273 mm (10.7 in)	182 mm (7.2 in)
360 - 432	36	30 - 36	241 kg/km (162 lb/1000 ft)	21.2 mm (0.83 in)	318 mm (12.5 in)	212 mm (8.3 in)

Chemical Characteristics	
RoHS	Free of hazardous substances according to RoHS 2011/65/EU

Transmission Performance

Multimode				
Fiber Core Diameter (µm)	62.5	50	50	50
Fiber Category	OM1	OM2	OM3	OM4
Fiber Code	K	T	T	T
Performance Option Code	30	31	80	90
Wavelengths (nm)	850/1300	850/1300	850/1300	850/1300
Maximum Attenuation (dB/km)	3.4/1.0	3.0/1.0	3.0/1.0	3.0/1.0
Serial 1 Gigabit Ethernet (m)	300/550	750/500	1000/600	1100/600
Serial 10 Gigabit Ethernet (m)	33/-	150/-	300/-	550/-
Min. Overfilled Launch (OFL) Bandwidth (MHz*km)	200/500	700/500	1500/500	3500/500
Minimum Effective Modal Bandwidth (EMB) (MHz*km)	220/-	950/-	2000/-	4700/-

EXHIBIT 4

ALTOS® All-Dielectric Gel-Free Cables, 6-432 Fibers

CORNING

Single-mode					
Fiber Name	SMF-28e+® LL	SMF-28® Ultra fiber**	Single-mode (OS2)	Single-mode (OS2)	LEAF® fiber
Fiber Category	G.652.D	G.652.D/G.657.A1	G.652.D	G.652.D	G.655
Fiber Code	L	Z	E	E	F
Performance Option Code	22	22	00	01	01
Wavelengths (nm)	1310/1383/1550	1310/1383/1550	1310/1383/1550	1310/1383/1550	1310/1383/1550
Maximum Attenuation (dB/km)	0.34/0.34/0.22	0.34/0.34/0.22	0.35/0.35/0.25	0.4/0.4/0.3	-/-/0.25
Typical Attenuation* (dB/km)	0.32/0.32/0.18	0.32/0.32/0.18	-	-	-/-/0.19
Fiber Name	SMF-28® ULL				
Fiber Category	G.652				
Fiber Code	P				
Performance Option Code	19				
Wavelengths (nm)	1310/1383/1550				
Maximum Attenuation (dB/km)	0.33/-/0.19				
Typical Attenuation* (dB/km)	0.31/-/0.17				

** For more information on typical attenuation please see the Corning whitepaper at http://csmedia.corning.com/opcomm//Resource_Documents/whitepapers_rl/LAN-1863-AEN.pdf*

** * SMF-28® Ultra fiber delivers up to 10x better macrobend loss performance compared to the G.652.D standard and up to 33 percent better macrobend loss performance than the G.657.A1 standard for 10mm radii bends.*

ALTOS® All-Dielectric Gel-Free Cables, 6-432 Fibers

CORNING

Ordering Information | *Note: Contact Customer Care at 1-800-743-2675 for other options.*

□ □ □	□	U	4	-	□	□	1	□ □	D	2 0
1	2	3	4		5	6	7	8	9	10

1 Select fiber count.
006-288
360-432 (SMF-28® Ultra fiber only)

2 Select fiber code.
K = 62.5 µm multimode (OM1)
T = 50 µm multimode (OM2/OM3/OM4)
E = Single-mode (G.652.D)
L = Single-mode (G.652.D) SMF-28e+® LL
Z = Single-mode (G.652.D/ G.657.A1) SMF-28® Ultra fiber
P = Single-mode (G.652) SMF-28® ULL
F = Single-mode (G.655) LEAF®

3 Defines cable type.
U = ALTOS® Loose Tube Cable with 2.5 mm buffer tubes

4 Defines outer jacket.
4 = All-dielectric

5 Select fiber placement.
T = 12 fibers/buffer tube (standard)
6 = 6 fibers/buffer tube
See Note 1.

6 Select length markings.
3 = Markings in meters
4 = Markings in feet (standard)

7 Defines tensile strength.
1 = 2700 N/600 lbf (standard)

8 Select performance option code.
30 = 62.5 µm multimode (OM1)
31 = 50 µm multimode (OM2)
80 = 50 µm multimode (OM3)
90 = 50 µm multimode (OM4)
01 = Single-mode (OS2)
(Max. attenuation 0.4/0.4/0.3 dB/km)
00 = Single-mode (OS2)
(Max. attenuation 0.35/0.35/0.25 dB/km)
22 = Single-mode (OS2)
(Max. attenuation 0.34/0.34/0.22 dB/km)
19 = Single-mode (Ultra Low-Loss)
(Max. attenuation 0.33/–/0.19 dB/km)
01 = Single-mode NZDSF*
(Max. attenuation –/–/0.25 dB/km)
**Non-Zero Disperson-Shifted Single-mode Fiber*

9 Defines cable type.
D = Gel-free cable

10 Defines special requirements.
20 = No special requirements

1) Cable outer diameter may change. Example: 48 F cable with 6 fibers per tube will require 8 active buffer and have an OD like a standard 96 F cable.

RoHS COMPLIANT

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CORNING

EXHIBIT 4

SOLO® ADSS Short-Span Cables, 12-144 Fibers

CORNING

Features and Benefits

Loose tube design
Stable performance and compatibility with all common fiber types

Self-supporting
Easy, one-step installation

Track-resistant jacket available
Suitable for installations up to 25 kV electric field potential

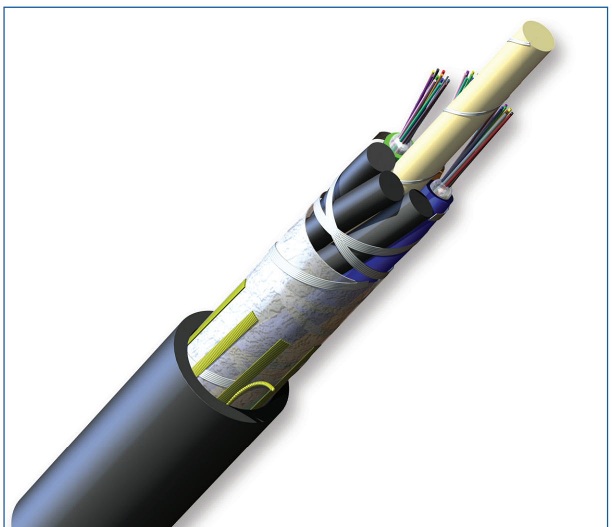
Innovative waterblocking cable core
Provides efficient and craft-friendly cable preparation

Standards

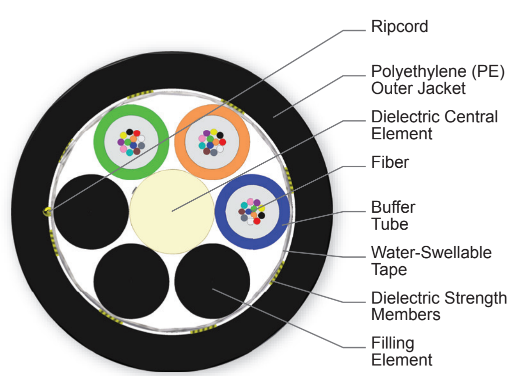
Approvals and Listings	RDUP 7 CFR 1755.900 (formerly RUS)
Common Installations	Outdoor self-supporting aerial
Design and Test Criteria	ANSI/ICEA S-87-640
Preformed Line Products® (PLP®) Dead-End Product	FIBERLIGN® dead-end for ADSS limited-tension dead-end

Corning SOLO® ADSS short-span cables are all-dielectric, self-supporting (ADSS) cables designed for easy and economical one-step installation in campus backbones with self-supporting installations where metallic messengers cannot be used. The loose tube design provides stable performance over a wide temperature range and is compatible with any telecommunications-grade optical fiber. The economical single-jacket design can span distances up to 600 ft in NESC light conditions, 500 ft in NESC medium conditions and 300 ft in NESC heavy conditions (see sag and tension chart for details).

This cable incorporates innovative waterblocking materials, eliminating the need for traditional flooding compound and providing efficient and craft-friendly cable preparation. While the concentric, self-supporting cable design allows easy, one-step installation using standard hardware and installation methods, the SZ-stranded, loose tube design isolates optical fibers from installation and environmental rigors and facilitates mid-span access. The ADSS optical cables are also available with a proprietary track-resistant polyethylene (TRPE) jacket suitable for installation in electric field potentials up to 25 kV.



SOLO ADSS Short-Span Cables, 36 Fibers | Photo PIM0637

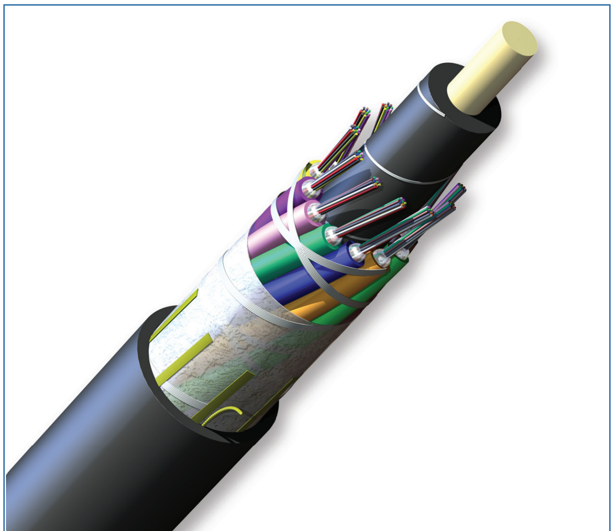


SOLO ADSS Short-Span Cables, 36 Fibers | Photo PIM1536

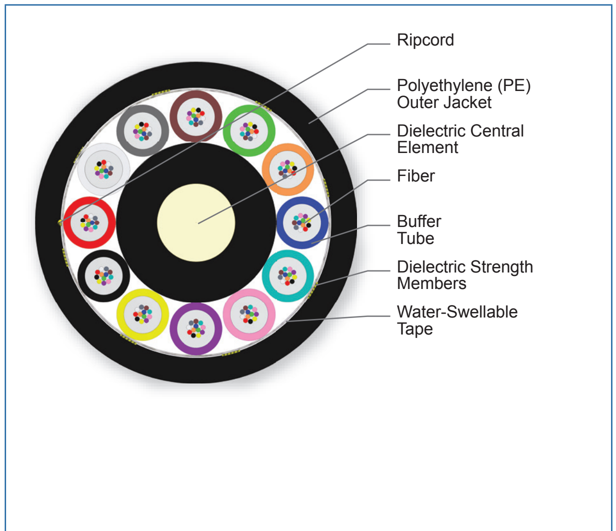
EXHIBIT 4

SOLO® ADSS Short-Span Cables, 12-144 Fibers

CORNING



SOLO ADSS Short-Span Cables, 144 Fibers | Photo PIM0642



SOLO ADSS Short-Span Cables, 144 Fibers | Photo PIM1541

Specifications

Temperature Range	
Storage	-40 °C to 70 °C (-40 °F to 158 °F)
Installation	-30 °C to 70 °C (-22 °F to 158 °F)
Operation	-40 °C to 70 °C (-40 °F to 158 °F)

** Note: Corning recommends storing cable in a proper temperature environment prior to installation to allow the cable temperature to meet installation temperature range specifications for best installation results.*

Fiber Count	Number of Tube Positions	Number of Active Tubes	Weight	Nominal Outer Diameter	Min. Bend Radius Installation	Min. Bend Radius Operation
12 - 72	6	1 - 6	92 kg/km (62 lb/1000 ft)	10.9 mm (0.43 in)	164 mm (6.5 in)	109 mm (4.3 in)
96	8	8	122 kg/km (82 lb/1000 ft)	12.6 mm (0.50 in)	189 mm (7.5 in)	126 mm (5.0 in)
144	12	12	196 kg/km (132 lb/1000 ft)	16.1 mm (0.63 in)	242 mm (9.5 in)	161 mm (6.3 in)

** Longer spans available on request.*

Chemical Characteristics	
RoHS	Free of hazardous substances according to RoHS 2011/65/EU

SOLO® ADSS Short-Span Cables, 12-144 Fibers

CORNING

Installation Conditions

	Initial Installation		NESC Light		NESC Medium		NESC Heavy	
Span	SAG	Tension	SAG	Tension	SAG	Tension	SAG	Tension
12-72 Fibers								
15 m (50 ft)	1.0 %	174 N (39 lbf)	0.4 %	488 N (110 lbf)	1.7 %	694 N (156 lbf)	2.4 %	1028 N (231 lbf)
30 m (100 ft)	1.0 %	348 N (78 lbf)	0.5 %	852 N (191 lbf)	2.0 %	1179 N (265 lbf)	2.9 %	1711 N (385 lbf)
46 m (150 ft)	1.0 %	522 N (117 lbf)	0.5 %	1173 N (264 lbf)	2.2 %	1602 N (360 lbf)	3.2 %	2300 N (517 lbf)
61 m (200 ft)	1.0 %	696 N (156 lbf)	0.5 %	1472 N (331 lbf)	2.3 %	1989 N (447 lbf)	3.5 %	2836 N (637 lbf)
76 m (250 ft)	1.0 %	870 N (195 lbf)	0.6 %	1754 N (394 lbf)	2.5 %	2353 N (529 lbf)	3.7 %	3336 N (750 lbf)
91 m (300 ft)	1.0 %	1043 N (235 lbf)	0.6 %	2025 N (455 lbf)	2.6 %	2699 N (607 lbf)	3.9 %	3810 N (857 lbf)
107 m (350 ft)	1.0 %	1217 N (274 lbf)	0.6 %	2287 N (514 lbf)	2.7 %	3032 N (682 lbf)		
122 m (400 ft)	1.0 %	1391 N (313 lbf)	0.6 %	2542 N (571 lbf)	2.8 %	3354 N (754 lbf)		
137 m (450 ft)	1.0 %	1565 N (352 lbf)	0.7 %	2790 N (627 lbf)	2.9 %	3667 N (824 lbf)		
152 m (500 ft)	1.0 %	1739 N (391 lbf)	0.7 %	3034 N (682 lbf)	2.9 %	3972 N (893 lbf)		
168 m (550 ft)	1.0 %	1913 N (430 lbf)	0.7 %	3274 N (736 lbf)				
183 m (600 ft)	1.0 %	2087 N (469 lbf)	0.7 %	3509 N (789 lbf)				
200 m (656 ft)	1.0 %	2282 N (513 lbf)	0.7 %	3769 N (847 lbf)				
73-96 Fibers								
15 m (50 ft)	1.0 %	230 N (52 lbf)	0.5 %	577 N (130 lbf)	1.6 %	780 N (175 lbf)	2.3 %	230 N (52 lbf)
30 m (100 ft)	1.0 %	460 N (103 lbf)	0.5 %	1007 N (226 lbf)	1.9 %	1328 N (299 lbf)	2.8 %	460 N (103 lbf)
46 m (150 ft)	1.0 %	690 N (155 lbf)	0.6 %	1391 N (313 lbf)	2.1 %	1809 N (407 lbf)	3.1 %	690 N (155 lbf)
61 m (150 ft)	1.0 %	920 N (207 lbf)	0.6 %	1748 N (393 lbf)	2.3 %	2251 N (506 lbf)	3.3 %	920 N (207 lbf)
76 m (250 ft)	1.0 %	1150 N (259 lbf)	0.6 %	2088 N (469 lbf)	2.4 %	2668 N (600 lbf)	3.6 %	1150 N (259 lbf)
91 m (300 ft)	1.0 %	1380 N (310 lbf)	0.7 %	2415 N (543 lbf)	2.5 %	3067 N (689 lbf)	3.7 %	1380 N (310 lbf)

SOLO® ADSS Short-Span Cables, 12-144 Fibers

CORNING

Installation Conditions

	Initial Installation		NESC Light		NESC Medium		NESC Heavy	
Span	SAG	Tension	SAG	Tension	SAG	Tension	SAG	Tension
107 m (350 ft)	1.0 %	1610 N (362 lbf)	0.7 %	2732 N (614 lbf)	2.6 %	3451 N (776 lbf)		
122 m (400 ft)	1.0 %	1840 N (414 lbf)	0.7 %	3041 N (684 lbf)	2.7 %	3823 N (859 lbf)		
137 m (450 ft)	1.0 %	2070 N (465 lbf)	0.7 %	3344 N (752 lbf)	2.8 %	4186 N (941 lbf)		
152 m (500 ft)	1.0 %	2300 N (517 lbf)	0.7 %	3642 N (819 lbf)	2.9 %	4541 N (1021 lbf)		
168 m (550 ft)	1.0 %	2530 N (569 lbf)	0.7 %	3935 N (885 lbf)				
183 m (600 ft)	1.0 %	2760 N (620 lbf)	0.7 %	4224 N (950 lbf)				
97-144 Fibers								
15 m (50 ft)	1.0 %	368 N (83 lbf)	0.6 %	723 N (163 lbf)	1.7 %	904 N (203 lbf)	2.4 %	1274 N (286 lbf)
30 m (100 ft)	1.0 %	737 N (166 lbf)	0.6 %	1277 N (287 lbf)	2.0 %	1559 N (351 lbf)	2.8 %	2141 N (481 lbf)
46 m (150 ft)	1.0 %	1105 N (248 lbf)	0.7 %	1779 N (400 lbf)	2.2 %	2143 N (482 lbf)	3.1 %	2901 N (652 lbf)
61 m (200 ft)	1.0 %	1473 N (331 lbf)	0.7 %	2254 N (507 lbf)	2.3 %	2688 N (604 lbf)	3.4 %	3601 N (809 lbf)
76 m (250 ft)	1.0 %	1842 N (414 lbf)	0.8 %	2711 N (610 lbf)	2.5 %	3208 N (721 lbf)	3.6 %	4261 N (958 lbf)
91 m (300 ft)	1.0 %	2210 N (497 lbf)	0.8 %	3156 N (710 lbf)	2.6 %	3709 N (834 lbf)	3.7 %	4893 N (1100 lbf)
107 m (350 ft)	1.0 %	2579 N (580 lbf)	0.8 %	3591 N (807 lbf)	2.6 %	4196 N (943 lbf)		
122 m (400 ft)	1.0 %	2947 N (663 lbf)	0.8 %	4019 N (903 lbf)	2.7 %	4672 N (1050 lbf)		
137 m (450 ft)	1.0 %	3315 N (745 lbf)	0.8 %	4441 N (998 lbf)				
152 m (500 ft)	1.0 %	3684 N (828 lbf)	0.8 %	4857 N (1092 lbf)				

CORNING

SOLO® ADSS Short-Span Cables, 12-144 Fibers

CORNING

Transmission Performance

Multimode				
Fiber Core Diameter (µm)	62.5	50	50	50
Fiber Category	OM1	OM2	OM3	OM4
Fiber Code	K	T	T	T
Performance Option Code	30	31	80	90
Wavelengths (nm)	850/1300	850/1300	850/1300	850/1300
Maximum Attenuation (dB/km)	3.4/1.0	3.0/1.0	3.0/1.0	3.0/1.0
Serial 1 Gigabit Ethernet (m)	300/550	750/500	1000/600	1100/600
Serial 10 Gigabit Ethernet (m)	33/-	150/-	300/-	550/-
Min. Overfilled Launch (OFL) Bandwidth (MHz*km)	200/500	700/500	1500/500	3500/500
Minimum Effective Modal Bandwidth (EMB) (MHz*km)	220/-	950/-	2000/-	4700/-

Single-mode					
Fiber Name	SMF-28e+® LL	SMF-28® Ultra fiber**	Single-mode (OS2)	Single-mode (OS2)	LEAF® fiber
Fiber Category	G.652.D	G.652.D/G.657.A1	G.652.D	G.652.D	G.655
Fiber Code	L	Z	E	E	F
Performance Option Code	22	22	00	01	01
Wavelengths (nm)	1310/1383/1550	1310/1383/1550	1310/1383/1550	1310/1383/1550	1310/1383/1550
Maximum Attenuation (dB/km)	0.34/0.34/0.22	0.34/0.34/0.22	0.35/0.35/0.25	0.4/0.4/0.3	-/-/0.25
Typical Attenuation* (dB/km)	0.32/0.32/0.18	0.32/0.32/0.18	-	-	-/-/0.19
Fiber Name	SMF-28® ULL				
Fiber Category	G.652				
Fiber Code	P				
Performance Option Code	19				
Wavelengths (nm)	1310/1383/1550				
Maximum Attenuation (dB/km)	0.33/-/0.19				
Typical Attenuation* (dB/km)	0.31/-/0.17				

** For more information on typical attenuation please see the Corning whitepaper at http://csmedia.corning.com/opcomm//Resource_Documents/whitepapers_rl/LAN-1863-AEN.pdf*

** * SMF-28® Ultra fiber delivers up to 10x better macrobend loss performance compared to the G.652.D standard and up to 33 percent better macrobend loss performance than the G.657.A1 standard for 10mm radii bends.*

EXHIBIT 4

SOLO® ADSS Short-Span Cables, 12-144 Fibers

CORNING

Ordering Information | *Note: Contact Customer Care at 1-800-743-2675 for other options.*

☐ ☐ ☐	☐	N	☐	-	T	☐	S	☐ ☐	A	2 0
1	2	3	4		5	6	7	8	9	10

1 Select fiber count.
Standard offerings: 012-144

2 Select fiber code.
K = 62.5 µm multimode (OM1)
T = 50 µm multimode (OM2/OM3/OM4)
E = Single-mode (G.652.D)
L = Single-mode (G.652.D) SMF-28e+® LL
Z = Single-mode (G.652.D/ G.657.A1) SMF-28® Ultra fiber
P = Single-mode (G.652) SMF-28® ULL
F = Single-mode (G.655) LEAF®

3 Defines cable type.
N = SOLO® single-jacket cable
See Note 1.

4 Select outer jacket.
4 = PE jacket (standard)
A = TRPE jacket

5 Defines fiber placement.
T = 12 fibers/buffer tube (standard)

6 Select length markings.
3 = Markings in meters
4 = Markings in ft (standard)

7 Defines tensile strength.
S = SOLO short-span cable

8 Select performance option code.
30 = 62.5 µm multimode (OM1)
31 = 50 µm multimode (OM2)
80 = 50 µm multimode (OM3)
90 = 50 µm multimode (OM4)
01 = Single-mode (OS2)
(Max. attenuation 0.4/0.4/0.3 dB/km)
00 = Single-mode (OS2)
(Max. attenuation 0.35/0.35/0.25 dB/km)
22 = Single-mode (OS2)
(Max. attenuation 0.34/0.34/0.22 dB/km)
19 = Single-mode (Ultra Low-Loss)
(Max. attenuation 0.33/–/0.19 dB/km)
01 = Single-mode NZDSF*
(Max. attenuation –/–/0.25 dB/km)
**Non-Zero Disperson-Shifted Single-mode Fiber*

9 Defines cable type.
A = Gel-filled cable

10 Defines special manufacturing code.
20 = No special requirements

RoHS COMPLIANT

Corning Optical Communications LLC • PO Box 489 • Hickory, NC 28603-0489 USA
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