Installation Instructions
AFL Optical Ground Wire (OPGW)

(Stainless Steel Tube Cable Designs)
(Aluminum Pipe Cable Designs)
(Slotted Core Cable Designs)

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1.0 GENERAL INFORMATION

Composite Optical Groundwire (OPGW) was developed to provide a large capacity telecommunications system utilizing overhead power transmission lines. Serving the additional purpose of an overhead ground wire, the OPGW is constructed of aluminum clad steel strands and aluminum alloy strands stranded with stainless steel tubes or surrounding a fiber unit (core) which contains optical fibers. OPGW can be installed using the basic stringing methods currently employed for overhead ground wires, with minor variations.

This document outlines basic installation methods applicable for existing and newly constructed transmission lines. The installer should be thoroughly familiar with the installation of conventional overhead ground wire and conductors. Additional information can be obtained from the latest revision of IEEE Guide to Installation of Overhead Transmission Line Conductors, IEEE Std 524.

2.0 PRECAUTIONS

Care must be taken to avoid damaging the OPGW during handling and stringing operations. Avoid sharp bends to the cable and take precautions to prevent crushing the OPGW during placement. The transmission quality of the optical fibers can potentially be degraded if the OPGW is subjected to excessive pulling tensions or excessively small bend diameters.

Always observe the recommended values for Maximum Stringing Tensions and Minimum Bend Radius. More information about these values is contained on the following pages.

OPGW is normally supplied on non-returnable wooden reels. The cable is packaged with a flex wrap or wooden lagging to provide additional protection during transportation. If the cable is not to be installed for a period of over four months from the delivery date, it is recommended that the cable be requested and shipped on steel reels rather than wood reels. Please contact AFL for more details or to request shipment on steel reels.

OPGW cable reels should always be transported and handled in an upright position. Never lay a reel of cable on its side. It is recommended that each reel of OPGW be tested prior to and after installation to ensure that fiber damage has not occurred during shipping.
and/or stringing operations. All cable protective packaging (wood lagging or flex wrap) must remain in place on all reels until placed on a pay-out rack and the rack is in position for cable stringing.

Above all, be familiar with and observe all of your company’s safety rules when working with overhead transmission lines. These installation recommendations should not supersede any established safety practices.

3.0 CABLE INSTALLATION

Reel Preparation Prior to Beginning a Pull

AFL ships the cable reels with the inner tail securely connected to the outside of the reel flange. This connection should be loosened, but not removed, prior to stringing. This allows the inner layers of cable to adjust themselves to the varying tensions seen during installation. As the cable makes these adjustments, the inner tail may lengthen, or “grow,” requiring periodic attention to ensure that the cable continues to be in a state where it can “grow” out.

The wooden reel will have through bolts connecting the two flanges. During shipment, these bolts can loosen. Prior to stringing, the bolts should be tightened to help prevent any issues while paying off the cable.

AFL recommends using the controlled tension stringing method of installation. Ordinary stringing equipment can be utilized as if installing standard overhead ground wire provided all of the minimum block sizes and other requirements of these instructions are followed. Suitable equipment includes pullers, tensioners, reel winders, and stringing blocks.

Figure 1 illustrates a typical stringing setup.

![FIGURE 1 - Typical Stringing Setup](image)

There is one primary difference between installing OPGW and conventional overhead ground wires. Standard ground wires are typically spliced using compression type connectors and locations of the splices are relatively flexible. The splice locations of the OPT-GW cable must be planned to allow for splicing of the optical fibers. The reel lengths will be engineered to locate the cable splices at predetermined towers on each end of a stringing section.

After installing deadends, the free ends of the OPGW are trained down the towers to the
ground for splicing. The length of the free cable should be at least the tower height, plus an additional 75 feet (23 meters) to accommodate the splicing. After stringing, this cable length is typically coiled and temporarily stored at the tower until the splicing occurs.

The OPGW will also use special attachment hardware, including deadends, suspension clamps, and wire fittings such as grounding clamps. The hardware is designed to provide the necessary holding strengths and prevent deformation of the fiber unit which could potentially damage the optical fibers.

**Temperature Ranges:**
Storage: -50°C to +85°C; Installation: -40°C to +85°C; Operation: -40°C to +85°C.

### 4.0 STRINGING PROCEDURES

Stranded wire pulling lines are generally used, although nylon ropes have also been employed. In either case, the line must be rated strong enough to withstand the required stringing tensions. The pulling line should have the same direction lay as the OPGW to help resist the tendency to rotate under stringing load.

If an existing overhead ground wire is to be removed, it can potentially be used as a pulling line for the OPGW. A visual inspection should be made of the existing ground wire to be sure it is in suitable condition. If there is any concern about the existing wire’s ability to withstand the stringing tensions, it should be pulled out and replaced with a pulling line.

It is recommended to use a bull-wheel type tensioner with round (not “V” type) polyurethane lined contact grooves. The tensioner should have two bull-wheels, each with multiple grooves to minimize cable damage. The tensioner should be capable of maintaining the required tensions at various pulling speeds. Positive braking systems are necessary for pullers and tensioners to maintain the tension when pulling is stopped. Minimum diameter of the bull wheels should not be less that 70 x D (diameter of the OPGW). For cable diameters greater than 0.787” (20 mm) please contact AFL.

The OPGW must be reeved (threaded) through the bull-wheel tensioner properly. Left hand lay OPGW (typical USA) is reeved from right to left, as shown in Figure 2, below. Right hand lay OPGW (typical International), is reeved from left to right. A thorough explanation of the reeving process can be found in the latest revision of IEEE Std 524. This arrangement is necessary to avoid any tendency to loosen the outer layer of strands and to avoid induced torque during installation.
The reel shall be placed directly in line with the tensioner. The distance from the reel to the tensioner should be at least 25 feet (7.5 meters). The OPGW shall not be permitted to scrape the reel flanges while being pulled.

The OPGW cable reels are not designed to withstand the braking forces present during stringing. Direct tensioning of the OPGW from the cable reel is not recommended. Back tension on the reel should only be enough to keep the cable properly seated in the tensioner grooves and to prevent overshooting and bird-caging.

Two basic types of pulling machines are recommended for tension stringing. These are either drum type or bull wheel type pullers. Positive braking systems are required in either case. On a drum type puller, the pulling line is taken up directly onto the drum. On the bull wheel type, the line is threaded onto two bull wheels, much like the tensioner, and onto a self winding drum.

Stringing blocks, sometimes called travelers or sheaves, are mounted on the structure at the OPGW attaching point in the normal manner. Please refer to Reference A, **OPGW Diameters and Bending Radius**, for information on blocks diameters.

The stringing blocks should have neoprene lined grooves. The linings should be in good condition and adhering to the block. Minor rough areas can be sanded out to ensure the lining is smooth.

“Radius Blocks”, “Banana Blocks” or “Array Travelers” as shown below in Figures 3A-C are strictly prohibited during the installation of OPGW. The decreased surface area in contact with the OPGW is sufficient to damage the OPGW at typical stringing tensions.
Uplift rollers (which attach to the installation sheave wheel) or hold-down blocks (which are separate blocks) need to be placed where uplift of the pulling line is likely to occur (due to its higher tension/weight ratio than the conductor). This will typically occur going up inclines or at a low point in a section. These devices should also have a break away feature in the event of fouling or incorrect installation. The size of the uplift rollers should follow the same guidelines as the installation sheaves shown in Reference A.

The tensioner and puller should be positioned for a 3:1 ratio to the stringing block on the first structure adjacent to the equipment. See Figure 1. The tensioner should be placed in line with the first two structures (or first span) of the pull. Likewise, the puller should be placed in line with the last two structures (or last span) of the pull. Doing so minimizes the line angle change seen by the cable during the installation process.

This minimum stringing block diameter and distance to the tensioner (3:1) are recommended to help prevent deformation of the fiber unit (aluminum pipe, stainless steel tube or slotted core), which protect the optical fibers in the OPGW.

The use of an Anti-Rotational Device (see sample drawing on Page 16) depends largely upon the construction of the optical ground wire. Such a device is used to prevent the OPGW from twisting while being pulled. Variations of these devices have been successfully used. Please consult the AFL for any inquiries regarding a particular form of anti-rotation device.

For cables with helically stranded stainless steel tubes, an anti-rotational device may or may not be required. To confirm whether one is needed for your particular application, contact AFL. When in doubt, the conservative approach is to conduct the installation with the use of an anti-rotational device. For cables constructed with an un-stranded stainless steel tube in the center of the cable or single layer cables, an anti-rotational device is always a requirement.

If the anti-rotational device is not preventing the cable rotation or if the anti-rotational device is wrapping around the OPGW, a stiffer or heavier device is required. The weight and length of the ARD will depend upon the construction of the optical ground wire.

The anti-rotational device attaches to the OPGW with a Kellum type grip. The grip must be appropriately sized for the OPGW diameter and pulling tensions.

Normally, the OPGW should be kept under constant stringing tension during the stringing process to keep the line clear of both the ground and other obstacles that could cause
damage to the cable.

Do not cut the OPGW with ratchet cutters or other types of tools that could crush or crimp the optical core. The use of a hacksaw will ensure the fiber optic units are free to move within the pipe. During stringing, the optical fiber core (design dependent) may pull back into the cable, requiring a few feet to be cut away upon splicing on the leading end to expose the optical core.

It is important to monitor the tensions and ensure that excessive tension is not applied as the OPGW passes from the reel to the tensioner.

The following values are recommended to help prevent damage to the OPGW.

1. Minimum Bull Wheel Diameter ...................... 70 x D  (D=OPGW diameter)
   For larger diameter OPGW cables where 70 x OD exceeds 60" (~1.5m), a 60" (~1.5m) bull wheel may be used. Please consult AFL in such cases.

2. Recommended Block Diameter for first and last structure .......... 40 x D
   Smaller diameters can be used at tangent structures. See Reference A.

3. Minimum Cable Bend Radius
   During Installation (Dynamic): 20 x D; After Installation (Static): 15 x D

4. Maximum Stringing Tension ……20% OPGW’s Rated Breaking Strength
   The stringing tension is always measured at the tensioner side. In general the maximum stringing tension should be a half of the maximum sagging tension and never should exceed 20% RBS of the OPGW.

5. Pulling Speed:
   60 meters per minute, or
   195 feet per minute, or
   3.6 km per hour, or
   2.2 miles per hour

6. Minimum distance from puller and tensioner to the stringing block .......... 3:1 Ratio

7. Total number of spans in each stringing section
   Typically 20 to 30*

5.0 SAGGING METHODS

The methods and procedures for sagging the OPGW are the same as those for normal overhead ground wires. For determining sags, the installer should use the sag-tension design information provided by the utility or AFL. Sagging and tensioning should be conducted from deadend to deadend. Care should be taken to avoid sagging the cable around angles greater than 30 degrees.

A temporary grip is installed on the OPGW for tensioning. The grip must be designed to
hold the OPGW without damage, and in particular not pinch the cable or crush the aluminum pipe. AFL can provide a come-along, sometimes called a pocketbook grip, that can be attached anywhere along the length of an OPGW. Figure 4 illustrates a satisfactory come-along design.

![FIGURE 4 –Come-along (Pocketbook Grip)]

Some types of gripping devices that might damage the OPGW such as Chicago grip or Kito grip are strictly prohibited to use for OPGW, as shown in Figures 5A & B.

![× Chicago grip (prohibited)]  ![× Kito Grip (prohibited)]

Figures 5A-B. Types of prohibited grips used to tension OPGW.

Certain types of formed guy grips can also be used successfully, but their use in stringing applications should be checked with the grip’s manufacturer.

### 6.0 DEADENDING AND CLIPPING IN

Deadends are installed on OPGW spans that terminate at splicing towers or ends of the system. Deadends are also used at angle structures when the angles are too great to use suspension clamps. Suspension clamps are normally used at the remaining towers. These types of hardware (dead end and single suspension) are illustrated in Figures 6 and 7.
In general, the rule for hardware use is the following:

Single Suspension to be used at structures with line angles between 0 and 30 degrees.

Double Suspension to be used at structures with line angles between 30 and 60 degrees.

Double Dead End to be used at structures with line angles over 60 degrees.

Sometimes, when double suspensions are not desired, the dead ends can be used starting from line angles of 30 degrees, instead of 60 degrees.

OPGW is installed using stringing blocks. If left in the stringing blocks for extended periods of time, the potential for motion induced damage (aeolian vibration) increases. Also, the creep of the cable is affected due to the change in the initial condition on the cable. In order to diminish the probability of motion induced damages and creep rate change, AFL recommends that tensioning and anchoring of the OPGW to the structure and removal of the stringing blocks be completed no later than 48 hours after pulling the cable in.

There are several ways to lift the OPGW from the stringing blocks in order to install the hardware. A come-along is attached on both sides of the block and a coffin hoist is placed over the tower arm. The hooks of the coffin hoist are attached to the come-along and jacked up to form a small loop in the OPGW. The block can then be removed and the armor rods can be placed on the OPGW then attached to the structure. Alternately, certain types of preformed wire grips can be used instead of come-along. The preformed grip can be used once as a come-along and then used permanently in the next span.

If vibration dampers are required for this span, these should be placed on the OPGW immediately after clipping in. Dampers may not be required at every structure; their locations will be specified by the utility or AFL. A drawing of an AFL Stockbridge damper is shown in Figure 8.
7.0 SPLICE POINTS

Splice points will be located at the beginning and end of each OPGW reel. After completion of sagging and clipping, the surplus OPGW should be coiled and attached temporarily to the tower. Coils should be approximately 3.5 to 5 feet (1 to 1.5 meters) in diameter. The coils should be fixed on the tower to prevent any damage to the OPGW prior to splicing.

The exposed ends of the OPGW should be re-sealed to prevent moisture from entering the fiber units. The cable reel may be supplied with a pair of plastic caps for sealing the cable ends. Electrical tape, RTV silicone, or other means can also be used for this purpose.

The OPGW will be trained down the tower and to the ground for splicing. Do not cut off any excess length of the OPGW at this time. To facilitate splicing, the OPGW should extend a minimum of 75 feet (23 meters) beyond the bottom of the tower. The length of OPGW running down the tower should be attached to the structure using appropriate guide clamps, spaced every 6 to 8 feet (1.8 to 2.4 meters) of running length. Several types of guide clamps are illustrated in Figure 9.

Figure 9 – OPGW Guide Clamps and Bonding Clamps

The splice enclosure will typically be installed on the structure between 15 and 20 feet
(4.5 to 6 meters) above the ground. In most cases, it will be desirable to store extra cable on the tower. This will allow the splice box to be removed and lowered to the ground if it is ever necessary. This can be accomplished with a simple loop of OPGW below the splice box or by permanently storing a coil of OPGW higher on the tower.

8.0 ANCHORING THE OPTICAL UNITS IN THE SPLICE ENCLOSURE

The following is an example of anchoring the optical units when installing AFL Loose Tube OPGW (Aluminum pipe designs) in an AFL Splice ENCLOSURE SBO1-72 (See Figure 10).

- Once the pipe is removed, the fiber core should be cut to length and the binders removed.
- Unwind the optical units and set aside the aramid yarn in the center of the unit.
- Wind the optical units back into their original position and use electrical tape every 15 inches to secure the units. Leave the end of the units free of tape so that the units can be prepped for splicing.
- Remove any excess aramid yarn, leaving at least 14-18 inches to tie off into the box.
- Secure the yarn to the eye bolt in the enclosure. (See Figure 10)
- Tape the units (duct tape is recommended) to the top outside radius of the box (See Figure 10). This will help support the units and prevent damage of the units at the bushing.
- Tighten the retaining nut of the connector kit so that the bushing is sealed around the pipe.
- Repeat the previous steps for the remaining OPGW cable(s).

A similar procedure is available for AFL Tight Structure, HexaCore and CentraCore OPGW and AFL OPTI-GUARD™ Splice Enclosure

** Ensuring that the optical core is “tied off” within the chosen splice enclosure (whether AFL splice enclosures or not) is a must. If not, the optical core may work its way back into the cable over time, damaging the splice box contents and potentially affecting the optical continuity. **
Note: There should be 30 ft of optical unit(s) prepped for each individual OPGW cable that is to be inserted into the Splice Box. The 30 ft of optical unit(s) is divided two sections:
1: 20 ft from box to ground, and 2: 10 ft for storing and splicing.
Should the Splice Box be mounted at a different height, then adjust the amount of OPGW cable to be prepped, stored and spliced.

Figure 10- Anchoring the Optical Units in the AFL Splice Box SBO1
REFERENCE A

STRINGING AND HANDLING OPGW DIAMETERS

AND

BENDING RADIUS

The following guides apply to AFL Telecommunications OPGW Optical Groundwire:

For cable diameters greater than 0.787” (20 mm) please contact AFL:

1. Maximum OPGW recommended stringing tension is 20% (at tensioner) of the rated breaking strength.

2. The minimum bull wheel diameter for tensioners is 70 x D.
   (D = OD of OPGW).
   For larger diameter OPGW cables where 70 x D exceeds 60” (~1.5m), a 60” (~1.5m) bull wheel may be used. Please consult AFL in such cases.

3. The recommended stringing sheave (root) diameter is 40 x D.
   (D = OD OPGW).
   This is based on a sheave through angle of 45° and maximum stringing tension (at tensioner) of 20% of the rated strength of the OPGW.

   NOTE: Refer to Table 1 for additional information on minimum diameters of the stringing blocks for other conditions.

4. The minimum bending radius after installation (static) for the OPGW is 15 x D.
   The minimum bending radius during installation (dynamic) for OPGW is 20 x D.
   (D = OD of OPGW).

   NOTE: Based on actual OPGW size, etc., care must be taken when bending the OPGW to avoid kinking the strands and, therefore, damaging the optical fibers contained within the central pipe.

5. The minimum permanent bending radius for the OPGW is 15 x D.
   The minimum permanent bending radius for the stainless steel tube is 45 x d.
   (d = OD of the stainless steel tube).

6. The minimum permanent bending radius for plastic buffer tubes is 3 inches (8 cm).

7. The minimum permanent bending radius for the optical fibers is 1.5 inches (3.8 cm).

8. The swinging angle of the stringing block shall be controlled corresponding to the swinging angle of the OPGW stringing plane to help prevent the cable from riding out of the traveler or excessive twisting during installation. The cable should travel through the
lowest part of the groove. At angle structures, this is done by tying a support rope to the sheave to keep it suspended.

The following are minimum diameters of stringing blocks at:

Sheave size Recommendations

The following sheave diameters are recommended for their respective stringing angles in Table 1. These sizes are considered satisfactory if the pulling line slope is at least three horizontal to one vertical from the traveler to the site and the stringing tension does not exceed 20% of the OPGW’s rated breaking strength.

<table>
<thead>
<tr>
<th>Stringing or Line Angle</th>
<th>Sheave Size (x OPGW OD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bull Wheel Diameter</td>
<td>70x</td>
</tr>
<tr>
<td>First and Last Structures</td>
<td>40x</td>
</tr>
<tr>
<td>Tangent Structures</td>
<td></td>
</tr>
<tr>
<td>$\theta &lt; 20^\circ$ Stringing Angle</td>
<td>30x</td>
</tr>
<tr>
<td>Tangent Structures</td>
<td></td>
</tr>
<tr>
<td>$20^\circ &lt; \theta &lt; 45^\circ$ Stringing Angle</td>
<td>40x</td>
</tr>
<tr>
<td>Tangent Structures</td>
<td></td>
</tr>
<tr>
<td>$45^\circ &lt; \theta &lt; 60^\circ$ Stringing Angle</td>
<td>50x</td>
</tr>
<tr>
<td>Tangent Structures</td>
<td></td>
</tr>
<tr>
<td>$60^\circ &lt; \theta &lt; 90^\circ$ Stringing Angle</td>
<td>60x</td>
</tr>
<tr>
<td>Tangent Structures</td>
<td></td>
</tr>
<tr>
<td>$90^\circ &lt; \theta$ Stringing Angle</td>
<td>No Go</td>
</tr>
</tbody>
</table>

Table 1. Sheave Sizes for different Stringing Angles.
FOCAS ARD Kit FARD-2

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td>3</td>
<td>10 ft weighted Tails, assembled</td>
</tr>
<tr>
<td>1</td>
<td>Rotating Swivel</td>
</tr>
<tr>
<td>1</td>
<td>P-38 Punch Lok Tool</td>
</tr>
<tr>
<td>15</td>
<td>4&quot; I.D. Punch Lok Clamps</td>
</tr>
<tr>
<td>1</td>
<td>Kellem Grip</td>
</tr>
<tr>
<td>2</td>
<td>Electrical Tape roll</td>
</tr>
</tbody>
</table>

NOTES:

1. Attach hydraulic hose and 7/8" wire Rope to OPGW using punch lok clamps or tubing clamps.
2. Apply heavy layers of electrical tape to attachment points to prevent damage to sheave wheels.
ANTI-ROTATIONAL DEVICE (EXAMPLE)