

NOANET CONSTRUCTION STANDARDS AND BEST PRACTICES



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Purpose

This document establishes comprehensive standards and procedures for the handling, installation, splicing, and testing of fiber optic cables intended for telecommunications, data transmission, security systems, and similar applications. It sets forth the minimum quality benchmarks for construction, splicing, as-built record keeping, safety compliance, and the final validation required for project acceptance.

Specifically, this document addresses:

- Proper handling techniques and storage requirements for all types of fiber optic cable to prevent damage before and during installation.
- Approved installation practices, including guidance on following manufacturer specifications, adhering to bend radius and pulling tension recommendations, and the use of certified equipment and materials for a “stress-free” environment.
- Detailed splicing procedures for both fusion and mechanical methods, covering equipment setup, splice enclosure use, and record-keeping for continuity and future maintenance.
- Standardized procedures for field testing, acceptance criteria using industry-accepted metrics (such as optical loss and reflectance), and documentation protocols to verify that installed cables meet performance requirements and customer expectations.
- As-built and red-line documentation requirements to ensure accurate, up-to-date records for project closeout, auditing, and future modifications.
- Safety guidelines for working with fiber optic cable, tools, and related installation environments.

The standards within this document are recommended for use by qualified professionals trained in fiber optic technology. They are designed to support consistent, high-quality installations and to facilitate troubleshooting and maintenance throughout the fiber cable’s operational life. Any deviations from these procedures must receive prior approval from the NoaNet OSP Management Team.

Scope

These standards outline procedures and require equipment for the installation, validation, and maintenance of fiber optic cables used for communications, security, device monitoring, and related functions. They establish a minimum baseline of quality for all testing and maintenance activities, and apply fiber optic cable construction, splicing, as-built red-lines, safety, and installation acceptance criteria.

This document includes:

- Manufacturer recommendations and field-proven techniques for proper cable installation.
- Use of approved equipment and Outside Plant (OSP) materials to ensure a stress-free installation environment.
- Guidance on fiber optic cable splicing equipment and best practices.
- Defined standards for fiber testing, acceptance, and documentation processes include red-lines and as-builts for accuracy and invoicing.

These guidelines are intended for qualified personnel experienced in fiber optic cable installation and testing as described within this document. Definitions and explanations are provided regarding fiber optic cable characteristics and their impact on handling and installation. Examples of various installation methods are included to assist in selecting appropriate approaches and materials that meet specific field requirements.

Any deviations from these construction standards or procedural changes must be approved by the NoaNet OSP Management Team.

Safety and Regulatory Compliance

All work performed under this standard shall fully comply with all applicable federal, state, local, and private safety and environmental regulations, including—but not limited to—those established by the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), and relevant municipal authorities. Ensuring the safety of personnel is the highest priority in both aerial and underground fiber optic cable installation environments.

The CONTRACTOR is solely responsible for establishing, maintaining, and monitoring safe work zones that align with all required OSHA and State/Local safety regulations and industry best practices. This includes, but is not limited to:

- Conducting comprehensive site hazard assessments before work begins and routinely throughout the project.
- Enforcing the use of proper personal protective equipment (PPE) for all employees and subcontractor personnel throughout the duration of the project.
- Implementing clear safety policies for operating heavy machinery, handling fiber optics, excavation, traffic control, and confined space entry.
- Providing ongoing safety training, routine safety meetings (tailgate talks), and immediate corrective action when unsafe conditions are identified.
- Maintaining documentation showing adherence to all applicable safety and environmental laws and making these records available for inspection upon request.

Accountability for compliance, incident prevention, and corrective actions reside entirely with the CONTRACTOR for all on-site employees and subcontractors. NoaNet personnel are authorized and required to conduct regular inspections, audits, and field oversight throughout all phases of fiber optic cable installation, construction, and splicing to ensure continuous adherence to safety standards and regulatory requirements. Deficiencies or violations identified by NoaNet will require immediate Contractor response and corrective action at no additional cost to NoaNet.

Work Zone Safety

Safety Procedures and Worksite Requirements

- The Contractor shall conduct safety briefings at the start of each shift and prior to commencing any critical work activity. All crew members, including subcontractor personnel, must attend and acknowledge understanding of the day's safety precautions, potential hazards, and emergency procedures.
- The Contractor is responsible for ensuring continuous compliance with all safety regulations throughout the project duration and for promptly correcting any unsafe practices observed in the field.

Work Zone Setup and Marking

- All work zones must be clearly defined and barricaded using appropriate warning signs, cones, and barriers placed within proximity to active work areas to protect both workers and the public.
- When work impedes active traffic lanes, the Contractor will comply with Washington State Department of Transportation (WSDOT) signage and flagging requirements, ensuring lane closures and detours are properly managed by certified flaggers.

Equipment and Incident Reporting

- All aerial lift devices (bucket trucks) used on site shall be equipped with insulated boom sections rated in accordance with prevailing safety standards.
- Any accident or safety-related incident, no matter how minor—must be reported immediately to Entrust project management and appropriately documented in a timely fashion.

Personal Protective Equipment (PPE) Requirements

- All personnel working on the job site must always wear the following PPE:
 - Flame-resistant (FR) rated clothing, at a minimum of category 2 protection level.
 - ANSI-approved hard hat.
 - High-visibility reflective vests in orange, lime, or yellow.
 - Safety glasses meet current ANSI standards.
 - Leather work gloves or approved equivalent hand protection.

- Safety-rated work boots with adequate toe protection during all cable construction and handling activities.

Failure to comply with these requirements may result in immediate removal from the work site and possible suspension of work until corrective measures are implemented.

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Fiber Optic Cable Construction Practices

All construction activities, material handling, and installation techniques must adhere strictly to the recommendations and specifications provided by manufacturers of Outside Plant (OSP) cables and related equipment. This ensures the continued integrity and optimal performance of fiber optic materials throughout all phases of construction, from receipt through post-installation.

- The Contractor is responsible for following established industry best practices for cable pulling, placement, and termination to prevent damage from excessive tension, improper bending, or environmental exposure.
- Equipment such as cable pulling winches, rollers, and tension meters must be used in accordance with manufacturer technical bulletins and guidelines to safeguard the cable and associated materials.
- During storage, transportation, and staging, fiber reels must be protected against impact, moisture, sunlight, and extreme temperatures, and should remain on manufacturer-approved stands or supports.
- Before installation, the Contractor must inspect and test each fiber reel provided using standard visual inspections and optical time domain reflectometer (OTDR) measurements to verify the absence of physical and optical defects. Any anomalies, discrepancies, or visible damage must be reported immediately to NoaNet material management for evaluation and possible replacement.
- All fiber reels are assumed to be defect-free upon issuance, as validated by the manufacturer's supplied test documentation. However, should a defect be discovered during Contractor inspection or during pulling, installation will be paused until NoaNet authorizes corrective action.

Following these procedures will help ensure that fiber optic installation is performed to the highest standards, minimizing risk of future faults and maximizing the longevity and reliability of the network infrastructure.

NESC Bonding and Grounding Requirements

The NESC (National Electrical Safety Code) establishes detailed requirements for bonding and grounding of communications cables and equipment, especially on joint-use poles and at service entrances.

Key NESC Bonding and Grounding Requirements

- **Bonding to Supply Ground:**
Communications messenger wires must be grounded at least four times per mile (every 1,320 feet) and bonded to the supply grounding conductor wherever possible.
 - When both supply and communications systems are grounded on a joint-use pole and a single grounding conductor exists, both must be connected to that conductor.
 - Where separate grounding conductors are required (per Rule 097A), they must be bonded together unless separation is mandated for specific technical reasons.
- **Grounding at Crossing Structures:**
Communications messengers, neutrals, and guy wires must be grounded and bonded together at crossing structures to ensure a low-impedance fault path and improve safety.
- **Service Entrance Bonding:**
At the customer's premises, the communications ground must be bonded to the electrical service ground using a conductor no smaller than #6 AWG copper. This meets both NESC Rule 099C and NEC 800.100(D) requirements, ensuring common potential and reducing surge risk.
- **Equipment and Guy Grounding:**
Communication equipment cases and anchor guys must be effectively bonded to a grounded neutral conductor or messenger for worker safety and fault protection.
- **Continuous Shield/Sheath Bonding:**
Direct-buried cables with metallic shields or armoring must be effectively grounded at

the required intervals and bonded to supply neutrals or other communication cables where specified.

Typical Practice

- Whenever possible, bond the communication ground system to the power multi-grounded neutral (MGN) system, using approved compression connectors.
- Ensure all bonding and grounding conductors are sized per NESC, properly installed, and securely attached to the structure or grounding electrode.
- Additional grounds may be required in high lightning or induction risk areas, per NESC Table 092C1.

Following these NESC requirements minimizes risk from induction, lightning, and ensures communications infrastructure safety on power infrastructure.

Key NESC Grounding and Bonding Rules

- Details additional supply and communications cable grounding practices, including pole-top, riser, and crossarm installations for both aerial and underground plant.

These rules ensure

- Multiple, effective grounding of communications infrastructure for safety against electrical faults, lightning, and induced voltages.
- Reliable fault current paths by bonding communications and supply grounds where installed on the same structure.
- Consistency across joint-use structures and at premises for all service providers.

Consult the current edition of NESC (ANSI C2-2023) for exact language and cross-referenced tables for your jurisdiction and utility owner requirements. The key National Electrical Safety Code (NESC) rules for grounding and bonding of communications cables and hardware are:

- **Rule 92C:** Ground the communications messenger at least four times per mile (every 1,320 feet) and at both ends, splices, and points of crossing or termination.
- **Rule 97:** All metal parts (including communication hardware, guy wires, and messengers) must be bonded and grounded and should be interconnected with the supply (power) neutral ground unless separation is expressly required.
- **Rule 99:** Customer premises communications ground must be bonded to the electrical service ground with a minimum #6 AWG copper wire.

- **Rule 239I:** Metallic shields, armor, and sheaths of buried cables must be grounded and bonded at all entrances, splices, and where exposed.
- **Rule 360–363:** Additional rules for grounding supply and communication risers, cables, and associated metallic equipment at the pole and service entrance.

These rules are essential for safety, protection from lightning/induced voltages, and ensuring common potential on joint-use poles. Always check the NESC in force (2023 edition or as adopted locally) for full requirements and consult utility- or jurisdiction-specific supplementary standards.

These rules ensure effective, redundant grounding and bonding for all communications infrastructure to minimize risk from faults, induction, or surges.

Aerial Fiber Construction: Strand & Lash

- **Overview:** In the strand and lash method, a steel messenger strand is first installed and tensioned between utility poles. The fiber optic cable is then lashed to the messenger using stainless steel or other corrosion-resistant lashing wire.
- **Messenger Installation:** The messenger strand is placed at the approved position (usually 40" below the neutral), with appropriate sag and tension based on span length, pole spacing, and environmental considerations (ice, wind, etc.).
- **Cable Placement:** The fiber cable is temporarily supported by the messenger using cable blocks or rollers. The cable may be placed using moving reel or stationary reel methods:
 - *Moving Reel:* The cable reel moves along the route as the lasher and cable advance together.
 - *Stationary Reel:* The cable is pulled out along the route and lashed in sections with the lasher either pulling cable blocks as it goes or with blocks removed as the lasher passes.
- **Lashing:** A powered lasher is pulled along the messenger, wrapping the fiber cable tightly to the strand with lashing wire. The lashing process ensures reliable cable support, vibration resistance, and long-term durability.
- **Slack and Splicing:** Slack loops for splicing and maintenance are left at designated poles or mid-span as required by engineering plans. Splice closures are mounted either on poles or the strand, with sufficient slack for future access and repairs.
- **Safety:** Work requires insulated bucket trucks, PPE, and only qualified personnel due to proximity to energized conductors.

Step-by-Step Lashed Aerial Fiber Installation Workflow

Project Preparation and Survey

- Review project designs and permits, confirming pole ownership and right-of-way access.
- Conduct a field survey to verify pole condition, span lengths, existing attachments, and identify splice points and slack storage locations.

Pre-Construction Meeting

- Coordinate with all stakeholders, including utility owners and project management, to review installation plans, safety requirements, logistics, and hardware needs.

Messenger (Strand) Installation

- Install the steel messenger strand at the approved pole position (typically 40" below the neutral).
- Tension and sag the strand as per design specifications, considering span length and environmental loading.

Temporary Cable Support

- Using cable blocks (rollers), temporarily support the fiber optic cable along the messenger strand.
- Select either:
 - Moving Reel Method: The fiber reel moves along the route with the lasher, best for accessible routes.
 - Stationary Reel Method: The fiber is pulled from a fixed reel, temporarily supported by blocks throughout the span.

Lashing Fiber to Messenger

- Attach a powered lasher to the messenger and pull it along the route, wrapping the fiber cable securely with lashing wire.
- Remove temporary supports (cable blocks) as lashing progresses or have the lasher push them to the next pole for collection.

Slack Storage and Splice Preparation

- Leave 150' of appropriate slack at designated poles for splicing and maintenance, adhering to project slack loop requirements.
- Prepare and install splice closures and mount them to the messenger as designed.

Grounding and Bonding

- Ground and bond the messenger strand and lashing wire at specified intervals (typically every quarter mile) and at vertical ground terminal points for safety and compliance per power pole owner requirements.

Inspection and Documentation

- Visually inspect all lashing, cable placement, sag, hardware terminations, and completed slack loops for workmanship and compliance.
- Document installation for as-builts, including locations of splices, slack storage, and hardware.
- Provide sequential data at all pole attachment locations and risers (entering and exiting).

9. Final Acceptance and Clean-Up

- Remove all temporary supports, tools, and waste from the worksite.
- Submit installation records and as-builts for project acceptance and closeout to engineer for review.

This step-by-step approach ensures a safe, efficient, and high-quality lashed aerial fiber installation from planning through project completion.

Aerial Fiber Construction: ADSS-Self Support

- Overview: ADSS cable is specifically engineered to be self-supporting and does not require a messenger strand. The cable's dielectric strength elements allow it to span pole-to-pole under its own weight.
- Placement: The ADSS cable is installed directly between poles:
 - Pulleys (rollers) are attached to each pole, and the cable is pulled through the rollers for the entire route.
 - When the cable is in place, it is tensioned by the manufacturer's specifications, then dead-ended and secured at each pole with specialized hardware and fittings.
- Sag and Tension: The amount of sag and cable tension is calculated based on span length, temperature, and expected worst-case loading (ice, wind). ADSS must never be over tensioned; manufacturer's span charts are always referenced.
- Attachment: At each pole, dielectric dead-end preform grips and supports are installed that match the diameter and requirements of the ADSS cable.
- Slack and Splicing: Slack loops for maintenance and splicing are provided at intervals per project documentation. Splice closures are mounted near poles with DDE hardware designed for ADSS.
- Advantages: No metallic components mean ADSS is immune to electrical interference and is suitable for installation beneath or alongside energized conductors.
- Safety: The absence of a messenger and high dielectric strength allow installation in high-voltage corridors, but all crew must still use lift equipment, PPE, and follow utility owner safety standards.

Step-by-Step ADSS Aerial Fiber Installation Workflow

Pre-Construction Survey and Planning

- Conduct a thorough site survey to assess pole conditions, route obstacles, required clearances, and environmental concerns.
- Identify and record all pole locations, span measurements, locations for slack storage, and potential splice or termination points.
- Obtain all required approvals and confirm route with OSP engineering/project management.

Cable Receiving, Inspection, and Staging

- Inspect all ADSS cable reels for damage; verify length, integrity, and factory test documentation.
- Store cable reels upright on firm, flat ground and shield them from sunlight and moisture until ready for use.
- Ensure adequate protection and access at the storage and staging areas near the work site.

Equipment and Safety Preparation

- Ensure all crew members have appropriate PPE: hard hats, safety vests, gloves, eye-wear, and footwear.
- Set up traffic and worksite safety controls (barriers, signs) according to regulations.
- Deploy insulated lift equipment/bucket trucks as needed.

Route Preparation and Hardware Installation

- Attach appropriate dead-end and suspension fittings at each pole. These should match cable specifications and span requirements.
- Install rollers (cable blocks) at every support point to guide cable during the pulling process.
- Confirm minimum bend radius and cable handling protocols are understood by all personnel.

Cable Pulling and Placement

- Position the cable reel at the starting pole, aligned properly for a straight feed into the first roller.
- Using a pull line or capstan winch, pull the cable through the sequence of rollers along the aerial route, carefully monitoring tension to avoid exceeding manufacturer tensile ratings.
- Communicate constantly during pull to coordinate the feeding and pulling teams.
- Avoid twists, kinks, and exceeding bend radius throughout the process.

Dead-Ending and Tensioning

- At each end and at each major directional change ($\geq 20^\circ$), anchor the cable using approved ADSS dead-end preform grips/hardware.
- Tension the cable according to manufacturer charts, considering span length, temperature, and anticipated environmental loads (wind, ice).
- Remove rollers and secure the cable at tangent supports between dead-ends.

Slack Storage and Splicing Points

- Create and secure 150' slack loops at designated locations to allow ease of future maintenance or rerouting.
- Use Snow-Shoe brackets to store and coil slack safely out of the way, following OSP engineering specs.

Post-Placement Inspection and Documentation

- Inspect the full aerial route for secure hardware attachment, proper cable sag, tension, and conformance to safety and clearance codes.
- Record all as-built information such as sequential data at all pole attachments and risers (entering and exiting) span lengths, slack locations including sequential footage, tension readings, and any deviations from original plans for closeout documentation.
- Test fiber using OTDR or related equipment to confirm proper installation and document cable integrity.

Site Restoration and Final Acceptance

- Remove all installation equipment, debris, and temporary safety controls from the work area.

- Repair any construction impacts to pole grounds, vegetation, or public infrastructure.
- Submit as-built documentation, OTDR test records, and maintenance recommendations for final project closeout and acceptance.

This workflow ensures safe, effective, and standards-compliant installation of ADSS aerial fiber and supports future maintenance and operational reliability.

Both strand and lash and ADSS methodologies require pre-construction surveys to determine the most appropriate approach for each route section, and approval from project management. Documentation of installation tension, sag measurements, and as-built details are required for system records and future maintenance.

Aerial Construction / Installation Hardware

To ensure secure and reliable aerial installation, only hardware and materials approved by the cable manufacturer and in compliance with utility standards must be used throughout the project. The hardware secures fiber optic cable to various pole types (wood, concrete, metal) while maintaining cable integrity and service longevity.

Essential Hardware Components

- Steel Messenger Strand: 6.6m (1/4") or 8m (5/16") Extra High Strength (EHS) galvanized steel strand to provide durable, tensioned support for lashed cable.
- Preforms: Wire preforms or grips for securing messenger strand to pole anchors and dead-ends.
- Auxiliary Eye Attachments & Down Guy Hardware: For side attachment points and guy anchor terminations.
- Machine Bolts (5/8" various lengths): Heavy-duty hardware for securing clamps and hardware to poles.
- Square and curved Washers & Nuts: Provide secure bolting and load distribution.
- Messenger Clamps: For attaching the messenger strand to poles and transferring mechanical loads.
- Single & Double Dead-End Sets: Secures messenger strand at span ends, maintaining required tension.
- Insulators (Johnny Balls): Electrically isolate messenger/guying from energized conductors where necessary.
- Span Guy & Anchor Assembly: Stabilizes poles subject to lateral loads from guy wires.

Fiber and Safety-Related Hardware

- Fiber Wrap-Around Markers: High-visibility tags (e.g., orange with black lettering) displaying owner or NOC (Network Operations Center) information for asset identification and safety.
- #6 Solid Copper Wire & Bonding Clamps: For grounding the messenger strand and hardware to mitigate electrical hazards.
- Guy Guards (Yellow): Plastic or composite covers to improve visibility and reduce tripping hazards at guy anchor locations.

- Bonding/ Split Bolts: For secure electrical connections between copper grounds and hardware.
 - Suspension and Tension Clamps: Maintain cable alignment, minimize vibration, and prevent sagging across long spans.
 - Cable Rollers/Blocks, Brackets: For guiding and temporarily supporting the cable during installation.
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Installation Process (Highlight Steps)

- Messenger Installation: Install steel messenger strand according to span requirements using approved preforms, clamps, bolts, and dead-end kits.
 - Guying & Anchoring: Install down guys, anchors, and guy guards to reinforce poles exposed to extra tension or large spans.
 - Grounding: Bond messenger to ground rods at specified intervals using #6 copper wire and bonding clamps.
 - Marker Placement: Place fiber wrap-around markers at key locations, such as road crossings and at regular intervals, to identify ownership and cable type.
 - Cable Placement: Use cable blocks and rollers to support cable as it's lashed to the messenger, ensuring minimum bend radius and avoiding sharp contacts.
 - Clamping and Dead-ending: Use suspension clamps, insulators if required, and dead-end assemblies to complete mechanical and electrical isolation at terminations.
 - Final Inspection: Verify all bolts are properly torqued, hardware grounded, and cable secured without excessive sag or bends.
-

All materials and installation methods must comply with NoaNet standards, local utility codes, and OSP best practices to ensure long-term system reliability and safety.

Fiber Cable Slack Storage

Aerial fiber slack storage using snowshoes is the best practice for protecting and managing excess cable in both ADSS (All-Dielectric Self-Supporting) and strand & lash installations. Snowshoes maintain minimum bend radius, reduce cable stress, and facilitate future maintenance.

Purpose and Benefits

- **Bend Radius Protection:** Snowshoes (fiber slack storage brackets) keep cable from exceeding its minimum bend radius, which is critical for both performance and longevity.
- **Mechanical Protection:** Distributes cable weight, absorbs wind and thermal contraction/expansion, and prevents macrobends and sheath damage in aerial deployments.
- **Maintenance Access:** Provides enough slack for future splicing, relocation, or emergency repairs without cutting the main cable.

Installation for ADSS and Strand & Lash

- **Location:**
- Typically installed near splice points, mid-span breakouts, or at regular intervals per engineering (e.g., every 1200–2000 ft or at key crossing points).
- **Mounting:**
- Attach snowshoe brackets to the messenger strand (for strand & lash) or directly to the pole, tower, or ADSS support hardware.
- Use approved mounting kits compatible with wood, steel, or concrete structures. For ADSS, ensure dielectric hardware is used to prevent electrical arcing.

Cable Routing:

- Lay excess cable in a figure-eight or circular pattern in the snowshoe, securing with UV-stable cable ties (not over-tight). Never coil cable tightly on the pole alone, always use a support bracket.
- Ensure cable loops maintain at least the minimum manufacturer-recommended diameter—commonly 18"–30" depending on cable spec and snowshoe size.

Best Practices

- **Slack Quantity:**
Store enough slack to allow lowering the cable for ground-level splicing (typically 100–200 ft at splice closures), or as specified by project standards.
- **Labeling:**
Label each slack storage site by location or with asset tags for future location reference.
- **Securement:**
Use all provided hardware—cable straps, locking nuts, and extension kits as needed—to ensure the cable is held firmly but not pinched.
- **Inspection:**
Regularly inspect after storms or high winds to verify cable is secure and no damage or excess sag has developed.

Summary Table

Method	Use Bracket On	Typical Size	Min. Dia.	Placement
ADSS	Pole/Span	12–30"	≥18–30"	Splice/termination/Poles/Span.
Strand & Lash	Messenger	12–30"	≥18–30"	Near closures/intersections/Span

Proper slack storage with snowshoes is essential for aerial fiber reliability and compliance with industry standards. Aerial fiber slack storage using snowshoes is standard for both ADSS (All-Dielectric Self-Supporting) and strand & lash fiber installations, ensuring protection of excess cable while maintaining minimum bend radius for network reliability.

Route Assessment & Planning

Prior to the start of any field construction activities, a rigorous review of the project's engineering maps, bill of materials, and proposed cable routes must be performed. Key steps include:

- **Engineering Review:** Study all construction plans, technical drawings, and design documents to confirm the intended routing and to ensure all necessary materials and equipment are accounted for.
- **Physical Route Assessment:** Walk or drive the proposed cable path to visually inspect and record existing site conditions, identify any discrepancies against the plans, and evaluate potential logistical challenges.
- **Obstacle and Risk Identification:** Document all critical areas that may impact construction, such as:
 - Large angles or extreme pole offsets requiring special hardware or construction methods
 - Crossings of railroads, highways, interstates, or bodies of water, which may demand regulatory approvals or specialized equipment
 - High-traffic intersections needing advanced traffic control planning
 - Environmentally sensitive or restricted areas requiring permits, specific work windows, or special mitigation measures
- **Site-Specific Hazards:** Note any existing utilities (overhead or underground), difficult terrain, vegetation, or right-of-way restrictions that can affect installation.
- **Traffic and Access Planning:** Develop a traffic control plan in coordination with local authorities if construction impacts vehicle or pedestrian flows.
- **Permitting and Coordination:** Verify all permitting requirements are met and coordinate with utility owners, municipalities, and railroads as needed for shared use and safe crossing overlays.
- **Stakeholder Engagement:** Communicate with property owners, public works, and stakeholders along the route to set expectations and minimize disruptions during construction.

Thorough route assessment and proactive planning ensure obstacles are addressed in advance, reduce the risk of delays or rework, and increase the overall efficiency and safety of fiber optic cable installation.

Joint-use Pole Attachment / Cable Installation Standards

- **Neutral Space Attachment:** The standard cable attachment height is 40" below the lowest power conductor, within the neutral space designated for telecommunications attachments.
- **Wood Poles:** Drill holes to size and install 5/8" galvanized machine bolts to anchor supporting hardware (messenger clamps, suspension brackets, etc.).
- **Steel or Concrete Poles:** Use approved steel banding systems to affix hardware; do not drill into steel or concrete poles under any circumstances.
- **Dead-End (DE) Attachments:** Required at both ends of new cable runs, and where attachment level or cable direction changes significantly. Use manufacturer-approved dead-end grips or assemblies.
- **Double Dead-End (DDE) Attachments:** Install at any pole where the cable route angle exceeds 15°, on both sides of all road crossings (unless otherwise specified for steel messenger), when changing cable size, and at least every 1,500 feet in continuous construction to manage tension and route stability.
- **Down Lead Clamps:** Use down-lead clamps to secure and guide the cable as it transitions vertically from the aerial run onto the pole (for drop to ground or device), spacing clamps approximately every 30" to support and organize the cable.
- **Down-Guy Strand & Hardware:** Install down-guy steel strand and attach with rated anchors and clamps at all poles with existing down-guys, and wherever cable attachment angle exceeds 22°. Bond new down guys to the electric utility's vertical ground using a bonding clamp and #6 solid copper wire. Only use open-eye anchors on communication utility anchors for new down-guys.
- **Fiber Wrap Around Markers:** Place fiber identification markers at every pole: in the drip loop area at pass-throughs and at the side of the pole at dead-end and transition points. Use custom-printed markers for asset management and emergency contact.
- **Bonding and Grounding:** In cases where required, bond the steel messenger strand to ground using #6 solid copper wire and approved bonding clamps or split bolts to existing utility ground systems for personnel and equipment protection.

These standards ensure long-term reliability, proper identification, and compliance with safety and utility requirements for aerial fiber optic installation.

Joint Use Pole Owner Attachment Agreements

General Provisions & Scope

- Purpose: Specifies the nature of the installation—communications, broadband, or electric utility services—and clarifies that the use is non-exclusive.
- Grant of License: Formal permission for the utility to occupy specified space on listed poles, subject to permit approval and compliance with codes.

Technical & Safety Requirements

- Designated Attachment Space: Defines the communication and supply zones, as well as required vertical clearances in accordance with the National Electrical Safety Code (NESC) and local authority requirements.
- Engineering Review: The Utility must submit pole-by-pole plans, strength calculations, and proposed attachment heights for the owner's review and permit approval before any work begins.
- Compliance: All installations must meet NESC, OSHA, local permitting, and municipal codes. Attachments within city limits must also comply with relevant franchise agreements and municipal codes.

Operational Responsibilities

- Maintenance & Relocation: The Utility is responsible for the maintenance and safety of its own facilities and must relocate or remove attachments if required by the owner (including transfers during pole replacements or abandonments).
- Permit System: Permit applications are required for new, modified, or transfer attachments, except for certain defined routine service drops.
- Abandonment: If either party abandons their facilities or poles, notification periods and removal/protection procedures are outlined.

Legal & Financial Terms

- Compensation: Specifies fees, cost allocation (make-ready, engineering, relocation), billing, and payment procedures. Rates must be just reasonable, and non-discriminatory as per Federal and State law.

- Insurance & Indemnification: The Utility must provide insurance coverage and indemnify the pole owner for damages or liability arising from its activities on the pole.

Duration & Termination

- Term: Agreement duration, renewal conditions, and notice requirements for termination or modification by either party.

Other Provisions

- Dispute Resolution: Methods for resolving conflicts, including arbitration or legal remedies.
- Applicable Law: Agreement specifies which state, local, or federal laws govern the contract.
- Access & Records: Owner retains right to inspect attachments and verify compliance at any time.
- Default and Remedies: Circumstances constituting breach and available remedies, up to and including removal of facilities.

A structured joint use agreement protects both the Utility and pole owner, ensures legal and technical compliance, and defines clear operational standards for all shared infrastructure.

NESC Riser and Stand-Off Bracket Placement

The NESC rule most directly governing riser standoff bracket placement on a pole is NESC Rule 217A2c. This rule requires that standoff brackets supporting conduit risers are arranged so that there is not less than 8 feet between either:

- The lowest bracket and the ground or other accessible surface, or
- The lowest two brackets (i.e., if two brackets, the separation between them must be at least 8 feet)

This is intended to preserve clear climbing space, public safety, and meet minimum accessibility requirements on wood poles.

Additional industry best practices (NESC-referenced):

- Brackets should be no lower than 8 feet from ground level.
- Bracket spacing should not exceed 10–15 feet; the last bracket is installed near the conduit's upper end.
- Minimum clearance from pole to conduit riser via standoff is typically 4–6 inches.

For full details, refer to NESC Rule 217A2c and consult local utility standards which frequently incorporate these requirements, supplemented with additional safety and spacing details.

The exact NESC rule text governing riser standoff bracket placement is found in NESC Rule 217A2c (from ANSI C2-2023 and recent prior editions):

NESC Rule 217A2c:

"Where standoff brackets are used on wood poles, the brackets shall be so arranged that there is not less than 8 ft (2.44 m) between the ground or other accessible surface below and either the lowest bracket or the lowest pair of brackets."

This rule ensures that riser standoffs for conduit or communication cables are placed high enough above ground for safety and accessibility, requiring the lowest bracket to be at least 8 feet above grade or the lowest two brackets to be at least 8 feet apart if using a two-bracket configuration. For utility and field implementation, always reference this rule directly when specifying riser and bracket installation.

Aerial Construction Vertical Clearances

Vertical Clearance Standards

- Ground (Non-Vehicular Access, e.g., yards, fields):
Minimum clearance from lowest point of sag to ground is 15'-6" (fifteen feet, six inches).
- Streets, Roads, and Areas Subject to Regular Vehicular Traffic:
Minimum clearance is 15'-6". For state roads or city streets subject to truck or bus traffic, clearances may be set at or above this value depending on state Department of Transportation (DOT) requirements.
- State Roads (Heavily Traveled or Truck Routes):
Minimum clearance is 24'-0" (twenty-four feet, zero inches) per most State DOT and highway codes; always confirm exact requirements with the local agency.
- State Roads - Parallel ROW (Right-of-Way):
Where fiber is installed parallel to a state roadway within the right-of-way but not over the roadway, a vertical clearance of 20'-0" is recommended.
- Interstate Highways:
Minimum vertical clearance is 24'-0" per Federal Highway Administration guidelines and most state codes.
- Railroads (Measured from Top of Rail):
Minimum vertical clearance is 27'-0", unless a greater height is required by the specific railroad authority's standards. Always consult with the railroad operator for special crossing approvals and standards.

Note:

Required vertical clearances may vary by state or local authority; always verify with the current State DOT, local municipality, and, for railroad crossings, with the controlling railroad operator. Installers shall reference latest National Electrical Safety Code (NESC) Table 232 and local amendments for compliance.

Underground Construction

Underground Construction

Underground construction is required when existing utilities are already underground, when aerial installation is not feasible due to pole make-ready constraints, or when necessary, overhead clearances cannot be achieved. Several established methods are used for underground fiber deployment, including open trenching, horizontal directional drilling (HDD), and vibratory plowing.

Backbone and Lateral Conduit/Cable Construction

Construction Methods

- **Open Trenching:** Involves excavating a trench along the designated route, laying conduit or direct-bury fiber, and then backfilling. This method allows controlled placement but is more surface-disruptive and labor-intensive.
- **Horizontal Directional Drilling (HDD):** Used to install conduit beneath obstacles (e.g., roads, driveways, waterways) by boring a path underground and pulling conduit through; it minimizes surface disruption, especially at crossings.
- **Plowing:** A vibratory plow slices through soil and feeds conduit/cable into place in a single pass, ideal for continuous long routes across open terrain, minimizing restoration work.
- **Micro-trenching:** For urban settings, a narrow, shallow trench is cut (typically 1-4" wide, 12-20" deep) along paved edges to install micro duct or fiber in high-density areas for minimal disruption and fast restoration.
- **Conduit Placement:**
Appropriately sized underground conduit (PVC, HDPE, or specified by design) is placed as each segment is constructed. Depth of burial is based on local codes but typically 42"-48" inches. Conduit diameter is chosen to accommodate planned cable count and allow future expansion.
- **Cable Placement:**
After conduit installation, cable is installed using pulling or blowing methods. Minimum bend radius and tension limits for the fiber cable must be strictly observed throughout to avoid damage

Purpose and Importance of Long Radius Sweeps for Fiber Cable

- **Maintaining Bend Radius:**
Fiber optic cables are highly sensitive to bending. Each cable type specifies a minimum bend radius (the smallest allowed curve without risking fiber breakage or excess optical loss). During pulling (installation), the bend radius is typically 20 times the cable's outer diameter; after installation, it is usually 10 times the diameter or greater.
- **Preventing Damage and Attenuation:**
Sharp or tight conduit bends can overstress or even fracture the delicate glass within fiber cables. Even if immediate breakage is avoided, excessive bending causes increased "bend loss"—signal attenuation from energy escaping the fiber core.
Long radius sweeps allow fiber cables to transition gradually around corners or between elevation changes, preventing exceedance of the minimum bend radius and supporting long-term durability and performance.
- **Code & Specification Compliance:**
Construction standards, including manufacturer requirements, often mandate that all underground conduit sweeps (elbows) be long radius: typically, Schedule 40 PVC, 36" minimum radius is a common specification. For aerial or pathway transitions, similar long, smooth curves are required.
- **Summary Table: Example Minimum Conduit Sweep Radii**

Application	Minimum Sweep Radius
Conduit Elbows (Vaults)	36" (Schedule 40 PVC)
Cable Bend (Pulling)	20x cable diameter
Cable Bend (Static)	10x cable diameter

Using long radius sweeps when routing fiber ensures the cable's physical integrity, minimizes optical losses, and keeps the installation compliant with both manufacturer and industry standards.

Handholes, Splice Enclosures, and Access Points

- **Handholes:**
Install handholes (vaults) of types and sizes specified in design packages at all major splice points, OFDC (Optical Fiber Distribution Cabinet) terminals, cable storage locations, and house drop access locations.
- **Splice Cases & Cable Storage:**
Inside each handhole, coil adequate slack (typically at least 150 feet per entry, as required by project standard), attach splicing cases securely, and rack cables to maintain bend radius and enable ease of future access and maintenance.

Recommended industry standards call for at least 12 inches vertical separation (directly above the conduit) for warning tape placement in open trench installations, and a minimum 1-foot lateral spacing between fiber conduit runs and other utility lines, unless otherwise required by joint utility agreements or local code.

Lateral Spacing Between Conduits

- Main fiber conduit runs should maintain a minimum 1-foot (12 inches) lateral separation from parallel utility conduits (such as power, water, or gas) to minimize risk and facilitate safe future access.
- This spacing helps avoid electromagnetic interference and physical damage from other utilities.
- Increased separation may be required in joint trench scenarios where congestion or utility type demands it.

Warning Tape Placement Relative to Conduit

- The warning tape must be placed directly above the conduit, with a standard vertical spacing of 12 inches below finished grade, and with at least 6–12 inches of compacted soil covering the conduit before tape placement.
- Tape should run continuously and center over the conduit path for the entire length of the installation, using overlaps as necessary where rolls change.

Special Notes

- For multiple fiber conduits within the same trench, maintain spacing as specified by project engineering standards, so that each conduit and corresponding warning tape can be distinctly detected and identified.

- Always confirm lateral spacing requirements with local utility coordination and municipal standards, which may call for greater separation (up to 36 inches or more in some jurisdictions).
- See trench cross-section diagrams in official fiber optic construction standards for project-specific details.

Underground Route Assessment & Planning

Before any field construction activity begins, a comprehensive review and assessment must be performed to ensure proper project execution and minimize unintended impacts.

Key Assessment Steps

- **Engineering Plan Review:** Examine final engineering maps and cross-verify with the bill of materials to ensure all construction components and placement locations are accurately represented.
- **Physical Walkout:** Conduct an on-site route walk or drive to inspect conditions, confirm map accuracy, and identify any obstacles not present on engineering drawings (e.g., new landscaping or unmarked features).
- **Equipment Setup Areas:** Designate and protect equipment laydown and setup zones. Utilize plywood, planking, or similar materials to prevent or limit damage to sod, pavement, or landscaping from heavy vehicles and machinery.
- **Access & Egress Pathways:** Identify clear and safe routes for crew and equipment movement to, from, and along the work area, considering traffic patterns, tight spaces, and public interface points.
- **Handhole and Access Point Locations:** Review and identify all proposed handhole placements. Confirm that positions meet design intent and avoid conflict with existing or future structures, utilities, or landscape features.
- **Hazard Assessment:** Identify and document adjacent roadways, intersections, and street hazards requiring specific traffic control plans; plan accordingly for signage, flaggers, or barriers.

- **Obstruction & Landscape Jeopardy:** Flag all physical obstructions (retaining walls, fences, trees, garden beds) and areas where construction may threaten landscaping or private property. Consider alternate routing or special construction techniques as needed.
- **Documentation & Verification**
- **Photo/Video Documentation:** Systematically record pre-construction conditions using photographs and/or video. Document driveways, sidewalks, lawns, gardens, other landscape elements, and property entrances adjacent to the construction route.
- **Damage Prevention & Claims:** All documented imagery should be time-stamped and stored securely as evidence for resolution of any future damage disputes or resident complaints.

These planning and documentation steps are critical for protecting customer and property owner interests, supporting defensible construction practices, and ensuring project compliance and professionalism.

Underground Utility Cable Locates

Before starting any underground excavation or directional boring, contractors must ensure that all existing buried utilities (telecom, power, gas, water, sewer, etc.) in the work zone have been accurately located and clearly marked.

- 811 One Call Protocol:
- Contractors must contact the local One Call system (811) at least 72 hours before work is scheduled to begin, providing complete dig location details and scope of excavation.
- Utilities (or their subcontracted locators) will visit the site to mark buried lines, typically with color-coded flags or paint:
 - Red: Electric
 - Yellow: Gas
 - Orange: Communications
 - Blue: Water
 - Green: Sewer
- If marks are missing or unclear, or if the contractor has any reason to suspect the presence of unmarked cables, they must immediately renew the 811 locate ticket request—do not dig until confirmation is received.
- Mark Validity and Ticket Management:
- Locate markings expire after 15 days (or sooner if eroded, moved, or construction delays occur).
- If the construction start is delayed or if initial paint/flag marks are no longer visible, the contractor must update or submit a new ticket for re-locating and marking the area.
- Work Start Authorization:
- Excavation, trenching, or boring should only commence once all known existing facilities are visually identified and clearly marked in the field.
- Contractors must keep active locate ticket documentation on-site for the duration of excavation activities.

- Safe Digging Requirements:
- No mechanical excavation or directional boring is allowed within 2 feet (24 inches) of a marked utility line.
- When a crossing or close approach is necessary, “pot-holing” (careful soft digging or vacuum excavation) is required to visually expose and confirm the exact location and depth of the existing utility before proceeding.
- Extreme caution must be taken to avoid damaging any marked or unmarked utilities, especially when working within congested urban corridors or near critical infrastructure.

Failure to follow these requirements may result in hazardous conditions, service outages, severe financial penalties, and project shutdowns. Strict adherence to One Call (811), utility location best practices, and jobsite documentation requirements is mandatory on all fiber construction projects.

Open Trenching

The open trench method for installing fiber optic cable involves a sequence of clearly defined steps focused on safety, efficiency, and network reliability. The method is widely used for new underground deployments where direct access to the soil is permitted, and restoration requirements are manageable.

Summary of Open Trench Method

The core steps are route marking, excavation, conduit or cable placement, backfill, and post-installation testing.

Step-by-Step Process

- **Route Marking & Utility Location**
Mark the entire cable path using paint or flags. Confirm the location of existing utilities to prevent damage during excavation.
- **Trenching (Excavation)**
Excavate a trench according to local depth and width standards—typically 36 inches deep, avoiding unnecessary soil disturbance. For handhole or large section placement, deeper trenches may be required.
- **Conduit Placement**
Place the required conduit directly into the open trench per the engineering specs. The conduit should lay flat, and all joints glued, and proper long radius sweeps installed per the design. The cable should be fed gently to avoid kinks and sharp bends (maintain minimum bend radius).
- **Backfilling & Warning Tape**
Backfill the trench with indigenous soil, restoring compactness to avoid future settling. Include a warning tape at a standard distance above the cable (e.g., 12 inches below the surface) to alert future excavators.
- **Cable Splicing & Testing**
After cable placement, complete splicing using fusion methods for reliability. Test with an OTDR or power meter to ensure signal integrity across the installed length.

Best Practices

- Avoid sharp bends in conduit/cable.
- Monitor cable tension during pulls to prevent fiber damage.

- Verify trench depth and alignment for consistent protection and performance.
- Use marking and safety protocols throughout the job.
- Restore site conditions upon completion in accordance with relevant environmental standards.

Notes

- Open trenching offers the advantage of immediate visual inspection and adjustment during installation.
- All procedures should strictly follow local codes, safety standards, and manufacturer recommendations concerning fiber cable minimum bend radius, conduit types, and soil backfill.

Horizontal Directional Boring

Process Overview

- Planning and Setup
- A bore path is designed based on engineering maps and existing utility locates, considering depth, alignment, and entrance/exit points.
- Entry and exit pits are excavated at the planned bore start and end to facilitate drilling equipment setup and to capture drilling fluids.
- Pilot Bore Drilling
- A pilot bore is drilled along the pre-determined horizontal path. The drill head is steered using real-time surface tracking/locating technology to maintain constant depth and alignment around utilities and obstacles.
- Drilling fluid (mud) is pumped continuously to cool/lubricate the bit and carry debris to the surface.
- Borehole Enlargement (Reaming)
- If the required conduit diameter is larger than the pilot bore, a back-reamer is attached to the bore rod and pulled back through the bore, enlarging the diameter in one or more passes as necessary.
- Drilling fluids are used to help maintain borehole integrity and remove cuttings.
- Conduit Installation
- The fiber conduit(s), with tracer wire securely taped alongside and swivel connections to prevent twisting, is attached behind the reamer and pulled back through the completed bore from exit pit to entry pit.
- The pipe must be free of kinks, excessive bends, or damage.
- Bore Logging and As-Built Documentation
- Bore logs are created for every HDD shot, documenting entry/exit points, depth, pitch, utilities crossed, conduit size/type, and pulling tonnage.
- This record is part of final as-built package and is critical for future maintenance and compliance.
- Restoration and Clean-Up

- The pits are backfilled/compacted and all work areas restored to pre-construction conditions with care to restore sod, pavement, or landscaping as appropriate.
- Drilling fluids are properly disposed of according to environmental regulations.

Advantages

- Minimally Invasive: Significantly less surface disruption compared to open trenching—ideal for installing under paved surfaces, railroad tracks, driveways, wetlands, and waterways.
- Efficient and Safe: Reduces traffic impacts, accelerates installation, and protects existing infrastructure.

Key Requirements

- All utilities must be safely potholed and verified before drilling.
- Tracer wire must always be installed with conduit for future locate purposes.
- Bore logs are required for every section for quality control and future reference.

Directional boring is the preferred method for fiber optic installation in complex areas due to its precision, reduced restoration requirements, and ability to navigate congested corridors with minimal risk to existing utilities.

Plowing

Plowing cable is a trenchless installation method ideal for rural, open areas with minimal buried utilities. It enables rapid conduit or cable placement with lower surface disturbance but is not suitable in constrained or utility-congested corridors.

Conduit Plowing

- **Optimal Conditions:**
Plowing is best suited for open land or rural rights-of-way where the risk of encountering multiple underground utilities is minimal and equipment has ample maneuvering space.
- **Plowing Equipment:**
A cable plow machine, typically a tracked or wheeled tractor—features a strong steel blade attached to its rear. The blade has a trailing “chute” that guides inner-duct or cable down into the soil as the machine moves forward.
- Vibratory plows use a vibrating action to ease the blade into the ground, minimizing soil displacement and the force needed for installation.
- Static plows use direct force, suitable for softer soils.
- **Installation Sequence:**
- **Route & Utility Clearance:**
- The intended path is clearly staked, and all underground utilities are located, marked, and cleared.
- Obstacles or structures (culverts, old foundations) are identified and managed before plowing.
- **Plowing Action:**
- The machine inserts the plow blade to the specified burial depth—typically 36" depending on cable type and local code.
- The inner-duct/conduit is continuously fed from the payout reel, through the guide chute on the plow, and placed at the bottom of the furrow as the blade advances.
- Marker tape (or warning tape) is also installed above the conduit or cable, usually about 12" below the final grade, to alert future excavators.

- Operation Completion:
- At the completion point, the blade is smoothly withdrawn from the ground, leaving the conduit exposed at both ends for later access (such as for handhole or splice vault installations).
- The conduit ends are cut clean, capped or taped, and left exposed until subsequent construction activities are complete.
- Restoration:
- The soil closes naturally over the narrow slot left by the plow, requiring minimal site restoration compared to open trenching. In some soils, additional backfill or regrading may be required.
- Key Precautions:
- Plowing should never be attempted through areas with dense utility congestion or where precision placement and numerous crossings are required—the risk of damaging existing facilities is too great.
- All plowing operations must strictly avoid existing locates, and a “ripping pass” without duct may be done first to scout the route in tough soils.

Cable plowing is a cost-effective, efficient, and environmentally friendly installation method for new fiber routes in suitable conditions, greatly speeding construction where utility risks are low and open land is available.

Underground Conduit Depths

Buried Conduit/Cable Depths

Construction Method	Minimum Depth	WSDOT Standard Depth
Open Trench	36"	60" in state highway ROW
Horizontal Directional Drilling	36"	60" in state highway ROW
Cable Plowing	36"	60" in state highway ROW

- **Open Trench:**
Standard burial for conduit and cable is 36 inches below finished grade for most local roads and easements. WSDOT requires 60 inches (5 feet) in state highway right-of-way to provide increased protection from future excavation and heavy traffic loading.
- **Horizontal Directional Drilling (HDD):**
Common burial depth for drilled conduit/cable is also 36 inches, matching open trench standards, with state highway crossings requiring a minimum of 60 inches per WSDOT requirements.
- **Cable Plowing:**
For rural and open areas, plowed conduit/cable is installed at 36 inches deep; again, 60 inches is the minimum for WSDOT-regulated state highway right-of-way cross-ings.

Note:

Local ordinances, the presence of existing utilities, geological conditions, and/or specific customer requirements may mandate increased burial depth or special protection measures for conduit or cable.

Any planned depth variation or deviation from these standards must receive explicit approval from NoaNet OSP management prior to construction.

This ensures compliance with state and local regulations while maintaining the safety and integrity of the fiber optic network.

Permitting Requirements

Required Permits

- **Right-of-Way (ROW) Permit:**
Issued by the authority having jurisdiction (city, county, or state) for construction activities in public roads, ROWs, or easements. Includes road crossings, shoulder work, and sidewalks.
- **Excavation/Dig Permit:**
Required for any type of excavation, grading, or open trench installation in public or private property.
- **Traffic Control Plan Approval:**
Needed when trenching adjacent to or within roads—specific plans for signage, flaggers, barriers, and safe pedestrian management, approved by the local road or highway department.
- **Erosion and Sediment Control Permit:**
Required by state/local agencies to ensure compliance with stormwater, erosion, and restoration plans for disturbing soil or working near waterways.
- **Railroad Crossing Permit or Utility License Agreement:**
Special permit/license required when trenching under or adjacent to railroad property, with plans often requiring engineering stamps and agency review.
- **Environmental Permit(s):**
Needed if work will impact wetlands, protected species/habitats, or other environmentally sensitive areas (may require coordination with EPA, Fish & Wildlife, or similar).
- **Franchise or Utility Installation Permit:**
Often required for installing public utilities/fiber in municipal or utility-owned corridors, can include insurance, bonding, and franchise agreements.

Utility Clearances

- **811 One Call / Utility Locate Ticket:**
Contractor must notify the local One Call system (811) prior to excavation, typically at least 72 hours in advance. All buried facilities (gas, electric, telecom, water, sewer) must be marked and cleared before digging begins.

- **Verification and Potholing:**
Required for all marked utilities prior to crossing—visual confirmation (potholing) is mandated to determine precise depth and alignment.
- **Utility Coordination/Relocation Approval:**
If a conflict is found, contractor must coordinate with utility owner(s) for relocation approval or risk mitigation.

Additional Documentation

- **Approved Construction Plans:**
Must include details of open trench alignment, conduit spacing, minimum depth, utility separations, and restoration measures, submitted to and approved by the local authority.
- **Performance Bond and Insurance:**
Most jurisdictions require proof of adequate insurance and a performance bond to cover restoration or damages.

Obtaining all proper permits and utility clearances is essential for legal compliance, safety, and protection from liability during open trench fiber optic installation

Hard Surface Removal/Replacement

Hard Surface (Pavement Removal/Replacement) Standards

- **Advance Approval Required:**
No pavement shall be cut or removed during the underground construction process without specific, advance authorization from NoaNet OSP Project Management. Contractors must submit a detailed work plan for prior review and approval outlining the scope, location, and restoration strategy for any pavement impact.

Restoration Requirements

- Any approved pavement excavation must strictly comply with local agency or regional pavement cut policies, including alignment, edge treatment, backfill materials, and compaction requirements to restore subsurface support.
- Road base must be reconstructed to match or exceed the original compaction (by specification or as indicated in local standards).
- Final surface restoration must use pavement materials (asphalt, concrete, or specialty materials) that match the pre-existing surface type, thickness, and finish, ensuring a flush and even transition at all joints.
- Pavement cuts typically require full-depth saw cuts with straight edges, and removal must avoid damaging adjacent slabs or pavement sections.
- Restoration includes the removal of all debris, temporary surface treatments, and excess materials from public ways.

Inspection and Warranty

- Restoration work is subject to inspection and acceptance by NoaNet, the relevant municipality, or agency.
- A warranty period (often 12–24 months) may be imposed for repairs to settle or fail prematurely, with the contractor responsible for re-work within this period.

Documentation

- All restoration work, including field testing of compaction and records of material placement, must be documented in as-built submittals.

Note: No unapproved pavement disturbance is permitted. Substandard restoration or unauthorized work may result in stoppage, additional corrective costs, and/or penalties as outlined in NoaNet and local agency standards.

Cable Placement in Conduit: Pull and Blowing Methods

Placing fiber optic cable in conduit is achieved by either the “Pull” or “Blowing” method, each suited to different conduit lengths, configurations, and site conditions.

Cable Placement in Conduit: Pull and Blowing Methods

Preparation for Both Methods

- The cable reel must be positioned in-line with the conduit pathway, allowing for smooth feed as the cable is pulled or blown in.
- Always pull cable off the top of the reel to avoid twists and ensure proper cable orientation.
- Trained personnel should be stationed at both the sending and receiving ends, equipped with line-of-sight or wireless communication to coordinate and monitor installation progress and address issues immediately.

Pull Method

- Best Use: Short conduit segments (generally less than 100 meters) or routes with multiple interim access points (break points) or bends.
- Setup: Requires a pre-installed pull rope or mule tape in the conduit, cable grips or pulling eyes, rollers at entry/exit to avoid sharp bends, and a powered cable puller or manual effort.
- Process: The cable is attached to the pull rope at one end and drawn steadily through the conduit to the other end. Proper tension control is critical to prevent exceeding the cable's maximum rated pulling force. Lubricant may be used to reduce friction.
- Advantages: Minimal equipment needed; effective for short, complex runs or building entryways. Simple to mobilize and reset for multiple segments.

Blowing Method

- Best Use: Long, continuous conduit segments—often hundreds or thousands of feet—with minimal splices or access point interruptions.
 - Setup: Specialized compressed-air blowing machine and seals; the cable is fed into the conduit entrance and propelled by high-pressure airflow, sometimes with a mechanical feed assist.
 - Process: The pressurized air reduces friction, allowing the cable to move smoothly around bends and through extended conduit runs. Personnel at start and end points track cable progress and communicate to avoid jams.
 - Advantages: Faster and much lower cable tension over long segments. Tens of thousands of feet may be installed in a single run if the conduit is clear and conditions are optimal. Particularly effective for modern large-diameter HDPE or micro duct systems with sweeping bends.
-

Safety and Best Practices

- Always Monitor cable tension and pathway; use proper lubricants compatible with the cable jacket.
- Use intermediate figure-eight lay-down techniques for long or complex pulls to prevent twisting or excess tension.
- Communication between all involved installers is essential for preventing cable damage and ensuring successful conduit placements.
- Test conduit for continuity/obstructions prior to installation to ensure a clear pathway.
- Follow manufacturer and industry standards for minimum bend radius and pulling tension in all conduit placement scenarios.

Both pulling and blowing, applied appropriately, enable efficient, damage-free fiber cable installation in conduit networks, supporting reliable, long-term network performance.

Underground Construction Materials

Below is a detailed overview of core underground construction materials for conduit and cable installation, with notes on common applications and best practices:

Underground Construction Materials

- **Conduit / Inner-Duct**
High-density polyethylene (HDPE) or PVC conduits in standard sizes (typically 1.5" or 2") used to protect and route fiber optic cable. For mainlines, inner-duct is often pre-installed with 3/4" 2500 lb.-rated mule tape for pulling or blowing fiber during cable placement. Multiple conduits may be used in a single trench based on design requirements.
- **Conduit Couplings**
Connect conduit lengths without kinks, bends, or internal obstructions. Couplings must meet manufacturer standards and maintain minimum bend radius requirements during cable placement.
- **Cable**
Fiber optic cable types vary by application (e.g., backbone, lateral, drop). It is typically dielectric or armored, with physical and optical specifications based on project scope.
- **Handholes**
Underground access points (vaults or handholes) sized to house splice enclosures, slack cable, OFDC terminals, and allow for easy cable access and future additions or repairs.
- **Rodent Screen Material**
Metallic or composite mesh screen placed in vulnerable handholes, conduit entries, or riser transitions to deter rodent intrusion and cable damage.
- **Aggregate (Compaction Rock)**
Crushed aggregate or rock bedding, placed beneath handholes and around conduit for stable, well-drained support and required base compaction.
- **Pea Gravel (Drainage Rock)**
Small-radius gravel backfills inside handholes, and vaults ensure proper drainage for splice cases and cable coil storage, preventing water accumulation and cable submersion.

- **Tracer Wire**
Insulated copper wire (typically 14 AWG or heavier) laid along conduit path and inside all buried ducts to enable future electronic location of cables for maintenance and avoidance.
- **Tracer Wire Bonding Clamps**
Connect tracer wire to ground rods, bonding points, or above-grade locator stations to ensure circuit continuity and signal transmission for locates.
- **Cable Marker Tape**
Bright, durable “Buried Fiber Optic Cable” warning tape is installed 12" above the conduit during open trench and plow construction for early warning during future excavation.
- **Cable Marker Posts / Test Stations**
Surface locators or posts installed at key route points (e.g., entry/exit of road crossings, bends, or handholes) labeled with cable owner info and contact details for emergency and test point identification.
- **Cable Wrap-Around Markers**
High-visibility, wrap-around plastic identifiers (orange with black lettering and NoaNet NOC or emergency info) attached to cable at entry/exit points in handholes or on riser guards for easy field identification.

Additional or specialized materials may be specified by engineering design or by customer requirements for segments requiring special protection, security, or identification.

Conduit

Conduit and inner-duct are essential for all underground fiber optic construction, providing physical protection, ensuring cable longevity, and allowing for future upgrades. The type, size, and number of conduits used may vary according to engineering design, local codes, and project-specific requirements.

Types and Uses of Underground Conduit/Inner-Duct

Standard Conduit Sizes and Materials

- 2" Schedule 40 PVC: Rigid polyvinyl chloride conduit, commonly used for both primary and secondary fiber routes. Offers good crush resistance and durability in underground environments.
- HDPE (High-Density Polyethylene): Available in various wall thicknesses such as SDR-9, SDR-11, and SDR-13.5. HDPE conduit is flexible, impact-resistant, and ideal for trenchless methods (like directional drilling and plowing) due to its ability to handle gradual curves and soil movements.
- Pin-point, Micro ducts, and Multi-cell: Specialty conduits (such as micro ducts or pinpoint) are used for high-density network deployments, allowing multiple cables (or future additions) in a single pathway.

Inner-Duct

- Placed inside a larger conduit to provide additional organization, separation, or future-proofing. Typically used when multiple fiber routes share a primary duct.
- Smooth wall HDPE inner-duct is preferred for direct burial and blowing/cable jetting applications. Corrugated forms are used for interior (riser/plenum) or short-run flexibility.

Tensile Support

- Mule tape (e.g., 3/4" 2500 lb.) is pre-installed for cable pulling or blowing, marked with footage indicators for precise installations and future pulls.

Multiple Conduits

- Multiple conduits may be placed simultaneously for backbone, lateral, or future expansion needs. Backfill and conduit separation should follow design drawings to ensure proper spacing and locate-ability.

Conduit Selection Considerations

- Mechanical protection (crush, impact, UV).
- Flexibility for installation method (trenching, bore, plowing).
- Chemical and environmental resistance.
- Ease of cable pulling/blowing based on interior surface.
- Future re-entry and expansion.

Always confirm conduit type, size, and placement with the current engineering design and construction maps for each phase of underground installation. Adhering to these requirements ensures robust, scalable, and code-compliant fiber network infrastructure.

Underground Conduit and Long Radius Sweeps

Conduit couplings and long radius sweeps are vital components in underground fiber optic installations, ensuring a continuous, safe cable pathway and minimizing risk of physical stress or damage during placement and throughout service life.

Purpose and Installation

- Conduit couplings are used to join individual conduit sections in cases where continuous conduit runs from start to finish are not possible due to transportation, access, or installation constraints.

Specifications

- All couplings must match the conduit manufacturer's specifications to provide a flush, smooth, and burr-free transition inside the conduit. Any mismatch, internal lip, or protrusion can obstruct cable movement or cause damage.
- Best Practices:
Use only manufacturer-approved mechanical, compression, or fusion (for HDPE) couplers. Upon joining, verify the inside diameter is clear and true before cable installation. Couplings must not create a step or edge internally that would increase cable friction or cause the cable to exceed its minimum bend radius.

Long Radius Sweeps

- Purpose:
Sweeps are used to change conduit direction (typically 90°) at handholes, vaults, or route turns while maintaining minimum cable bend radius inside the bend. This is critical to prevent micro-bends, macro-bends, or kinking which degrades fiber performance or causes eventual failure.
- Minimum Requirements:
All conduit transitions and bends must use long radius sweeps. The minimum acceptable specification is a 90-degree, 36" radius Schedule 40 sweep. This complies with common fiber optic installation standards, ensuring cables never exceed manufacturer minimum bend radius for both installation and long-term operation.
- Field Guidance:
Never use tight (short-radius) electrical sweeps or elbows intended for power wiring. All bends must be gradual and documented in construction drawings and as-built records.

Strict adherence to these coupling and sweep guidelines ensures that fiber cables can be installed efficiently, safely, and without excessive friction, reducing the risk of attenuation, signal loss, or sheath damage.

Fiber Cables

In most underground conduit installations, standard armored fiber cable is used to protect against physical damage and rodent intrusion. Throughout installation, strict adherence to cable pulling tension and bend radius standards is critical to prevent micro-bending, attenuation, or permanent fiber damage.

Key Installation Standards for Underground Armored Fiber

Cable Pulling Tension

- Always respect the manufacturer's maximum rated pulling tension (commonly in the range of 600-800 lbs. for most outside plant cables but should always be confirmed for the cable on hand).
- Use a calibrated dynamometer or continuous tension monitor when using powered pullers to ensure forces are never exceeded.
- Utilize proper pulling grips and protect the cable ends from stress or kinking during installation.

Bend Radius

- Maintain a minimum bend radius during pulling—typically 20 times the outer cable diameter—and 10 times the diameter once in final position (refer to cable manufacturer's data sheet for specific values).
- Installers must use long radius sweeps at all conduit bends and ensure cable pathways are free of sharp angles or obstructions.

Pulling/Blowing Methods

- For short runs or routes with many access points, the pull method (using pre-installed mule tape or rope) is acceptable if tension is closely monitored.

- For long, continuous segments or difficult routes, cable blowing (jetting) is preferred, as it keeps the cable under lower tension and reduces risk of exceeding bend radius in bends and handhole transitions.

Conduit Verification

- All conduit should be proofed (checked for continuity and blockages) before cable installation to ensure a clear, smooth path with no tight bends or internal obstructions.

Marking and Documentation

- Cable segments, transitions, and handhole entries must be clearly labeled, with wrap-around markers for easy identification and as-built documentation for long-term maintenance.

Testing and Inspection

- After placement, all cables must be OTDR and power-meter tested to ensure optical integrity and no excess loss from bending, pulling, or physical stress encountered during installation.

Strict compliance with these standards ensures that armored fiber is installed safely, reliably, and in accordance with all industry's best practices for underground construction.

Handholes

Handholes are critical underground access structures used in fiber networks to accommodate splice enclosures, optical fiber distribution cabinets (OFDC), slack storage, and provide access for ongoing maintenance or expansion. Proper sizing, placement, and material selection are essential for network reliability and ease of future work.

Handhole Design and Sizing

- **Purpose and Placement:**
Handholes are strategically located at splice points, OFDC and MST installations, drop/access points, and other network locations requiring access to cables and equipment. Their placement aligns with network design for both current needs and future flexibility.
- **Standardized Size Categories:**
To streamline engineering and inventory, handholes are categorized by size—small, medium, large, and extra-large—to suit the specific logistical and equipment requirements for each project segment.
 - **Small:**
Typically used for drop access or housing small splice enclosures.
 - **Medium:**
Suited for OFDC/MSTs or standard splice enclosures, and often for single backbone or distribution cables.
 - **Large:**
Accommodates multiple devices, large or multiple splice enclosures, large slack coils, or special hardware; often specified for traffic-rated or main backbone locations.
 - **Extra Large:**
Reserved for heavy traffic or specialty installations, or where future expansion is anticipated.
- **Selection Criteria:**
The appropriate handhole size depends on:
 - Equipment physical requirements (closure/enclosure size, slack storage needs, minimum bend radius for coiled cable)

- Customer or owner preferences
- Handhole manufacturer's standard product dimensions and field availability
- Anticipated future expansion or network densification needs

Typical Size Examples

Category	Common Inside Dimensions (inches)	Typical Use Case
Small	12 x 18 x 18; 17 x 30 x 36	Drop access, small splice
Medium	24 x 36 x 24; 24 x 36 x 36	OFDCs, standard splices
Large	30 x 48 x 36; 36 x 60 x 36	Backbone/traffic rated
Extra Large	48 x 60 x 36/48	Multi-device, future expansion

- **Minimum Sizing Calculations:**
Ensure handhole width and length accommodate both the minimum cable coil diameter (as determined by cable bend radius) and the length of the largest enclosure/splice case to be installed.

Installation Considerations

- **Excavation:**
Excavate sufficiently deep for handhole plus aggregate bedding; allow at least 6" clearance on each side for placement and leveling.
- **Bedding and Drainage:**
Place compacted aggregate/rock below handhole; use pea gravel inside for drainage.
- **Sod Restoration:**
Preserve and reuse removed sod around the handhole for landscape restoration whenever feasible.
- **Duct Entry:**
Duct entries are typically located near the corners to maximize coiling/storage area.

- **Product Selection:**
Select handholes rated for the anticipated load (standard, light traffic, or heavy/traffic-rated lids as specified by project scope).
 - **Documentation:**
Record precise handhole locations for as-builts (sometimes including GPS coordinates) and ensure all equipment/cable types and storage details adhere to OSP design.
-

Standardizing handhole sizes and selection criteria ensure network reliability, efficient field operations, and cost-effective long-term maintenance for underground fiber plant.

Handhole Placement Standards:

Here are detailed placement standards and best practices for fiber optic handholes, based on current industry guidelines and construction standards:

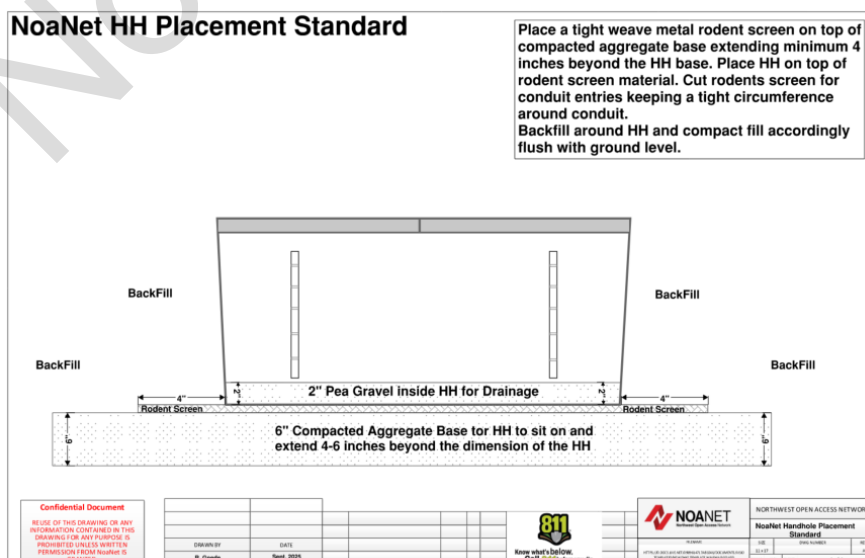
Handhole Placement Standards

- **Top Alignment with Landscape:**
The installed top surface of each handhole must be level with the existing terrain or finished grade, ensuring flush alignment for safety, drainage, and unobstructed access.
- **Rodent Screen Protection:**
Place rodent screening at the base of the handhole. The screen should overlap the edge of the handhole by at least 4 inches to prevent rodent penetration and protect internal cables and equipment.
- **Compacted Aggregate Base:**
Before placing the handhole, add a layer of compacted aggregate rock for stability:
 - Large handholes: minimum 6 inches.
 - Small handholes: minimum 4 inches.The aggregate base levels the structure provides structural support.

Pea Gravel for Drainage

- Place a minimum of 2 inches of pea gravel inside the bottom of every handhole. This drainage layer helps prevent water accumulation under and around cables and splices.
- **Field Verification:**
Field-verify the precise handhole location, orientation, and size prior to excavation and construction start. Confirm alignment with design maps, utility locates, and project requirements. Check for unanticipated obstructions or environmental conditions at each proposed site.
- **Design Changes and Red-Lines:**
Any deviation from the approved design, including handhole location, orientation, or size, requires written authorization from NoaNet OSP Project Management. All design modifications must be clearly documented as red-lines and included in the final as-built construction records.
- **Excavation Dimensions and Restoration:**
The handhole excavation should extend a minimum of 6 inches beyond each sidewall to accommodate placement, leveling, and compaction around the entire perimeter. Reuse removed sod, if possible, for restoration and to improve post-construction landscape appearance.

Following these standards ensures handhole stability, cable protection, proper drainage, and a professional, maintainable underground fiber network.



Handhole Materials

Aggregate (compaction materials) is a foundational element used to provide a stable, level, and well-drained base for handhole installations in underground fiber optic construction. Its correct selection and placement are essential for long-term performance and stability of underground enclosures.

Aggregate (Compaction Materials) for Handholes

Type

- Aggregate used beneath handholes is typically clean, crushed stone or compactible rock such as limestone, granite, or white rock. The material should be free from fines, clay, or organic debris that might settle or retain moisture.

Purpose

- Creates a level, stable base to support the handhole structure, preventing settling and shifting caused by soil movement or water infiltration.
- Improves drainage under and around the handhole, reducing the risk of water accumulation or frost heave that can destabilize the enclosure or damage cables.
- Provides uniform load transfer from the handhole to the surrounding soil, maintaining alignment with finished grade and adjacent terrain.

Installation and Thickness

Thickness by Handhole Size

- For large handholes: A minimum of 6 inches compacted aggregate base.
- For small handholes: A minimum of 4 inches compacted aggregate base.
Adjustments may be made based on specific soil conditions, customer requirements, or manufacturer guidance.
- Excavation:
The excavation area should extend at least 6 inches beyond each edge of the handhole to allow for proper placement, leveling, and compaction of the aggregate around the full perimeter.

- **Compaction:**
Aggregate must be placed in layers (lifts), each lightly watered and compacted with a mechanical tamper or hand tool to reduce voids and ensure long-term stability.

Source and Specification

- Aggregate is sourced in bulk from local quarries and should meet local or project-specific gradation and compaction standards. The rock size is generally in the 3/4" to 1" range, but specifications may vary.

Additional Considerations

- **Pea Gravel Drainage:**
A separate 2-inch layer of smaller pea gravel is typically placed inside the handhole above the compacted base to further enhance drainage and cable protection.
- **Adaptability:**
The thickness and type of aggregate may be adjusted to suit project scope, manufacturer specifications, geographic region, and customer preferences.

Proper use of aggregate compaction materials is critical for handhole durability, ease of maintenance, and long-term reliability of underground fiber infrastructure.

Pea gravel is a small, smooth, rounded aggregate—typically about 1/4" in size—used inside fiber optic handholes to promote water drainage and minimize water accumulation around sensitive cables and splice hardware.

Pea Gravel (Rock) for Handholes

Purpose and Function

- **Drainage:** Pea gravel creates an open, porous layer within handholes, allowing any water that enters to percolate through to the bottom, where it can drain out or evaporate, rather than pooling around cable jackets or splice cases. This reduces risks of corrosion, insulation degradation, or water-related cable failures.
- **Material Characteristics:** Pea gravel is generally smooth, rounded, and sized around 1/4" (but may range from 1/8" to 3/8"). Its uniform nature, without fine particles, prevents compaction and preserves drainage over time.

- **Source and Availability:** Pea gravel is widely available at local landscape or building supply yards and can be purchased in bulk or bags depending on project scope and logistics.

Usage Guidelines

- **Depth:** Typical installation calls for a minimum of 2" of pea gravel placed inside every handhole and vault, but the exact level may vary based on customer requirements, handhole size, or soil drainage conditions.
- **Placement:** The gravel is poured as a level layer just above the aggregate base, after the handhole itself is set and before cabling or splicing hardware is placed.
- **Adaptability:** In areas with poor native drainage (clay or low spots), customer specifications may call for deeper layers of pea gravel to further enhance water management or to surround and support cables.

Benefits

- Maintains a dry environment for fiber cable and hardware.
- Reduce settlement and erosion within the handhole over time.
- Easily replenished or adjusted during routine maintenance or upgrades.

Proper use of pea gravel in handholes is a standard best practice for ensuring long-term performance and maintainability of underground fiber networks.

Tracer Wire

Tracer wire is a critical component in all underground fiber optic conduit and cable installations, providing a continuous, easily detectable metallic path that enables precise location of buried infrastructure by utility locators.

Tracer Wire Specifications and Best Practices

Purpose

- Utility Locating: Tracer wire allows future detection and mapping of non-metallic (plastic/HDPE/PVC) conduits, ensuring cables can be safely traced and excavated for maintenance, repair, or upgrades without accidental damage.

Material and Sizing

- Wire Type: The recommended tracer wire for fiber installations is #12 AWG EHS (Extra High Strength) copper-clad steel, designed to maintain signal integrity through long runs and resist stretching or breakage during installation.
- Jacket: Orange HMWPE (High Molecular Weight Polyethylene) jacket is standard for fiber optic tracer wire, indicating telecom usage and providing resistance to moisture, abrasion, and chemicals.
- Alternative Applications: Integrated conduit/tracer wire solutions (e.g., Dura-Line, Pin-Point) can streamline installation and improve continuity. Detectable mule tape is a secondary option but may have locate limitations due to low conductor mass; its continuity must always be verified after installation.

Installation Requirements

Placement

- In trenching, lay tracer wire directly beside the conduit at the trench's bottom, running uninterrupted from origin to termination.
- For directional boring or plowing, pull or insert tracer wire in parallel, taped or zip-tied to the conduit exterior.
- Standalone placement inside conduit is not recommended unless project management specifically approves, as signal distortion and discontinuity are more likely.

Continuity

- All breaks, splices, or joints in tracer wire must be bonded using waterproof split bolts or approved ground clamps, especially at every handhole, pull box, or splice vault to maintain an unbroken circuit for electronic locators.
- At handholes and transition points, securely tie at least 3 feet of tracer wire off inside the vault for access and future testing.

Grounding & Bonding

- Bonding:
- Tracer wire should be bonded at power vertical ground at riser poles, or to a ground rod where required by local code, to complete the metallic locate circuit and provide optimal locate performance on long runs.
- Testing:
- After installation, perform a continuity and locate test on all tracer wire segments, including across all splices and junction points. All alternative methods (such as using mule tape) must be tested for reliability and continuity.

Documentation & Marking

- Identification:
- Mark locations of tracer wire at all access points, handholes, and at surface test stations. Clearly label for identification and future maintenance.
- As-Built Records:
- Record tracer wire location, splicing, bonding points, and test results as part of final as-built construction documentation.

Notes

- Local conditions, customer specifications, or unique project requirements may require heavier-gage wire, different color codes, or additional ground rods for extremely long or complex routes.
- Any deviations from standard installation practices must be reviewed and approved by project management and documented on red-lined as-built drawings.

Adhering to these tracer wire installation guidelines ensures reliable future location capability, enhances system integrity, and supports safe, efficient maintenance for the life of the underground fiber network.

Tracer Wire Bonding

Tracer wire bonding clamps ensure electrical continuity and locate-ability of the tracer wire throughout underground fiber installations by securely connecting tracer wire segments at junctions, grounding points, and splices.

Purpose and Locations

- Bonding to Ground:
- Bonding clamps are used to connect tracer wire to existing vertical ground wires at riser poles, providing a reliable return path for locator signals.
- In handholes or pull boxes, clamps are used to tie tracer wire ends from different conduit segments together to maintain a continuous detection circuit.
- Ground Rods:
- Where a handhole is far from grounded utility infrastructure or where local specifications are required, a ground rod may be installed in the handhole and the tracer wire bonded to it for both continuity and enhanced locate signal quality.

Fiber Locate Marker Test Station Bonding

A fiber locate marker test station is used to access and bond the tracer (locate) wire for underground fiber—with the goal of ensuring a reliable signal path for utility locators. Proper bonding is essential for accurate locating and long-term network integrity.

Materials & Tools Needed

- Approved test station (usually a marker post with an internal terminal block)
 - Tracer wire (copper-clad steel, orange jacketed)
 - Split-bolt connector, ground clamp, or test station terminal lugs
 - #6 AWG bonding jumper if required by code
 - Dedicated ground rod (usually 8' copper-clad), if site grounding is used
 - Waterproof/tamper-resistant test station cover
-

Step-by-Step Bonding Procedure

Expose Tracer Wire Ends

- At the test station (marker post or designated handhole), strip 2–4 inches of tracer wire insulation.
- Use a wire brush or alcohol wipe to clean the exposed conductor.

Bond Tracer Wires Together

- If multiple tracer wire segments are present (e.g., from two duct directions), connect them using a split-bolt connector, stainless steel crimp sleeve, or on the provided terminal lugs inside the test station, ensuring all ends are securely bonded for electrical continuity.

Attach to Test Station Terminal

- Terminate a clean tracer wire lead on the station's internal terminal, following the manufacturer's specific terminal arrangement.
- Allow 12–18 inches of extra wire coiled inside the post for future testing and repair access.

- Keep the connection neat and protected from accidental pulls or moisture.

Bond to Ground (if required)

- In many systems, especially for long routes or at ends, bond the test station terminal (with attached tracer wire) to a dedicated ground rod at the site.
- Use a ground clamp and #6 AWG bonding jumper (preferred for code compliance) to connect to the 8' ground rod.
- NEVER bond tracer wire to a power company vertical ground or to utility grounds shared with energized equipment—always use a dedicated, isolated ground to prevent stray voltage and interference.
- Integrity/Continuity Check
- Test end-to-end continuity between adjacent marker posts/handholes for low resistance (target <1000 ohms, lower is better).
- Troubleshoot and rework any high-resistance or failed paths before closing test stations.

Final Steps

- Label the test station according to OSP standards: "Fiber Optic Locate/Tracer Test Point," date, and circuit route if required.
- Secure all connections, replace station cover, and log results and location in project documentation.

Additional Notes

- After use, always disconnect locate equipment to leave tracer wire "floating" (unconnected to ground) except at designated test points—this protects the network from lightning and stray current.
- All bonding must comply with local code and project engineering standards.
- Document terminal block assignments and ground points for future maintenance reference.

This procedure ensures the tracer wire provides a continuous, accessible locating path along the entire underground fiber route, compliant with best safety and performance practices for buried cable networks.

Types of Clamps

- Copper Alloy Split Bolt Connector (6 preferred):
 - A robust, corrosion-resistant connector for mechanically binding multiple wire ends—most used for #6 wire or similar. Split bolts are favored for their strong connection and resistance to loosening overtime.
- Copper 1-Bolt Bonding Clamp:
 - A single-bolt clamp designed for rapid, secure connections between tracer wire and ground rods or other wires, often featuring serrated jaws for enhanced grip.
- Other Acceptable Connectors:
 - These may include alligator-style clamps for armored cable, B-bond clamps, or manufacturer-approved mechanical lugs—always ensuring good electrical contact, weather resistance, and physical robustness.

Installation Best Practices

Preparation

- Strip insulation from tracer wire ends as required, taking care not to nick or weaken the conductor.
- Clean the bonding point (especially on older ground wires or rods) for best conductivity.

Connection

- Use split bolts or approved clamps to secure all wire ends at handholes, ground rods, or riser grounds. Tighten securely and check for any movement.
- Multiple tracer wires can be joined under a single connector, provided all are in good contact and well-aligned.

Protection

- Once connected, wrap all exposed connections with electrical tape, corrosion-protective compound, or heat-shrink tubing if specified, to minimize corrosion and ensure long-term performance.

Inspection and Testing

- After installation, perform continuity and locator signal tests to confirm the entire tracer wire path is intact and reliably bonded through all connections.

Correct use of approved bonding clamps is essential for maintaining utility locate compliance and long-term reliability of underground fiber optic networks.

Cable Marker Warning Tape

Cable Marker Warning Tape is a crucial safety and identification tool used during open trench fiber optic conduit installation. It serves as a highly visible warning to alert future excavators that fiber optic cables or conduits are buried below, helping prevent accidental dig-ins and service outages.

Cable Marker Warning Tape Specifications and Installation

- Placement:
- Warning tape must be installed in the trench 12" above the top of the conduit or cable during backfill, ensuring it is encountered by anyone excavating before they reach the buried asset below.
- The tape should run continuously along the length of every trench where fiber optic cable or conduit is installed using open trench or plowing methods.
- Tape Characteristics:
- Color: Bright orange is the standard color for communications and fiber optic lines, per APWA (American Public Works Association) codes.
- Width and Thickness: A minimum width of 3 inches is recommended; thickness typically 4.5 to 5 mils for durability.
- Legend: Clearly printed with a repeating warning message such as "CAUTION BURIED FIBER OPTIC LINE BELOW" or similar, in bold contrasting black lettering for high visibility.
- Material: Made of polyethylene; available as non-detectable (visual warning only) or with a built-in metallic foil core (detectable) for electronic locators.
- Resistance: Engineered to resist degradation from soil acids, alkalis, and environmental conditions for long operational life underground.

Best Practices

- Ensure tape is installed straight, wrinkle-free, and above the entire length of all new conduits/cables within the trench.
- If possible, select detectable tape with an aluminum core for critical backbone or public ROW installations, allowing it to be found with non-ferrous metal locators during future marking operations.

The proper use and installation of Cable Marker Warning Tape significantly reduce the risk of accidental damage to buried fiber optic infrastructure and help maintain network reliability and safety for the long term.

Cable Route Marking Posts & Locate Test Stations:

Cable Route Marker Posts and Locate Testing Stations are above-ground devices installed along fiber optic cable routes to provide visual warning of buried infrastructure and enable effective cable location and maintenance. Their standardized placement enhances long-term safety, utility coordination, and operational reliability.

Cable Route Marker Posts

Placement Protocols

General Spacing

- Place marker posts at a minimum interval of every 1,500 feet along continuous conduit/cable paths.
- In WSDOT right-of-way (ROW), more frequent placement is required—every 500 feet and at each handhole location.

Handhole and Splice Locations

- Install marker posts with an integrated or adjacent locate/test station at every handhole and splice location for ready identification and maintenance access.

Residential Exception

- Marker posts are generally not installed inside residential subdivisions unless specifically called for and approved by engineering or customer requirements.
- However, a marker post should be placed at the entrance to each subdivision on the side where the cable enters for visibility and safety.

Physical Characteristics

- Visible Colors/Labeling
- Fiber optic marker posts are typically orange or bright yellow, featuring prominent warnings and “Fiber Optic Cable” legends, and often company or emergency contact info printed in contrasting color.
- Construction
- Made from UV-resistant plastics or fiberglass to prevent fading or deterioration

Locate Testing Stations

- Test Station Integration:
- Dedicated locate/test stations are incorporated at all handholes, splice points, or at regular intervals, providing an accessible, secure terminal for tracer wire continuity and signal testing.
- Terminate and label tracer wire at these stations so locators can easily attach test equipment for accurate path finding.

Engineering Plan Details

- As-Built Map Inclusion
- All marker post and test station locations must be shown on engineering plans and included in final as-builts
- Site-Specific Adjustments
- Final marker post placement may vary due to customer requirements, physical site restrictions, or local ordinances; all exceptions should be documented.

Best Practices

- Installation
- Posts should be set deep enough to withstand impact and remain upright (consult manufacturer for depth), tamping earth or setting concrete as appropriate for soil conditions.
- Documentation:
- Record GPS or reference locations for all marker posts and test stations for maintenance and emergency response.

Consistent use of marker posts and locate test stations along fiber optic routes is the best industry practice for operational safety, utility coordination, and rapid restoration in case of accidental dig-ins.

Construction Redline Drawings: Key Functions and Procedures

Construction redline drawings are essential real-time records created during fiber optic construction to document all deviations, field changes, additions, and clarifications from the engineered design. These annotated drawings not only capture as-built conditions but also ensure that cable quantities, hardware installed, and the precise position and depth of buried infrastructure are accurately tracked for quality management, payment, and future maintenance.

Construction Redline Drawings: Key Functions and Procedures

Purpose and Use

- **Field Documentation:**
Redline drawings are marked up in the field to reflect all construction deviations, including routing adjustments, additional or deleted splice points, and changes in cable lengths and hardware locations.
- **Verification and Reconciliation:**
They are the authoritative reference for invoice reconciliation (verifying work performed against materials billed), facilitating QC inspections, and tracking actual field work.
- **As-Built Production:**
After construction, the redline set is “cleaned up” (transcribed clearly and professionally) to create the official as-built drawings delivered to the customer, design engineering teams, and retained for regulatory or maintenance purposes.

Items Documented on Redline Drawings

- **Cable Sequential Footage:**
Tick marks at conduit entrances/exits, handhole walls, risers, and pole attachments, indicating distance from pull start or reel.
- **Slack Loops:**
Location and footage of cable slack reserved for splicing or maintenance.
- **Distribution Terminal (Type/Location):**
Optical Fiber Distribution Cabinets types and installed positions.
- **Splice Enclosure Additions/Deletions/Moves:**
Documenting all splice case changes, including hardware swaps or new locations.

- **Hardware Changes:**
Noting substitution or installation of non-planned connectors, brackets, etc.
- **Attachment Height Variance:**
Marking actual cable or messenger heights, especially at roadway, driveway, or mid-span crossings.
- **GPS Data:**
Capturing handhole, splice, and key structure coordinates for GIS and maintenance records.
- **Cable Path in ROW/Easement:**
For underground installs, mark position and depth relative to ROW boundary and major landmarks at 20-ft intervals or as specified.
- **Splicing and Fiber Data:**
Variations in splicing plan, strand reassignments, or loss budgets.

Process and Management

- **Archiving and Distribution:**
The original field redlines must be archived digitally (shared drive or project folder) for reference against design questions, damage claims, or as part of compliance documentation.
- **Workflow:**
Prior to construction, the project team clarifies the flow how redlines move from the field to QC/inspection, to engineering and customer deliverables, minimizing information loss or errors.
- **Standardization and Format:**
Redlines are typically color-coded (e.g., red for changes/additions, blue for removals) and cleaned up for clarity before final as-built submission.
- **To accurately record conduit and warning-tape locations on as-built drawings, best practices require clear documentation of actual installed horizontal and vertical position, depth, and reference points for future locating and compliance.**

Key As-Built Documentation Elements

- **Horizontal Location:**
Show the exact route on scaled site plans using surveyed coordinates, dimensions relative to fixed landmarks, and swing ties from permanent objects (such as buildings, curbs, or utility poles).

- **Vertical Profile and Depth:**

Indicate installed depths for both conduit and warning tape—include vertical elevation data (finished grade to top of conduit and warning tape). Note changes in depth, elevation at bends, and any slope along the route.

Example:

- “Conduit top at 48 inches below finished grade.”
- “Warning tape at 12 inches, centered above conduit.”
- **Reference Points & Tie-ins**
Mark major features such as handholes, splice points, terminations, and bends with GPS coordinates or offsets from site benchmarks.

Drawing Techniques

- Red-line (markup) the original design drawings to show "as-built" versus "as-designed" conditions.
- Use “clouding” or highlighting to call out as-built data—especially where the field installation differs from design details.
- For buried warning tape, note distance intervals (e.g., “3” orange warning tape placed 12” above conduit”) and label on longitudinal profiles.
- For multi-duct installations, include cross-section diagrams showing lateral separation and tape location relative to each conduit.

Records and Annotation

- Include installation dates, crew notes, and manufacturer/part numbers for tape and conduit.
- Add photographic documentation or electronically scanned field notes for critical locations, connections, and tape placement for added accuracy.
- All documented data should allow for future verification via utility locating equipment or excavation.
- Proper as-built records are critical for future maintenance, construction, and damage prevention. They help support compliance with utility marking laws and internal network management.

Below is a recommended standard annotation legend for conduit and warning tape as shown on fiber optic as-built drawings, based on APWA utility color-code guidance and common CAD/construction practices.

Symbol / Annotation	Description	Color
---	Fiber Optic Conduit (PVC, HDPE, Steel—specify type)	Orange
---	Conduit Size (ex: 2" PVC)	Text Only
---	Conduit Depth (ex: 36" BFG)	Text Only
---	Warning Tape (Detectable/Non-Detectable)	Orange
[WT]	Warning Tape Placement (12" below finished grade)	Orange
•	Handhole/Splice Box	Black
[L]	Lateral Separation Indicator (distance in feet/inches)	Text Only
[GPS]	GPS Install Location/Key Reference Point	Black
X	End-of-Run or Termination Point	Black

Standard Annotation Legend for As-Builts

Legend Notes:

- Orange line/symbol consistently denotes telecommunication assets (fiber optic conduit and warning tape).
- Conduit runs and warning tape lines should be clearly labeled with depth, size/type, and installation notes such as "Warning Tape: 12" centered above conduit, overlapped every 20' as required."
- Lateral separations to other utilities should be annotated and dimensioned in plan view (e.g., "Minimum 12" from water main").
- Each run of warning tape should be noted in longitudinal profiles and cross-section diagrams for completeness.

Red line as-built guidelines ensure all field construction changes are captured for accurate post-construction documentation in fiber optic projects. The following best practices and typical markups support high-quality redline drawing preparation:

Red Line As-Built Guidelines for Fiber Optic Construction

- Use Red Ink or CAD Markup Tools
- Mark all deviations from design in red on physical drawings or digital markups to visually highlight changes.
- Record Field Modifications
- Document actual routes, offsets to permanent landmarks, conduit runs, hand-holes, fiber cable locations, and lateral separation from other utilities.
- Amend depths, sizes, and installation method notes when varying from planned design (e.g., open trench vs. directional bore).
- Update Features and Assets
- Add handhole, splice case, junction box, and termination locations with measured field data and GPS coordinates if available.
- Note cable sequential footage at entry/exit points, slack loop locations, and any additional features introduced during construction.
- Label Changes Clearly
- Annotate all adjustments with dates, who performed the markup, and legible notes explaining the reason for change if required by project standards.

- Use project-specific abbreviations and legends to keep documentation consistent.
- Include Depth, Elevation & Dimensional Data
- Show installed depths for conduit and cable, warning tape placement, and vertical/lateral offsets from reference objects.
- Maintain On-Site Access Throughout Construction
- Preserve redlined drawings on site until final as-built submittal so all field crews and inspectors can reference current updates, minimizing lost change history.
- Coordinate With As-Built Drawing Production
- After construction, transfer all redlines markings to final as-builts with scale-matched, neat, and clear information; do not omit interim updates from crews.

Typical Redline Drawing Items for Fiber Optics

- Conduit type/size changes and installed depth
- Actual cable pathway (horizontal and vertical route)
- Swing tie dimensions to permanent features/structures
- Handhole & splice box locations (w/GPS or reference points)
- Warning tape, slack loop, and meter/tic mark labels
- Lateral separation and crossing details with utilities
- Date and initials for each marked-up change

Consistent, clear redline practices ensure efficient as-built record production, regulatory compliance, and reliable future maintenance. Red line as-built guidelines for fiber optic construction should be consistently applied to capture all field changes for post-construction documentation and compliance. The most important best practices are outlined below

Red Line Drawing Procedures

- Use red ink or equivalent digital markup to highlight every change from the issued-for-construction (IFC) drawings.
- Record actual field location for conduit runs, handholes, cable paths, slack loops, and utility crossings, providing swing-ties or measured offsets to permanent site features (e.g., curb, pole, building).

- Indicate all vertical and horizontal dimension changes, including depth/elevation for conduit, cable, and warning tape placement.
- Clearly note the type and size of installed conduit and fiber cable if different from plan.
- Annotate changes with field dates and initials for traceability; maintain a legend matching original drawing nomenclature and abbreviations.
- Document GPS coordinates at key assets such as handholes, splice points, and every 100 feet for long backbone routes.
- Include meter/tic marks at cable entry, splice, handhole, or exit locations for accurate sequential tracking.
- Keep a dedicated red line set on-site throughout construction, and ensure all crews update it regularly until project closes out.

Typical Fiber Redline Markups

- Cable route deviations (plan vs. installed)
- Depth changes for trench or conduit
- Lateral offset and alignment to permanent markers/structures
- Actual handhole or splice case installed locations
- Crossing details for other utilities (label, dimension, and type)
- Addition/removal of field-installed accessories (slack loops, marker posts)
- Final cable counts and fiber strand usage, if different from plan

Thorough redline documentation is essential for creating accurate as-builts and ensuring ongoing network maintenance and safety.

GPS Data Collection for Red-Lines

For fiber optic as-builts, the standard requirement is to collect GPS data with sub-meter horizontal accuracy (± 1 foot or ± 0.3 meters), using survey-grade or real-time kinematic (RTK) GPS, and to document coordinates in decimal degrees (latitude and longitude) to at least five decimal places for compatibility with GIS and mapping systems.

Required GPS Precision

- Horizontal Accuracy:
 ± 1 foot (± 0.3 meters) is best practice for buried asset location, and in many jurisdictions this level (sub-meter) is a minimum for regulatory or permitting compliance.
- Vertical Accuracy:
 ± 0.1 foot (± 0.03 meters) when elevation data is captured, especially for critical depth/bury documentation.

Coordinate Format

- Decimal Degrees (WGS84):
Example:
 - Latitude: 47.60985
 - Longitude: -122.33322Record to at least five decimal places for 1-meter resolution.
- Alternative formats:
 - UTM (Universal Transverse Mercator) or State Plane, if required by local jurisdiction or engineering standards.
- X, Y, Z (Easting, Northing, Elevation):
Used if site benchmarks reference a specific projection.

Field Protocols

- Document all significant assets—handholes, splice vaults, major bends, slack loops—with discrete GPS points.
- Use continuous line-string or segmented points for long conduit paths if supported by asset management system.
- Always specify coordinate reference system (CRS), such as "WGS84," on as-built documentation.

Following these guidelines ensures all as-built GIS data is precise, field-verifiable, and interoperable with all major mapping and locating platforms. Industry best practices for fiber as-built GPS documentation require sub-meter accuracy (± 1 foot or ± 0.3 meters) horizontally and decimal degree coordinate format captured to at least five decimal places, referenced to WGS84 or the project's required datum.

Recommended GPS Precision

- Horizontal: ± 1 foot (± 0.3 meters) minimum accuracy for buried assets, achieved via RTK GPS, post-processed differential correction, or survey-grade equipment.
- Vertical: ± 0.1 foot (± 0.03 meters) if elevation is specifically required for project documentation.

Standard Coordinate Format

- Decimal Degrees (WGS84 datum)
- Latitude: 38.89768
- Longitude: -77.03655
- Record to five decimal places (e.g., 38.12345) for sub-meter asset mapping.
- Alternative formats:
- UTM, State Plane, or other local coordinate systems if required for the project, with explicit note of the coordinate reference system (CRS) on documents.
- For elevation (vertical), add the Z value in meters or feet.

Documentation Protocol

- List the coordinate system and datum on all as-built plans and GPS data summaries.
- Document individual points for major assets (handholes, splice cases, vaults) and line strings for conduit runs.
- Include import logs and post-processing files if required by client or regulatory deliverables.

Using these standards supports accurate fiber network asset management, regulatory compliance, and reliable future utility locating. The required GPS precision for fiber optic as-builts is typically sub-meter accuracy (± 1 foot/0.3 meters horizontally), which is achievable with survey-grade GNSS or RTK GPS. Coordinates should be recorded in decimal degrees format (e.g., 47.12345, -122.54321), with at least five decimal places to ensure 1-meter or better spatial resolution.

Precision and Format Standards

- Horizontal accuracy: ± 1 foot (± 0.3 meters) minimum; ideally to sub-meter level using differential or RTK GPS.
- Vertical accuracy: ± 0.1 foot (± 0.03 meters) when elevation is provided or required.
- Coordinate format: Decimal degrees (WGS84), e.g., 47.12345, -122.54321. Record the CRS (Coordinate Reference System) with all data.
- Alternative coordinate systems: UTM NAD83 or State Plane may be required by some agencies or clients, include details on deliverables if used.
- Data documentation: Note specifics of the survey method, device, and correction files in project records.

Field Practice

- Record discrete GPS points for all major features (handholes, splice vaults, cable transitions) and at representative intervals along long continuous runs.
- Label each asset on the drawing with the latitude, longitude (and elevation where relevant), using the agreed format.

These standards allow high-confidence location data for future maintenance, damage prevention, and regulatory compliance. For as-built documentation of fiber optic construction, the standard required GPS precision is sub-meter horizontal accuracy (± 1 foot/0.3 meter) for all key assets and changes in alignment. The accepted coordinate format is decimal degrees (latitude and longitude, e.g., 47.12345, -122.12345) to at least five decimal places, with the WGS84 datum or a project-defined coordinate system clearly specified.

Key points for GPS data in as-builts:

- Use professional mapping or RTK GPS equipment that provides sub-meter accuracy.
- Record coordinates in decimal degrees (latitude and longitude), with a minimum of five decimal places.
- Document elevation (Z) to ± 0.1 foot if required for project depth verification.
- Note the coordinate reference system (CRS) usually WGS84 or local State Plane/UTM as required.
- Provide GPS data for all critical features (handholes, vaults, alignment changes, crossings).

- Retain field and post-processing data for compliance and audit purposes.

This ensures locations are compatible with GIS, regulatory, and client requirements for asset location and future utility management.

There are several GPS technology options for collecting data in fiber optic construction as-builts, ranging from basic handheld units to advanced survey-grade solutions offering sub-meter accuracy. The right choice depends on required precision, budget, and integration with asset management systems.

GPS Options for As-Built Data Collection

Basic Handheld GPS Units

- Devices like Garmin eTrex or Magellan handhelds.
- Provide 3–5-meter accuracy—adequate for rough mapping but not suited for precise utility locating.

Mapping-Grade GNSS Receivers

- Units from Trimble, Leica, or Topcon (such as Trimble Geo 7X, Leica Zeno).
- Typically achieve 1–3-meter accuracy and integrate with field mapping apps for asset documentation.
- Suitable for non-regulated projects and asset mapping where sub-meter accuracy is not critical.

Survey-Grade GPS (RTK GNSS)

- Capable of sub-meter to centimeter accuracy (e.g., Trimble R10, Leica GS18, Topcon HiPer).
- Uses reference stations or real-time correction (RTK) for ± 1 foot or better accuracy required in utility and fiber as-builts.
- Typically paired with tablet/mobile platforms, GIS apps, and data loggers.

GNSS Mobile Mapping Systems

- Integrated GPS+IMU systems on vehicles or handheld rigs.
- Ideal for high-volume, linear assets (long conduit runs or backbone fiber) with real-time georeferenced mapping capability.

Smartphone and Tablet GPS (Consumer Devices)

- Accuracy ranges from 3–10 meters; Field apps (ArcGIS Collector, ESRI Field Maps) can collect and sync data but are limited in precision.
- Useful for preliminary mapping but not sufficient for regulatory or asset management documentation.

Recommendations

- For high-precision as-builts, use survey-grade RTK GNSS receivers with GIS integration.
- For inspection or field checks, mapping-grade GNSS or mobile mapping is often sufficient.
- Always ensure devices can export coordinates in decimal degrees and documentation complies with specified accuracy and coordinate system standards.

Selecting the right GPS solution ensures reliable asset tracking, regulatory compliance, and smooth data integration into GIS and mapping platforms.

This legend ensures clear, standardized identification, supporting future locate requests and network maintenance. If project-specific symbols are required, add custom legend items to match organizational design standards.

Abbreviation	Full Name	Description
PVC	Polyvinyl Chloride Conduit	Standard plastic conduit for direct burial
HDPE	High-Density Polyethylene	Flexible, continuous duct for long pulls and HDD
EMT	Electrical Metallic Tubing	Thin-walled metallic conduit (for exposed/interior runs)
RMC	Rigid Metal Conduit	Rigid steel conduit
IMC	Intermediate Metal Conduit	Lighter than RMC, approved for many of the same uses
RNC	Rigid Nonmetallic Conduit	Generic plastic/concrete raceway; often overlaps with PVC
LFMC	Liquid-tight Flexible Metal	Flexible, water-resistant metallic conduit
GRC/GRMC	Galvanized (Rigid) Metal Conduit	Heavy-duty, corrosion-resistant steel
PLA	Plastic (generic)	Used for nonstandard or various plastic pipes

Common Conduit Type Abbreviations

For as-built documentation, the following industry-standard abbreviations are recommended for different conduit types and sizes. These abbreviations improve clarity, reduce plan clutter, and are widely recognized by engineers and inspectors.

Conduit Size Annotation

- Indicated by inside diameter in inches or mm (example: 2" PVC, 4" HDPE)
- For multi-duct packages, use: (3) 1.25" HDPE (denotes three 1.25" HDPE ducts)
- For metric: 110mm HDPE

Typical Abbreviation Usage in Plan Notation

- 2" PVC @ 36" BFG: 2-inch PVC conduit at 36 inches below finished grade
- 4" HDPE @ 36" BFG: 4-inch HDPE at 36 inches below finished grade

Cable/Innerduct

- SM: Single-mode fiber
- MM: Multimode fiber
- PLB: Polyethylene Lined Steel Bore
- CIC: Cable-In-Conduit (often prefabricated assembly)
-

Standardizing these abbreviations supports consistency and quick reference in any construction documentation or fiber optic network as-built record. Always reference the project's specific legend for any additional custom abbreviations.

Utilizing thorough, well-managed redline drawings is a recognized best practice and contractual requirement in fiber network construction, directly supporting quality, accountability, and effective network operation.

Fiber Optic Cable Splicing Standards and Best Practices



Fiber Cable Prep for Splicing:

Here's a detailed summary of standard fiber optic cable preparation (prep) and the industry standard fiber splicing order:

Fiber Cable Preparation Steps

- Safety and Tools
 - Gather tools: fiber jacket stripper, buffer tube stripper, Kevlar cutters, fiber cleaver, isopropyl alcohol wipes, lint-free wipes, fusion splicer, splice sleeves, and safety glasses.
 - Access the Cable
 - Remove the outer cable jacket carefully, expose buffer tubes or ribbon, and trim strength members like aramid yarn as needed.
 - Buffer Tube Removal
 - Strip buffer tubes to reveal color-coded fibers, leaving enough exposed fiber for routing and preparation.
 - Clean the Fibers
 - Use isopropyl alcohol wipes to thoroughly clean bare fibers. Repeat with fresh wipes to prevent contamination.
 - Precision Cleaving
 - Cleave the fibers so each end is flat and perpendicular (ideally 90°) critical for low-loss splicing.
 - Splice Protection
 - Slide the splice sleeve onto one fiber before splicing, so it can be easily placed over the finished fusion splice for protection.
-

Standard Splicing Order (Color Code)

TIA-598-C Color Sequence for Individual Fibers (repeats every 12 in large cables)

- Blue
- Orange
- Green
- Brown
- Slate (Gray)
- White
- Red
- Black
- Yellow
- Violet
- Rose (Pink)
- Aqua

Standard Splicing Order

- Always splice matching colors between cables to maintain logical continuity for troubleshooting and future test/repair.
- For cables over 12 fibers, the color code repeats: Fibers 13–24 start again at blue but may have a colored stripe to distinguish tube/bundle.

Standardized splicing orders for 288, 144, and 48-fiber cables, showing how fibers are typically designated for transport, future use, and distribution:

Standard Splicing Order Examples

288-Fiber Cable

- Fibers 1–24: Reserved for Transport (long-haul or critical backbone circuits)

- Fibers 25–60: Reserved for Future Use (for growth, restoration, or future customers)
- Fibers 61–288: Used for Distribution Feeder Fibers from the cabinet to the subscriber/service areas
- Splicing Process: Start splicing at the highest fiber count position down (i.e., begin with fiber 288, work downward as necessary for distribution splices; reserve the lower counts).

144-Fiber Cable

1. Fibers 1–24: Reserved for Transport
2. Fibers 25–48: Reserved for Future Use
3. Fibers 49–144: Used for Distribution Feeder Fibers
4. Note: "Highest cable count down" means distribution splices typically begin at fiber 144 and descend, retaining lower numbers for trunk and growth.

48-Fiber Cable

- Fibers 1–12: Reserved for Future Use
- Fibers 13–48: Used for Distribution Feeder Fibers
- Order: Splicing starts with fiber 48 (distribution) and proceeds downward, leaving the lowest fibers unused or for planned expansion.

1		Blue
2		Orange
3		Green
4		Brown
5		Slate
6		White
7		Red
8		Black
9		Yellow
10		Violet
11		Rose
12		Aqua

Fiber Splice Case Enclosure: Step-By-Step Guide

Here's a detailed, standardized step-by-step process for preparing and installing a fiber optic splice case enclosure, incorporating best practices for both safety and reliable network performance:

Preparation

- Gather the splice closure kit and all required hardware (grommets, sealing rings, retention clamps, ground wires, mounting brackets).
- Ensure all fiber cables to be installed are onsite and have slack available for splicing.
- Prepare all necessary fiber tools: jacket and buffer tube strippers, fiber cleaver, fusion splicer, scissors, and measuring tape.
- Get cleaning supplies—alcohol wipes, lint-free cloths—for cable and fiber prep.
- Have all consumables ready: zip ties, heat shrink splice sleeves, labeling tape, work gloves, and safety glasses.

Site Prep

- Choose a clean, dry, well-lit work area—ideally a bench in a splicing trailer or controlled environment.
 - Lay out all tools and materials within easy reach.
-

Step-by-Step Installation Process

Cable Preparation

- Remove the outer cable jacket to the specified length, exposing buffer tubes at the base of the sheath opening.
- Unravel and clean buffer tubes; remove excess filling compound and aramid yarn or armor as required.
- For mid-sheath (“express”) splices, keep non-cut tubes intact and stow them above or below spliced tubes, tying off slack for organization.

Splice Closure Setup

- Review splice closure instructions and parts layout. Identify all ports to be used.
- Install cable entry sealing rings, grommets, and hardware matching each cable's diameter.
- Secure cables in the closure using retention clamps and brackets per manufacturer specs. For armored cable, attach the armor bond and connect the ground wire as needed.
- Make sure each cable is strain-relieved and aligned to prevent movement after installation.

Splice Tray Preparation

- Attach or insert the proper number of splice trays into the closure base.
- Place slack buffer tubes for splicing in the bottom of the tray and tie them down. For pass-through or "tail" tubes, route and secure them above spliced tubes, each with its separate tie point.
- Carefully mark and remove the buffer tube jackets to expose splicing-length fibers, clean all fibers with alcohol wipes.

Fiber Splicing

- Slide splice sleeves onto one set of fibers before fusion.
- Using the fusion splicer, splice fibers according to the standard color code and splicing plan.
- After each splice, protect the joint with the heat shrink sleeve and place/organize it into the tray slot.
- Route and store fiber slack neatly within the tray to maintain bend radius and prevent tangling.

Final Assembly

- Neatly organize all fibers and buffer tubes, secure with provided cable ties, and double-check splices for correct order and integrity.
- Attach the cover to the closure base, ensuring all seals are properly seated.
- If required, pressurize the closure and check for air leaks using a soapy water solution.

Final Inspection/Testing & Deployment

- Inspect all seals, hardware, and fiber routing for compliance.
- Perform end-to-end continuity and/or OTDR testing before final burial or mounting.
- Label the closure exterior according to project requirements.
- Restore the work area and ensure the closure is securely mounted or buried as specified.

This standardized sequence ensures a clean, reliable, and easily maintainable splice point in outside plant fiber networks.

All fiber splice tray labeling must be machine-generated for consistency, legibility, and durability, in accordance with telecommunications standards and best practices

Splice Closure/Tray Labeling Requirements:

Labeling Method

- Use only a label maker (mechanical or electronic label printer) for all splice tray and closure labeling.
- Labels must be printed on appropriately sized durable material, preferably with a white background and black text for maximum contrast and readability.

Label Content

- Label each tray with relevant information, such as cable ID, tray number, splice position, and service type (e.g., feed/field, cabinet port/fiber numbers).
- Use only label material rated for the environment (temperature, humidity, and exposure) and of appropriate adhesive/longevity to remain legible throughout the life of the enclosure.

No Handwritten Labels

- Handwritten labels are strictly prohibited on any fiber splice tray, closure, or housing.
- Do not use marker, pen, or temporary labels for final documentation—use only printed labels from the approved label maker.

- Placement:
- Secure the printed label on a flat, visible part of the tray or enclosure for easy identification during maintenance or future work.

Summary Table: Splice Tray Labeling Standards

Attribute	Requirement
Labeling Method	Machine-printed (label maker only)
Background	White
Text	Black
Content	Cable ID, tray #, splice data, etc.
Durability	Environmental & adhesive appropriate
Handwritten	Not allowed

This approach ensures a standardized, professional, and maintainable fiber management system compliant with industry documentation and QC requirements.

Cable Splicing & Testing

Cable splicing and testing are critical steps after fiber optic cable construction, ensuring that individual fibers are joined for network continuity and performance from the originating light source to the subscriber. The process is systematic, follows specific technical standards, and is typically overseen by the contractor's splicing supervisor in coordination with the project management team and the customer.

Cable Splicing Process Overview

- **Splicing Initiation:**
Splicing usually begins at the originating device (optical line terminal or headend in a building or cabinet). In PON systems, this could be an active electronics cabinet or passive optical splitter cabinet. All required fibers are spliced to designated ports on the Fiber Distribution Panel (FDP), and jumpers are installed back to active equipment (light source).
- **Backbone and Lateral Junctions:**
Along cable routes, multiple intermediate splice points ("splice locations") are used where backbone cables, lateral cables, drops, and branch circuits are interconnected. Here, both end-to-end continuity splices and distribution splices (sending certain fibers to other cables or splitters) are performed.

Splice Types

- **Fusion Splicing:** The industry standard method, which uses a fusion splicer to align and permanently fuse (weld) two bare fiber ends using an electric arc. This results in very low optical loss and long-term reliability.
- **Mechanical Splicing:** Occasionally used for temporary or field repairs, involving an alignment sleeve and index-matching gel. Mechanical splices generally have higher loss and are not typical for backbone or PON construction.

Splicing Steps (Fusion Method)

- **Preparation:** Strip buffer coatings from the fibers, clean with alcohol, and cleave ends to a precise 90° angle.
- **Alignment:** Place both fibers in the fusion splicer, where they are automatically or manually aligned.

- **Fusion:** An electric arc is applied to melt and fuse the fiber ends. The splicer reports an estimated splice loss—typically less than 0.1 dB for high-quality work.
- **Protection:** A heat-shrink splice sleeve is applied over the joint and shrunk down using the splicer's heater.
- **Organization:** Completed splices are arranged in splice trays within closures, cabinets, or handholes to protect them from environmental hazards and stress.

Testing and Quality Assurance

- **Continuity Checks:** Immediately after splicing, each fiber is tested to confirm continuity and low optical loss (using OTDR, power meter, and light source tests). All failed or high-loss splices must be reworked.
- **End-to-End Verification:** After segment completion, end-to-end testing ensures the designed fiber paths provide the required signal quality up to splitter or subscriber points.
- **Documentation:** All splicing activities, test results (including dB loss per splice and per link), and as-built fiber allocation records are logged and reported as part of closeout documentation.

Splicing activities are coordinated with NoaNet OSP project management and completed according to the project schedule and customer requirements, with plans adjusted as needed to accommodate field conditions, QC feedback, or adjustments in network routing.

Fusion Splicing

Fusion splicing for telecommunications grade single mode fiber must meet stringent requirements for equipment, personnel qualification, process control, and loss/test documentation. The focus is on individual single fiber splicing—ribbonizing or mass fusion of loose tube fibers is not accepted unless explicitly approved. All equipment must be up to date, suitable for telecom environments, and properly calibrated.

Fusion Splicing Standards

Equipment & Environment

Splicer Type

- Use automatic core alignment fusion splicers (typically three-axis or “active core” models) capable of <0.1 dB typical splice loss on single-mode fiber.

Associated Tools

- Precision cleaver for preparing fiber ends
- Approved stripping tools and cleaning supplies
- Heat shrink/sleeve oven for splice protection

Environment

- Equipment must be rated for:
- Temperature: -10 to +45°C (14 to 133°F)
- Humidity: 0–95% RH
- Elevation: 0–5000 meters

Operator Requirements

- All splicers must have current training and certification on the specific fusion and test equipment used.
- Only technicians with documented experience in telecom-grade fiber preparation and fusion splicing may perform this work.

Splicing Procedure

- Strictly single (one-at-a-time) fusion splicing—no mass fusion or ribbonizing of loose tube fiber unless specifically approved.
- Fibers must be stripped, cleaned, and cleaved to a 90° end-face.
- The fusion splicer carries out optical core alignment, applies an electric arc to fuse the fibers, and reports an estimated splice loss for each connection.
- Each completed fusion is immediately protected in a heat-shrink sleeve and placed in the splice tray.

Testing & Documentation

- All automated splice machine loss results must be verified with manual OTDR traces at both 1310 nm and 1550 nm. Splice events, fiber length, and ORL are documented for every tested link.
- NoaNet standard: minimum acceptable fusion splice loss is 0.3 dB/km, per EIA/TIA 568. If a single splice loss exceeds this, rework is required.
- Splicing and test equipment must be calibrated by the manufacturer's recommended schedule (usually annually or every two years); calibration documentation/cert stickers must be provided if requested. No uncalibrated test set or splicer may be used on the project.

Best Practices

- Fiber, splicer, and test equipment cleanliness is essentially inspected and clean before every splice or test.
- Each step (splicing and testing) is to be logged, preferably in both electronic and physical forms, and submitted as part of project closeout.

These standards ensure fiber continuity, minimal loss, reliable operation, and full traceability of the optical network for quality assurance and long-term service.

Splice Tray Labeling

A standard labeling scheme for splice trays and Fiber Distribution Panel (FDP) ports is crucial for fiber management, troubleshooting, and long-term documentation. The best practice in industry is to use clear, unique, and systematic identifiers that correspond to cable, fiber, and splice locations, and make it easy to trace fiber continuity along the entire route.

Splice Tray Labeling Scheme

- **Tray Identifier:**
Each splice tray is assigned a unique tray number or letter (e.g., ST-1, ST-A).
- **Cable and Fiber Designation:**
Every fiber in the tray is labeled with:
 - Incoming/outgoing cable ID (e.g., CBL-101)
 - Tube number or color (if applicable)
 - Fiber position (standard color code or numerical order: 1–12, 1–24, etc.)
- **Splice Number:**
Each fusion or mechanical splice is labeled according to tray position (e.g., ST-1/F12, meaning Splice Tray 1, Fiber 12).
- **Splice Map Sheet:**
Attach a laminated or protected label sheet (or a permanent tray map) to the inside of each splice closure showing the tray assignment, cable entry, fiber color/number, and customer route ID.

Example (Label in Tray or Map)

Tray	Cable Entry	Tube No.	Fiber Color	Splice No.	To/From Device or FDP Port
ST-1	CBL-101	3	Blue	ST1/F1	FDP-A/Port-01
ST-1	CBL-201	7	Orange	ST1/F12	FDP-A/Port-12

FDP Port Labeling Scheme

- **Port Numbering:**
Ports on the FDP are labeled sequentially (e.g., Port 1, Port 2, ... Port N), matching the exact fiber landed for each subscriber, splitter, or network segment.
- **Panel/Cabinet Name:**
Each FDP itself is labeled with a unique identifier, such as FDP-A or Main-FDP, along with its physical location (cabinet, room, or vault ID).
- **Path Description:**
For clarity, labels should include the cable/fiber origin and termination points (e.g., “To ST-1/F1”, “To Building X, Rack 4, Port 3”).
- **Color Coding:**
If applicable, match port colors or grouping with fiber color codes for troubleshooting (e.g., blue for Fiber 1, orange for Fiber 2, etc.).

Example (FDP Label)

- Panel: FDP-A, Closet 2
- Port 01: ST-1/F1 – Main Riser, Blue
- Port 12: ST-1/F12 – Lateral CBL-201, Orange

Best Practices

- Use durable labels that are water-resistant and legible over time.
- Keep electronic and physical records of all labels, port assignments, and tray maps. Update immediately if moves, adds, or changes are made.
- Match all tray and port labeling in the network documentation and red-line drawings for easy cross-reference.

Here is a QC checklist specifically for verifying fiber tray labels during installation:

QC Checklist: Splice Tray Label Verification

- Label Presence
 - Every splice tray has a label affixed.
- Label Type
 - All labels are machine-printed using a label maker (no handwritten labels present).
- Material and Format
 - Label has a white background with black text.
 - Label is appropriately sized and securely attached to a visible, flat part of the tray.
- Text Content and Order
 - Label includes, in the following order:
 - Tray Number/ID (e.g., "Tray 1")
 - Cable IDs and feed/field/entry directions (e.g., "IN: CBL-1201 OUT: CBL-1301")
 - Fiber Assignment/Range (e.g., "Fibers 1–24")
 - Service/Note if used (e.g., "Transport Reserved")
- Accuracy & Legibility
 - All information matches network documentation and as-built drawings.
 - Print is clear and legible (no smudging, fading, or font too small).
- Standard Compliance
 - Labeling order and field content follow project or organizational standards.
 - No extraneous information or missing mandatory fields.
- Durability
 - Label appears resistant to peeling, abrasion, and environmental conditions (touch test and visual).
- Correction/Action
 - Any non-compliance corrected and retested; issue documented for follow-up.

Final Sign Off

- Inspector Name:
 - Date:
 - Project/Tray ID:
 - Non-conformances (describe):
-

This checklist ensures every fiber splice tray label is present, permanent, legible, and consistent—streamlining future maintenance and supporting system documentation.

Systematic labeling guarantees operational clarity, efficient maintenance, and precise fiber tracing in the field.

Connector Inspection & Cleaning

Connector inspection and cleaning are essential for maintaining fiber optic link performance and reliability. Every connector, adapter, and bulkhead must be inspected and cleaned prior to testing or mating, following industry standards and best practices.

Connector Inspection & Cleaning

- **Protective Covers:**
Always use protective caps on all connectors and bulkheads when not in use to prevent dust and contamination.
- **Inspection:**
 - Use a fiber microscope with at least 200x magnification to inspect every fiber optic connector, adapter, or bulkhead before connecting or testing.
 - Follow the IEC 61300-3-35 standard for visual inspection, ensuring there are no scratches, dirt, oil, or other defects on the end face.
- **Cleaning Procedures:**
 - **Dry Cleaning:** Begin with a dry lint-free wipe or dedicated dry cleaning tool (optic cassette or click cleaner). Gently wipe the connector end face before inspection.
 - **Wet Cleaning:** If contamination persists, use a cleaning solution or moistened lint-free wipe for a wet clean, immediately followed by a dry wipe to prevent residue. Avoid using excessive solvent and never touch the cleaned surface with bare hands.
 - Inspect the end face after each cleaning cycle and repeat as necessary until the connector passes inspection.
 - Do not use hard surfaces or figure-eight motions; use only straight-line cleaning for best results.

Insertion Loss (end of line) Testing

Insertion loss testing of an installed fiber optic plant (end-of-line) is most performed using a light source and power meter (Optical Loss Test Set, OLTS), following standardized procedures such as TIA/EIA OFSTP-14 for multimode and OFSTP-7 for single mode fibers.

End-of-Line Insertion Loss Testing Procedure

Equipment Needed

- Stabilized light source (matching system wavelengths, e.g., 1310/1550nm SM, 850/1300nm MM)
- Power meter calibrated for the test wavelengths
- Reference test cords (high-quality launch cables)
- Adapters to match connectors on the cable under test

Step-by-Step Process

- Clean and Inspect
- Clean all fiber connectors with appropriate tools and inspect with a scope to ensure they are free of dirt and scratches.
- Set Reference ("Zero")
- Connect light source to power meter using the reference test cord(s).
- Set the reference reading to zero on the power meter (0 dB), establishing a baseline for the test setup as specified by the 1-cord, 2-cord, or 3-cord reference method.
- Connect to Installed Fiber Link
- Move the reference cord from the power meter to the near end of the installed plant.
- Connect a matching reference/test cord from the power meter to the far end of the link.
- Test Each Fiber
- Transmit light from the source through each installed fiber to the power meter.
- Record the output power in dB; the difference from zero is the insertion loss for that fiber.

- Verify Results
 - Loss must not exceed the calculated link loss budget.
 - Insertion loss should be less than the project's maximum—for example, often <2 dB end-to-end for short links, higher for longer spans or complex link budgets.
 - Document & Report
 - Record all readings alongside fiber IDs, wavelengths, and test setup details.
 - Submit results for certification and system acceptance.
-

Key Points

- Use high-quality test cords and correct reference procedures as per standards.
- Cleanliness is critical—dirty connectors often create artificially high loss readings.
- OLTS/Power Meter test is Tier 1 certification; OTDR is Tier 2 and supplements but does not replace OLTS results.

For detailed standards and reference methods, see TIA/EIA OFSTP-14 and ISO/IEC 11801/14763 series.

A typical port reading at a fiber optic distribution terminal (such as an OFDC port in a PON or FTTH network) for receive power is usually in the range of -12 dBm to -28 dBm. This range ensures reliable service and falls within the generally accepted window for most GPON/Active Ethernet and similar systems.

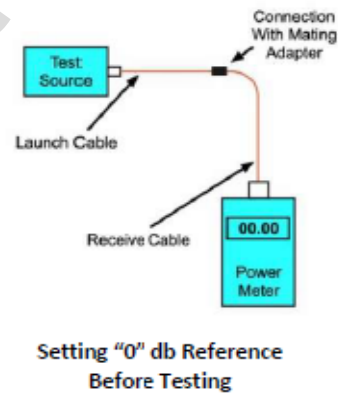
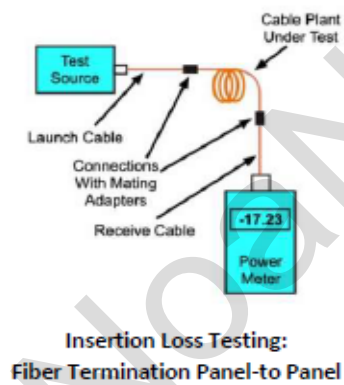
- Normal Operating Range:
- Most systems prefer port readings between -12 dBm and -28 dBm.
- Readings around -20 dBm are considered strong and typical for many installations.
- At or lower than -28 dBm is often considered the lower limit for reliable operation—below this, connectivity becomes unreliable or fails completely.
- What if outside range?
- Above -12 dBm (closer to zero) may risk damaging sensitive receivers.

- Below -28 dBm indicates excessive link loss and must be investigated and corrected for system stability.

Summary Table

Type	Typical Acceptable Range
Standard OFDC Port	-15 dBm to -28 dBm
Minimum for Service	-28 dBm (some up to -30)
Strong Typical Value	-18 dBm to -22 dBm

Values within this range confirm a healthy and properly engineered fiber link.



By ensuring measured insertion loss is within budget and closely grouped across all ports, network designers and operators can guarantee consistent performance, ease of troubleshooting, and compliance with telecom standards.

OTDR Testing

OTDR (Optical Time Domain Reflectometer) testing is an advanced fiber optic field test used to evaluate the integrity, performance, and physical characteristics of installed and spliced fiber links. It is required for all engineered active fibers and backbone segments and provides a visual "trace" to pinpoint issues, document link health, and certify that construction meets telecom standards.

OTDR Testing: Methodology and Standards

Equipment & Setup

- Recommended OTDR: EXFO FTB1 platform with FTB 730 module (or approved equivalent) calibrated to current standards.
- Launch Cable: Minimum 1 Km long, matching the fiber type, used between the OTDR and the fiber under test to mitigate the dead zone and reveal near-end connector/splice loss. A receive (tail) cable is also used for bidirectional testing.
- Ancillary Tools: Power meter, light source, visual fault locator (VFL), inspection scope, cleaning tools, connector adapters, pigtails as needed.

OTDR Test Process

Preparation

- Inspect and clean all connectors, adapters, and launch/receive cables.
- Connect launch cable to OTDR and fiber under test.
- Set OTDR to appropriate wavelength (typically 1310nm and 1550nm for single mode).

Unidirectional Testing

- Shoot an OTDR trace from the cabinet (FDP/Active/Splitter) to the OFDC or subscriber terminal.
- Record trace, documenting total fiber length, event locations (splices, connectors), and loss values.

Bidirectional Testing

- Required for backbone fiber links for highest accuracy.

- Shoot from both ends of the link, then average the measured splice and event loss to account for differences in fiber properties and eliminate "gainers" due to modal field diameter mismatch.

Trace Review

- OTDR results must show all connectors, cable segments, splices, and loss/reflection events.
- Document optical return loss (ORL), length, and all significant reflectance/splice loss events per standard.

Result Submission

- Traces must be saved in both raw .trc (native) file and PDF format, then uploaded to the specified shared folder for NoaNet OSP review.
- Results must meet or exceed contract and engineering requirements. Any failure on key parameters (loss, reflectance, splice quality) requires remediation and retesting.

Best Practices and Standards

- Calibration: All OTDR and supporting test equipment must be calibrated according to manufacturer and telecom standards.
- Fiber Type & Event Mapping: Use matching launch and tail fibers, and correct OTDR profiles for the fiber under test.
- Testing Direction: Always include location, direction, port/fiber identifier, and environmental notes in results for as-built documentation.
- Frequency: OTDR is required on all backbone and distribution fibers, with intervals defined by project scope and industry guidelines.

OTDR testing provides full-route fiber characterization, rapid fault detection, and certification for every major fiber segment, ensuring the integrity and long-term reliability of the constructed network.

Fiber Characterization

Fiber characterization is a comprehensive suite of tests conducted on a fiber optic cable link to determine its performance, integrity, and suitability for current or future applications (such as high-speed data or DWDM systems). This process ensures that fiber links meet both the required network standards and vendor specifications before being commissioned or upgraded.

Fiber Characterization Process and Key Tests

Connector End-Face Inspection

- Purpose: Identify contamination, scratches, or damage that may impair optical performance.
- Standard: Use a fiber inspection scope against IEC standards; clean and retest as needed.

Insertion Loss (IL) Measurement

- What: Measures total optical power lost across the fiber span due to connectors, splices, and intrinsic fiber losses.
- How: Use a calibrated light source and power meter; test bi-directionally at operating wavelengths (typically 1310/1550 nm for single mode).

Optical Return Loss (ORL) Measurement

- What: Evaluates the amount of reflected light, which can adversely affect transmitter performance and system stability.
- How: Performed with an OTDR or optical return loss tester from both ends of the link.

OTDR Testing

- What: Optical Time Domain Reflectometer testing provides a “trace” showing points of loss, reflection, and the physical location of splices, connectors, or faults, as well as total length.
- How: Perform at multiple wavelengths and bi-directionally; analyze for consistency and to ensure no hidden faults.

Dispersion Testing

- **Chromatic Dispersion (CD):**
Measures time delay differences among wavelengths; critical for high-speed or DWDM systems.
- **Polarization Mode Dispersion (PMD):**
Measures time delays due to different polarization states in the fiber; important for 10G+ transmission and long distances.

Spectral Attenuation

1. **Purpose:** Assess signal attenuation at different wavelengths, especially for systems using multiple channels (WDM).
2. **Method:** Use a spectral attenuation profile (SAP) analyzer or broadband source with an optical spectrum analyzer.

Documentation and Analysis

- All results are compiled into a professional, comprehensive report that summarizes cable quality, system capability, and any remedial action recommended for non-compliant fibers.
- Documentation includes span diagrams, OTDR traces, IL/ORL data, CD/PMD values, and spectral attenuation graphs.

Summary Table: Standard Fiber Characterization Tests

Test Type	Measurement	Notes
Connector End-Face Inspection	Visual	Microscopic, per IEC standard
Insertion Loss (IL)	dB	Bi-directional, all used wavelengths
Optical Return Loss (ORL)	dB	Bi-directional, minimized for optimal performance

Test Type	Measurement	Notes
OTDR Trace	dB, meters	Bi-directional, all wavelengths, trace analysis
Chromatic Dispersion (CD)	ps/nm·km	Required for high-speed >10G, DWDM
Polarization Mode Dispersion (PMD)	ps/km	Sensitive for 10G+ or long-haul links
Spectral Attenuation	dB	WDM links, wavelength-dependent

Comprehensive fiber characterization is an industry best practice—required for dark fiber acceptance, upgrades, and system turn-up—to ensure robust, high-performance network service and simplify future troubleshooting.

Fiber Testing Step-By-Step Process for PON Network

Here is a step-by-step guide to OTDR testing for a PON network, covering best practices for initial setup, configuration, execution, result interpretation, and documentation:

OTDR Testing: Detailed Process

Initial Setup

- **Connector Cleaning & Inspection:**
Clean all connectors, adapters, and bulkheads using inspection scopes and approved cleaning tools. Visual inspection using a microscope (>200x) ensures no dust, oils, or scratches that can distort test results.

- **Launch Cable Connection:**

Connect a minimum 100m OTDR launch cable to the OTDR and to the output port of the active PON cabinet. The launch cable helps to overcome dead zones and allows accurate measurement of splice and connector loss at the near end.

Testing from Active PON Cabinet to Splitter Cabinet

OTDR Configuration

- Wavelengths: 1310 nm and 1550 nm (recommended for single mode PON networks).
- Pulse Width: Medium (100ns) is a good starting point but adjust based on the length and desired resolution—a longer pulse for longer span, shorter for higher resolution testing of short links or splitters.
- Averaging Time: 1–3 minutes.
- Range: Set to the estimated fiber span (5–20 km typical for access, longer for backbone; avoid too-long ranges on short fibers).

Execution

- Perform OTDR trace from the PON cabinet (origin) to the splitter cabinet. Analyze the trace for insertion loss, reflectance, event locations (connectors, splices), and overall fiber length.

Testing Through the Splitter Cabinet

Splitter Testing

- Disconnect the direct test path at the splitter cabinet.
- Connect the OTDR to the input of one of the splitter's 1xN ports. Use another launch cable or tail fiber at one output port, run to OFDC or test output port.
- Splitters introduce high loss (typically 6–8dB for 1x4 or 1x8); ensure the OTDR dynamic range is sufficient to see through the splitter.

Execution

- Shoot traces for each splitter output path, carefully recording insertion loss and trace shape for each. Note that splitters may increase the apparent dead zone.
-

Testing from Splitter Cabinet to OFDC Terminal

- **Downstream Testing:**
With the OTDR at the splitter output, test each fiber segment between the splitter and the OFDC or distribution terminal.
Verify total end-to-end link loss, sum of all splice, connector, and splitter loss, and check for reflections or unintentional high-loss points.
Ensure total link loss is within the loss budget (usually not exceeding 28 dB for PON systems).

Final Validation and Documentation

- **End-to-End Power Testing:**
At the OFDC port, use a power meter (and light source at cabinet) to measure actual receive power.
Ensure it falls within the design limits (typically -15 dB to -28 dB for standard PON links).
- **Documentation:**
Save raw (.trc) OTDR files and PDFs for each tested path.
Record all test parameters, port/fiber IDs, loss values, and annotate any high-loss or reflection events.
Upload results to the designated review folder as required for approval and record-keeping.

Troubleshooting & post-testing

- Use a Visual Fault Locator (VFL) to pinpoint visible breaks or severe loss locations not clearly defined on the OTDR.
- Investigate, re-clean/re-test, or re-splice as needed to ensure all results pass project-defined PASS/FAIL thresholds.

Recommended OTDR Pass/Fail Thresholds

Parameter	Value/Aim
Splice Loss	0.0 – 0.3 dB
Mated Connector Loss	<0.2 dB (APC) / <0.5 dB (UPC)
Splitter Loss (1x8)	7–8 dB
Reflectance	-40 dB or better
Fiber Attenuation	<0.35 dB/km 1310 nm / <0.20 dB/km @ 1550 nm
Optical Return Loss (ORL)	>32 dB conn, >45 dB link

Using the above process ensures accurate documentation, effective troubleshooting, and reliable performance for every link in a PON or FTTH deployment.

Fiber Testing Step-By-Step Process for End-to-End Network

Here is a step-by-step guide to end-to-end fiber optic cable testing, following industry standards for verifying the quality and performance of installed fiber links:

End-to-End Fiber Testing Procedure

Preparation

- Visual Inspection: Inspect and clean all fiber ends, connectors, and adapters using a fiber scope (minimum 200x magnification) and appropriate cleaning tools. Repeat until connectors are free of dirt, dust, and scratches.
- Documentation: Record cable, port, or location IDs. Prepare test equipment (Optical Loss Test Set [OLTS], power meter, light source, launch cord, etc.) for the proper fiber type and wavelength.

Continuity and Polarity Check

- Visual Fault Locator (VFL): Inject visible red light at one end; check for clear transmission and correct routing at the far end.
- Fiber Identifier (optional): Confirm traffic presence and polarity in live systems.

Insertion Loss (IL) Measurement (Tier 1 Testing)

- Set up:
- Attach the calibrated light source to one end and the power meter to the other.
- Use reference-grade test jumpers and follow one-cord, two-cord, or three-cord reference methods based on project requirements.
- Test:
- Measure insertion loss at all operating wavelengths (e.g., 1310/1550 nm for single mode).
- Document loss for each fiber. Typical maximum link loss is project-specific, but standard limits are usually <0.35 dB/km 1310nm and <0.20 dB/km 1550nm for the fiber span (plus allowances for connectors and splices).
 - Pass/Fail

- Results must meet the engineered link loss budget for each fiber span.

Optical Return Loss (ORL) Measurement

- Test:
- Some power meters support ORL; otherwise, use an ORL meter or analyze reflectance using OTDR data.
- Goal:
- Keep ORL above the minimum required (often >32 dB at connectors, >45 dB for the entire link).

OTDR Testing (Tier 2/Advanced)

- Set up:
- Connect the OTDR with 1 Km launch and tail fibers (test box) at each end.
- Test:
- Shoot trace at required wavelengths, both directions.
- Document all events: splices, connectors, macrobends, faults, end-of-fiber.
- Average results if testing bi-directionally; analyze for excessive loss, reflectance, or ORL.

Pass/Fail

- All events must fall within allowed maximums (splice <0.3 dB, connector <0.5 dB typical).

Troubleshooting (if span fails)

- Inspect/clean connectors and repeat tests
- Use VFL or OTDR event table to locate and repair high-loss points or breaks
- Replace defective jumpers, connectors, or faulty cable sections as needed

Documentation & Reporting

- Save all test data (power meter, OTDR .trc and PDF files, test plans)
- Complete test reports with fiber routing, loss values, pass/fail status, and event logs

- Submit for review before system handover Systematic end-to-end fiber testing ensures each installed fiber link meets standards for attenuation, reflectance, and continuity—delivering reliable high-performance communications.

Recommended Launch/Receive Cable Lengths by Link Length

Recommended launch and receive cable (tail) lengths for OTDR testing vary by the overall link length and the pulse width being used. Here are typical industry guidelines:

Recommended OTDR Launch/Receive Cable Lengths

Link Length	Pulse Width	Launch/Receive Cable Length
≤ 2 km (short links, enterprise, FTTx, LAN)	Up to 200 ns	150–200 meters
2–10 km (typical access/backbone)	Up to 500 ns	500 meters
10–50 km (backbone/long-haul)	Up to 1 μs	1,000 meters (1 km)
>50 km (long-haul, outside plant)	2–10 μs	2,000–3,000+ meters (2–3 km)

Additional Notes

- The launch/receive cables should always be long enough to exceed the OTDR's event and loss dead zone for the largest pulse width used on that link.
- For most PON and typical backbone links, a 1 km launch/receive cable is considered best practice.
- For FTTx/MDU applications with short pulse widths, 150–300 meters is generally sufficient.
- When testing through high-loss elements (like splitters), ensure the launch cable is not too short, as this will hinder accurate near-end loss measurement.

- Launch and receive cables must match the type of fiber under test (e.g., SM or MM, same core size/MFD).

These recommendations help ensure OTDR measurement accuracy for both connector and link loss at all tested endpoints.

Link Loss Budget Calculator

Calculating a fiber optic link loss budget involves summing up the expected losses from fiber attenuation, connectors, splices, and adding a safety margin. This ensures the total loss between transmitter and receiver does not exceed what the system can tolerate for error-free performance.

Step-by-Step Fiber Link Loss Budget Calculation

- Gather Component Loss Values
- Fiber Attenuation: Typical values:
 - Single mode: 0.35 dB/km 1310nm, 0.25 dB/km 1550nm
 - Multimode: 3.5 dB/km 850nm, 1.5 dB/km 1300nm
- Connector Loss: TIA standard is 0.75 dB per mated pair (many real-world connectors achieve 0.5 dB or less).
- Splice Loss: TIA standard is 0.3 dB per fusion splice; field values may be lower (as little as 0.1 dB for high-quality fusion splices).
- Splitter Loss: Include if splitters are present (typically 7 dB for 1x8 split, etc. per manufacturer's specs).
- Calculate Individual Loss Contributions
- Fiber Loss:

Fiber Loss (dB)=Fiber Length (km)×Attenuation (dB/km)
Fiber Loss (dB)=Fiber Length (km)×Attenuation (dB/km)

- Connector Loss:

Total Connector Loss (dB)=Number of Connector Pairs×Loss per Pair
Connector Loss (dB)=Number of Connector Pairs×Loss per Pair

- Splice Loss:

Total Splice Loss (dB)=Number of Splices×Loss per Splice
Splice Loss (dB)=Number of Splices×Loss per Splice

- Safety/Engineering Margin: Typically add 1–3 dB to account for aging, repairs, and variable conditions.
- Sum for Total Loss Budget
- Formula:

Link Loss Budget (dB)=(Fiber Length (km)×Attenuation (dB/km))+(Number of Connector Pairs×Loss per Pair)+(Number of Splices×Loss per Splice)+Splitter Loss (if any)+Margin
Link Loss Budget (dB)=(Fiber Length (km)×Attenuation (dB/km))+(Number of Connector Pairs×Loss per Pair)+(Number of Splices×Loss per Splice)+Splitter Loss (if any)+Margin

Example Calculation

For a 10 km single mode link 1310nm, with 2 connector pairs, 4 splices, and 2 dB margin:

Link Loss Budget=(10×0.35)+(2×0.75)+(4×0.3)+2=3.5+1.5+1.2+2=8.2 dB
 Link Loss Budget=(10×0.35)+(2×0.75)+(4×0.3)+2=3.5+1.5+1.2+2=8.2 dB

Use this process to evaluate whether a proposed fiber route and design will perform reliably for the system's requirements.

Recommended acceptance limits per TIA/EIA and IEC standards

Recommended acceptance limits for fiber optic networks per TIA/EIA (ANSI/TIA-568) and IEC standards ensure reliable link performance by specifying maximum allowable losses for attenuation, connectors, and splices, along with best practices for physical installation and testing.

TIA/EIA-568 and IEC Acceptance Limits

Fiber Attenuation (Maximum Loss per Kilometer)

Single mode

- 1.0 dB/km 1310 nm (indoor)
- 0.5 dB/km 1310 nm (outdoor, typical real world)

Multimode

- 3.5 dB/km -850 nm
- 1.5 dB/km 1300 nm
- 50/125 OM3/OM4: 3.0 dB/km 850 nm (industry best practice is often lower)

Connector/Mating Loss

- Maximum Allowed (per mated pair):
- 0.75 dB (TIA/EIA-568 and IEC 11801)

Splice Loss (Fusion)

- Maximum Allowed:
- 0.3 dB per fusion splice (field experience and many specs use 0.1–0.2 dB as best practice)

Return Loss

- Minimum Required:
- ≥ -26 dB (PC), ≥ -60 dB (APC, angled physical contact), per IEC/TIA/EIA for connectors

Optical Return Loss (ORL)link

- 32 dB per connector, >45 dB for total link (typical best practice)

Physical Criteria

- Bend Radius:
- 10× cable OD minimum (unloaded); 15× cable OD if under tension
- Pulling Tension:
 - Max 2670 N (600 lb.) for outside plant (check cable spec)

Insertion Loss Testing

- Test Wavelengths (single mode):
- 1310 nm and 1550 nm
- Limits:
 - Must not exceed calculated link loss budget using above component maxima

Documentation & Testing

- All tested values (OTDR, IL, ORL) must be recorded, and any values exceeding specification require remediation.

Summary Table: Standard Acceptance Limits

Parameter	TIA/EIA & IEC Standard
Single mode Attenuation	1.0 dB/km 1310 nm
Multimode Attenuation	3.5 dB/km 850 nm
Connector Mating Loss	0.75 dB per pair
Splice Loss	0.3 dB per fusion splice

Parameter	TIA/EIA & IEC Standard
Return Loss (Connector)	> -26 dB PC, > -60 dB APC
ORL (Entire Link, Best Practice)	>32 dB connector, >45 dB link
Bend Radius	10× cable OD (installed)

Using these limits as acceptance criteria in construction and testing ensures the fiber optic network will perform to international expectations and is reliable for high-speed applications.



Fiber type	Connector Body	Strain Relief/ Mating Adapter
62.5/125	Beige	Beige
50/125	Black	Black
50/125 laser optimized	Aqua	Aqua
Singlemode	Blue	Blue
Singlemode APC	Green	Green

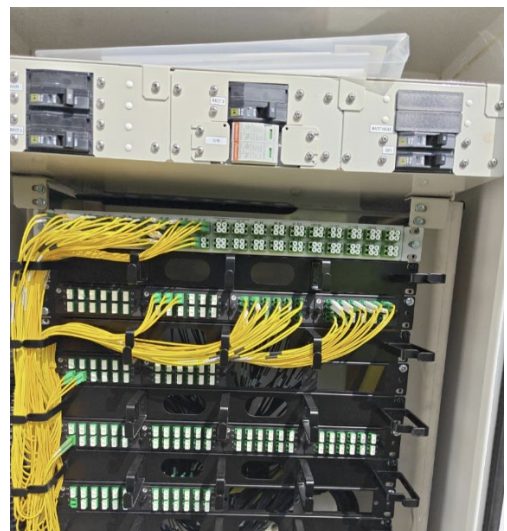
Connector Mating Loss (Connection Loss):

Fiber Type	Wavelength (nm)	Loss (dB)	Optical Return Loss (dB)
Multimode	850	0.75	20
	1300	0.75	20
Singlemode	1310	0.75	26 (CATV:55)
	1550	0.75	26 (CATV:55)

Exhibit Examples

Fiber Backbone POP & PON Cabinets Examples:

Active PON Cabinet



Pole Mount PON Splitter Cabinet



Slab mounted PON Splitter Cabinet



Fiber Backbone Equipment Huts/Colo



Fiber Backbone Equipment Cabinet



Distribution Terminal Options



CommScope OFDC Terminal

<https://www.commscope.com/product-type/hubs-closures-terminals-boxes/access-terminals/fiber-terminals-non-hardened/ofdc/>



Distribution Terminal Options Continued

Corning MST Terminals

<https://www.corning.com/optical-communications/worldwide/en/products/npi/mst-multiport-service-terminal.html>



For NoaNet Use Only

Channell Yellow Jacket

<https://www.channell.com/product/aerial-terminals/>



Fiber Splice Case Enclosure Options

AFL-APEX Splice Enclosure

<https://www.aflglobal.com/en/Products/Fiber-Optic-Connectivity/Splice-Closures/Apex-Fiber-Optic-Splice-Closures>

Apex X-2S Sealed Splice Closure



20" x 12"

Capable of up to 216 single fusion Splices



Features:

- Individual cable sealing ports with tool-less release mechanism and gel sealing.
- Hinging, lockable splice trays
- Plastic slack storage basket with optional segmented basket to separate ribbon and loose tube slack storage.
- Six ports with up to six ground lugs.
- Capable of up to 16 drop cables with an expressed distribution cable using multi-drop entry kits.
- Splice trays with universal splice modules capable of holding single fusion, mass fusion, and mechanical splices as well as other devices such as passive optical splitters.
- Dome-to-base O-ring seal retained into dome to prevent loss or damage but is still replaceable if necessary.



AX-TRAY-2S-2

Splice trays with modular splice holders that are organized in a hinging array that automatically lock when tilted to the upward position for easy access to the splice trays and slack storage below. Passive optical splitters can be preinstalled into the Apex X-2 splice tray.

SPLICE TRAY

<https://www.commscope.com/product-type/hubs-closures-terminals-boxes/splice-closures/fiber-splice-closures/>



BUILDING-BOOK: FOSC Modular Solids. Choose either wall.

[illegible]

ORDERING INFORMATION

It configures a complete ROSC Module (plus Chassis-IMC), the following information to be specified and ordered as indicated:

2. Closure

The KJG, Shikhar, Gupta Concerns are stopped simply how all content on red page.

3. Cell results

Total number of gel loads per channel 100,000 equal 1 assuming the 30 s exposure protocol is optimal for this sequencing technology.

3 Cable termination joints

Order one cable termination unit (CTU) for each cable. Licensed installers require two cable termination units. Standard cable termination brackets are included on the back of each cable.

4. *Staphylococcus aureus*

The K92 Modbus Slave Converter is compatible with all existing K92 C and E type - slaves, such as:

OPTIONAL/ADDITIONAL ORDERING INFORMATION

Extra procedures

- Volume and routing buffers
- Self-adaptive call control logic

Continuing to 20 pages, or outside

Admission accepted
 Study program finished

State. The authors are grateful to the
 Georgia Institute of Technology.

WISDOM OF COURAGE
 Pages of extraordinary officers and OPRs are
 on www.dod.mil

Source: FISCAL AND ECONOMIC DATA

BUILDING BLOCK 3: Dome & base enclosure



FOSC commonality

Compatible with existing sound dome (see manual)

Protein: originally used in F102, 800 and F103C dSW series.

State-of-the-art design for fast re-entry

Remains completely invisible from your work, allowing full functionality during installation and upgrade.

Easy-to-use from installation and testing you

Superior quality

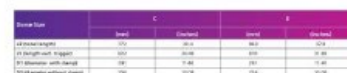
labeled for underground drainage, ground heat, and so on.

Microtube optimized

Overlapping base to shield off unprotected cables, coming out of tubes.

Flexible fixation of modules by use of module adapters and hole clamps

Internal location markers for optimal strain level



Source Size	C		B	
	(sec)	(disks)	(sec)	(disks)
44 megabyte	550	30-5	98.0	424
71 megabyte (big)	550	30-5	15.0	5-20
97 megabyte with flags	151	7-8	151	15-40
200 megabyte with flags	170	7-10	157	15-20

Coyote Splice Enclosure Options

<https://plp.com/communications/fiber-networks/splice-cases/coyote-splice-case>

COYOTE® RUNT Closure

Catalog Number:
8006671 - Standard RUNT (A)
8006794 - Expanded RUNT (B)
8006692 - RUS-listed RUNT (C)



Closure Information		
Type	Standard	Expanded
Tray Part Numbers	80807701 - 12 ct. single fusion tray (x3) 80806033 - 12 ct. single fusion tray (x2) 80807114 - 72 ct. ribbon tray (x1)	80807701 - 12 ct. single fusion tray (x6) 80806033 - 12 ct. single fusion tray (x4) 80807114 - 72 ct. ribbon tray (x2)
Dimensions (L x W x H)	14.8" x 8.5" x 3"	14.8" x 8.5" x 4.8"
Ports	3	
Ground Studs	2	
Splice Capacity	36 single fusion or 72 ribbon splices	72 single fusion or 144 ribbon splices

COYOTE® ONE Dome Closure

Catalog Number:
COY1-001 - ONE for Buffer Tube (A, B, C)
COY1-002 - ONE for Ribbon (A, B, C)



Closure Information	
Tray Part Numbers	80809958 - 24 ct. single fusion tray (x4) 80813152 - 36 ct. single fusion tray (x4) 80808945 - 40 ct. single fusion tray (x2) LGSTR144 - 144 ct. ribbon tray (x2)
Dimensions (L x W x H)	16.0" x 10.8" x 5.7"
Ports	3
Ground Studs	3
Splice Capacity	144 single fusion or 288 ribbon splices

COYOTE® PUP Closure

Catalog Number:
8006622 - PUP for Buffer Tube (6-Port) (D)
80010515 - PUP for Buffer Tube (4-Port) (E)
8006621 - PUP for Ribbon (F)
8006661 - RUS-listed PUP (G)



Closure Information	
Tray Part Numbers	80807701 - 12 ct. single fusion tray (x6) 80806033 - 12 ct. single fusion tray (x4) 80807114 - 72 ct. ribbon tray (x2)
Dimensions (L x W x H)	17" x 8.5" x 7"
Ports	6 or 4
Ground Studs	6 or 4
Splice Capacity	72 single fusion or 144 ribbon splices

COYOTE® 6.5" x 17" Dome Closure

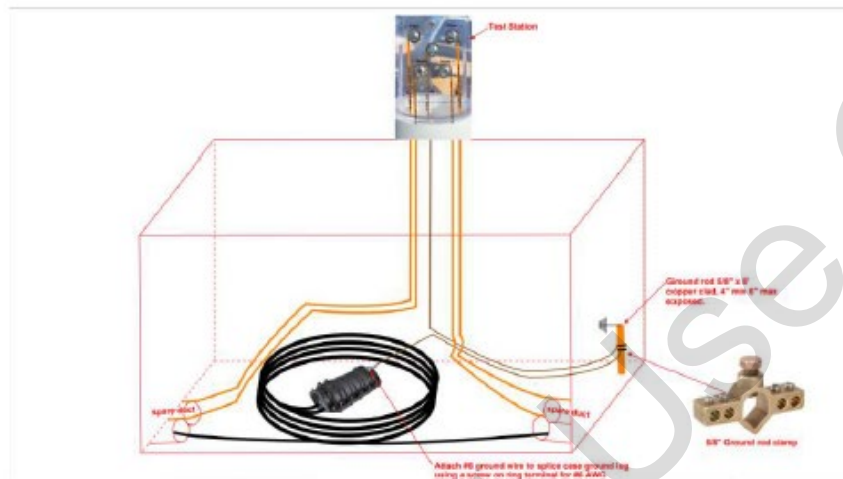
Catalog Number:
8006944 - Dome for Buffer Tube (D, E, G)
8006945 - Dome for Ribbon (F)



Closure Information	
Tray Part Numbers	80809958 - 24 ct. single fusion tray (x6) 80813152 - 36 ct. single fusion tray (x6) 80808945 - 40 ct. single fusion tray (x3) LGSTR144 - 144 ct. ribbon tray (x3)
Dimensions (Diameter x L)	8.6" x 17.9"
Ports	4
Ground Studs	4
Splice Capacity	216 single fusion or 432 ribbon splices

Fiber Route Markers & Test Station Examples

Locate Marker Test Station Bonding



Locate Testing Station



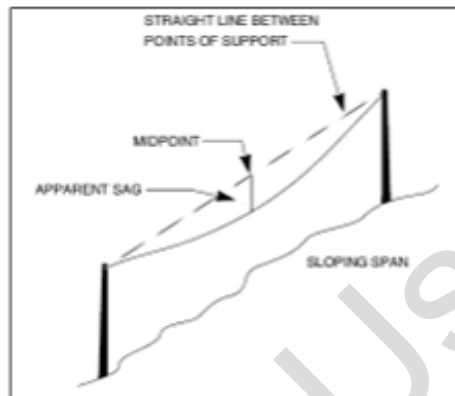
Cable Marker Post



Chapter 6 TENSION AND SAG

The NESC addresses Tension and Sag in Sections 235, 251, 252, 253, 260, 261, 263, and 277.

Figure 6.1 – Illustration of Sag



Definition of Tension

The NESC defines two types of tension:

- **Initial:** The tension in a conductor prior to the application of any external load.
- **Final:** The tension in a conductor under specified conditions of loading and temperature applied after it has been subjected for an appreciable period to the loading specified for the loading district (zone) in which it is situated, or the equivalent loading, and this loading removed. Final tension includes the effect of inelastic deformation (creep).

In other words, tension can be explained as force pulling the cables or wires at either end by what they are attached to or the weight of the cable itself. Tension is also applied to insulators.

Definition of Sag

The NESC provides the following definition of sag:

- The distance measured vertically from a conductor to the straight line joining its two points of support. Unless otherwise stated in the rule, the sag referred to is the sag at the midpoint of the span (see Figure 6.1).
- **Initial Sag:** The sag of a conductor prior to the application of any external load.
- **Final Sag:** The sag of a conductor under specified conditions of loading and temperature applied, after it has been subjected for an appreciable period to the loading specified for the

Tension & Sag

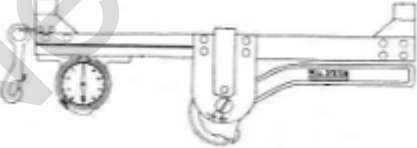
clearance zone in which it is situated or equivalent loading, and this loading is then removed. Final sag includes the effect of inelastic deformation.

Engineering Design

The appropriate sag and tension are determined by several factors, including span lengths, strand size, load, storm loading area, temperature, vertical clearances above grade, vertical clearances from other utilities, pole lengths, and class of pole.

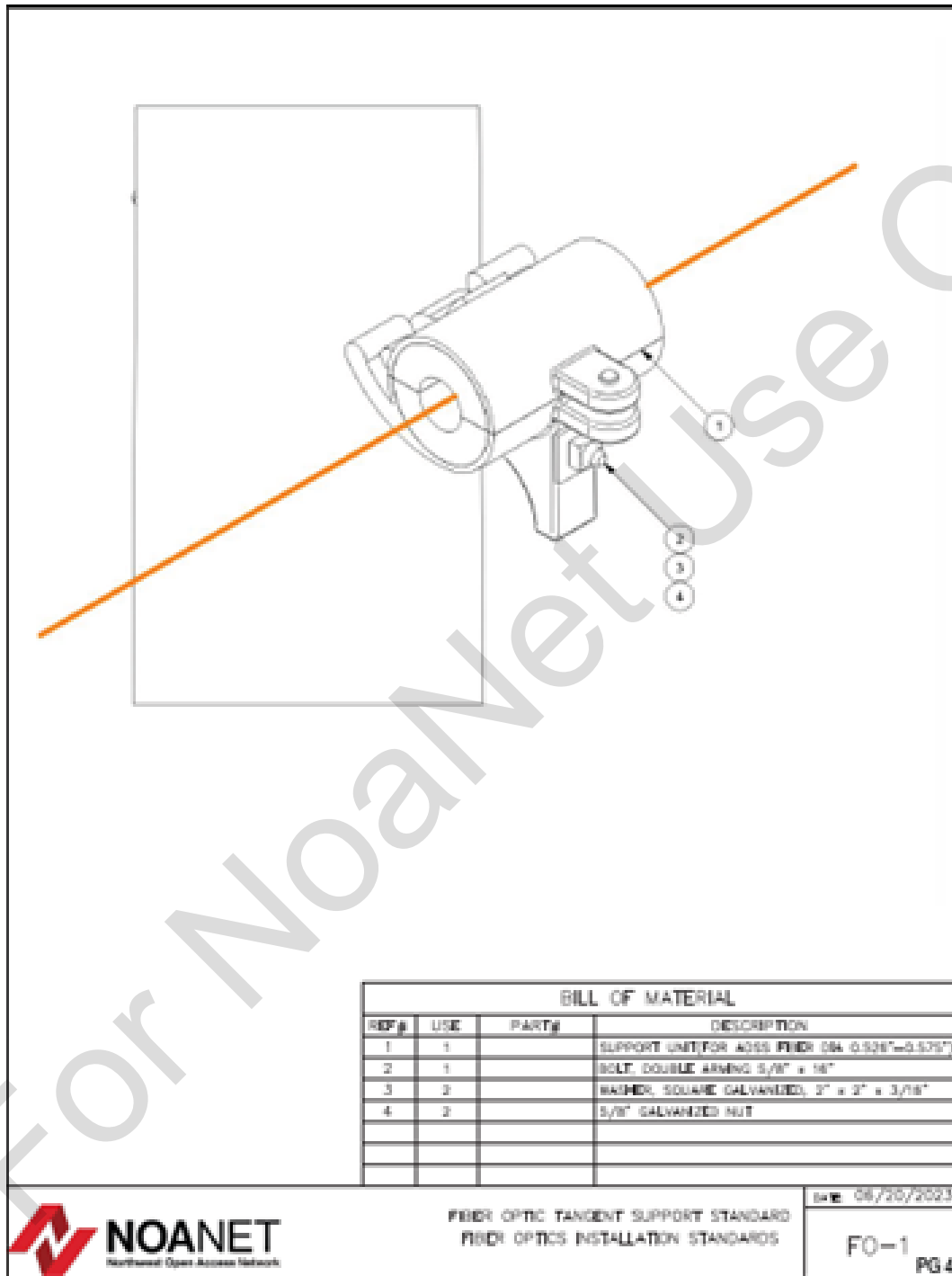
Methods of Tensioning

Figure 6.2 – Dynamometer Tensioning

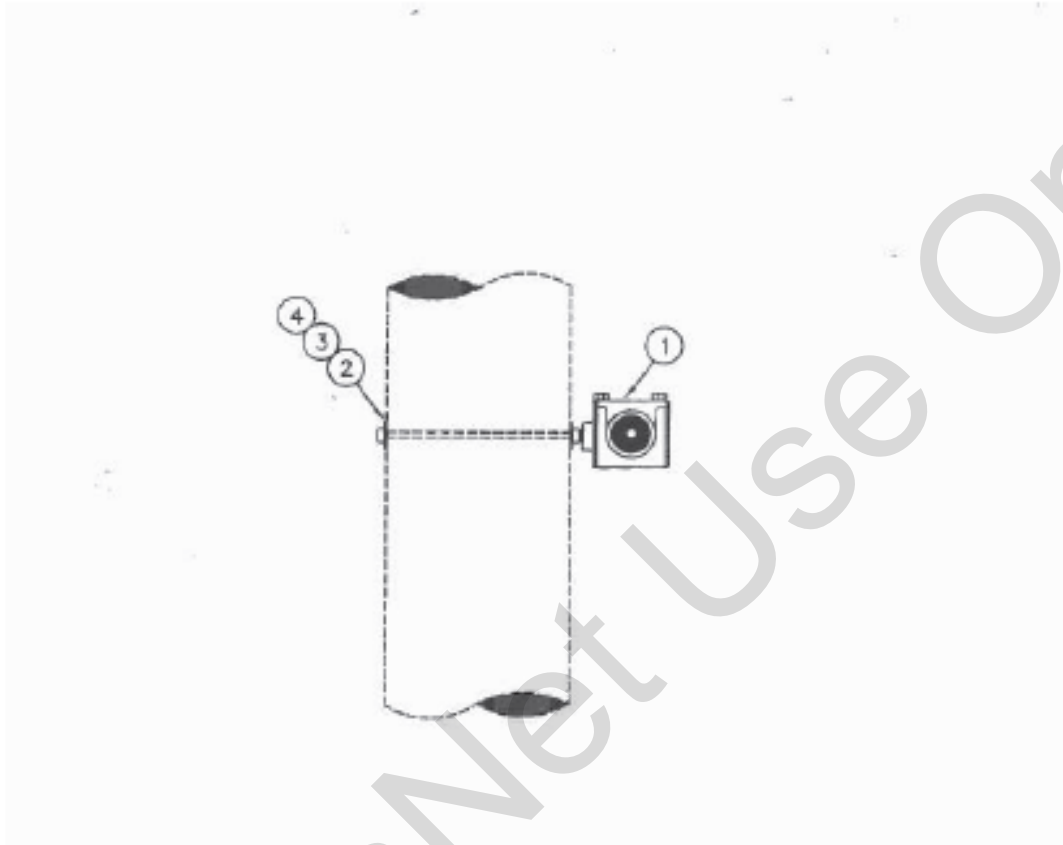
Electronic		
		Dynamometers are the preferred method for testing tensioning
Mechanical		
		

Methods of Tensioning

RUS Design Examples and Best Practices

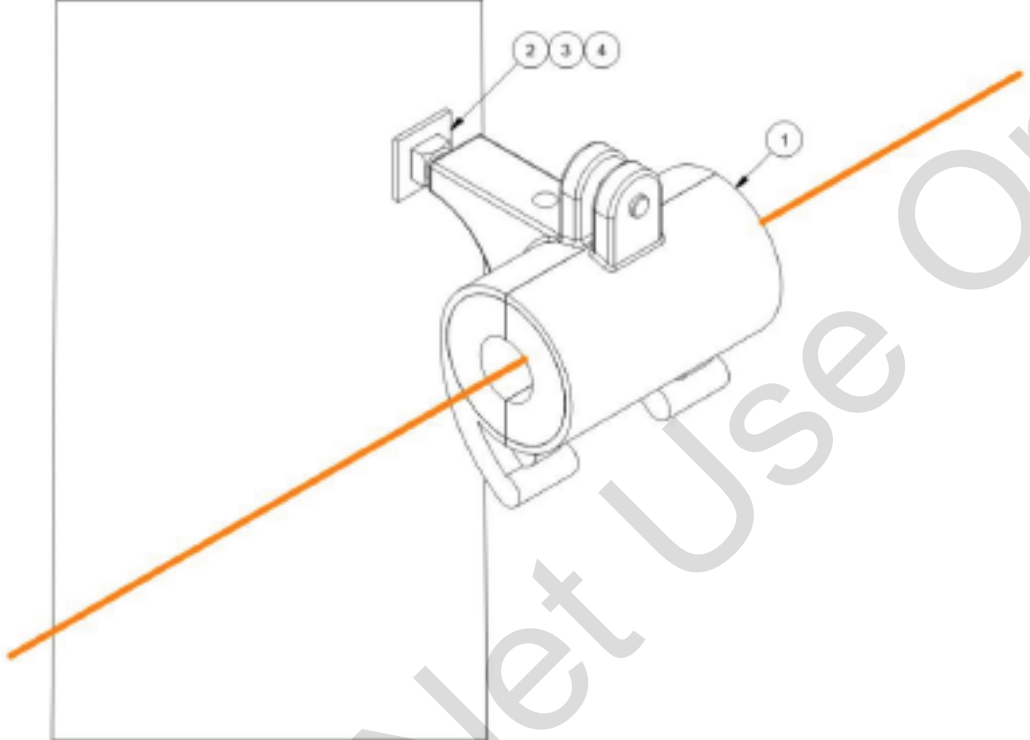


RUS Design ADSS Support Clamp



BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		Fiber Dielectric Support 0.65
2	1		Bolt DA 5/8" x 14"
3	2		Curved, 2-1/4" x 3/16", 11/16" Hole
4	2		Nuts Palmul Lock 5/8"

RUS Design ADSS Suspension Unit



BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		SUPPORT MOUNTED—SUSPENSION UNIT WITH ARMOUR
2	1		BOLT, DOUBLE ARMING 5/8" x 16"
3	2		WASHER, SQUARE GALVANIZED, 2" x 2" x 3/16"
4	2		5/8" GALVANIZED NUT

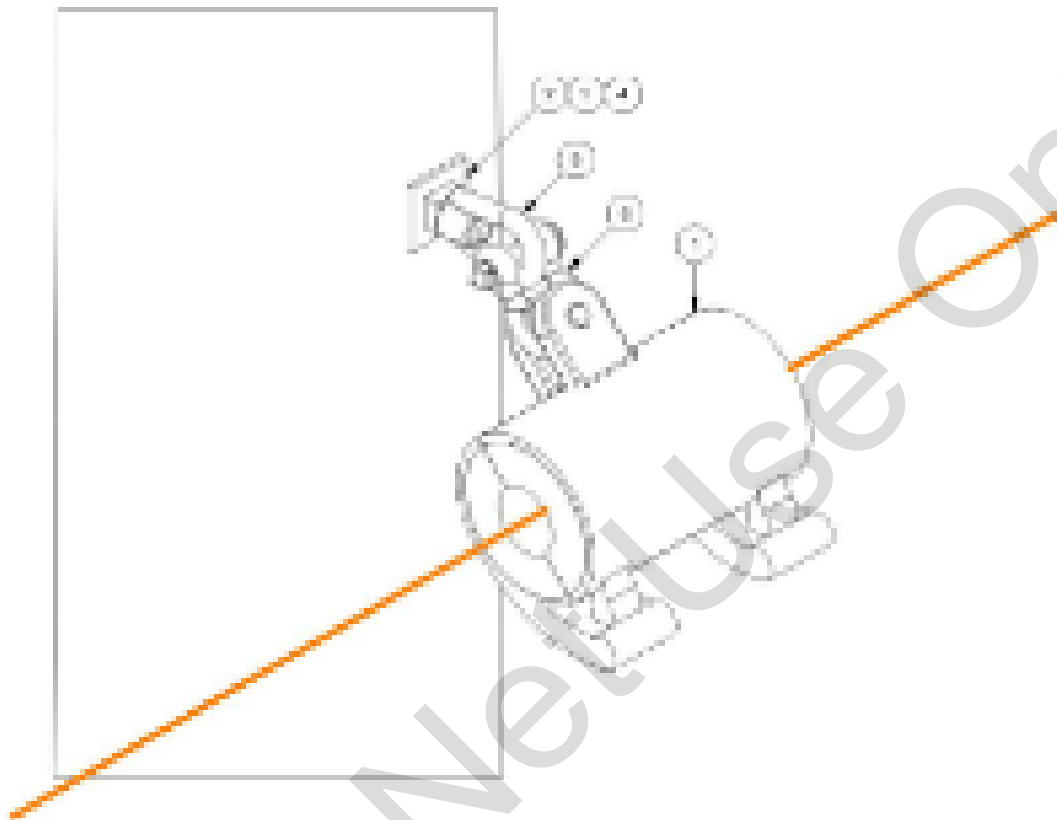


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FIBER OPTIC SUSPENSION UNIT – SUPPORT MOUNTED
FIBER OPTICS INSTALLATION STANDARDS

DATE: 06/20/2023
FO-2
PG 6

RUS Design ADSS Suspension Unit Extension



BILL OF MATERIAL			
REF#	QTY	Part#	DESCRIPTION
1	1		PLATE, SUSPENSION SUPPORT PLATE
2	1		BRAK, SUSPENSION BRACKET 2" x 1"
3	2		NUTS, SUSPENSION BRACKET 2" x 1" x 0.25"
4	2		SCREW, SUSPENSION BRACKET 2" x 1" x 0.25"
5	1		CABLE, SUSPENSION UNIT
6	1		WIRE, SUSPENSION UNIT
7	1		WIRE, SUSPENSION UNIT



NOANET
Network Solutions

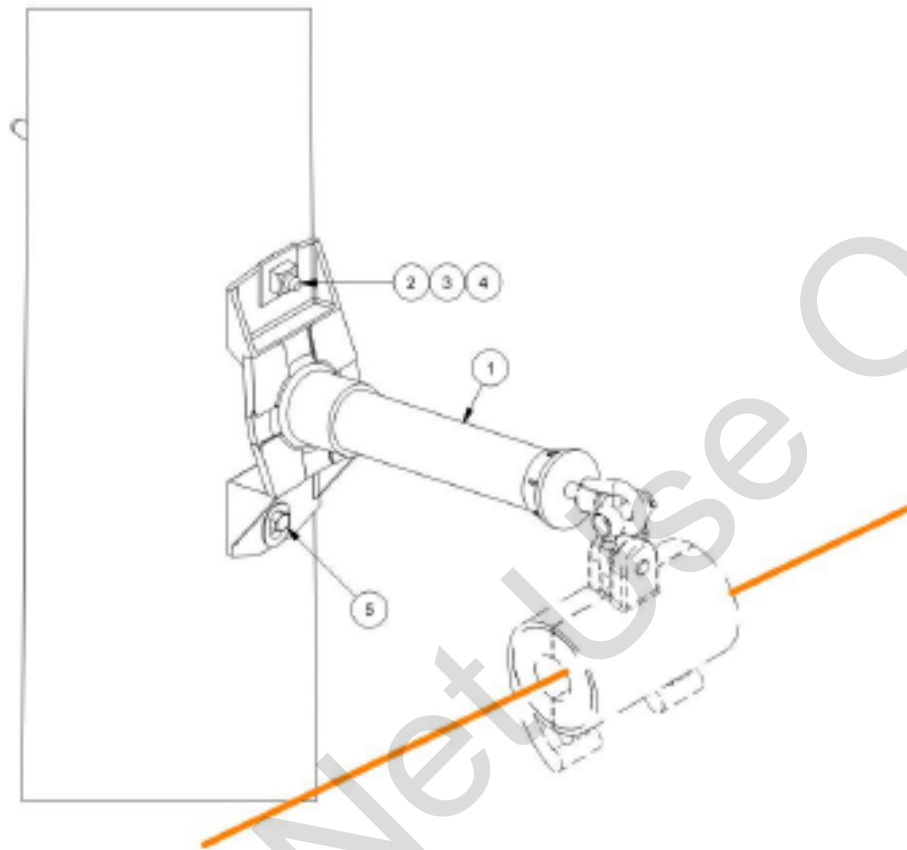
RUS: OPTIC SUSPENSION MOUNTS
RUS: OPTIC INSTALLATION STANDARDS

REV. 01/20/2001

FO-3

10/17

RUS Design 12" Extension FGA



BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1	50210012	12" EXTENSION BRACKET
2	1	10115816	BOLT, DOUBLE ARMING 5/8" x 16"
3	2	10941022	WASHER, SQUARE GALVANIZED, 2" x 2" x 3/16"
4	2	10661021	5/8" GALVANIZED NUT

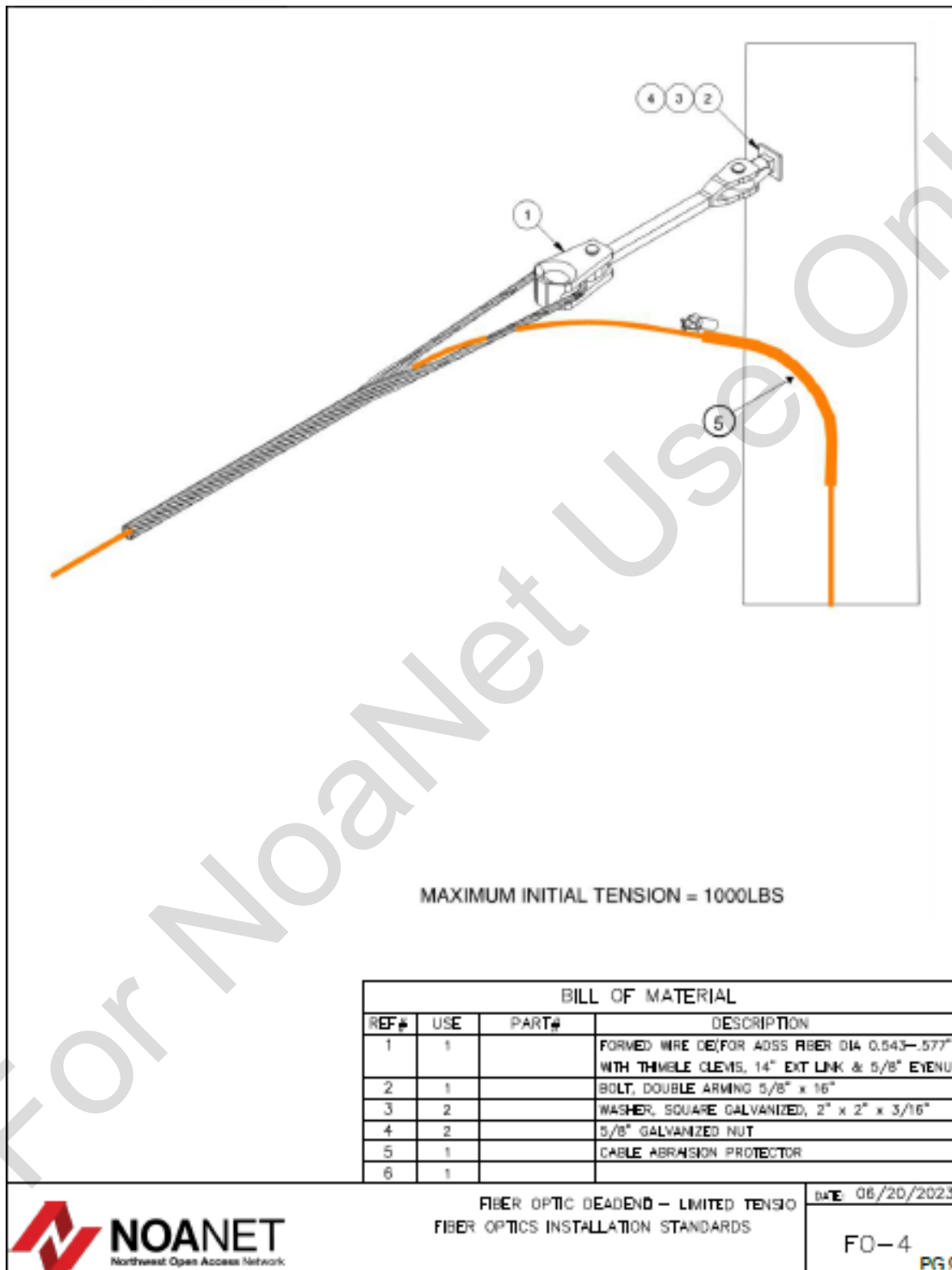


12" EXTENSION BRACKET FOR FIBER HARDWARE
FIBER OPTICS INSTALLATION STANDARDS
- - - -

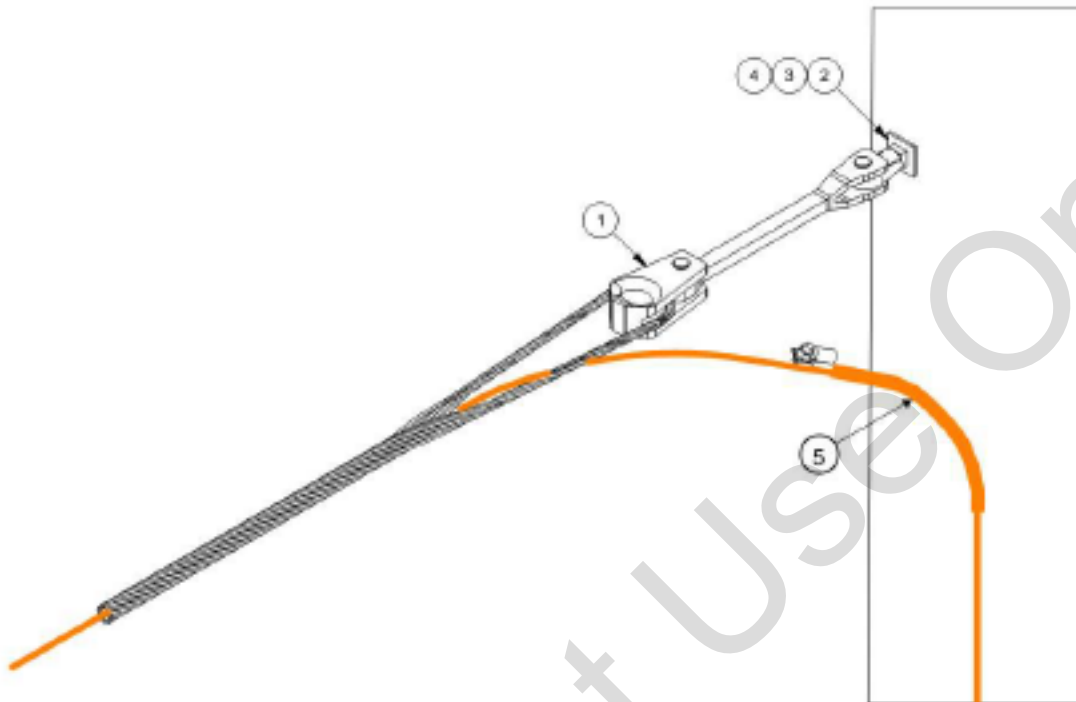
DATE: 06/20/2023

FO-EXT
PG 8

RUS Design Dead-End-Limited Tension



RUS Design Dead-End Medium Tension



MAXIMUM INITIAL TENSION = 2000LBS

BILL OF MATERIAL			
REF #	USE	PART #	DESCRIPTION
1	1		FORMED WIRE DE(FOR ADSS FIBER DIA 0.543-.577")
			WITH THIMBLE CLEVIS, 14" EXT LINK & 5/8" EYEVIEW
2	1		BOLT, DOUBLE ARMING 5/8" x 16"
3	2		WASHER, SQUARE GALVANIZED, 2" x 2" x 3/16"
4	2		5/8" GALVANIZED NUT
5	1		CABLE ABRASION PROTECTOR
6	1		

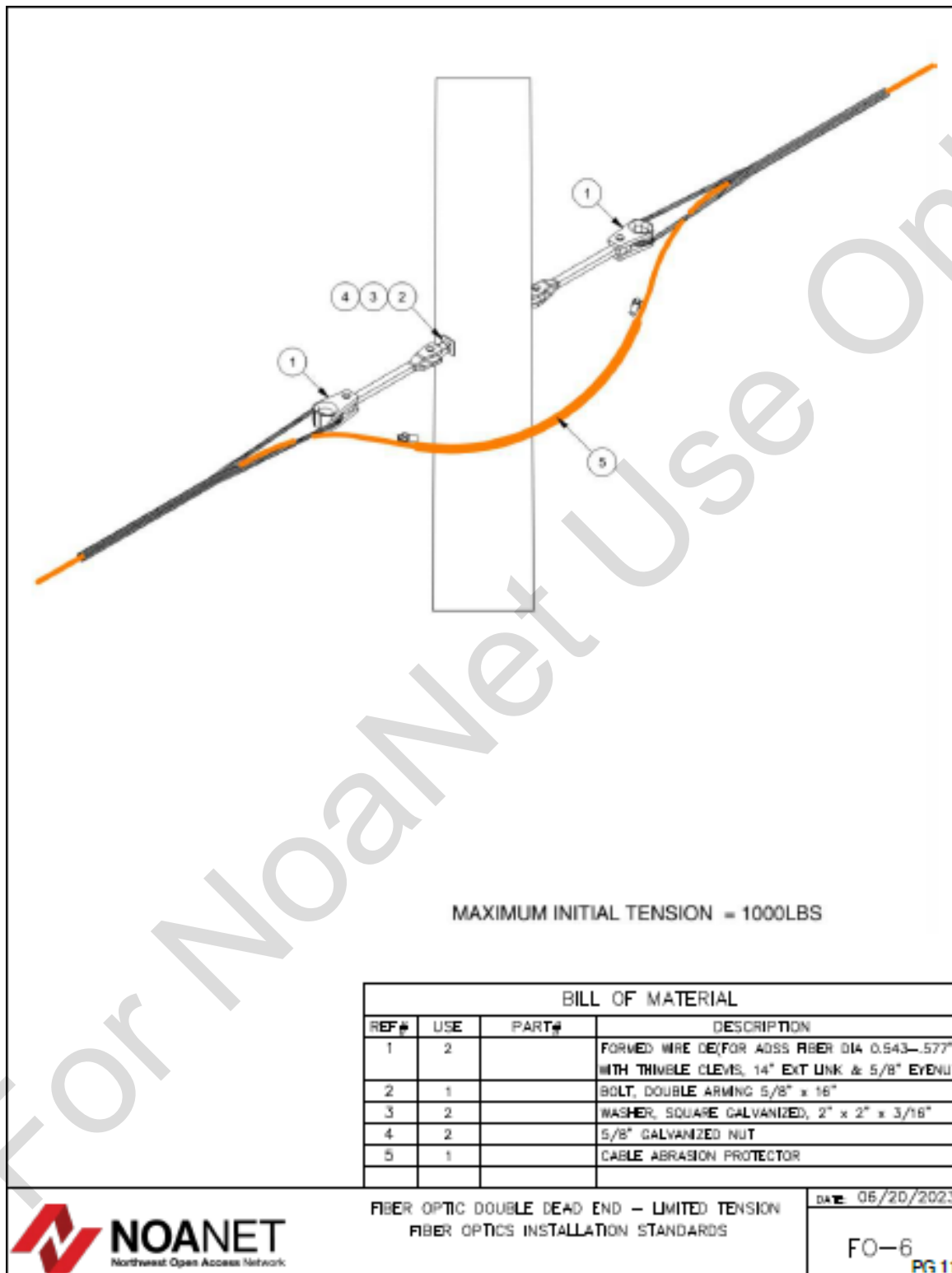


FIBER OPTIC DEADEND STANDARD— MEDIUM TENSION
FIBER OPTICS INSTALLATION STANDARDS

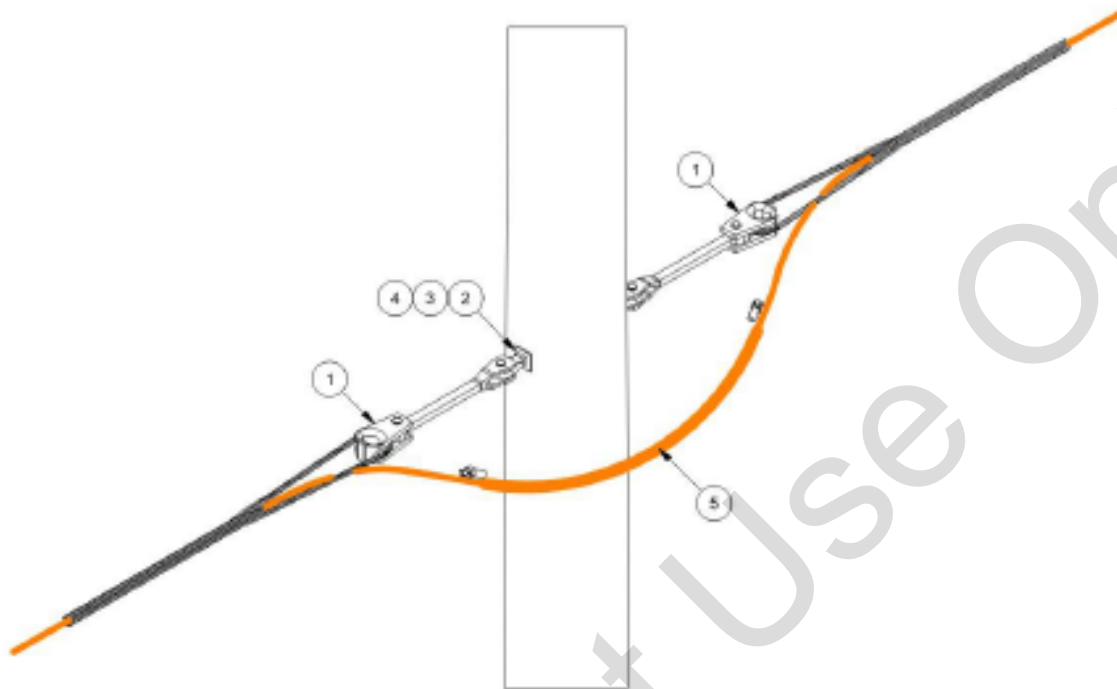
DATE: 06/20/2023

FO-5
PG 10

RUS Design Dead-End Maximum Tension 1000Lbs



RUS Design Dead-End Maximum Tension 2000Lbs



MAXIMUM INITIAL TENSION = 2000LBS

BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	2		FORMED WIRE DE (FOR ADSS FIBER DIA 0.543-.577") WITH THIMBLE CLEVIS, 14" EXT LINK & 5/8" EYE NUT
2	1		BOLT, DOUBLE ARMING 5/8" x 16"
3	2		WASHER, SQUARE GALVANIZED, 2" x 2" x 3/16"
4	2		5/8" GALVANIZED NUT
5	1		CABLE ABRASION PROTECTOR
6	1		

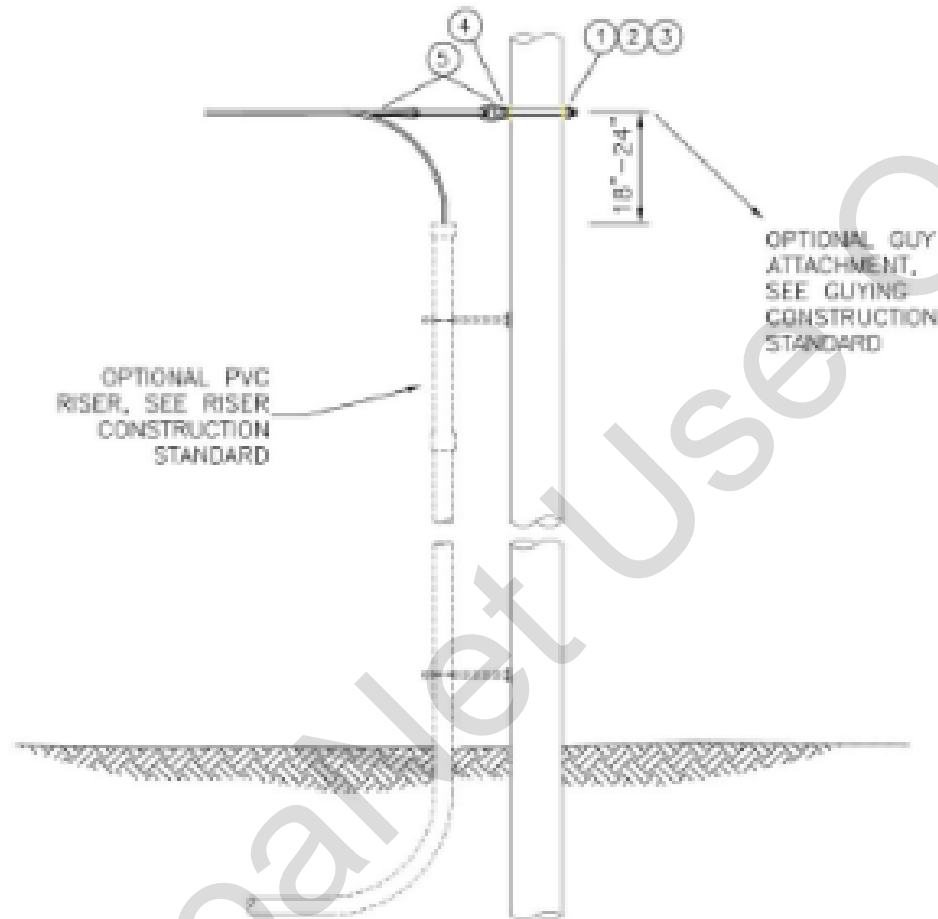


FIBER OPTIC DOUBLE DEAD END MEDIUM TENSION
FIBER OPTICS INSTALLATION STANDARDS

DATE: 06/20/2023

FO-7
PG 12

RUS Design Single Fiber Dead-End



BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		Nut, Mech. 5/8" x 12"
2	1		Washer 5/8" Lock Only 5/8"
3	2		Conduit, 3-1/4" x 3/16", 11/16" Hole
4	1		Nut TE 5/8"
5	1		Fiber Dead-end ADSS 0.0055 Dia.



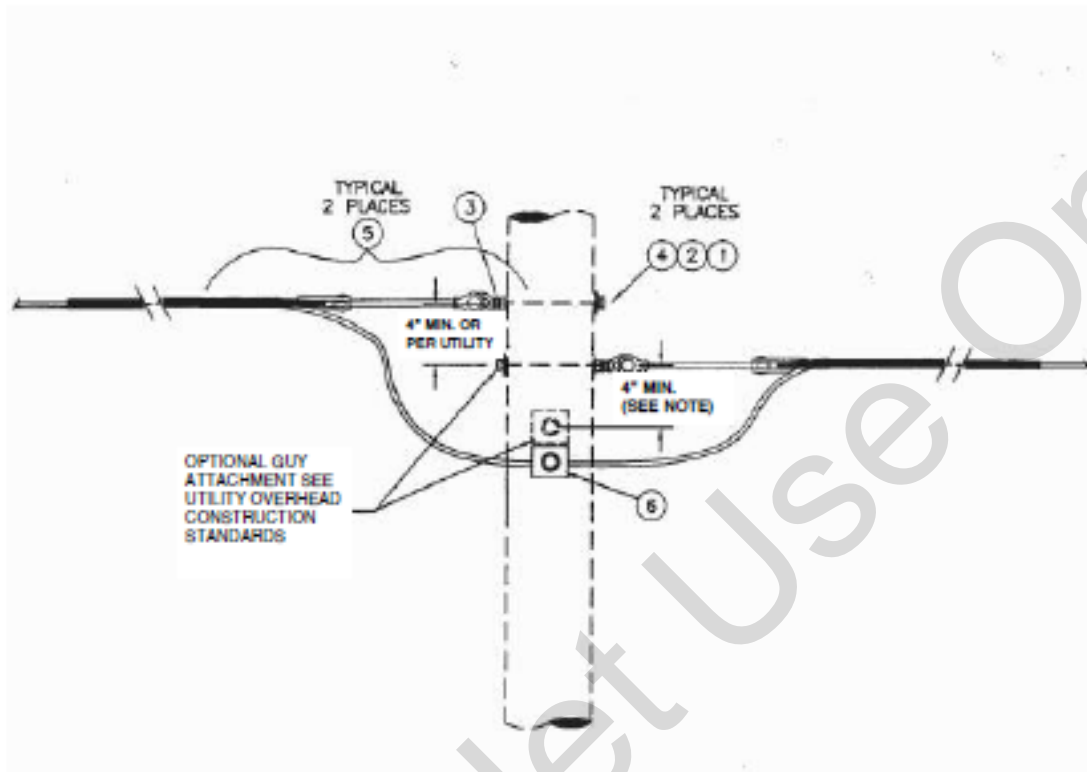
ADSS Fiber Optic Cable Single Dead-End

DATE 05/03/23

FO-DD1

PG 13

RUS Design Double Dead-End



1. CHECK UTILITY POLE OWNER REQUIREMENTS FOR MINIMUM SEPARATION BETWEEN DRILLED HOLES.

BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	2		Bolt Mach 5/8" x 12"
2	2		Washers, SP Lock, Galv 5/8"
3	2		Nuts Palmul Lock 5/8"
4	2		Curved, 2-1/4" x 3/16", 11/16" Hole
5	2		Fiber Dead-end ADSS 0.6555 DIA
6	1		Fiber, Down-lead Cushion, 0.535



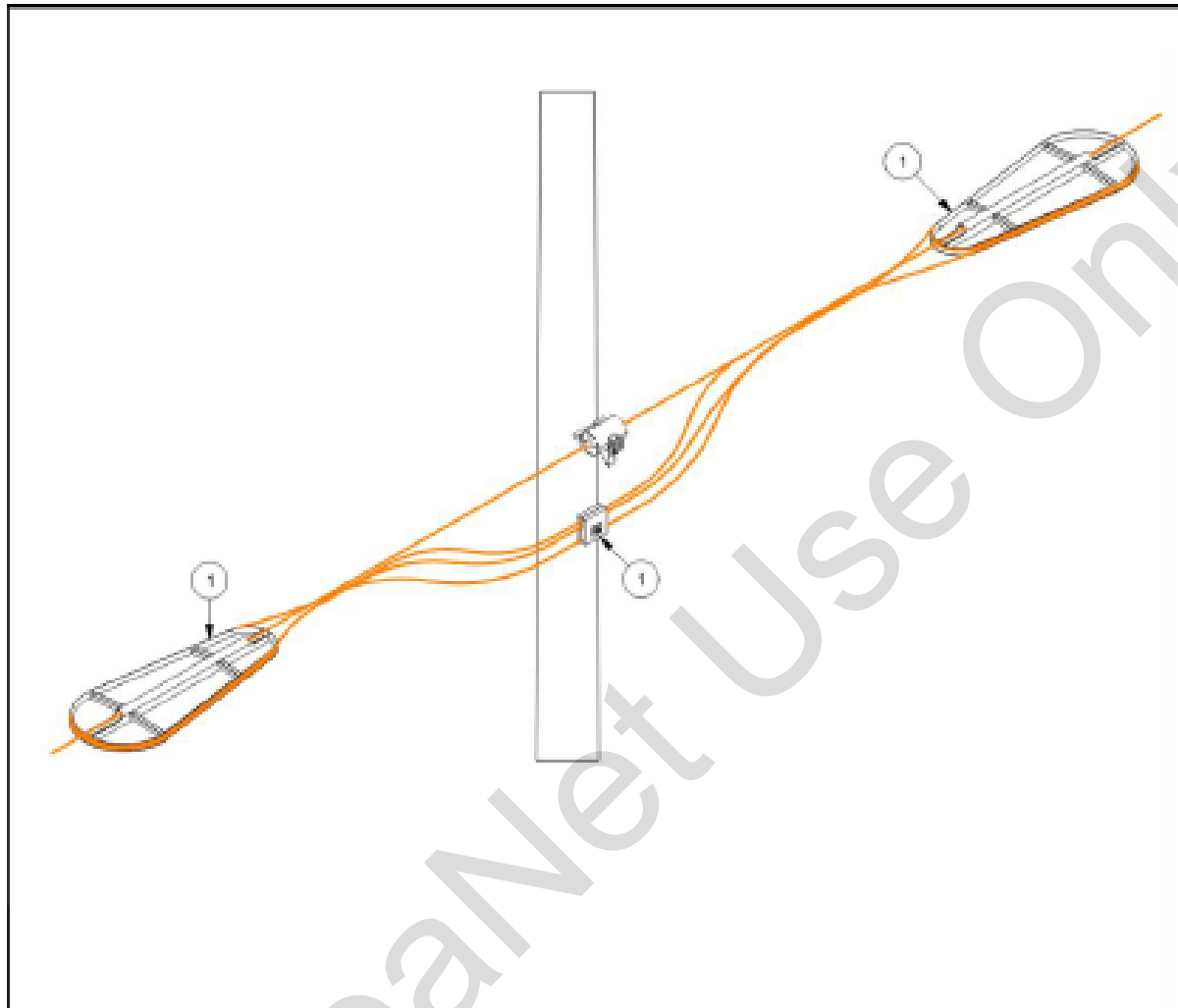
ADSS Fiber Optic Cable Installation
Double Deadend 0 to 90 Degrees

DATE: 06/2023

FO-DD2

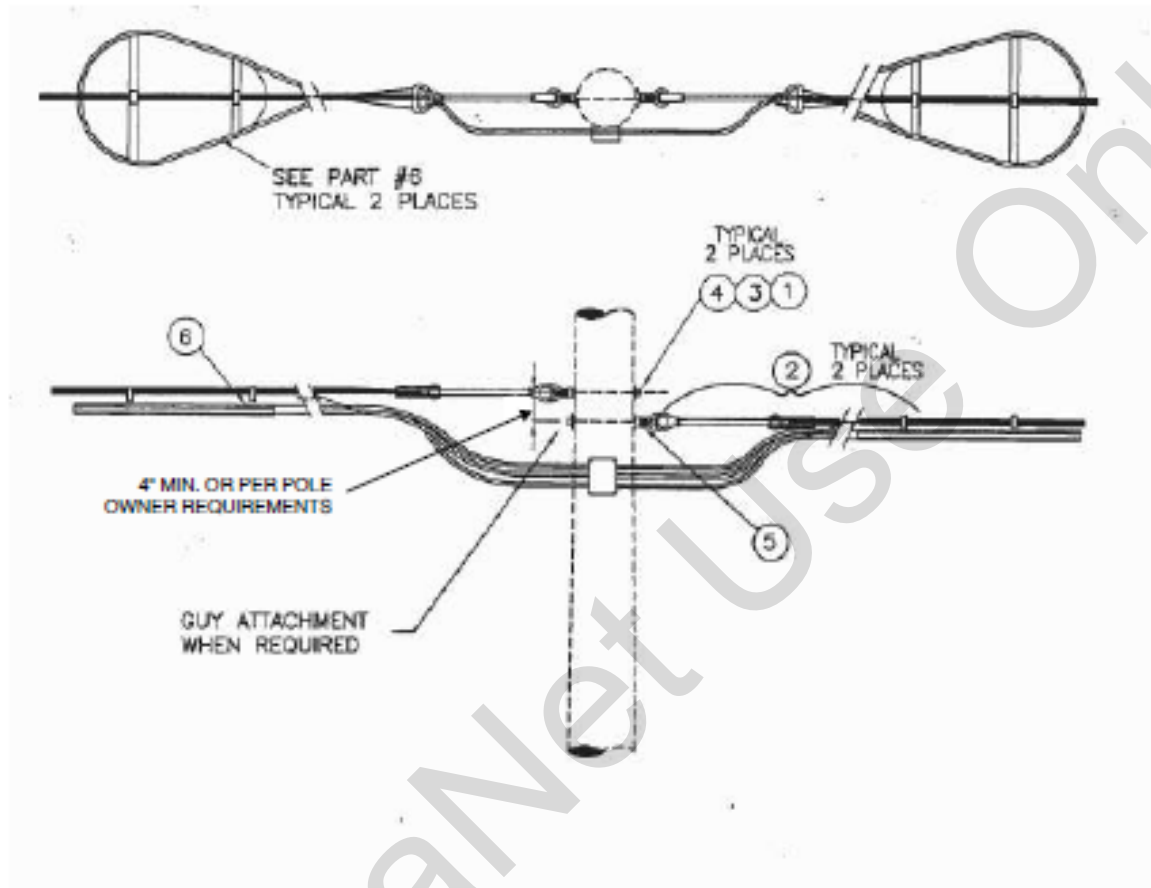
PG 14

RUS Design ADSS Storage-No Splice Case



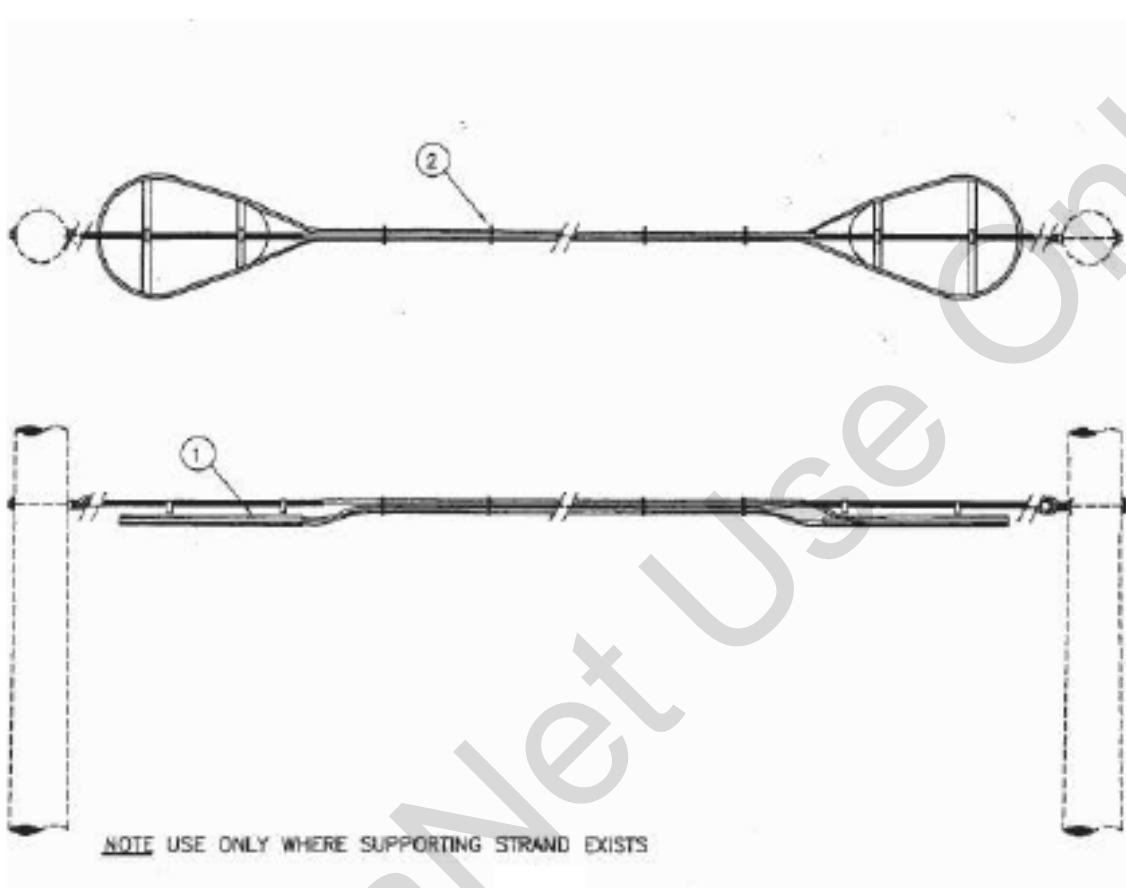
BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		IN-SPAN STORAGE SYSTEM FOR ADSS
			(CABLE SIZE .310"-.575") COMPLETE WITH 2.
			STORAGE RACKS (HORSE SHOES), ARMOR RODS,
			CABLE PROTECTION BRACKET, MISC HARDWARE
2	25		8" CABLE TIES
5			
6			

RUS Design Storage Loop Dead-End Assembly



BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	2		Bolt, Mach, 5/8" x 12"
2	2		Fiber Dead-end ADSS 0.6555 Dia.
3	2		Washers, SP Lock, Galv 5/8"
4	4		Curved, 3" x 3" x 1/4L x 11/16" Hole
5	2		Nuts Palnut Lock 5/8"
6	1		In-Span Storage System, 0.6555

RUS Design Strand & Lash Fiber Storage



NOTE USE ONLY WHERE SUPPORTING STRAND EXISTS

BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		In-Span Storage System .650-.730 DIA.
2	AS REQD		Cable Ties (Tie Wraps)
1	1		In-Span Storage System .510-.575 DIA.
2	AS REQD		Cable Ties (Tie Wraps)

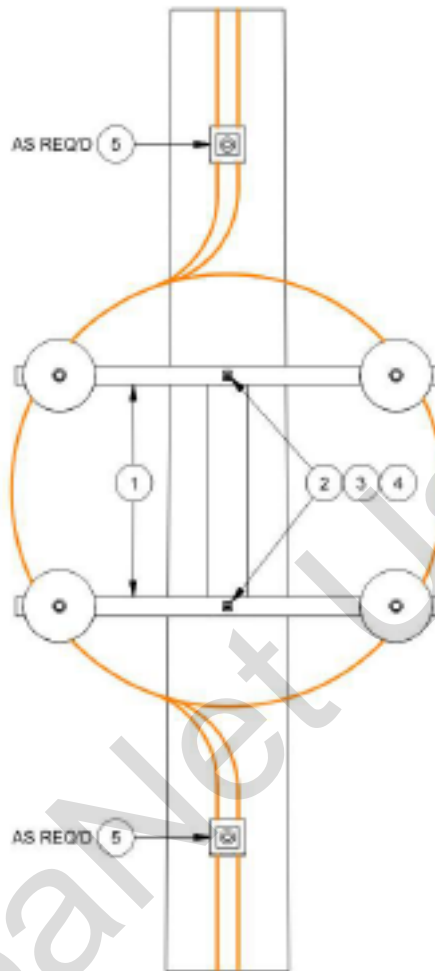


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**Fiber Optic Cable In Span
Storage Assembly**

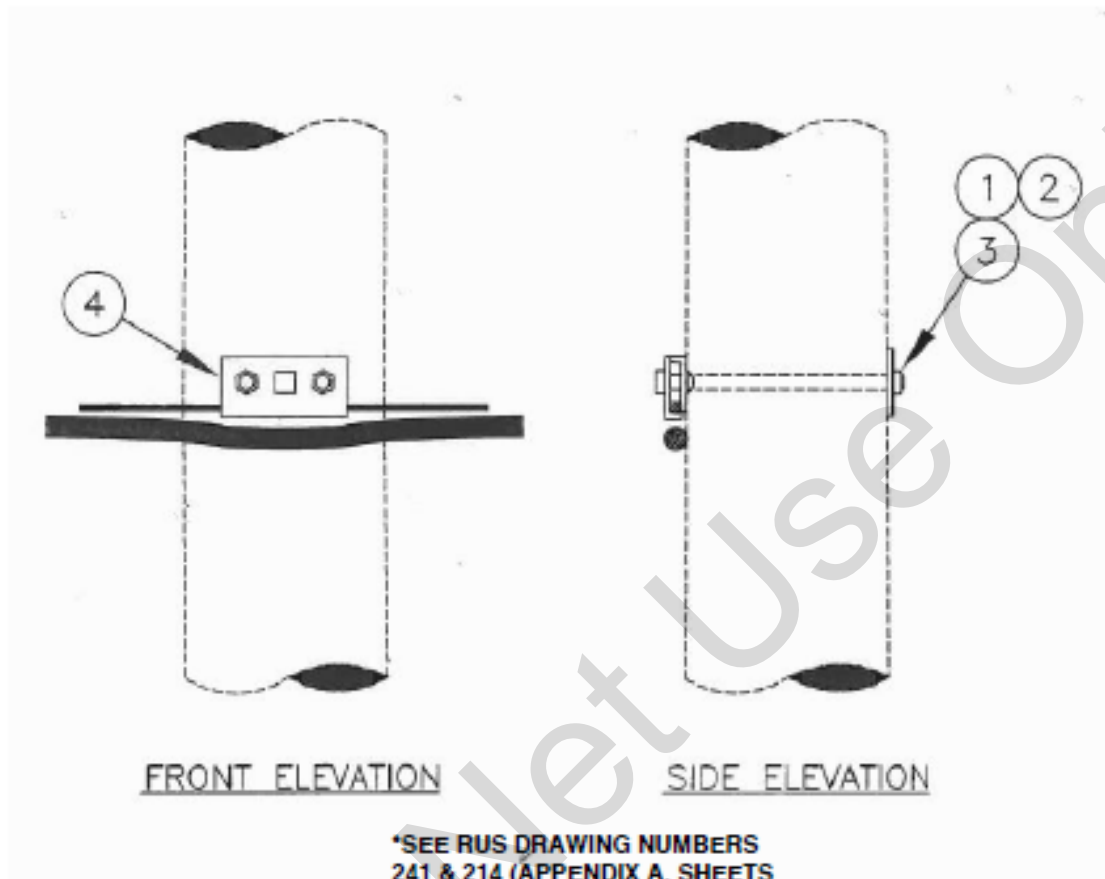
DATE: 12/2022
**FO-8C
FO-8D**
PG 17

RUS Design ADSS Storage Bracket on Pole



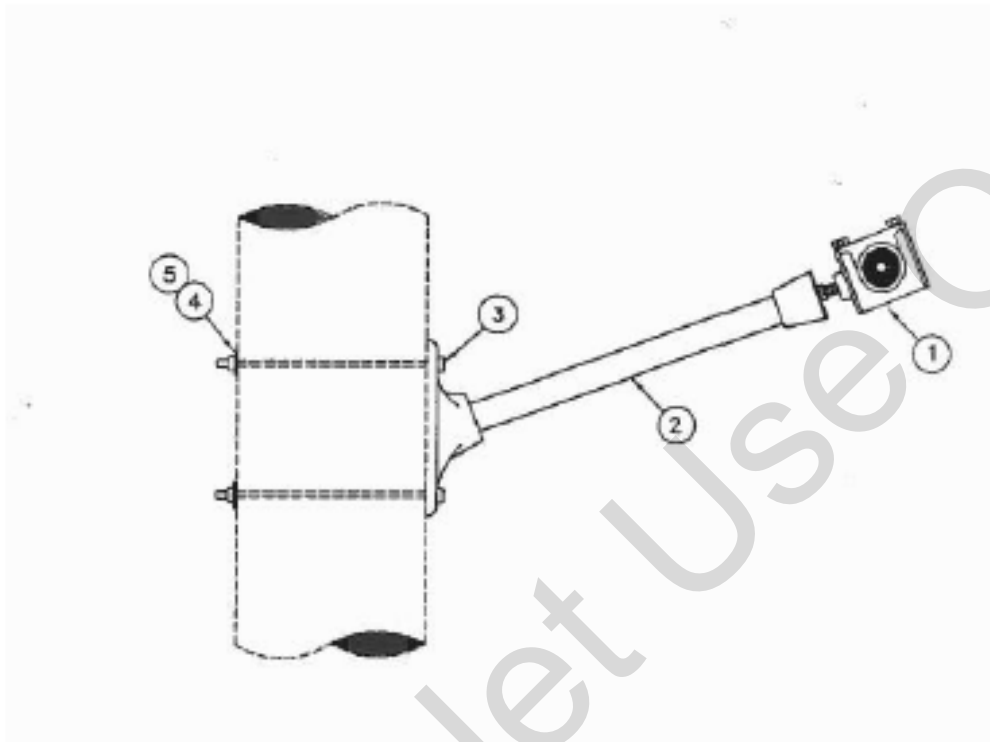
BILL OF MATERIAL			
REF #	USE	PART #	DESCRIPTION
1	1		VERTICAL CABLE STORAGE DOUBLE ARM COMPLETE WITH 2 STORAGE ARMS WITH 4 STORAGE SPOOLS CABLE PROTECTION BRACKET, MSC HARDWARE CABLE PROTECTION BRACKET, MSC HARDWARE
2	2		MACHINE BOLT, 5/8" x 14"
3	2		5/8" GALVANIZED NUT
4	4		WASHER, SQUARE GALVANIZED, 2" x 2" x 3/16"
5	3		DOWNLEAD CUSHION WITH HARDWARE

RUS Design Messenger Suspension Clamp



BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		Bolt, Mach, 5/8" x 12"
2	1		Washer SP Lock Galv 5/8"
3	1		Curved, 2-1/4" x 3/16", 11/16" Hole
4	1		Clamp, Messenger, Tangent Bolt, Fiber

RUS Design Fiber ADSS Support Clamp FGA



	Aluma-Form Part #
12"	F1CA-MV-A12-F2
18"	F1CA-MV-A18-F3
24"	F1CA-MV-A24-BF2
30"	F1CA-MV-A30-BF2

BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		Fiber Dielectric Support 0.65
2	1		Fiber Fiberglass Bracket (specify length per chart)
3	2		Bolt Mach 5/8" x 12"
4	2		Curved, 2-1/4" x 2-1/4" x 3/16" x 11/16" Hole
5	2		Washer SP Lock Galv 5/8"



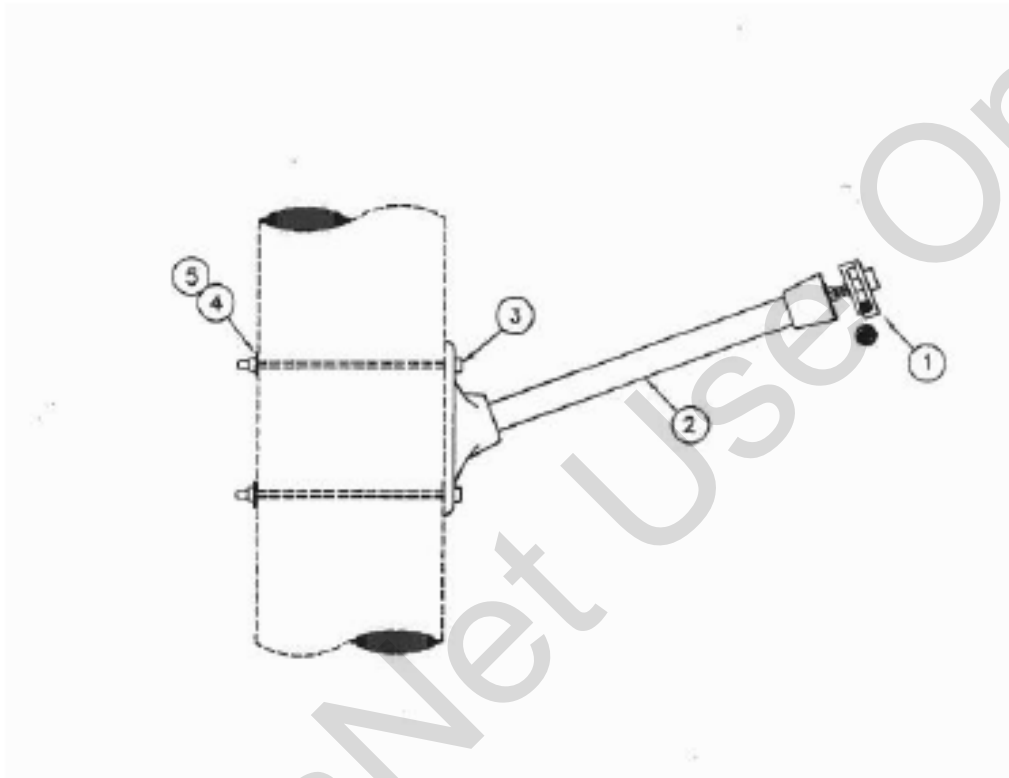
Fiber Optic Cable ADSS Support Clamp
on Fiberglass Stand Off Bracket

DATE 12/2022

FO-EXTB

PG 20

RUS Design Fiber Messenger Clamp Support FGA



	Aluma-Form Part #
12"	F1CA-MV-A12-F2
18"	F1CA-MV-A18-F3
24"	F1CA-MV-A24-BF2
30"	F1CA-MV-A30-BF2

BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1	390023	Clamp, Messenger, Tangent, Three Bolt, Fiber
2	1	3500	Fiber Fiberglass Bracket
3	2	320260	Bolt Mech 5/8" x 12"
4	2	344116	Curved, 2 1/4" x 2 1/4" x 3/16", 1 1/16" Hole
5	2	344215	Washer SP Lock Galv 5/8"

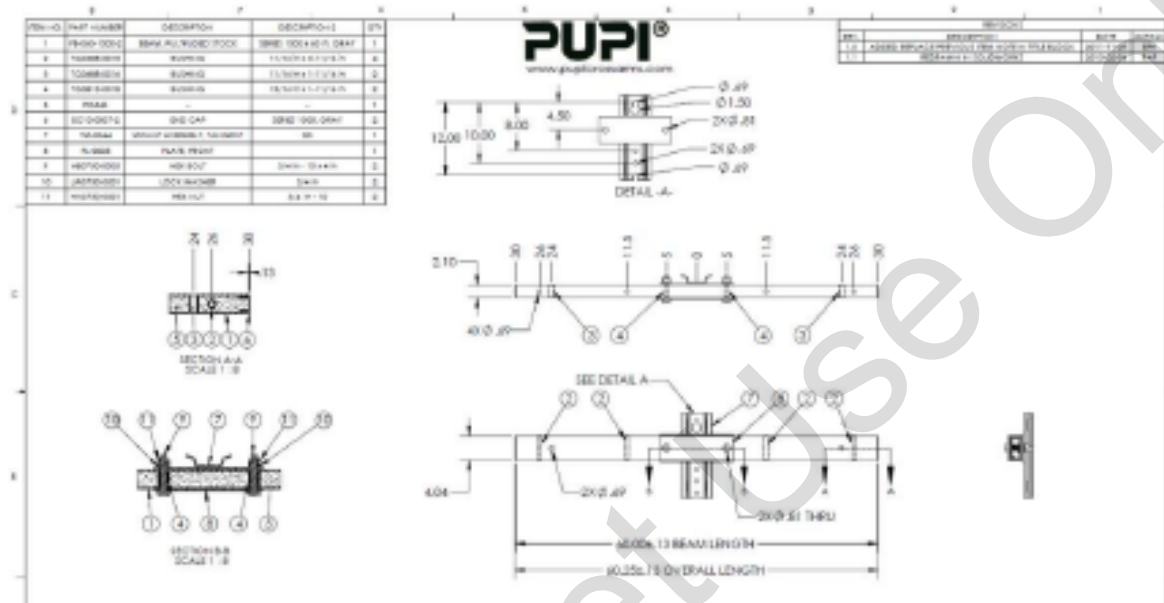


Fiber Optic Cable Messenger Clamp on
Fiberglass Stand Off Bracket

DATE: 12/2022

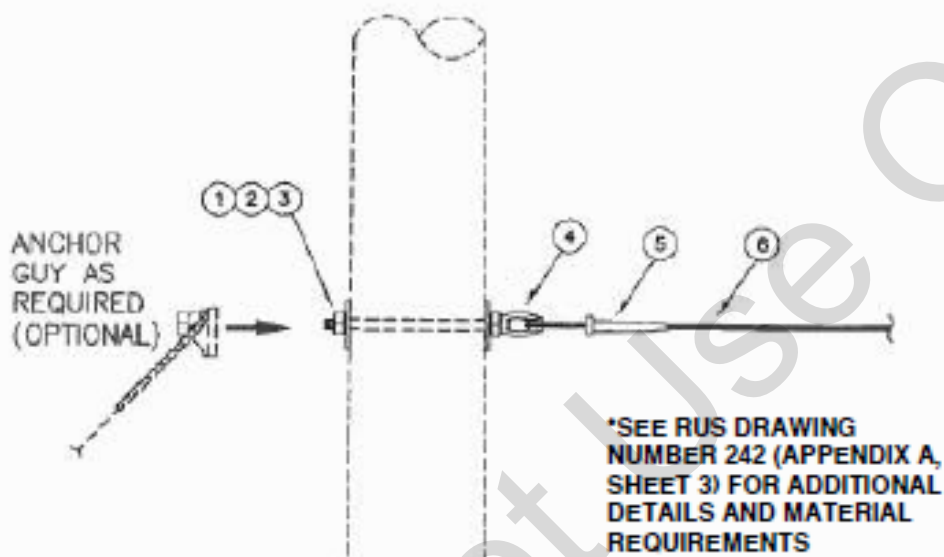
FO-EXTC
PG 21

RUS Design PUPI Arm Assembly



BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		PUPI Fiberglass Arm, 60"
2	2		Bolt, Mech Sq Head Galv 3/4" x 14" w/ Sq Nut,
3	2		Washer Sq Curved, 3/4" HD Galv 3" x 3" x 1/4
4	2		Washer double coil , 3/4" HD Galv Spring Lock HD Galv

RUS Design 6000 LBS Messenger Single Dead-End

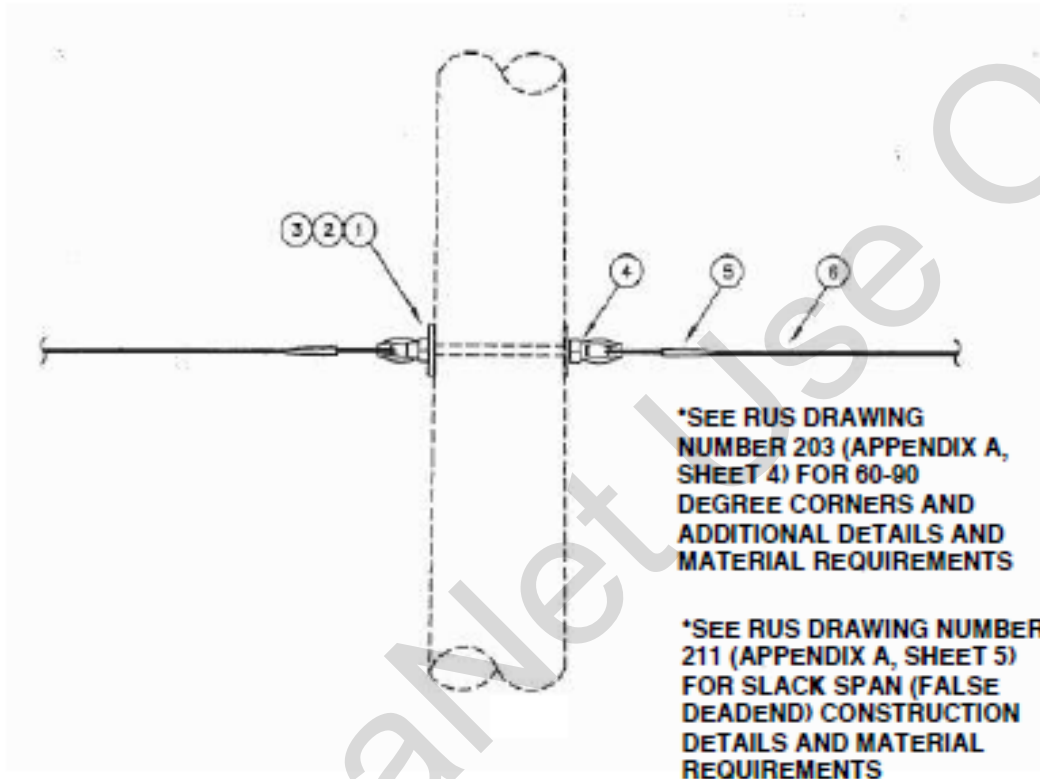


BILL OF MATERIAL

REF#	USE	PART#	DESCRIPTION
1	1		Bolt DA 5/8" x 14"
2	2		Washers, SP Lock, Galv 5/8"
3	2		Curved, 3" x 3" x 1/4L x 1 1/16" Hole
4	1		Nuts TE 5/8"
5	1		DE Auto 5/16" Short Bolt
6	A/R		5/16" Guy Strand

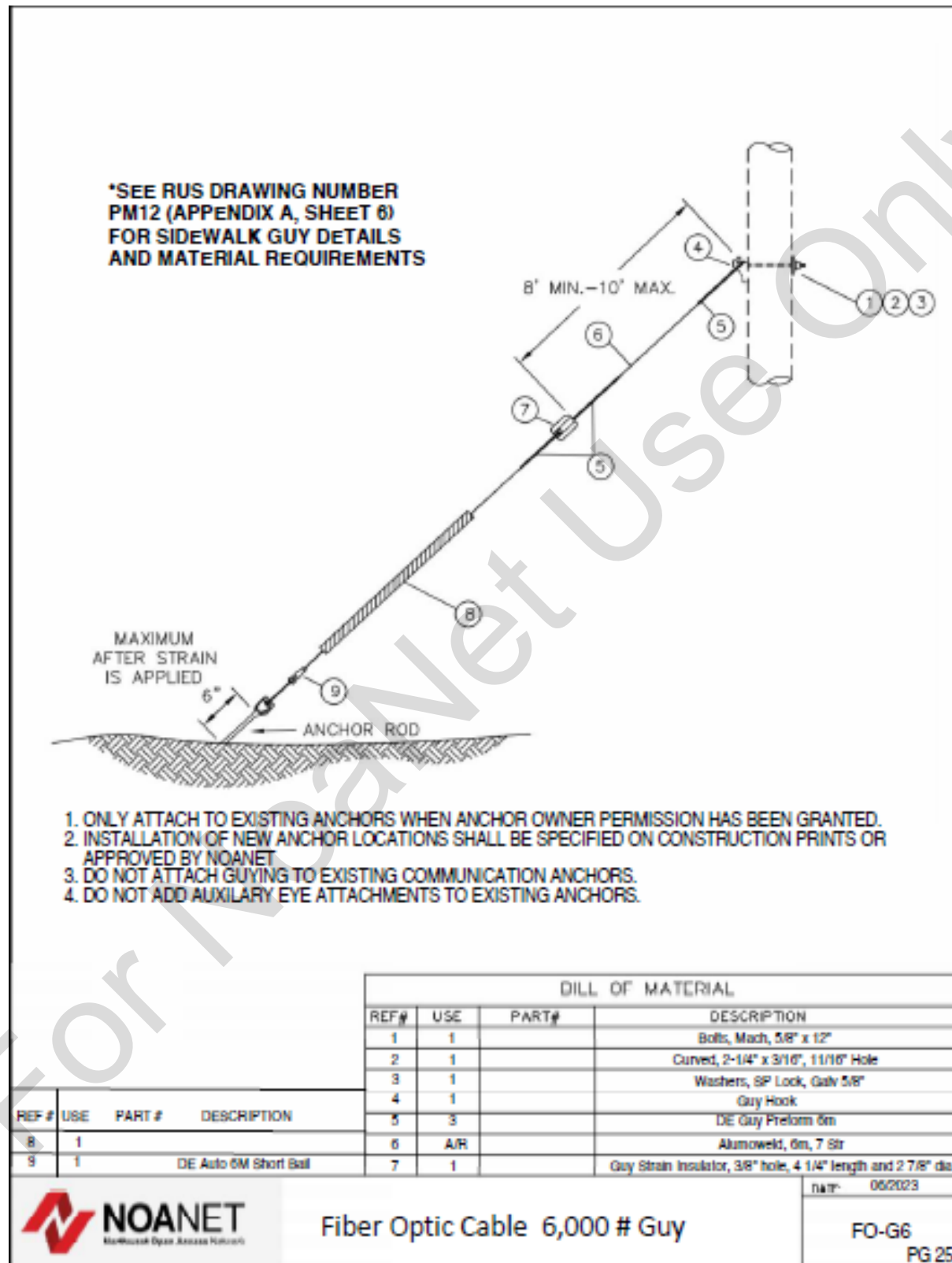
Note: Fiber Contractor to Provide Material

RUS Design 6000 LBS Messenger Double Dead-End

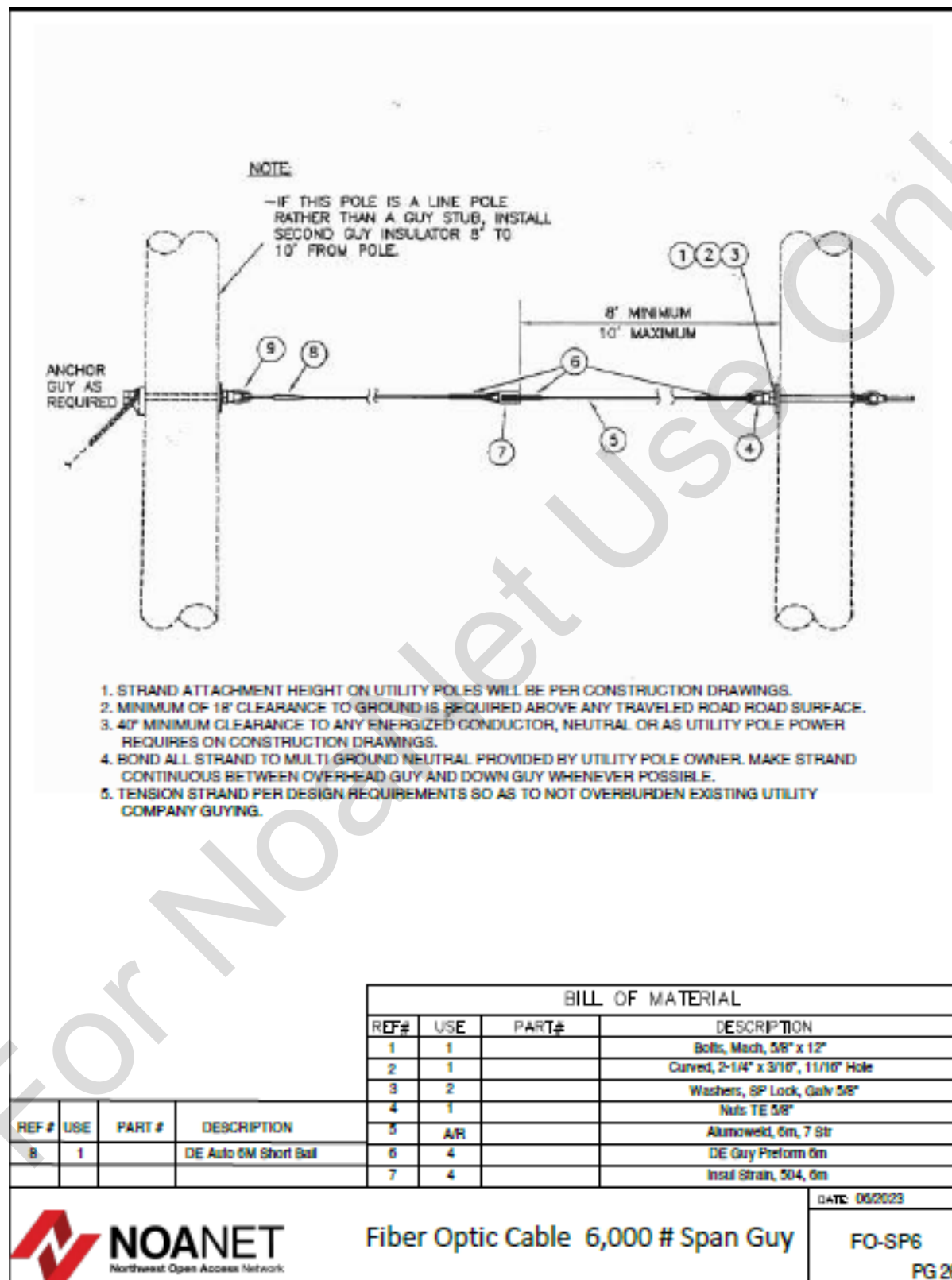


BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1	320075	Bolt DA 5/8" x 14"
2	1	344215	Washers, 6P Lock, Galv 5/8"
3	2	344120	Curved, 3" x 3" x 1/4L x 11/16" Hole
4	2	336020	Nuts TE 5/8"
5	1	335360	DE Auto 6m Short Ball
6	A/R	130160	Alumoweld 6m 7 Str

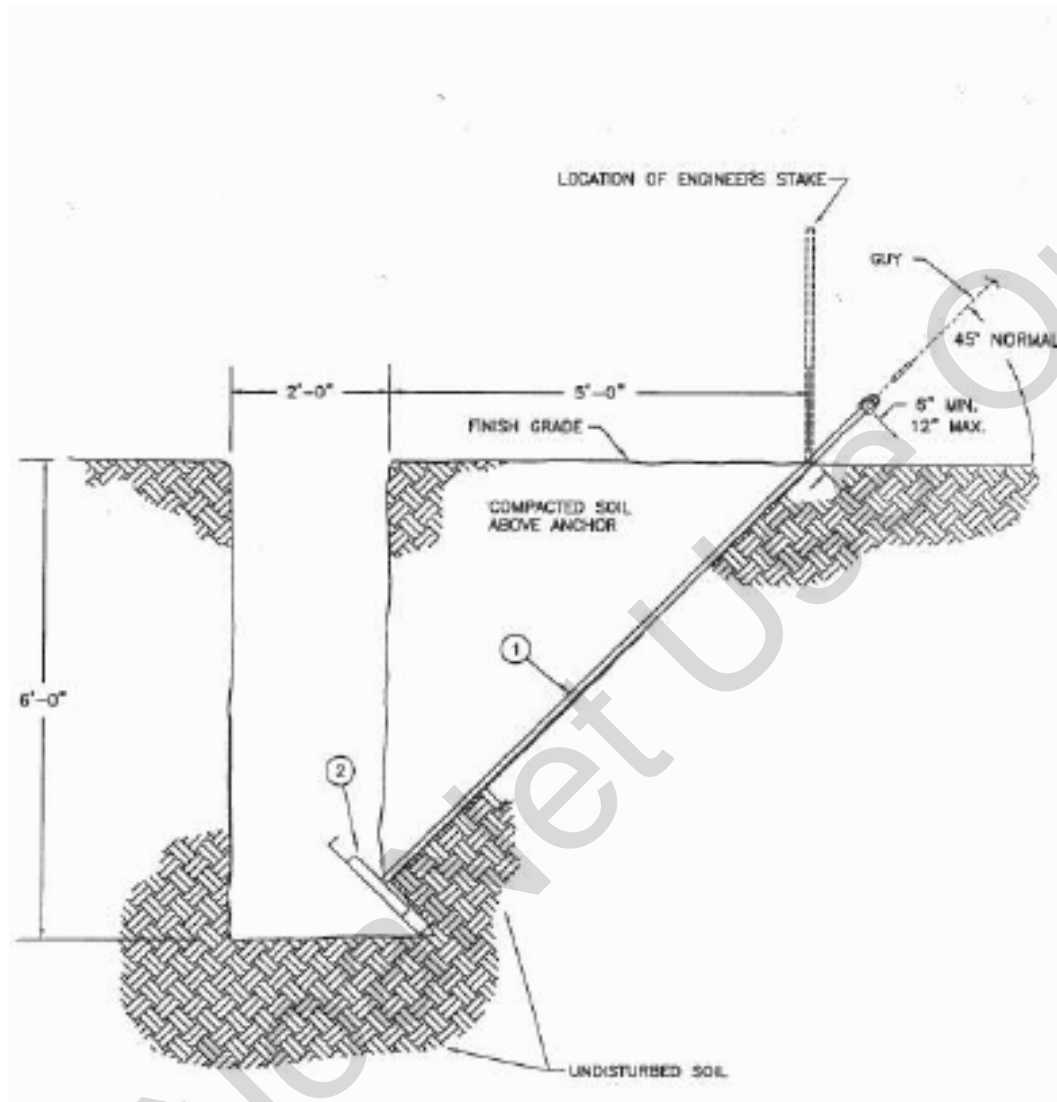
RUS Design 6000 LBS Down Guy w/Insulator



RUS Design 6000 LBS Span Guy



RUS Design Plate Anchor Assembly



BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		Anchor Rod Twin Eye 3/4" x 8'
2	1		Anchor Cross Plate Type, 16" (includes Nut Retainer)

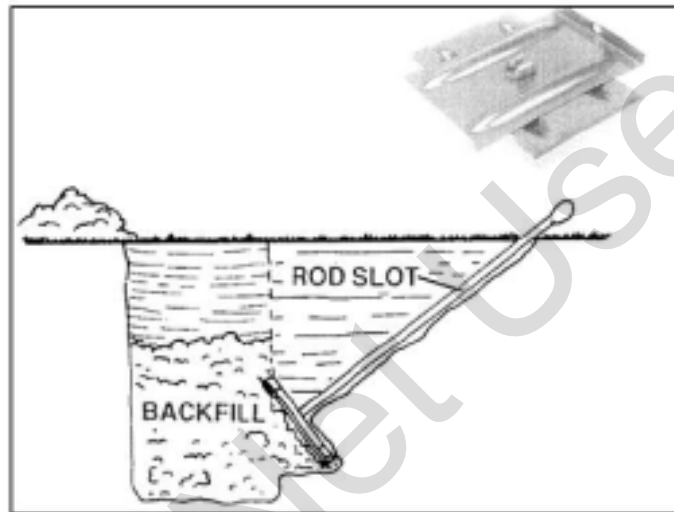
RUS Design Plate Anchor Installation

Common Types of Anchors and Installation

Plate Anchor

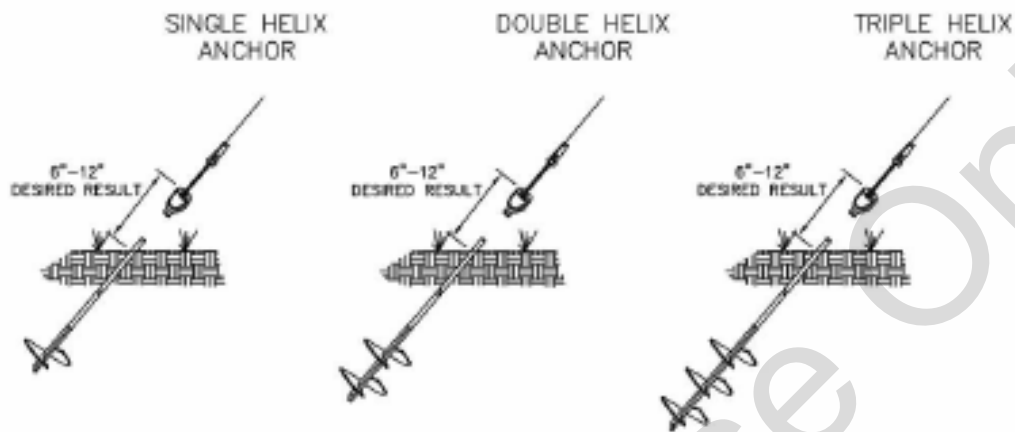
The Cross-Plate anchor is made for installation in holes drilled by power diggers. Because the size of the hole does not affect holding capacity, the same auger that is used to dig the pole holes on transmission projects can dig the hole. Cross-Plate anchors are installed in a diagonal bored hole, which is undercut so the anchor is at right angles to the guy. A rod trench is either cut with a trenching tool or drilled with a small power auger. Both anchor and rod trench should be refilled and tamped.

Figure 3 - Cross-Plate Anchor



BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION

RUS Design Helix Screw-In Anchors



HELIX/SCREW-IN ANCHOR

SCREW-IN ANCHORS ARE RECOMMENDED FOR SOFTER SOIL TYPES, INCLUDING CLASSES 5-7 IN THE SOIL CLASSIFICATION DATA CHART. THEY DO NOT WORK WELL IN ROCKY SOILS. SCREW-IN ANCHORS ARE USUALLY INSTALLED BY A POWER DRIVE MACHINE. SCREW-IN ANCHORS CAN ALSO BE USED IN APPLICATIONS WHERE AN ANCHOR WILL BE EMBEDDED IN CONCRETE.

SOIL CLASSIFICATION DATA

Class	Common Soil Type Description	Geological Soil Classification	Probe Values in-lb. (NMI)	Typical Blow Count "N" per ASTM D1586
0	Sound hard rock, unweathered	Granite, Basalt, Massive Limestone	N/A	N/A
1	Very dense and/or cemented sand; coarse gravel and cobbles	Cobbles, (8/16-in. bearing gravel/rock)	750 - 1500 (185 - 181)	40-100+
2	Dense fine sands; very hard silts and clays (may be preloaded)	Basal till; boulder clay; caliche; weathered laminated rock	600-750 (98 - 85)	45-60
3	Dense sands and gravel; hard silts and clays	Glacial till; weathered shales, siltst., grains and siltstones	500 - 600 (55 - 68)	35-50
4	Medium dense sand and gravel; very stiff to hard silts and clays	Glacial till; hardpan; marls	400 - 500 (45 - 56)	24-40
5	Medium dense coarse sands and sandy gravels; stiff to very stiff silts and clays	Sagittaria, residual soils	300 - 400 (34 - 45)	14-25
6	Loose to medium dense fine to medium sands to stiff clays and silts	Dense hydraulic fill; compacted fill; residual soils	200 - 300 (23 - 34)	7-14
**7	Loose fine sands; Alluvium; loose; medium- stiff and varied clays; fill	Flood plain soils; lake clays; silts; gumbo, fill	200 - 200 (11 - 23)	4-8
**8	Peat, organic silts; interstratified silts, fly ash very loose sands, very soft to soft clays	Miscellaneous fill, swamp marsh	less than 200 (0 - 11)	0-5

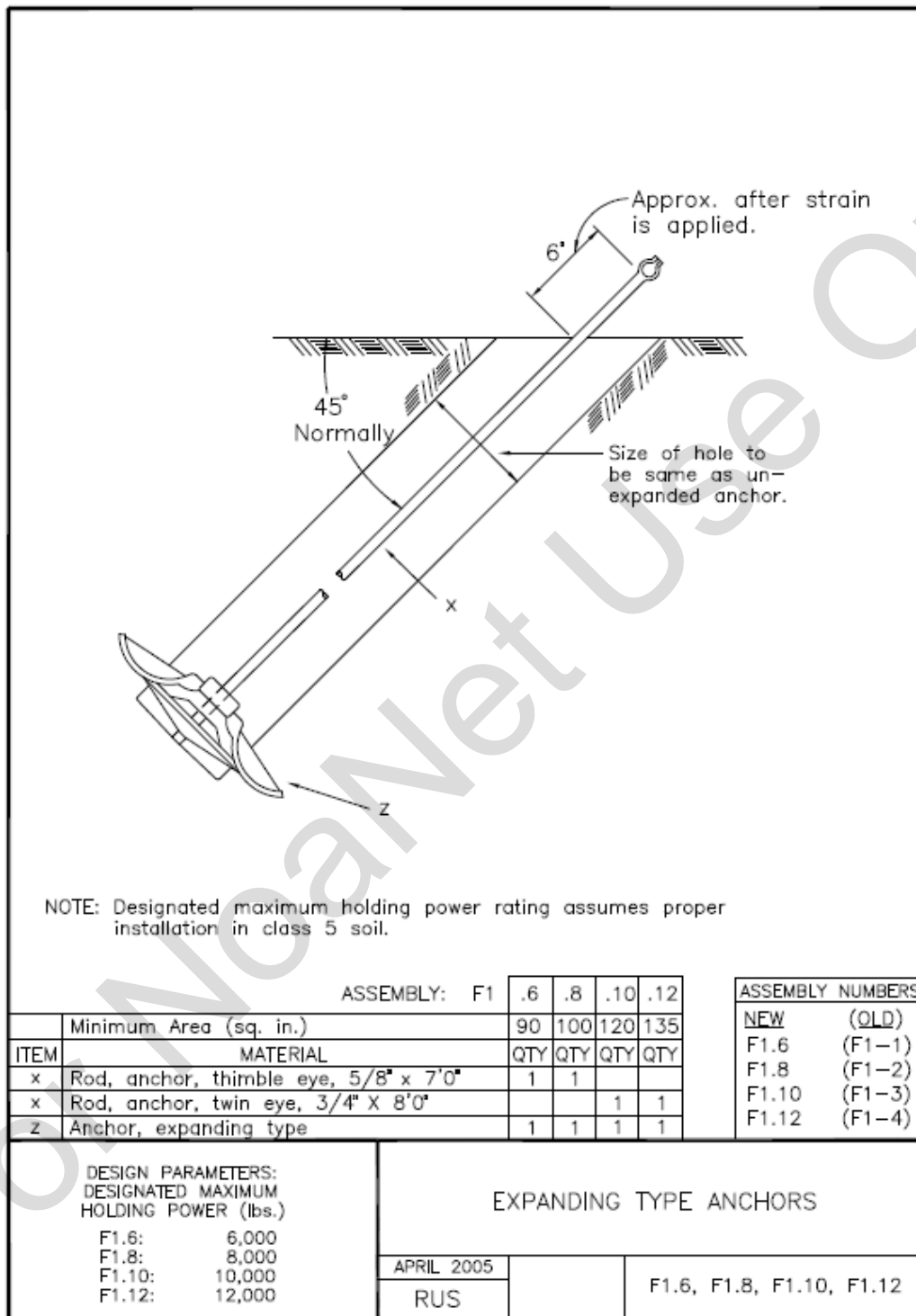
Class 1 soils are difficult to probe consistently and the ASTM blow count may be of questionable value.

**It is advisable to install anchors deep enough, by the use of extensions, to penetrate a Class 5 or 6, underlying the Class 7 or 8 Soils.

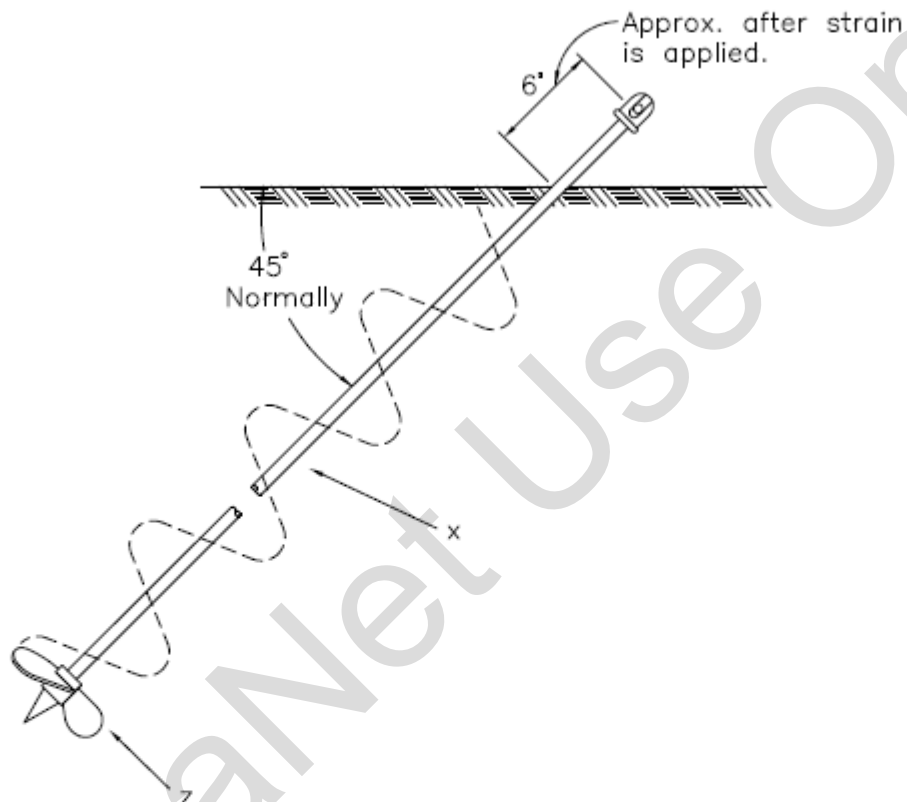
BILL OF MATERIAL

REF#	USE	PART#	DESCRIPTION
	1		Screw Anchor, 16,000lb

RUS Design Expanding Type Anchors



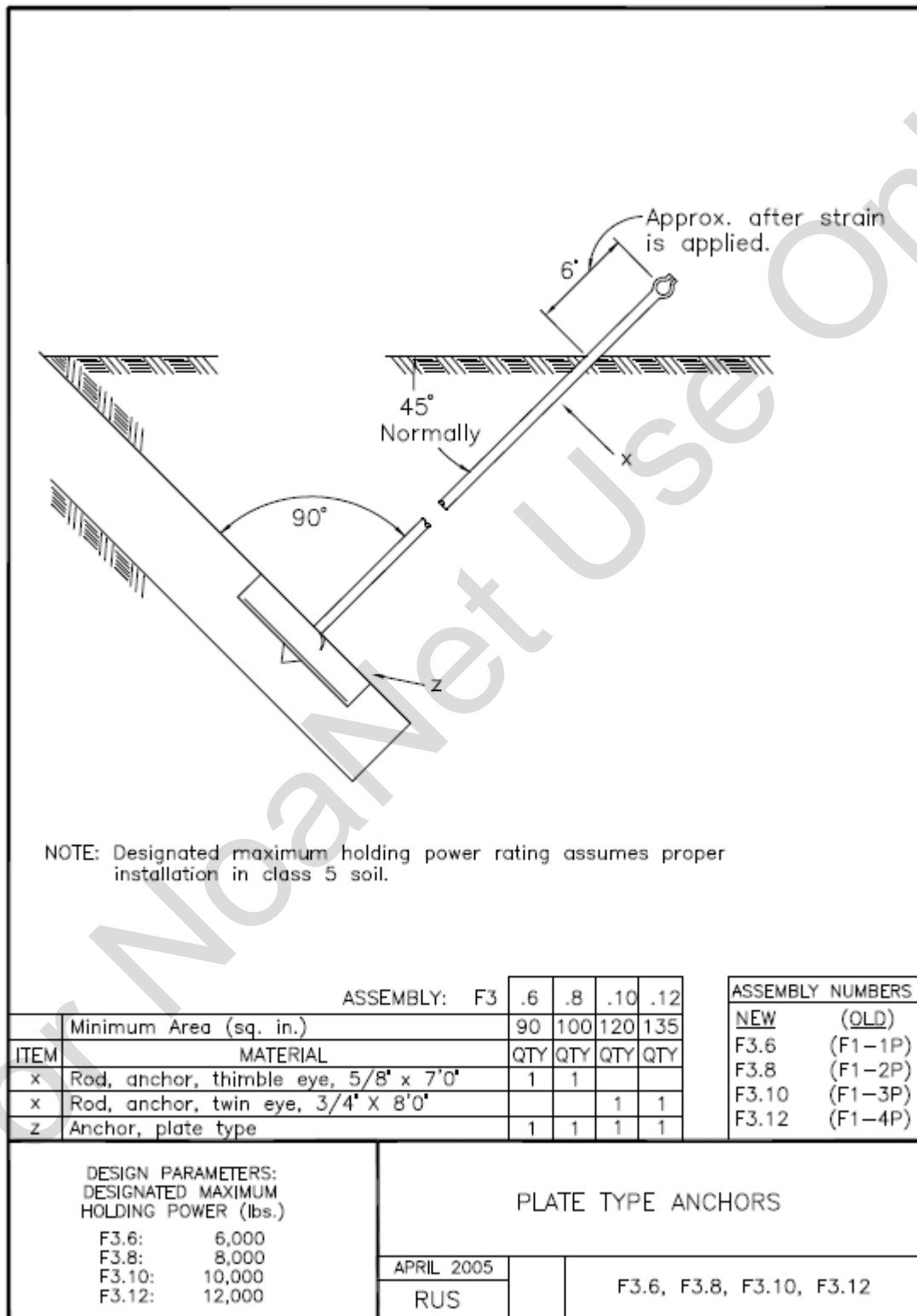
RUS Design Screw Anchors (Power Installed)



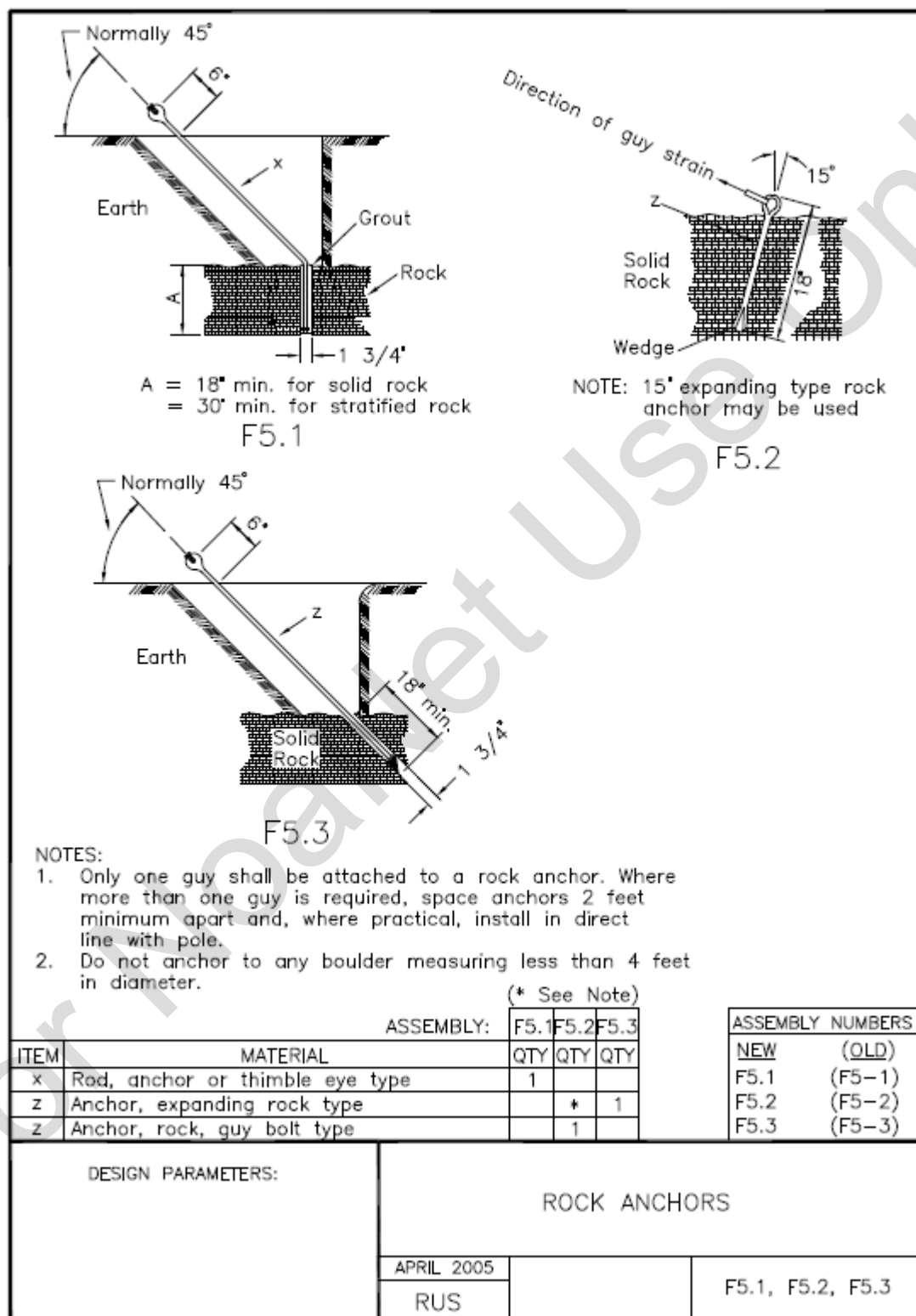
NOTE: Designated maximum holding power rating assumes proper installation in class 5 soil.

ASSEMBLY: F2		.6	.8	.10	.12	ASSEMBLY NUMBERS	
	Minimum Area (sq. in.)	90	100	120	135	NEW	(OLD)
ITEM	MATERIAL	QTY	QTY	QTY	QTY	F2.6	(F1-1S)
x	Rod, anchor, thimble eye, 5/8" x 7'0"	1	1			F2.8	(F1-2S)
x	Rod, anchor, twin eye, 3/4 X 8'0"			1	1	F2.10	(F1-3S)
z	Anchor, screw type, power installed	1	1	1	1	F2.12	(F1-4S)
DESIGN PARAMETERS: DESIGNATED MAXIMUM HOLDING POWER (lbs.) F2.6: 6,000 F2.8: 8,000 F2.10: 10,000 F2.12: 12,000		SCREW ANCHORS, (POWER INSTALLED)					
		APRIL 2005		F2.6, F2.8, F2.10, F2.12			
		RUS					

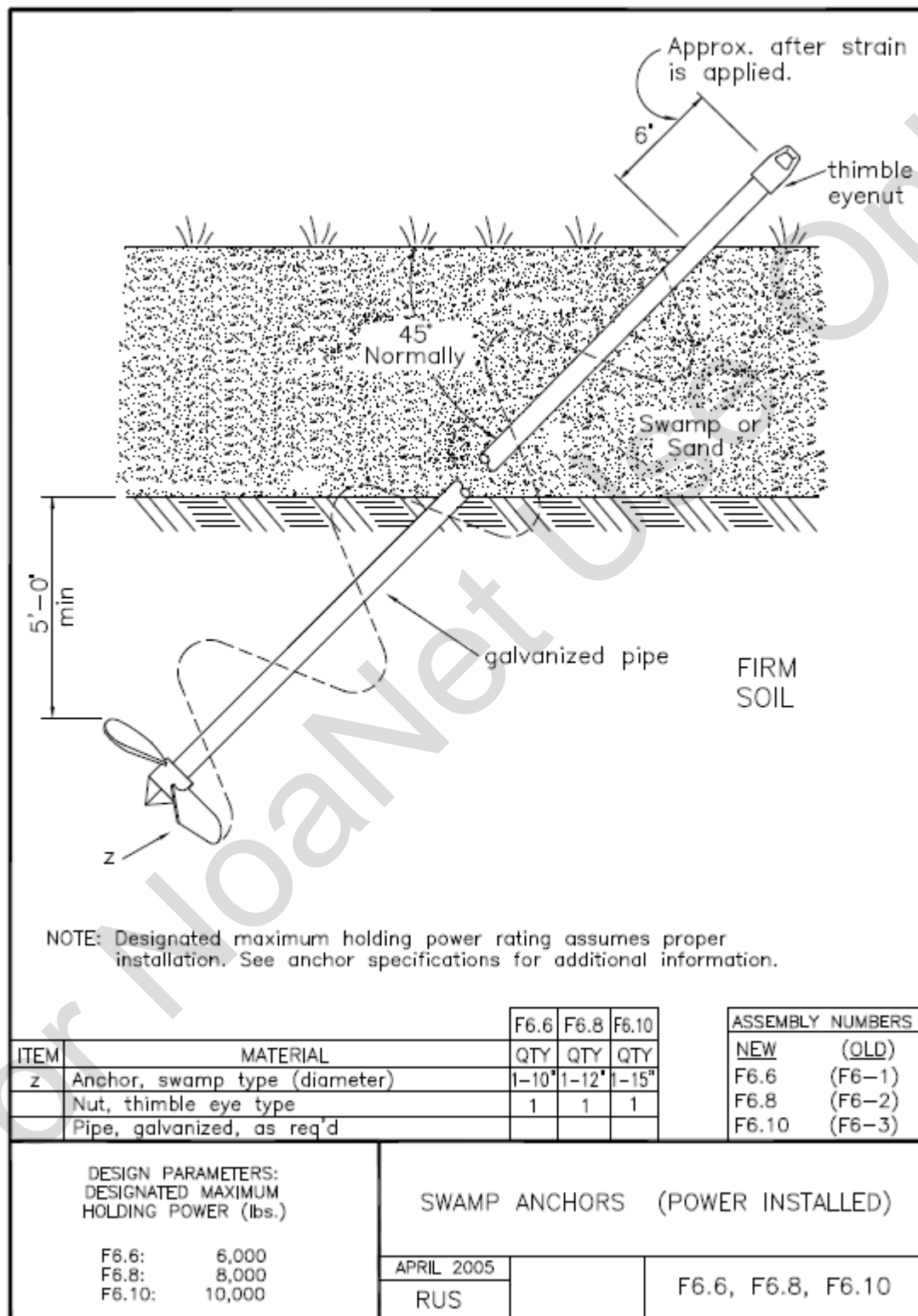
RUS Design Plate Type Anchors



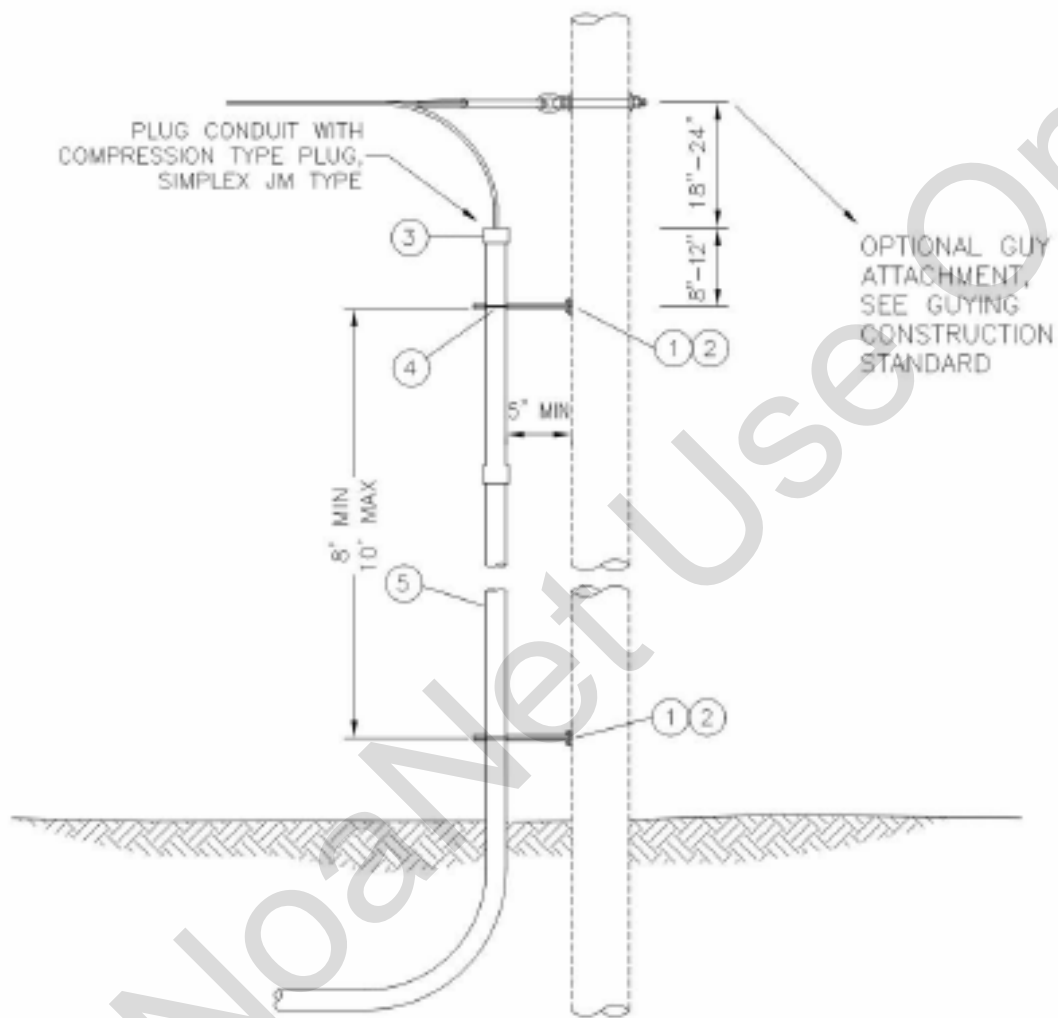
RUS Design Rock Anchors



RUS Design Swamp Anchors (Power Installed)



RUS Design Fiber Cable Riser



BILL OF MATERIAL

REF#	USE	PART#	DESCRIPTION
1	2		Screws, Lag, 1/2\" x 4\"
2	1		Bracket, Conduit Standoff, 8 1/2\"
3	1		PVC Bell End, Size per Conduit
4	1		Conduit Clamp, Standoff Bracket, Size per Conduit
5	AS REQD		PVC Conduit - Size per construction print

NoaNet Design Underground Fiber Installation

GENERAL VAULT INSTALLATION NOTES

1. VAULTS ARE NEVER TO BE PLACED IN VEHICULAR DRIVING SURFACES. VAULTS ARE RATED FOR H22 LOADING, OCCASIONAL VEHICLE TRAFFIC ONLY.
2. ALL DUCTS ENTERING OR EXITING VAULT WILL BE PLUGGED WITH COMPRESSION TYPE PLUGS, SIMPLEX JM TYPES OR FOAM SEAL CABLES IN DUCTS.
3. VAULTS ARE TO BE PLACED FLUSH WITH GROUND SURFACE NEVER TO CAUSE A TRIP HAZARD.
4. VAULTS TO BE PLACED ON 5/8" MINUS GRAVEL OR WASHED PEA GRAVEL LEVELED AND COMPACTED TO SUPPORT VAULT PLACEMENT. MINIMUM OF 4" OF GRAVEL INSIDE VAULT. WIRE MESH MATERIAL REQUIRED TO COVER THE ENTIRE BOTTOM OF THE VAULT FOR RODENT PROTECTION. WIRE MESH WILL BE PLACED UNDER GRAVEL.
5. ALL INNERDUCT WILL BE EXTENDED DIRECTLY INTO VAULTS FOR FIBER PULLING PURPOSES. INNERDUCT WILL BE HDPE PVC, SDR 9 or 11 ORANGE, SMOOTH OUTSIDE, LONGITUDE RIBBED INSIDE. DUCT WILL NEVER EXTEND MORE THAN 6" INSIDE VAULT WALL. ENTRANCE HOLE THRU SIDE OF VAULT WILL BE DRILLED OR PRESSED.
6. CONDUIT SHALL BE SCHEDULE 40 ORANGE. CONDUITS CAN ENTER THROUGH THE BOTTOM OF THE VAULT, IN A 90 DEGREE FASHION, PLACED IN THE CORNERS OF THE VAULTS.
7. PLACE FIBER CABLE PER MANUFACTURER'S SPECIFICATIONS, NEVER PULLED OR TENSIONED MORE THAN 600 (MROL) CABLE LOAD POUNDS, BEND RADIUS OF FIBER SHALL BE NO LESS THAN 18". TAG CABLES PER OWNER SPECIFICATIONS.
8. RACKING OF FIBER COIL AND SPLICE CASE IS ALWAYS REQUIRED. UTILIZE UNI-STRUT RACKING AND CABLE SHOES. SECURE SPLICE CASE WITH TIE WRAPS.
9. SECURE VAULT LID WITH PROVIDED LOCK DOWN BOLTS.
10. ALL LARGE VAULTS REQUIRE A GROUND ROD AND MARKER SIGN. GROUND ROD 5/8" x 8" COPPER CLAD AND #6 UNCOATED SOLID SOFT DRAWN COPPER.

STORAGE, TAGGING AND RACKING

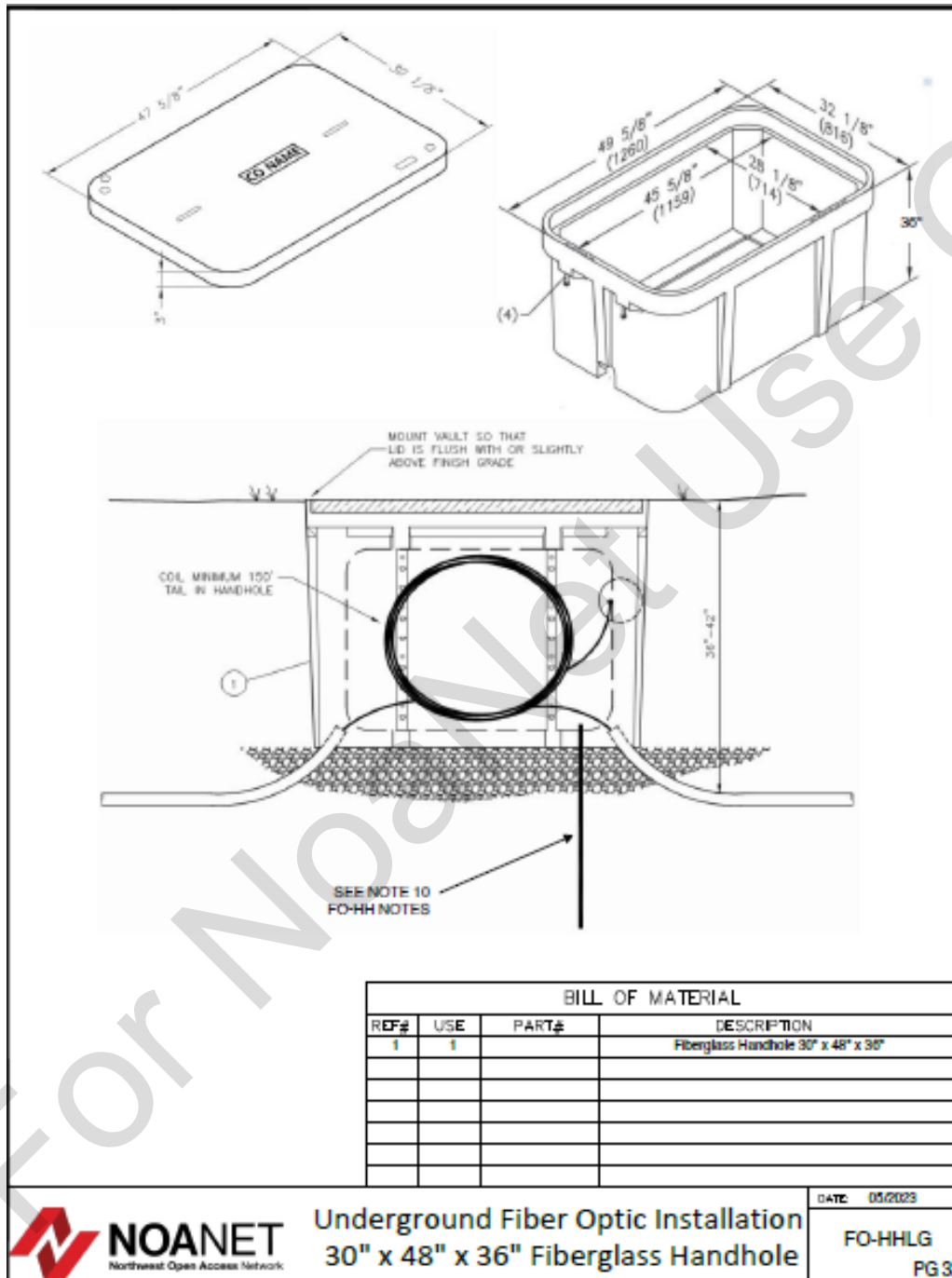


MARKER PLACEMENT



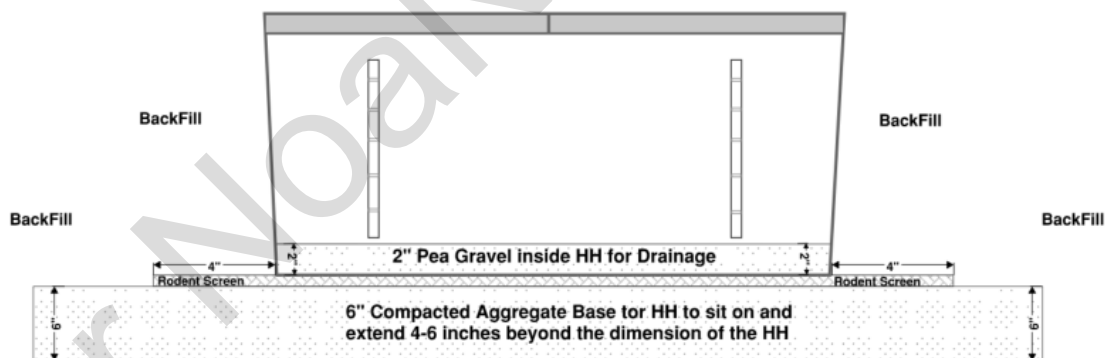
RUS Design Fiber Optic Handhole Installation

Refer to the HH Placement Standards-Pg. 60



NoaNet Handhole Placement Standard.

Place a tight weave metal rodent screen on top of compacted aggregate base extending minimum 4 inches beyond the HH base. Place HH on top of rodent screen material. Cut rodents screen for conduit entries keeping a tight circumference around conduit. Backfill around HH and compact fill accordingly flush with ground level.



Confidential Document

REUSE OF THIS DRAWING OR ANY INFORMATION CONTAINED IN THIS DRAWING FOR ANY PURPOSE IS PROHIBITED UNLESS WRITTEN PERMISSION FROM NoaNet IS GRANTED.

DRAWN BY	DATE				
R. Goode	Sept. 2025				



NORTHWEST OPEN ACCESS NETWORK

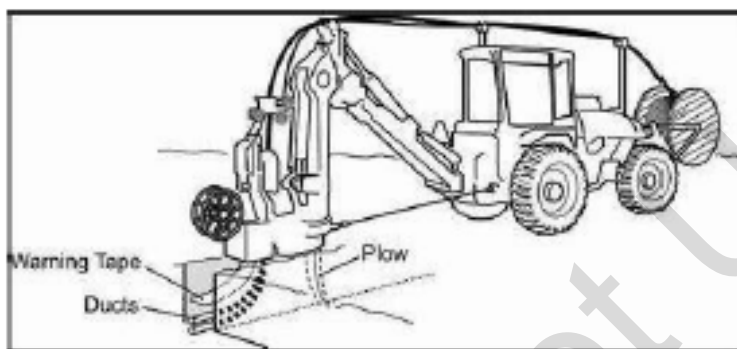
NoaNet Handhole Placement
Standard

Standard		
SIZE	DRWG NUMBER	REV
11 x 17		A
SCALE	N/A	1 of 1

RUS Design PLOW Example Drawing

Trenching / Plowing Conduit Installation Requirements:

1. All trenches shall be excavated according to the trench detail and construction design.
2. The trench shall be straight and the bottom smooth, level and free from rocks, obstructions and sharp objects.
3. The conduit shall never be bent or kinked, with a minimum bend radius of 26" in 90degrees. Conduit will be coupled to withstand 125psi blowing pressure.
4. Orange fiber optic warning tape shall be placed at 12" above the conduit in trench and plow construction methods.
5. A minimum of one cable plow ripping pass will be made at full burial depth to ensure the conduit route is clear of obstructions. The plowing operation will be continuously observed for depth and proper feeding of conduit in plow shoot.
6. One foot of separation is required between fiber conduit and any other utilities. (or per joint utility owner)
7. Minimum depth of conduit must be 42"
8. Contractor shall call for utility locates prior to digging.
9. Depths of existing utilities will be potholed for verification of location. Conflicts with existing utilities will be resolved prior to conduit placement.



Trenching/ Plowing in Right of Way

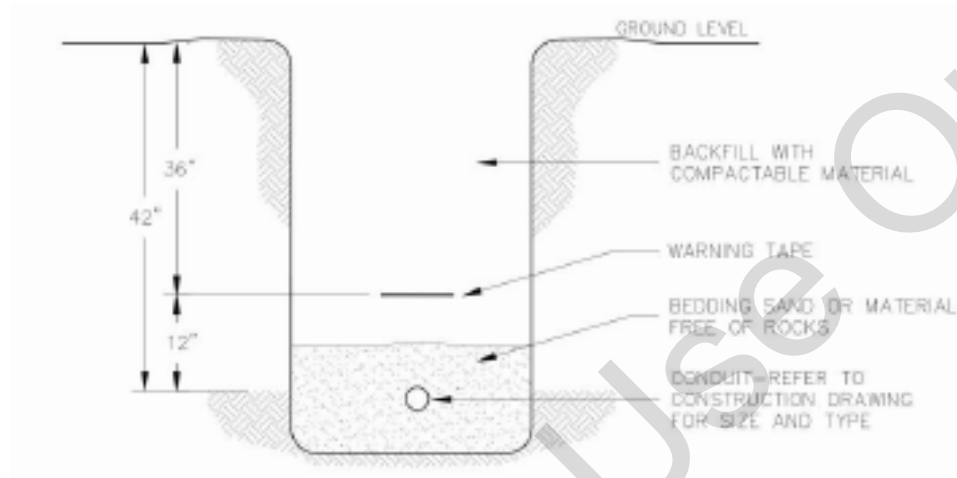
1. All State and County Road crossings shall meet the installation requirements outlined in the right of way permit issued by the authority having jurisdiction and construction design.
2. An approved, licensed and bonded excavation contractor must perform all work in the road right of way.
3. Any work in the right of way must meet the erosion and sediment control requirements of the local jurisdiction.

Fiber Installation Requirements:

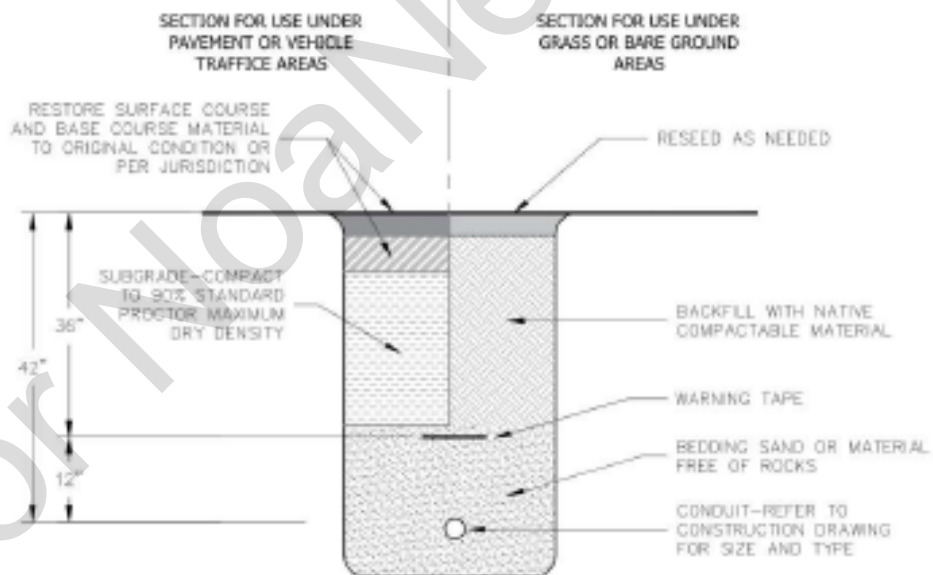
1. Conduit shall always be proofed for integrity prior to placement of fiber optic cable.
2. Cable will never be pulled over 600 pounds of pulling pressure or blowing pressure.
3. Avoid excessive cable twists.
4. Pulling or blowing speeds shall never exceed 150 feet per minute.
5. The use of capstan winches shall be calibrated with never to exceed limits of 600lbs of force. Capstans shall be sized to meet the minimum bend radius requirements under tension.
6. Never bend over 15 x OD of cable, or a maximum bend radius of 18".
7. Installation temperature must always stay between -22 and 140 degrees Fahrenheit.
8. Cable pulling lubricant used shall be recommended for cable pulling or blowing. Polywater, hydralube or equivalent. Never use soaps or detergents that cause the cable sheath to breakdown.
9. Refer to design maps for splicing locations. Fiber optic cable is never to be cut except only where designed.
10. Fiber optic cable sequential numbers are required at each pole location and vault wall. Sequential numbers will identify conduit length, and slack left in vaults and at poles.

RUS Design Trench Conduit Installation Example

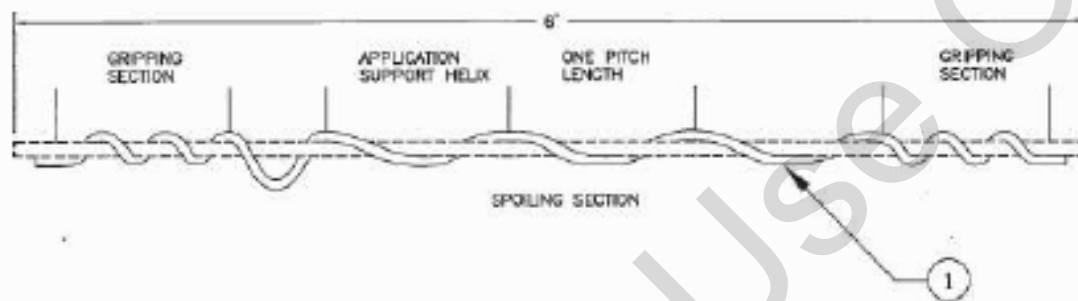
TYPICAL TRENCH/PLow SECTION



TRENCH RESTORATION



RUS Design ADSS Air Flo Spoiler Example

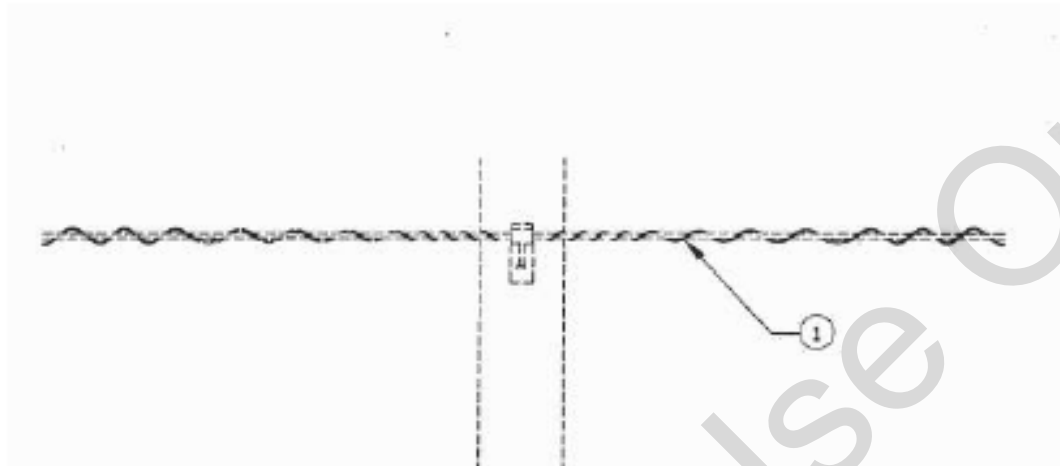


SPAN LENGTH		SPOILERS PER SPAN
FEET	METERS	
120-180	36.6-54.9	3
181-240	55.2-73.2	4
241-300	73.5-91.4	5
301-350	91.7-106.7	6
351-400	106.9-121.9	7
401-450	122.2-137.2	8

APPLICATION: 1/4" MESSENGER +1 .564"-.760" CABLE
 5/16" MESSENGER +1 .373"-.565" CABLE
 MULTIPLE MESSENGER + CABLE .575"-.717" TOTAL

BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		Air Flow Spoiler, .564" - .760" Diameter (PUPCAT.00410a)

RUS Design ADSS Spiral Vibration Dampener



Air Flow Spoilers

Air Flow Spoilers are designed to eliminate the damage caused by high winds. High amplitude vibration can cause physical damage to the cable, and damage to the supporting structure and hardware at the point of attachment.

Air Flow Spoilers are designed to eliminate aerodynamic loading by creating a smooth profile of the cable in the wind. The spoilers are made of high strength, corrosion resistant plastic. The spoilers are designed to be installed on the cable in the direction of the wind. The spoilers are made of high strength, corrosion resistant plastic. The spoilers are designed to be installed on the cable in the direction of the wind.

Air Flow Spoilers have proven effective in the field, significantly reducing galloping, vibration and fatigue, and extending the life of the cable.

Part No.	Part Description	Part No.	Part Description	Part No.	Part Description
000001	1.000' x 0.500' x 0.125' Spoiler	000002	1.000' x 0.500' x 0.125' Spoiler	000003	1.000' x 0.500' x 0.125' Spoiler
000004	1.000' x 0.500' x 0.125' Spoiler	000005	1.000' x 0.500' x 0.125' Spoiler	000006	1.000' x 0.500' x 0.125' Spoiler
000007	1.000' x 0.500' x 0.125' Spoiler	000008	1.000' x 0.500' x 0.125' Spoiler	000009	1.000' x 0.500' x 0.125' Spoiler
000010	1.000' x 0.500' x 0.125' Spoiler	000011	1.000' x 0.500' x 0.125' Spoiler	000012	1.000' x 0.500' x 0.125' Spoiler
000013	1.000' x 0.500' x 0.125' Spoiler	000014	1.000' x 0.500' x 0.125' Spoiler	000015	1.000' x 0.500' x 0.125' Spoiler
000016	1.000' x 0.500' x 0.125' Spoiler	000017	1.000' x 0.500' x 0.125' Spoiler	000018	1.000' x 0.500' x 0.125' Spoiler
000019	1.000' x 0.500' x 0.125' Spoiler	000020	1.000' x 0.500' x 0.125' Spoiler	000021	1.000' x 0.500' x 0.125' Spoiler
000022	1.000' x 0.500' x 0.125' Spoiler	000023	1.000' x 0.500' x 0.125' Spoiler	000024	1.000' x 0.500' x 0.125' Spoiler
000025	1.000' x 0.500' x 0.125' Spoiler	000026	1.000' x 0.500' x 0.125' Spoiler	000027	1.000' x 0.500' x 0.125' Spoiler
000028	1.000' x 0.500' x 0.125' Spoiler	000029	1.000' x 0.500' x 0.125' Spoiler	000030	1.000' x 0.500' x 0.125' Spoiler

Notes: 1. Spoilers are made of high strength, corrosion resistant plastic. 2. Spoilers are designed to be installed on the cable in the direction of the wind. 3. Spoilers are made of high strength, corrosion resistant plastic. 4. Spoilers are designed to be installed on the cable in the direction of the wind.

Notes: 1. Spoilers are made of high strength, corrosion resistant plastic. 2. Spoilers are designed to be installed on the cable in the direction of the wind. 3. Spoilers are made of high strength, corrosion resistant plastic. 4. Spoilers are designed to be installed on the cable in the direction of the wind.

BILL OF MATERIAL			
REF#	USE	PART#	DESCRIPTION
1	1		ADSS Fiber Vibration Dampeners, 0.655

NoaNet Handhole Splice Case Placement-1

Cable Preparation and Storage Requirements:

1. Prepare cables for splicing by laying out flat on ground, reducing twists and bends.
2. For an aerial splice case application the Aerial Slack Loop will be in place prior to splice work taking place.
3. The aerial splice case shall be mounted with aerial adjustable offset brackets for ADSS or Strand and Lash applications.
4. Once splicing is completed, white cable tag to be placed on Cable denoting cable direction. Tag should be no more than 12" from plate on case.
5. Tape cable tails together to form a coil that neatly combines within the vault.
6. Cable bend radius should never be less than 18"
7. In vaults, verify conduits are plugged and visible in the bottom of the vault.
8. Coil cable neatly in the vault placed on cable shoes. Splice case will be supported on shoes with tie wraps.
9. Bond/Ground splice case to the ground rod or cable locator marker station.
10. Tag cable with owner cable tag, visible when vault is open, at top of coil, or in a aerial application at the splice case.
11. The aerial splice case shall be mounted with aerial mounting adjustable offset brackets for ADSS or strand and lash applications. Strap and tie wrap aerial ADSS cable slack. Overlash slack in a strand and application.
12. All aerial splice cases needed to be re-hung and mounted into aerial application within 48 hours of splice work completion



Fiber Splicing Requirements:

1. Cable openings shall match splice case procedures as outlined in manufacturer's requirements.
2. Fiber splicer is required to completely read and understand procedures documented in the coyote products application manual prior to work being performed.
3. Fiber splice will never cut a spliced fiber without check the light activity with a calibrated light detector prior to cutting.
4. No more than 24 fibers per tray.
5. End plates are always to be arranged to allow for additional future cable access.
6. Always flash test the splice case prior to storing case in vault.

NoaNet Handhole Splice Case Placement-2

Fiber Splicing Documents and Methods of Procedure Notifications:

1. Anytime a splicer is to access an active splice case, place a new splice case on existing lit backbone or lateral fiber, or work requiring splicing fibers in an active panel, a Method of Procedure (MOP) is needed, except for in the case of an outage.
2. A MOP is not needed for OTDR testing or splicing on dark fiber.
3. A MOP will be provided by NoaNet and will be sent to the Network Operations Center (NOC), contractor, and splicer a minimum of 10 business days prior to scheduled work. MOP window will be between 1AM and 5AM.
4. In certain instances, a MOP can be scheduled prior to the 10 day window for emergency needs and fiber repair work. It will be handled on a case-by-case basis depending on necessity of work and what fibers are on existing backbone. MOP will list a description of work, splice cases to be entered, or locations of installation of new splice cases. MOP will also provide a list of active customers on cables being worked on.
5. MOP will list NoaNet Engineer Contact information as well as NOC contact information.
6. NoaNet will provide Splicing Documents (Splice Docs) prior to work taking place. Splice Docs will provide splice locations, fiber splicing assignments, and distances to Cabinet, COLO or other end site location if not splicing back to a NoaNet Cabinet or COLO.
6. Fiber splicer is to always test for light prior to cutting. If light is found on fiber assignments, fiber splicer is to contact NoaNet Engineer before proceeding further.
7. If discrepancies are found regarding distances provided, or large fiber events/breaks on either existing backbone or newly installed fiber, fiber splicer is to contact NoaNet Engineer before MOP window closes as to fix any issues that may arise from said discrepancies.

Fiber Testing and Documentation:

1. Fiber splicer is to notify NOC prior to splice work is to begin, and prior to access to any NoaNet facilities, whether splicing or testing is to take place.
2. Fiber splicer must follow MOP instructions provided. Fiber splicer is to notify NOC and close out ticket once splice work has been completed.
3. Prior to splicing fiber, strands provided on splice docs must be tested on existing fiber and new fiber install to verify distances and any potential breaks or large loss events (greater than a 0.3dB loss and/or high reflection event in case of jumpers placed). As noted previously, if any issues arise NoaNet Engineers need to be notified of issue immediately.
4. Once splicing is complete bi-directional OTDR reports will be required in both 1310nm and 1550nm. OTDR should run for a minimum of 1 minute, and for up to 3 minutes on longer distance reports. On these occasions splicer will be notified of the necessary run times on long distances prior to work taking place.
5. NoaNet will provide splicer with building contact information for customer site. NoaNet will provide access information for splicer to enter NoaNet facilities for testing.
6. All OTDR traces need to be delivered in raw format within 48 hours of splice work completion.

Acceptance of OTDR Testing and Splice Completion:

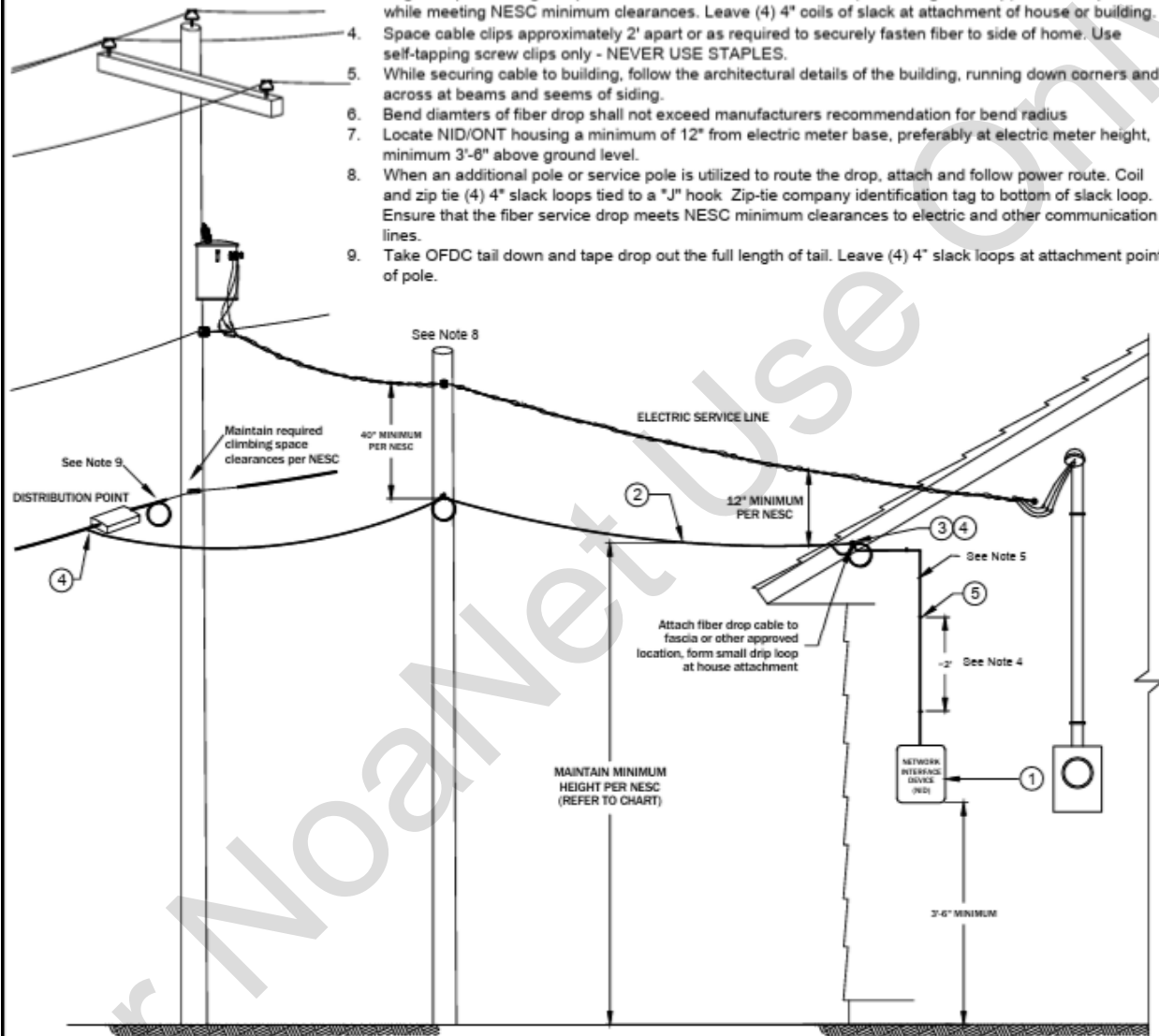
1. No fiber strand will be accepted that has an individual splice location event greater than 0.3dB (TIA Standard). This only pertains to strands spliced during work window, excludes existing network splices.
2. In certain instances, depending on job and contract for work, the individual splice event standards may be more strict. In these instances NoaNet will notify splicer prior to work taking place.
3. Fiber splice locations with reflections are not acceptable and will be rejected. This does not include connectors used during testing, jumpers at panels, or patch panel ports.
4. When testing with OTDR, fiber optic jumpers and ports to be cleaned every time both prior to OTDR testing and after testing has completed. Port caps always need to be replaced on unused ports after testing has completed. NoaNet may require individual splice locations to be re-spliced to meet standards listed. If this was a new splice, the cost to fix the splice issue that does not meet standards outlined will not be re-imbursed by NoaNet.
5. If splicer does not follow MOP, testing requirements, or bi-directional testing, NoaNet will not re-imburse cost to fix splice issue that arise from not following procedures correctly.
6. Splicer and/or contractor to provide pictures of fiber install on customer premises. Either picture of fiber coiled on backboard if no panel is installed, or picture of mounted term panel after fiber has been spliced and tested. Pictures need to be delivered to NoaNet within 24 hours of being taken.



Aerial Service Drop Installation

REQUIREMENTS FOR AERIAL FIBER SERVICE DROP INSTALLATION

1. Fiber service drop must maintain minimum clearances above grade at lowest point. Refer to the chart on this page for requirements.
2. Fiber service drop must not attach to electric service weatherhead.
3. Sag from point of origin at pole to attachment on house shall be (1% of length of drop) whenever possible while meeting NESC minimum clearances. Leave (4) 4" coils of slack at attachment of house or building.
4. Space cable clips approximately 2' apart or as required to securely fasten fiber to side of home. Use self-tapping screw clips only - NEVER USE STAPLES.
5. While securing cable to building, follow the architectural details of the building, running down corners and across at beams and seams of siding.
6. Bend diameters of fiber drop shall not exceed manufacturers recommendation for bend radius
7. Locate NID/ONT housing a minimum of 12" from electric meter base, preferably at electric meter height, minimum 3'-6" above ground level.
8. When an additional pole or service pole is utilized to route the drop, attach and follow power route. Coil and zip tie (4) 4" slack loops tied to a "J" hook. Zip-tie company identification tag to bottom of slack loop. Ensure that the fiber service drop meets NESC minimum clearances to electric and other communication lines.
9. Take OFDC tail down and tape drop out the full length of tail. Leave (4) 4" slack loops at attachment point of pole.



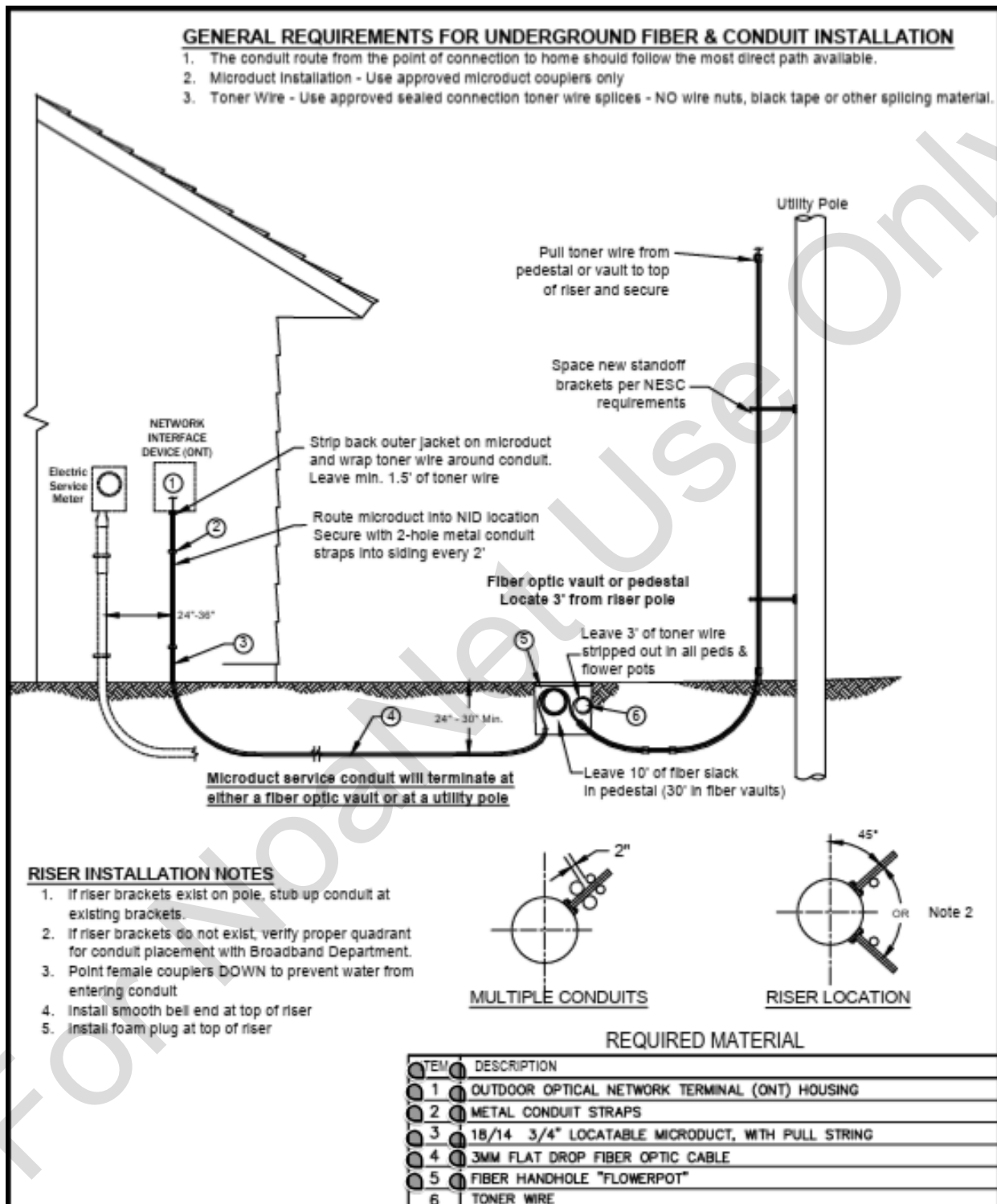
National Electric Code Minimum Clearance Requirements	
Communication Service Drop to Electric Service Wire in Span	12"
Clearance Over Driveways, Areas Subject to Truck Traffic	15'-6"
Clearance Over City and County Roads*	15'-6"
Clearance Over Washington State Highways - Joint use with Electric	20'
Clearance Over Washington State Highways - Communications Only	24'
Clearance over Pedestrian Traffic Only	12"
Minimum Clearance Lowest Electric to Communications at Pole	40"
Electric Service Drops to Communication Service Drops at Midspan	12"
Vertical Spacing from Comm to Comm at Pole	12"

*Additional City and County Minimum Clearance Requirements may Apply.

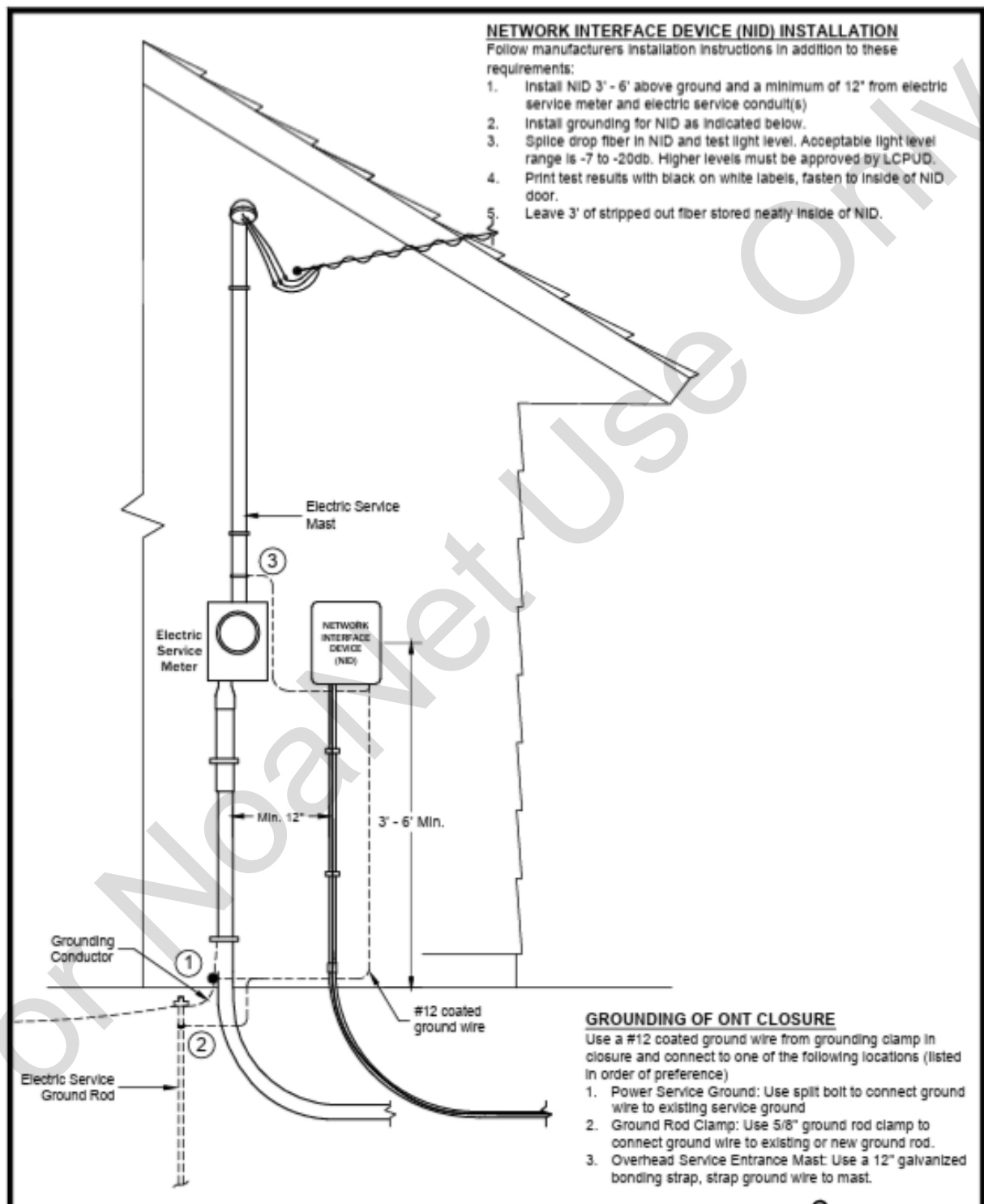
REQUIRED MATERIAL

ITEM	DESCRIPTION
1	NETWORK INTERFACE DEVICE (NID, ONT HOUSING)
2	3MM FLAT DROP FIBER OPTIC CABLE
3	HOUSE ATTACHMENT - HOUSE KNOB STYLE
4	6 1/2" WEDGE CLAMP CONNECTOR .250"-.414" MSI 7187 (NOT "P" CLAMP)
5	SELF-TAPPING SCREW CLIPS

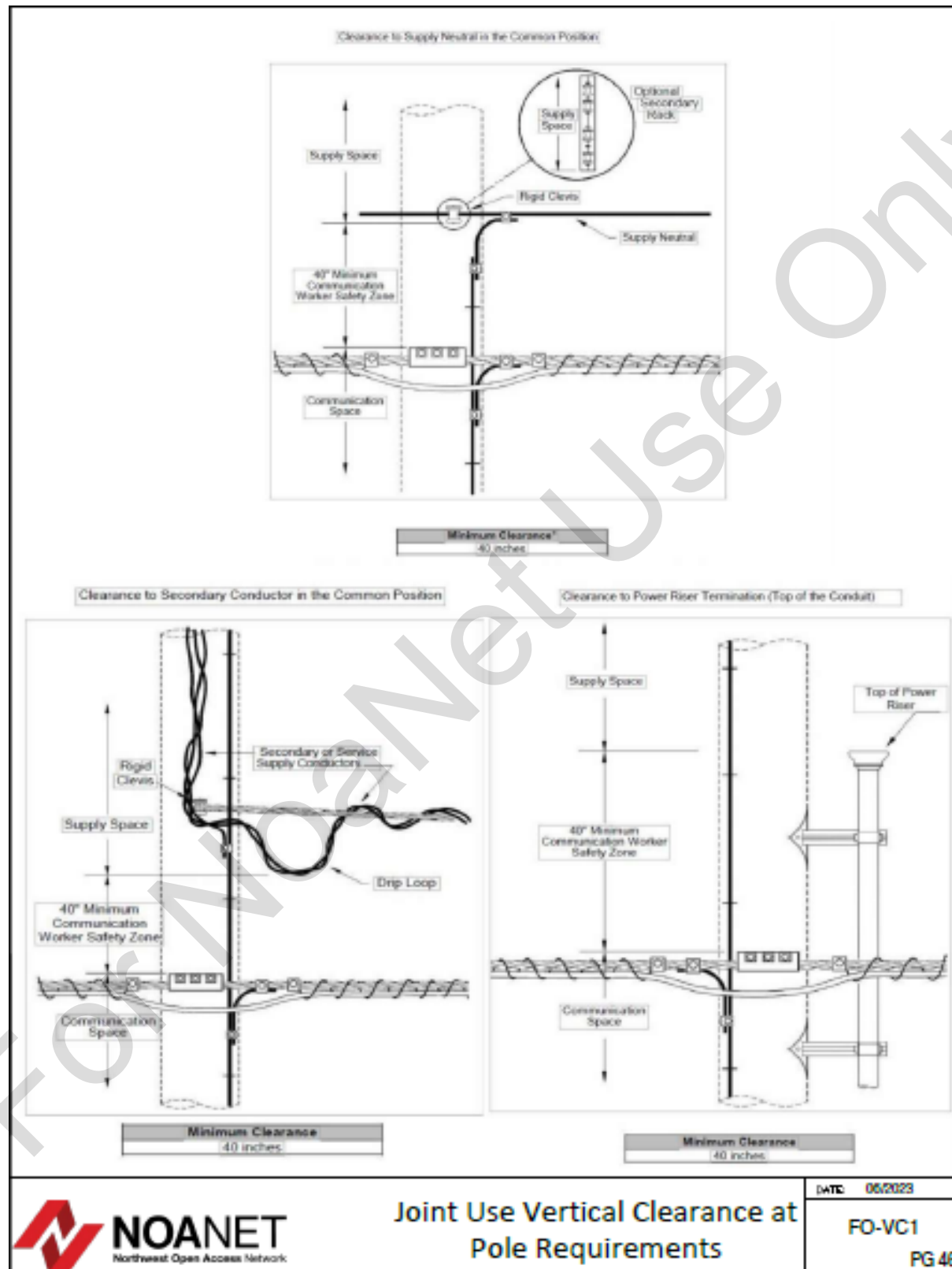
Underground Fiber Service Installation



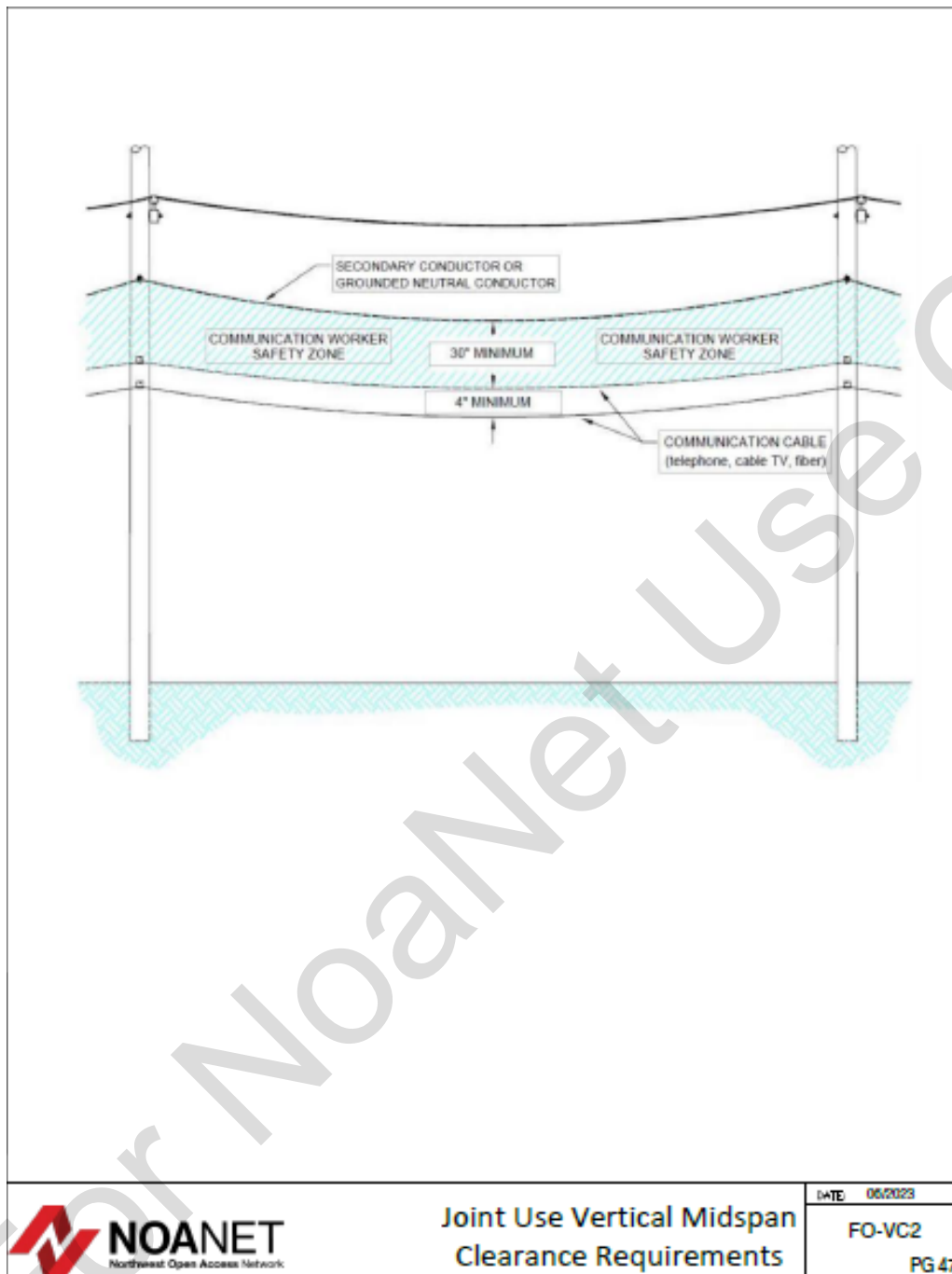
NID Installation and Grounding



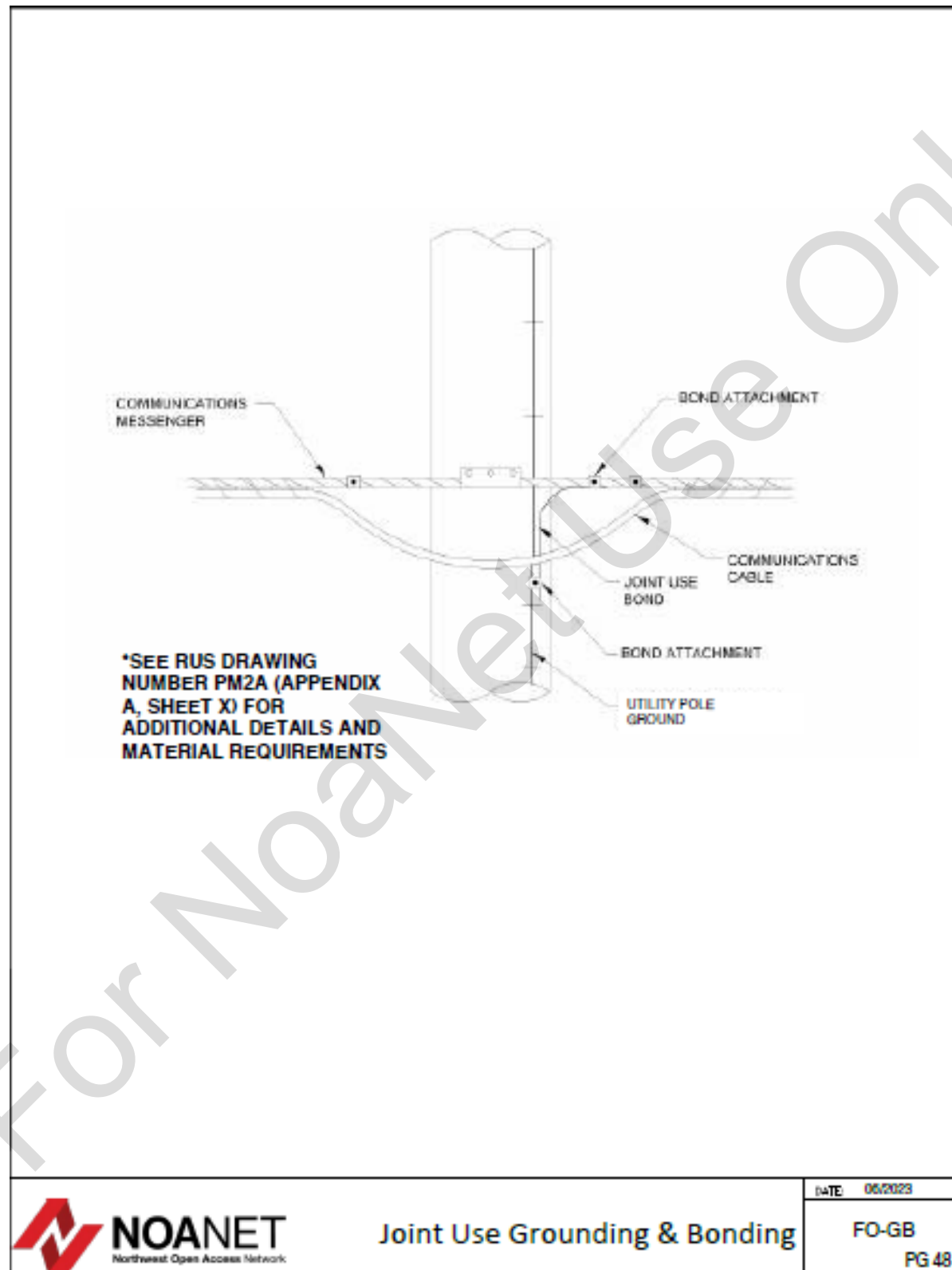
RUS Design Joint Use Vertical Clearance at Pole



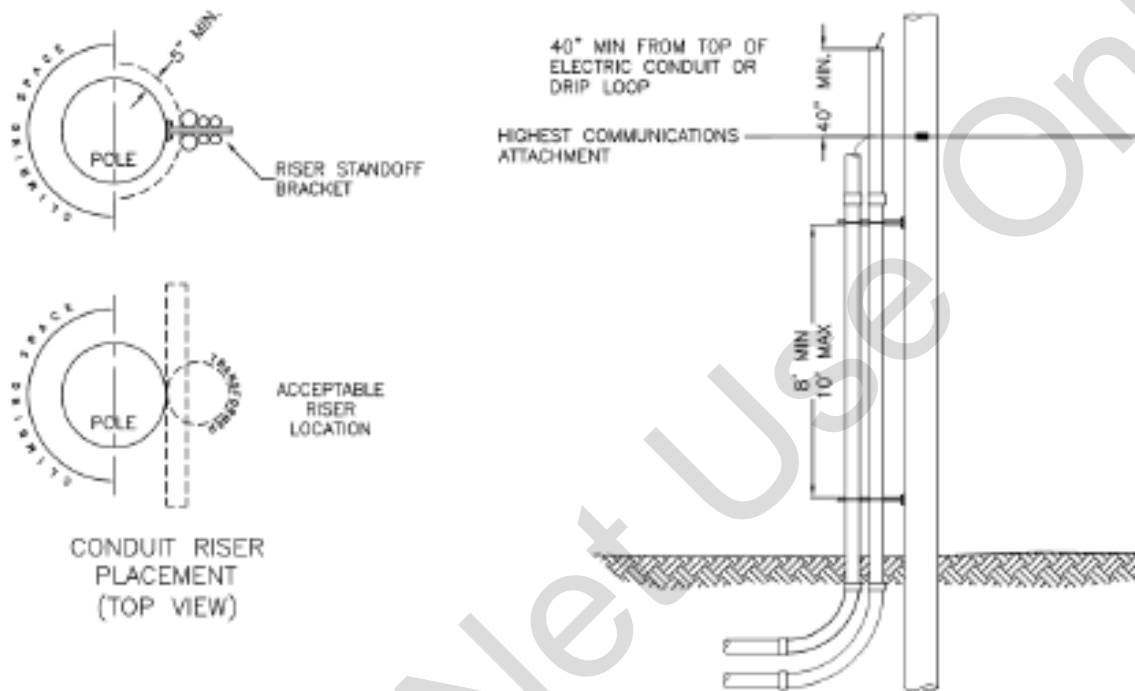
RUS Design Joint Use Mid-Span Clearance



RUS Design Joint Use Grounding & Bonding

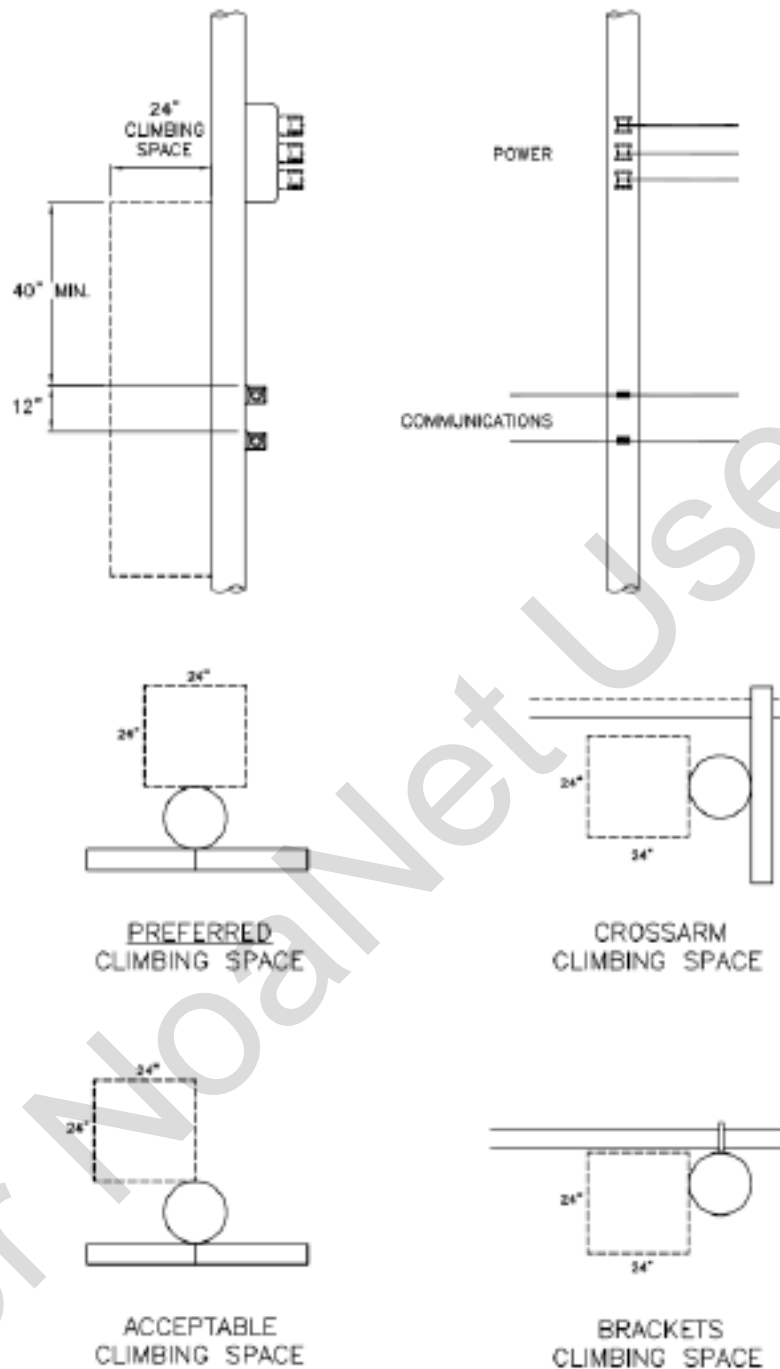


RUS Design Joint Use Riser Installation



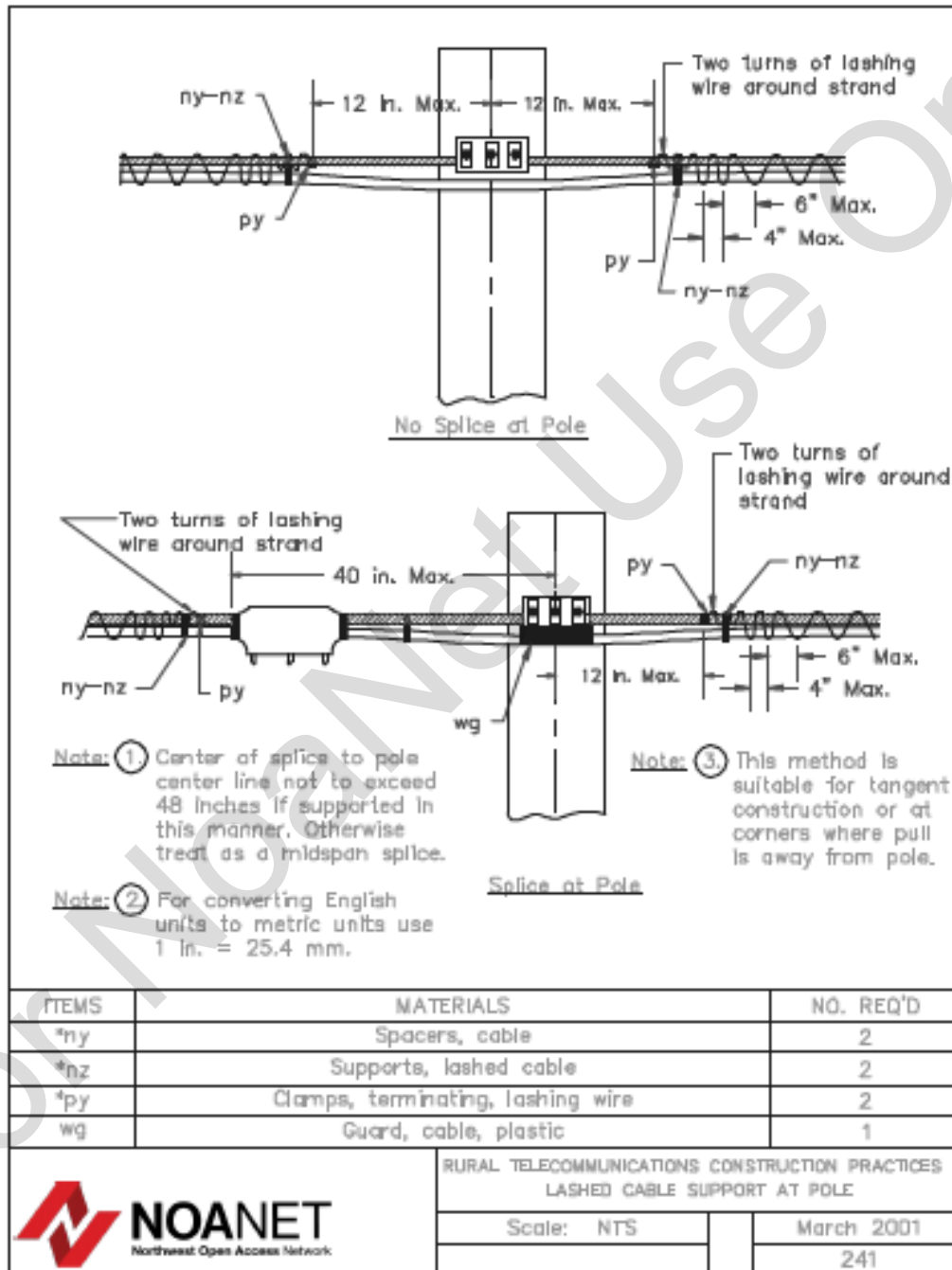
1. NEW RISERS SHALL BE ATTACHED TO EXISTING POWER STAND-OFF BRACKETS WHEN AVAILABLE.

RUS Design Joint Use Climbing Space



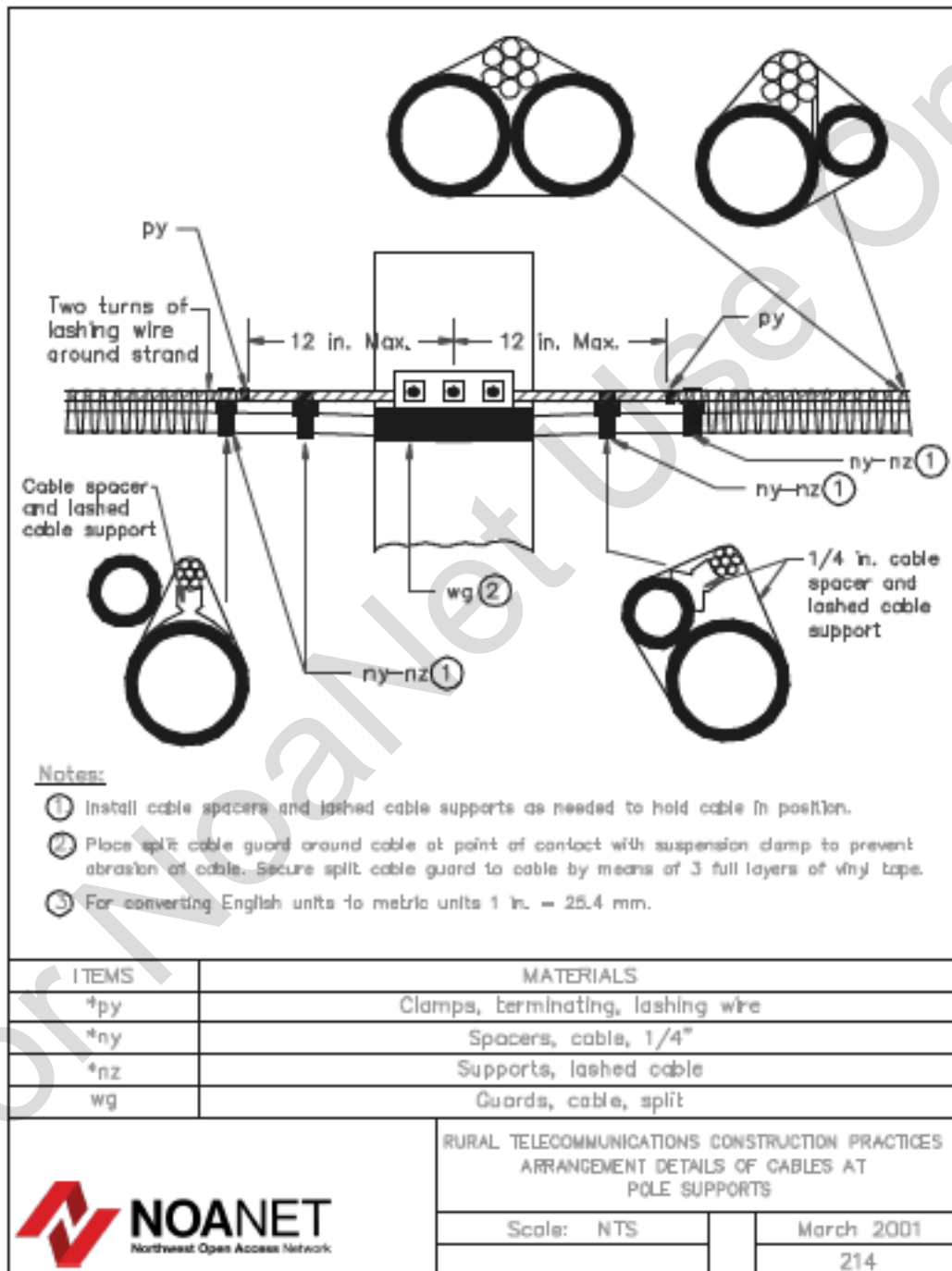
RUS Design Lashed Cable Support at Pole

Bulletin 1753F-152
Construction Guide Drawing
Page 63



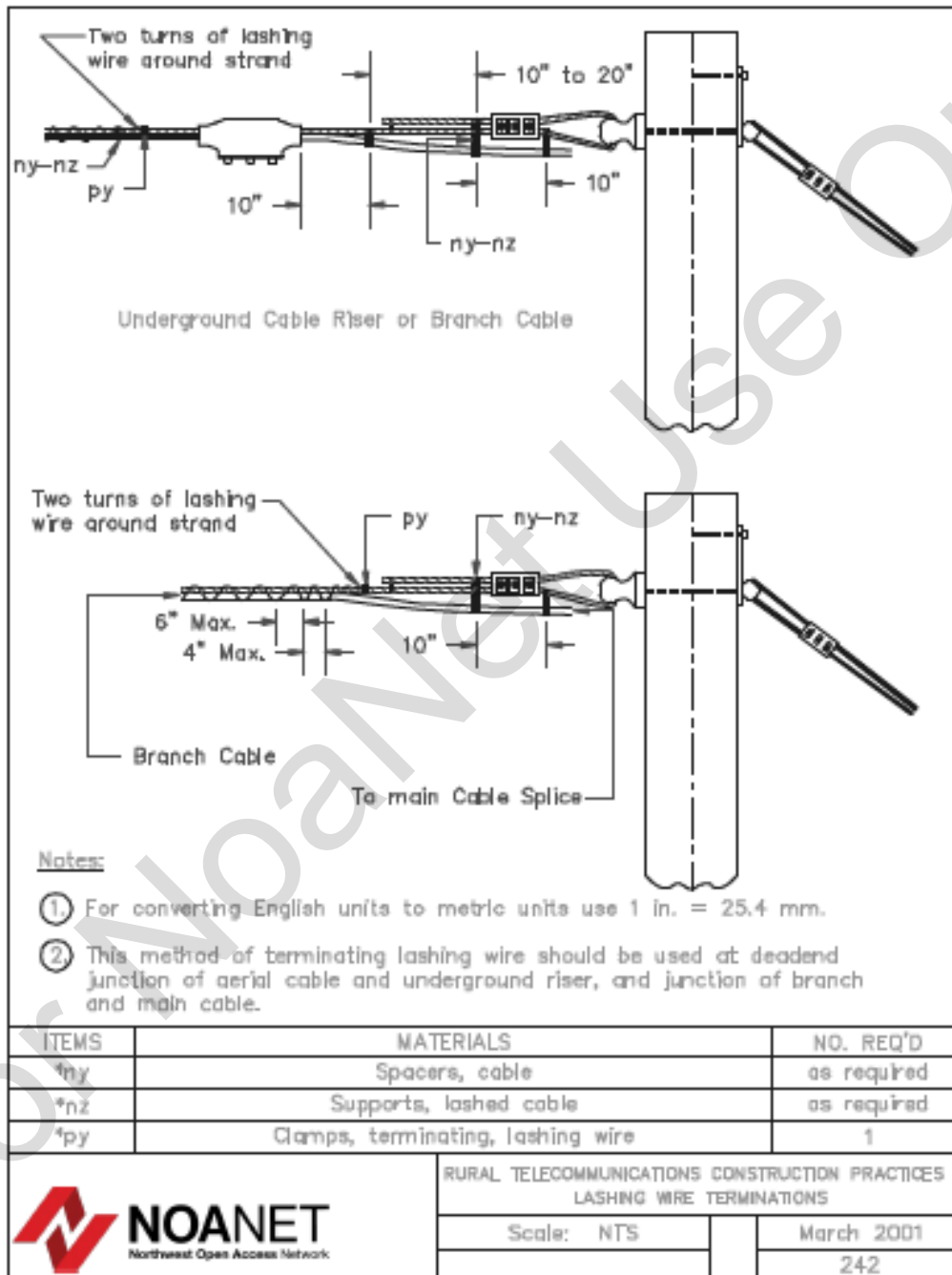
RUS Design Cable Arrangements at Pole

Bulletin 1753F-152
Construction Guide Drawing
Page 62



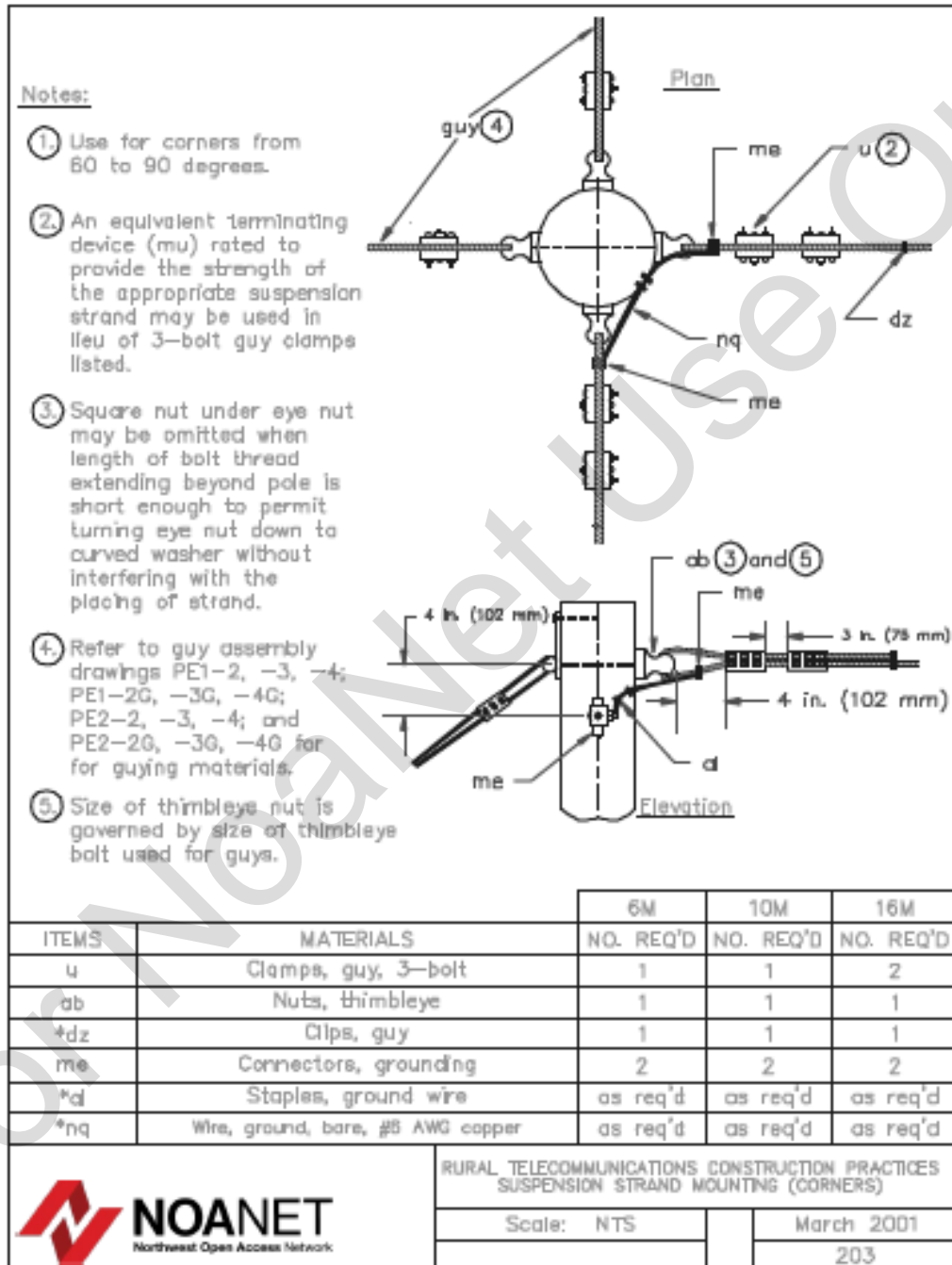
RUS Design Lashing Wire Terminations

Bulletin 1753F-152
Construction Guide Drawing
Page 64



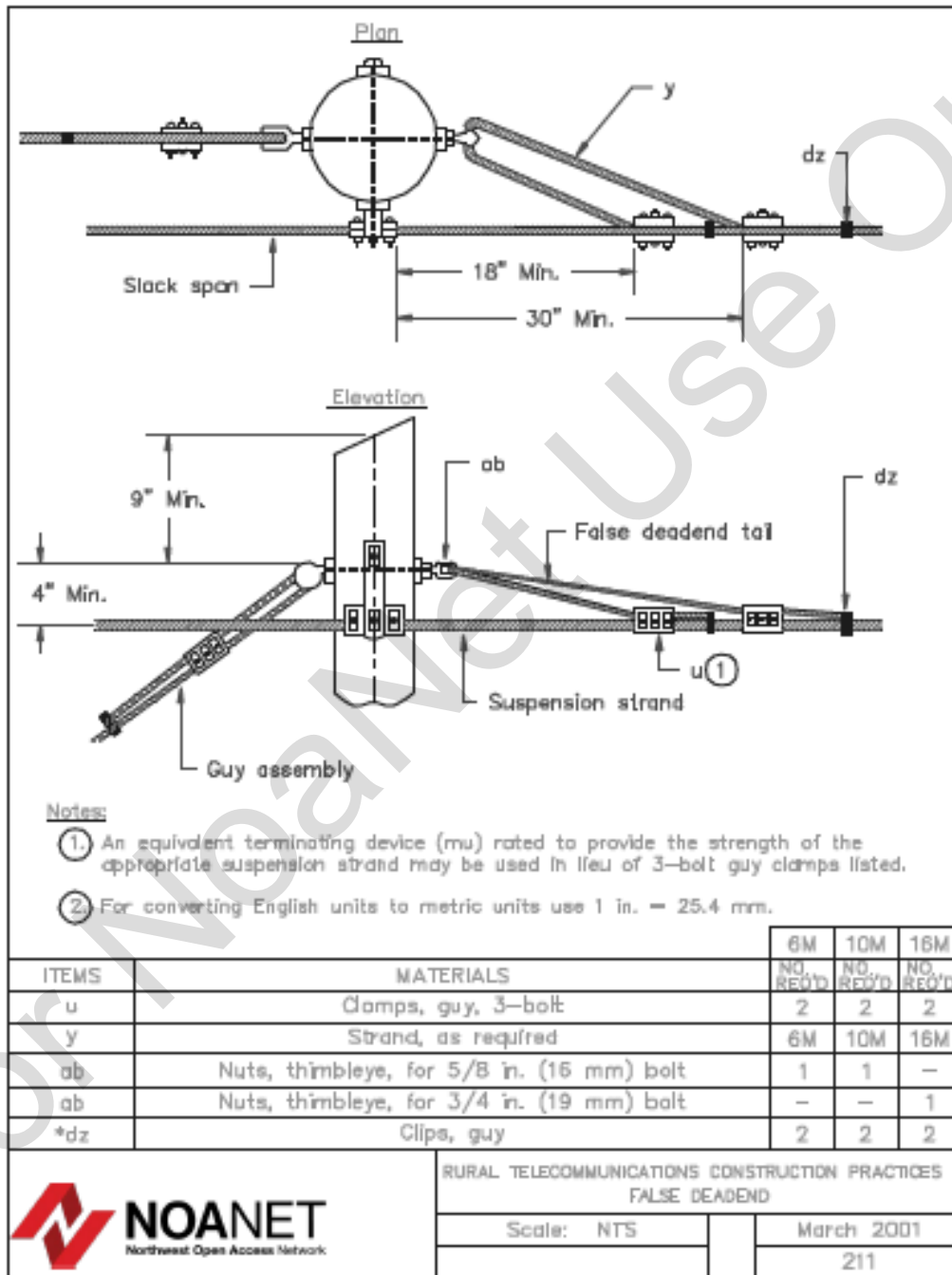
RUS Design Suspension Strand Mounting (Corners)

Bulletin 1753F-152
Construction Guide Drawing
Page 53



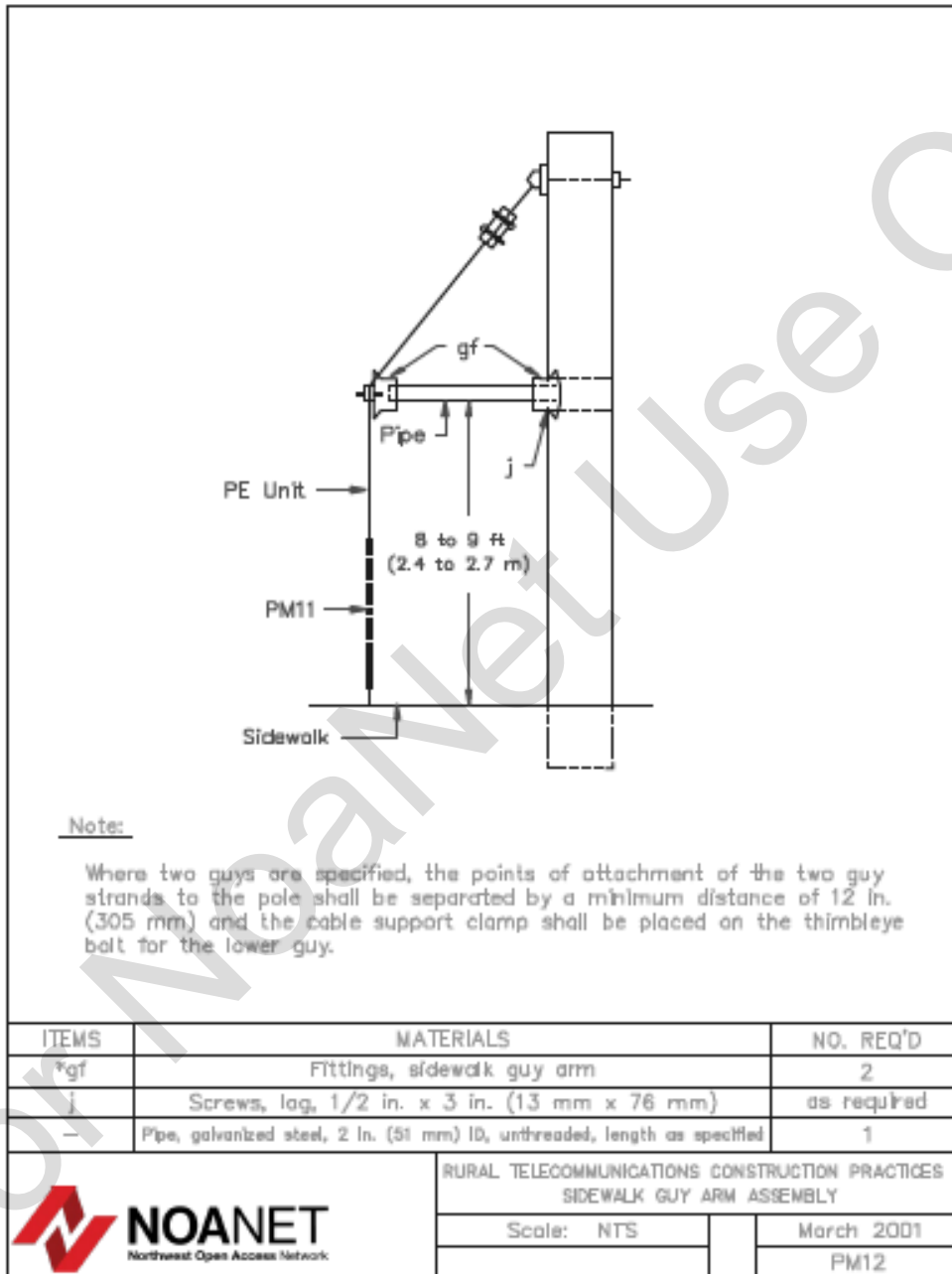
RUS Design False Dead-End

Bulletin 1753F-152
Construction Guide Drawing
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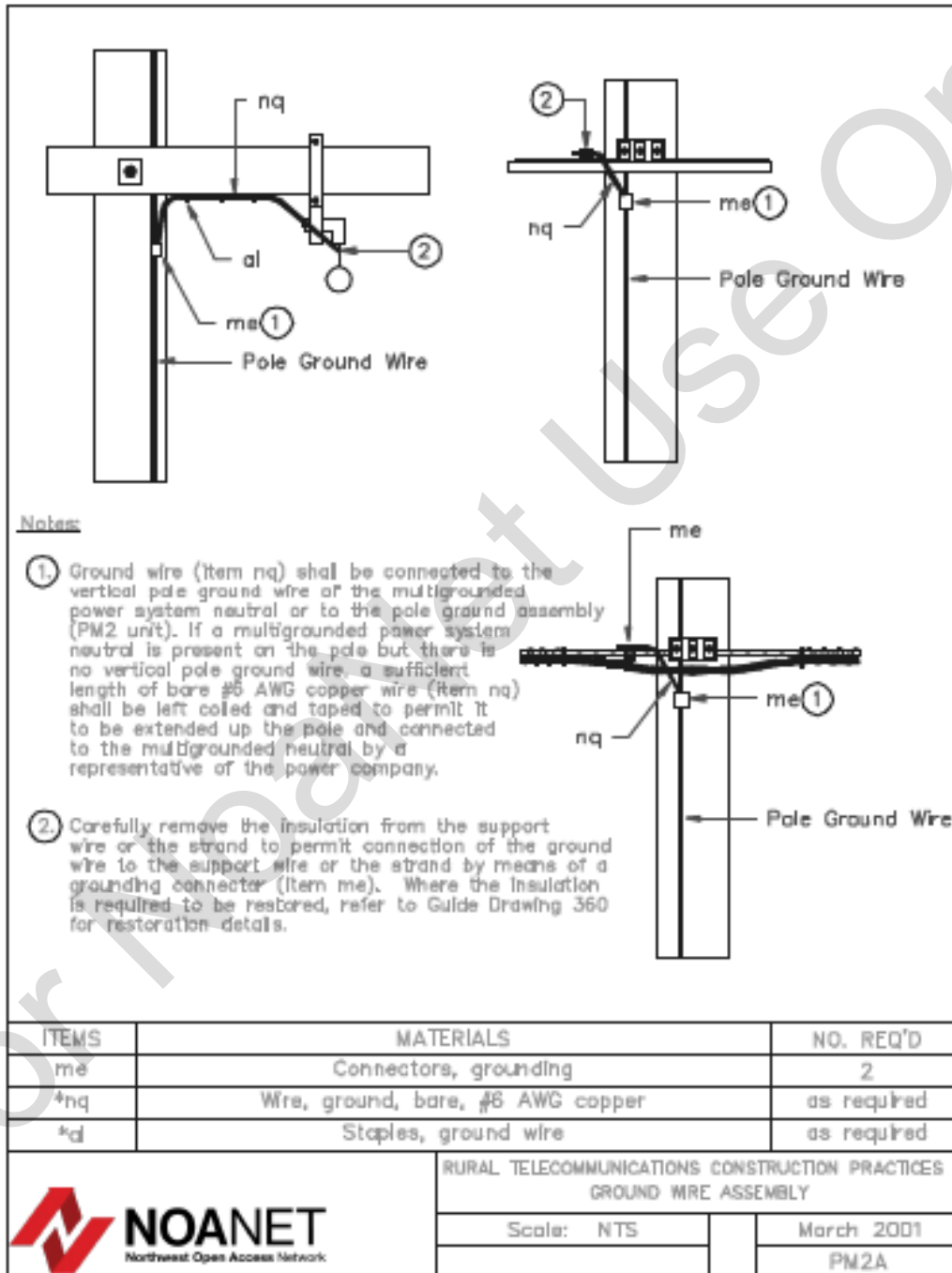
RUS Design Sidewalk Guy Assembly

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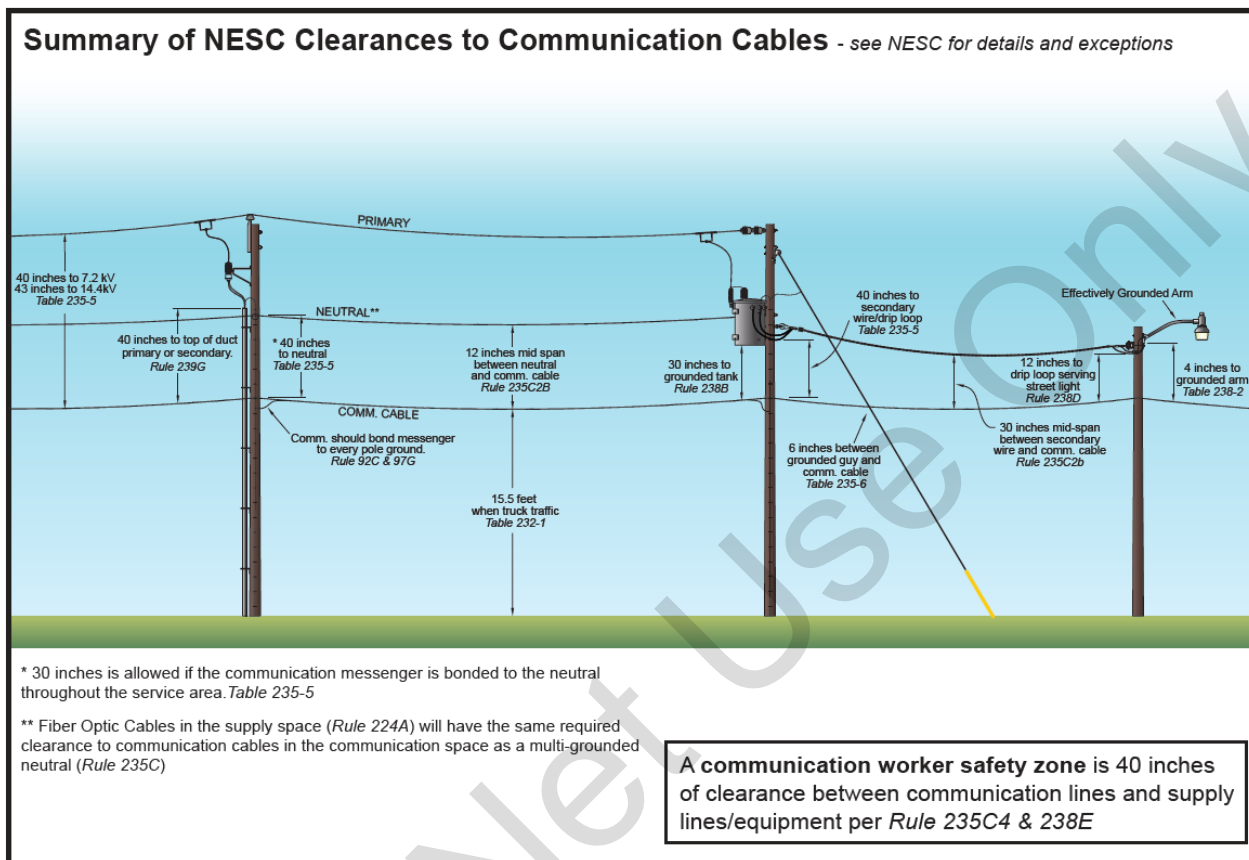


RUS Design Ground Wire Assembly

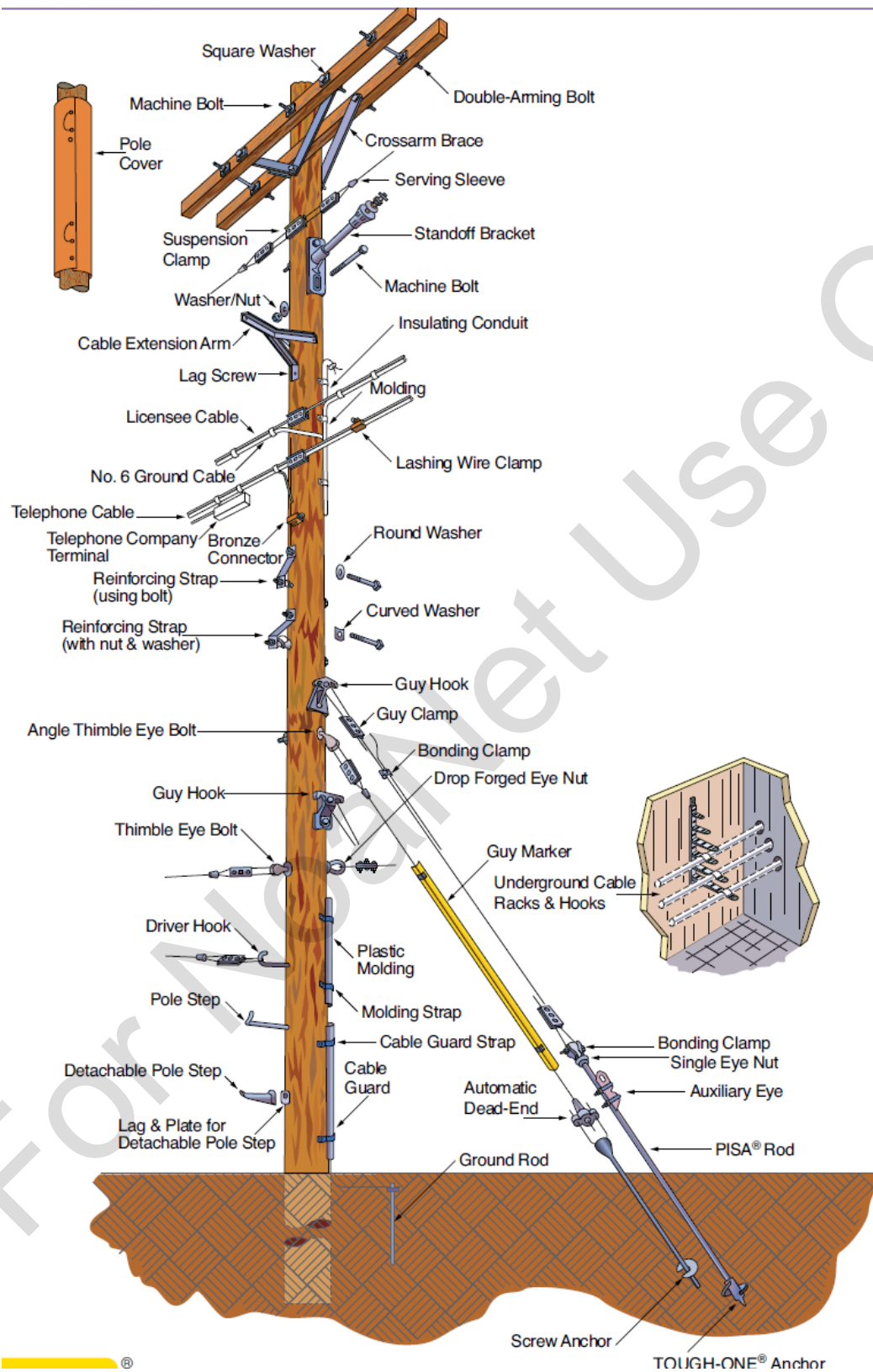
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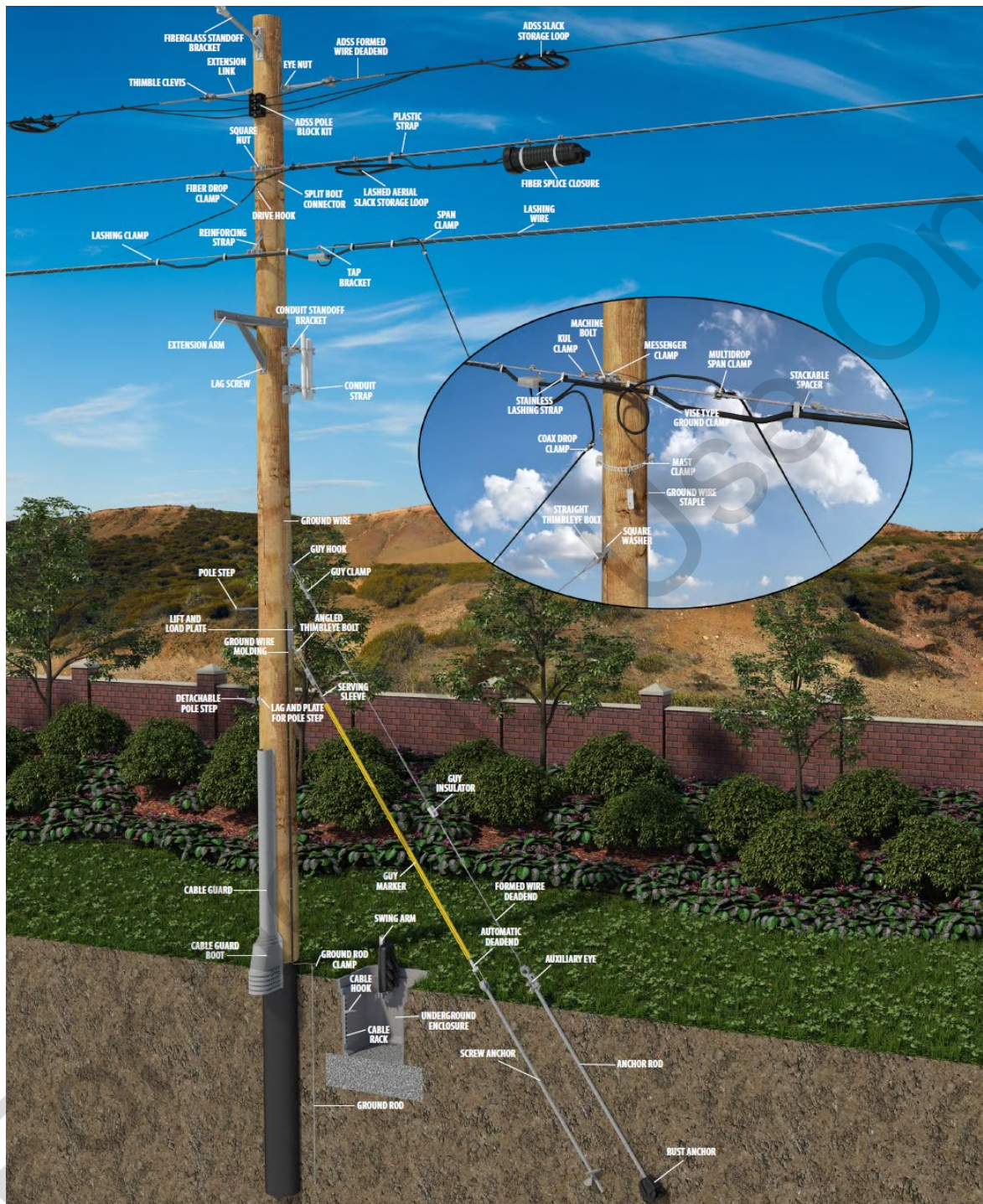
NESC Clearances Summary Example



HUBBELL Telecom OSP Hardware Example



HUBBELL Telecom Osp Pole Hardware Example



US Pole Loading Districts

Figure 6.7 - Loading Districts in the United States



Loading District

Varying environmental conditions create hazards that affect aerial cables differently. When looking at the loading district map of the United States, it appears that all of Oregon has a “Medium” loading district. However, special wind regions change the standard “Medium” loading district to “Extreme.” There are four types of loading districts:

- **Heavy** loading district is generally in the central and northeast U.S. states. There is an assumption of lower temperatures and greater ice buildup on cables and conductors. This may require adjustments made such as open-wire conductors having breaking strength reduced by 50 percent. Where there are copper or steel cables or conductors, span lengths should be kept to a minimum
- **Medium** loading district covers much of the northwestern states, including Oregon. Where the standard for ice in the heavy loading district is $\frac{1}{2}$ inch, in the Medium zone it is assumed $\frac{1}{4}$ inch. This may require adjustments. One example is an open-wire conductors having breaking strength reduced by 33 percent. Where a limiting span length in the Heavy zone is 150 feet, it may be increased to 175 feet in a Medium or Light zone.
- **Light** loading district covers most of the southern states. It is the lightest, most flexible loading zone. Where the Medium loading district assumes $\frac{1}{4}$ inch of ice, the Light loading district assumes no ice.
- **Extreme** loading district covers the entire coast, Columbia Gorge, and some other areas of Oregon. This zone does not have ice but has higher than usual winds. The current code assumes wind above 60 feet must withstand extreme wind.