Incab

Field Problems with Aerial Fiber Optic Cables, Part 2 - ADSS

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PURPOSE AND LEARNING OBJECTIVES

This course will teach you the biggest problems that utilities experience with their aerial fiber optic cables and how to prevent them (where possible).

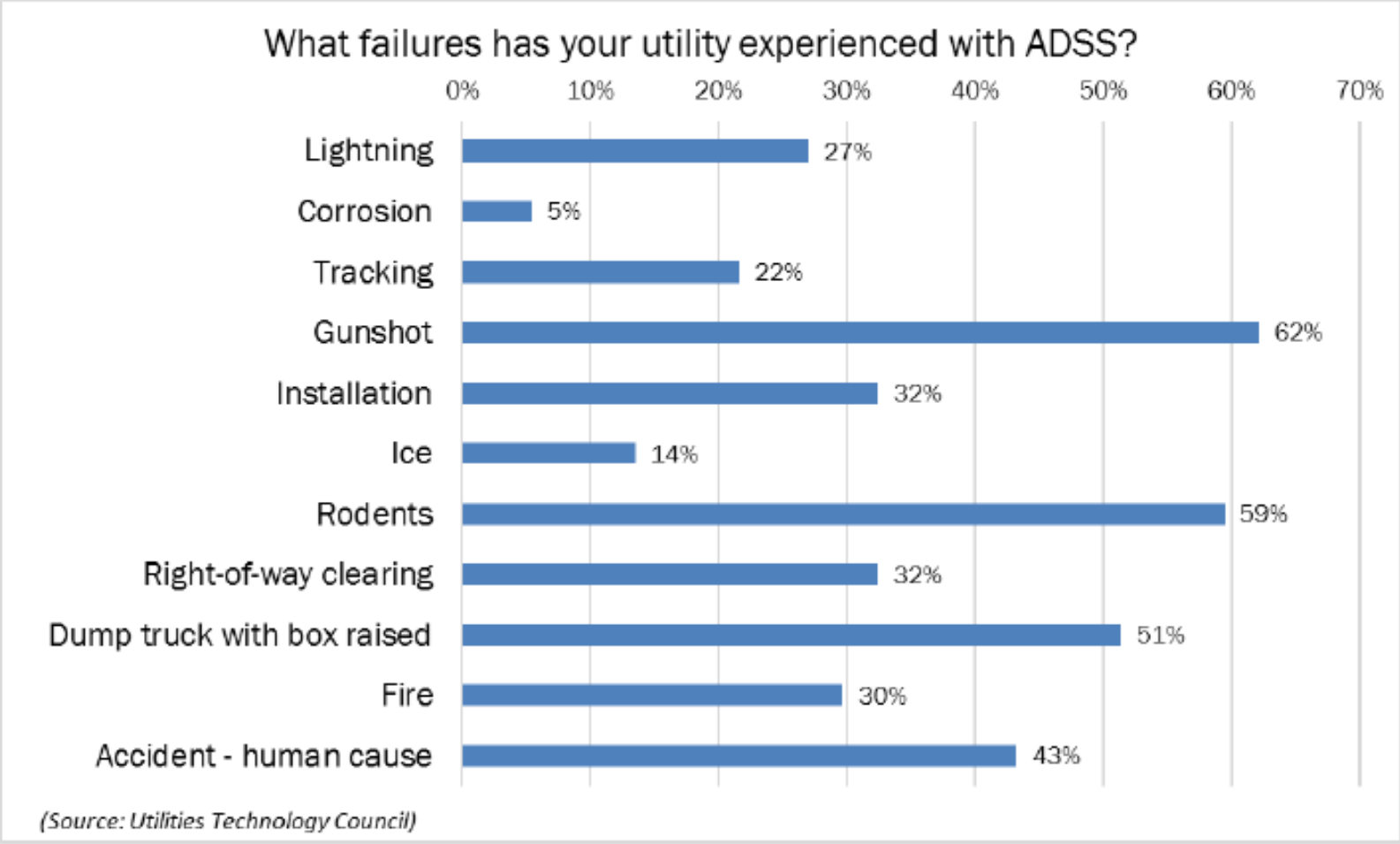
After this class, you will be able to:

1. Explain at least 3 ways ADSS can fail because of accidents and vandalism and how to prevent them
2. Explain at least 3 ways ADSS can fail because of environmental factors and how to mitigate against them
3. Explain at least 2 ways ADSS can fail because of installation and how to mitigate against these
4. Explain the "pistoning" problem that can occur at splice points
5. Explain Fiber Strain
    - What it is
    - Why it is important
    - How it affects ADSS
    - How it can be controlled
6. Explain why the preceding problems do not just disappear by putting fiber optic cables underground.

Incab University “School of Excellence in Fiber Optics”
Agenda

- Introduction
- Learning Objectives
- Presentation
- Q&A (Technical questions only)
- Let’s start!

Consider this Graph of ADSS Failures by Type



Note: Full citation at end

That's quite a few with many different causes... Let's group them...

ADSS Failures by Type - Categorized

- Accidents and Vandalism
  - Gunshots
  - Dump trucks
  - Accident – human cause
  - Right-of-way clearing
- Environmental
  - Rodents
  - Fire
  - Lightning
  - Ice
- Installation and Material
  - Installation
  - Corrosion – material defects
- Tracking

- We'll talk about each group and specific causes within each
- Plus, we will discuss "pistoning" in splice enclosures which does not always lead to optical failure, but is certainly a problem worthy of attention

Accidents and Vandalism Failures

Accidents and Vandalism

Causes and Solutions

1. **Gunshots** - The leading cause of ADSS failure
   - Small comfort to differentiate between intentional hits (ADSS as target) versus unintentional hits (target was a bird or something else)
   - Usually leads to immediate optical damage

Solutions:

There is not a direct solution; only mitigating measures:

- Be prepared to use an OTDR to pinpoint the location
- Have a good emergency restoration plan to include:
  - Replacement cable (on a steel reel?), *plus*
  - Accessories (at least a couple of deadends and a splice enclosure)

An indirect solution might be to use a different type of cable in areas where shotgun damage has been or could be a concern:

- Optical Phase Conductor (OPPC) or Neutral (OPNW)
- Metallic Aerial Self-Supporting (MASS) or Optical Messenger (OPMW)

  ➔ But, there are significant matters to evaluate when thinking about such a change (Reference: "Fiber Optic Cables 101")

The "Holy Grail" of ADSS cable design is one that provides protection against at least shotgun damage

Operational Failures

Causes and Solutions

- Illustrations! Gunshot damage

Bullet

Shotgun

Operational Failures

Causes and Solutions

- Perhaps I should have said “projectiles”?

Accidents and Vandalism

Causes and Solutions

2. **Dump trucks, Accidents, and ROW Clearing** - Variations on a theme: ADSS is vulnerable because it's

   - Attached lower on structures = closer to ground
   - Made of plastic and other non-metallic materials

   Solutions:

   - Sag must be checked, both vertical and horizontal, and code clearances maintained
     - Code clearances are minimums!
   - Know your service area and design accordingly
   - Otherwise, there are not solutions; only mitigating measures as against gunshot damage
     - Be prepared to use an OTDR to pinpoint the location
     - Have a good emergency restoration plan to include:
   - Perhaps OPPC, OPNW, MASS, or OPMW?

Operational Failures

Causes and Solutions

Illustration! Dump truck snagged a cable

Note that the cable supplier was proud that several poles failed before their cable did

Environmentally Induced Failures

Environmentally-induced failures

Causes and Solutions

1. **Rodents, including/especially squirrels** – Second leading cause of ADSS failure!
   - Because aramid (Kevlar™) is tasty!
   - Tends to occur in specific areas

   Solutions:

   A. Begins with "Know your service territory"

   B. Anti-rodent cable protection measures:

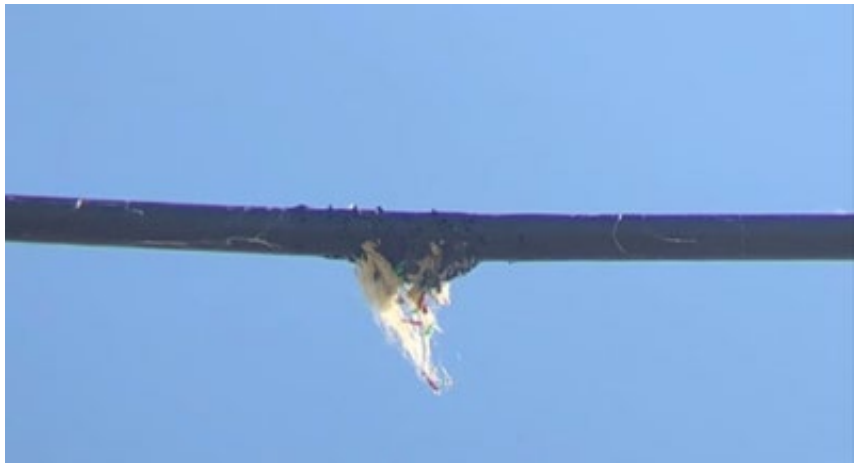
      1. Deterrent additive in the jacket = C^-
         - How long will it last? Months to a few years?
      2. Use fiberglass yarn for strength instead of aramid = B
         - Still get outer jacket damage, but can repair with jacket repair tape
         - Suggest an inner jacket to protect optical core (double jacket construction)
      3. Use fiberglass-glass reinforced plastic rod (FRP) for strength = A
         - Still get outer jacket damage, but can repair with jacket repair tape
         - Must have an inner jacket (double jacket construction)

Dishonorable mention for large bird talons

Environmentally-induced failures

Causes and Solutions

Illustrations!



Environmentally-induced failures

Causes and Solutions

2. Fire
   - Note that once ignited, the polyethylene (PE) (whether LDPE, MDPE, or HDPE) will tend to continue to burn, so it can help a fire propagate (Yikes!)

Solutions:

A. Again, know your service territory
B. "Fire Rated" cables
   - Self-extinguishing jacket materials so fire does not spread
   - Fire resistant tape to give warning
     - About the best that you can get is three (3) hours

Environmentally-induced failures

Causes and Solutions

3. **Lightning** – An indirect cause of failure
   - Lightning caused fires on structures and damage to hardware

Solutions:

A. Good grounding and bonding helps
B. “Fire Rated” cables might help too

Environmentally-induced failures

Causes and Solutions

4. **Ice** – If someone tells you, “Snow and ice don’t accumulate on ADSS in the field”, please show them these pictures

Environmentally-induced failures

Causes and Solutions

- Ice – Not likely to outright fail the cable (see the pictures), but…
  - Increased sag can lead to violating ground clearance (recall the pictures on the last slide)
    - Inadequate clearance can lead to contact and damage (recall the dump truck for example)
  - Also, “Ice tubes” have formed and caused problems
    - Broken off, slid down a span, and crashed into hardware, damaging it and/or the cable

Solutions:

A. Again, know your service territory and design for a realistic accumulation of ice
B. “Ice breakers” prevent ice tube damage
   - Helpful in spans with significant elevation differences

Installation Induced Failures

Installation-induced failures

Causes and Solutions

1. **Damage during installation**

   A. Jacket damage during stringing

   B. Damage during splicing
      - Fiber damage
      - Tray issues

      (“Pistoning” will also be discussed later)

   Let’s look at these separately…

Installation-induced failures

Causes and Solutions

A. Jacket damage during stringing

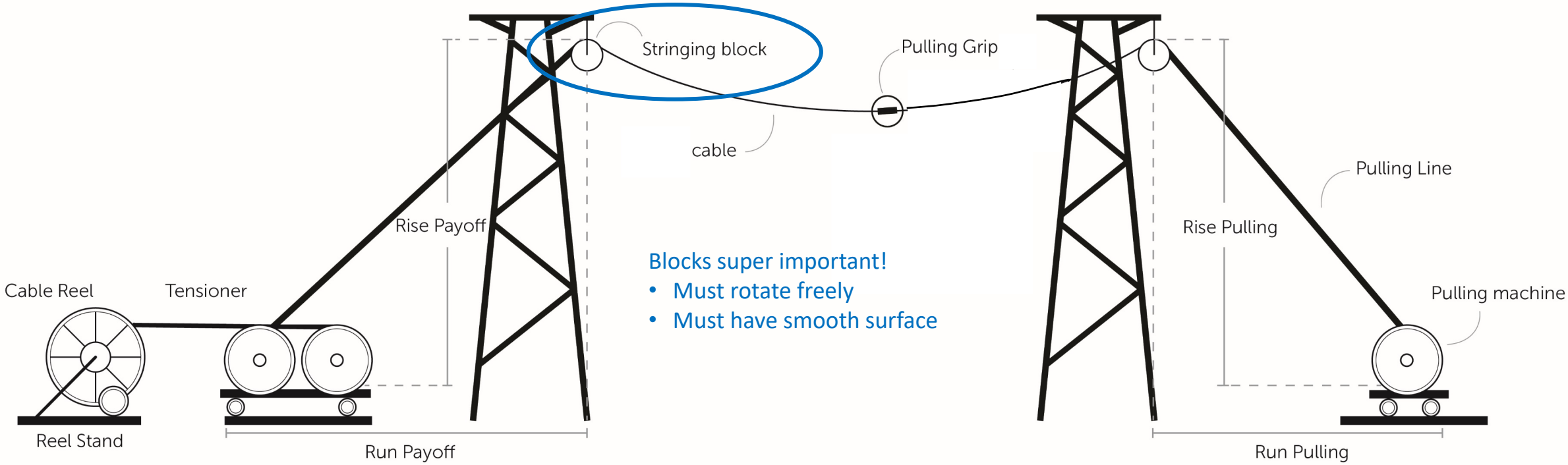
- Abrasion, scuffing or jacket tears/breaches during pull-in can be caused by:
  - When using Controlled Tension Stringing" (pulling line and blocks)
    - Cable riding up out of block groove and dragging along frame
    - Block not rotating freely
    - Damaged block surface
    - Use of "trunnion" type supports in lieu of blocks – Which cable manufacturers often disapprove of!
  - When using Moving Reel Stringing
    - Damage during hoisting cable up to attachment point
  - For both methods: Tools and equipment

- Damage during stringing is *not* a big problem (surprising?)
  - Most of the time, damage is only superficial
  - Must be severe (e.g. jacket breech) to be problematic
    - Even then, jacket repair tape usually can fix

Quick primer...

ADSS Installation - Stringing

Controlled Tension Stringing



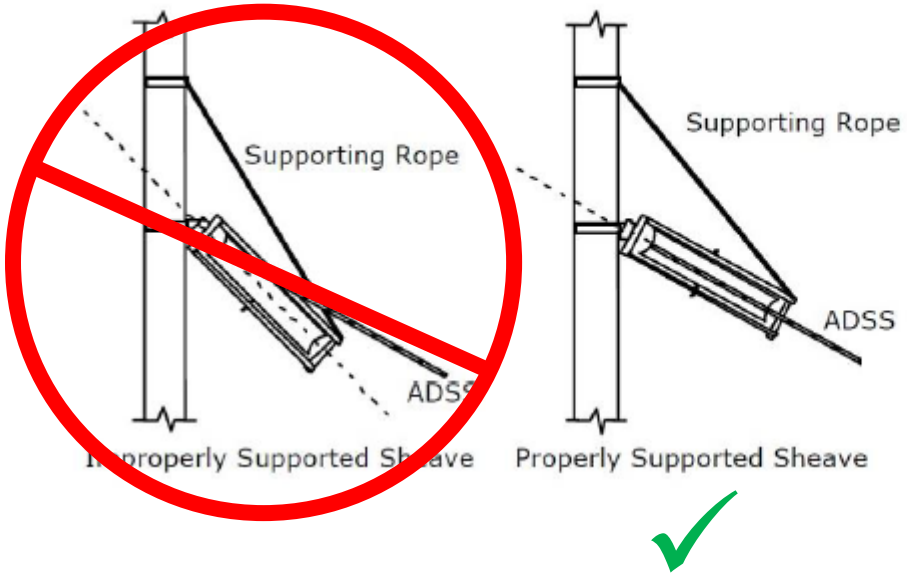
Typical Set-up for Controlled Tension Stringing

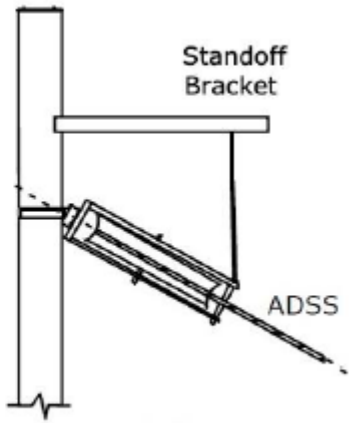
(Note: Stringing discussed in tedious detail in our ADSS Installation webinar)

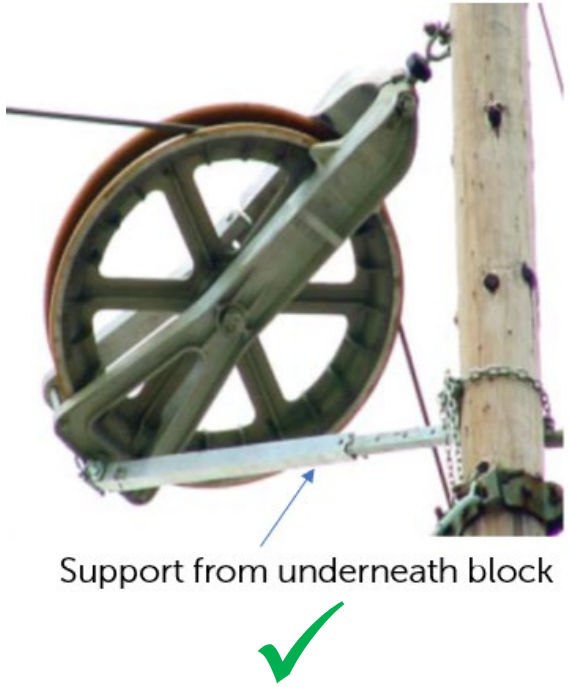
Installation-induced failures

Causes and Solutions

Illustrations!







The ADSS and the block must be in the same plane during the pull!

➔ If they aren't, then the cable can ride up and out of the block

Installation-induced failures

Causes and Solutions

Illustrations!

Tip:

Plastic "Aerial Buddy" blocks from Jameson are superb for ADSS!

24" size is good for most cables and most angles (Gotta check!)

Quick primer...

ADSS Installation - Stringing

Moving Reel Stringing

When using this method:

- Be careful with tools
- Be vigilant in the process of hoisting the cable up at each structure

Installation-induced failures

Causes and Solutions

B. **Damage during splicing** – (With apologies to splicing techs) Always poor handling

1) Kinking the tubes, bending them too tight, poor entry
   - Polypropylene (PP) tubes are more forgiving to the careless
   - Polybutylene (PBT) is the more reliable, durable material; but easier to kink so one must be reasonably careful

2) Damaging the fibers -
   - Damage to the fibers during tube entry (coating or cladding)
   - Poor stripping and/or cleaving - which could be the stripper or cleaving device

Installation-induced failures

Causes and Solutions

B. More damage during splicing

3) Poor splicing
   - Exceeding fiber minimum bending radius
   - Could result from poor stripping or cleaving
   - Contamination present during the process
   - Splicer not working properly

4) Poor buffer tube and/or tray management
   - Exceeding tube minimum bending radius
   - Not properly arranging or securing splice protectors
   - Not properly arranging or securing trays

Installation-induced failures

Causes and Solutions

B. Conclusion of damage during splicing - Solutions

- Proper training of splice techs and good experience are a must!
- Follow *both* cable *and* enclosure manufacturer guidelines!
- Poor buffer tube and/or tray management
  - Exceeding tube minimum bending radius
  - Not properly arranging or securing splice protectors
  - Not properly arranging or securing trays

Installation-induced failures

Causes and Solutions

2. “Corrosion” and Material Defects

   A. Corrosion on hardware leading to cable damage = hardware problem
      - Anything that looks like corrosion to the cable jacket is really “material and/or manufacturing defect”

   B. Material defects
      - Quality of the materials themselves
      - Quality of the manufacturing processes, especially…
        - Moisture or contamination present during extrusion

Solution: Buy from quality suppliers

Installation-induced failures

Causes and Solutions

What about jacket tears?

Installation-induced failures

Causes and Solutions

Jacket Tears (especially at deadends)

- 60% chance caused by deadend design
  - Stress concentration and/or inadequate coupling distance
- 40% chance caused by cable design
  - Tension in strength element must couple to deadend through the jacket
- But, it doesn't really matter which: Cable and hardware must work as a system!

Solution:

➔ **Confirm compatibility** with *both* the **cable** *and* the **hardware manufacturer**!

Tracking Induced Failures

Tracking-induced failures

Causes and Solutions

Tracking is nearly always the result of ADSS being in too high of an electric field

- Standard jacket in field > 12.5 kV/m
- Track-resistant jacket in field > 25 kV/m
  - But, can use “grading bars” or tubes as a workaround
- Exception: Heavy pollution plus poor natural wash cycle
  - Lowers above guidelines by one level
  - Consider your utility’s experience with insulators as a surrogate

Solutions:
Space potential analysis!

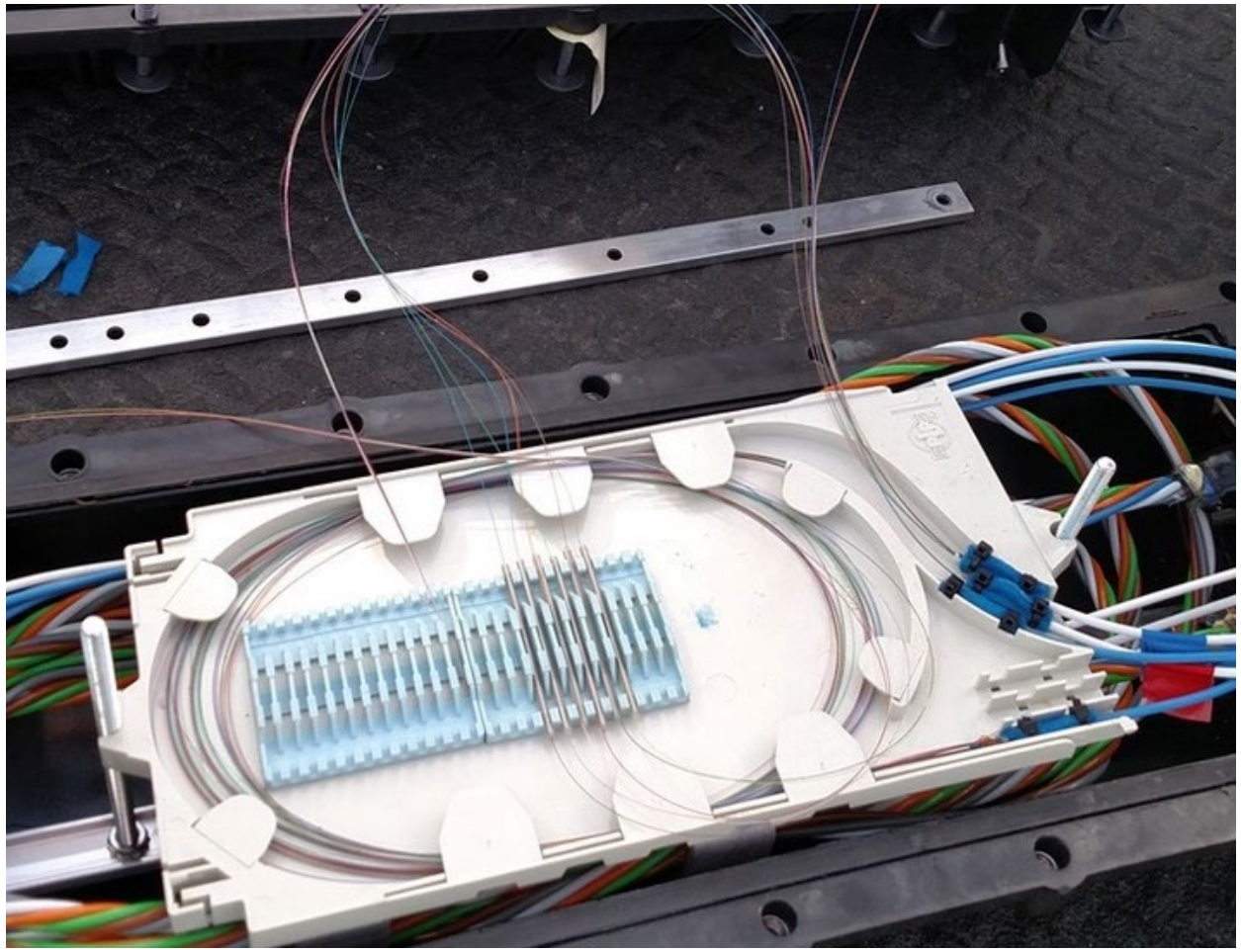
(Note: Tracking and space potential analysis discussed in nauseating detail in our webinar on ADSS in high electric fields)

Pistoning

(at long last)

Pistoning

Causes and Solutions



Pistoning is the fibers pushing out of the tubes into the tray and possibly out of the tray too

Can lead to:

- Macrobending, leading to increased attenuation
- Broken fibers

Occurs sporadically here and there

Pistoning

Causes and Solutions

The cause(s) of pistoning is still debated, but contributing factors likely include

- Tubes being stranded with too long of a laylength
  - Head this off by checking the fiber strain at MRCL ("maximum rated cable load") – Ideal is 0%, Max is 0.2%
- Tube material?
  - Lower coefficient of friction of the material itself?
- Tube type
  - Dry tubes – Should be more likely because of no gel
  - Flooded tubes – Should be less likely, but what if gel too thin (low viscosity)?
- Environmental
  - The periodic nature of low frequency wind sway?

Solution:

- Talk to the cable manufacture and remember: Doing the same thing and expecting a different result is the definition of insanity (something needs to change)
- The industry needs to collect more data about this problem so that trends and patterns can be analyzed

Fiber Strain – An important concept

Optical Failures

Fiber Strain kills optical fibers and therefore fiber optic cables!

- What is Fiber Strain? Answer: When the fibers have tension on them
- Why should you care about it?

  Key Concepts as Background

  - Every cable has a “zero fiber strain margin” (ZFSM) point
  - Below ZFSM, the fibers do *not* have tension on them (Strain = 0% = good!)
  - Above ZFSM, the fibers do have tension on them (Strain > 0% = bad!)
  - At Maximum Rated Design Tension (MRDT = Maximum Rated Cable Load (MRCL)) there *may* be fiber strain or not, depending upon the cable design

Operational Failures

Fiber Strain kills optical fibers and therefore fiber optic cables!

- Why should you care about it?
  - Per Corning (and others), probability of fiber failure if strain = 0.2% is “very low”
    ➔ Expected life when strain = 0.2% on standard fiber is 40+ years (a probability, not a guarantee)
  - Higher strain = increasing probability of failure
    ➔ Expected life when strain = 0.3% is 40 days (Yikes!)
    - The effects of “high” strain, accumulate over time
    - That is, expected life is reduced even if strain returns to 0%
      - Why? Because of microscopic damage to the core or cladding
    - So, if this year, 1 day of strain at 0.3%, then the “allowance” of strain in the future reduced to 39 days
    - Cyclic loading is a compounding factor because fiber is glass and is strong, but brittle

Operational Failures

Fiber Strain kills optical fibers and therefore fiber optic cables!

- Where does Fiber Strain come from? Sources in Operation
  - Cable Design
    - Sinusoidal shape of the fibers inside a tube
    - Laylength of the tubes
  - Cable Manufacturing
    - “As-made” could be lower than as designed if poor Excess Fiber Length (EFL) control
    - Poor processing can damage the fiber (microscopically)
  - Operating Conditions
    - Wind or ice conditions cause the cable to experience higher tensions than designed, and/or
    - More time under strain than expected

Operational Failures

Fiber Strain kills optical fibers and therefore fiber optic cables!

- Solutions – Let “No strain; No problem” be your general guide
  - Cable Design – Know if you can expect to have strain or not
    - Basic guideline: 0% strain “everyday” (no ice/no wind); ≤ 0.2% strain at your max. ice/wind load
    - Consider the cable’s ZFSM given *both* code loading criteria *and* actual loading in your area
      - The code is a guideline; respect your reality
    - Every supplier knows their cable’s ZFSM, but often you must ask for it
      - Consider this carefully during your cable selection process
  - Cable Manufacturing – Know that your supplier has in-process EFL control for tubes
    - All types of tube should have 0.25% or more
  - Operating Conditions
    - Collect weather data and look for weather where strain would be expected
    - Estimate the level of strain and exposure time to adjust expected life
      - Working on a guideline for this

You can predict when your ADSS is likely to have problems!

OMG! Maybe I should go underground?!

- Seems like a high risk of problems!
- Remain calm! Consider the context
  - ADSS still has an excellent track record!
    Good cable design + Good manufacturing + Good hardware + Good installation
    = 25+ years of service life
  - Underground cables have problems too
    - Rodents, especially rats
    - (Rogue) Backhoes – Dig-ins are the #1 killer of underground systems of all types

      ➔ Repair of underground systems tends to be harder, take longer, and cost more

➡ ADSS remains a “go to” solution for putting fiber on all power lines!

Acknowledgement to the UTC

- The UTC Fiber Subcommittee research report on ADSS Fiber Life Cycle was my starting point for this webinar and is a huge source of information
  - Many of the illustrations are from that report
- I offer the UTC my gratitude for their work
- I offer you the tip that you can get this report from the UTC at:
  - https://utc.org/resources/#research
- They have a similar report for OPGW which was my starting point for Part 1 of this series on Field Problems with Aerial FO Cables

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Thank you

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