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Signs of End of Life FM Antennas and Transmission Line Systems

Thomas B. Silliman, PE

Introduction

- Factors that influence the life of antennas and feed lines

Factors that influence the life of Antennas and Feed lines

- Storm damage
 - Wind
 - Tower movement
 - Lightning
- Salt on insulators
 - Sea coast
- Time in use
 - Bullet failure if station is not on air 24 hours a day

Factors that influence the life of Antennas and Feed Lines

- Age of Antenna
 - Time between failures
- Vandals
 - Bullet holes in transmission line near lights
- Tower or pole vibration
 - Guy wire galloping
 - Snubbers
- Vortex shedding
 - Not likely with side mount antennas

Factors that influence the life of Antennas and Feed lines

- Antenna and tower inspections
 - Many FM multiplex antenna systems are inspected annually.
 - Broken hangers
 - Pressure leaks
 - Worn out insulators or insulators that need to be coated
 - Most single station side mount antennas are only inspected if a problem occurs
 - VSWR
 - Pressure loss

Inspection of feed line showing missing button



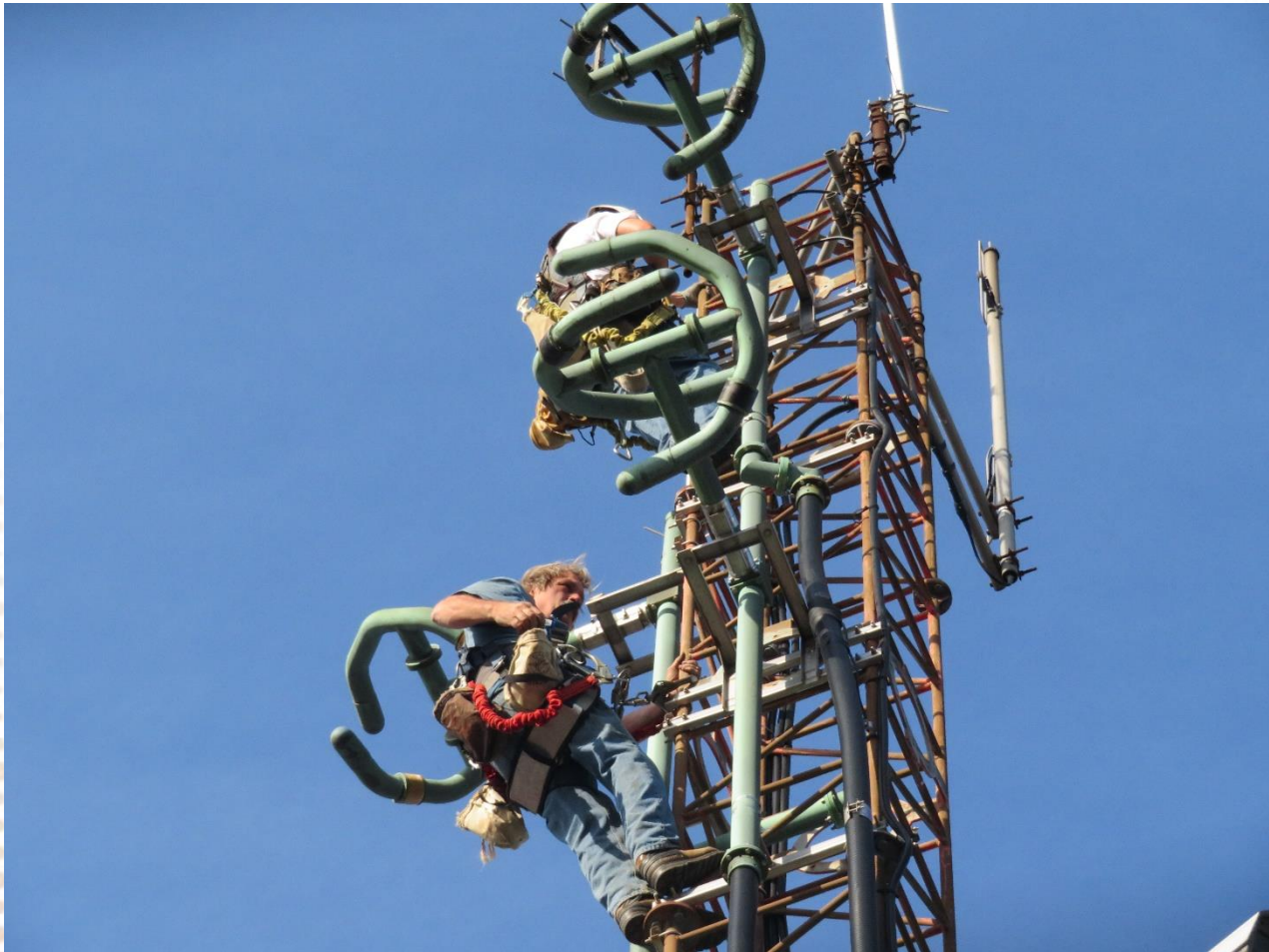
Inspection of Multiplex Painted Antenna Insulator





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Antenna Inspection of Side Mounted FM Antenna

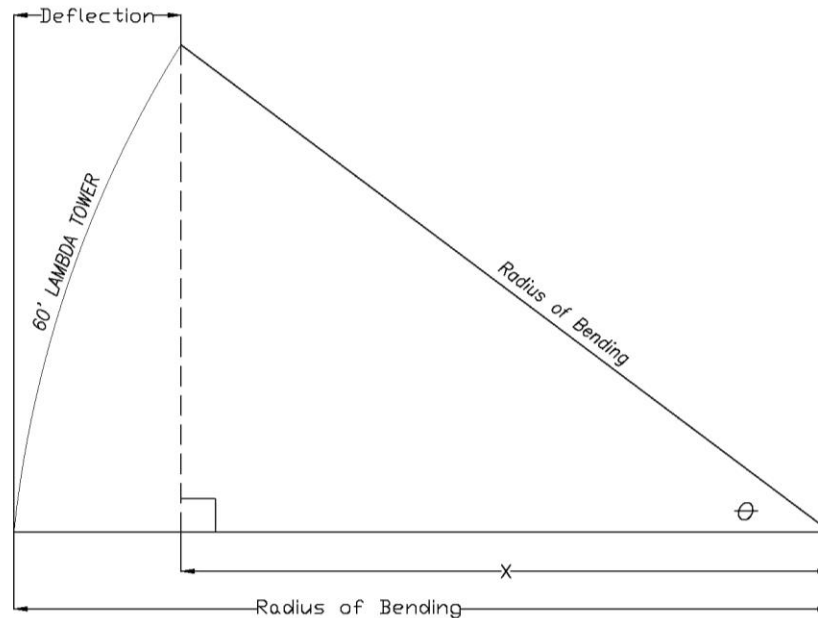


Antenna Inspection Measuring All Components



Storm Damage: Wind - Tower Movement

Example of Tower Movement Calculation



Sample Calculation of Lambda Deflection

- Assume a 60 foot tall Lambda Tower
- Specification of radius of curvature for the Lambda Tower is $R = 3000$ feet at full wind design under G
- $R(\Theta) = 60$ feet where Θ is radians
- $\Theta = 0.02$ radians = 1.1459 degrees
- $X = (3000) \cos 1.1459 = 2999.4$ feet
- Deflection = $3000 - 2999.4 = .6$ feet
- $.6$ feet = 7.2 inches

One Solution to Tower movement

- First Lambda Tower installed in 1990
- Replaced a top mounted pole on a tower in Pittsburgh
- Antenna on pole had failed every year since it was installed
- Has never failed since mounted on Lambda tower

Analysis of Tower Deflection

- Tower analysis today can be done with finite element analysis
- Finite element analysis will predict tower movement and deflection
- If antenna failures occur in less than three years after installation, the tower should be analyzed to determine if excessive movement is causing the premature antenna failure.

Causes of excessive Tower Movement

- Guy wires not tensioned properly
- Tower design
 - Ice on wires
 - Lack of snubbers
 - Improper reinforcement design
 - Antenna installed without analysis of tower prior to additional loading
- Working on problems in the field, I have seen all of these tower design issues.

Lightning Damage



Lightning Damage is Repairable

- Symptoms
 - Loss of pressure
 - High VSWR
- Can allow moisture to enter antenna and transmission line.
- Does not necessarily have an adverse affect on the life time of the antenna or transmission line if repairs are done quickly.

Salt deposits on antenna and insulators and tower steel

- Will affect antennas located near ocean
- Radomes can be added to the antenna to protect insulator surface
- Towers near sea coast should be inspected every five years
 - Guy wire deterioration
 - Leg steel
 - If hollow legs, can deteriorate leg steel.
 - Inner members can rust if not protected.

Example of Guy Wire Deterioration



Example of Tower leg Deterioration



Time in use

- FM antennas have inner connector connectors, bullets.
 - As temperature of inner conductor changes, the inner conductor will expand and contract differently than the outer conductor.
 - Temperature varies due to outside air temperature
 - Temperature varies when antenna input power is turned off and then turned on at a later time.
 - Excessive movement of inner causes bullet₁₉ failure.

Example of Bullet Failure



Age of Antenna

Time Between Failures

- Antennas can be repaired or rebuilt to extend the life of the antenna.
 - New bullets
 - New insulators
 - New inner conductors
- Rigid coax can also be rebuilt to extend its life.

Antenna being Rebuilt in the Field



Vandals

- Often, we find that someone has shot an antenna. We usually find the hole near a tower light. Can be patched.
- If maintained, antenna life is unchanged.
- Symptoms:
 - Loss of pressure
 - Change in VSWR

Guy Wire Galloping

- Can result when wires are not tensioned properly
- Often will occur with ice on the wires
 - Wind causes ice to form a trailing edge
 - Trailing edge of ice on wire causes lift with stiff wind.
 - Wire will jump up and down shaking the tower which can result in violent antenna movement resulting in antenna damage.

Guy wire Snubbers

- Significantly reduce guy wire galloping.
- Cables ride up and down on the guy wire near the anchor on pullies.
- These cables are attached to shock absorbers that are anchored to the ground near the guy wire anchor.
- Are often used on tall towers 1000 feet tall and taller.
- Can be added to existing towers.

Guy wire Snubbers



Guy wire Snubbers



Guy wire Galloping

- Can cause cracks in the antenna components and limit the useable life time of the antenna.

Voltage Standing Wave Ratio

- $VSWR = (1 + p)/(1 - p)$
- Forward power = $p+$
- Reflected power = $p-$
- $p = \text{Square Root } (p-/p+)$
- Return loss = $10 \log(p)$

Antenna VSWR

- Typical VSWR of installed antenna without field matching will be in the order 1.15
- Field matched FM antennas can have a VSWR of less than 1.02.
- Return Loss for 1.02 VSWR = 40.09 dB

Signs of End of Life

- Improvements in Technology
- Excessive loss of pressure
- Periodic VSWR trips
- Finding antenna parts on the ground around the tower

Example:

IDS Multiple user Antenna

- Antenna had multiple dipoles that were fed with pressurized flex coax
- Due to excessive air leaks in system, George Werle, the site managing engineer, had drilled drain holes in the flex lines to drain out water.
- Antenna components often broke off and fell to the roof of the IDS Building
- Decision was made to replace the antenna.

Example:

One Shell Plaza Antenna

- This nine station FM multiplex facility operated for years in down town Houston, Texas.
- The Shell Building is a 50 story building.
- As Houston grew, other buildings were built causing excessive shadowing.
- Senior Road Tower was built with new nine station FM Antenna.

Definition of End of Life of an FM Antenna

- My definition of end of life is simple.
- The end of life of an FM antenna occurs when the cost of repairing the antenna exceeds the cost of replacing it.
- If properly maintained, there is no reason that a side mounted ERI FM antenna should remain in service for less than 30 years assuming that none of the issues presented earlier exist.

Questions?



Guy Wire Galloping Video

