COMMUNICATIONS POLE INSPECTION & MAINTENANCE
PROTECT YOUR ASSETS & PROLONG THEIR LIFESPAN

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With the explosive growth of wireless cell sites in the last twenty years, communications poles have been increasingly sited in urban areas in close proximity to the public. While communications poles have not been known to experience a free-fall style collapse, the wireless industry has suffered multiple pole collapses since the early 2000's. Planned maintenance and inspection of your communications pole structures including careful attention to the base welded connection will protect your assets and prolong their lifespan.

STEEL POLES

Tubular steel poles have been utilized as a support structure in the communications, utility, sports lighting, and the transportation industries for a half century. In the wireless industry alone, steel poles have been in service since the growth of cellular in the late 1980's. Combining a long history of reliable performance in the utility industry, competitive pricing, and ease of use and installation, steel poles became the wireless industry's leading choice for antenna support.

As the count of wireless cell sites in the United States increased by over 300% from 1995 to 2000 according to the CTIA, tubular steel pole use as antenna support increased dramatically. Favored by zoning boards and the public alike for their aesthetics and concealment options, steel pole use in urban markets facilitated site acquisition in otherwise difficult areas to site. Treepoles, flagpoles, slimline poles, and other tubular steel concealment structures became popular and prevalent in the mid to late 1990's. As a structure very familiar to the utility industry, dual-purpose communications/utility pole structures also became popular.

The steel pole fabrication industry in the United States is unique and specialized. The manufacture of multi-sided tubular steel poles requires specialized press and welding equipment not readily available in most fabrication shops. In the early

1990's, barely a half-dozen fabricators possessed the capability to produce multi-sided poles. Round pipe poles, not requiring the specialized manufacturing equipment, were more readily available from a few of the industry's larger tower manufacturers and small regional fabricators. The industry's larger manufacturers are well known for their quality programs including American Institute of Steel Construction, ISO-9000, American Welding Society, and Canadian Welding Bureau certifications.

During the massive growth and expansion of the wireless industry, a number of manufacturers came on line with new multi-sided steel pole fabrication capabilities. Existing manufacturers increased their manufacturing capacities through plant or greenfield expansions. In addition, new manufacturers rushed to join the market. Capacity constrained, the communications pole industry was hard pressed to meet the industry demand for the popular structures.

POLE FAILURES

With the continued growth of pole usage in increasingly populated areas, preventative maintenance and upkeep of these structures is crucial to not only preserve your assets but also the public welfare. Properly maintained, tubular steel poles can safely remain in service well over a half century.

Pole collapses, while relatively unheard of in the wireless industry, have made news in recent years. For the first time, the wireless industry was dealing with negative publicity and more pointed structural adequacy questions. In addition, as the industry strived to optimize existing communications pole structures and the structural modifications industry has grown, the original design envelopes of the structures were being exceeded.

The pole failures seen in recent years possess similar characteristics:

- Cracks in the pole structure shaft wall above the base plate weld that propagate along the weld over time
- Socket base plate connection (base plate sleeves over pole wall)
- Thin base plates (under-designed) allowing for excessive movement resulting in fatigue at the base plate/pole wall welded connection

In instances where field repairs have been performed on the base plate weld connection prior to structure failure, the following characteristics have been noted:

- Cracks in the pole structure shaft wall above the base plate weld that propagate along the weld over time
- Cracks at the bend points at the toe of the weld on multi-sided poles

- Both complete joint penetration groove weld and socket base plate connections

A number of communications pole bases inspected in recent years possessed defects. Cracks have been found ranging from 1" to over 100" on the pole base diameter circumference. In one case, a repair was conducted on a multi-sided pole where every bend point (12-sided) was cracked clear through the pole wall shaft thickness. Repairs conducted to date show the importance of monitoring and repairing this important connection as required.

POLE BASE DETAILS

A steel pole base plate connects the structure via the anchor bolts to the foundation. More specifically, the base plate attaches the pole shaft structure to the anchors. The connection is facilitated by welding of the members during fabrication at the original manufacturer's facility. As the only connection and one that is non-redundant, the structural adequacy and integrity of this connection is crucial to the performance of the structure. A failure, if one was to occur at this joint, will in almost all cases be catastrophic resulting in the collapse of the pole structure. The connection detail of the pole shaft structure to the base plate can vary depending on the type of pole (multi-sided vs pipe) or the original manufacturer.

Various communications pole base details:

- Complete joint penetration groove weld – the base plate is butted against the pole shaft and consists of 100% complete weld penetration. In other words, the connection zone is all weld material.
- Socket base plate connection (base plate sleeves over pole wall) with double fillet welds.

While other joints may be possible including stiffeners, the majority of poles manufactured fall into one of the two categories.

ANATOMY OF A CRACK

A crack in a weld or base metal is a break in a material that was solid previously and separated due to stress. Cracking occurs in a weld and base metal when the localized stresses at the connection exceed the ultimate strength of the steel material. Left in place without repair, cracks may propagate over time and loading and can be very detrimental to structural adequacy. The American Welding Society (www.aws.org) Structural Welding Code D1.1 does not allow a crack to be left after inspection (Table 6.1, Part 1), regardless of size or location.

While all the contributing issues and their interactions are not yet fully understood, cracks at pole bases can occur due to problems in the following areas:

- Design – incorrect base plate design resulting in an under-sized base plate
- Materials – includes quality of material being joined, yield strength, and brittleness
- Production – poor welding quality, lack of pre-heat during welding fabrication, incorrect welding settings in the factory
- Quality – poor manufacturing quality control; quality checks at the original manufacturer after fabrication and galvanizing overlooked or incorrectly performed
- Galvanizing – cracks due to thermal expansion during the galvanizing process – referred to as 'toe cracks' occurring immediately after galvanizing or delayed
- Installation – loose leveling nuts or improper grouting of the base plate which may cause unanticipated stress increase in the weld joint
- Fatigue – long term loading effects in combination with any of the above

A crack in a pole base plate weld connection can occur during fabrication, galvanizing, or after loading of the structure. While a crack can originate and propagate from a longseam weld (vertical weld along pole axis joining pole half-shells), cracks originating at the based welded connection appear to be more common. A toe crack is defined as a crack in the base metal at the toe of a weld**.** Toe cracks are generally cold cracks that initiate approximately normal to the base material surface and then propagate from the toe of the weld where residual stresses are higher. These cracks are generally the result of thermal shrinkage strains acting on a weld heat-affected zone that has been embrittled. The crack can occur immediately after galvanizing or a period of time after galvanizing.

The American Society of Civil Engineers (www.asce.org) Manual 72, "Design of Steel Transmission Pole Structures," dated 1990, discusses toe cracks and their occurrence in transmission tubular steel poles. According to the Manual, Section 3.5.3.3 Special Design Considerations, toe cracking of weldments: "Toe cracks, around T-joint welds, undetectable prior to galvanizing have been detected after galvanizing. The formation of these cracks appears to be influenced by several factors in the fabrication process. Requirements for post-galvanizing inspection should be considered. If the manufacturer can provide historical proof that the practices used do not provide toe cracks after galvanizing, this requirement may be waived." Toe cracks not addressed as part of the original pole manufacturer's quality control program can be detrimental to the long term service of the structure. Manufacturers without sufficient QA/QC processes, inexperienced manufacturers, or manufacturers rushing to meet industry demand during the peak growth of the late 1990's were all susceptible to overlooking this critical issue.

POLE MAINTENANCE

ANSI/TIA/EIA-222 Revision F, dated 1996, *"Structural Standards for Steel Antenna Towers and Antenna-Supporting Structures"* contains Annex E entitled *Tower Maintenance and Inspection Procedures*. The Annex of the Standard recommends that owners of towers should perform initial and periodic tower inspection and maintenance to assure safety and to extend service life. It recommends that major inspections be performed, at a minimum, every 3 years for guyed towers and every 5 years for self-supporting towers (and poles). The maintenance requirements of the Standard are as follows for self-supporting structures:

- Members
- Finish
- Lighting
- Grounding
- Foundation
- Tower Assembly (antennas, feedlines, mounts)
- Alignment
- Insulators (as required)

Released in August of 2005, ANSI/TIA-222 Revision G, *"Structural Standard for Antenna Supporting Structures and Antennas"* contains Section 14.0 *Maintenance and Condition Assessment* and Annex J entitled *Maintenance and Condition Assessment*. Per Revision G, maintenance and condition assessment shall be performed as follows:

- Three-year intervals for guyed towers and five-year intervals for self-supporting structures
- After severe wind and /or ice storms or other extreme conditions

- Shorter inspection intervals may be required for Class III structures (structures that due to height, use or location represent a high hazard to human life and/or damage to property in the event of failure and/or used primarily for essential communications) and structures in coastal regions, in corrosive environments, and in areas subject to frequent vandalism.

The individual maintenance requirements of Revision G are very similar to Revision F. While very comprehensive from an overall structure and component standpoint, neither Revision F or G addresses pole base weld inspection directly.

Normal communications pole maintenance is conducted by tower crews typically experienced in new tower construction, structural modifications, or lines and antenna installation. In years past, corrosion was touched-up and forgotten, even at the pole base weld connection. Any signs of corrosion at this connection should be inspected immediately by qualified personnel. The stakes are high; the average tower crew member will not have sufficient qualifications to adequately assess the condition of the base weld connection.

RECOMMENDED BASE PLATE MAINTENANCE

Supplemental to the TIA Standard's minimum pole maintenance requirements, an additional maintenance program is recommended. The program is differentiated by a careful weld inspection involving both visual and non-destructive testing.

The AWS Welding Code in Section 5.26 addresses repair of welded connections and in Section 8 addresses the strengthening and repairing of existing structures. To ensure the long term comprehensive performance of your communications pole structure, the diagnosis and repair of cracks at a pole base should be accomplished as follows:

1. Identify Base Connection Detail:
   a. Complete penetration joint, or
   b. Socket base plate connection
2. Visual Inspection – Visual identification of any abnormalities in the joint to American Welding Society (AWS) D1.1 Table 6.1 criteria conducted by a Certified Welding Inspector (CWI) or inspector meeting the qualifications as stated in the AWS Code. Note, however, that a visual inspection may only detect very aggravated conditions with pronounced defects. In almost all cases, this is not sufficient for conclusive results.
3. NDT Magnetic Particle Testing – Conducted by an inspector with American Society for Non-Destructive Testing (ASNT – www.asnt.org) Level II Certification. This non-destructive test is utilized to assess surface cracks in joints that are not 100% complete penetration joints; i.e. socket base plate connections. Defects hold the magnetic particle material during the test and

identify the presence of a crack. The crack in the picture below can be seen holding red powder.

Magnetic Particle Test (MT) Powder at Revealing Toe Crack

4. NDT Ultrasonic Testing – Also conducted by an inspector with ASNT Level II Certification. Utilized for testing of joints that are 100% complete penetration joints. The test utilizes ultrasonic waves that are interrupted by any material inconsistency (crack) in the joint.

Ultrasonic Test (UT) of Pole Base Plate Weld

5. Surface Preparation – Depending on the coating on the structure (galvanizing, paint), the coating may require removal via grinding.
6. Identify Defect Presence – Mark and label extent of cracks. Document locations and lengths. In Picture X,
7. Assessment of Defects – Assess extent of cracks, length, and position
8. Defect Repair - The last stage is to repair the weld and/or reinforce the pole base connection. The scope of the strengthening stage will depend on the results of the diagnosis and analysis stage. Significant cracks may require drilled terminations. A reinforcement stiffener installation is shown at the right.
9. Coating Repair – Repair the areas damaged by the surface preparation and/or welding. Hot-stick galvanizing or two coats of brush-on cold-galvanizing paint is recommended.
10. Documentation – Maintenance of the project close-out documentation including weld inspection results, PE sealed design and drawings if applicable, and passing weld inspection report is imperative. Tracking your results as you inspect your inventory is crucial for monitoring the performance and load-carrying capability of your structures.

It is imperative that your inspections are carried out by qualified personnel with CWI credentials and non-destructive ASNT credentials. Inspectors with heavy structural steel weld inspection would also be recommended. It is strongly recommended your communications pole base connections are inspected at the TIA recommended minimum of five years. In addition, every time the structure is structurally modified the connection should be inspected.

CONCLUSION

There is certainly much to be learned on this subject by the industry. While there appears to be many contributing factors and variables, careful attention to the following is recommended to reduce your risk:

- For existing communications poles, a program should be established to check the pole base connection as part of an ongoing inspection and maintenance program
- Do not structurally modify an existing pole and increase the structure loading without inspecting the pole base weld connection
- Purchase your new communications poles from a reputable manufacturer with a sound reputation for accurate designs and established QA/QC programs
- Do not paint signs of corrosion at the pole base plate connection!

With increased attention to your communications pole base connections, you will prolong their lifespan and ensure the long term financial performance of your assets.

About the author:
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