Steel Pole Inspection, Repair, Corrosion Management

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Introduction

According to the American Iron and Steel Institution there are about 185 million utility poles in service in the United States. Of those 2-3 million are replaced annually with steel poles being used in about 10% or 200-400 thousand of the replacements. Steel poles have been utilized on transmission circuits for about 50 years however steel distribution poles have only been widely used for about 10 years. So the steel pole industry is still young and we continue to understand more with each maintenance cycle completed. Currently the NESC safety code has no allowance for corrosion on either the loading or the material side. The corrosion process cannot be prevented so corrosion needs to be managed. The time of the corrosion process from initiation to significant structural damage is short so locating corrosion early and taking appropriate action is important. Repair options are very limited so a high number of rejects will need to be replaced. NACE (National Association of Corrosion Engineers) together with IEEE (Institute of Electrical and Electronics Engineers) have formed a new joint committee to make recommendations to consider corrosion in design, inspection, and maintenance practices. The committee is composed of electric utilities, contractors, and manufactures with the first meeting scheduled for mid March 2007.

Steel Maintenance Best Practices

Steel pole maintenance begins with line design. Planning for corrosion management will help insure a full service life with fewer surprises. A right-of-way site survey is recommended to obtain information on the local environments that could affect the corrosion rate. To estimate local environmental corrosivity several local factors need to be identified. These factors include soil resistivity, soil pH, soil type, the water table, voltage potential, and redox potential. Many DC voltage sources such as buried pipelines or rapid transit systems on or near the right-of-way could accelerate corrosion. If the grounding system has copper components the grounding systems specifications need to be reviewed for possible corrosive potentials. After interpreting the corrosion data collectors, an initial corrosion management system can be specified that will manage corrosion beyond the next maintenance cycle.

Storage and handling can impact the poles useful service life. Poles need to be stored horizontally with one end elevated for water runoff. Factory applied coatings are generally not UV resistant. So coatings need protection from UV exposure. Careful handling is important because any mechanical damage will compromise the initial corrosion protection system and could impact the load bearing capacity of the pole.

Inventory rotation is important so the first pole received needs to be the first pole shipped.

In-service steel poles should be inspected on a regular basis. The American Heart Association has identified several factors that if present increase the likely hood of a person having or developing heart disease. These factors include: age, gender, family history, tobacco use, blood cholesterol, physical activity, obesity, and diabetes. If a person has one of these issues it may not be a big deal, but if they had 2 or 3, a more detailed evaluation needs to be performed. Pole maintenance Company has developed risk factors for identifying corrosion “hot spots”. The corrosion hot spot risk factors include (Figures 1, 2): 1) a visual inspection for corrosion or mechanical damage; 2) the soil electrical conductive properties by mapping out the soil resistivity; 3) evaluating the water table; 4) cataloguing the soil type for porosity; 5) soil chemistry by capturing the soil pH; 6) measuring the structure to soil voltage potential using a half cell; 7) measure the soils redox potential in millivolts; and 8) identify any stray DC currents entering or exiting the pole.

After interpreting the corrosion risk data, the poles are rated by corrosion severity.

- Condition A = Good condition no visual corrosion
- Condition B = Surface corrosion < 10%
- Condition C = Corrosion 10%-25%
- Condition D = Heavily corroded > 25%

A typical distribution by corrosion severity that could be expected:

- o Condition A = 46% of the total population
- o Condition B = 29% of the total population
- o Condition C = 16% of the total population
- o Condition D = 09% of the total population

Action recommended by corrosion severity:

- Condition A = No action until next inspection
- Condition B = No action until next inspection
- Condition C = Further inspection to quantity damage and corrosivity
- Repair as needed, update corrosion protection
- Priority: 1-3 years
- Condition D = Further inspection to quantity damage and corrosivity
- Repair as needed, update corrosion protection
- Priority: Immediate to 1 year

By identifying and eliminating Conditions A & B, 75% of the poles will be suited for continued service until next inspection, this allows one to focus on the Condition C & D poles, about 25%.

Condition C&D inspection options (Figure 3):

- Deeper excavation and visual
- Interior voltage potential
- Ultrasonic wall thickness test (Fig. 3a)
- Coating dry film thickness test (Fig. 3b)
- Zinc thickness test
- Video probe exam of interior (Fig. 3c)
- Borescopic exam of interior (Fig. 3d)+

Steel Pole Repairs

Repair options are limited to steel plate weld repair at this time (Figure 4). We are currently evaluating in-service steel truss repairs and fiber wrap repairs. Both repair methods are widely utilized to repair in-service wood poles at this time and may be suited for steel. Other technologies might include field application of galvanizing similar to that done today for undercoating of vehicles. The use of two-part liquid polyurethane backfill products may aid in stabilizing poles in-line.

Corrosion Management

Root cause of corrosion damage is key because the repaired or replaced pole will be exposed to the same corrosion potentials that caused the initial damage. Overcoming the corrosion potential is attainable once understood. Corrosion management options include:

- Cathodic protection
- Grade alteration
- Coatings
- Combination of Cathodic Protection and Coatings

Cathodic protection utilizes, a sacrificial metal usually magnesium or zinc that will sacrifice itself to protect the steel pole. When property engineered and installed a cathodic protection system will overcome even aggressive local corrosivity.

Site grade alteration at the pole groundline will prevent water from pooling at the base of the pole.

Coatings require matching the particular coating system to the application and applying as per manufacturing specification. Proper surface preparation is difficult on in-service applications but is critical to achieve a good coating to substrate bond and is commonly overlooked.

Optimal protection can be obtained by combining cathodic protection and coatings. The coatings reduce the bare steel surface area to be protected, and the cathodic protection will protect coating holidays, voids and pinholes. This combination of cathodic protection and coatings working in concert insures the longest possible service life at the lowest cost. Remember, this level of protection is not needed on the vast majority of poles just on the few poles exposed to corrosion hot spots.

One challenge continues to be our ability to quantify corrosion under insulation. PMC is currently developing guided wave ultrasonic technology which may offer solutions to this inspection problem (Figure 5). Features of guided wave technology include 100% coverage, diameters of 2-48 inches, service temperatures up to 125° F, and typical test ranges of ± 30 m.

Stray Currents

Stray currents from nearby DC voltage sources can cause extensive damage in a short amount of time. Possible DC voltage sources that are common to rights of way include pipelines and mass transit systems. Identifying the stray current source is important as damage can be prevented by installing a drainage bond to a groundbed or bonding the pole to the DC current source with a decoupler. Also, the stray voltage source may share in the cost of protecting the affected poles.

Inspection Cycles

Appropriate inspection cycles, usually 7-15 years, can be established after interpreting the corrosion data and estimating the anticipated corrosion rate and comparing that to the corrosion management system utilized. Safety factors should be used to anticipate changes in the local environment such as property development and new pipelines sharing the right of way.

Conclusions

This paper has covered the important aspects of steel pole maintenance. Pole maintenance begins at the design stage. Proper storage and inventory rotation are important and critical. In-service poles should be inspected on regular cycles and defective poles repaired or replaced as necessary. Corrosion management systems should be updated as corrosivity is identified. Further, good management practices dictates that inspection cycle duration be updated as corrosion information dictates.

While this paper focuses on steel poles, the fundamentals apply to any embedded steel including towers, trusses, and anchors.

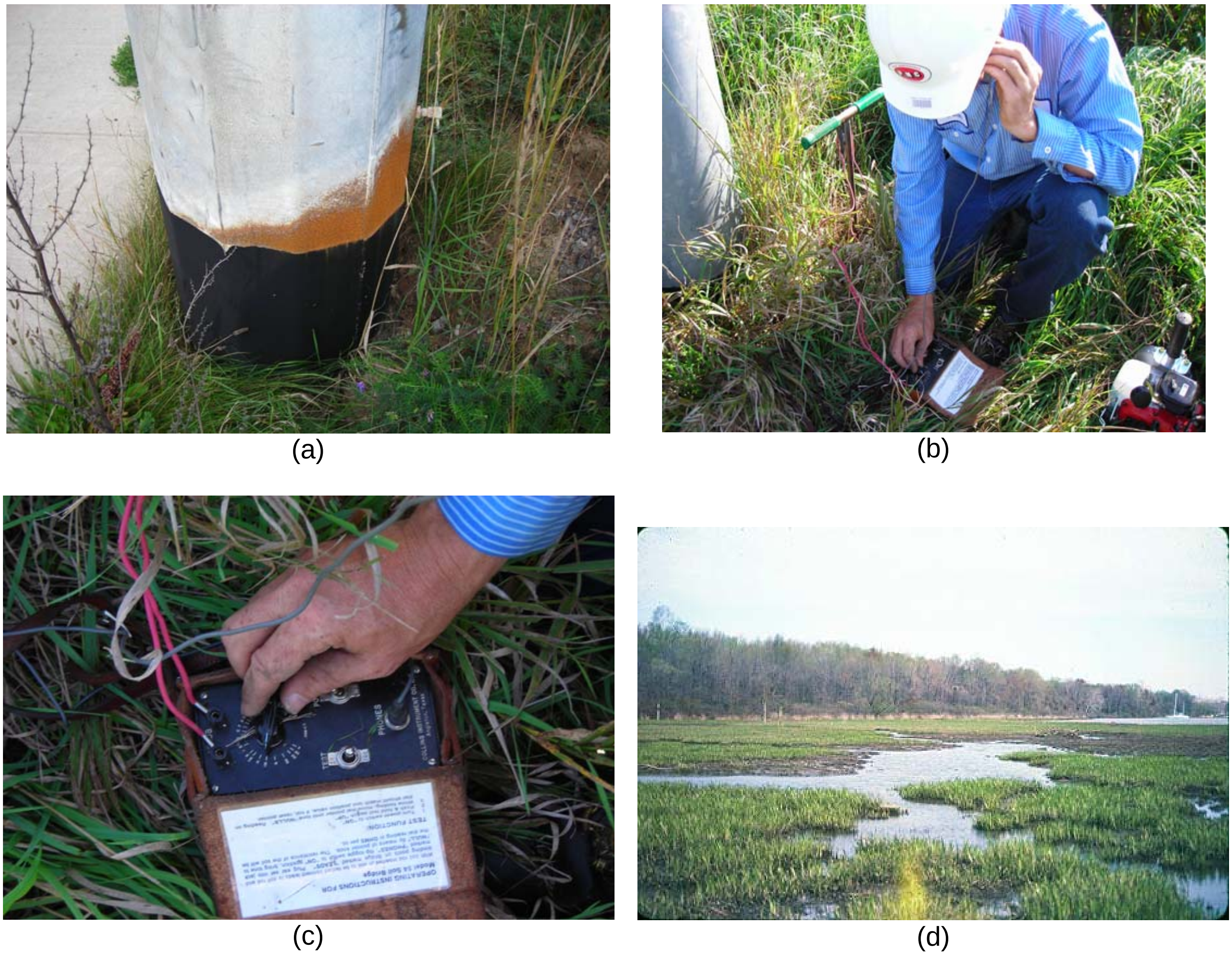


Figure 1. Hot spot risk factors for corrosion should include (a) visual inspection, (b, c) soil resistivity, and (d) water table.

Figure 2. Other risk factors include (a) soil type, (b) soil pH, (c) voltage potential, and (d) redox potential.

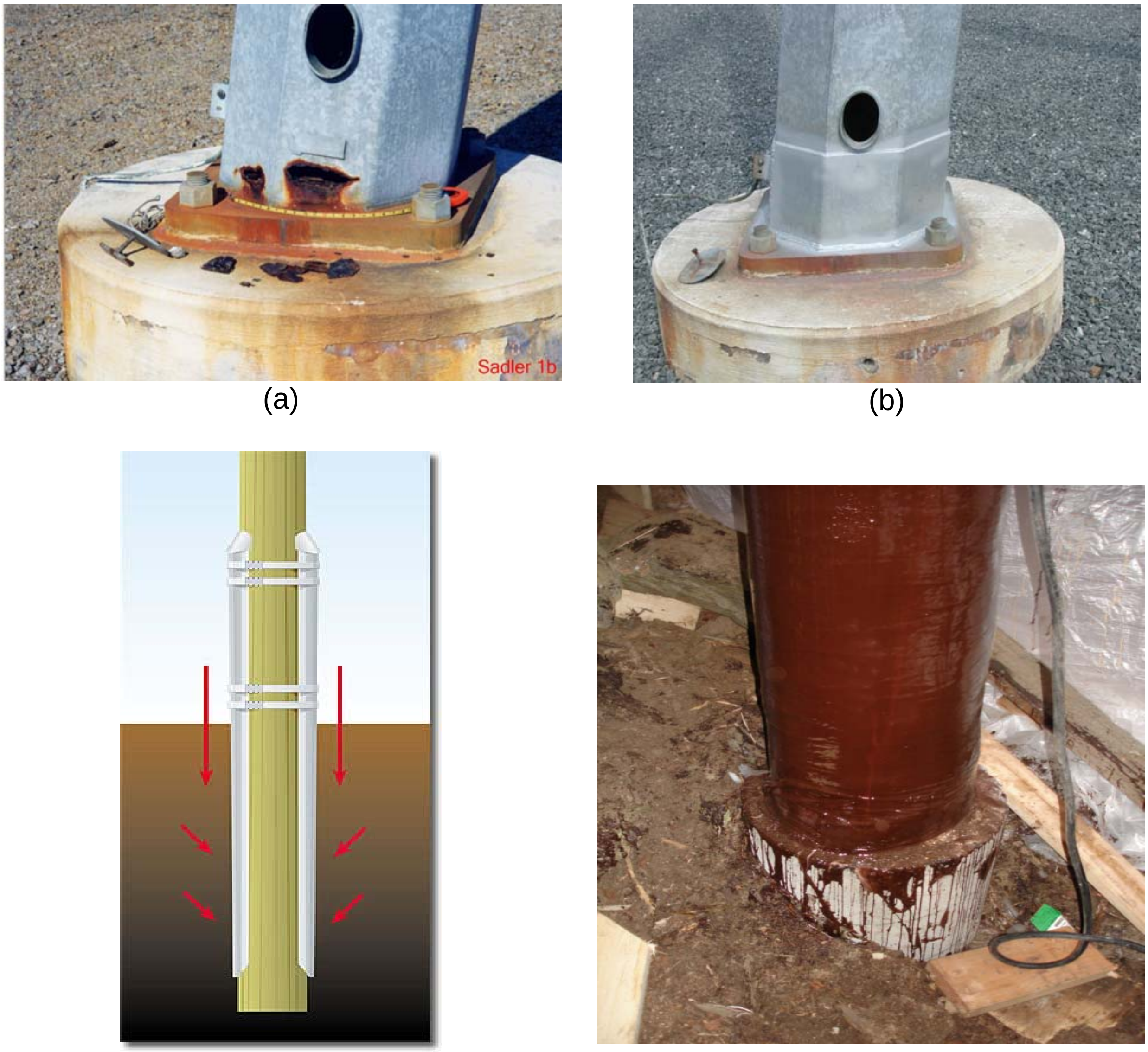
(a)

(b)

(c)

(d)

Figure 3. Among several techniques, Level 2 inspections include (a) ultrasonic wall thickness, (b) coating/film thickness, (c) video probe interior inspection, and (d) borescopic interior inspection.



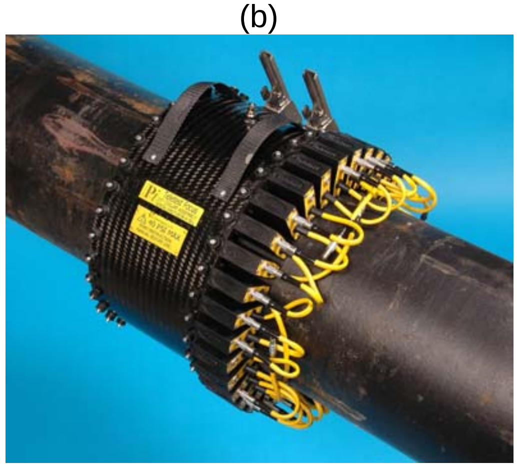
(a) (b)

(c) (d)

Figure 4. Repair of (a) steel poles is currently limited to (b) plate weld repair but (c) truss and (d) fiber wrap repair technologies are being developed.

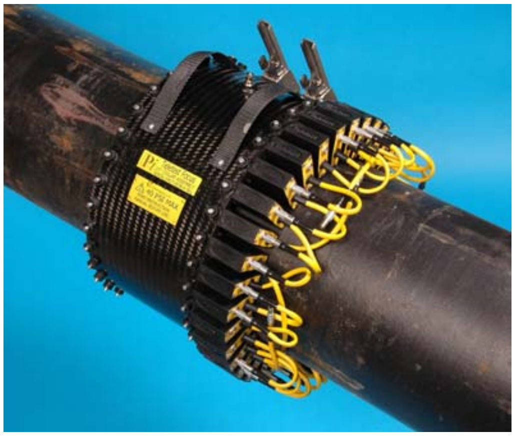
(a)

(b)



(c)

Figure 5. Determination of corrosion under insulation (a) is a problem that new guided wave ultrasonic (b, c) technology may solve.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