Specifications

1. General

1.1 Guyed tower anchor shaft corrosion is recognized as a problem by the Telecommunications Industry Association / Electronic Industries Association (ANSI/TIA/EIA-222-F) and the Canadian Standards Association (CAN/CSA-S37-M86). The specifications herein are intended to compliment applicable industry standards.

1.2 Corrosion on guy anchors varies significantly from site to site (and even from anchor to anchor at the same site) based on many interrelated factors. Corrosion control measures beyond hot-dip galvanizing are virtually always appropriate as a precaution, and depending on site-specific conditions, may be essential.

1.3 Corrosion is an electrochemical process by which refined metals return to a native state. Certain conditions must exist for a corrosion cell to function. There must be metal or metals with at least two energy levels, an electrolyte (such as soil, water, or concrete), and a conductor. The metal that gives up energy (anode) corrodes, while the metal receiving energy (cathode) maintains its form. See ANSI/TIA/EIA-222-F, Annex J for discussion.

2. Factors Affecting the Rate of Anchor Corrosion

2.1 Many factors affect corrosion activity on guy anchors in direct contact with soil. Generally, the corrosivity of the soil, the magnitude of electromotive force (emf) between dissimilar metals, and the relative size of the anode to the cathode are primary factors. Stray direct current from an outside source can also contribute to rapid corrosion.

2.2 Soil corrosivity is complex, but is generally more severe as: soil resistivity decreases below 10,000 ohm/cm, soil pH is below 3 or above 9, and redox potential (a measure of microbiologically influenced corrosion potential) decreases below 100 mV. The presence of chlorides, sulfides, salts, organic materials, different oxygen levels, poor drainage, different soil types and moisture content are among the factors that can contribute to corrosivity. Factors can vary seasonably. For example, soil resistivity generally decreases as temperature rises. Also, site specific activities such as doping the soil to enhance grounding can increase soil corrosivity.

2.3 Lower soil resistivity provides a more conductive environment for the flow of current. With regards to resistivity, table 1 illustrates a classification that can be used to indicate corrosivity of soil.

Table 1. Soil Resistivity Classification

Resistivity in ohm/cm	Category
0-2000	Very corrosive
2000-5000	Corrosive
5000-10,000	Moderately corrosive
10,000-25,000	Mildly corrosive
Over 25,000	Progressivly less corrosive

2.4 Differences in the energy potential of various metals have been documented in the Galvanic Series (see table 2). Metals listed higher on the series are more active and will release energy to ones below. Non-uniform conditions along the surface of a metal can also cause different energy potentials. For example, the portion of an anchor embedded in concrete typically has lower energy potential than the portion exposed to soil.

Table 2. The Galvanic Series

Metal	Approximate Volts to $CuCuSo_4$
Magnesium Alloy	-1.60
Zinc	-1.10
Alluminum Alloy	-1.05
Mild Steel (Clean & Shiny)	-0.50 to -0.80
Mild Steel (Rusted)	-0.20 to -0.50
Cast Iron	-0.50
Lead	-0.50
Mild Steel in concrete	-0.20
Copper, Brass, Bronze	-0.20
Mill Scale on steel	-0.20
Carbon, Graphite, Coke	+0.30

3. Conditions That Require Corrosion Control Measures

3.1 The following conditions indicate risk of anchor corrosion and therefore require corrosion control measures beyond hot-dip galvanizing (see Section 5).

3.1.1 Corrosion is visible below grade on the anchors in question or other adjacent structures, or underground corrosion has previously been identified as a problem in the area.

3.1.2 A soil sample measured in a saturated state, or a "Wenner four-pin" soil resistivity test at the tower site indicate soil resistivity to be equal to or less than 10,000 ohm/cm.

3.1.3 Tower grounding incorporates more than one copper-clad ground rod at each anchor and more than three at the tower base, or tower is electrically connected to other buried structures, i.e., fencing, buildings, buried tanks, underground power cables, etc.

3.1.4 Tower anchors are subject to "stray current" generated from sources such as adjacent buried pipelines or other cathodically protected structures, welding or plating facilities, electrified railways, HVAC systems or other sources of artificially induced DC ground current.

3.1.5 Tower is located near electrical substation or other highly grounded facility.

3.1.6 Guy anchors are located in water, saturated soil or soil rich in salts.

3.1.7 Tower is located where fertilization of plant life is common.

3.1.8 Soil at the tower site is determined to be corrosive (see Section 2.2).

3.2 Corrosion control measures may be necessary under conditions not listed herein. Consult a corrosion specialist for guidance.

4. New Guyed Tower Procedures

4.1 The geotechnical report should include information regarding the corrosivity of the soil, stating as a minimum the soil resistivity in ohm/cm.

4.2 The tower site conditions shall be noted with regard to applicability of items listed in Section 3 herein.

4.3 Any tower purchase checklist should include "guy anchor corrosion control."

4.4 The grounding system should be specified to minimize corrosion on the anchors due to dissimilar metals. Ground rods should be galvanized steel and grounding wire should be tinned copper wire.

4.5 At each anchor point, care should be taken to ensure uniform backfill conditions along the anchor.

5. Corrosion Control Measures

5.1 All anchorage steel below grade shall be hot-dip galvanized.

5.2 Tower anchors determined to be at risk from corrosion shall be protected by a galvanic anode cathodic protection system designed for tower anchors (AnchorGuard® or equivalent), with magnesium sacrificial anodes and monitoring system. The monitoring system should be capable of providing anchor to reference cell corrosion potential readings and system current output readings. Zinc anodes may be substituted when soil resistivity is low. Galvanic anode cathodic protection uses the known variables of the corrosion cell to direct corrosion away from where it is not wanted. Other corrosion control measures listed herein are secondary options.

5.2.1 AnchorGuard® model selection is based primarily on the amount of metal underground to protect, approximated by tower face width. Model selection is as follows: Less than 19" face tower = AG1, 19" to 60" face tower = AG2, Over 60" face tower = AG3. Based on site conditions, an upgrade may be necessary.

5.2.2 Installation and testing of galvanic anode cathodic protection system shall be in accordance with manufacturer's instructions.

5.3 Impressed current cathodic protection employs a DC rectifier to supply current to anodes. This method is effective but generally involves higher design and maintenance costs than with galvanic anode cathodic protection.

5.4 Anchor coatings can assist in limiting corrosion but cannot be considered adequate corrosion control in themselves. Virtually all coatings have or develop flaws. A small anomaly in the coating can cause accelerated corrosion in one area and have a detrimental effect on the anchor. Coatings can be beneficial, however, when used in combination with cathodic protection.

5.4.1 Anchor coatings should be suitable for hot-dip galvanized steel. Surface preparation and application are critical to coating performance and should be done in accordance with coating manufacturer's instructions.

5.5 Concrete encasement of the entire anchor shaft may be employed to control anchor corrosion. Total concrete encasement passivates the anchor and impedes an anode/cathode relationship on the anchor shaft itself. One disadvantage of this approach is if the concrete becomes seriously cracked or broken, water or soil could fill the cracks and lead to accelerated corrosion at the exposed area.

5.5.1 Concrete encasement should extend at least 6 inches above grade. Care should be taken to ensure that the entire anchor shaft is solidly encased in a large concrete block, such as with the caisson type design. The concrete mix should be sulfate resistant (Type V) when soluble sulfates exist in the soil or groundwater.

5.6 Electrical isolation using guy wire strand insulators eliminates the electrical path between the tower and the anchor support. If properly installed, this method protects the anchor from corrosion associated with copper grounding systems and from stray current corrosion. Electrical isolation does not, however, prevent an anode/cathode relationship on the anchor shaft itself.

6. Guy Anchor Maintenance Procedures

6.1 Tower inspection procedures should specify the following:

6.1.1 Periodic inspection of anchor rod condition below earth. (Note for inspectors: Corrosion is usually more severe near the concrete anchorage.) Inspection of a corroded anchor to include exposing, cleaning and measuring of anchor. Maintain structural capacity of the anchor during inspection. Attachment to a temporary anchorage may be advisable.

6.1.2 Tower inspection reports to state anchor corrosion control measures in place.

6.1.3 (As applicable) Cathodic protection system (i.e., AnchorGuard®) to be monitored once per year. Measurements in volts to show potential relative to copper-copper sulfate reference electrode.

7. References

1. Structural Standards For Steel Antenna Towers and Antenna Supporting Structures. TIA/EIA-222-F, Telecommunications Industry Association, Arlington, VA., 1996.

2. Antenna, Towers, and Antenna-Supporting Structures. CAN/CSA-S37-M86, Canadian Standards Association, Rexdale, Ontario, Canada, 1986, pp. 71-73.

3. Understanding and Preventing Guyed Tower Failures Due to Anchor Shaft Corrosion. Snyder, C. M., Sioux Falls Tower Specialists, Inc. / AnchorGuard L.L.C., Sioux Falls, SD, 1996.

4. The Guyed Tower Anchor Shaft Corrosion Problem. Thorin, T. L., Sioux Falls Tower Specialists, Inc., Sioux Falls, SD 1996.

5. Evaluating Soil Corrosivity Then and Now. Fitzgerald III, J. H., Corrosion 93, The NACE Annual Conference and Corrosion Show, 1993, Paper No. 4.

6. Causes of Underground Corrosion. Husock, B. Paper HC-36, Distributed by Harco Technologies Corporation, Medina, OH.

7. Corrosion and Corrosion Control. Burke, N. D. and Kroon, D. H., Paper CP-1, Distributed by Corrpro Companies, Inc., Medina, OH.