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The Telecommunications Industry Foundation (TIF) and NATE are pleased to announce publication of the following TIF White Paper.

Direct Buried Steel Corrosion Considerations with Emphasis on Guy Anchors

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INTRODUCTION

This TIF White Paper (**"White Paper"**) is intended to provide an overview of the standards and codes that apply and how a structure owner may elect different methods to manage the design of sites, as well as the maintenance and condition assessment of its sites, which is a part of the corrosion management program that the structure owner has elected. It is recognized that our industry has two distinct environments; existing structures and new structures. The standard that the existing structures were designed under will govern unless there has been a changed condition[1] that requires the structure to be brought to a current revision of the standard. Modifications to structures to comply with current standard revisions often are a result of a structural analysis calculated overstress and not based on buried steel design. However, a structure owner's program for corrosion of direct buried steel must address the risk for these legacy structures. For new structures, proper planning, and application of the information in Annexes G and H of the ANSI/TIA-222 Standard will allow for the effective corrosion prevention through design in accordance with the structure owner's corrosion management program.

The ANSI/TIA-222 Standard has addressed, through Annexes G and H, guidance for direct buried steel. These Annexes are based upon information from many subject matter experts and information from the Association for Materials Protection and Performance (**AMPP**). A primary focus of this is upon the anchor shafts used to support the guyed masts used in the telecommunications industry, however, the standard can be applied to all direct buried steel. It is important to note that the International Building Code (**IBC**) has adopted the ANSI/TIA-222 Standard for use when designing, maintaining, or modifying a telecommunications structure.

CHAPTER I
CATHODIC CELLS AND CORROSION PREVENTION METHODS

The issue is direct buried steel, even if galvanized, can be subject to corrosion if an aggressive cathodic cell is created (*See* Figure 1-1). Essentially, this is the un-refining of the steel due to the directly buried steel acting as an anode to a cathodic environment; this is a flow of electrons from one location to another (*See* Figure 1-2). There are equations that allow the determination of material loss based upon the current flow measured in the cathodic cell and the associated materials. It must be noted that the corrosion will occur over the direct buried steel but most often will be most significant at the location of the anchor block. This is typically due to this area being the lowest resistivity location of the directed buried steel, allowing for more current flow and hence more material "un-refining" (*See* Figure 1-3). In the ANSI/TIA-222 Standard it is outlined that anything with a soil resistivity of less than 50 ohm-m should be addressed through additional corrosion prevention methods.

[1] See TIF White Paper "An Examination of Changed Conditions; as Defined by ANSI/TIA-222-H"

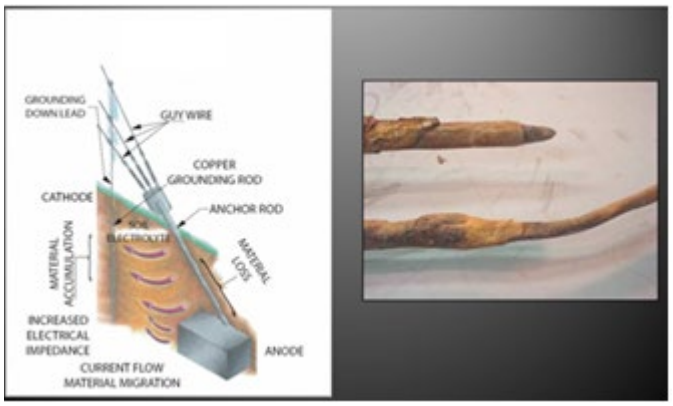
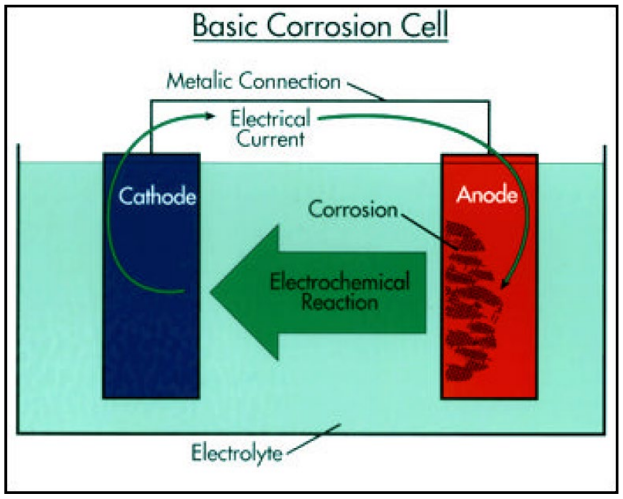


Figure 1-1: The Cathodic Cell

The following is a direct excerpt from the ANSI/TIA-222-I Standard[2] and provides normative[3] detail concerning additional corrosion methods for steel in contact with soil:

ANNEX H: ADDITIONAL CORROSION CONTROL (Normative)

"This Annex provides additional corrosion control methods for steel guy anchorages and ground embedded poles in direct contact with soil. Additional corrosion control methods are required for steel in direct contact with soil when the measured soil electrical resistivity is less than 50 ohm-m and/or the measured soil pH values are below 3 or greater than 9 for Risk Categories II, III and IV structures. Additional corrosion control methods are also recommended for AM antenna sites and sites known to be in close proximity to underground buried pipelines, underground buried cables that utilize a concentric neutral or located within 1,000 ft. [300 m] of an electrical substation. Sites with soils with a high salt or organic content, oxygen differential or transfer, significant moisture content fluctuation, or with high redox potential (microbiological corrosion potential) may be susceptible to accelerated corrosion and it is recommended that a corrosion control expert establish the control measures for the site.



[2] The Telecommunications Industry Association (**TIA**) has granted TIF permission to include this direct quotation from ANSI/TIA-222-I Annex H in this White Paper.

[3] Informative v. Normative. Informative Annexes are for information purposes only, while Normative Annexes are to be considered authoritative and fully a part of the compliance standard.

Figure 1-2: Demonstration of the Current Flow in a Basic Corrosion Cell

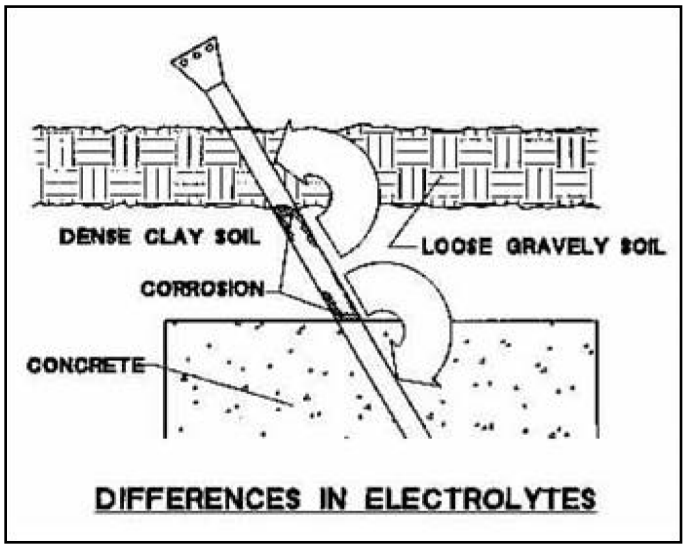


Figure 1-3: Differences in Electrolytes

Additional Corrosion Control Methods

1. Cathodic protection utilizing sacrificial anodes: the size, type and placement of anodes are to be determined by a competent corrosion control specialist or firm.
2. Cathodic protection utilizing an impressed current: a competent corrosion specialist or corrosion control firm shall determine the impressed current system to be utilized. (Outside 222 rev I: Additional information available https://www.icorr.org/how-does-cathodic-protection-work/)
3. Concrete encasement or backfill: sulfate resisting concrete mix designs should be used for all concrete below grade depending upon the concentration of soluble sulfates that exist in the soil or groundwater. When a concrete deadman is used with an anchor, the reinforcing in the concrete encasement shall be properly developed into the concrete deadman to prevent excess cracking and the concrete encasement shall extend a minimum of 6 in. [150 mm] above grade.
4. Taping or coating steel in direct contact with soil with special corrosion control products that are designed to remain crack free and chemically stable over the anticipated life of the structure. Special precautions are required for this method during installation and backfill operations to avoid damage to the coating. Accelerated corrosion may occur at the damaged location."

With the above in mind, a structure owner should first work with the engineering firms and tower manufacturers on corrosion prevention through the design process of new sites. Information that should be included in a geotechnical study is the soil PH and the resistivity for any location where there will be direct buried steel. In addition, the site location should be evaluated for items containing high salt or organic content. An example would be having an anchor installed where there is run off from an adjacent cattle feed lot. Finally, it is important to assess if the site will be impacted by an induced current from an anode bed which can be found as a part of protecting a pipeline. The capture of this data as a part of the Geotechnical studies is part of the recommendations in the informative Annex G of the ANSI/TIA-222 Standard. The reason it is informative is that the engineer's judgement must come into play to ensure that they are assessing the owners' needs for the site-specific location.

CHAPTER II

ADDRESSING ANCHOR CORROSION AT INSTALLATION

Once the proper data has been captured, it is then possible to design the new site to address any concerns with corrosion of direct buried steel. This prevention through design is the most cost-effective manner to address corrosion of direct buried steel as it allows for the lowest possible cost to address because it is a part of the initial construction of the site. Typical means to address anchor corrosion at the time of installation include the following:

1. *Cathodic protection using sacrificial anodes.* The following must be considered:
    a. Proper installation per the manufacturer is critical.
    b. Baseline current measurements are required for future readings.
    c. Structure owners must have a program for testing cathodic protection systems and replacing the anodes when depleted (**NOTE: the current measurements are snap shots in time, so the natural environment must be considered as a part of the program. As an example, if the measurements are taken in the middle of a drought period, this will yield readings that show lower current than when the soil is not experiencing drought.**).
2. *Cathodic protection using impressed current* – It does require maintenance, however, the current can be measured remotely in properly designed systems. It is also more expensive than the use of sacrificial anodes. It should be noted that properly designed this method can be remotely monitored.
3. *Concrete encasement* –This is one of the most effective methods to address corrosion of buried steel when using the correct concrete (*See* Figure 2-1). Initial costs are higher than the other options and an inspection is required per IBC and to ensure quality installation. However, once installed the maintenance costs are reduced as only exposed concrete assessments are necessary. NOTE: Different encasement types have different reliability modes and maintenance requirements.

Figure 2-1: Example of Concrete Encasement – Caution with this type to avoid any cracking of the concrete due to the movement of the anchor shaft.

4. *Taping or coating of the direct buried steel* – Taping or coating is an effective manner to protect buried steel. However, the installation quality is critical. Lack of uniform application or damage to the tape or coating could lead to a localized focal point for accelerated corrosion. This method can be combined with use of anodes to provide additional protection. Note: Testing of a coating may be required based on the owners program (such as a holiday inspection)
5. *Drilled pier anchor* – An alternative solution to installation of direct buried steel (dead man anchor) is the installation of a drilled pier anchor (*See* Figure 2-2). Drilled pier anchors can be utilized on a new structure, or as an alternative design to an existing anchor where corrosion exists.

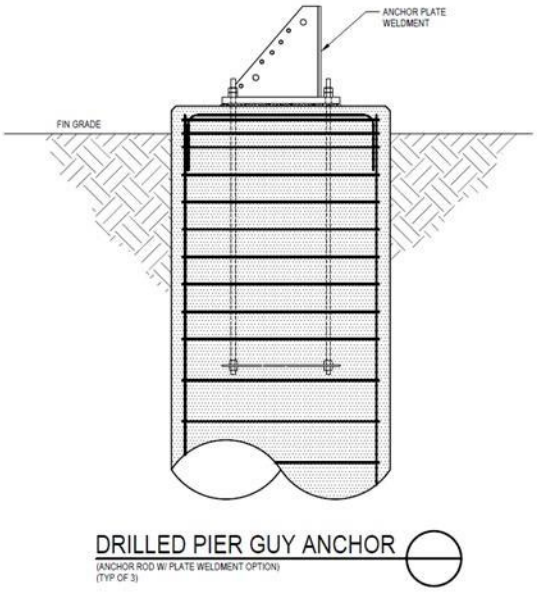


Figure 2-2: Drilled Pier Guy Anchor

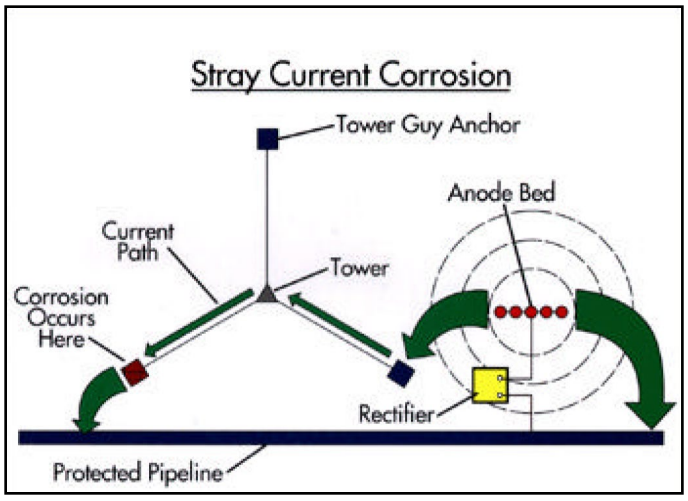


Figure 2-3: Example of a induced current anode bed typically found utilized to protect pipelines from corrosion.

https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

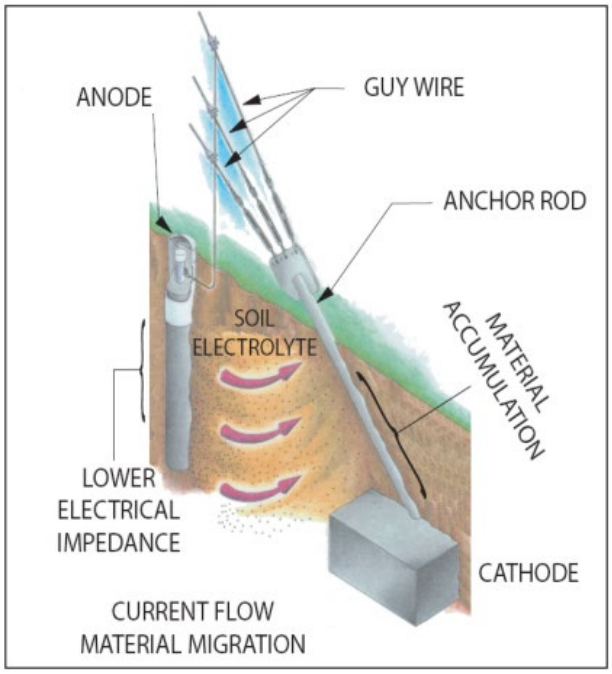


Figure 2-4: Current Flow Material Migration

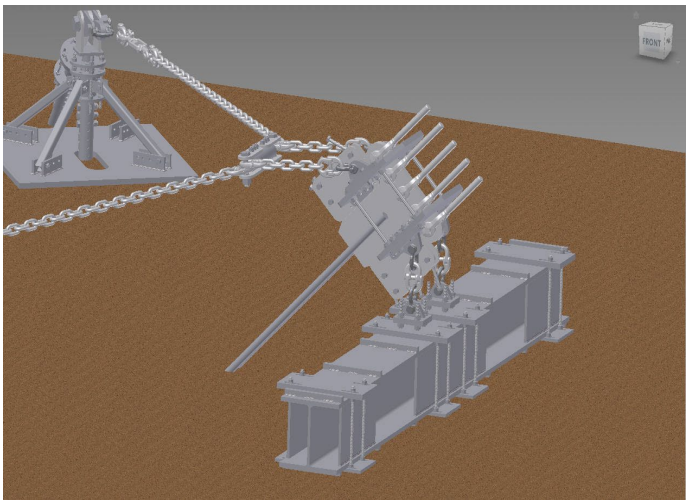


Figure 2-5: Enter Text

CHAPTER III
MANAGING EXISTING SITES

Existing sites are to be managed through the structure owner's program. The assessment of risk for existing sites will be addressed in the annex on assessment of risk for owners existing sites. Below are some examples of typical structure owner mitigation programs:

1. No risk of corrosion – to determine the risk of anchor corrosion, ANSI/TIA-222 Annex H should be referenced.

2. Anodes – There are two basic types of passive and active.
3. Encasement in concrete.
4. Coating the direct buried steel.
5. How the owner may move to a risk category 1 and even look to create a CAZ (Controlled Access Zone) for the site.
6. Use of non-destructive and non-evasive means that have been adequately tested and verified to provide additional information regarding buried steel loss.
7. Use of a transducer to evaluate corrosion in an existing anchor shaft - the concern on smaller more typical anchor designs needs to be considered. Anything under 1", the transducer will not yield an effective reading. Getting a clean back wall in the readings is questionable.
8. ACR (Anchor Corrosion Report) how to use the USGS/Pipeline/AM database and other information to assess risk based on these resources.
9. Stray current from the MNO equipment. Note from experience this has been a neutral event, but it should be considered as a part of a corrosion mitigation program.

Risk assessment of legacy sites that may or may not have had consideration applied to address corrosion of direct buried steel. Legacy sites are any site that are built in such a manner that Annex H of the ANSI/TIA 222-G was not applied during the design phase. This Annex outlines the requirements to deal with corrosion of steel in soil or other environmental conditions that can create an elevated risk of corrosion. There should be a risk assessment of any site with direct buried steel that is not being managed. This assessment should address the concerns outlined in the ANSI/TIA-222-H. For any on-site work, a safe working environment is required. The minimum requirements of the ANSI/ASSP A10.48 should be applied.

The structure owner may decide that an anchor remediation process or a dig to block, or **"DTB"**, is necessary for an existing site[4]. This decision is based on the structure owner's corrosion risk assessment or corrosion management program, which considers factors such as soil pH, structure age, soil resistivity, evidence of corrosion, and proximity to external potential currents. A qualified contractor will have to address several items prior to excavation or remediation. Validation of the structure risk category, along with the importance of the site, must be taken into consideration prior to developing a construction plan as required by the ANSI/ASSP A10.48-2023 Standard. The contractor's qualified person must evaluate this written plan and if determined to be Class IV they must engage a Qualified Engineer (**QE**) for review of the plan. Due to the critical nature of the anchors for guyed towers, it is very likely that the construction plan will meet the requirements of the ANSI/ASSP A10.48-2023 standard to be a Class IV Construction Plan. As stated in the ANSI/ASSP A10.48-2023, when performing a SOW of removing soil from a foundation, this has the potential to affect the stability of the structure. A Class IV construction plan must be completed. This includes the anchor remediation SOW and an engineering design, based on the structure and soils.

The qualified person will ensure that the site-specific considerations are addressed and have this as a part of their construction plan. Part of this plan will be an evaluation of the structures' risk category and importance. The construction plan should include an assessment of the twist and plumb of the structure to ensure that there are no issues prior to starting work, as well as the sequence of events. This will also require the duration and possibly monitoring of the structure and the anchors. The contractor should identify any issues with the weather and how it will be communicated as a part of the plan as work on anchors must be done with wind speeds less than 25mph. Very often, these types of plans will define the CAZ and who is authorized for entry for the work at hand based upon their training and experience. Some of the plans may have an initial approach and an escalation approach in the event that there is failure eminent in the structure identified. The qualified person must ensure that the construction plan identifies the equipment and

[4] A DTB or 'Dig to Block' is a full anchor shaft excavation and inspection.

procedures required in accordance with the ANSI/ASSP A10.48-2023. This will provide for the safety of personnel and the stability of the structure and equipment.

Once the qualified person has completed the Class IV construction plan, this must be submitted by the contractor to the identified Qualified Engineer (QE) for review to determine the structure's stability based on duration and wind loading per the ANSI/TIA 322 Standard. If the site's risk category and importance are high and a DTB scope has been determined to be performed, a proposed temporary anchorage solution should be utilized (*See* Figure 3-1).

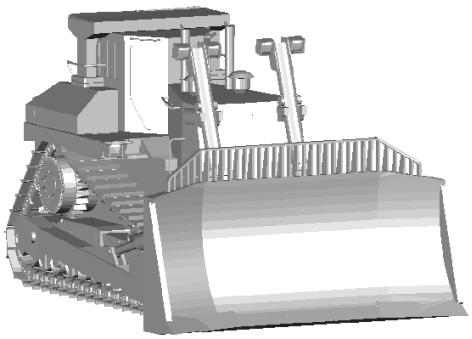


Figure 3-1: Example of a temporary anchorage solution.
NOTE: This must be verified by a QE.

A QE will evaluate the forces and communication should occur between the QE and the qualified person to address the towers reactions and the means and methods the contractor anticipates utilizing. It is important to note that these conversations do not take control of the project away from the contractor. The contractor controls the means and methods that the QE reviews to ensure structural stability will be maintained with the contractor managing their construction plan. If conditions or methods change, a QE review must be conducted.

Several items must be considered prior to performing excavation on a site. Each structure owner's program may have additional requirements that must be considered. Utility 811 locates must be completed to identify any underground utilities in close proximity to the excavation location. Depending on the jurisdiction having authority a permit may be required to excavate. Landscaping weed barrier should be removed if applicable, and the grounding system around the area of excavation should be located or removed. When excavation begins, caution must be taken to not come into contact with the anchor shaft. A best practice of remaining a minimum of 6" away can be utilized, which should consider soil conditions. An excavation plan may be required that may consist of benching, sloping or shoring. Excavation must be performed all the way down to the concrete block, as this is where most of the corrosion typically exists.

Anchor remediation is a solution that removes the direct buried steel out of the equation. Examples of these anchor remediation solutions include but are not limited to: (i) the Inverted-U, (ii) Guy Lock, and (iii) drilled caissons with above grade steel structure. Once the anchor shaft is exposed, cleaning any remaining soil must take place with careful consideration. Documentation of the anchor shaft condition can be captured as per the structure owner's requirements along with any repairs or corrosion mitigation materials installed. During the restoration process of the scope, proper backfill materials and compaction is necessary

along with grading to prevent water accumulation. Installation of weed barrier, rock, fencing, or bollards also must be installed meeting the structure owner's requirements.

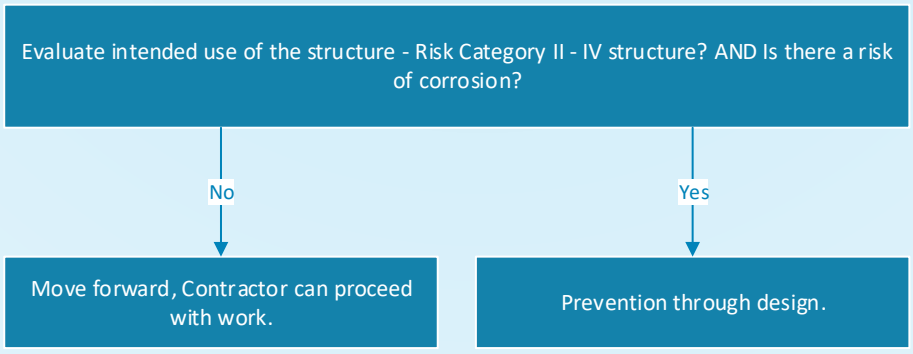
CONCLUSION

This paper was intended to raise awareness of the standards and options that are available to the industry to prevent issues through design on new or modification to existing sites. The paper also intended to outline some considerations for the owners of existing infrastructure to consider for their maintenance and condition programs for sites with direct buried steel. Communication between stakeholders is essential to all facilities of work in the telecommunications industry. Finally, the authors are excited to receive feedback (through tifonline.org) of additional planning, remediation or practices that yield a reliable, safe and efficient infrastructure.

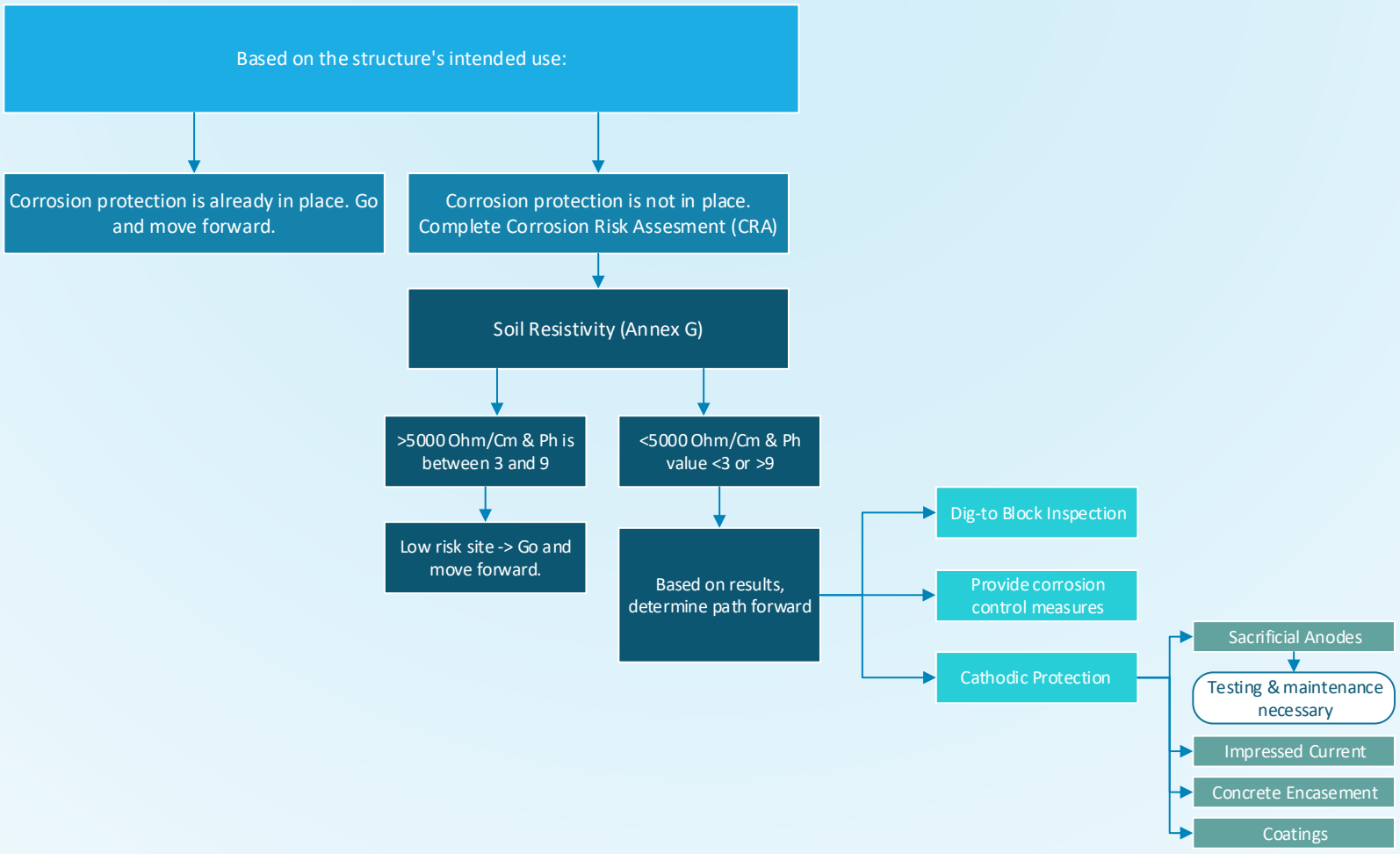
APPENDIX A – ILLUSTRATIVE EXAMPLES

Illistrative Example of Owner's Corrosion Management Plan for New Sites with Proposed Direct Buried Steel

Prevention through design – This flow chart is intended to outline the effective use of the ANSI/TIA 222 standard as required in the IBC for prevention through design of direct buried steel. All new sites with direct buried steel should follow the requirements outlined in annex's G and H of the standard.



Illistrative Example of Owner's Risk Managment Program for Existing Sites



Illustrative Example of Contractor's Management Plan of an Existing Site

Respect the property through proper planning preparation and communication instead of just digging up a guy anchor. Take the time to understand the owners use, maintenance & program and needs through communication.
DONT ask for data that is not needed.
DO understand the SOW of the site.

The contractor's qualified person shall ensure the construction plan complies with the ANSI/ASSP A10.48/OSHA/AHJ Requirements for a safe working enviornment.

If SOW requires, perform a Structural Assessment (Other items may be required to ensure a safe environment.)

Direct buried steel?

Yes

Climbing / Rigging or other impacts to the structure?

Yes

Qualified person has to review the owner's buried steel management/anchor corrosion program to investigate wether a potential hazard impacts the SOW.
If none provided, work with owner on how they want to proceed.

Anchor Corrosion Report (ACR)

Design by a corrosion engineer

Previous dig to the block report

Anodes managment plan

No direct buried steel

Temporary anchorage design

Depending on SOW and impact to the structure, a qualified person can always engage with a qualified engineer per the ANSI/ A10.48 and ANSI/TIA-322

If encasement of anchors, contractor can proceed with work.

No

Contractor can proceed with work.

No

Contractor can proceed with work.

NOTE: Owner determines mitigation path

Mitigate need to dig to block.

Offer Recommendations and ensure the EOR is engaged?

What is current use of the tower?

Dig to the block needed?

Will use increase the reaction at the anchors?

Anode Plan in compliance with the ANSI/TIA 222 Annex H.

Replacing Anchors

Encasement of Anchors (eliminates direct buried steel)

Inverted U

Guy Lock

Horizontal Beam

Based on findings it was determined that dig to block is needed.

Dig to block to be done following the owner's intended use and the ANSI/ASSP A10.48 and the ANSI/TIA-322.

Level of planning and coordination varies depending on:

Network Redundancy

Sloping and Benching

Soils Drainage

Time of Year / Weather

Safe Work Environment

Must have a ANSI/ASSP A10.48 construction plan.

OSHA applies for employees involved.

Based on findings.

Replacement

What are the current and planned reactions?

Temporary Anchorage Needed?

How to Avoid?

Remediation

Significant Structural Material Lost?

Yes

Address Structural Needs

Encasement, anodes, coatings

No

Install Anodes

NOTE: The owner's program working with the EOR utilizing the ANSI/TIA-322 and ANSI/TIA-222 to determine what significant is.

Note: Additional information avilable in ANSI/TIA-222 Annex H.

AUTHORSHIP CONTRIBUTIONS

TIF would like to recognize the following individuals who volunteered their time and expertise to the development of this TIF White Paper[5]. Without their dedication and commitment to the furtherance of greater understanding within the telecommunications industry, this TIF White Paper would not have been possible. These individuals made substantial contributions to the conception, design, research, and ultimate drafting of this TIF White Paper and were critically important to its intellectual and technical content.

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