Cathodic Protection

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Introduction

The initial investment in land, material and installation for underground utility infrastructure is significant. To ensure the continued long-term operation of these assets, an engineered corrosion protection solution is required to protect the asset from the environment and even the product being moved.

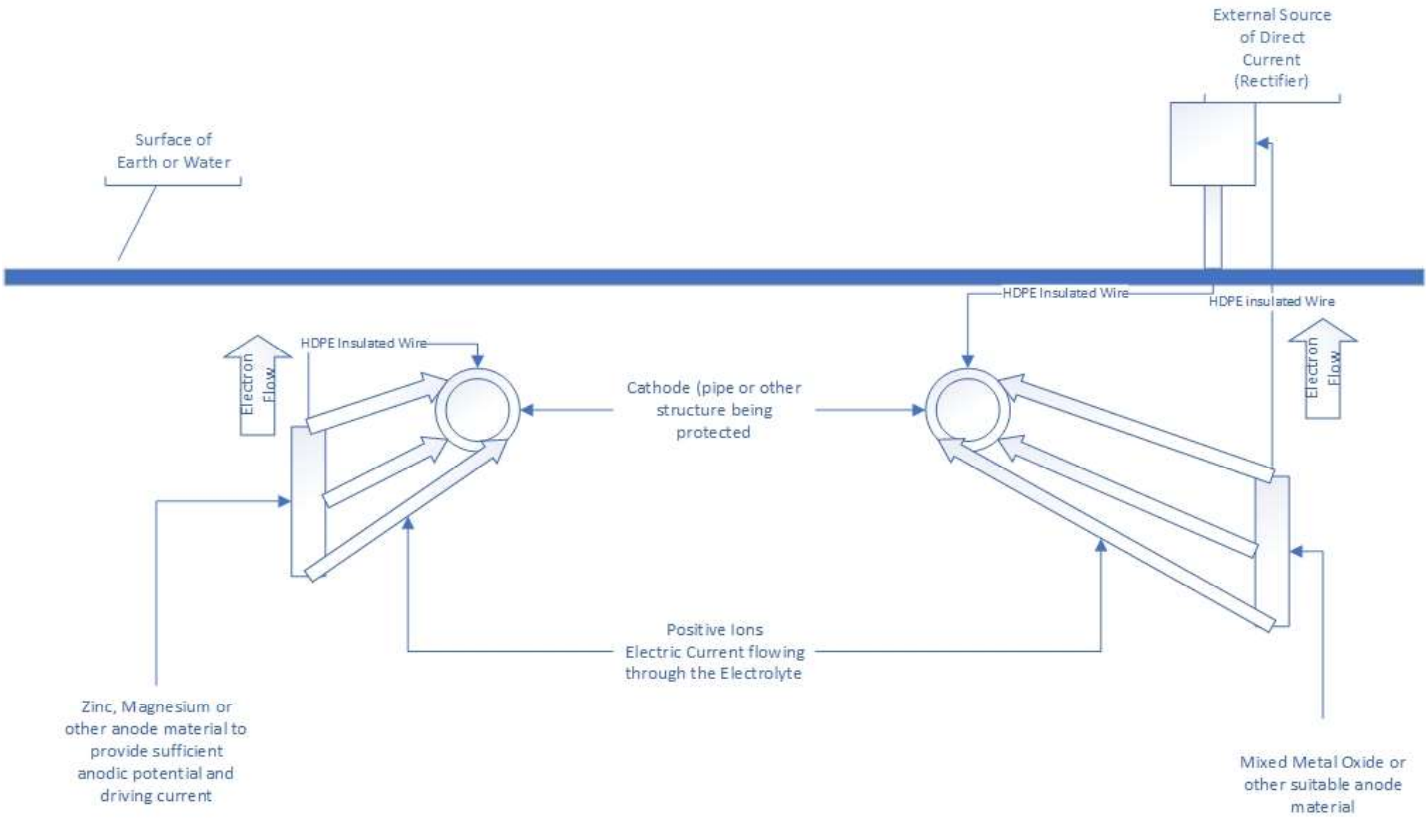
The design and installation of a system to protect underground utility infrastructure from corrosion to meet federal, state, local and operator codes and regulations is a complex endeavor requiring specialized knowledge as well as the input from multiple engineering disciplines. The utilization of an integrated design team as well as select specialists ensures a cost-effective, constructable corrosion solution capable of protecting an asset for the effective design life. This document addressess Cathodic Protection design with little or no considerations of the complexities associated with Alternating Current Interference Mitigation (ACIM) but it should be noted by the reader that ACIM can affect the cathodic protection system.

Corrosion: Demystified

Corrosion of a metal pipeline is the result of an electrochemical process, which is to say a chemical reaction accompanied by a flow of electrical current. Unfortunately, most refined metals used in engineering are found in nature with a naturally low free energy state. The same selective process utilized to extract material from the ore in which they are found also renders those materials more susceptible to corrosion as they naturally have a tendency to return to the preferred and more conservative lower energy state. The release of electrons through an electrolyte from the metal (oxidation or anodic reaction) results in not only a return to a lower state for the metal but also by necessity the formation of other chemical byproducts (reduction or a cathodic reaction); both reactions are necessary for corrosion to occur. Disruption of either or both reactions allows us mitigate damage to the protected metal.

Cathodic Protection

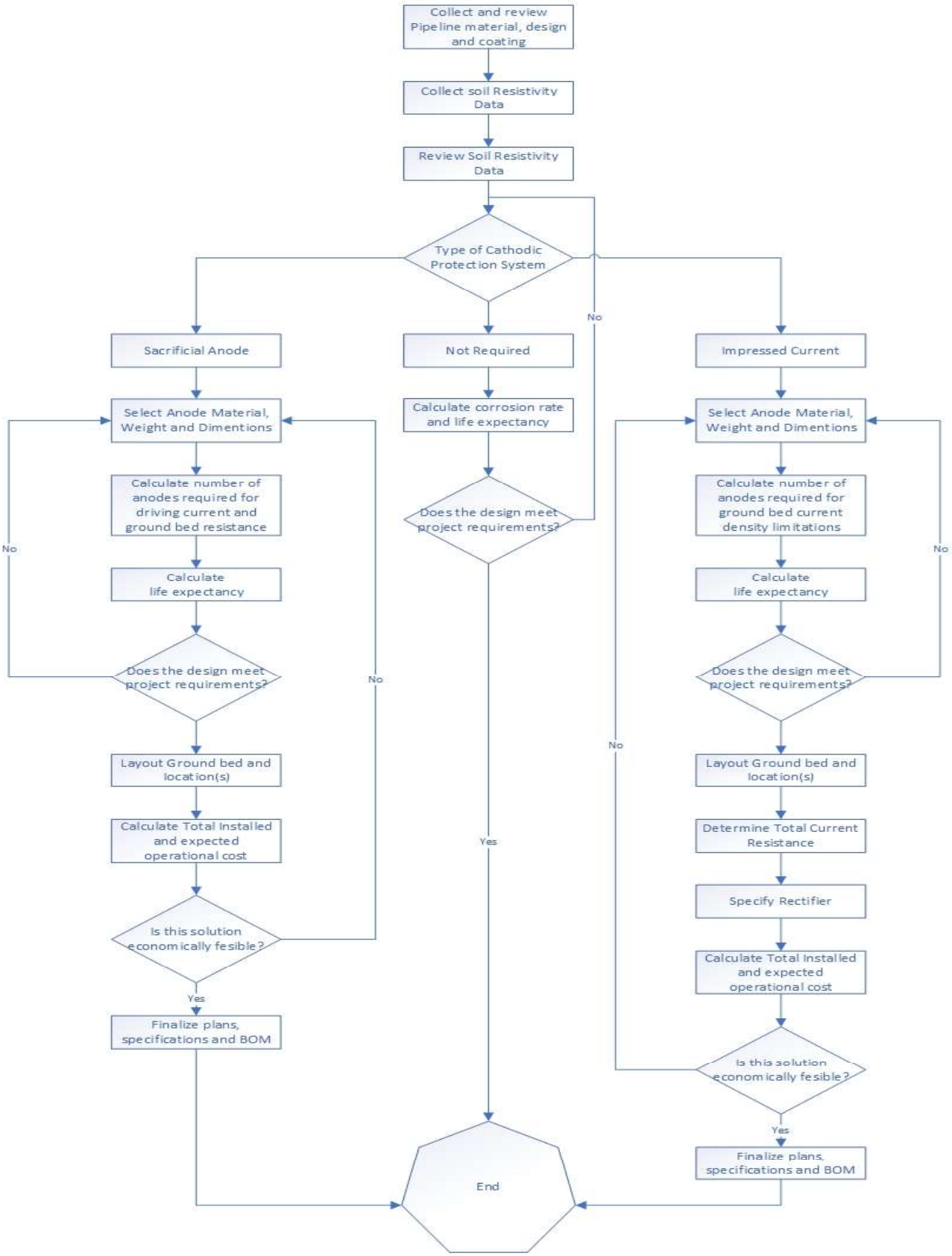
Two metals when interacting through an electrically conductive media, can form a galvanic cell, depending on their electromotive potentials. Whereas corrosion occurs on the anodic side of a reduction-oxidation reaction, protection can be provided as illustrated in Figure 1. Through the utilization of material selection, bonding, and/or impressed electrical current we are able to shift the effective electromotive potential in a protected structure such that the structure is Cathodic with respect to the "protective" Anode where corrosion will occur thus the term Cathodic protection.



Mil-HDBK-1004/10 Figure 1

Design Process

While the chemical process is fairly straight forward the difficulty in simulation and design stems from the approximation of the protective coating effectiveness and degradation, approximation of the corrosion cell, evaluation of the electrolytic media (soil), protective system selection, life cycle cost calculations and finally the material section with installation details. The inherent complexity involved in each step of the overall process shown in figure 2 represents a technical challenge in approximating partial or highly dynamic data sets, such as soil resistivities across the length of a pipeline. Discipline specific engineers not only specialized in pipeline design but also in integrating cathodic protection are essential in developing a constructable pipeline system with temporary and permenant cathodic protection that can be installed simultaneously, protected and ready to move product once commissioning is complete.


Collect and review Pipeline material, design and coating
Collect soil Resistivity Data
Review Soil Resistivity Data
Type of Cathodic Protection System
Sacrificial Anode
Not Required
Impressed Current
Select Anode Material, Weight and Dimentions
Calculate corrosion rate and life expectancy
Select Anode Material, Weight and Dimentions
Calculate number of anodes required for driving current and ground bed resistance
Does the design meet project requirements?
Calculate number of anodes required for ground bed current density limitations
Calculate life expectancy
Calculate life expectancy
Does the design meet project requirements?
Does the design meet project requirements?
Layout Ground bed and location(s)
Layout Ground bed and location(s)
Calculate Total Installed and expected operational cost
Determine Total Current Resistance
Specify Rectifier
Is this solution economically fesible?
Calculate Total Installed and expected operational cost
Is this solution economically fesible?
Finalize plans, specifications and BOM
Finalize plans, specifications and BOM
End
No
No
No
No
No
Yes
Yes
Yes

UPI Capabilities

UPI offers a full complement of solutions including: Conceptual selection, FEED, Project development, including Total Installed Costs for funding, and EPC/EPCM. The EPC/EPCM solutions include Project Management, Engineering and Design Services, Procurement Services, Sub Contractors Management, Survey, Laser Scanning, Construction Management, Inspection, Mobile Inspection Platform, Systems Integration, Automation, and Controls.

UPI has a rich heritage of pipeline and facilities project experience for pipeline planning design and construction management. UPI has engineered over 35,000 miles of pipeline and installed over 5 million Hp of pumps and compressors.

UPI's recent CO_2 pipeline projects include over 800 miles of pipeline and facilities including:

- 500-mile CO_2 pipeline upgrades to increase flow from 1.3 to 1.9 billion standard cubic feet per day (BSCFD). The scope included 70 miles of pipeline, five (5) greenfield pump stations, four (4) brownfield pump stations, and 4 miles of gathering lines.
- 220-mile CO_2 pipeline with three (3) pump stations.
- 260 miles of HVL pipeline.

Closing

UPI looks forward to talking with you about how we can help you with your project.