CATHODIC PROTECTION SYSTEM FOR UNDERGROUND STORAGE TANK

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ABSTRACT

There is provided a method for implementing a cathodic protection system for an underground storage tank. A DC voltage source provides a test current between the installed anode and storage tank resulting in the flow of electrical current. If the output is above a defined value, an automatic control DC power supply has sufficient voltage capacity to deliver the required current. If the anode test currents fall below the required minimum current, additional anode(s) are installed as set forth in a pre-engineered table. The method allows for the installation of a cathodic protection system by technicians and other non-experts.
CATHODIC PROTECTION SYSTEM FOR UNDERGROUND STORAGE TANK

BACKGROUND

[0001] The present exemplary embodiments relate to a cathodic protection system and method. It finds particular application in conjunction with underground storage tanks, and will be described with particular reference thereto. However, it is to be appreciated that the present exemplary embodiment is also amenable to other like applications.

[0002] Metallic surfaces, such as are common in the field of pipelines and related structures, such as buried tanks and distribution systems, are adversely affected by numerous corrosive electrolytic fluids that contact these surfaces. For example, in the natural gas and petroleum industries, corrosion occurs extensively on the outer surface of both buried and above-ground pipelines.

[0003] In order to reduce, or preferably eliminate, this undesirable metallic surface corrosion, anti-corrosion protective coatings have been extensively used in the underground storage tank industry. These ubiquitous anti-corrosion protective coatings frequently take the form of a helically-applied tape-like protective outer wrapping. The tape-like protective component may be applied directly over an unprepared tank's outer surface, or may, in fact, be overlaid onto a primer-coated, pretreated tank outer surface. Other forms of protective coatings also exist, including coal tar epoxy, asphalt, and fusion bonded epoxy coatings. Despite the use of such coating compositions and materials, external corrosion of underground tanks is still a concern when there is a breach of the coating or when such coatings have been poorly applied or not applied at all.

[0004] Thus, to protect against external corrosion, underground storage tanks (and other buried metallic structures) are typically cathodically protected, either in addition to or in lieu of being coated as described above. The cathodic protection (hereafter alternatively referred to as "CP") system is designed to protect the tank and associated buried pipe where coating defects occur. Cathodic protection, as it is used here, refers to the phenomenon and practice of applying a small potential to a metallic tank that is buried in the ground. This imparted cathodic potential of the buried tank will tend to limit or protect against corrosion attacking the metal surface.

[0005] Cathodic protection provides corrosion protection to any bare metal areas exposed to soil due to coating defects by causing direct current to flow from the soil into the structure, thereby polarizing the structure as a cathode. Protection is ensured by modifying the environment around the steel as well as reducing the dissolution rate of the steel by reducing the anodic overpotential. The required direct current output of the cathodic protection system varies both with the existence and quality of any coating and the soil moisture and chemical contents. For example, a good quality coating substantially reduces the bare metal area of the structure exposed to soil thus reducing the amount of metal that has to be protected by cathodic current flow.

[0006] Two cathodic protection systems are generally in use for corrosion protection of metal structures. The first, termed an impressed current cathodic protection system, consists of a DC power supply, insulated wires connecting the plus terminal of the DC power supply to a buried anode (for instance graphite cylinders), insulated wire connecting the negative terminal of the DC power supply to the protected structure, and test stations installed at the structure. The test stations typically consist of a pipe or a valve box with one or more insulated wires attached to the structure, typically by brazing, and a terminal board for termination of the wires. The test stations are used for monitoring the corrosion protection levels by measuring potentials between the structure and a reference electrode in an electrical contact with ground above the structure. The reference electrode usually consists of a copper rod fixed in a plastic body filled with saturated copper-sulfate solution, and having a porous plug to facilitate electrical contact with the ground.

[0007] The second, termed a sacrificial (galvanic) cathodic protection system, consists of magnesium or zinc anodes buried next to the structure and often directly connected by an insulated wire to the structure. The protective current is generated by the potential difference between the structure and the anode. The structure with sacrificial anodes also has test stations for the cathodic protection testing and evaluation of its corrosion protection effectiveness.


[0009] Even when cathodic protection is used, corrosion and defects usually still occur. Coating defects generally take the form of either exposed bare steel or a disbondment where the coating remains intact but a gap is formed between it and the bare steel. CP systems effectively deliver current to defects directly exposed to soil or water and therefore mitigate corrosion.

[0010] The above described cathodic protection methods are often complex and cumbersome to install, typically requiring specialized equipment and personnel to be present during the installation of a tank and for detailed filed surveys or soil testing to be performed, thereby adding to the cost of such a system. Thus, despite the above-described methods and materials for protecting a buried tank from corrosion, and for monitoring any corrosion that may occur, improvements in the industry are still desired. For example, there is a continued need for a simpler and less costly cathodic protection system and a method for installing such a system that can be performed by a general tank installer contractor especially where the buried tank(s) and piping are of smaller capacity. Such conditions exist on buried tanks and piping used to store and deliver fuel oil to home and small apartment building heating systems and for diesel and gasoline storage for emergency electrical generating systems.

BRIEF DESCRIPTION

[0011] In accordance with one aspect of the present exemplary embodiments, there is provided a cathodic protection system for an underground storage tank. The system includes a constant current DC power supply of sufficient capacity to provide corrosion mitigation up to a given size tank system in any common environment regardless of the coating condition. Connected to the positive terminal of the power supply are one or more anodes placed in the ground an appropriate distance from the storage tank. The negative terminal of the power supply is connected to the tank.

[0012] In accordance with a second aspect of the present exemplary embodiments, there is provided a method for
implementing a cathodic protection system for an underground storage tank. The method includes the steps of installing an anode at preset locations adjacent to the storage tank, using a DC voltage source to provide a test current between the installed anode and storage tank resulting in the flow of electrical current.

[0013] If the output is above a defined value, the as yet to be installed automatic control DC power supply has sufficient voltage capacity to deliver the required current. If the anode test currents fall below the required minimum current, additional anode(s) are installed as set forth in a pre-engineered table.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0014] **FIG. 1** is a diagram showing the steps needed for determining the appropriate number of anodes required for any particular HOUST system.

[0015] **FIGS. 2A and 2B** are graphs showing the number of anodes necessary based on the test current measured for a HOUST system.

[0016] **FIG. 3** is a diagram of the installed cathodic protection for a HOUST system.

**DETAILED DESCRIPTION**

[0017] The present exemplary embodiments relate to a system and method for providing impressed current cathodic protection to an underground storage tank or pipe. By way of example, the exemplary embodiments will be described with reference to an underground heating oil storage tank for home or residential use, which applicants envision as the primary market for the present invention. However, the invention is in no way limited to such tanks but in fact can be extended to any underground storage tank or pipe for holding or transporting a material. For convenience, applicants may make reference herein when describing the present embodiments to a HOUST system, which is an acronym for Home Oil Underground Storage Tank. The present described embodiments can be employed in conjunction with both new and existing HOUST systems. In addition, although the described embodiments make reference to underground tanks, above ground metallic structures in need of cathodic protection are also amenable to the present process.

[0018] Typical HOUST's are usually small and of only two general sizes (500 to 550 gallon and 1000 to 1100 gallon). Because of their relatively small size, the total current required for cathodic protection for such tanks is also small, generally being less than ½ ampere. Since they are all typically bare steel, a standardized design for all such systems may be supplied, thereby eliminating the need to do expensive field surveys or testing prior to installation of the present system.

[0019] Generally, the only variable that significantly impacts the cathodic protection system design is the soil resistivity. That is, the higher the soil resistivity, the more difficult it is to deliver current to the HOUST to be protected. Measuring the resistivity at each site can be expensive and, in some case, misleading if not measured by a person expert in making these measurements.

[0020] Additionally, it has become standard practice for larger UST (under-ground storage tank) systems such as those found at fuel dispensing locations (service stations) to conduct a detailed corrosion evaluation study as outlined in the ASTM standard practice for Testing UST prior to upgrading with Cathodic Protection (ASTM G158-98).

[0021] The present embodiments avoid the need for measuring soil resistivity or performing detailed corrosion evaluation studies since the system has sufficient voltage capacity combined with constant current control to deliver the necessary current for a very wide range of soil resistivities. The described system can be set up by any contractor with minimal training. It thus provides cathodic protection at a fraction of the cost of prior systems.

[0022] When installing the present system on an already existing HOUST, the first step is to confirm that the HOUST has been determined to be not currently leaking using one of many standard test procedures available for this purpose. Such testing procedures are well known in the industry. Next, a battery system or power supply is implemented that can provide a constant amount of cathodic protection current regardless of the soil resistivity (e.g. soils varying from a low of 100 ohm-cm to a high of 50,000 ohm-cm).

[0023] An anode configuration table that any contractor can follow together with a contractor testable method (as described in more detail below) is provided to ensure that the output of the system will provide the designed standard current without complicated testing.

[0024] A constant current output DC power supply is provided that is able to produce the required current for the system which are commercially available. Such systems are typically powered via an AC outlet. The DC constant current output of the power supply may be set to any level, but in one embodiment it is set at about twice the maximum current required to protect the HOUST itself in the most aggressive soil to allow for some current losses to other underground metal structures in the vicinity such as water lines, electrical grounding systems, etc.

[0025] The DC power supply will automatically increase or decrease the DC power supply voltage to accommodate any difference in system circuit resistance created by different soil resistivity values from site to site and variations at each site in seasonal soil moisture content, soil contaminants (fertilizer application, etc.), etc.

[0026] In this respect, the DC power supply may further include a rectifier. The rectifier automatically increases or decreases the voltage to accommodate any difference in system circuit resistance. As noted, such differences can be created by different soil resistivities from site to site and variations at each site in soil moisture content, soil contaminants, and other variables.

[0027] A field implementation and testing system is then provided wherein the contractor simply installs a single anode (or additional number of anodes as required for the size HOUST) per a pre-engineered selection chart provided with the system as described below) at preset locations adjacent to the HOUST. The contractor then uses a simple car battery or other DC voltage source to provide a test current between the installed single (or multiple) anode(s) and measures the resulting current flow.

[0028] If the output is above a defined value (also provided by the standard design table), he does not have to install any more anodes as the automatic control DC power supply has sufficient voltage capacity to deliver the required current. If the anode test current falls below the required minimum current, the contractor uses the actual lower measured current to look up on a table how many additional anodes he needs to install.
The specifics of this process are outlined in FIG. 1. A contractor first installs a single anode 10 adjacent the underground tank 12. Although the appropriate distance between the tank and the anode may vary, a typical distance is from 5 to 8 feet. The anode and the tank fill 14 of the tank are then connected respectively to the positive 18 and negative 20 electrodes of a car battery or other DC voltage source and the voltage V<sub>1</sub> is recorded. Assuming the use of a 12 volt battery, if V<sub>1</sub> is less than 11.0 volts, the battery should be recharged or replaced and retesting conducted. The current A<sub>1</sub> from the HOUST to the negative battery terminal is then measured. From this measurement, the correct number of anodes needed for the specific HOUST can be determined.

For a 500–550 gallon tank, the relationship of A<sub>1</sub> to the number of anodes needed for the site can be determined from a chart similar to FIG. 2A, wherein test current values are expressed in thousandths of an ampere. Thus, in table format, this relationship can be expressed as:

<table>
<thead>
<tr>
<th>Anode Selection Table for 500–550 Gallon HOUST</th>
<th># Anodes Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&lt;sub&gt;1&lt;/sub&gt; &gt; 0.100 amperes</td>
<td>1</td>
</tr>
<tr>
<td>0.060 &lt; A&lt;sub&gt;1&lt;/sub&gt; &lt; 0.100</td>
<td>2</td>
</tr>
<tr>
<td>0.040 &lt; A&lt;sub&gt;1&lt;/sub&gt; &lt; 0.060</td>
<td>3</td>
</tr>
<tr>
<td>&lt; 0.040</td>
<td>Additional cathodic protection needed</td>
</tr>
</tbody>
</table>

Similarly, for a 1000-1100 gallon tank, the relationship of A<sub>1</sub> to the number of anodes needed for the site can be determined from a chart similar to FIG. 2B, wherein test current values are expressed in thousandths of an ampere. In table format, this relationship can be expressed as:

<table>
<thead>
<tr>
<th>Anode Selection Table for 1000–1100 Gallon HOUST</th>
<th># Anodes Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&lt;sub&gt;1&lt;/sub&gt; &gt; 0.160 amperes</td>
<td>2</td>
</tr>
<tr>
<td>0.120 &lt; A&lt;sub&gt;1&lt;/sub&gt; &lt; 0.160</td>
<td>3</td>
</tr>
<tr>
<td>0.090 &lt; A&lt;sub&gt;1&lt;/sub&gt; &lt; 0.120</td>
<td>4</td>
</tr>
<tr>
<td>&lt; 0.090</td>
<td>Additional cathodic protection needed</td>
</tr>
</tbody>
</table>

Additional tables can be provided for various other type and sizes of tanks by calculating the number of anodes needed for these sites, which can be done by one skilled in the art. By providing these tables to a contractor, the contractor merely needs to select the table appropriate for the tank for which he is installing the cathodic protection system. No additional calculations need to be made by the contractor. The automatic DC power supply is simply plugged into a convenient receptacle, typically in the home owner’s basement, one wire each from the anode(s) and wire connected to the HOUST fuel line(s) are then connected to the power supplies positive and negative (DC) terminals respectively.

The installed cathodic protection system is diagrammed in FIG. 3. As can be seen, the combined DC power supply 30 is plugged into an AC power outlet via connecting wires 32. A wire 36 from each of the anode(s) 34 is connected to the positive terminal of the DC power supply. Another wire 38 connects the negative terminal of the power supply to the HOUST, typically through the fuel line 40 entering the house or dwelling.

Additional features that may be supplied to the system include:

- Providing the constant current DC power supply with a current output monitoring circuit. This circuit would indicate correct operation by lighting a “green” monitoring light or other indicator when the current is at an acceptable level and thus providing effective corrosion mitigation (e.g. a 1 ampere system's output is at least 0.8 amperes). If the output falls below a set level (e.g. a 1 ampere system's output falls below 0.8 amperes), the light would go out, another color light would activate or some other warning system would be engaged.

- This same current monitoring circuit can be used to drive a “good time” hour meter that would record the number of hours that the system has been operating at the correct output current (same as when the green light is lit). At any time in the future, this sealed hour meter could be examined to assure that the system has been providing the necessary current for the entire life of the system.

- In another embodiment, one could provide the system with an anode wire junction box mounted to the exterior of the building near the HOUST. This junction box would be provided a switch that would allow brief interruption of the system output to facilitate taking “instant-off” potential measurements as required by and in accordance with well established criteria documented by NACE International.

- In another embodiment, there could be provided a cathodic protection monitoring tube that would facilitate placing a portable reference electrode at a fixed (same) position each time the system is tested by the contractor. It would also allow the electrode to be located near the bottom of the tank where corrosion is typically the worst. Finally, the same tube could be used for sampling the soil, water or vapors in the soil near the bottom of the tank to make sure that no new contamination by hydrocarbons is occurring in the soil from mechanical or other unforeseen breaches in the HOUST system.

- In another embodiment, there could be provided a constant current DC power supply energized by alternate power sources including but not limited to solar, wind, fuel cell, or oil powered devices.

- In another embodiment, there could be provided anodes of various alloys and anodes with various cladding or coatings. Anodes are used to inject DC current into the earth and onto the storage tank. Additionally, anode shapes may be varied to address special site conditions.

- In another embodiment, there could be provided permanent or temporary means to monitor the cathodic protection effectiveness. Monitoring facilities could include but are not limited to standardized reference electrodes based on metal ions of copper, silver, graphite, zinc, or potassium. Arrays of metallic electrodes or standardized reference cells monitoring voltage gradients in the storage tank vicinity may be used to monitor cathodic protection effectiveness. Additionally, monitoring may be provided by measurement of the electromagnetic fields produced by the cathodic protection current flows.

The exemplary embodiment has been described with reference to the preferred embodiments. Obviously,
modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the exemplary embodiment be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. A system for impressing current for cathodic protection of a metallic structure comprising:
   a constant current DC power supply having a positive and a negative terminal, wherein said constant current DC power supply contains means for receiving AC current;
   at least one anode, wherein said anode is electronically connected to the positive terminal of the DC power supply;
   an associated metallic structure, wherein said associated metallic structure is electronically connected to the negative terminal of the DC power supply; and
   a current output monitoring system.

2. The system of claim 1, further comprising a sensor indicating when current output is at target amperes and a meter or recorder for displaying the time the system has operated at the correct current.

3. The system of claim 1, further comprising an anode wire junction box configured to allow interruptions of the current output to facilitate the taking of instant potential measurements in accordance with established national guidelines.

4. The system of claim 1, further comprising a cathodic protection monitoring tube disposed a fixed distance from the metallic structure.

5. The system of claim 1, wherein the power supply is energized by wind, solar, fuel cell or oil power.

6. A method for providing cathodic protection to an associated metallic structure comprising:
   providing a power supply with a positive terminal and a negative terminal;
   installing at least a first anode a first specified distance from the structure;
   electrically connecting the positive terminal of the power supply to the first anode;
   electrically connecting the negative terminal of the power supply to the associated metallic structure;
   measuring the current (A1) flowing between the metallic structure and the negative terminal of said power supply;
   determining the appropriate number of additional anodes needed to provide adequate cathodic protection to said metallic structure via reference to a standardized system.

7. The method of claim 6, wherein the power supply is a DC voltage source.

8. The method of claim 7, wherein the DC voltage source is a 12 V battery.

9. The method of claim 7, wherein the power supply provides a constant current at a level which is at least twice the maximum current required to cathodically protect the associated metallic structure.

10. The method of claim 6, further comprising the step of first confirming the metallic structure is not leaking.

11. The method of claim 6, further comprising the step of providing the power supply with a current output monitoring system.

12. The method of claim 11, wherein the current output monitoring system further comprises an element recording or displaying the time of operation at the target current output.

13. The method of claim 6, wherein the first specified distance between the anode and the metallic structure is from 5 to 8 feet.

14. The method of claim 6, wherein the power supply is energized by wind, solar, fuel cell or oil power.

15. The method of claim 6, further comprising the step of providing an anode wire junction box configured to allow interruptions of the current output to facilitate the taking of instant-off potential measurements in accordance with established national guidelines.

16. The method of claim 6, wherein said standardized system is a chart or other reference correlating the number of anodes required based on the current measured.

17. The method of claim 16, wherein the number of additional anodes needed for a 500-550 gallon underground storage tank is determined by reference to the following chart:

<table>
<thead>
<tr>
<th>A1</th>
<th># additional Anodes Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0.100 amperes</td>
<td>1</td>
</tr>
<tr>
<td>0.060 &lt; A1 &lt; 0.100</td>
<td>2</td>
</tr>
<tr>
<td>0.040 &lt; A1 &lt; 0.060</td>
<td>3</td>
</tr>
<tr>
<td>&lt;0.040</td>
<td>Additional cathodic protection needed</td>
</tr>
</tbody>
</table>

18. The method of claim 16, wherein the number of additional anodes needed for a 1000-1100 gallon underground storage tank is determined by reference to the following chart:

<table>
<thead>
<tr>
<th>A1</th>
<th># Anodes Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0.160 amperes</td>
<td>2</td>
</tr>
<tr>
<td>0.120 &lt; A1 &lt; 0.160</td>
<td>3</td>
</tr>
<tr>
<td>0.090 &lt; A1 &lt; 0.120</td>
<td>4</td>
</tr>
<tr>
<td>&lt;0.090</td>
<td>Additional cathodic protection needed</td>
</tr>
</tbody>
</table>

19. The method of claim 6, further comprising forming a cathodic protection monitoring tube adjacent said metallic structure.

20. The method of claim 6, wherein the power supply further comprises a rectifier to automatically increase or decrease a voltage of said power supply based on differences in circuit resistance.

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