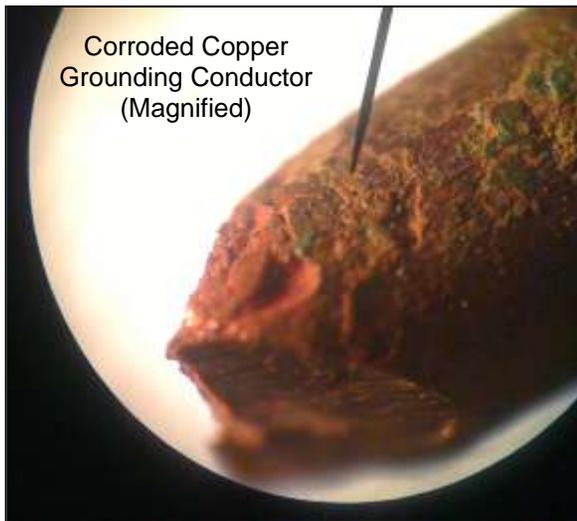


Minimize Corrosion of Electrodes and Grounding Conductors in Irrigation Systems

Irrigation professionals have been using various grounding grids for electronic equipment for over 30 years. Some rare corrosion occurrences have been reported to bare copper grounding conductors recently. Other reports of premature corrosion of zinc ground plates have been reported in the past. This White Paper discusses the theory of this subject and offers possible solutions/improvements to the specific potential corrosion problems.



Vince Nolletti
Bachelor of Electrical and Electronics Engineering, 1971, City University of New York
Partner and Executive Vice President
Paige Electric Co. LP
2683 W. Lake Van Ness Circle, Fresno, CA 93711 USA
Phone: 559-431-2346
Fax: 559-431-2574
Cell: 559-906-9075
<http://www.paigewire.com/>

Minimizing Corrosion of Grounding Conductors and Electrodes in Irrigation Systems

By Vince Nolletti

Only a few different metals and metal alloys are used in the electrical circuits of irrigation systems. Wire conductors are usually made from copper, tinned copper, or aluminum. For protection from lightning and power surges, Grounding, Bonding, and Shielding circuits use copper wire, copper ground plates, and copper-clad ground rods.

Corrosion of underground metals is an electro-chemical process caused by stray electrical currents flowing in the ground. The electrical current flow is caused by “corrosion cells.” A corrosion cell is a condition that can be created when:

- A metal surface is in contact with a dissimilar metal. For example, if a galvanized steel structure is grounded to an electrode using copper wire, corrosion will be created at the point where the copper meets the galvanized steel.
- A metal is in contact with soils with dissimilar chemistry. This typically happens when a ground rod is driven into the earth and it intersects more than one layer of soil.
- A metal is in contact with similar soils with dissimilar oxygen content, usually caused by excavation. Trenching causes oxygen to mix with the soil.

Types of metals - When dissimilar metals are in contact with each other, a small current flows from the metal that is more “anodic” to the more “cathodic”. The further apart the metals are on the Table shown, the higher the current flow, and the faster the corrosion takes place. From this information it can be assumed that:

- Copper ground plates are more corrosion resistant than zinc ground plates. Zinc ground plates should never be used for irrigation purposes because they corrode too quickly.
- Bare copper wire is more corrosion resistant than tin coated copper wire. Copper wire is tinned to make it more tarnish resistant and to facilitate soldering. This is usually done when the wire needs to be soldered to printed circuit boards.

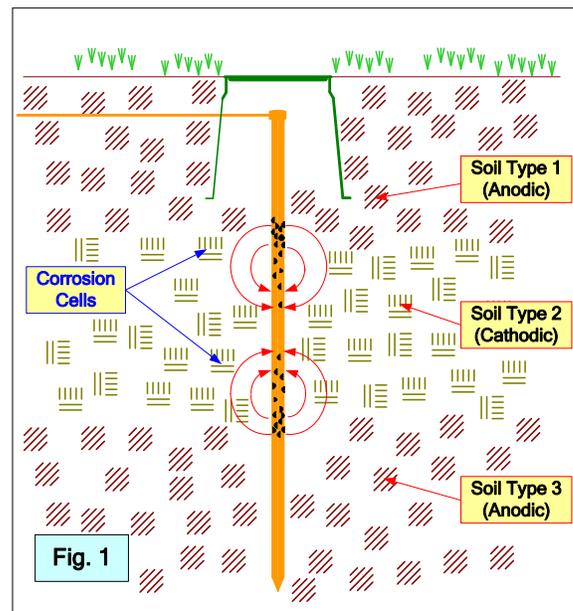
Generally speaking, copper is almost impervious to corrosion, from most soils, due to its “noble” nature. This is evident from the countless well-preserved copper artifacts, some more than 5000 years old, that have been recovered in many parts of the world. Copper is believed to be the best choice for all uses in irrigation systems.

There are situations where even copper corrodes, when exposed to certain environmental conditions. These will be discussed below, along with the solutions.

Metals in contact with soil – Corrosion cells in irrigation systems are more likely to be created when:

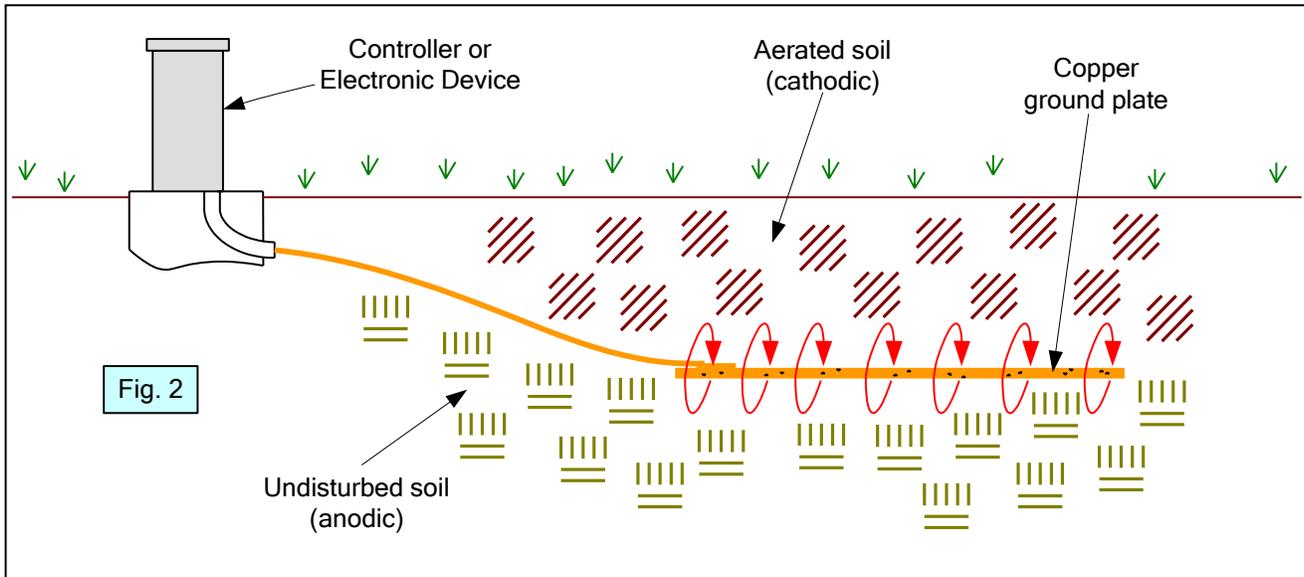
- A grounding electrode, usually a copper-clad ground rod or copper ground plate, is surrounded by dissimilar soils. Figure 1 shows a ground rod

Active or Anodic <i>Most Corrosive</i>
Magnesium
Zinc
Galvanized steel
Aluminum
Mild steel
Wrought iron
Stainless steel
Tin
Bronze
Brass
Nickel
Copper
Titanium
Silver
Gold
Platinum
Noble or Cathodic <i>Least Corrosive</i>

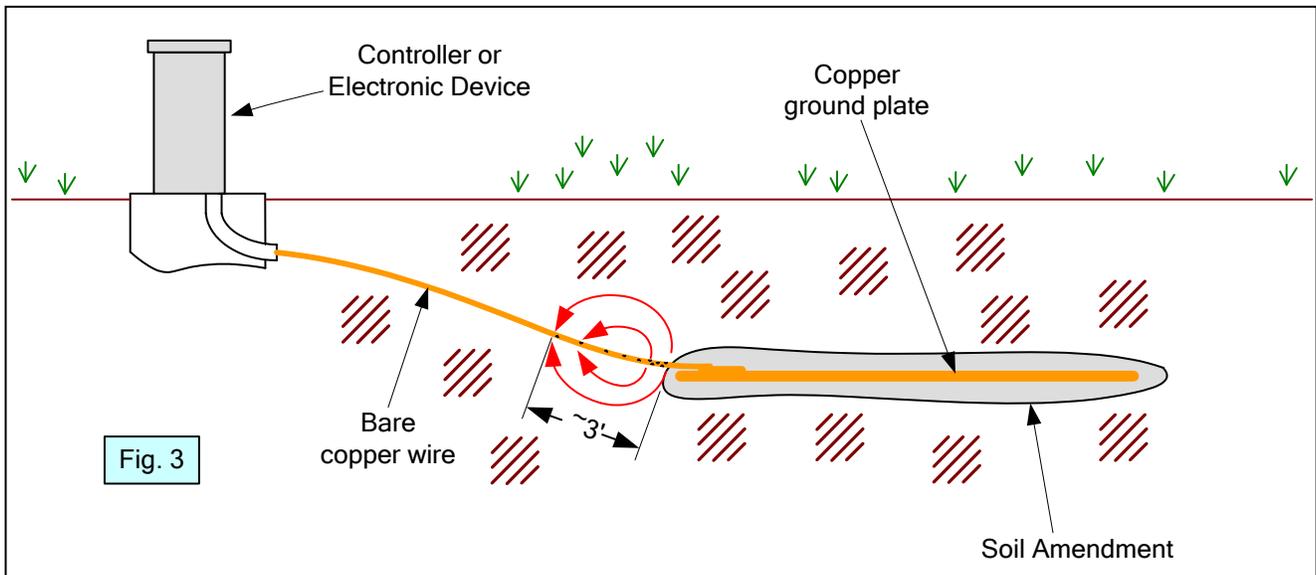


that is driven into the earth, intersecting three layers of dissimilar soil. This is a normal occurrence. Soils type 1 & 3 are anodic while soil type 2 is cathodic. The ground rod will experience corrosion along a section of the cathodic side of the center of each corrosion cell. The highest concentration of corrosion will be experienced at the point where the two different soils meet and will diminish with distance. Corrosion will become minimal within a few feet of each corrosion cell. Some ground rod manufacturers publish a life expectancy of between 5 and 30 years. The huge difference is due to the wide range of possible soil conditions and the electric current flowing at the ground rod location.

- A metal in contact with soil that has a differential aeration (oxygen content) of adjoining soils will be exposed to potential corrosion cells. Figure 2 shows a ground plate installed in uniform soil. The soil under the ground plate is undisturbed, but the soil on top of the ground plate contains more oxygen because it is tilled backfill material from the trenching process.

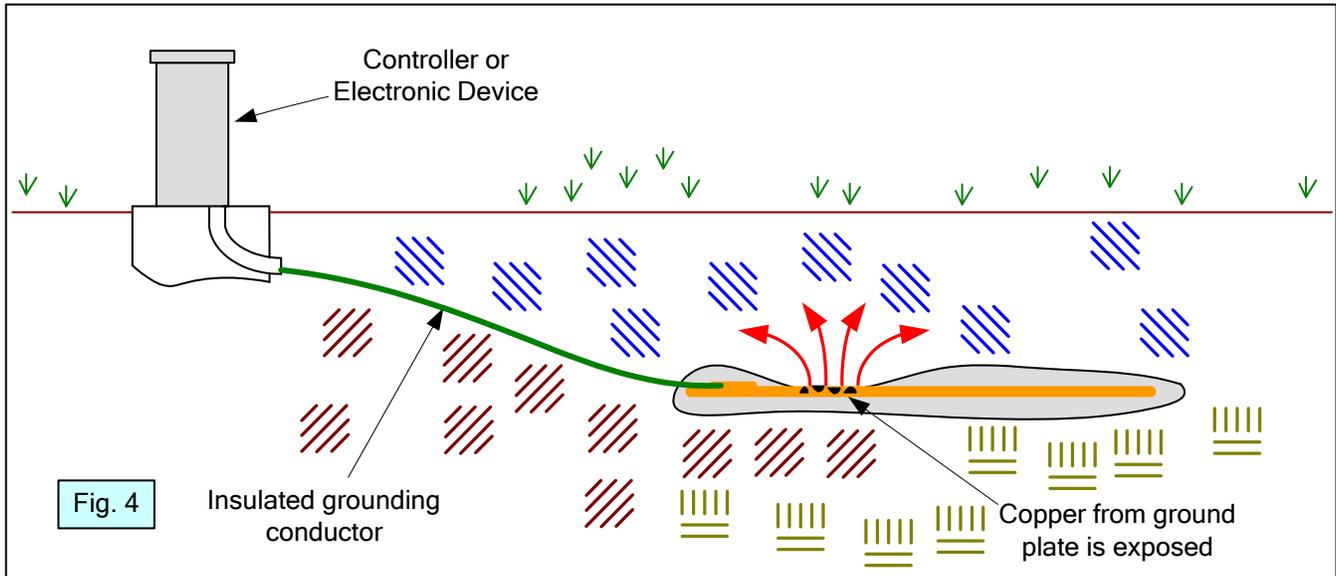


- Figure 3 shows a ground plate installed with a carbon based soil amendment to achieve lower resistance-to-earth (~40% reduction.) The ground plate is connected to the irrigation controller with a bare copper grounding wire, partially surrounded by the soil amendment. The natural soil is uniform. Because the natural soil is very different from the soil amendment, a corrosion cell can

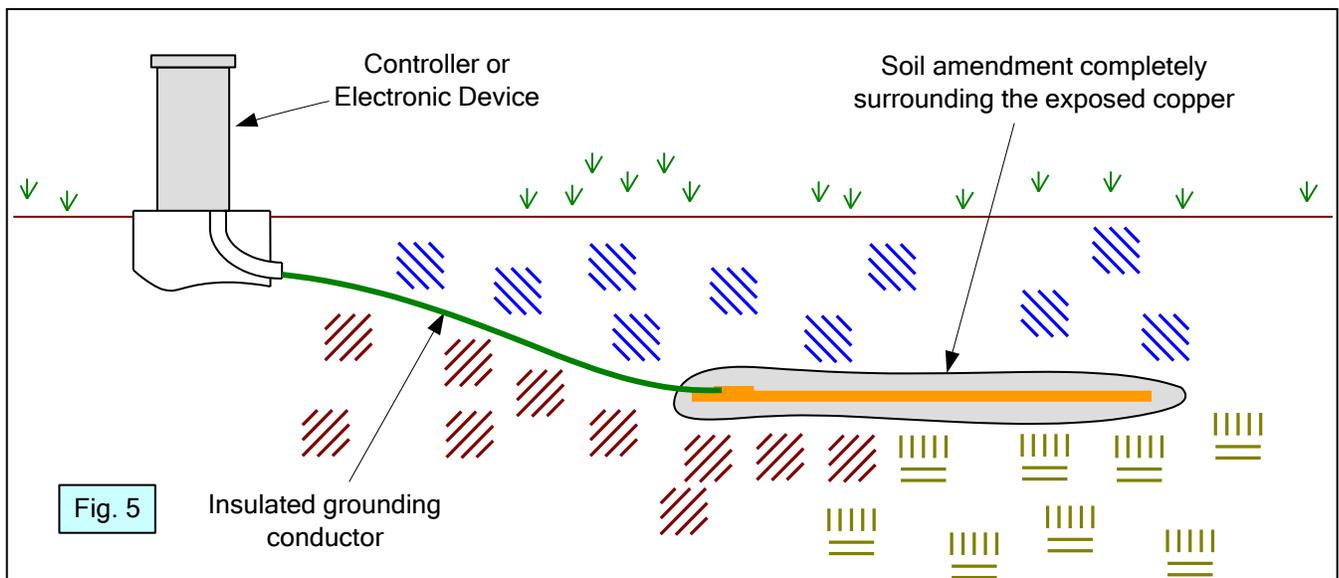


form at the point where the bare copper wire exits the soil amendment. It would be advantageous for the copper conductor connecting the ground plate to the controller to be insulated.

- Figure 4 shows a ground plate connected to a controller with a green-insulated copper conductor. When surrounding copper electrodes with soil amendments, caution must be taken to make sure that no bare copper is in contact with the natural soil, disturbed or undisturbed. The layer of soil amendment material should have a minimum thickness of 1" in order to achieve low earth resistance characteristics and to eliminate the possibility of exposing any bare copper. Exposed bare copper will result in a corrosion cell, as shown in Figure 4. And, the smaller the exposed surface, the more concentrated the corrosion cell will become.

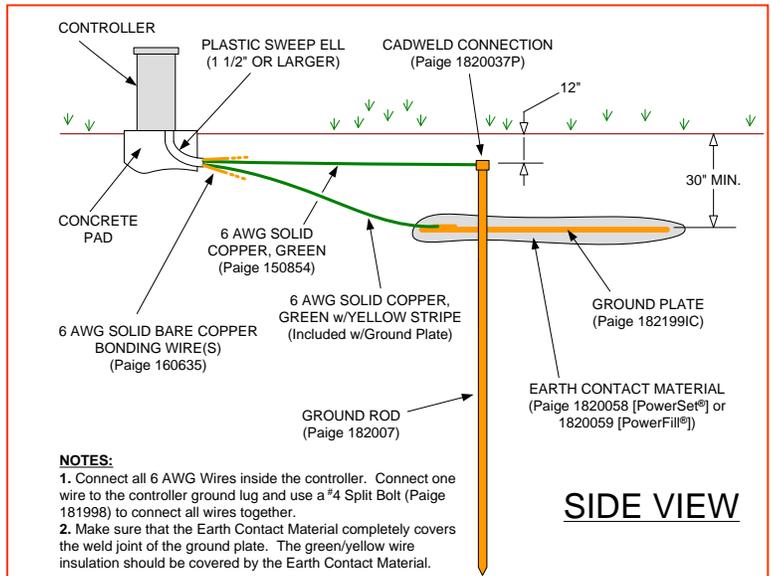
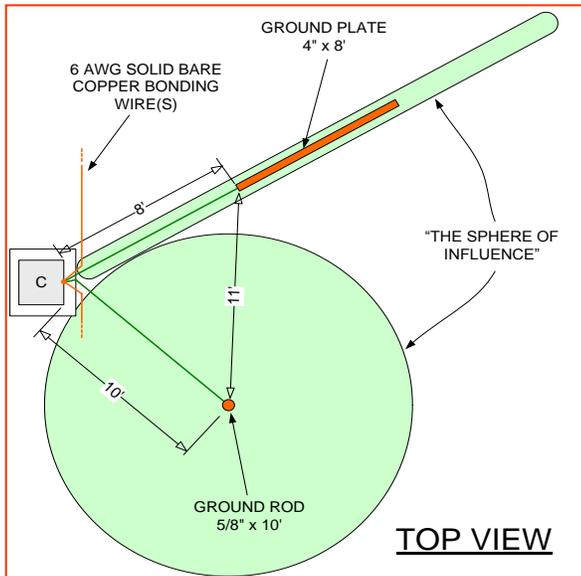


The generic solution - Figure 5 shows a copper ground plate that is connected to the irrigation controller with an insulated copper grounding conductor. All the bare copper (and some of the insulation of the grounding conductor) is completely surrounded by a soil amendment. Since all the bare metal is in contact with exactly the same type of soil (amendment), the probability of creating a corrosion cell is virtually eliminated.



Practical solutions – It is necessary to apply the information contained in this White Paper to both conventional and Decoder/2-Wire/2-Core irrigation systems. On conventional systems, all ground grids are located at the controller locations. On Decoder/2-Wire/2-Core irrigation systems it is necessary to ground the controller(s) and the decoders/electronic receivers.

- Grounding controllers** - The following details show the proper methods for grounding irrigation controllers and other electronic equipment (weather stations, interface units, etc.) The ground rod can also be surrounded with PowerSet® to minimize its corrosion and enhance grounding. This can be accomplished by boring a 4" diameter hole slightly deeper than the length of the ground rod. Also shown are details on how to bond ground grids to each other. The bonding wires are then used for shielding the other underground wires from lightning surges.



NOTES:
 1. Connect all 6 AWG Wires inside the controller. Connect one wire to the controller ground lug and use a #4 Split Bolt (Paige 181998) to connect all wires together.
 2. Make sure that the Earth Contact Material completely covers the weld joint of the ground plate. The green/yellow wire insulation should be covered by the Earth Contact Material.

- Grounding Decoder systems** – Figures 6 & 7 show the proper methods for grounding decoders and other electronic equipment in Decoder/2-Wire/2-Core systems. Also shown are details on how to bond ground grids to each other. The bonding wires are then used for shielding the Decoder/2-Wires/2-Core cables from lightning surges. Figure 6 is for a decoder with an integral lightning arrester and that incorporates a ground wire.

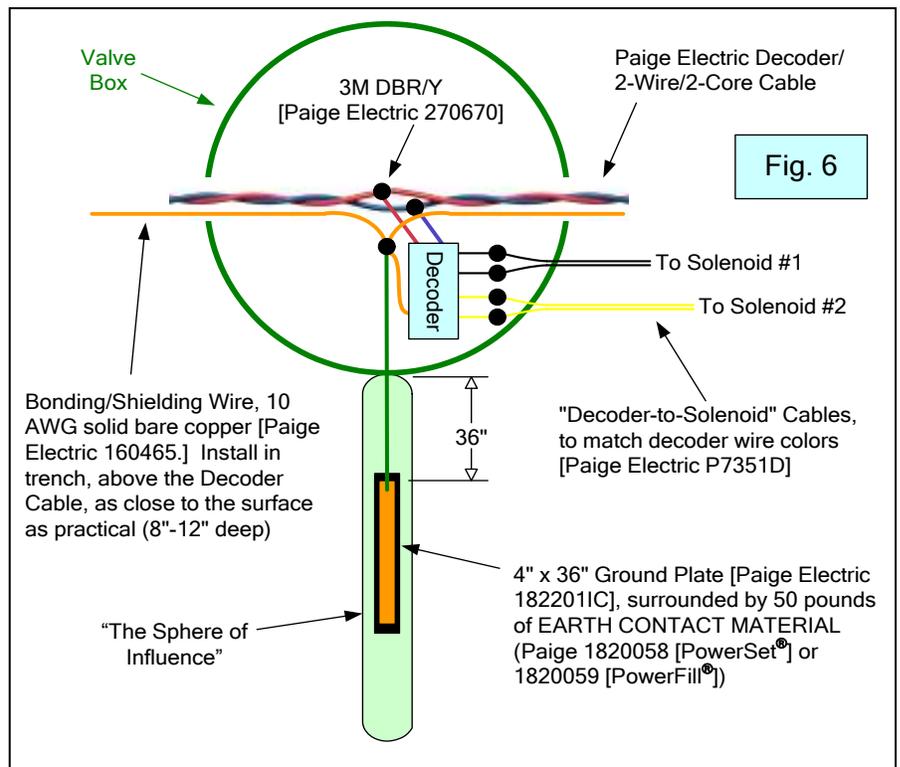
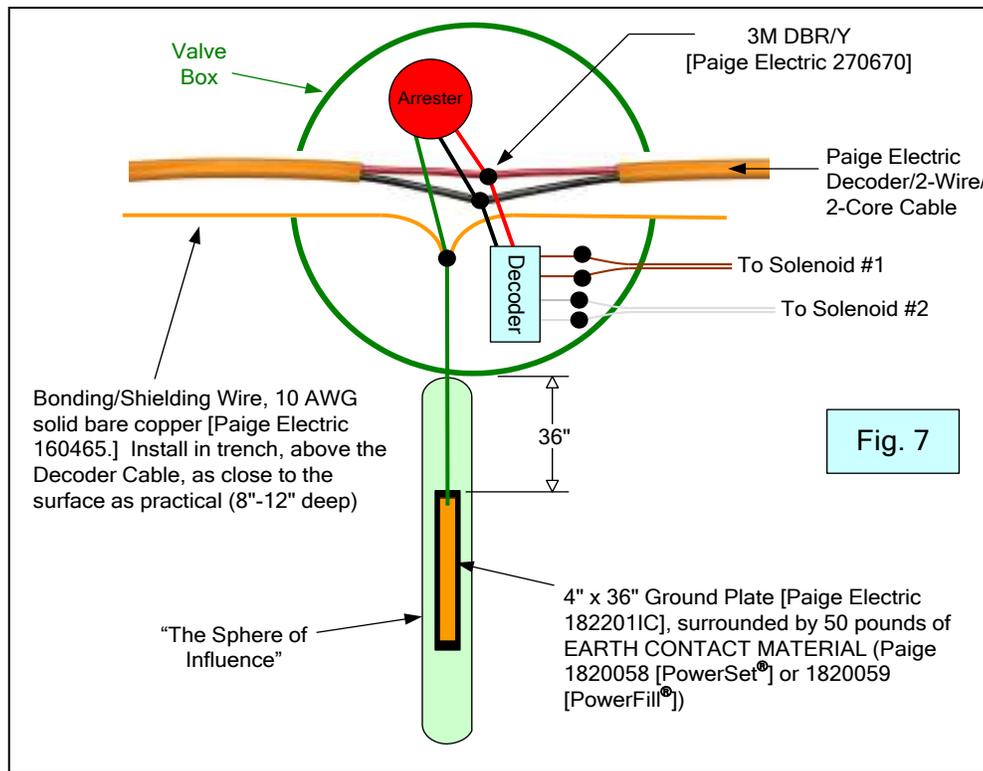


Figure 7 is for a decoder/receiver that uses external lightning arresters.



Additional information – The staff of the Irrigation Division of Paige Electric has vast knowledge on the contents of this document. For more detail on this subject, visit the Paige Electric website at www.paigewire.com, or contact the author (see cover page.)

References:

The following documents and references were used as a basis for this White Paper. This material is subject to change.

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Disclaimer: Paige Electric has made every effort to ensure that the information and recommendations contained within are correct. However, neither Paige Electric nor any of its employees warrants nor accepts any liability for the use of this information. National and local electrical codes should always be followed. Wiring, grounding, shielding, and bonding irrigation system components often require competent engineering judgment on a case-by-case basis. Competent engineering assistance should be sought from firms specializing in this field. The manufacturer(s) of the irrigation equipment being protected should also be consulted.

