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EFFECTS OF ELECTRICAL GROUNDING ON CORROSION

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It is common practice to electrically bond underground metallic structures to provide electrical continuity between the structures through a metallic path in power plants and other piping networks to minimize soil gradients. Common bonding produces an economical, low resistance ground path for power systems. The National Electrical Code permits use of an underground metallic water pipe as the primary grounding electrode. (Ref. 1) Power plants install copper grounding mats to reduce the voltage gradient, associated with a fault, near the surface of the earth. These mats are designed on the basis of maximum fault current and soil resistivity to minimize the voltage gradient over the distance a man may step or reach to a safe value. This is to assure the safety of operating personnel and the general public. Homes, offices, and industrial plants also ground all major electrical equipment.

Interchange of fault currents between closely spaced, unbonded metallic structures have caused failure of structures by the power arc associated with the fault. (Ref 2)

Corrosion control design requirements generally are in direct conflict with electrical grounding requirements and standard practices. Electrical isolation from dissimilar materials of construction, found in other underground utilities, will greatly reduce the corrosion rate on buried ferrous utility plant. Corrosion control by cathodic protection is much simpler and more economical if the structure to be protected is electrically isolated from all other underground structures. Some materials of construction, such as copper, may require twenty or more times the amount of current needed to protect the same surface area as that required by a bare steel surface if the two are tied in common. When dealing with an effectively coated structure to be protected, the ratio between current requirements for an isolated system versus a shorted network is even more dramatic. Unfortunately, copper is the most common material of construction for electrical grounding systems due to it's apparent corrosion resistance. Consequently, cathodic protection design requirements may be severely altered by the presence of electrical grounds required for protection of personnel or the structure.

Cathodic protection of an entire downtown underground utility network has been attempted with limited success. (Ref 3) The installation and operation of such a system is quite costly and the results are frequently less than those desired. Similar problems exist in many generating stations and industrial plants where all utilities tend to be bonded in common. (Ref 4 ,5) Again, costs for cathodic protection are considerably higher with an integrated network than would be the case if all ferrous structures were isolated from the grounding grid. Consequently, corrosion engineers have attempted to electrically isolate the structure under cathodic protection from the balance of the underground network. Assuming that effective electrical isolation can be provided and maintained, cathodic protection costs are dramatically reduced.

Once a cathodically protected structure has been isolated from the balance of the underground network, it becomes more susceptible to influence from and damage by electrical earth currents such as power system induced energy and natural static discharges to earth. All of these phenomenon can cause power levels in the cathodically protected structure high enough to be of concern. They may cause physical harm to personnel or to the structure itself. Proper cathodic protection system design should take these factors into account. (Ref 6)

Installation of new utility lines, either cross country or across major urban areas, are being confined on or adjacent to existing utility rights-of-way as a result of governmental regulations or economic considerations. Shared rights-of-way look very attractive to utility company management who tend to be unaware of the problems associated with joint use of rights-of-way. Considerable emphasis has been placed on the concept of "common corridor" rights-of-way to meet future utility transportation requirements over considerable distances. Under the "common corridor" concept, all major intrastate and interstate utilities and/or transportation systems would be constructed at fixed spacings on a common right-of-way.

Certain economies in right-of-way aquisition make the proposal appear quite attractive as reduced time and expense would be incurred by second and third parties purchasing right-of-way in an established "common corridor". It is generally envisioned that all utility conflicts can be resolved by planned vertical and horizontal seperation on the common right-of-way. However, an operating A.C. system will tend to induced electrical energy into any continuious metallic structure, such as a pipeline or a communications circuit, either aboveground or belowground, that operates in the vicinity of the power system by transformer action. (Ref 7) The case of continuiously parallel utilities produces the most pronounced effects on the utilities foreign to the power system. Properly designed electrical grounding of the effected structure and selective use of insulating fittings to sectionalize the structure may be the most effective methods available to mitigate the undesirable effects. Electrical grounding requirements for safety are again in conflict with the need for isolation to facilitate cathodic protection.

Since engineering design decisions must be made both to achieve effective grounding and effective levels of cathodic protection, the corrosion engineer and the grounding engineer should be involved in the design of such facilities at the inception of the project. It is far easier and less costly to "design out" problems on paper, prior to construction, than to initiate remedial measures in the field after the structure has been completed. In many instances, special grounding practices will be required during the construction phases to assure adequate safety for all personnel involved in the project. These practices and procedures should be spelled out in the plans and specifications and/or contract documents.

Over the years, a number of schemes have been tried to provide electrical isolation for cathodic protection voltages while maintaining the system effectively grounded for electrical safety. (Ref 8) Improved devices are now on the market each with it's good points and drawbacks. These devices are referred to in NACE Standard RP-01-77 as "DC Decoupling Devices". Electrolytic grounding cells, polarization cells and some lightning arrestors are examples of DC decoupling devices that are available as off the shelf components. The use of cathodic decoupling devices allow for conventional cathodic protection system design on a more or less effectively isolated structure while providing a low impedance path to ground for undesirable electrical energy induced on the structure. Very careful design is required to assure that the protective devices are of adequate capacity and will not agraviate the problem under certain conditions.

From a structural standpoint, the most deleterious effects to be prevented are disbondment of protective coatings or even puncture of the structure wall by a power arc as the unwanted energy attempts to leave the structure. Personnel operating the structure and the public that may be in the vicinity must be protected from excessive levels of "step and touch" potentials (Ref 9)

Protective measures such as grounding grids or mats and/or surface insulating materials may be required in many instances to provide effective levels of protection at acceptable cost. Cathodic protection facilities (such as distributed sacrificial anodes), may be effective in reducing unwanted power levels, if properly designed. If sacrificial anodes are considered to be a part of the electrical grounding system, their design life must be equal to or greater than the design life of the structure. In the event that such a long design life cannot be assured, the cathodic/grounding system design must contain provisions for periodic testing and replacement of components as necessary. Complete design will designate minimum conductor sizes and connections from the individual anodes to the structure. To be safe and effective, these devices must be carefully engineered and installed. Periodic testing and maintenance is essential to maintain the effectiveness of such devices. The corrosion engineer is now called upon to be responsible for electrical safety design in addition to his corrosion control design responsibilities. A careful integration of the two design functions can produce a structure well protected from corrosion and probable serious electrical influence at a reasonable cost. Too much emphasis cannot be placed upon the necessity for review of the available literature and careful design of the proposed facilities.

As more experience is gained in mitigating undesirable electrical effects on cathodically protected structures, the industry can look to operation of systems with improved relability and safety.

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