CHAPTER 5

SYSTEM SELECTION

5-1. Corrosion Protection. Corrosion occurs on all metallic structures that are not adequately protected. The cost of replacing a structure which may have been destroyed or weakened due to excessive corrosion is substantial but avoidable, and means should be taken to consistently prevent or mitigate this added cost through cathodic protection. In addition to preparing and applying protective coatings to the surface of a structure, corrosion protection can be provided by applying a protective electric current to the structure surface which is immersed and in contact with an electrolyte. In the presence of certain other metals contacting the electrolyte near the structure, this technique transforms the structure into a cathodic electrode. A properly selected and designed cathodic protection system can prevent surface corrosion of the structure, or drastically reduce the rate at which it occurs.

5-2. Types of CPSs.

a. Sacrificial CPS. This type of system helps reduce surface corrosion of a metallic structure immersed in an electrolyte by coupling a less noble metal with the structure. Sacrificial CPSs work through the sacrifice of an anodic metal, i.e., one that has a negative electrochemical potential relative to the protected ferrous structure, to prevent deterioration of the structure through corrosion. Sacrificial anodes for fresh water applications typically are composed of zinc- or magnesium-based alloys. In the past, installation of sacrificial anodes has often been done on an ad hoc basis, relying largely on the installer's individual knowledge and experience. However, recent research on sacrificial anode materials has provided an improved engineering basis for designing civil works applications of these systems.

b. Impressed current CPS. This type of system uses direct current applied to an anode system from an external power source to drive the structure surface to an electrical state that is cathodic in relation to other metals in the electrolyte. A number of impressed current anode materials and geometries are used. Materials include mixed metal oxides, precious metals (e.g., platinum-clad titanium, niobium), and high-silicon chrome-bearing cast iron. The most common geometries are slab or button anodes, rods, and strings. Any anode mounted on the structure must be isolated with a dielectric shield to assure effective current distribution.

5-3. CPS Selection. When selecting which type of system to use, the designer should consider the size of the structure to be protected and past project experience in operating and maintaining both types of systems. Early in the selection process, if practical, it is useful to perform a current requirement test to help define the total amount of electrical current needed to protect the structure (see PROSPECT Corrosion Control course handbook [009, 2003-01 et seq]). For large structures with significant expanses of bare or poorly coated metal, where the total current requirement tends to be very high, a properly maintained impressed current system can provide

10 to 30 years of effective corrosion protection. Where current requirements are lower and the structure's protective coatings are well maintained, sacrificial anode systems can be very effective. Improved modern coating systems and maintenance practices today allow for a wider use of sacrificial CPSs on large civil works structures than was the case in the past. For both types of systems, preliminary design estimations and comparisons of costs, current output, and overall design life should give an adequate indication of which system is preferable for the specific application. Other factors such as future maintenance needs, reliability, accessibility, and impact on operations may also warrant consideration.

a. Basis for selecting an impressed current system.

(1) Can be designed for a wider range of voltage and current applications.

(2) Higher total capacity (i.e., ampere-years) can be obtained from each installation.

(3) One installation can protect an extensive area of the surface of a metallic structure.

(4) Voltage and current can be varied to meet changing conditions, providing operational flexibility that is very useful to increase protection of the surface coating.

(5) Current requirement can be read and monitored easily at the rectifier.

(6) System can be designed to protect bare or poorly coated surfaces of metallic structures.

b. Basis for not selecting an impressed current system.

(1) First costs for design, acquisition, and installation are high.

(2) Installation is complex due to the need for an external power supply, cabling, and numerous electrical connections.

(3) Maintenance costs can be high.

(4) System can create stray currents that may potentially corrode other nearby ferrous structures.

(5) If an excessive amount of current output is used, hydrogen gas may form between the substrate and coating, causing paint blistering or possible hydrogen-embrittlement of high-strength steel.

c. Basis for selecting a sacrificial anode system.

(1) External power source is not required.

(2) Installation is less complex since an external power source, including rectifier, is not required.

(3) System works very well when electrolyte resistivity is low, surfaces are well coated, structure is easily accessible, and significant deterioration of the coating is not expected within 5 to 10 years.

(4) System is easier to install on moving complex structures such as tainter valves where routing of cables from an impressed current system could present a problem.

d. Basis for not selecting a sacrificial anode system.

(1) Current output per anode is low and may not be sufficient to protect large structures with significant expanses of uncoated or poorly coated bare metal.

(2) System generally cannot be economically justified where large surface areas of a poorly coated metallic structure require protection.

(3) Anode replacement expenses and/or the number of anodes required can be high compared with impressed current systems for structures with high current requirements.

(4) Current output cannot easily be adapted to seasonal changes in water resistivity or to unexpected changes in coating coverage caused by weathering, routine wear, or impact damage due to debris, ice, or aquatic vessels.

(5) Due to the buildup of algae, silt, or other deposits on sacrificial anodes, current output to the structure may be reduced.

(6) Monitoring system operation in accordance with NACE criteria is labor-intensive and inconvenient because it requires that structure-to-electrolyte potential measurements be taken in the field.