TechData Sheet

Naval Facilities Engineering Service Center
Port Hueneme, California 93043-4328

TDS-2020-SHR **June 1995**

CATHODIC PROTECTION SYSTEM DESIGN I -- The Pre-Design Field Survey

There are two basic scenarios for the design of cathodic protection systems: designing cathodic protection of a new facility and retrofitting the cathodic protection of an existing facility. In both cases, it is necessary to determine many site and facility specific factors in order to design a successful cathodic protection system. The details of surveys to determine these factors are given in MIL-HDBK-1004/10 "Electrical Engineering Cathodic Protection," Appendix A.

Three critical factors that affect the design of any cathodic protection system are the:

- Materials to be protected.
- Effective surface to be protected.
- Characteristics of the environment surrounding both the structure to be protected and the cathodic protection anodes.

The potential criteria and current density requirements for effective protection depends on the materials to be protected. For example, a potential of -850 millivolts is a common potential criteria for protecting steel in soils. Other criteria are presented in MIL-HDBK-1004/10 or NACE RP-0169. This value is an important input to cathodic protection system design. Protecting other materials such as lead, copper, or aluminum have different protection criteria in different environments. The current density requirements for specific materials can be estimated from environmental characteristics for design of new facilities, or can be measured on facilities to be retrofitted with cathodic protection. The primary environmental parameter that determines current density requirements is the resistivity of the environment. However, many other environmental characteristics such as the pH (acidity or alkalinity) of the environment, aeration, and levels of sulfate and chloride are also pertinent and should be evaluated.

The surface area to be protected determines the total current that must be supplied. This total current requirement is needed in order to determine the number and size of anodes needed in a sacrificial anode system or the number and size of anodes and the capacity of the rectifier in an impressed current system. For bare structures, this surface area is easily determined geometrically. For coated structures, however, the effective surface area depends on the insulating qualities of the coating and coating damage. For new structures, the effectiveness of coatings in reducing current requirements can only be estimated. However, past experience with similar coatings can be used to estimate the reduction for the current requirement. It is good practice to allow for some long term coating deterioration and damage. For existing systems to be retrofitted with cathodic protection, whether bare or coated, the actual current density required for protection can be determined by field testing. In these field tests, a temporary cathodic protection system is installed and the current required to achieve the desired protection level is determined directly.

The primary environmental parameter used in cathodic protection system design is the resistivity of the environment. This parameter has a large influence on the current density required for protecting the structure and has a primary influence on both the output of sacrificial anodes and the resistance of impressed current anodes.

In soil environments, this parameter can vary significantly from place-to-place at an activity, with depth and with the season of the year. Many Naval activities have more variation of resistivity with location and depth than is common in other locations due to the heavy use of fill, particularly in waterfront locations. Soil resistivity and the variation of soil resistivity with depth is best measured using the

Wenner 4-pin method that will be described in the next Techdata Sheet in this series.

In water environments, the resistivity of the environment is also an important cathodic protection design parameter. Resistivity of water is usually measured directly with a conductivity meter, or by a variation of the Wenner 4-pin method that uses a specially designed container with four electrodes.

In addition to resistivity, many other environmental characteristics such as the pH (acidity or alkalinity) of the environment, aeration, and levels of sulfate and chloride can also affect current density requirements and anode performance and should be evaluated.

Design of cathodic protection systems for underground structures on Navy installations is frequently complicated by surrounding buried metal structures. If adjacent, or "foreign" buried metal structures are in electrical contact with the structure to be protected, as shown in Figure 1, the current protecting the structure will flow to the foreign structure. Unless the cathodic protection system is designed to protect both structures, the foreign structure must be electrically isolated from the structure to be protected. Electrical contact with other metallic systems in a building is a common cause of such problems. Several common problems are shown in Figure 2.

It is common practice to isolate all metallic underground systems where they enter a building. Even if electrically isolated, buried metallic structures in the area of cathodically protected buried systems can cause problems both for the structure to be protected and for the foreign structure. As shown in Figure 3, the distribution of current from the anodes to the structure to be protected is disturbed and corrosion of the foreign structure is locally increased. The range of these interference problems depends on many factors, but is primarily a function of the distance between the anodes and the structure to be protected. As a rule of thumb, interference must be considered on structures closer than 10 times the distance between the anodes and the structure to be protected. Thus, interference is usually much less of a problem in sacrificial anode cathodic protection where the anodes are commonly located close to the structure to be protected than it is in impressed current cathodic protection systems that commonly have a much larger separation between the structure to be protected and the anoded bed. Fortunately, problems with electrical isolation and interference can be detected during potential surveys of the system and can be mitigated through electrical isolation and electrical bonding.

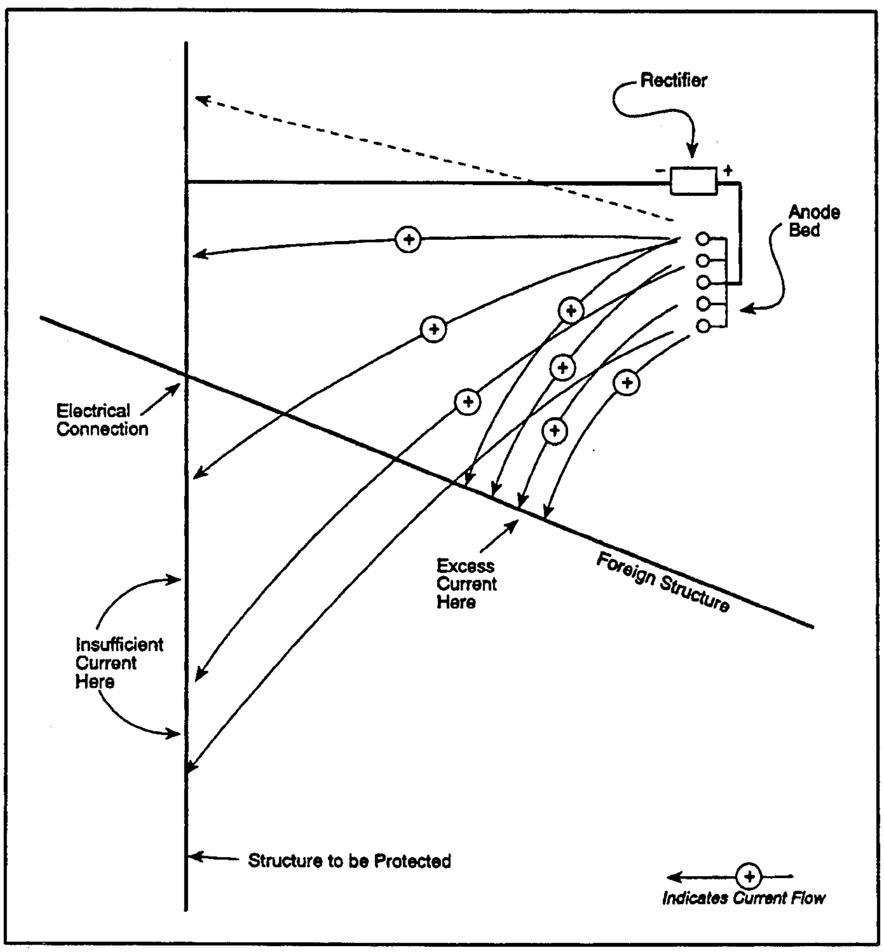

Figure 1. Example of current flow to electrically connected foreign structure.

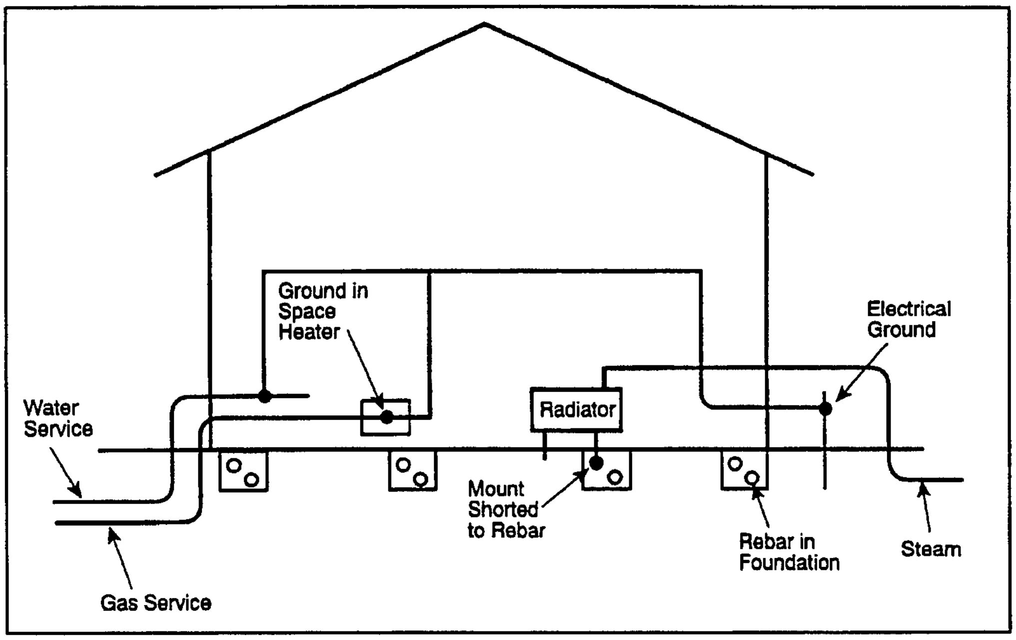

Figure 2. Examples of electrical continuity problems in buildings.

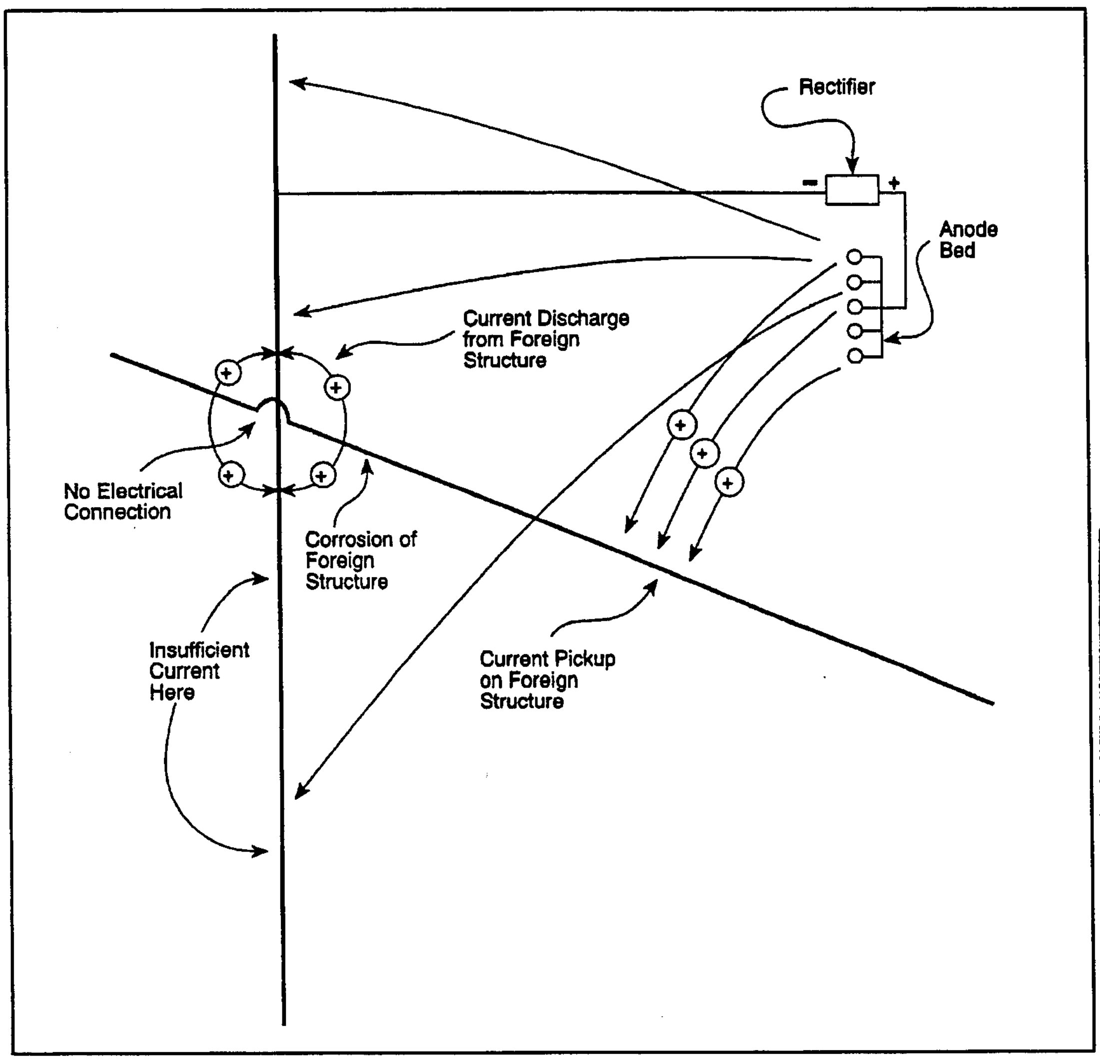

Figure 3. Example of interference.

NFESC CONTACTS

Mr. Jim Jenkins, Code ESC63
Waterfront Materials Division
Comm: (805) 982-4797, DSN: 551-4797
FAX: (805) 982-1197
or
Answering Machine: Comm: (805) 982-4070, DSN: 551-4070

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-018*

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE June 1995	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE

CATHODIC PROTECTION SYSTEM DESIGN I -- The Pre-Design Field Survey

5. FUNDING NUMBERS

6. AUTHOR(S)

Jim Jenkins

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSE(S)

Naval Facilities Engineering Service Center
Port Hueneme, CA 93043-4328

8. PERFORMING ORGANIZATION REPORT NUMBER

TDS-2020-SHR

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESSES

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

There are two basic scenarios for the design of cathodic protection systems: designing cathodic protection of a new facility and retrofitting the cathodic protection of an existing facility. In both cases, it is necessary to determine many site and facility specific factors in order to design a successful cathodic protection system.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Cathodic protection system design, pre-design field survey, electrical engineering cathodic protection	3
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL