REMR Technical Note EM-CR-1.3

USE OF CERAMIC ANODES TO PREVENT CORROSION

PURPOSE: To describe a method to prevent corrosion of metallic structures immersed in water.

DESCRIPTION: This method involves applying a small electric current from an outside source to the corroding structure. One ampere of current will keep 500 sq ft of uncoated steel from corroding. This current is applied through an anode which is eventually consumed (by the current). The anode is the positive terminal in the circuit, and the structure is the negative.

The ceramic anode (Figures 1 and 2) developed by the Construction Engineering Research Laboratory is proving to be a major technological breakthrough in corrosion prevention. The consumption rate of conducting ceramic materials such as precious metal oxides is 20,000 times lower than that of currently used silicon-iron and graphite anodes. The system consists of a mixed metal oxide coating (RuO_2 or IrO_2 with TiO_2) on a passive metal substrate (titanium). It can be fabricated in a variety of configurations tailored to particular cathodic protection applications.

APPLICATION: In the cathodic protection system for navigation lock and miter gates (Figures 3 and 4), the structure is protected by both disc and rod-type ceramic anodes. In the design shown in Figure 3, the skin side of the gate is protected by 15 disc anodes and 8 strings of rod anodes in the quoin and miter areas. More anode material is located in the quoin, miter and gate seal areas because of the amount of uncoated, dissimilar metal present there. A greater level of current is required to protect such areas. The compartment side of the gate (Figure 4) is protected by 1 string of rod anode material in each column of compartments and 8 strings of rod anodes in the quoin and miter.

Ceramic anodes have a limitation of 10 volts maximum which is adequate for installations in water storage tanks, lock gates, and small underground structures. To protect long pipelines or large fuel tanks, more and/or longer anodes are needed. Using these anodes may not be as cost-effective as the conventional high-silicon, cast-iron, chromium bearing anodes.

Dam (tainter) and sector gates are provided cathodic protection by systems of disc anodes and rod anodes respectively.

ADVANTAGES: The use of ceramic anodes has several advantages:

a. The anode has a lightweight design and thus is easier to install.

b. Ceramic coated anodes can be installed underwater, thereby eliminating the need to wait for dewatering of the lock or dam. Normally, dewatering takes places for routine maintenance every 10 to 12 years.

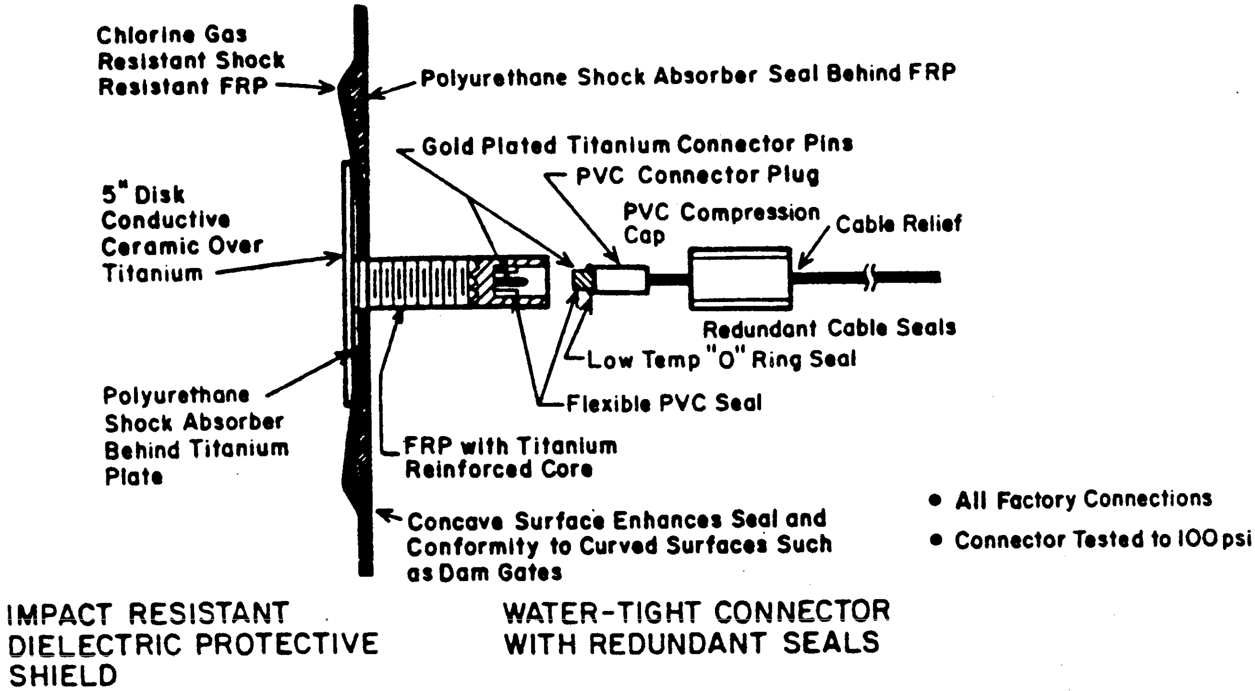

Figure 1 - The Flat Disc Ceramic Anode, 20 cm in diameter, is made of conductive ceramic coating on titanium substrate. The anode-to-wire connection is made of gold-plated titanium pins for redundancy.

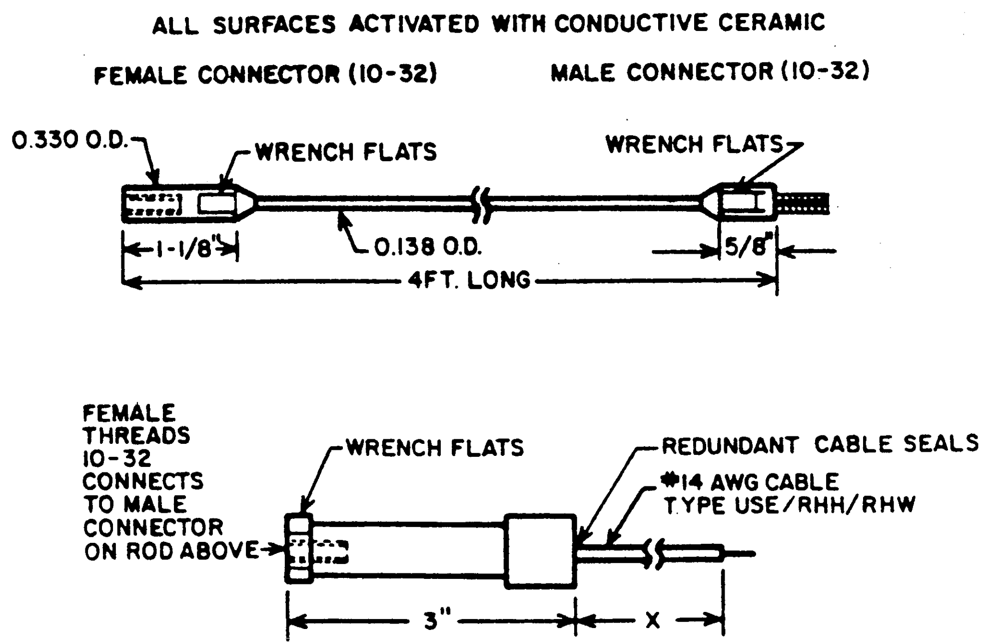

Figure 2 - Rod type ceramic anodes are 1.2 meters long, have a current discharge life of 80 amp-years, and weigh only 18 ounces. An equivalent HSCBSI anode with the same current discharge life weighs 80 pounds. The anode-to-wire connection is made through a titanium connector for redundancy.

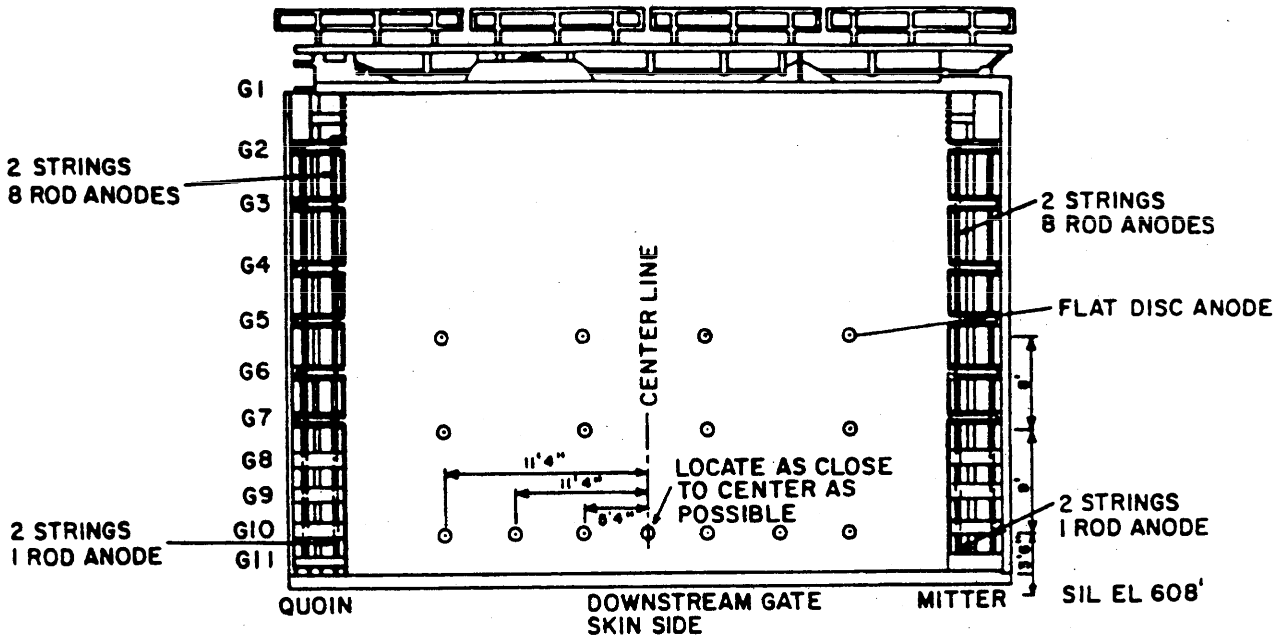

Figure 3 - The skin side of a typical navigation lock gate uses flat disc ceramic anodes as well as rod-type anodes to protect the gates.

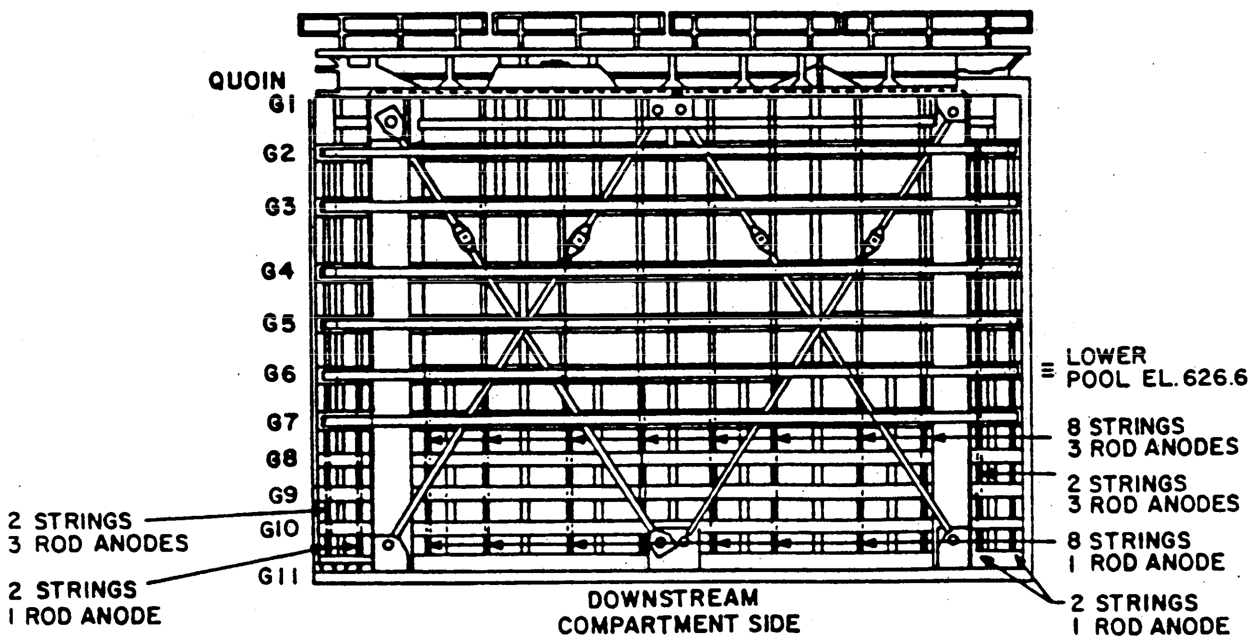

Figure 4 - The compartment side of a typical navigation lock gate uses rod-type anodes enclosed in perforated plastic pipes. The plastic pipes can be protected from mechanical damage from ice by surrounding them with split-steel pipe bumpers.

c. Because the anode has a factory-made connection, the problem of electrical shorting to the gate has been virtually eliminated.

d. The anode is resistant to damage from floating debris.

FIELD PERFORMANCE: Complete cathodic protection systems that use USA-CERL-developed ceramic anodes were installed by the Nashville District on tainter (dam) gates at the Cordell Hull Dam in 1986 and on the Cape Canaveral lock gate (Jacksonville District) in April 1987. Ceramic anodes were also installed on miter gates at Pike Island, WV, by the Pittsburgh District in 1987. Pittsburgh District also installed ceramic anodes on miter gates at Maxwell Lock, PA, in August 1987.

TM 5-811-7 and Guide Specifications have not yet been revised to include the ceramic anodes. OCE, the technical monitor of the ceramic anode development at CERL, was not able to provide a date when the revision would be done.

BACKGROUND: For the past 30 years, silicon iron and graphite have been used in making cathodic protection anodes. However, these materials are brittle, cannot be machined or welded, and have consumption rates of about 1 lb per ampere-year; that is, if 1 ampere of current is passed through the anode for 1 year, 1 lb of the anode will be consumed. Consequently, large anodes have been required. The size of these anodes made them vulnerable to debris or ice damage and also prone to field installation problems, such as failure of the field-made anode-to-wire connection.

Ceramic anodes installed at Fort Ord and in TM 5-811-7 are outdated per CERL, 26 April 1987.

ENVIRONMENTAL CONSIDERATIONS: When used for the protection of potable water supply systems, appropriate local, state, and federal health standards should be followed.

REFERENCES:

a. Ceramic coated anode for cathodic protection. A. Kumar, E. G. Segan, J. Bukowski. In: Materials Performance, Vol 23, Jun 1984.

b. Improved ceramic anodes for corrosion protection. J. H. Boy et al. Technical Report M/85/02/A149492, US Army Construction Engineering Research Laboratory, Champaign, IL, 1985.

c. Ceramic anodes prevent corrosion. A. Kumar. In: The Military Engineer, Vol 77, No. 502, pp 436-437, 1985.

d. New cathodic protection designs using ceramic anodes for navigation lock gates. In: Corrosion '87, Paper No. 71, Mar 1987.