Internal Cathodic Protection (CP) Systems in Oil-Treating Vessels

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Foreword

This standard practice is a general guide for the application of effective cathodic protection to all types of oil-treating vessels containing a free water phase. This standard covers design criteria, the selection and installation of applicable systems, and the operation, monitoring, and maintenance of installed systems. There are many design variations in existing oil-treating vessels, with new designs being introduced continually. The preparation of standard practice for the cathodic protection of each vessel design is not practical. Therefore, this standard is not specific concerning one or more vessel designs. It is intended for use by corrosion engineers involved in oil and gas production, especially those concerned with surface facilities. Nothing contained in this standard is intended to conflict with applicable codes, including OSHA[(1)] regulations. Coatings and materials are discussed in this document in conjunction with the cathodic protection design, as the coating is a major factor when designing a cathodic protection system.

Scope

This standard provides a general guide for the application of effective cathodic protection (CP) to all types of oil-treating vessels containing a free water phase (the electrolyte). It is intended to be used by facility owners, contractors, inspectors, vessels equipment specialists, CP system designers, manufacturers, and others concerned with corrosion mitigation by using cathodic protection systems. The procedures in this standard may best be applied under the direction of a corrosion engineer and by persons with experience and knowledge of the design, installation, operation, maintenance, and control of corrosion protection in the oil-treating vessels containing the electrolyte.

Coatings and materials are discussed in this document in conjunction with the cathodic protection design, as the coating is a major factor when designing a cathodic protection system.

Rationale

The standard is being revised to comply with AMPP's five-year review policy. It has been updated to reflect current industry technology and terminology.

> In AMPP standards, the terms *shall* and *must* are used to state requirements and are considered mandatory. The term *should* is used to state something that is recommended, but is not considered mandatory. The term *may* is used to state something considered optional.

[(1)] U.S. Occupational Safety and Health Administration (OSHA), www.osha.gov.

Section 1: General

1.1 This standard presents recommended practices for the cathodic protection (CP) of internal surfaces of oil-treating vessels, heat exchangers, or the waterside of process vessels. This standard provides a tool for managing and maintaining the integrity of the oil-treating equipment of concern. CP is one of the effective methods used in the Industry for managing internal metal loss in oil-treating vessels caused by corrosion due to the presence of the electrolyte. The design and operation of the CP system must consider the effects of the electrolyte type, properties, and composition, as well as the properties of the other phases present. In addition, the service type, and variations of operating conditions of the oil-treating vessel must be an integral part of the CP system design, operation, and maintenance. It is recommended that this standard be used in conjunction with the other applicable AMPP standards and practices, as well as with other industry standards.[1-17]

1.2 The provisions of this standard should be applied under the direction of a corrosion engineer. The term "corrosion engineer," as used in this standard, refers to a person who, because of knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control. Typically, a Cathodic Protection Specialist would perform the design.

1.3 Effective performance of the CP system requires operation within the limits of the design, monitoring of the system, and maintenance to replace damaged and consumed parts.

1.4 CP is not effective when applied to steel surfaces in the oil or gas phase because of the absence of a free water phase (the electrolyte). Coatings or chemical inhibitors should be used as a primary defense to control corrosion on the steel surfaces in the oil and gas phase.

Section 2: Definitions

Cathodic Protection Specialist: A person trained and qualified in CP, typically an AMPP Cathodic Protection Specialist or AMPP CP4 or per ISO 15257 an Inner Surfaces of Metallic Structures Containing an Electrolyte Certification.

Corrosion Engineer: A person, who because of knowledge of the physical sciences and the principles of engineering and mathematics acquired by professional education and related practical experience, is qualified to engage in the practice of corrosion control.

Electrolyte: A chemical substance containing ions that migrate in an electric field. For the purpose of this standard, electrolyte refers to the free water phase, including the chemicals contained therein, adjacent to and in contact with a submerged bare metal surface.

GACP—Galvanic Anode: A metal that provides sacrificial protection to another metal that is more noble when electrically coupled in an electrolyte. This type of anode is the electron source in one type of cathodic protection, also known as Sacrificial Anode Cathodic Protection (SACP).

Salt Bridge: A salt solution used with a reference electrode to bridge a gap in an electrochemical cell to enable free flow of ions (electrical current).

Steel-to-Water Potential: The potential difference between a steel vessel surface and a reference electrode immersed in the free water phase with which the steel vessel surface is in contact (sometimes referred to as cathodic solution potential).

Note: Refer to NACE/ASTM G193, Standard Terminology and Acronyms Relating to Corrosion,[14] for any definitions not included in the above list.

Section 3: Determination of Need for CP

3.1 General

3.1.1 Experience reveals that corrosion and metal loss are to be expected in any oil-treating vessel in which any portion of the internal steel surface is exposed to oilfield brines because of their aggressive corrosive nature. The need for CP is contingent on the severity of existing or anticipated corrosion and the extent to which it affects equipment operation. Consistent with the latter, CP should be installed when it will accomplish one or more of the following: remove or minimize unsafe conditions caused by failure, provide economical control over equipment failures and losses, and remove or minimize the possibility of vessel content loss because of leaks or vessel collapse.

3.1.2 In the water-wetted zone of oil-treating vessels, internal coatings (linings) are the primary defense against corrosion and may be used in conjunction with CP. The typical selection of coatings (linings) for the specified service shall evaluate the following parameters:

a) Design and operating pressure.
b) Design and operating temperature.
c) Thermal dilatation differences between the vessel steel wall and the internal coating.
d) Internal turbulence and interstitial velocities in the water wet zone.
e) Levels of corrosive gases (H_2S/CO_2).
f) Water-to-fluid and gas operating ratios.
g) Microbial presence and activity.
h) Levels of solids and sludge entrainment (silts, fines, sand).
i) Chemical additives (process treating chemical, well stimulation).
j) Maintenance mechanical and pressure water cleaning.
k) Maintenance steam and chemical cleaning.
l) Vessel configuration (confined and “dead” zones, cone bottoms, etc.).
m) Configuration and sizes of nozzles, flanges, and other wall penetrations.
n) Coating stability in long-term service.
o) Coating pressure sensitivity (pressure and decompression cycling).
p) Coating sensitivity to CP disbondment at service conditions.
q) Water-wetted zone level stability and/or fluctuation during the steel vessel service.

The internal coating (lining) reduces the surface area of unprotected steel and thus reduces the required size of the CP system.

3.2 Corrosion Rates

3.2.1 The corrosiveness of a fluid stream is a function of the following:

3.2.1.1 Corrosion usually becomes more severe as the conductivity (dissolved solids content) of water (the electrolyte) increases, but low-conductivity water can also be corrosive.

3.2.1.2 Corrosion in produced oilfield brines usually increases as the partial pressure of acid-forming components, such as carbon dioxide (CO_2) or hydrogen sulfide (H_2S), increases.

3.2.1.3 Corrosion is accelerated by even trace amounts of oxygen.

3.2.1.4 Accumulation of foreign deposits such as silts, corrosion products and/or microbial encrustations can trigger under deposit corrosion.

3.2.1.5 Corrosion usually increases with increasing temperature unless scaling is increased.

3.2.1.6 Corrosion usually increases with increasing flow velocity and turbulence.

Section 4: Design and Selection of CP System

4.1 Basic Design Criteria

4.1.1 The design of a vessel's CP system depends on the internal configuration of the vessel. Selection of the appropriate system depends on factors such as initial cost, maintenance, type, condition, the anticipated longevity of the coating (lining), (if any), power availability and cost, and system life.

4.1.2 Vertical cylindrical vessels containing no baffles, compartments, firetubes, etc., are usually protected with anodes or strings of anodes suspended from the deck (roof) of the vessel. This design method offers two advantages over other designs: (1) better current distribution because anodes are parallel to the vessel walls, and (2) deteriorated or depleted anodes can be replaced without lowering the water level or draining the vessel.

4.1.3 Compartmented vessels or those containing baffles, firetubes, spreaders, etc., should have at least one anode installed in each compartment exposed to the corrosive fluid. If a vessel is not designed to accommodate a CP system that will provide effective protection throughout, it may be necessary to make modifications or redesign the vessel interior to provide access to areas needing CP by installing fittings in the vessel for inserting anodes through the walls. An example of such modification is the positioning of a spreader in a heater treater below the firetubes so there is sufficient clearance to install an anode between the firetube and spreader.

4.1.4 To function properly, the CP anodes must be continuously submerged in the water-wet zone of the vessel. Correct location and position of anodes in vessels are essential for proper current distribution. CP anodes should be placed such that their protective current can be distributed to all surfaces exposed to the corrosive electrolyte. Each anode should be located as near to the center of the compartment or the center of the minimum anticipated free-water (electrolyte) level as practical.

4.1.5 Factors determining the number, weight, and shape of anodes required for CP of vessels are:

a) area of water-immersed uncoated steel to be protected;
b) the current density required;
c) anticipated current output of the anodes and their expected service conditions (i.e., electrolyte temperature, pH, aggressivity, etc.);
d) anode manufacturer's recommended maximum allowable current discharge of each anode type in the target service;
e) vessel configuration; and
f) desired life of the CP system.

4.1.6 Current density requirements can range from 54 to 430 mA/m^2 (5 to 40 mA/ft^2) of uncoated water-immersed steel. In the absence of specific current density data, 108 mA/m^2 (10 mA/ft^2) is commonly used for design, unless produced water can be shown to be fresh to brackish, cool and slow moving, a minimum current density of 430 mA/m^2 (40 mA/ft$^{2)}$ should be used. Vessels handling water-containing depolarizers, such as H_2S and oxygen, or operating at high temperatures or high flow rates, could require higher current density to maintain protective potentials. Internal coating of vessels decreases the area of uncoated steel in contact with water and reduces the amount of current required for corrosion protection.

4.2 System Selection

4.2.1 CP can be provided by impressed current cathodic protection (ICCP) or galvanic anode cathodic protection (GACP) systems. Performance data commonly used for the two CP systems' anodes are shown in Table 1. Before the application of either of the two CP systems' anodes, it must be ensured that service electrolytes are chemically compatible with the anode.

Table 1
Anode Performance Data for Commonly Used ICCP and GACP Systems

Type of Anode	A-h/kg[(A)]	A-h/lb.[(A)]
	ICCP Anodes	
Linseed oil-impregnated graphite	13,000 to 15,000 (14,000)	6,000 to 7,000 (6,500)
High silicon cast iron with chromium	18,000 to 24,000 s (19,000)	8,000 to 11,000 (8,500)
MMO Ti Anode[(B)]	6 mg per amp year in seawater / 0.5 to 1 mg per amp year in soil or fresh water	
	GACP Anodes	
Magnesium	1,000 to 1,100 (1,000)	450 to 500 (450)
Aluminum[(C)]	400 to 2,000 (1,300)	200 to 950 (600)
Zinc[(D)]	700 to 800 (800)	300 to 350 (350)
–High Temperature Zinc Anode[(E)]	690 to 780 (780)	290 to 350 (350)

[(A)] Values in parentheses are commonly used in design calculations.

[(B)] MMO (Mixed Metal Oxide) ICCP anodes have a very low consumption rate and thus they are typically rated for a given output and service life.

[(C)] Caution: The performance and efficiency of aluminum anodes vary with the alloy, and with certain alloys, they vary with the heat treatment. Their performance declines at temperatures exceeding ~40 °C (~100 °F). Magnesium GACP anodes are recommended for high-temperature, and/or high-resistivity electrolytes.

[(D)] Zinc GACP anodes use is limited to service temperatures below 54 °C (130 °F) and low resistivity electrolytes. Zinc anodes may reverse polarity when operated above 54 °C (130 °F).

[(E)] A special high temperature zinc alloy has been developed and tested to 85 °C (185 °F) to meet the demand for a GACP anode for use at elevated temperatures in a low resistivity seawater environment.

Note: Anode efficiencies vary widely, particularly for GACP anodes. Factors influencing this include anode locations, position and surface area, electrolyte composition, pH, service temperature, and selective electrochemical attack.

4.2.2 ICCP systems have greater flexibility if high current demand is anticipated.

4.2.2.1 ICCP systems can be used in any water, but are usually the most practical in high-resistivity electrolytes in which an appreciable amount of current is required to achieve protection.

4.2.2.2 ICCP systems typically require more monitoring and maintenance than GACP systems.

4.2.2.3 Automatic potential rectifier systems decrease the likelihood of underprotection or the excessive use of power and coating disbondment resulting from overprotection (see Paragraph 4.3.2).

4.2.2.4 ICCP anodes should be provided with individual lead wires to the rectifier for control and measurement of current output from each anode.

4.2.3 GACP systems are commonly used when electrical power is not feasible to use or is not available. They may be preferred for low-current-requirement installations, even if electrical power is available. The effects of the produced fluid chemistry on the performance of a GACP anode should be considered. The pH of produced fluids containing dissolved CO_2 or H_2S can be lowered to acidic levels that can attack zinc, aluminum, or magnesium. Large concentrations of H_2S may also react with the anode to alter its performance, causing passivation. The possibility of the presence of other impurities, such as amines, emulsions, or even small quantities of mercury, should be considered. Consideration should be given to the effects of the various oilfield treating chemicals and workover fluids that may flow through the vessel being protected. Residual acids from stimulation treatments may cause a severe attack on all GACP anodes. The potential effects of demulsifiers, scale and corrosion inhibitors, drilling mud, and other material that might be added to production should be considered.

4.2.4 GACP anode materials most commonly used are aluminum, magnesium, and zinc alloys. The composition, resistivity, and temperature of the electrolyte largely dictate which material is most suitable.

4.2.4.1 Aluminum alloys are commonly used in brines with resistivities below 100 ohm-cm. Aluminum's lower driving potential, compared with that of magnesium, leads to lower current output and longer life. Generally, more than one aluminum anode is required to provide current output equivalent to that of magnesium.

4.2.4.1.1 Consideration must be given to the selection of the proper aluminum alloy (pure aluminum should not be used as an anode) to ensure adequate protection at the optimum economy. The electrochemical properties (potential and current capacity) of aluminum anodes are dependent on the alloy, the electrolyte composition, and the electrolyte temperature. Temperatures above 49 °C (120 °F) can reduce the current capacity of aluminum anodes and, thus this renders them unusable for elevated tempertaure service.

4.2.4.2 Magnesium alloys are commonly used in brines with resistivities above 100 ohm-cm. Magnesium's higher driving potential, compared with that of aluminum, leads to higher current output and shorter life. If magnesium anodes are used in low-resistivity electrolytes, the current output should be controlled by resistors in the external circuits. Magnesium GACP is the preferred choice for elevated temperature service.

4.2.4.3 Zinc alloys are not commonly used in vessels because they may show a decrease in potential with the increase in electrolyte temperature and may become cathodic to steel (i.e.; reverse polarity) at temperatures of 54 °C (130 °F). A special high temperature zinc alloy has been developed and tested to 85 °C (185 °F) to meet the demand for a GACP anode for use at elevated temperatures in a low resistivity seawater environment. The presence of H_2S in the electrolyte affects the service performance of both zinc alloy types.

4.3 Internally Coated (Lined) Vessels

4.3.1 Correctly applied CP is capable of mitigating corrosion at coating (lining) holidays.

4.3.2 Excessive CP potentials may cause coating damage. Generally, at polarized potentials more negative than –1.05 to –1.10 V (copper/copper sulfate reference electrode [CSE]), excessive hydrogen can be formed and cause coating damage in the form of cathodic blistering and cathodic disbondment. To minimize damage, a coating designed for this service that is formulated to withstand cathodic disbondment and / or cathodic blistering should be used. Elevated service temperatures increase the chance of coating (lining) degradation and/or failure.

Section 5: Anode Installation

5.1 Vertical Suspension / Vertical Cylindrical Anodes

5.1.1 Anodes must be spaced to distribute current uniformly to the vessel vertical water - wetted walls, bottom, and appurtenances, and at a depth that assures some anodes are submerged regardless of water level. Either type of anodes (GACP or ICCP) can be installed in this manner.

5.1.2 ICCP anodes must be suspended from a suitable hanger (deck mount), properly isolated to prevent grounding of the lead wire to the vessel.

5.1.3 GACP anodes should be electrically isolated where current monitoring is contemplated.

5.2 Internally Supported

5.2.1 GACP anodes may be placed on supports on the vessel floor and isolated from the vessel. Anode leads can be brought out through watertight connections welded in the clean-out plate and connected back to the vessel wall. Shunts and resistors may then be installed in the external anode electrical cables (leads) to monitor or regulate anode performance. The leads shall not be used for anode suspension.

5.2.2 Alternatively, GACP anodes may be bolted or welded to brackets permanently affixed to the vessel internal surface. However, this type of installation does not allow any method for monitoring the anode output or knowledge of anode consumption other than by visual inspection. High output magnesium anodes may require shield plates and/or certain stand-offs (separation) for preventing CP disbondment and blistering of the underlying coating (internally coated [lined] steel wall).

5.3 Vessel Wall Placement / Horizontal Cylindrical Vessels

5.3.1 Galvanic or impressed current anodes can be installed horizontally in compartmented vessels through mountings welded into the side of the vessel.

5.3.2 Anode heads for installation in nipples are most commonly made of a nonmetallic (dielectric) material designed to withstand the temperature and pressure within the vessel. The shield portion of the head must be of sufficient length to prevent anode grounding to the vessel or excessive current discharge close to the anode entrance port. In all cases, actual lengths of the nipple and the anode head, as well as the positioning of the nipple on the curved surfaces, must be related in design to prevent this undesired current discharge. Anode entrance ports should be installed during the fabrication of vessels. Materials and welding procedures should be consistent with primary vessel design. Improperly sealed vessel wall penetrations may cause product leakage.

5.3.3 When steel anode mounting heads are considered, they must be properly designed to provide isolation between the anode mounting head and the vessel. Maintaining a proper stand-off of the ICCP anodes from the vessel wall is advisable, although less critical than in the case of the GACP anodes.

Section 6: Reference Electrode Entrance

6.1 Methods

6.1.1 Entrance ports for insertion of reference electrodes should be installed in the vessel at the same time as the anode entrance ports.

6.1.2 The type of vessel wall penetration/port for the reference electrode may differ by the type of the device, i.e., for the permanent or retrievable types of reference electrodes, respectively.

6.1.3 In compartmented vessels, reference electrode ports must be installed as far from the anodes as possible to obtain potentials representative of the steel surface. Typically, for the retrievable reference electrodes, these ports are usually 25 mm (1 in) diameter connections welded into the vessel wall in each compartment and equipped with a 25 mm (1 in) full-opening valve so that the reference electrode may be inserted into the vessel.

6.1.4 In vertical cylindrical vessels equipped with roof-type hatches, the reference electrode may be inserted through the top hatches. If this is anticipated, the anodes should be installed at the maximum distance from the hatch.

Section 7: Criteria for Protection

7.1 Steel-to-Water Potential

7.1.1 The presence of a protective potential should be verified after the vessel is polarized. Depending on service temperature, the polarization normally occurs within two weeks in internally uncoated vessels and within a few minutes in internally coated (lined) vessels.

7.1.2 The internal surfaces of steel vessels are protected if the surface is more negative than -0.85 V vs. a copper/copper sulfate reference electrode (CSE) (-0.80 V vs. an Ag/AgCl electrode). However, if the fluid contains sulfides/H_2S, a protection potential of -0.95 V vs. a CSE (-0.90 V vs. an Ag/AgCl electrode) is required to achieve protection. Polarization and protection of the vessel are generally assured if the potential immediately after switching the CP current off is equal to or more negative than these values.

7.1.3 CP Coupons may be installed to monitor the effectiveness of the CP. The CP coupons shall be electrically connected to the vessel wall and be fabricated from the same type of material. Coupon potential measurements are used to determine the effectiveness or the cathodic protection.

7.2 Coupon Weight Loss Tests

7.2.1 Weight loss coupons may be installed to monitor the effectiveness of the CP. The coupons shall be electrically connected to the vessel wall and must be fabricated from the same type of material. Coupon weight loss measurements are used to determine the effectiveness of protection.

Section 8: Monitoring, Records, and Maintenance

8.1 Monitoring

8.1.1 Operating personnel should visually inspect surfaces under CP for signs of coating (lining) failure or internal corrosion, whenever vessels are opened for cleaning or maintenance. In addition, to determine CP effectiveness periodic thickness measurements of vessel walls should be taken (preferably from the external surface side of the water-wet zone under CP) to determine CP effectiveness by using:

8.1.1.1 Manual UT (ultrasonic) wall thickness measurements

8.1.1.2 Automatic or robotic UT (ultrasonic) wall thickness measurements

8.1.1.3 Opportunistic wall thickness measurements and visual surveys when the vessel is shut down

8.1.2 Potential or anode current output surveys should be made monthly after the initial installation of CP equipment until current requirements are established. After current requirements are established, quarterly surveys are usually adequate, unless dictated otherwise by the local and/or national codes and regulations.

8.1.2.1 Care must be taken in placing the reference electrodes into the treating vessel. For potential measurements, the reference electrodes must be as far from the anodes as possible. In pressure vessels, the reference electrodes are "inserted" (introduced into the vessel against existing vessel pressure) through a full-opening valve installed in the vessel for that purpose (see Paragraph 6.1.2). Reference electrodes manufactured to withstand pressure and temperature can also be permanently installed.

8.1.2.2 Contamination of the reference electrodes (retrievable or permanent types) with oil or sediments such as iron sulfide must be avoided. A salt bridge may be used to prevent contamination of the reference electrode.[18]

8.1.2.3 Location of a reference electrode near an anode may indicate a higher potential than elsewhere in the vessel.

8.1.2.4 Fluctuating or lower than normal free water may result in corresponding changes of CP potentials because of the increased or decreased current density. For an ICCP system, constant potential CP rectifiers are available and recommended for vessels with changing operating scenarios.

8.1.3 GACP anodes are sometimes installed without shunts. However, if the CP system cannot be monitored by potential measurements, shunts of known resistance (normally 0.01 ohm) should be installed. Current measurements can be obtained by measurement of the potential across the shunt of known resistance.

8.2 Records

8.2.1 Record keeping is vital to effective maintenance of CP systems (and thus continued protection of the vessels).

8.2.2 Monthly records should be kept for all ICCP anode installations. The records should show DC voltage and amperage readings for each anode. In parallel, service parameters of the electrolyte shall be recorded as well.

8.2.3 Quarterly records should be kept for GACP anode installations. The records should show current readings on galvanic anodes as well as the service parameters of the electrolyte.

8.2.4 Establish and maintain a database of periodic monitoring and/or performing maintenance to rectify vessel wall penetrations and/or external leaks.

8.3 Maintenance

8.3.1 CP equipment malfunctions should be repaired promptly to ensure desired CP system performance. Corrosion damage can occur whenever the potentials are less negative than the values indicated in Paragraph 7.1.2.

8.3.2 CP system anodes must be replaced periodically as they are consumed. Zero current readings usually indicate deteriorated anodes, broken anode cables, malfunctioning rheostats, or loose connections in the circuit. Low current readings in GACP systems may indicate similar problems.

8.3.3 Zero-reported voltage or current readings may occur because of various malfunctions. The rectifier manufacturer troubleshooting guide should be consulted when such malfunctions occur.

8.3.4 When coating failures or wall loss caused by corrosion are detected by visual inspection during the scheduled or opportunistic shutdown or during periodic UT external wall thickness surveys, the effectiveness of the CP system shall be reassessed. Deterioration of the internal surface or welds may indicate a need for a CP system upgrade, a need for anode quantity increase and/or relocation, or an overall appraisal of the CP system.

Section 9: Safety

9.1 Precautions must be taken to avoid sparks in the presence of flammable substances and explosive gas mixtures that may be present around oil-treating vessels equipped with ICCP systems.

9.2 The cable-to-anode connections in ICCP systems shall never be disconnected, nor shall the anode be removed, while the rectifier is in operation.

9.3 Appropriate precautions to prevent fire or explosion must be taken before a CP system can be installed or repaired in a vessel handling water mixed with oil or gas.

9.4 **CAUTION**: Appropriate precautions must be taken and proper Personal Protective Equipment (PPE) must be worn when monitoring or performing maintenance on CP systems in vessels containing H_2S. If the anodes in such vessels are to be removed for replacement or inspection, the appropriate PPE approved for use in H_2S environments must be worn. Additional information on the toxicity of H_2S can be obtained from the American Chemistry Council's[(2)] "Chemical Safety Data Sheet SD-36"[19] and Dangerous Properties of Industrial Materials.[20]

9.5 The rectifier case, external AC disconnect switch box, and any related metallic equipment must be grounded.

9.6 Depending on the area classification, explosion-proof rectifiers and electrical devices may be required.

9.7 Special gaskets capable of withstanding high temperatures should be used to mount CP anodes, reference electrodes, and associated equipment in fired vessels, particularly if the gaskets are located near the fire tubes.

9.8 Equipment, wiring, enclosures, and installation of CP systems must comply with all applicable local and national codes, including OSHA regulations.

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(2) American Chemistry Council, www.americanchemistry.com.

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