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CORROSION CONTROL OF GAS FACILITIES

O-16

Department: Gas Distribution and Technical Services **Section:** Gas Engineering and Planning

Approved by: [redacted] **Date:** 04-14-05

Rev. #11: This document replaces Revision #10. For a description of the changes, see Page 11.

This document also appears in the following manuals:

- *Gas Applicant Design Manual*
- *Gas Distribution Maintenance Manual*

Purpose and Scope

This gas standard outlines PG&E's corrosion control program for all gas facilities, including PG&E-owned gas gathering lines, gas transmission facilities, and gas distribution facilities maintained by OM&C. UO Standard S4133 applies to CGT-maintained facilities or to gas facilities that are maintained by OM&C but are fully comprised of CGT facilities.

Acronyms

AWG:	American wire gauge
CFR:	*Code of Federal Regulations*
CGT:	California Gas Transmission (organization within PG&E)
CP:	cathodic protection
CPA:	cathodic protection area
CPUC:	California Public Utilities Commission
dc:	direct current
ETS:	electrolysis test station
E&M:	Estimating and Mapping
GD&TS:	Gas Distribution and Technical Services
HMWPE:	high molecular weight polyethylene
HVac:	high voltage alternating current
IGIS:	Integrated Gas Information System
kV:	kilovolts
mA:	milliamperes
MSDS:	Material Safety Data Sheet
mV:	millivolts
NACE:	National Association of Corrosion Engineers
OM&C:	Operations, Maintenance and Construction
PCM:	Pipeline current mapper
P/S:	pipe-to-soil
RSPA:	Research and Special Programs Administration
UO:	Utility Operations
Vac:	volts alternating current
WRO:	work at the request of others (a budgeting term)

References

Document

Gas Standards

Corrosion Control of Gas Facilities

References, continued . . . . . **Document**

Gas Standards, continued

Meter Valves	F-80
Electrolysis Test Station Connection to Main	O-10
Cathodic Protection Rectifiers Installation and Purchasing Data	O-11.1
Connection – Details, Wire Splices	O-12
Galvanic Anodes Installation and Purchasing Data	O-13.1
Flange Insulation	O-22

Utility Operations Standards

Leak Survey and Repair of Gas Transmission and Distribution Facilities	D-S0350/S4110
Cathodic Protection Standards for Cased Pipeline Crossings	D-S0354/S4126
CPA Assessment/Resurvey Procedures	D-S0467
Design and Construction of Gas Distribution Facilities	S0470
Corrosion Control of Gas Transmission Facilities	S4133

NACE Standards

NACE	Standard RPO177

General Information

1. Requirements for Protection

   Install all new, reconditioned, converted, or replaced buried metallic pipeline facilities with an approved coating, and cathodically protect the facilities within 1 year after the installation date. This requirement applies to all gathering lines, transmission lines, distribution mains, and services. This requirement also applies to PG&E-owned, buried, metallic gas houselines maintained and operated by gas distribution.

   Based on 49 CFR, generically:

   - Metal, gas-carrying facilities installed after July 31, 1971, shall be placed under CP within 1 year of completion of construction. Exceptions are noted in 49 CFR 192.455.
   - Metal, gas-carrying distribution facilities with effective coatings installed before August 1, 1971, with active corrosion, shall be protected.
   - Adequately coated gas transmission facilities other than compressor, regulation, and measuring stations shall be protected.
   - Transmission compressor, regulator, and measuring stations with active corrosion shall be placed under CP.

   A. Attachment A describes cathodic protection guidelines for steel mains and services.

   B. Transmission and gathering line cathodic protection requirements shall be determined either by testing or by investigating the historical current requirements. Galvanic anodes or rectifier stations shall be installed as required.

   C. Ensure the following adequately coated equipment is cathodically protected: gathering lines, transmission lines, mains, services, PG&E-owned gas houselines, and other buried metallic gas facilities. Bare or poorly coated steel pipe should not be cathodically protected and shall be subject to the appropriate Leak Survey. Known sections of metallic main and services that are not under CP and are deemed as being in a non-corrosive environment shall be verified that they are included in at most a 3-year leak survey. The corrosion department shall provide a record of the aforementioned facilities to the E&M department, which will ensure that these facilities are part of, at most, a 3-year leak survey. Transmission lines not cathodically protected shall be subject to either an electrical survey every 3 years or an annual flame ionization leak survey.

   D. When pre-August 1, 1971, previously unprotected services or mains are discovered, the party discovering this condition must report it to the corrosion department. If this piping cannot be cathodically protected or it is not practical to protect it, then this piping shall be included in, at most, a 3-year leak survey schedule.

   E. If, in any case, metallic gas carrying facilities that should have been leak surveyed within a given period of time have not been leak surveyed, then the subject facilities shall be surveyed by the end of the following month. If metallic gas-carrying facilities that should have been leak surveyed within a given period of time have

been leak surveyed, then the subject facilities shall be appropriately scheduled for future surveys, if they are not appropriately scheduled.

2. Designing and Installing Cathodic Protection Areas (CPAs)

   Design CPAs according to the following guidelines:

   A. Use good judgment when engineering CPAs so they are not excessively large or small. Ideally, an area should contain no more than 50,000 square feet of steel pipe. This guideline may not apply to some existing systems or to long-line systems.

   B. Complete the "Cathodic Protection Station Report" (Attachment C) for each rectifier location.

   C. Design and operate cathodic protection systems to ensure they do not significantly interfere with other underground metallic structures. Select rectifier sites which maintain a minimum distance of separation between the anode bed and any non-PG&E, underground metallic structures, such as water lines, underground electric lines with bare neutral wires, metal-sheathed telephone or television cable, metal fence posts, electric ground rods and guy wire anchors, and similar facilities. A minimum distance of separation is any distance, verifiable through testing, that does not register interference. Employees must maintain a minimum distance of separation between all anodes and protected gas mains or services to prevent coating damage. Document the results on the "Interference Test Form" (Attachment E).

   D. To prevent coating damage, the P/S on-potential shall not exceed –1,600 mV when measured with a copper-copper sulfate electrode anywhere on the protected, gas-carrying structure. Consider voltage resistance (IR) drop in this measurement. Perform interference response testing or make engineering calculations on rectifier sites that cannot meet the requirements documented in this subheading 2D, as well as in locations where non-PG&E facilities may be affected. Notify non-PG&E facility owners of the new or proposed rectifier sites or of the possibility of increased current outputs. Arrange to conduct testing, if required. Testing should include interrupting the rectifier current and measuring the on and off P/S potentials on nearby non-PG&E facilities. Measure and record hard wire current flows, when necessary. Document the results using the "Interference Test Form" (Attachment E). It is recommended that the highest rectifier reading that does not interfere with other's facilities and does not cause the P/S readings on the gas facilities to exceed –1,600 mV be determined and documented on the "Interference Test Form" (Attachment E). to identify the maximum setting the rectifier could be adjusted to and not require additional interference tests.

   E. For proposed sites, consider establishing temporary drains to measure potential influences and cathodic protection current necessary to protect the area.

   F. Insulating devices may be used in underground vaults. Take care to prevent possible electrical arcing. Use only approved flanges, gaskets, and insulating sleeves for insulating purposes (as described in Gas Standard O-22 or Gas Standard B-45.1). Design the facility to prevent accidental contact or shorting across the insulating device (i.e., avoid using foil-backed sound insulation on vault lids; it could fall and contact the insulating device).

   G. It may be necessary to provide galvanic grounding or other protection in the following cases:

      (1) On pipelines which closely parallel HVac electric transmission lines.

      (2) On pipelines where the anticipated or measured voltage between the pipeline and ground exceeds 15 Vac open circuit or has a source current capacity of 5 mA. For example, protect pipelines that parallel 230 kV or 500 kV HVac circuits of appreciable distance (over 1 mile) and are within 1,000' of a HVac conductor, and any pipeline that parallels a HVac circuit for any distance when the separation is small.

      (3) On pipelines where the electrical transmission towers are present.

      The need for special precautions is greater when electric loads are higher, and when pipelines are well-coated and/or installed in high-resistance soil. These precautions apply to both pipelines under construction and pipelines operated under the conditions described in this section (Item 2G). See the NACE Standard RPO177 for additional guidelines, or contact the respective CGT Corrosion Engineering section, if applicable.

   H. Install wire test leads according to Gas Standard O-10 and at the following locations:

      (1) At new installation transmission/distribution pipeline areas.

      (2) On both sides of buried, insulated fittings (Type D installation as shown in Gas Standard O-10).

      (3) On pipeline at new cased crossings (Type B installation as shown in Gas Standard O-10), where the casing cannot be determined to be continuous, or where specified by other standards.

(4) Consider installations on crossings with other metallic pipelines.
(Additional test leads should also be attached to major non-PG&E pipelines, if the owners will consent.)

(5) In enough additional locations to ensure that the pipeline is accessible at least every 3 blocks on distribution and every 1 mile on transmission.

(6) Install current span test stations at least every 5 miles for gathering and transmission lines (Type E installation).

(7) One on each side of a rectifier (Type F installation as shown in Gas Standard O-10).

(8) When installing numerous plastic services on a steel main, test leads are required every 1,500' unless there is sufficient access to the pipeline at existing test leads or existing steel services.

I. Where stray currents from non-PG&E protection systems, both cathodic and anodic, are detrimentally affecting the cathodic protection of PG&E gas lines, contact non-PG&E facility owners and take corrective measures to limit or eliminate the stray current condition. Non-PG&E protection systems may include pipelines, transit systems, telluric earth currents, etc. When other's facilities are to be installed near existing PG&E gas-carrying facilities and these foreign facilities are likely to cause interference to PG&E's gas-carrying facilities, then the other party should be contacted and before-and-after readings should be taken regarding PG&E's facilities. If interference is encountered, the third party must be informed of the situation and told to correct the situation. This investigative work should be charged to WRO expense.

J. Clear all CPA contacts before designating the CPA as protected. Before excavation, when practical, confirm the location of underground contacts with current span calculations as well as with a locator (PCM, Tinker, or pipe locator). Cathodic protection systems will be considered adequately protected when the lowest P/S on-potential is a minimum of −850 mV with reference to copper-copper sulfate electrode with protective current applied. Other NACE recognized protection criteria may be used when the −850 mV on-potential criteria is not practical. Obtain baseline current profiles with a PCM unless extenuating circumstances (such as the gas main running in the middle of the street) dictate otherwise. Trace the PCM currents to 15 mA and hard-wire currents to 50 mA. It is typical that the PCM transmitter current is set at one-third of the CP current during "final span down."

K. When trying to account for current on transmission and gathering lines, employees may use a combination of protective current history, current requirements representative of the age and type of coating, P/S potentials, electrical surveys, or other methods to account for current when spanning is not practical (i.e., too few spans or services off the pipeline). In areas where there is reasonable evidence that other facilities contact the transmission lines, perform electrical surveys such as close interval P/S potential readings, PCM, or tinkering.

L. The number of final P/S on-potential readings (P/S profile) which are conducted when an area is initially placed under protection or as part of a resurvey shall be one per block, if read points are reasonably available. When there are one-way solid steel multiblock mains, there is no need to take a P/S reading for each block. A reading should be made at least at the beginning and the end of the main or in close proximity of the end of the main.

M. Gathering lines and transmission lines shall use the method described above (Item 2L) except when there are no branch services. Final P/S readings should document approximately one P/S potential reading per mile, unless field conditions warrant otherwise.

N. Meet cathodic protection requirements for buried, metallic, PG&E-owned gas houselines by ensuring that the gas houseline is insulated from the service line (normally at the service riser valve) and is insulated at the original gas meter location or at the first point that the gas houseline comes above ground. Do this by using an insulating union. Apply cathodic protection with at least one 5-pound zinc or at least one 9-pound magnesium anode that is electrically attached to the buried gas houseline. The coating on the gas houseline will be an approved PG&E coating as listed in Gas Standards E-24 and E-25. This facility shall be part of the 10% monitoring program. Cathodically protects the facility for 1 year after the date of creation and/or installation.

O. All gas construction jobs installing buried steel, gas-carrying facilities (pipeline, main, or service) or tying plastic mains into existing buried steel, gas-carrying pipelines or mains must ensure that the cathodic protection levels of the affected steel facilities are checked before closing out the job. Note the cathodic protection levels on the as-built construction drawing where the P/S measurements were taken. Each applicable construction job drawing must be stamped with the stamp shown in Figure 1 on Page 5. A corrosion mechanic or other qualified* employee must sign off on the as-built construction drawing before the job is completed. If only full-length plastic services are installed, the above requirement does not apply. Report

* A qualified employee is an employee trained to take a P/S cathodic protection measurement.

any deficiencies in the cathodic protection levels to the local corrosion supervisor for remedial action. Do not consider a construction job to be complete and ready to be closed out until adequate cathodic protection levels are noted on the installed or affected steel facilities.

Installation Tested or Inspected and Noted on Drawing. All Levels Satisfactory per PG&E GS&S O-16	
Qualified Employee	**Date**
Corrosion mechanic's signature is required when a CPA boundary is within the scope of the project.	

Figure 1
Stamp Used on the Construction Job Drawings

3. Cathodic Protection Maintenance and Operation

Maintain cathodic protection systems according to the following procedures:

A. Rectified Areas

In rectified areas, employees shall monitor for cathodic protection effectiveness according to the schedule listed in Table 1 on Page 5.

B. Transmission, Gathering Lines, and Distribution Mains Maintained by OM&C

The test locations selected for monitoring cathodic protection effectiveness shall be representative of locations where the level of protection is the lowest for that CPA or shall be at locations where the loss of effective cathodic protection in the CPA would be detected. For CGT-maintained facilities, this includes at least one pipeline and casing test station per casing and one test station on both sides of insulating devices.

C. Monitoring Schedule

As documented in a state of California Waiver Resolution, PG&E is exempt from the federal CPA Rectifier Inspection Monitoring Schedule as required in 49 CFR 192.465 (b). Reference: CPUC Resolution SU-39 February 23, 1996, Order Authorizing Pacific Gas and Electric Company to Deviate From General Order 112-D, Section 192.465 (b), to Exempt the Company From the Requirement of Bi-Monthly Rectifier Inspection (A copy of this waiver is located in the *Gas Distribution Maintenance Manual*, Section II, Part O). The approved monitoring schedule is shown in Table 1 on Page 5.

Table 1 Schedule of Monitoring Intervals [1]

	P/S Monitoring	Rectifier Monitoring
UO, CGT [2]	Bimonthly [3]	Annually [4]

[1] Record P/S measurements on a PG&E "Standard Cathodic Protection Maintenance Report," Attachment D.
[2] CGT intervals are the same as UO when maintained by UO.
[3] "Bimonthly" means six times each calender year with intervals not to exceed 2-1/2 months.
[4] "Annually" means once each calendar year with intervals not to exceed 15 months.

In some distribution rectified CPAs, yearly, routine, P/S on-potential monitoring points can be established in addition to required bimonthly monitoring points. These yearly locations do not have an "anniversary month" but may be read at any time during the calendar year. Each rectified distribution CPA must have at least one bimonthly, routine, P/S on-potential monitoring point.

D. Test Locations

Test locations selected for monitoring cathodic protection effectiveness shall be representative of locations where the level of protection is the lowest for that CPA or shall be at locations where the loss of effective CP in the CPA would be detected.

Caution: Before taking pipe-to-soil readings at the meter sets and/or risers, be aware that there could be an unexpected ac potential at the meter set.

E. Yearly Reads

Yearly P/S on-potential monitoring points shall be established to supplement required bimonthly monitoring points on distribution CPAs in the following circumstances:

- Where previous history reveals locations where a segment has and could become isolated and not be detected by the routine monitoring, a yearly read shall be established.
- Where a regulator station is tied to a CPA via a wire, the regulator station shall be established as a yearly read.

These yearly read locations do not have an "anniversary month," but shall be read at least once during each calendar year.

Additionally, consider establishing yearly monitoring points at locations where the failure of a locating wire is probable and may cause a section of steel main to become unprotected. Yearly monitoring points may also be established at other points to further verify the effectiveness of CP within the CPA.

F. Rectifier Monitoring and Maintenance

Rectifiers shall be monitored annually. A "Rectifier Test and Site Evaluation" form (Attachment A of Gas Standard O-11.1, Form FO-11.1-A) shall be completed and filed in the CPA file, each calendar year, with intervals not to exceed the day of the previous read on the 15th month, to ensure that they are functioning correctly. Include the voltage and amperage measurements when taking rectifier readings. Also, record the rectifier readings on the PG&E "Standard Cathodic Protection Maintenance Report," Attachment D, when it is being used for the bimonthly P/S readings.

G. Rectifier Adjustment

If the rectifier output (amperage) needs to be increased to achieve effective levels of cathodic protection, an additional interference test may be required to ensure that the interference is not occurring on non-PG&E structures. It is recommended that the highest rectifier reading that does not interfere with other facilities and does not cause P/S readings on the gas facilities to exceed –1,600 mV be determined and documented on the "Interference Test Form," Attachment E, to identify the maximum setting the rectifier could be adjusted to and not require an additional interference test. A previous interference test within 20% of the new higher current setting is sufficient to meet this requirement, if this new higher setting does not exceed a level where previous testing identified interference or excessive P/S readings within the CPA. Clear all contacts before raising the rectifier amperage output settings. In addition, document the reason the rectifier output setting had to be adjusted on the back of the "Standard Cathodic Protection Maintenance Report," Attachment D. Acceptable reasons for adjusting the rectifier outputs include:

(1) Tying another CPA into the area.

(2) Disconnecting another rectifier in the CPA.

(3) Adding more steel piping to the CPA.

(4) Adjusting for summer dryout conditions.

(5) Deterioration of pipe coating.

H. Casing Monitoring and Maintenance

Casing monitoring requirements are included in UO Standard D-S0354/S4126.

I. Remote Monitoring

Cathodic protection rectifier locations, or P/S locations, can be monitored remotely to meet PG&E requirements. The gas distribution, cathodic protection remote monitoring system will be programmed to take a minimum of one daily reading and report a reading weekly. The gas distribution remote P/S system will initiate an alarm if a reading is out of range for a prescribed time period or if any other prescribed alarm conditions exist. Any field-based system alarm shall be treated the same way as a P/S being found down. Electronic reading data may be kept as official data for the current year and previous years. The minimum electronic P/S on-read data for a CPA that had no down reads is one set of reads per month. The hard copy of the monthly consolidated electronic P/S data will be printed, reviewed and signed by the corrosion mechanic and the supervisor, and filed in the CPA file.

J. CPA Restoration

(1) Schedule CPAs for restoration when the areas show P/S on-potentials to be below adequate levels of protection. Check rectifier readings before restoring a CPA. Restore areas within 30 calendar days from the date they are found to be inadequately protected, as defined by the current version of 49 CFR 192, Subpart I (barring acceptable extenuating circumstances). Document the reason(s) for any delays in the restoration work. Once restored, an area shall have approximately the same P/S on-potentials and rectifier output as existed before the level dropped, unless re-evaluation of the system indicates that different values are more appropriate. After the CPA has been restored and re-polarized, record final P/S on-potential measurements on the PG&E "Standard Cathodic Protection Maintenance Report," Attachment D.

(2) Extenuating circumstances may cause a CPA's restoration to go beyond the 30-calendar-day timeframe. Examples of acceptable extenuating circumstances may include employee safety, public safety, population density, environmental concerns, climatic conditions, material availability, government permitting processes, and land acquisition requirements. PG&E employees shall determine if CPA restoration work is being delayed by an acceptable extenuating circumstance.

Some suggested interim or, in some cases, permanent steps that can be taken to resolve or mitigate the down time or the extent of the downage area are:

- Bonding the CPA to an adjacent CPA.
- Appropriately adjusting the rectifiers (validate that there is no interference or excessive P/S readings).
- Installing shallow bed anodes.
- Installing galvanic anodes.
- Isolating the suspect problem services and/or mains from the CPA and proceeding to restore CP to isolated facilities.

Any of the above mentioned actions, if taken, shall be documented in the respective CPA records.

(3) If the CPA restoration work is (or is expected to be) over 30 days, the "CPA Follow-Up Action Plan" form (Attachment B) must be used and developed within 30 calendar days from the date the CPA is found below adequate levels of protection, as defined by the current 49 CFR 192, Subpart I. The action plan shall list and document the extenuating circumstance(s), to the extent known, the cause of the CPA problem (to the extent the cause is known), the desired solution(s), the actions needed to implement the solution, the estimated time to take those actions, and the employees who will perform those actions. The action plan shall be updated in intervals not exceeding 30 calendar days, until the CPA restoration work is completed and the CPA shows adequate levels of protection. Updates to the action plan shall document the incremental work that has been completed to date, detailed status updates of needed actions that have not had any significant progress from previous updates, and the work that needs to be completed to achieve adequate protection. (Reference: WIN. DOT - DOT RSPA Interpretation Letter #16 for 49 CFR 192.465 – May 19, 1989.)

(4) Attachment B is the "CPA Follow-Up Action Plan" form. When using this action plan, file it with the respective CPA P/S maintenance worksheet. Document routine circumstances using the back of the "Standard Cathodic Protection Maintenance Report," Attachment D.

(5) The OM&C office or CGT pipeline department shall provide a monthly status report regarding CP maintenance on CGT gas facilities to CGT. The OM&C office shall provide a monthly status report regarding CP maintenance on gas distribution facilities to Engineering and Planning.

K. Monitor facilities protected with galvanic anodes by using P/S on-potentials as follows:

(1) Annual Galvanic: Monitor isolated gas distribution main pipe segments that are over 100' long but less than or equal to 8 blocks of steel main or 1 mile of steel main at least once each calendar year, but with intervals not to exceed 15 months from the day of the previous read. Monitoring includes plastic systems using locating wire to distribute protection to steel service risers, steel pipes, steel valves, etc. Consider monitoring these sections more frequently, as conditions justify.

(2) Bimonthly Galvanic: For gas distribution galvanic systems that contain more than 8 blocks of steel main or more than 1 mile of steel main, monitoring shall be conducted bimonthly (not to exceed 2-1/2 months) and read not less than six times per year.

(3) 10% Monitoring: Monitor individual isolated services of any length; fittings; individually buried, metallic, PG&E-owned gas houselines; and isolated main segments less than 100' long at least once each 10 years. Monitor at least 10% of all such facilities each year. Each successive year, monitor a different selection of at least 10% of the facilities.

(4) Unprotected Pipe: Evaluate non-insulated sections of unprotected metallic main and services at 3-year intervals using repaired and active leak data.

L. Monitor the cathodic protection on bare transmission line either by performing an electrical survey every 3 years or by performing an annual flamepack ionization leak survey.

M. Review the gas distribution CPAs and bimonthly galvanics as noted in Item K(2) above, using the "CPA Assessment Worksheet" at 5-year intervals not to exceed the final day of the 5th year, using UO Standard D-S0467. This standard is located in the *Gas Distribution Maintenance Manual*, Section II, Part O.

N. Review transmission line CPAs according to methods, schedules, and priorities developed by the CGT Pipeline Re-Evaluation Program. The operating headquarters should use UO Standard D-S0467, except when other methods are developed and recommended by the CGT corrosion engineer. CGT will normally use electrical surveys to re-evaluate pipelines, but may also use the Gas Distribution department's method if the CGT corrosion engineer determines it to be appropriate.

O. Electrically check each PG&E reverse current switch, diode, or interference bond that jeopardizes protection for proper performance annually, not to exceed the day of the previous read on the 15th month.

4. Voltage (IR) Drop Considerations

Always consider the IR drop in the measurement circuit when interpreting the results of P/S on-potential measurements. Elements of the measuring circuit that may cause IR drop include the voltmeter, reference cell placement, reference cell contact resistance, test leads, and pipe and soil resistance.

A. Voltmeters: Take all P/S on-potential measurements with an approved electronic voltmeter, having an input impedance equal to or greater than 10 megohms.

B. Reference Cell Placement: Since it is not always expedient to excavate for the sole purpose of taking P/S on-potential measurements, place the reference cell as close as possible over the pipe. At risers, place the reference cell approximately 6" to 12" from the riser and over the service.

C. Reference Cell Contact Resistance: If sufficient moisture is not present, moisten the ground or the conductive surface (sponge) at a location where the P/S on-potential measurement is being taken.

D. Test Leads: Since only approved voltmeters are used for making P/S on-potential measurements, IR drop in the test leads is insignificant.

E. CP Current Flow: Current flow on a pipeline from cathodic protection can cause an IR drop in the pipe and in the soil. When conducting close-interval surveys, refer the data to the corrosion specialist and/or corrosion engineer to determine if and how the IR drop in the pipe should be considered.

F. Soil: Evaluate the IR drop in the soil using the following considerations:

(1) The 850 mV criterion for cathodic protection was developed with an allowance of at least 50 mV for IR drop and other measurement errors.

(2) The IR drop from a galvanic anode system is usually insignificant due to the small amount of current flow. Typically, the reference cell is placed over the pipe and away from the galvanic anode.

5. Inspection and Leak Repair

Inspect a pipeline for evidence of external corrosion and take remedial action, as appropriate, any time it is exposed.

A. Make a written report of each inspection as outlined in UO/CGT Standard D-S0350/S4110. Use Form 62-4060, "Leak Survey, Repair, Inspection, and Gas Quarterly Incident Report," for all distribution and transmission pipeline facilities and services. Do not mark "Corrosion" as the cause of leakage unless it is observed. If in doubt, contact the local headquarters OM&C corrosion group.

B. Repair, replace, or recoat corrosion-damaged pipe according to the applicable gas standards and UO standards.

C. When external corrosion leaks are repaired on steel pipe that is not cathodically protected, regardless of whether the pipe is wrapped or bare, install at least one 9-pound magnesium or one 5-pound zinc anode

(preferred) direct buried according to the instructions found in Gas Standard O-13.1. Do not install anodes at leak repairs in cathodically protected areas unless they are part of a cathodic protection improvement plan or approved by the corrosion department. Investigate continuing corrosion leakage in protected areas and take corrective measures, where appropriate.

D. Where an external corrosion leak occurs on a buried gas steel transmission line, a corrosion mechanic must take a P/S on-potential measurement and a soil resistivity measurement at the leak repair site. If it is safe and practical, immediately take the P/S on-potential reading at the corroded site as the pipe is exposed. If low levels of protection are identified as a possible cause for the leak, take remedial measures.

E. Where an external corrosion leak occurs on a normally cathodically protected buried gas steel distribution facility, take a P/S on-potential measurement at the leak site at the time of the repair. If low levels of protection are identified as a possible cause for the leak, take remedial measures, if needed.

F. Each external corrosion leak repair on a previously reported, cathodically protected, buried metal gas distribution facility shall be reviewed and evaluated by a qualified corrosion person to determine if any cathodic protection related corrective measures are needed.

(1) If it is discovered that the facility is not under cathodic protection and is not required to be under cathodic protection, the appropriate IGIS changes shall be made. This information should be noted on the Form "A" (Form 62-4060).

(2) If the cathodic protection facility was reported as "down" at the time of the leak repair, this investigation shall be documented in the respective facility's cathodic protection maintenance record. Any actions taken or findings related to a "down" (less than –850 mV) reading shall be noted on the Form "A" and on the respective facility's cathodic protection maintenance record.

6. Internal Corrosion

A. Perform internal corrosion tests, where practical, where evidence of internal pipeline corrosion is noted and has been verified, or where pipeline liquids are present.

B. When found, sample and analyze pipeline liquids according to guidelines in the *Corrosion Manual*. If the sample is determined to be corrosive, initiate an internal corrosion control program. If evidence of internal corrosion is found, regardless of the pipeline liquid sample analysis results, initiate an internal corrosion monitoring and/or control program.

C. The effectiveness of the internal corrosion control program is usually monitored with electrical resistance probes or coupons and data recorded on "Probe Data Sheets" or "Coupon Data Sheets." Also, inhibitor concentrations may be measured by properly sampling liquid and analyzing it at designated liquid collection points. Each pipeline section may have its own internal corrosion control program depending on the operation and environment of that section of the system. Consult the *Internal Corrosion Mitigation Plan* for the specific pipeline sections and for details regarding the internal corrosion control program.

D. It is recommended to take all electrical resistance probe readings and to log them in at monthly intervals not to exceed a period of 90 days for the life of the system or until the probe is retired from service.

E. Whenever steel pipe is removed from a pipeline, inspect it for evidence of internal corrosion. Record this inspection as outlined in UO/CGT Standard D-S0350/S4110 using Form 62-4060, "Leak Survey, Repair, Inspection, and Gas Quarterly Incident Report."

F. It is strongly recommended to swiftly retire idle pipelines that could potentially be wet. This action significantly reduces the risk of internal corrosion and, therefore, the need to eventually treat these idle pipelines with other methods (i.e., installing probes and inhibitor injection sites).

G. Evaluate well sites upstream of PG&E-owned lines that are in potentially internally wet areas of operation (i.e., downstream of a wet well but upstream of dehydration facilities) as described in the *Corrosion Manual*. Log the result of these evaluations.

H. Locate all inhibitor-injection sites on a map. Include information on the type of chemical found, the volume of the chemical tank, and county where the site is located. Send the information to the operating headquarters' environmental coordinator. Update these maps as necessary. They are used to track and determine county permitting and spill plan requirements. Log all information regarding the type of inhibitor and the delivery rates. If possible, set the delivery rates off of the total flow to ensure that chemicals are not delivered to the pipeline when the gas flow is zero. Ensure that all inhibitor injection sites have an MSDS displayed and a placard indicating whether the inhibitor is flammable, since it is considered to be a hazardous material.

7. Records

   A. Maintain records to show the location details of all protected structures. Ensure that the records contain sufficient test data to demonstrate the adequacy of installed corrosion control measures. Maintain a file folder containing location maps illustrating the protected piping system for each cathodic protection system. The file folder should also contain information on the number, kind, and location of rectifiers and anodes; a complete history of monitoring information; bond data; pipe square footage; final saturation P/S on-potentials; final current (PCM/hardwire) spans; gas facility maps; and any other pertinent information. Maintain these records for the life of the facility.

      This is a list of the records that shall be part of the CPA file folder:

      - Maps of all protected facilities.
      - CP station reports for each rectifier.
      - Interference test reports for each rectifier.
      - CP maintenance reports including a complete history of P/S monitoring records and maintenance work.
      - CPA follow-up action plans.
      - PCM or CP hardwire baseline data.
      - Interference and other bond data.
      - CPA current requirement worksheet (all historical sheets and the current sheet).
      - Initial CPA assessment worksheets.
      - A copy of the most current saturation surveys (to verify that the proper P/S locations are being monitored).
      - CPA field resurvey checklist/CPA file review checklist.
      - "Rectifier Test and Site Evaluation" form.
      - Other pertinent information.

   B. Use an approved computer software database management system to maintain part or all of the records and information required in Item 7A.

8. Atmospheric Corrosion Control

   A. General

      This section outlines requirements for lessening the damage caused by corrosive environments to aboveground PG&E gas facilities in compliance with current CPUC General Order 112-E and 49 CFR 192.

      (1) Atmospheric corrosion is present on aboveground or exposed piping by corrosion pitting or substantial wall thickness loss. Surface rust or passive surface oxidation does not constitute atmospheric corrosion.

      (2) Coat all new pipe installed aboveground with a PG&E-approved product (Section E, "Coating and Wrapping," in *Gas Standards and Specifications*). It is strongly recommended to use an approved petrolatum wax tape on manifolds and meter sets in highly corrosive environments.

      (3) Operating organizations are responsible for designating areas subject to aggressive atmospheric corrosion. Use Electric Engineering Document 032911, which defines known aggressive atmospheric corrosion areas. Maps or descriptions of the aggressive atmospheric corrosion areas shall be prepared and maintained by the operating organizations.

   B. Compliance

      (1) Comply with Gas Information Bulletin 171, "Atmospheric Corrosion Program for Exposed Mains and Services."

      (2) Comply with any associated Customer Service standards and procedures relating to atmospheric corrosion.

   C. Monitoring

      (1) Inspect all aboveground gas facilities at intervals not greater than 3 nominal years.

(2) During inspection, analyze all piping or meter sets to determine the extent of corrosion and whether the damaged facility needs to be repaired by removing the corrosion and recoating it, or whether it must be replaced.

D. Maintenance

Complete all repairs or replacements according to the appropriate gas design standards.

E. Coatings

Galvanized piping does not require coating. Take care to minimize the number of scratches on galvanized pipe.

F. Records

Each operating organization shall maintain a file that includes the following information:

(1) A map or schedule of the atmospheric corrosion survey areas.

(2) Documentation from each survey indicating the following information: dates the surveys were taken, physical locations of the pipe requiring remedial attention, the type of action required, and dates of remedial actions taken.

Attachments

Attachment A . . . Cathodic Protection Guidelines for Installing New, Replaced, or Transferred Steel Mains, and Steel or Plastic Services
Attachment B . . Form FO-16-B, "CPA Follow-Up Action Plan"
Attachment C . . Form FO-16-C, "Cathodic Protection Station Report"
Attachment D . . Form FO-16-D, "Standard Cathodic Protection Maintenance Report"
Attachment E . . Form FO-16-E, "Interference Test Form"
Attachment F . . . Form FO-16-F, "Cathodic Protection Area Current Requirements Worksheet"

Revision Notes

Revision 11 has the following changes:

1. Added a caution note to Item 3D on Page 5.
2. Clarified the conditions for establishing yearly reads in Item 3E on Page 6.
3. Added Item 5F on Page 9.
4. Added the instructions for the interference test on shallow bed and deep well anode installations to Form FO-16-E, "Interference Test Form."
5. This document is part of Change 56.

Attachment A

Cathodic Protection Guidelines for Installing New, Replaced, or Transferred Steel Mains, and Steel or Plastic Services

Proposed New or Replaced Gas Facility / Existing Main Piping System	Mains	Services			
	Steel Main	**Direct Burial Plastic Service (See Note 5) or Plastic Service Insert (See Note 6) With Noncorrodible Riser**	**Plastic Service Insert with Noncorrodible Riser Where Plastic Service Locating Wire Cannot Be Inserted Through Service Case Pipe**	**Plastic Service Insert Through Existing Steel Riser (See Note 7)**	**New or Transferred Steel Services or Steel Risers**
Cathodically Protected Steel Main or Plastic Main With a Locating Wire That is Part of a Cathodic Protection System	1. Tie new steel main into existing steel main. 2. Bond existing plastic main locating wire to installed steel main, if doing so does not cross CPA boundaries. 3. Ensure adequate P/S readings on installation. 4. Contact a corrosion mechanic to ensure proper cathodic protection requirements are met.	1. Bond installed plastic service wire to existing steel main or existing plastic main locating wire. 2. Insulate plastic service locating wire from the riser by wrapping it around the service riser. 3. Insulate at the riser valve. 4. Insulate plastic service locating wire from the inserted steel casings.	1. Insulate plastic service locating wire from existing steel main or existing plastic main locating wire. 2. If plastic service locating wire is needed (see Note 7), bond plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Bond another plastic service locating wire to the plastic service case pipe at the riser end of the service case pipe and insulate the plastic service locating wire from the riser by wrapping it around the service riser. 4. Insulate at the riser valve.	1. Insulate plastic service locating wire from existing steel main or plastic main locating wire. 2. If the plastic service locating wire is needed (see Note 7), bond the plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Insulate at the riser valve.	1. Tie steel service at the steel main. 2. Bond steel service to the plastic main wire. 3. Insulate at the riser.
Wrapped, Unprotected Steel Main	**100' or Less Replacement Repair, or Relocation** 1. Tie new steel main to existing steel main. 2. Install at least one 17-pound magnesium or one 15-pound zinc anode on each end of the new pipe. 3. Monitor in accordance with applicable leak survey requirements. **Over 100' and All Main Extensions** 1. Insulate at each end of main-to-main connections. 2. Install the appropriate number of galvanic anodes. 3. Monitor P/S annually. 4. Ensure P/S readings are adequate.	1. Bond installed plastic service wire to existing steel main. 2. Insulate plastic service locating wire from the riser by wrapping it around the service riser. 3. Insulate at the riser valve. 4. Insulate plastic service locating wire from inserted steel casings.	1. Insulate plastic service locating wire from existing steel main. 2. If plastic service locating wire is needed (see Note 7), bond the plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Bond another plastic service locating wire to the plastic service case pipe at the riser end of the service case pipe and insulate the plastic service locating wire from the riser by wrapping it around the service riser. 4. Insulate at the riser valve.	1. Insulate plastic service locating wire from existing steel main. 2. If the plastic service locating wire is needed (see Note 7), bond the plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Insulate at the riser valve.	**Any Length:** 1. Tie to existing steel main. 2. Use an insulated valve stop riser (Gas Standard F-80). 3. Install at least one 9-pound magnesium or one 5-pound zinc anode on the service pipe. 4. Monitor in accordance with applicable leak survey requirements.

Attachment A, continued

Cathodic Protection Guidelines for Installing New, Replaced, or Transferred Steel Mains, and Steel or Plastic Services

Proposed New or Replaced Gas Facility / Existing Main Piping System	Mains	Services			
	Steel Main	**Direct Burial Plastic Service (See Note 5) or Plastic Service Insert (See Note 6) With Noncorrodible Riser**	**Plastic Service Insert with Noncorrodible Riser Where Plastic Service Locating Wire Cannot Be Inserted Through Service Case Pipe**	**Plastic Service Insert Through Existing Steel Riser (See Note 7)**	**New or Transferred Steel Services or Steel Risers**
Unwrapped, Unprotected Steel Main	**10' or Less Replacement Repair, or Relocation** 1. Tie new main to existing main. 2. Install at least one 9-pound magnesium or one 5-pound zinc anode. 3. Monitor in accordance with applicable leak survey requirements. **Over 10' and All Main Extensions** 1. Insulate at each end of main-to-main connections. 2. Install the appropriate number of galvanic anodes. 3. Ensure P/S readings are adequate. 4. Monitor P/S yearly on 10% of those pipe sections which are 100' long or less. Monitor annually if pipe length is over 100'.	1. Bond installed plastic service wire to existing steel main. 2. Insulate plastic service locating wire from the riser by wrapping it around the service riser. 3. Insulate at the riser valve. 4. Insulate plastic service locating wire from the inserted steel casings.	1. Insulate plastic service locating wire from existing steel main. 2. If plastic service locating wire is needed (see Note 7), bond the plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Bond another plastic service locating wire to the plastic service case pipe at the riser end of the service case pipe and insulate the plastic service locating wire from the riser by wrapping it around the service riser. 4. Insulate at the riser valve.	1. Insulate plastic service locating wire from existing steel main. 2. If the plastic service locating wire is needed (see Note 7), bond the plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Insulate at the riser valve.	**Any Length** 1. Insulate steel service at both the main and the riser. 2. Install at least one 9-pound magnesium or one 5-pound zinc anode on the service pipe or a driveable anode per Gas Standard O-13.6. 3. Ensure P/S readings are adequate. 4. Monitor P/S yearly on 10% of these installations.
Cast Iron Main	**Any Length** 1. Insulate cast iron-to-steel transition with an approved insulating coupling (per Gas Standard B-91.4). 2. Install the appropriate number of galvanic anodes. 3. Ensure there are adequate P/S readings on the installation. 4. Monitor P/S yearly on 10% of those pipe sections which are 100' long or less. Monitor annually if pipe length is over 100'.	1. Insulate installed plastic service wire from existing cast iron main by wrapping around tee. 2. Insulate plastic service locating wire from the riser by wrapping it around the service riser. 3. Insulate at the riser valve. 4. Insulate plastic service locating wire from inserted steel casings.	1. Insulate plastic service locating wire from existing cast iron main. 2. If plastic service locating wire is needed (see Note 7), bond plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Bond another plastic service locating wire to the plastic service case pipe at the riser end of the service case pipe and insulate the plastic service locating wire from the riser by wrapping it around the service riser. 4. Insulate at the riser valve.	1. Insulate plastic service locating wire from existing cast iron main. 2. If the plastic service locating wire is needed (see Note 7), bond the plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Insulate at the riser valve.	**Any Length** 1. Install malleable iron saddle, Universal 90. Install a small section of plastic pipe to isolate the service from the cast iron main. 2. Wrap the saddle and tee according to Section E of the *Gas Standards and Specifications*. 3. Install at least one 9-pound magnesium or one 5-pound zinc anode on the service pipe or a driveable anode per Gas Standard O-13.6. 4. Ensure P/S readings are adequate. 5. Monitor P/S yearly on 10% of these installations.

Attachment A, continued

Cathodic Protection Guidelines for Installing New, Replaced, or Transferred Steel Mains, and Steel or Plastic Services

Proposed New or Replaced Gas Facility / Existing Main Piping System	Mains	Services			
	Steel Main	**Direct Burial Plastic Service (See Note 5) or Plastic Service Insert (See Note 6) With Noncorrodible Riser**	**Plastic Service Insert with Noncorrodible Riser Where Plastic Service Locating Wire Cannot Be Inserted Through Service Case Pipe**	**Plastic Service Insert Through Existing Steel Riser (See Note 7)**	**New or Transferred Steel Services or Steel Risers**
Plastic Main (Insert or Direct Buried) With Locating Wire That is Not Part of a Cathodic Protection System	1. Insulate at each end of main-to-main connection. 2. Do not bond existing plastic main locating wire to steel main. 3. Install the appropriate number of galvanic anodes. 4. Ensure P/S readings are adequate. 5. Monitor P/S yearly on 10% of those pipe sections which are 100' long or less. Monitor annually if pipe length is over 100'.	1. Insulate installed plastic service wire from existing plastic main by wrapping it around the tee. 2. Insulate plastic service locating wire from the riser by wrapping it around the service riser. 3. Insulate at the riser valve. 4. Insulate plastic service locating wire from inserted steel casings.	1. Insulate plastic service locating wire from existing plastic main locating wire. 2. If plastic service locating wire is needed (see Note 7), bond the plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Bond another plastic service locating wire to the plastic service case pipe at the riser end of the service case pipe and insulate the plastic service locating wire from the riser by wrapping it around the service riser. 4. Insulate at the riser valve.	1. Insulate plastic service locating wire from existing cast iron main. 2. If plastic service locating wire is needed (see Note 7), bond the plastic service locating wire to the inserted steel casing and wrap it around the tee. 3. Insulate at riser valve.	**Any Length** 1. Insulate steel service at both the main and the riser. 2. Install at least one 9-pound magnesium or one 5-pound zinc anode on the service pipe or a driveable anode per Gas Standard O-13.6. 3. Ensure P/S readings are adequate. 4. Monitor P/S yearly on 10% of these installations.

Notes:

1. For new mains or services, or when reconstructing plastic services by insertion, use AWG No.14 copper HMWPE wire (Code 294378). Use AWG No.10 copper HMWPE wire (Code 294414) for mains.
2. Use compression fittings and wrap them with Tac-Tape (Code 507036). Then wrap splices with electrical tape. Soldered splices may be used instead of compression fittings (refer to Gas Standard O-12).
3. Thermite weld all wire connections to steel pipe. Strap locating wire to the service line with electrical tape or Tie-Locks (Code 399093) to ensure close proximity. Tape other than electrical tape is not permitted for strapping unless approved by the corrosion supervisor.
4. Ensure that anodes are a minimum of 12" from other underground metallic facilities.
5. Strap a locating wire to the service riser aboveground, but below an insulated service valve. Use Tie-Locks (Code 399093). Do not bond the wire to the riser.
6. Do not bond plastic service locating wire to existing service case pipe or to a new, noncorrodible, prefabricated riser. If plastic service locating wire can be inserted successfully, strap it to the service riser aboveground, but below an insulated service valve. Use Tie-Locks (Code 399093).
7. Do not bond plastic service locating wire to steel main or plastic main locating wire. For distances less than 3' from the metallic service case pipe to the main, a plastic service locating wire is not required. For longer distances, bond a plastic service locating wire to a metallic service case pipe, but never to steel main or the plastic main locating wire.
8. Driveable anodes can be thermite welded or clamped.