ELECTRICAL TECHNICAL PAPER 18
FREQUENTLY ASKED QUESTIONS ABOUT CATHODIC PROTECTION SYSTEM EQUIPMENT TESTING

CATHODIC PROTECTION SYSTEM EQUIPMENT TESTING

Question No. 1

What should I (the contractor) check in a rectifier during a commissioning test?

Answer:

During a commissioning test, check the following:

1. Compare the rectifier input/output ratings on the nameplate to that called for in the drawings/specs to ensure proper size.

2. Check to ensure the proper AC input electrical power has been provided.

3. Where physically possible, ensure wire connections are proper and tight.

***** CRITICAL *****

Verify that the positive and negative header cables have been appropriately connected (anodes to the rectifier positive terminal and the structure to the negative terminal). Reversing these connections will result in rapid corrosion failure of the structure

4. Set the rectifier output taps to the lowest settings and turn on the rectifier. Read the built in meters to ensure that the rectifier is operating. Verify the accuracy of the built in meters with a portable meter.

5. Turn off the rectifier, set the adjustment taps up one setting, turn the rectifier back on and verify that the rectifier is operating. Repeat increases until you reach either the rectifier maximum output voltage or current. Note that for rectifiers with FINE and COARSE tap adjustments, increase the FINE settings until you reach the highest setting. Then turn the Fine down to the lowest setting and increase the COARSE by one setting. Repeat adjustment with the FINE setting. Repeat entire process until all settings have been tested or until you reach rectifier maximum voltage or current.

Question No. 2

How do I verify the accuracy of the rectifier built in meters?

Answer:

To verify the accuracy of the DC output voltage meter, use a portable voltmeter or multimeter (set to an appropriate DC volt scale) to measure the voltage across the rectifier positive (anode) and negative (structure) output terminals. Compare with the built in meter.

You can verify the accuracy of the DC output ammeter in two ways:

1. Use a DC current clamp on meter to measure the magnitude and direction of the DC output current. Compare the reading to the built in meter. Also ensure that the current in the positive (anode) cable is flowing away from the rectifier to the anodes.

2. If you do not have a DC current clamp on meter, first locate the shunt, usually a copper/brass bar, on the rectifier front panel. Using a portable voltmeter or multimeter set to the millivolt scale, measure the voltage across the terminals on the shunt. Calculate the current using the following equation:

$$\text{DC current} = \frac{\text{millivolts measured}}{\text{shunt millivolt rating}} \times \text{shunt current rating}$$

Question No. 3

What is the purpose of an anode shunt box?

Answer:

In many CP systems, the anode shunt box is a junction box where cables from each anode are connected to the rectifier positive cable. Current shunts for each individual anode are sometimes provided to allow measurement of the current in each anode. If bar type shunts are provided, calculate the current using the equation in question no. 2 above. If manganin wire shunts are provided, calculate the current using the following equation:

$$\text{DC current} = \frac{\text{millivolts measured}}{\text{shunt resistance (usually 0.01 ohm)}}$$

Question No. 4

How can I check the operation of a sacrificial anode and why do we need to measure anode current?

Answer:

A sacrificial anode can be checked by measuring its open circuit potential and closed circuit current. The open circuit potential measurement test is similar to a structure-to-electrolyte test. Disconnect the anode leads from the structure lead. Connect the meter positive lead to the anode lead and the meter negative lead to the copper sulfate reference cell and you should obtain the following approximate readings:

Type of Anode	Anode Potential Ranges
Zinc	-1.0 to -1.2 volts (-1000 to -1200 millivolts)
Magnesium	-1.4 to -1.55 volts (-1400 to -1550 millivolts)
High potential magnesium	-1.6 to -1.75 volts (-1600 to -1750 millivolts)

To measure the closed circuit anode current, measure the millivolts across the wire shunt and calculate the current using the equation shown in ***Question No. 3*** above. You may have to temporarily insert a shunt in the circuit if the anode leads are directly connected to the structure lead.

Question No. 5

The contractor is taking “native potential” readings? What is a “native potential” reading?

Answer:

“Native” or “static” potential readings are the “as found” potentials of the structure taken before the CP system is energized.

Question No. 6

The contractor has hooked up an interrupter to the rectifier. What is this for?

Answer:

An interrupter is an automatically controlled switch used to periodically turn off the rectifier and allow the reading of “instant off” potentials.

STRUCTURE-TO-ELECTROLYTE TESTING

Question No. 1

Most Navy and Air Force Manuals and other literature show a test setup with the meter positive lead connected to the reference cell and the negative lead to the pipeline (or other structure).

(a) When I setup the equipment as shown in the manuals, the meter displays a positive reading, yet the criteria calls for a reading more negative than -0.85 Volts (-850 millivolts). Is something wrong with the CP system?

(b) I notice that the contractor connects the meter opposite to that shown in the manuals (negative to the reference cell and positive to the structure), or sets it up one way this time and the other way another time. Is there something wrong with this setup?

Answer:

In most DC electrical measurement circuits, the meter negative lead is connected to a reference point such as a power supply negative or equipment ground. CP testing is no different, and the reference point, which is the reference cell, should normally be connected to the meter negative lead. However, most manuals show the reference cell connected to the meter positive lead and this is explained by going back in time to the days before digital meters and analog meters with polarity switches. Most old analog meters (d'Arsonval meters with the needle pointer) had only a positive scale (0 to +XXXX Volts), and Structure-to-electrolyte (S/E) potentials are normally negative. Therefore, in order to read negative S/E readings, the positive and negative connections to the meter had to be switched (positive lead connected to the reference cell, negative lead to the structure), and the test reading read as a positive number, but recorded as a negative number. This has been the method generally followed to this day, and can be very confusing to someone not experienced in conducting these tests.

Modern digital meters and analog meters with the polarity switch set to negative will allow reading negative numbers even though the reference cell is connected to the negative lead. The industry is now starting to move more toward this test setup.

To answer question (a), if the reading is greater than 0.85 volt (850 millivolts), this actually translates to more negative than -0.85 volt and the system is OK (assuming there is no stray current interference). To minimize confusion, connect the reference cell to the negative lead and the positive lead to the structure. The meter should then display a negative number (assuming a steel or iron structure and no stray current interference).

To answer question (b), as explained above, it does not matter which setup scheme the contractor uses as long as he understands and can explain (similar to the above) what numbers to expect. Observe contractors setup scheme and the polarity of the meter reading (see table F-1). Ask the contractor why he is using (or switching) the particular meter setup. In most cases there is no problem with hookup scheme, but a contractor who does not fully understand the outcome may overlook readings that indicate stray current interference problems.

Question No. 2

When conducting the S/E tests, and the meter reading constantly fluctuates what does this mean?

Answer:

In almost all cases, this is due to a poor connection in the meter test circuit. Check the following items in the order shown:

1. The connection between the structure and the meter structure lead. Make sure you are contacting bare metal, and make sure that portion of the structure is not electrically isolated from the rest of the structure.

2. Check meter lead connection to and placement of the reference cell. Make sure that the reference cell is full of solution and that you have removed the plastic/rubber tip cover. Moisten the ground with water to ensure better contact.

3. If reading still fluctuates, check the continuity of the test leads. Although the test lead insulation may still be intact, the wire inside may have broken through.

4. If test leads are OK, try a different meter.

If the readings still fluctuate after checking all of the above, they may be influenced by stray currents, radio equipment (walkie talkies), or by other electromagnetic devices in the area. You need to then ascertain and try to eliminate the cause.

Table F-1. Structure-to-Electrolyte Reading Meter Conventions			
Meter Type	Meter/Test Lead Connection Scheme	Expected Polarity of Meter Readings	Precautions
Analog	No Polarity switch Positive to ref. Cell Negative to structure	Positive	Meter peg at zero may mean interference.
Analog	No Polarity switch Positive to structure Negative to ref. cell	Meter peg at zero	Can damage meter. Possible interference.
Analog	Has polarity switch set to positive (+) Positive to ref. Cell Negative to structure	Positive	Meter peg at zero may mean interference.
Analog	Has polarity switch set to positive (+) Positive to structure Negative to ref. cell	Meter peg at zero	Can damage meter. Possible interference.
Analog	Has polarity switch set to negative (-) Positive to ref. Cell Negative to structure	Meter peg at zero	Can damage meter. Possible interference.
Analog	Has polarity switch set to negative (-) Positive to structure Negative to ref. cell	Positive	Meter peg at zero may mean interference.
Analog	Has Center Zero scale Positive to ref. Cell Negative to structure	Positive	Negative reading may mean interference.
Analog	Has Center Zero scale Positive to structure Negative to ref. cell	Negative	Positive reading may mean interference.
Digital	Positive to ref. Cell Negative to structure	Positive	Negative reading may mean interference.
Digital	Positive to structure Negative to ref. cell	Negative	Positive reading may mean interference.

Question No. 3

What types of meters are acceptable for S/E tests?

Answer:

Any voltmeter or multimeter with an input impedance greater than 100,000 ohms. An input impedance of 10 megohms is preferred, and most digital electronic multimeters meet this requirement. Commonly used brands include Beckman, Fluke, and M.C. Miller (MCM). Many analog meters do not have the sufficient input impedance, although some have been specifically manufactured for CP testing (e.g. M.C. Miller).

Question No. 4

How can I check the accuracy of my (the contractor's) copper sulfate reference cell?

Answer:

The first thing is to inspect the reference cell solution. The solution should have a bluish color, not greenish or milky. The solution should also be a saturated solution. Assuming that the reference cell was prepared the previous day, the quickest way to determine this is to note if there are excess copper sulfate crystals in the solution. The excess crystals mean that no more crystals will dissolve, and therefore, the solution is saturated. If there are no excess crystals, more should be added.

Generally, if the solution is not contaminated, the reference cell should be accurate. If you have reason to believe that the solution may be contaminated (abnormal color or observed use of the copper sulfate cell in seawater), actual testing for accuracy will require three different reference cells. Place the tips of two cells on the ground side by side (or tip to tip). Connect one meter lead to each cell (the polarity is unimportant at this stage). With the meter set to the millivolt scale, there should be less than 5 millivolts difference between the two cells. If the difference is greater than 5 millivolts, each cell will have to be compared with the third cell to determine which cell is inaccurate.

Question No. 5

What reference cell should I (the contractor) use to conduct S/E tests in seawater? What is the criteria for adequate protection when using silver chloride cells.

Answer:

A silver-silver chloride reference electrode should be used for conducting S/E tests in seawater. For silver chloride cells, potentials that are more negative than -.80 volt (-800 millivolts) indicates adequate protection. As with the copper sulfate cell, the meter test lead hookup scheme will determine the polarity of the test reading. Table I above can also be used as a guide for test lead hookup schemes for silver chloride reference cells.

Question No. 6

Can I use a copper-copper sulfate reference cell in seawater?

Answer:

Yes. However, the porous plug as well as any cracks or leaks in the reference cell will allow the seawater salt and chloride intrusion into the porous plug and copper sulfate solution. The accuracy of the copper sulfate cell is then questionable. The copper sulfate cell would then have to be cleaned, and a new tip and new copper sulfate solution made before the cell can be used again.

Question No. 7

Why pour water on the ground at the reference cell placement point? Is it necessary?

Answer:

The water is used to moisten the soil to provide a better contact between the soil and the porous plug of the reference cell increasing the accuracy of the test reading. It is necessary to pour water on soils that are dry to ensure more accurate readings.

Question No. 8

What are zinc reference cells, and what is the criteria for adequate protection for these cells?

Answer:

A zinc reference cell is a bar of zinc normally prepackaged in a cloth bag containing a special backfill material. Zinc cells are used as permanently installed reference cells. S/E potentials more negative than +0.23 volt (+230 millivolt) indicate adequate protection (see Figure F-1). As with the other reference cells, the meter hookup scheme will determine the polarity of the reading displayed on the meter. For zinc cells, it is critical to know how the meter test leads are hooked up and understand what polarity readings to expect.

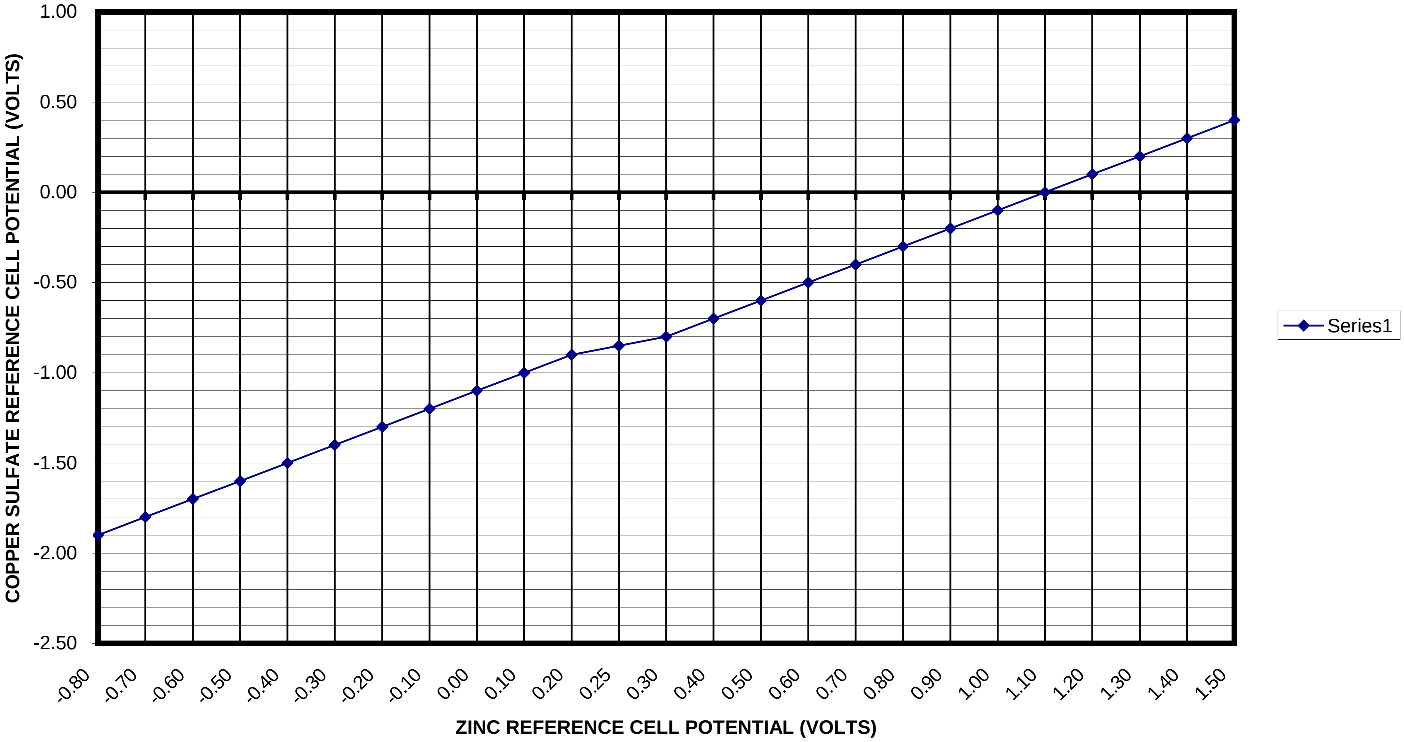

Figure F-1
Zinc to Copper Sulfate Reference Cell Conversion Chart

<u>Question No. 9</u>

If I take a potential reading using a wire reel connected to a test station and the reference electrode located some distance away, do I record this reading as being at the test station since I connected there?

Answer:

No. The potential reading is at the point where the reference electrode contacts the electrolyte, not where the structure connection is made. Accordingly, the test location should be described as such (e.g. 50 feet north of Test Station X).

Question No.10

What is an “off” reading?

Answer:

The “off” reading in most cases refers to an “instant off” potential where the potential reading is taken at the instant the CP current is interrupted or shut off. When using a common digital multimeter, a conservative method is to read the second reading to blink on the display after the current is interrupted. This reading often blinks very quickly, and the process may need to be repeated a few times to ascertain the reading.

Occasionally, a reading taken when the current has been shut off for some time is also referred to as an “off” reading. However, this number should not be used to determine conformance with the criteria that requires interruption of the current.

Question No. 11

Can I take a potential reading with the cell placed on asphalt? How about concrete?

Answer:

A metering circuit is electrical in nature and requires a conductive medium. Asphalt is not a conductive medium and you will not obtain a good reading with the cell placed on asphalt. On the other hand, concrete is a conductive medium, but the reading obtained will be dependent on the moisture in the concrete. When taking readings on concrete, the cell tip should be placed on a wet sponge or cloth to reduce the contact resistance. Note that a reading taken on generally dry concrete, even with a wet sponge, cannot always be compared to a reading taken on generally wet concrete (e. g. after a rainy day). The best way to get potentials in an area paved with asphalt or concrete is to provide test stations or pavement inserts that allow the reference electrode to contact the soil below the pavement.

Question No. 12

Where should I place the reference cell to get the most accurate reading?

Answer:

Where practicable, place the reference cell on the soil right over the pipe or tank or in the water just adjacent to the structure. Readings taken with the reference cell place some distance away are not necessarily inaccurate, but are actually reading the average potential over a larger area of the structure. By placing the electrode just above or just adjacent to the structure, one may be better able to detect areas that are not adequately protected.

Question No. 13

What is a close interval potential survey, and why is it conducted?

Answer:

A close interval survey is potential testing done with the reference cell placed at very close intervals, e.g. every 10 or 25 feet. CP test stations are normally located much further apart (e.g. 500 to 1000 feet), and readings taken at the test stations provide only general indications of system effectiveness. A close interval survey provides a more detailed indication of system effectiveness and can help identify anomalies along the structure that would not normally be detected by taking readings only at the test stations.