

Field Corrosion Measurement Procedures

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Purpose:

Provide standard procedures to quantify corrosion risk to subsurface installations of electrical equipment. Measurements include corrosion (galvanic) potential and/or chemical analysis.

Conditions Needed to Perform Tests:

1. Subsurface vault or manhole with ≥ 6 inches (≥ 0.15 meters) of standing water
2. Electrical equipment installed in the vault (equipment under test)

Measurements Performed:

1. Chemical Analysis
2. Corrosion (Galvanic) Potential

Equipment Required:

- For Corrosion (Galvanic) Potential Test
 - High-Resistance Volt Meter
 - Example: M.C. Miller LC-4.5 Voltmeter (a basic multimeter is not acceptable)
 - Submersible Reference Electrode
 - Example: Submersible Copper/Copper Sulfate Electrode
 - Example: Silver/Silver Chloride Electrode
- For Chemical Analysis Test
 - Clean glass sampling jar (1 L)
- Personal Protective Equipment (PPE) as required per employer or organization doing the work

Data Collection Procedure:

1. Record vault conditions:
 - a. Record date & time
 - b. Record location of vault (address or GPS, street or sidewalk, etc.)
 - c. Record average depth of water in the vault (average from ≥ 4 locations)
 - d. Record average ambient air temperature in the vault (average from ≥ 4 locations)
 - e. Record average water temperature in the vault (average from ≥ 4 locations)
2. If performing Chemical Analysis on the water in the vault:
 - a. Mix the water in the vault as much as possible
 - b. Collect 1 L of water from the bottom of the vault
 - c. Seal and label jar so it can be identified
 - d. Send sample to a laboratory qualified in surface or groundwater testing
 - i. The USA Environmental Protection Agency (EPA) has information on labs certified in each state for drinking and wastewater testing. Most labs can perform this analysis.
 - ii. Elsewhere, contact national or regional environmental agencies for similar labs.
 - e. Analysis should include:
 - i. pH
 - ii. Conductivity
 - iii. Halide (Chloride) content
 - iv. Oxidation-Reduction potential (ORP)

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3. If measuring Corrosion (Galvanic) Potential:
 - a. Follow manufacturer's instructions to prepare and validate performance of reference electrode used. Submersible electrodes may require soaking in tap water prior to use. (See Annex 2 & 3.)
 - i. The type (material) reference electrode should be recorded with the collected measurement.
 - b. Connect the positive (red) test lead to the voltmeter, and then connect the other end to bare metal on the equipment ground provision of the equipment to be measured (equipment under test).
 - i. The electrical connection between the voltmeter lead and the point of connection should be sealed to insulate it from the electrolyte.
 - ii. Skillful application of insulation tape or a special terminal could be used to insulate the electrical connection to the equipment under test.
 - c. Connect the common (black) test lead to the voltmeter, and then use a submersible connector to attach the other end to the submersible reference electrode.
 - i. If a submersible connector is not available, the electrical connection between the voltmeter lead and reference electrode must be sealed to insulate it from the electrolyte.
 - d. Place the submersible reference electrode adjacent to (but not touching) the positive test lead connection to the equipment ground.
 - e. Use the voltmeter to measure the DC voltage present across the equipment under test to the reference electrode. Refer to manufacturer instructions for the equipment used to ensure accurate measurements, and see Annex 1 if equipment manufacturer instructions do not exist.
 - i. Wait until measured voltage stabilizes. Measurement shall be considered stable once it changes < 1 mV/minute. Depending on reference electrode and other variables, it may take up to two hours for the measurement to stabilize. Only the final stable voltage measurement should be recorded.
4. Reporting data to the Task Force:
 - a. Upon completion of measurements and/or analysis, any collected data should be forwarded to the Task Force.
 - b. All data submitted to the Task Force should include basic information of the vault.
 - i. All results should include: date, time, location, average air & water temperatures inside the vault
 - c. If Chemical Analysis was performed, forward the complete report from the lab to the Task Force if possible.
 - i. Results should include: conductivity, halide (chloride) content, oxidation-reduction potential (ORP)
 - d. If Corrosion (Galvanic) Potential was performed, forward all data collected to the Task Force.
 - i. Results should include: measured corrosion potential (DC voltage), type (material) reference electrode used for the test

Annex Information:

1. Voltmeter Input Resistance Selection:
 - a. When making a corrosion (galvanic) potential measurement, the lowest input resistance of the meter should be used that provides an accurate measurement.
 - i. Perform the voltage measurement using the lowest input resistance, typically 10 M Ω .
 - ii. Increase the input resistance to the next possible input resistance and perform the voltage measurement.
 - If the voltage measurement does not change, the measured voltage is an accurate measurement.
 - If the voltage measurement does change, the measured voltage is not accurate.
 - iii. If the initial measurements are not accurate (per the last step), iteratively increase the input resistance and take voltage measurements until two consecutive voltage measurements are precisely equal. Two consecutive and equal voltage measurements on adjacent input resistances constitutes an accurate measurement.
 - If the voltage measurement changes between the voltmeter's two highest input resistance options, then an accurate voltage measurement is not possible with the voltmeter being used.
2. Reference Electrode Validation:
 - a. Reference Electrodes may degrade over time depending on handling, storage, and application. The condition of a previously used reference electrode can be compared to a new reference electrode to validate the performance of the reference electrode that has been previously used.
 - i. Submerge both the new and the used reference electrodes in any electrolyte.
 - ii. Measure the voltage between the two reference electrodes with a voltmeter, using either lead on each electrode.
 - iii. If zero volts are measured between the two reference electrodes, then the previously used reference electrode is still a valid reference electrode and may be used for further field measurements.
3. Restoring Copper Sulfate Reference Electrodes (that are not designed for submersible applications):
 - a. Submersible copper sulfate reference electrodes have a nonporous ionically conducting plug that does not allow the copper sulfate solution to transfer out of the electrode.
 - b. Traditional copper sulfate electrodes (not designed for submersible applications) use a porous plug. Porous copper sulfate electrodes require cleaning after every use in a liquid electrolyte.
 - c. To restore the functionality of a porous copper sulfate reference electrode, perform the following before using it for any measurement:
 - i. The cell should be emptied of solution and thoroughly cleaned with de-ionized water.
 - ii. The copper electrode should be cleaned and sanded to a new shine finish.
 - The sandpaper used shall not contain any type of metal materials, only clean sand abrasives should be used.
 - iii. The reference cell should then be reassembled, and new copper sulfate solution should be added to the reference cell to the original full level location mark from before use.
 - iv. The bottom contact porous surface should always be protected and clean.
 - Inspect the surface of the porous plug. It should be cleaned of debris prior to any testing to allow full material contact with the soil, concrete or surface medium. The reference electrode should not be used if the plug is damaged.