Task 1.1—Measure Structure-to-Soil Potentials

1.0 Task Description

This task consists of taking a structure-to-soil reading with a half cell during an annual survey or CP analysis.

The task begins with equipment selection. This task ends with documenting the readings as required by the operator's procedure.

2.0 Knowledge Component

The purpose of the task is to verify electrical continuity between structures and soil.

An individual performing this task must have knowledge of:

— Equipment calibration (e.g., calibration certificates and/or field calibration).

— Cathodic protection (CP) systems.

— Types of reference cells to use in combination with a high-impedance volt-ohm meter (VOM):

  — copper/copper sulfate (Cu/$CuSO_4$) half cells,

  — saturated potassium chloride (KCl) calomel half cells,

  — saturated silver/silver chloride (Ag/AgCl) half cells.

— Minimum requirements for negative voltage.

— Considerations that must be made to account for IR drop. Voltage drops other than those across the structure-to-electrolyte boundary must be considered.

Terms applicable to this task:

data logger
A digital device used to record multiple structure-to-soil potentials.

electrolyte
A term used to describe a medium that allows for ion flow, and includes soil and water.

half cell
Another term for a reference electrode or reference cell.

IR drop
The voltage or potential difference as a result of current flow. From Ohm's Law, V = IR. When evaluating structure-to-soil measurements, IR drop is the voltage drop other than the drop across the structure-to-soil boundary.

Volt-ohm meter (VOM)
Another term for a voltmeter or voltage meter.

Abnormal operating conditions (AOC) associated with the performance of this task include:

AOC Recognition	AOC Reaction

Damaged coating; scratches, dents, and gouges.	Implement mitigation measures per Operator's procedures.

3.0 Skill Component

To demonstrate proficiency of this task, an individual must perform the following steps:

Step	Action	Explanation
1	Select the proper instrumentation (test leads, voltmeter or data logger, and reference electrode) to be used and verify proper operation.	Incorrect or faulty equipment will not provide accurate results and shall be repaired, replaced, or calibrated, as required.
2	Identify the correct test point locations where measurements will be taken.	The reference electrode must be correctly located to obtain accurate results. A structure may have several locations for taking measurements.
3	Connect the test leads to the voltmeter or data logger and reference electrode.	Damaged equipment or improper connection of equipment will lead to inaccurate potential measurements. If test points, leads, and/or stations are missing or broken, repair the test leads or equipment as needed.
4	Measure the structure-to-soil potential.	This step takes the actual potential difference between the soil and the structure being tested.
5	Field-analyze readings and check polarity to ensure that they are within the desired range of readings.	Readings should be reviewed as they are taken to ensure that measurements fall within the desired range with the correct polarity. This is not meant to be an engineering analysis or to account for IR drop considerations. This may include a comparison to historical data at that location. If readings are outside desired range or are erratic or floating, implement mitigation measures per Operator's procedures.
6	Document the readings as required by Operator's procedure.	Documentation is critical to future analysis and identification of problem areas.

Task 1.2—Conduct Close Interval Survey

1.0 Task Description

This task consists of using equipment to obtain and record structure-to-soil potential readings at specific intervals along the length of a located pipeline.

The task begins with identifying the test point locations where connections will be made. The task ends when the readings are documented as required by the operator's procedures.

Data analysis is not part of this covered task.

The performance of this covered task may require the performance of other covered tasks such:

— Locate Line (reference Task 14.1).

— Measure Structure-to-Soil Potentials (reference Task 1.1).

2.0 Knowledge Component

The purpose of this task is to verify electrical continuity between structures and soil (electrolyte) along the length of a pipeline section being surveyed.

An individual performing this task must have knowledge of:

— Types of close interval surveys; these may include, but are not limited to, the following:

  — "On" survey,

  — interrupted survey,

  — depolarized survey.

— Cathodic protection (CP) systems and components comparable to AMPP/NACE Certification Level CP 2. This knowledge includes, but is not limited to, the following:

  — The specific survey being conducted and the designated spacing between readings. Spacing determines the amount of data collected and the accuracy of the data profile.

  — The location of the pipeline and appurtenances (road crossings, test stations, river crossings, foreign crossings, casings, valves, isolation devices, rectifiers, galvanic anodes, aerial markers, bonds, pump stations, etc.) typically found in alignment sheets or system mapping should be marked on the survey for validation of the line and its location.

Terms applicable to this task:

current interrupter
A device that stops/interrupts the transfer of an electric charge used to cycle rectifiers, anodes, bonds, etc., on and off. This may include remote monitoring units with current interruption capabilities.

data logger
A digital device used to record multiple structure-to-soil (electrolyte) potentials.

depolarized (off) survey
Measures the potential difference between the structure and the soil (electrolyte) after the CP current has been switched off long enough for the structure-to-soil to stabilize.

electrolyte
A term used to describe a medium that allows for ion flow, which includes soil and water.

“instant off” potential
The polarized half-cell potential of an electrode taken immediately after the CP current is stopped. This process closely approximates the potential without IR drop.

interrupted (on/off) survey
Measures the potential difference between the structure and the soil (electrolyte) as the CP current is switched on and off.

IR drop
The voltage or potential difference as a result of current flow. From Ohm’s Law, V = IR. When evaluating survey measurements, IR drop is the voltage drop other than the drop across the structure-to-soil (electrolyte) boundary.

“on” survey
Measures the potential difference between the structure and the soil (electrolyte) as the CP current is applied.

Abnormal operating conditions (AOC) associated with the performance of this task include:

AOC Recognition	AOC Reaction
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3.0 Skill Component

To demonstrate proficiency of this task, an individual must perform the following steps:

Step	Action	Explanation
1	Identify the test point locations where connections will be made.	To confirm that potentials taken are on the intended pipeline and are the most accurate readings.
2	Select the instrumentation to include survey wire, voltmeter, data logger, reference electrodes, test leads, etc. to be used. Verify components function properly.	Damaged, incorrect, or faulty equipment will not provide accurate results and shall be repaired, replaced, or calibrated, as required. Make appropriate notifications if there are missing, damaged, or malfunctioning components.
3	Verify that current sources are operational (on for “on”/interrupted surveys and turned off/disconnected for depolarized survey).	If a current source is not operational, make appropriate notifications per Operator procedures.
4	For interrupted surveys, install current interrupters and/or utilize remote monitoring units with current interruption capabilities at all identified current sources. They should be set at the Operator-determined time cycle and synchronized.	Current interrupters are necessary to obtain accurate “instant off” potentials. Time cycle selection is important to prevent excessive depolarization of the structure when performing an interrupted survey. Synchronization is important to get an accurate “instant off” potential.
5	Connect the voltmeter or data logger to the survey wire, test leads, and reference electrode.	Improper connection of equipment will lead to inaccurate potential measurements.
6	Place the reference electrode directly above the pipeline being surveyed.	The reference electrode must be in contact with the electrolyte and as close to the structure as possible to

		obtain accurate results.
7	Measure the structure-to-soil (electrolyte) potential according to the desired intervals for this survey.	This step takes the actual potential difference between the soil and the structure at specified intervals to establish a potential profile of the pipeline. If readings are outside desired range, erratic or floating, or the polarity is reversed, implement mitigation measures per Operator’s procedures.
8	Verify data is recorded.	Readings should be continuous; a lack of data may be a sign of equipment failure or faulty electrode location.
9	Document the readings as required by Operator’s procedures.	Documentation is critical to future analysis and identification of problem areas.

Task 1.3—Test to Detect Interference

1.0 Task Description

This task consists of testing a cathodically protected structure for interference from other sources.

This task begins with testing for direct current (DC) or alternating current (AC) interference. The task ends when the readings are documented as required by the Operator's procedures.

The performance of this covered task may require the performance of other covered tasks such as the following.

— Measure Structure-to-Soil Potentials (reference Task 1.1).

— Obtain a Voltage and Current Output Reading from a Rectifier to Verify Proper Performance (reference Task 3).

2.0 Knowledge Component

The purpose of this task is to assess structures in proximity to each other and their respective CP systems.

An individual performing this task must have knowledge of:

— Cathodic protection (CP) systems and components comparable to AMPP/NACE Certification Level CP 2. This knowledge must include, but is not limited to, the following:

  — Determining interference by analyzing abnormal DC and/or AC measurements (current or potentials)

  — Communicating with foreign structure owners for collaboration of testing (working with other cathodic system owners enables the interruption of their systems and coordination for testing for both cathodic systems)

  — Interrupting a CP system to detect its influence on other structures (installation of current interrupters, or remote monitoring units with current interruption capabilities, on either or both systems is necessary to determine the extent of system interference)

  — Troubleshooting CP systems

  — Documenting the readings and recommendations for future reference

Abnormal operating conditions (AOC) associated with the performance of this task include:

AOC Recognition	AOC Reaction
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3.0 Skill Component

To demonstrate proficiency of this task, an individual must perform the following steps.

Step	Action	Explanation
1	Select instrumentation, test leads, and reference electrodes. Verify components function properly.	Incorrect equipment and/or improper usage will not provide accurate results. Damaged, incorrect, or faulty equipment will not provide accurate results and shall be repaired, replaced, or calibrated, as required. Make appropriate notifications if there are missing, damaged, or malfunctioning components.
2	Assess the area for other CP systems or sources of electrical interference.	Potential sources of electrical interference can be the sources of cathodic interference.
3	Measure the structure-to-soil (electrolyte) potential.	This step takes the actual potential difference between the soil and the structure pipe being tested.
4	Field-analyze readings to ensure that the readings fall within the desired range.	Readings should be reviewed as they are taken to ensure readings fall within the desired range. This may include a comparison to historical data at that location. If readings are outside the desired range check for possible causes such as reversed polarity, open bonds, shorted diodes, or changes in cathodic system. Take appropriate action per Operator’s procedures.
5	Interrupt rectifiers to determine if interference exists.	Interrupting one of the structure’s CP systems can help detect its influence on other structures.
6	Document all results. If interference is found, take corrective action.	Documentation is critical to future analysis and identification of problem areas. Corrective action may involve making notifications.

Task 1.4—Inspect and Perform Electrical Test of Bonds

1.0 Task Description

This task consists of the visual and electrical inspection of connections related to the electrical connection (bond) of two or more structures.

This task begins with identifying the location of the bond(s). The task ends with the collection of data.

2.0 Knowledge Component

The purpose of this task is to test for electrical continuity and the direction and magnitude of current flow between two or more structures.

An individual performing this task must have knowledge of:

— How to identify the location and type of bond that is currently in place.

— Types of bonds that may include critical and noncritical interference bonds (other bonds that may be inspected include continuity bonds).

— Voltmeters, multimeters, and/or data loggers.

— Shunts [bond currents are measured by taking a millivolt reading across a shunt that has a defined resistance; the current passing through the shunt (bond) is calculated by dividing the voltage reading by the shunt's resistance].

Terms applicable to this task:

continuity bond
A connection, usually metallic, that provides electrical continuity between structures that can conduct electricity.

critical bonds
Bonds whose failure would jeopardize the integrity of a pipeline.

interference bond
An intentional metallic connection, between metallic systems and contact with a common electrolyte, designed to control electrical current interchange between the systems.

Abnormal operating conditions (AOC) associated with the performance of this task include:

AOC Recognition	AOC Reaction
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3.0 Skill Component

To demonstrate proficiency of this task, an individual must perform the following steps:

Step	Action	Explanation
1	Identify the bond locations where measurements will be taken.	To confirm that potentials and current measurements are taken at the correct location.
2	Conduct a visual inspection of the bond test station for physical damage to the bond station, a burned or damaged shunt, loose connections, disconnected wires, arcing across terminal, etc.	Faulty equipment can cause inaccurate results. Repair or request a repair and document. If the shunt is burned or damaged, measure the current to ensure that it is not underrated.
3	Select the instrumentation, including voltmeter or data logger, test leads, or reference electrode. Verify components function properly.	Incorrect equipment and/or improper usage will not provide accurate results. Damaged, incorrect, or faulty equipment will not provide accurate results and shall be repaired, replaced, or calibrated, as required. Make appropriate notifications if there are missing, damaged, or malfunctioning components.
4	Make connections with the test equipment to take and record readings.	Equipment that is improperly connected, scaled, or has incorrect settings may yield faulty data. Repair/replace any damaged tests leads or equipment.
5	Measure the potentials for each of the structures at the bond location, if required.	This step allows for comparison of the pipe-to-soil (electrolyte) potentials of each structure.
6	Identify the shunt type and size.	This step is required to calculate current flow.
7	Measure the direction and magnitude of current flow between the structures.	A change in current magnitude or current direction may indicate a need for further testing.
8	Field-analyze the readings to confirm that they are within a desired range of readings, including a check of the polarity.	Readings should be reviewed as they are taken to verify that measurements fall within the desired range with the correct polarity; this is not meant to be an engineering analysis. This may include a comparison to historical data at that location. If readings are outside desired range or are erratic or floating, implement mitigation measures per Operator's procedures.
9	Document readings as required by Operator's procedures.	Documentation is critical to future analysis and identification of problem areas.

Task 1.5—Inspect and Test Electrical Isolation

1.0 Task Description

This task consists of the inspection and testing of electrical isolation.

The task begins with identification of the isolation device. The task ends when measurements have been taken and recorded.

The performance of this covered task may require the performance of other covered tasks such as the following.

— Measure Structure-to-Soil Potentials (reference Task 1.1).

2.0 Knowledge Component

The purpose of this task is to assure that electrical isolation is adequate.

An individual performing this task must have knowledge of:

— Isolation devices (which may include insulated flanges, couplings, unions, monolithic insulating pipe joints, and nonmetallic pipe and structural members).

— Casings (which need to be electrically isolated from the carrier pipe so as not to shield the carrier pipe from CP).

— Proper use of equipment [which may include a reference electrode and voltmeter/data logger or isolation (flange) tester; most tests for isolation are based on potential differences in structures using a reference electrode and voltmeter/data logger].

NOTE Using the ohmmeter setting to check the effectiveness of an isolation device is not reliable because of the parallel resistance paths through the soil (electrolyte).

— Isolation (flange) testers (which are based on high radio frequency and can be used to validate the isolation of flange joints or for troubleshooting shorted joints; these testers are not typically used for isolation joints other than flanges).

Abnormal operating conditions (AOC) associated with the performance of this task include:

AOC Recognition	AOC Reaction
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3.0 Skill Component

To demonstrate proficiency of this task, an individual must perform the following steps:

Step	Action	Explanation
1	Identify the isolation locations and isolation device where measurements will be taken.	This step is to confirm that measurements are taken at the correct location.
2	Conduct visual inspection of the isolation location for physical damage to the test station, a burned or damaged shunt, loose connections, disconnected wires, arcing across a terminal, etc.	This step verifies that there is no visual damage. Implement mitigation measures per Operator's procedures.
3	Select the instrumentation, including voltmeter/data logger, isolation (flange) tester, test leads, or reference electrode. Verify components function properly.	Incorrect equipment will not provide accurate results. Damaged, incorrect, or faulty equipment will not provide accurate results and shall be repaired, replaced, or calibrated, as required. Make appropriate notifications if there are missing, damaged, or malfunctioning components.
4	Make connections with the test equipment to take and record readings.	Improper usage will not provide accurate results.
5	If using a reference electrode, measure the potential for each of the structures. The reference electrode should remain in the same location during the measurements.	This step allows for a comparison of pipe-to-soil (electrolyte) potentials to help determine if structures are isolated. If the difference in potential is approximately 100 mV or greater, the isolation is effective. If the reading is less than 100 mV, further testing may be necessary. If readings are outside the desired range or are erratic or floating, implement mitigation measures per Operator's procedures.
6	Check for continuity on flanges using an isolation/flange tester.	Verifies electrical isolation (or lack of continuity) between flanges.
7	Document the readings as required by Operator's procedures.	Documentation is critical to future analysis and identification of problem areas.