## KS650.680 Procedure for making electrical measurements for cathodic protection of principal spillway conduits

### (a) General

The pipe to soil potential is the voltage between the metal pipe and a standard reference electrode in electrical contact with the soil. A copper-copper sulfate electrode is used by the Natural Resources Conservation Service (NRCS).

The natural potential of mild steel in a neutral soil, referred to a copper-copper sulfate electrode, is about -0.5 to -0.8 volt. That of zinc (or a new galvanized pipe) is about -1.1 volts. A pipe to soil potential that measures less than -0.85 volt on plain steel pipe or -1.15 volts on galvanized steel pipe indicates that the pipes are in need of protection by an outside source of electrical current.

A copper-copper sulfate electrode and a high resistance voltmeter are necessary for measuring pipe-to-soil potentials.

### (b) Care of the electrode

The copper sulfate reference electrode must be kept clean, and the porous plug must be kept moist. The copper rod or sleeve may be cleaned by submerging it in a 10 percent solution of nitric acid for a few minutes. Rinse well before reassembling. Keep the electrode full of saturated copper sulfate solution or gel with a few excess copper sulfate crystals or powder to ensure that the solution will remain concentrated. Keep the porous plug covered when not in use to keep it from drying out. The electrode should be cleaned and refilled with fresh solution at least annually. The construction engineer in the state office will maintain a schedule documenting proper care of the electrode.

### (c) Care of the equipment

All equipment used to test cathodic protection will be maintained at the state office. The construction engineer will be responsible for scheduling the equipment to the field as needed based on requests. A list of all equipment will be maintained in the storage box along with instructions for making tests. Any lost or broken equipment should be brought to the attention of the construction engineer for repair or replacement.

### (d) Test procedures

General set up. All measurements will be made near the outlet end of the principal spillway. The test box near the outlet contains the wires from the pipe and the anodes. The wires may be connected with a switch or a split-bolt connector. If color designations are used, the copper wire or connection to the anode should be marked red. If there are no markings, the wire or connection should be identified and marked in the test box by covering with red coding tape or similar means. The wire or connection from the pipe to the test box can easily be identified by use of the meter or a battery and lamp circuit. When it is identified, the other remaining wire or connection in the test box is the anode wire. Refer to Figure KS6-1 for instructions on making connections for the following tests.

#### (1) Test circuit of pipe

To determine if the bridge connections at pipe joints are good, do the following:

**Step 1**. Set the meter to continuity or resistance (Ω on the dial).

**Step 2**. Connect the red test lead to the red terminal labeled ⏚ on the Fluke (or similar) multimeter and the copper wire or connection in the test box that leads to the pipe.

**Step 3.** Connect one end of the wire reel to the common terminal (black) on the meter. Connect the other end of the wire reel to the downstream end of the pipe. This is a check for the pipe-to-wire connection to the test box.

**Step 4**. Unroll the wire from the reel and connect to the pipe riser on the upstream side of the dam. This is a check of continuity along the pipe. If no continuity, move the red test lead to the pipe and check again.

**Step 5**. Record test results on Form KS-ENG-30. (See Example KS6-1.)

**(2) Anode-to-soil potential**
With anodes disconnected, do the following:

**Step 1.** Set the meter to Volts, DC (V on the dial).

**Step 2.** Place the electrode in the soil over the principal spillway pipe. The porous plug, with cap removed, should be in firm contact with moist earth. This may require "digging in" where the earth's surface is dry. In
extremely dry areas, it may be necessary to moisten the earth around the electrode with fresh water.

**Step 3.** Do not permit grass or weeds to contact the exposed electrode terminal.

**Step 4.** Connect the electrode to the red terminal (volts) of the meter using the red test lead.

**Step 5.** Connect the black test lead to the common terminal (black) of the meter and leave it there for Tests (2) through (6). Connect the other end of the black test lead to the copper wire or connection in the test box that leads to the anodes. The copper wires connected with a split-bolt connector must be disconnected and those using a switch must have the switch in the "off" position.

**Step 6.** Record the reading on Form KS-ENG-30. This reading should be in the range of 1.4 to 1.6 volts. Measurements less than 0.3 volt indicate a broken wire or faulty connection.

**(3) Pipe-to-soil potential**
With anodes disconnected, do the following:

**Step 1**. Set the meter to Volts, DC (V on the dial).

**Step 2.** Follow the same procedure as for anode-to-soil potential measurements except the black test lead from the voltmeter will contact the copper wire or connection in the test box that leads to the pipe, or this may be done by direct contact of the black test lead to the pipe.

**Step 3.** Record the reading on Form KS-ENG-30. The normal range is 0.4 to 0.7 volt.

**(4) Anode-to-pipe potential**
With anodes disconnected, do the following:

**Step 1.** Set the meter to Volts, DC (V on the dial). The split-bolt connector in the test box should be disconnected; or if a switch is used, it should be in the “off” position.

**Step 2.** Connect the red terminal (volts) of the meter to the copper wire or connection in the test box that leads to the pipe using the red test lead. Connect the common

terminal of the meter to the copper wire or connection that leads to the anodes using the black test lead.

**Step 3.** Record the reading on Form KS-ENG-30.

**(5) Anode current**
With anodes disconnected, do the following:

**Step 1.** Set the meter to measure amps, AC (A on the dial). The split-bolt connector in the test box should be disconnected; or if a switch is used, it should be in the “off” position.

**Step 2.** Connect the red terminal (amps) of the meter to the copper wire or connection in the test box that leads to the anodes using the red test lead. Connect the common terminal of the meter to the copper wire or connection that leads to the pipe using the black test lead.

**Step 3.** Record the reading on Form KS-ENG-30. The normal range is 0.020 to 0.30 amp.

**(6) Pipe-to-soil potential**
With anodes connected, do the following:

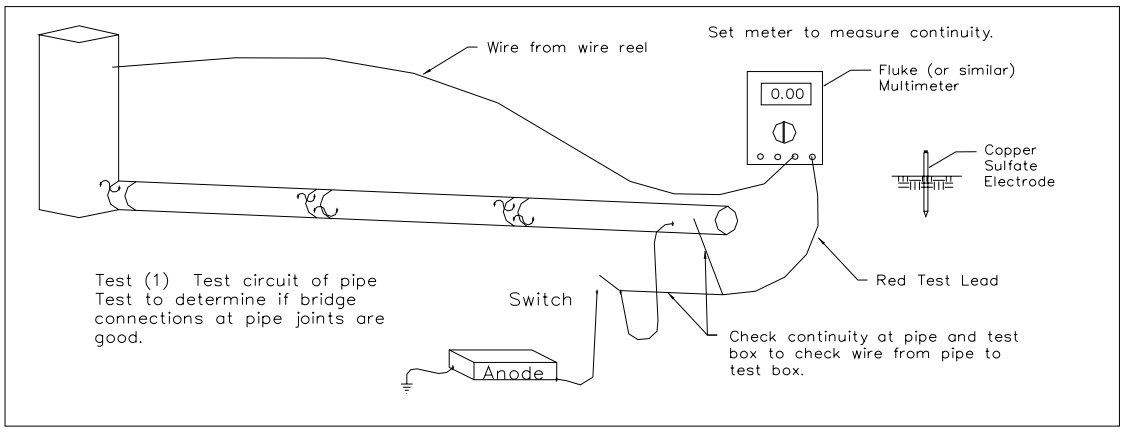
**Step 1.** Set the meter to Volts, DC (V on the dial).

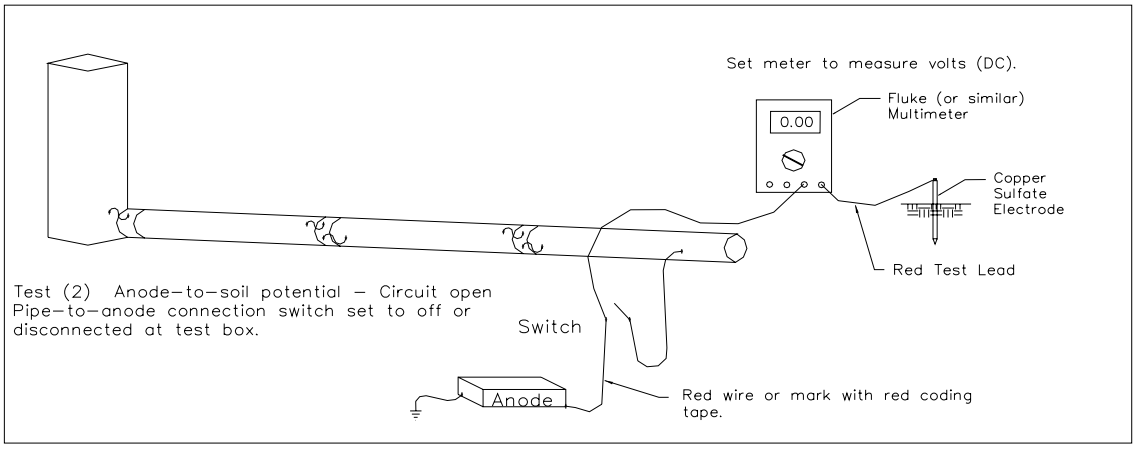
**Step 2.** The procedure is exactly the same as the pipe-to-soil potential test with the anodes disconnected except the wires in the test box are joined together with the split-bolt connector; or if a switch is used, the switch is placed in the "on" position.

**Step 3.** Record the reading on Form KS-ENG-30. The normal range is 0.85 to 1.2 volts. Readings less than 0.8 volt indicate a potential corrosion problem with the pipe.

**After all testing is completed, connect the copper wires in the test box with the split-bolt connector; or if a switch is used, place the switch in the "on" position. Make a clean, tight connection with the split-bolt connector and insulate completely with electrical plastic tape. Replace the cover to the test box.**

Figure KS6-1 Connections to make cathodic protection measurements



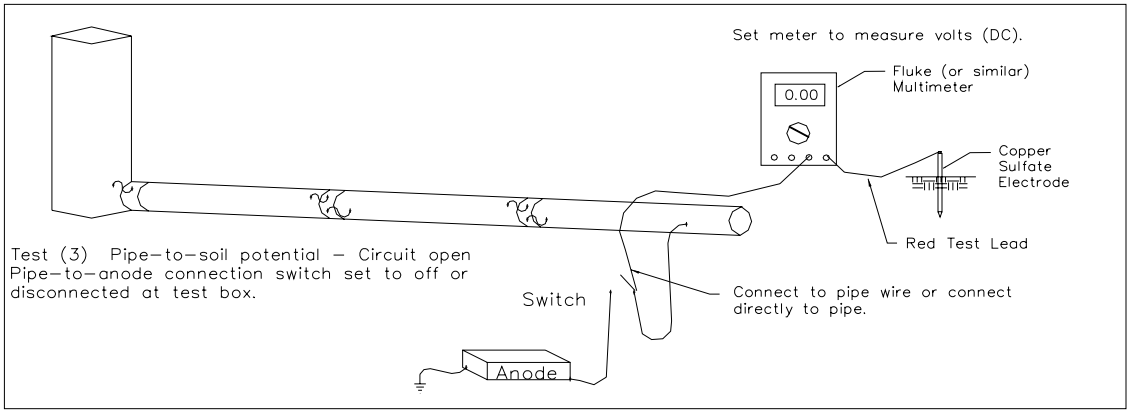
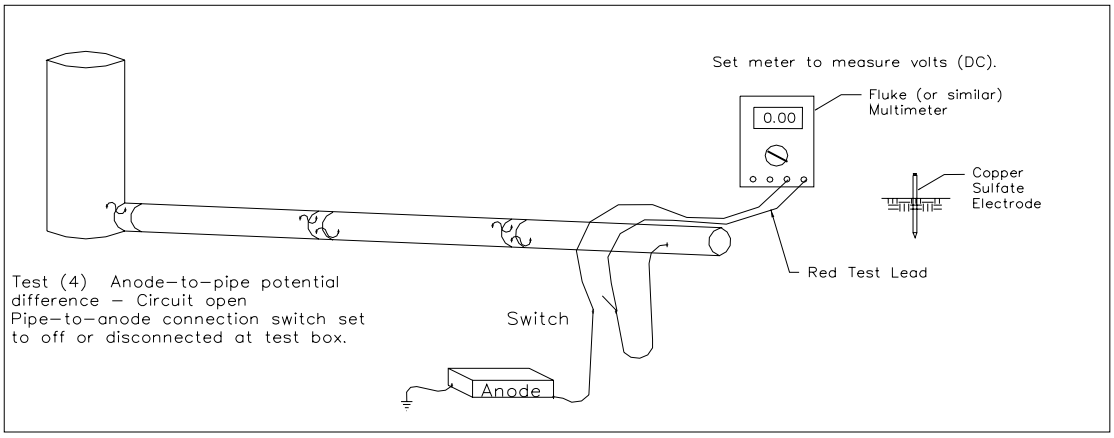
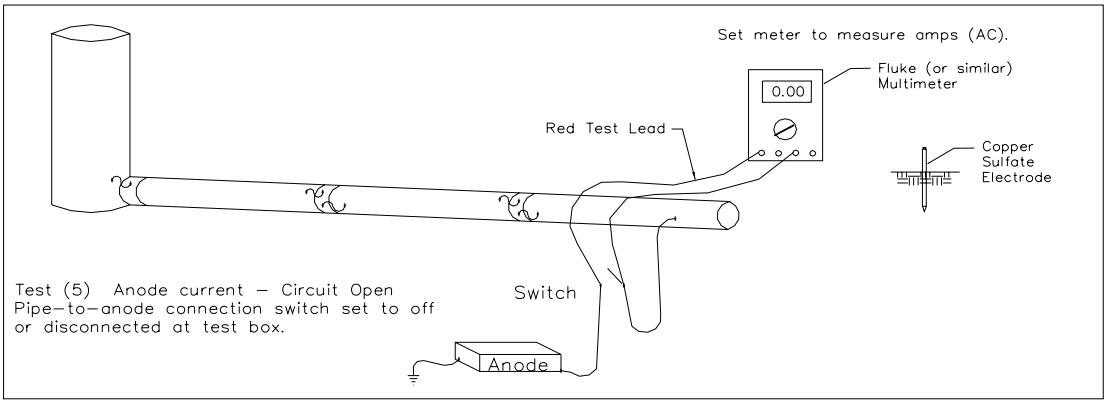
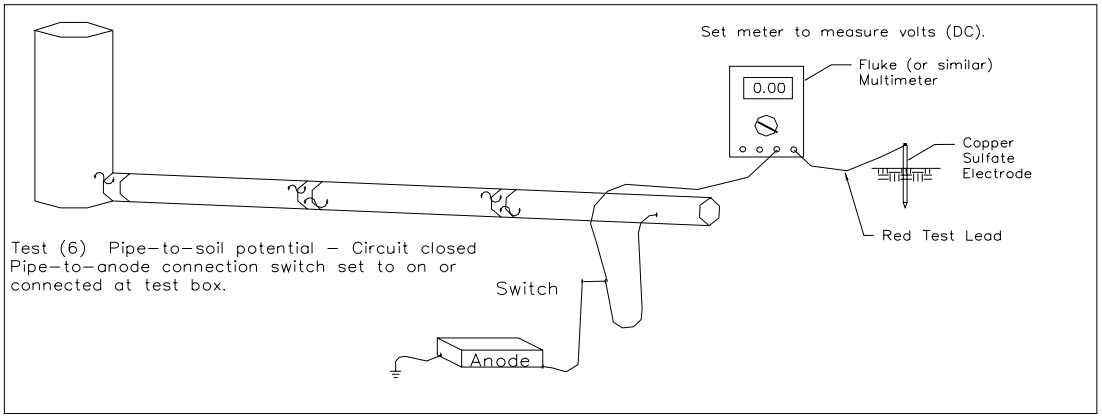



Figure KS6-1 (continued) Connections to make cathodic protection measurements



Example KS6-1 Recording test results on Form KS-ENG-30

USDA
NRCS

**Cathodic Protection Monitoring Data Sheet for Measurements**

KS-ENG-30
Rev. 6/07

Watershed or Project: North Black Vermillion
Dam Name and/or Number: Sie 108 — Type of Pipe: 24" CMP
Field Office: Marysville — Coating Material: Asphalt Coating

Monitoring Date: 7/12/05 — Date of Last Monitoring: 6/14/00

Cathodic Protection Condition No.: 1

Condition: 1. Adequate - No maintenance required
2. Potential Problem - Monitor again
3. Deficient - Future repairs required
4. Deficient - Immediate repairs required

| Test Items | Readings | Remarks |
|---|---|---|
| (1) Test circuit of pipe (pipe bridges) - continuity | ☒ Yes ☐ No | Checked Wire & Pipe |
| (2) Anode-to-soil potential (circuit open) - volts | 1.45 | Normal range is 1.4 to 1.6 volts. Readings less than 0.3 volt indicate connection problems. Ok, Within Normal Range |
| (3) Pipe-to-soil potential (circuit open for at least 10 minutes) - volts | 0.68 | Normal range is 0.4 to 0.7 volt. Ok |
| (4) Anode-to-pipe potential (circuit open for at least 10 minutes) - volts | 0.79 | |
| (5) Anode current (circuit open) - amps | 0.62 | Normal range is 0.020 to 0.30 amp. Ok |
| (6) Pipe-to-soil potential (circuit closed) - volts | 1.06 | Normal range is 0.85 to 1.2 volts. Readings less than 0.8 volt indicate potential corrosion problems with the pipe. Ok, within normal range |
| (7) Item (2) minus Item (3) - volts | 0.77 | Reference check - The result should be nearly equal to Step 4. Ok, within 0.02 volts of #4 |

Joe Conservationist — NRCS Representative(s) — 6/8/07 — Date
John Q. Public — Owner/Sponsor — 6/8/07 — Date

Distribution instructions:

Original to district conservationist for operation and maintenance (O&M) file for permanent retention (See General Manual [GM] Title 120, Section KS408.63, File Code 210-28, Item 12.)

Copy to assistant state conservationist for field operations for follow-up--if needed (For retention, see GM Title 120, Section KS408.63, File Code 210-28, Item 12.)

Copy to owner/sponsor

## KS650.681 Kansas standard engineering drawings

Kansas standard engineering drawings are approved for use, within Kansas Practice Approval Certification, on conservation measures in Kansas. An assembly of applicable standard engineering drawing sheets plus any special sheets prepared by the designer constitutes a set of construction plans for a project. Most standard drawings have guide plans or instructions to provide guidelines or examples to aid in completing the sheets.

Standard drawings approved for use in Kansas that are in electronic files are on the Kansas Web site > Technical Resources > Engineering > Standard Drawings and Instructions.

Listed below are the older standard drawings in paper format that are in the National Engineering Handbook Part 650, Engineering Field Handbook, Kansas Supplement to Chapter 6, Standard Engineering Plans (the large green book).

| | Date |
|---|---|
| * Guide Plan for completing KS-ENG-400 (JS) | 3/02 |
| * KS-ENG-400 (JS) - Design Sheet | 3/02 |
| * Guide Plan for completing KS-ENG-401 (JS) | 3/02 |
| * KS-ENG-401 (JS) - Profile and Cross Section without pipe | 3/02 |
| * Guide Plan for completing KS-ENG-401a (JS) | 3/02 |
| * KS-ENG-401a (JS) - Profile and Cross Section with Canopy Inlet Pipe | 3/02 |
| * KS-ENG-401b (JS) - Grid for Profile | 3/02 |
| * Guide Plan for completing KS-ENG-402, 403, 409 and 410 (JS) | 3/02 |
| * Guide Plan for completing KS-ENG-402 (JS) | 3/02 |
| * KS-ENG-402 (JS) - C.M. Pipe Drop Inlet with Concrete Base | 3/02 |
| * Guide Plan for completing KS-ENG-403 (JS) | 3/02 |
| * KS-ENG-403 (JS) - C.M. Pipe Drop Inlet with Metal Base | 3/02 |
| * Guide Plan for completing KS-ENG-405a (JS) | 3/02 |
| * KS-ENG-405a (JS) -Timber Pipe Support | 3/02 |
| * Guide Plan for completing KS-ENG-405b (JS) | 3/02 |
| * KS-ENG-405b (JS) - C.M. Pipe Support | 3/02 |
| * Guide Plan for completing KS-ENG-406 and 410 (JS) | 3/02 |
| * KS-ENG-406 (JS) - Anti-Seep Collar - For Metal Pipe | 3/02 |
| * KS-ENG-407 (JS) - Coupling Bands | 3/02 |
| * Guide Plan for completing KS-ENG-408 (JS) | 3/02 |
| * KS-ENG-408 (JS) - Water Supply Line | 3/02 |
| KS-ENG-417 (JS) - Cathodic Protection | 4/79 |
| Guide Plan for completing KS-ENG-428 (JS) | 9/90 |
| KS-ENG-428 (JS) - Trickle Irrigation System | 9/90 |
| * KS-ENG-437 (JS) - Cover Sheet | 3/02 |

*These are available as AutoCAD drawing files on a compact disk (CD) or electronically by e-mail from the State Office Engineering Section.

| | Date |
|---|---|
| * Guide Plan for completing KS-ENG-443 (JS) | 4/02 |
| * KS-ENG-443 (JS) - Concrete Block Lined Chute | 4/02 |
| * Guide Plan for completing KS-ENG-449a (JS) | 12/02 |
| * KS-ENG-449a (JS) - Concrete Chute Inlet Structure (page 1) | 12/02 |
| * Guide Plan for completing KS-ENG-449b (JS) | 12/02 |
| * KS-ENG-449b (JS) - Concrete Chute Inlet Structure (page 2) | 12/02 |
| * Guide Plan for completing KS-ENG-450(JS) | 4/02 |
| * KS-ENG-450 (JS) - Reinforced Concrete Retaining L Wall - 5’ Maximum Height | 4/02 |
| * Guide Plan for completing KS-ENG-451(JS) | 4/02 |
| * KS-ENG-451 (JS) - Reinforced Concrete Retaining T Wall - 5’ Maximum Height. | 4/02 |
| * Guide Plan for completing KS-ENG-452(JS) (2 pages) | 3/02 |
| * KS-ENG-452 (JS) - Sediment Basin Details | 3/02 |

*These are available as AutoCAD drawing files on a CD or electronically by e-mail from the State Office Engineering Section.