AUCSC

Chapter 8

Cathodic Protection System Maintenance and Troubleshooting Procedures

Maintenance Program

- Periodic Surveys
- Coating Maintenance
- Rectifier and Anode Bed Maintenance
- Galvanic Anode Maintenance
- Test Station Maintenance

Coating Maintenance

- Above and Below Ground Coatings
- All damage should be repaired at time of discovery
- Repair should be as good or better than existing coating
- Repair crew should be trained in proper preparation and application (READ THE INSTRUCTIONS)

Coating Maintenance

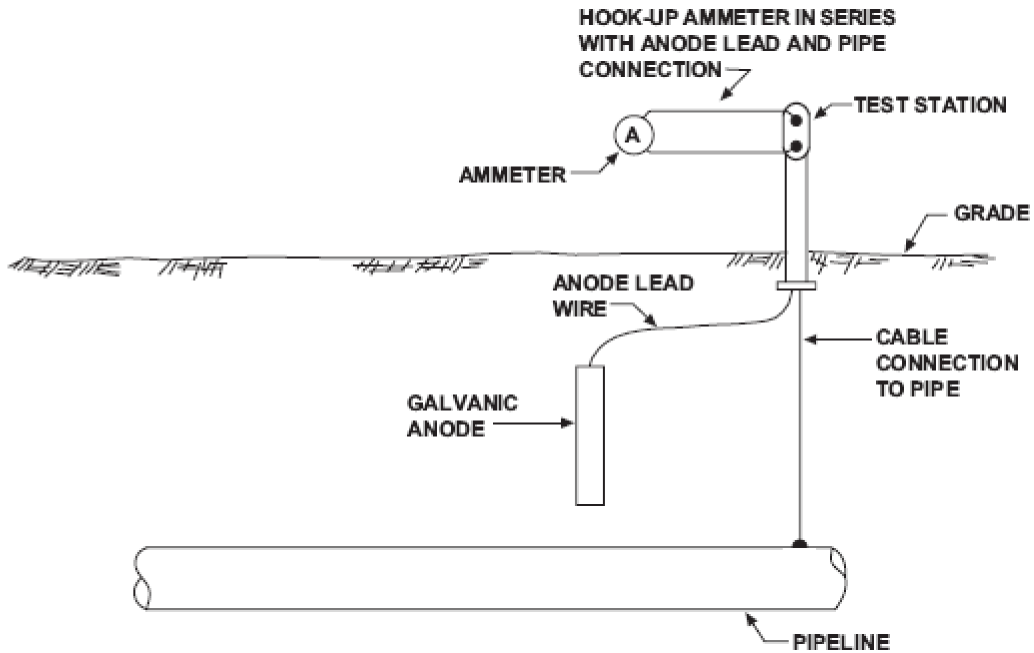
- Keep records of type of coatings found and condition
- Documentation
  - Existing coating
  - Repair coating
  - Environmental conditions
  - Date
  - Weather conditions

Rectifier and Anode Bed Repair

- Impress current anode bed usually limited to a visual inspection
- Recent construction activity
- New underground structures near anode bed
- Inspect overhead power service

Galvanic Anode Maintenance

- Anode bed limited to visual inspect as previous mentioned
- Header cables should be large diameter wire (ex. #8 or #6 AWG)
- Test stations should have anode connections cleaned, free of corrosion (copper antiseize)
- Measure and record anode current output
  - To determine anode life and consumption rate



MEASURING CURRENT OUTPUT OF GALVANIC ANODE

FIGURE 8-5

Periodic Surveys

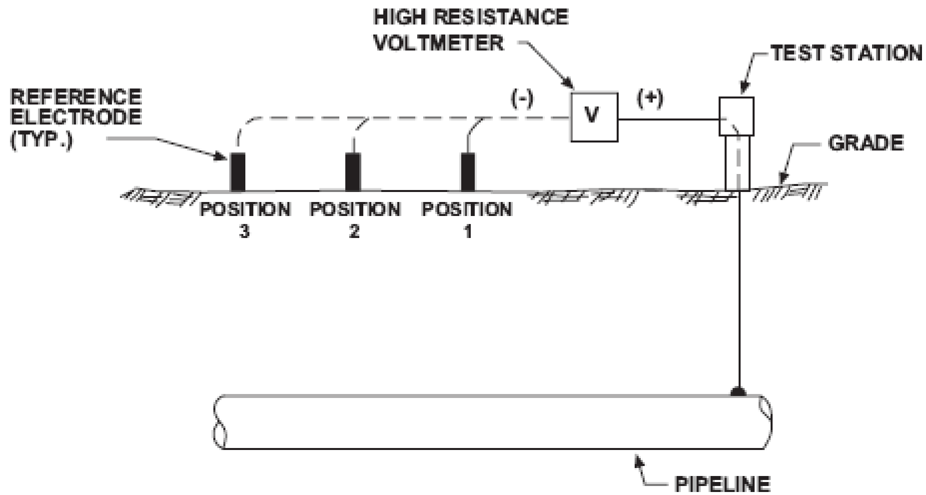
- Pipe to Soil Potential Survey
- Effective Coating Resistance
- Rectifier Inspection
- Impressed Current Anode Junction Box
- Impressed Current Ground Bed Resistance
- Galvanic Anode – Current Output and Ground Bed Resistance
- Bonds – Non Critical and Critical

Periodic Surveys

- Casings – Resistance and Potentials
- Isolation Joints – Working, Lightening Arrestors, Spark Gaps, and Grounding Cells
- Dynamic Stray Current Areas – Bonds, Drains and Switches
- Isolation Jumpers – Continuity
- Any other special equipment installed as part of cathodic protection system – AC mitigation, remote read equipment, etc.

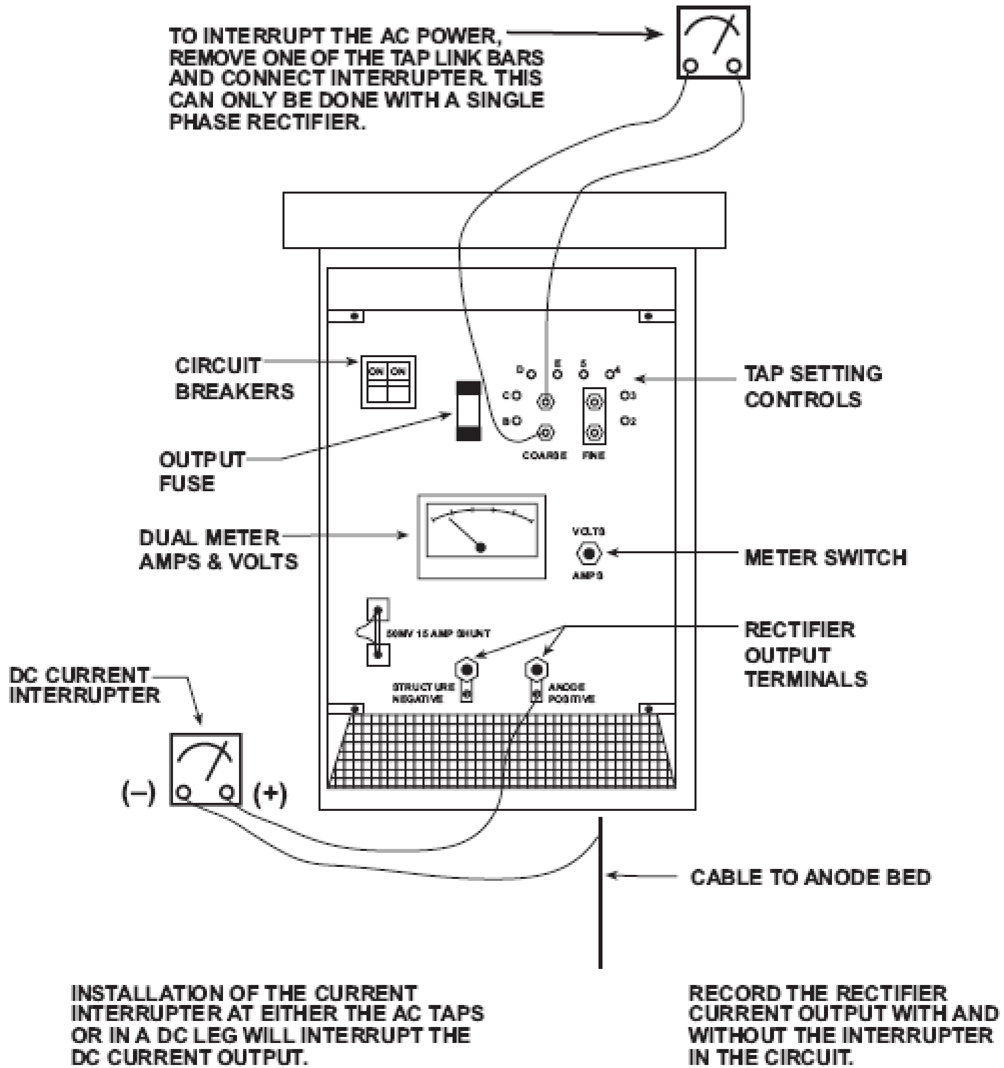
Pipe to Soil Potentials Surveys

- **Equipment Required**
- High resistance volt meter – 10 meg-ohm or higher
- Test Leads
- Reference electrode (Figure 8-1)
- Current Interrupter (Figure 8-2)



PIPE-TO-SOIL POTENTIAL SURVEY

FIGURE 8-1



INTERRUPTING A RECTIFIER

FIGURE 8-2

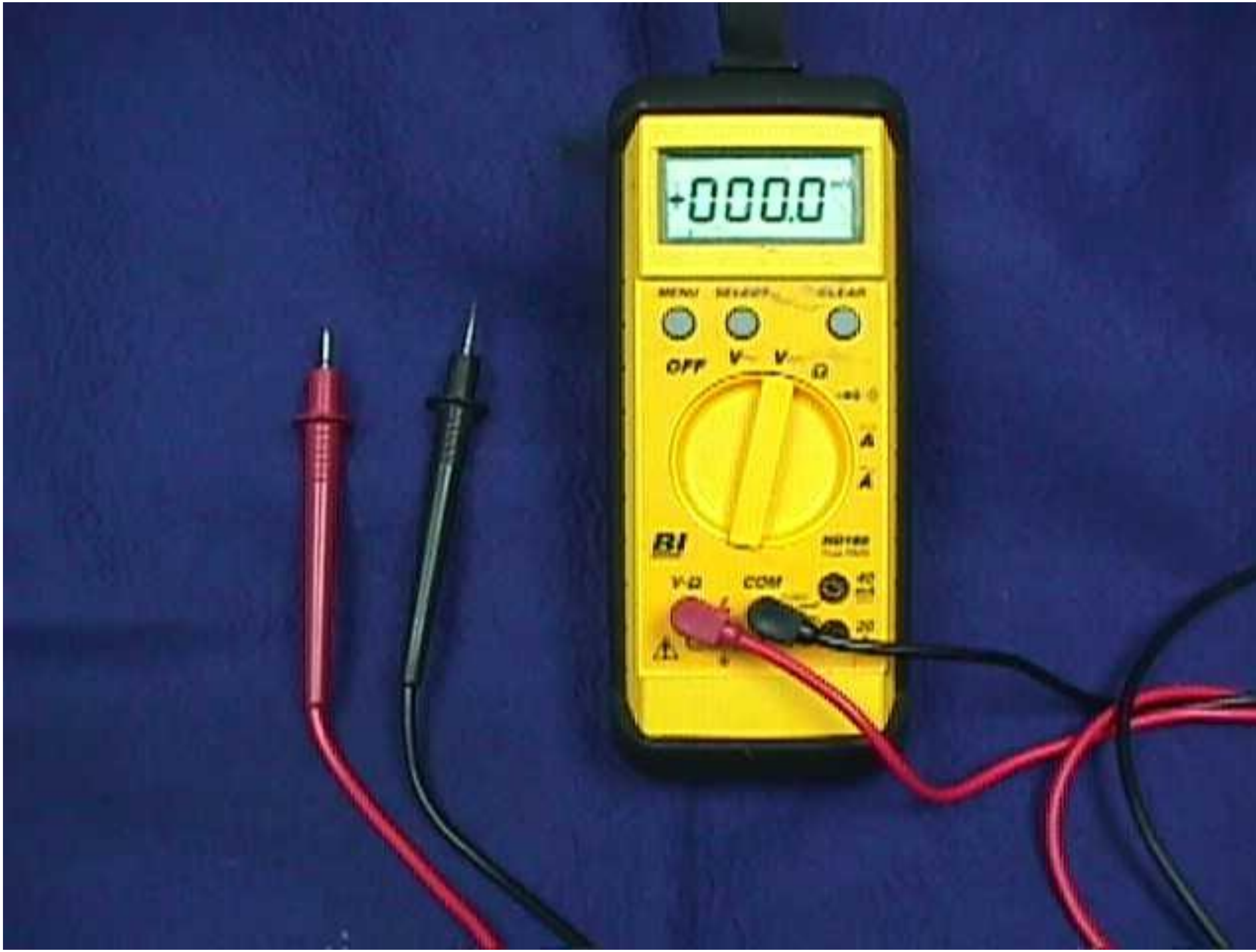
Pipe to Soil Potentials Surveys

- **Procedure**
- Install Current Interrupter (if required)
- Place reference electrode directly centered over pipeline
- Moisten dry soil
- Good soil contact, no loose stone or rocks, no dry leaves or grass

Pipe to Soil Potentials Surveys

- **Meter connection**
- Digital Meter – Pipeline = Positive Lead (Display negative value)
- Analog Meter – Pipeline = Negative Lead (Causes up scale needle movement)

Note: Follow your company standard


-000.0
MENU
CLEAR
OFF
COM


Polarity
C.C.C.
On
Adj
Normal
Zero
Zero
Polarity
20mv
2v
1v
10a
20a
Bal
Off
100v
Bal
Off
10v
20v
1M
10M
L/VM
R/VM
INPUT RES
AMMETER
Amps
Volts
Off
MILLER METER - MODEL M3A1

Pipe to Soil Potentials Surveys

- Calculating Ground Voltage Coupling to determine increase of current to meet a criteria

Ground Voltage Coupling

- Step #1 Calculate the potential change

$$\triangle V = V_{ON} - V_{OFF}$$

$$= -0.82V - (-0.65V) = 0.17 \text{ volt}$$

- Step#2 Calculate Ground Voltage Coupling

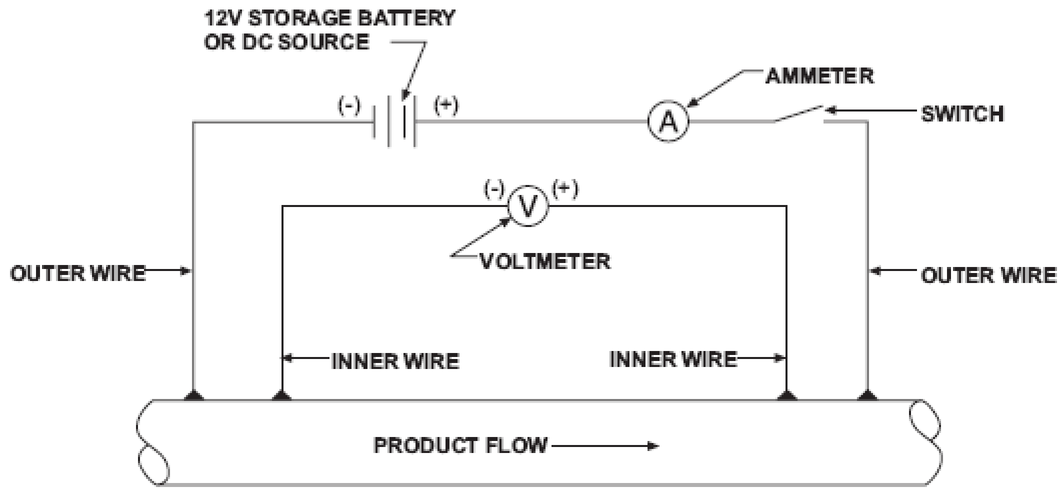
$$RVG = \frac{\triangle V}{I} = \frac{0.17V}{3A} = 0.057 \text{ volt/amp or ohms}$$

Ground Voltage Coupling

- Step #3 Calculate addition current required to raise pipe to soil

$$I_{rqd} = \frac{\triangle V_{rqd}}{R_{vg}} = \frac{0.03 \text{ volts}}{0.057 \text{ volts/amp}} = 0.53 \text{ amps}$$

0.53 amps required to raise to -0.85V



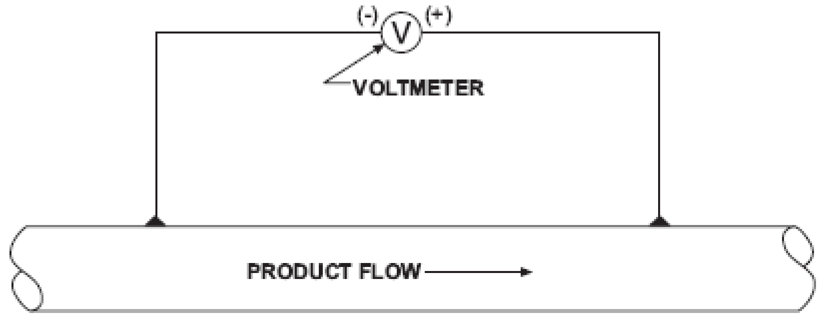
$$K = \frac{\Delta I}{\Delta E_{MV}} = X \ \ A/mv$$

WHERE: ΔI = AMPS

ΔE_{MV} = MILLIVOLTS

CALIBRATION OF IR DROP SPAN

FIGURE 8-13



$$I_{CALCULATED} = \Delta E_{MV} \times K$$

$$\%I_{TEST} = \frac{\Delta E_{MV} \times K \times 100\%}{I_{TEST}}$$

WHERE: K = CALIBRATION FACTOR IN AMPS / MV

INDIRECT MEASUREMENT OF CURRENT

FIGURE 8-14

Coating Effectiveness

- $R_c = R_{vg}$ x Surface Area of the Structure
- Surface Area = π x diameter x length(ft)
- = 3.14 x (1) x 32,000 = 100,480 FT^2

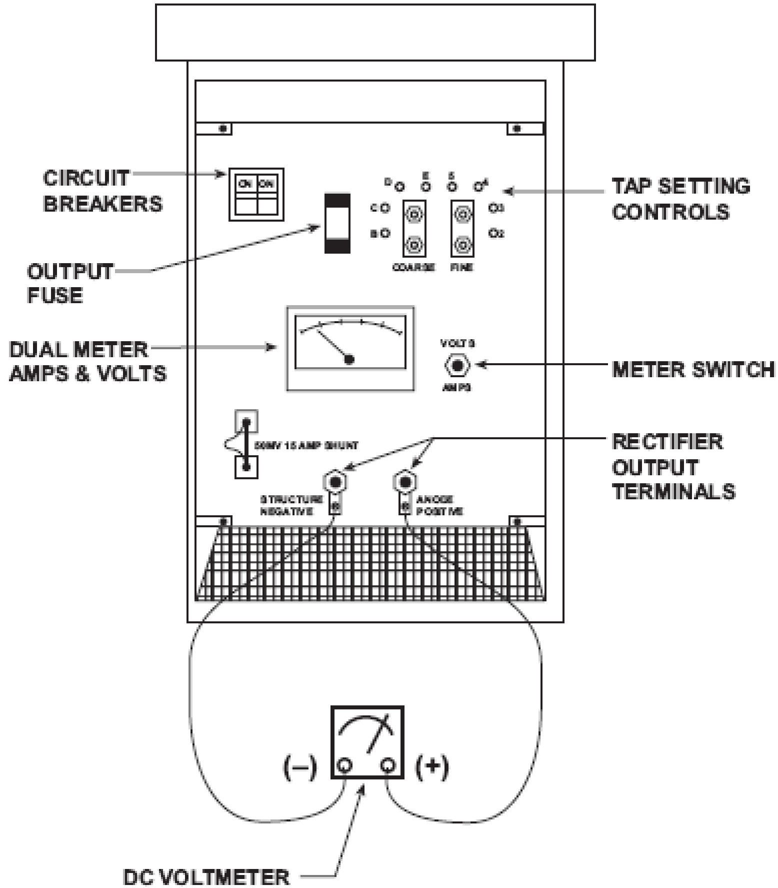
- R_c = 8 ohms X 100,480

- R_c = 803,840 ohm-ft^2 greater than 300,000

Rectifier Inspection

- Measure DC voltage, current and Pipe to Soil potential (Figures 8-3, 8-4)
- Collect information to calculate efficiency
- Visually inspect for burnt components, loose wires
- Visually inspect and clean if necessary top and bottom screens
- Oil bath units inspect oil level and fill if necessary
- Calculate anode bed resistance


SHUNT FACTOR : .6



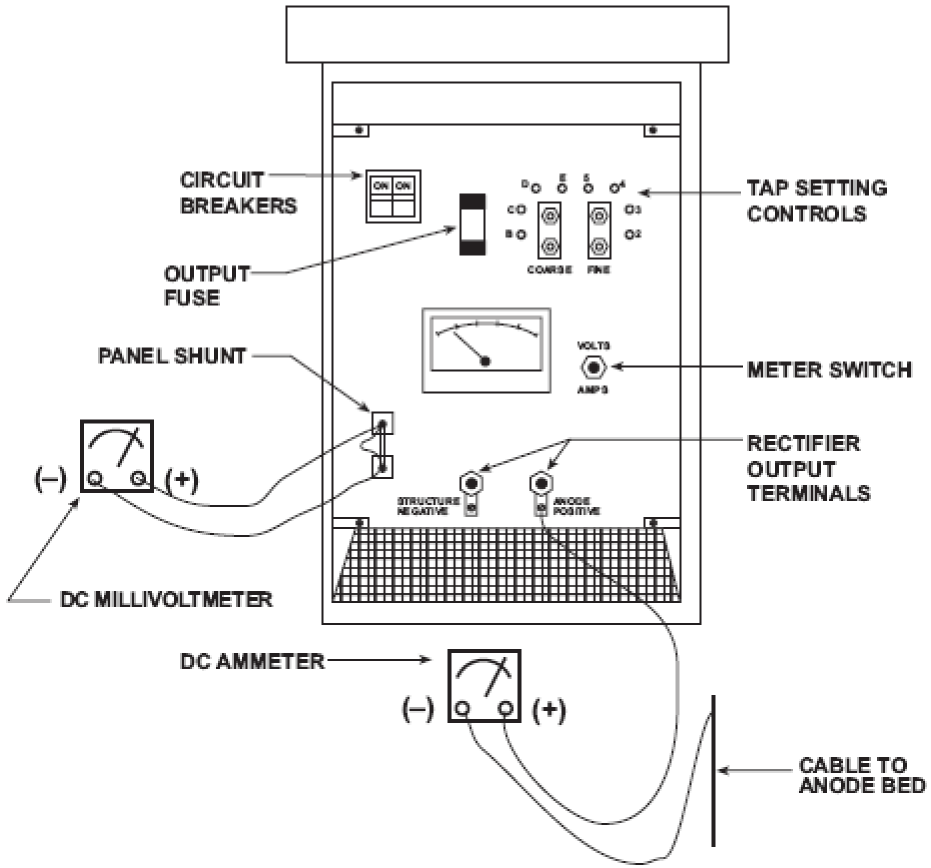
MEASURING RECTIFIER VOLTAGE

FIGURE 8-3

TWO METHODS:

1. DC AMMETER IN SERIES WITH ONE OF THE DC LEGS.
   CURRENT READ DIRECT IN AMPERES.

2. DC MILLIVOLTMETER IN PARALLEL WITH PANEL SHUNT.
   RATING OF SHUNT WILL USUALLY BE STAMPED INTO THE SHUNT.

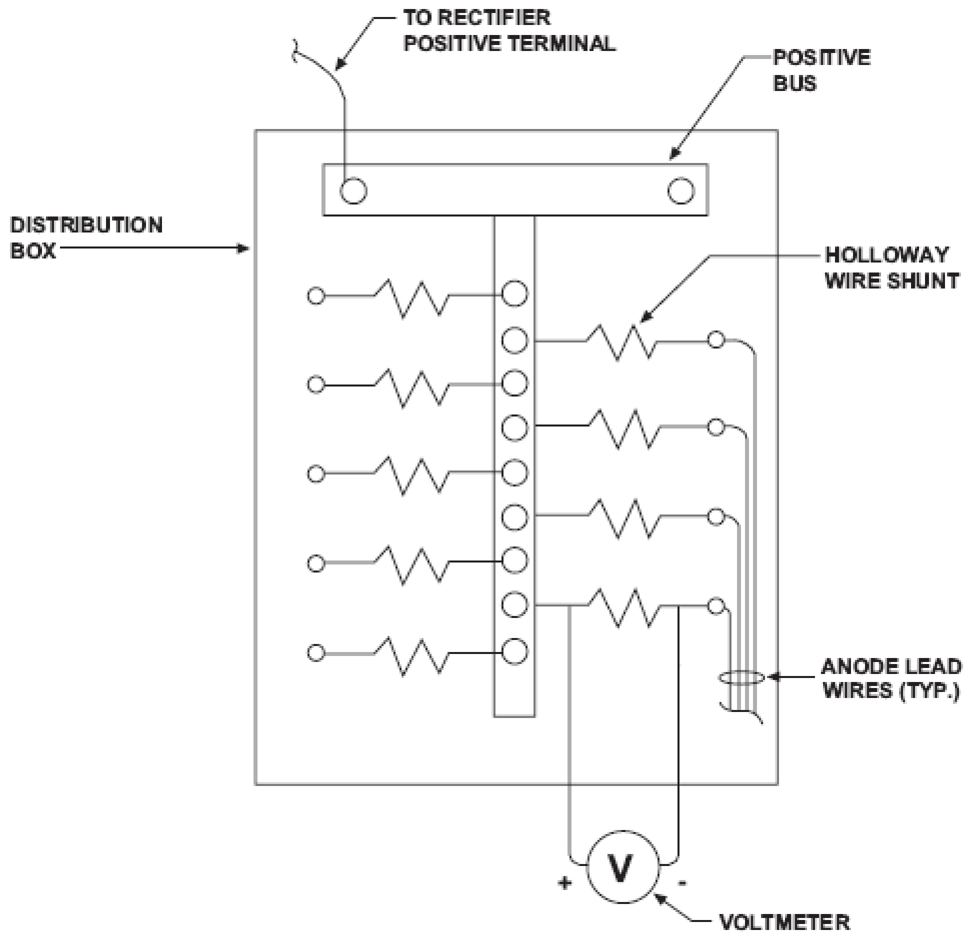


MEASURING RECTIFIER CURRENT

FIGURE 8-4

Impressed Current Junction Box

- Measure current output to each anode and compare with previous measurements(Fig 8-6)



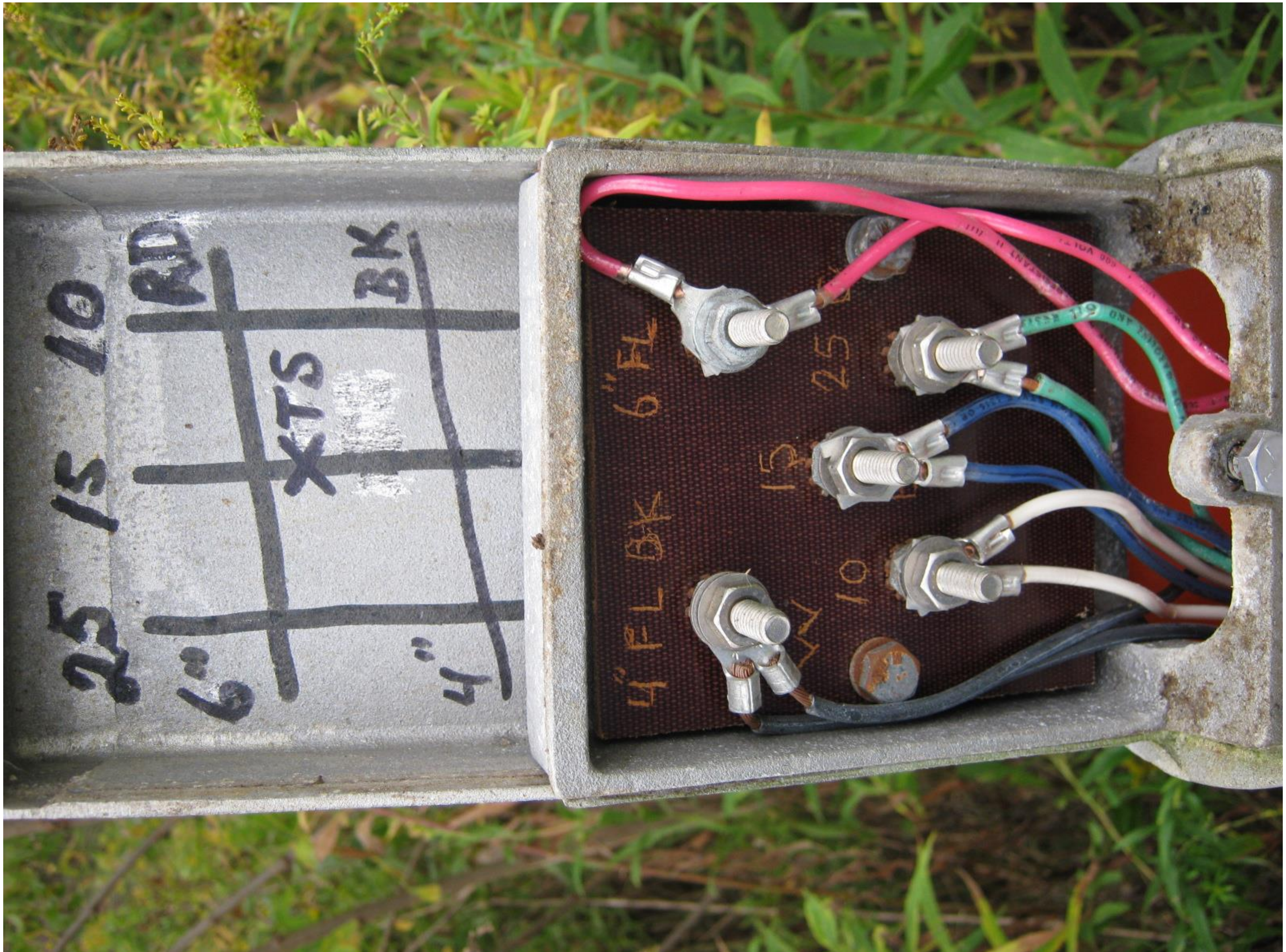
MEASURING IMPRESSED CURRENT ANODE CURRENT OUTPUT AT DISTRIBUTION BOX

FIGURE 8-6

Bonds – Critical and Non Critical

- Measure Pipe to Soils of each structure bonded and unbonded
- Measure current flow thru bond and identify current flow direction

Use your company standard for meter connection


25 15 10
RD
BK
XTS
6"
4"
6" FL
4" FL BK
25
15
10

Casings

- Measure resistance between casing and carrier
- Periodically perform Casing Short Test
  - How to set up and perform test later in chapter

Dynamic Stray Current Areas

- Verify that bonds, switches, or other corrective methods are functional
- Periodically set data recording instruments to measure pipe to soil and current flow

Isolation Joints

- Verify that isolation joints are functioning properly
- Inspect the spark gaps and grounding cells function properly
- Inspect jumpers installed across isolation joints for continuity

Any Other Cathodic Protection Devices

- Inspect and test all other devices for proper function
- Remote monitoring devices
- Solar cells
- Generators

Records and Data Sheets

- Date and Time
- Technician or Technicians
- Weather Conditions
- Location of test or inspection
- Instruments – serial and model numbers
- Polarity (+/-)
- Meter scale if non auto ranging

Records and Data Sheets

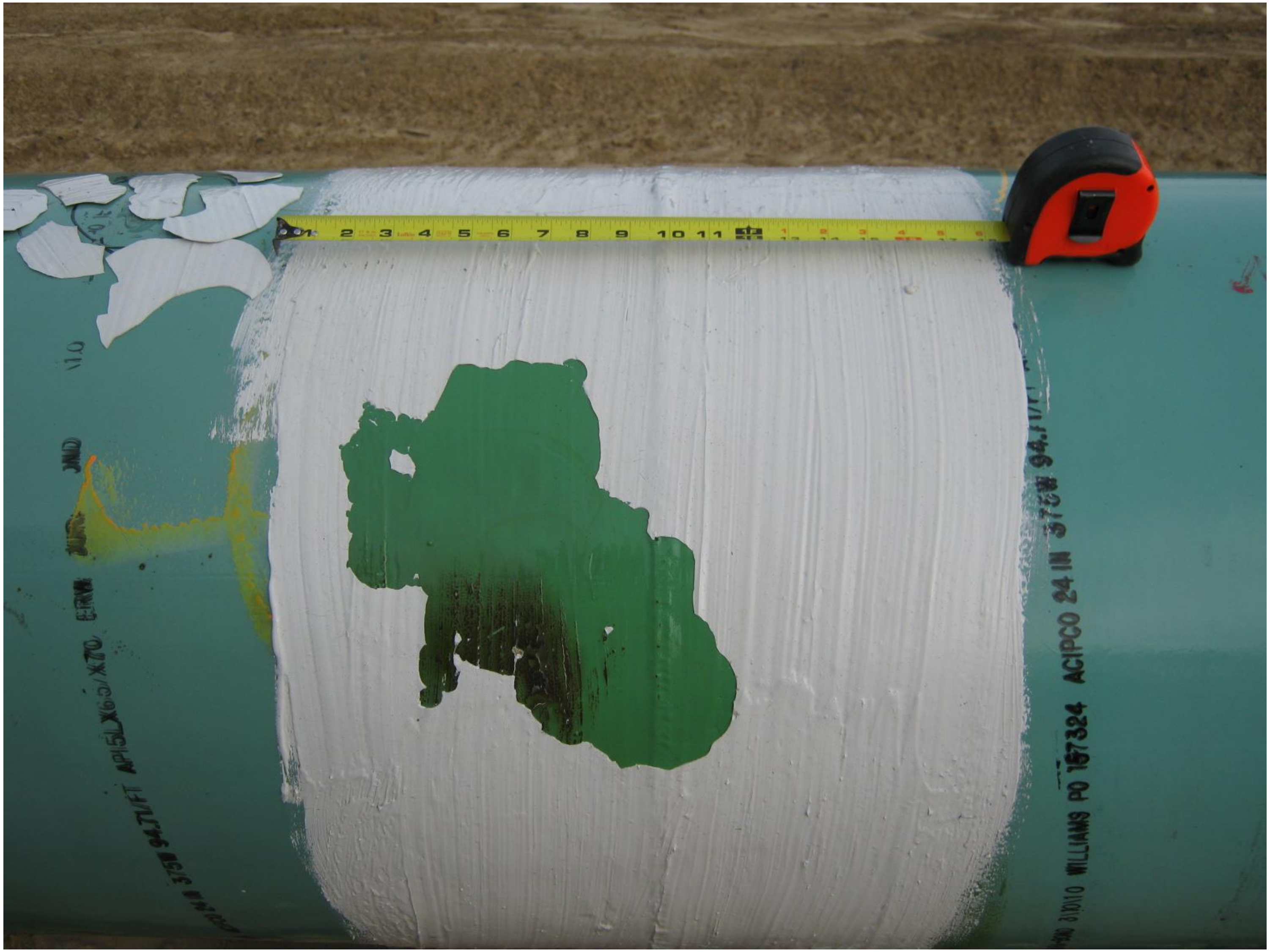
- Conditions when data was taken:
  - Rectifer on/off
  - Bonds in/out
  - Current source
  - Type of reference cell and location
  - Soil conditions
  - Any unusual conditions

Repair or Replacements

- Coatings
- Rectifiers
- Impressed Current Anode Beds
- Galvanic Anodes
- Test Stations

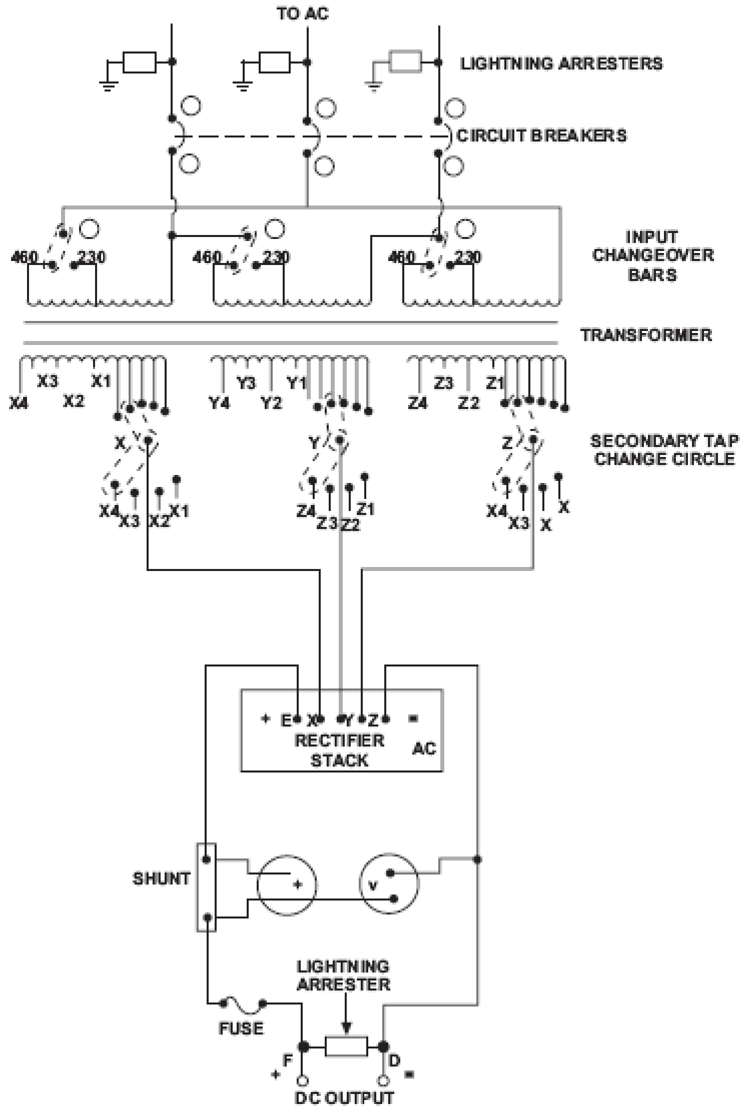
Coatings

- Recoating is expensive
- May be necessary when cathodic protection requirements become to great
- Recoat material should be selected to with stand environment of pipeline
- Installed to company or manufacturers procedures
  - Properly trained installers


ACIPCO 24 IN
WILLIAMS PO 157324

Rectifiers (Figure 8-7)

- Troubleshooting
- READ MANUAL and SCHEMATIC
- Turn off when possible to troubleshoot
- Check fuses and circuit breaks first
- Use senses: touch, smell and sight
- Start with AC input side work to DC output
- Take specific class for troubleshooting



TYPICAL RECTIFIER CIRCUIT

FIGURE 8-7

Impressed Current Anode Beds

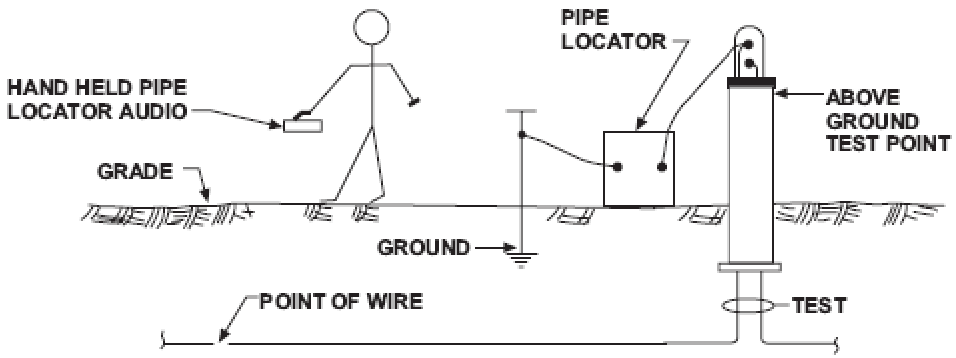
- Damaged or broken cable
- Damaged anodes
- Consumed anodes
- Improper installation of splices
- Improper installation of splice isolation kits

Galvanic Anodes

- Broken or damaged wires
- Depleted anodes

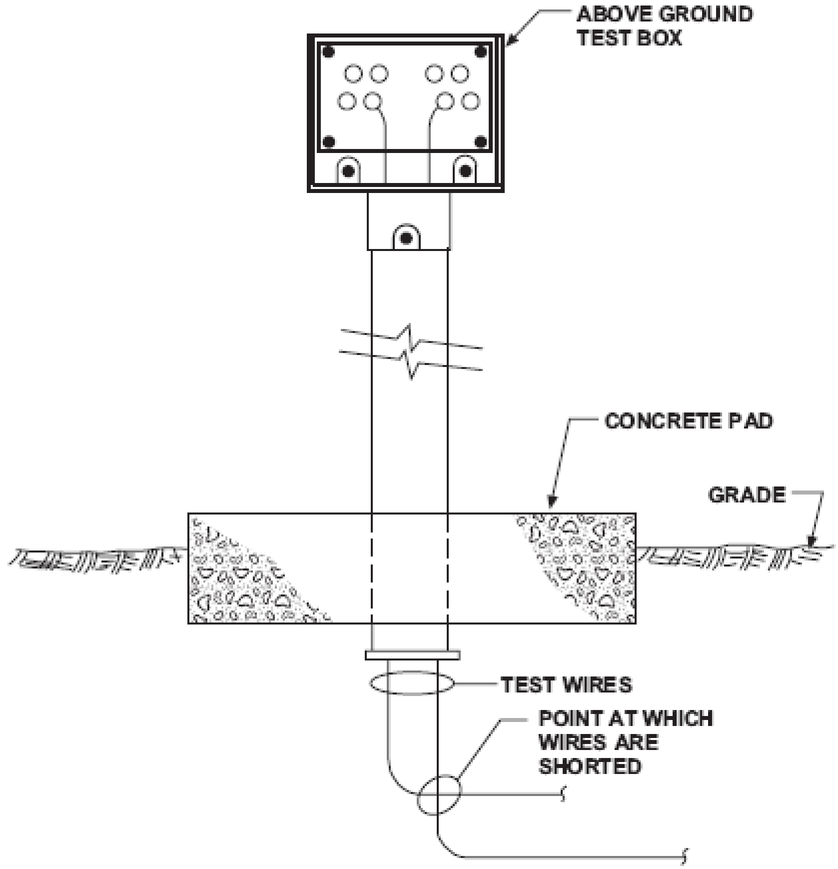
Test Stations

- High resistance connections
- Broken wires – Use locator to perform "over wire survey" to find break (Figure 8-8)
- Measure resistance of wires, to calculate resistance/foot to determine break location (Figure 8-9)



OVER THE WIRE SURVEY USING
PIPE LOCATOR

FIGURE 8-8

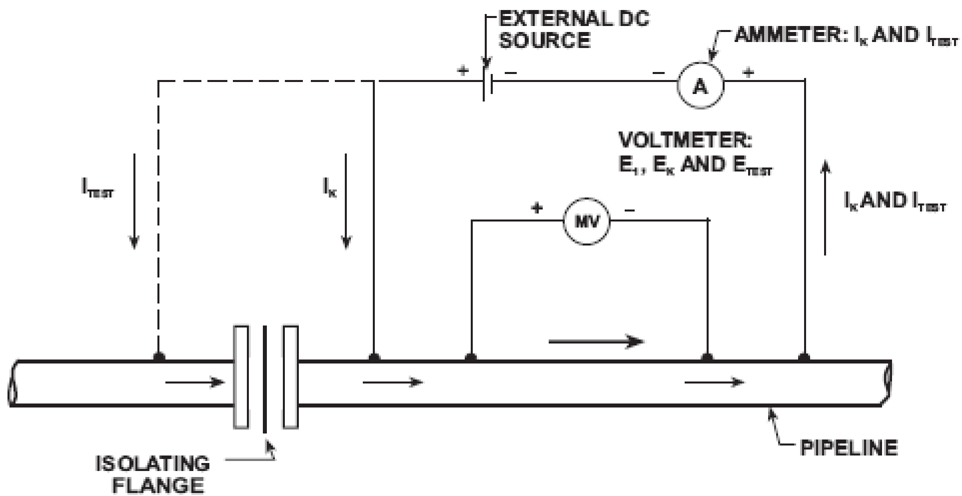


TEST STATION WITH SHORTED TEST WIRES

FIGURE 8-9

Tests Used in Cathodic Protection System troubleshooting

- Percent Leak Test (Figure 8-10)
- System Current Profile (Figures 8-11, 8-12)
- Surface Potential Surveys
  (Figures 8-15, 8-16, 8-17)
- Testing Pipeline in Contact with Casing
  (Figure 8-20)



MEASURING PERCENT LEAKAGE THROUGH ISOLATING JOINT

FIGURE 8-10

Percent Leak test

$$K\ (\text{amp/mv}) = \frac{\text{calibration current}}{\text{calibration voltage (mV)}}$$

$$K = \frac{I_k}{E_k - E_1}$$

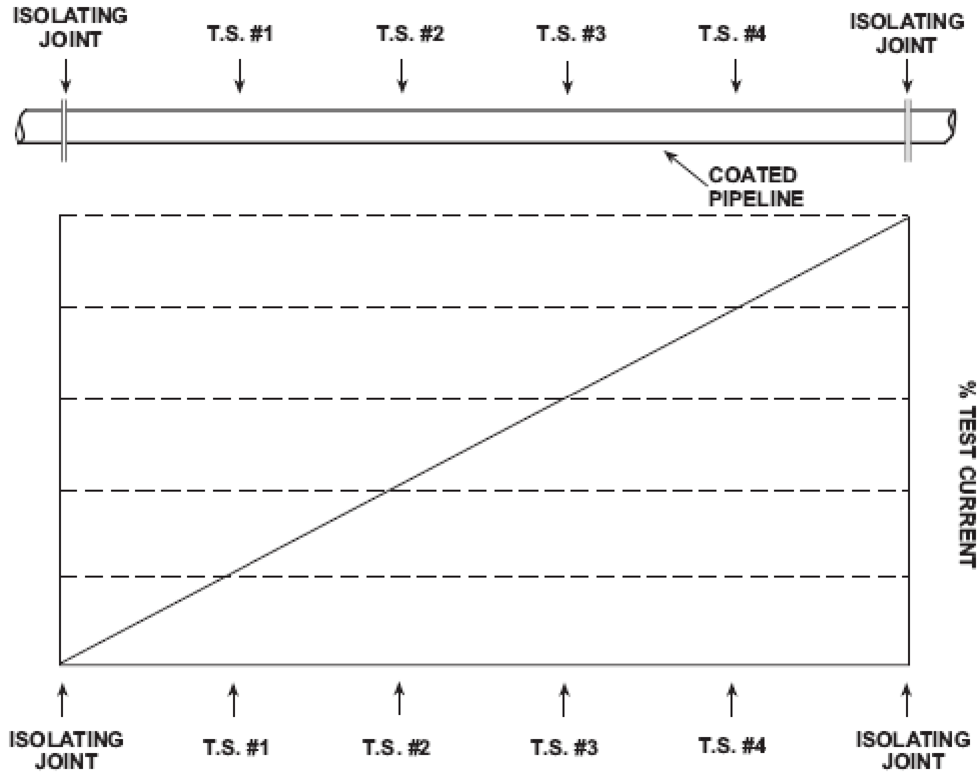
Percent Leak Test

$$\text{Precent Leakage} = \frac{K \times (E_{test} - E_1)}{I_{test}} \times 100$$

System Current Profile

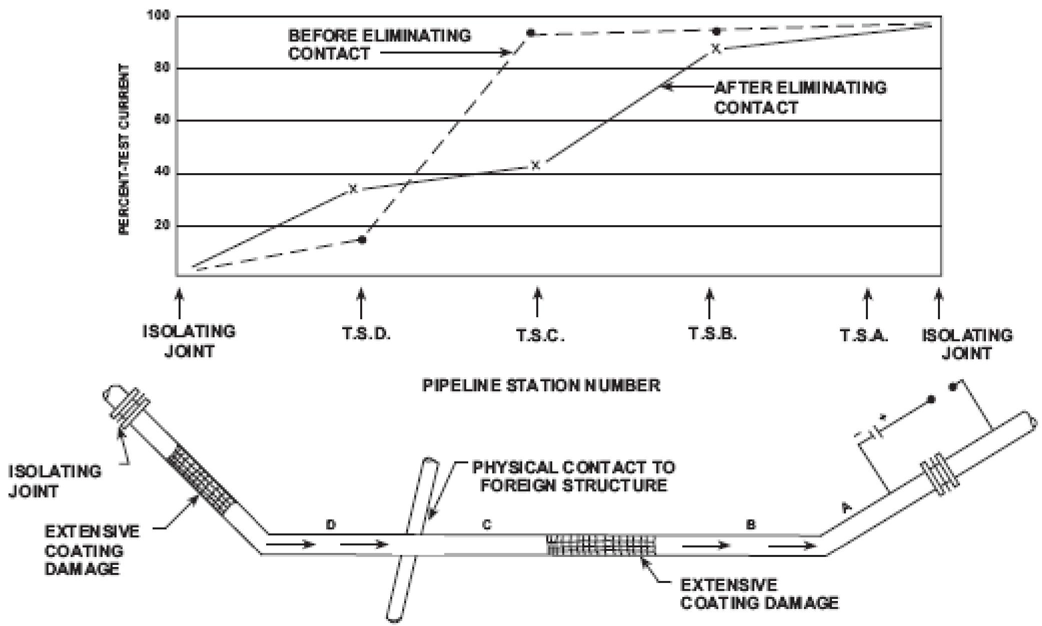
(Fig 8-11 & Fig 8-12)

- Using millivolt drop measurements
- Plot of test station location vs percent test current
- Problem areas are located and futher test should be preformed
- Other tests: short locating, surface potential surveys, more extensive millivolt drop tests, and current flow direction tests



IDEAL CURRENT PROFILE FOR PROTECTED PIPE SECTION

FIGURE 8-11



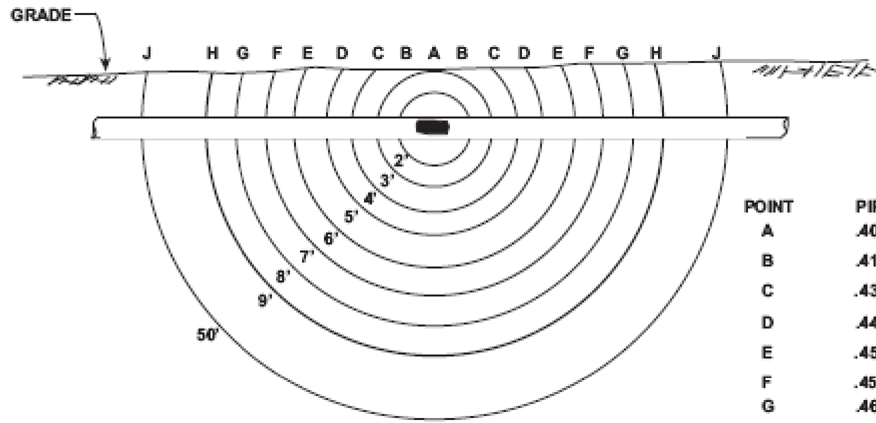
"CURRENT PROFILE"
TO EVALUATE COATING QUALITY

FIGURE 8-12

Surface Potential Surveys

(Fig 8-15, Fig 8-16, Fig 8-17, Fig 8-18, & Fig 8-19)

- Identically calibrated reference electrodes
- Measures current flow direction in soil
- Useful to locate holidays, anodes, and anodic areas on pipelines
- Single electrode method and two electrode methods
- Can be combined with side drain measurements

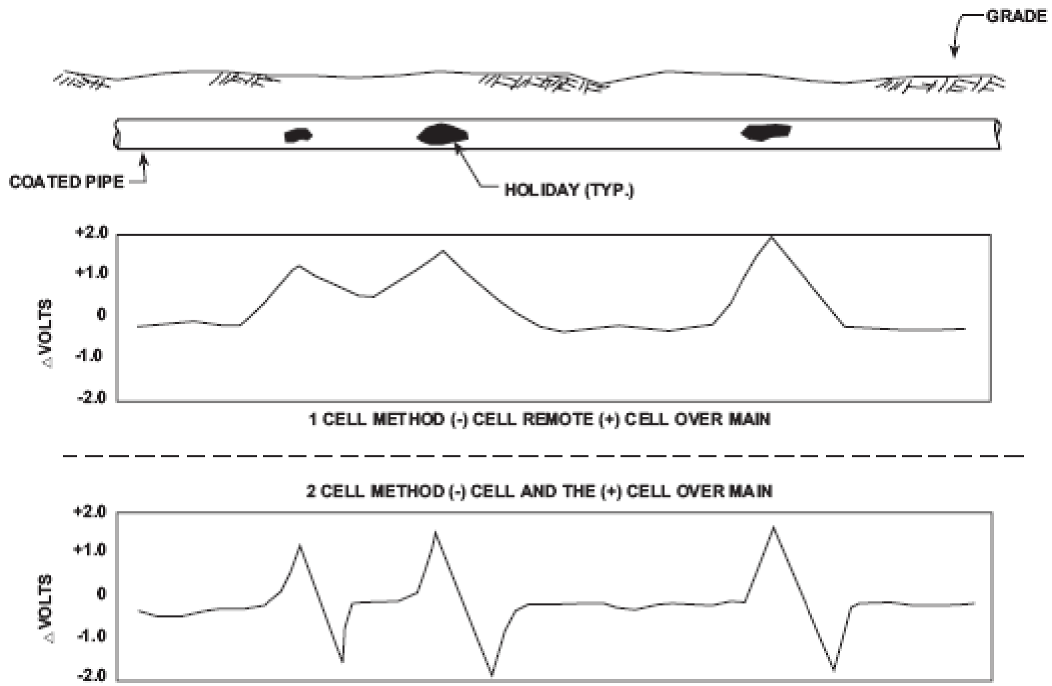


POINT	PIPE
A	.407
B	.418
C	.435
D	.446
E	.454
F	.459
G	.464
H	.480
J	.500

VOLTAGE GRADIENTS DEVELOPED AT A HOLIDAY FROM CATHODIC PROTECTION CURRENT CHANGING PIPE TO SOIL POTENTIAL OF PIPE 0.50 VOLTS.

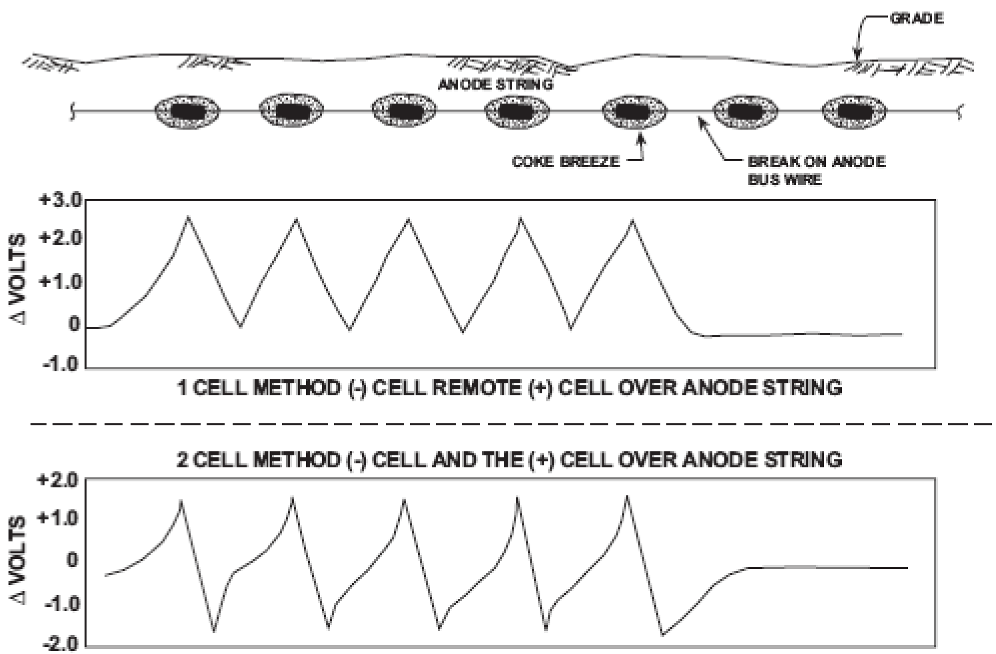
HOLIDAY GRADIENTS

FIGURE 8-15



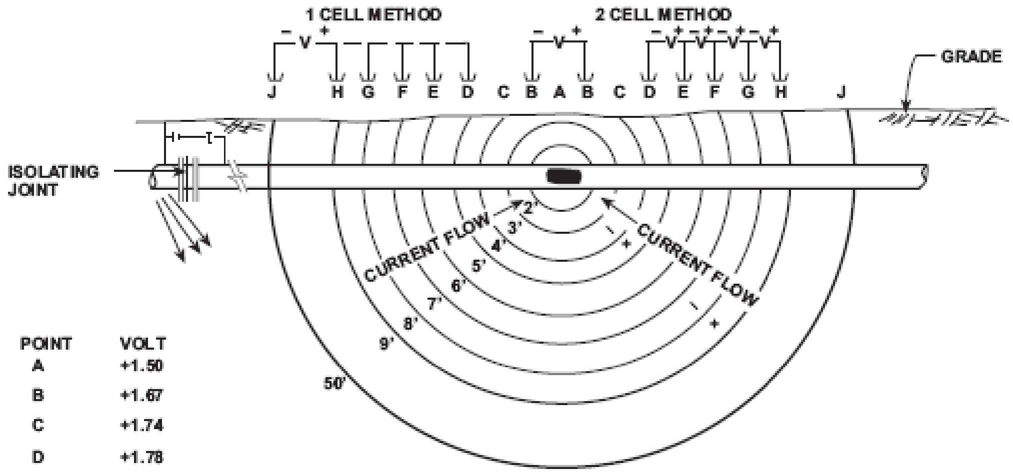
SURFACE POTENTIAL SURVEY
MEASURING HOLIDAY VOLTAGE GRADIENTS

FIGURE 8-17



SURFACE POTENTIAL SURVEY
MEASURING ANODE VOLTAGE GRADIENTS

FIGURE 8-19



POINT	VOLT
A	+1.50
B	+1.67
C	+1.74
D	+1.78
E	+1.82
F	+1.84
G	+1.86
H	+1.92
J	+2.00

SURFACE POTENTIAL SURVEY
MEASURING ANODE VOLTAGE GRADIENTS

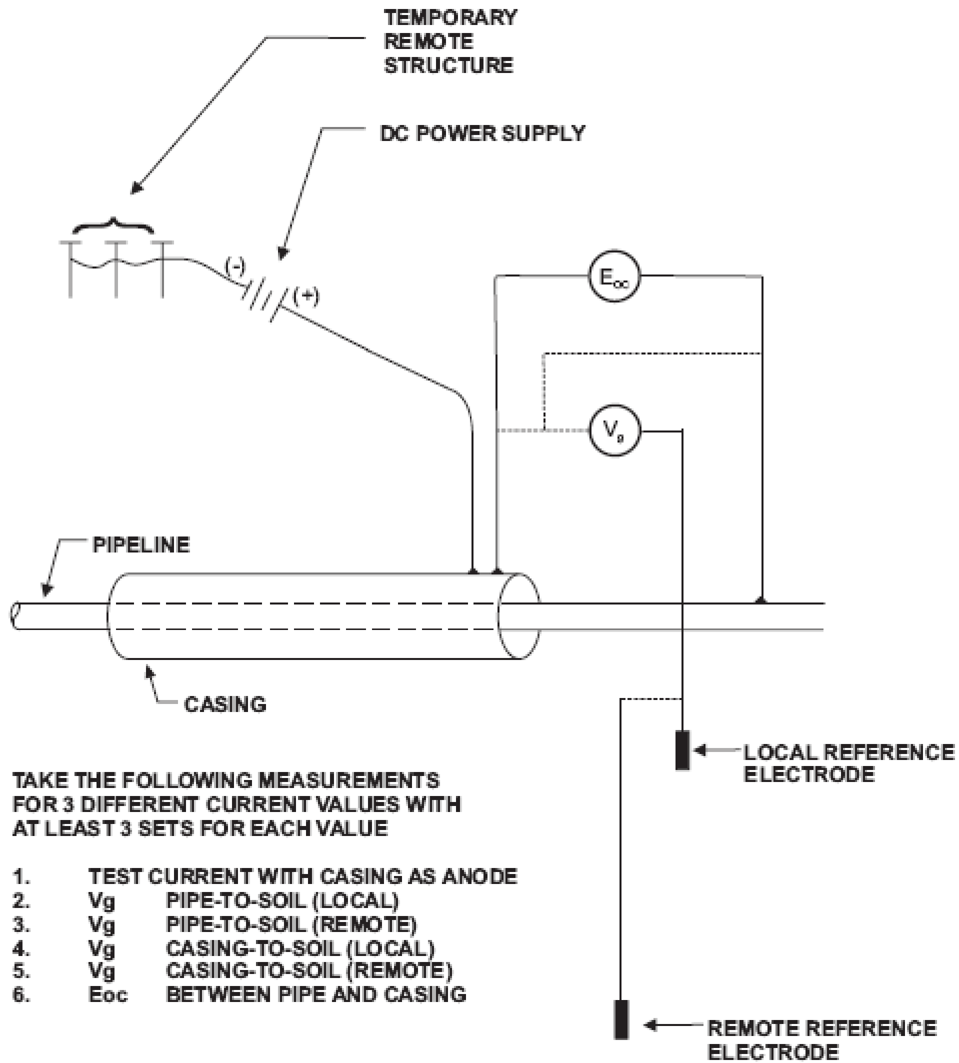
FIGURE 8-16

Testing Pipelines in Contact with Casings

- Two types of contacts – electrolytic or metallic
- Electrolytic = annular space is filled with water or other electrolyte
- Metallic = carrier and casing are in direct contact with each other
- A low resistance contact will effect the operation of the cathodic protection system

Testing Pipelines in Contact with Casings

- Casing short test (Fig 8-20)



DETERMINATION OF TYPE OF CASING "SHORT"

FIGURE 8-20