Cathodic Protection Criteria and IR Drop Consideration

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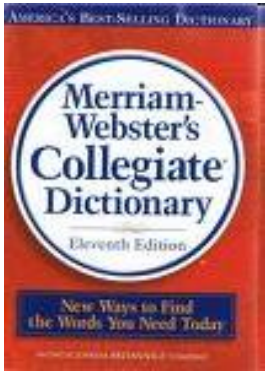
Safety

- Most often you work alone
- Know where you're putting your hands
- Get help when needed
- Tell people where you'll be working
- Check in regularly
- Drive safely

Criteria

- What is meant by criteria?
- Merriam-Webster dictionary says:

Main Entry: **cri·te·ri·on**
Pronunciation: \krī-'tir-ē-ən *also* krə-\
Function: *noun*
Inflected Form(s): *plural* **-ria** \-ē-ə\ *also* **cri·te·ri·ons**
Etymology: Greek *kritērion,* from *krinein* to judge, decide — more at CERTAIN
Date: 1622
1 : a standard on which a judgment or decision may be based
2 : a characterizing mark or trait
synonyms see STANDARD



Definitions

- CSE = copper-copper sulfate reference electrode
- Cu-$CuSO_4$ = copper-copper sulfate reference electrode

The Criteria

- -850 mV ON potential vs CSE
- -850 mV polarized potential vs CSE
- 100 mV polarization decay
- 300 mV shift
- E log I
- Net current

Criteria

- The criteria we're discussing can be used alone or in combination
- Criteria that has been successfully applied on existing systems can continue to be used
- It must achieve corrosion control comparable to others

The CSE

- When a copper rod of a CSE is placed in the copper sulfate crystals and distilled water solution, a voltage develops between the copper rod and the saturated copper sulfate crystals and distilled water solution with the copper rod being negative to the solution.

The CSE

- Think of it as “sea level” – it’s not always in the exact same spot but it’s close enough to know if we’re going to get wet or not
- The CSE is constructed so it can be used as a standard reference anywhere on earth so long as proper corrections are made for temperature

The CSE

- Portable CSE
  - Lightweight
  - Accurate within a large temperature range
  - Easy to maintain
  - Parts and solution easily available

Permanent CSE

- Permanent CSE
  - Installed in areas that may not be easily reached
  - Use where continuous monitoring is required
  - Stable throughout its design life

Other considerations

- Other references are available
  - Calomel
  - Silver chloride
  - Hydrogen
- Use and care
  - Test against a standard
  - Maintain extra crystals to insure saturation

The Meter

- High impedance
- Lightweight
- Accurate
- Analog or digital
- Inexpensive
- User friendly
- Colorful

Typical multimeters

Calibrations

- Half cell
  - Have a reference that never touches the earth in a desk drawer
  - Calibrate the field half cell against the desk one
- Multi-meter
  - Send to manufacturer or test lab at least every other year

Record Keeping

- Document the half cell tests
  - Identify half cells
  - Document each comparison
  - Folder in desk
- Multi-meters
  - Sticker on meter with invoice

Record Keeping

- Pipe to soil potentials
  - Record each and every reading in program
- Interference
  - Insure the records are complete and understandable
- Cross reference all documents

Criteria for Cathodic Protection

- -850 mV ON
- -850 mV instant off
- 300 mV shift
- 100 mV of depolarization
- E log I
- Net current

Criteria limitations

- Potentials can vary as a result of:
  - Soils
  - Coatings
  - Interference
  - Temperature
  - Bacteria
  - Over protection

Other piping metals

- Criteria for aluminum
  - An amphoteric metal
  - No more than -1200 mV, or
  - 100 mV of polarization
- Criteria for copper
  - 100 mV of polarization
- Dissimilar metals
  - Protect the most anodic

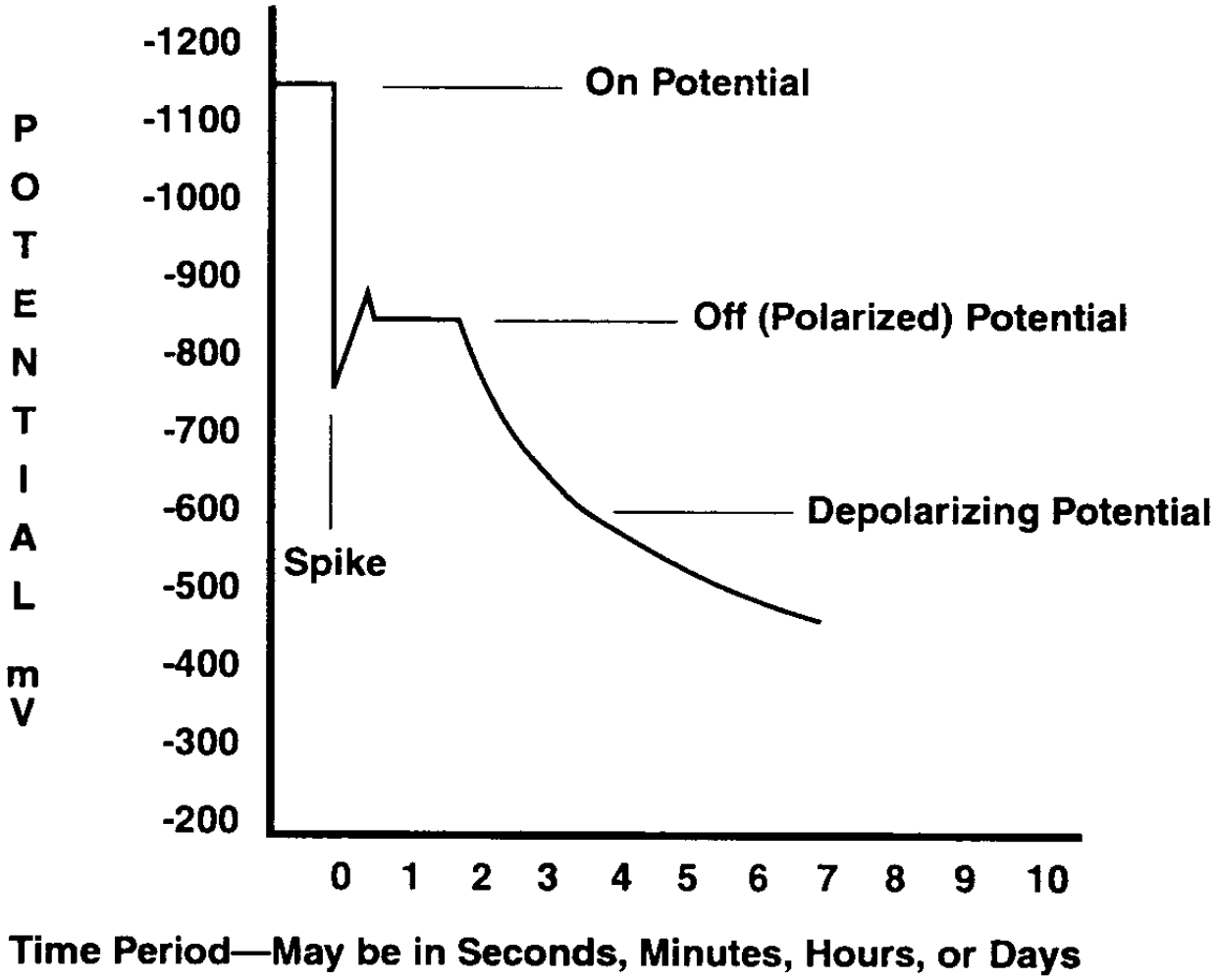
-850 mV On

- Easiest criteria to apply
- Valid 98% of the time
- Requires minimal equipment
- Good for well coated structures with small current requirements
- IR drop must be considered

-850 mV instant off

- Also known as -850 mV polarized
- More difficult to apply
- Requires additional equipment
  - Current interrupters
  - Another person
- More expensive to achieve
- Applies in unusual environments
  - Acidic soils

-850 mV instant off



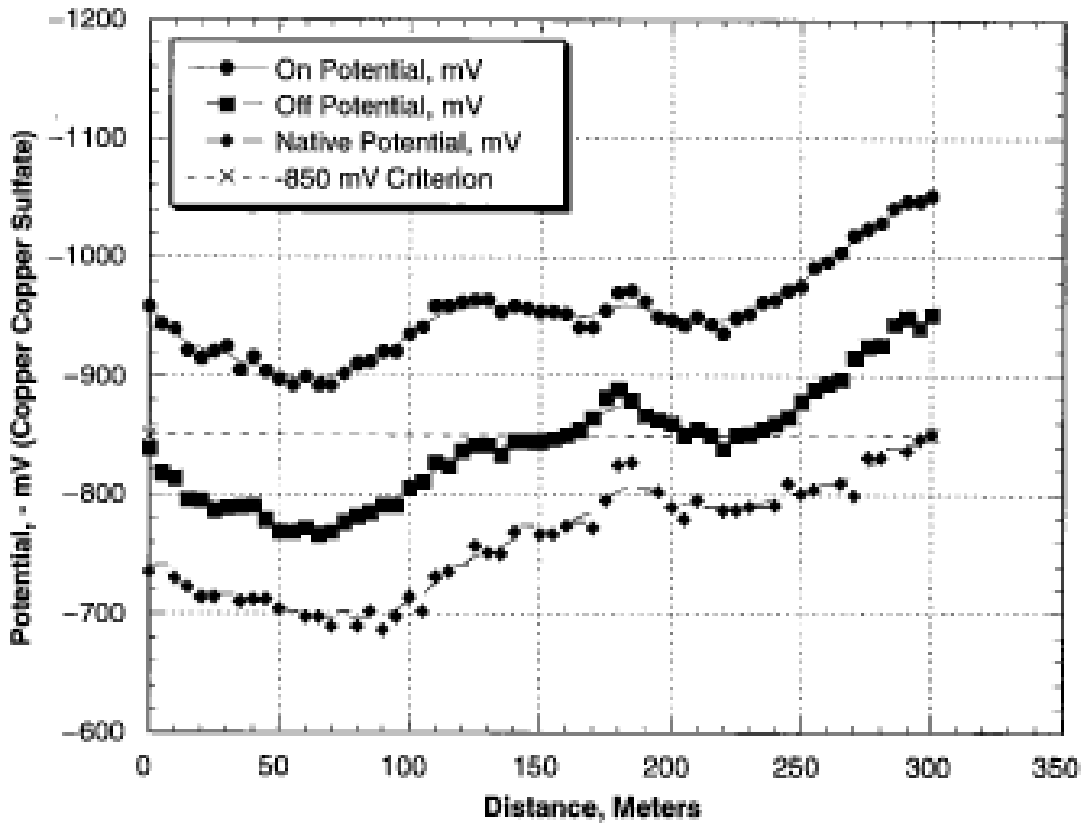
300 mV shift

- Rarely used anymore
- Need to know potential before application of CP (native)
- No scientific proof it works
- Empirical data only

100 mV of depolarization

- Most accurate criteria
- Apply only as much CP as necessary
- Time consuming to apply and check
- Labor intensive
- How often to resurvey?

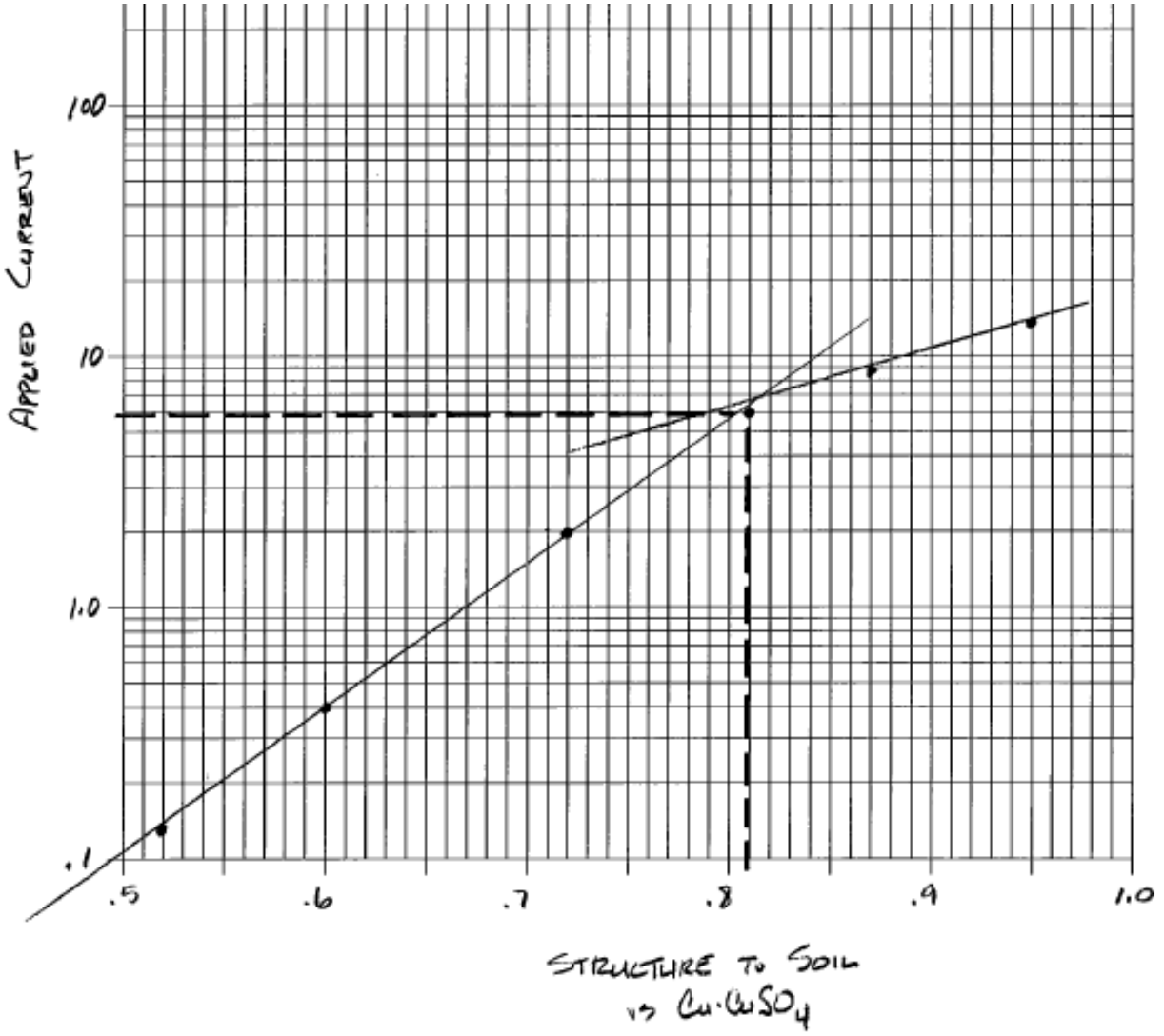
100 mV Polarization



E log I

- Most difficult to apply
- Works best for isolated structures (underground storage tanks)
- Technique dependent
- Absolute amount of CP determined for absolute protection

E log I


APPLIED CURRENT
100
10
1.0
.1
.5
.6
.7
.8
.9
1.0
STRUCTURE TO SOIL
vs Cu·CuSO4

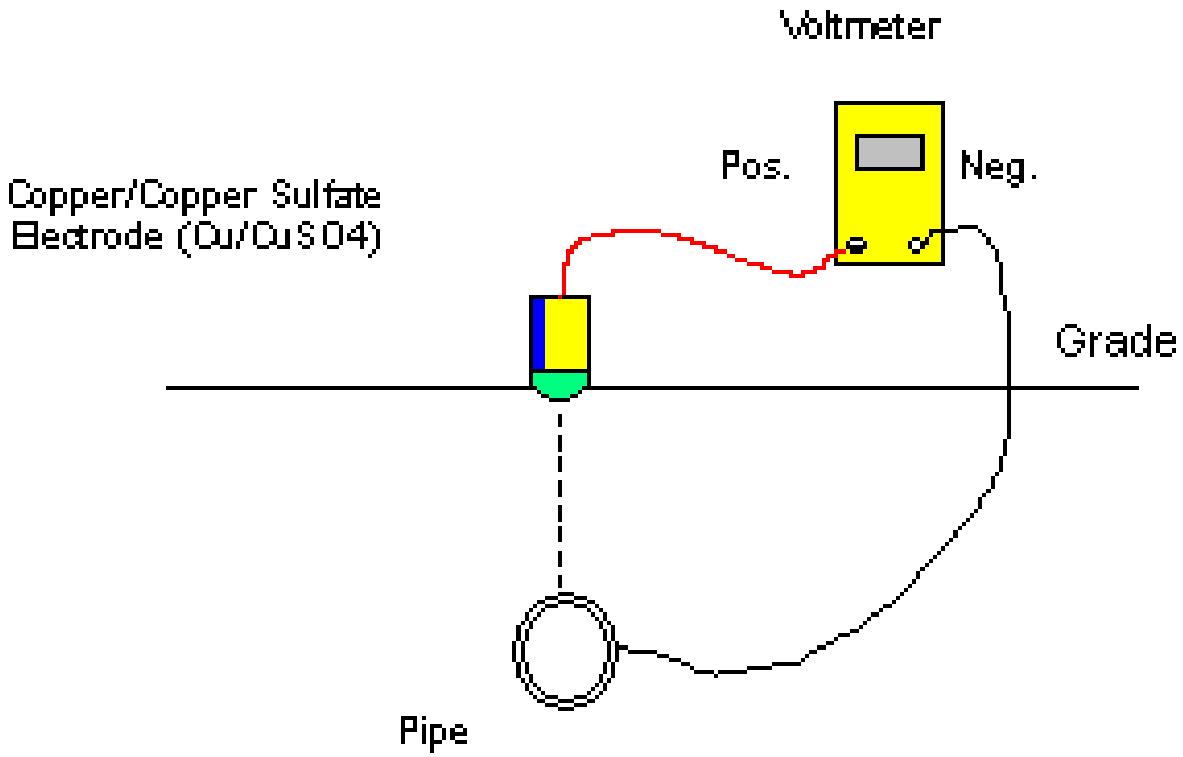
Net current

- Poorest criteria
- Assume protection by current flow direction
- Used for bare or hot-spot protected pipelines

The Set-up

- Place CSE over the pipe in moist soil
- Connect the negative of the meter to the test station
- Connect the positive of the meter to the CSE
- Set the meter to read DC voltage
- Record the reading without lingering

The Set-up


Voltmeter
Pos.
Neg.
Copper/Copper Sulfate
Electrode (Cu/CuSO4)
Grade
Pipe

The reading

- What did you get?
  - -850 mV or higher (more negative)?
  - A really big number?
  - The meter would not lock onto a number!
  - No number at all?
  - Something below -850 mV (more positive)?

What measurements mean

- -850 mV or higher (more negative)
  - This is usually good
- -850 mV or less (more positive)
  - This is the sign that we need to do more investigation
- No number or bouncing around
  - Check all connections and the CSE cover

IR drop

- Voltage drop that occurs when current flows through a resistor
- Multiple resistors in a CP circuit
  - Test leads and meter
  - Wire and connection to pipe
  - Pipe and coating
  - Earth
  - Ground bed and rectifier

IR Drop Consideration

- NACE Recommended Practice (RP)0169-2002 states:
  - A negative (cathodic) potential of at least 850 mV with the cathodic protection applied. This potential is measured with respect to a saturated copper/copper sulfate reference electrode contacting the electrolyte. Voltage drops *other than those across the structure to electrolyte* boundary must be considered for valid interpretation of this measurement.

IR Drop Consideration

- IR drop consideration for -850 mV On
  - Measuring or calculating the voltage drop(s)
  - Reviewing the historical performance of the CP system
  - Evaluating the physical and electrical characteristics of the pipe and its environment
  - Determining whether or not there is physical evidence of corrosion

Consideration

- Several methods to “consider” IR drop
  - Ignore it
  - Estimate the error to be negligible
  - Assume IR is constant and measure at remote earth
  - Current interruption
  - Determine by excavation
  - Reference cell placement

Ignore it

- Let’s consider IR drop for a moment
- There, that feels better!

- Usually dangerous
- Not recommended

Assume IR drop is negligible

- Excellent coating
- Low rectifier current output
- These two in combination create a very low current density, therefore a very low voltage drop, in the soil. IR drop becomes too small to measure.

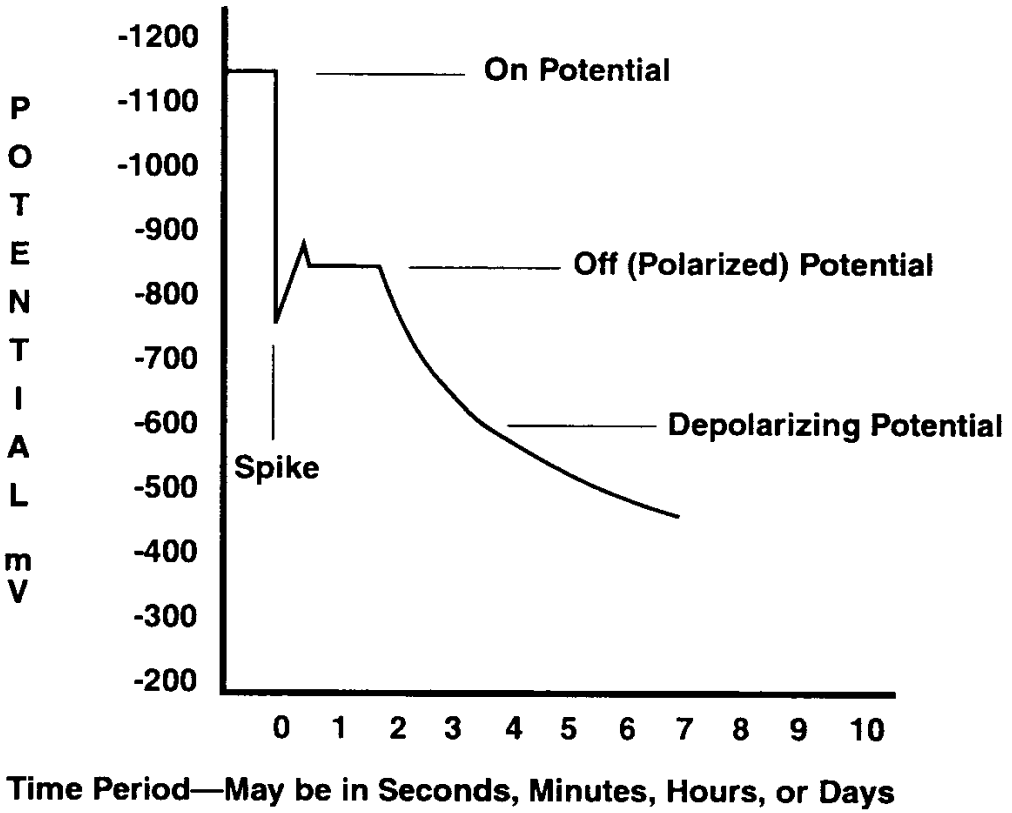
Constant IR drop

- In this case assume that IR drop exists but it is constant. All readings are displaced by a constant value represented by the IR drop included in a reading at remote earth.
- For instance, always subtract 25 mV
- Accurate only so far as current and resistance are constant

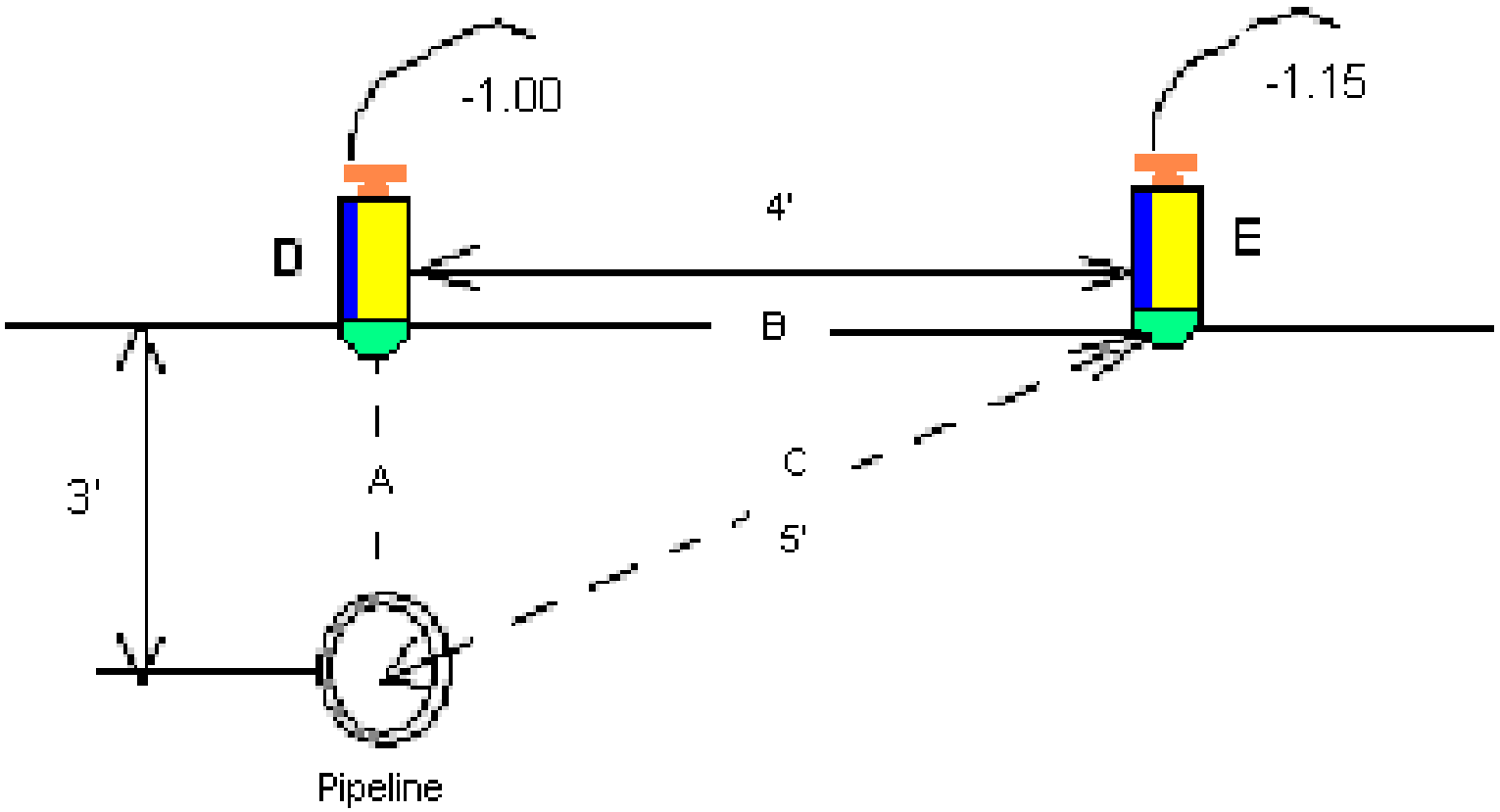
Current interruption

- Install current interrupters in rectifiers
  - Synchronize if multiple rectifiers
- Take reading as soon as the rectifier shuts off.
- This is the polarized potential just before polarization begins to decay

Current interruption



Calculate the IR drop



The Formula

FORMULA

$TR = D - [(E - D)/(C-A) \times A]$

TR = TRUE READING
A = 3' (36")
B = 4' (48")
C = 5' (60")
D = 1.00
E = -1.15

$C = (A^2 + B^2)^{0.5}$
$C = (3^2 + 4^2)^{0.5}$
$C = (9 + 16)^{0.5}$
$C = (25)^{0.5}$
$C = 5$

TRUE READING SOLVED IN INCHES

$D = 1.00 - [(1.15-1.00) / (60 - 36) \times 36]$
$D = 1.00 - [(.15 / 24) \times 36]$
$D = 1.00 - [0.0065 \times 36]$
$D = 1.00 - [.225]$
$D = 0.775$

TRUE READING SOLVED IN FEET

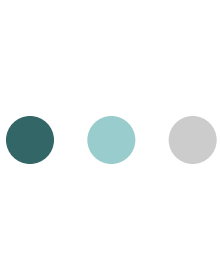
$D = 1.00 - [(1.15-1.00) / (5 - 3) \times 3]$
$D = 1.00 - [(.15 / 2) \times 3]$
$D = 1.00 - [.075 \times 3]$
$D = 1.00 - [.225]$
$D = 0.775$

Determine by Excavation

- Expose the pipeline
- Examine for corrosion damage
- Record both remote and near readings.
- Proof that IR drop should be considered or is not necessary

Reference cell placement

- Use any above ground appurtenance
- Place the reference cell at the pipe-to-soil interface
- Eliminates IR drop in the soil
- Record both remote and near



Questions?