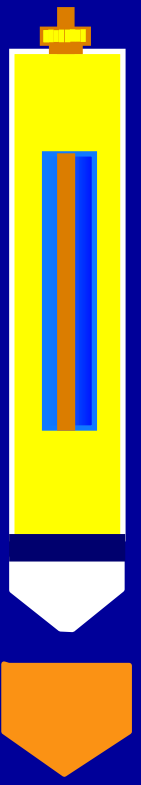
Testing Requirements

- Tank to Soil Potential Readings
- Equipment Basics
- Effects of field conditions on measurements
- Importance of reference cell placement
- Determination of electrical continuity
- Need for documentation

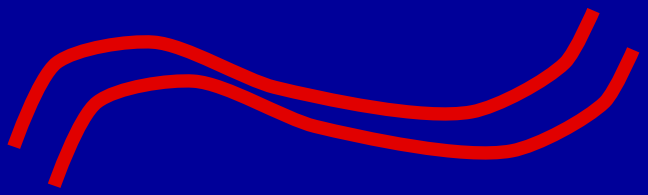
Testing Equipment

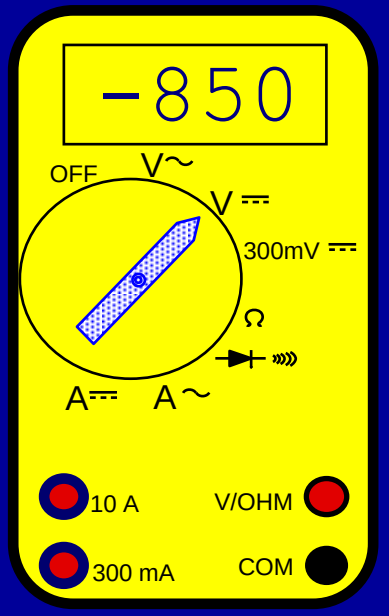


Reference Cells

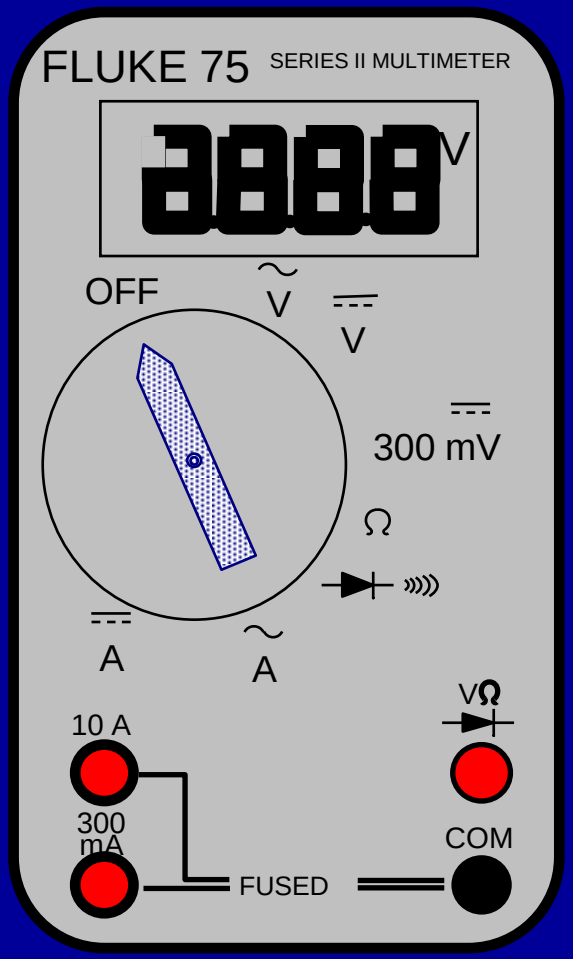
Voltmeters

Test Leads





Multimeters



DC Volt symbol = V

Always
Use
DC V

Correct scale?

- If the meter reads “OL” (overload) or “1” then meter is on too low a scale and you need to switch to a higher scale.

- If the meter reads 0 (zero) you have the meter on too high a scale and you need to switch to a lower scale.

- Keep in mind that you always want to use the lowest scale possible to get the highest degree of resolution in the measurement.

Multimeters

What is meant by resolution?

- Since we are dealing with very small voltages, it is important to have as much resolution as possible.

- Bottom line - Always start with the lowest scale and switch to a higher scale if needed.

Resolution – Lowest Scale

200 mV Scale

Move Resolution Up One Notch

2 V Scale

UNITS OF MEASURE

1 MILLIVOLT = 0.001 volts

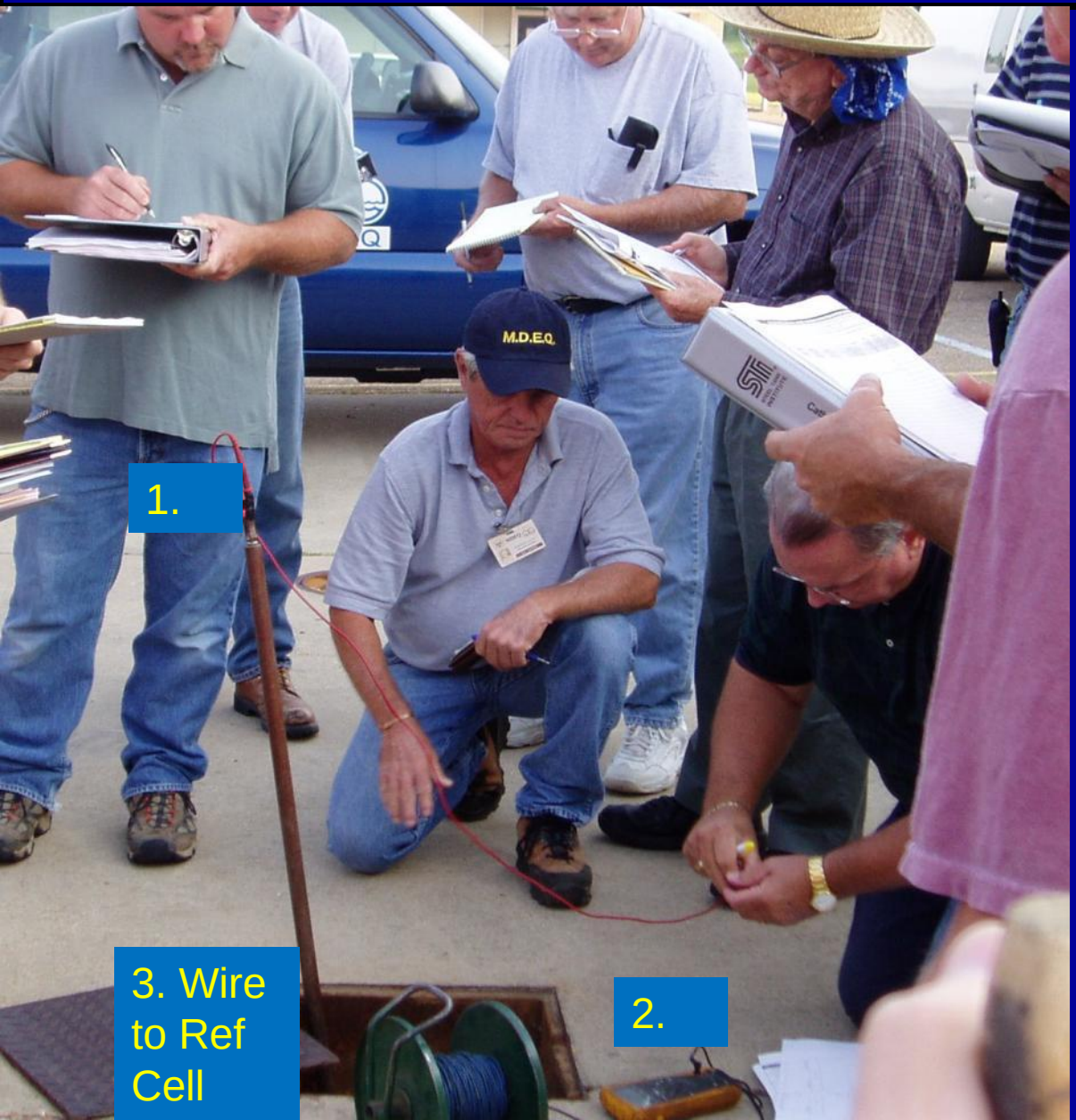
1 VOLT = 1000 millivolts

Do not mix units, i.e.,
use Volts with Amps and
millivolts with milliamps

Copper/Copper Sulphate Reference Cell

- Use 99% pure Copper Sulphate crystals
- Add distilled water or special antifreeze solution, about ¾ full, at least night before use
- Crystals must be visible to know that solution is saturated and good for use
- Reference cell liquid should be clear blue, not milky

Testing Cathodic Protection



1. Connection to tank

2.Meter

3.Reference cell

Make good electrical connection to tank

What is wrong with this picture?

Reference cell placement

- Where you place the reference cell means everything
- Where you touch the structure being tested does not really matter

Tank to soil potential readings

DO place reference cell in moist soil/ backfill

DO NOT place reference cell in

- Dry soil
- Fuel contaminated soil
- Frost or frozen soils
- Vegetation (grass)
- Concrete, asphalt or paving of any kind
- Plastic lined flower beds

Testing Galvanic Cathodic Protection

Summary of Test Procedure for sti-P3 Structure Potentials

- Set Meter to 2 Volt DC scale (or autoranging)
- Take the cap off the reference cell
- Plug black lead into the negative terminal on multi-meter and clip to reference cell.
- Place red lead into the positive terminal and clip to the structure under test.
- Moving tank connection shouldn’t change potential reading!!
- Place reference cell in remote earth – normally 30 ft from tank, adding water to dirt as needed

Summary of Test Procedure For sti-P3 Structure Potentials

- Move reference cell 10 feet further away and verify reading is approximately the same
- Record the remote measurement and reference cell placement on site map
- Move reference cell to center of tank
- Continue moving reference as needed to obtain required number of readings & accurate test.
- Conduct continuity testing if required.
- Record all measurements and reference cell placements on site map

WHAT DOES THE LOCAL POTENTIAL MEASURE?

Only the top portion of tank is measured

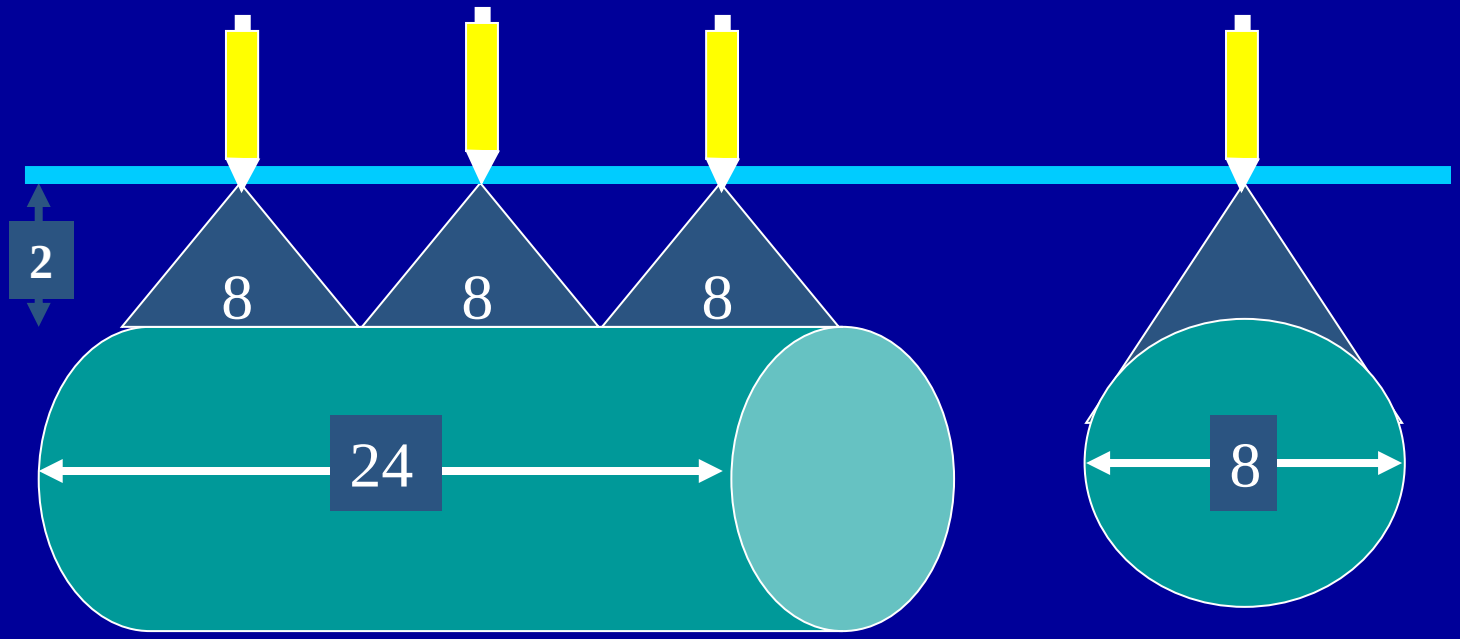
Reference Cell radius of influence = 4 x height above structure

"3 point test rule"

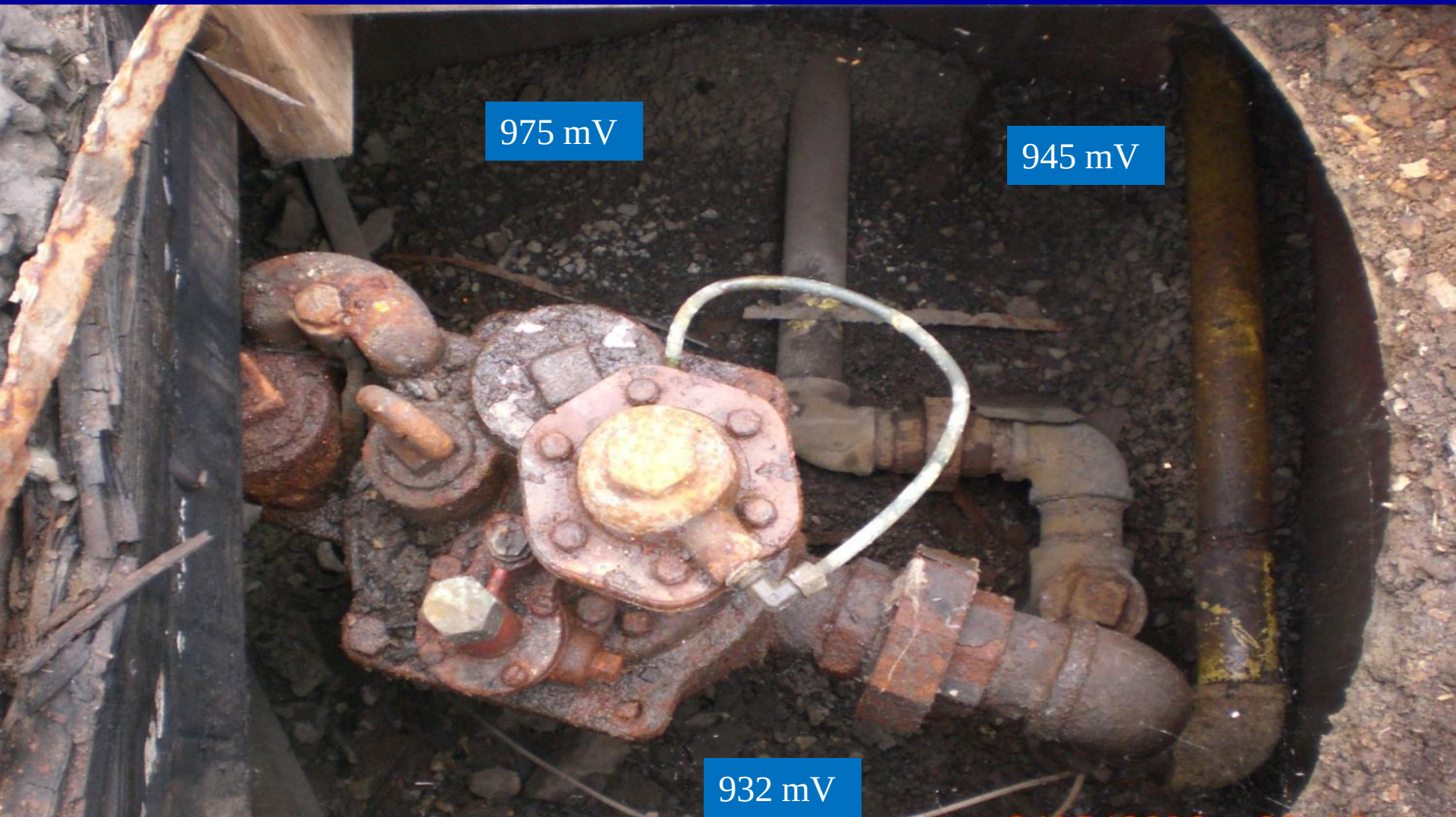
Burial depth = 2 feet

Tank diameter = 8 feet

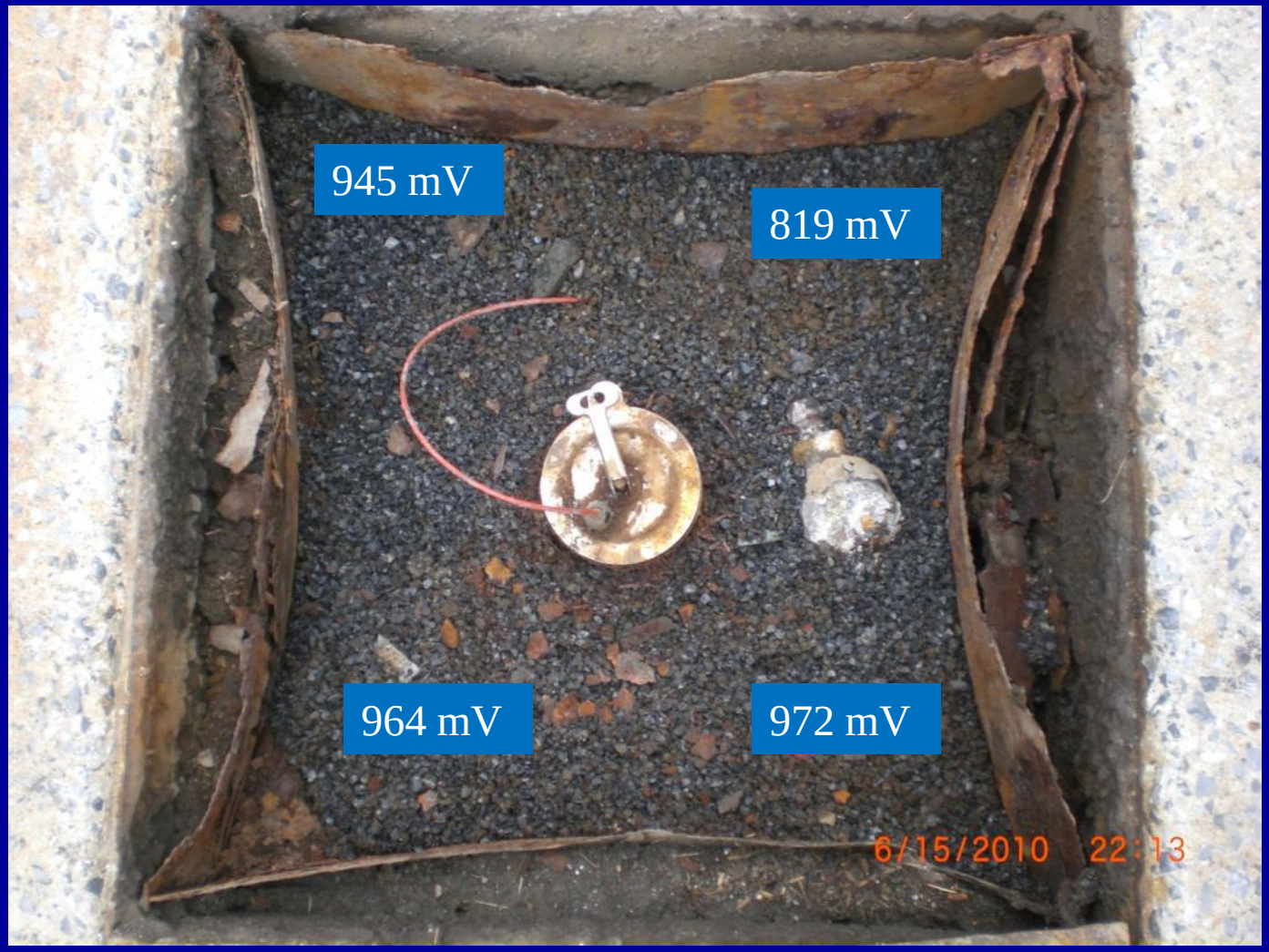
Tank length = 24 feet



Backfill in STP



Backfill in ATG

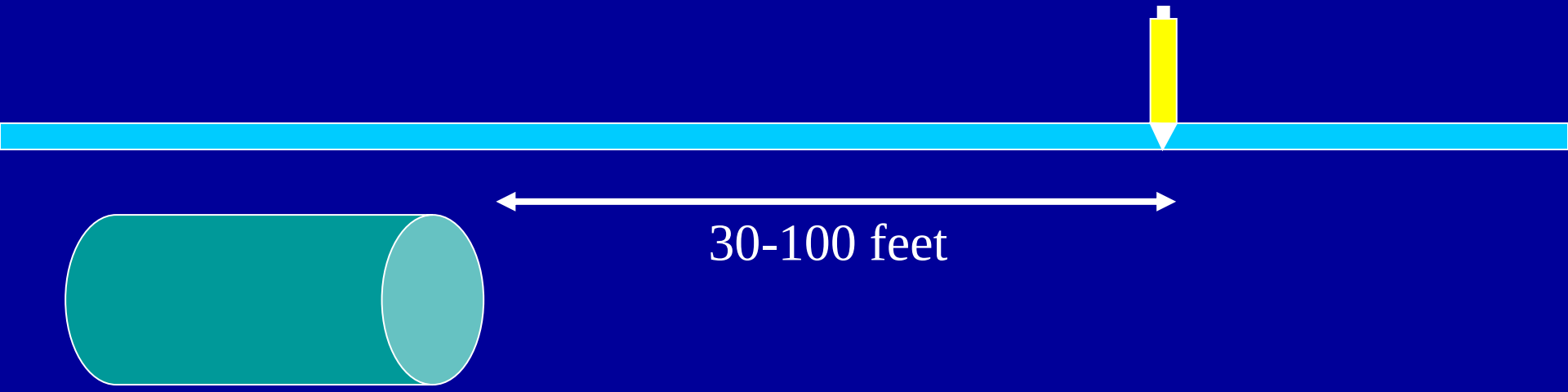


Pencil Reference Cell

Remote reading

WHAT DOES THE REMOTE EARTH POTENTIAL MEASURE?

May be thought of as representing the average potential over the entire tank



WHY MEASURE THE REMOTE?

- Mitigate environmental factors that can influence test measurements over tank (“shielding”)
- Eliminate influence nearby anodes can have on test measurements over tank (“raised earth”)

RAISED EARTH

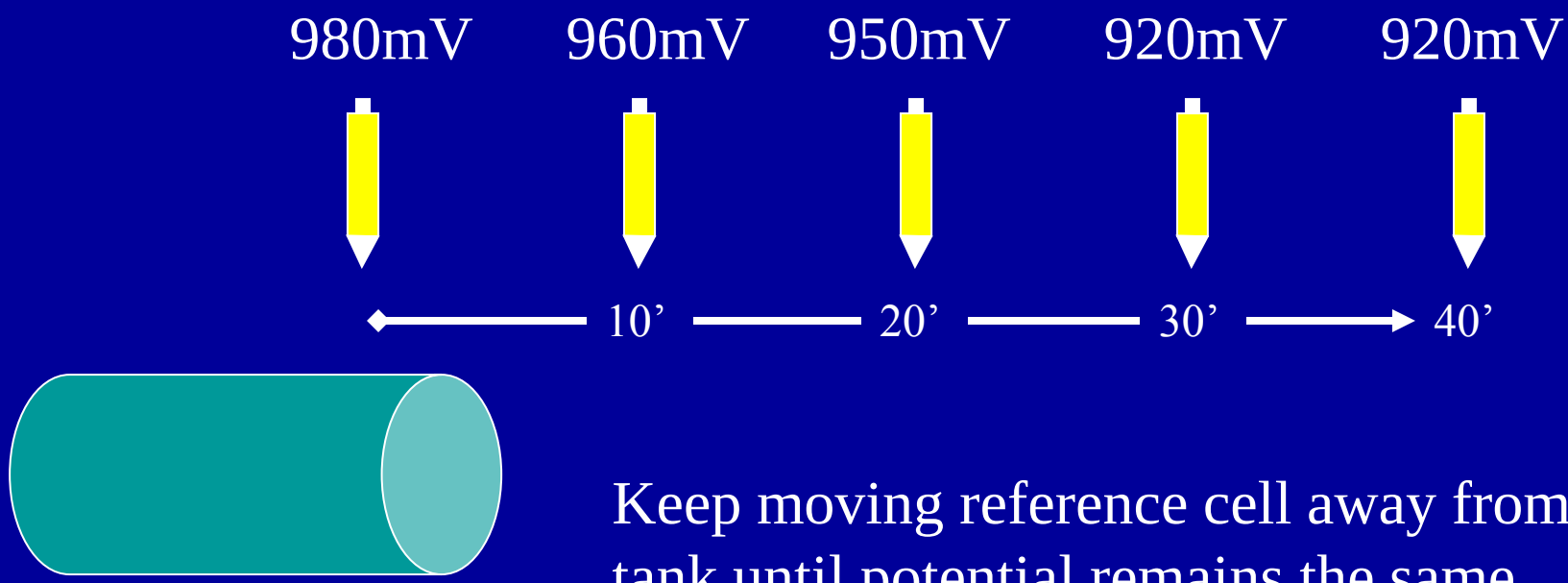
RAISED EARTH

PEA GRAVEL/CRUSHED STONE

PEA GRAVEL/CRUSHED STONE

⊗ Remote = -940

HOW DO YOU ESTABLISH REMOTE EARTH?



Keep moving reference cell away from tank until potential remains the same

Pass/Fail Criteria

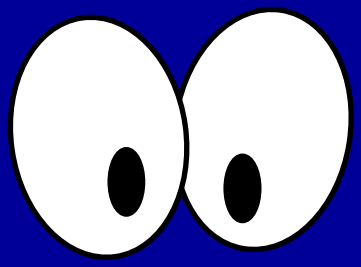
- **PASS:** -850 mV or more ON readings for all recorded readings. OR
- **PASS:** -850 mV or more Instant Off readings for all recorded readings.

“Bad” CP Readings

What are some other things that can cause the reading to be wrong, unstable or zero?

1) Broken or frayed test leads
2) Bad connection to tank
3) You are making contact with the circuit
4) The cap is on the reference cell
5) The stick moves & you lose connection
6) The tank is internally lined (or is FRP)

Accurate Structure Potentials

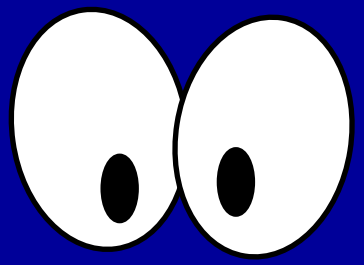


Observe the potential.

If it's jittery or unstable re-adjust clips

Check electrode contact

Check the test leads



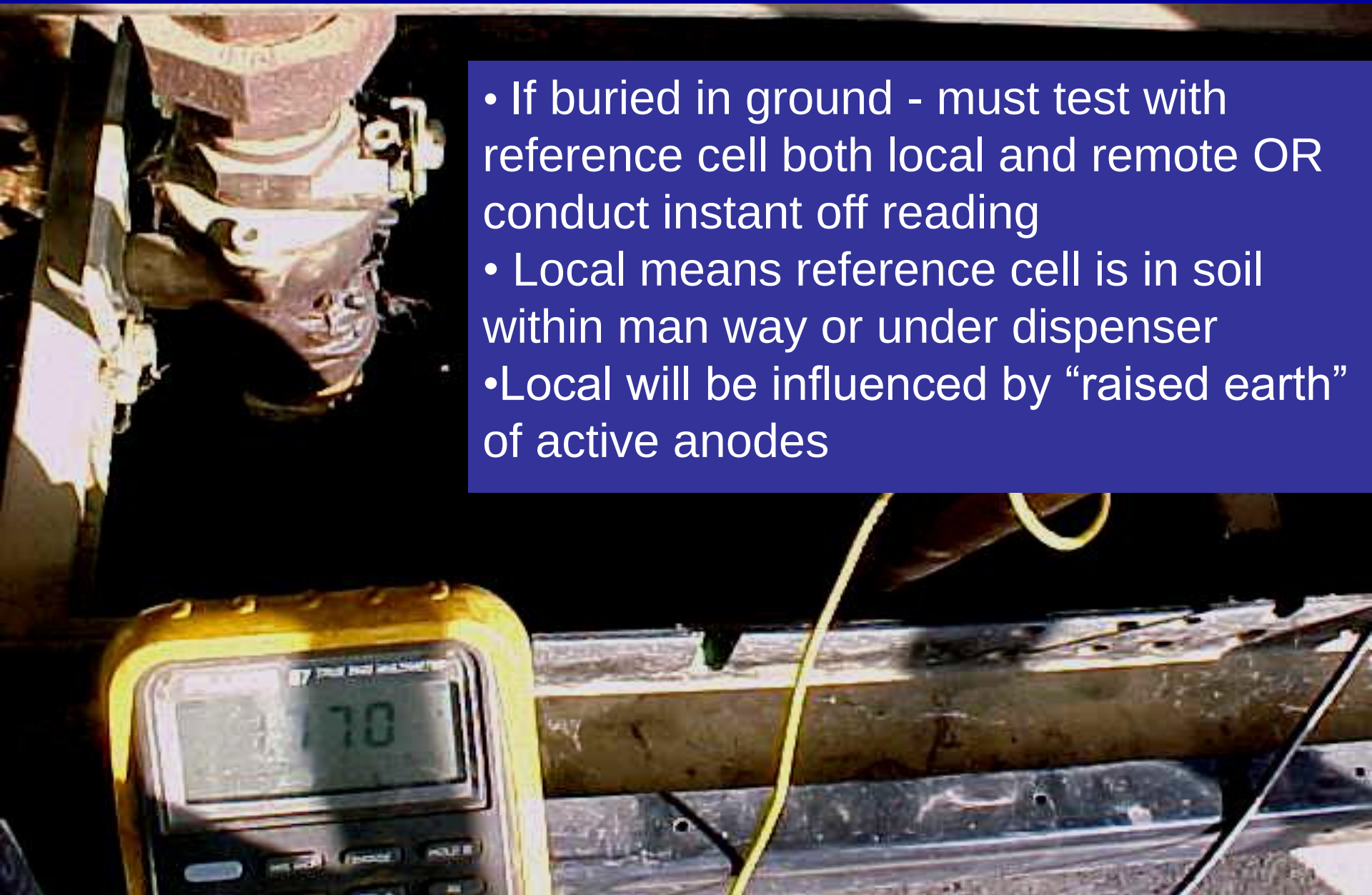
COMMON SENSE

Put on your thinking cap. If the data doesn't make sense it's probably wrong!!

Testing Other Structures

- When testing a galvanic cathodic protection system, you should test all metal structures that routinely contain product
- Flex connectors
- Metal product piping
- Place reference cell away from anodes

TESTING FLEX CONNECTOR CP



- If buried in ground - must test with reference cell both local and remote OR conduct instant off reading
- Local means reference cell is in soil within man way or under dispenser
- Local will be influenced by “raised earth” of active anodes

TESTING FLEX CONNECTOR CP

- If contained within sump – usually can only test locally
- Sump will probably “shield” remote reference cell

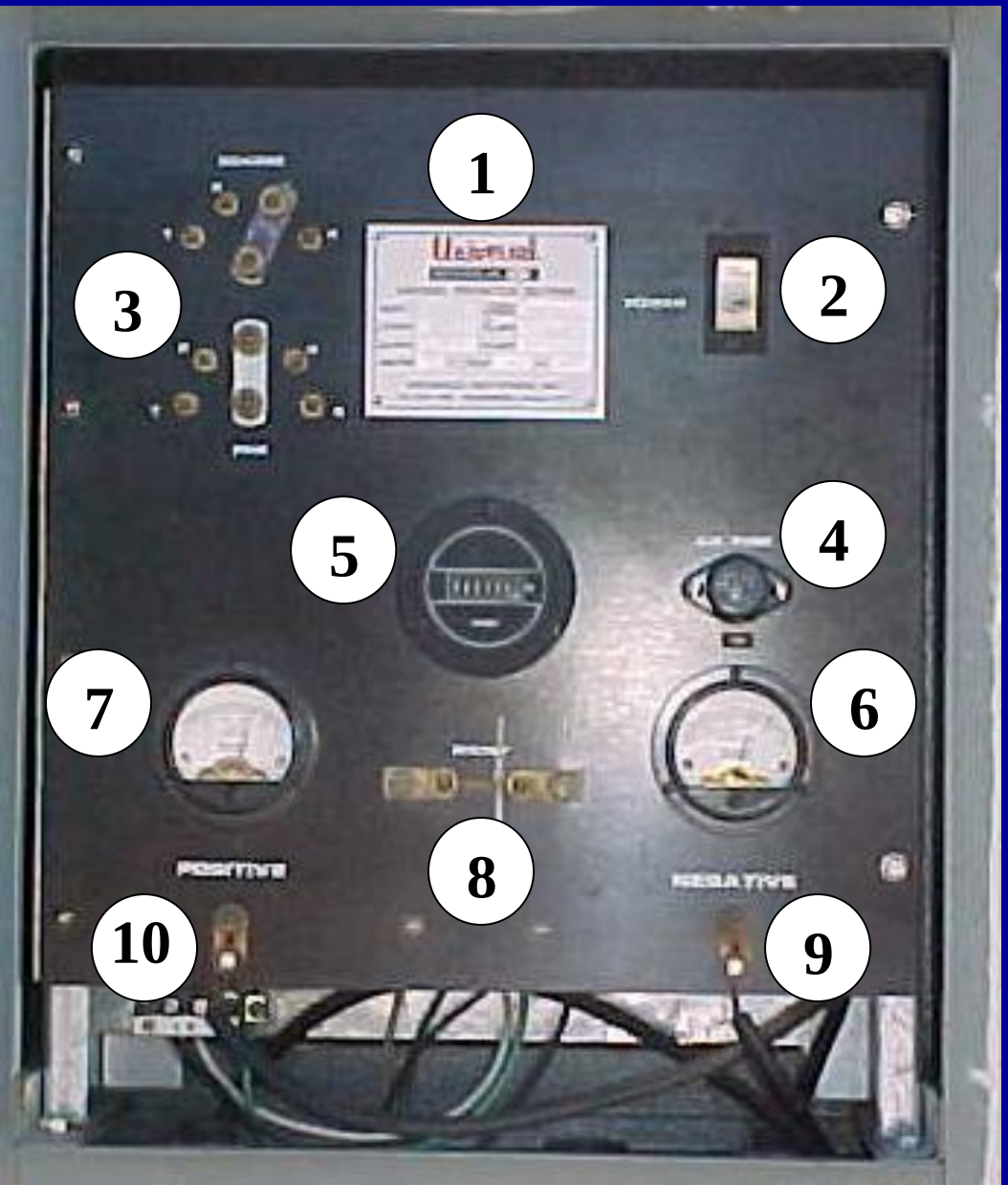
TESTING FLEX CONNECTOR CP

- Reference cell must be placed within water of sump
- Do not completely submerge reference cell

TESTING FLEX CONNECTOR CP

TESTING FLEX CONNECTOR CP

TYPICAL RECTIFIER



1. Data Plate
2. On/Off Switch
3. Tap Settings
4. Fuse
5. Hour Meter
6. Amperage
7. Voltage
8. Shunt
9. Negative
10. Positive

IMPRESSED CURRENT TESTING

- **PASS:** -850 mV or more negative instant off or 100 mV shift has been demonstrated at all local potential testing points

- **FAIL:** Unable to obtain -850mV or 100 mV shift at one or more local testing points

IMPRESSED CURRENT TERMS

- **Native Potential** - Potential measured before any CP has been applied
- **Static Potential** – Also called the depolarized potential…it is measured after CP has been interrupted and structure is allowed to depolarize completely
- **Polarized Potential** – Also called the instant off potential… the 2nd number observed on digital voltmeter after rectifier power has been interrupted

IMPRESSED CURRENT GENERALIZED TEST PROCEEDURE

- Check operation of rectifier
  - Output Voltage/Amperage
- Place reference cell in soil over tank/pipe
- Record “on” potential
- Temporarily interrupt rectifier power
- Record “instant off” potential
- Repeat as many times as needed
- Conduct 100 mV polarization decay if needed
- Establish continuity of all protected components

Test Procedure for ICCS Structure Potentials

- Set Meter to 20 volts DC (unless auto-ranging)
- Take the cap off the reference cell
- Plug black lead into the negative terminal on multi-meter and clip to reference cell.
- Place red lead into the positive terminal and clip to the structure under test.
- Place reference cell directly over center of tank, or as close as possible adding water to backfill as needed

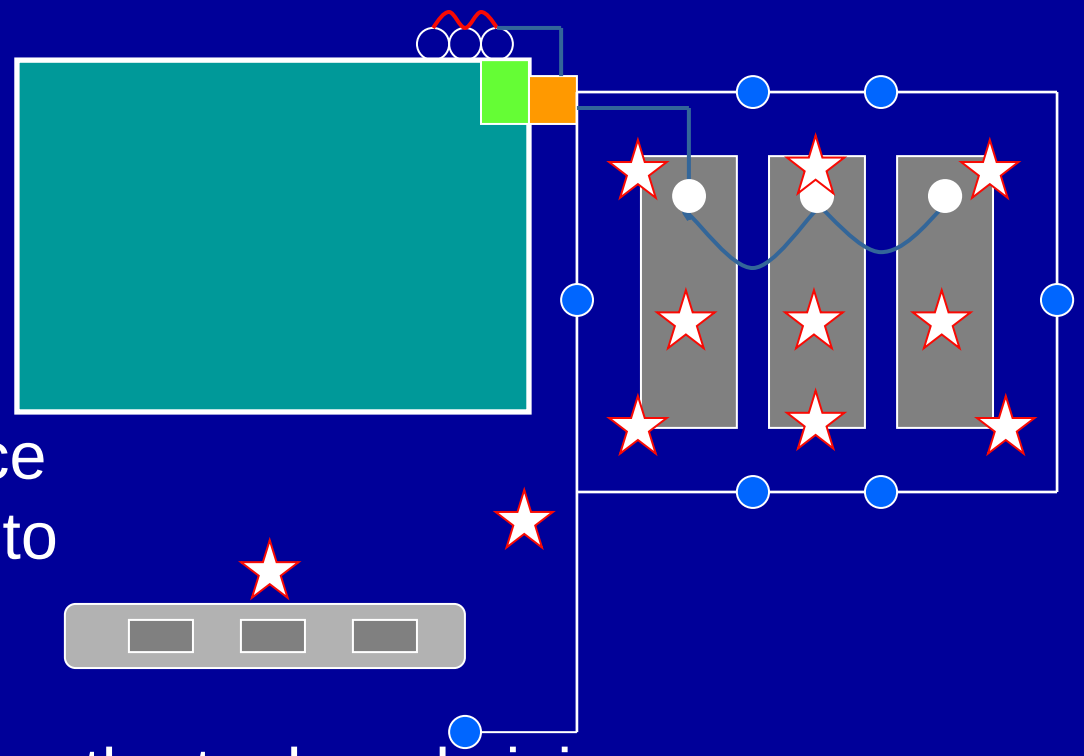
Test Procedure for ICCS Structure Potentials

- Record “on” potential at first reference cell location for Structure #1
- Interrupt rectifier power and record instant off potential (without moving reference cell)
- Move reference cell and record on/off potentials as many times as needed for tanks & pipes
- If all off potentials are more negative than -850 mV, you are done with potential survey
- Record all data on site map and form(s)

Test Procedure for ICCS Structure Potentials

- If one or more of the off potentials do not meet the -850 criterion, conduct 100 mV polarization decay
  - Place reference cell in spot where lowest (most positive) potential reading was observed and cut off rectifier.
  - Leave rectifier off until polarization has decayed at least 100 mV.
  - By doing this, you test the “worst-case” location first

REFERENCE CELL LOCATIONS FOR TANK-TO-SOIL POTENTIALS



Place reference cell directly onto soil

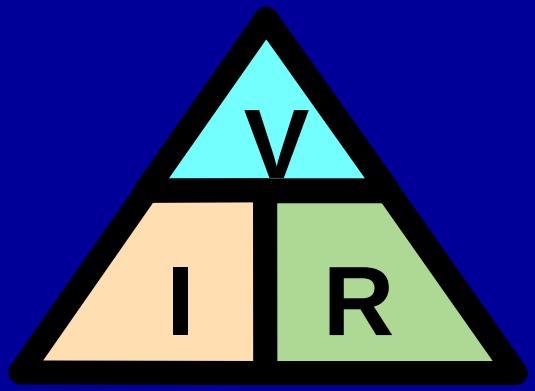
- Over or near the tank and piping
- Maximize distance from anodes
- Piping should be tested at both ends

Cathodic Protection Criteria measured with a copper/copper sulfate reference cell

- -850 mV Structure to Soil Potential
  - Measurement must allow for IR drop.
- 100 mV Polarization
- STI-P3 Criterion -850 mV Structure to Soil Potential.
  - Anodes permanently connected to tank

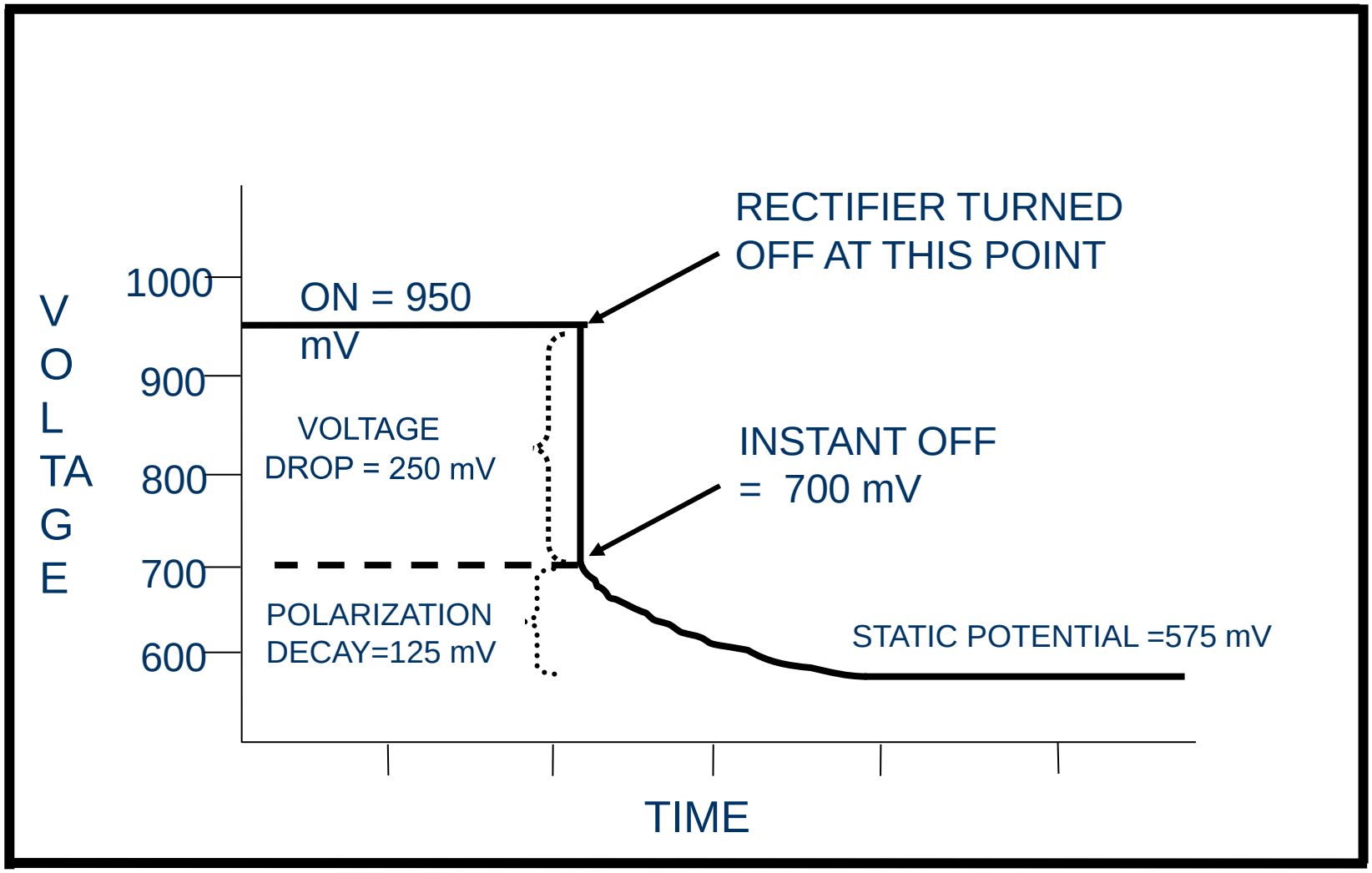
IR DROP IN VOLTAGE MEASUREMENTS

Current flow through a resistor creates a voltage drop



IR drop is usually more significant on impressed current systems as compared to galvanic systems

Voltage Drop / Polarization Decay



Continuity Testing

- Structures that are electrically isolated do not touch in any way
- sti-P3 tanks are designed to be electrically isolated from all other structures.

Nylon bushings

Nylon bushings utilized in all sti-P3 tank bungs to isolate the tank from any other metallic structure.

Tank hold down straps must be nonmetallic or isolated from tank shell.

Not isolated if conduit is sitting on tank

Continuity Testing

- Structures that are galvanically protected must be isolated from other metallic structures
- With Impressed Current systems, all structures are bonded together (continuous)
  - Continuity is critical for Impressed Current systems

Continuity Testing

- Structures that are electrically isolated do not touch in any way
- Structures that are electrically continuous are grounded to each other
- sti-P3 tanks are designed to be electrically isolated from all other structures.

METHODS TO TEST CONTINUITY

POINT TO POINT METHOD

- Reference cell is not used – voltmeter only
- With ICCS rectifier must be turned off
- Two structures of interest are contacted with voltmeter leads
- Potential difference should be 1 mV or less to verify continuity
- Potential difference should be 10 mV or greater to verify isolation
- Readings > 1 mV and < 10 mV inconclusive

METHODS TO TEST CONTINUITY

POINT TO POINT METHOD

- Turn off rectifier
- Disconnect negative cable at rectifier
- Use negative as one point
- Stretch wire out and touch everything else you need to test continuity on.

Vent lines	STP's
Steel piping	Water lines
Flex connectors	Natural gas lines
Tank risers	Conduits

Cathodic Protection Surveys

- Surveys must be performed by a cathodic protection tester
- Surveys should include:
  - Potential survey
  - Continuity testing (for impressed systems)
  - Rectifier operation (for impressed systems)
  - Shunt readings (for impressed current systems)
- Always include a detailed report of findings and recommendations for continued operation.