Indirect Inspection

ACVG

Alternating Current

Voltage Gradient

Instructor – Jim Walton

Indirect Inspection

ECDA is a four step process consisting of:

1. **Pre-Assessment**
2. **Indirect Inspection**
3. **Direct Examination**
4. **Post Assessment**

Indirect Inspection

- Keep it simple and well organized
- Use familiar test methods and available equipment
- Accept that it is time consuming
- Don’t cheat on the footage
- Review and evaluate daily
- Work safely

Tool Selection
AUCSC Field Workshop

- **Current Attenuation**
- **Close Interval Survey**
- **Alternating Current Voltage Gradient**
- **Direct Current Voltage Gradient**
- **Other**

Tool = ACVG

NACE definition

"A method of measuring the change in leakage current in the soil along and around a pipeline to locate coating holidays and characterize corrosion activity."

Tool = ACVG

- **Locate pipeline**
- **Locate coating defects**
- **Locate galvanic anodes**
- **Locate foreign structures (X or //)**
- **Location of bonds**

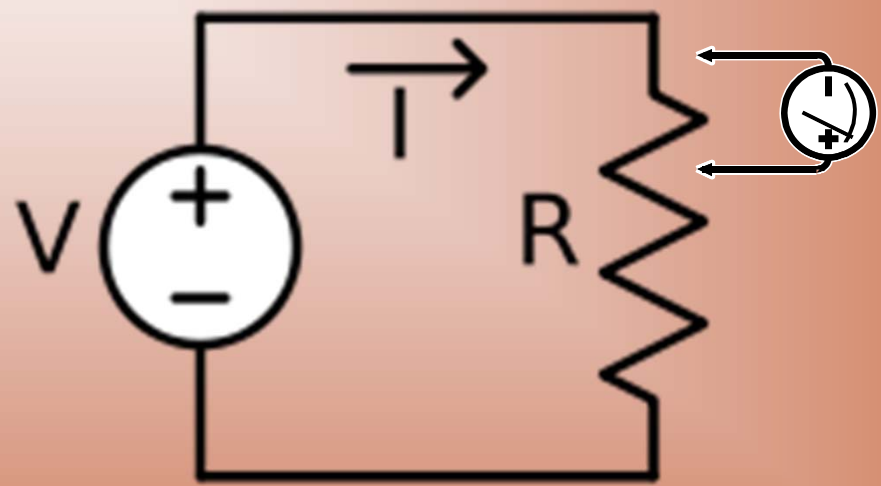
VOLTAGE GRADIENT

Current flowing through a RESISTOR will produce a voltage drop.

V = I x R

… also called ??

VOLTAGE GRADIENT

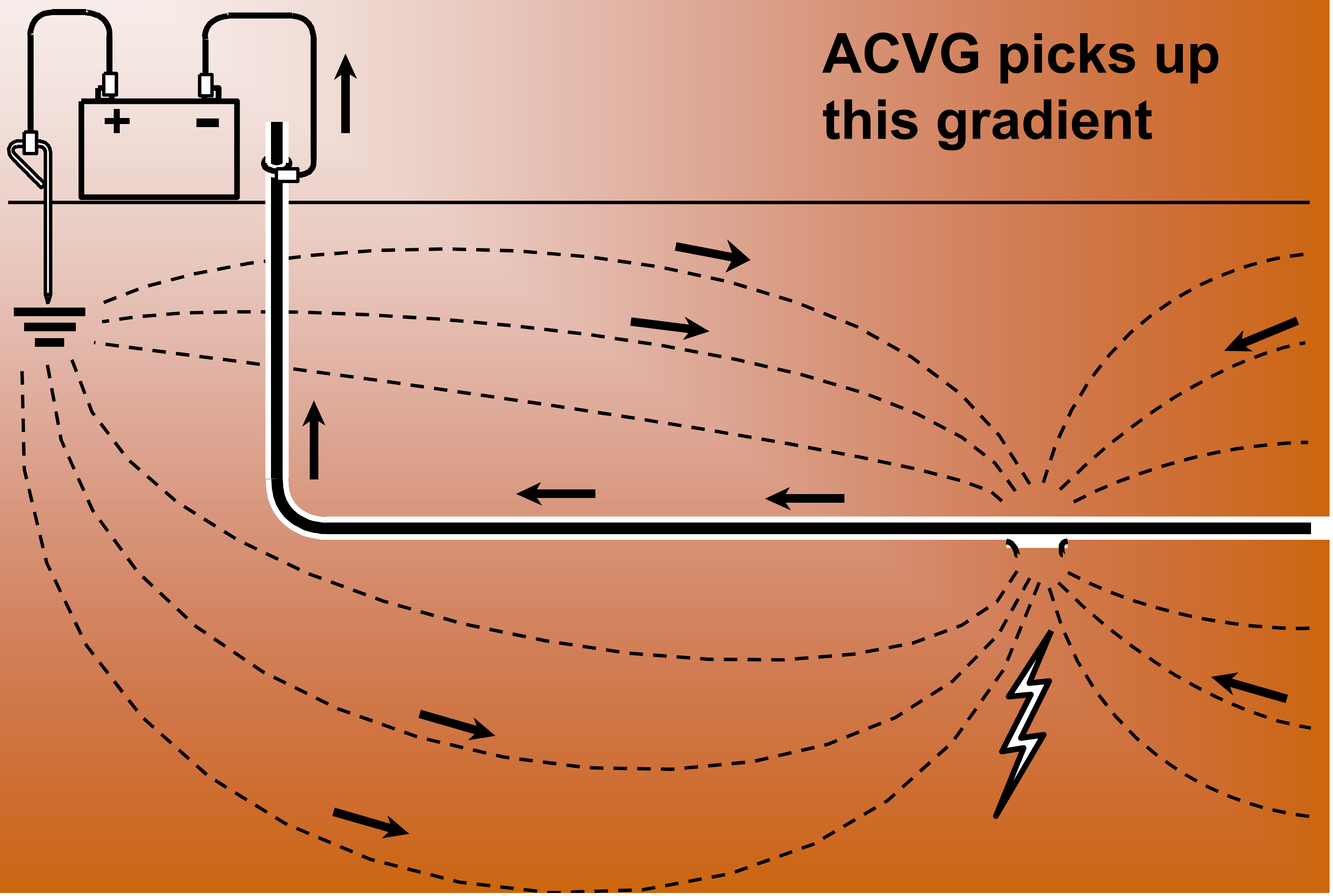


Voltage Drop

Voltage Drop

Gradient =ΔV/Δd

ACVG - Current Flow



ACVG Hardware

1. ACVG Transmitter
   - Generates a signal for performing pipeline survey.

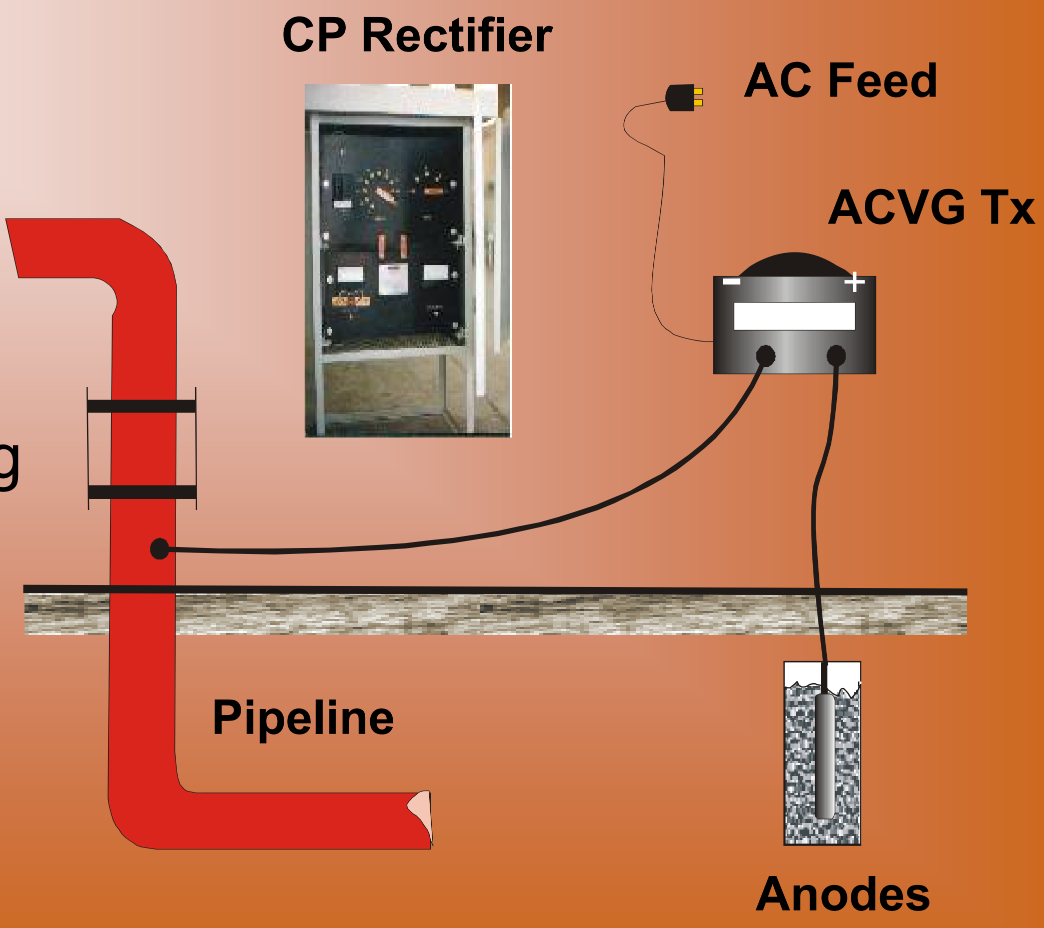
2. ACVG Receiver
   - Processes ACVG signal and displays results.
   - Optional data logger and/or GPS.

ACVG Hardware

- Transmitter (Tx)
  - Generates three frequencies:
    1. Locate frequency
    2. 4 Hz for fault finding
    3. 8 Hz for direction to fault
- Receiver (Rx)
  - Locate pipeline
  - Attachment for ACVG readings
    - Use 4 Hz de measure µV
    - Use 4 + 8 Hz to determine fault direction (phase shift)

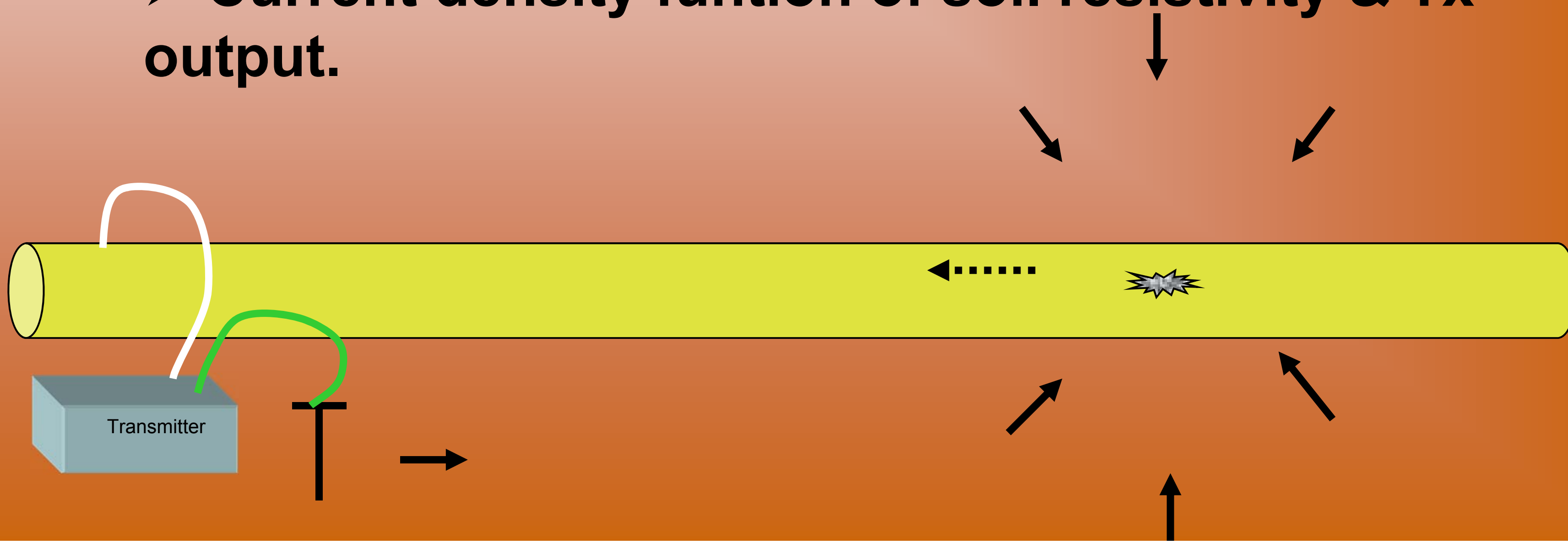
Tx - Connections

- Rectifier
- Test Station
- Metering & Regulating



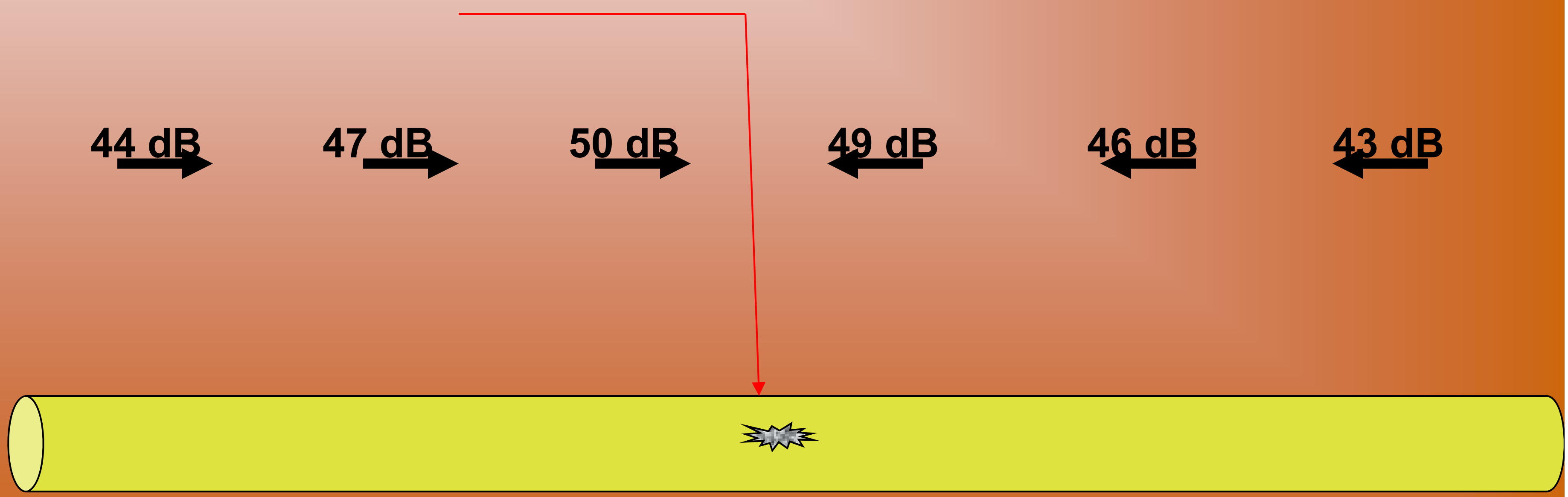
Transmitter

- Current from the transmitter creates a voltage gradient around coating defects.
- Current density greatest at interface between the defect and the surrounding environment.
- Current density funtion of soil resistivity & Tx output.

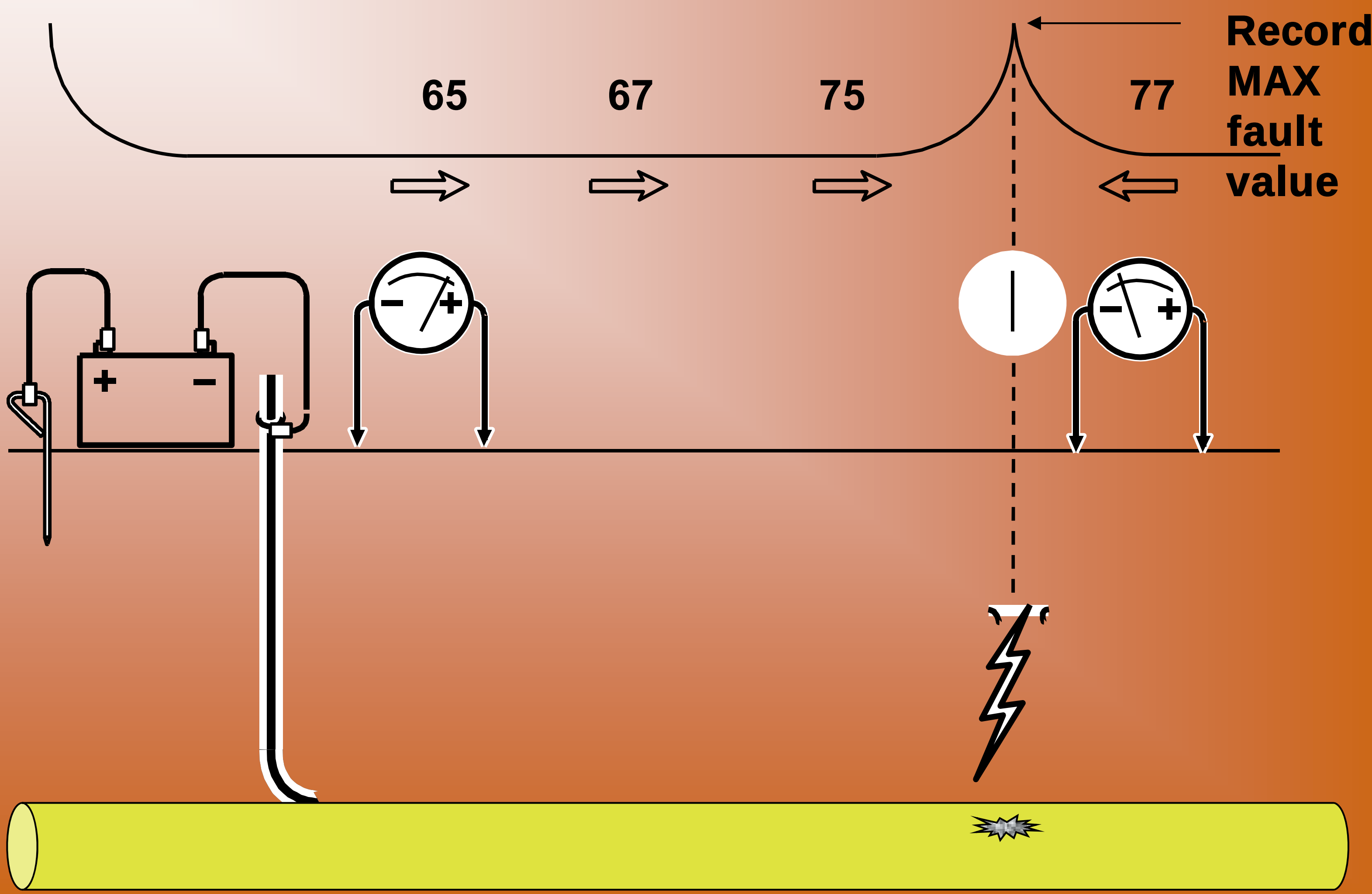


ACVG – Receiver Readings

- An increase in voltage gradient will cause an increase in current density near a given coating defect on the pipeline under test
- Signal Current and Voltage effects viewed on instrument's display
- Signal Current direction is displayed as an arrow
- Voltage is identified as decibels (dB)

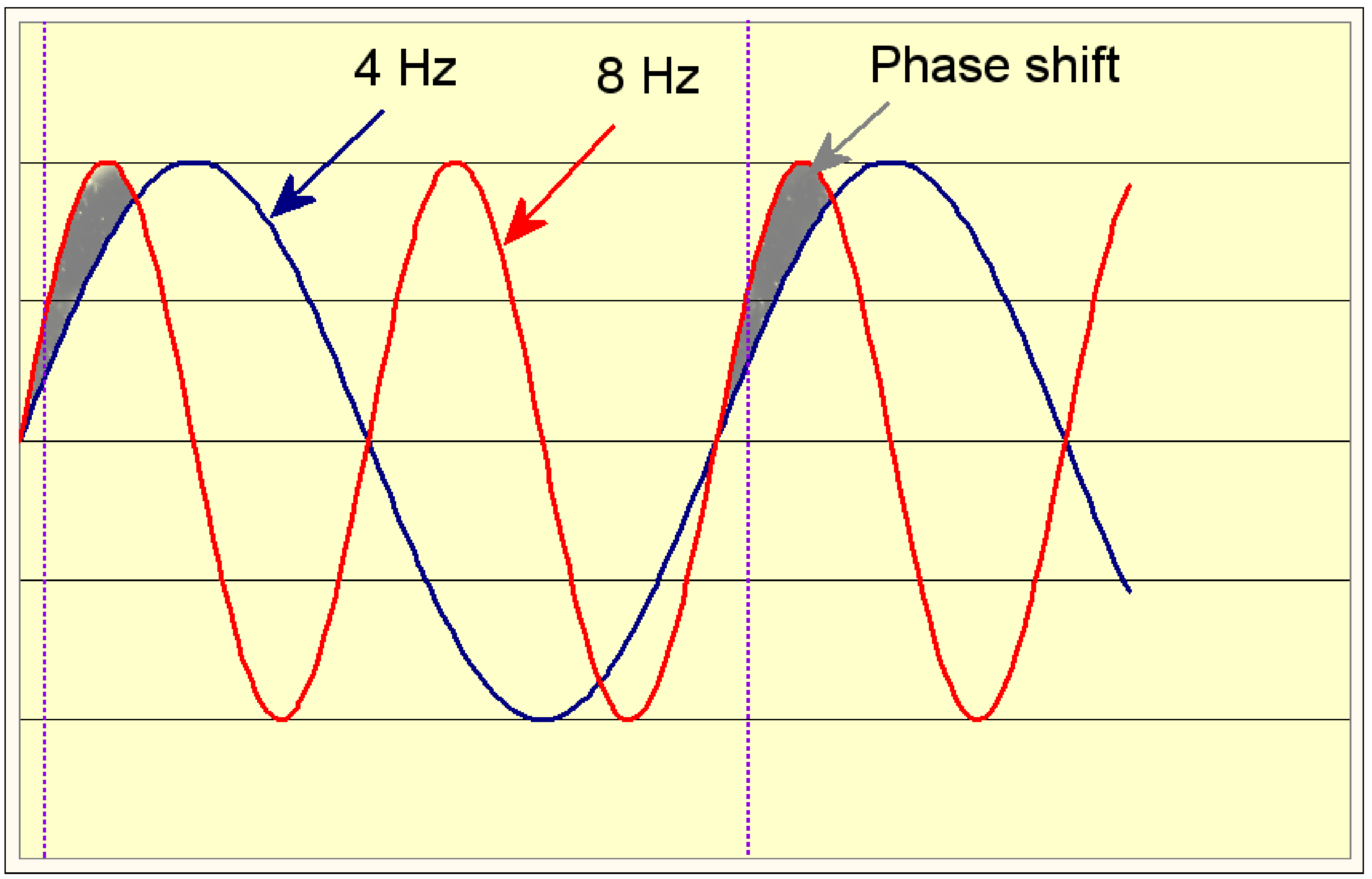


ACVG – Shape of Readings



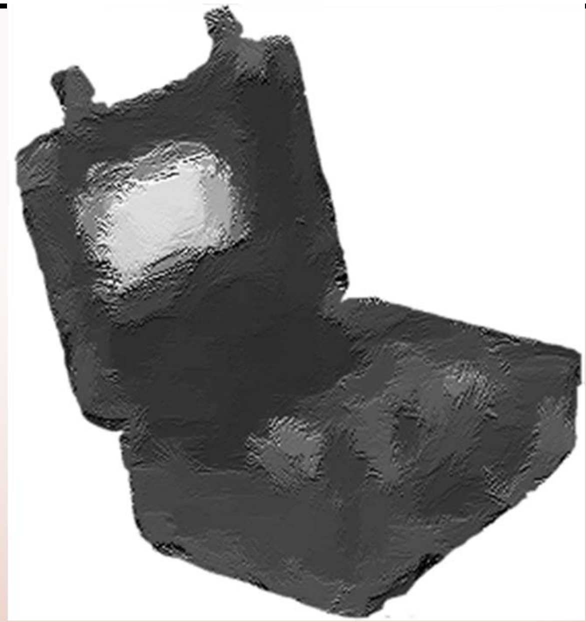
Rx – Direction to Fault

Rx – Direction to Fault



Fault Magnitude – dB **(decibel)**

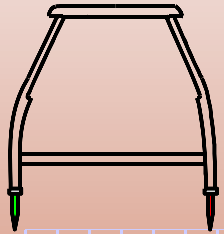
- A decibel is a logarithm of a ratio, multiplied by a constant, or number, usually ***10*** or ***20***.
- If the ratio you are comparing is that of two voltage gradients, then $dB = 20 \log (\Delta V_2 / \Delta V_1)$
- Reference Voltage is $\Delta V_1 = 1\ \mu V$
- Every time you double or half your ***voltage***, the level change is ***+/-6 dB***

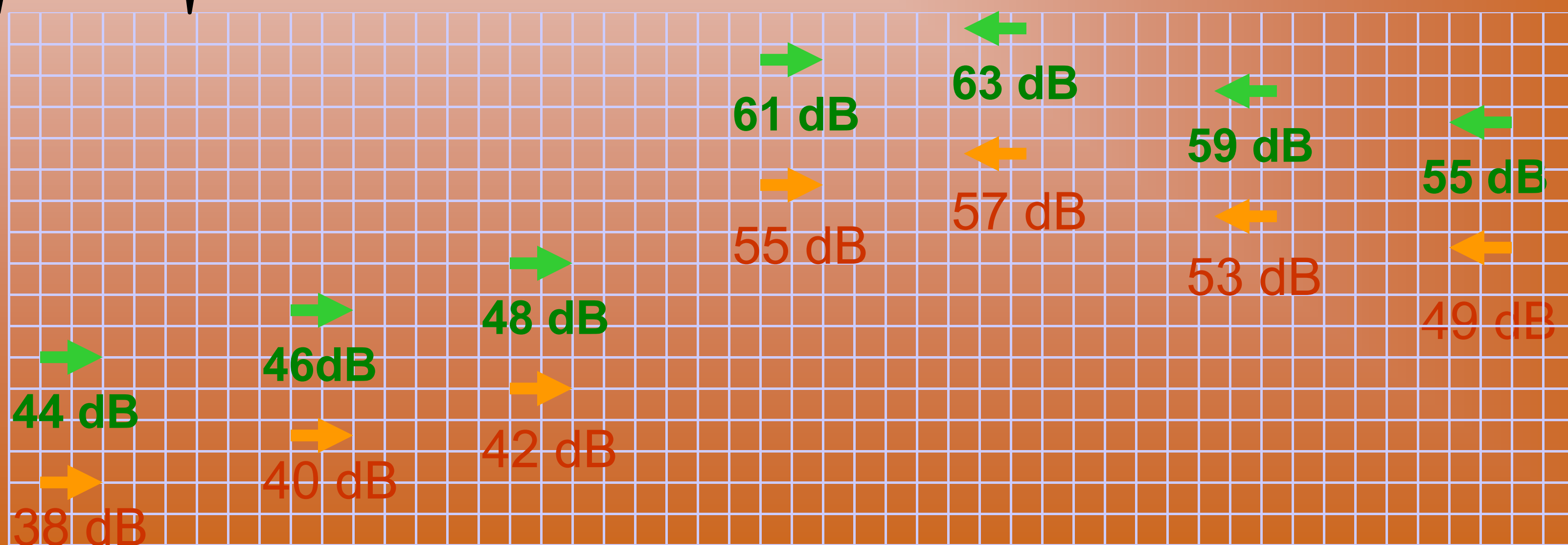


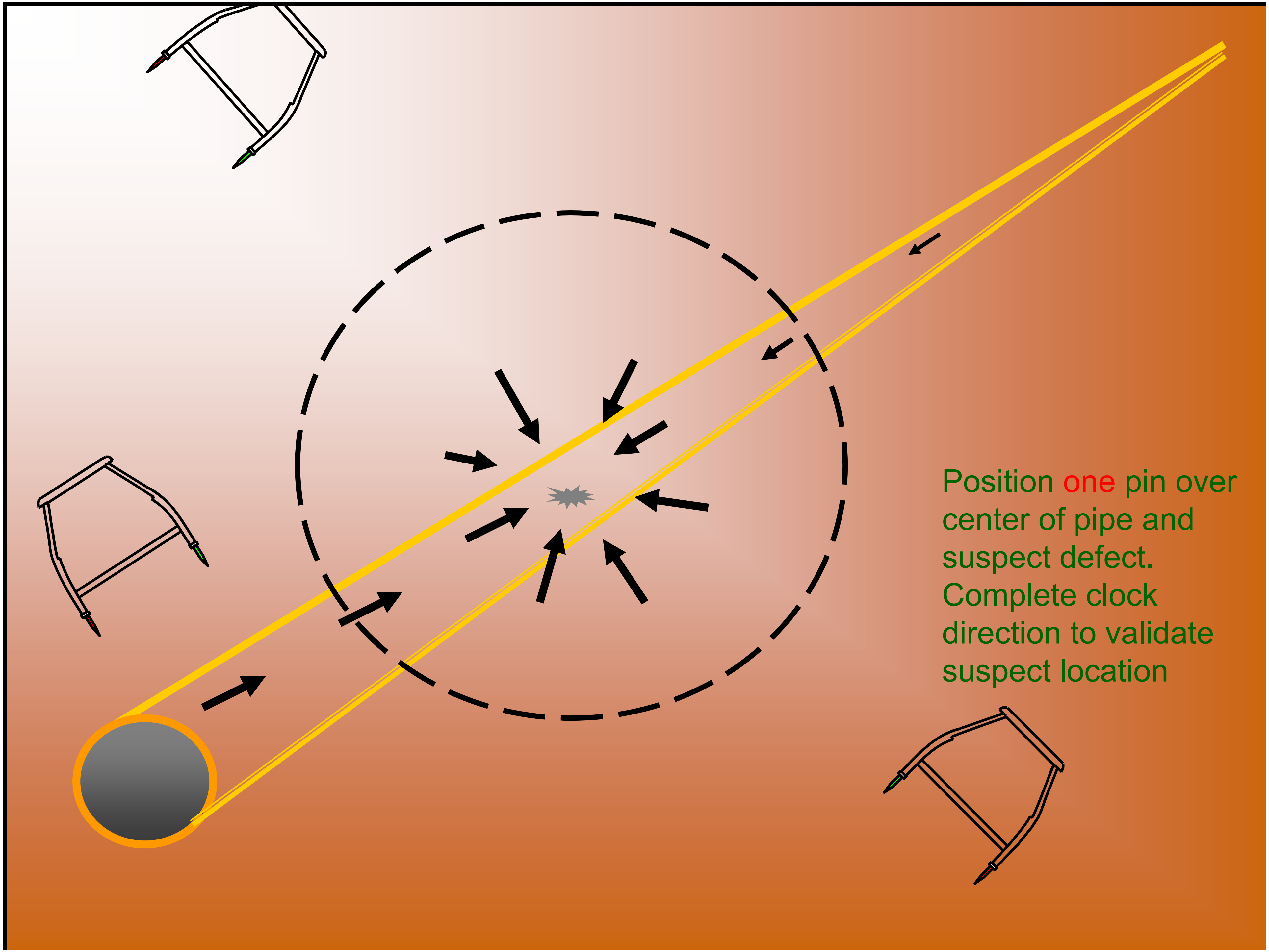
Current Settings & dBs

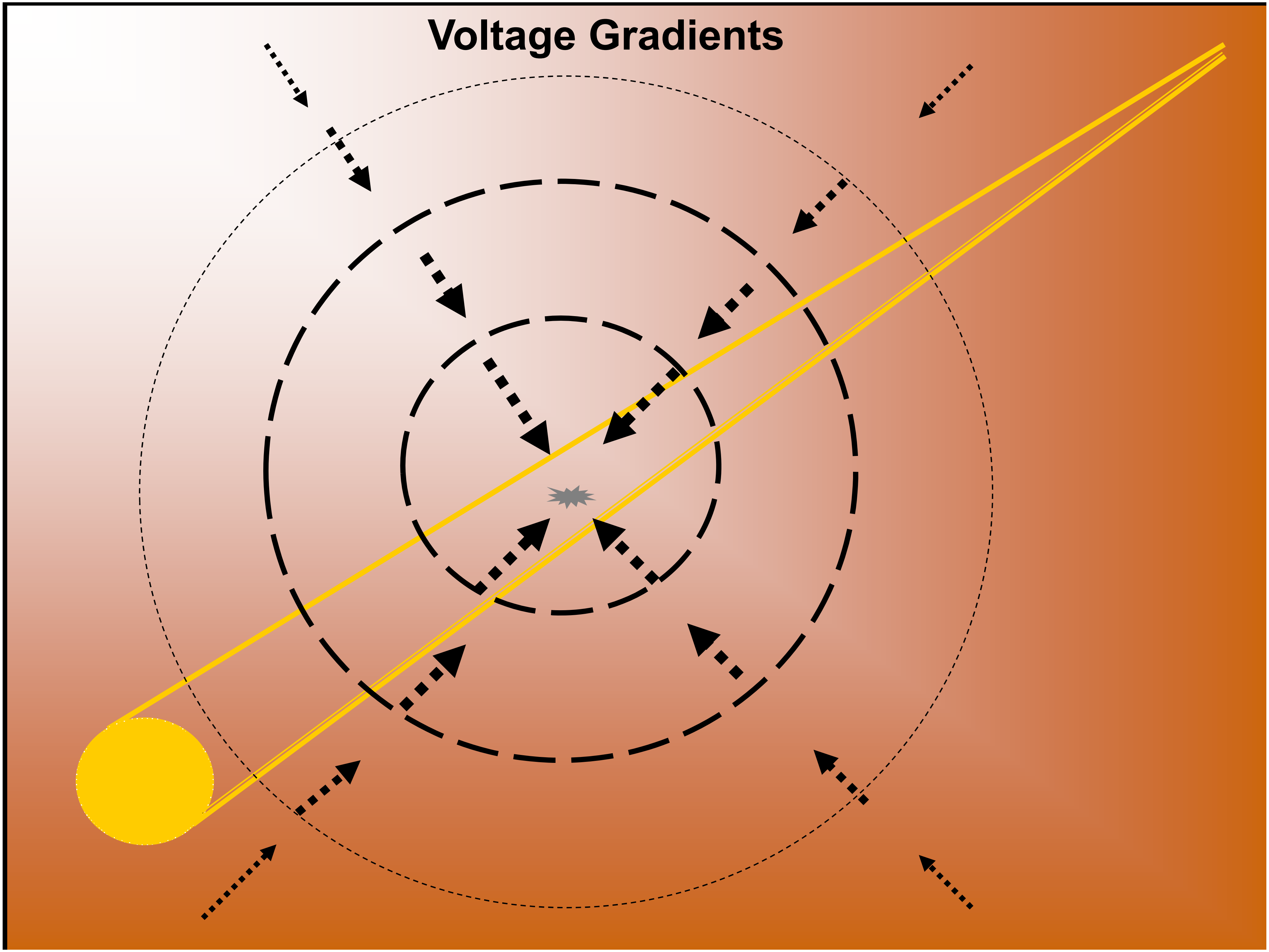
600 mA @ 40V

300 mA @ 20V

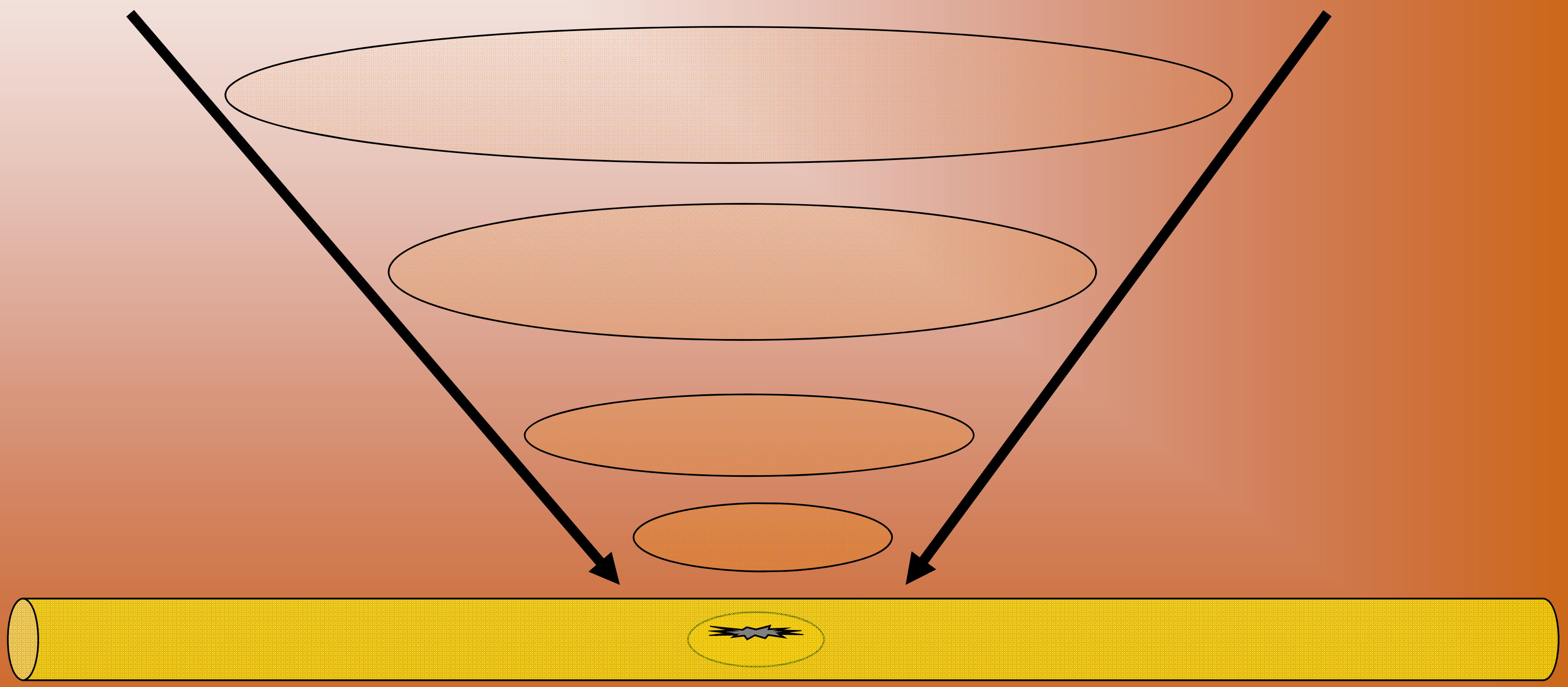




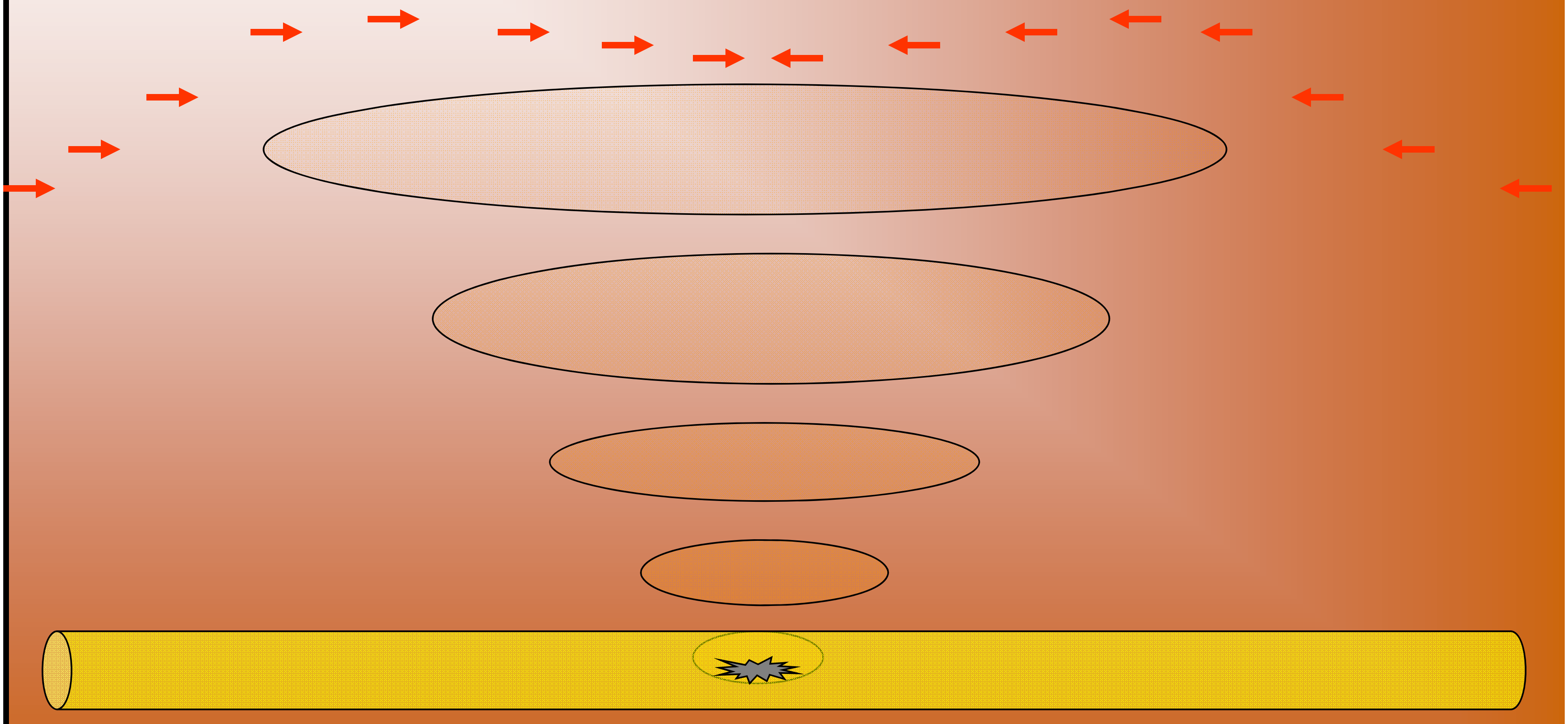

Position one pin over
center of pipe and
suspect defect.
Complete clock
direction to validate
suspect location

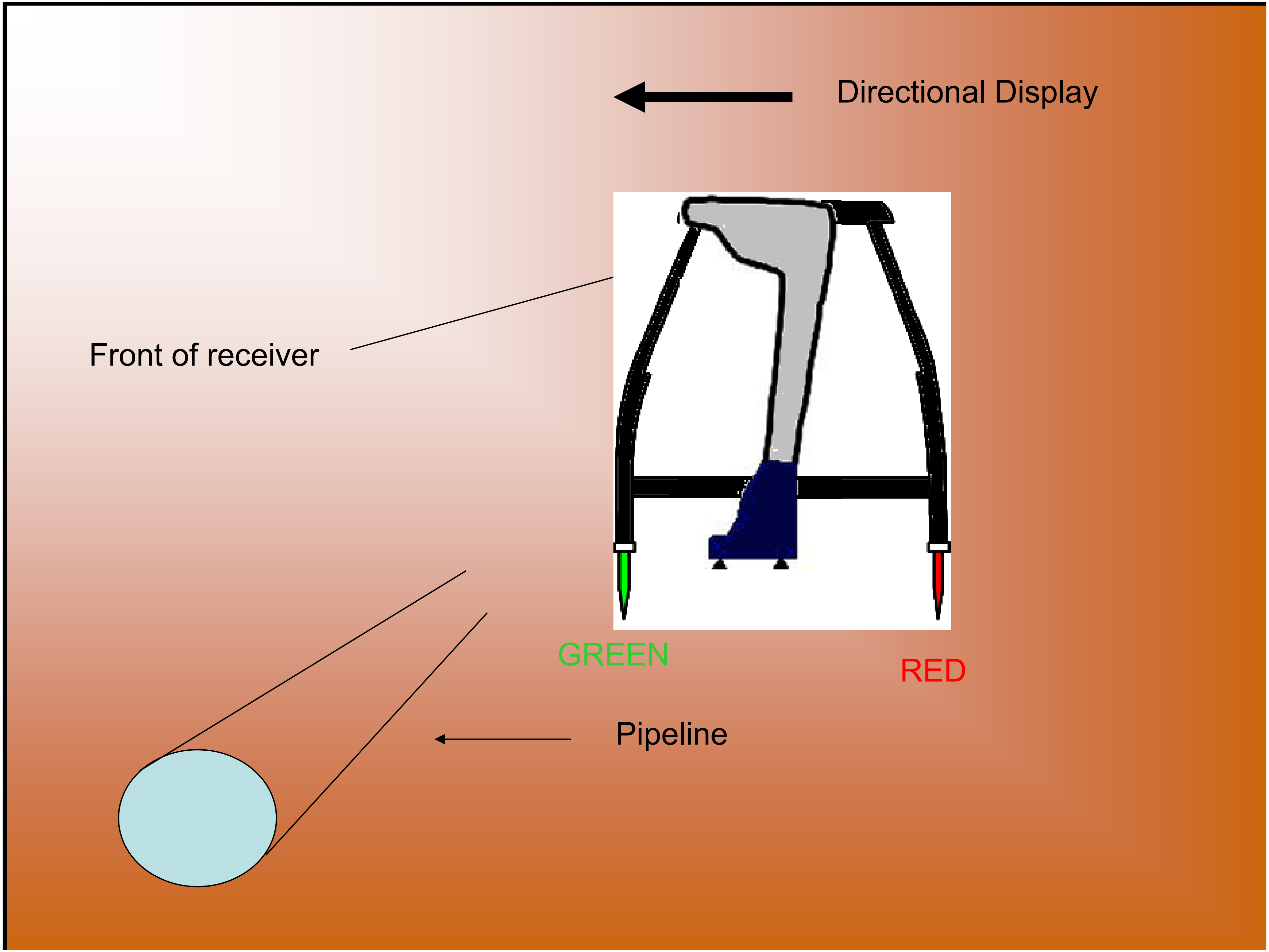

Voltage Gradients

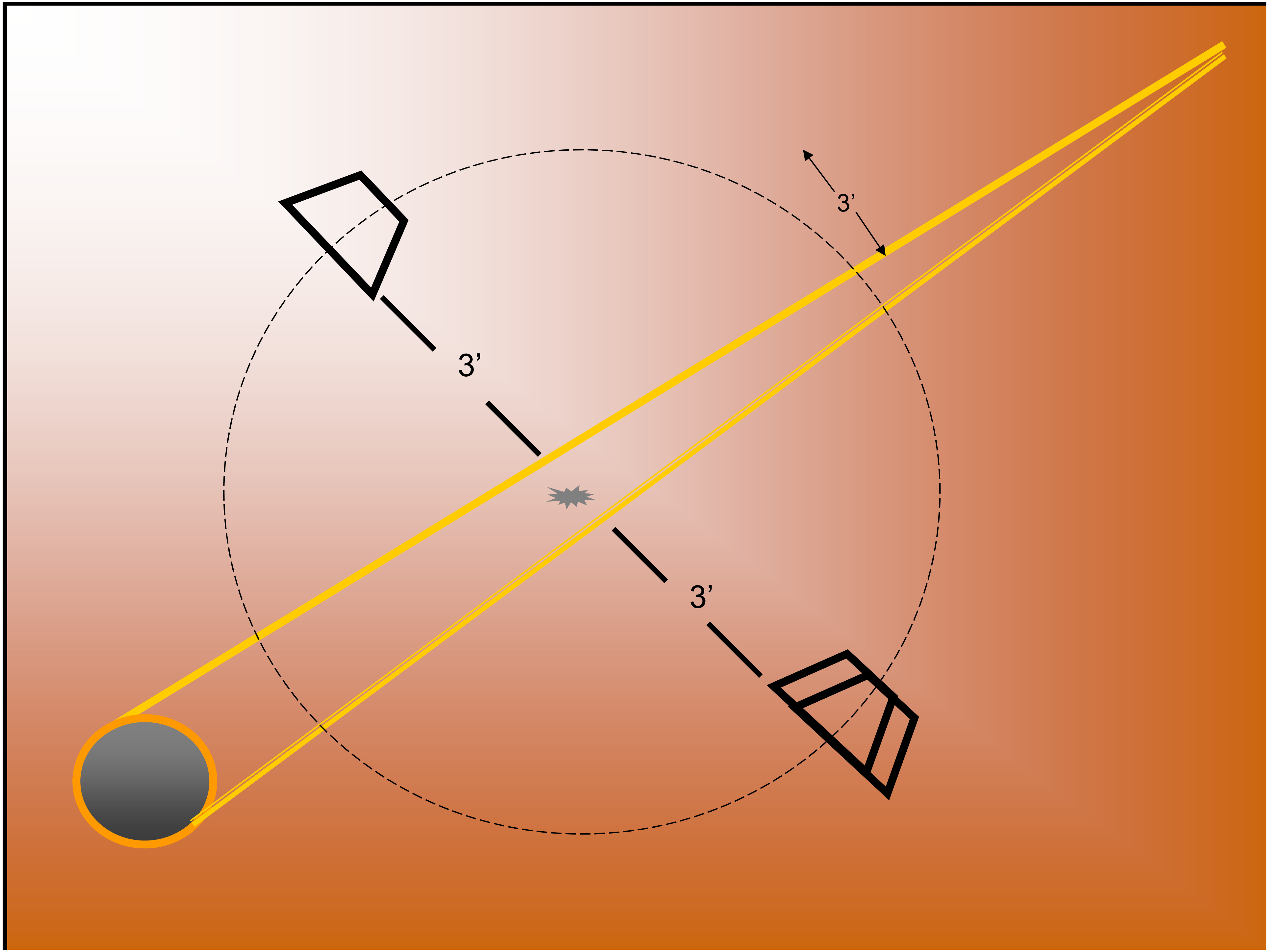
4 Hz Signal Voltage Gradient



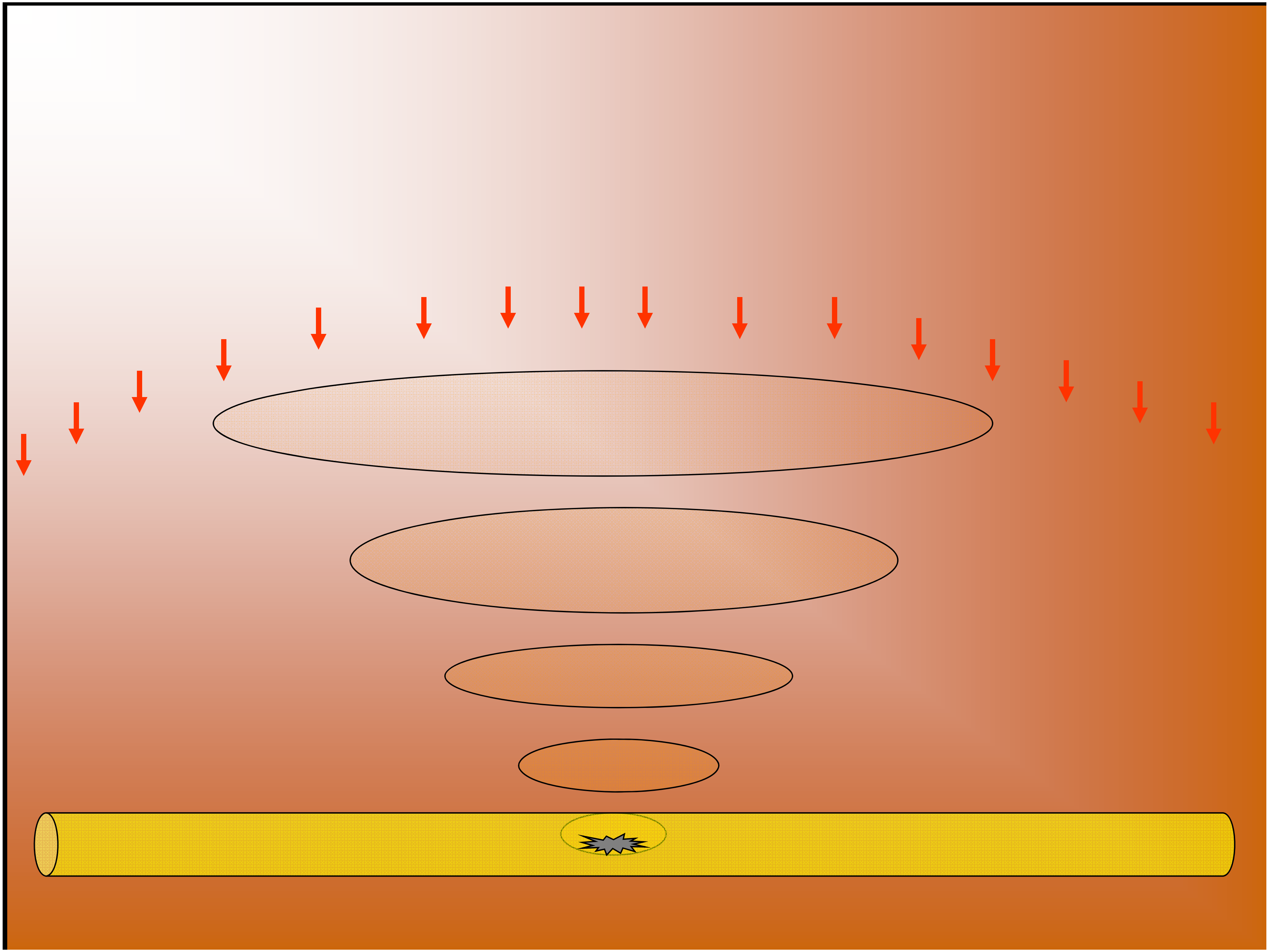
Shape of ACVG response over coating defect




Directional Display
Front of receiver
GREEN
RED
Pipeline



3’
3’
3’



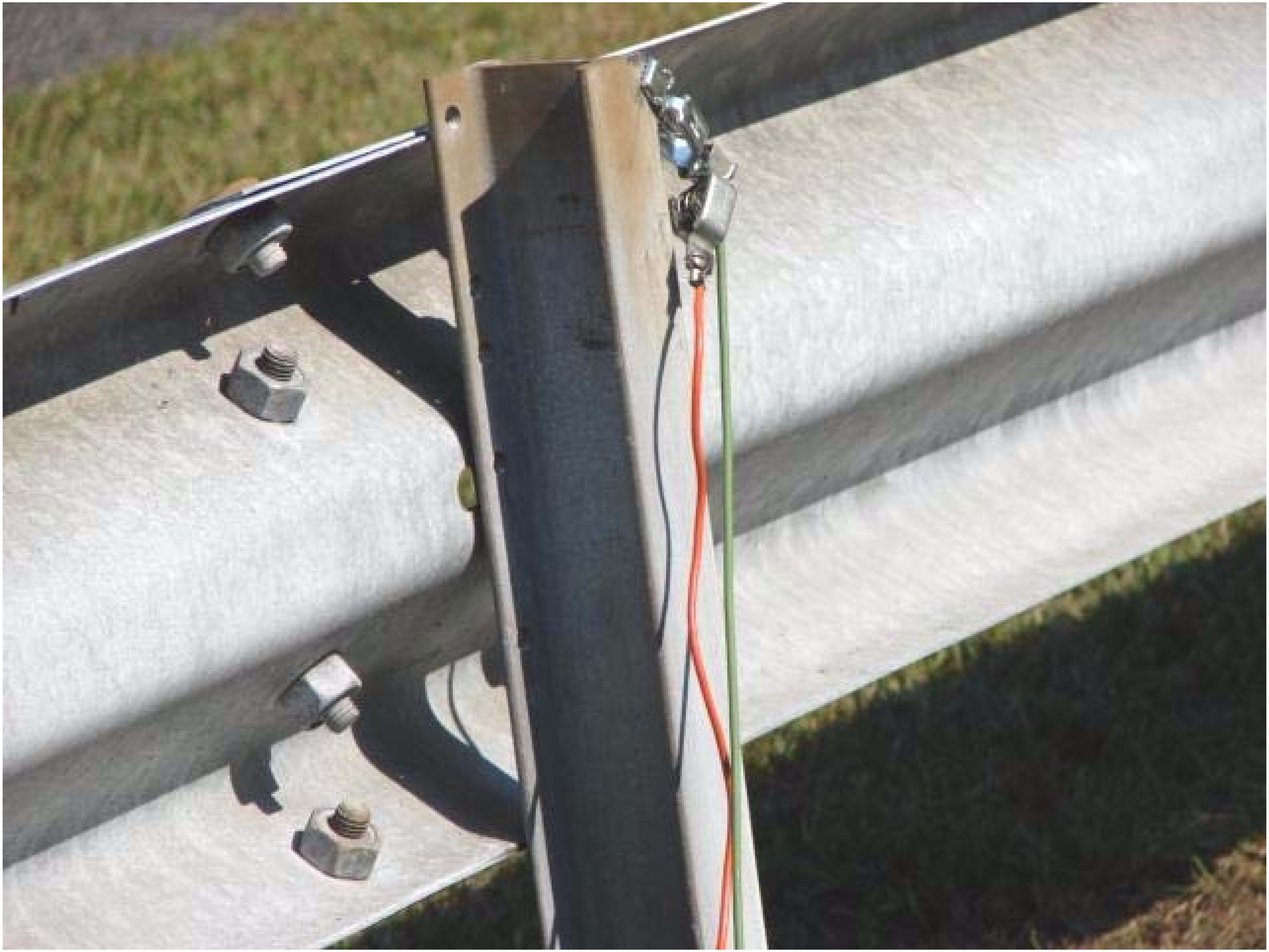
Make sure probes are in good contact with electrolyte


NEW YORK PLAINVIEW
UNITED METHODIST CHURCH
Probe contact in sidewalk seam

ACVG Rx Readings

Pipe 2’ to 3’ off curb and under macadam road surface


Using guard rail as
remote ground for
transmitting signal




Connection to structure at grade level test box using #8 cu stranded wire connected to pipe below grade

Output Off
Over Temperature
Power Limit
Voltage Limit
Output Voltage Level
Output Level
Frequency Select
Serial No.
AC Input
DC Input


Pipe location below
grade


ACVG


Pre-measured
distance for
ACVG data
collection

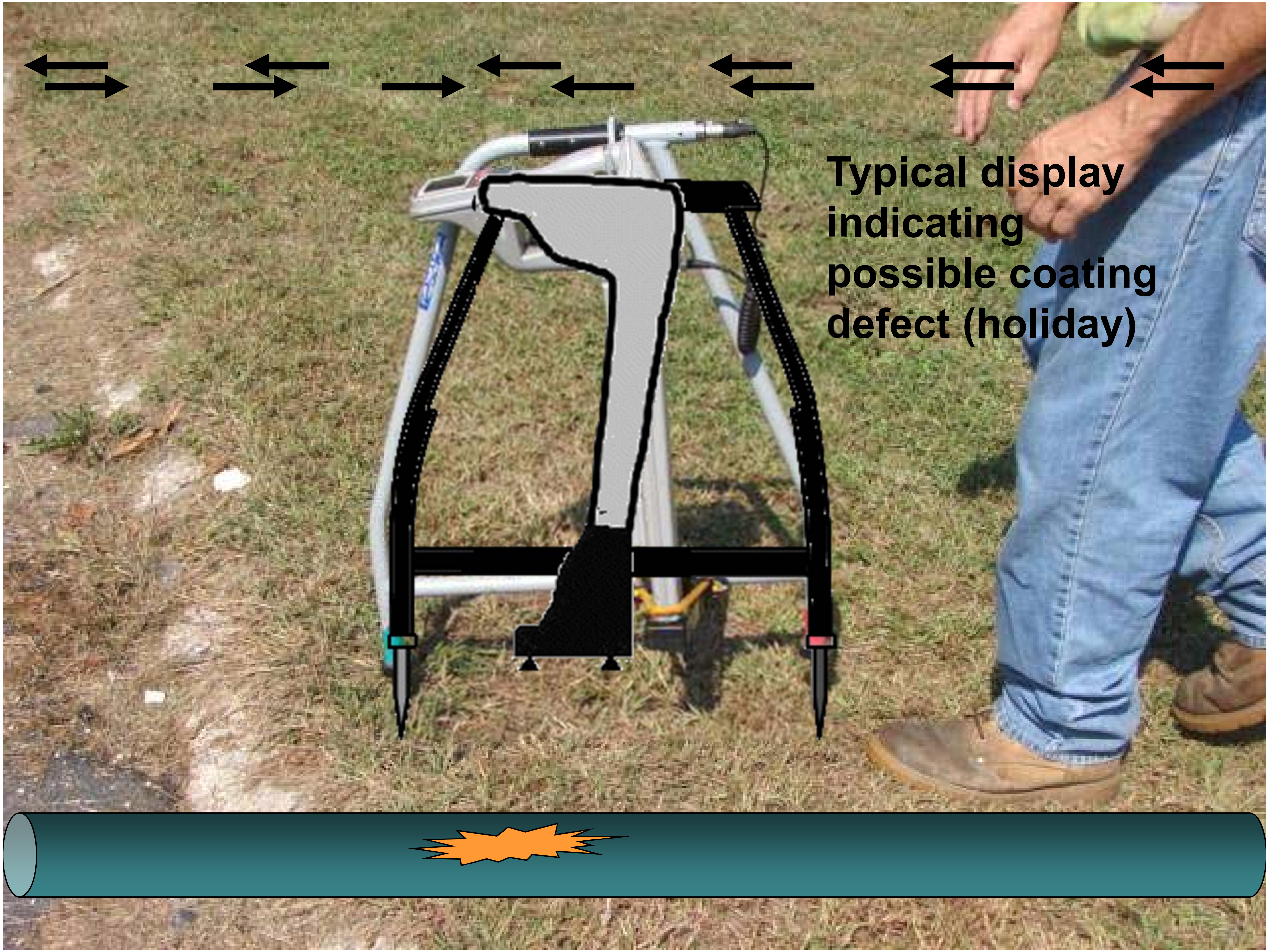

Push the A-Frame spikes into
the ground to take a reading.
No Rx adjustments.


ELF LF 8k CPS
74
Review
On/Off
Peak/Null
Depth
Current


ELF LF 8k CPS
76
Review
On/Off
Peak/Null
Depth
Current


Make good electrical contact
with ground.

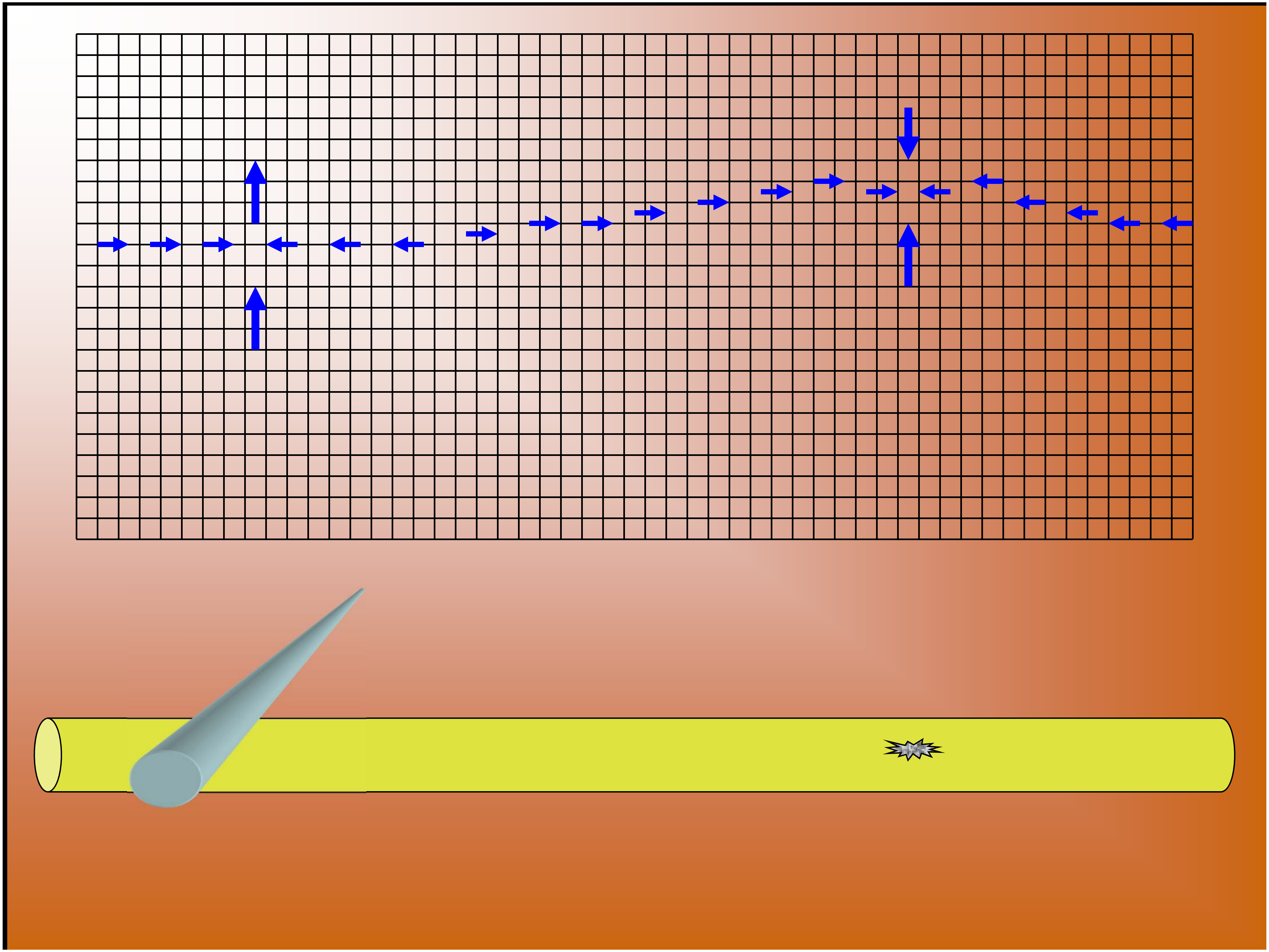

Moisten roadway to ensure good surface contact

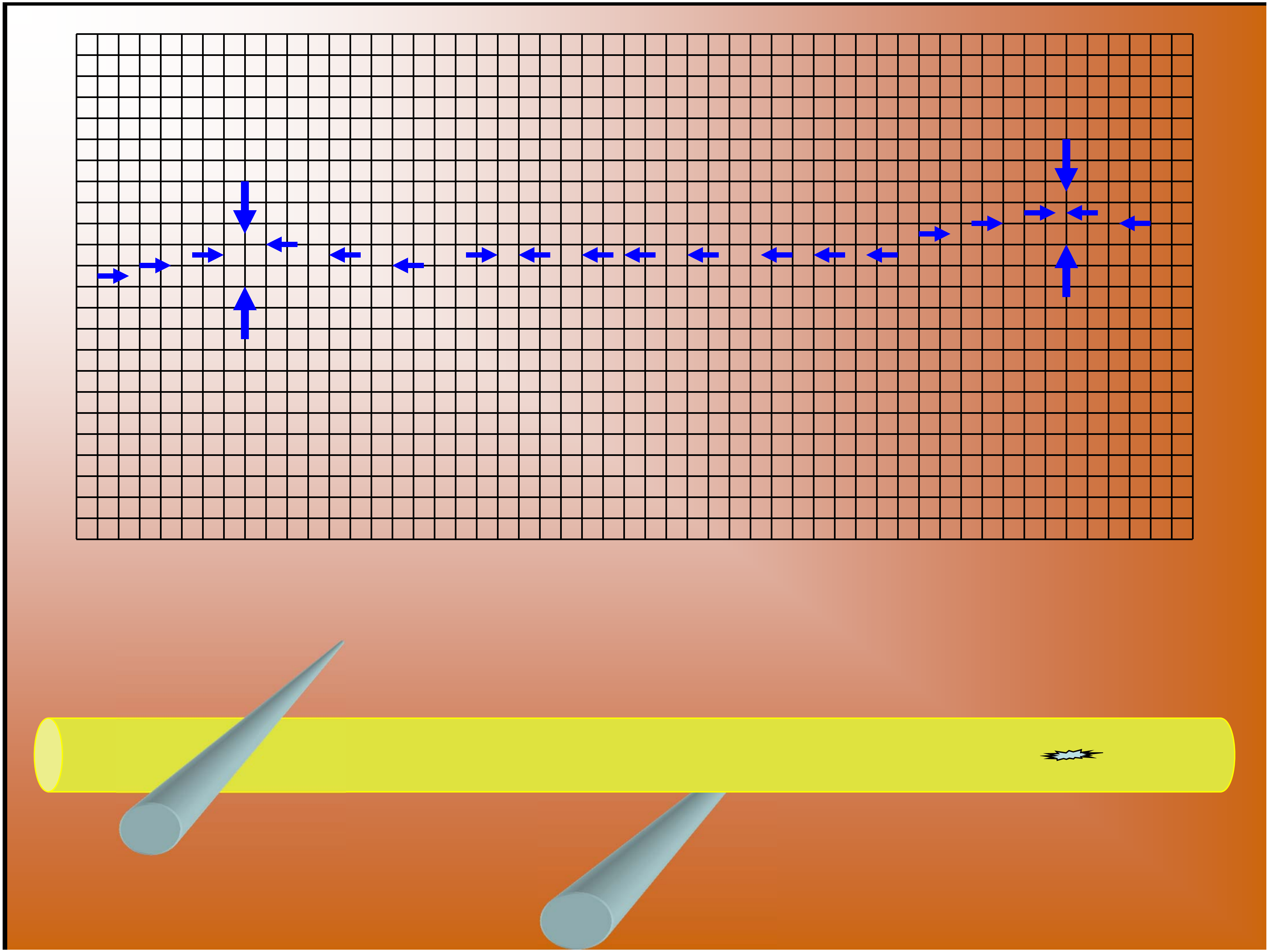

Typical display indicating possible coating defect (holiday)

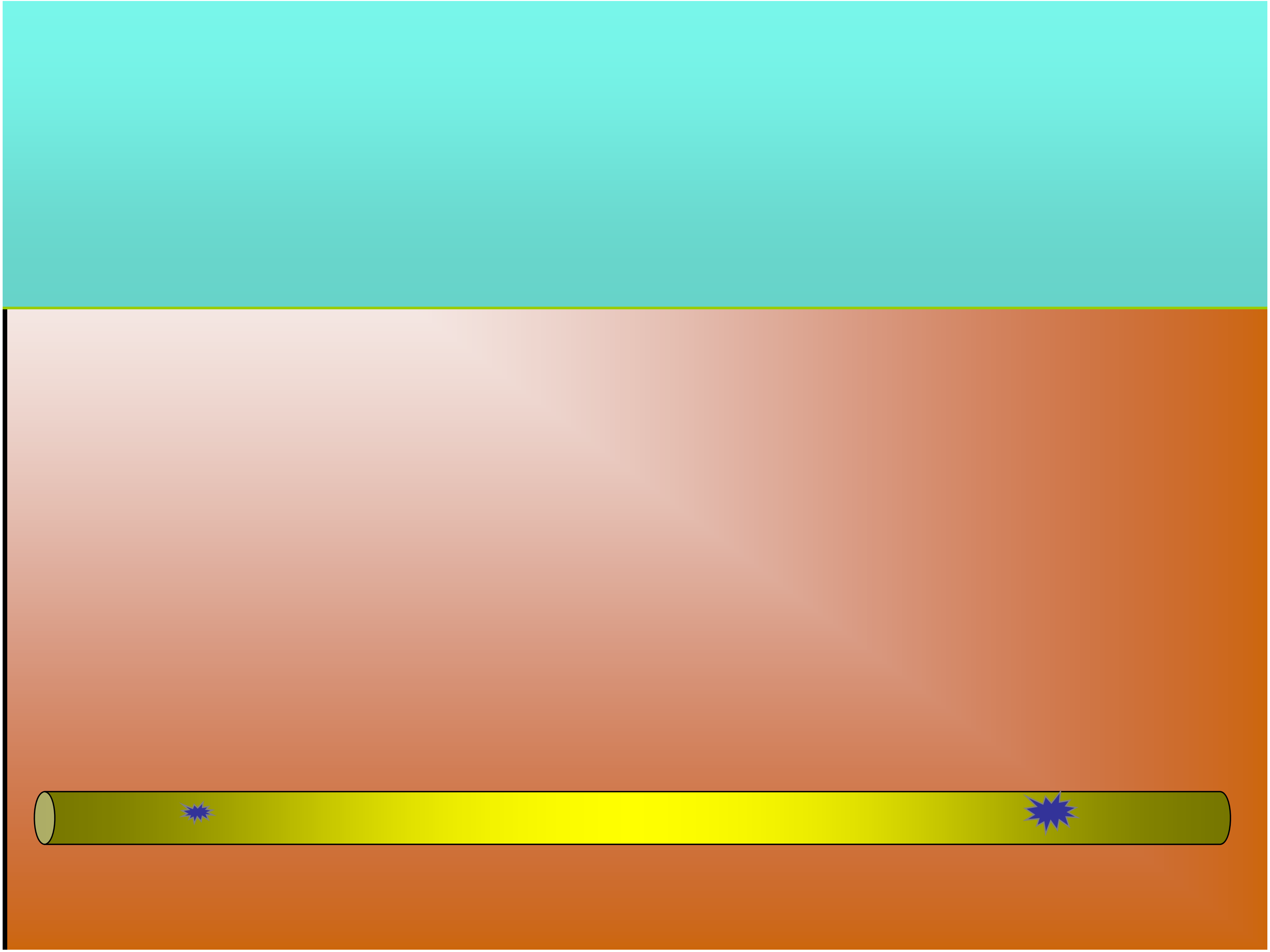

E
D
C
Coating defects observed after excavation of pipeline


Section of coating removed from pipeline after excavation


Damage
observed after
coating removed







Data logging w/GPS

Interpreting Results

- No direct correlation between dB and size of fault
- dB indicates severity of current loss
- Factors affecting dB readings
  1. Tx output
  2. Current available at fault
  3. Quality of contact to ground:
     - Concrete
     - Sand
     - Railroad ballast
  4. Conductivity of path fault-to-ground (electrolyte, rain)

Interpreting Results

- Normally Faults are CATEGORIZED
    1. Manufacturer's recommendations
    2. Gas Technology Institute
    3. Own internal documentation

- Note that Tx output will affect dB readings. Apply correction if different outputs used.

Interpreting Results

- Example:

  1. Severe – 80-100 dB
  2. Moderate – 65-80 dB
  3. Minor – 50 - 65 dB
  4. Note – 0-50 dB

Interpreting Results

- Use 1A as a “std.” output, and refer all readings to it.

- Conversion

100 mA	+20 dB
300 mA	+10 dB
600 mA	+ 4 dB
1 A	no correction
2 A	- 6 dB
3 A	-10 dB

Ext. Corrosion Direct Assessment:

Four step process consisting of:

1. Pre-assessment
2. Indirect Inspection
3. Direct examination
4. Post assessment

Indirect Inspection requires the use of two complementary tools

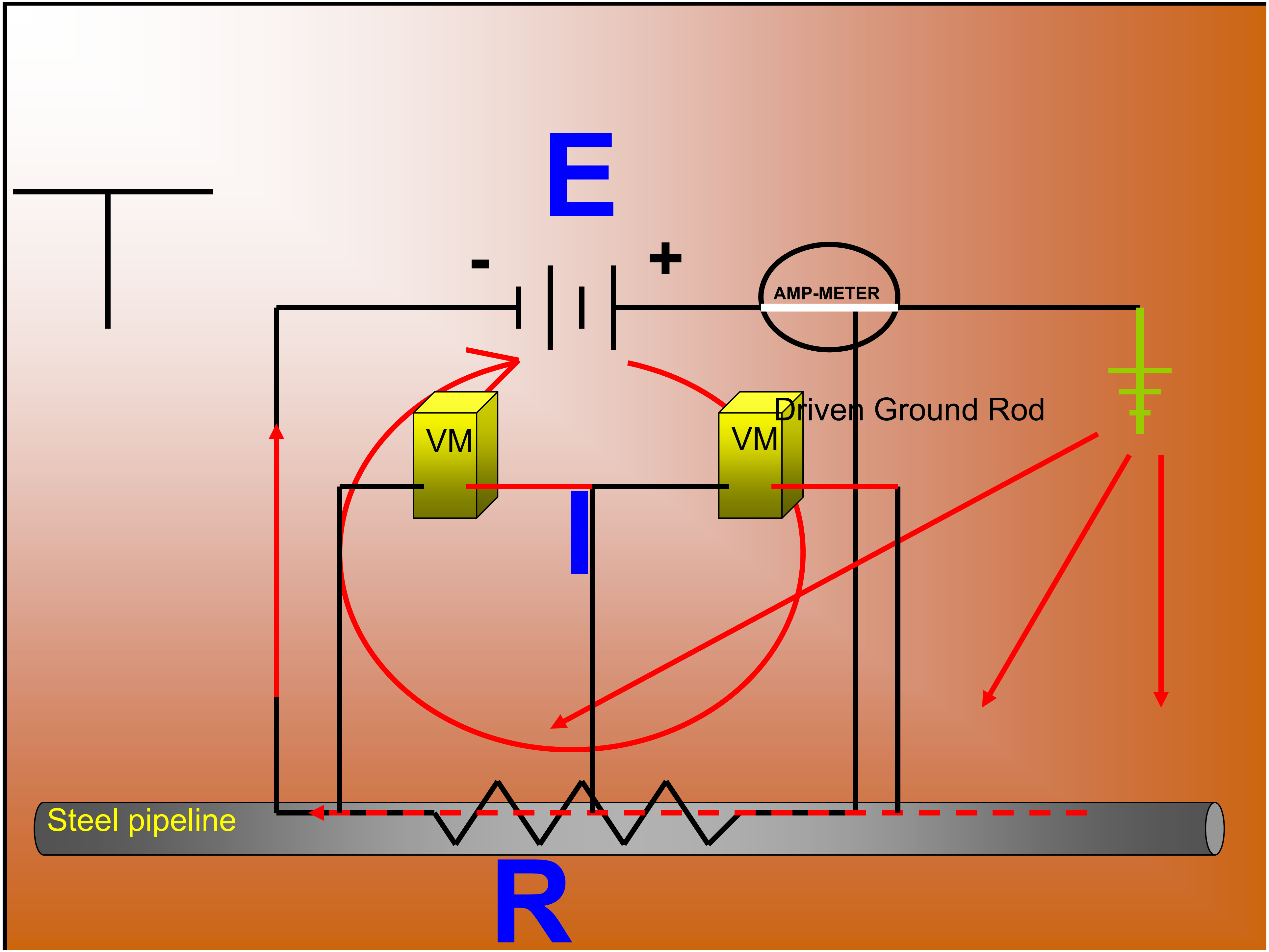
One of these tool choices can be

ACVG

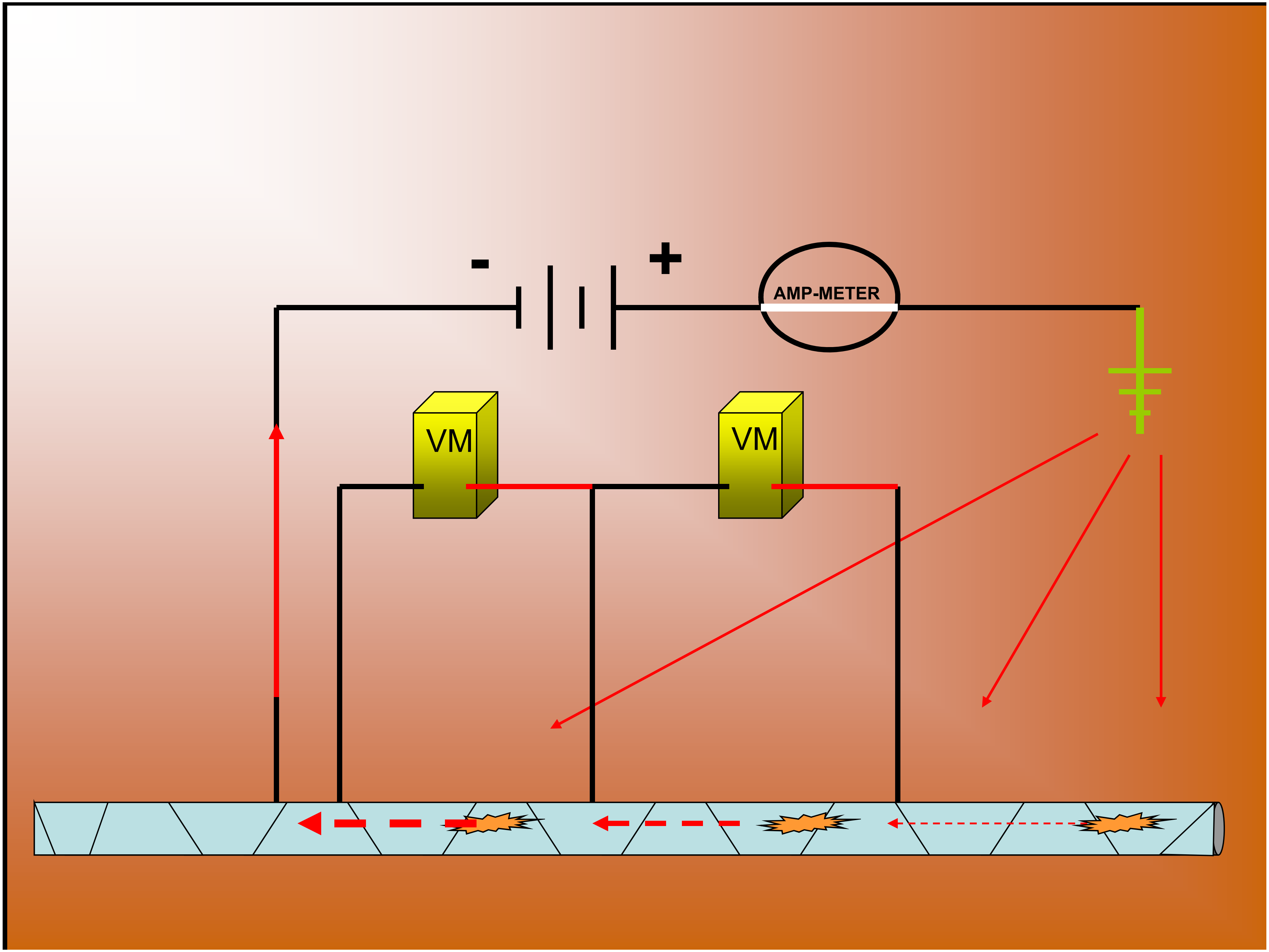
AC Current Attenuation

<u>Introduction to Basic Concepts</u>

Need to understand behavior of AC current on a pipeline.



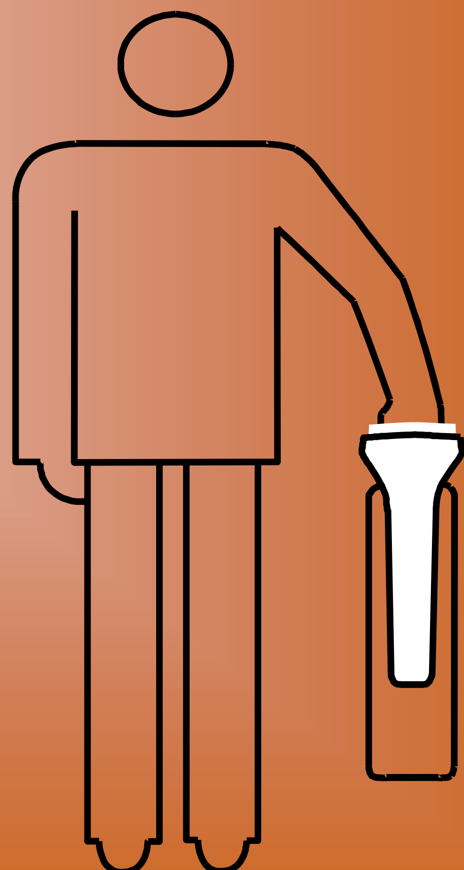
E
-
+
AMP-METER
Driven Ground Rod
VM
VM
I
Steel pipeline
R



-
+
AMP-METER
VM
VM

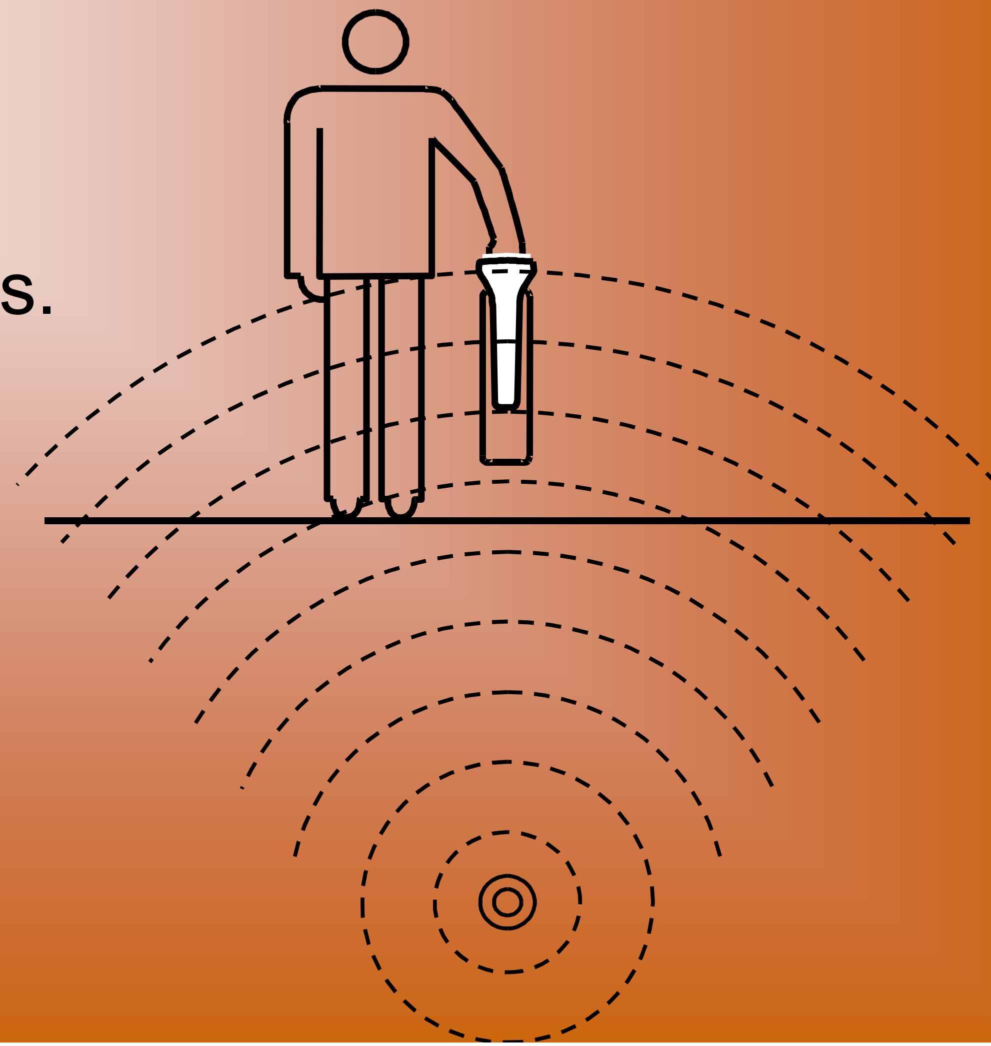
AC Current Attenuation

Pipe and Cable locators do not find pipelines (or header cables.....)



AC Current Attenuation

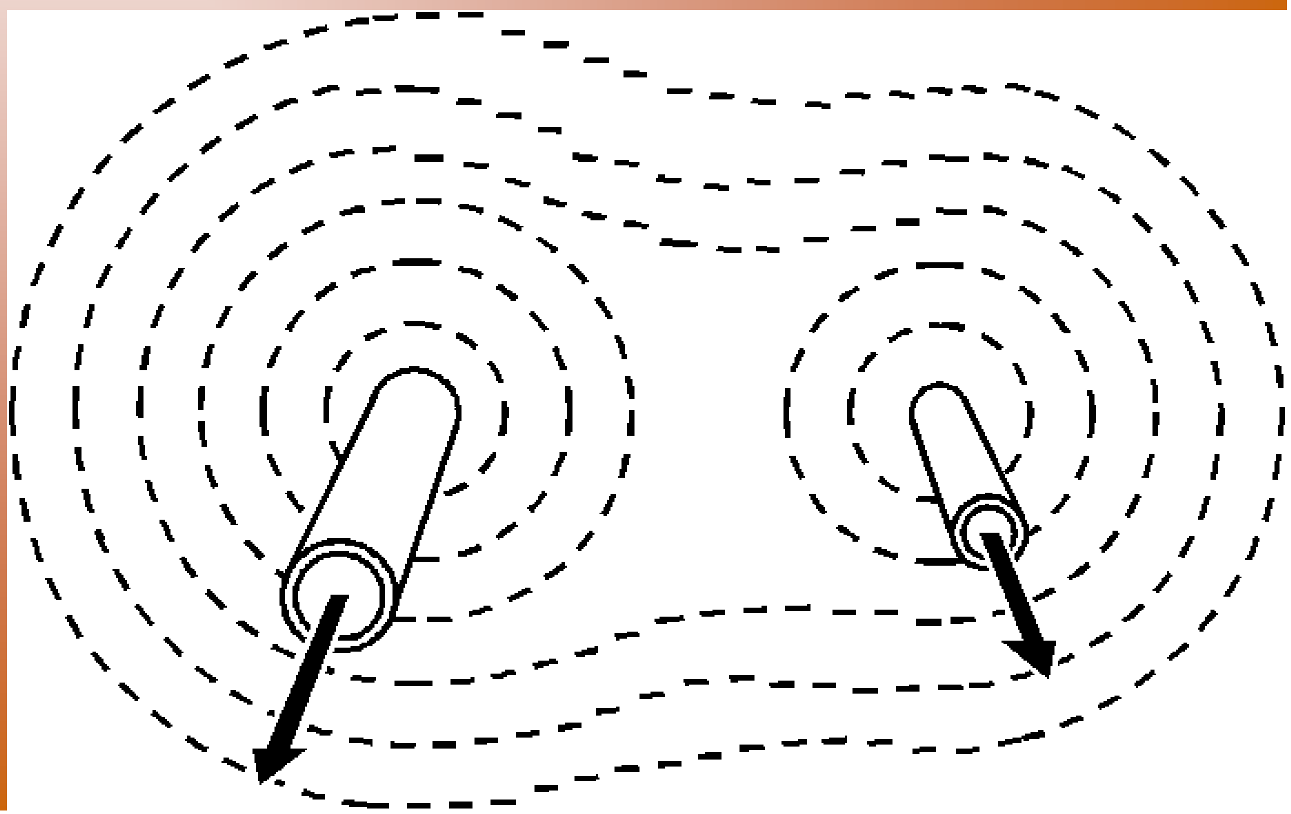
....they find magnetic fields.



AC Current Attenuation

WHY DOES IT MATTER ?

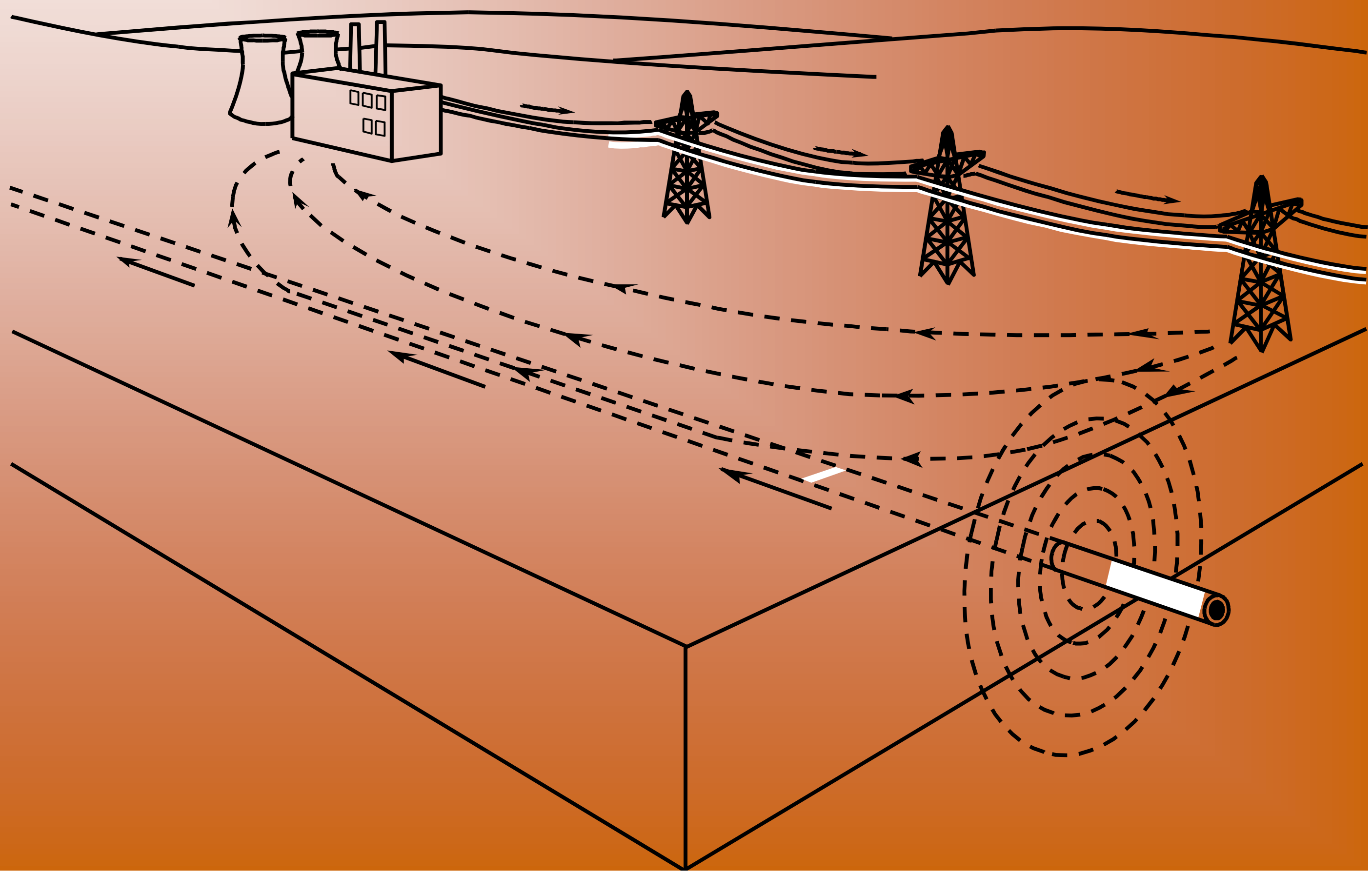
Distortion



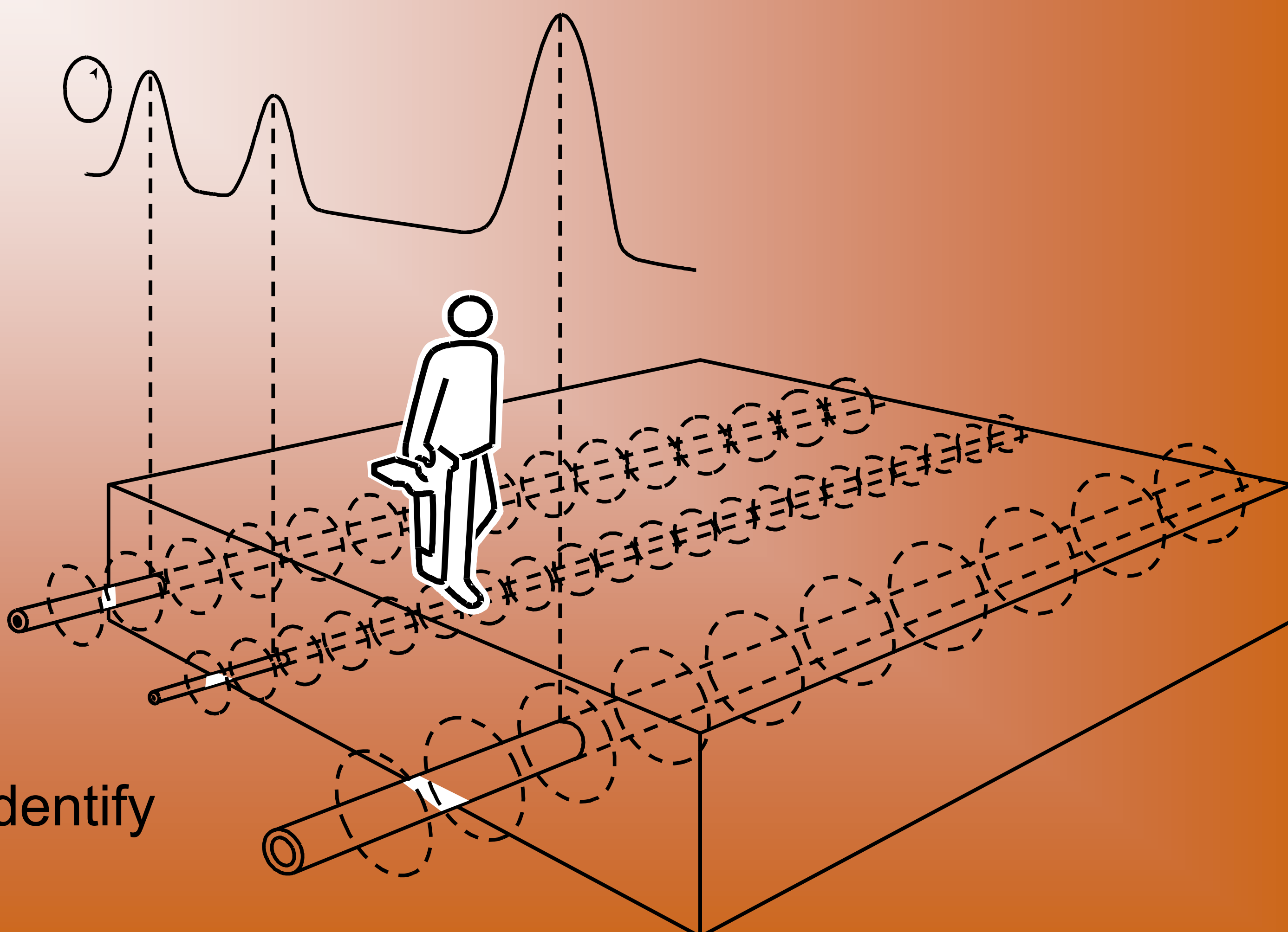
AC-Current Attenuation

- [x] Passive
- [ ] Active

AC Current Attenuation



AC Current Attenuation



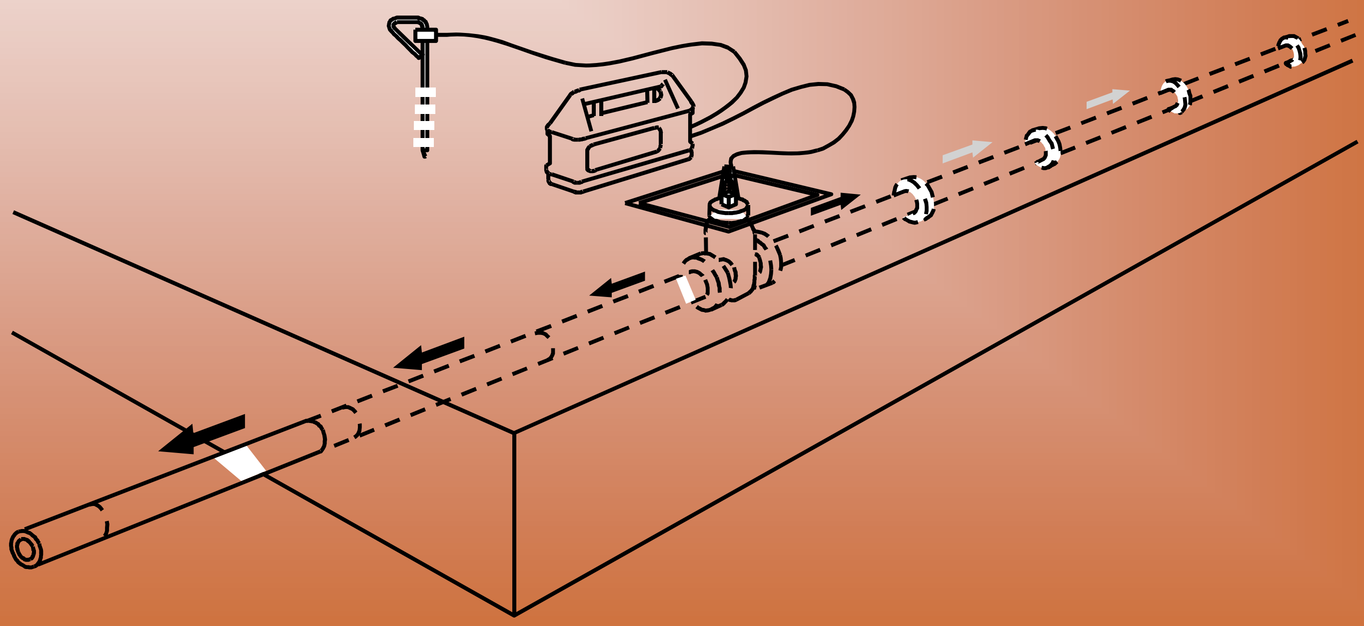
- ☐ Fast
- ☐ Easy
- ☐ Does not identify

AC Current Attenuation

☐ Passive

☑ Active

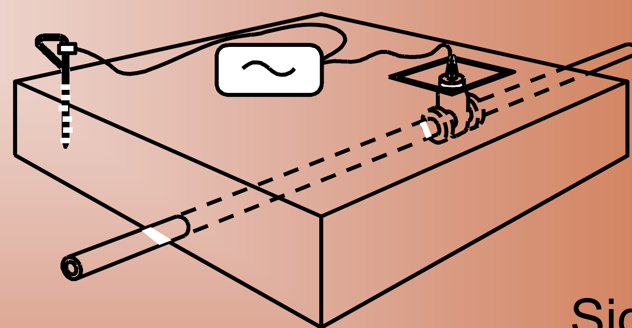
AC Current Attenuation



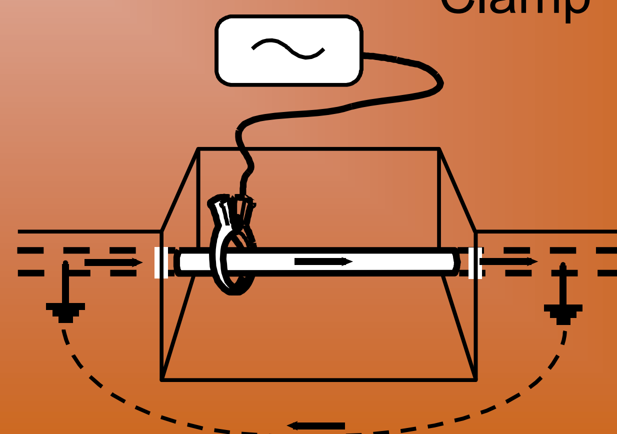
AC Current Attenuation

Applying a Signal

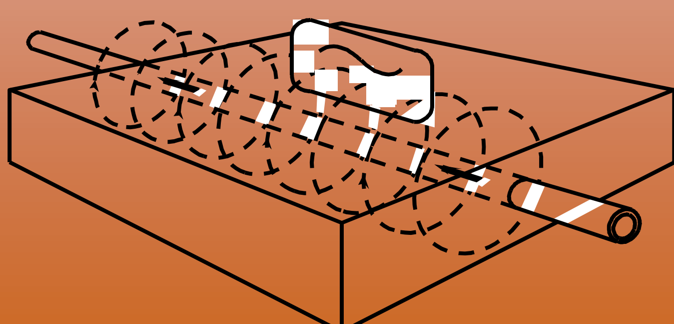
Connection "Clip"



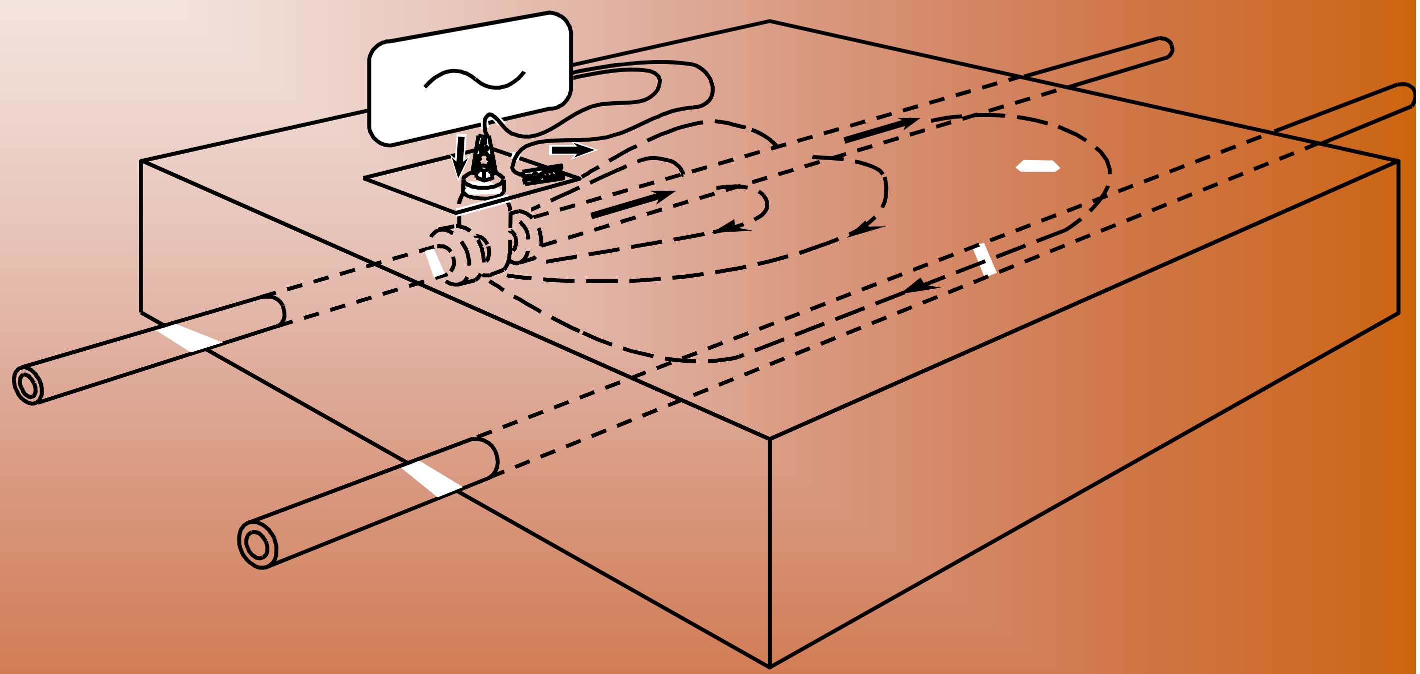
Signal Clamp "Clamp"



Induction "Spill"

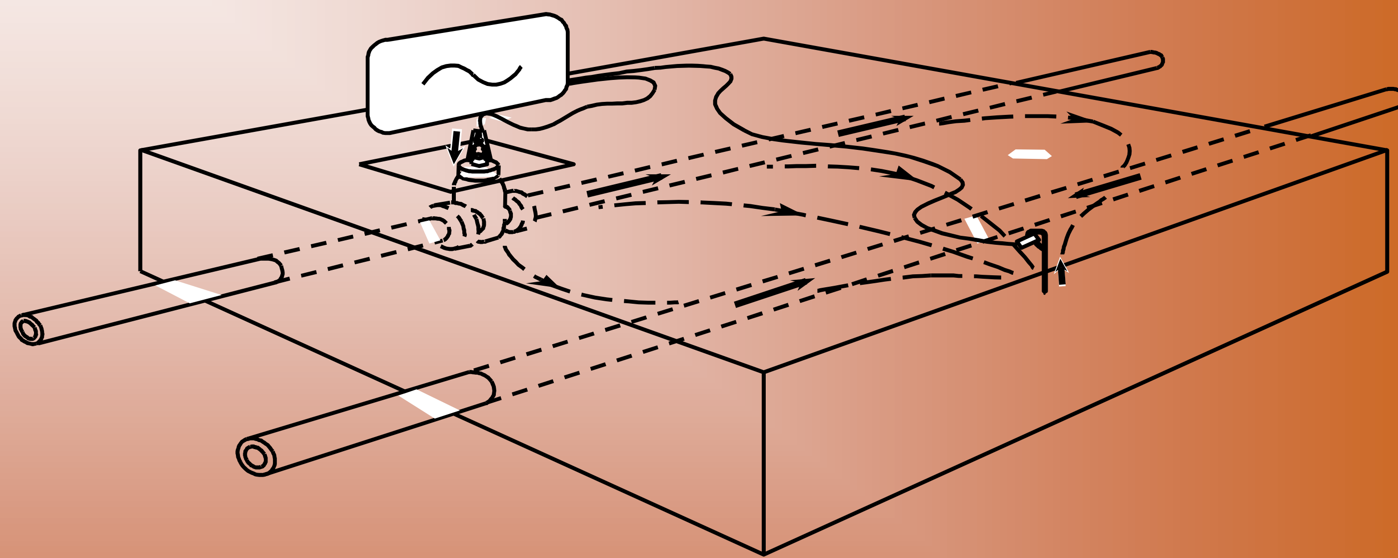


AC Current Attenuation



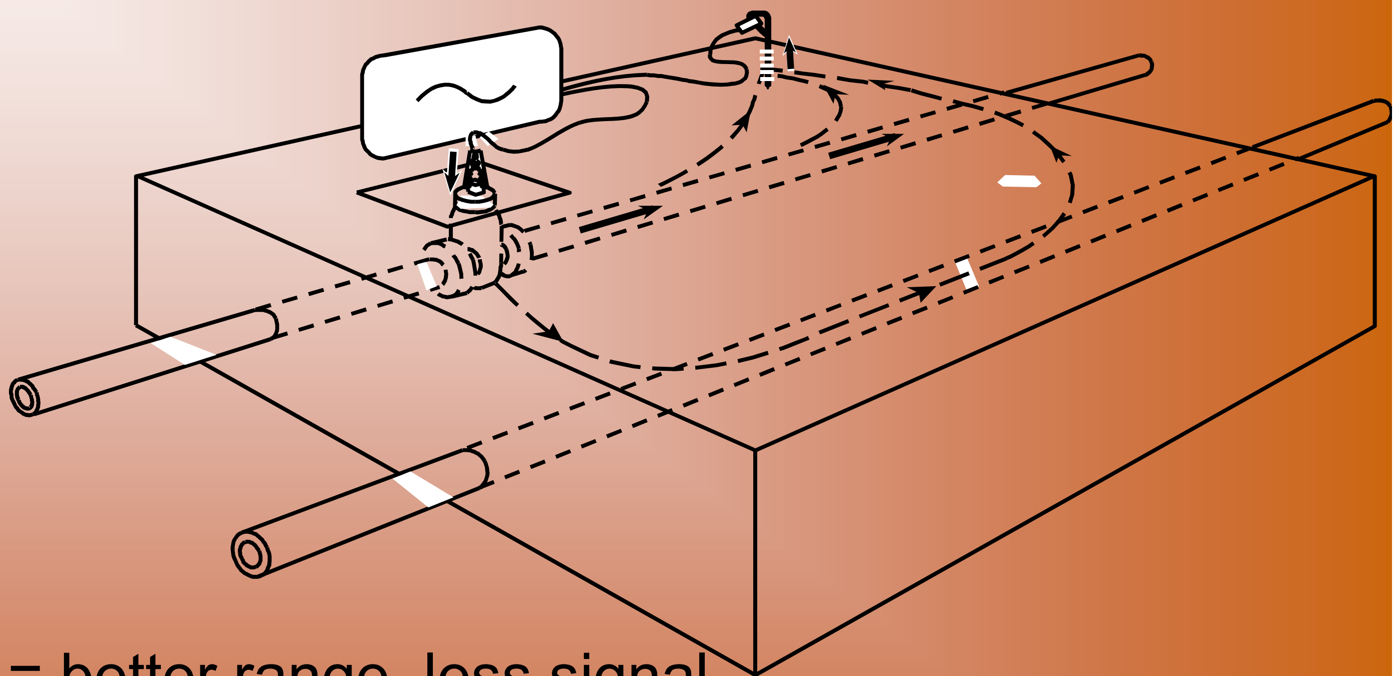
Ground stake too close to target conductor:
Less range, some signal transfer.

AC Current Attenuation



Bad ground choice causes more bleed off.
Place ground rod away from known adjacent pipes/utilities which may act as return paths.

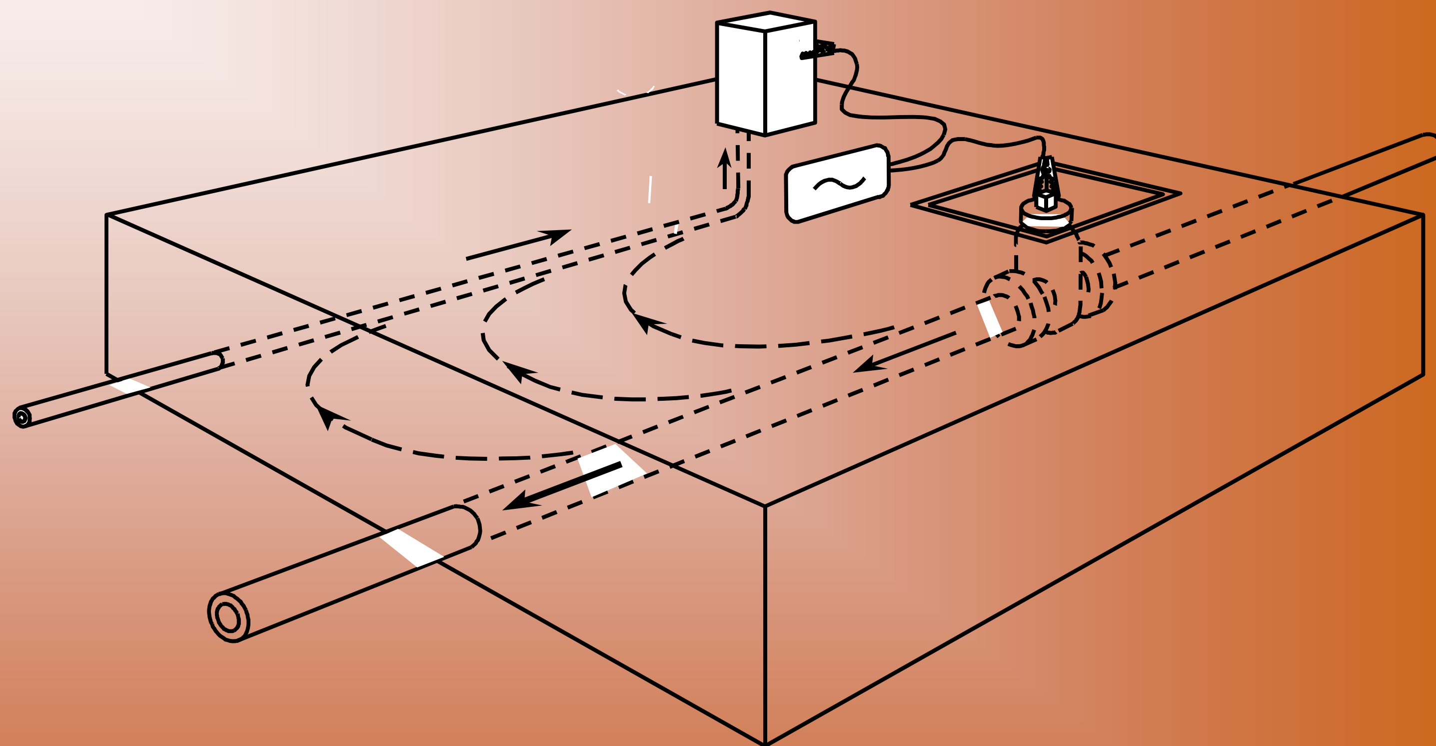
AC Current Attenuation



Remote ground = better range, less signal transfer.

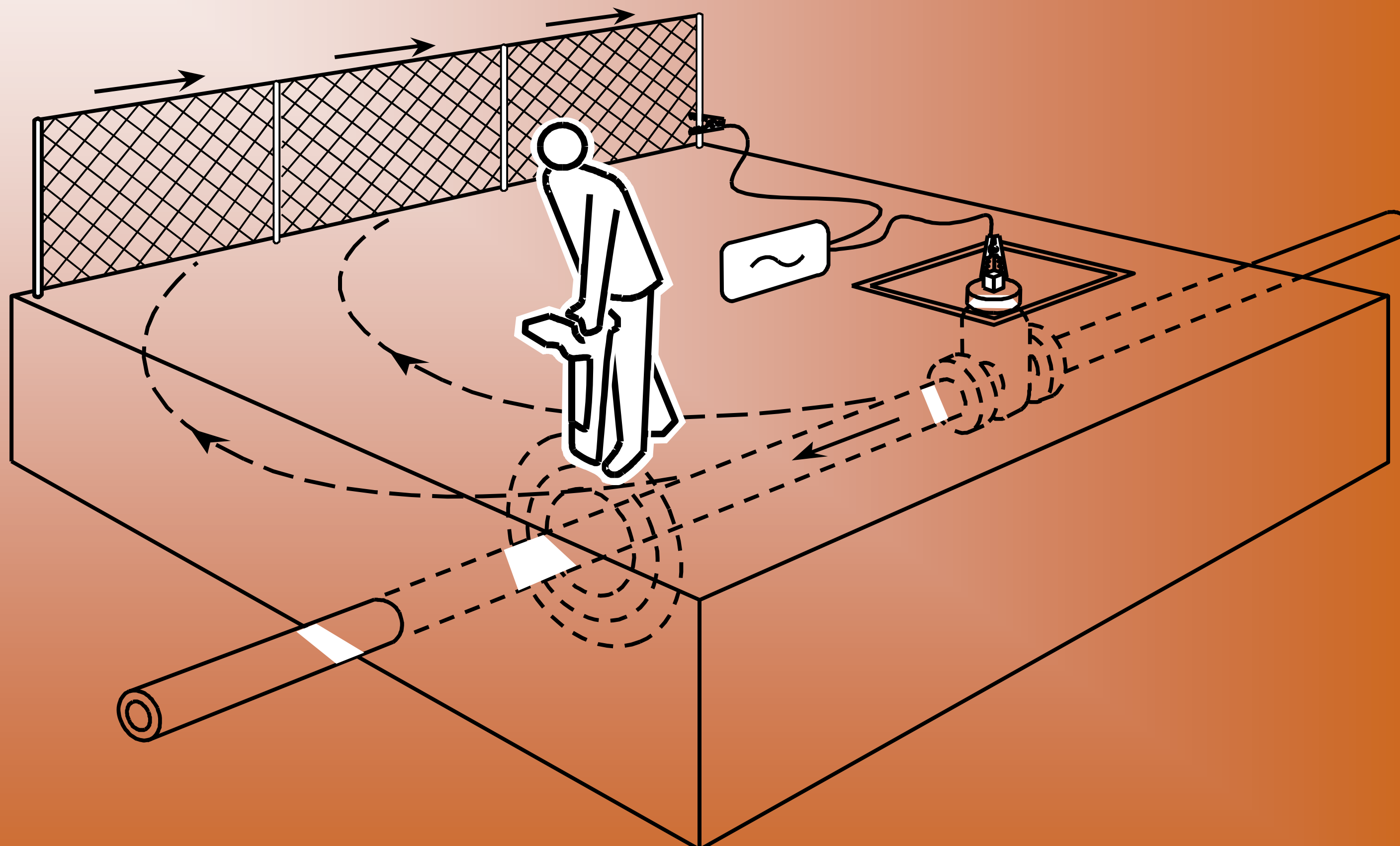
GENERAL RULE: position ground point at right angles to pipe.

AC Current Attenuation



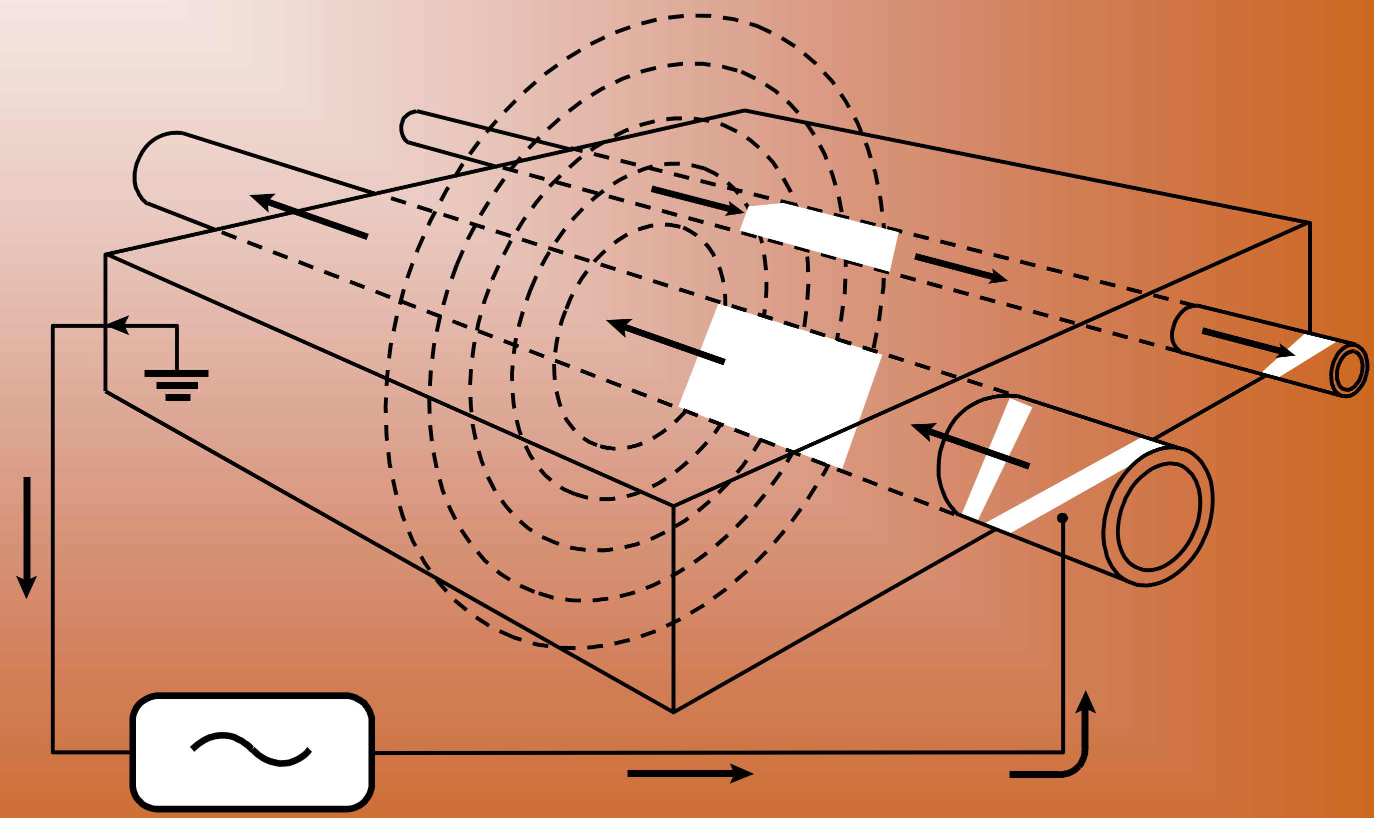
Grounding to a structure which is also grounded can produce multiple signals.

AC Current Attenuation



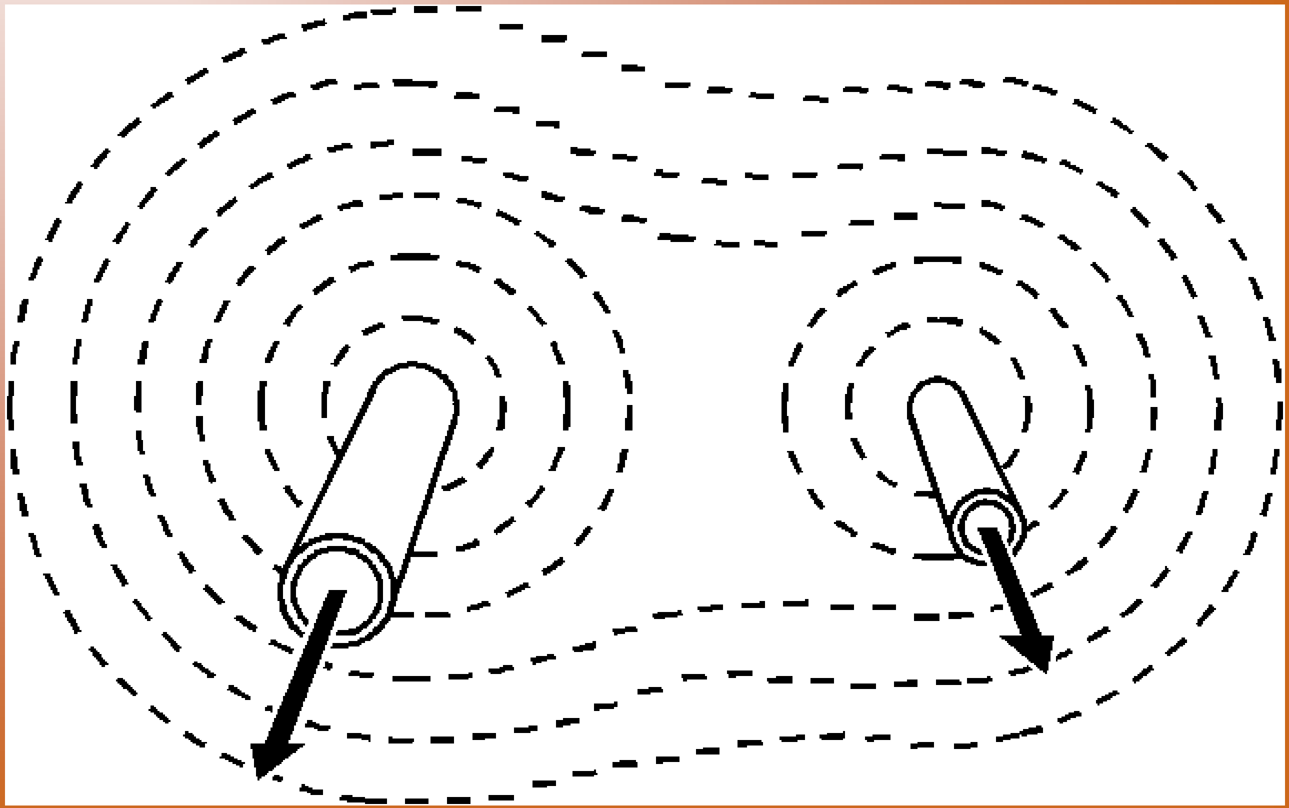
AC Current Attenuation

Distortion

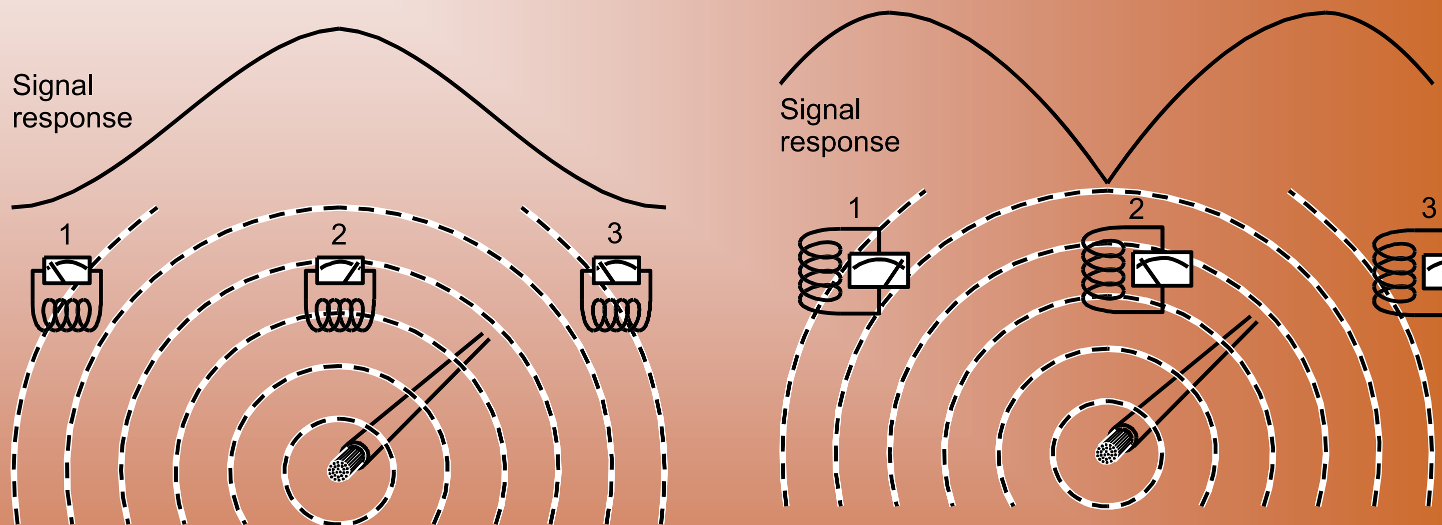


AC Current Attenuation

Distortion



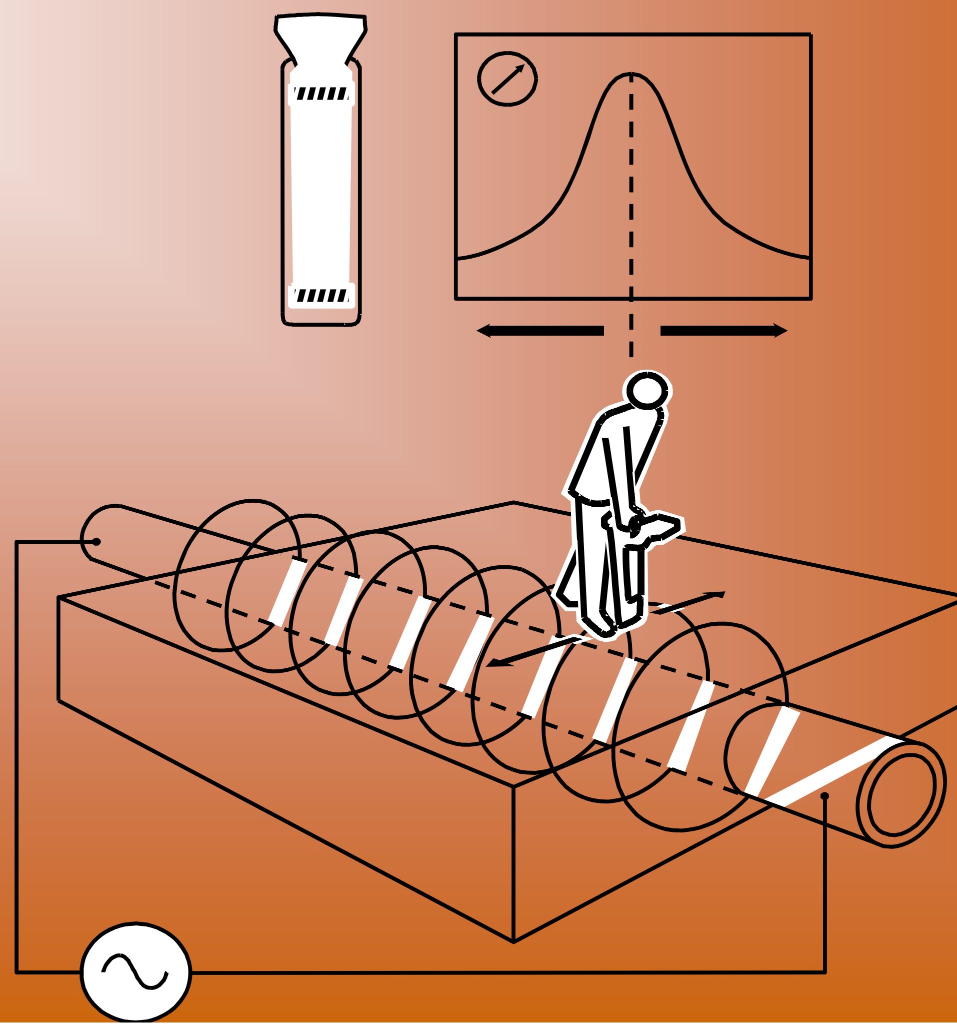
AC Current Attenuation



Aerial Responses

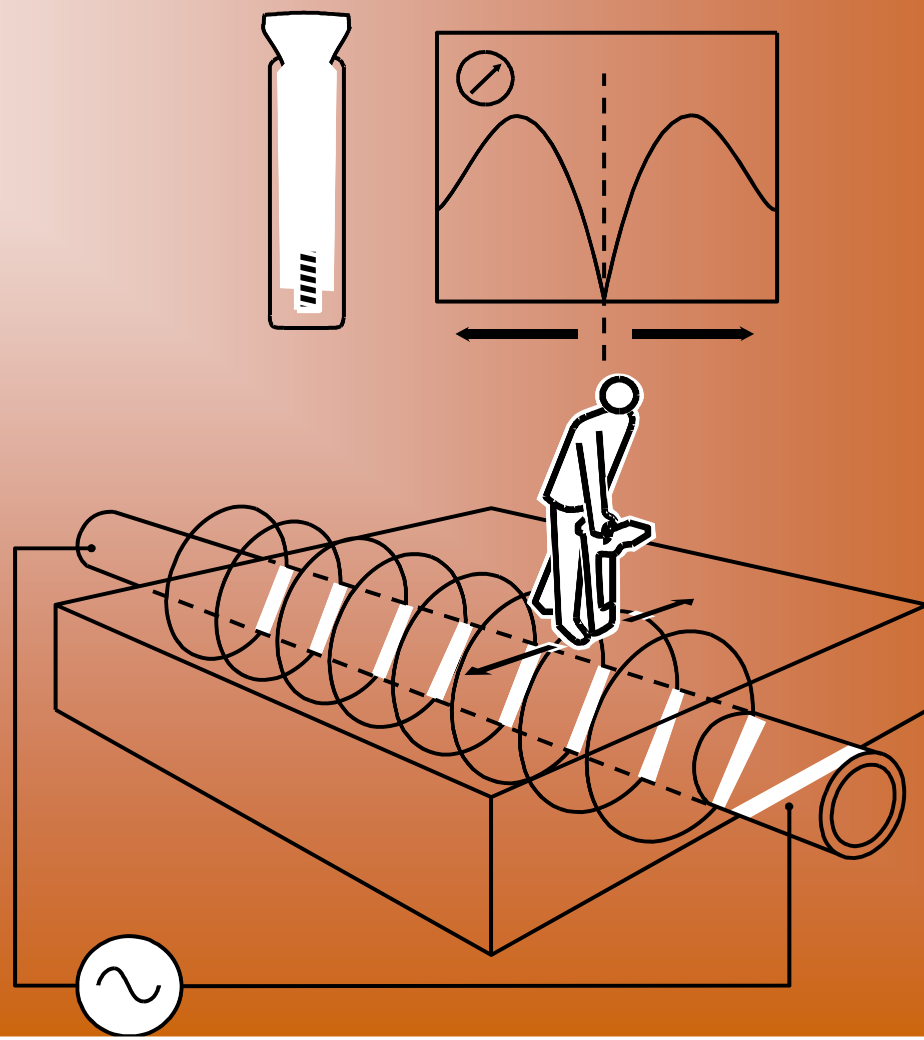
AC Current Attenuation

PEAK Response

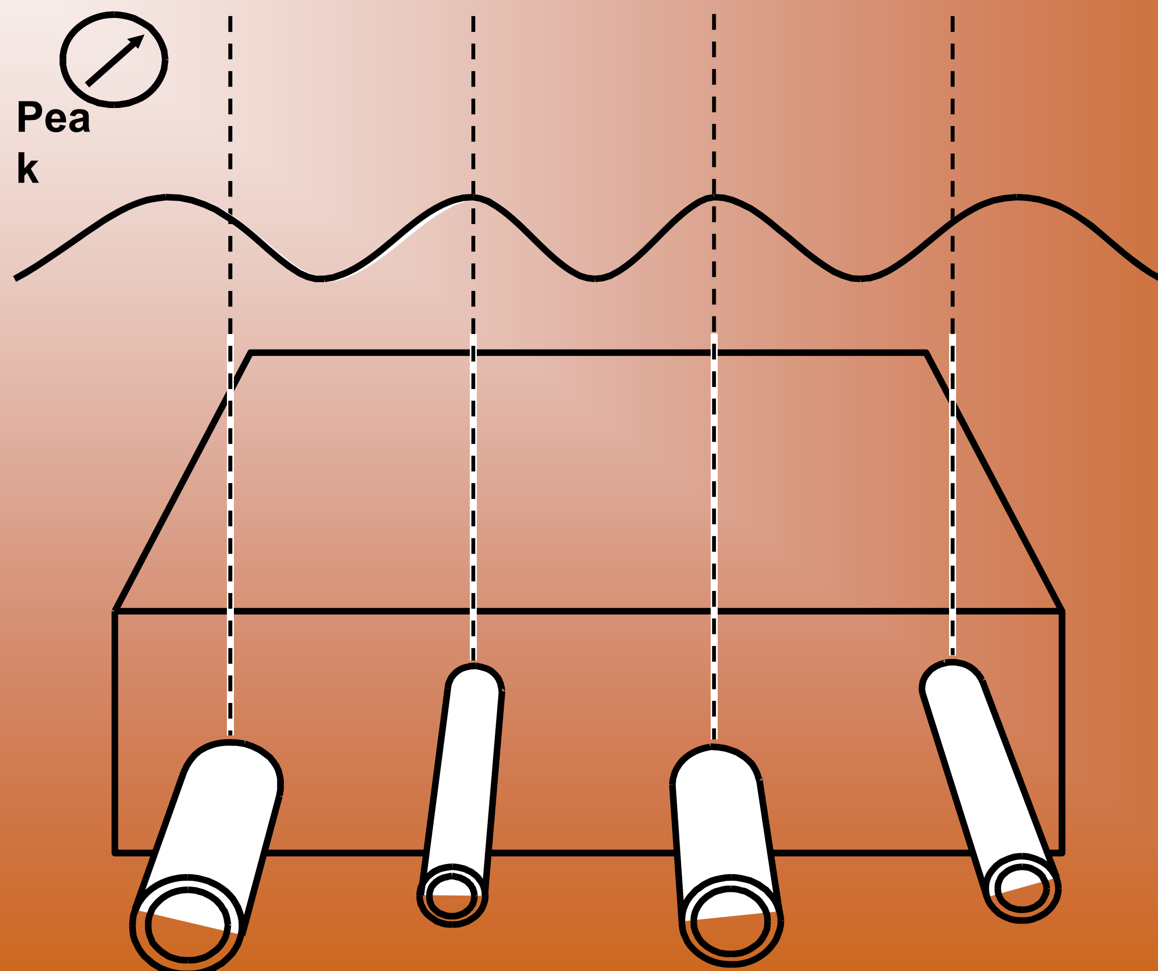


AC Current Attenuation

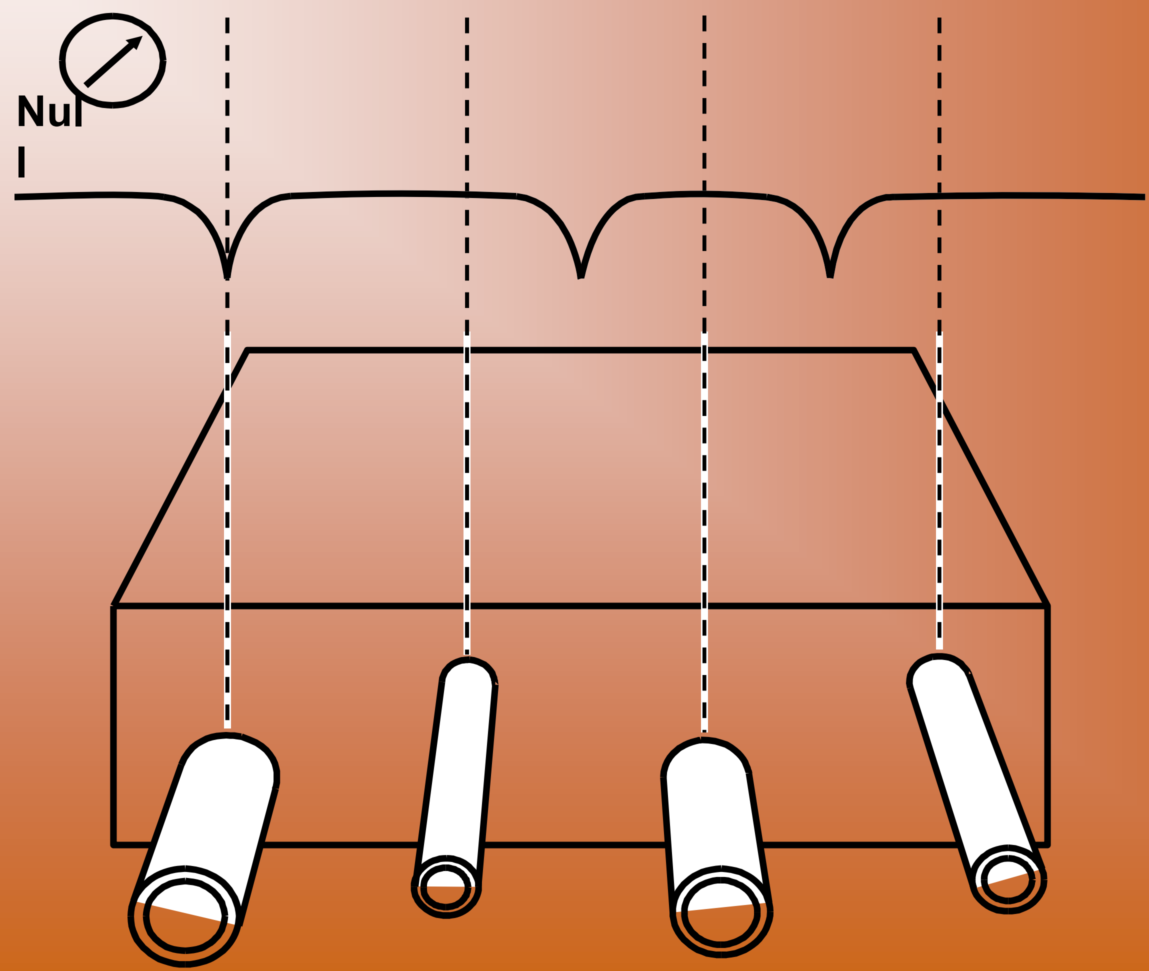
NULL Response



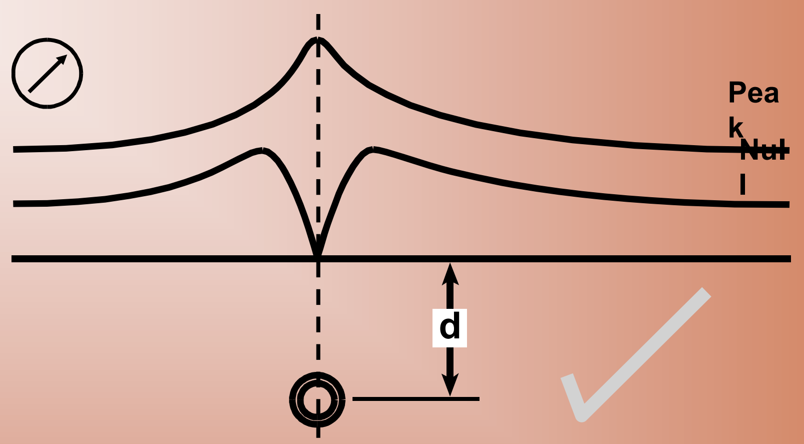
AC Current Attenuation



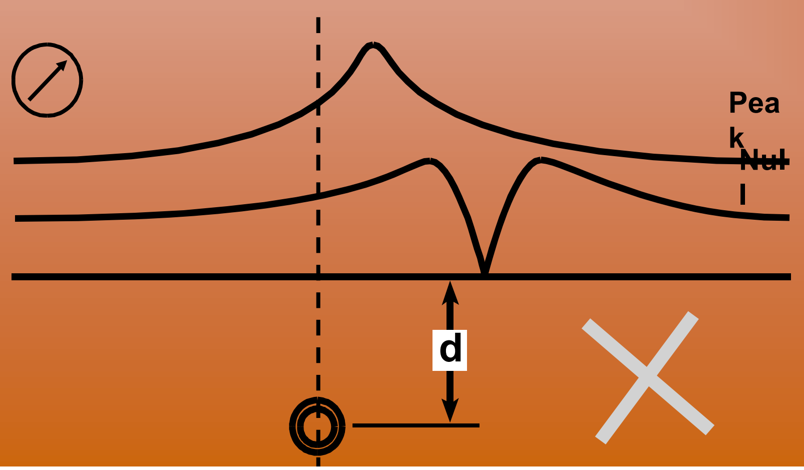
AC Current Attenuation



AC Current Attenuation



Peak response will **ALWAYS** be more accurate.



Current Attenuation & DCVG AUCSC - 2008

Instructor - Jim Walton

What can CA data tell us?

- It is a macro tool that highlights the bigger problems in a coated pipeline system including:
  - Shorts to other structures
  - Grounding to electric neutral
  - Bad insulators
  - Large coating defects
  - Shorted casings
  - Other current distribution problems
  - Depth of cover at the same time (possible TPI)

  Any or all may affect the ability of the other tools to perform in a consistent and reliable manner.

Things to remember when conducting Current Attenuation Surveys

1) Always direct connect
2) Always use an independent ground
    a) Anode Bed b) Ground Stake c) Across an insulator?
3) Always have a map of the facility
4) Never use another utility as the ground return.
5) Never assume anything.
6) Shorts
    a) First signal loss may not be the short.
    b) There may be more than one short.
    c) There may be an unknown source.
7) Coating defects
    a) Take readings at the same intervals.
    b) Make sure unit and boot are perpendicular to the pipe.
    c) Hold unit steady and upright when reading current.
8) You do not always have to connect closest to the suspected short or coating defect.
9) More is not always better.

FACTS TO REMEMBER

1) Lower frequencies couple less.
2) Locators with a digital depth readout, current measurement and current direction provide more information and lead to more answers.
3) Verify with peak and null locates.
4) Log readings manually or digitally.
5) Take readings at every split or at equal distance.

Current Measurement
and
Current Direction

1) Current measurement is depth compensated.
2) If depth readings are erroneous, so is current.
3) PCM uses 98Hz for depth & 4 Hz for current.
4) PCM Current Direction is displayed in relation to Cathodic Protection current (from the anode to the pipe and back to the rectifier).
5) CD gives us the final determination many times before we dig a short. CD normally does not help in determining coating defects alone.
6) Electromagnetic receivers can obtain readings over various soil conditions including asphalt, concrete and water and still will obtain accurate readings.
7) Unit does not have to touch the ground but must be steady.

Other Applications with Current Attenuation

1) Looking for hot spots.

2) Determining the best location for a permanent ground bed.

3) Determining the effectiveness and life of a ground bed.

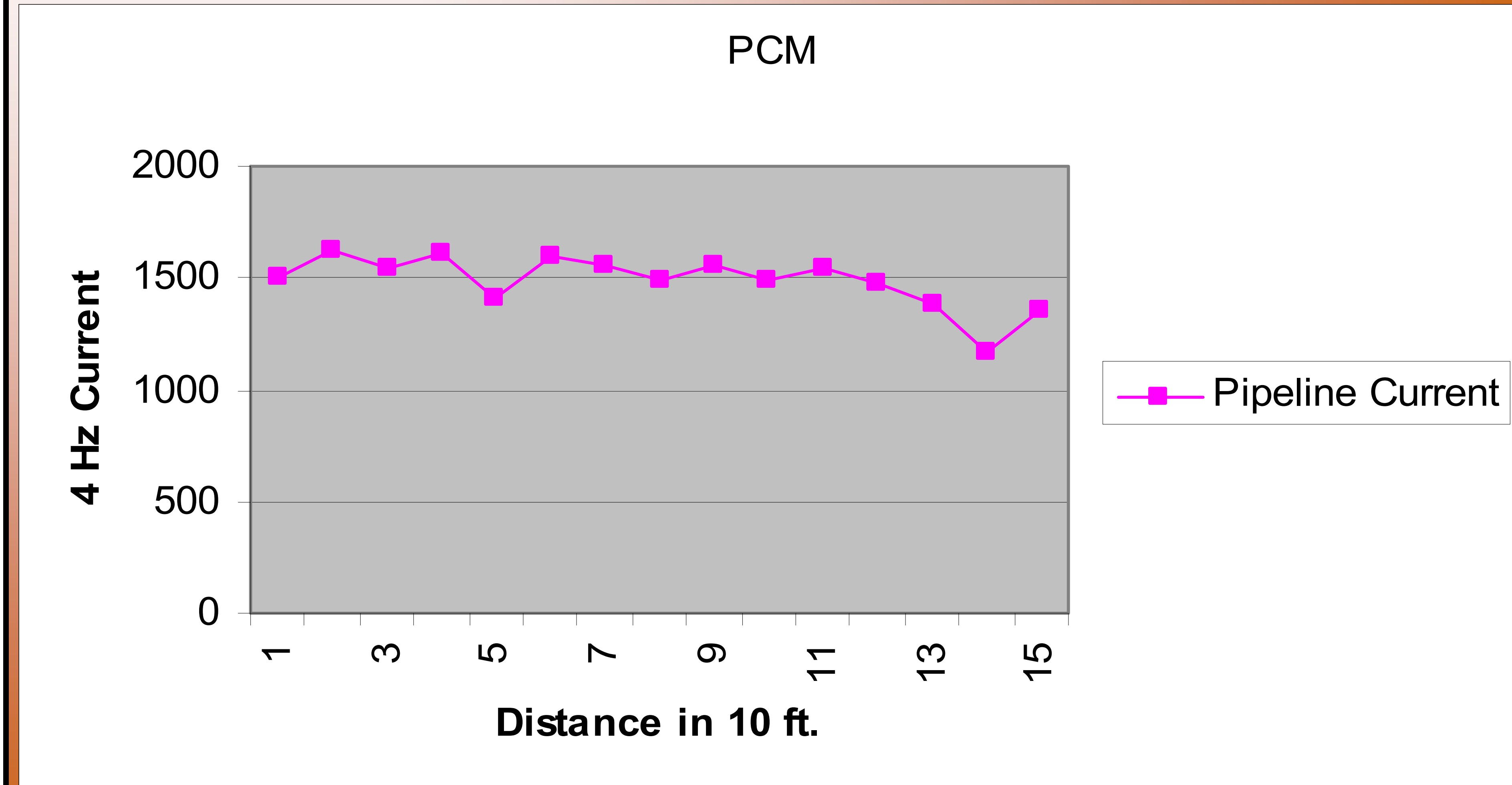
4) Pinpointing coating damage with an A-frame.

5) Yearly analysis of coating conditions.

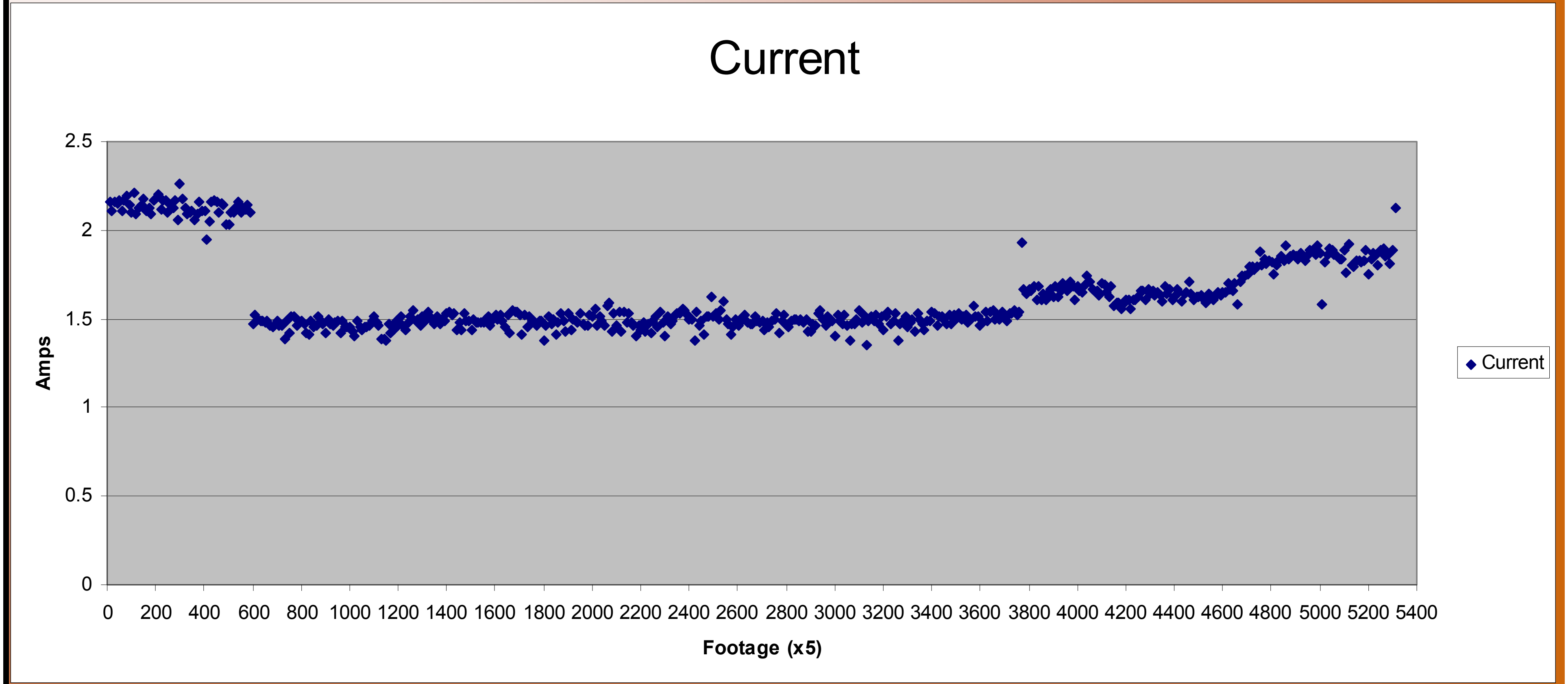
Methodology using PCM for Current Surveys

- Use an independent ground and try to mimic your CP circuit when possible
- Make sure rectifiers are not influencing the signal (turn off AND disconnect if necessary)
- Isolate your circuit whenever possible (disconnect bonds for better surveys)
- Take readings at equal distances and record your distances
- Every 50 feet is a good standard(others can be used dependant on location)
- Use it as a macro tool and depth of cover tool (use A-frame for micro)
- Look for anomalies with more than a 5% change normally
- Make sure unit is upright and perpendicular to the pipe
- Stay on peak and check peak and null readings and verify depth when readings are suspect.
- Take multiple readings in one location if you are suspect of the accuracy.
- Know what is in the area of your pipe and what it is connected to it

Graphed data



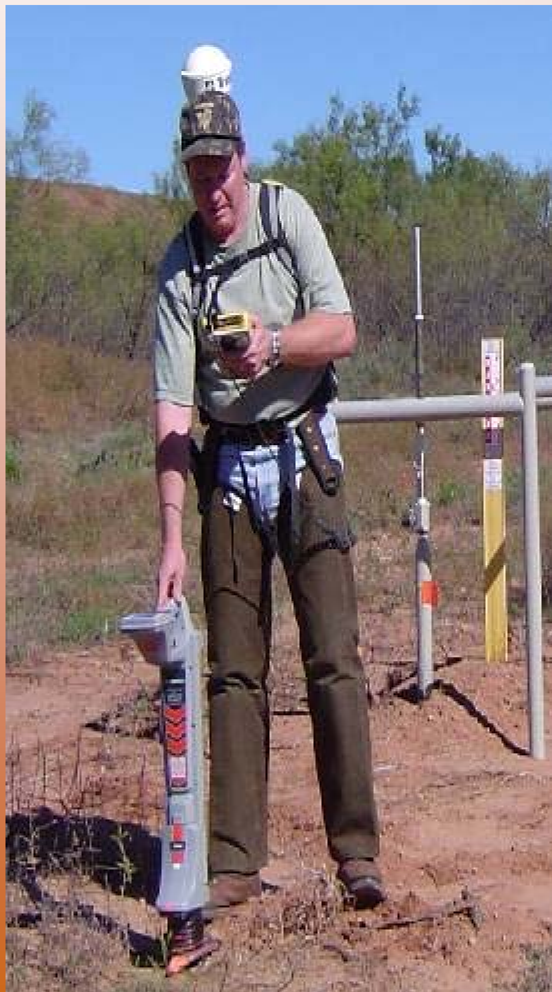
CA Data



Current
2.5
2
1.5
1
0.5
0
Amps
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 3600 3800 4000 4200 4400 4600 4800 5000 5200 5400
Footage (x5)
Current

Current Attenuation Tools

PCM



Vivax-PDM
The Pipeline Defect Mapper

C-SCAN
2000 SERIES

Principles of DCVG

DCVG uses the differences between two reference electrodes. These differences can assist in pinpointing holidays and corrosion cells on a pipeline. DCVG, because it uses DC current, can also determine if the holiday is cathodic (protected) or anodic (corroding).

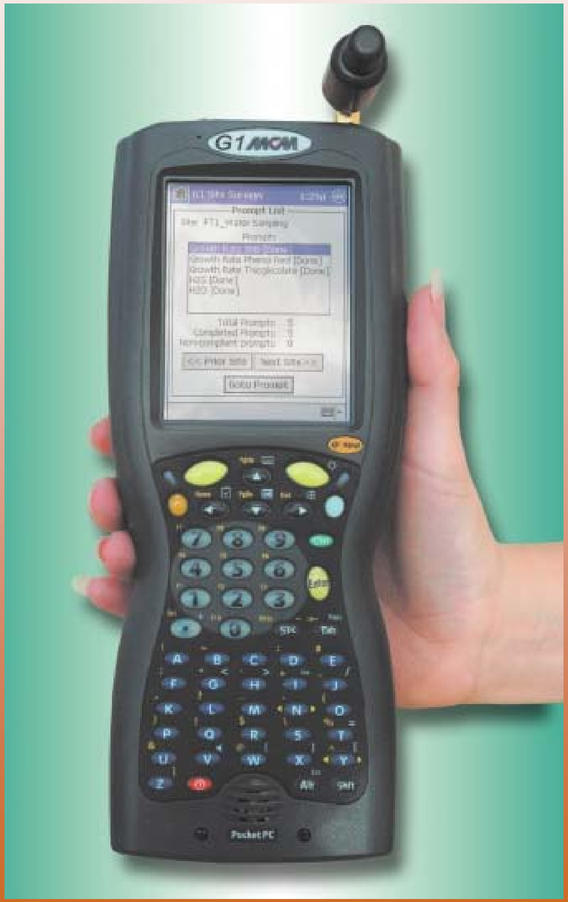
- Asynchronous interruption (0.3sec on, 0.7sec off) is required
- Accurately (± 4″) locates coating anomalies
- Differentiate between isolated (discrete) and continuous anomalies
- Predict relative importance/severity of anomaly
- Examine the direction of the current flow (anodic vs. cathodic)

What can DCVG data tell us?

- It is a micro tool that pinpoints coating defects and in some instances can give us a relative state of the cathodic protection at that indication and can find:
  - Large coating defects
  - Small Coating defects
  - Severity of the coating defect
  - Possible interference areas
  - Shorted casings
  - CP cable breaks
  - Position of Anodes
  - Cathodic/Anodic condition at the time

DCVG tools

G1



PCS-2000

DCVG meter

Similarities to ACVG

- Both require sufficient ground contact.
- Both require sufficient current flow on the pipeline to provide sufficient voltage gradient fields at holidays.
- Both can accurately detect and pinpoint positions of holidays, shorts, anodes, cable breaks and other areas of metal to dirt contact.
- Both can be used in water.
- Both do not require trailing wires.
- Both can detect the severity of the indication.
- Both can indicate if it is a single anomaly or a continuous anomaly.
- Both are affected by large indications overpowering nearby small indications.
- Both ACVG and DCVG can be less sensitive in high contact resistance areas (i.e. paved surfaces, very high resistant soils or rocky surfaces).

Differences from ACVG

- DCVG uses interrupted CP source or sources. ACVG uses either low frequency AC or interrupted DC (mimicking an AC signal).
- DCVG uses two poles with half cell type of contact probes. ACVG uses two metal probes.
- DCVG probe space varies. ACVG probe space is fixed.
- DCVG can be interfered with from existing or stray DC sources. ACVG normally is not.
- DCVG normally requires 400 – 500 mv shift which cannot be obtained in all pipeline conditions. ACVG requires a minimum amount of low frequency applied current.
- DCVG can be less sensitive under paved surfaces than ACVG.
- ACVG performs very well in high AC corridors.
- ACVG requires less operator interpretation because of the fixed spacing, unique applied signal and directional indication.
- Digital DCVG meters have a fixed directional indication like ACVG.
- DCVG can provide a relative cathodic/anodic condition of CP at an indication at that moment in time.

DCVG in-line technique

In carrying out a survey, the surveyor walks the pipeline route testing at regular intervals with the probes in a position of one in front of the other, separated by 3’ to 6’ above the pipeline. As a fault is approached, the surveyor will see the volt meter start to respond to the ON/OFF pulsed current, which is either a coating fault or interference from another structure. When the fault is passed, the needle deflection completely reverses and slowly decreases as the surveyor moves away from the fault. The surveyor then back up along the pipeline and where the needle or arrow indication reverses again, the fault is sited.

This procedure is repeated at right angles to the first set of observations and where the two midway positions cross is the epicenter of the voltage gradient. This is directly above the coating fault.

DCVG side by side technique

In carrying out a survey, the surveyor walks the pipeline route testing at regular intervals with the probes side by side to each other with one probe over the pipe and one off to the side 3’ to 6’. As a fault is approached, the surveyor will see the volt meter start to respond to the ON/OFF pulsed current and give a higher voltage measurement and or greater needle or arrow deflection. When the fault is passed, the voltage measurement decreases. The surveyor now moves the probes in-line with the pipe and continues in the same manner as an in-line survey. The surveyor then back up along the pipeline and where the needle or arrow indication reverses again, the fault is sited.

This procedure is repeated at right angles to the first set of observations and where the two midway positions cross is the epicenter of the voltage gradient. This is directly above the coating

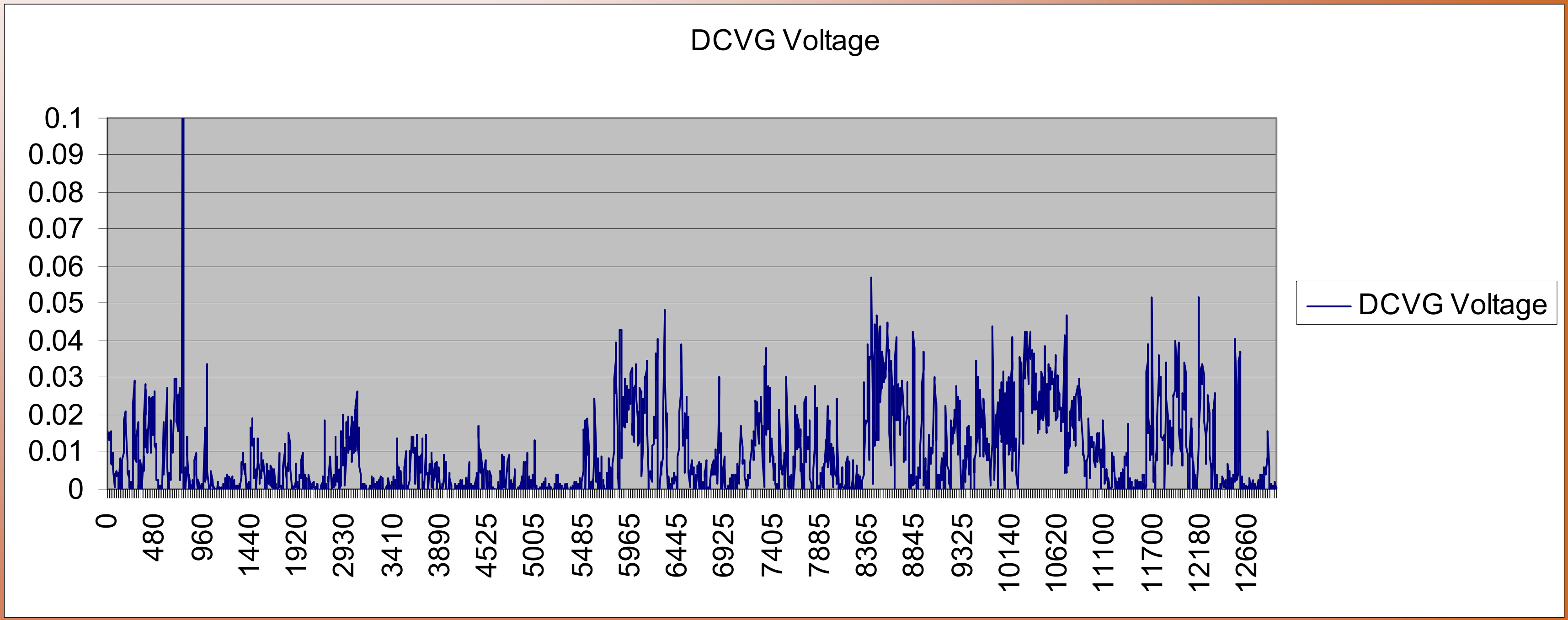
DCVG side drain and %IR

- Once an indication is found, the surveyor now must take a side drain measurement. This is completed by taking measurements over the pipe and at continuous distances to the side of the pipe until remote earth is reached. This total voltage value will be the total side drain voltage.
- This voltage is then used in conjunction with voltage measurements taken at pipe access points and the indication distance from those points to calculate a % IR. Digital meters can calculate this automatically while analogue meters will require manual calculation.
- DCVG indications are normally categorized as 1- 15% IR – very minor, 16% - 35% IR - minor, 36% - 60% IR – moderate, 61% - 100% IR - severe.

Problems/Solutions to DCVG surveys

- P - DC noise level too high for proper interpretation of field indications due to interfering DC sources. S - Add current with portable rectifiers to raise the amount of current change and voltage gradient near the indications.
- P - Fluctuating voltages due to interfering DC sources. S- Conduct survey at less interfering times (i.e. nighttime).
- P - Inability to find indications due to AC grounding for AC mitigation. S - Use filter(s) in CP system that discharges AC current but blocks DC current from earth where grounding is necessary for safety.
- P – Paved surfaces. S- wet down pavement or drill holes for lower contact resistance. May also have to raise the amount of current on the pipe.

DCVG graph results



DCVG Cathodic/Anodic results

36500	Custom 8	0	0	0	FLAG 730
36730	DCVG Anomaly: DCVG Max/Total	0.014264	0.014264	3.648994	
36730	DCVG Anomaly: DCVG Max On/Off	0.004001	-0.01026	0	Cathodic/Anodic
36755	DCVG Anomaly: DCVG Max/Total	0.024353	0.052707	13.48348	
36755	DCVG Anomaly: DCVG Max On/Off	0.018961	-0.00539	0	Cathodic/Anodic
37000	Custom 8	0	0	0	FLAG 740
37205	DCVG Anomaly: DCVG Max/Total	0.027136	0.085584	21.89396	
37205	DCVG Anomaly: DCVG Max On/Off	0.025049	-0.00209	0	Cathodic/Anodic
37500	Custom 8	0	0	0	FLAG 750
37540	DCVG Anomaly: DCVG Max/Total	0.011829	0.038965	9.967984	
37540	DCVG Anomaly: DCVG Max On/Off	0.039487	0.027658	0	Cathodic/Cathodic

What data is most important?

- IT DEPENDS!
  - What is the history of the line?
    - Leaks, Stray Current, TPI, dis-bondment, soils, CP, etc.
  - Are there shorts or bonds in the system?
  - Is there new coating followed by old coating?
  - Are there paved or very rocky areas?
  - How many rectifiers are in the system to be surveyed?
  - How many foreign crossings are there?
  - And the list goes on…

What data is most important? (cont.)

Multiple applicable tools are key to having a good ECDA indirect inspection survey.

While the rule only requires two inspection techniques it is almost always required at some locations to have a minimum of three.

Knowing where your holidays are AND the cathodic protection state are key in making informed decisions about External Corrosion.

Soils can also be of added value where the tools need supplemental data for support.

Of course any and all Pre-Assessment data is crucial to success.

Summary

- Combining data and tools are crucial to proper identification of possible external corrosion.
- Other items in the indirect inspections such as depth of cover and foreign crossings should be included in the analysis at indications to look for Third Party Damage.
- If one tool shows an indication and the others do not, it should be verified as to why this occurred and not ignored.
- Coating is not perfect. Therefore if you find nothing you need to find out why the tools didn't work, resolve the issues and resurvey where necessary.
- All local conditions must be considered before deciding what indications are monitored, scheduled and immediate.

QUESTIONS?

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