Evaluation of Underground Coatings Using Aboveground Techniques

By Jim Walton

Mears Group, Inc.

INTEGRITY SOLUTIONS

PREVENTION ▲ INSPECTION ▲ REMEDIATION

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A QUANTA SERVICES COMPANY

Outline

- Introduction
- Reference procedures
- Safety considerations
- Pipe locating
- Direct Current Voltage Gradient (DCVG)
- Alternating Current Voltage Gradient (ACVG)
- Close-Interval Survey (CIS)
- AC Current Attenuation (Electromagnetic)
- Pearson Survey
- Summary

Introduction

- Detecting Coating Flaws on buried Pipelines
  - Pipeline Locating is used to establish the location and centerline of the pipeline.
  - Direct Current Voltage Gradient (DCVG) Surveys are used to locate and size coating holidays
  - Alternating Current Voltage Gradient (ACVG) Surveys are used to locate and size coating holidays.
  - Close-Interval Surveys (CIS) are used to determine cathodic protection (CP) levels, electrical shorts to other structures, static stray current conditions, and large coating holidays.
  - Alternating Current (AC) Attenuation Surveys are used to assess coating quality.

Reference Procedures

- SP0502-2010, Pipeline External Corrosion Direct Assessment Methodology.
- SP0207-2012, Performing Close-Interval Potential Surveys and DC Surface Potential Gradient Surveys on Buried or Submerged Metallic Pipelines
- TM0109-2009, Aboveground Survey Techniques for the Evaluation of Underground Pipeline Coating Condition.
- NACE/CEA 54277, Specialized Surveys for Buried Pipelines 1988
- NACE Standard TM0497-2012, Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
- NACE Standard SP0169-2013, Control of External Corrosion on Underground or Submerged Metallic Piping Systems
- NACE Standard SP0177-2014, Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems

Safety

- Be knowledgeable in electrical safety precautions before installing, adjusting, repairing, removing, or testing impressed current CP equipment.
- Use properly insulated test lead clips and terminals to avoid contact with an unanticipated high voltage (HV).
- Use caution when long test leads are extended near overhead high-voltage alternating current (HVAC) power lines, which can induce hazardous voltages onto the test leads. Refer to NACE Standard RP0177.
- Use caution when performing tests at electrical isolation devices.
- Avoid testing when thunderstorms are in the area.
- Use caution when stringing test leads across streets, roads, and other locations subject to vehicular and pedestrian traffic.
- Observe appropriate Company safety procedures, electrical codes, and applicable safety regulations.

Table 2
ECDA Tool Selection Matrix [(A)]

CONDITIONS	Close-Interval Survey (CIS)	Voltage Gradient Surveys (ACVG and DCVG)	Pearson[8]	Current Attenuation Surveys
Coating holidays	2	1, 2	2	1, 2
Anodic zones on bare pipe	2	3	3	3
Near river or water crossing	2	2	2	2
Under frozen ground	3	3	3	1, 2
Stray currents	2	1, 2	2	1, 2
Shielded corrosion activity	3	3	3	3
Adjacent metallic structures	2	1, 2	3	1, 2
Near parallel pipelines	2	1, 2	3	1, 2
Under high-voltage alternating current (HVAC) overhead electric transmission lines	2	1, 2	2	2
Under paved roads	3	3	3	1, 2
Crossing other pipeline(s)	2	1, 2	2	1, 2
Cased piping	3	3	3	3
At very deep burial locations	3	3	3	3
Wetlands	2	1, 2	2	1, 2
Rocky terrain/rock ledges/rock backfill	3	3	3	2

(A) **Limitations and Detection Capabilities:** All survey methods are limited in sensitivity to the type and makeup of the soil, presence of rock and rock ledges, type of coating such as high dielectric tapes, construction practices, interference currents, and other structures. At least two or more survey methods may be needed to obtain desired results and confidence levels.

Shielding by Disbonded Coating: None of these survey tools is capable of detecting coating conditions that exhibit no electrically continuous pathway to the soil. If there is an electrically continuous pathway to the soil, such as through a small holiday or orifice, tools such as DCVG or current attenuation may detect these defect areas. This comment pertains to only one type of shielding from disbonded coatings. Current shielding, which may or may not be detectable with the indirect inspection methods listed, can also occur from other metallic structures and from geological conditions.

Pipe Depths: All of the survey tools are sensitive in the detection of coating holidays when pipe burials exceed normal depths. Field conditions and terrain may affect depth ranges and detection sensitivity.

KEY

1 = Applicable: Small coating holidays (isolated and typically < 600 mm^2 [1 in^2]) and conditions that do not cause fluctuations in CP potentials under normal operating conditions.
2 = Applicable: Large coating holidays (isolated or continuous) or conditions that cause fluctuations in CP potentials under normal operating conditions.
3 = Applicable where the operator can demonstrate, through sound engineering practice and thorough analysis of the inspection location, that the chosen methodology produces accurate comprehensive results and results in a valid integrity assessment of the pipe being evaluated.

Pipeline Locating

- Pipeline centerline must be known for most of these survey techniques.
- Some coating survey equipment locates pipe and evaluates coating condition
- Stationing (footage) along pipeline critical for finding indications later
  - *Number 100 foot station markers*
  - *Sub-meter GPS stationing*

100 Foot Station Numbers

GPS Stationing

What is DCVG?

- Direct Current Voltage Gradient
  - *Coating holiday detection survey*
  - *If a coating holiday exists, direct current from CP system will go to the holiday*
  - *Voltage gradient created by current traveling to holiday measured by voltmeter*
  - *Nearest CP system interrupted*
  - *Voltmeter "points" to holiday.*
  - *Isolated survey vs. Combined survey*

Equipment

- Current interrupter
  - *AC or DC interruption*
  - *Typically fast cycle w/ON less time than OFF*
    - 0.3 seconds ON/ 0.7 seconds OFF
- Sensitive voltmeter
  - *Analog with ability to illustrate "+" and "-" values*
  - *Digital meters now available*
- 2 reference electrodes
  - *Doesn't need to be copper sulfate*


mV
Pipe-CAMP™ INSTRUMENTS
PCS - 2000
RANGE SELECTOR
10
20
50
100
200
500
1000
2000
5000
B-TEST
OFF
ON
MODE
100
1000
M Ohm

Current Interruption

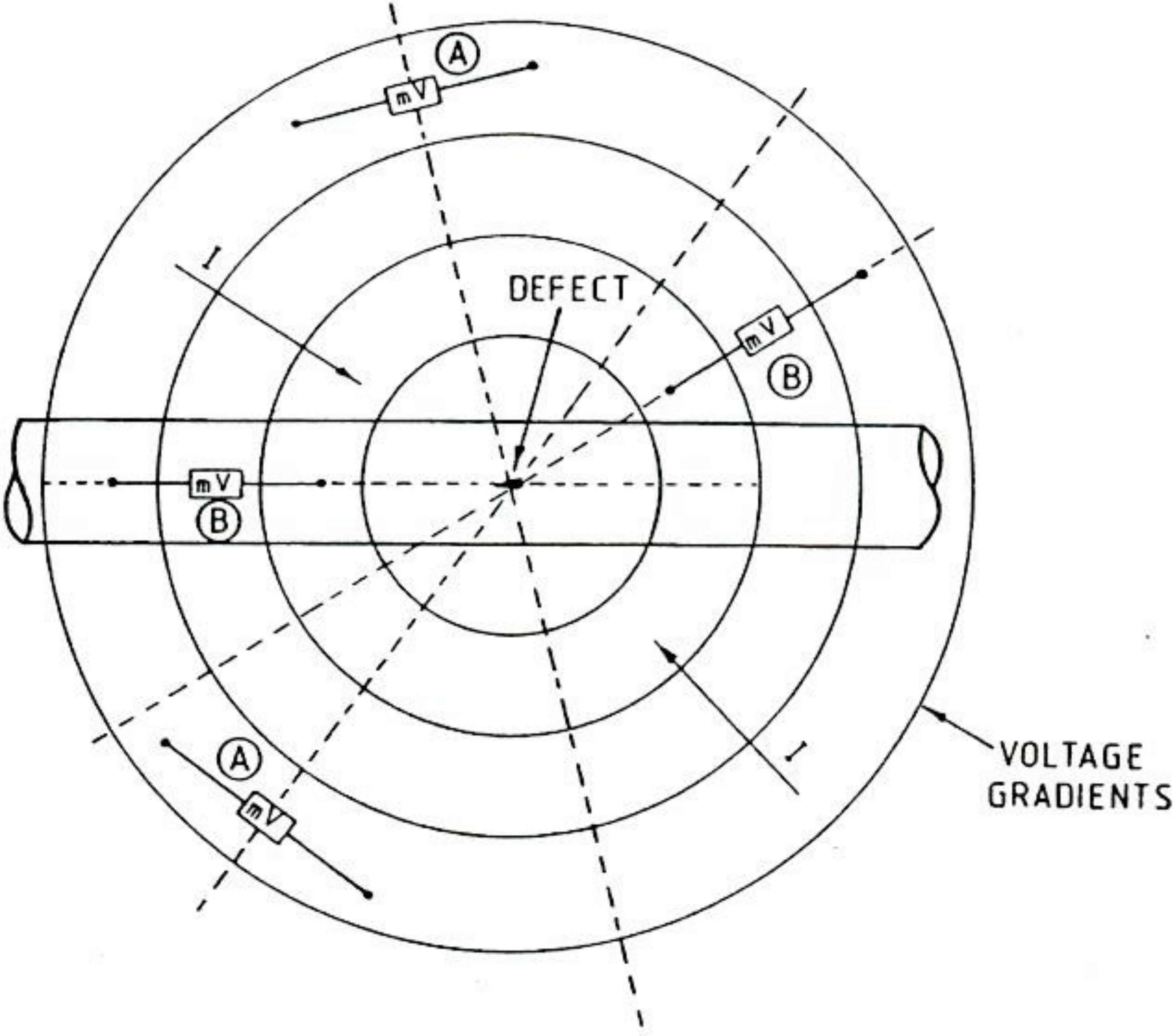
- Nearest CP source
  - *Only 1 interrupted at a time????*
  - *Fast cycle with ON less time than OFF*
    - 0.3 seconds ON/0.7 seconds OFF
  - *Desire significant IR drop at test stations in survey segment:*
    - 100 to 400 mV or more on soil
    - More signal when high resistance contact??
  - *Increase rectifier output if necessary*
  - *Use temporary CP system*

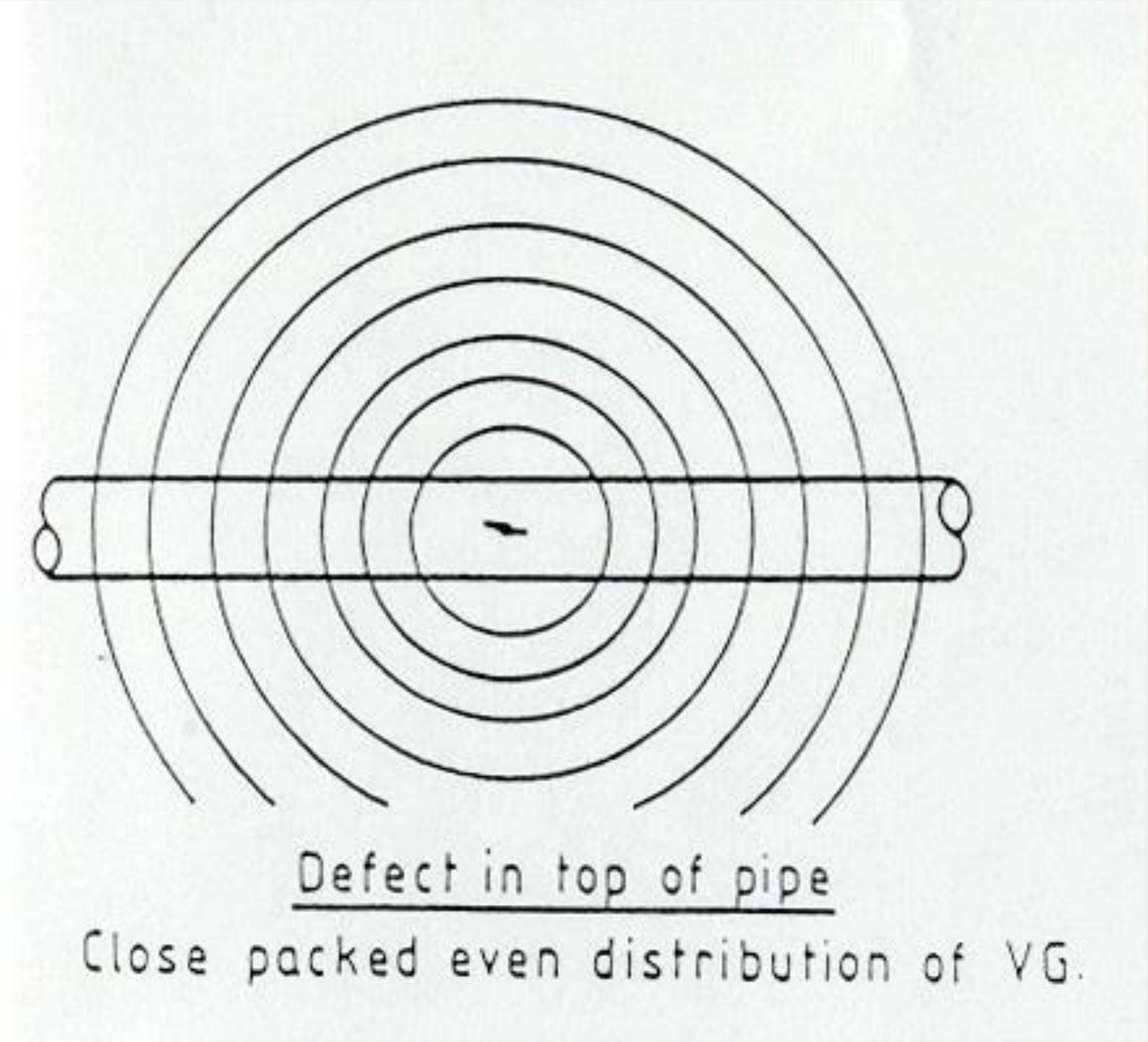

17 5:19PM

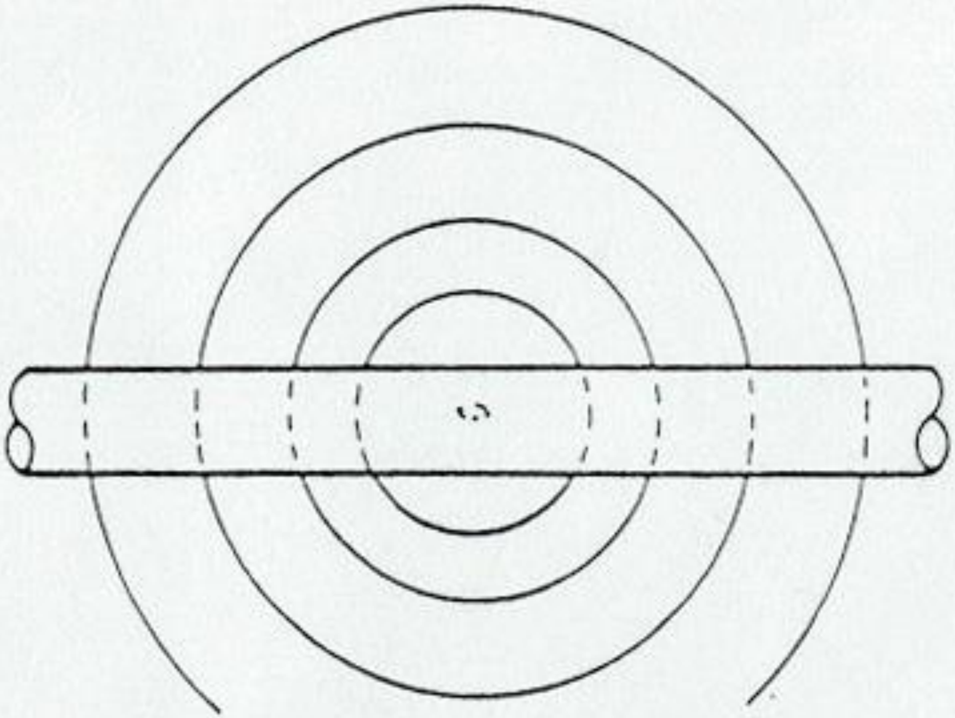

CHICKEN
9 2:36 PM

Procedure

- Locate pipeline
- Interrupt CP source (s)
- Measure and record IR drop at beginning test station
- Walk pipeline with one probe over pipe, one perpendicular as far as comfortable
  - *Alternative method both probes over pipe.*
- Find coating holidays (maximum voltage gradient-document)
- Pinpoint coating holiday epicenter
- Measure and record the sum of all lateral drains until 1 mV measured
- Continue along pipeline with survey
- Measure IR drop at next electrical connection point and document
- Calculations back at the office

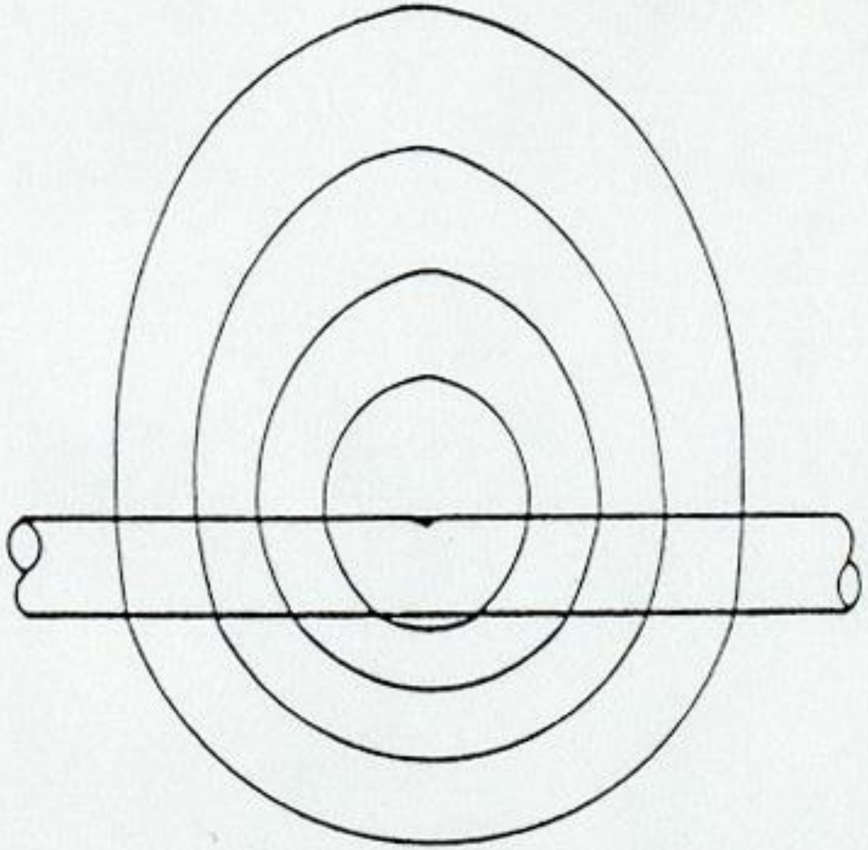

A
mV
DEFECT
I
mV
B
mV
B
A
mV
I
VOLTAGE
GRADIENTS


Defect in top of pipe
Close packed even distribution of VG.



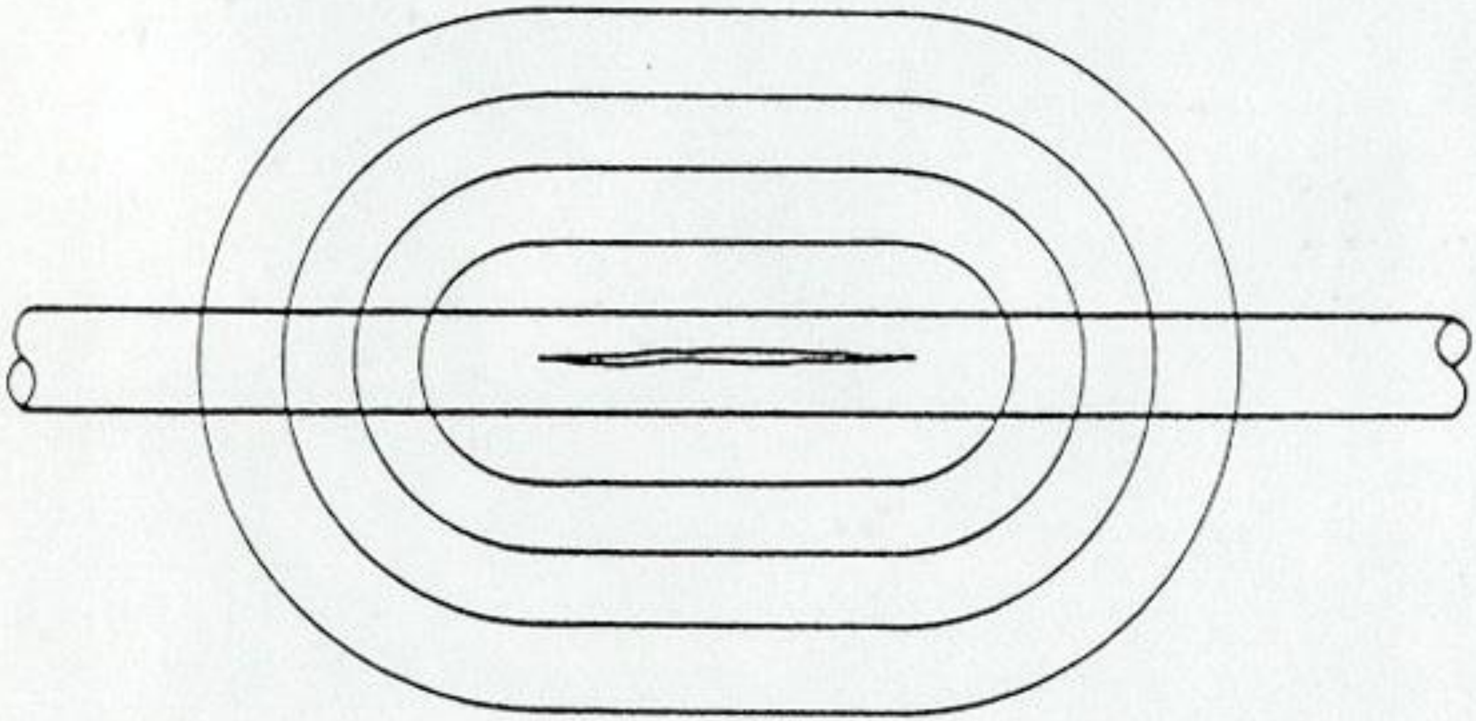
Defect in bottom of pipe

VG evenly distributed but spread out.



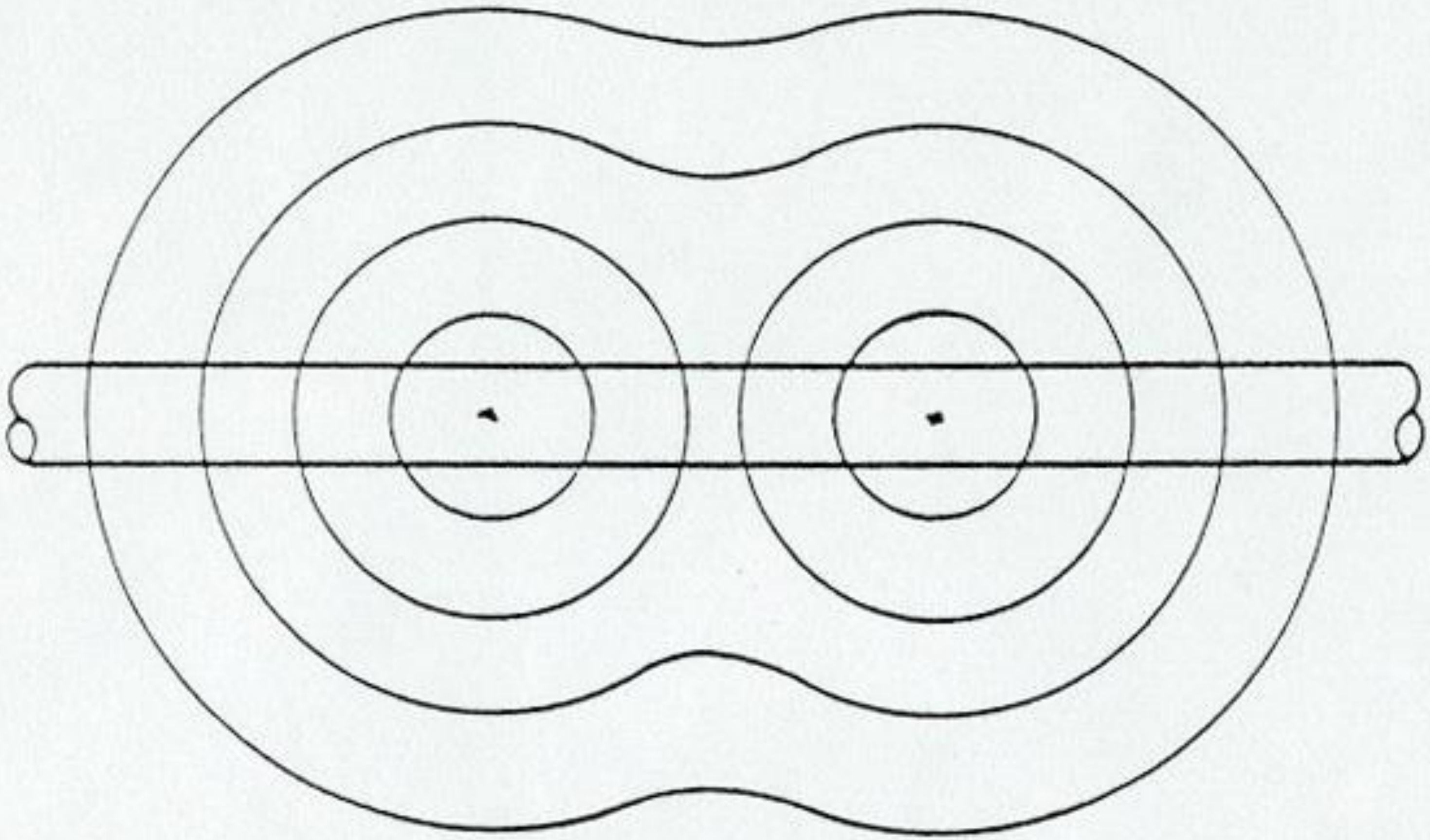
Defect in side of pipe

VG more spread out on defect side of pipe.



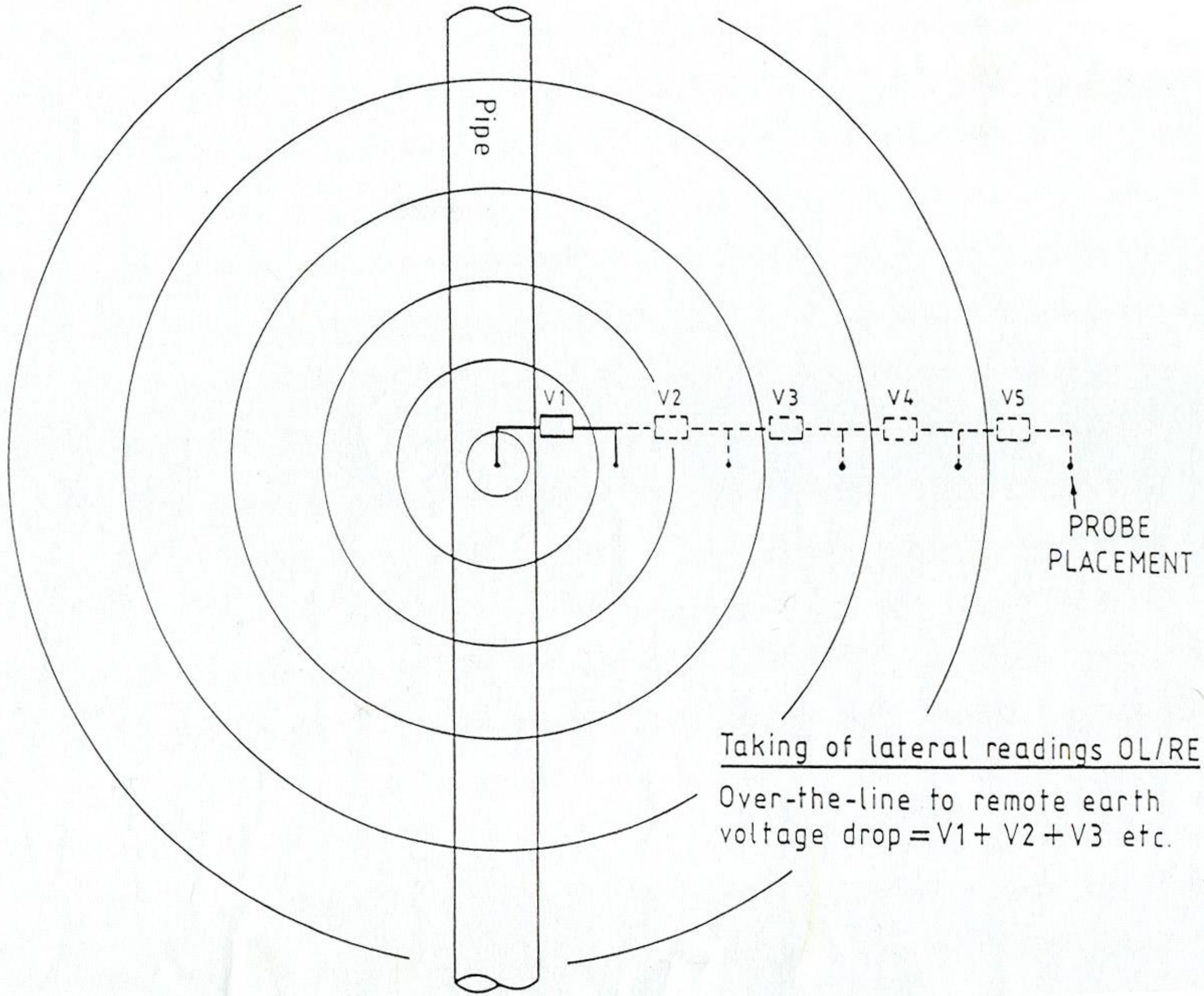
Coating with long scratch or split

VG are elongated.



Two or more defects in close proximity

VG have an overlapping effect.



Taking of lateral readings OL/RE

Over-the-line to remote earth voltage drop = V1 + V2 + V3 etc.

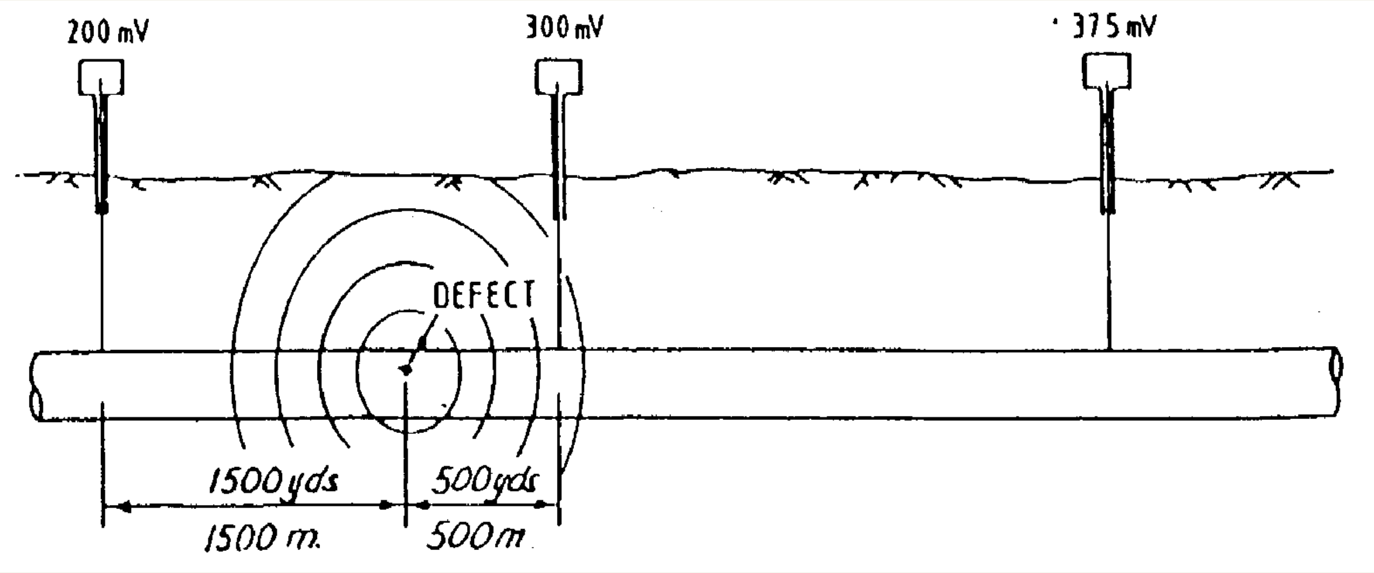
Calculations

- Straight line attenuation is assumed
- Signal strength:

=200mV +((1500/(500+1500))(300-200))mV

=200mV + 75mV

=275 mV



Calculations (Cont'd)

Remote earth voltage = 25+15+6+4+3+1+1 mV

= 55 mV

Percentage IR=(Remote earth voltage/Signal Strength) * 100%

= (55/275)*100

= 20%

Calculations (Cont'd)

- *Category 1*: 1 to 15% IR—Holidays in this category are often considered of low importance. A properly maintained CP system generally provides effective long-term protection to these areas of exposed steel.
- *Category 2*: 16 to 35% IR - These holidays are generally considered of no serious threat and are likely to be adequately protected by a properly maintained CP system. This type of holiday may be slated for additional monitoring. Fluctuations in the levels of protection could alter this status as the coating further degrades.

Calculations (Cont'd)

- *Category 3*: 36 to 60% IR - The amount of exposed steel in such a holiday indicates it may be a major consumer of protective CP current and that serious coating damage may be present. As in Category 2 indications, this type of possible coating holiday may be slated for monitoring as fluctuations in the levels of CP could alter the status as the coating further degrades.
- *Category 4*: 61 to 100% IR - The amount of exposed steel indicates that the holiday is a major consumer of protective CP current and that massive coating damage may be present. *Category 4* holidays typically indicate the potential for very serious problems with the coating.

What is ACVG?

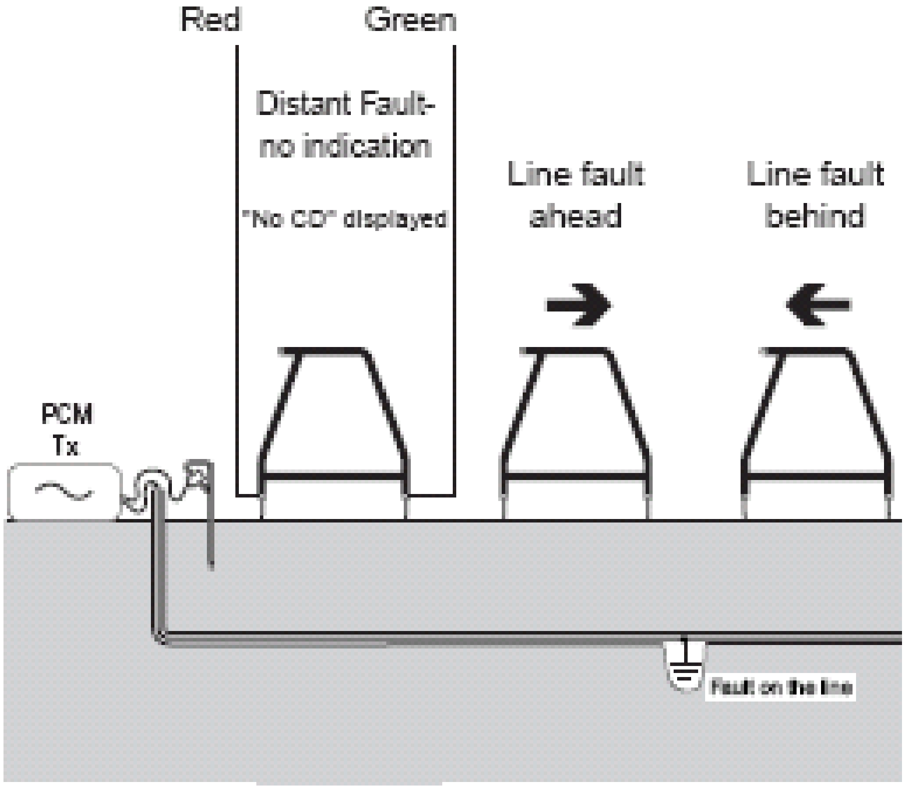
- Alternating Current Voltage Gradient (ACVG)
- Locate coating holidays
- Apply an AC signal using low frequency transmitter connected to pipeline
- Use existing or temporary anode beds as ground
- Operator walks above pipeline measuring signal direction at specified intervals.
- Once coating holiday passed, reverse direction and shorten intervals
- When holiday is centered, the magnitude will be zero

ACVG Transmitter

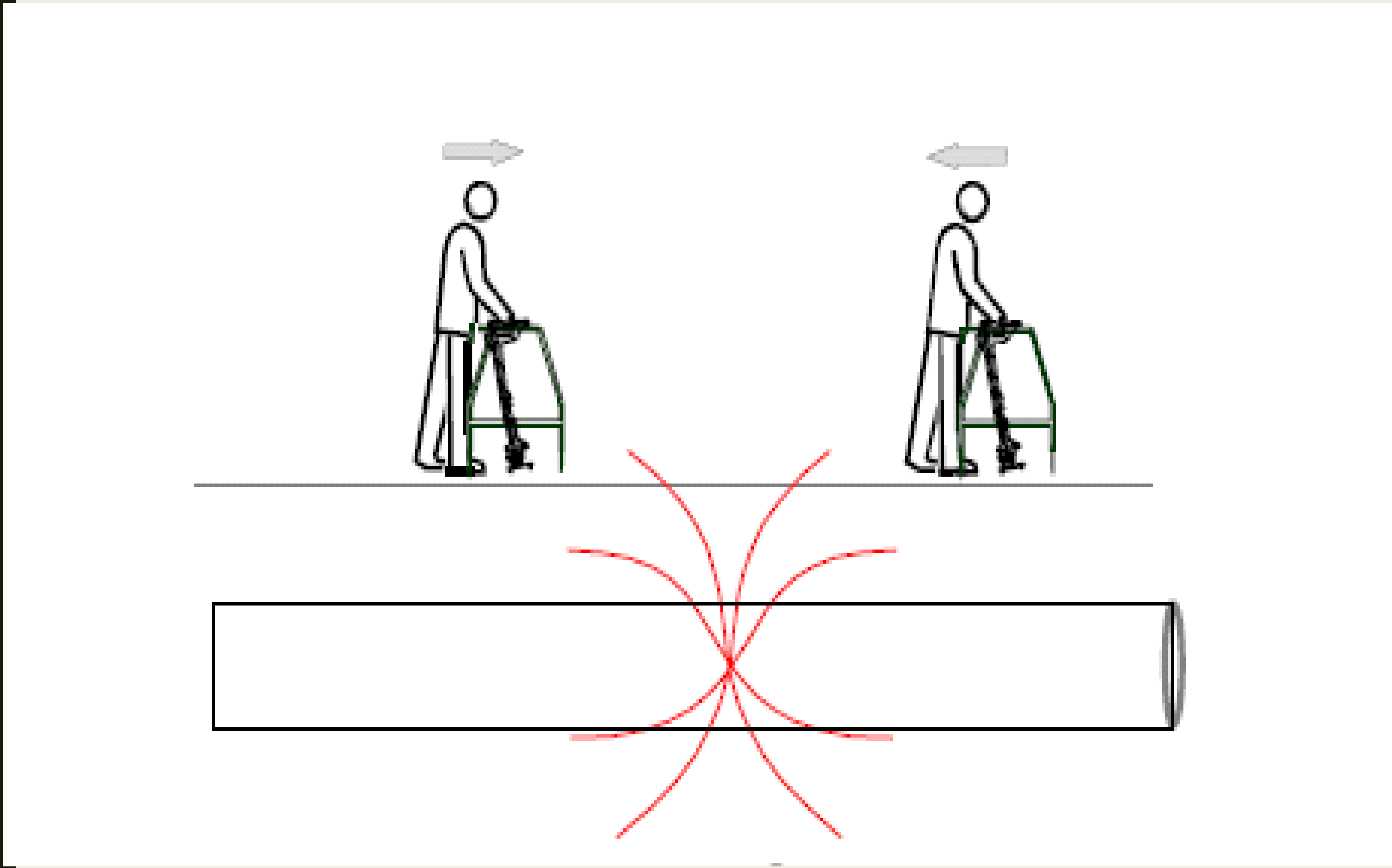
ACVG Probes

ACVG Receiver Face

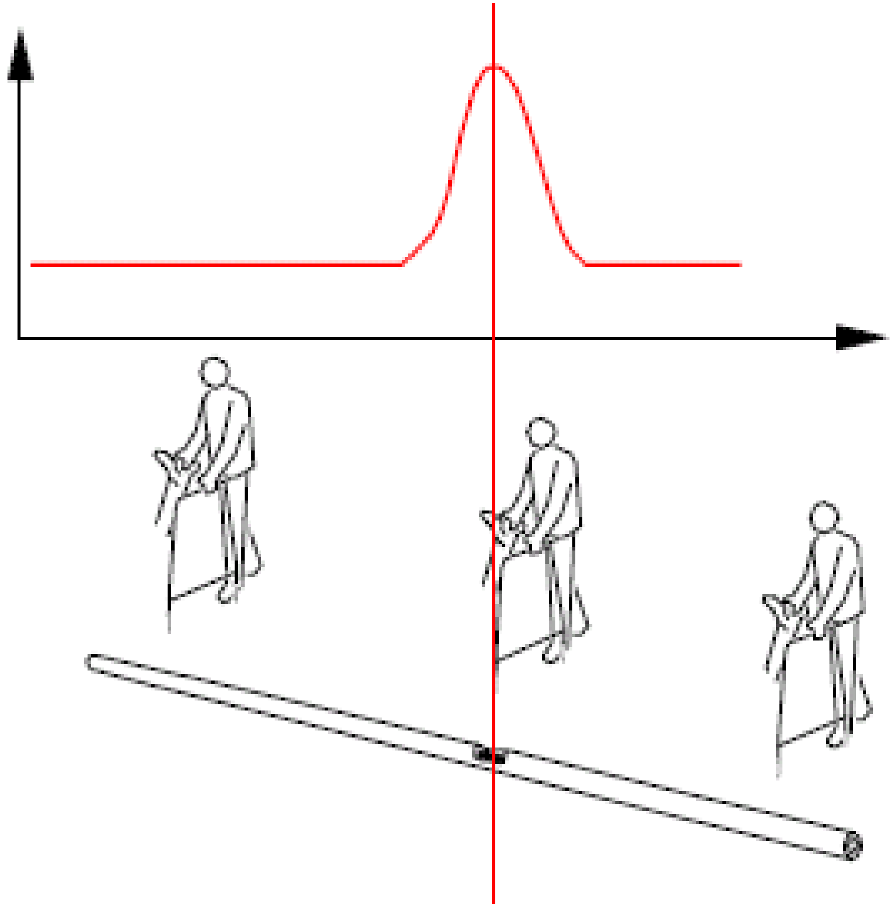
ACVG Setup


Red
Green
Distant Fault-
no indication
"No CD" displayed
Line fault
ahead
Line fault
behind
PCM
Tx
Fault on the line

ACVG Along Pipeline



Severity Ranking



Alternating Current Voltage Gradient (ACVG)

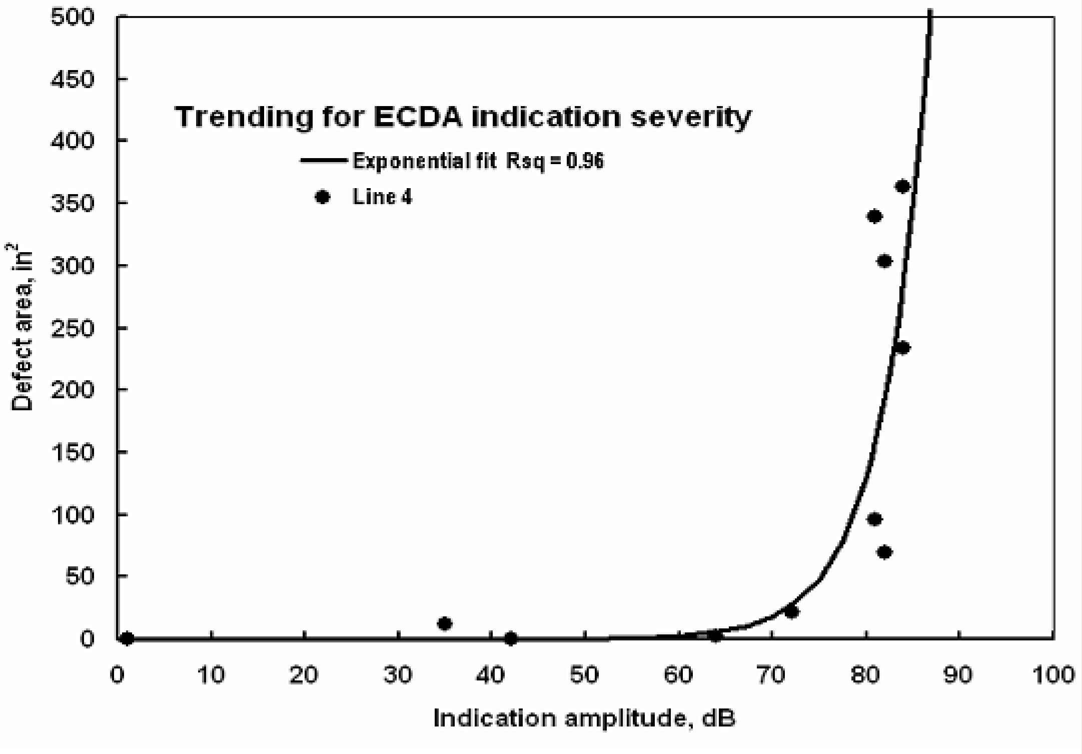
Usually the holiday location can be located to within a foot, however the accuracy of the location can be impacted by numerous variables.

Sizing of holidays is very problematic, and can be easily impacted by depth of cover, soil resistivities, other sources of AC and DC currents, etc.

Most operators have realized the above, and use the methodology to identify the “location” of a holiday, and NOT the “size” of the holiday.

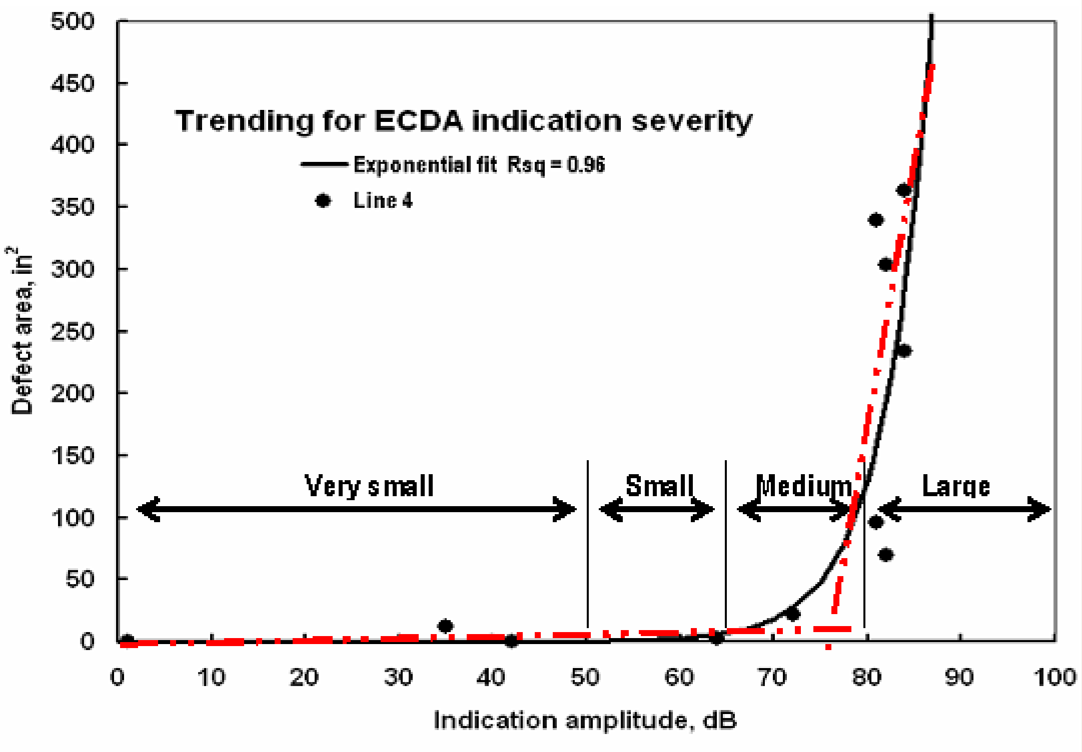
Operators then integrate data from other tools, primarily CIS, and investigate holidays that may be subject to reduced or potentially inadequate CP.

Correlations Between ACVG Indirect and Direct Examinations



A Report to PHMSA, "Applying External Corrosion Direct Assessment (ECDA) In Difficult-to-Inspect Areas," DTRS56-05-T-0003, March 2007

Operator B Validation of Anomaly Severity Categories



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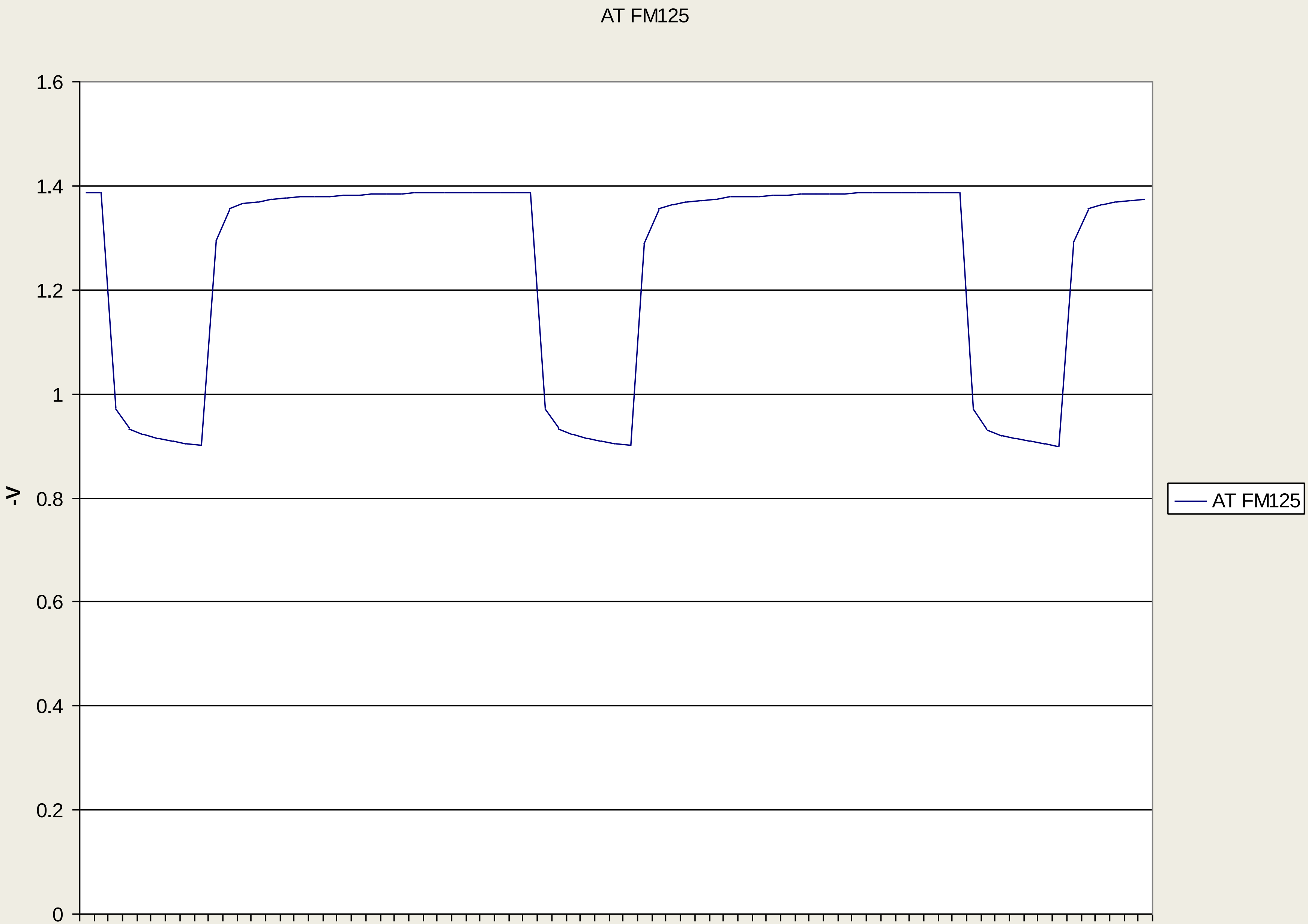
Close-Interval Survey (CIS)

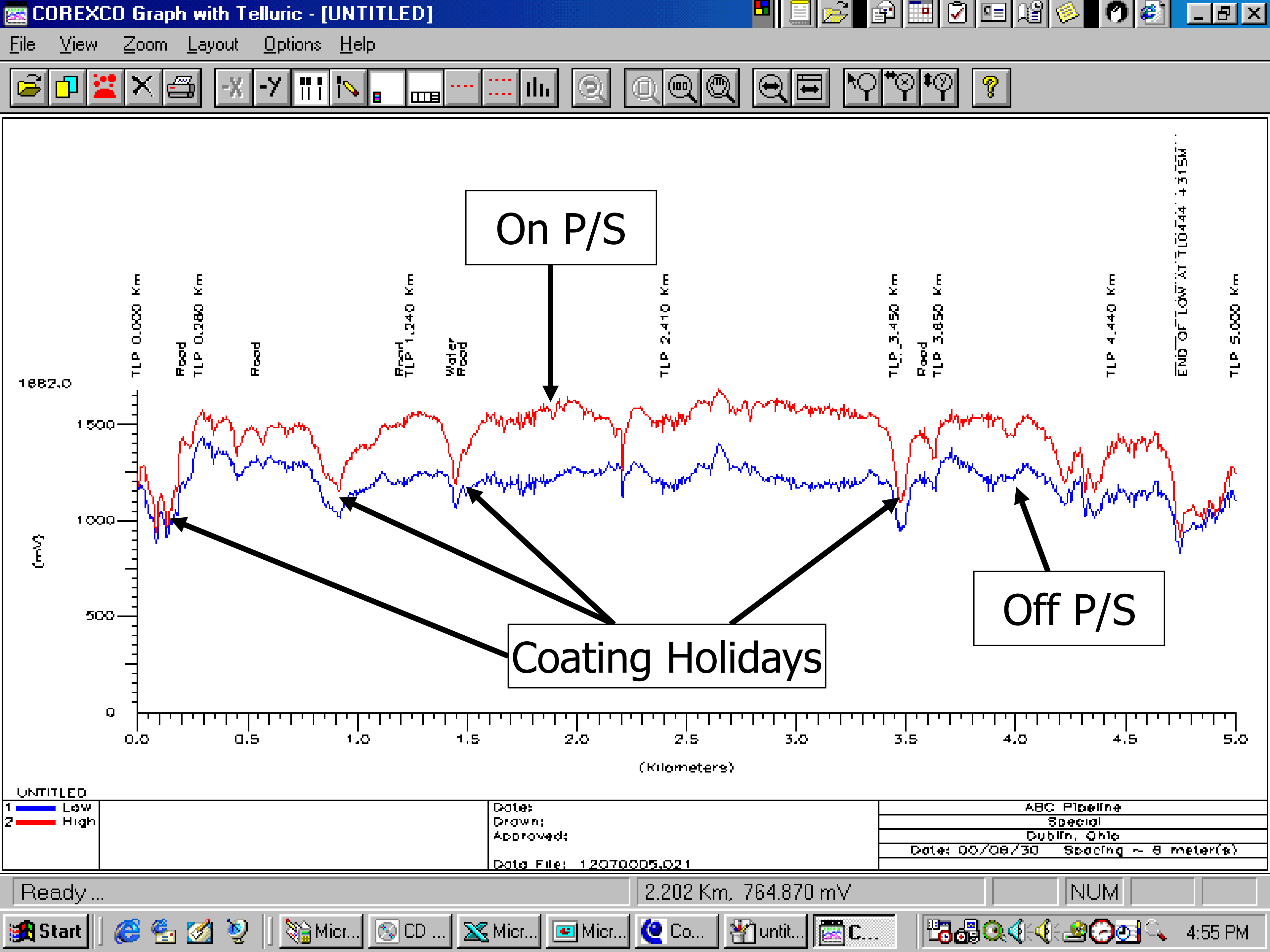
- Used to measure CP levels and identify:
  - *Interference*
  - *Shorted casings*
  - *Areas of electrical/geologic current shielding*
  - *Contact with other metallic structures, and*
  - *Defective electrical isolation.*

CIS (cont'd)

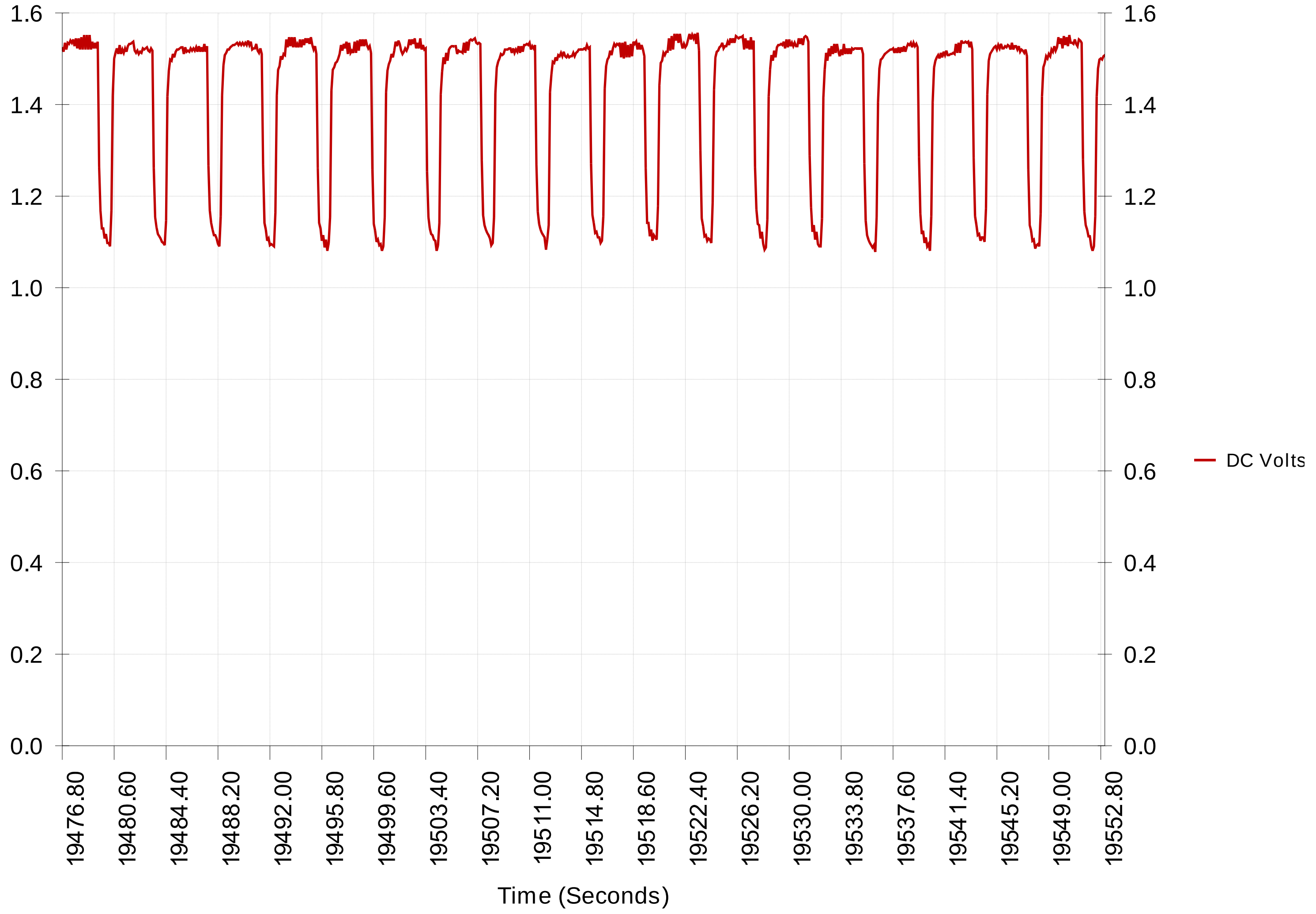
- To satisify a CP criteria, often On/Off potential surveys are completed
  - *Interrupted surveys require knowledge of what to interrupt*
  - *Testing to determine which sources and when to interrupt.*
  - *Proper interruption cycle*
    - Minimize depolarization during survey
    - Minimize depolarization during Off cycle
    - Prevent recording of Off potentials during spike



AT FM125
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-V
AT FM125



COREXCO Graph with Telluric - [UNTITLED]
File View Zoom Layout Options Help
On P/S
Coating Holidays
Off P/S
TLP 0.000 Km
Road
TLP 0.280 Km
Road
Road
TLP 1.240 Km
Water
Road
TLP 2.410 Km
TLP 3.450 Km
Road
TLP 3.850 Km
TLP 4.440 Km
END OF LOW AT TL0444 +315M
TLP 5.000 Km
1682.0
1500
1000
500
0
(mV)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
(Kilometers)
UNTITLED
1 Low
2 High
Date:
Drawn:
Approved:
Data File: 12070005.021
ABC Pipeline
Special
Dublin, Ohio
Date: 00/08/30 Spacing ~ 8 meter(s)
Ready ...
2.202 Km, 764.870 mV
NUM
Start
4:55 PM



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CIS Equipment

- High input impedance voltmeters/ dataloggers
- CIS wire - 30 to 34 gage
- Copper sulfate electrodes
- Pipe locaters
- Measuring device
  - *chainer*
  - *100 ft tape*

CIS Equipment


L E D

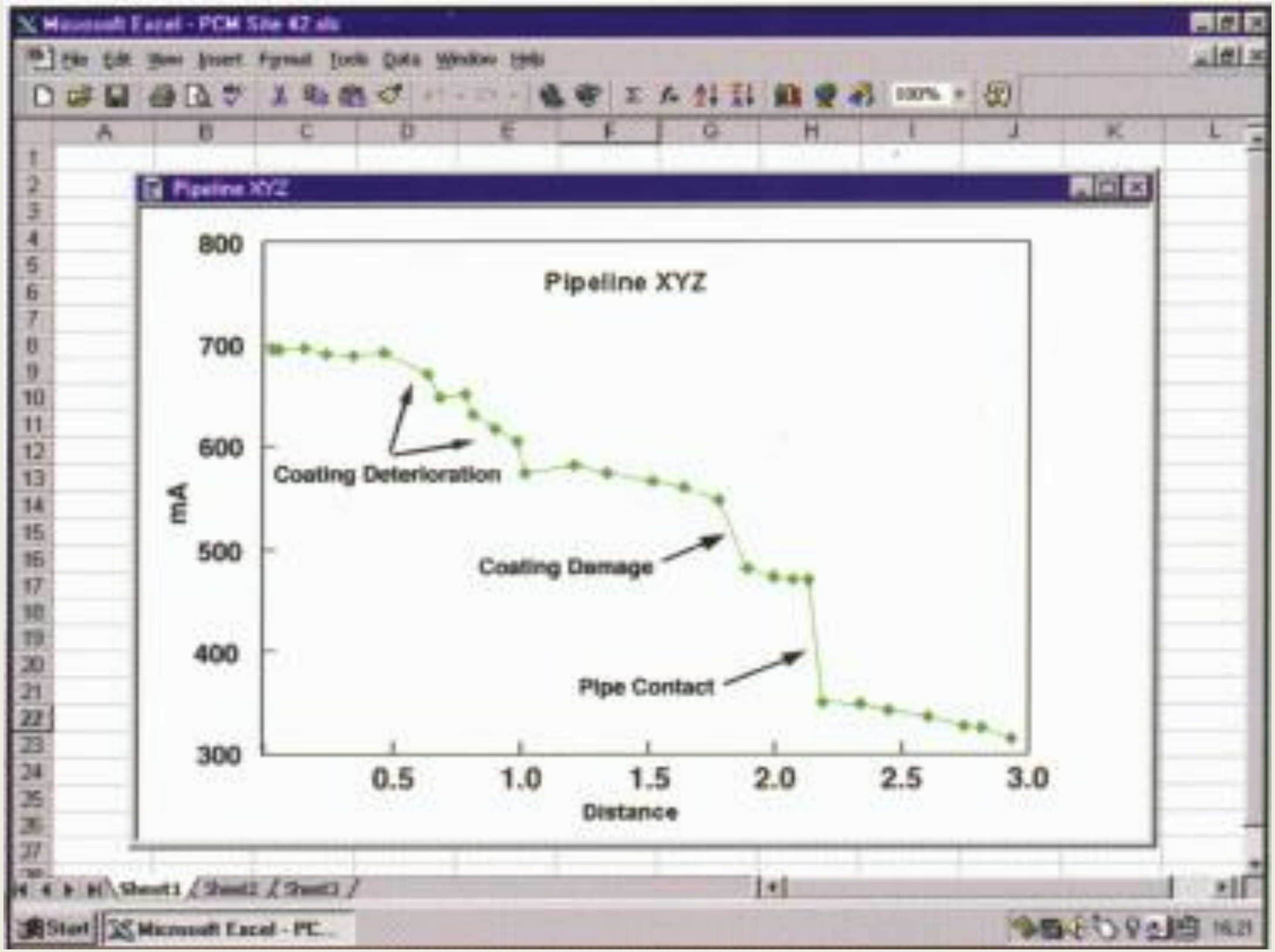
AC Attenuation

- Locate large coating holidays
- Apply an AC signal using low frequency transmitter connected to pipeline
- Use existing or temporary anode beds as ground
- Operator walks above pipeline measuring signal at specified intervals.
- Intervals can be 20 to 1000 foot depending upon company procedure/specifications

AC Attenuation Transmitter

AC Attenuation Receiver

Graphical Presentation



What is a Pearson Survey?

- Pearson Survey:
  - *Locates coating holidays*
  - *Apply AC audio frequency to pipeline*
  - *Reciever picks up frequency at coating holidays*

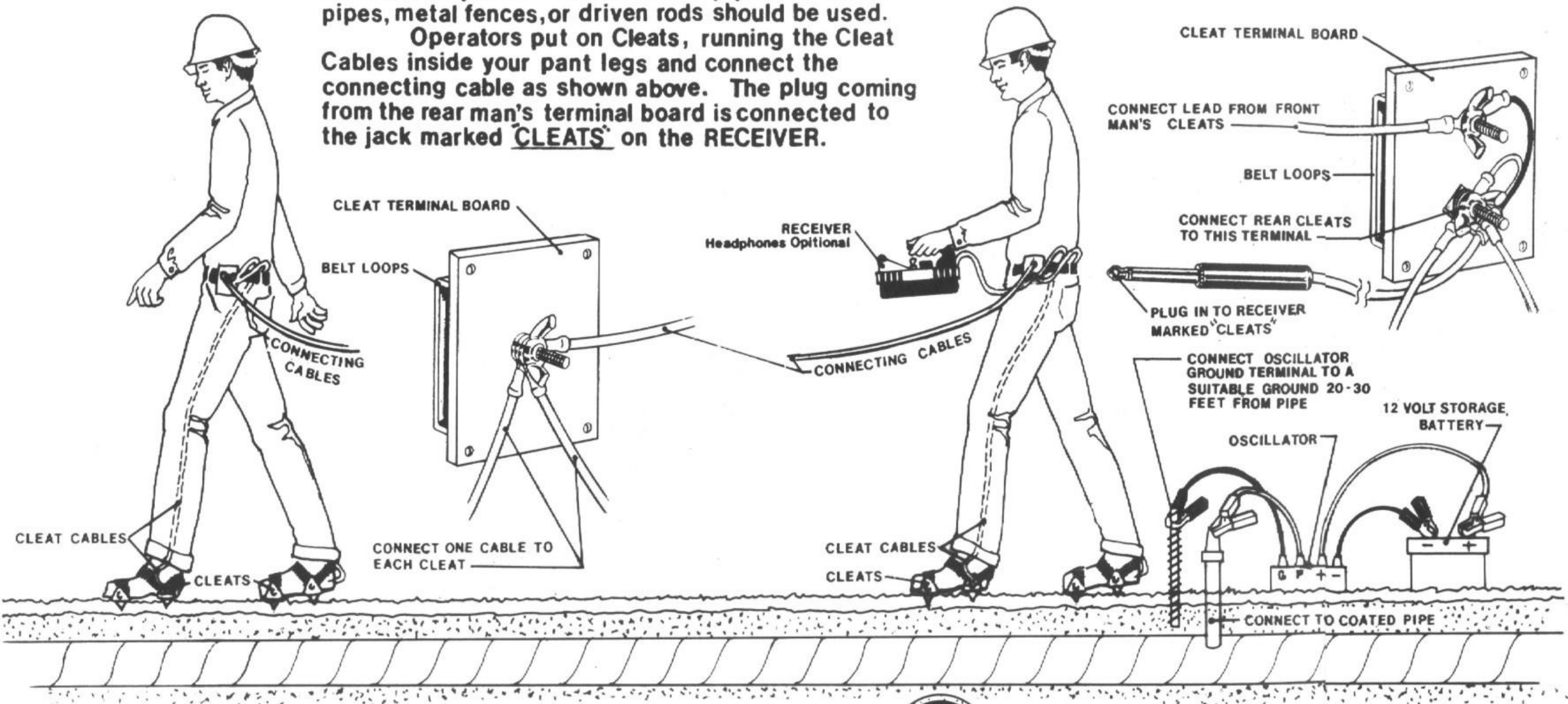
Remove the AUDIO OSCILLATOR from the carrying case and connect a 12 volt storage battery to the terminals marked "12 VOLT BATTERY" observe polarity.

Connect the pipe to the oscillator terminal marked "PIPE" and connect the ground cable from the terminal marked "GROUND" to a GOOD EARTH contact at a position remote to the pipeline. Water pipes, metal fences, or driven rods should be used.

Operators put on Cleats, running the Cleat Cables inside your pant legs and connect the connecting cable as shown above. The plug coming from the rear man's terminal board is connected to the jack marked "CLEATS" on the RECEIVER.

Turn on the OSCILLATOR following the instructions printed on the front panel.

Turn on RECEIVER and begin traverse along the pipeline. For details about Shorts, locating Holidays, see Instruction Manual.



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Summary

- These above grade survey techniques can locate coating holidays
- Some techniques can relatively size coating holiday
- CIS technique determines CP levels
- Proper alignment of data critical if utilizing the ECDA process
- Survey techniques require practice and knowledge of how equipment and principles work.
- Surveys do not work in all situations.

QUESTIONS?

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