APPALACHIAN UNDERGROUND CORROSION SHORT COURSE

AUCSC

Education and Training for Corrosion Control

Intermediate Course

CHAPTER 5

STATIC STRAY CURRENT INTERFERENCE TESTING

Appalachian Underground Corrosion Short Course
West Virginia University
Morgantown, West Virginia

Introduction

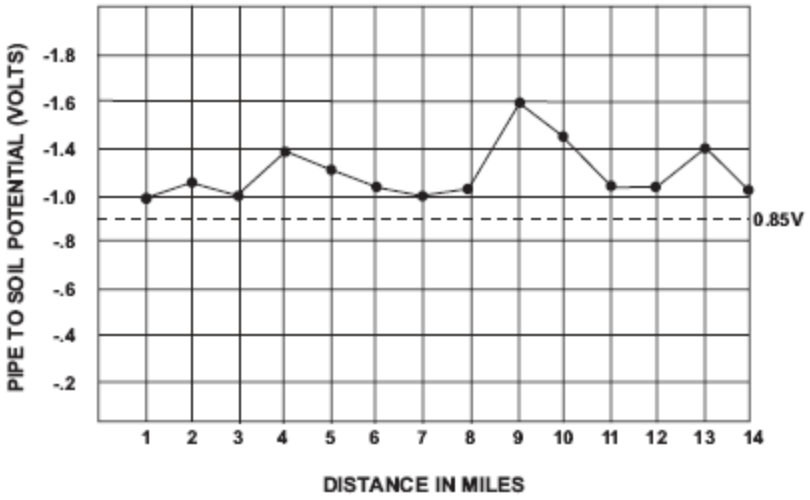
- Objective – to recognize interference conditions when they exist and take appropriate step to solve them
- Preliminary causes of interference conditions were related to DC traction systems & Mining operations
- Now CP systems are the major contributors as ROWs become more congested

Static vs. Dynamic

- There are 2 types of interference:
  - Static – steady state interference (railroad signal batteries and CP systems)
  - Dynamic – continually varying in magnitude and direction (DC welding operations, traction systems or mining operations)

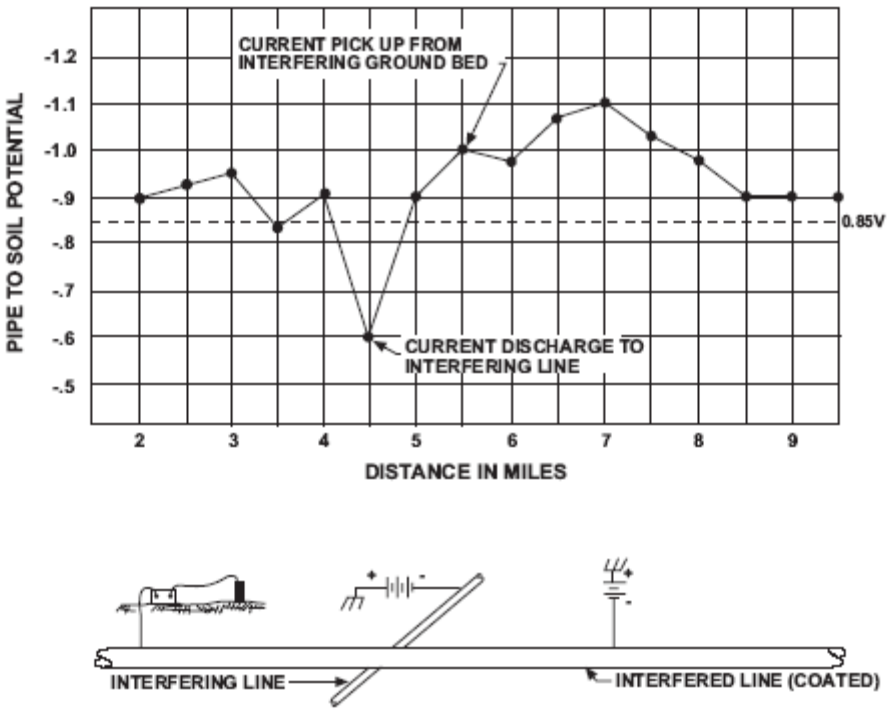
Static Interference

- Proper planning for pipeline layout is important
- Consulting with local corrosion committee can save weeks of field investigative work
- Use Pipe to Soil data when conducting periodic surveys to analyze areas of possible interference.



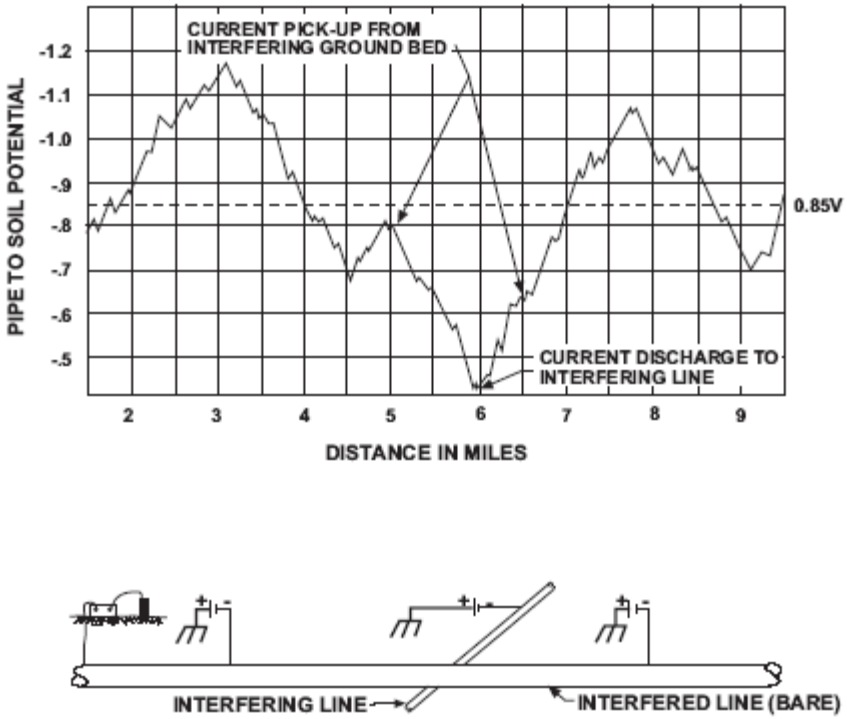
POTENTIAL VS DISTANCE PLOT

FIGURE 5-1



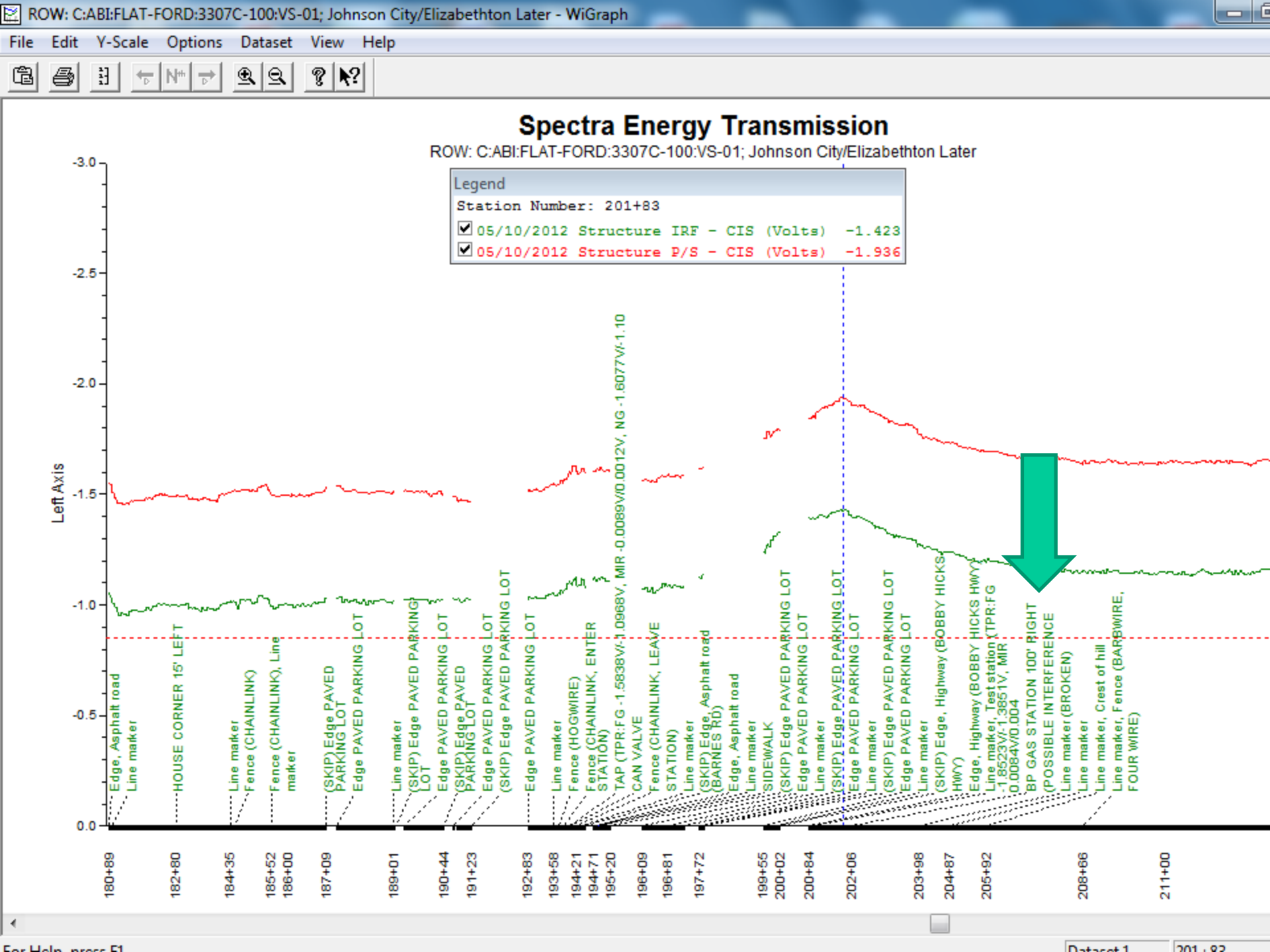
POTENTIAL PLOT WITH INTERFERENCE COATED PIPELINE

FIGURE 5-2



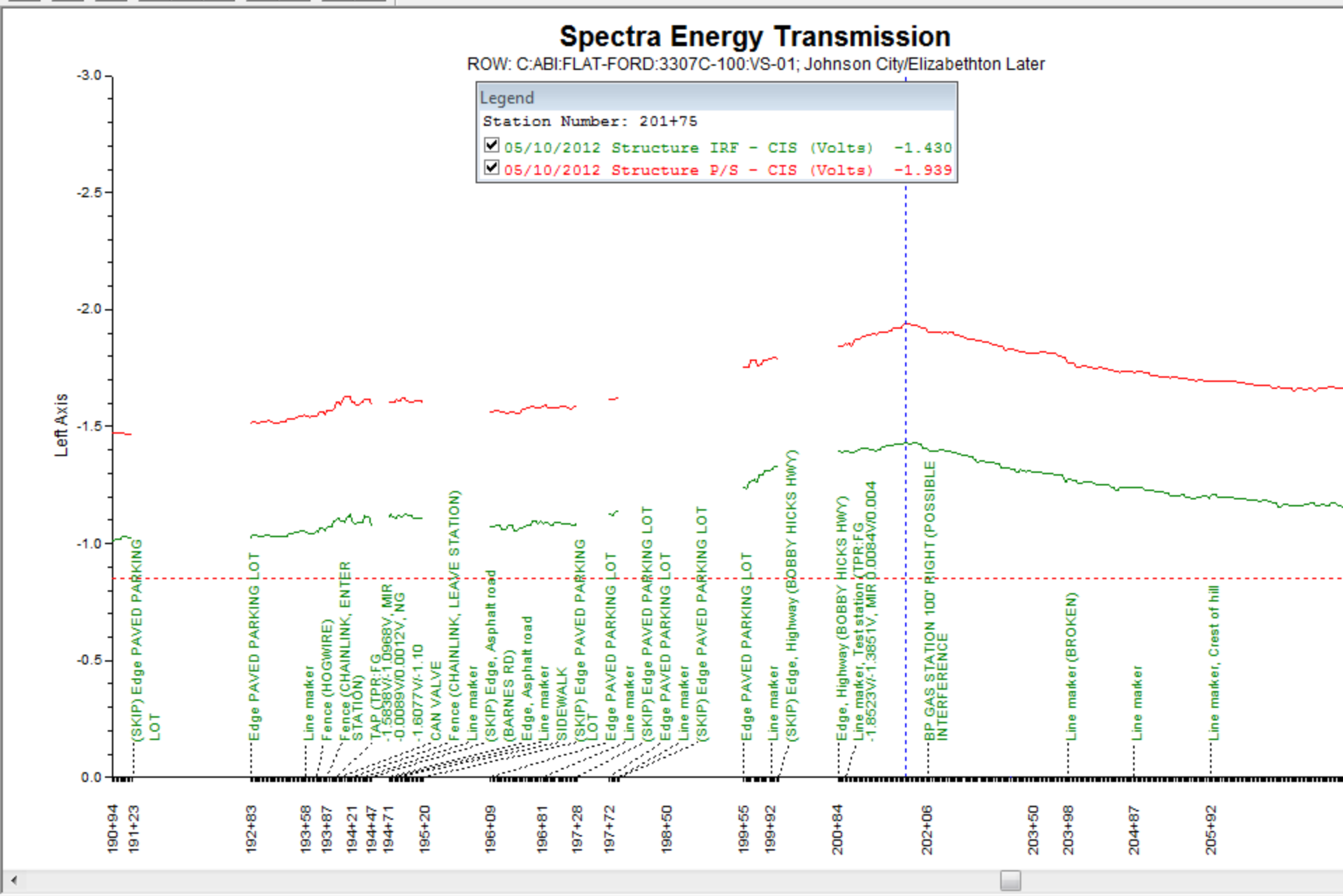
POTENTIAL PLOT WITH INTERFERENCE
BARE PIPELINE

FIGURE 5-3


ROW: C:ABI:FLAT-FORD:3307C-100:VS-01; Johnson City/Elizabethton Later - WiGraph
File
Edit
Y-Scale
Options
Dataset
View
Help
Spectra Energy Transmission
ROW: C:ABI:FLAT-FORD:3307C-100:VS-01; Johnson City/Elizabethton Later
Legend
Station Number: 201+83
05/10/2012 Structure IRF - CIS (Volts) -1.423
05/10/2012 Structure P/S - CIS (Volts) -1.936
Left Axis
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
Edge, Asphalt road
Line marker
HOUSE CORNER 15' LEFT
Line marker
Fence (CHAINLINK)
Fence (CHAINLINK), Line marker
(SKIP) Edge PAVED PARKING LOT
Edge PAVED PARKING LOT
Line marker
(SKIP) Edge PAVED PARKING LOT
(SKIP) Edge PAVED PARKING LOT
Edge PAVED PARKING LOT
(SKIP) Edge PAVED PARKING LOT
Edge PAVED PARKING LOT
Line marker
Fence (HOGWIRE)
Fence (CHAINLINK, ENTER STATION)
TAP (TPR:FG -1.5838V/-1.0968V, MIR -0.0089V/0.0012V, NG -1.6077V/-1.10
CAN VALVE
Fence (CHAINLINK, LEAVE STATION)
Line marker
(SKIP) Edge, Asphalt road (BARNES RD)
Edge, Asphalt road
Line marker
SIDEWALK
(SKIP) Edge PAVED PARKING LOT
Edge PAVED PARKING LOT
Line marker
(SKIP) Edge PAVED PARKING LOT
Edge PAVED PARKING LOT
Line marker
(SKIP) Edge, Highway (BOBBY HICKS HWY)
Edge, Highway (BOBBY HICKS HWY)
Line marker, Test station (TPR:FG -1.8523V/-1.3851V, MIR 0.0084V/0.004
BP GAS STATION 100' RIGHT
(POSSIBLE INTERFERENCE
Line marker (BROKEN)
Line marker
Line marker, Crest of hill
Line marker, Fence (BARBWIRE, FOUR WIRE)
180+89
182+80
184+35
185+52
186+00
187+09
189+01
190+44
191+23
192+83
193+58
194+21
194+71
195+20
196+09
196+81
197+72
199+55
200+02
200+84
202+06
203+98
204+87
205+92
208+66
211+00
For Help, press F1
Dataset 1
201 : 83

ROW: C:ABI:FLAT-FORD:3307C-100:VS-01; Johnson City/Elizabethton Later - WiGraph

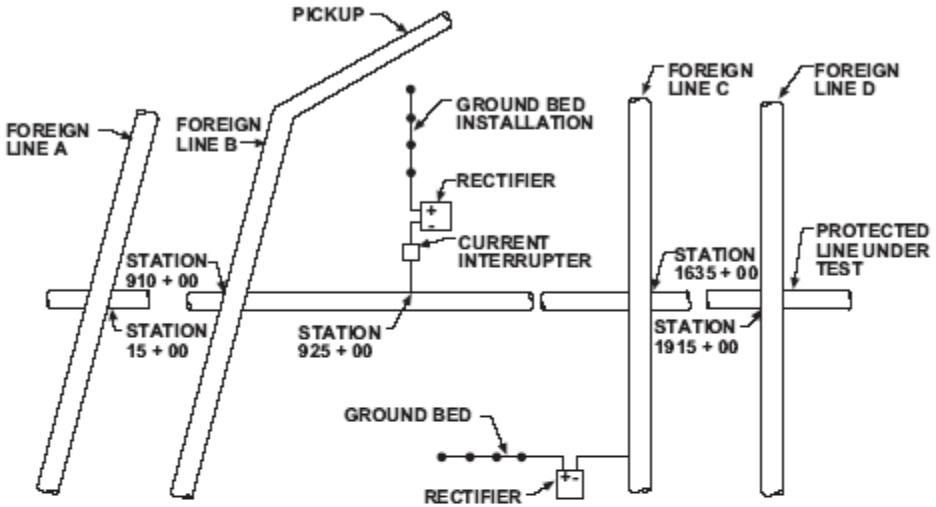
File Edit Y-Scale Options Dataset View Help



For Help, press F1 Dataset 1 201 : 75

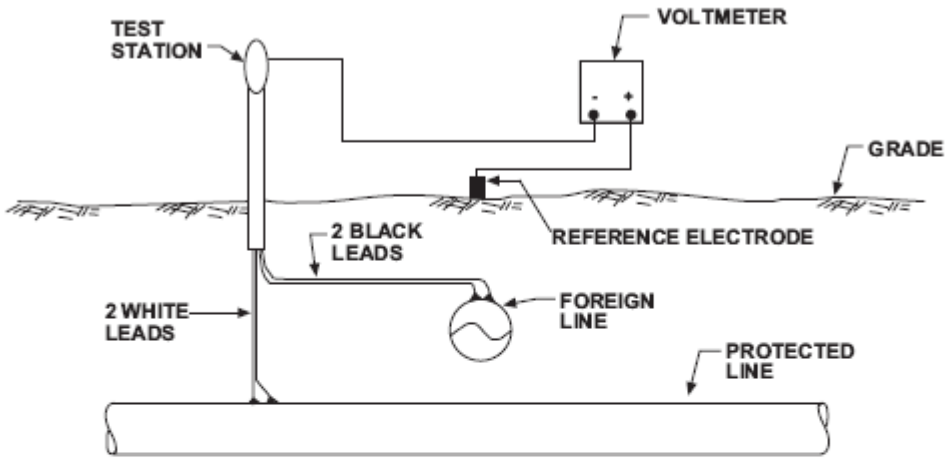
Static Interference

- Interference can be suspected if potential profiles:
  - Show abnormal curves from previous surveys
  - Show high negative values remote from CP current sources
  - Show low negative or positive values
- Note: Coated lines normally have smother potential profiles than bare lines. This makes bare line data more difficult to analyze



FOREIGN LINE CROSSINGS

FIGURE 5-4

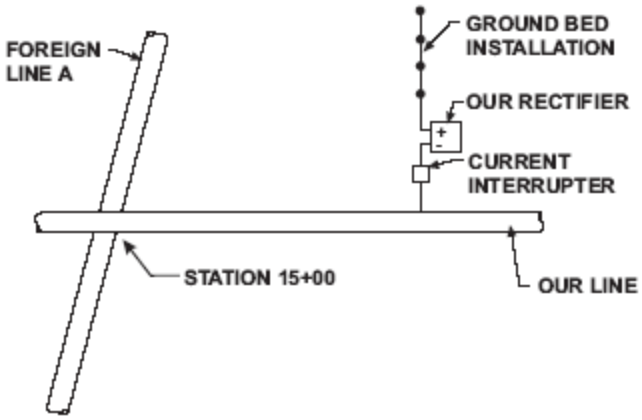


TYPICAL FOREIGN LINE CROSSING TEST POINT

FIGURE 5-5

Interpretation of Data

- Example with a cathodically protected line crossing 4 foreign lines with test stations at each crossing.
- Interrupt rectifiers on the line under test and record ON and OFF potentials on both lines at each crossing.



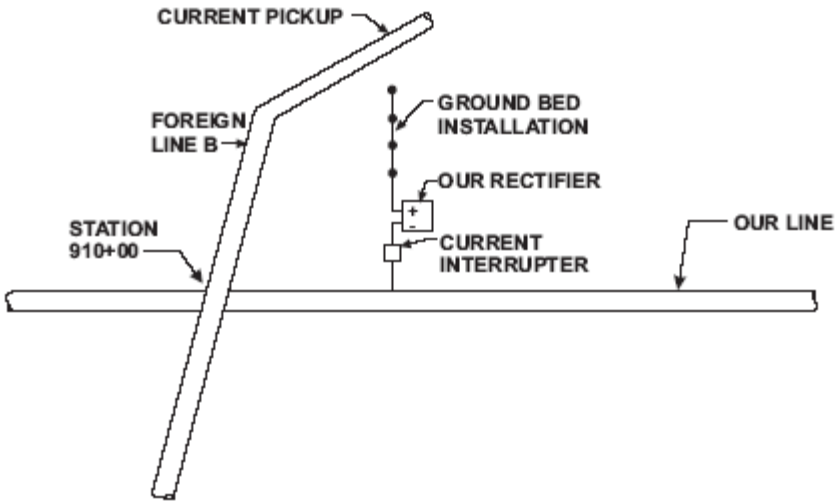
FOREIGN LINE A		OUR LINE	
ON	−0.86 V	ON	−0.89 V
OFF	−0.88 V	OFF	−0.85 V
ΔV	+0.02 V	ΔV	−0.04 V

FOREIGN LINE CROSSING A

FIGURE 5-6

Crossing A

- With our rectifier ON:
  - Our P/S is -0.89
  - P/L A's P/S is -0.86
- With our rectifier OFF:
  - Our P/S is -0.85
  - P/L A's P/S is -0.88
- Both pipelines are considered to be protected



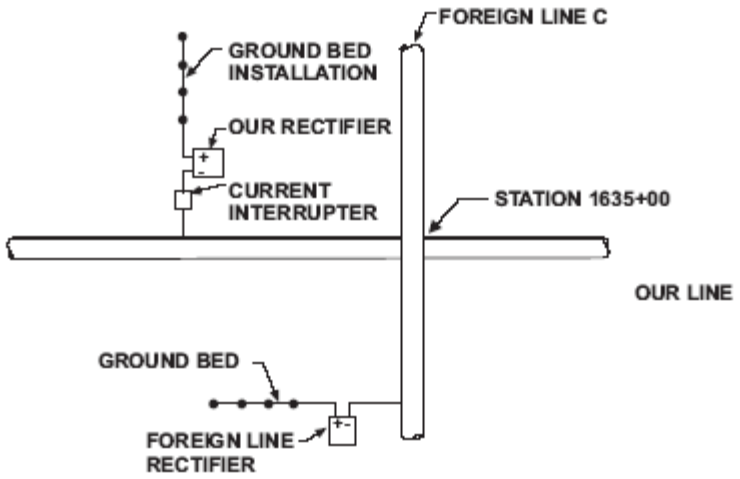
FOREIGN LINE B		OUR LINE	
ON	−0.48 V	ON	−1.85 V
OFF	−0.71 V	OFF	−1.04 V
ΔV	+0.23 V	ΔV	−0.81 V

FOREIGN LINE CROSSING B

FIGURE 5-7

Crossing B

- With our rectifier ON:
  - Our P/S is -1.85
  - P/L B's P/S is -0.48
- With our rectifier OFF:
  - Our P/S is -1.04
  - P/L B's P/S is -0.71
- Our P/L is protected while P/L B is not protected even when our rectifier is off
- An interference condition does exist and can be confirmed by performing close interval over the crossing to locate the discharge point and in the vicinity of our anode be to locate the pickup point



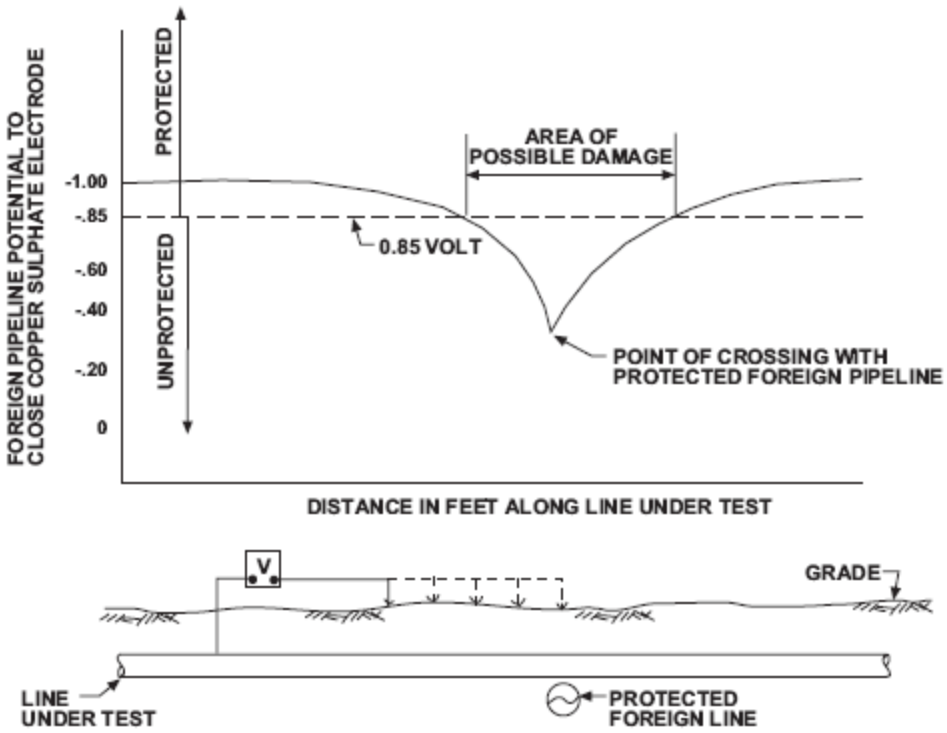
FOREIGN LINE C		OUR LINE	
ON	−0.75 V	ON	−0.71 V
OFF	−0.75 V	OFF	−0.65 V
ΔV	0 V	ΔV	−0.06 V

FOREIGN LINE CROSSING C

FIGURE 5-8

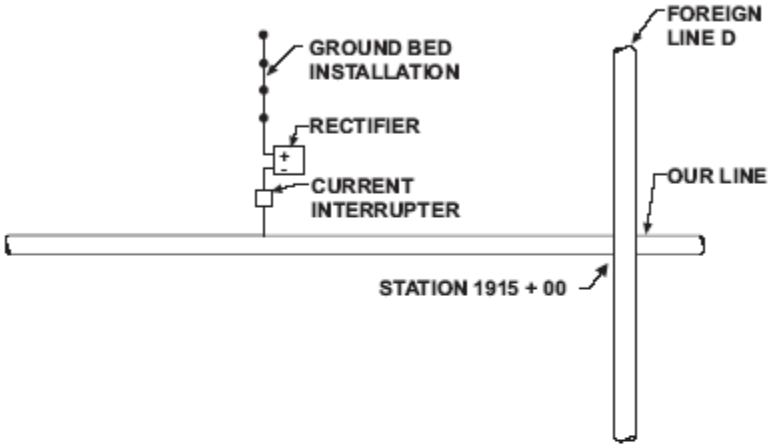
Crossing C

- With our Rectifier ON:
  - Our P/S is -0.71V
  - P/L C's P/S is -0.75V
- With our Rectifier OFF:
  - Our P/S is -0.65V
  - P/L C's P/S is -0.75V
- Our line is not protected, P/L C's cathodic protection system may be interfering with us and further testing should be done by examining our potentials with their rectifiers interrupted
- P/L C's line is not protected but we are not interfering with them



TYPICAL INTERFERENCE AT CROSSING WITH PROTECTED FOREIGN PIPELINE

FIGURE 5-9



FOREIGN LINE D		OUR LINE	
ON	– 0.65 V	ON	– 0.97 V
OFF	– 0.65 V	OFF	– 0.93 V
ΔV	0 V	ΔV	– 0.04 V

FOREIGN LINE CROSSING D

FIGURE 5-10

Crossing D

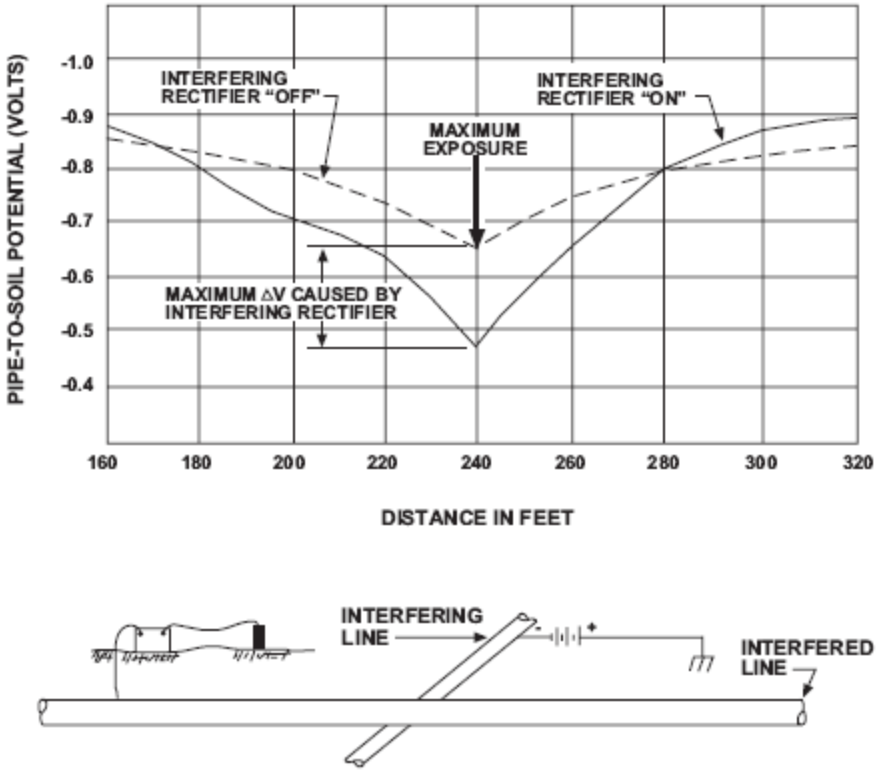
- With our rectifier ON:
  - Our P/S is -0.97
  - P/L D's P/S is -0.65
- With our rectifier OFF:
  - Our P/S is -0.93
  - P/L D's P/S is -0.65
- Our line is protected and not interfering with pipeline D
- Pipeline D is not protected

Finding the Source

- Stray current presence is not obvious due to steady state characteristics
- Structure currents flowing towards the point of discharge may reveal the source
- Close Interval Survey is required to pinpoint source of interference
- Low negative or positive potentials are an indication that a foreign structure is interfering with your system

Finding the Source

- First step to correcting the situation is to locate the structure and identify it
  - Inquire of it's owners
  - Follow it geographically
  - Examine it's route map
- If you can't locate a foreign structure talk to land owners and local utilities

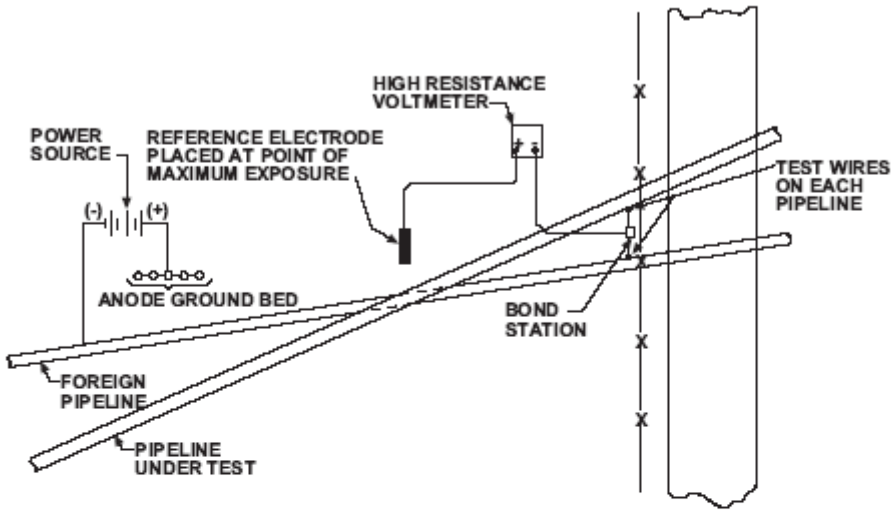


POTENTIAL PROFILE
INTERFERING SOURCE INTERRUPTED

FIGURE 5-11

Point of Maximum Exposure

- Point of maximum exposure is defined as the region where the most adverse electrolytic effect exists (point of discharge) and must be cleared.
- It may not always be possible to install drainage bond at POME.
- If you install drainage bond at someplace other than the POME, it must clear the interference condition at the POME



MEASURING STRUCTURE TO SOIL POTENTIAL AT POINT OF MAXIMUM EXPOSURE WITH INTERFERENCE BOND AT ANOTHER LOCATION

FIGURE 5-12

Mitigation

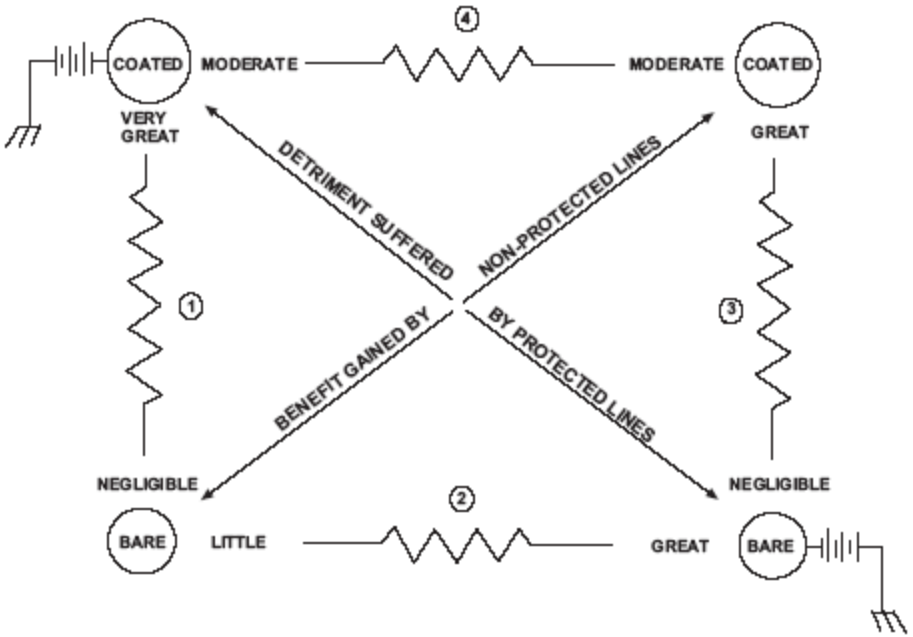
- Mitigation usually accomplished by installing a bond.
- Bonds drain stray current off the affected structure in a non-electrolytic manner
- At the point of connection, the potential of the interfering line must be more negative than the affected structure, otherwise current will flow in the wrong direction and the problem will be made worse – negative resistance condition

Mitigation

- Ideal connection point for drainage bond would be the negative terminal of the DC power source of interference.
- Bond conductors and shunts must be sized correctly based on the amount of current they will be carrying
- Permission from operators is required before your may bond to their structure

Effects of Bonds

- One P/L always loses some level of protection when bonded
- One P/L always gains some level of protection when bonded
- How much is lost or gained is dependent on many factors



BONDING EFFECTS EXPECTED WITH DIFFERENT PIPE COMBINATIONS

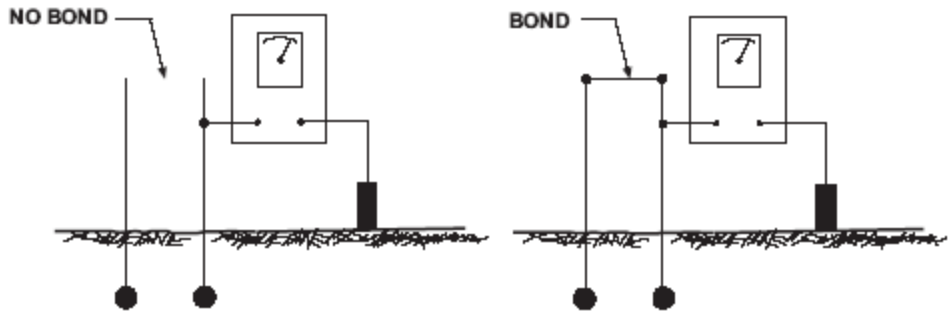
FIGURE 5-13

Effects of Bonds

- #1 – A well coated protected line bonded to a bare unprotected line will have a negligible effect on the bare line and a detrimental effect on the coated line
- #2 – A bare protected line bonded to a bare unprotected line will have a detrimental effect on the protected line and a negligible effect on the unprotected line
- #3 – A bare protected line bonded to a coated unprotected line will have negligible effect on the bare line and a great effect on the coated line
- #4 – A well coated protected line bonded to a well coated unprotected line has a moderate effect on both lines

Mitigation by Addition CP

- Galvanic anodes or drain rectifiers may be used to drain interfering current from the effected pipeline
- This reduces the effects of bonds on interfering pipelines
- Galvanic drains are used for small current flows, larger amounts of current will cause the anodes to be consumed quicker
- Use a bonding wire and Ammeter to estimate current flow and base design calculations on

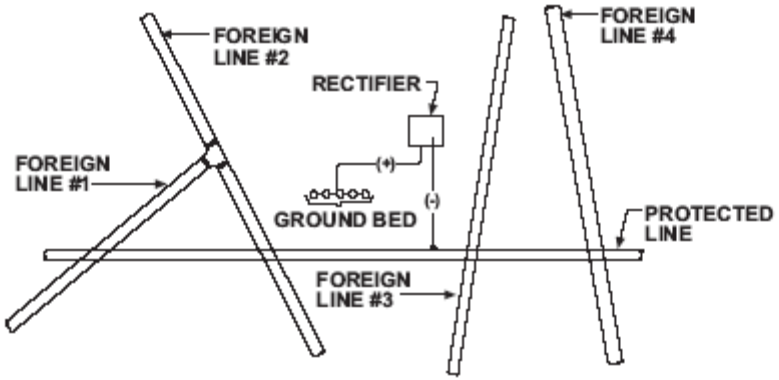


NATURAL POTENTIAL MITIGATION "IN A NUTSHELL"

FIGURE 5-14

Natural Potential Criteria

- Used to determine when the clearance of interference currents has been achieved.
- When a resistive bond is in place, the effected pipelines P/S is the same as when the interfering rectifier is turned off with no bond in place

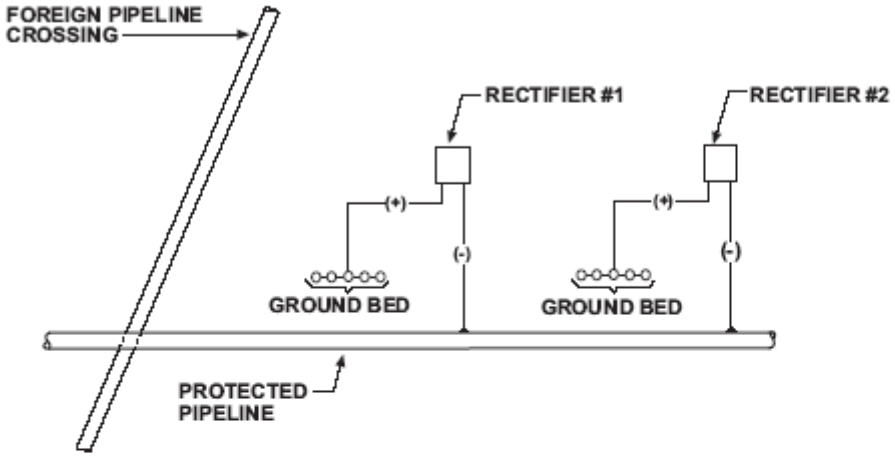


ONE PROTECTED PIPELINE CROSSED BY SEVERAL NON-PROTECTED LINES

FIGURE 5-15

Example #1

- Protected P/L crossed by several unprotected foreign lines
- Begin testing on the line closest to the groundbed and work out on each side.
- Re-adjust bonds as necessary
- Use natural potential criteria and record potentials on lines 1 & 2 then install bond on line 2 to see if it clears line 1.
- Work out to lines 3 & 4 using natural potential criteria then re-adjust bond on lines 1 & 2 if necessary

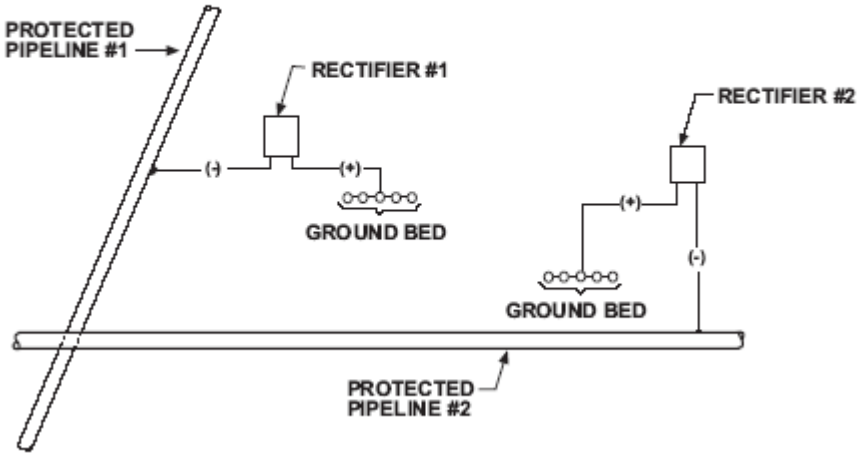


TWO OR MORE RECTIFIERS ON ONE PIPELINE AND NONE ON THE OTHER LINE

FIGURE 5-16

Example #2

- Cathodically protected line w/ 2 groundbeds crossing an unprotected line.
- When more than 1 source is causing interference the sum of all sources must be cleared
- Use natural potential criteria by de-energizing all rectifiers on the interfering line affecting the crossing
- This may be done by simultaneously or by de-energizing them one at a time and adding the voltage changes



**MUTUAL INTERFERENCE INVOLVING TWO PIPELINES
THE EFFECTS OF WHICH ARE TOLERABLE
TO THE OPPOSITE STRUCTURE**

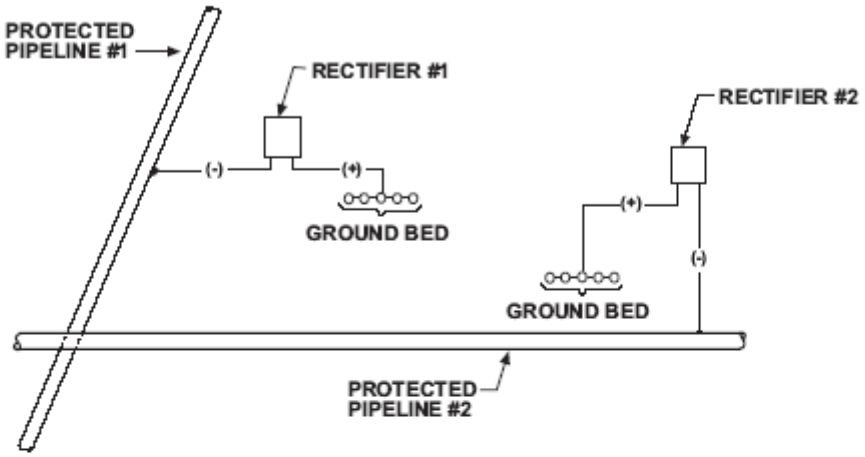
FIGURE 5-17

Example #3

- 2 pipelines protected by respective CP systems
- Mutual interference exists but is tolerable, which is a frequent occurrence.
- Both lines pick up some current from the others CP systems away from the crossing
- Some current is exchanged at the crossing but as long as readings at the crossing on both lines are at least -0.85 no action needs to be taken.

Example #3

- If a significant interference condition did exist at the crossing, the interfered pipeline could install a groundbed near the crossing and shift the potential curve for the entire area in the negative direction
- This would not eliminate the interference, just mitigate it – making it milder or harmless
- Mitigation may be done by:
  - Adjusting output on existing rectifiers
  - Installing addition CP devices at crossings (mag drains)
  - Using a bond as a last resort

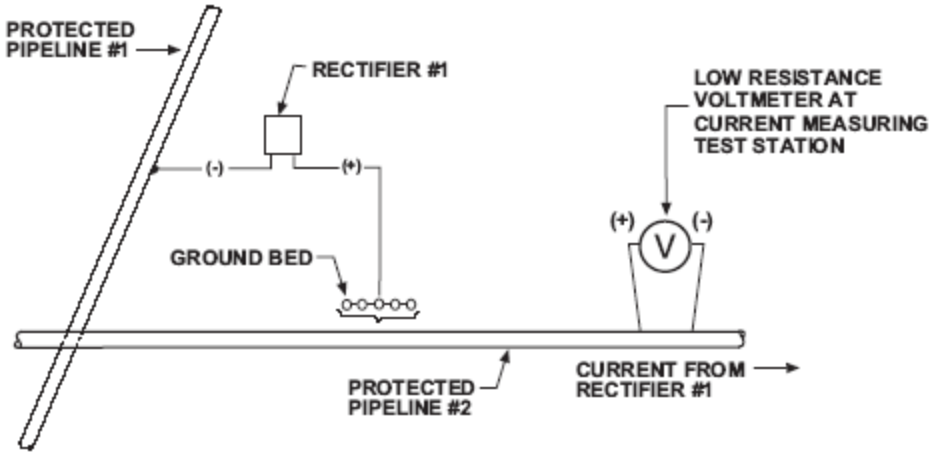


MUTUAL INTERFERENCE INVOLVING TWO PIPELINES WHERE ONE IS EXERTING OVERWHELMING INFLUENCE ON THE OTHER

FIGURE 5-18

Example #4

- 2 Cathodically Protected structures but one is overwhelming the other one
- Rectifier #1 has a huge effect on pipeline #2 due to close proximity of the anodes.
- With Rectifier #2 on and #1 interrupted:
  - PL #2 with #1 ON: -0.5V
  - PL #2 with #1 OFF: -0.8V
- With Rectifier #1 on and #2 interrupted:
  - PL #1 with #2 ON: -1.10
  - PL #1 with #2 OFF: -1.20
- Rectifier #1 is the dominant one
- Pipeline #2 is not protected even when Rectifier #1 is OFF but is still depressing Pipeline #1
- Pipeline #2 needs to add current to their system
- Rectifier #1 may have enough current to loan some to Pipeline #2 until they can add current

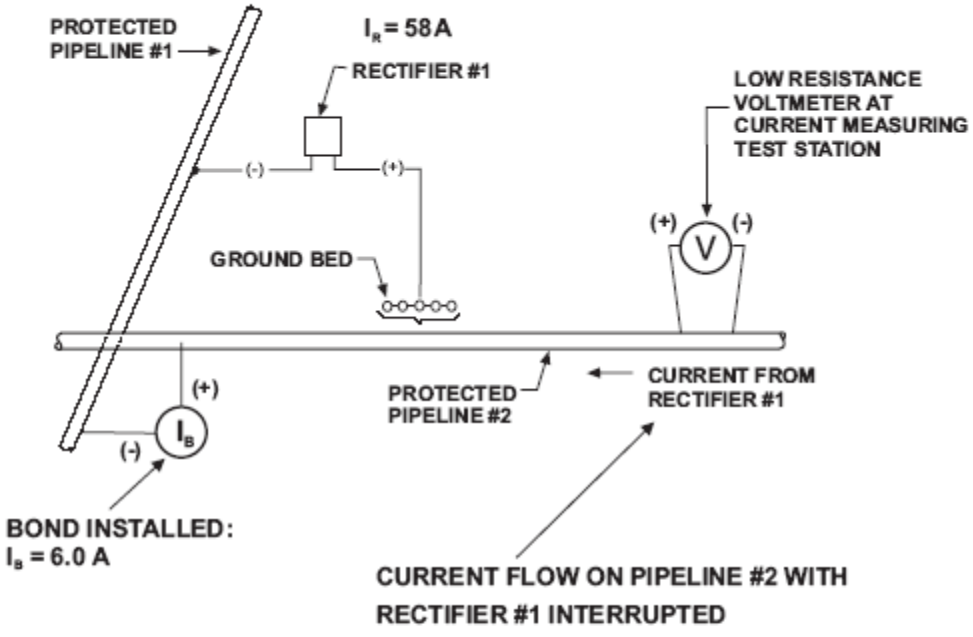


END-WISE INTERFERENCE

FIGURE 5-19

Example #5

- The most unbalanced condition occurs when P/L #2 passed through P/L #1's groundbed.
- If this current flows away from the crossing it will discharge at a remote location in a condition known as Endwise Interference
- This is corrected by installing a bond at the crossing so current flows to the crossing and back to P/L #1



END-WISE INTERFERENCE MITIGATED

FIGURE 5-20

Summary

- A positive shift in potential is not always harmful and may be tolerable provided protection levels are maintained.
- Sometimes the point of maximum exposure may be located a point remote of the crossing – Endwise Interference.

Things to Watch For

- Bonding to non-electrically continuous lines will increase corrosion rates on joints adjacent to the bonded joint – use galvanic drains instead of bonds in this situation
- Bonds may only be used when the potential of the interfered line is less negative than the protected line. Otherwise current will flow in the wrong direction and make the situation worse – Negative Resistance condition.