# Evaluation of Pipeline Casing (sleeve) Testing Methods and What to do with a Shorted Casing

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**Abstract:** Various methods exist for pipeline casing testing. The testing is primarily to determine the electrical condition (status) of the carrier pipe and casing – either isolated or shorted. The methods used vary from company to company and country to country and some of the test methods are not very conclusive of the casing electrical condition.

The first part of the paper will list and describe each test method, discuss the test methods on effectiveness and practicality and provide some possible research ideas for future test methods.

When a casing is shorted, the pipeline operator has several options. These options are affected by local or national regulations/codes, company policy and what criteria is being followed for the pipeline.

The second part of this paper will discuss what options are typically followed, what the risk is of doing nothing and what is the most common-sense approach to addressing a shorted casing. Various methods to address a shorted casing will be discussed and the benefits of these methods (if any) will be addressed.

**Keywords:** shorted casing, casing testing, clearing a shorted casing.

**Introduction:** The use of cased carrier pipe for pipelines crossing under highways and railroads have been a common practice in the industry. The original concept of using casing was to allow the casing pipe to handle the external load and/or provide a method to remove the carrier pipe for maintenance or replacement. Installation methods, materials and practices have changed over the years and today's cased pipe installations require less maintenance and repairs. The use of casing has been minimized by using sound engineering practices to install heavy-wall pipe, concrete coated pipe as well as deeper pipe at crossings to eliminate the external loading issue. When using casing, engineered casing spacers and end seals are used which prevent casing & carrier pipe contact and egress/ingress of foreign material into the annular space.

However, cased crossings do short out and/or casings do have egress/ingress of foreign material and this causes issues with the Cathodic Protection – CP of the carrier pipe and this condition needs to be addressed. [1]

**Discussion:** When a cased crossing appears to be shorted, this condition needs to be verified and if the casing and carrier pipe are indeed shorted the condition needs to be addressed especially if the CP levels of the carrier pipe are compromised.

We will discuss first, methods to determine if the casing and carrier pipe are shorted. Then second, we will discuss how the shorted condition can be mitigated.

Determine shorted condition: When a casing appears shorted, it can either be truly shorted and have metallic contact between the casing and carrier pipe. The casing can also be filled or partially filled with an electrolyte and this condition may appear to be a short, but it is an electrolytic contact and not a short. The following methods will discuss/describe the various typical test methods used in the field to determine the casing/carrier pipe condition.

The most common test (initially) is a pipe to soil vs. casing to soil potential test. This can be performed with the current on or the current interrupted. If the potential difference is quite small between the two structures (typically less than 100 millivolts) then further testing is usually performed.

Precautionary note: If the casing is cathodically protected, the cathodic protection system needs to be de-energized prior to this test and the casing allowed to de-polarize. A polarized casing can skew the results. If the casing has direct connected galvanic anodes attached this will also skew the results and invalidate the test results.

Close Interval Potential Survey – CIS or CIPS can also be used for the voltmeter test. With the current on, it is a pipe to soil vs. casing to soil test. With the current interrupted, it is still a pipe to soil vs. casing to soil but same direction and similar magnitude suggests metallic contact, same direction but reduced casing to soil shift suggests an electrolytic contact and a casing to soil shift quite small or reverse indicates clear.

Internal Resistance: This method indicates whether direct metal to metal contact exists between the carrier pipe and the casing pipe by measuring the electrical resistance. A 4-pin soil resistance meter or a megger type meter need to be used for this test. A low resistance value indicates a possible metallic short. A high resistance indicates an isolated (clear) casing.

Note: The resistance of the parallel path through the soil (electrolyte) needs to be considered as well as the lead wire resistance and vent pipe resistance if used.

Casing Depolarization: This technique indicates isolation status by discharging a direct current DC from the casing. A significant potential difference occurs between the casing and the carrier pipe if the two structures are not in metallic contact.

Direct Current Voltage Gradient – DCVG: A coating holiday indication near the end of the casing denotes a possible metallic or electrolytic path between the casing and the carrier pipe.

Alternating Current (AC) Current Attenuation – ACCA: Compares current flow at each end of the casing. Measured in mA or dBmA/m (dBmA/ft.

Alternating Current Voltage Gradient with A Frame - ACVG: Measure dBuA signal strength and direction at each end of the casing.

Temporary Intentional Short: Compare pipe to soil vs. casing to soil with a temporary direct short connected and disconnected. No shift/change indicates a contact already existed.

Each method has its strengths and weaknesses. The method that works well for one casing may not work well on a different casing. The method chosen should be one the tester is comfortable with and has extensive experience is using to test the casings status.

Additional methods have become popular if the casing end and carrier pipe can be exposed, GWT - Guided Wave Technology can locate a short as well as corrosion of the carrier pipe. There are three versions of guided wave technology available to perform a pipeline/casing inspection:

LRUT – Long Range UT & GUL – Guided Ultrasonic

MsS – Magnetostrictive

EMW-C – Electromagnetic Wave

All these monitoring techniques have some reasonable doubt about the results. The person performing these tests must be experienced with the test selected and can interpret the result and realize when an alternate test should be performed to verify the results.

Upon verification of the short, it can be useful to attempt to pinpoint the actual location of the short. This is important as where the short is located will determine the steps needed to clear a shorted casing. One test method that works uses the vent pipes or casing wires and the carrier pipe test station to connect a power source between the carrier pipe and the casing and measure the millivolt drop across the casing. Using the carrier pipe information (diameter-wall thickness-length of span-resistance per foot) the millivolt drop can be measured and the approximate location of the short then calculated. This is a similar test to the above casing depolarization test and is useful as if the short is not at the ends than to clear the short becomes quite difficult.

Appendix A provides details of one method to test a casing and determine its condition or status.

Appendix B provides details of an alternate method to test a casing and verify it is shorted.

**What to do about a shorted casing?** After the electrical condition of the casing and carrier pipe has been determined, the condition needs to be evaluated and a plan of action created. Typically, when a casing is shorted to the carrier pipe the CP of the carrier pipe is compromised and the carrier pipe can be out of compliance. At this point, the action plan would be created, and several options considered:

Clear or attempt to clear the short. This is always the best solution. Removing the short would involve excavation of the casing ends and inspecting the carrier pipe and locating the short. The short would then be cleared, the pipe recoated, the CP test facilities replaced and upgraded, and the casing end seals replaced.

A casing will typically short at the end where the carrier pipe transitions into the casing pipe. This is due to the casing pipe and/or carrier pipe settling/shifting/etc. The short can also be caused by the spacers shorting out between the casing and the carrier as older spacers had metallic components and over time they can short out. Spacers can also fail due to loading when light duty spacers are used for a liquid line and they collapse over time. Spacers and end seals can also fail due to the temperature of the product in the pipeline. Again, if the temperature rating is too low for the product being transported then over time the spacers and end seals will fail. Finally, some cased crossings were designed improperly and were installed shorted. This was due to older construction practices using steel slides and spacers or supports.

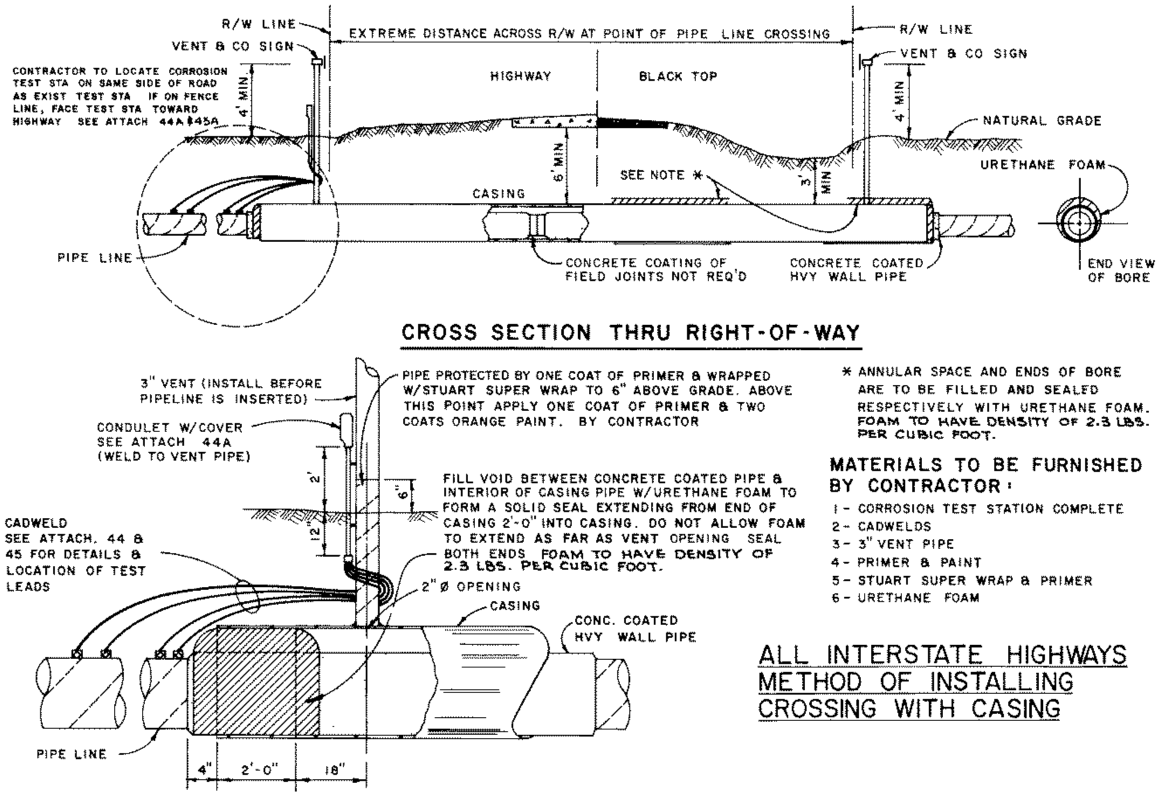
If the short cannot be cleared, then the second choice is normally upgrade the CP on the carrier pipe or install an individual CP system for the cased crossing and bring the carrier pipe into compliance with the applicable criteria.

Another option would be to fill the casing with a dielectric filler, a vapor phase inhibitor or a conductive grout. The concept with fillers is to fill the annular space with a material that will displace any electrolyte and encapsulate the pipe and fill the annular space.

Appendix C provides details of one method of clearing a shorted casing.

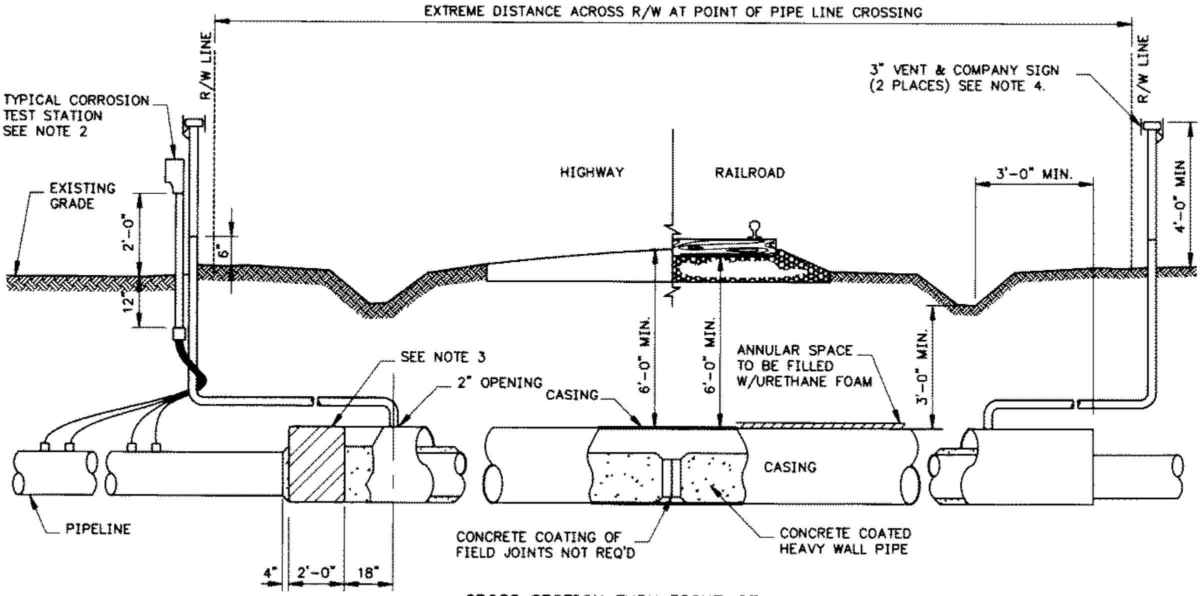
Appendix D provides details of one method of removing a casing – either clear or shorted.

**Drawings:** The following drawings show some typical methods of installing a casing/carrier pipe and some test facilities. These are just typical versions from various operating companies. [2]




ALL INTERSTATE HIGHWAYS
METHOD OF INSTALLING
CROSSING WITH CASING

ATTACHMENT 43
7-8-92




CROSS SECTION THRU RIGHT-OF-WAY

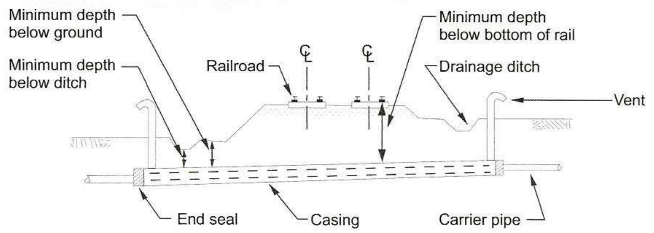
NOTES.

1 CASING TO EXTEND 3' BEYOND TOE OF SLOPE, 3' BEYOND BAR DITCH OR 25' BEYOND CENTERLINE OF OUTSIDE TRACKS, WHICHEVER IS THE GREATER DISTANCE, UNLESS OTHERWISE SPECIFIED BY COMPANY. CASING VENT TO BE EXTENDED HORIZONTALLY TO R/W LINE AND THEN VERTICALLY AS SHOWN
2 SEE ATTACHMENTS 44 & 45 FOR DETAILS AND LOCATION OF TEST STATION, LEADS AND CADWELDS
3 FILL VOID BETWEEN CONCRETE COATED PIPE AND INTERIOR OF CASING PIPE WITH URETHANE FOAM TO FORM A SOLID SEAL EXTENDING FROM END OF CASING 2'-0" INTO CASING. DO NOT ALLOW FOAM TO EXTEND AS FAR AS VENT OPENING. SEAL BOTH ENDS
4. INSTALL VENT BEFORE PIPELINE IS INSTALLED PIPE PROTECTED BY ONE COAT OF COAL TAR EPOXY TO 6" ABOVE GRADE ABOVE THIS POINT APPLY ONE COAT OF PRIMER & TWO COATS ORANGE PAINT

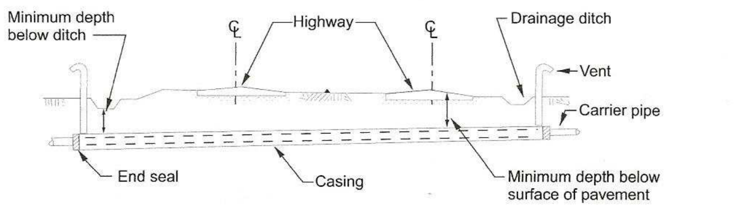
METHOD OF INSTALLING HIGHWAY AND RAILROAD CROSSING W/CASING

ATTACHMENT 48

AE10481B JCZ 12/6/93



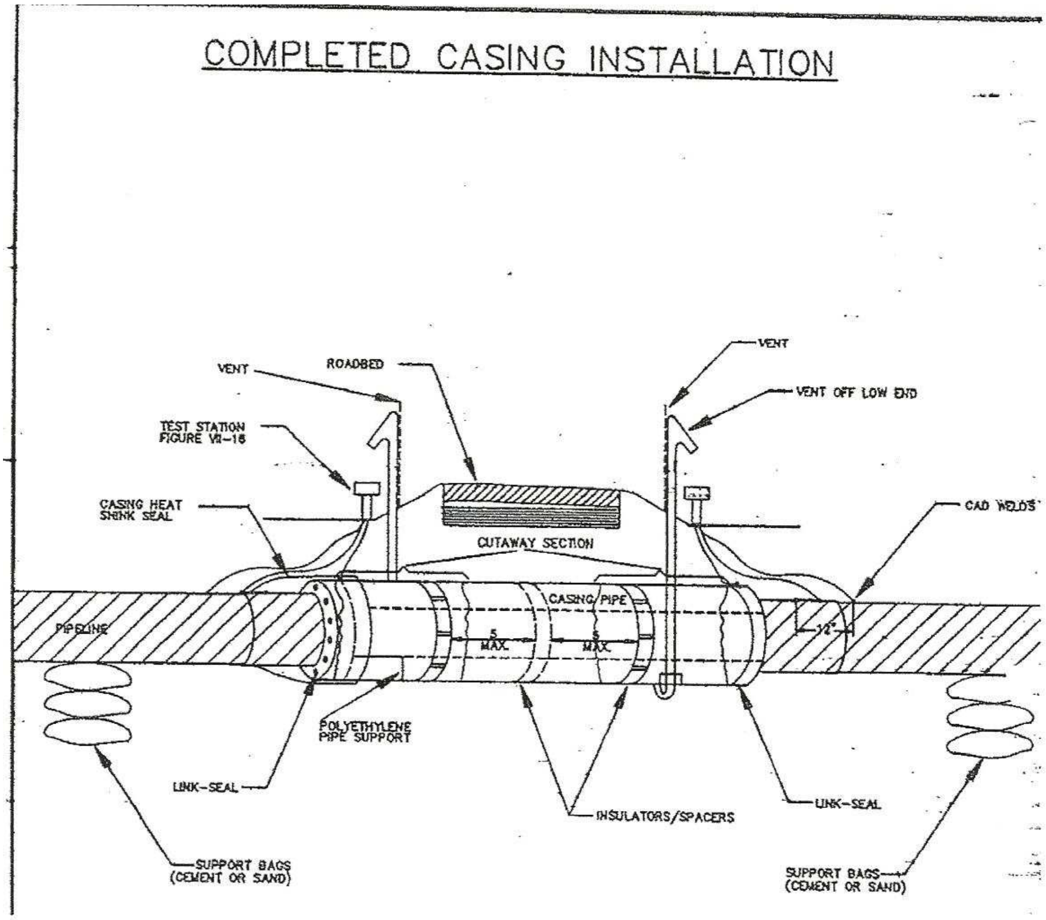

**RAILROAD CROSSING**




**HIGHWAY CROSSING**

NOTE For simplicity, drawing does not include insulators/spacers or test station

**Examples of Cased Crossing Installations**




Casing exposed for analysis and carrier pipe being evaluated for corrosion.

Casing and carrier were shorted, and casing pipe was cut back to clear the short as well as expose the corroded area. [3]

## References


1. NACE SP0200 (latest revision), “Steel - Cased Pipeline Practices” (Houston, TX: NACE).
2. API RP 1102 (latest revision), “Steel Pipeline Crossing Railroads and Highways” (Washington, DC: API).
3. NACE SP0286 (latest revision), “Electrical Isolation of Cathodically Protected Pipelines” (Houston, TX: NACE).

## Appendix A – TEST METHOD

## CASING SHORT TEST

I. General

To provide a method for determining if a casing pipe is shorted to the carrier pipe.

II. Method

Testing for shorted casings with typical field-testing equipment is sometimes difficult with results being inconclusive. When this happens, the following method is used to determine if the casing is clear or shorted.

A. Depolarize the casing by using a temporary, variable DC power source, a temporary anode bed, and a connection to the casing (See Figure 1). The positive lead wire from the power source is connected to the casing and the negative is connected to the anode bed. The anode bed should be at least 50 feet away from the casing. Activation of the circuit will drive the potential of the casing in a positive direction.

B. Place a copper-sulphate reference electrode firmly in the ground over the carrier pipe and as near as possible (an estimate) to the point where the casing ends. The electrode is to remain at this location throughout the entire test procedure. Take and record readings on both the casing and the carrier pipe.

C. Energize the system at a low current output and take structure-to-soil readings on both the pipe and the casing. Increase the current output through three to five steps (up to about 5 amps) and take structure-to-soil readings on both the pipe and the casing at each current level.

D. A minimum of three measurements should be made with different current outputs. In some cases, up to five measurements may be necessary. Current output should vary for each test (up to 5 amps).

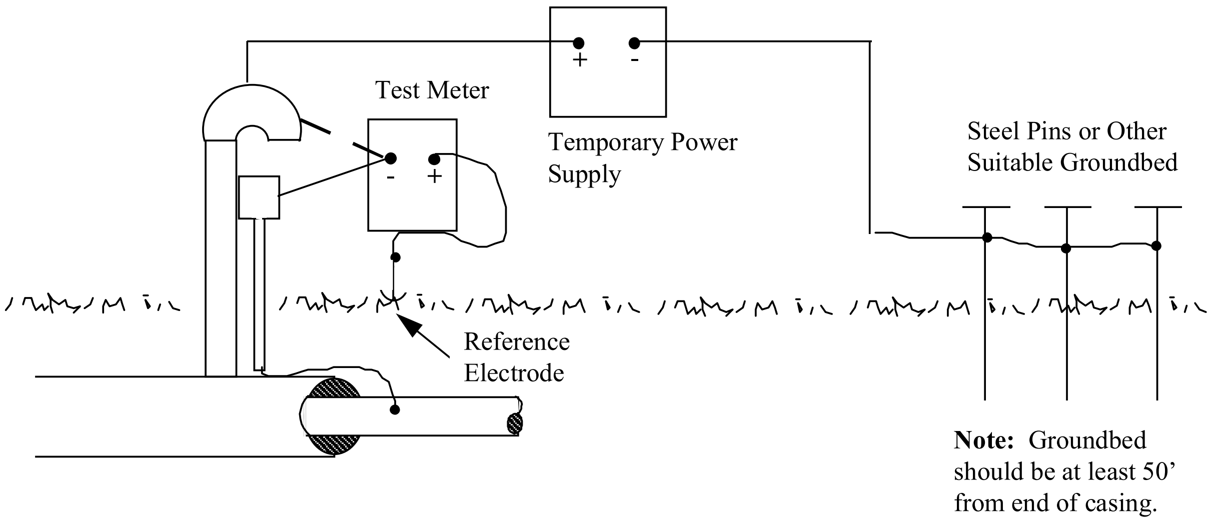



Fig. 1

## III. <u>Results</u>

### A. If Casing Is Shorted

If the casing is shorted, the casing-to-soil potential will shift in a positive direction. The pipe-to-soil potential will also shift in a positive direction, usually by about the same magnitude of the casing. As subsequent steps are taken, the pipe-to-soil potential will, , track the positively shifting potentials of the casing. (See Policy and Procedure Manual for possible remedial measures.)

### B. If Casing Is Clear

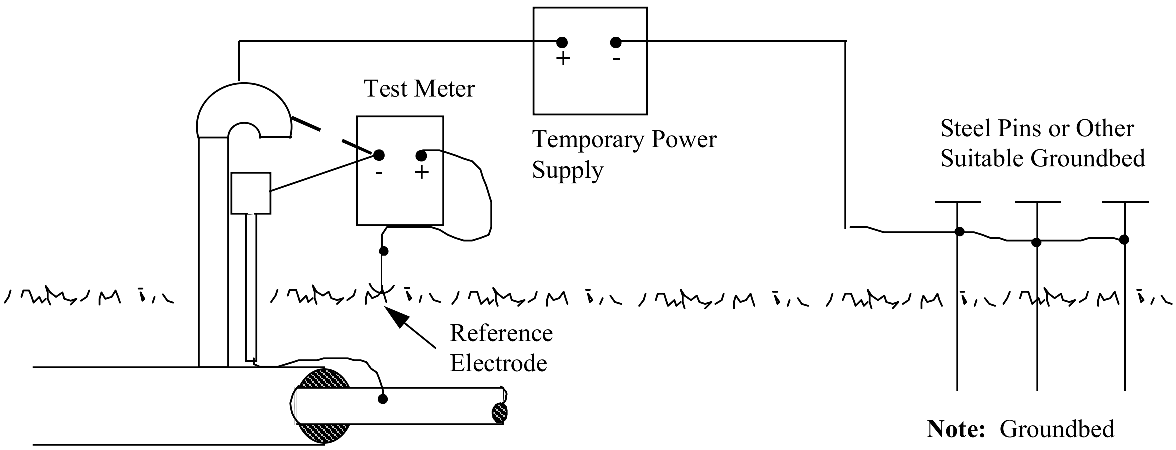
If there is no short, the pipe-to-soil potential may shift in a positive direction by only a few millivolts; whereas, there will be a dramatic shift in the casing-to-soil potential. In some cases, the pipe-to-soil potential may shift in a negative direction by a few millivolts.

<u>SAMPLE FORM</u>

Test for Possible Shorted Casing

Line__________________________Road (or other csg.) _________________________

Sta. No.________________________________




**Note:** Groundbed should be at least 50' from end of casing.

| | | | | | P/S Pot. | C/S Pot. | mV Diff. |
|---|---|---|---|---|---|---|---|
| Initial Readings | | | | | ________ | ________ | ________ |
| Step 1 | ________ | Volts | ________ | Amps | ________ | ________ | ________ |
| Step 2 | ________ | Volts | ________ | Amps | ________ | ________ | ________ |
| Step 3 | ________ | Volts | ________ | Amps | ________ | ________ | ________ |
| Step 4 | ________ | Volts | ________ | Amps | ________ | ________ | ________ |
| Step 5 | ________ | Volts | ________ | Amp | ________ | ________ | ________ |

________ ________ s ____________ ____________ ____________

# EXAMPLES

| | | | | | P/S Pot. | C/S Pot. | MV Diff. |
|---|---|---|---|---|---|---|---|
| Initial Readings | | | | | .975 | .850 | 0.125 |
| Step 1 | 6 | Volts | .25 | Amps | .974 | .710 | 0.264 |
| Step 2 | 18 | Volts | .68 | Amps | .975 | .505 | 0.470 |
| Step 3 | 45 | Volts | 1 | Amps | .981 | .210 | 0.771 |
| Step 4 | 65 | Volts | 1.8 | Amps | .986 | +.010 | 0.996 |
| Step 5 | | Volts | | Amps | | | |

Conclusion: Casing is clear (not shorted)

| | | | | | P/S Pot. | C/S Pot. | mV Diff. |
|---|---|---|---|---|---|---|---|
| Initial Readings | | | | | 1.246 | 1.242 | 0.004 |
| Step 1 | 6 | Volts | .234 | Amps | 1.211 | 1.195 | 0.016 |
| Step 2 | 18 | Volts | .594 | Amps | 1.050 | .980 | 0.07 |
| | 30 | Volts | 1 | Amps | .796 | .710 | 0.086 |
| Step 4 | 45 | Volts | 1.2 | Amps | .610 | .540 | 0.070 |
| Step 5 | 75 | Volts | 2 | Amps | .135 | .100 | 0.035 |

Conclusion: Casing is shorted

| | | | | | P/S Pot. | C/S Pot. | mV Diff. |
|---|---|---|---|---|---|---|---|
| Initial Readings | | | | | 1.250 | 1.210 | 0.04 |
| Step 1 | 6 | Volts | .086 | Amps | 1.139 | .700 | 0.439 |
| Step 2 | 18 | Volts | .258 | Amps | 1.104 | .140 | 0.964 |
| Step 3 | 30 | Volts | .413 | Amps | 1.060 | +.240 | 1.30 |
| Step 4 | 42 | Volts | .566 | Amps | 1.022 | +.490 | 1.512 |
| Step 5 | | Volts | | Amps | | | |

Conclusion: Casing is clear (not shorted)

## APPENDIX B – ALTERNATE TEST METHOD

### PANHANDLE EASTERN METHOD

The basic concept of this method is to make the casing temporarily the anode of an impressed current system. Then determine the isolation of the carrier by determining the potential shift of the carrier pipe. The magnitude of the reverse current required to produce an increase in potential difference between the carrier and casing is a measure of the net resistance between the carrier and casing. Normally, the casing can be driven increasingly positive with respect to the carrier pipe. If a low resistance short circuit exists between the casing and carrier, even large currents applied to the casing will not cause a separation of carrier and casing potentials. The following is a step by step procedure by which the insulation status of the casing can be determined.

#### Step 1

Construct a temporary metallic structure to be used as a "structure." This structure must be a minimum of 50 ft. from the casing/carrier end. (This structure will be used as the cathodic side in this procedure.) The structure should be constructed of several rods, aluminum foil in water, culvert pipe, etc. perpendicular to the cased crossing.

#### Step 2

Using the previously constructed structure as the cathode, connect the structure to the negative side of the DC power source. Connect the casing to the positive side of the power source.

#### Step 3

Using one of the acceptable means for measuring current, apply varying amounts of current from 0.5 amps to 10 amps in about 0.5-amp steps. (Adjust as you deem prudent for the actual resistance of your circuit – may start at 0.1 amps and go to 5 amps if you get good divergence.) At each current level, measure the casing to soil potential (CSP) and pipe to soil potential (PSP) at each end of the casing. (You will get increased accuracy by measuring the PSP about 200 feet away from the casing but directly over the pipe.) The degree to which the carrier's potential changes versus the degree to which the casing potential changes has a direct relationship to the amount of current being applied to the casing. (Keep in mind that it may not be necessary to apply 10 amps to small diameter casings to determine the effective isolation. In the same way it may take more than 10 amps on larger diameter casings.)

Step 4

After all the readings have been taken for the different values of applied current, the resistance of casing installation can be determined using the following equation.

R=(P-C)/I x 1000 Formula 1

Where $P = P_0 – P_n$ (in mV)

$C = C_0 – C_n$ (in mV)

$I – 0 + I_{applied}$ (in amps)

The definition of each term of equation 1 through 3 are listed below.

$P_0$ = The steady state value of the PSP, taken with the normal cathodic protection currents applied (in mV)

$C_0$ = The steady state value of the CSP taken with the normal cathodic protection currents applied (in mV)

$P_n$ = The value of the PSP taken with the temporary current source energized (in mV)

$C_n$ = The value of the CSP taken with the temporary current source energized (in mV)

$I_{applied}$ = the value of the temporary current applied (in amps)

R = the calculated value of resistance using formula 1 above.

After the calculations for resistance have been made, the determination as to the condition (shorted or not shorted can be made. A calculated resistance greater than 0.080 ohms would indicate an effectively insulated installation, and any cased crossing with a calculated resistance less than 0.080 ohms would be considered shorted and corrective action must be taken. Also keep in mind that the resistance calculated using formula 1 represents an overall resistance.

## Appendix C
## Clearing a Shorted Casing

Clearing a shorted casing normally involves excavating one or both ends of the casing, exposing several feet of pipe, examining the ends of the casing, possibly lifting the pipe and restoring the casing spacers and end seals.

All work performed in attempting to clear a shorted casing must include a work plan documenting what is required for personal safety, public safety, pipeline excavation, moving & lifting procedures, ditch safety and any local or national codes and permits that apply.

The first step in clearing a shorted casing is to research the method of construction, materials used for the casing, spacers, end seals, etc., alignment sheets, records and any history about the cased crossing. Doing this research and determining how it was installed may highlight the area of the casing that is shorted and may verify the location of the short or may determine that the casing was installed shorted due to the materials used and/or the construction methods.

The second step is to analyze the corrosion records, any ILI information and any ( if any) previous attempts to clear the short. The ILI data may locate the short if it is a “hard” metallic contact. Knowing where the short is located will simplify the process. If the ILI data cannot determine the location of the short, then the casing could be sitting on collapsed spacers and is shorted at multiple locations.

The third step is to prepare for the attempt to clear the casing by procuring casing spacers, end seals, nonmetallic spacers & shims, vent pipe material, test station material and pipe coating. Having all the materials on hand is important as most casing clearing projects become time sensitive and the work needs to be performed safely and efficiently and having the materials on hand will assist in not delaying the project.

The fourth step is to excavate the casing end or casing ends to locate or clear the short. Using the work plan to ensure it is a safe project, the casing needs to be excavated and several feet exposed. Normally several feet are exposed to expose the vent pipe, have enough casing exposed in case it needs to be cut off and trimmed and to provide adequate area for working. The pipeline (carrier pipe) also needs to be excavated and stripped back several feet to start and possibly several hundred feet if it is determined the pipe is to be moved. Once the pipe is excavated and the casing end exposed, the existing end seal (if any) needs to be removed, the annular space between the carrier pipe and casing pipe examined (sample water for MIC and estimate amount of water drained}. Any broken casing spacers need to be removed and if the casing and carrier pipe are touching this spot needs to be evaluated and determine if this is the short.

Note: When the pipe is stripped out it may move (rise) on its own depending on the installation methods and sometimes clear the short on its own.

The fifth step is to clear the short.

## Appendix D
## Removing a Casing

- Perform any CIS, DCVG, PCM, ACVG, and intentional short prior to starting the excavation
- Take a P/S reading on each end of the casing before starting the excavation.
- Excavate pipe to 12” below casing bottom, support as necessary.
- Examine casing ends to see if carrier pipe is centered.
- Remove any end seals.
- Confirm that casing is not wax filled.
- Document amount of water in casing, if any.
- Sample water for MIC bugs.
- Install shims to hold carrier off of main.
- Cut pipe off with 2 cuts 180° apart.
    - Align cuts with largest gap between carrier and main.
    - Make a girth cut every 8’ to 10’
    - Once the previous section is removed, re-align cuts to largest gaps between carrier and main
    - Remove sections of casing.
    - Remove any spacers.
- Document type of end seal and spacers, as well as dimension between spacers.
- Document any mud or debris in annulus.
- Perform a direct exam of the carrier pipe.
- Document soil environment (pH, resistivity)
- Take a P/S on both ends of the excavation opening once the casing is removed.
- Take a P/S after the pipe is covered.
- Larger diameter pipe may require 3 cuts, or a girth cut resulting in shorter lengths.

Cutting process

- Acetylene torch, grinding with abrasive disc, or saw with a diamond blade may be used
    - Note: Coated casings make use of a diamond blade difficult as it coats the surface, reducing effectiveness.
- If torch
    - Operator is to look for signs of damaging the coating on the carrier pipe.
    - Use a hammer to break loose any slag holding casing sections together
- If grinding
    - Use a side grinder to make the first pass cut, removing 70% to 90% of the metal
    - Use a die grinder to finish the cut

Operator is to pay close attention to the metal, looking for signs of complete cut without getting into the coating of the carrier pipe.