Cathodic Protection Shielding Definition

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(Incorporated comments from several AGA Corrosion Supervisory Committee members, R. J. Babnick, T. J. Barlo, J. Dabkowski, M. K. Han, N. G. Thompson, and R. V. Young)

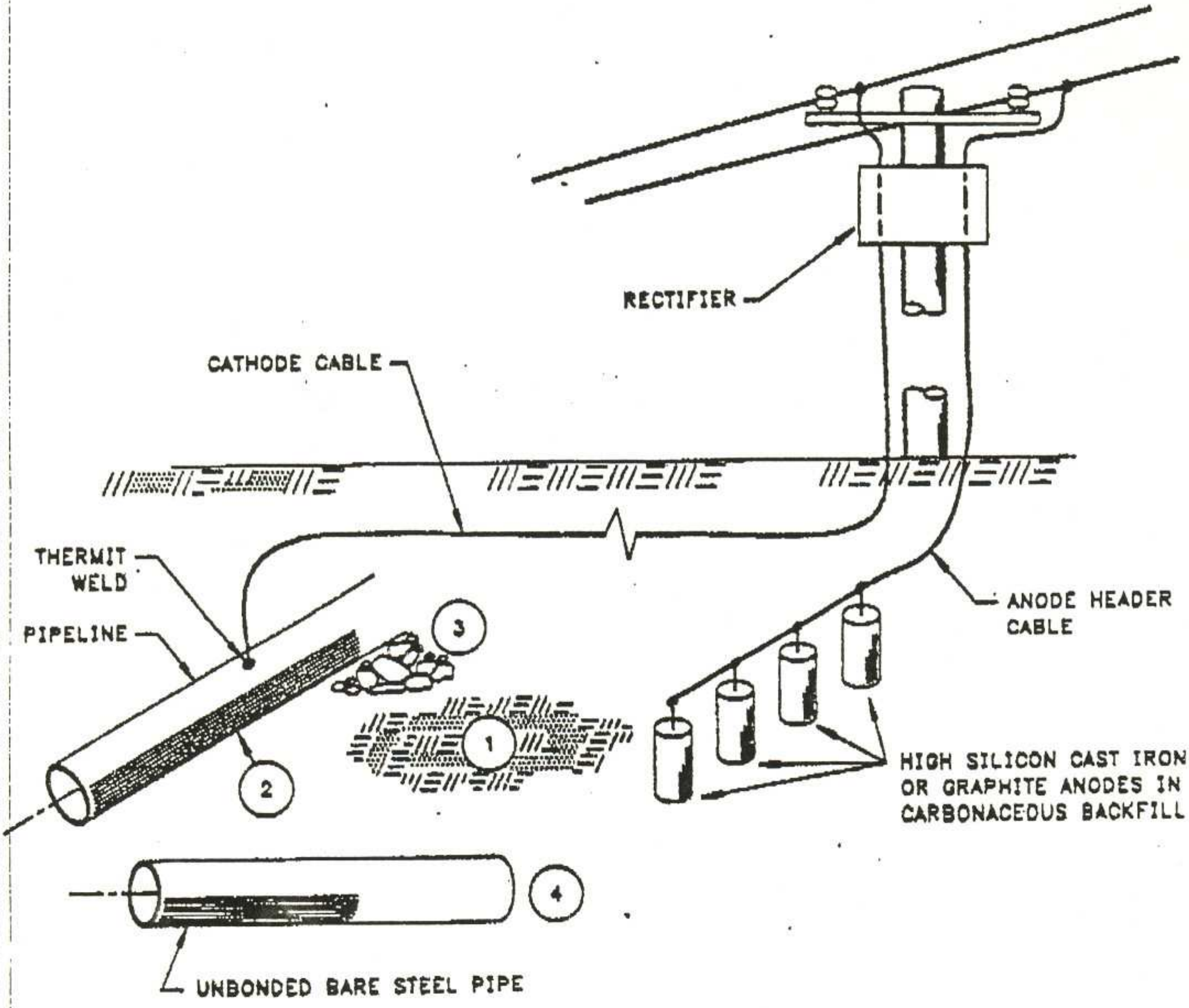
<u>Cathodic protection current shielding</u> is not fully understood or appreciated, yet it is a condition that plays a major role in corrosion of our natural gas pipeline systems. This document represents several key people's understanding (definition) of this condition as it applies to gas transmission pipeline corrosion prevention.

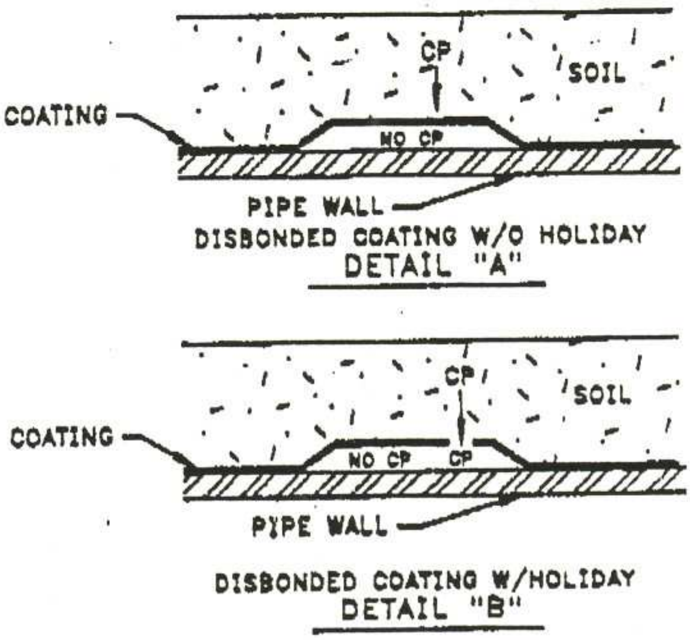
> <u>Cathodic protection current shielding</u> can be defined as any condition which reduces the amount of protective cathodic protection current that reaches the pipe metal surface. This becomes a problem whenever the current level is reduced to a value that is less than that required to protect (polarize) the pipe surface from corrosion attack. Cathodic protection shielding can occur anywhere through the path from the anode bed to the pipe metal surface. Examples of shielding as defined here are: (1) coatings that are defect-free through their thickness and have high dielectric strength; (2) high resistivity soils including those that have a high amount of rocks; (3) other buried structures near the pipeline; and (4) certain casing conditions. Figure 1 illustrates this definition, also see attachment #1.

Clearly, shielding is only a potentially hazardous situation when the pipe metal surface is subjected to a corrosive environment such as could occur under a disbonded coating. In this situation, surface potential measurements may be misleading and not indicate inadequate protection of the pipe surface in the regions where the coating is disbonded.

Imperfect coatings (slightly porous or cracked coatings) may be desirable whenever disbondment has occurred i.e., current is allowed to protectively polarize the pipe through the imperfections and, if polarization is sufficient, corrosion will be prevented. This is why most feel that CP is more effective on a coal tar enamel system than it is on a polyethylene coated system. Because a polyethylene system is ductile (non-brittle), has high dielectric strength (high insulating properties) and has been found in many cases to disbond globally over large sections of pipe, it can easily shield cathodic protection currents from the pipe metal surface under a disbonded site. Coal tar has not been as highly prone to the shielding problem because inherent imperfections in the coal tar have allowed protective current to reach the pipe metal surface in the disbonded area.

Regardless of coating type, the shielding phenomenon must continue to be recognized as a significant condition that may contribute to corrosion problems in natural gas pipelines.





SOURCES OF SHIELDING

1. SOIL
2. COATING (SEE DETAIL A & B)
3. ROCK(S)
4. FOREIGN OBJECTS
5. SHORTED CASING (NOT SHOWN)

FIGURE 1: SCHEMATIC VIEWS SHOWING:

1. IMPRESSED CURRENT TYPE CATHODIC PROTECTION FOR AN UNDERGROUND PIPELINE
2. TYPICAL SHIELDING CONDITIONS

Electrical Shielding and Cathodic Protection

An electrical shield can be defined as any barrier that will prevent or divert from a pipeline for which protection is intended, the flow of cathodic protection current from soil or water. This electrical shielding can be of two types. One may result from a non-metallic insulating barrier which prevents current flow. The other type involves diversion of current to other metallic structures surrounding and in electrical contact with a pipeline to be protected. Each type will be discussed.

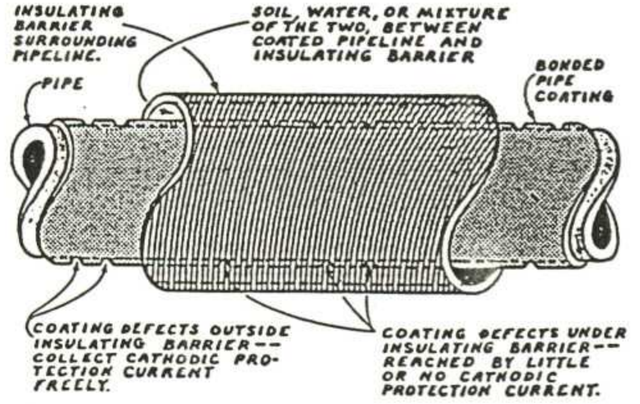


Figure 4-7 -- Electrical shielding by an insulating barrier

Shielding by Insulating Barrier. Figure 4-7 illustrates a condition in which part of a coated pipeline is surrounded by a loose insulating barrier. The space between this barrier and the pipeline may be filled with earth or water. If there are defects in the pipeline coating, the exposed steel will be subject to corrosion. Further, if the pipeline is under cathodic protection, the protective current may not reach the exposed steel at coating defects under this barrier.

An analysis of the implications in Figure 4-7 might support an argument that cathodic protection current could flow to the shielded coating defects through the soil or water between the insulating barrier and the pipeline. It can, but often not in sufficient amounts for protection. For a given distance between the end of the shield and a coating defect under that shield, the amount of current reaching bare metal at the coating defect will be a function of the longitudinal resistance of the layer of soil or water between shield and pipe through which the current must flow. The closer the spacing between shield and pipeline, the higher the per unit longitudinal resistance of the electrolyte (soil or water) because of reduced cross-section volume carrying protective current. This means that the ability of electrical current to penetrate such spaces is not great. As a practical matter, one normally should not expect to force current into the space a distance greater than about three times the thickness of the layer between shield and pipeline. This figure is not rigorous but serves as a guide to the approximate relationships involved.

The foregoing discussion applies to a completely insulating barrier. It need not completely encircle the pipe, as shown in Figure 4-7, but may partially shield an area, as might a large rock. If the barrier is an insulating material but is sufficiently porous to absorb enough soil moisture to become conductive, the moisture may pass enough current to partially or completely protect the pipe at coating defects. Such a barrier would not, then, act as a complete shield.

Shielding by Shorted Cased Crossing. Figure 4-8 illustrates one of the common situations involving a metallic shield which diverts cathodic protection current from its intended path. This condition results at cased pipeline crossings where the casing is in metallic contact with the pipeline. Such contacts can prevent cathodic protection of a pipeline enclosed by the casing.

This figure shows a pipeline in half section as well as a casing installed with end seals and insulating spacers. Spacers and seals are intended to keep the casing completely free from metallic contact with the pipeline. This is not always accomplished. Contacts may develop from such conditions as:

1. Improperly installed end seals.

2. Insufficient number of, or failed, spacers.

3. Forcing line pipe through crooked or out-of-round casing.

4. Welding "icicles" inside casing which may contact carrier pipe where clearances are small as a result of conditions 2 and 3 above.

5. Test point wiring (see Chapter 13) contacting end of casing or vent pipe.

6. Metallic objects or scrap inadvertently left in casing during construction.

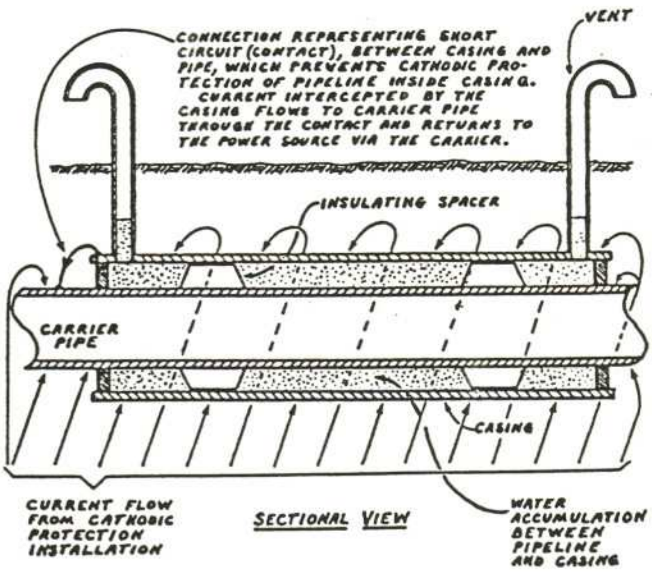


Figure 4-8 -- Electrical shielding by a shorted pipeline casing

ATTACHMENT #1