Corrosion Inhibitor Solutions for Proactive Control of Corrosion Inside Cased Pipeline Crossings

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Pipeline integrity management programs are being expanded to include assessment and control of carrier pipe corrosion within cased pipeline crossings. The application of vapor phase corrosion inhibitor (VCI) chemistry, combined with a corrosion rate monitoring system, provides an excellent method to mitigate and monitor corrosion within the annular space of cased pipeline sections.

According to a Southwest Research Institute 2007 study,[1] cased pipe segments are generally believed to be very safe since the time-independent threats, including third party excavation and outside force damage, are largely eliminated. However, external corrosion of carrier pipes in casings still poses a threat to pipeline safety. Understanding the causes and characteristics of carrier pipe corrosion in casings is an important step forward to better management of corrosion threats within cased crossings.

External corrosion on the carrier pipe can occur due to a variety of factors:

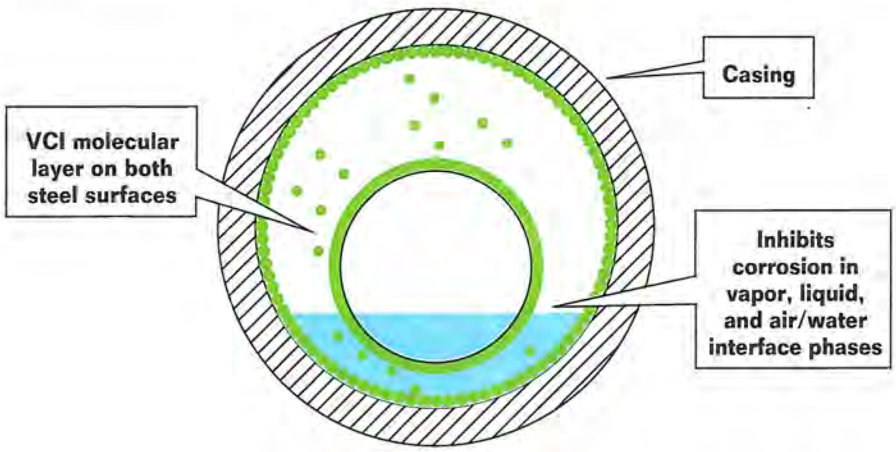
- If condensation accumulates at coating holidays on the carrier pipe coating, a high concentration of diffused oxygen can lead to an accelerated rate of corrosion.
- General atmospheric corrosion can occur at coating holidays on the carrier pipe.
- Accelerated corrosion can happen at coating holidays in direct contact with an electrolyte such as water or other debris.
- Localized corrosion can develop because of concentration cells or the presence of bacteria.
- For casings located near a compressor station, elevated temperature may accelerate any existing corrosion problem. Elevated temperatures may also cause coating damage and expose the carrier pipe surface.

An example of a significant pipeline safety incident attributed to carrier pipe corrosion inside a cased crossing is described in a National Transportation Safety Board (NTSB) report issued on February 18, 1987.[2] It was reported that the incident occurred on April 27, 1985 in Beaumont, Kentucky, when a natural gas pipeline leaked under a state highway. The escaping gas ignited and burned an area about 700 ft (213 m) long and 500 ft (152 m) wide. Five persons in one house were killed and three others burned as they ran from their mobile home. There was extensive damage to buildings, construction equipment, and other property.

The corrosion was attributed to several factors. The NTSB report stated the probable cause of the accident to be "... unsuspected and undetected atmospheric corrosion." Atmospheric corrosion occurs on a pipeline where moisture from the air, along with contaminates, comes into contact with exposed metal.

This casing was located about two miles (3.2 km) downstream of a compressor station with the line temperatures in the range of 140 to 160 °F (60 to 71 °C). With high heat, the coating was badly damaged. With the presence of vents and the consis-

FIGURE 1



Multiphase corrosion control within casing annular space.

FIGURE 2

Custom ER probe for casings.

tently higher line temperatures than the local temperature, cyclic water condensation occurred on the carrier pipe, which provided the electrolyte necessary for the atmospheric corrosion.

Annular Space Corrosion Mitigation Solutions

As pipeline integrity assessment programs and processes generate improved information on external corrosion of carrier pipe inside casings, new external corrosion threats are being discovered within those environments. Options for mitigation of the external corrosion on the annular space metals of a cased crossing include the following:

1. Apply vapor phase corrosion inhibitor (VCI) products inside the annular space and monitor effectiveness with electrical resistance corrosion rate probes.
2. Fill the casing annular space with a newly developed gel that contains a significant dosage of multiphase corrosion inhibitor chemistry.
3. Fill the annular space with cold petroleum blend filler or a hot-applied petrolatum wax.

This article addresses only the first and second options, utilizing corrosion inhibitors for proactive corrosion mitigation.

VCI Basics

A well-sealed annular space of a cased pipeline crossing is an ideal environment for the application of VCI technologies and systems. With the development of the VCI filler gel, even greater flexibility is available for casings that may not be totally sealed.

It is important to utilize VCIs that provide corrosion control in all three potential phases that may exist inside a cased crossing (Figure 1):

1. The liquid/solids phase where the metal surfaces are covered with water or soils that have migrated inside the casing.
2. The region along the interface of vapor and liquid/solids where accelerated corrosion may normally exist.
3. The vapor space exposed to atmospheric corrosion conditions.

An effective VCI product forms a protective mono-molecular layer on the metal's surface throughout all three phases described above. This molecular layer inhibits the electrochemical reaction on the metal surface. Mitigation of corrosion with VCI chemistry is mature and well proven. VCI products have been in existence for more than 30 years and there are multitudes of successful applications within numerous environments similar to the annular space of a pipeline casing.

An early documented example of VCI application for cased crossings was written by Klechka.[3] Among other VCI projects, this article describes the successful application of VCIs to mitigate corrosion inside numerous cased sections along the Trans-Alaska Pipeline.

Evaluating the Corrosiveness of the Annular Space Environment

Measuring the corrosiveness of the environment inside cased crossings in real time is a valuable integrity management program component. Mature and reliable technology is available to assess the corrosiveness of the annular space in real time. This is accomplished through the use of custom-designed electrical resistance (ER) corrosion rate probes. Figure 2 shows an example of such a probe. The probe is designed to be lowered down to the carrier pipe surface and has a shield that prevents contact of the probe sensing element with the carrier pipe.

ER probes are commonly used on a daily basis to understand the corrosiveness of many types of environments inside a variety of structures. ER probes can be installed as part of a casing integrity program before inhibitor is applied to identify casings with corrosive environments. They are also very useful after a VCI is applied to evaluate the inhibitor effectiveness over the long term.

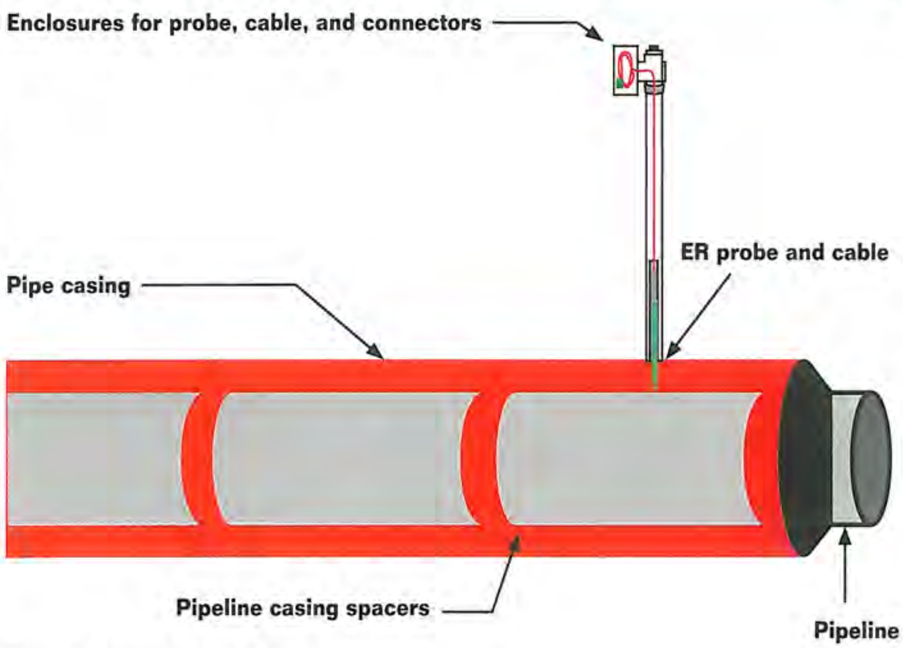
Casing vent pipes normally located on each end of a cased crossing provide the only readily available access for installation of ER probes into the annular space (Figure 3). From a corrosion evaluation perspective, and per industry studies, the casing ends are found to normally experience the most aggressive corrosion. This is due to potential infiltration of water and soil debris through the casing ends plus the introduction of fresh air through the vents. Therefore, if the corrosion rate is acceptable near the ends, there's a reasonable chance the rate will be acceptable throughout the rest of the casing.

Using a VCI System Inside Casing Annular Space

If the casing system is well sealed and the operator determines that the casing does not need to be filled in order to prevent future migration of water and other debris into the annular space, a liquid VCI product can be used to mitigate annular space corrosion. This is accomplished by inserting a special tool down one or both vent pipes and spraying atomized liquid VCI into the annular space (Figure 4). Many factors are considered and engineered into this approach to be sure that sufficient quantities of the inhibitor are effectively applied. If the correct multiphase VCI products are utilized, the inhibitor molecules will mix with, and migrate through, any water, soil debris, and vapor space that might exist inside the casing. Therefore, corrosion control is produced on all annular space metal surfaces. These products are environmentally friendly—their release into the environment around the casing is not a hazard.

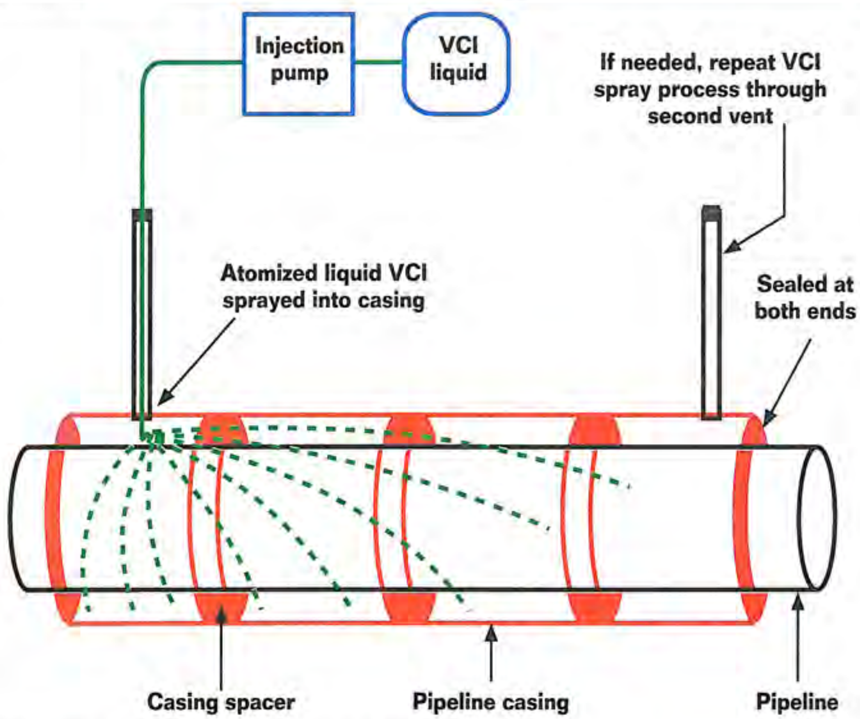
The VCI system should include insertion of ER probes into the casing vents at each end in order for the operator to monitor the annular space environment for a future change in the corrosion rate. The system should also include modifications to the casing vents to prevent infiltration of fresh air into the annular space. Caps and special two-way check valves are used to control the air infiltration while allowing the casing to breathe if needed.

FIGURE 3



Typical ER probe installation.

FIGURE 4



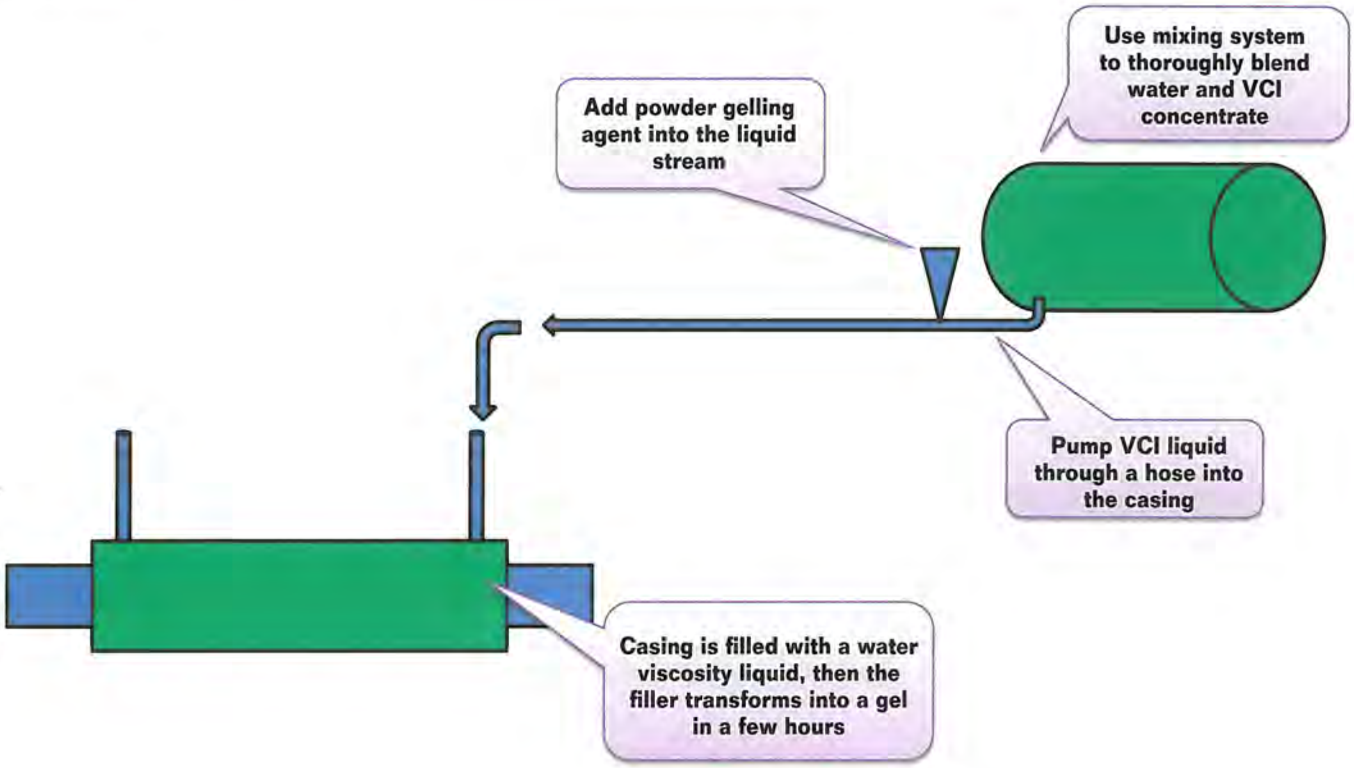
Application of atomized VCI into the annular space.

Filling the Casing Annular Space with a VCI Filler Gel

This option was developed for the pipeline operator who determines the annular space should be filled with a product that mitigates annular space corrosion, while also preventing future infiltration of water and air into the casing. In 2011, chemists and other experts in corrosion control within the author's company developed the CorroLogic† VpCI† Filler for Pipeline Casings (patent pending). Development was at the request of a North American pipeline corrosion engineering group. This new product is designed to totally fill the annular space of cased pipeline crossings with a water viscosity product that transforms into a gel within a short period of time. This product is engineered to proactively control corrosion on the carrier pipe surface while also preventing the intrusion of fresh air and water inside the casing. Initial applications of this innovation were completed in late 2011. Many more are scheduled for 2012.

†Trade name.

FIGURE 5



Filler gel installation schematic.

This product is produced in two parts. Part A is a high dosage of a specially designed liquid VCI concentrate that is mixed with water in the field. Part B is a superabsorbent polymer powder. These are nonhazardous, environmentally friendly products.

Installation is accomplished by pumping the liquid mixture into the annular space of a cased pipeline crossing (Figure 5). The superabsorbent powder is added into the liquid discharge stream as it flows to the casing. The powder absorbs the liquid over a short time period and converts it into a gel after it is delivered inside the casing. The gel bathes the carrier pipe with a corrosion inhibitor that has been proven to provide effective multiphase inhibition of corrosion for many years. It is applied at ambient temperature. An incomplete fill of the casing due to air pockets, etc. is not a concern because the inhibitor has a vapor phase component that will also provide corrosion control on the carrier pipe surface within any void space. Again, the system should also include modifications to the casing vents to prevent infiltration of fresh air.

Mitigation of annular space corrosion is accomplished through multiple processes:

- The filler is electrically conductive and allows migration of cathodic protection current to the carrier pipe surface.
- It contains a high dosage of proven corrosion inhibitors for long-term corrosion control at coating holidays and on the interior surface of the casing.
- The inhibitor migrates on a molecular level to mitigate corrosion under disbonded carrier pipe coating.
- The filler prevents the migration of oxygen and fresh water to the pipeline.

Conclusions

Pipeline operators are increasingly adding components to their integrity management programs that address mitigation of carrier pipe corrosion inside cased crossings. VCIs and VCI products provide an effective and economical way to evaluate, monitor, and mitigate corrosion inside casings. The environment inside a casing system is ideal for application of multiphase corrosion inhibitors.

References

1 Southwest Research Institute, "Statistical Analysis of External Corrosion Anomaly Data of Cased Pipe Segments," INGAA Foundation, Report No. F-2007-10, December 2007.
2 National Transportation Safety Board, "Pipeline Accident Report," Report No. NTSB PB87-916501, April 1987.
3 Ernest W. Kletchka, "Use of Corrosion Inhibitors on the Alaska Pipeline," Cortec Supplement to *MP* 40, 1 (2001).

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