Topic Paper #4-8

PIPELINES CROSSING UNDER ROADS/RAILROADS: CASED CROSSINGS VS. ENGINEERED UNCASED CROSSINGS

Prepared for the

Technology Advancement and Deployment Task Group

On December 12, 2019 the National Petroleum Council (NPC) in approving its report, *Dynamic Delivery – America's Evolving Oil and Natural Gas Transportation Infrastructure*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Permitting, Siting, and Community Engagement for Infrastructure Development Task Group. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached paper is one of 26 such working documents used in the study analyses. Appendix C of the final NPC report provides a complete list of the 26 Topic Papers. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

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Topic Paper (Prepared for the National Petroleum Council Study on Oil and Natural Gas Transportation Infrastructure)		
4-8	**Pipelines Crossing Under Roads/Railroads: Cased Crossings vs. Engineered Uncased Crossings**	
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SUMMARY

The improvements in horizontal directional drilling (HDD) have enabled natural gas and liquid petroleum pipelines to be installed under roads, rivers, levees, and railroads utilizing engineered designs that do not require a pipe casing or open cutting of ground surfaces. Historically, casings have been installed routinely at sites requiring additional structural support and mechanical protection in locations such as highway and railroad crossings. While offering structural support and mechanical protection, the casings themselves are susceptible to pipeline integrity threats that are unique to cased crossings. This topic paper addresses HDD technology development, the benefits of HDD for installing pipe, and the regulatory challenges to deploying HDD.

I. Introduction

The improvements in horizontal directional drilling (HDD) have enabled natural gas and hazardous liquid pipelines to be installed under roads, rivers, levees, and railroads utilizing engineered designs that do not require an additional pipe casing. This eliminates some of the corrosion problems caused by pipeline casing interference. However, there is still a lack of understanding and/or acceptance of uncased pipeline crossings. This lack of understanding results in some jurisdictions (e.g., railroad commissions or local/county bodies) requiring cased crossings that introduce additional long-term risks (e.g., corrosion of or damage to the pipeline). Collaboration and knowledge sharing are required to facilitate the acceptance of the benefits afforded by this construction and maintenance technology.

II. Integrity Threats Associated with Pipeline Casings and Steel Carrier Pipe

Historically, casings have been installed routinely at sites requiring additional structural support and mechanical protection in locations such as highway and railroad crossings. While offering structural support and mechanical protection, the casings themselves are susceptible to threats of external corrosion, internal corrosion, manufacturing-related defects, welding- and fabrication-related defects, third-party damage, and weather-related and outside force damage. There are four conditions that may exist at a casing that present varying degrees of corrosion threat to the carrier pipe. These include

- Electrically isolated casing with a dry annular space (isolated),
- Electrically isolated casing with the annular space filled with water and/or mud (electrolytic couple),
- A metallic contact (electronic short) between the casing and the carrier pipe with a dry annular space, or
- A metallic contact (electronic short) between the casing and the carrier pipe with the annular space filled with water and/or mud (electrolytic couple).

The first condition, isolated with a dry annular space, is the desirable condition as it provides the best conditions for cathodic protection to protect the carrier pipe from the threat of external corrosion. Though even with the desirable condition, the presence of the casing introduces challenges in assessing the condition of the carrier pipe and it's coating.

The second condition, isolated with a wet annular space, is acceptable provided measures are taken to ensure cathodic protection is reaching the carrier pipe. A variety of water displacing substances are used to prevent water and water vapor-related problems inside pipeline casings. Many are wax-based, or petrolatum-based agents that may provide an effective barrier between the pipe and potentially corrosive elements. These substances are designed to fill the casing. Unfortunately, the filling process doesn't always displace all fluids and solids, and these contaminates become trapped allowing corrosion to occur. The materials used are subject to degradation over time. It is difficult to measure or monitor on an on-going basis the effectiveness of these barrier agents due to the difficulty of detecting voids that can develop inside areas of the casing

The third condition, shorted casing with a dry annular space, is not acceptable; however, corrosion growth on the carrier pipe would likely be low. The fourth condition is not acceptable as the electronic short causes the casing to electrically shield the carrier pipe from cathodic protection and, with a corrosive media in the annular space, the carrier pipe is likely to experience significant external corrosion.

While there are measures that can be taken to promote isolation and a dry annular space between the carrier pipe and casing pipe (e.g., proper supports especially near the ends of the casing to prevent metallic contact, electrically nonconductive annular space filler, and casing end seals designed to prevent the ingress of water and debris), metallic contact and electrolytic coupling is a reality for the United States onshore pipeline industry. Current data and statistics provided publicly by Pipeline and Hazardous Materials Safety Administration (PHMSA) and the National Transportation Safety Board (NTSB) do not facilitate in-depth analytics of incident sub-causes such as corrosion within a casing; therefore, the impact of this threat to pipeline safety could not be readily quantified.

The assessment of the carrier pipe beneath casings is also considered an industry challenge for pipeline segments in which hydrostatic pressure testing and/or in-line inspection are impractical. Common alternative inspection technologies employed locally at each casing location are guided wave ultrasonic inspection and electromagnetic wave inspection. Additionally, in 2010, PHMSA published a technical report describing an external corrosion direct assessment (ECDA) methodology specifically to assess the cased pipe using indirect inspection techniques. The study provided guidelines for the ECDA of cased pipeline segments; however, it concluded the following[1]:

- "Standard Indirect Inspection surveys on cased pipe may produce definitive data for evaluating the condition of the coating and the effectiveness of cathodic protection, and for predicting the likelihood of corrosion, but only under specific conditions. As a minimum, specific conditions include electrical isolation of the pipe from the casing, a conductive electrolyte in the casing annulus, and a bare casing.
- Standard Indirect Inspection surveys on cased pipe will not produce definitive data for evaluating the condition of the coating and the effectiveness of cathodic protection, or for predicting the likelihood of corrosion, where:
- the pipe is electrically shorted to the casing,
- there is not a conductive electrolyte in the casing annulus, or
- where the casing is coated.
- The results of standard Indirect Inspection surveys on cased pipe are useful for ranking and prioritizing cased pipes for further integrity assessment and/or remedial action.
- Additional research and testing is required to develop methods for ascertaining the validity of standard Indirect Inspection survey data collected on cased pipe."

Considering the practicality challenges of systemwide assessment of carrier pipe within casings and with today's design capabilities and available industry guidance, the risk of external corrosion under the casing can be higher than the threats that casings are installed to mitigate. Section 3.1.1 of NACE SP0200-2014[2] states that *"Unless prohibited by regulation or right-of-way agreement, consideration should be given to adding supplementary carrier pipe wall thickness or pipe burial depth, in lieu of casing (refer to API RP 1102 or other applicable standards)."*

III. Regulatory and Societal Challenges

Jurisdictional requirements regarding the use of casings varies from natural gas to hazardous liquids and from federal to state level regulations. It is considered beneficial to the pipeline industry if the regulations were consistent and allowed for the use of one or more methodologies to design the carrier pipe in such a way to mitigate any needs of additional mechanical

[1] "Improvements to the External Corrosion Direct Assessment (EDCA) Process (WP #360) – Cased Pipes (Project #241)". Department of Transportation – Pipeline and Hazardous Materials Safety Administration (PHMSA). June 2010. Accessed: February 25, 2019.
[2] "Steel-Cased Pipeline Practices" NACE International, Standard Practice. NACE SP0200-2014.

protection. The following subsections summarize the various regulations specified by the federal and state levels.

a) Hazardous Liquids

Title 49 CFR Part 195.256 requires that constructed pipelines installed at railroad and highway crossing must adequately withstand the dynamic forces at the crossing.

With the exception of an excavation criterion related to cased pipe in Appendix C, Part 195 does not address the installation of casings for mechanical protection of hazardous liquid pipelines.

b) Natural Gas Pipeline

Title 49 CFR Part 192 does not specifically require casings at crossings, but rather §192.111 requires a design factor of 0.60 or less in the §192.105 design formula for steel pipe in Class 1 locations that (1) cross the right-of-way of an unimproved public road, without a casing, (2) crosses without a casing, or makes a parallel encroachment on, the right-of-way of either a hard surfaced road, a highway, a public street, or a railroad. For Class 2 locations, a design factor of 0.5, or less, must be used in the design formula in §192.105 for uncased steel pipe that crosses the right-of-way of a hard-surfaced road, a highway, a public street, or a railroad. Additionally, §192.323 contains requirements with which casings must comply, if installed.

c) State Regulations

According to NAPSR and NARUC[3], there are a number of state regulations related to casings that exceed those specified in federal regulations. As indicated in Table 1, the state regulations introduce a level of variability in the regulations.

Table 1 – State regulations related to casings that exceed those specified in the federal regulations

Federal Regulation	Additional or More Stringent State Requirement	State	State Regulatory Body
§192.323	Casings prohibited on metallic pipelines	Florida	Natural Gas Safety Rules of the Florida Public Service Commission, Chapter 25-12
§192.323	All Railway and Highway crossings with a pipeline require a casing and must be at installed at 90 degrees to traveled way when operating >200 psig	Massachusetts	Department of Public Utilities, Code of Massachusetts Regulations,

[3] "Compendium of State Pipeline Safety Requirements & Initiatives Provided Increased Public Safety Levels compared to Code of Federal Regulations" National Association of Pipeline Safety Representatives (NAPSR) and the National Association of Regulatory Utility Commissioners (NARUC). Second Edition, September 9, 2013.

Federal Regulation	Additional or More Stringent State Requirement	State	State Regulatory Body
	All highway crossings with a pipeline require a casing and must be 54 inches of cover to the top of the casing and the casing shall extend 25 feet beyond the pavement or to the ROW when operating >200 psig		Title 101 General Requirements
§192.323	Casing requirements of highway authorities shall be followed; however, construction type shall not be any less than provided by 49 CFR 192.323	Wisconsin	Wisconsin Administrative Code, Public Service Commission (PSC) Chapter 135 Gas Safety Subchapter II Additions to 49 CFR Part 192
§192.323	Whenever a steel pipeline is installed under a railroad track and a casing is not used, the operator shall install the pipeline using the methods prescribed in Gas Research Institute report number GRI−91/0285, entitled "Guidelines for Pipelines Crossing Railroads and Highways."	Wisconsin	Wisconsin Administrative Code, Public Service Commission (PSC) Chapter 135 Gas Safety Subchapter II Additions to 49 CFR Part 192

d) Societal Challenges

A brief overview of the Federal Railroad Administration (FRA) regulations (Title 49, Subtitle B, Chapter II) determined it was silent on below grade crossings and did not contain any reference to pipelines. Despite the lack of regulatory requirements, railroad operators, in general, are resistant to allowing pipeline crossings of their rights-of-ways without installation of a casing.

IV. Technology Applications

There are a number of design methodologies that are available and proven, including the following:

- API 1102 offers design considerations for uncased crossings but has limitations to its methodology (i.e., 3 feet of cover)
- CEPA offers a modified Spangler Stress Equation with Soil Restraint for a screening methodology for pipelines subject to surface traffic.[4]

[4] "Development of a Pipeline Surface Loading Screening Process & Assessment of Surface Load Dispersing Methods" Canadian Energy Pipeline Association (CEPA) Final Report No. 05-44R1. Revised October 16, 2009.

- GRI commissioned a report that developed "Guidelines for Pipeline Crossing Railroads and Highways" and is likely complimentary to GRI's "Guidelines for Pipelines Crossing Railroads."[5]

It is anticipated that if pipeline regulations regarding uncased engineered crossings based on these design methodologies are aligned and made consistent, it would provide other industries such as the railroad and highway industries with greater confidence to transition away from the blanket requirement for installing casings at all crossings.

[5] "Guidelines for Pipelines Crossing Railroads" Gas Research Institute. Transport and Storage Research Department, December 1991. Prepared by: School of Civil and Environmental Engineering, Cornell University. (GRI-91/2083