

Laboratory and Full-Scale Qualification of an Abrasion Resistant Overcoat Wrap

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ABSTRACT

As onshore pipeline rights-of-way become more congested and urban sprawl increases, the number of horizontal directional drills (HDDs) will likely increase. HDD is a trenchless pipeline installation method that requires drilling a larger pilot hole where the mainline pipe can be subsequently pulled through the drilled hole. However, HDDs have an increased probability for coating damage, even when coated with traditional mill or field applied abrasion resistant overcoat (ARO). This coating damage includes abrasion, impact, gouging, denting, tearing, bending, etc. and that damage may exist for the life of the pipeline due to an HDD being inaccessible for future maintenance. Therefore, there remains a need for a high quality, sacrificial overcoat to protect the underlying coating, both on the mainline and field joints.

This paper details the development of a new moisture-cured urethane ARO to provide protection within an HDD installation. Traditional laboratory test methods referenced in AMPP (formally NACE), CSA, or ASTM examines a coating product on a wide range of material properties on a subscale level. While the coupon-level laboratory abrasion and gouging test provides a good sub-scale metric, they are not truly representative of the gouging risk that exists when a pipeline is being pulled through an HDD. To address the shortcomings of the sub-scale testing regimen, a comprehensive full-scale test program was developed and executed to compliment the sub-scale test results to demonstrate the ability of the developed ARO to resist damage when subjected to an array of gouging instruments and loading conditions. These results provide the end user with a more representative test set to gain confidence when choosing the appropriate product to provide protection during an HDD.

Key words: Coating (process), Coatings, Protective Coatings, Abrasion, Impact, Materials Performance, Erosion Resistance, Infrastructure, Standardization, Test Methods

INTRODUCTION

As onshore pipeline rights-of-way become more congested and urban sprawl increases, the number of horizontal directional drills (HDDs) will likely increase. HDD is a trenchless pipeline installation method that requires drilling a larger pilot hole where the mainline pipe can be subsequently pulled through the drilled hole. However, HDDs have an increased probability for coating damage, even when coated with traditional mill or field applied abrasion resistant overcoat (ARO). This coating damage includes abrasion, impact, gouging, denting, tearing, bending, etc. and that damage may exist for the life of the pipeline due to an HDD being inaccessible for future maintenance. Therefore, there remains a need for a high quality, sacrificial overcoat to protect the underlying coating, both on the mainline and field joints. A representative photograph of coating damage occurring during an actual HDD is shown in Figure 1. In this example, gouging occurred along the length of the pipe, both to the FBE+ARO base coating and sacrificial overcoating.



Figure 1: Photograph of representative coating damage during an HDD.

The loading subjected to the pipeline during an HDD pull is a function of the axial force required to pull the given pipeline through the drilled hole (dependent on the pipe outer diameter and wall thickness), any ballast or mud used during the pull, and the resultant friction between the pipe and formation (dependent on the pull angle)^{1,2}. Assuming the same pull angle and ballast/mud, increased force would be subjected to the pipeline as the pipe's weight increases.

This paper provides an innovative approach to test and validate an ARO coating system to provide protection during HDD installations. While current industry standards focus on subscale laboratory testing, this paper outlines a more representative full-scale testing approach. A laboratory pull-test set-up is more representative of an actual pull-through as the pipe (and ARO coating) is pulled past obstructions, where the force resulting from obstructions to the ARO can vary. Laboratory bench-top subscale testing provides a reproducible quality check; however, the test doesn't fully represent a pipeline being pulled through a drilled hole. One such sub-scale test is the Taber Abrasion test, which imparts a circular abrasion pattern in a single given area at loads lower than what might be expected during an HDD. Therefore, this study supplements the traditional laboratory bench-top testing with a full-scale alternative designed to represent a pipe being pulled through a drilled hole – by controlling both the obstruction and the load applied by that obstruction.

EXPERIMENTAL PROCEDURE

To better develop and qualify a new sacrificial overcoat, both sub-scale laboratory and full-scale tests were performed and are discussed in the subsections below. Laboratory testing is widely accepted, whereas the innovative full-scale test that is the subject of this paper provides a more representative testing scenario to simulate the conditions during an HDD.

Laboratory Testing

Several laboratory bench-top tests were performed to qualify the ARO overcoat system. This included tensile tests, Taber Abrasion, and sub-scale gouge testing of the polymer matrix. Representative panels, 12-inches x 12-inches x 0.25-inch (0.3-m x 0.3-m x 6.4-mm), were fabricated using a vacuum table during the curing process, shown in Figure 2. This vacuum table helps to debulk composite materials by ensuring a consistent wet-out and cure under the application of a vacuum.

Tensile tests were performed to ASTM D3039³, Taber Abrasion was performed to ASTM D4060⁴, and subscale gouge testing was performed to CSA Z245.20, Section 12.15⁵.



Figure 2: Preparation of composite panels.

Full-Scale Testing

A full-scale testing rig was designed and fabricated, as shown in Figure 3. This full-scale test rig consisted of an I-Beam containing a track with a testing cage centered along the beam's length. Within the testing cage, three pneumatic cylinders were installed 90 degrees from each other. Each pneumatic cylinder was affixed with a different type of obstruction. Using a high-load winch, a pipe sample containing the ARO overcoat was pulled through the testing cage while the obstructions were pushed radially against the pipe at a predefined load. The obstructions, shown in Figure 4, were as follows:

- Granite block: A granite block with a cross section of 2.25-inches (57-mm) x 1.25-inches (32-mm) selected to represent rock found in a natural formation that might be encountered during an HDD.
- Round tip: 2.375-inches (60-mm) round cap selected to represent wear while pulling through a drilled HDD hole.
- Carbide-tipped machining inserts: Three spaced carbide-tipped lathe inserts meant to simulate aggressive gouging that may occur during an HDD, similar to that observed in Figure 1.

A photograph of the assembled testing cage is shown in Figure 5.

The number of layers, as well as the applied radial load, was varied throughout the testing. Presumably, an increased layer count (resulting in an increased thickness) would provide additional resistance from increased applied load. Therefore, the following was examined:

- 2 layers with a 50% overlap (0.2-inch (5-mm) thick)
- 4 layers with a 75% overlap (0.4-inch (10-mm) inch thick)

The pneumatic cylinders contained a bore, 4.5-inch (114.3-mm) in diameter and were actuated using nitrogen gas bottles with a regulator applying sufficient gas to apply radial force of approximately 250 lbf (1.1 kN), 500 lbf (2.2 kN), and 1,000 lbf (4.4 kN) in separate test pulls. This applied load was selected based on calculated typical normal forces experienced during an HDD.

All testing was performed after the coatings cured for approximately 24 hours resulting in a hardness of at least 65 Shore D. The coating was visually examined after completing the test to document the ability of the coating to resist damage, especially damage extending to the base pipe.

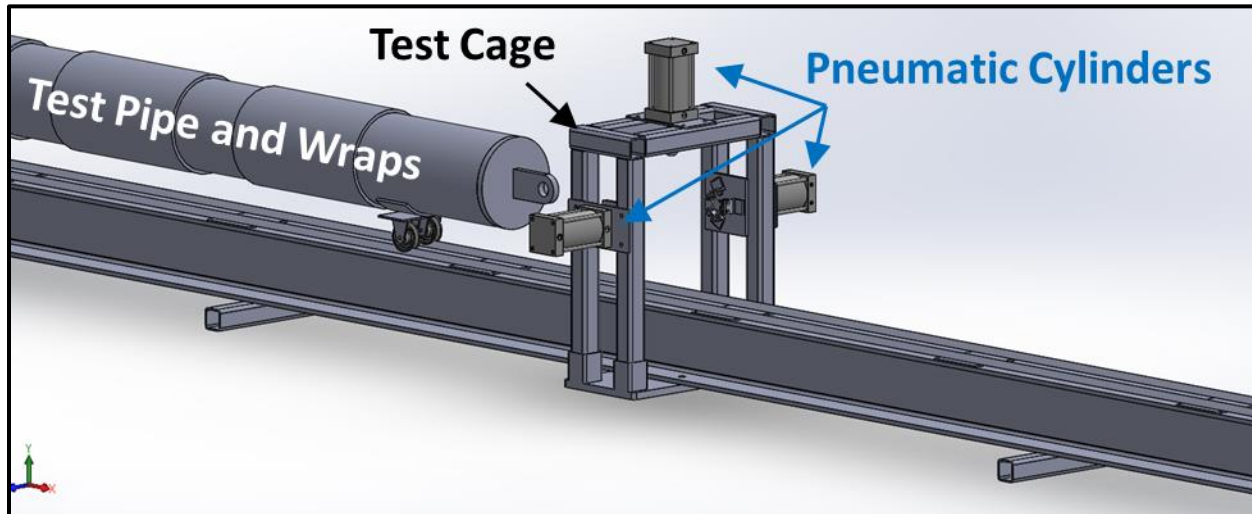


Figure 3: Screen capture of test rig design.

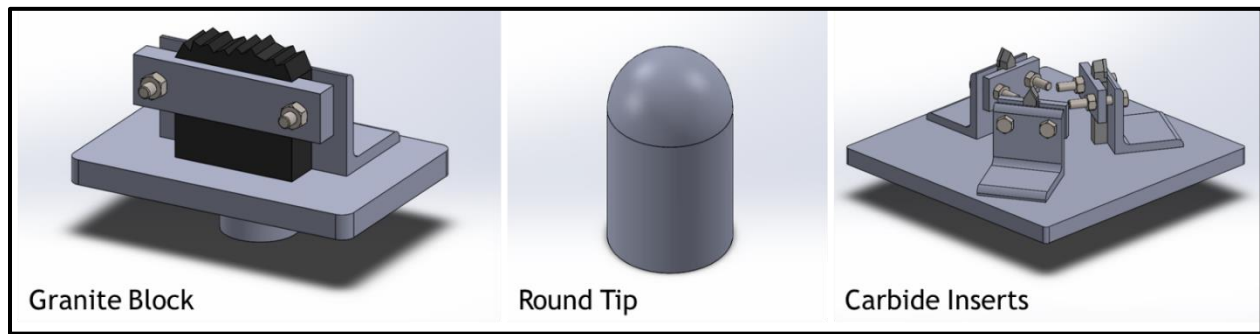


Figure 4: Screen capture of designed obstructions used during full-scale test.