Polyethylene (PE) Pipes and Fittings for Gas Distribution

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Introduction

Polyethylene (PE) plastic pipe and fittings are the main materials currently used in new medium- and low-pressure natural gas distribution systems and to repair older steel and cast iron systems. While PE has many advantages over steel in terms of corrosion resistance and ductility, its use nonetheless carries risk, especially near joints. During investigation of several recent field failures in PE gas distribution pipelines, Exponent discovered that bentonite clay, used extensively during horizontal drilling to install PE piping, can act as a surface contaminant prohibiting effective joint fusion and integrity.

As with steel, joining of PE pipe and fittings requires skilled workers following verified procedures. Unlike steel, PE under stress is known to have finite life as an unavoidable result of polymer physics. Accordingly, it is a fundamental design principle that the finite life must far exceed any reasonably anticipated service lifetime.

Discussion

Bentonite clay is an ingredient of drilling mud that is used extensively drilling mud for oil and gas wells and boreholes for geotechnical and environmental investigations. We found that PE electrofusion saddle joints were at particular risk of failure due to bentonite contamination. In these joints, resistance heater wires are built into the fitting at the interface where the pipe and saddle are fused together. However, when present, bentonite can form an invisible barrier that impairs effective fusion. Our work led to the development and validation of revised field cleaning procedures to reduce the risk of contamination. We also found, based on laboratory bend tests, that fusion joints could better tolerate exposure to other plausible contaminants, like machinery grease and certain native soils. Exposure of the joint to bentonite therefore presents a greater risk of joint failure than exposure to these other contaminants.
When presented with failed PE assemblies, it is still important to test the fitting and pipe materials in case deficiencies in the materials themselves may have contributed to the failure. A suite of analytical and material characterization techniques is normally used to determine whether materials may have degraded and/or are in accord with manufacturer specifications. For example, gel permeation chromatography (GPC) can be used to determine whether polymer molecular weight distributions are in the expected range. Understanding the pipe and fitting material properties at the molecular level can aid in determining the cause of failures.

Exponent is often asked to help determine whether new gas distribution components such as valves and fittings satisfy specific performance or technical specifications. Exponent has tested components according to utilities’ internal specifications and according to ASTM standards, such as ASTM D2513. Exponent’s in-house laboratories and testing capabilities include accelerated life testing to estimate the long-term durability of new products and materials and pressure-testing of gas valves for leak resistance. Such tests often involve exposing them to hot and cold temperatures, as well as reasonably anticipated external stresses while monitoring for leaks and other signs of failure via remote video feeds.

Summary

Polyethylene pipes and fittings are widely utilized for gas (and water) distribution. Maintaining their integrity is critical to long-term use without incident. It is important to not only ensure that new products are fit for their intended use, but also to understand the effect of environmental factors during installation and use. We have found that contamination with compounds such as bentonite-based clay that is commonly used in horizontal-directional drilling mud can prevent effective joint fusion, potentially creating leaks with adverse ramifications.

With mechanical engineering and polymer materials expertise as well as testing facilities in-house, Exponent routinely solves client problems involving PE distribution pipes and fittings.

Authors

Richard W. Klopp, Ph.D., P.E.
Principal Engineer, Mechanical Engineering
(650) 688-6777 | rklopp@exponent.com

Stephanie Benight, Ph.D.
Managing Scientist, Polymer Sciences & Materials Chemistry
(650) 688-7119 | sbenight@exponent.com