Electrostatic Pinholing in PE Service Lines

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Abstract

This article will document a case of pinholing in PE natural fuel gas distribution pipe that has significant implications for local distribution companies (LDCs).

Most operators see static in PE pipe as only a safety issue. However, this incident will show how static in PE pipe can cause pinhole leaks and unaccounted gas.

Memphis Light Gas and Water installed a 1" IPS PE service line according to the PE pipe manufacturer's recommendations. After installation the service line passed the pressure test for integrity and was stubbed for later service installation. No gas flowed through the line. Two months later, the line was reopened for installation of the gas service. After the service was installed, the line was again pressure tested. Although the pipe was never in service, the PE pipe service line failed to hold pressure. The pipe was removed from the ground and returned to the manufacturer for inspection and testing where tests revealed the pinholes were caused by electrostatic discharge while the PE pipe was buried underground and not in service. This paper will review the probable cause of this damage, what LDCs need to look for to determine if the pinholes are caused by electrostatic discharge (the morphology of pinholes) and the service implications for LDCs of electrostatic pinholing in PE pipe.

Introduction

PE fuel gas pipe is used extensively throughout the US. Because PE pipe is inexpensive, easy to install and has a long service life, it is the material of choice for fuel gas distribution for LDCs. However, if this material is damaged beyond repair and must be replaced, it becomes a very expensive problem. This article will consider how a common industry practice can cause electrostatic pinholing and can damage installed PE pipe beyond repair requiring removal and replacement.

Background

The first field evidence of electrostatic pinholing was documented in an article in 1989 by Mark Staker at Mountain Fuel Supply. In 1984 Mountain Fuel repair crews discovered an electrostatic pinhole leak after a squeeze-off procedure. Additional research of industry reporting pinholing incidents discovered pinholing during purging and through multi saddles and inline tees when 3rd party damage breaking a service line resulted in increased gas flow.

What is pinholing?

Pinholing is the creation of a hole between the inside and outside walls of the pipe. It can be caused by a material defect or electrostatic discharge.

Electrostatic pinholing occurs when electrostatic charges elevate to a sufficient level to overcome the dielectric strength of the pipe material. This results in a hot arc from the charge to ground, melts the material, and in the process, creates a leak.

The voltage necessary to create a pinhole is dependent upon the dielectric strength characteristics of the material and the thickness of the material. The thicker the material, the higher the voltage necessary to overcome the dielectric strength of the material. The dielectric strength for HDPE is 510 V/mil.

The Event

A subcontractor for Memphis Light Gas and Water installed a 1" IPS PE service line. After installation, the service line was pressure tested and passed the pressure test.

It was stubbed for later connection to service. No gas flowed through the line. Two months later, a MLGW crew returned to connect the line to the service. After service was connected and the line was again pressure tested, this time, however, the line failed the pressure test. MLGW crews removed the PE pipe from the ground and performed a hydrostatic pressure test above ground. It failed the pressure test again above ground and demonstrated numerous pinhole leaks throughout the PE pipe. Because of the failure, a claim was filed against the contractor for faulty installation. The contractor maintained there was nothing faulty in his installation.

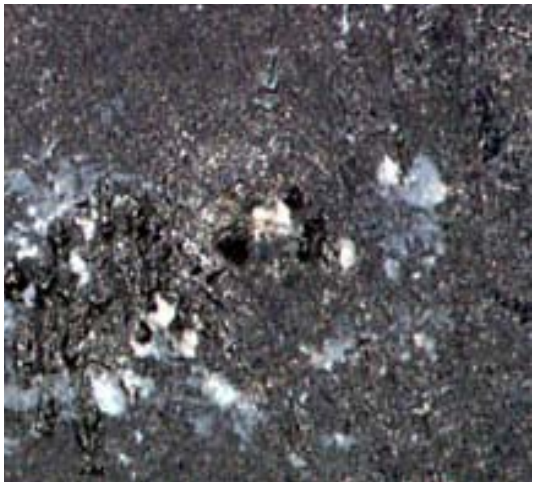
MLGW has been in operation since 1939. As a municipal utility, MLGW furnishes 60 billion cubic feet of gas per year to its 305,000 gas customers. Therefore, MGLW crews are well experienced in handling PE pipe.

Materials Analysis

The PE pipe removed from installation by MLGW crews as well as the balance of the coil from which the installed pipe was taken were shipped to the manufacturer, Performance Pipe, for materials testing at their Plastics Technical Center in Bartlesville, OK. When the manufacturer pressure tested the damaged pipe, numerous pinholes were prevalent at 80PSI. There were no pinholes present in the remaining pipe on the original coil. The manufacturer checked all production records for the damaged pipe. All production records showed the PE pipe was manufactured to specifications. Additionally, samples of the damaged PE pipe were sent to the resin supplier and all properties tests for the material were normal. A review of the resin lot failed to turn up anything out of the ordinary with the resin material or its manufacture. No regrind material was used in the manufacture of the pipe.

Investigation by the pipe manufacturer revealed numerous pinholes throughout the damaged pipe. Sectioning the pipe under a light microscope the pipe manufacturer documented a channel through the pipe wall. The pipe samples were section cut under a microscope. The shape or characteristic of the pinhole channel was consistent with electrostatic pinholing.

Interior pinhole of damaged pipe



Exterior pinhole of damaged pipe

Probable Cause

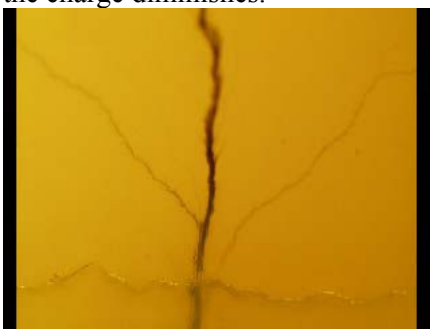
Based upon their investigation, the pipe manufacturer determined the probable cause of the pinholing was electrostatic discharge. The manufacturer's test lab concluded that during the filling of the pipe with air for pressure testing and the resulting release of the air at the end of the test, the volumes and velocity of the air and the condition of the air, (i.e. sometimes referred to as dirty air) resulted in the buildup of a static charges that exceeded the dielectric strength of the material thickness found in the wall of a 1 inch pipe. With a 0.122 inch nominal wall thickness and a dielectric strength of 510 V/mil, the voltage that was necessary to cause the resulting pinholes were calculated to be a minimum of 62,220 volts! For comparison purposes, approximately 2000 volts will ignite a gaseous mixture. Performance Pipe found dirt clogging the pinholes of the damaged pipe indicating dirt was present in the pipe at the time pinholing occurred.

Morphology or shape of pinhole channel

LDCs need to know how to identify electrostatic pinholing. The morphology or shape of the pinhole channel identifies whether the pinhole is a material defect or due to electrostatic discharge.

The morphology of channels caused by electrostatic discharge are distinctive in 2 aspects. First, the diameter of the pinholes on the inside and outside will be different. One pinhole will be substantially larger than the other. This is because the electrostatic voltage charge is higher one side of the pipe wall than the other. When discharge occurs and the voltage drops, the heat from the static declines and the final exit hole diameter is smaller. The larger hole indicates where the charge started and the small hole indicates where it ended.

The second distinctive of the morphology is the shape of the channel. The channel will be tree shaped with branching. There will rarely be a direct channel through the pipe wall and the channel will become smaller as the charge diminishes.



Typical channel of electrostatic discharge

Material defect pinholes, unlike the distinctive shape of the tree, will generally be a single channel with no branches.

Implications of the event

Before this event, it was thought that only in unusual service applications over time would pinholing occur to the degree that would render the PE pipe not repairable. This event disproves that assumption. Field experience is showing that there are more numerous occasions for electrostatic pinholing to occur than previously thought.

Some operators believe the use of regrind material might contribute to pinholing. However, according to Performance Pipe, the use of regrind in pipe should not change the dielectric strength of the pipe providing similar resins are mixed.

Electrostatic pinholing can be an expensive problem. PE pipes with pinholes must be replaced since they cannot be repaired. Since the damage in this event was due to the electrostatic discharge of the pipe, the contractor was not held liable. Therefore MLGW absorbed the cost of $3,641.92 for the replacement of the line.

Not only does electrostatic pinholing cause significant repair issues, it causes unaccounted gas. The service line in this incident had 8 pinholes with an average size of .75mm. At an operating pressure of approximately 99 psi, these 8 leaks would release 880 cfh. Each year the leaks in this

line were undetected, the gas loss would be 7,708,800 cf per year.

In this failure event at MLGW, the damage was discovered. How much pinholing is occurring, however, which is not discovered? When Mark Staker at Mountain Fuel advised crews to soap all squeeze offs in the two weeks after the initial discovery of electrostatic pinholing, Mountain Fuel crews reported six additional instances of electrostatic pinholing during squeeze off. In preparation for this paper, an operator advised us that during routine leak surveys of residential services at his company, they discovered numerous small leaks in ½ and ¾ inch service lines. The service lines were uncovered and soaped. Small bubbles appeared on the surfaces. The operator said that although the leaks didn't cause a pressure drop they were detectable. The utility assumed it was defective pipe. In retrospect, he suspects the cause was probably electrostatic pinholing since all the pipe passed pressure tests at the time of installation which indicates no material defect from manufacturing was present at the time of installation.

This type of electrostatic pinholing would most likely be caused by a 3rd party pipe break causing a unrestricted flow of gas through the system. Upstream from the break the rushing gas would act just like a line purge causing undetected pinholing in a system unknown to operators until detected by leak surveys years later. The break would be repaired and there would be no indication that upstream of the break numerous pinhole leaks were created by the line break.

Conclusion

This event brings to full circle the events that can cause pinholing. In virtually all distribution operations the possibility of electrostatic pinholing, although slight, can occur. Operators need to be aware of the possibility of pinholing because if pinholing does occur, replacement of pinholed lines is the only - and expensive - remedy.

Static in PE pipe, normally seen as primarily a safety issue, has the possibility of becoming primarily a system integrity issue. As this problem becomes more widely understood, we can expect more reports of numerous unexplained small leaks.

In order to determine the extent of electrostatic pinholing, the industry monitoring of electrostatic pinholing by the Plastic Pipe Database Committee would be well advised.

Images courtesy of Pam Maeger at CPChem Technical Center.
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