Electrostatic Pinholing Can Cause Serious Problems For LDCs

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Most operators of local distribution companies (LDCs) see static in polyethylene pipe as only a safety issue. However, the incident discussed here will show how static in PE pipe can cause pinhole leaks and unaccounted for gas, thus having significant implications for gas utilities.

Memphis Light, Gas and Water installed a 1-inch 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 article 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.

PE fuel gas pipe is used extensively throughout the United States. 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 requires replacement, it becomes a very expensive problem. A common industry practice can cause electrostatic pinholing and can damage installed PE pipe beyond repair, requiring removal and replacement.

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 third- party damage resulted in breaking of a service line and 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 that melts the material, and in the process, creates a leak.

The pinholed pipe removed from the ground and coiled to be shipped back to Performance Pipe.

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 that is necessary to overcome the dielectric strength of the material. The dielectric strength for HDPE is 510 V/mil.

The Incident

A subcontractor for Memphis Light, Gas and Water installed a 1-inch IPS PE service line. After installation, the service line was successfully pressure tested. 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, the line was again pressure tested, this time unsuccessfully. MLGW crews removed the PE pipe from the ground and performed a hydrostatic pressure test above ground. It failed that test as well and demonstrated numerous pinhole leaks throughout the PE pipe. Because of the failure, a claim was filed against the contractor for faulty installation. But the contractor insisted there was nothing faulty in the installation.

MLGW has been in operation since 1939. As a municipal utility, MLGW furnishes 60 Bcf of natural gas annually to its 305,000 gas customers. Therefore, MGLW crews are well-experienced in handling PE pipe.

Materials Analysis

The PE pipe removed 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 its Plastics Technical Center in Bartlesville, OK. When the manufacturer pressure tested the damaged pipe, numerous pinholes were prevalent at 80 psi. There were no pinholes present in the remaining pipe on the original coil. The manufacturer checked all production records for the damaged pipe, which showed the PE pipe was manufactured to specifications. Additionally, samples of the damaged PE pipe were sent to the resin supplier and 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 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.

Probable Cause

Based upon its 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 was calculated to be a minimum of 62,220 volts. For comparison purposes, approximately 2,000 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 is due to electrostatic discharge.

The morphology of channels caused by electrostatic discharge are distinctive in two 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 electro-

static voltage charge is higher on one side of the pipe wall than the other. When discharge occurs and the voltage falls, 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 distinction 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.

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

Implications

Before this event, it was thought that only in unusual service applications, over time, would pinholing occur to the degree that the PE pipe could not be repaired. But this event disproves that assumption. Field experience is showing that there are numerous occasions when electrostatic pinholing can occur than was 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, provided that similar resins are mixed.

Electrostatic pinholing can be an expensive problem. PE pipes with pinholes must be replaced since they cannot be repaired. Because the damage described here 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 lead to significant repair issues, it also causes unaccounted-for gas. The service line in this incident had eight pinholes with an average size of .75 mm. At an operating pressure of approximately 99 psi, these eight leaks would release 880 cf/h. Each year that the leaks in the line remained undetected, the gas loss would total 7,708,800 cf.

In this failure event at MLGW, the damage was discovered. However, how much pinholing is occurring that 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's crews reported six additional instances of electrostatic pinholing during squeeze off.

In preparation for this article, an operator advised that during routine leak surveys of residential services at his company, they discovered numerous small leaks in one-half and three-quarter-inch service lines. The service lines were uncovered and soaped. Small bubbles appeared on the surfaces. The operator said that although the leaks did not cause a pressure drop, they were detectable. The utility assumed it was defective pipe. In retrospect, he suspects the cause was probably electrostatic pinholing because all the pipe passed pressure tests at the time of installation, which indicates no material defect from manufacturing was present at the time.

This type of electrostatic pinholing would most likely be caused by a third- party pipe break creating an 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 until detected by leak surveys years later. The break would be repaired and there would be no indication that, upstream, numerous pinhole leaks were also created.

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 it does occur, replacement of pinholed lines is the only — albeit expensive — remedy.

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

In order to determine the extent of electrostatic pinholing, the industry's monitoring of electrostatic pinholing by the Plastic Pipe Database Committee would be well-advised. ***P&GJ***

The authors wish to thank to Pam Maegerat CPChem Technical Center and Mark Staker at Questar for their technical assistance.