Understanding Graphitization Risk

Pennsylvania Public Utility Commission
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Understanding Graphitization Risk

Outline

Who needs to focus graphitization risk

What is graphitization

How to identify it

Assessing the Risk

Why this is important
The Who Is Simple
Whoever has **cast iron** pipes in their systems that are old or subject to corrosive conditions.
Prior to steel, cast iron was widely used for pipeline construction.
The Who

In 2012: 34,000 miles of cast iron main lines and 15,000 miles of service lines
The Who

**Cast iron** pipe now found mostly in:

NJ, NY, MA, PA, MI (main lines)

large cities (service lines)

e.g., NYC, Boston, Washington, Philadelphia
What Is Graphitization
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Selective leaching of iron from cast iron

Cast iron is a combination of iron and graphite

When the iron exits, that leaves graphite behind
What Is Graphitization

The result is a weakened and brittle pipe

But to the eye, the pipe may look unaffected
What Is Graphitization

Maybe we should rename it, de-ironification

Then it would be easier to understand
What Is Graphitization

Other examples of selective leaching:

the de-Zincification of brass

the de-Calciﬁcation of bones
(better known as osteoporosis)
How to Measure Graphitization
How to Measure Graphitization

The HAMMER method

“Clang and Clunck”
Sensing Graphitization Non-Destructively

Localized leaching of iron during graphitization changes the magnetic permeability of the pipe.

This can be used to detect graphitized areas.
The Method

Prototype sensor being used to measure the thickness of inset graphite patches
Measured voltage varies as the graphite layer gets thicker.
Sensing Graphitization Non-Destructively

Dr. Zee’s patent: US 7719266 B1

Pipes undergoing graphitization may appear sound.
Sensing Graphitization Non-Destructively

Dr. Zee’s patent: US 7719266 B1

Graphitized regions of pipe wall will be brittle and subject to failure under load as the result of temperature variation, heavy traffic, or shock.
Sensing Graphitization Non-Destructively

Dr. Zee’s patent: US 7719266 B1

A sensor measures the interaction of an applied magnetic field to a sample surface that includes magnetic materials to determine whether the samples surface has been corroded.
How to Measure Graphitization

... when the pipe is underground?
What is Risk
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The nature of risk is *uncertainty*
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Desired outcomes are inherently under threat of failure due to events that may occur during the asset life-cycles
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The nature of risk is *uncertainty*

Desired outcomes are inherently under threat of failure due to events that may occur during the asset life-cycles

Such events vary in their degree of probabilistic occurrence, magnitude of impact (severity), and manageability
Key Risk Factors in Graphitization

- Age
- Soil chemistry
- Soil resistivity (soil conductivity)
- Stray current
- Corrosion rate
Key Risk Factors in Graphitization

Age

Cast iron pipe has been in use in the U.S. for over 150 years

Ductile iron pipe could be up to 60 years
Key Risk Factors in Graphitization

- Soil chemistry
- Soil resistivity (soil conductivity)

- Chlorides, sulfates, sulfides
- Low soil resistivity (high conductivity)
- Acidity (low pH)
- Wet-dry fluctuations
- Differential aeration
Key Risk Factors in Graphitization

- Stray current
- Corrosion rate
Proactive Steps

Comprehensive surveys
  e.g., correlate by age, soil conditions, impact, priority test, access, history, electrical test

Cathodic protection

Pipe replacement

Risk-based inspection program
Proactive Steps

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Risk-based inspection program
Why Is This Important

There are widely recognized risks associated with cast iron pipe in natural gas systems.

Graphitization is a dominant factor.
“About every other day over the past decade, a gas leak in the United States has destroyed property, hurt someone or killed someone”

“cast-iron pipe — some of it more than a century old — . . . is the chief suspect”

(USA TODAY Network)
A Notice by the PHMA on 03/23/2012

Pipeline Safety: Cast Iron Pipe
(Supplementary Advisory Bulletin)
the need for continued safety improvements to aging gas pipeline systems urges owners and operators to conduct a comprehensive review of their cast iron distribution pipelines and replacement programs (PHMA)
Summary

Who needs to focus graphitization risk

What is graphitization

How to identify it

Assessing the Risk

Why this is important
Conclusions

Graphitization introduces serious risk
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Non-destructive magnetic detection of graphitization is feasible
Conclusions

Graphitization introduces serious risk

Non-destructive magnetic detection of graphitization is feasible

Risk assessment should be applied
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Thank you for attending

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Question & Answer