



Unprotected Steel Rehabilitation Considerations

ARPA-e Workshop – REPAIR

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75-year History of Turning Raw Technology into Practical Energy Solutions

FOR A BETTER ECONOMY AND A BETTER ENVIRONMENT

SUPPLY



CONVERSION



DELIVERY



UTILIZATION



RESEARCH & DEVELOPMENT



PROGRAM MANAGEMENT



TECHNICAL/ANALYTICAL



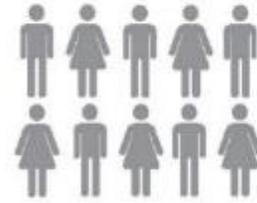
CONSULTING



TRAINING



COMMERCIALIZATION



EMPLOYEES



World-class piloting facilities headquartered in Chicago area

GTI's Energy Delivery R&D Program Summary

- GTI has an expanding R&D portfolio focused on industry priorities:
 - Safety, Integrity, Reliability, Operational Efficiency, and the Environment
- Work closely with gas industry customers, Federal and State government agencies, and industry suppliers to:
 - Bring exciting new technologies and products into development
 - Push for implementation of results
- Collaborative R&D efforts:
 - Highly cost effective
 - Leverages collective intelligence and experience of funders to develop the best possible solutions



GTI Managed Collaborative Organization



Operations Technology Development (OTD)

Mission

- Identify, select, fund, and oversee research projects resulting in innovative solutions and the improved safety, reliability, and operational efficiency of natural gas systems

Goals

- Enhance safety
- Enable operational excellence
- Minimize environmental impact
- Provide good science

OTD Working Groups

- > Smart Utilities
- > Risk & Integrity Management and Environmental Matters
- > Infrastructure and Gas Operations

OTD Members

Serving 50 million gas consumers in the US and Canada



<p>27 member organizations</p>	 <small>Southern California Gas Company</small>  <small>A Semptra Energy utility</small>	 Pacific Gas and Electric Company		 SOUTHWEST GAS
 Ameren <small>FOCUSED ENERGY. For Life.</small>	 conEdison	 CenterPoint Energy	 Entergy	 PEOPLES GAS <small>NATURAL GAS DELIVERY</small>
 INTERMOUNTAIN GAS COMPANY <small>A Subsidiary of MW Resources Group, Inc.</small>	 NYSEG RG&E	 National Fuel	 AVISTA	 NiSource
 NW Natural <small>We grew up here.</small>	 <small>APGA Research Foundation</small>	 Oklahoma Natural Gas. <small>A Division of ONE Gas</small>	 ENBRIDGE	 Washington Gas <small>A WGL Company</small>
 Dominion Energy	 Nicor Gas	 TECO. <small>PEOPLES GAS AN EMERA COMPANY</small>	 DUKE ENERGY	 spire
 nationalgrid	 Liberty Utilities	 PSNG ENERGY <small>A SCANA COMPANY</small>		

Unprotected Steel Mains in Natural Gas Distribution

- Natural gas distribution operators are focusing on addressing issues with cast iron, unprotected steel and other aged piping infrastructure.
- Approaches currently in use to deal with the problem:
 - Replace with PE or new coated steel pipe materials
 - Apply cathodic protection to try and maintain integrity
 - Rehabilitation methods
 - Cured-In-Place pipe liners (Starline) and other in-situ methods
 - Localized repairs (external and internal)
 - Bursting / slitting pipes and pull in PE pipe
- Replacement – accelerated replacement programs
 - Barrier to replacement of all unprotected and other aged piping systems:
 - Main replacement can be very costly – cost per mile to replace from \$1 to \$5 million or more.

Gas Distribution Steel Miles – Bare and Unprotected

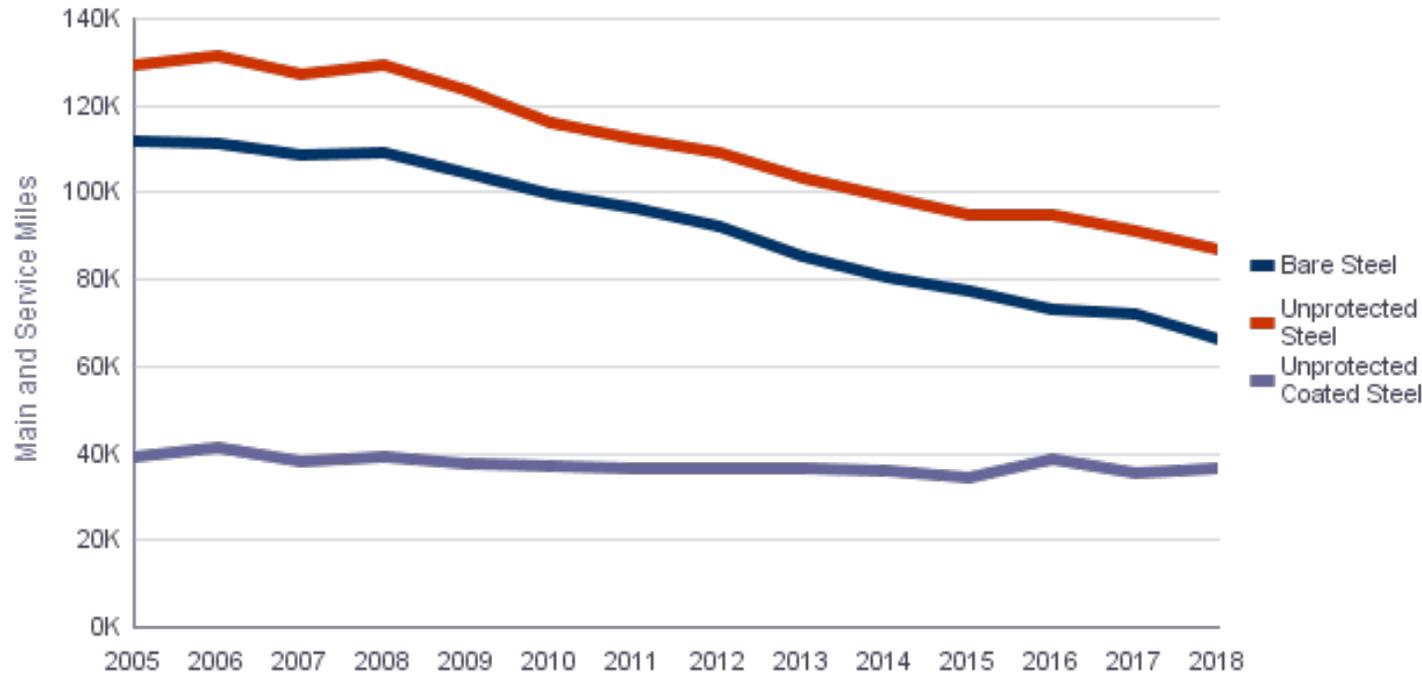
Data Source: US DOT Pipeline and Hazardous Materials Safety Administration
Data as of 10/6/2019

Steel pipelines with neither an external coating nor cathodic protection have a higher corrosion risk than coated and protected steel

Bare Steel pipelines are 5% of the gas distribution pipeline systems currently in service

Unprotected Steel pipelines are 7% of the gas distribution pipeline systems currently in service.

Unprotected Coated Steel pipelines make up 3% of the gas distribution pipeline systems currently in service.



Bare Steel Mains in Natural Gas Distribution

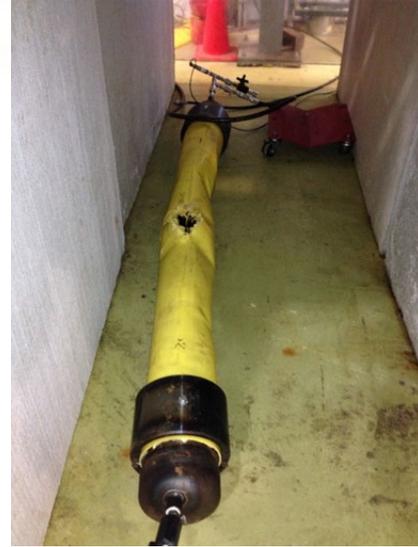
- Operators (top 11) list by total miles of bare steel main in service →
 - Over 44,000 miles remain in US
 - Over 1.8 million services

Calendar Year	Main Miles		
	2005	2018	Change
Operator Name			
DOMINION ENERGY OHIO	3,512	3,850	338
SOUTHERN CALIFORNIA GAS CO	3,554	3,239	-315
ATMOS ENERGY CORPORATION - MID-TEX	3,689	3,112	-577
PEOPLES NATURAL GAS COMPANY LLC	1,998	2,324	326
KEYSPAN ENERGY DELIVERY - LONG ISLAND	2,998	2,133	-865
KANSAS GAS SERVICE COMPANY, A DIVISION OF ONE GAS, INC.	2,611	2,124	-487
COLUMBIA GAS OF OHIO INC	3,765	2,077	-1,688
MOUNTAINEER GAS CO	1,681	1,560	-121
NATIONAL FUEL GAS DISTRIBUTION CORP - NEW YORK	2,548	1,449	-1,099
COLUMBIA GAS OF PENNSYLVANIA	2,318	1,225	-1,093
DOMINION ENERGY WEST VIRGINIA	1,408	976	-432
Total	30,082	24,069	-6,013

Data Source: US DOT Pipeline and Hazardous Materials Safety Administration Portal – Data as of 10/6/2019

GTI Projects Related to Developing & Evaluating Pipe Repair / Rehabilitation Technologies

- Developing and testing cured in place liner technologies (Starline)
 - Low and high pressure applications
 - Development of performance standards
- Evaluating various Structural Liners
 - Engineering assessment of composite and structural liners
 - Line permeation and dis-bondment evaluations
- Testing & analysis of composites for external repairs
- Design of composite repair systems
- Testing & development of spray-on repairs
- Composite Pipe Workshop & Roadmap.



Operators Efforts to Replace/Repair Aging Infrastructure

- Operators working with their State Commissions to implement accelerated main / service replacement programs
- Focusing on risk based pipe replacement / repair of aging infrastructure
- Identifying and deploying state-of-the-art technology that is fit for purpose to help replace / repair aging infrastructure
- Focus of replacement / repair is for unprotected steel, cast iron (especially smaller diameter), and vintage plastic piping systems to increase safety and reduce methane emissions.

Operational Issues & Performance Requirements

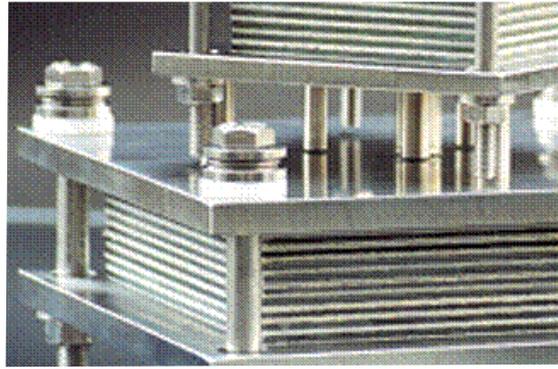
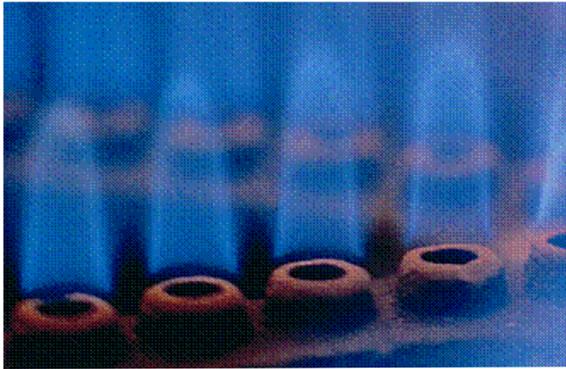
- Rehabilitated pipe needs to be considered “new asset” for rate recovery treatment
- Target life > 50 years
- Proven & demonstrated performance \geq PE pipe
- Qualify for removal from PHMSA / State bare steel list
- Desire to avoid service interruption during rehab
- Need to maintain integrity of host pipe?
- Continue to monitor rehabilitated pipe through leak surveys and in integrity management programs



Summary

- Operators need various technologies that are fit for purpose to help replace / repair aging infrastructure
 - Cast iron
 - Unprotected steel
 - Vintage plastic
- Technology should have proven & demonstrated performance
- Operators need re-conditioned pipe classification
 - Remove from “leak prone” pipe lists
 - Can monitor and maintain as a replaced piping system

Tackling Important Energy Challenges and Creating Value for Customers in the Global Marketplace



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