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R&D Perspectives on Safety Improvements for Gas Gathering Pipelines

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OTD
Operations Technology Development

Operations Technology Development (OTD) Overview

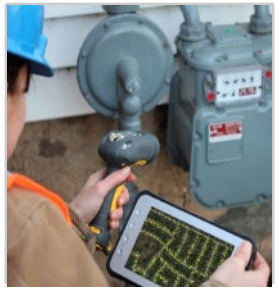
Established 2003

Stand-alone, not-for-profit, member-controlled company where gas utilities work together to develop technology solutions to common issues

27 Members

- Annual membership dues are calculated based on number of customer meters
- New projects selected by members based on needs
- Each member votes their own dollars to specific projects
- All members have access to all project information

$12M annual dues	**$150-$750k** member/yr	**$0.50** meter/yr



OTD Mission and Goals

OTD Operations Technology Development

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
- Practice good science

OTD Members

Serving 50 million gas consumers in the US and Canada

OTD Operations Technology Development

Research Foundation	Southern California Gas Company, A Sempra Energy utility	Pacific Gas and Electric Company	ATMOS energy	SOUTHWEST GAS
Ameren FOCUSED ENERGY. For Life.	conEdison	CenterPoint Energy	Entergy	PEOPLES GAS NATURAL GAS DELIVERY
INTERMOUNTAIN GAS COMPANY A Subsidiary of MDU Resources Group, Inc.	NYSEG RG&E	National Fuel	AVISTA	MiSource
NW Natural We grew up here.	PSNC ENERGY A SCANA COMPANY	Oklahoma Natural Gas A Division of ONE Gas	ENBRIDGE	Washington Gas A WGL Company
Dominion Energy	Nicor Gas	TECO PEOPLES GAS	DUKE ENERGY	spire
nationalgrid	Liberty Utilities	Black Hills Energy		

Overview of Operational Safety of a Natural Gas Pipeline

- **Installation best-practices**
  - Already established by the gas industry for most aspects:
    - Operator qualification, welding/fusion procedures, pressure testing, backfill procedures, etc.
- **Tracking and Traceability (including mapping/GIS)**
  - Various platforms and products for tracking who/what/where/when are available and operational
- **Operation best-practices**
  - Corrosion monitoring/mitigation
  - Residual lifetime based on pressure and temperature history
  - Monitoring of soil movement/subsidence
  - Heavy hydrocarbon permeation derating
  - Leak surveys
  - Inspections

Overview of Operational Safety of a Natural Gas Pipeline (continued)

- **Total Quality approach**
  - Implementing QA/QC, tracking and traceability, and continuous improvement processes in all operating aspects from material specifications to installation, to repair and retirement.
  - Improves situational awareness and risk assessments by providing reliable information on what's in the piping system, where it is located, how and when it was installed, and who installed it.

Overview of Managing Polymer Piping System Material Performance

1. **Establish a lifetime prediction model**
   - Determines MAOP in conjunction with:
     - System design factor, e.g. 0.32 for natural gas
     - Applicable stress intensification factors (SIFs), e.g. SIF per joint type, rock impingement, etc.
     - Operating temperatures
     - Derating factor for hydrocarbon permeation
     - Derating factors for chemical attack, stabilizer depletion (aging), UV exposure
2. **Monitor system pressure, temperature, and hydrocarbon permeation**
3. **Utilize the lifetime prediction model and monitoring data to continuously estimate residual lifetime (digital twin)**
   - Able to accommodate pressure and temperature cycling and surges
   - Provides a basis for risk-informed mitigation and replacement plans
   - ExAI can assist in detecting and responding to upset conditions

Overview of Managing Metallic Piping System Material Performance

1. **Establish a lifetime prediction model**
   - Determines MAOP in conjunction with:
     - System design factor
     - Applicable stress intensification factors (SIFs), e.g. SIF per joint type, weld efficiency, etc.
     - Corrosion rates
     - Critical flaw size
2. **Monitor system pressure, temperature, and inspect corrosion**
   - Track corrosion and update corrosion rates
   - Track crack propagation, flaw sizes, wall loss, etc.
3. **Utilize the lifetime prediction model and monitoring data to continuously estimate residual lifetime (digital twin)**
   - Able to accommodate pressure and temperature cycling and surges
   - Provides a basis for risk-informed mitigation and replacement plans
   - ExAI can assist in detecting and responding to upset conditions and predicting corrosion

Perspectives on Composite Piping Systems

- **Quality of installation procedures**
  - Sensitivity to environmental control (temperature, humidity)
- **Robustness of composite structure**
  - Manufacturing quality of each layer
  - Sensitivity to damage of fibers and/or matrix (critical flaw size)
  - Sensitivity to gas diffusion and entrapment (debonding)
  - Sensitivity to erosion
  - Polymer stabilizer reserves and depletion
- **Performance of pipe and joints**
  - Lifetime prediction (based on pressure, temperature, etc.)
  - Fault tree of composite structure
  - Corrosion protection for metallic joints
- **Inspection methods**
  - Detection of defects, e.g. delamination, etc.

Ongoing Research and Remaining Gaps

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R&D Efforts / Needs for PE Piping Systems:

- **Development of a field tool to assess the level of heavy (liquid) hydrocarbon (HHC) permeation**
  - Follow up on PHMSA Project 554, *Effects of Hydrocarbon Permeation on Plastic Pipe Strength and Fusion Performance* (CY2014)
  - Currently looking at correlating measurements to degree of permeation (of octane)
  - Next steps (future projects):
    - Correlate degree of permeation to time-to-failure, i.e. determine derating factor
    - Explore permeation of various heavy hydrocarbons (C6, C8, C10, etc.) individually and in mixtures
- **Effect of HHC permeation on mechanical joints**
  - Proposed under a joint plastic pipe industry effort
  - Need to explore mechanical response of permeated elastomers

Ongoing Research and Remaining Gaps

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R&D Efforts / Needs for Gathering Pipelines:

- **Corrosion, Erosion-Corrosion, Material Compatibility, and Associated Design**
  - Develop knowledge-based study on gathering corrosion, erosion-corrosion mechanisms based on the mixed-mode flow (solid, liquid, and particulate) and gas composition variability.
  - Include material susceptibility, pressure and flow considerations, and geologic (regional) considerations.

- **Operations, Maintenance, and Inspection – Accelerated Technology Implementation Roadmap from Other Pipeline Sectors**
  - Develop an accelerated technology implementation roadmap to assist with Operations, Maintenance, and Inspection of gathering lines and systems.
  - Gain insight from advances in the distribution and transmission areas of operations, safety, joining of materials and inspection systems.

Ongoing Research and Remaining Gaps

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R&D Efforts / Needs for Metallic Pipelines:

- **Validating Non-Destructive Tools for Surface to Bulk Correlations of Yield Strength, Toughness, and Chemistry (PHMSA-OTD)**
  - Focused on Transmission lines
  - Determine NDE methods result viable in assessing pipeline conditions
- **Microbiological Analysis of Hydraulic Fracture Test Site (HFTS) Operations (DOE co-funded)**
  - Characterize waters associated with the hydraulic fracturing and production
  - Gain insight into possible bio-transformations that may have implications for corrosion
  - More than 50% of Gathering incidents caused by corrosion between 2002 and 2019 were related to MIC according to PHMSA reports

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