GTI ENERGY
solutions that transform

PAPUC
PENNSYLVANIA PUBLIC UTILITY COMMISSION

GTI Energy- Research and Technology Overview

Dennis Jarnecke

PA PUC Safety Seminar | September 8, 2022

GTI Energy Overview

Serving the Energy Industry Since 1941

- Independent, not-for-profit research, technology development and deployment organization
- Areas of research include energy production and conversion, energy delivery, and end-use
- Technology development focus on safety, improving efficiency, and reducing emissions
- Research Facilities
  - 18-acre campus near Chicago
  - Laboratories in Agoura Hills, CA and Davis, CA
  - Pilot and demo facilities worldwide

Our Capabilities

GTI is addressing global energy and environmental challenges across the energy value chain

Supply

Expanding the supply of natural gas and renewable energy

Conversion

Transforming natural resources into clean fuels, power, and chemicals

Delivery

Ensuring a safe and reliable energy delivery infrastructure

End Use

Promoting the clean and efficient use of energy resources

GTI's Energy Delivery R&D Program

- GTI has an expanding R&D portfolio focused on industry priorities:
  - **Safety, Integrity, Reliability, Operational Efficiency, and the Environment**
- Collaborative R&D efforts:
  - Highly cost effective
  - Leverages collective intelligence and experience of funders to develop the best possible solutions

SAFETY & RISK MANAGEMENT

DIGITALIZATION & DATA UTILIZATION

MINIMIZING METHANE EMISSIONS

EXPANDING ROLE FOR RENEWABLE GAS & H2

PHMSA

OTD Operations Technology Development

CALIFORNIA ENERGY COMMISSION

Operations Technology Development

GTI ENERGY

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
Operations
Technology
Development

OTD Members

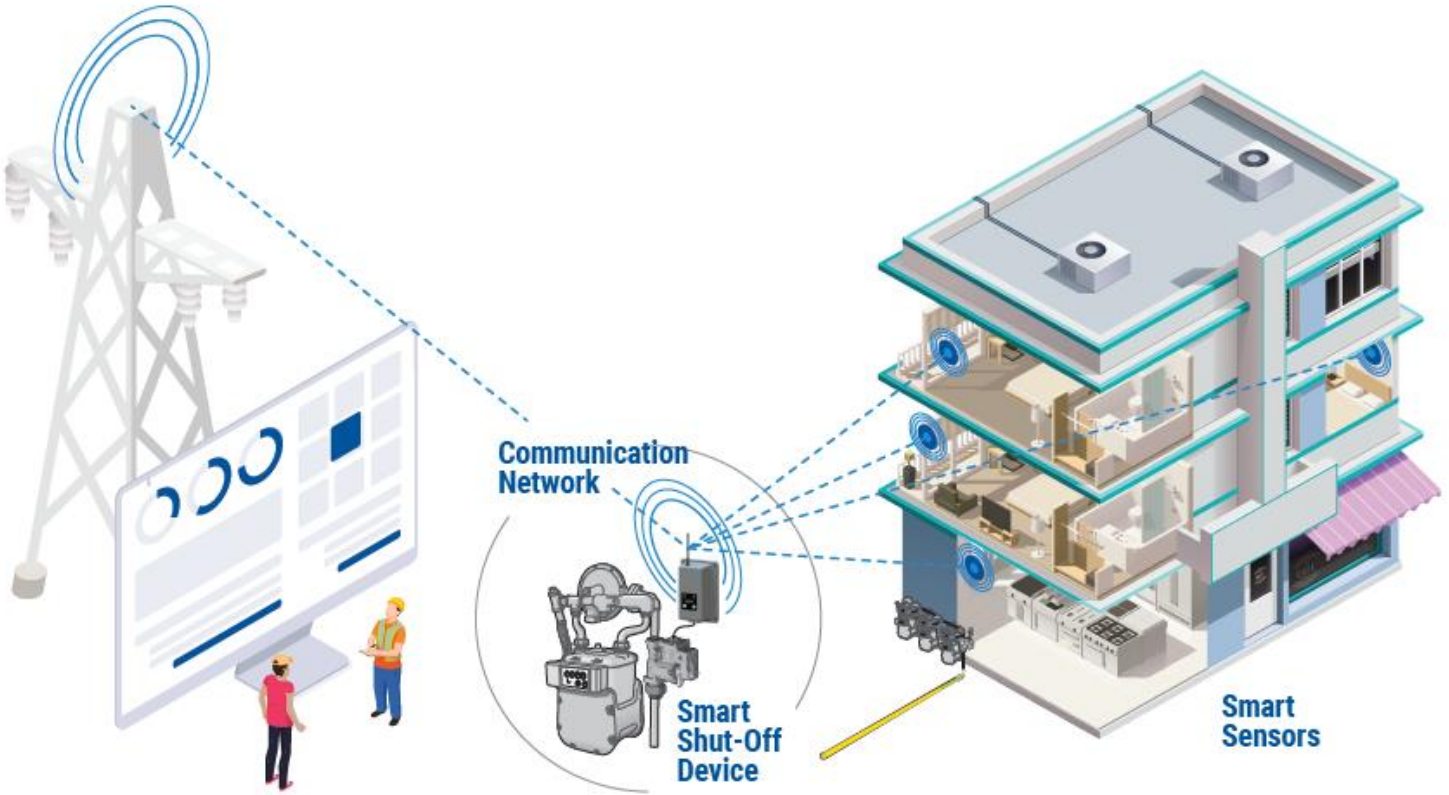
Serving 60 million gas consumers in the U.S., Canada & France

GTI ENERGY

Research Foundation	SoCalGas	DTE	ATMOS energy	SOUTHWEST GAS
Ameren FOCUSED ENERGY. For life.	conEdison	CenterPoint Energy	Entergy	PEOPLES GAS NATURAL GAS DELIVERY
INTERMOUNTAIN GAS COMPANY	NYSEG RG&E	National Fuel	AVISTA	MiSource
NW Natural We grew up here.	nationalgrid	Oklahoma Natural Gas. A Division of ONE Gas	ENBRIDGE	Washington Gas A WGL Company
Dominion Energy	Nicor Gas	TECO PEOPLES GAS AN EMERA COMPANY	DUKE ENERGY	spire
Exelon.	Liberty	Black Hills Energy	GRDF GAZ RÉSEAU DISTRIBUTION FRANCE	

Smart Safety Systems

Natural Gas Safety Devices

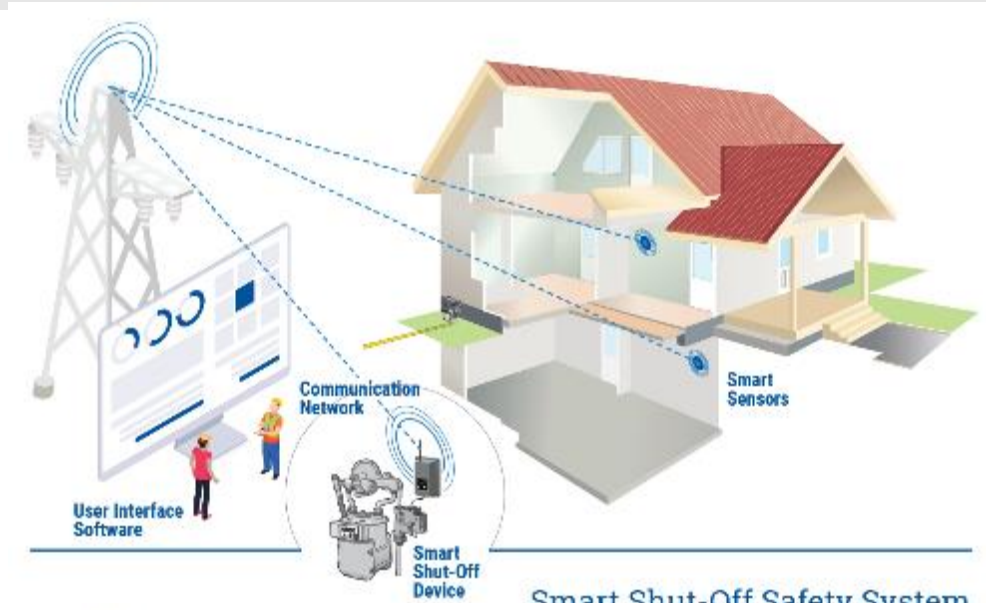


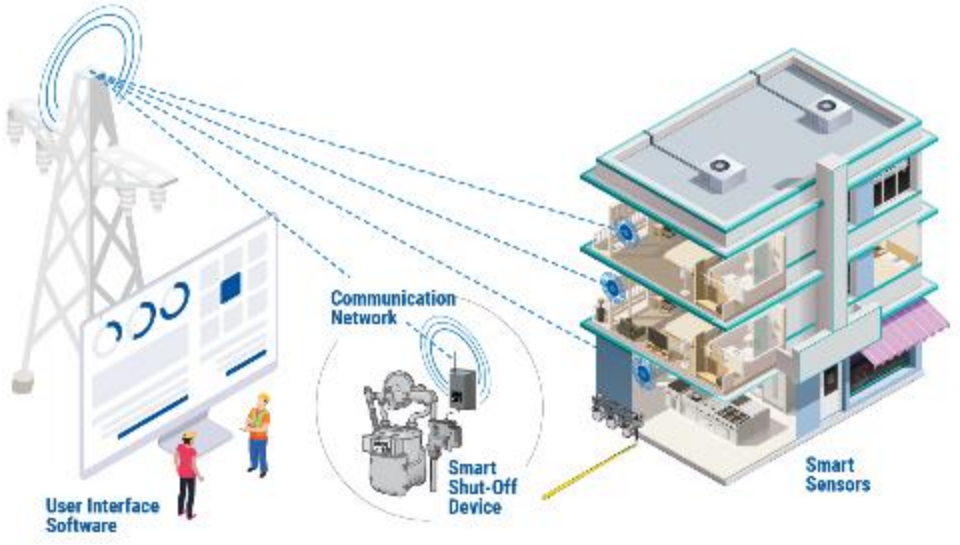
Smart technologies and wireless communications can help reduce risks from leaks and other natural disasters

Smart Safety Shutoff System

Work with stakeholders, manufacturers, and vendors to determine the best products for use for the four main components of a Natural Gas Smart Shutoff Safety System (residential and commercial building):

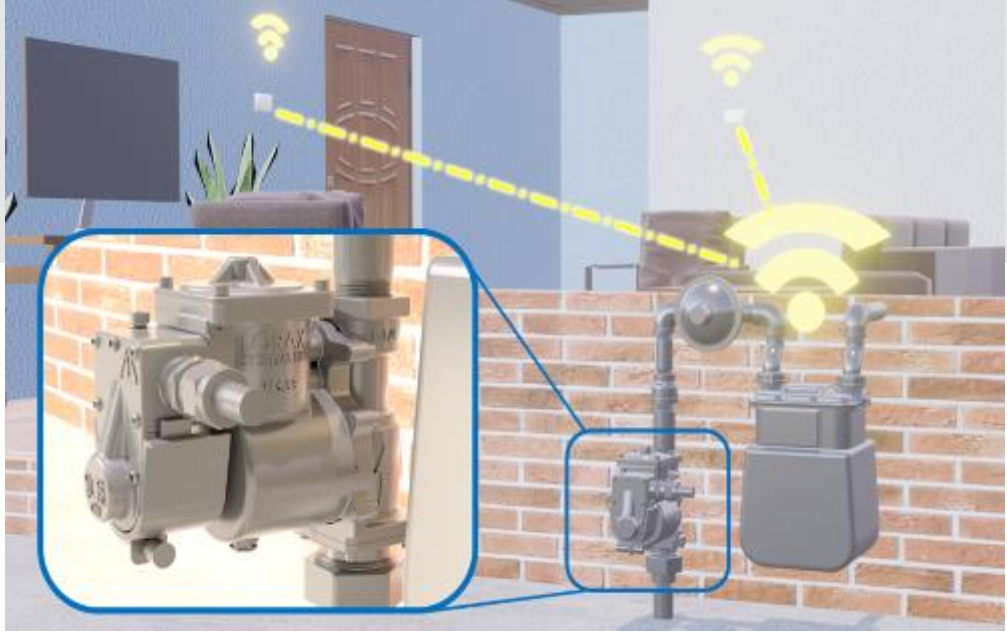
1. **Smart Sensors**: methane detector (RMD), temperature (fire) sensor, water sensor, etc.
2. **Smart Shutoff Valve**: stand-alone valve and/or integrated meter valve, etc.
3. **Communication**: Cellular, AMI, LPWAN (LoRaWAN), e.g.
4. **User Interface Software**: allows the gas utility to view hazards and take corrective actions, including the shutting off of the natural gas supply to the building.





Smart Safety Shutoff Valve

- GTI and Lorax Systems Inc. are developing a smart meter shutoff valve to remotely terminate gas flow.
- The smart meter shutoff valve and various sensors communicate back to the utility
- Efforts funded by OTD & California Energy Commission



- National Grid – Testing the Lorax Smart Shutoff Valve
  - Passed all testing
  - Implementing initial pilot of 250 smart shutoff valves
  - Integrating with methane and moisture sensors

https://www.youtube.com/watch?v=wbTo3NeTCQo

Smart Shutoff System Development & Pilots

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Safety System Equipment

- Lorax Smart Valve & Honeywell Smart Meter
- New Cosmos RMD
- eLichens RMD
- Embedded Works Fire Detector
- LoRaWAN Tektelic Gateway
- Web Browser Based: ThingsBoard User Interface Software

Enhancing Safety Through Adoption of Residential Methane Detectors

- RMDs are commercially available however there is low customer adoption
- Extensive laboratory testing of commercially available RMDs
- National pilot study was conducted to collect performance data in various residential settings

Recent NTSB findings have recommended the use of residential methane detectors

Improve Accuracy and Reliability

- Work collaboratively with manufacturers to ensure commercial products deliver safety enhancement expectations for the gas industry

Adoption of Codes and Standards

- NFPA code for RMD use and installation
- Modify existing UL 1484 standard with emphasis on lower detection limit
- Certification through International Code Council

Enhanced Awareness and Education

- Continue stakeholder education and outreach and develop formal advocacy plans

Product Advancement

- Determine optimal placement of detectors based on U.S. building construction practices and typical ventilation effects

ConEdison Efforts (per Rick Trieste – R&D Manager)

Detect > AMI Enabled Natural Gas Detectors

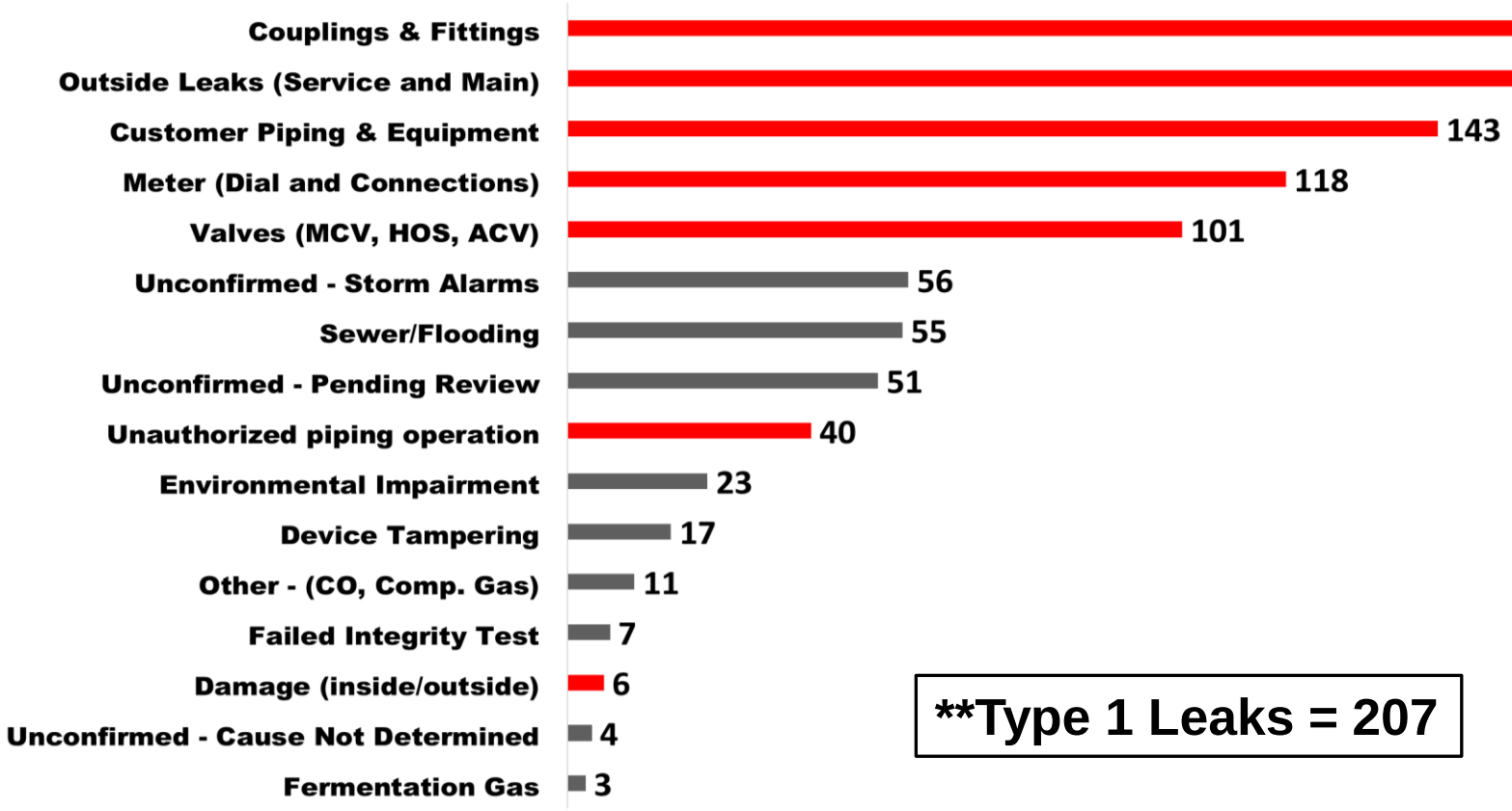
- Company asset
- Battery powered - 7 yrs.
- 10% LEL alarm (0.5% gas-in-air) exceeding UL 1484 minimum alarm requirement!
- Developed emergency response protocols
- Created new leak type – GLA

Con Edison – Methane Detector Programs

CON EDISON NY PROGRESS TO DATE:

- 2 Different NGD Programs
  - NGD Customer give-away program (consumer grade gas detectors)
    - Approximately 75,000 detectors provided to customers
  - Communication capable NGD program
    - Note: Con Edison application is specific to jurisdictional piping and not each individual end user application within a building.
    - Currently installed **~124K** NGD across Manhattan and Westchester and just started a program in Orange & Rockland.
    - Goal: **376K** Natural Gas alarms installations by 2025 in its gas service area systemwide.

Communication Capable NGD - Alarms & Reliability
As of May 2022



****Type 1 Leaks = 207**

ALARM CATEGORY	May-22	Subtotal Program	% of Total Alarms
Inside Leaks	54	617	49%
Outside Leaks	16	207	17%
Residual Gas	13	149	12%
Unconfirmed	11	111	9%
Unauthorized Piping Operation	5	40	3%
False Alarms	0	14	1%
Sewer/Flooding	3	55	4%
Device Tampering	2	17	1%
Environmental Impairment	0	23	2%
Other Gases (CO, Comp.)	0	11	1%
Fermentation Gas	0	3	0%
NGD Alarm Location			
Westchester	56	1022	82%
Manhattan	6	106	9%
Bronx	19	50	4%
Queens	23	69	6%
Total Program	**104**	**1247**	

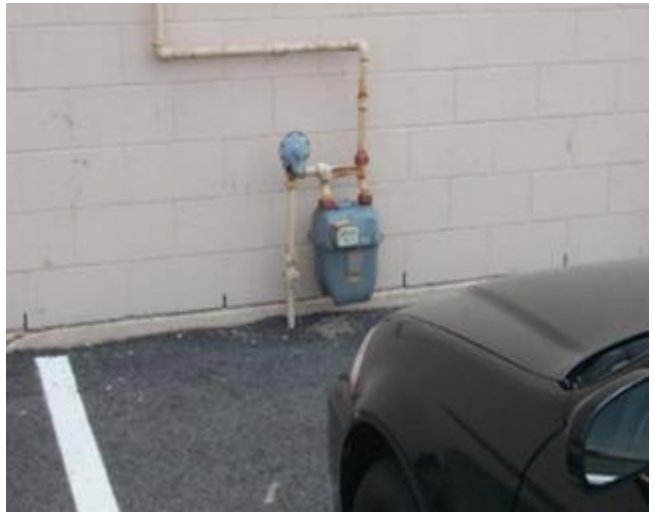
*Environmental Impairment alarms are due to building fires or water damage

Alarms from an Outside Area Leak

- Cracked 4” low pressure CI main
- Buildings in area with NGDs picked up gas readings
- Con Ed crew measured gas in other houses without NGDs

Natural Gas Safety Devices

“At Risk” Gas Meters



Natural Gas Safety Devices

- What Can Happen to “At Risk” Meters?

Meter Breakaway – Shut off Device
Vehicular Impacts and Falling Snow and Ice

- Breakaway disconnect/shutoff can be easily installed to protect meter sets and other above ground piping.
- Reduce risk from vehicle collision, seismic events, falling ice & snow, etc.
- Commercially available

Features & Benefits

Ideal For Any High-Risk Meter Sets

- High-Traffic Areas
- High-Snow Areas
- Installation in addition to bollards or where they aren't practical

Immediately seals in the event of a hard impact

HaloValve Now Commercially Available

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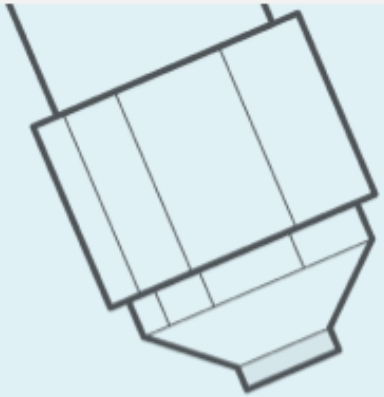
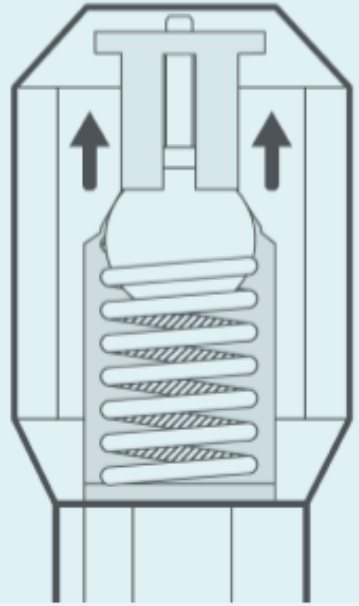
Halo Valve

- www.HaloValve.com
- Available in ¾" and 1" diameters of various lengths and end configurations
- High and Extra-high Pressures

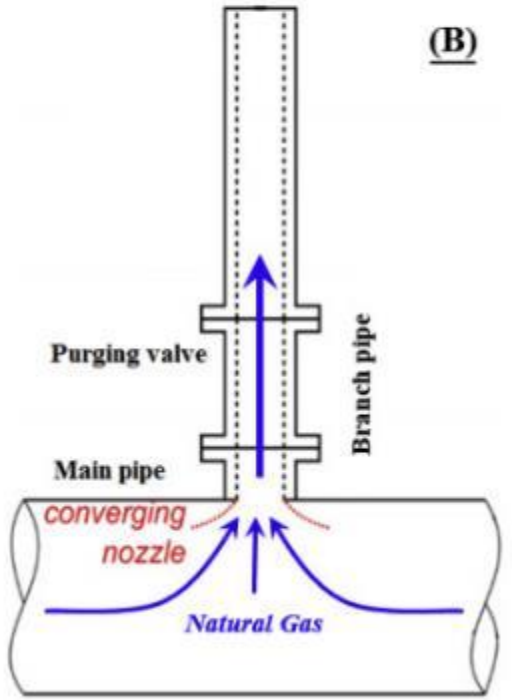
How the Natural Gas Safety Breakaway Works

- The breakaway is installed into the meter set or other gas piping
- Design withstands nominal lateral forces
- If a significant lateral force occurs, the fitting breaks
- The ball acts as a plug stopping the escape of gas
- Stopping the flow of natural gas minimizes risk of fire, explosion, property damage and serious injury





What Is Your Company Doing to Reduce Emissions?



Reducing Methane / Carbon Emissions

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Methods to Prevent Methane Venting to the Atmosphere

- Purging pipes IN TO and OUT OF service

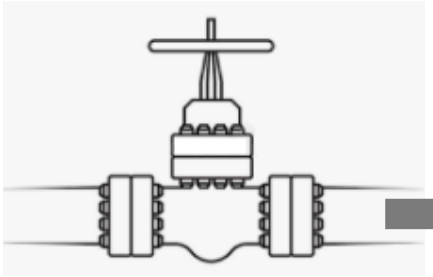
- Pipeline blowdown – taking pipes out of service – is a common practice, but solutions are limited
  - Pipeline blowdown mitigation practices may include:
    - Divert to low pressure line: Transfer gas to a parallel line
    - In-Line compression: Operate downstream compression after upstream valve is closed
    - Mobile compression: Use additional compressors to move gas or pull line down to lower pressure (e.g., incremental gain)
    - Flaring: Rarely used

Reducing Methane Emissions During Purge Operations

- Pipe blowdowns - all of the gas must be removed.
- Traditional purge operations can cause significant amounts of methane to be emitted to the atmosphere.

Gas Compression

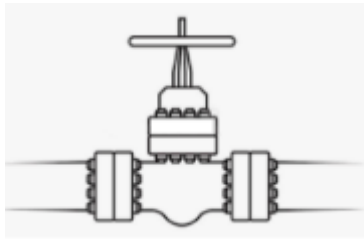
The GoVAC FLEX can draw a pipeline down to near zero psig using the natural gas in the pipeline as its source of power.



Pipeline inlet

Recover the gas and either:

1) Transfer into an adjoining pipeline,



2) Or compress it up to 3600 PSI into a tube trailer for transport.

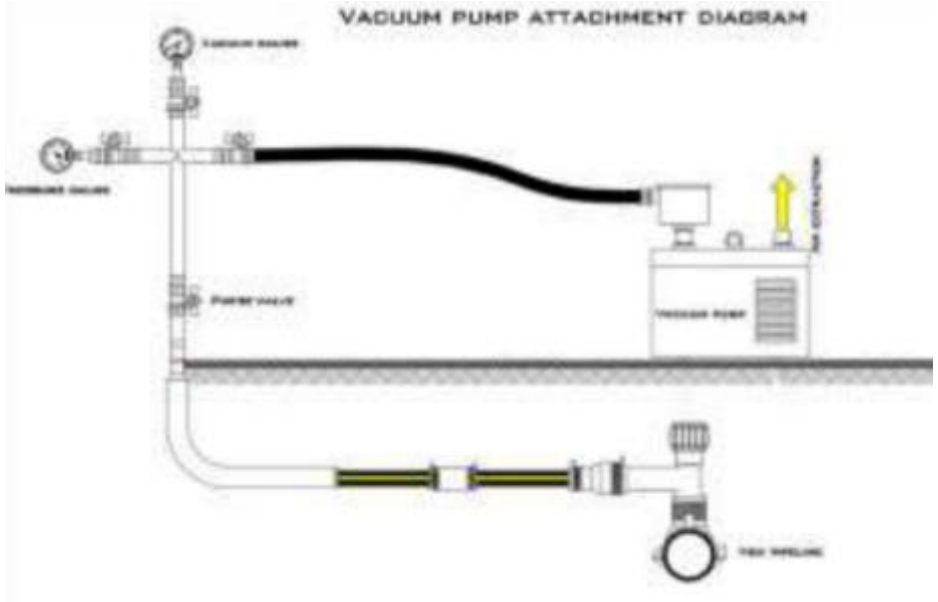
Near-zero Emissions / No Diesel Required

Purging a Pipeline Into Service (energize)

- Addressing “operational” methane emissions
- By removing all of the air in a natural gas pipeline with a vacuum, only pure natural gas is introduced.
- When the air is eliminated, there is no longer any mixing of air and natural gas.
- This process also eliminates “trapped air” when purging a line into service – even when various laterals and loops exist.

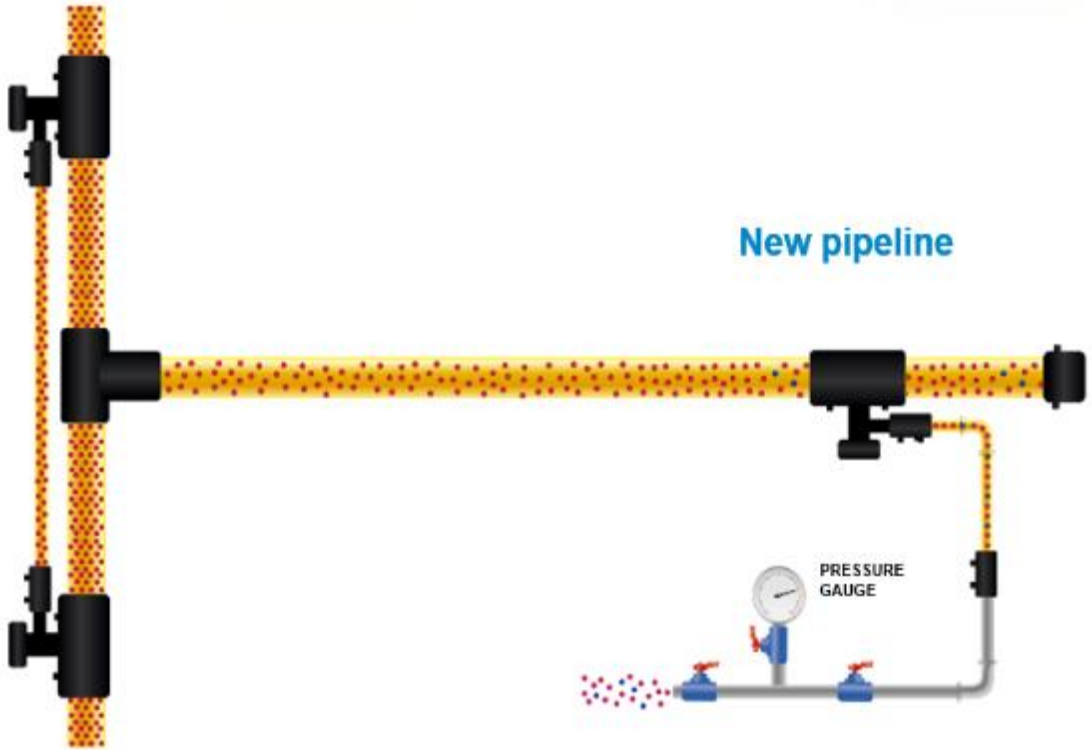
Vacuum Purge Technology

- Addressing “operational” methane emissions
- Partnering with a commercializer to make the “system” field ready
- Demonstrating w/ OTD Utilities

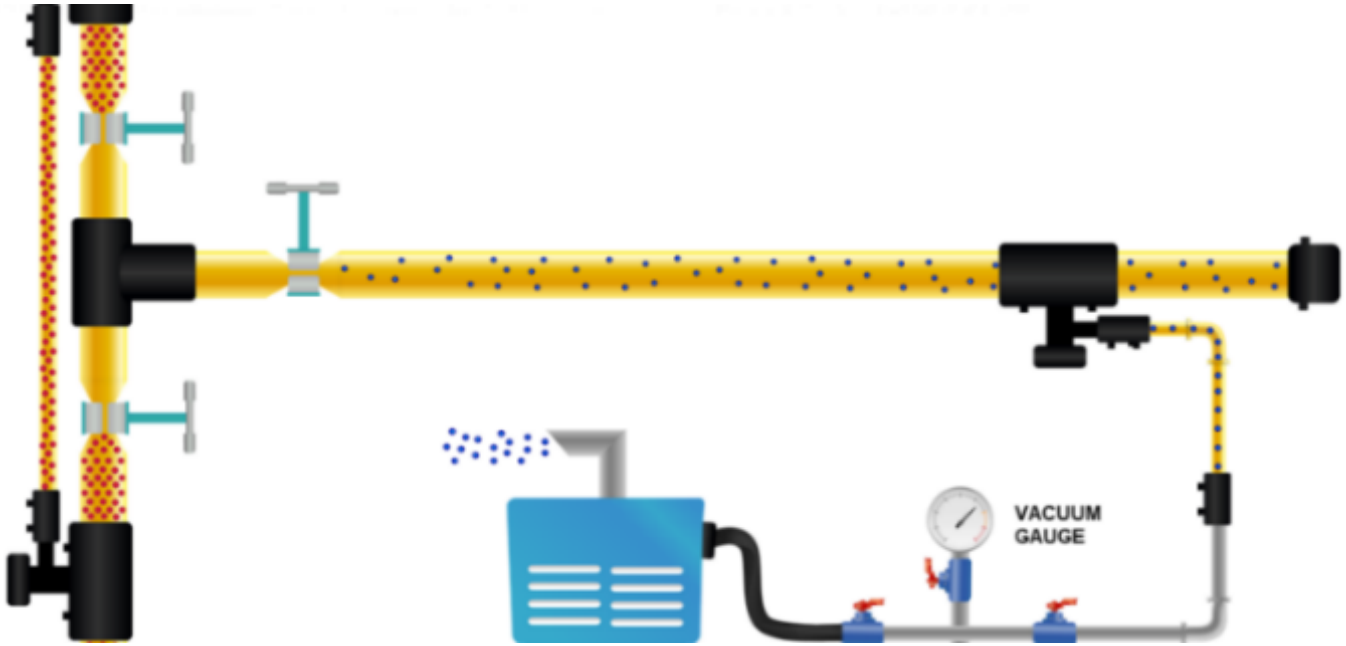


Purging Gas Pipes into Service without Venting

- Traditional method versus vent-free method to energize a new pipe (purge into service)



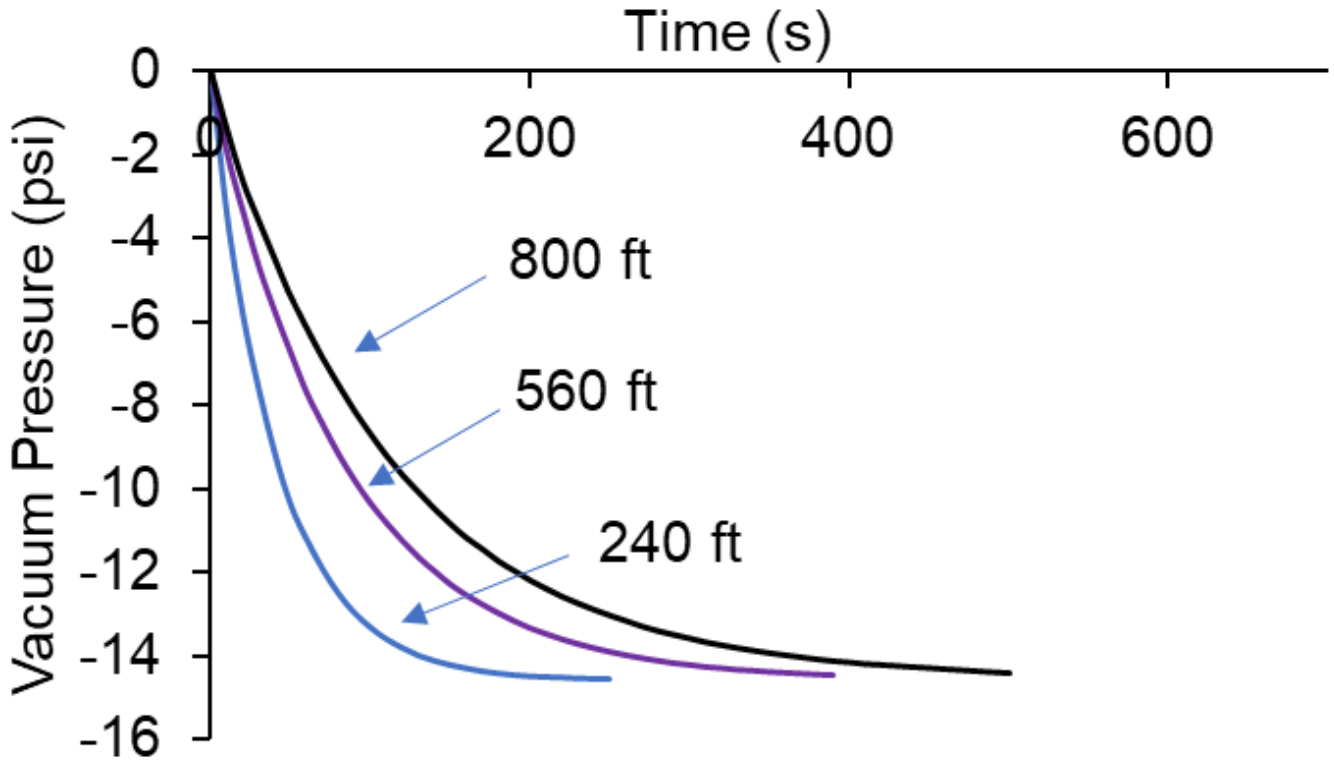
Traditional Purge Procedure



Vent-free Purge Procedure

Time to Purge Pipelines – 4-inch diameter

- Dependent on volume of pipe being purged into service
  - –Pipe diameter
  - –Pipe length
- Not dependent on system pressure
- Not dependent on system complexity
- Vacuum purging is likely more efficient than traditional purging practices
  - –No need to segment system
  - –Can backfill installation except for tie-in / purge excavation



Vacuum Purge Technology

- Important to obtain proper vacuum levels
- If not, then will require larger quantities of methane to be vented to the atmosphere
- Approximately -14 psig or greater is required to ensure proper methane concentration

Purging Service Lines - EFVs

- Evaluated purging service lines with excess flow valves (EFVs) installed.
- Vacuum operation did not trip the EFV

Next Steps

- Take the system on the road
  - –Work with OTD members to evaluate on actual new gas pipe installations
- Continue to work with commercializer to determine final system layout / configuration

Need for 3D/Accurate Mapping of Underground Utilities

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Live Gas Mapping Probe

The Live Gas Pipe Mapping Project was a success!

- The Live Gas Mapping System successfully collected accurate location data on a live gas mains at various utility locations.
- The integrated system can achieve at least 600 ft of pipeline mapping.
  - This mark was an internal team goal and a limitation of lab space to perform testing. The maximum length is still undetermined.
- Mapping campaigns on live natural gas pipes operating at pressures up to 60 psig.
- The system has been tested in 2" and 4" pipes.

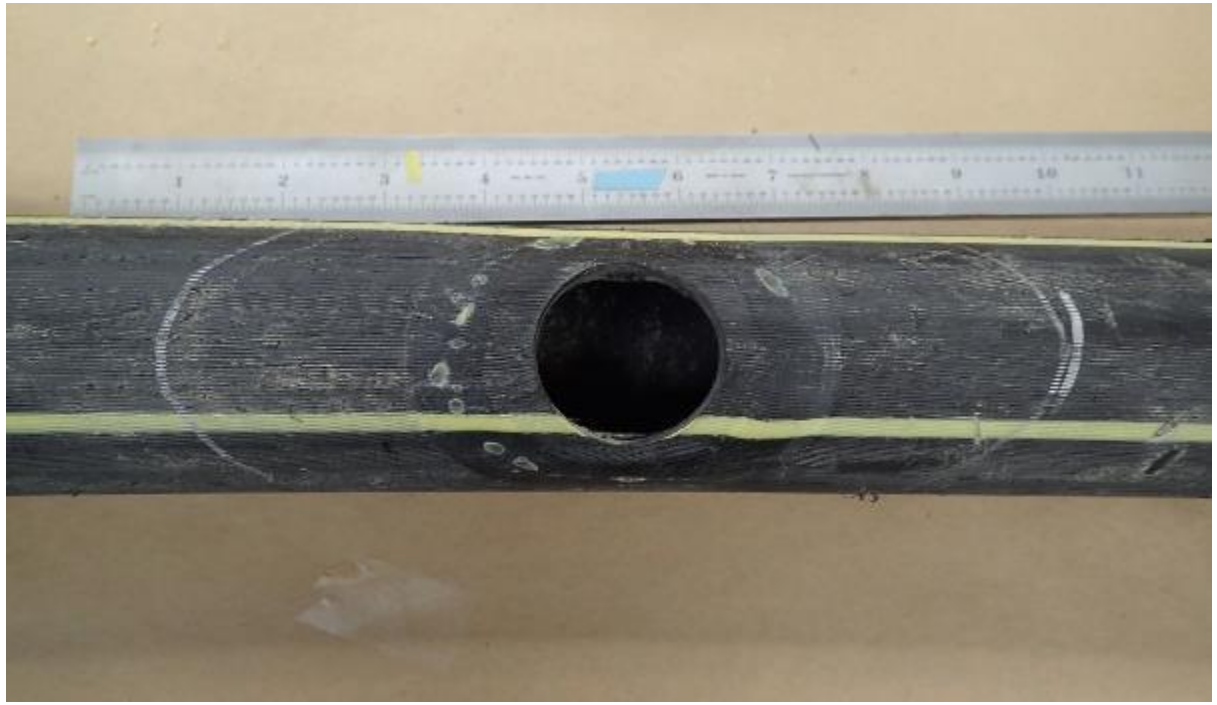
PHMSA

OTD Operations Technology Development

REDUCT

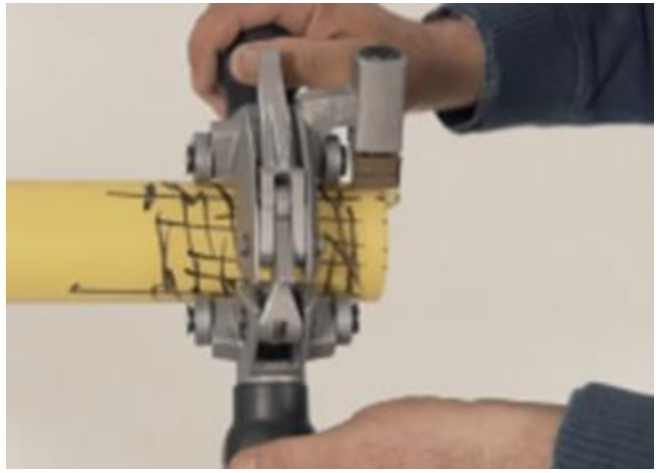
Electrofusion Failures

- Improper scraping / peeling of the pipe surface
- Contamination in the joint interface
  - Common ingredient in drilling mud could lead to ineffective bonding of electrofusion joints.



PE Fusion Procedures – Industry Differences

- Different types and condition of scrapers can lead to mixed results.



PE Fusion Procedures – Cleaning

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Cleaning

- Pipe Preparation is essential, and the removal of surface contamination and oxidized layers requires proper cleaning and scraping.
- A clean and uncontaminated surface is the single most important factor in achieving a good fusion bond.
- Types of contamination that will reduce PE joint integrity:
  - Dirt
  - Drilling mud
  - Grease or oily deposits
  - Oxidation due to air and/or UV
  - Soap
  - Water / cleaning solvents

Develop fusion joining preparation best practices

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Completed a series of fusion joining preparation projects

- Summary of GTI/OTD Work to Date:
  - Various scrapers tested with respect to scrape depth, scrape uniformity, and contamination (bentonite powder) removal, at different temperatures.
  - Three solvents (99% & 91% isopropyl alcohol, acetone) were tested with respect to contamination removal (talc, bentonite powder, silicone grease), with three different cleaning tools (polyester fiber wipe, paper towel, cotton rag).
- The three critical steps of pipe preparation for fusion are:

1. Removal of all loose and spreadable contaminants (dirt, oil, grease, sweat).
2. Proper scraping of the pipe promptly after cleaning.
3. Assembly of the fitting and performing the fusion promptly after scraping.

Develop fusion joining preparation best practices

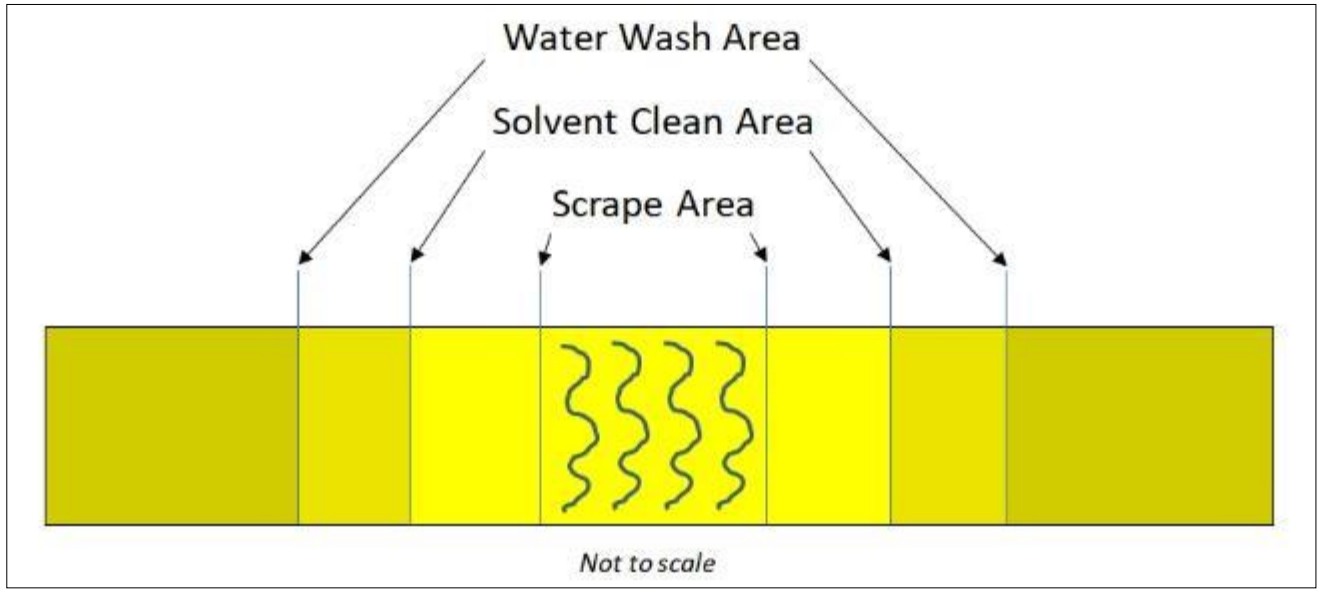
GTI ENERGY

Major takeaways from scraping and cleaning projects:

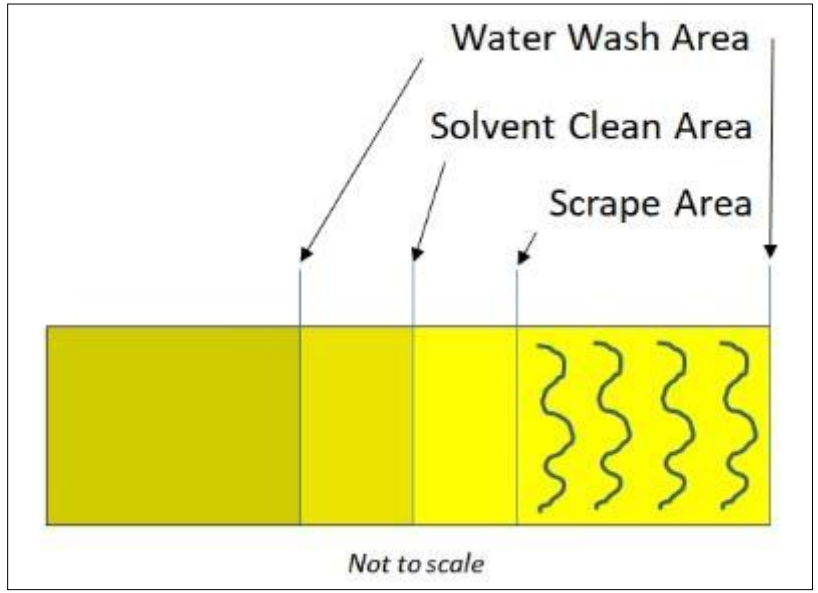
- All tested scrapers achieved the minimum scrape depth (0.007 in), with exception of the half-moon scraper which was not effective at -10°F (-23°C). Some scrapers required more than one pass to achieve this depth.
- Rotary "peelers" with non-serrated blades provided the most consistent depth (0.007" min.) and scraping uniformity versus other scraper types. They typically required only one pass to achieve the minimum scrape depth.
- Solvent cleaning, on its own, was found to be an unreliable method of contamination removal.
- Cleaning solvent choice is not critical if the three critical steps of pipe preparation are followed.
- Multiple solvent cleaning wiping passes may be a valid pipe preparation option when scraped pipe has been contaminated.

Plastic Electrofusion Joining Preparation – Suggested Procedure / Best Practices

	Yellow MDPE Pipe	Black HDPE Pipe
Minimum Scrape Depth	0.007 inches (0.014 inches of pipe OD)	0.004 inches (0.008 inches of pipe OD)
Maximum Scrape Depth for EF fittings	Dependent on EF fitting	
Absolute Maximum Scrape Depth	10% of pipe wall thickness	



Pipe Preparation for a Saddle



Pipe Preparation for a Coupling

Develop fusion joining preparation best practices

- New PPI Generic electrofusion installation guideline document:
  - New **TR49** titled "Generic Electrofusion User Guide for Field Joining of Polyethylene Gas Piping"
  - Includes more robust cleaning and pipe preparation:
  - Provides for a more consistent, manufacturer agnostic, gas industry guideline
- In addition, a new ASTM project to create a PE electrofusion installation practice for pressure piping systems including gas distribution.
  - **ASTM WK61117** – "Standard Practice for Electrofusion Joining Polyethylene (PE) Pipe and Fittings for Pressure Pipe Service".

Hydrogen in a Pipeline Network: Is it Feasible?

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Can I Transport H2 in My Pipelines?

What are the Economics?

What is the End Use Impact of Hydrogen Injection?

Are “Lifecycle” and Social Benefits of Hydrogen Injection

Are There Adverse Impacts on Material

Is Gas Leakage Manageable?

Source Documents: NREL, “Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues”, Melaina, Antonia, and Penev, March, 2013

HYDROGEN TECHNOLOGY CENTER

Investing in Resources and Capabilities

Talent

- Added Technical Staff
- Energy Transition Manager/Market Analyst
- Large Scale Project Development

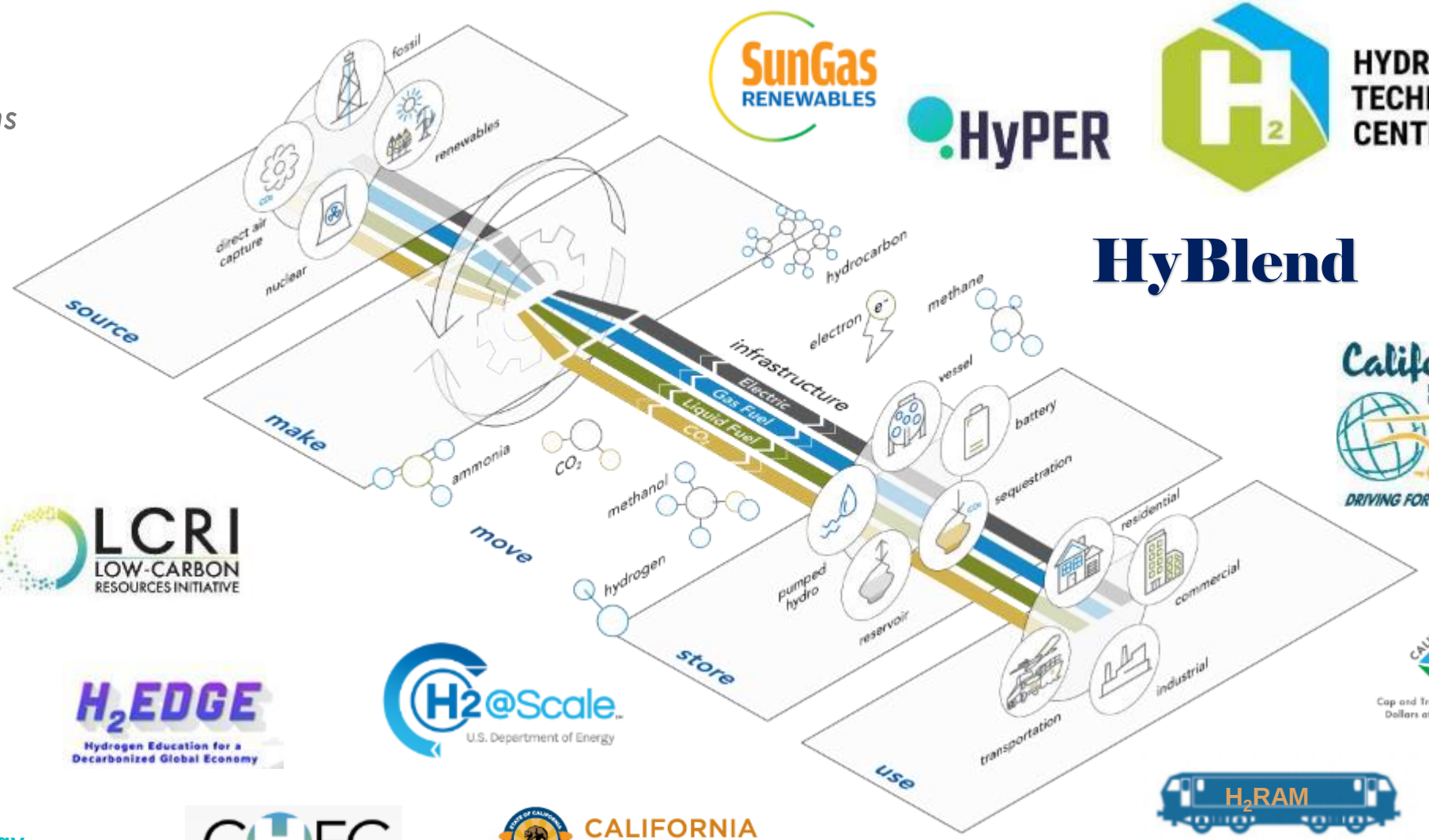
Facilities

- Exterior H2 Test “pad”
- H2 Res/Com Lab
- Hydrogen Generator Pilot
- H2 Infrastructure – Simulated Systems
- Hydrogen Production

Low Carbon / Hydrogen Programs

- *Low-Carbon, Low-Cost*
- *Hydrogen Energy Systems*

GTI's Hydrogen Technology Center offers integrated hydrogen testing and demonstration facilities across the entire value chain—leveraging deep expertise to bring real solutions to the market.



www.H2TechCenter.energy

DOE HYBLEND Project

Impacts of Hydrogen Blending

HyBlend
U.S. DEPARTMENT OF ENERGY

1. Hydrogen compatibility of piping & pipelines
   a) Metallic material/pipe evaluations
   b) Polymer / PE material evaluations

$13+ million w/cost share: Project kicked off August 2021

National Lab Lead

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

University Lead

Stony Brook University

Industry Lead

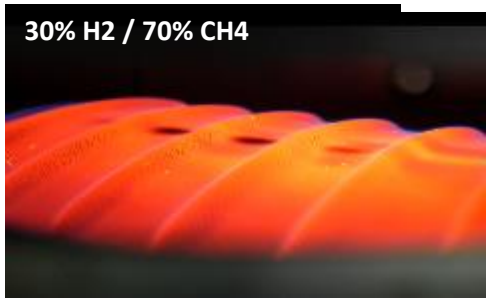
GTI ENERGY

20+ participants from industry & academia

Enabling Hydrogen Use For Residential/ Commercial/Industrial Applications

Current GTI Projects

- Demonstrate solutions to utilize high hydrogen blends in residential, commercial, and industrial combustion equipment
- Performance testing with varying hydrogen blends
- Quantify the ability of equipment to retain normal operations (emissions, efficiency, cycling)
- Hydrogen sensor development for “behind the meter” applications and in-situ sensing

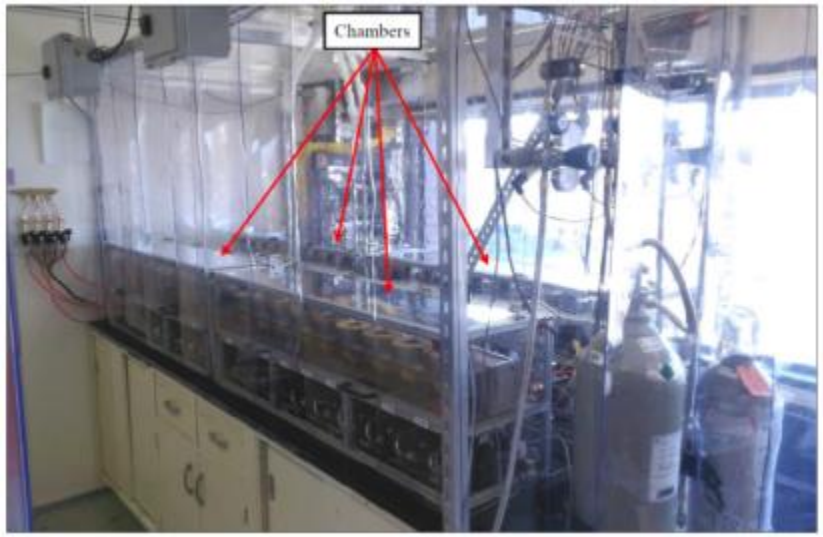


Engagement with Industry

WEIL-McLAIN
BRADFORD WHITE WATER HEATERS
A.O. Smith
Rheem
TRANE TECHNOLOGIES
DGC Danish Gas Technology Centre
gwi Gaswärme-Institut e.V. Essen
TOKYO GAS
ENGIE
DVGW
le gaz naturel

Research on Hydrogen Blending's Impact on Plastic Pipe and Components

- GTI completed (in March 2022) research for the University of California Riverside (UC-R) as part of a California Public Utilities Commission (CPUC) funded project.
  - Assessing long-term performance of a common PE2708 MDPE resin with 20% hydrogen blend.
  - Investigating if stabilizer consumption is accelerated by presence of hydrogen.
  - Also testing the aging impact on NBR gaskets.



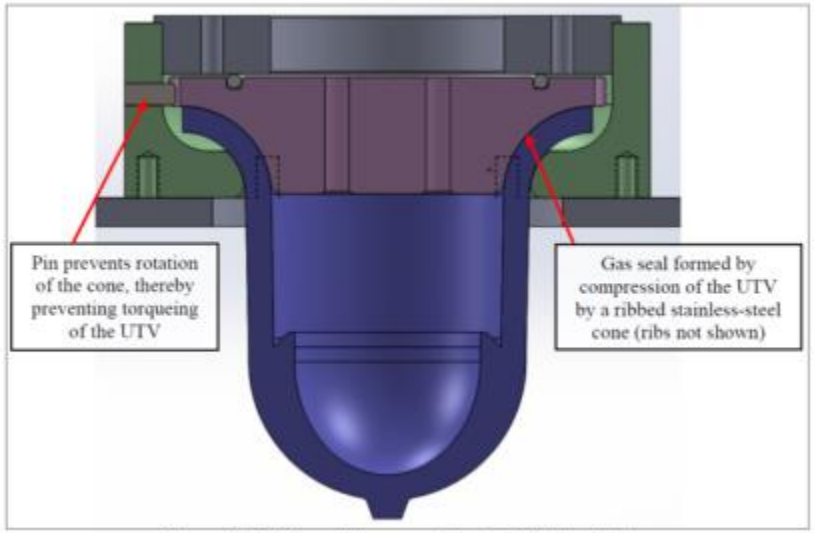
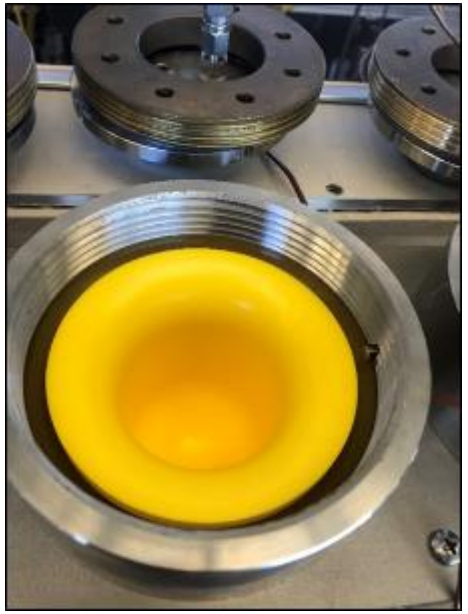


Figure 132. CAD model cross-section of a UTV in a fixture



Research on Hydrogen Blending Impact – GTI Projects

"Hydrogen Blending Impact on Aldyl-A and M8000 Pipes"

- Objective – To develop a lifetime prediction and risk model for Aldyl-A and vintage HDPE pipes
  - Remaining life of Aldyl-A pipes exposed to 20% hydrogen blend.
  - Impact on stabilizer consumption.
  - Initial test data expected in mid to late summer 2022.
- The new test rig for testing pipes with hydrogen blends will also accommodate future investigation of joints/fittings, leak rates, and permeation rates.

Additional Research on Hydrogen Blending Impact – GTI Projects

- Testing meter-sets, service regulators, and threaded connections on MSAs.
  - Constructing two test rigs for flow recirculation of various H2 blends.
- Evaluation of new "smart meters" and performance with various H2 blends
  - Ultrasonic meters
  - Thermal mass flow meters
- Addressing gaps in US Codes, Standards and Regulations for hydrogen blending and pipeline repurposing
  - Using work in UK, Europe, Japan and Australia as benchmark approaches

Utility Hydrogen Blending Pilots

- Several Operators have initiated H2 / NG blending pilots:
  - GTI supporting operators in simulating distribution system
    - Testing of materials (exposed and not exposed to various blends of H2)
    - Appliance testing and exhaust emissions analysis
    - Review of safety procedures and equipment related to various blends of H2
  - Providing various operators with engineering design and analysis prior to conversion (pilot) to hydrogen blends up to 20% and beyond.
    - Material and component review (tolerances)
    - End use equipment selection
    - Sources of supply and blending options
    - Operational considerations

Supporting and consulting on various H2 demonstration projects

GTI ENERGY

solutions that transform

Questions / Comments

GTI Energy develops innovative solutions that transform lives, economies, and the environment

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