Procedures for Retrofitting Indoor Gas Service Regulators

PHMSA Project No. 916
PHMSA Agreement No. 693JK32010005POTA

Contractor: Gas Technology Institute (GTI)

GTI: Joe Carlstrom (Principal Investigator)
Khalid Farrag (Project Manager)

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- ## GTI Project Team:

Khalid Farrag, Ph.D., P.E., PMP
Project Manager, GTI
kfarrag@gti.energy

Joe Carlstrom
Principal Investigator, GTI
jcarlstom@gti.energy

- ## PHMSA AOR/TTI:

Vincent Holohan, vincent.holohan@dot.gov

Robert Smith, Robert.W.Smith@dot.gov

- ## Acknowledgment:

OTD Utilities support and co-funding contributions.

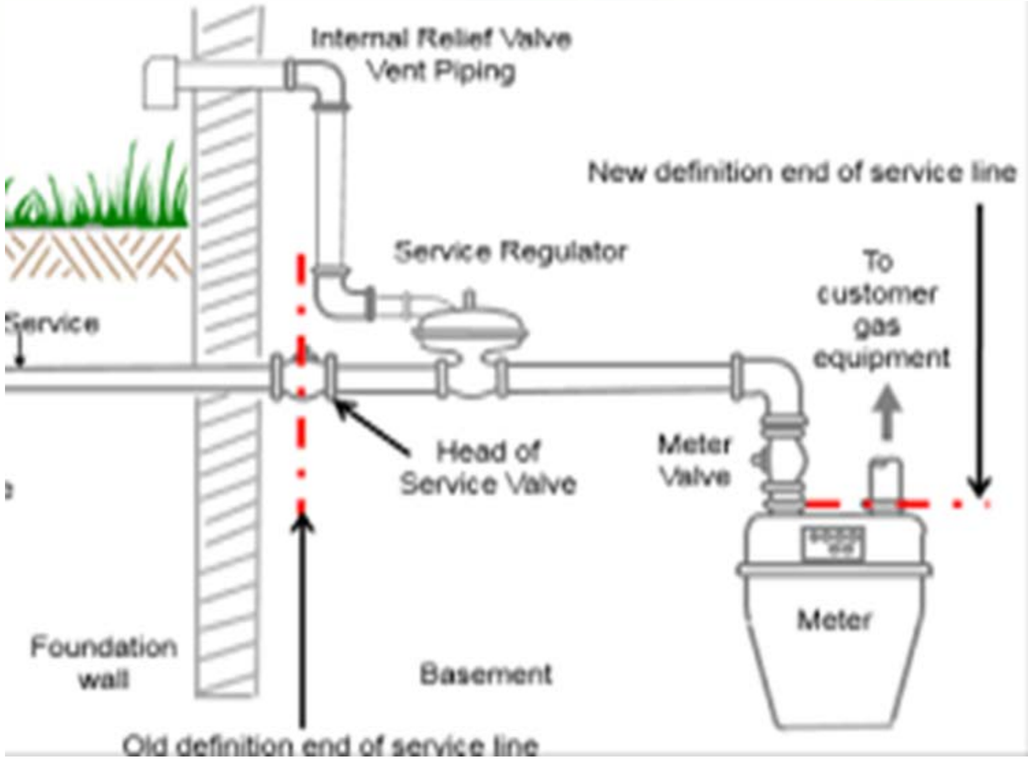
Agenda

- Background and Objective
- Industry Challenges & Needs
- Current Utility Practices and Procedures
- Monitoring and Retrofitting Indoor Regulators
- Inspection and Rehabilitation of Indoor Piping Systems
- Best Practice Guidelines & Recommendations
- Conclusions.

Background

Various threats on indoor regulators and meter sets were reported by PHSMA:

- Regulator leaks in confined space
- Threads and connections leaks
- Atmospheric corrosion
- Improper installation
- Operation: Maintenance and access
- Outside force [flood, damage to vents]
- Tampering.



Layout of indoor meter-regulator set

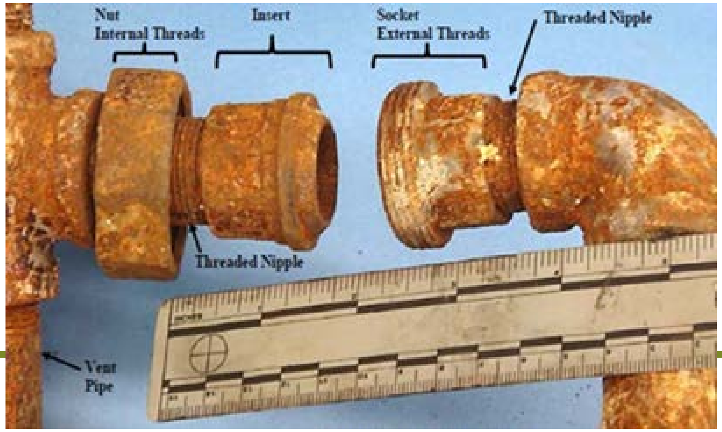
Background

YEAR	CAUSE	NARRATIVE
1985	OTHER	VENT TO INDOOR REGULATOR WAS PLUGGED . THIS DID NOT ALLOW REGULATOR TO OPERATE PROPERLY.
1984	CORROSION	THE METER AND REGULATOR LOCATED INSIDE THE BASEMENT. A CORROSION HOLE APPROXIMATELY 3/8 INCH IN DIAMETER WAS FOUND ON THE TOP OF THE SERVICE PIPE.
1990	OTHER	BASEMENT FLOODING AND THE FAILURE OF FLOOR DRAINS RESULTED IN A RISING WATER LEVEL.
1994	OUTSIDE FORCE	EMPLOYEE OF A FUMIGATING COMPANY WERE ATTEMPTINGTO SHUT OFF THE GAS SERVICE.
1996	OUTSIDE FORCE	OPERATOR STRUCK A REGULATOR VENT PIPE EXTENDING FROM THE METER RROM. THE VENT PIPE CAUSED THE DIAPHRAGM AND SPRING TO BREAK OFF
2005	INCORRECT OPERATION	WHILE COMPLETING LEAK SURVEY ON INSIDE METER SET, THE EMPLOYEE MADE SEVERAL ATTEMPTS TO TIGHTEN THE PIPE PLUG BUT FAILED TO STOP THE LEAK.
2015	OUTSIDE FORCE	CAR DOOR STRUCK AN UNDETERMINED PIPE/OBJECT INSIDE THE GARAGE AND BREACHED GAS METER/REGULATOR SET INSIDE THE GARAGE.
2016	INCORRECT OPERATION	IMPROPER INSTALLATION OF THE VENT LINES AT THE TIME OF THE INITIAL INSTALLATION. VENT LINES WERE UNSLEEVED AND CORRODED OVER TIME.
2017	OUTSIDE FORCE	PRIMARY FIRE AND SOURCE OF IGNITION WERE RELATED TO ELECTRICAL WIRING IN THE KITCHEN.
2017	INCORRECT OPERATION	RELOCATION OF GAS METERS FROM THE BASEMENT OF THE BUILDING TO THE OUTSIDE. THE WORKERS WERE UNABLE TO MITIGATE THE RELEASE OF THE GAS.
2018	OTHER	A LEAK FROM A PLUG ON THE SERVICE TEE INSIDE THE BASEMENT HAD BEEN MECHANICALLY REMOVED.
2018	INCORRECT OPERATION	UNAUTHORIZED TOOL WHILE PERFORMING A METER CONVERSION.
2019	OUTSIDE FORCE	SERVICE REGULATOR APPEARED TO HAVE BEEN INTENTIONALLY TAMPERED
2016	CONSTRUCTION	NTSB PAR-19-01: REGULATOR FAILURE WITH UNCONNECTED VENT LINE ALLOWED GAS IN METER ROOM

Background

The National Transportation Safety Board (NTSB) issued accident report: Building Explosion and Fire, Silver Spring, Maryland, NTSB/PAR-19/01. The report included the following safety recommendations:

- Require all new service regulators be installed outside occupied structures. (P-19-001).
- Existing interior service regulators be relocated outside occupied structures whenever the gas service line, meter, or regulator is replaced. Multifamily structures should be prioritized over single-family dwellings. (P-19-002).



Industry Challenge

- Relocating inside regulators to outdoors is not always feasible as some multi-units, business district structures, and buildings in historic districts do not provide outside space.
- In these situations, what safe options exist to retrofit inside installations, manage vented gas, and provide a warning and emergency shutoff?
- Retrofitting indoor regulators should provide an equivalent level of safety to outside installations. How to quantify these levels of safety for comparison?

Industry Need

- Provide a procedural roadmap for a consistent decision-making tool when a gas service regulator needs to stay inside.
- Identify equipment and devices to monitor natural gas and provide warning and emergency shutoff if gas accumulates indoors.
- Establish best practices for inspection, recording, and maintenance of gas regulators and utility indoor piping systems.

Objective

- To provide natural gas LDCs with best practices, new technologies, and guidelines for retrofitting inside gas service regulators and associated piping.
- Reduce risk when gas service regulators and associated higher pressure piping are installed inside to maintain the same level of safety as the one for regulators installed outside.

Thermal image of gas venting from a large leak in a regulator diaphragm

Project Schedule

Task	Task Description	Q-1	Q-2	Q-3	Q-4	Q-5
1	Project Scoping and Technical Advisory Panel					
2	Evaluate Current Practices and Technologies					
3	Inspection and Retrofitting of Indoor Regulators					
4	Inspection and Rehabilitation of Piping System					
5	Best Practice Guidelines and Recommendations					
6	Technology Transfer and Final Report					
7	Project Management					

Project Duration: 15 months
PHMSA: $290,000
OTD Cost-share: $77,000

Fast Facts	
Research Award Recipient:	Gas Technology Institute 1700 South Mount Prospect Road Des Plaines, IL 60018-1804
AOR/TTI:	Vincent Holohan, vincent.holohan @ dot.gov, 202-366-1933 Robert Smith, Robert.W.Smith @ dot.gov, 919-238-4759
Contract #:	693JK32010005POTA
Project #:	916
Researcher Contact Info:	Name: Joe Carlstrom Phone: 224-388-3938 jcarlstrom @ gti.energy
Downloads of Project Reporting	
Since Jan 1, 2017	500
Financial and Status Data	
Project Status:	Completed
Start Fiscal Year:	2020 (09/30/2020)
End Fiscal Year:	2022 (12/31/2021)
PHMSA $$ Budgeted:	$290,000.00

Task 1 – Kickoff and TAP Group

- Project kickoff and scope review
- Establish Technical Advisory Panel (TAP)
- Identify and collect safety and excavation incident data from available government and organization records.
- Evaluate Federal and State requirements.

Task 1 – Kickoff and TAP Group

Organization		Name
PHMSA	PHMSA - AOR	Vincent Holohan
		Robert Smith
Operation Technology Development	OTD - Co-Funding	Mike Adamo
Organization	ANSI/AGA B109	Patrick Donnelly, NiSource
LDC's	Washington Gas	Kevin Murphy
	conEdison	Richard Trieste
		Tom Flynn
	PG&E	Aaron Rezendez
		Melissa Dunlap
	National Grid	Mike Wyrick
Manufacturers	Emerson	John Anderson

Task 1 – A Look at Federal Requirements

§ 192.353 Customer meters and regulators:

(a) Each meter and service regulator, whether inside or outside a building, must be installed in a readily accessible location and be protected from corrosion and other damage ...

(b) Each service regulator installed within a building must be located as near as practical to the point of service line entrance.

(c) Each meter installed within a building must be in a ventilated place and not less than 3 feet from any source of ignition.

(d) Where feasible, the upstream regulator in a series must be located outside the building, unless it is located in a separate metering or regulating building.

Task 1 – A Look at Federal Requirements

§ 192.355 Customer meters and regulators - Protection from damage:

(a) Protection from vacuum or back pressure: A device must be installed to protect the system.

(b) Service regulator vents and relief vents: Must terminate outdoors, and the outdoor terminal must -

(1) Be rain and insect resistant;

(2) Gas from the vent can escape freely into the atmosphere and away from any opening into the building; and

(3) Protected from damage caused where flooding may occur.

Task 1 – A Look at Federal Requirements

§ 192.357 Customer meters and regulators – Installation:

(a) Each meter and regulator must be installed so as to minimize anticipated stresses upon the connecting piping and the meter.

(b) When close all-thread nipples are used, the wall thickness remaining after the threads must meet the minimum wall thickness requirements.

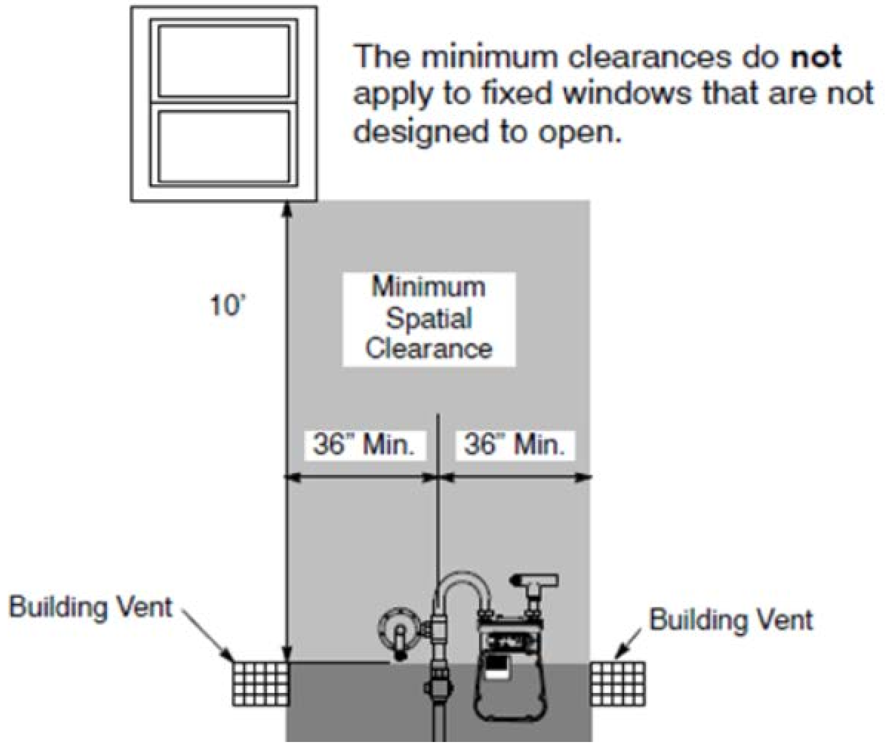
(c) Connections made of lead or other easily damaged material may not be used.

(d) Each regulator that might release gas in its operation must be vented to the outside atmosphere.

Task 2 – Industry Regulators Installations Practices

Minimum clearances for meter sets to windows, vents, utility boxes:

- NFPA-54-2006 (3 ft ignition sources)
- Distance from vents & windows
- Under windows (some do not allow to install under a window)
- Meters/Regulators can only be installed inside if no other options are available.



Task 2 – Industry Indoor Installations Practices

Engineering Dept. is contacted for all inside installations. If install inside garages, a bollard evaluation is performed.

No indoor installation in these cases:

- In confined rooms containing engine, boiler, heater or electrical equipment.
- In living areas, (restrooms, bathrooms, closets, cabinets).
- Under water pipes, stairways or near elevator shafts.
- Inside a front building to supply a rear building.
- Through a floor or crawl space.

Task 2 – Industry maintenance Practices

§192.481 Atmospheric corrosion control: Monitoring

§192.723 Distribution systems: Leakage surveys

§192.1007 DIMP: Continually identify, assess, and address risks to the system.

Industry common inspection practices:

- Accessibility of gas utility equipment (no cabinets, garbage)
- Proper installation (levelled, adequate supports, no loads on the pipe)
- Visual inspection of continuous length of vent pipe to the outside
- Proper material and appearance of all fittings
- That there are no foreign bonds
- A sealed gas service pipe entry point.

Task 2 – Industry Practices - Interviews

1. Do you have procedures that you can share for the installation and inspection of inside company-owned piping and regulators?

- All LDCs interviewed have detailed procedures used in the training and qualifications for inside piping installations and inspections.
- The majority of the LDCs have systems and processes in place for code compliance of inside piping.
- Most utilities have electronic systems in place to ensure the timeliness of the required inspection orders.

Task 2 – Industry Practices - Interviews

2. Do you have records you keep for the installation, inspection, and maintenance of inside company-owned piping and regulators?

- All LDCs interviewed have records that detailed their distribution systems, installations, and inspections requirements.
- However, the types of records and available information on indoor installations varied and may need standardization.

Task 2 – Industry Practices - Interviews

3. Do you have information on the number of inside regulators in your service territory?

- All LDCs interviewed had information whether a meter set or sets were located inside a structure.
- However, information on the location of the regulator varied and are not necessarily recorded.
- Discussions indicated an agreement that tracking the number, type, age, and condition of inside regulators were mostly lacking and would be beneficial as part of the DIMP plan.

Task 2 – Industry Practices - Interviews

4. Has your company used any type of newer regulators that contain a slam shut and/or a vent limiter? Are there any special considerations for an inside regulator as compared to an outside?

- All LDCs interviewed were familiar with the Pietro Fiorentini FE regulator and have used them, or similar new types, to some extent.
- None of the LDCs interviewed had considered utilizing different regulator types for inside installations as compared to outside.

Task 2 – Industry Practices - Interviews

5. What can be retrofitted with indoor regulators to improve safety to a level equal or better than an outside regulator?

- Discussions indicated that regulators' lifespans were unknown, and there is a need for a risk-based approach utilizing the data gathering in #3.
- Retrofitting an inside regulator with Residential Methane Detectors (RMD) and smart valves would improve safety and reduce leak risk.

Task 2 – Industry Practices - Interviews

6. Has your company developed any policies on the use of RMD?

- LDCs have indicated that they have members and/or following the updates on NFPA 715, but currently they have no documented policy that is in place for RMDs.
- Some LDCs have performed research and had success with connecting RMDs to their existing AMI communication networks.

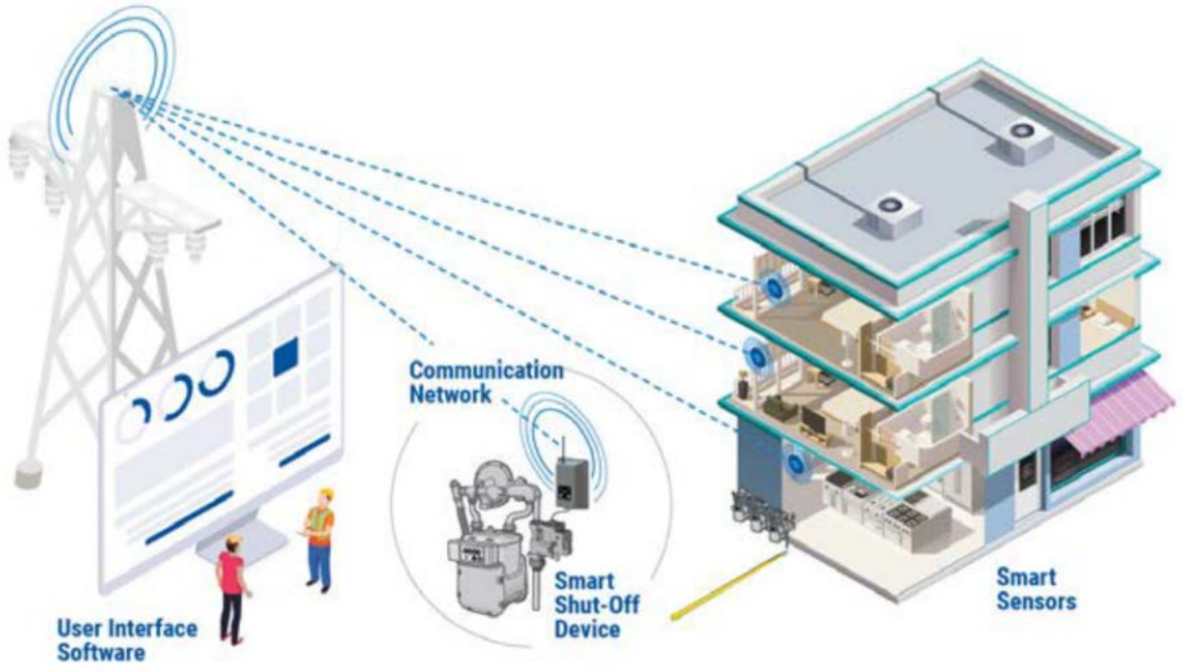
Task 2 – Industry Practices - Interviews

7. Any developments on the use of smart technologies, such as remote shut-off valves, communication sensors, and others?

- One LDC has a system that is being tested which communicates RMD data for dispatching field employees.
- Mixed discussions on implementation since there are many unknowns on how to standardize an RMD, smart shutoff valve, and communication network system with existing systems.

Task 3 – Retrofitting Indoor Regulators

- Low Emission Regulators (2-stage, OPSO)
- Residential Methane Detector (RMD)
- Comprehensive Smart Safety Shutoff System:
  - RMD
  - Smart Shutoff Valve
  - Communication Network
  - User Interface Software.



Task 3 – Retrofitting Indoor Regulators

- Two-Stage Regulators
  - Vent Limited (designed to ANSI Z21.80/CSA 6.22 limiting vent flow to less than 2.5 scfh in the event of diaphragm failure).
  - Redundant Diaphragm
  - Over Pressure Shutoff (OPSO)
  - Smaller Space Requirements as Compared to Single Stage
  - Disadvantage: More Expensive than a single stage regulator

Pietro Fiorentini FE200

Belgas P100SX slam shut regulator

Task 3 – Retrofitting Indoor Regulators

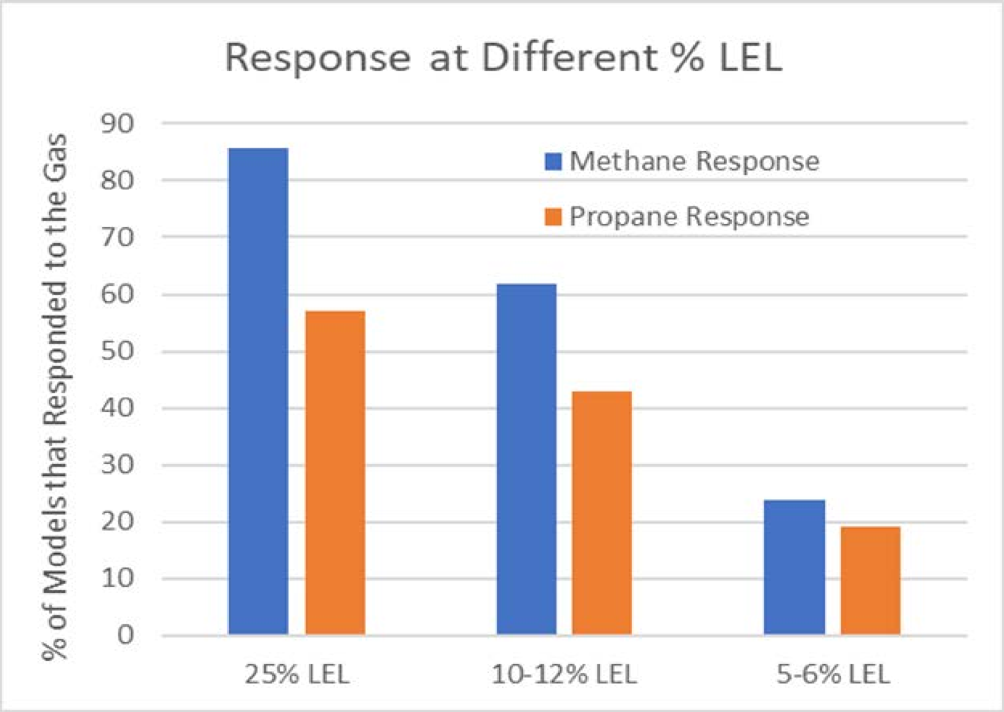
- RMD Performance Standards

Performance Standards for Methane Detectors				
Standard	Section	Organization	Details/ Title	% LEL Alarm Activation Point
UL-1484	43.1.1	ANSI/ Underwriters Laboratories	Standard for Safety: Residential Gas Detectors	<25%
BS EN 50194-1:2009	4.3.3	British Standards Institute	Electrical apparatus for the detection of combustible gases in domestic premises - Part 1 : Test methods and performance requirements	3-20%
49 CFR 192	.736	DOT	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards: Compressor Stations: Gas Detection	<25%
2012 NFPA 30A	7.4.7	NFPA	The gas detection system shall be designed to activate when the level of flammable gas exceeds 25 percent of the lower flammable limit (LFL).	25%

Task 3 – Retrofitting Indoor Regulators

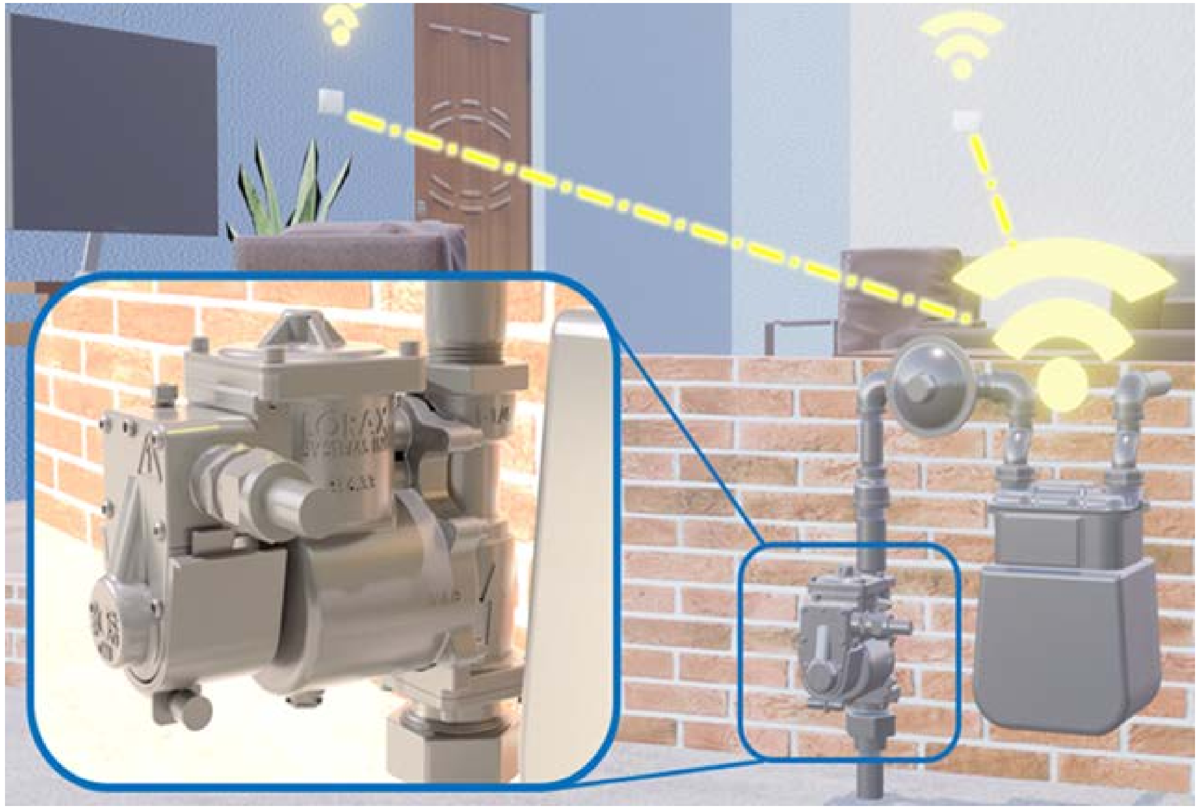
- RMD Performance Standards
  - GTI works with NFPA on the new standard NFPA 715 "Standard for the Installation of Fuel Gases Detection and Warning Equipment".
  - GTI work included testing 21 brands of RMD devices.
  - The current version incorporates:

    10% LEL alarm recommendation, ethanol, and acetone interference test suggestions, mounting distances from the ceiling, and increased safety messaging



Task 3 – Retrofitting Indoor Regulators

- Smart Valve Retrofitting
  - Installed upstream of the Inside Regulator
  - Tested to ASME Standards
  - Rated at Distribution Pressures.



Lorax Smart Shutoff Meter Valve

Task 4 – Rehabilitation of Piping System

AGA Study on Indoor atmospheric leaks:

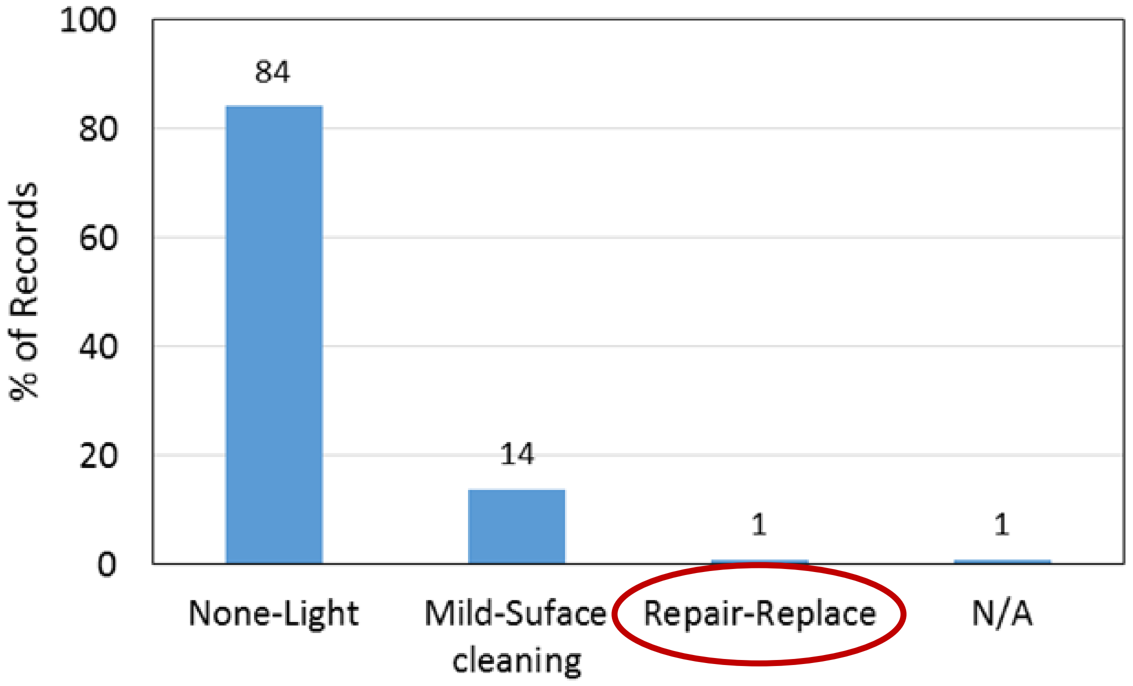
- Atmospheric corrosion and leaks were lower in inside sets than outside.
- Most of indoor leaks resulted from loose and poorly connected threads and couplings rather than due to atmospheric corrosion.
- Indoor risk factors such as contact with wall and soils increase the risk of corrosion.

[*] Atmospheric Corrosion Inspection and Leak Survey Study, Avent Design Corp., for American Gas Association, 2009.

Task 4 – Rehabilitation of Piping System

GTI Study on Indoor atmospheric leaks in the Northeast LDCs:

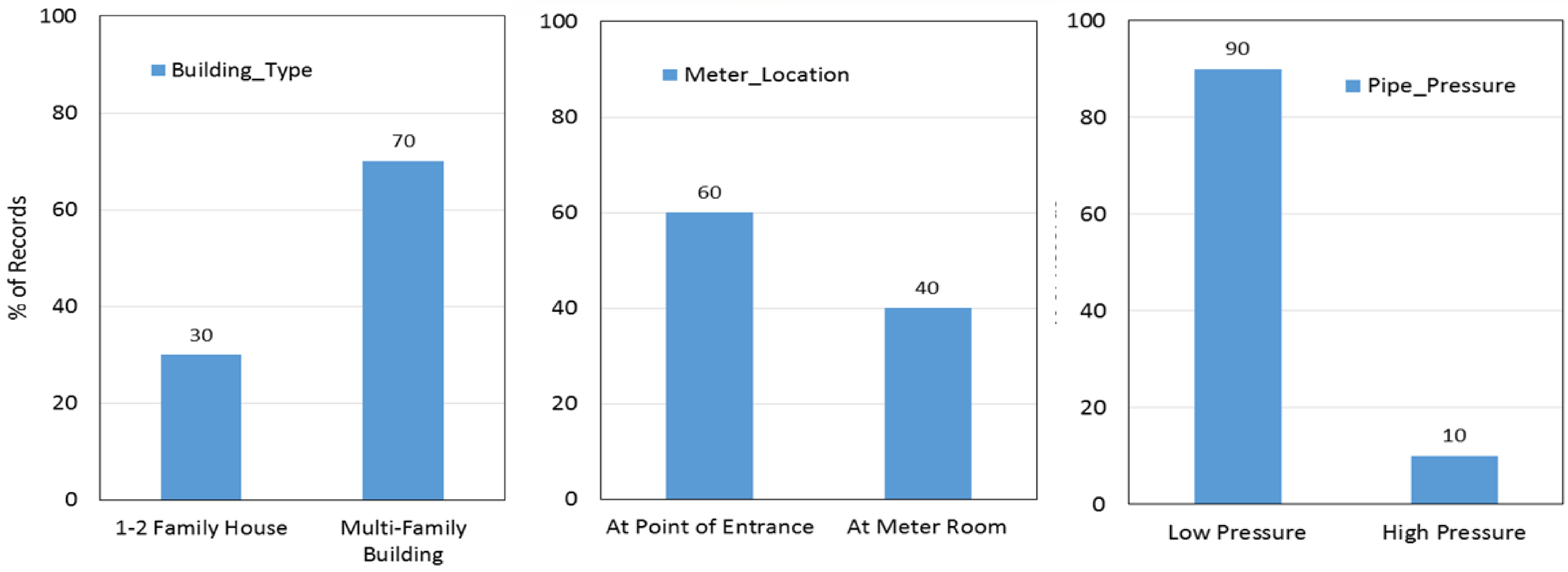
- most of the inspections had no-corrosion to mild surface condition.
- About 1% of the inspections had corrosions which required repair or replacement.



[*] Risk-Based Atmospheric Corrosion/ Leak Survey Considerations, GTI, Project 21678, 2014.

Task 4 – Rehabilitation of Piping System

Further investigation of the corrosion records which required repair:



Task 5 – Best practice Guidelines

DIMP Requirement	Best Practice Recommendation
(a) **Knowledge.** An operator must demonstrate an understanding of its gas distribution system developed from reasonably available information.	**Do you have inside service regulators?** ▪ Capture and verify existing data identifying inside service regulators. ▪ The number and location of inside service regulators should be quantified and entered in the DIMP risk model. ▪ Inside service regulator knowledge should be captured or verified during inspections for: - Leak survey, - Corrosion monitoring, - Patrolling activities, - Customer visits or service Calls. ▪ Operating procedures need to be updated directing how the inside service regulator data are captured, verified, and reviewed to incorporate into DIMP.

Task 5 – Best practice Guidelines

DIMP Requirement	Best Practice Recommendation
(b) **Identify threats**. Consider the following categories of threats to each gas distribution pipeline: Corrosion, natural forces, excavation, other outside force damage, material or welds, equipment failure, incorrect operations, and other issues that could threaten the pipeline.	**Threats on piping upstream of the inside service regulator are greater than the threats on piping downstream of the inside service regulator.** ▪ Operating procedures should detail how to identify the threats separately in upstream higher-pressure piping and the lower pressure downstream piping. ▪ The higher-pressure piping inside a building will amplify the hazard when exposed to threats.
(c) **Rank risk**. Determine the relative importance of each threat and estimate and rank the risks posed to its pipeline.	**The risk of inside service regulator is greater in comparison to an outside service regulator.** ▪ Weigh the consequences of threats in a risk model greater for inside service regulator piping and at higher upstream sections.

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Task 5 – Best practice Guidelines

DIMP Requirement	Best Practice Recommendation
e) **Measure performance**, monitor results, and evaluate effectiveness. Develop and monitor performance measures from an established baseline to evaluate the effectiveness of its IM program.	**Risk Performance Metrics:** - Number of RMDs installed - Number of RMD alerts. What were the causes of the alerts? - Number of smart and shutoff valve closes and the causes - Type of damage (Inside/outside) - Meter leak (piping and connections) - Vent piping leak and its cause - Inside service regulator failure - Unauthorized piping operation - Device tampering - Gas utility-owned valve leak - Outside leak that migrated to the inside - Customer piping and Equipment condition - Other and unknown causes.

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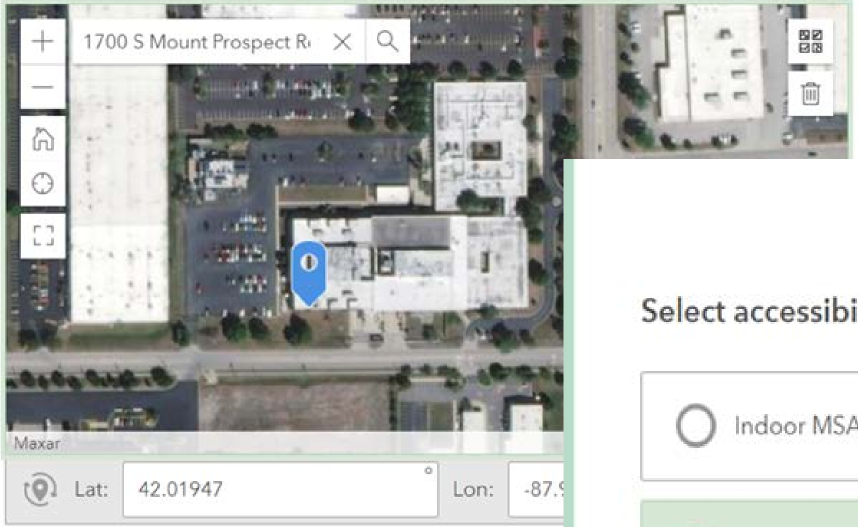
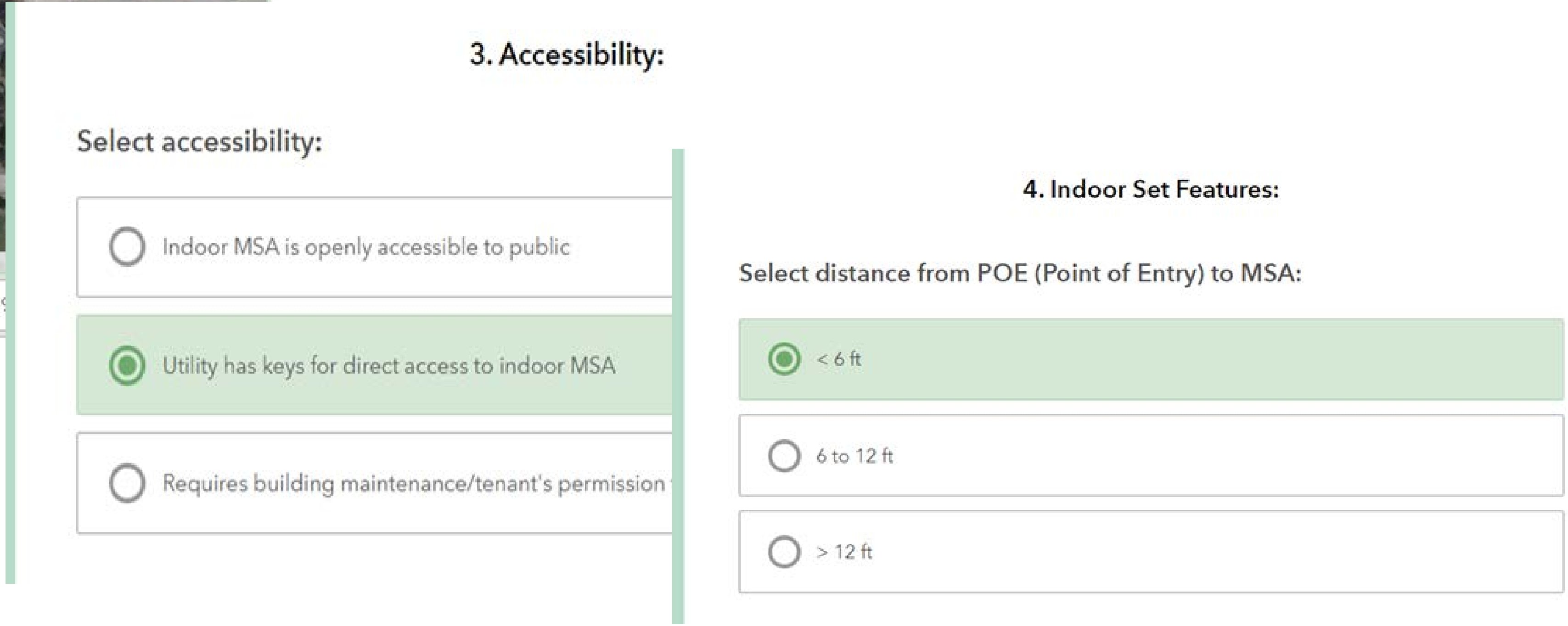
Task 5 – Best practice Guidelines

GIS-Based Web Data Capture for DIMP





Link to Form: https://arcg.is/1jPrCj2

Task 5 – Best practice Guidelines

6. Regulator Vent to Outdoor:

Is there a regulator vent to outdoor?

- Yes
- None, vented indoor

Select vent pipe material:

- Steel
- Plastic
- Other

Select vent inspection:

- As per utility specification
- Needs work/relocation

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Select corrosion location:

- [x] At Point of Entry (POE)
- [ ] At contact with soil
- [ ] Coating damage
- [x] At Uncoated surface

Select leaking Item:

- Fitting threads
- Pipe/coupling
- Meter
- Regulator
- Unknown/Other

Task 6 - Conclusions

- Best Practices, new regulators, and monitoring technologies provide safe options to retrofit inside installations, manage vented gas, and provide a warning and emergency shutoff [when Outside regulators are not visible].
- Retrofitting indoor regulators should provide an equivalent level of safety to outside installations: Compare indoor and outdoor Risk factors including consequences.

Task 6 – Conclusion

Risk Assessment and Mitigation in Outdoor and Indoor Installations

Threat	Outdoor Installation	Indoor Installation
Gas leak and emissions from regulators and piping system	Lower risk when gas emissions escape to the atmosphere. Mitigation: - install low emission regulators and excess flow valves.	Higher risk due to high consequences of indoor gas accumulation. Mitigation: - Implement decision-making tools for moving indoor installations to outdoors. - Install low emission regulators. - Install smart shutoff valves, OPSI protection, and RMD with remote monitoring and shutoff. - Install communication network. - Increase periodic Inspections and immediate repair of indoor systems.
Atmospheric corrosion	Higher occurrence but lower risk, Mitigation: Scheduled inspection of outdoor meter sets.	Higher risk due to high consequences and when access is restricted for inspections. Mitigation: - Increase public awareness and inspections. - Control humidity and improve coating at POE.

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Task 6 – Conclusion

Risk Assessment and Mitigation in Outdoor and Indoor Installations

Threat	Outdoor Installation	Indoor Installation
Improper installation	Mitigation: Maintain safe clearances from buildings inlets.	Higher risk in long piping systems. Mitigation: Implement best practices.
Operation: Maintenance and access	Lower risk due to unrestricted access the meter set.	- Higher maintenance risk due to restricted access to meter rooms and private homes. - Higher probability and consequences of gas accumulation in multi-regulator rooms in high-rise buildings. Mitigation: Implement best practices.
Outside force	Higher risk of vehicles hits, wind, and other outside force.	Risk to flooding and vents blockage and damage. Mitigation: Implement best practices.
Tampering	Higher risk of tampering.	Lower risk in controlled-access meter rooms.

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Task 6 - Conclusions

Next Steps:

- Smart shutoff Technology Implementation.[*]
- Field demos of low-emission regulators and monitoring technologies at utility sites.
- Continue working with NFPA on the 715 RMD Performance standard for acceptance and implementation.
- AGA Community outreach (AGA meeting, May 2022).

[*] Smart Shutoff Technology for Residential and Commercial Buildings, OTD and California Energy Commission (CEC), Project 22801, current.

Procedures for Retrofitting Indoor Gas Service Regulators

Khalid Farrag,
Project Manager, GTI
(847) 344-9200
kfarrag@gti.energy

Joe Carlstrom
Principal Investigator, GTI
(224) 388-3938
jcarlstom@gti.energy

Project page and final reporting are available at:

https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=916

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