Natural Gas utilized the Manufactured Gas Low Pressure Delivery Systems
Typically Older Systems (1800’s - early 1900’s)

• Integrity Management Issues
  o Leaks and difficulty in repairing leaks
  o Cast Iron, Wrought Iron, Bare Steel
    o Bell and Spigot, Bell/Bell Chill ring
    o Steel services off CI mains.
  o Antiquated Equipment - Valves
  o Poor Meter set locations. i.e. curb meters, basement meter sets
  o Leak Migration - Wall to wall pavement

Multiple Inlet Sources

• Increase susceptibility to risk of failed open regulation

No Pressure Regulation between the distribution system and Customer Equipment.
Low Pressure System Recent Incidents

Recent Incidents involving Over-Pressurization

Recent Incidents involving Cast Iron Pipeline Failure
Incidents Involving Over-Pressurization

Scenario 2: Alameda, CA

September 14, 2018
- Damaged 131 Structures
- 5 Homes Destroyed
- 1 Fatality
- 21 Injuries

Key
R: Regulator
M: Monitor
S: Sensing Line
Recent Incidents Involving Cast Iron Pipeline Failure

**January 20, 2018 - Brooklyn, NY**
Gas Fire. Injured four. 6-inch CI installed 1927. Apparent cause - frost heave.

**July 31, 2016 - Shreveport, LA**
Gas Fire. 1 fatality and 1 injury. 4-inch CI installed in 1911. Apparent cause - erosion.

**March 5, 2015 - Detroit, MI**
Gas Leak. 1 fatality, 1 injury, 6-inch CI installed 1923. Apparent cause - Circumferential crack.

**January 27, 2015 - Cordova, AL**
Home explosion. 1 fatality and 3 injuries. CI installed in 1952. Apparent cause - Earth movement.

**January 9, 2012 - Austin, TX**
Home explosion. 1 fatality and 1 injury. 4-inch CI installed in 1950. Apparent cause – ground movement rainfall that followed extended drought conditions.

**February 9, 2011 - Allentown, PA**
House Fire. 5 fatalities 3 injured 8 homes destroyed 12-inch CI installed in 1928. Apparent cause – break.

**January 18, 2011 - Philadelphia, PA**
Explosion and fire. 1 fatality several injuries 12-inch CI installed in 1942. Apparent cause – break.
Why not just replace it?

Because it’s Hard!

We have been trying for a long time!

In 1983 Operators reported 61,536 miles of CI/WI main
### Cast/Wrought Iron Main Miles and Service Count by Year

#### State: (All Column Values)

<table>
<thead>
<tr>
<th>Year</th>
<th>Main Miles</th>
<th>Service Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>39,645</td>
<td>32,862</td>
</tr>
<tr>
<td>2006</td>
<td>38,704</td>
<td>27,232</td>
</tr>
<tr>
<td>2007</td>
<td>37,720</td>
<td>22,050</td>
</tr>
<tr>
<td>2008</td>
<td>36,813</td>
<td>21,216</td>
</tr>
<tr>
<td>2009</td>
<td>35,623</td>
<td>21,323</td>
</tr>
<tr>
<td>2010</td>
<td>34,592</td>
<td>20,728</td>
</tr>
<tr>
<td>2011</td>
<td>33,669</td>
<td>15,408</td>
</tr>
<tr>
<td>2012</td>
<td>32,406</td>
<td>13,511</td>
</tr>
<tr>
<td>2013</td>
<td>30,904</td>
<td>11,991</td>
</tr>
<tr>
<td>2014</td>
<td>29,359</td>
<td>11,618</td>
</tr>
<tr>
<td>2015</td>
<td>27,770</td>
<td>10,028</td>
</tr>
<tr>
<td>2016</td>
<td>26,224</td>
<td>9,345</td>
</tr>
<tr>
<td>2017</td>
<td>24,493</td>
<td>7,652</td>
</tr>
<tr>
<td>2018</td>
<td>22,861</td>
<td>6,985</td>
</tr>
</tbody>
</table>

**At this rate we still have 20 years to go.**

- 1983 - **61,536** miles of CI/WI in operation
- 2005 – **39,645** miles in operation
- 2018 – **22,861** miles in operation

Replacement Challenges

- Maintaining Gas Service During Replacement
- Cast iron systems
  - Replacement and shut-off is difficult
    - Can’t weld on it or cut it
- Congested Utilities
  - Abandoned facilities present
  - No place to install
  - Thick street cross sections
  - Limited Work Hours - Traffic Control Requirements
- Poor Meter Locations
  - Customer fuel gas line requires modification
- Etc.
NTSB Recommendations

1. Require a professional engineer’s seal

2. Engineering and constructability review processes

3. Records Review - traceable, reliable and complete

4. Apply management of change process identify system threats that could result in a common mode failure

5. Job Procedures and Monitoring – Clearances, Shut Down and Tie In. Hang Gauges etc.
AGA Leading Practices to Reduce the Possibility of a Natural Gas Over-Pressurization Event:

- Design Practices for all Pressure Classifications: 18
- Standard Operations and Maintenance Practices: 11
- Construction, Tie-Ins, Tapping, Uprates, and Abandonments Practices: 4
- Damage Prevention Practices: 5
- Records Practices: 6

Human Factors:
- Management of Change - 4
- Training for Recognition and Prevention of AOC’s - 4
- Filed Oversight Practices - 5
- Management of Risk of an Overpressure Event
  - General - 2
  - DIMP - 4

TOTAL: 63
Accurate Records

Operating Diagrams
Locate sensing lines locations

Equipment Records and Maintenance Management Systems

Confirmation that records match what’s installed.

“Health” Score card.

Stations Included in DIMP
GTS Station Evaluation and Risk Mitigation™

Planning

Foundational Activities

- Test Records
- Inspection Records
- Drawings (e.g. As-Built)
- Other Documents

Project Team Assembly

- Assembly
- Planning

Project Controls

- Bills of Material

SFL and Draft OD Build

- OD Build
- OD Review
- DIMP

Field Evaluation

- OD & Calcs Confirmation
- Project Controls
- Risk Algorithm

Issues Resolution

- Issues Resolution
- Budgeting for Issues Resolution

- Confirm Station Operation
- Locate Sensing Lines
- Gather Equipment, Operating and Risk Data

- Confirm Station Operation
- Locate Sensing Lines
- Gather Equipment, Operating and Risk Data
Operating Diagram Standard

- **Potential Changes/Additions**
  - Operations: Valve tagging conventions
  - AGA Leading Practices: sensing tap locations, telemetry points
  - Ex: Single feed, bypass valves and connection, slamshut
Station Health Field Checklist

Checklist items based on:

- Code Compliance, PHMSA Gas Dist. IA Question Set
- Company Standards
- AGA Leading Practices, Risk Algorithm, Experience

<table>
<thead>
<tr>
<th>Station Health - Review Checklist</th>
<th>Complete During Site</th>
<th>Station:</th>
<th>Service Center:</th>
<th>Form Completed By:</th>
<th>Date Completed:</th>
<th>Compliance</th>
<th>REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 1 - Alarming, Abnormal Operating Conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1. Are there mechanisms in place to generate an alarm on abnormal operating conditions? | | | | | | | | A | AGA LP OP 41, p.6
| E.g. failed control valve, overpressure, excessive flow. Examples: alarm relay ("whistle", "hatchet", "hobbin"), full relief valves, pressure recording devices, pressure signals to Gas Control, etc. | B, C | AGA EN 303 p.3 Southern OPW Dir 56-71, 56-72 (for press. regulators) |
| Enter Yes or No | | | | | | | | |
| 2. Availability of Mechanisms in Place on Req Runs? | | | | | | | | B, C | AGA LP OP 41, p.6
| Enter: None, Some, All | | | | | | | | AGA EN 303 p.3 |
| 3. Is SCADA available at the site(s) and pressures, flow rates, and other data points are transmitted to Gas Control? | | | | | | | | C | AGA LP OP 49, p.8 Southern OPW Dir 512-93, 512.4 |
| Enter Yes or No | | | | | | | | | |
| 4. Does the station include any remotely controlled valves? | | | | | | | | B, C | AGA LP OP 49, p.8 |
| E.g. for isolation, regulator valves, etc. | | | | | | | | | |
| Enter Yes or No | | | | | | | | |
| **Section 2 - Equipment Issues** | | | | | | | |
| 5. Are any of the valve(s) inoperable, have severe blow by or leak to atmosphere? | | | | | | | | B | |
| Enter Yes or No | | | | | | | | | |
| 6. Are any of the valve(s) hard to operate or cannot get positive shutoff? | | | | | | | | B | |
| Enter Yes or No | | | | | | | | | |
| 7. Are any of the valve(s) somewhat hard to operate or have some issues? | | | | | | | | A | 49 CFR 192.745 |
| Enter Yes or No | | | | | | | | | |
## Incorporation Into DIMP

<table>
<thead>
<tr>
<th>Algorithm Development</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Assemble SME Panel</td>
<td>Include Engineers, Technicians, Gas Control etc.</td>
</tr>
<tr>
<td>Determine Risk and Consequence Categories</td>
<td>Consider incident history, maintenance records, Material failure reports etc.</td>
</tr>
<tr>
<td>Determine Risk and Consequence Drivers &amp; Impact Level</td>
<td>Ballot Process Assign an Impact Level – High Medium or Low</td>
</tr>
<tr>
<td>Algorithm Scrubbing</td>
<td>Review ballot results for redundancy and to eliminate insignificant drives.</td>
</tr>
<tr>
<td>Algorithm Vetting</td>
<td>Apply the algorithm to a sample set of stations and consider the outcomes</td>
</tr>
</tbody>
</table>
Example Reg Station Risk Algorithm

**Probability of Failure X Consequence of Failure**

\[ (A_{eq} + B_{dd} + C_{plc} + D_{nc} + E_{3p}) \times (F_{lp} + G_{env} + H_{bus}) = \text{Total Station Risk} \]

Where:
- \( A_{eq} \) = Probability of Equipment related risk
- \( B_{dd} \) = Probability of a Design Deficiency related risk
- \( C_{plc} \) = Probability of a Pipeline Contamination related risk
- \( D_{nc} \) = Probability of risk related to Natural Causes
- \( E_{3p} \) = Probability of Damage by Third Party
- \( F_{lp} \) = Consequence to life or property
- \( G_{env} \) = Consequence to the environment
- \( H_{bus} \) = Consequence to business

This algorithm is being offered as an example strictly for this presentation. Operating conditions, incident history, environment etc. vary from operator to operator. A unique risk algorithm needs to be developed for each operator and therefore GTS does not endorse its use.
## Example Station Risk Algorithm

### POF CATEGORIES

<table>
<thead>
<tr>
<th>POF Category</th>
<th>Risk Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req = Equipment</td>
<td>27</td>
</tr>
<tr>
<td>Rdd = Design Deficiency</td>
<td>23</td>
</tr>
<tr>
<td>Rpc = Pipeline Contaminants</td>
<td>17</td>
</tr>
<tr>
<td>Rnc = Natural Causes</td>
<td>15</td>
</tr>
<tr>
<td>Rtp = Damage by Third party</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

### POF SUB-CATEGORIES

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Enter Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regs Monitors</td>
<td>41</td>
</tr>
<tr>
<td>Ancillary Equipment</td>
<td>20</td>
</tr>
<tr>
<td>Control Loop Assemblies</td>
<td>24</td>
</tr>
<tr>
<td>Block Valves</td>
<td>6</td>
</tr>
<tr>
<td>Vaults</td>
<td>9</td>
</tr>
</tbody>
</table>
# POF Risk Driver Impacts

<table>
<thead>
<tr>
<th>Control Loop Assemblies</th>
<th>1.0</th>
<th>High</th>
<th>Location of sensing lines unknown and/or equipment is obsolete, no spare parts available, prone to failure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.8</td>
<td>Medium</td>
<td>Equipment is obsolete, no spare parts available, prone to failure</td>
</tr>
<tr>
<td></td>
<td>0.6</td>
<td>Low</td>
<td>Equipment is antiquated and does not perform to modern expectations.</td>
</tr>
</tbody>
</table>
Results

- Records Review Performed and Confirmed with Field Assessments
- Comprehensive Equipment List and Maintenance Management system updated.
- Health Issues identified and included in management tracking mechanism.
- Relief Valve and Reg Station Capacity Calcs current and repeatable
- Accurate Operating Diagrams to facilitate Station Clearance Procedures
- Stations will be Included into the DIMP program
  - Benefit from a cross prioritization with pipeline mitigations
  - Supports rate case submittals
Questions?

Scott Clapp
GTS Chief Strategy Officer
www.gtsinc.us