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Failure Investigations and Root Cause

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U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration

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Regulations

- §§ 192.617 & 195.402(c)(5)
  - Post-failure and incident procedures
  - Post-failure and incident lessons learned
  - Analysis of rupture and valve shut-offs
  - Rupture post-failure and incident summary
- "Investigating and analyzing pipeline incidents/accidents and failures…"

Definitions

§191.3 Incident

- An event involving a release of gas from a pipeline, gas from an underground natural gas storage facility (UNGSF), liquefied natural gas (LNG), liquefied petroleum gas (LPG), refrigerant gas, or gas from an LNG facility, and that results in one or more of the following consequences:
  - Death or personal injury necessitating in-patient hospitalization
  - Estimated property damage of $153,600 (July 1st , 2026)
  - Unintentional estimate gas loss of 3 million cubic feet (mcf) or more
  - Emergency shutdown of LNG facility or UNGSF
  - Significant event per operator judgement

§195.50 Accident

- Each failure in a pipeline system subject to this part in which there is a release of the hazardous liquid or carbon dioxide transported resulting in any of the following:
  - Explosions or fire not intentionally set by the operator
  - Release of 5 gallons or more of hazardous liquid or carbon dioxide
  - Death of any person
  - Personal injury necessitating hospitalization
  - Estimate property damage exceeding $50,000

Failure

- A condition in which a human, structure, component, device, or system fails to adequately perform its intended purpose. (PHMSA Glossary)
- General term used to imply that a part in service has become completely inoperable; is still operable but is incapable of satisfactorily performing its intended function; or has deteriorated seriously, to the point that is has become unreliable or unsafe for continued use. (ASME B31.8S Managing System Integrity of Gas Pipelines)

Root Cause

- The most basic reason(s) for a failure or condition, which if removed will prevent (or minimize the risk of) recurrence
- Near misses, near hits, and close calls stem from the same root causes as major incidents

Contributing Factors

- Action, lack of action, or other condition influencing the failure by increasing its likelihood, accelerating the failure time, or affecting the severity of the consequences
- Not a direct (root) cause for failure

When Do We Investigate?

Operator Goals

- Most operator's goals when responding to a failure/incident/accident include
  - Correcting the unsafe condition
  - Restoring service
  - Documenting new installation

Identify Events

- Operators need to identify what events will trigger an investigation
  - Major incidents/accidents
  - Fires/explosions
  - Death/serious injury
  - Significant impact to operations

Needs Investigation

- Excavation/outside force damage
- Leaks/corrosion/maintenance
- Equipment/component failures
- Operations/procedural failures
- Design/construction/materials
- Environmental/biological

Include in the Procedure

- Event classifications
- Assigning the investigation
- Expectations of investigations
- Evidence collection and security
- Post investigation responsibilities
- Investigation training

How Do We Conduct a Failure Investigation?

Preparation

- Pre-investigation preparation
  - Procedures in place before the need
  - Required equipment
    - Personal safety equipment
    - Investigation forms
    - Camera (memory cards, extra film, batteries)
    - Notepads, pens, markers
    - Sample/evidence collection supplies
    - Measuring equipment, scene markers
- Training or other resources

Initial Response

- Scene size-up
- Isolation and resolution
- Collection of perishable evidence
- Documentation and photography
- Identification of witnesses

Data Collection

- Witness statements
- Operational records
- Historical records
- Control room data
- Environmental data
- Manuals, bulletins, technical specs
- Leak reports
- Odor calls
- Locate requests
- Work orders
- Purchase history
- Maintenance records

Data Analysis

- Lab analysis reports
- Subject matter experts
- Testing/reconstruction
- Simulation
- Theory evaluation

Post Investigation

- Identification of cause(s)
- Identification of contribution factor(s)
- Written failure report
- Review (training, procedures, policy)

Lessons Learned

- The documented information reflecting both the positive and negative experiences of a failure
- Contributing factors can lead to a positive outcome of a failure

Ruptures

- If an incident or accident involves the closure of a rupture mitigation valve (RMV), an analysis must be conducted of all factors to determine impact and consequences
- Any incident/accident with a rupture or RMV closure requires 90-day (quarterly) summary reviews until investigation and post summary are completed

Effective Use of Investigative Tools

Photography

- Ensure photos tell the story
- Utilize a macro-micro approach
- Capture images of items as found
- Capture evidence collection activates
- Use of scale

Evidence Collection

- Document description, location, orientation, characteristics of item
- Do not alter or clean
- Do not minimize recovery size
- Document chain of custody
- Ensure post collection access is limited and documented

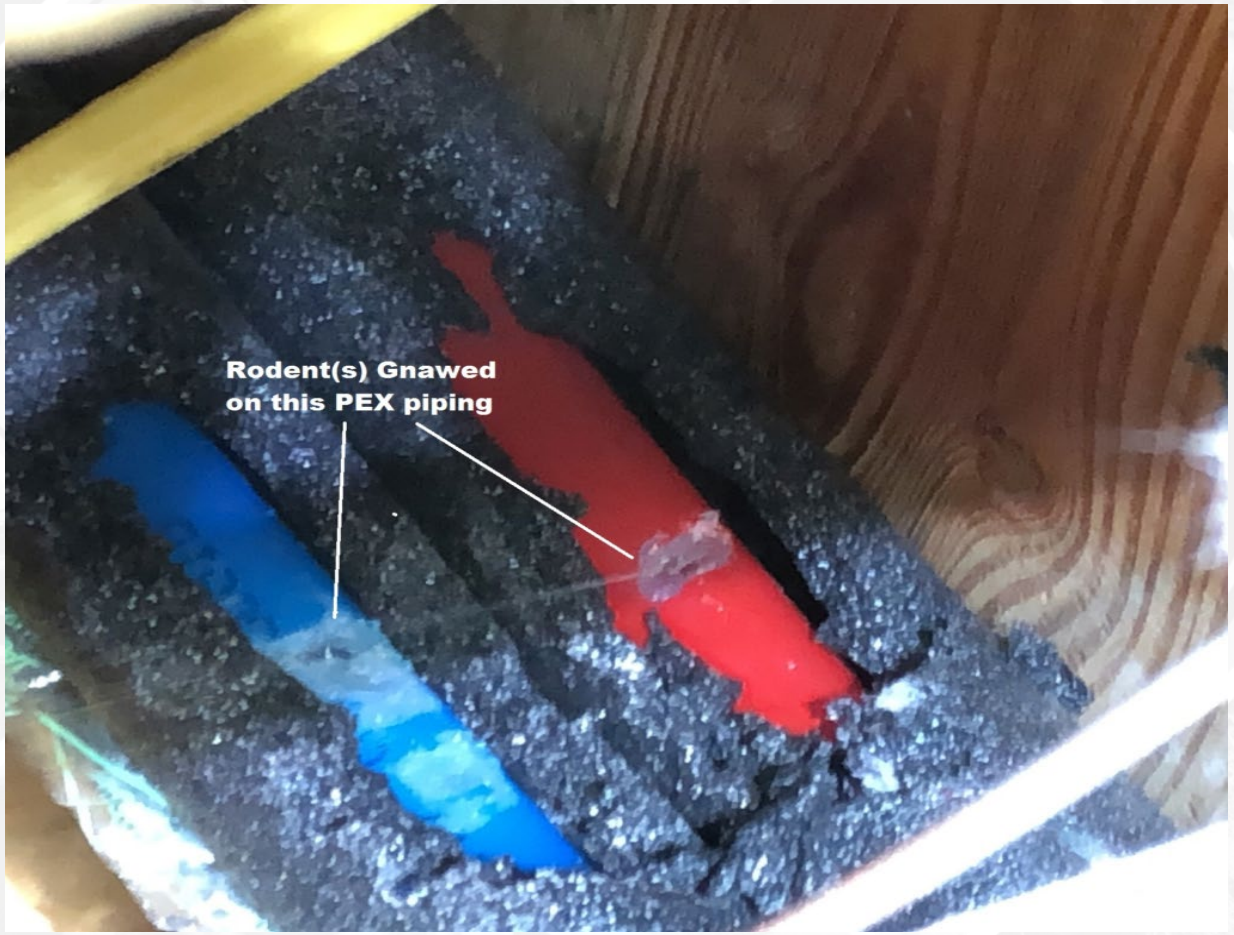
Interviews/Witness Statements

- Collect facts, not admission of guilt
- Do not use leading questions
- Remain neutral
- Collect written statements
- Ask, is there anything I missed that you feel is important for me to know?

Photographic Evidence

Horizontal (Directional Drilling)

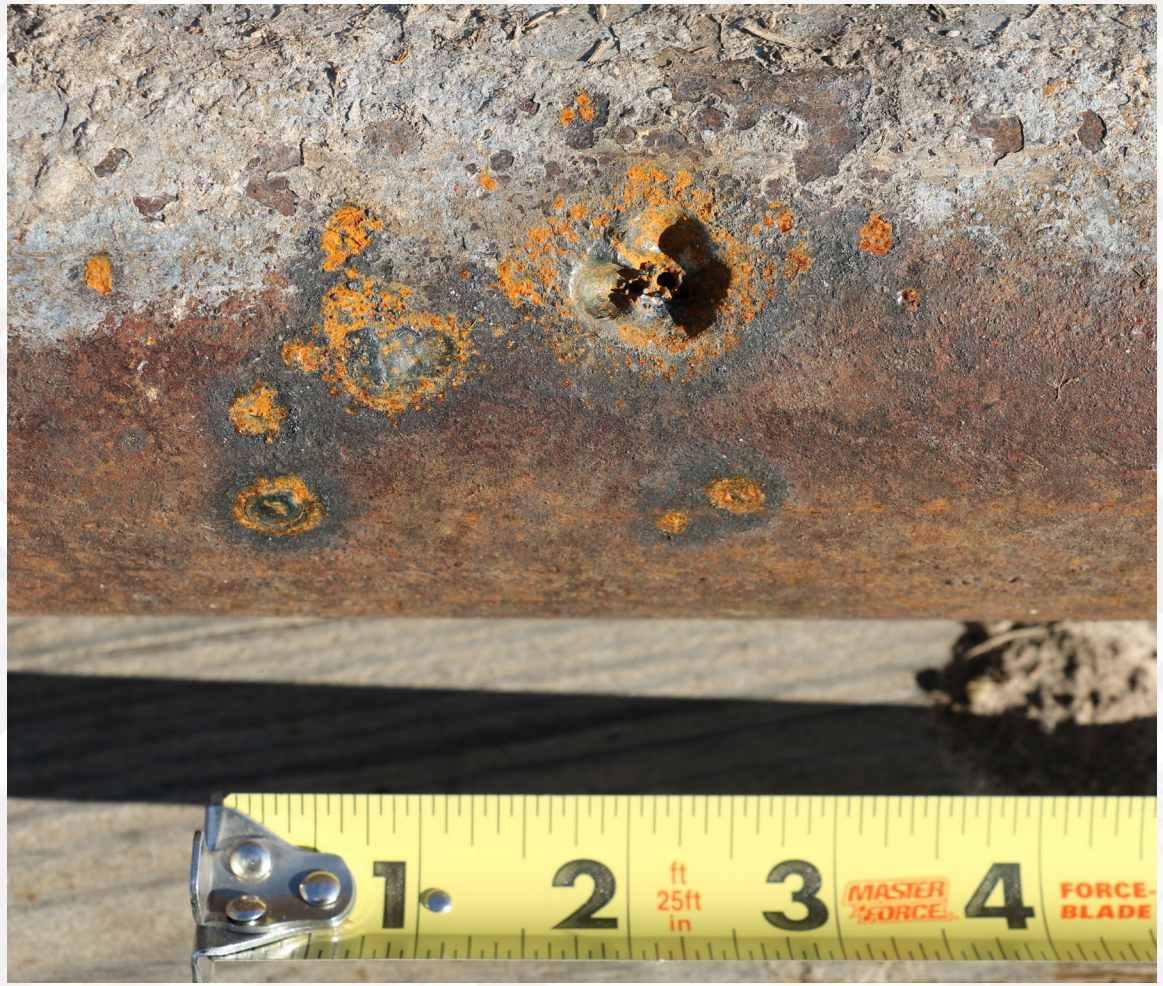
Rodent / Insect Damage



External Force Damage

External Force/Fire Damage

Electrical Arc Damage



Thank you

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PHMSA Training and Qualifications