UNDERGROUND NATURAL GAS STORAGE- INTEGRITY & SAFE OPERATIONS

Overview of White Paper

Prepared for:

American Petroleum Institute, American Gas Assoc. and Interstate Natural Gas Assoc. of America

Andrew Theodos

PHMSA Workshop, Denver, Colorado

July 14, 2016

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Background

- API Recommended Practice 1170 and 1171 initiatives
  - Industry and government teams to develop consensus standards
    - 1170 membership – 7 operators, 6 engineering & geological firms and reps from FERC, PHMSA, MS and TX
    - 1171 membership – 13 operators and reps from FERC, PHMSA, CA, KS, MI, and PA
  - Started March 2012
  - Published in September 2015
  - Voluntary consensus standards
- Industry work following the API 1170 and 1171 development
  - Starting effort to align existing integrity efforts with the recommended practices

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Background cont.

- Establishment of Joint Industry Task Force (JITF)
  - Response to Aliso Canyon incident
  - 15 storage operators
  - American Petroleum Institute (API), American Gas Assoc. (AGA) and Interstate Natural Gas Assoc. of America (INGAA)
- INGAA filed petition in Jan. 2016 to have API 1170 & 1171 incorporated into Federal Regulations (Docket No. PHMSA-2016-0024)
  - Petition would “convert” a voluntary recommended practice into a regulation
  - Have a comprehensive, standardized set of integrity management practices
- July 2016 white paper
  - Enhance technical understanding and context of API 1171 and other topics on well integrity
  - http://www.energyinfrastructure.org/energy-101/natural-gas-storage

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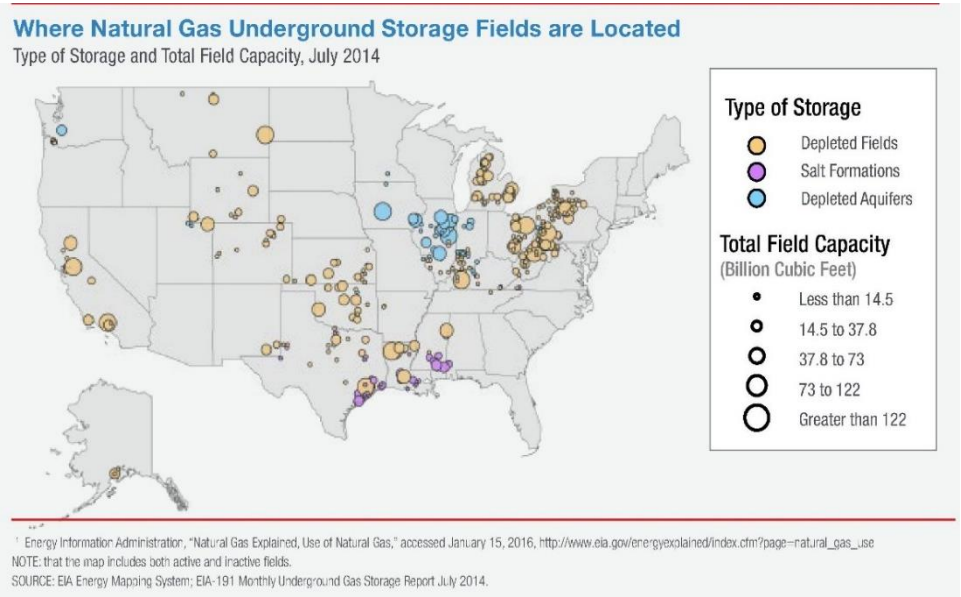
US Storage Assets

- Approximately 400 storage fields
- Total of about 17,500 storage wells
- 1st storage field developed in 1916
- 4 basic physical components
  - Compressor station
  - Pipelines
  - Wells
  - Reservoir



- Storage field compressor station and pipelines facilities already covered by PHMSA's Part 192 regulations
- INGAA's petition would bring the last 2 components (wells and the reservoir) under PHMSA

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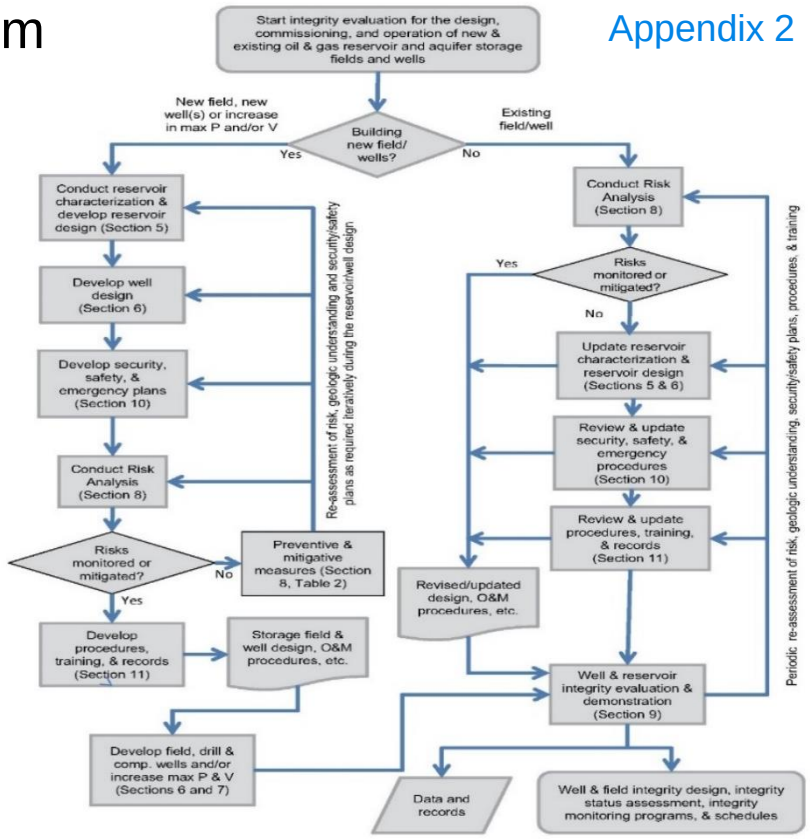
White Paper- Storage Well Integrity

- Goals of storage well integrity management-
  - Contain the gas with in the system
  - Verify its containment
- Life cycle of a well
  - Design
  - Construction
  - Commissioning
  - Operations
  - Maintenance
  - Abandonment
  - Procedures and training

Appendix 2



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1. Storage Well Risk Assessment

- Risk management program has 3 components:
  - Physical plant design, processes and human factors
- Assessment includes:
  - Data collection, hazard and threat identification, likelihood of occurrence estimation, consequence severity determination, and periodic review and reassessment
    - Appendix 3 - threats and hazards
    - Appendix 4 - preventative, mitigative and monitoring practices
- Basis for:
  - Developing integrity demonstration, verification and monitoring tasks
  - Frequency of monitoring tasks
- Incorporate new procedures, practices and technology as appropriate

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Storage Well Risk Assessment (cont.)

- Concepts to keep in mind:
  - Many potential hazards and threats- need to identify and manage
    - Interaction between threats
  - Many preventative and mitigative (P&M) measures to manage identified hazards and threats- some have very specific applicability
  - Issue of time
    - Age is not synonymous with threat
      - Issue- attributes and environment the well is in
        - Magnitude and type of exposure to downhole and surface threats
    - Threats can change over time

Diverse variety of potential threats → Addressed by → *Diverse variety of preventative & mitigative tools*

No one P&M measure will address all threats

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2. Foundation for Integrity Management

- Operators represent large percentage of US storage assets with decades of experience
- Reviewed past industry incidents to incorporate lessons learned
- Reviewed Canadian and European storage standards
- Reviewed other consensus standards on well design, construction and operations

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3. Storage Well Design Factors

- Well design factors (wellhead, casing, cement, etc.)
  - Design factors for casing
    - API 5C3 bulletin includes a 12.5 % safety factor
    - Higher safety factor when designed for stimulation treatment after drilling
      - Ex. 5.5” J55 15.5# = 4,810 psi yield strength in 1,200 psi MAOP field
    - Zonal isolation is achieved by combinations of casing (i.e. surface, intermediate & production) and cement
    - Reference many industry standards
      - Ex. API RP 5A3, API RP 5C1, API TR 5C3, API Spec 5CT, API 10A, ASTM C 150/C 150M, and others
    - Threaded connections engineered for mechanical loads while providing a seal
      - Make-up per API 5CT, thread compound per API 5A3
      - Permits replacement of sections of non-cemented casing
    - Internal coatings generally not beneficial

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Emergency Shutdown Valves

- Detailed review in Appendix 6
  - Subgroup reviewed technology, experience and pros & cons
  - Use since 1960's for higher risk storage wells, e.g. near homes or roads
- Types:
  1. Surface safety valves (SSV)
  2. Subsurface safety valves (SSSV)
- Estimated 500-900 storage wells have SSSVs
- Key ESV observations:
  1. Physical barrier that require specific set of conditions to activate
  2. Can reduce the consequences of an event by minimizing duration and impact
  3. Location of valve determines the risk reduction
  4. Increases the number of well re-entries, blockages, and malfunctions which erode the risk reduction benefits
  5. Mitigation with 2 or more passive physical barriers (e.g. casing with cement) have comparable or better safety rates and are inherently more reliable

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Emergency Shutdown Valves (cont.)

- Recommendations
  - Support, develop and implement risk-based integrity management plans
    - ESV are a specific tool for a specific problem, not a tool applicable to all threats
  - Industry align with PHMSA's Storage Advisory
    - Periodic function tests for all ESV systems and repair deficiencies
    - Evaluate the need on new, removed, or replaced tubing strings or production casing using risk assessment aligning with API 1171
    - Where not installed, used risk assessment for decisions on inspection frequencies and incident mitigation criteria

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4. Storage Well Operations

- Well integrity evaluation, verification & monitoring
  - Covers every storage well and 3rd party wells that penetrate the storage reservoir or buffer zone
  - Risk assessment determines tasks and frequency
  - Discusses tubular monitoring and downhole evaluation tools
- Site security and emergency response
  - Site specific plans
  - Incident response drills

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Storage Well Operations (cont.)

- Procedures and training
  - Align existing procedures with API 1171 and expand and develop new processes and procedures to be in conformance with API 1171
  - Expand training
  - Management of change
  - Record keeping
- Total API 1171 implementation
  - Estimate 7-10 years to reach full conformance with API 1171 and evaluate the mechanical integrity of each active well as per the high standards of API 1171

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Thank you

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