



**2023 PHMSA UNGS Public Workshop**  
**Research and Development Projects**  
Tuan Tran, Abey John, Jonathan Wohlhagen



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Pipeline and Hazardous Materials  
Safety Administration

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# Projects Over the Years

- Funded 8 Projects since 2018
  - 5 Closed, 3 Active
- \$5.3 Million dollars funded
- Multiple Research Outfits
  - C-FER
  - Battelle
  - Pipeline Research Council (PRCI)
  - Oceanit
  - Gas Technology Institute
  - Fossil Energy and Carbon Management



# Tubing and Packer Life Cycle Analysis Battelle Memorial Institute



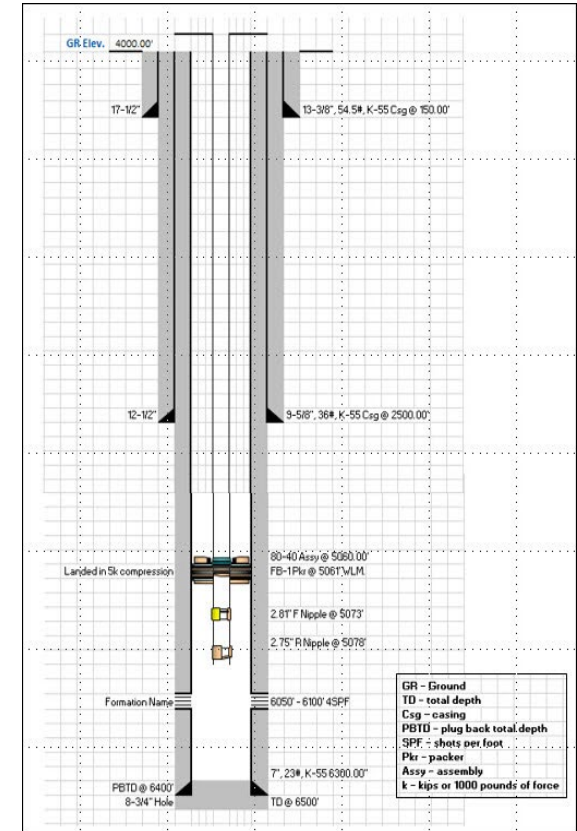
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# Tubing and Packers (T&P)

- Used by operators now for various applications
  - Dual barrier system
- Do dual barrier systems improve system integrity?
  - Increased frequency and complexity of workovers / maintenance
  - Deliverability restrictions
  - Production casing inspection
  - Risk introduced



# Tubing and Packers (T&P)

- Conducted by Battelle/Sandia (October 30, 2020)
- Assess the role of Tubing/Packer systems
- Based on 2022 Annual Report data
  - 2,477 wells with flow through production tubing
- Plan
  - Literature Review for data
  - Evaluation of well-entry impacts throughout tubing and packer life-cycle
  - Develop recommendations and improvements to current design





# Tubing and Packers (T&P)

- No real database to collect failure data
  - Failure rate data
  - Safety data
- Developed a quantitative risk model
  - Used modeling based on API 580/581 methodology and storage well-specific model created by 2017 Joint Industry Task Force
  - Assessed risk of 4 different styles of wells
  - Used industry-accepted modeling techniques and typical data for reservoir and well deliverability
  - Factors (well design, reservoir pressure, total amount of stored gas, nearby population density) and evaluate risk before/after T&P installation.



# Tubing and Packers (T&P)

- Findings
  - T&P may reduce risk in some, but not all UGS wells based on risk modeling
  - Low risk wells would generally not benefit from a T&P application
    - T&P-related workovers: frequency and complexity
  - Moderate risk wells based on likelihood of failure will depend
    - Possible cost-beneficial option at reducing risk
  - High Risk wells based on likelihood of failure will depend
  - T&P systems may introduce more risk due to workover needs
  - Quantitative risk model should be assessed for each well individually to determine



# Tubing and Packers (T&P)

- Project Link
  - <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=745>





# Reliability of Subsurface Safety Valves

## Battelle Memorial Institute



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# Subsurface Safety Valve (SSSV)

- General usage
  - To cutoff flow to a well that is connected to a hydraulic switch (hydraulic fluid and pressure)
  - Areas with trains, airplanes, and offshore production
- Do subsurface safety valves improve system integrity?
  - General Reliability/Maintenance
    - Control system, Annual testing
  - Risk Introduced
    - Generally installed on Tubing & Packer
    - Workover, malfunction, repair
    - Leak location

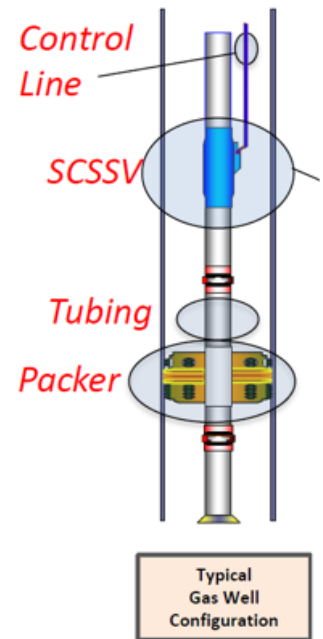


Image courtesy of Baker Hughes



# Subsurface Safety Valve (SSSV)

- Conducted by Battelle/Sandia (October 30, 2020)
- Assess the role of Subsurface safety valves (SSSV)
- Based on 2022 Annual Report data
  - 539 wells with subsurface safety valves
- Plan
  - Literature Review for data
  - Evaluation of SSSV characteristics and SSSV-related workover safety risks
  - Develop recommendations and improvements



# Subsurface Safety Valve (SSSV)

- No real database to collect failure data
- Developed a quantitative risk model
  - Used modeling based on API 580/581 RP methodology and storage well-specific model created by 2017 Joint Industry Task Force
  - Assessed risk of 4 different styles of wells
  - Factors such as different reservoir rate potentials, feed volumes/pressures, population densities.
    - If tubing-mounted, then additionally Tubing/Packer should be assessed.
    - Evaluate risk before/after SSSV installation



# Subsurface Safety Valve (SSSV)

- Findings
  - Low risk wells would generally not benefit from a SSSV application
  - Moderate risk wells based on likelihood of failure will depend
    - Possible cost-beneficial option at reducing risk
  - High Risk wells based on likelihood of failure will depend
  - SSSV's may introduce more risk due to workover needs
  - SSSV's may reduce risk in some, but not all UGS wells based on risk modeling
  - Quantitative risk model should be assessed for each well individually to determine





# Subsurface Safety Valve (SSSV)

- Project Link
  - <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=743>



# Evaluation of Well Casing Integrity Management for Underground Storage Wells Pipeline Research Council International



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# Evaluation of Well Casing Integrity Management

- Project Purpose
  - Identify logging technologies- Ultrasonic testing (UT), Magnetic flux leakage(MFL), Multi-finger Caliper (MFC), Electromagnetic (EM) Technologies
  - Factors affecting tool response
  - Methods calculating remaining casing strength
  - 4.5", 5.5", 7" casing sizes. All J55
  - Properly allocate resources to address high risk issues
  - Predict areas of concerns and classify levels of risks

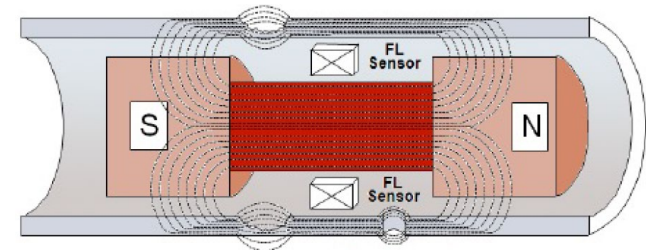


Image courtesy of Baker Hughes

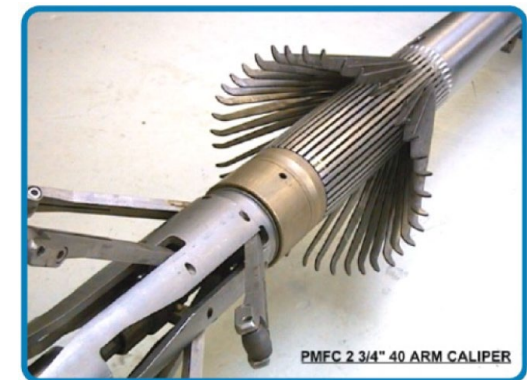


Image courtesy of Baker Hughes



# Evaluation of Well Casing Integrity Management

- Project Findings
  - MFL and UT generally have capability to conduct high-resolutions inspection of isolated casing corrosion features
  - Usage of multiple tools helps minimize uncertainties.
  - Operator / Vendor Communication
  - MFC used for measuring casing inner wall
    - Possible error from assumption of nominal casing dimension
    - Initial screening tool
  - EM tools for through-tubing logging have limitations
    - Estimate average wall loss around casing
    - Detection of only severe metal loss
    - Additional research warranted such as establish expectation of tool's capabilities, detection range.



# Evaluation of Well Casing Integrity Management

- Project Findings (continued)
  - Remaining Burst Strength prediction models
    - B31G, modified B31G, RSTRENG, LPC-1, BS 7910, API 579-1
    - Analytical prediction models all under-estimated from 10%-36%
    - ASME B31G and Modified B31G found to have lowest random error levels
    - Casing diameter-to-thickness ratio accuracy
  - Further lab testing and algorithm development
    - Strain-rate effect on remaining burst strength of corroded casing
    - Test broader range of metal loss features, casing grades
  - Consider more rigorous downhole corrosion logging system qualification guideline
    - Possibly based on API Standard 1163- standardized workflow





# Evaluation of Well Casing Integrity Management

- Project Findings (continued)
  - Research to identify and understand additional downhole threats that compromise casing integrity
    - Environmental-assisted cracking in casing pipe and threaded connections
    - Casing deformation in weak formation or tectonically active areas or salt cavern storage wells
    - Long-term casing connection sealability and structural integrity for wells using API connections or subjected to high frequency temperature and pressure cycles
  - Research on cement integrity and remediation methods to improve well integrity



# Evaluation of Well Casing Integrity Management

- Project Link
  - <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=747>



# Risk Assessment and Treatment of Wells C-FER Technologies



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# Risk Assessment and Treatment of Wells

- Project Purpose
  - Develop a relative, quantitative and probabilistic risk assessment guidelines
    - Failure frequency and failure consequence estimation
  - Develop guidelines for use
  - Provide support for regulators to evaluate risk assessment methods and models



# Risk Assessment and Treatment of Wells

- Project Summary
  - Quantitative risk analysis is highly dependent on assumed failure frequencies and failure modes
  - Cavern wells have a higher safety and environmental risk
  - Storages do not pose a significant safety risk unless in close proximity to the wellhead
  - Modest setback distances will increase safety
  - Well entry activities are the largest contributor to risk
    - Well configurations can lower risk but have a lower life-cycle





# Risk Assessment and Treatment of Wells

- Project Link
  - <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=740>



# Advancement of Through-Tubing Casing Inspection For Underground Storage Wells Pipeline Research Council International



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# Advancement of Through-Tubing Casing Inspection

- Project Purpose
  - Provide an understanding for through-tubing casing corrosion logging technology (magnetic eddy current)
  - Improving technology
  - Develop a reliability-based assessment framework
  - Three rounds of lab tests
  - Perform a field trial
  - Ongoing project



# Advancement of Through-Tubing Casing Inspection

- Lab Trials
  - C-FER Technologies Lab
  - 3 rounds of testing
  - Each round 3 different casings are tested with same-size tubing
    - Casings: 4.5”, 5.5”, 7”. All J55 and SMLS
    - Tubing: 2-7/8” that is L80 and SMLS
  - Metal loss features machined into casing
  - Vendors are Baker Hughes, GoWell, Schlumberger
  - Round 1 testing completed



# Advancement of Through-Tubing Casing Inspection

- Project Link
  - <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=943&text1=>



# Smart Well Assessment and Reservoir Management System (SWARMS) Oceanit Laboratories, Inc.



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# Smart Well Assessment and Reservoir Management System

- Project Purpose
  - Provide an innovative approach for leak identification and mitigation
    - Using nano-technology buoyant particles
- Project Findings
  - SWARM particles are suspended in topkill fluid to help kill wells
- Project has submitted for phase 2 of research





# Smart Well Assessment and Reservoir Management System

- Project Purpose
  - Develop a reliability-based assessment framework
  - Perform a field trial
  - Ongoing project



# Smart Well Assessment and Reservoir Management System

- Project Link
  - <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=975&text1=>



# Establishing the Technical Basis for Enabling Safe and Reliable Underground Hydrogen Storage Operations Fossil Energy and Carbon Management.



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# Establishing the Technical Basis for Enabling Safe and Reliable Underground Hydrogen Storage Operations

- Project Objectives
  - Identify and understand existing PHMSA regulatory functions
  - Quantify the suitability of existing UGS facilities
  - H2 resource loss processes, UGS asset degradation, and estimating transient behavior
  - Ongoing project
- Project Purpose
  - Establish the technical criteria for pure and blended hydrogen storage
  - Providing guidance: assessing the suitability of existing engineered systems, quantifying the possible operational expectations during conversion, and forecast transient operational behavior and end-state performance.



# Establishing the Technical Basis for Enabling Safe and Reliable Underground Hydrogen Storage Operations

- Project Link
  - <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=999>



# Expanding Hydrogen Storage to Porous Rock Formations: A Framework for Estimating Feasibility & Operational Considerations Gas Technology Institute



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# Expanding Hydrogen Storage to Porous Rock Formations: A Framework for Estimating Feasibility & Operational Considerations

- **Project Objectives**
  - industry expansion of underground hydrogen storage beyond salt caverns
  - Considerations for selecting suitable porous rock formations as potential storage sites
  - Guidelines for monitoring potential hydrogen movement or loss
  - Ongoing project
- **Project Purpose**
  - Demonstrate the feasibility of large-scale underground hydrogen storage (UHS) in porous rock formations through bench-scale experiments and field scale dynamic reservoir simulations.





# Expanding Hydrogen Storage to Porous Rock Formations: A Framework for Estimating Feasibility & Operational Considerations

- Project Link
  - <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=984>





# Lunch



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