Wellbore Integrity

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OVERVIEW

• Goal of presentation
• Carbon capture and storage (CCS) project risk
• Define wellbore integrity
• Wells
• Well failure
• Corrosion
• Wellbore evaluation
• Remediating a well
• Conclusions
GOALS

• This presentation aims to help you understand:
  – What wellbore integrity is and how it fits into risk management and the overall CCS project.
  – What the potential risk indicators are for out-of-zone migration.
  – How wellbore integrity issues are monitored and identified.
  – How projects minimize risk or remedy problems if they do occur.
CCS PROJECT RISK

- Risk analysis/management is an essential component of any CCS project.
- Geologic storage is a viable option for carbon management, but what are the risks for a project?
  - Operational
  - Surface Infrastructure
  - Financial
  - Reservoir integrity
CCS PROJECT RISK

• Potential pathways for out-of-zone migration:
  – Overpressurizing and cracking the seal/cap rock
  – Natural faults/fractures
  – Wells

• Wells are the most likely pathway because:
  – Reservoir and caprock pressure is typically monitored and/or understood.
    ♦ In enhanced oil recovery (EOR), fluids are being produced, thus reducing the pressure.
  – Faults/fractures are generally known or observed before injection begins.
Wellbore integrity is the ability of a well to maintain isolation of geologic formations and prevent the vertical migration of fluids. (Zhang and Bachu, 2011; Crow and others, 2010)

For this discussion, leakage is defined as a loss of CO$_2$ or other fluid from its intended storage formation and not necessarily losses to the atmosphere.
WELLS

• A well is a complex hydromechanical system designed to fulfill many requirements:
  – Connects surface to storage formation
  – Long-term
  – Compatible with injection stream (CO₂ and impurities)
  – Materials (steel, cement, elastomers, annular fluids)
  – Barriers for fluid flow
  – Economical
  – Repairable
  – Geologically compatible (formations, stresses, fluids)
  – Environmentally acceptable
WELLS

• Some components of a well:
  – Borehole
  – Casing
  – Cement
  – Perforations

Photo: U.S. Department of Labor – OSHA

Diagram: U.S. EPA Class VI well guidelines
WELL TYPES

- Wellbore integrity for a CCS project involves more than the CO$_2$ injection well
  - Legacy wells
  - USDW wells
  - Monitoring wells
  - Pressure relief wells
WELLBORE FAILURE

- What are the leakage pathways?
- How do we evaluate wellbore integrity?

Photo: OSHA

Modified from Celia and others, 2004.
WELLBORE FAILURE

• Problems may include:
  – Poor cement job.
  – Joint failure.
  – Casing corrosion.
  – Poor abandonment plugs.
• Industry is actively addressing the issues surrounding wellbore integrity.
• Corrosion is a complex, naturally occurring phenomenon involving the deterioration of materials because of reactions with the environment.
• Total cost of corrosion according to NACE International (2014) is US$1.372 billion:
  – US$589 million in surface pipeline and facility costs
  – **US$463 million annually in downhole tubing**
  – US$320 million in capital expenditures related to corrosion
WELLBORE EVALUATION

• Methodologies have been developed for high-level evaluation of leakage potential.
  – (Watson and Bachu, 2007, 2008; Bachu and others, 2012)
• Potential indicators based on this research include:
  – Age of the well.
  – Regulations.
  – Abandonment method.
  – Cement.
  – Completion activities.
  – Operator.
  – Well type.
• Data-driven methodology.
• Results intended to direct future efforts to assess wellbore integrity.
WELLBORE EVALUATION

• Site specific methods
  – Operational indicators:
    ♦ Pressure
    ♦ Fluid production
  – Mechanical integrity tests.
  – Well logs:
    ♦ Caliper
    ♦ Casing imaging tool
    ♦ Vertilogs
    ♦ Cement bond logs (CBL)
    ♦ Sector bond logs (SBL)
    ♦ Ultrasonic logs
    ♦ Noise logs
WELLBORE EVALUATION

• Logs offer a visual representation of what is present downhole.

• Logs show:
  – Formation characteristics.
  – Casing condition.
  – Cement condition.
  – Joint locations.

• Expensive to run; typically only run when there is an indication of an issue.

• Logs frequently targeted to a specific depth interval.
REMEDIATION

• The problems discussed can be remediated.
  – Oil and gas industry has decades of experience and numerous techniques to address problems.
• Repair:
  – Squeeze job
  – Casing patches or new sections
• Plugging and abandonment
  – Closure of access to storage formation
  – Multiple steel/elastomer/cement plugs
  – Optimal placement of plugs
MINIMIZING RISK

• Awareness of safety
• Understanding CO₂ pathways
• Project planning
  – Monitoring, verification, and accounting (MVA), modeling, risk assessment, and site characterization
• Regulation
MINIMIZING RISK

• Increased experience and understanding
  – Geology
  – Wellbore construction
    ♦ Materials
    ♦ Barriers
    ♦ Monitoring
SUMMARY

• Maintaining wellbore integrity of all wells is important in any CCS project.
• Various tools and techniques are available for monitoring and remediating wells.
• Significant resources are available on this topic.
REFERENCES


• Watson, T.L., and Bachu, S., 2008, Identification of wells with high CO₂ leakage potential in mature oil fields developed for CO₂ enhanced oil recovery: Presented at the Society of Petroleum Engineers (SPE) Improved Oil Recovery Symposium, Tulsa, Oklahoma, April 19–23, SPE Paper 112924.

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THANK YOU!