Wellbore Leakage Technology Road Map

Intervention Strategies to Increase Wellbore Leakage Remediation Success Rates
Outline

• Project objectives and scope
• Current state of the industry
  – Regulatory
  – Technology
• Identified gaps and suggested actions
  – Regulatory
  – Technology
Objectives

• Document current wellbore leakage remediation practices and limitations

• Identify areas for regulatory change or technology R&D
  – Improve remediation success rates
    • Accessing leak source/path
    • Placing isolation material
    • Long-term material integrity/effectiveness
  – Decrease cost

• Used by a wide range of industry stakeholder to address issues with wellbore leakage
Scope

- Focused on remediation only
  - Active wells
  - Shut-in wells
  - Abandoned wells
- Leakage and difficult remediation operations are often associated with failure of the cement sheath to provide hydraulic isolation

Potential Leak Paths in a Well (Davies et al 2014)
Current State of the Industry

Regulatory
Regulations, Standards and Guidelines Reviewed

- Documents reviewed for requirements and technical guidance on wellbore leakage remediation
- Canada
  - AB, BC, NB, SK, NL
- USA
  - API
  - BSEE
  - Pennsylvania DEP
  - Texas RRC
- Norway
  - NORSOK D-010
- UK
  - UK O&G
- Other
  - Carbon Capture and Sequestration (CCS)
  - Storage industry (reservoir and cavern)
  - Geothermal
Regulatory Overview Canada

- AB, BC, NB define serious SCVF/GM by rate, fluid, pressure build-up, and well parameters
  - Defines time of remediation (Serious: within 90 days; Non-serious: can be delayed to time of abandonment)
  - Describe methods for leakage measurement
  - Notes ‘cement squeezes’ are a routine remedial operation
- SK requires reporting to regulatory field office which will recommend the appropriate action
- NL requires monitoring of cement/casing integrity over a well’s operating life. After evaluation, remediation may be required which may include ‘cement squeezes’
- No one universal definition, classification and necessary remedial actions across Canadian provinces
Regulatory Overview
USA

• API RP 90 Recommended Practices for Annular Pressure Management considers:
  – Causes
  – Evaluation methods
  – Management plans and risk assessment

• Notes that remedial practices are planned to be discussed in API 65-3 (Practices to Prevent or Remediate Annular Casing Pressure); However, this API RP appears to be currently unavailable

• Other relevant documents related to annular isolation (but do not provide detailed guidance on remediation activities) include:
  – API 65-2 Isolating Potential Flow Zones During Well Construction
  – API RP 96 Deepwater Well Design and Construction
  – API 51R Environmental Protection for Onshore Oil and Gas Production Operations
Regulatory Overview
USA

- Code of Federal Regulations requires action when Sustained Casing Pressure (SCP) exceeds maximum allowable wellhead pressure
- Regulations require sustained casing pressure management as described in API RP 90
- Pennsylvania DEP requires that annular wellhead pressure remains below 9.8 kPa/m x casing shoe depth, otherwise action required
  - Note that this is more conservative than the limit of 11 kPa/m used to classify serious SCVF in AB
Regulatory Overview

USA

- Texas RRC notes a minimal amount of annular pressure is allowed
  - Limit of 11.3 kPa/m * Casing Setting Depth where reporting and management or remedial activities are necessary
• NORSOK D-010 requires annular pressure monitoring

• Norwegian Oil and Gas Association Recommended Guidelines for Well Integrity No 117 suggests a risk-based approach
  - Casing pressure may require remediation depending on flow rate and build-up pressure
  - Notes that API RP 14B provides acceptable leak rates for SSSVs with manageable consequences, and suggests this may provide a guideline for acceptable annular leakage rates
Regulatory Overview

UK

• Oil & Gas UK Well Integrity Guidelines suggest risk-based (ALARP)
  – Remedial work should be considered if less than two barriers remain for hydrocarbon zones

• Oil & Gas UK Guidelines for Suspension and Abandonment of Wells notes that while Portland cement is currently a primary choice for annular sealing, other materials may be acceptable
Regulator Overview
Other Industries

• CCS
  – Wellbore remediation practices generally adopted from the oil and gas industry

• Underground Storage
  – Method to remediate caprock not well developed (Perry 2005)

• Geothermal
  – New Zealand Standard Code of Practice for Deep Geothermal Wells NZS 2403:2015 notes that remediation from surface may be acceptable; however, concerns about trapped water exist
Regulatory Overview

• Many regulations allow for some leakage during a well’s operating life, but zero leakage at abandonment
• Many do not define acceptable leakage, and suggest a risk-based assessment
• Some regulations and guidelines define when a leak requires management, monitoring and remediation, but not the practices or methods to improve the success rate
• Squeeze cementing noted as a typical remedial operations, but little technical guidance or requirements are provided
Current State of the Industry

Technology
Current Practices
Squeeze Cementing

• Generally well-established perforating and pumping practices, but several possible variables that affect success
  – Perforating – shot size, density, depth
  – Slurry – Fluid loss characteristics class, particle size distribution, rheology, setting behavior
  – Fluids – Preflushes, perforation washing fluids, spacers, gas blocking gels, etc.
  – Method – Bradenhead, packer/retainer, circulation
  – Pressure profile – Pressure applied with time (e.g. hesitation squeeze)
  – Pressure – Relative to fracture pressure
• Past success rate suggests other contributing factors (lithology, well design, application, detection methods, other field practices)
• DACC Primary and Remedial Cementing Guidelines (1995) provides some guidance on planning and executing squeeze jobs
Alternate Remedial Materials and Methods

- May offer advantages in terms of:
  - Sealability
  - Placement
  - Reliability, longevity
    - Mechanical response
    - Chemical resistance
    - Thermal stability

- Types
  - Thermosetting resins
  - Pressure-activated sealants
  - Sodium silicates
  - Metals
  - Clastic and geo-materials
  - Self-healing cements
  - Mechanical casing expansion methods (microannulus remediation)

- Various groups working on development
  - Range of Technology Readiness Levels (TRL)
Wellbore Leakage Remediation

Gaps and Suggestions for Future Work
#1. Review of Leak Rates and Required Actions

- Gap: Understanding of acceptable leak rates
- AB, BC and NB define severe SCVF/GM and associated actions
- Other jurisdictions generally require risk-based assessment
- Suggest risk-based review of leakage rates and impacts
  - Probabilities and consequences
#1. Review of Leak Rates and Required Actions

**Considerations:**

- Remedial operations present some inherent risk
- May consider instantaneous or cumulative leakage
- Leakage rates and associated risks may be compared to other sources to evaluate risk tolerance (e.g. agricultural, landfills)
- Results may help define risk mitigation options and actions
- Potentially develop a consistent risk-based tool for stakeholders
#2 Remediation IRP

- **Gap:** Reviewed regulations and guidelines provide few specific practices, methods, or materials for remediation.
- **Suggest development of wellbore leakage remediation IRP**
- **Appear to be some potential documents in development**
  - API 65-3 (mentioned in API RP 90 but not yet available)
  - Extension of 2016 DACC IRP 25: Primary Cementing
#2 Remediation IRP

• Considerations for inclusion in IRP:
  – Data collection approaches
  – Decision-making and management processes
  – Slurry and sealant selection
  – Determining appropriate job parameters
  – Selecting appropriate depth intervals
  – Description of alternative materials and methods (evaluation process)
  – Risk assessment approach
  – Post-job assessments
    • Metrics of successful remediation
    • Long term tracking
Several groups have recognized the need for improved remediation methods and materials

Gap: Lack of standardized test procedures to evaluate or “qualify” remedial technologies and define their appropriate uses

Such standards would be expected to benefit all stakeholders
#3 Qualification of Remediation
Material and Methods

• Considerations:
  – UK O&G Guidelines on Qualification of Materials for the Abandonment of Wells may provide a starting point
    • Guideline identifies recommended properties of sealant materials and evaluation methods
  – Technologies must meet operational, functional and OH&S requirements (long and short term)
  – Qualification methods may include small and large scale testing, engineering analysis, and modelling
#4 Remediation Data Analysis and Sharing

• Remedial operation results and “success rate” depend on a large number of variables (technology, application, and implementation)

• Gap: Industry may benefit from a consistent method of tracking and sharing information on remediation experience

• Provide framework for consistent post-remediation assessment and long-term well integrity studies
  – Identification of key influential factors
  – Accelerate industry learnings and success rate
  – Means to assess progress over time
  – Consistent information, metrics
#4 Remediation Data Analysis and Sharing

• Considerations:
  – Wellbore leakage is an industry-wide problem where improvements in efficiency, success rate, reliability and cost benefit all stakeholders
  – Tracking both “successes” and “failures” can provide statistical information, useful for risk assessments and a better understanding of the problem, leading to technological improvements
  – Industry data sharing has precedents for artificial lift, sand control
  – Will require a consistent data standards and definitions
  – May take the form of a database, which could serve a larger purpose related to well integrity