Review of Failures in Wells used for CO2 and Acid Gas Injection

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Introduction

• General Information
• Regulation
• Failure
• Risk
• Future Considerations
• Conclusions
General Overview

• Review of all wells that are, or have injected acid gas or CO₂
  – Tour report review
  – Cement, casing inspection and zonal isolation log review
  – Electronic data review
  – Regulation review

• Acid gas may be a mixture of H₂S and CO₂ as a waste stream from natural gas/oil production.

• Particular attention to the failures experienced by each well, causes and remedies.
Area: 664,332 km² (256,610 sq.mi)

Injector Location in Alberta

31 CO₂ Injectors (5 abandoned)
48 Acid Gas Injectors (3 abandoned)

Widely distributed around the province
Number of Wells by Category

Original or Converted

Injecting prior to regulation

Totals

Number of Wells
Injection Reservoir Type

Number of Wells

Acid Gas
Carbonate
Sandstone

CO₂
Carbonate
Sandstone
Coal
Regulation

• Injection and Disposal Well Guide issued March 1994 (Guide 51).
• Prior to 1994 wells were approved for injection on an individual basis.
• Groundwater concerns were addressed in the regulations, but had not been specifically addressed prior to 1986.
• Classified injection wells in 1994.
# Well Classifications and Requirement Summary

<table>
<thead>
<tr>
<th>SECTION</th>
<th>CLASS 1a</th>
<th>CLASS 1b</th>
<th>CLASS II</th>
<th>CLASS III</th>
<th>CLASS IV</th>
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Requirements

• Hydraulic isolation
  – Cement evaluation
  – Temperature survey
  – Radioactive log
• Groundwater protection
  – Cement top location
• Casing condition
  – Casing inspection
• Monitoring
  – Annual packer isolation testing
Acid Gas Injector
Wellbore Condition

Spud in 1969
Converted in 1997
SCVF exists
Well cemented with 200 sacks 1-1-2
Casing grade K55
Log information for 00/05-34-115-06 W6
Failure per Well
Regulation Impact

Failure/well

Well Type

Acid Gas
Pre 1994

Acid Gas
Post 1994

CO2
Pre 1994

CO2
Post 1994
Built for Purpose

• It was expected that wells drilled, cemented and originally completed as injectors would indicate fewer failures of all types.
• This hypothesis was confirmed, with acid gas injectors showing a stronger indication.
Failure per Well
Original Use and Converted

Acid Gas original Acid Gas converted CO2 original CO2 converted

Well Type
Failure Modes

• The majority of failures caused by injection were tubing and packer failures.
• These failures are easy to detect and there are annual testing requirements to ensure integrity of tubing, packer and casing above the packer.
• Failures must be repaired immediately.
• Failures not associated with injection are comparable to the general well population.
Failures by Mode

Failures Caused by Injection

Number of Failures

- Casing Failure
- SCVF
- Tubing
- Packer
- Zonal Isolation

General Wellbore Failures

- Casing Failure
- SCVF
- Tubing
- Packer
- Zonal Isolation
Identification of Potential Risk

• From prior work cement blends which contain extenders such as bentonite have been indicated as a potential for zonal isolation failure due to cement reaction with acidic fluids.
  – 3 of 16 acid gas injectors built for purpose had specialized cement to combat the affect of acidic environment.

• Groundwater protection is an important focus in Alberta.
Risk Factors for Failure

- Cement Type
- Groundwater
- Exposed
- Low Cement Top

Number of Wells

Acid Gas

CO₂
Future Regulation Changes

- Daily monitoring of annular pressure
- Hydraulic isolation testing every 5 years
- Cement across all groundwater
- Surface casing set and cemented below groundwater depth for acid gas injectors
  - Groundwater defined as <4000 mg/l TDS
- Acid gas injectors will be classified as 1a injectors and require additional safe guards.
Conclusions

• Wells built for purpose have fewer failures than wells converted.
• Wells placed on injection after the advent of regulatory controls in 1994 have fewer failures.
• Injectors have comparable failures, which are not caused by injection, to the general well population
• Updated regulations should have a positive impact on injector integrity.