Factors Affecting or Indicating Potential Wellbore Leakage

Dr. Stefan Bachu
Alberta Energy and Utilities Board
Stefan.Bachu@gov.ab.ca

Theresa Watson
T.L. Watson and Associates Inc.
Theresa.Watson@TLWatson.com
Old Wells or New Wells?

Should we worry more about the integrity of future CO₂ injection wells, or about the existing and future wells drilled for purposes other than CO₂ injection?
Deep Wells Drilled in Alberta

End of 2004
- 316,439 total
- 108,706 abandoned

End of 2006
- 362,265 total
- 116,550 abandoned

Oldest: 1893

Area: 664,332 km²
(256,610 sq.mi)
Conditions for Well Leakage Occurrence

- Leak source
- Driving force (head differential, buoyancy)
- Leakage pathway
  - Poorly cemented casing/hole annulus
  - Casing failure
  - Abandonment failure
Surface Casing Vent Flow and Gas Migration Flow Pathways in a Well
Wells with SCVF/GM Compared with Wells Drilled - Annual Basis -
Wells with SCVF/GM Compared with Wells Drilled
- Cumulative -

Cumulative Wells Spud (x1000)

Year

1900 1920 1940 1960 1980 2000

Cumulative Wells Spud
% of Cumulative Wells with SCVF/GM
Example of SCVF and GM Testing

1. Testing for SCVF
2. Testing for GM
Abandoned Well Leaking Brine and Gas near Peace River, Alberta
Gas Bubbling at the Cap Welding of the Surface Casing
Gas Bubbling at the Cap Welding of the Production Casing
Analysis of Factors Affecting Well Leakage

- Data mining
  - EUB’s public databases on wells and production
  - EUB’s databases on SCVF, GM, casing failure and non-routine well abandonment

- Historical documents and regulatory changes

- Casing inspection logs and cement logs for ~500 wells, of which 142 had adequate data for full evaluation

- Depth of groundwater protection
Example of Cement and Casing Quality in a Well in the Haynes Field, Alberta
Example of Well Log Analysis Showing Corrosion Due to Cement Channeling
Factors of No Apparent Impact

- Well age
- Well operational mode: production, injection or disposal
- Completion interval
- Presence of H$_2$S and/or CO$_2$
Factors of Minor Impact

- Licensee
- Depth of surface casing
- Total depth
- Well density
- Topography
Factors of Major Impact

- Geographic area (Test Area)
- Well deviation
- Well type:
  - drilled and abandoned (SCVF/GM incidence rate of 0.5%)
  - cased and abandoned (SCVF/GM incidence rate of 14%), for 98% of the total
- Abandonment method (bridge plugs, welded caps)
- Economic activity, regulatory changes and SCVF/GM testing
- Uncemented casing/hole annulus!
Areas in Alberta where Testing for Gas Migration was/is Required
Occurrence of SCVF/GM in the Test Area, Alberta
Corrosion Location

68% Minimal

23% External

9% Internal

129,773 m logged in 142 wells
External Corrosion versus Cement Quality

- 66% No Cement
- 15% Poor
- 8% Fair
- 6% Good
- 5% Excellent

10,442 m logged in 142 wells
Location of SCVF/GM Source versus Cement Top

- 81% Above Cement Top
- 11% <200m Below Cement Top
- 8% >200m Below Cement Top

64 wells
Location of Casing Failure versus Cement Top

- 52% Above Cement Top
- 19% >200m Below Cement Top
- 29% <200m Below Cement Top

64 wells
Interpretation of Cement Bond Logs in the Same Well in the Zama Field
Leakage Potential along a Well

Shallower, upper part
Higher potential for leakage

Deep, lower part completed in producing zones
Less potential for leakage
Well Attributes for Leakage Assessment in Alberta

- Type: drilled and abandoned, or cased
- Cementing requirements and practices
- Location (in Test Area or outside)
- Direction: vertical or deviated (including horizontal)
- Time of drilling in relation to economic activity and regulatory changes
- Time of abandonment in relation to regulatory changes
Potential for Well Leakage Inside Production Casing

Abandonment Type

Other

Bridge Plug

Increasing Probability of Leakage Inside the Casing
Assessment of the Potential for Well Leakage

Increasing Probability of Leakage due to SCVF and/or GM
Conclusions

- The majority of well leakage is due to time-independent mechanical factors controlled during well drilling, construction or abandonment, mainly cementing.

- Uncemented casing is the main factor in SCVF/GM and/or casing failure occurrence.

- Good quality cementing will likely protect wells against cement degradation and casing corrosion.

- The deep portion of wells is usually well cemented and zonally isolated.

- Good and properly-enforced regulations are key in controlling and detecting well leakage.
Answer to Question on the First Slide

It is not the CO$_2$ injection wells that may/will pose a risk, they will be properly constructed and monitored, and, relatively speaking won’t be too many.

It is the existing wells that will pose the greater risk!

Bachu and Watson – Possible Indicators for CO$_2$ Leakage along Wells, GHGT-8, 2006
Watson and Bachu - Factors Affecting or Indicating Potential Wellbore Leakage;
SPE Paper 106817, 2007