Acid Gas Injection: An Operators' Perspective

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Acid Gas Injection: An Operators Perspective

- Devon currently owns and operates five acid gas injection systems in north-central Alberta.
- Development area is often referred to as the Peace River arch.
- These 5 projects were developed from 1996 until late 2000.

AGI – Puskwaskau

- Puskwaskau, Alberta, 1996 original project development.
- 21 MMSCFD of raw sour natural gas feed.
- 300 psia inlet pressure.
- 25 USGPM of amine sweetening.
- Propane refrigeration.
- 3000 HP of gas compression.

AGI - Puskwaskau

Operators AGI – SOGAT 2004

AGI - Puskwaskau

- Acid Gas rate of 1.94 tonnes/day of H_2S equivalent after Board Approval.
- H_2S inlet: 2 400 ppm.
- Acid gas rate of 0.106 MMSCFD.
- Acid Gas: 45 % H_2S, 51% CO_2, and 4% C_1

Operators AGI – SOGAT 2004

AGI – Puskwaskau Disposal Wellbore

- Wellbore parameters:
  - Depth: 2670 meters (8759').
  - Pressure: 29.5 MPa (4278 psia).
  - Temperature: 82 °C.
  - Location: approx 500 m south of plantsite.

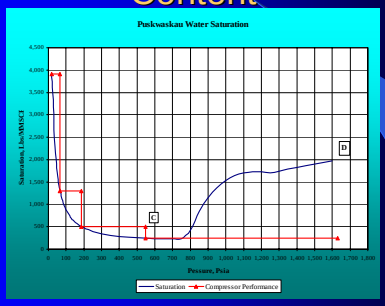
Operators AGI – SOGAT 2004

AGI - Puskwaskau

- AGI Compression parameters:
  - Suction: 6-7 psig.
  - Discharge: 1600 psig.
  - Four stages of reciprocating compression.
  - Suction from amine regeneration into stage 1 directly.
  - No interstage dehydration.

Operators AGI – SOGAT 2004

AGI – Puskwaskau H_20 Content



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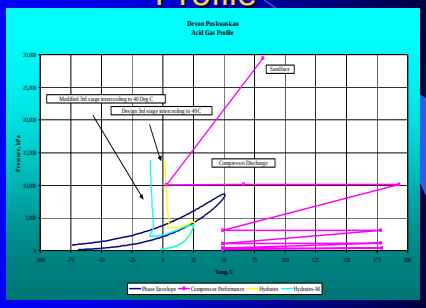
AGI – Puskwaskau Injection Profile



Operators AGI – SOGAT 2004

AGI - Puskwaskau

- Critical design parameters
  - Design for maximum flexibility and turndown
  - Low speed operation, 900 RPM maximum
  - Designing for bumpless transfer of controls

Operators AGI – SOGAT 2004

AGI - Puskwaskau

- Critical design parameters
  - Maximum use of stainless steels for corrosion resistance and safety.
  - Maintain control over possible leakage of acid gas.
  - Difficult to predict acid gas density due to temperature problems.

Operators AGI – SOGAT 2004

AGI - Puskwaskau

- Startup Issues
  - Winter conditions, temperatures lower than -25 °C and snow every day.
  - Random blow-downs.
  - Logistically difficult for 1st time.
  - Nitrogen/He leaks.
  - Too many personnel.
  - Wellbore problems.

Operators AGI – SOGAT 2004

AGI - Puskwaskau

- Injection History
  - Injection continuing to date with pressures varying from 9100 kPa to 9800 kPa.
  - No unusual maintenance problems.
  - Motor changed and compressor re-cylindered for higher capacity.
  - No methanol injection.

Operators AGI – SOGAT 2004

AGI - Puskwaskau

Operators AGI – SOGAT 2004

AGI - Puskwaskau

Operators AGI – SOGAT 2004

AGI – Normandville

- 21 MMSCFD of raw sour natural gas feed.
- 75 psia inlet pressure.
- 25 USGPM of amine sweetening.
- Propane refrigeration.
- 3000 HP of gas compression.

Operators AGI – SOGAT 2004

AGI - Normandville

- Acid Gas rate of 1.91 tonnes/day of H_2S equivalent after Board Approval.
- H_2S inlet: 2 500 ppm.
- Acid gas rate of 0.1 MMSCFD.
- Acid Gas: 67 % H_2S, balance of CO_2, and small amount of C_1

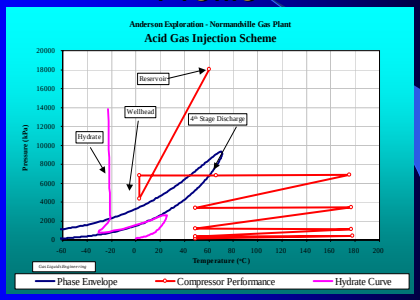
Operators AGI – SOGAT 2004

AGI – Normandville Disposal Wellbore

- Wellbore parameters:
  - Depth: 1858 meters.
  - Pressure: 19.014 MPa.
  - Temperature: 60 °C.
  - Location: approx 500 m south west of plantsite.

Operators AGI – SOGAT 2004

AGI – Normandville Injection Profile



AGI - Normandville

- Start-up Issues
  - Severe cold weather, winter conditions, temperatures lower than -30 °C.
  - Wellbore gas buildup due to dual startup.
  - Compressor bypass valve.
  - Compressor bolting.
  - Wellhead leaks.

AGI - Normandville

- Injection History
  - Injection continuing to date with pressure at 4300 kPa.
  - No unusual maintenance problems.
  - Plant has since been expanded to include LPG recovery and better separation equipment.

AGI - Normandville

Operators AGI – SOGAT 2004

AGI – West Culp

- 21 MMSCFD of raw sour natural gas feed.
- Differing gas blends on inlet.
- Some solution gas processing.
- 150 psig inlet pressure.
- 125 USGPM of amine sweetening.
- Propane refrigeration.
- 3000 HP of gas compression.

Operators AGI – SOGAT 2004

AGI – West Culp

- Acid Gas rate of 14.3 tonnes/day of H_2S equivalent after Board Approval.
- H_2S inlet: 1.32 – 4.11%.
- Acid gas rate of 0.6 MMSCFD.
- Acid Gas: 48 – 80% % H_2S, balance of CO_2, and small amount of C_1

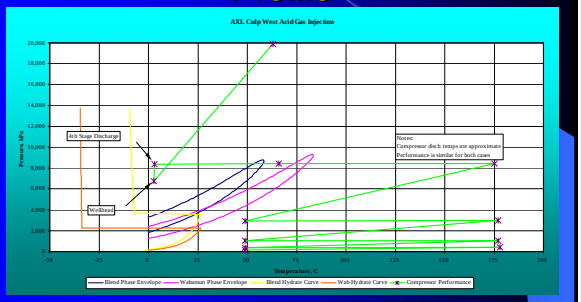
Operators AGI – SOGAT 2004

AGI – West Culp Disposal Wellbore

- Wellbore parameters:
  - Depth: 1943 meters.
  - Pressure: 20.2 MPa.
  - Temperature: 63 °C.
  - Location: approx 500 m east of plantsite.

Operators AGI – SOGAT 2004

AGI – West Culp Injection Profile



Operators AGI – SOGAT 2004

AGI – West Culp

- Start up Issues
  - Some plugging on startup.
  - Wellbore hydrates after some deviation from design conditions.
  - Compressor and piping leaks.

Operators AGI – SOGAT 2004

AGI – West Culp

- Injection History
  - Injection continuing to date with pressure at 5800 kPa.
  - No unusual maintenance problems.
  - Plant has since been expanded to include better separation equipment.
  - Methanol injection continuing.

Operators AGI – SOGAT 2004

AGI – West Culp

Operators AGI – SOGAT 2004

AGI – West Culp

Operators AGI – SOGAT 2004

AGI – West Culp

Operators AGI – SOGAT 2004

AGI – Rycroft

- 24 MMSCFD of raw sour natural gas feed.
- Differing gas blends on inlet.
- 150 Psig inlet pressure.
- 125 USGPM of amine sweetening.
- Propane refrigeration.
- 3000 HP of gas compression.

Operators AGI – SOGAT 2004

AGI – Rycroft

- Acid Gas rate of 20.4 tonnes/day of H_2S equivalent after Board Approval.
- H_2S inlet: 2.07%.
- Acid gas rate of 0.8 MMSCFD.
- Acid Gas: originally 64% - since upgraded to 90%, balance of CO_2, and small amount of C_1

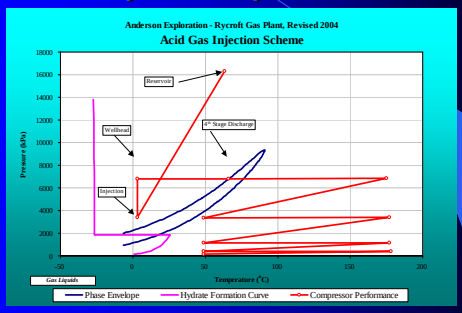
Operators AGI – SOGAT 2004

AGI – Rycroft Disposal Wellbore

- Wellbore parameters:
  - Depth: 1780 meters.
  - Pressure: 16.33 MPa.
  - Temperature: 63 °C.
  - Location: approx 200 m west of plantsite.

Operators AGI – SOGAT 2004

AGI – Rycroft Injection Profile



Operators AGI – SOGAT 2004

AGI – Rycroft

- Start up Issues
  - Difficulty on nitrogen-helium testing.
  - Must be cautious of over-condensing on 4th stage suction.
  - No problems injecting at all.
  - No methanol injection necessary.

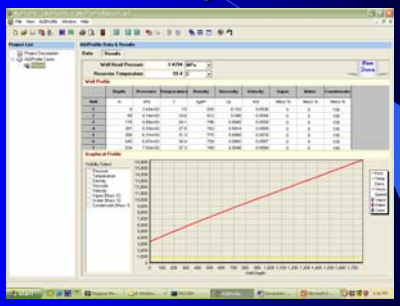
Operators AGI – SOGAT 2004

AGI – Rycroft

- Injection History
  - Injection continuing to date with pressure at 3300 kPa.
  - No unusual maintenance problems.
  - Scheme has since been re-licenced to inject up to 90 % acid gas.

Operators AGI – SOGAT 2004

AGI – Rycroft



Operators AGI – SOGAT 2004

AGI – Rycroft

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AGI – Rycroft

Operators AGI – SOGAT 2004

Acid Gas Development

- Realizing throughout the project that the acid gas injection process is unique.
- Thorough selection of reservoir zone and injection parameters – involve reservoir staff immediately.
- Selection of wellsite location and/or acquisition of the proposed injection well.
- Immediate involvement of operating personnel in the design process.
- Thorough development of phase behaviour and understanding of the injection process.

Operators AGI – SOGAT 2004

Acid Gas Project Development

- Scheduling and budgeting of proper equipment.
- Close interaction with equipment suppliers.
- Engineering support throughout construction, commissioning, start-up and operating.
- Continued technical support through the facility operating life.

Operators AGI – SOGAT 2004

AGI Success

- Detailed process simulation of the acid gas system with approximate interstage conditions.
- Full phase envelope development.
- Hydrate prediction, water behaviour, and water handling.
- Engineering review of alternative process gas analyses.

Operators AGI – SOGAT 2004

AGI Success

- Discussion with equipment vendors ensuring that they understand the project objectives.
- Detailed equipment bid specifications and drawing reviews.
- Verify process simulations with predicted compressor interstage conditions.

Operators AGI – SOGAT 2004

AGI Success

- Thorough drawing reviews with field operating staff and instrument/controls engineering groups.
- Very detailed commissioning and start-up planning, looking at contingencies, spare parts, vendor service technicians, and 3rd party tech services.
- Careful control of services, personnel, and timing during start-up.

Operators AGI – SOGAT 2004

AGI Success

- Subsequent post-start-up audits and review of operations.
- Continued operations and process support for life of facility.

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AGI Acknowledgements

- Bob Masters, P.Eng, Devon Project Management (Retired).
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