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Controlled Document

Quest CCS Project

Quest CO₂ Pipeline Operations Report 2015

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Summary

This document summarizes the operation of the Quest CO2 pipeline in 2015 to satisfy the post-startup requirements of sections 2.1, 2.2, and 2.3 of the annual report.

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CO2 Pipeline Operations Report

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1. PIPELINE COMMISSIONING SUMMARY

The CO₂ pipeline was cleaned, dewatered and dried in 2014. By the beginning of the current reporting period (2015), the pipeline was being preserved by a low pressure nitrogen pad. The pipeline first fill with CO₂ and pressure up prior to injection occurred August 19th through 22nd, 2015.

1.1. Cleaning, Dewatering, Dry-out

Cleaning, dewatering and drying activities were undertaken by first running brush pigs through the line followed by foam pigs. Multiple pig trains were first pushed by dry air, followed by N₂. In total, roughly 600 pigs were run through each pipeline section, until the penetration of debris into the foam pigs met the 1/4" spec. The final water dew point achieved was -48°C (target -45°C) in October 2014.

1.2. First Fill and Startup

Filling activities for the pipeline were only conducted during the day to minimize the impact to residents living near the pipeline at night due to noise concerns with venting CO₂.

The initial fill of the pipeline was achieved by:

- 1) The low pressure N₂ pad was displaced with low pressure CO₂ from the compressor (pipeline pressure ~0.2 MPag during N₂ displacement). The N₂ was vented from the line until the composition changed to predominantly CO₂, as measured by a portable gas detector.
- 2) The line pressure was increased to 4 MPag (gas phase CO₂) and left to stabilize for roughly 24 hours to equalize temperatures and pressure across the line, as well as provide an opportunity for leak checking of the system. Wellhead pressure was equalized with the main line at this pressure level to minimize the pressure drop across the wellsite choke (flow valve) during initial injection.
- 3) Line pressure was then increased to 10 MPag (dense phase CO₂) prior to commencing with injection.

A copy of the operations procedure has been included in Appendix A.

There were no noted cases where the pipeline showed signs of expansion or movement during the first fill/pressure-up/warm-up of the line.

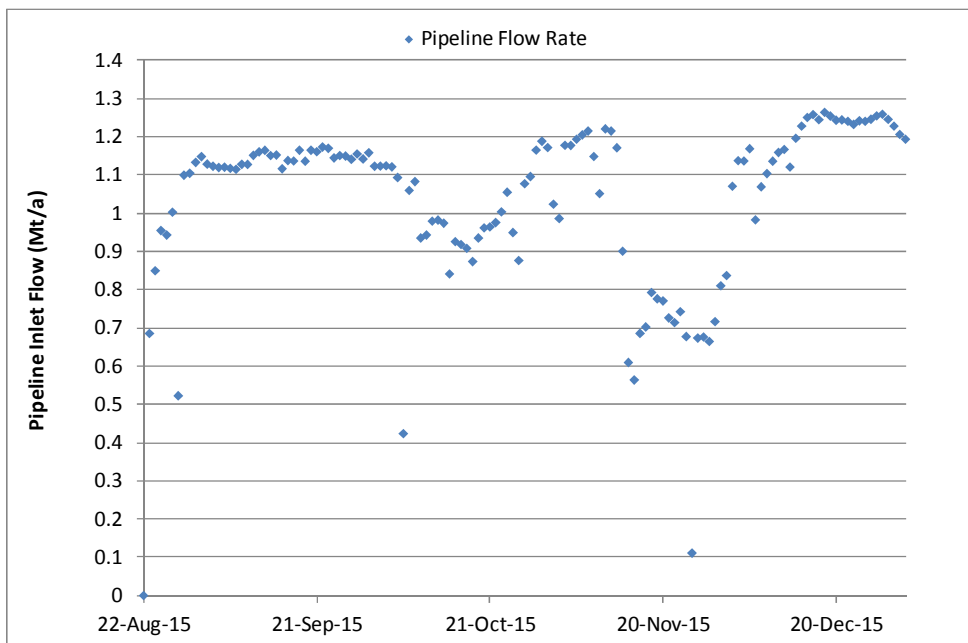
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2. 2015 OPERATING SUMMARY

The following sections summarize the operating data obtained from 2015.

2.1. Capacity

The pipeline, as designed, was provided with significantly more capacity than required for day to day operation of the Quest asset (2.2 Mt/a installed vs 1.2 Mt/a required on a regular basis). Figure 1 below shows the daily averaged throughput in the line during the 2015 operating period. The pipeline has demonstrated sufficient performance at or above the 1.2 Mt/a nameplate.



None

Table 1: Annual average pipeline composition

Component	Actual Operating 2015 (vol%)
CO ₂	99.45
H ₂	0.48
CH ₄	0.06
CO	0.02
N ₂	0
H ₂ O	0.0046

Figure 2 below displays the variability in composition data over the period. Composition variations were typically associated with amine absorber operation, which changes the amount of entrained H₂, CH₄, CO in the pipeline stream.

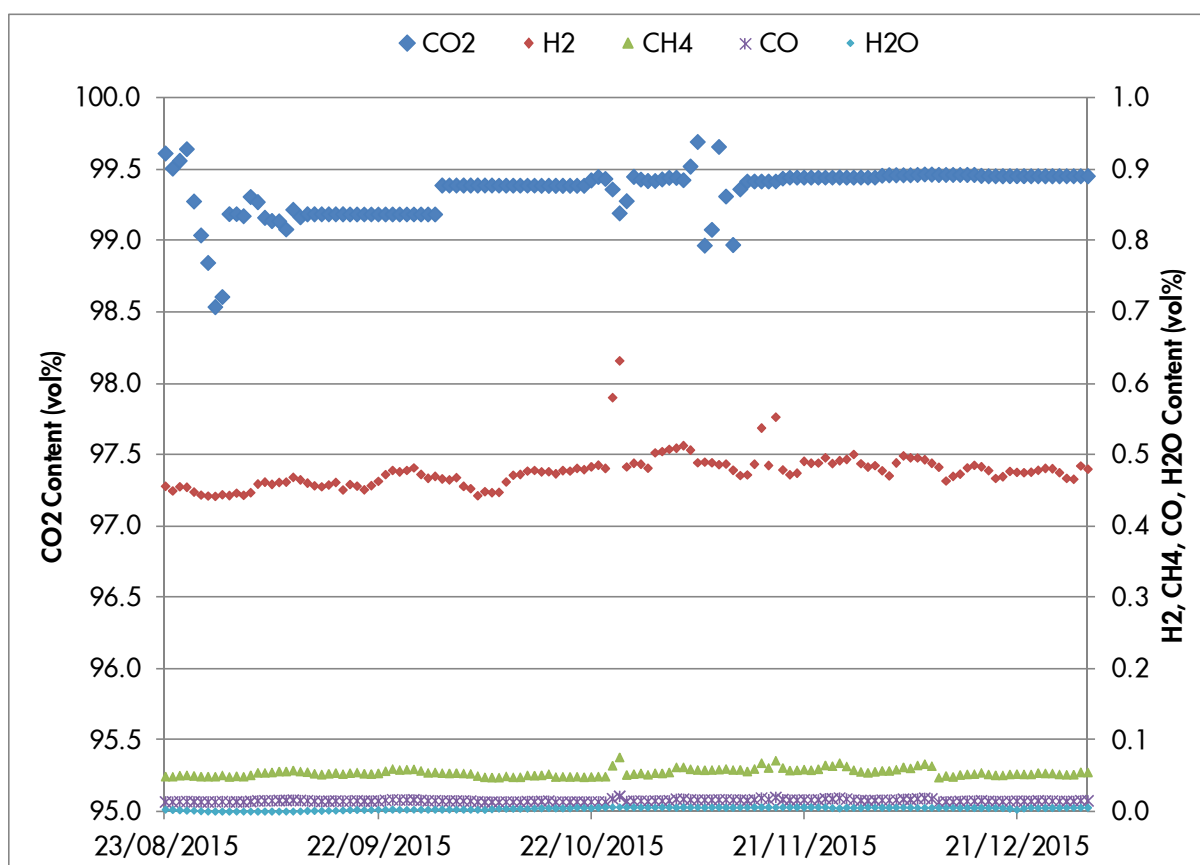


Figure 2: Pipeline Stream Daily Averaged Composition

The variability in composition was well within design parameters and did not affect pipeline operation. Pressure drop, and capacity were well within design tolerance. The pipeline remained in dense phase transport during the entire operating period.

The pipeline water content was maintained on spec easily. Refer to the document "Quest CO2 Dehydration Performance" for more information on water content over the reporting period. The average content was 46 ppm on volume basis, or 19 ppm on weight basis. This was well within the winter specification of 4 lb / MMScf (84 ppmv, 35 ppmw).

The pipeline inlet pressure was on average 9.4 MPag (9400 kPag) with an average pressure drop of around 0.6 MPa. Figure 2 below shows the daily average inlet pressure to the pipeline, and the average pressure drop from inlet to each wellsite in service.

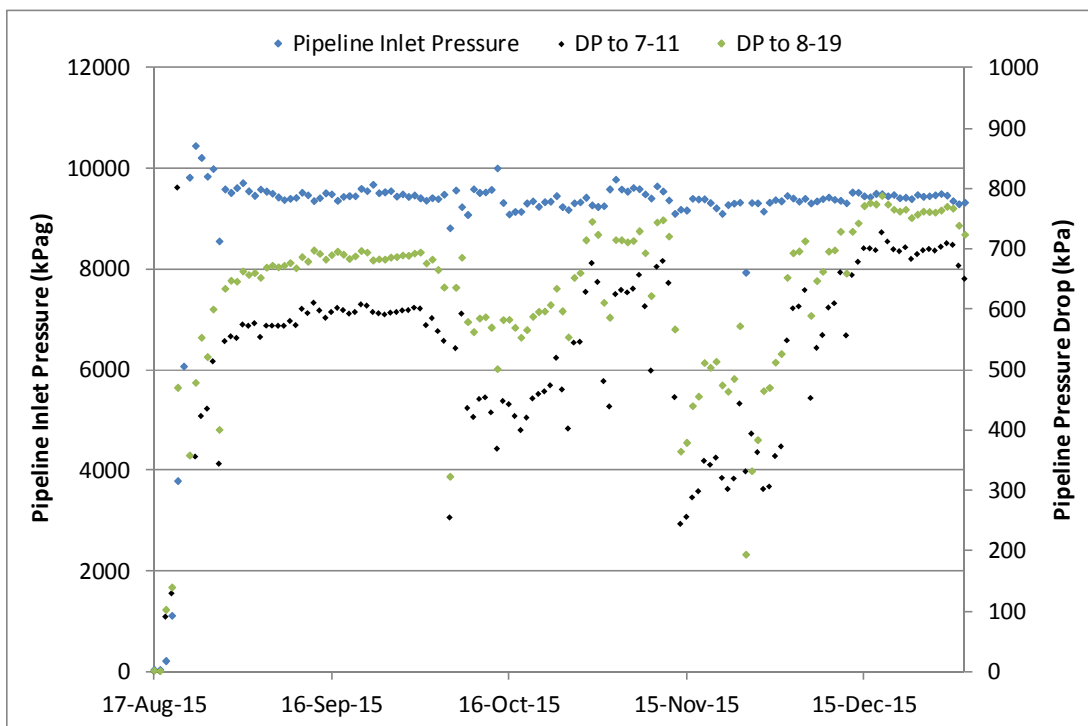


Figure 3: Pipeline Inlet Pressure and Pressure Drop to Each Wellsite

The temperature profile has been included in Figure 3. The inlet temperature for most of the year was maintained around 43°C, while the outlet temperature, depending on the wellsite, rate, and ambient conditions, was typically in the 8-17°C range. The further wellsite, 8-19, was on average 3-5°C cooler than 7-11 due to additional ambient heat loss over the extra line length.

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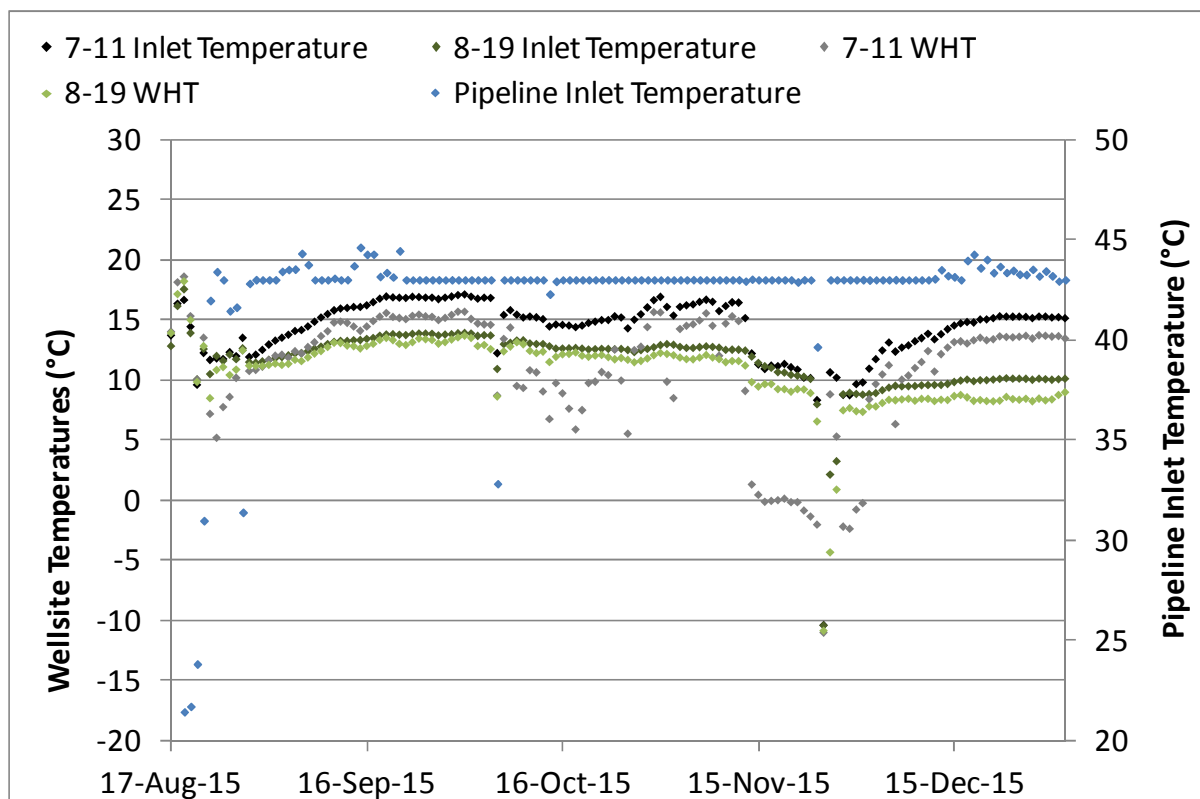


Figure 4: Pipeline Inlet Temperature and Temperatures at each Wellsite

Based on the process data in Figures 2 and 3, and the composition in Table 1, it can be concluded that the phase of the CO₂ leaving the Scotford site is in the supercritical phase (dense phase), and arriving at the wellsites the CO₂ is in the liquid phase (also referred to as dense phase typically in industry) since the pressure is above the critical pressure, but the temperature is below the critical temperature. This phase behavior held true for all operating periods in 2015, with the exception of the initial pressure up activities prior to August 23rd.

2.3. Operating Issues and Lessons Learned

- During the first fill, there was no acoustic or visual changes noticed when the vented stream changed from nitrogen to CO₂. This was assessed to be due to venting dry CO₂ (no moisture) while the fluid was in the vapour phase in the line, so there was not a significant Joule Thompson cooling effect of the CO₂ causing condensation of water vapour in the air. A portable gas detector was used instead to check for the completion of the nitrogen displacement.
- The most significant reliability issue on the pipeline has been the power supply to the LBVs (line break valves). At LBV3 in particular, the solar panel/battery bank setup has had issues maintaining a decent charge on the batteries to manage nighttime operation in the winter during extended periods with overcast

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conditions. The problems were worst at LBV3 due to solar panel shading, and under-cycling the battery voltage leading to poor battery performance. This resulted in several near-loss of power events, and one actual pipeline trip due to closure of LBV3 because the power to the solenoid had dropped off.

- Actuation of the flow valve at each wellsite was done using a supply of compressed nitrogen. The style of valve in use was found to consume significant amounts of nitrogen when making moves to control tightly to a flow setpoint. This resulted in frequent deliveries of nitrogen bottles to the wellsites to mitigate the issue (not typically a problem when the valve is located at a large site, being fed off the common instrument air system). A change was made to the valve control scheme to adjust position when the flow measured was deviating from the setpoint by greater than ~2.5 tonnes/hr. The control scheme change along with some tuning of the valve itself, reduced nitrogen consumption to manageable levels.
- The control philosophy of the pipeline was to have the ability to run each wellsite flow valve (choke) in either pressure or flow control. Flow control has worked sufficiently, but controlling pipeline pressure directly off one of the wellsite flow valves proved difficult due to the large, pressurized volume of the 64 km line. Instead, the pipeline pressure was monitored by the panel operator, and flow setpoint adjustments were made to the wells when the pressure moved outside of the desired range.

3. PIPELINE INSPECTION AND MAINTENANCE

No post startup inspection activities have taken place to-date (with the exception of verifying that the cathodic protection was functioning properly), and no significant maintenance activities have occurred. No wellsite particulate filter replacements were required due to the extensive cleaning campaign taken in 2014. Only a few minor issues were addressed, such as the flow valve nitrogen consumption issues, and replacement of batteries/removal of the anti-climb device on the communications tower shading the solar panels at LBV3.

No inspection results were available for metal/wall loss in 2015, but preliminary results from above ground piping monitoring only in 2016 are indicating zero corrosion/wall loss. During 2016, a pipeline smart pig will be run through the line to satisfy the commitment made to perform an in-line inspection within the first year of operation.

4. CO2 PIPELINE INSTALLED DEVIATIONS FROM DETAILED DESIGN

There were no significant deviations taken from the CO2 pipeline detailed design phase. The only clarification required from the BDEP was that no chemical injection facilities (e.g. methanol) were ever installed, as the risk of hydrate formation/corrosion was managed

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None

completely by adequate drying of the CO₂ stream via the triethylene glycol (TEG) dehydration unit below the winter water content specification described above.

5. LEAKS AND SPILLS AND DAMAGE

During the 2015 reporting periods, there were no noted occurrences of damage to the pipeline, nor were there any spills or releases reported from the line.

APPENDIX A: QUEST PIPELINE FIRST FILL PROCEDURE

Refer to the document "Quest Pipeline First Fill Procedure.pdf" for the operations steps required to fill, and pressure up the pipeline.

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