

355-7R OPERATING PROCEDURES

Operational Procedures [40 CFR 146.82(a)(10)]

Injectors will be operated to inject the desired rate of CO₂ over the life of the project.

For a target rate of 15MMSCFPD, bottom hole and surface pressures have been estimated for the well over the life of the project. These pressures were estimated using results from the Plume simulation as an input into the multiphase well nodal analysis software – PROSPER by Petroleum Experts Ltd. PROSPER has been used extensively in CO₂ EOR to model CO₂ injection wells. All calculations are done assuming a 100% CO₂ stream, and operating conditions will be updated as CTV defines the injection stream and impurities.

At the start of injection, as the A1-A2 reservoir is depleted in pressure, a surface and bottom hole injection pressure of 695 psi and 762 psi respectively, are only required to inject. As the pressure in the reservoir builds up, higher surface and bottom hole pressures will be required. At the end of injection, the estimated surface and bottom hole pressures required are 1,175 psi and 3,923 psi respectively, which is the maximum pressure CTV expects to operate the well at.

Based on the fracture stimulation data in the area, the expected fracture pressure gradient for the reservoir is 0.82 psi/ft. Using a 10% safety factor, as per the EPA's guidelines, the maximum allowable BHP is 6,260psi (calculated at the top perforation). The injection well will be controlled using automation so as to never cross this maximum BHP. 40+ years of gas and water injection experience into the Monterey Formation A1-A2 reservoir supports that these operating limits are appropriate and effective.

The expected pressures for 355-7R over the life of the project are summarized in Table 1.

Table 1: 355-7R Proposed operational procedures.

Parameters/Conditions	Limit or Permitted Value	Unit
Maximum Allowable Pressure	Using 0.82psi/ft frac gradient from data in the area	
Surface	2,990	psig
Downhole	6,260	psig
Injection Pressure	Average over time	
Surface Minimum / Maximum	695 / 1,175	psig
Downhole Minimum / Maximum	762 / 3,923	psig
Maximum Injection Rate	15	mmscfpd
Injection Rate range	10-15 530-794	mmscfpd tonnes/day
Average Injection Volume and/or Mass	8 million	tonnes
Annulus Pressure	Average over time	
Surface Minimum / Maximum	100 / 299	psig
Downhole Minimum / Maximum	3,824 / 4,023	psig

Annulus Pressure

Annular pressure between the tubing and production casing above the packer will be maintained to achieve the requirements of 40 CFR 146.88 (c).

The minimum applied annular surface pressure will be maintained at or greater than 100 psi during injection. This ensures a low-pressure alarm can be used to indicate loss of annular pressure as a potential well integrity concern. Surface pressure will be monitored continuously and evaluated according to Attachment C: Testing and Monitoring Plan.

CTV will maintain downhole annular pressure at the packer greater than 100 psi above injection pressure for all bottomhole injection pressures. This pressure differential is achieved by the combination of hydrostatic pressure from annular packer fluid and surface applied annular pressure, as needed.

CTV intends to use 4% KCl completion fluid with corrosion inhibition and biocide as packer fluid. 4% KCl is compatible with all well components and is not corrosive. The specific gravity of the packer fluid is estimated to be 1.024.

The range of annular pressures described in Table 1 are suitable to the well design and will not impact the well integrity or induce formation fracture.

Maximum Injection Rate

Surface wellhead and downhole conditions will be monitored continuously. Injection rate or mass flow is one of the parameters to be monitored at surface. Thresholds will be established based on limitations of well equipment and geological concerns downhole with respect to the maximum injection rate.

At this time CTV expects a maximum injection rate of 15 million cubic feet per day for which the maximum expected bottom hole injection pressure is 3,923 psi. A threshold of 10% over these will be used to configure the automation and alarms, which equates to 16.5 million cubic feet per day and 4,315 psi. If either threshold is achieved or exceeded, the system will deliver alarms to indicate there is an issue. Resolution will depend on the type of alarm and systems installed to regulate the injection rate. Typically, this will require a reduction in the injection rate without the need for a shutdown. But the situation will be reviewed to understand what systems failed or did not perform properly and thus created an excessive injection rate.

Shutdown Procedures

Under routine conditions (e.g., for well workovers), CTV will reduce CO₂ injection at a rate of 130 tons per day over a 6-day period to ensure protection of health, safety, and the environment. This would be the same for routine well shutdown.

Automated Shutdown System

Downhole temperature and pressure along with surface flow or mass movement, surface pressure, and temperatures will be monitored in real time. Data will be collected in an automated system and monitored by a control system with established operating thresholds. After a threshold is seen or exceeded, the software will issue visual, audible, and digital alerts and/or begin with an unload procedure and transition into the shutdown process for appropriate equipment until it is understood why the thresholds were achieved and what corrective measures must be implemented.

CTV has not established the monitoring system at this time. Upon establishing the system and thresholds, CTV will communicate with the EPA.