

357-7R OPERATING PROCEDURES

Document Version History

Version	Submission Date	File Name	Description of Change
1	3/31/2022	357-7R Operating Procedures	Standalone document of Operating procedures for 357-7R submitted in response to EPA Evaluation responses dated 01/11/2022. Updated fracture gradient discussion, Table 1, Annulus pressure, Maximum Injection rate, Shut-down procedures, Automated shut-down system
2	11/4/2022	357-7R Operating Procedures V2	Updated document to address EPA evaluation responses dated 07/20/2022. Updated “Maximum Injection rate” section, Table 1

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 maximum 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.

At the start of injection, as the A1-A2 reservoir is depleted in pressure, a lower injection pressure is required. As the pressure in the reservoir builds up the injection pressure required is expected to rise. Over the life of the project an average surface injection pressure of 905 psi and average bottom hole pressure of 2302 psi is expected.

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 Injection Pressure for 357-7R is 6281 psi (calculated at the top perforation). The injection well will be controlled using automation to never exceed this maximum downhole pressure. 40+ years of gas and water injection experience into the Monterey Formation A1-A2 and other Monterey formation reservoirs supports that these operating limits are appropriate and effective.

The expected pressures for 357-7R over the life of the project are summarized in Table 1.

Table 1: Proposed operational procedures.

Parameters/Conditions	Limit or Permitted Value	Unit
Maximum Injection Pressure	90% of Fracture pressure using 0.82 psi/ft frac gradient from data in the area	
Surface	2,993	psig
Downhole	6,281	psig
Average Injection Pressure		
Surface	905 *	psig
Downhole	2302 **	psig
Maximum Injection Rate	15 per well	mmscf/d
Injection Rate range	10-15 530-794	mmscf/d tonnes/day
Average Injection Volume and/or Mass	8 million	tonnes
Average Annulus Pressure		
Surface	100	psig
Downhole	3834	psig
Annulus - Tubing pressure differential at Packer	1531 ***	psig

* Average Surface injection pressure values shown over life of the project from the PROSPER modeling

** Average Downhole injection pressure values shown over life of the project from Plume simulation

*** Positive pressure indicates annular pressure higher than tubing pressure

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.

CTV expects a maximum average injection rate of 15 million cubic feet per day. To account for fluctuations in rate and pressure in daily operations, a threshold of 10% below the expected maximum injection rate and 10% below the Maximum Injection Pressure will be used to configure automation and alarms, which equates to 13.5 million cubic feet per day and 5,653 psi. This ensures that the well will not exceed the maximum downhole injection pressure of 6,281 psi. If either threshold is exceeded, the system will deliver alarms to indicate there is an issue, and CTV will take appropriate steps to resume operating within the acceptable ranges of injection rate and pressures.

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.