Underground Injection Control
Carbon Sequestration
Class VI Permit Application

INJECTION WELL OPERATIONS
40 CFR 146.82(7) & (10)
Section 7.0

NexGen Carbon Oklahoma, LLC
Vanguard CCS Hub

June 2025

7.0 INJECTION WELL OPERATIONS [40 CFR 146.82(a)(7)&(10)]

Vanguard CCS Hub

Facility Information

Facility name: Vanguard CCS Hub
Vanguard I-1
Vanguard I-2
Vanguard I-3
Vanguard I-4
Vanguard I-5
Vanguard I-6
Vanguard I-8
Vanguard I-9
Vanguard I-10
Vanguard I-12

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Well locations: Osage County, Oklahoma

Vanguard I-1: Lat 36.633288°N, Lon -96.571029°W (NAD 83)
Vanguard I-2: Lat 36.660083°N, Lon -96.534652°W (NAD 83)
Vanguard I-3: Lat 36.664329°N, Lon -96.586951°W (NAD 83)
Vanguard I-4: Lat 36.710244°N, Lon -96.542370°W (NAD 83)
Vanguard I-5: Lat 36.744047°N, Lon -96.533843°W (NAD 83)
Vanguard I-6: Lat 36.724157°N, Lon -96.489526°W (NAD 83)
Vanguard I-8: Lat 36.823356°N, Lon -96.620496°W (NAD 83)
Vanguard I-9: Lat 36.849167°N, Lon -96.592912°W (NAD 83)
Vanguard I-10: Lat 36.893849°N, Lon -96.578026°W (NAD 83)
Vanguard I-12: Lat 36.785641°N, Lon -96.594085°W (NAD 83)

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Acronyms and Abbreviations

°	degrees
A	
AoR	area of review
B	
BHP	bottomhole pressure
C	
CFR	Code of Federal Regulations
CO_2	carbon dioxide
E	
EPA	U.S. Environmental Protection Agency
F	
F	Fahrenheit
M	
MMcf	million cubic feet
Mt	million tons
Mta	million tons per annum
mol%	mole percent
P	
psi	pounds per square inch
psig	pounds per square inch gauge
ppm	parts per million
T	
TVD	true vertical depth
U	
USDW	underground source of drinking water

7.0 INJECTION WELL OPERATIONS [40 CFR 146.82(a)(7) and (10)]

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

The following information (**Table 7.1**) provides the operating parameters and engineering criteria during injection operations required under 40 CFR 146.82(a)(7) and (10). Using these criteria, the injection wells will be operated to prevent the migration of carbon dioxide (CO_2) from the approved zone and into an underground source of drinking water (USDW).

Table 7.1—Proposed injection well operating parameters for Vanguard I-1, Vanguard I-2, Vanguard I-3, Vanguard I-4, Vanguard I-5, Vanguard I-6, Vanguard I-8, Vanguard I-9, Vanguard I-10, Vanguard I-12.[1]

Item	Values	Description/Comments
Injected Mass and Volume		
Total Injected Mass (Mt)	71	Based on expected injection
Total Injected Volume (MMcf)	1,347,773	Based on expected injection
Injection Rates		
Proposed Average Injection Rate (Mta)	3.5	Based on expected collective injection for all 10 injection wells
Calculated Maximum Injection Rate (Mta)	3.5	Modeled maximum injection rate based on wellhead pressure limit of 1,140[2] psi. None of the simulated injection wells exceeded 90% of the fracture gradient during injection period.
Proposed Average / Maximum Injection Rate (MMcfpd)	18.0	
Pressure (Vanguard I-1) see Table 7.3 for all ten proposed injection wells[3]		
Formation Fracture Pressure at Top Perforation (psi)	2,191	Estimated formation fracture gradient of 0.706 psi/ft at a top perf depth of 3,104 TVD
Average Operating Surface Injection Pressure (psi)	1,140	Proposed average surface injection pressure
Maximum Operating Surface Injection Pressure (psi)	1,140	Based on wellhead pressure conditions in the model
Average Operating BHP (psi)	1,457[4]	Based on expected injection
Maximum BHP (psi)	1,972	Based on 90% of fracture gradient at top perforation
Annulus Pressure / Tubing Differential (psi)	+100	
Tubing-Casing Annular Pressure	1,240	100 psi above maximum surface injection pressure

Notes: Mt = million metric tons, Mta = million metric tons per annum, psi = pounds per square inch, BHP = bottomhole pressure

[1] NTD: Total Injected Volume and Mass is in - NexGen Mass Storage Summary.xlsx
[2] NTD: Value for the Vanguard I-1, values for Vanguard I-2 through I-12 maybe estimated using the same approach.
[3] NTD: These values are for the Vanguard I-1 all values are outlined in Appendix 1
[4] NTD: From simulation model nexgen_CO2_v7-18MMCF-20Y-13w-PV2k-pt5d-no11-v6.2_no7_12_100y

7.1.1 Injection Rate

The injection rate for CO_2 into the upper Arbuckle Group is modeled and estimated to be constant at 3.5 Mta collectively for all ten injection wells.

7.1.2 Maximum Injection Pressure

The fracture gradient of the Arbuckle Group is estimated to be 0.706 psi/ft. The maximum allowable sand face pressure gradient, for Vanguard I-1, is calculated by multiplying the fracture gradient by 90%. This yields a maximum injection pressure gradient of 0.706 psi/ft × 90% = 0.6354 psi/ft, or 1,972 psi at the top perforation at 3,104 ft TVD. Injection operations at the Vanguard CCS Hub are limited by surface facilities and therefore the surface wellhead pressure will be limited to 1,140 psi. The maximum bottomhole injection pressure modeled for the Vanguard I-1 will be 1,472 psi.

7.1.3 CO_2 Volume

The total volume of CO_2 injected and stored, after the 20 year injection period, in the upper Arbuckle Group is estimated to be 71 Mt.

7.1.4 Annulus Pressure

The annulus will be filled with base oil with a nitrogen cap. Temperature fluctuation can occur downhole during startup and shutdown of injection operations. The requirement to maintain the annulus pressure at least 100 psi above the tubing pressure will be affected by changes in annulus temperature and, consequently, pressure. The nitrogen cap will provide a compressible cushion to absorb pressure fluctuations in the annulus. The annulus pressure will be at least 100 psi above the tubing wellhead pressure. With the tubing wellhead pressure limited to 1,140 psi, the expected maximum allowable annulus pressure is 1,240 psi.

7.1.5 Well Stimulation Procedures

It is possible that some or all of the ten injection wells may require a stimulation program over selected intervals after well perforation, depending on downhole conditions. The zones will be chosen based on well log, core, and formation testing evaluations. Core testing will be performed for fluid compatibility and reactivity. Additional data will be used to design stimulation procedures submitted to EPA Region 6 for approval. Any downhole-injected chemicals will comply with state and federal regulations. See *Section 12—Stimulation Program* for details on the planned stimulation program, should it be needed.

7.2 Proposed Carbon Dioxide Stream [40 CFR 146.82(a)(7)(iii) and (iv)]

Table 7.2—Expected composition of an injectate stream.

Constituent	Limit
CO_2	≥ 95 mol%
Carbon Monoxide (CO)	< 0.4 mol%
Hydrogen (H_2)	< 0.5 mol%
Hydrogen Sulfide (H_2S)	< 20 ppm
Total Sulfur	< 35 ppm
Total Nitrogen Oxides (NO_X)	< 10 ppm
Oxygen (O_2)	< 10 ppm (w)
Water (H_2O)	< 150 ppm
Hydrocarbons	< 4 mol%
Glycol	0.3 gallons/MMcf
Maximum dew point at 400 psig	30°F
Non-condensable gases	< 3 mol%

Notes: mol% = mole percent, ppm = parts per million, MMcf = millions of cubic feet, psig = pounds per square inch gauge

NexGen plans to inject an average of 3.5 Mta of CO_2 for 20 years into the ten injection wells. The total volume to be injected is 71 Mt over the life of the Project. The maximum expected bottomhole injection pressure, for the Vanguard I-1 of 1,457 psi is less than 90% of the formation fracture pressure (1,972 psi), reducing the risk to USDWs.

7.3 Appendix 1 – Operational Configuration and Pressures for All Ten Injection Wells

Table 7.3—Proposed configuration and operating pressures for ten injection wells.

Injection Well	Top Perf (TVD ft)	Base Perf (TVD ft)	Maximum Bottomhole Injection Pressure (90% of fracture gradient) (psi)	Average Expected Bottomhole Injection Pressure (psi)
Vanguard I-1	3,104	3,664	1,972	1,457
Vanguard I-2	3,055	3,551	1,941	1,462
Vanguard I-3	3,240	3,788	2,059	1,470
Vanguard I-4	3,092	3,529	1,964	1,470
Vanguard I-5	3,072	3,476	1,952	1,481
Vanguard I-6	2,919	3,344	1,855	1,420
Vanguard I-8	3,307	3,772	2,101	1,556
Vanguard I-9	3,308	3,841	2,102	1,536
Vanguard I-10	3,168	3,748	2,013	1,422
Vanguard I-12	3,305	3,772	2,100	1,570