# PRE-OPERATIONAL TESTING PROGRAM
# 40 CFR 146.87 [LAC 43:XVII:3617..B]

## Venture Global CCS Cameron, LLC $CO_2$ Sequestration Project

### Facility Information

Facility Name: Venture Global CCS Cameron, LLC $CO_2$ Sequestration Project

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Injection Well Location: West Cameron Block 5 CS004 Well No. 001, Cameron Parish, Louisiana
[redacted]

## 1 Introduction

The testing activities at the CS004 Well 001 and Monitor Well 002 described in this module are restricted to the pre-injection phase. Testing and monitoring activities during the injection and post-injection phases are described in the "Testing and Monitoring Plan" and "Post-Injection Site Care and Site Closure Plan" respectively, along with other non-well related pre-injection baseline activities such as geochemical monitoring.

## 2 Pre-Injection Testing Plan – Injection Well

The following tests and logging will be conducted during drilling, casing installation and after casing installation in accordance with the testing required under 40 CFR 146.87(a), (b), (c), and (d) [LAC 43:XVII:3617.B.1, LAC 43:XVII:3617.B.2, LAC 43:XVII:3617.B.3, and LAC 43:XVII:3617.B.4]. The pre-injection tests and procedures are described below and in the "Injection Well Construction" module of the Application.

### *2.1 Deviation Checks*

Measurement while drilling (MWD) technology, and directional drilling best practices will be incorporated into the bottomhole drilling assemblies to enable real time measurements that will continuously ensure the well does not deviate from its planned well trajectory. This process will help eliminate the risk of building unintended wellbore inclination and tortuosity, intersecting adjacent wellbores, and ensures the well reaches the intended injection zone.

### *2.2 Tests and Logs*

The following tests and logging will be performed.

### *2.2.1 Open Hole Logging Plan*

The drilling string for each section will include a logging-while-drilling (LWD) tool equipped with basic resistivity, gamma ray (GR), density, and neutron logging capabilities.

Prior to installing and cementing [redacted] each open hole section will be logged with an extensive suite of tools to fully characterize the geologic formations, as required by 40 CFR 146.87 [LAC 43:XVII:3617.B]. The objective for open hole logging is the full lithological and geochemical characterization of the confining zone, the gross injection interval, and the lower confining layer.

Surface casing section wireline logging will include a directional gyro survey, GR, spontaneous potential (SP), resistivity, density, neutron porosity, temperature, cross dipole acoustic, and caliper logs to identify rock properties and enable well construction calculations. The long string casing section logging will include a directional gyro survey, spectral gamma ray, resistivity, density, neutron porosity, temperature, cross dipole acoustic, caliper, and gamma ray logs to identify rock properties. Electrical and ultrasonic wellbore imaging, magnetic resonance imaging, and formation lithology logging will also be recorded over the injection interval to provide high resolution reservoir characterization data. Rotary sidewall cores will be collected over the long string casing section to augment recovered whole core data. A summary description of the logging plan and sequence is presented in Table 1.

**Table 1: Open Hole Logging Plan - Injection Well**

| Trip | Hole Section | Logging Suite | Target Data Acquisition | Open Hole Diameter | Depths of Survey (TVD) |
|---|---|---|---|---|---|
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |

| Trip | Hole Section | Logging Suite | Target Data Acquisition | Open Hole Diameter | Depths of Survey (TVD) |
|---|---|---|---|---|---|
| | | [redacted] | | | |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |

#### *2.2.1.1 Coring Plan*

[redacted]

#### *2.2.1.2 Formation Fluid Testing*

Fluid sampling to characterize the chemical and physical properties of the formation fluids in the injection zone will be performed (40 CFR 146.82(a)(8) and 40 CFR 146.87(b) [LAC 43:XVII:3607.C.2.g and LAC 43:XVII:3617.B.2]) as well as recording of the fluid temperature, pH, specific conductivity/salinity, reservoir pressure, and static fluid level (40 CFR 146.87(c) [LAC 43:XVII:3617.B.3]). These measurements are used to determine the compatibility of the injectate with the formation fluids (40 CFR 146.82(c)(3) [LAC 43:XVII:3619.A.3]).

#### *2.2.1.3 Formation Fluid Testing Method*

Fluid sampling will be conducted prior to setting the long casing string. Samples of the formation fluid will be obtained via a wireline open hole fluid recovery tool. The wellbore will be cleaned of drilling mud as much as possible before the samples are taken. Fluid samples may alternatively be obtained after well completion via a flow-through device, or at the surface by pumping the fluids for collection. Analyses of the chemical and physical properties of the formation fluids will include major anions and cations, pH, temperature, pressure, alkalinity, total organic carbon, and total inorganic carbon. Fluid sample recovery depth sections will be determined based on open hole log analysis. Two samples will be taken per section, as described in Module 7 - Construction Details.

### 2.2.2 *Cased Hole Logging Plan*

After the casing strings are installed and cemented into place, cased hole logging will be performed. The objective of the cased hole logging is to ensure the integrity of the injection tubing, confirm the wellbore is safe, and ensure efficient $CO_2$ stream injection operations. The cased hole logging plan is detailed in Table 2.

**Table 2: Cased Hole Logging Plan - Injector Well**

| Trip | Hole Section | Logging Suite | Target Data Acquisition | Casing Dimension | Depth of Survey |
|---|---|---|---|---|---|
| [redacted] | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |

| Trip | Hole Section | Logging Suite | Target Data Acquisition | Casing Dimension | Depth of Survey |
|---|---|---|---|---|---|
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | | [redacted] | | |

### *2.2.2.1 Initial Step Rate Injectivity Test*

Prior to the commencement of $CO_2$ injection, Venture Global will conduct a step-rate injectivity test to measure the fracture gradient of CS004 Well 001, in compliance with 40 CFR 146.87(d)(1) [LAC 43:XVII:3617.B.4.a] and 40 CFR 146.87(e)(3) [LAC 43:XVII:3617.B.5.c]. This information, in conjunction with predictions of pore pressures within the injection zone, will be used to support a determination of an appropriate injection pressure to ensure that injection will not initiate or propagate fractures in the confining zone consistent with 40 CFR 146.83(a)(2) [LAC 43:XVII:3615.A.2]. In addition, this information will be used to confirm or refine the preliminary site characterization information described in the "Main Narrative."

Venture Global will notify the Director at least 30 days prior to conducting pressure tests, temperature logs, casing inspection logs and any additional mechanical tests, logs, or inspections and provide a detailed description of the testing procedure. Notice and the opportunity to witness these tests/logs shall be provided to the Director at least 48 hours in advance of a given test/log.

#### *2.2.2.1.1 Step Rate Testing Method*

A bottomhole pressure-temperature gauge will be deployed at the total depth of the wellbore capable of continuous, high precision sampling. Initial bottomhole pressure (BHP) and temperature readings will be measured prior to injection. Venture Global will ensure all gauges are calibrated before testing.

1. Prior to testing, shut in the well long enough (but not less than 48 hours) to ensure the BHP is at or near the shut-in formation pressure.
    a. Pressure should be recorded for the duration of the shut in to confirm stabilization.
2. Set the required number of 500-bbl frac tanks to complete the test, per the proposed schedule.
    a. Fill with clean brine water.
3. Rig up pumps and casing.
    a. Move in, rig up pressure pumping equipment, and lay casing.
    b. Pumps must be positive displacement with digital recording of rate.
    c. Pumps, casing, and flow control should be sized so that steps in rate will not create pressure or rate transients, other than those caused by the intended steps.

   d. Rig up flow meter and pressure gauges (ensure pressure gauges are recently calibrated and able to accommodate the full range of expected pressures).

4. Move in and rig up wireline.
5. Perform gauge ring run.
6. Pick up BHP gauge and run-in hole to top perforation depth; ensure the gauge is calibrated.
   a. BHP gauge should have a continuous surface readout.
7. If not already in place, install surface pressure gauge with a continuous readout.
8. If surface pressure indicates fluid level is beneath the surface, fill hole with brine at a constant rate of [redacted] barrels per minute (bpm).
9. Once the well is full, stop pumping and allow the pressure to descend to [redacted] psi, indicating fluid level is at surface.
10. An injection rate schedule should be developed with the following goals:
    a. Begin at sufficiently low rates to ensure there are two or three steps below fracture pressure.
    b. Continue to high enough rates to ensure a minimum of three steps over the fracture pressure.
11. Begin test at the initial injection rate of [redacted] bpm for [redacted] minutes.
12. Step up rates per the predetermined rate schedule of [redacted] bpm increments until approximately three measurements are taken both below and above the estimated formation fracture initiation pressure, up to a rate of [redacted] above the maximum, which is determined once reservoir properties are established.
13. Hold each stage for a duration of [redacted] minutes.
14. Upon reaching a stabilized pressure after completing the final step, record pressures at the highest frequency of the gauge for a period indicated by the step-up phase of testing to calculate the rate of pressure bleed off.
    a. Plot BHP versus rate in real time. If necessary, adjust the rate schedule adjusted during the test to ensure three steps below and three steps above the fracture pressure.
    b. Injection rate must not exceed the recommended limit of [redacted] ft/sec in the tubing.
    c. Surface pressure should not exceed [redacted] of the maximum pressure rating of the wellhead at any time.
    d. Changes in flow rate must occur over as short of intervals as possible.
    e. Injection rates should be controlled with a constant flow regulator.
    f. All injection flow rates, including hole conditioning treatments prior to the test, must be documented on service company forms.
       i. Refill frac tanks as needed.
    g. A minimum of three fluid samples should be collected at the beginning, middle, and end of the test.
       i. The density of the samples will be read by an in-house method and recorded for later reference.

15. Upon completion of the final injection stage, the line valve must be closed to stop injection immediately and allow the pressure to bleed off into the formation.
    a. Ensure pressure values are recorded at the highest obtainable frequency during shut-in.
    b. Continue to capture falloff pressure data for a minimum of one hour.
16. Conclude test, rig down, and move out pumps and wireline unit.

# 3 Pre-Injection Testing Plan – Deep Monitoring Well CS004 Monitor Well No. 002

## *3.1 Deviation Checks*

MWD technology, and directional drilling best practices will be incorporated into the bottomhole drilling assemblies to enable real time measurements that will continuously ensure the well does not deviate from its planned well trajectory. This process will help eliminate the risk of building unintended wellbore inclination and tortuosity, intersecting adjacent wellbores, and ensures the well reaches the intended injection zone.

## *3.2 Tests and Logs*

The following tests and logging will be performed for CS004 Monitor Well No. 002.

### *3.2.1 Open Hole Logging Plan*

The drilling string for each section will include an LWD tool equipped with basic resistivity, GR, density, neutron logging capabilities.

Prior to installing and cementing [redacted] each open hole section will be logged with an extensive suite of tools to fully characterize the geologic formations, in a similar manner as the testing performed on the injection well.

Surface casing section wireline logging will include a directional gyro survey, GR, SP, resistivity, density, neutron porosity, temperature, cross dipole acoustic, and caliper logs to identify rock properties and enable well construction calculations. The long string casing section logging will include a deviation survey, spectral gamma ray, resistivity, density, neutron porosity, temperature, cross dipole acoustic, and caliper logs to identify rock properties. A summary description of the logging plan and sequence is presented in Table 3.

**Table 3: Open Hole Logging Plan – Deep Monitoring Well**

| Trip | Hole Section | Logging Suite | Target Data Acquisition | Open Hole Diameter | Depths of Survey (TVD) |
|---|---|---|---|---|---|
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| [redacted] | | [redacted] | [redacted] | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| [redacted] | | [redacted] | [redacted] | | |
| | | [redacted] | | | |
| | | [redacted] | | | |

| Trip | Hole Section | Logging Suite | Target Data Acquisition | Open Hole Diameter | Depths of Survey (TVD) |
|---|---|---|---|---|---|
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| [redacted] | | [redacted] | [redacted] | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |

### 3.2.2 Cased Hole Logging Plan

After the casing strings are installed and cemented into place, cased hole logging will be performed. The objective of the cased hole logging is to ensure the integrity of the casing and cement and confirm the wellbore is safe. The cased hole logging plan is detailed in Table 4.

**Table 4: Cased Hole Logging Plan - Deep Monitoring Well**

| Trip | Hole Section | Logging Suite | Target Data Acquisition | Casing Dimension | Depth of Survey |
|---|---|---|---|---|---|
| [redacted] | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | | [redacted] | | | |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |

| Trip | Hole Section | Logging Suite | Target Data Acquisition | Casing Dimension | Depth of Survey |
|---|---|---|---|---|---|
| [redacted] | | [redacted] | [redacted] | | |
| [redacted] | [redacted] | [redacted] | | [redacted] | [redacted] |
| [redacted] | | [redacted] | [redacted] | | |

## 4 Demonstration of Mechanical Integrity

Mechanical integrity tests (MITs) will be conducted to guard against movement of wellbore fluids (annular or injected) into geologic formations other than the intended injection layer via the tubing-casing annulus or outside of the casing (i.e., behind pipe). Cement and system mechanical integrity will be verified after well construction with wireline cement ultrasonic imaging logs with a radial capability combined with temperature logging. Additionally, mechanical integrity will be confirmed by pressure testing the casing prior to perforating. The tubing/casing annulus will be pressure tested after the packer is installed.

Pre-operational MITs are also conducted to provide baseline measurements for subsequent planned interval MITs. A summary of the MITs and pressure fall off tests to be performed prior to injection are listed in Table 5:

**Table 5: Pre-Operational Testing Schedule**

| Class VI Rule Citation | Rule Description | Test Description | Program Period |
|---|---|---|---|
| **40 CFR 146.89(a)(1) [LAC 43:XVII:3627.A.1.a]** | MIT - Internal | Annulus Pressure Test | Prior to operation |
| **40 CFR 146.87(a)(4) [LAC 43:XVII:3617.B.1.d]** | MIT - External | Temperature Log | Prior to operation |
| **40 CFR 146.87(a)(4) [LAC 43:XVII:3617.B.1.d]** | MIT - External | Casing Inspection Log | Prior to operation |

| Class VI Rule Citation | Rule Description | Test Description | Program Period |
|---|---|---|---|
| **40 CFR 146.87(e)(1) [LAC 43:XVII:3617.B.5]** | Testing prior to operating | Pressure Fall-Off Test | Prior to operation |

Venture Global will notify the Director at least 30 days prior to conducting pressure tests, temperature logs, casing inspection logs and any additional mechanical tests, logs, or inspections and provide a detailed description of the testing procedure. Notice and the opportunity to witness these tests/logs shall be provided to the Director at least 48 hours in advance of a given test/log.

## *4.1 Annulus Pressure Test Procedures for Injection Well:*

In accordance with 40 CFR 146.89(b) [LAC 43:XVII:3627.A.2.a.i] and 40 CFR 146.87(a)(4) [LAC 43:XVII:3617.B.1.d], Venture Global will ensure mechanical integrity by performing annular pressure tests after the well is completed, prior to the start of injection, and after subsequent recompletion stages.

### *4.1.1 Annulus Pressure Test Method*

The annular pressure tests demonstrate mechanical integrity of the casing, tubing, and packer. The test will be run using the following procedure:

1. Stop injection and allow well to stabilize.
2. Confirm connectivity to and functionality of permanent gauges or install pressure gauge on annulus.
3. Rig up pump, pressurize annulus to [redacted] psi fluid pressure.
4. Use a block valve to isolate the test pressure source from the test pressure gauge upon test initiation, with all ports into the casing annulus closed except the one monitored by the test pressure gauge.
5. Monitor and record the pressure change over a [redacted] period (taking a measurement at least every [redacted] minutes) using a pressure gauge with sensitivities that can indicate a loss of [redacted]
6. Any significant pressure drop will be investigated to verify that mechanical integrity is intact and corrected as necessary. Pressure test will be rerun following investigation / remediation to confirm integrity. The well will be deemed to have failed the annulus pressure test if a pressure change of greater than [redacted] occurs over the [redacted] period.
7. Plot the gathered data and determine volume of fluid loss, if any.
8. The data obtained, including recorded charts from the tests, shall be submitted as required by the permit.

All annulus pressure test results will be submitted to the Director within 30 days of completion.

## *4.2 Temperature Log*

In accordance with the requirements in 40 CFR 146.89(c) [LAC 43:XVII:3627.A.3], Venture Global will conduct temperature logs before initiating injection operations to establish a baseline for comparison with future annual logs. The well will be shut in for a duration of approximately [redacted] hours prior to running the temperature logs to allow temperatures to stabilize. Satisfactory mechanical integrity is demonstrated by proper correlation between the baseline and subsequent logs.

All temperature logs recorded during the MIT will be submitted to the Director within 30 days of log run completion.

### *4.2.1 Temperature Logging Method*

To ensure the mechanical integrity of the injection well, temperature data will be recorded through tubing. The well should be in a state of injection for at least [redacted] hours prior to commencing operations in order to cool injection zones. The following procedures will be employed:

1. Move in and rig up an electrical logging unit with lubricator.
2. Run a temperature survey from the base of the surface casing to the deepest point reachable in the well while injecting at a rate that allows for safe operations.
3. Stop injection, pull tool back to shallow depth; wait [redacted].
4. Run a temperature survey over the same interval as step 2.
5. Pull tool back to shallow depth,;wait [redacted].
6. Run a temperature survey over the same interval as step 2.
7. Pull tool back to shallow depth; wait [redacted] hours.
8. Run a temperature survey over the same interval as step 2.
9. Evaluate data to determine if additional passes are needed for interpretation.
10. If additional passes are needed, repeat temperature surveys every 2 hours for [redacted] hours, over the same interval as step 2.
11. Rig down the logging equipment.
12. Data interpretation involves comparing the time lapse well temperature profiles and looking for temperature anomalies that may indicate a failure of well integrity (i.e., tubing leak or movement of fluid behind the casing). As the well cools down the temperature profile along the length of the tubing string is compared to the baseline. Any unplanned fluid movement into the annulus or outside the casing creates a temperature anomaly when compared to the baseline cooling profile.

## *4.3 Casing and Cement Inspection Log*

Per 40 CFR 146.89(d) [LAC 43:XVII:3627.A.4], at the time of initial well completion, a comprehensive cased hole logging suite will be run on the injection casing string. This suite of logs will include a radial cement investigation, a multi-arm caliper, and a digital log to establish the condition of the casing metal. This survey will characterize the original state of the wellbore materials. Following the installation of the tubing and packer, an initial through-tubing inspection log will be run on the well. This survey will serve as the baseline survey for future casing inspection efforts.

Casing inspection logs will be performed every five years or at recompletion, providing the condition of the cement and casing to verify continuous monitoring methods. An ultrasonic pulse echo casing and cement evaluation tool employing a rotating transducer for 360-degree assessments will be used to deliver high-resolution measurements of cement channels as narrow as 1.2 inches and detects casing problems including drill wear, ovality, and corrosion. The casing inspection log will be used to determine the thickness, external condition, and internal condition of the long string casing for its entire length.

#### *4.3.1 Casing and Cement Inspection Log Method*

The pre-operational casing inspection logging will be performed in each completed cased hole section in combination with other cased hole logging tools as detailed in Table 2 and Table 4.

### *4.4 Pressure Fall-off Test*

Venture Global will perform a required pressure fall-off test at recompletion or no less than once every five years, per 40 CFR 146.90(f) [LAC 43:XVII:3625.A.6]. The tests will measure near-wellbore formation properties and monitor for near-wellbore environmental changes that may impact injectivity and result in pressure increases.

All pressure fall-off test results will be submitted to the Director within 30 days of test completion.

Field equipment will undergo inspection and testing prior to operation. Manufacturer calibration recommendations will be followed during use of pressure gauges in the fall-off test. Documentation certifying proper calibration will also be enclosed with the test results. Further validation of the test results will be recorded using a second BHP gauge.

Venture Global will notify the Director at least 30 days prior to conducting these tests and provide a detailed description of the testing procedure. Notice and the opportunity to witness these tests/logs shall be provided to the Director at least 48 hours in advance of a given test/log.

#### *4.4.1 Pressure Fall-off Testing Method*

The injection rate and pressure will be held as constant as possible prior to the beginning of the test, and continuous data will be recorded during testing. Once the well is shut in, continuous pressure measurements will be taken via two BHP gauges. One gauge will serve as a contingency to verify data quality or as a backup. The fall-off period will end once the pressure decay data plotted on a semi-log plot is a straight line, indicating radial flow conditions are reached.

Near-wellbore conditions, such as the prevailing flow regimes, well skin, and hydraulic property and boundary conditions, will be determined through standard analytical methods. This determination is accomplished via analysis of observed pressure changes and/or pressure derivates on standard diagnostic log-log and semi-log plots. Significant changes in the well or reservoir conditions can be exposed by the comparison of pressure fall-off tests prior to initial injection with later tests. The effects of two-phase flow effects will also be considered. Such well parameters resulting from fall-off testing will be compared against those used in the area of review (AoR) determination and site computational modeling. Notable changes in reservoir properties may indicate an AoR reevaluation is necessary.