5.0 PRE-OPERATIONAL TESTING PROGRAM

40 CFR 146.82(a)(8), 146.87

CLECO DIAMOND VAULT PROJECT

Facility Information

Facility name: DIAMOND VAULT

Facility contact: [redacted]

Well name: CLDV-IW1

Well location: RAPIDES PARISH, LOUISIANA
[redacted] [redacted]

Table of Contents

List of Figures

List of Tables

5.0 Pre-Operational Formation Testing Program

5.1 Introduction

The pre-operational testing program meets the testing requirements of 40 CFR 146.87 and well construction requirements of 40 CFR 146.86. The pre-operational testing program provides and verifies the depth, thickness, mineralogy, lithology, porosity, permeability, and geomechanical information of the Wilcox-2 (carbon dioxide [CO_2] storage formation), the overlying confining layer, and other relevant geologic formations. In addition, pre-operational testing data are used to provide baseline information for the site that will be used for comparative purposes throughout the project. For example, fluid samples collected during the pre-operation testing will be used as a reference to identify geochemical changes in samples collected during injection operation that may result from the injection of CO_2.

An overview of the project site is presented in Figure 5-1 which shows the location of the six proposed injection wells relative to Lake Rodemacher and local infrastructure. The Area of Review (AoR) for the project is also shown. This AoR encompasses the pressure fronts from all injection wells. Figure 5-2 shows the eastern well pad with CLDV-IW1 highlighted.

A stratigraphic test well (STW) will be drilled at the site to characterize the subsurface within the Area of Review (AoR) at the Diamond Vault facility. Extensive wireline logging, coring, fluid sampling, and formation hydrogeologic testing will be performed in the STW well. The data will be incorporated into the site static earth and dynamic models (Permit Section 2) from which the AoR is derived.

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Figure 5-1: Map of Diamond Vault showing six proposed injection wells and AoR.

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Figure 5-2: Map of proposed injection well CLDV-IW1

5.2 Pre-Operational Testing During Injection Well Installation (146.87 (a))

Pre-operational testing will be completed to verify depth, thickness, porosity, permeability, and lithology of, and the salinity of any formation fluids in all relevant geologic formations to ensure conformance with the injection well construction requirements under § 146.86 and to establish accurate baseline data against which future measurements may be compared.

In addition to the characterization data collected during the installation of the injection well, information will be collected that will serve as baseline data for the monitoring performed during the operation of the CO_2 injection system. A brief description of the baseline sampling/monitoring is provided in this section, and details are included in the Testing and Monitoring Plan (Permit Section 7).

5.2.1 Deviation Surveys (146.87 (a)(1))

Deviation surveys are obtained as wells are drilled to determine the wellbore path from the surface to the total depth (TD) of the well. Typically, the tool used to perform deviation surveys is placed in the drill string just above the drill bit and records the inclination of the tool and borehole.

The subject well is proposed with an "S-curve" plan to achieve the desired bottom hole location given the available surface hole location. Directional drilling tools including MWD (measurement while drilling) will be in the drillstring from surface to TD giving survey information throughout the well.

Hole deviation of the vertical section through the caprock and injection interval will be maintained to less than 5 degrees off vertical. In the vertical section survey points will have a frequency of no less than every 90 ft. The directional drilling assembly already in the hole will be used to 'nudge' the trajectory back to vertical.

5.2.2 Well Logging: Surface Section (146.87 (a)(2))

Open hole well logs will be acquired prior to setting surface casing as well as after surface casing is set and cemented. Open hole logs will likely include gamma ray, density, neutron porosity, spontaneous potential (SP), resistivity, sonic, and caliper logs. Table 5-1 summarizes the well logs that will likely be acquired before and after surface casing is set and the purpose of each well log.

The cased hole well logs will be acquired after the surface casing has been set and cemented. Cement integrity will be evaluated through a basic cement bond log – variable density log (CBL-VDL) with a gamma ray tool for depth correlation (Table 5-1).

Open/ Cased Hole	Log Type	Parameters Obtained
Open Hole	Gamma Ray	Lithology
	Density	Porosity, Density
	Neutron Porosity	Porosity
	Spontaneous Potential	Permeability
	Resistivity	Fluid Saturation, Permeability
	Sonic	Porosity, Formation Velocities
	Caliper	Borehole Diameter, Stress
Cased Hole	Cement Bond Log - Variable Density Log	Cement Integrity

Table 5-1: Summary of wireline logs and associated parameters of logging tools to be run before and after surface casing in the injection well.

5.2.3 Well Logging: Intermediate Section (146.87 (a)(2))

Open hole well logs will be acquired in the intermediate section of the injection well after the intermediate section of the well has been drilled to characterize the deeper geology at the proposed site. Open hole logs will include caliper, gamma ray, SP, resistivity, neutron porosity, density, and sonic. Table 5-2 summarizes the well logs that will be acquired in the intermediate well section and the purpose of each well log. Data from the resistivity log will be used to evaluate the salinity (total dissolved solids [TDS]) of the geologic formations above the caprock and will be used to confirm the deepest underground source of drinking water (USDW). If the resistivity logs from STW and injection wells display inconsistent results, samples may be collected from one or both wells to confirm the log data.

After the intermediate casing string has been cemented, logs will be acquired to evaluate the cement integrity. Cement integrity will be evaluated through a CBL-VDL and an advanced ultrasonic logging tool that will be run with a gamma ray tool for depth correlation (Table 5-2).

Open/ Cased Hole	Log Type	Parameters Obtained
Open Hole	Caliper	Borehole Diameter, Stress
	Gamma Ray	Lithology
	Spontaneous Potential	Permeability
	Resistivity	Fluid Saturation, Permeability
	Neutron Porosity	Porosity
	Density	Porosity, Density
	Sonic - DT	Porosity, Formation Velocities
Cased Hole	Cement Bond Log - Variable Density Log	Cement Integrity
	Ultrasonic Cement Evaluation	Cement Integrity

Table 5-2: Summary of wireline logs and associated parameters of logging tools to be run before and after intermediate casing in the injection well.

5.2.4 Well Logging: Deep Section (146.87 (a)(3))

Open hole well logs will be acquired in the deep section of the well after drilling this section of the well to characterize the deeper geology at the site. Open hole logs will include caliper, gamma ray, SP, resistivity, neutron porosity, density, dipole sonic, magnetic resonance, and formation imager. Table 5-3 summarizes the well logs that will be acquired in the deep section and the purpose of each well log.

After the long string casing has been cemented, logs will be acquired to evaluate cement quality and provide baseline data for external well integrity. Cement quality will be evaluated through a CBL-VDL log and an advanced ultrasonic logging tool with a gamma ray tool for depth correlation (Table 5-3). Finally, a pulsed neutron log in sigma mode and a temperature log will be acquired to serve as a baseline dataset for the Testing and Monitoring Plan (Permit Section 7). The pulsed neutron capture log and temperature log will be performed after drilling muds are no longer present near the well and temperature has stabilized to ensure accurate results from the logging effort.

Open/ Cased Hole	Log Type	Parameters Obtained
Open Hole	Caliper	Borehole Diameter, Stress
	Gamma Ray	Lithology
	Spontaneous Potential	Permeability
	Resistivity	Fluid Saturation, Permeability
	Neutron Porosity	Porosity
	Density	Porosity, Density
	Dipole Sonic - DT	Porosity, Formation Velocities
	Magnetic Resonance	Porosity and Permeability
	Formation Imager	Detection of fractures and geologic features
Cased Hole	Cement Bond Log - Variable Density Log	Cement Integrity
	Ultrasonic Cement Evaluation	Cement Integrity
	Temperature	Temperature
	Pulsed Neutron	Lithology, Fluid Saturation, Porosity

Table 5-3: Summary of wireline logs and associated parameters of logging tools to be run before and after long string casing in the injection well.

5.2.5 Injection Well Mechanical Integrity Testing (146.87 (a)(4))

5.2.5.1 Internal Mechanical Integrity Testing (146.87 (a)(4)(i))

Internal mechanical integrity refers to the integrity or seal within the long casing string (i.e., between the long casing string, tubing, and packer). The quality of this seal can be confirmed with a mechanical integrity test (MIT) and annular pressure monitoring. Corrosion of the tubing string can result in internal mechanical issues, and inspection of the tubing will be performed to monitor the tubing for corrosion (Testing and Monitoring Plan, Permit Section 7).

After the packer, tubing, and downhole equipment have been installed, and the tubing/casing annulus has been filled with a corrosion-inhibited fluid (a dilute potassium chloride [KCl] solution with additives), a MIT will be conducted on the annular space of all deep wells to ensure that there are no leaks in the tubing, casing, or packer. The MIT will be performed by pumping additional annular fluid into the annulus to increase the pressure to the maximum allowable injection pressure. The annular pressure will be monitored for 30 minutes to measure pressure loss. A pressure loss of less than 3% of the initial value would indicate proper internal mechanical integrity. If a pressure loss greater than 3% is observed, the cause of the poor mechanical integrity will be identified and corrected.

Once injection commences, injection pressure, annular pressure, and annular fluid volumes will be monitored continuously to ensure internal well integrity and proper annular pressure is maintained (Testing and Monitoring Plan, Permit Section 7).

5.2.5.2 External Mechanical Integrity (146.87 (a)(4) (ii – iv))

External mechanical integrity refers to the absence of fluid movement/leaks through channels between the long casing string and the borehole or the intermediate casing string. Migration of fluids through this zone could result in contamination of USDWs. The external integrity of the wells that penetrate the caprock will be confirmed throughout the project.

Generally accepted methods for evaluating external mechanical integrity include the following:

- Temperature or noise log
- Oxygen-activation logging or radioactive tracer logging

A baseline temperature measurement will be acquired from surface to total depth (TD) of the injection well to provide initial temperature conditions over the well. Temperature measurements acquired after injection has started will be compared to this log to determine if anomalies are present in the subsequent logging events that may be attributed to external integrity issues (Testing and Monitoring Plan, Permit Section 7.0). If the temperature measurement data suggest an issue with external well integrity exists, an oxygen-activation logging run will be performed to evaluate external well integrity with greater sensitivity.

In addition to the baseline temperature log, a CBL-VDL and an advanced ultrasonic cement evaluation log will be run over the entire depth of the long casing string shortly after completion of the injection well to confirm that the casing string was properly cemented. CBL-VDLs are recorded with sonic tools that detect the bond of the casing and formation to the cement between the casing and wellbore to identify damage. Ultrasonic tools provide higher accuracies and resolutions for cement evaluation.

5.3 Injection Well Core Program (146.87 (b)(d))

Whole and side wall cores will be collected from the STW. These core analyses will serve as the primary geologic characterization for the injection site, and no additional coring efforts are currently planned for the injection well. However, if wireline log data gathered from the injection well display unique results or results that are inconsistent with the data from the STW or if required by the UIC Director, additional side wall cores may be collected during the installation of the injection well.

5.4 Injection Well: Fluid Sampling and Analysis (146.87 (b – d))

Characterization of reservoir fluids will be performed using samples acquired from the STW. The analytical results from these samples will be used to:

- Determine the deepest USDW
- Provide baseline geochemical conditions in the injection reservoir, the deepest water bearing zone above the caprock and the deepest USDW
- Evaluate geochemical reactions that may occur during the injection of the CO_2 that could affect the porosity and/or permeability of the reservoir or caprock formations

No additional fluid sampling is planned for the injection well unless the wireline data display inconsistent or unique results compared to the data from the STW or if required by the UIC Director, in which case additional samples will be collected for geochemical analyses.

The analyses performed on the fluid samples collected from the STW provide baseline geochemical conditions of the aquifers at the injection site. These data will be used for comparative purposes through the operational/injection and post-injection phases of the project. Additional details on the sampling and analysis of samples collected throughout the remainder of the project are provided in the Testing and Monitoring Plan and Post-Injection Site Closure Plan (Sections 7 and 9 respectively).

5.5 Injection Well Geomechanical Testing (146.87 (d))

The geomechanical characterization for the site will be completed using data from the STW and is described in the Project Narrative (Permit Section 1.1), however additional samples will be collected and/or analysis will be performed on the injection well, if required by the UIC Director.

5.6 Injection Well Hydrogeologic Characteristics (146.87 (e))

Hydrogeologic characterization of the injection site will be performed through testing conducted at the STW, and limited additional testing is planned for the injection well. Data from the hydrogeologic testing on the STW will be used in the development of the dynamic flow models to determine the CO_2 plume geometry and distribution. These data are described in the AoR and Corrective Action Plan (Permit Section 2).

Flowmeter testing is planned for the injection well to confirm the zones within the injection formation which accept the greatest amount of flow during injection. These data will be used to determine the best perforation strategy for the injection well. The flowmeter testing will be performed by injecting brine into the open borehole after it has been drilled to TD and running a flowmeter tool across the open hole interval.

Additional hydrogeologic testing may be performed as required by the UIC Director.

5.7 Injection Well Schedule (146.87 (f))

Cleco Power, LLC will provide the UIC Director with the opportunity to witness all logging and testing activities associated with the drilling and testing of the injection well. Cleco Power, LLC will submit a schedule of such activities to the UIC Director 30 days prior to conducting the first test and submit any changes to the schedule 30 days prior to the next scheduled test.

Figure 5-3 and Table 5-4 provide a tentative schedule based on the numbers of days to complete each task. It is anticipated that the drilling schedule will be updated once the Class VI permit is received.

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Figure 5-3: Tentative injection well drilling schedule.

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Table 5-4: Tentative injection well drilling schedule.