For assistance with 508 accessibility, please reach out to Allan Batka (email: batka.allan@epa.gov, phone: 312-353-7316)

6.0 PRE-OPERATIONAL TESTING PROGRAM

For a Class VI Permit, a proposed pre-operational well and formation testing program is required to verify proper construction of the well and obtain an analysis of the chemical and physical characteristics of the injection and confining zones per 40 CFR 146.82 (a) (8). This program must also meet the requirements of 40 CFR 146.87, which includes elements related to both site characterization and well integrity.

6.1 PRE-OPERATIONAL FORMATION TESTING

The pre-operational formation testing program will be executed to obtain an analysis of the chemical and physical characteristics of the injection zone and confining zone and that meets the testing requirements of 40 CFR 146.87 and well construction requirements of 40 CFR 146.86. The pre-operational testing program will include a combination of logging, coring, formation geohydrologic testing (e.g. a pump test and injectivity tests) and other activities during the drilling and construction of the CO_2 injection well.

The pre-operational formation testing program will determine or verify the depth, thickness, mineralogy, lithology, porosity, permeability, and geomechanical information of the Mt. Simon Sandstone (CO_2 injection zone), the overlying Rome formation (confining zone), and other relevant geologic formations. In addition, formation fluid from the Mt. Simon Sandstone will be taken to establish the baseline data against which future may be compared to after the start of injection operations. The results of the testing activities will be documented in a report and submitted to the EPA after the well drilling and testing activities have been completed but before the start of CO_2 injection operations.

6.1.1 WIRELINE LOGGING

Open-hole logs will be run to obtain in situ, structural, stratigraphic, physical, chemical, and geomechanical information for the Mt. Simon Sandstone, the Rome confining zone, and other important formations. Open-hole characterization logs will be conducted at the surface casing point, intermediate casing point, vertical pilot hole into the Mt. Simon Sandstone, and longstring casing point. The open-hole logs will not be run in the conductor casing hole.

As shown in Table 6-1, the open-hole logs include gamma, spontaneous potential, resistivity, neutron, density, sonic, resistivity based, caliper, and formation micro-imager/fracture finder well logs.

The cased-hole logs that will be run include cement bond logs, temperature logs, baseline casing inspection logs including imaging caliper and Vertilog, and baseline oxygen-activation logs.

6.1.2 CORING

Sections of borehole core will be collected from the Mt. Simon Sandstone CO_2 injection zone and the Rome confining zone when drilling the 9 ½ inch vertical pilot hole from 4450 feet to 5200 feet. No cores will be taken in the horizontal portion of the well. The cores will provide reservoir characterization data for the injection interval and confining zone.

6.2 DEMONSTRATING THE WELL'S MECHANICAL INTEGRITY PRIOR TO INJECTION

To demonstrate the internal and external mechanical integrity of the injection wells prior to initiation of regular CO_2 injection, tests and logs will be conducted. External mechanical integrity refers to the absence of fluid movement/leaks through channels adjacent to the injection wellbore that could result in fluid migration into the USDW. Internal mechanical integrity refers to the absence of leaks in the injection tubing, injection packer, and the casing above the packer.

After the injection tubing, injection packer, and annular fluid is installed in the well, an annulus pressure test (APT) will be conducted to verify internal mechanical integrity. The APT is a 30-minute test where the fluid in the casing-tubing annulus is pressurized, the well is shut-in, and the pressure of the annular fluid is monitored for leak-off. EPA Region 5 requires comparison of the pressure change (from start-time to test-end at 30 minutes) to less than 3% during the test period. If the pressure change is less than 3%, the well possesses internal mechanical integrity. If the well fails the APT, the injection tubing and the injection packer may need to be removed to determine the cause of the leak. The EPA Region 5 guidance will be consulted when performing the APT. During the CO_2 injection phase, the annulus monitoring system will be continuously monitoring the internal mechanical integrity of the well as discussed in the Testing and Monitoring Plan (see Testing and Monitoring Plan on Class VI UIC Project Plan Submissions).

The external mechanical integrity can be evaluated using a radioactive tracer survey, oxygen-activation logs, or a temperature or noise log. During the injection/service life of the wells, one or a combination of these methods will be used annually to evaluate the external mechanical integrity of the injection wells. A baseline temperature log and oxygen-activation log (as listed in the Table 6-1) will be run in the well after well construction but prior to starting CO_2 injection to provide a baseline reference for comparing future temperature logs and oxygen-activation logs as they relate to the well's external mechanical integrity.

6.3 STIMULATION PROGRAM

The need for stimulation to enhance the injectivity potential of the Mt. Simon Sandstone is not anticipated. The need for stimulation will be determined once the characterization data from geophysical logs, core testing, and hydrogeologic testing is reviewed and analyzed. If it is determined that stimulation techniques are necessary, a stimulation plan will be developed and submitted to EPA Region 5 for review and approval prior to conducting any stimulation.

Table 6-1 Wireline Logging Program

Depth Interval	Logs	Purpose/Comments
Sensitive, Confidential, or Privileged Information	• No open-hole logs • No cased-hole logs (no cement bond log)	• N/A • N/A
	• Open-hole logs: Triple Combo logging suite (gamma ray, formation density, neutron porosity, resistivity, spontaneous potential), caliper log • Cased-hole logs: Cement-bond log	• Characterize basic geology (lithology, mineralogy, porosity) and confirm base of USDW. • Evaluate cement integrity of surface casing
	• Open-hole logs: Triple Combo logging suite (gamma ray, formation density, neutron porosity, resistivity, spontaneous potential), caliper log • Open-hole logs: Enhanced logging suite (spectral gamma, dipole sonic shear log, resistivity-based and/or acoustic-based image log (fracture finder log), nuclear magnetic resonance log, elemental capture spectroscopy log) • Cased-hole logs: Cement-bond log	• Characterize basic geology (lithology, mineralogy, porosity) • Enhanced characterization of geologic and geomechanical properties that control injectivity and confining zone/seal integrity. • Evaluate cement integrity of longstring casing
	• Open-hole logs: Triple Combo logging suite (gamma ray, formation density, neutron porosity, resistivity, spontaneous potential), caliper log • Open-hole logs: Enhanced logging suite (spectral gamma, dipole sonic shear log, resistivity-based and/or acoustic-based image log (fracture finder log), nuclear magnetic resonance log, elemental capture spectroscopy log) • Cased-hole logs: baseline casing inspection logs	• Characterize basic geology (lithology, mineralogy, porosity) • Enhanced characterization of geologic and geomechanical properties that control injectivity and injection interval integrity and identification of natural fractures. • Obtain a baseline assessment of casing condition through confining zone for comparison to future casing inspection logs, if performed. • Determine natural geothermal gradient outside well for

	• Cased-hole logs: baseline temperature survey • Cased-hole logs: baseline oxygen activation log • Cased-hole logs: Cement-bond log	comparison to future temperature logs for external mechanical integrity evaluations. Will be run from total depth to the surface. • Provide baseline measurement for future pulsed neutron capture logging runs aimed at detecting distribution of CO_2 outside the well for external mechanical integrity evaluations. • Evaluate cement integrity of longstring casing

Note: The triple combo (gamma ray, formation density, neutron porosity, resistivity, spontaneous potential) logs, caliper log, baseline temperature log, and cement-bond log are required by EPA UIC Class VI permit requirements (10 CFR 146.87)