**R644. Natural Resources, Oil, Gas and Mining; Carbon Sequestration.**

**R644-9. Well Construction and Completion.**

**R644-9-1. Injection Well Approval and Construction Requirements.**

(1) General. Each phase of Class VI well and Class VI Geophysical test well construction shall be supervised by a person knowledgeable and experienced in practical drilling engineering and familiar with the special conditions and requirements of injection well construction. Any materials and equipment used in the construction of the well and related appurtenances shall be designed and manufactured to meet or exceed the operating requirements of the specific project, including flow induced vibrations. Any well permitted as a Class VI Geophysical test well will need to meet the requirements of this rule before it can be permitted for use as a Class VI well. The operator must ensure that each well is constructed and completed to:

(a) Prevent the movement of fluids into or between USDWs or into any unauthorized zone;

(b) Allow the use of appropriate testing devices and workover tools; and

(c) Allow for continuous monitoring of the annulus space between the injection tubing and long string casing.

(2) Casing and Cementing of Class VI Wells

(a) Casing, cement, and other materials used in the construction of each Class VI well must have sufficient structural strength and be designed for the life of the geologic sequestration project. All well materials must be compatible with fluids that the materials may be expected to come into contact with and must meet or exceed standards developed for such materials by the American Petroleum Institute, ASTM International, or comparable standards acceptable to the division. The casing and cementing program must be designed to prevent the movement of fluids into or between USDWs. In order to allow the division to evaluate casing and cementing requirements, the operator must provide the following information:

(i) Depth to each injection zone;

(ii) Injection pressure, external pressure, internal pressure, and axial loading;

(iii) Hole size;

(iv) Size and grade of each casing string, including wall thickness, external diameter, nominal weight, length, joint specification, and construction material;

(v) Corrosiveness of the carbon dioxide stream and formation fluids;

(vi) Down-hole temperatures;

(vii) Lithology of each injection zone and confining zone;

(viii) Type or grade of cement and cement additives; and

(ix) Quantity, chemical composition, and temperature of the carbon dioxide stream.

(b) Surface casing must extend through the base of the lowermost USDW and be cemented to the surface through the use of a single or multiple strings of casing and cement.

(c) At least one long string casing, using a sufficient number of centralizers, must extend to the injection zone and must be cemented by circulating cement to the surface in one or more stages.

(d) Circulation of cement may be accomplished by staging. The division may approve an alternative method of cementing in cases where the cement cannot be recirculated to the surface, provided the operator can demonstrate by using logs that the cement does not allow fluid movement behind the wellbore. A copy of the cementing company's job summary or cementing tickets indicating returns to the surface shall be submitted as part of the pre-operating requirements.

(i) If cement returns are lost during cementing, the operator shall have the burden of demonstrating, using wireline logs, that sufficient cement isolation is present to prevent the movement of fluid behind the well casing.

(ii) If adequate cement isolation of the USDW or the injection zone within the casing-formation annulus cannot be demonstrated, remedial cementing shall be performed prior to proceeding with further well construction, completion, or conversion.

(3) Cement and cement additives must be compatible with the carbon dioxide stream and formation fluids and of sufficient quality and quantity to maintain integrity over the design life of the geologic sequestration project. The integrity and location of the cement shall be verified using technology capable of evaluating cement quality radially and identifying the location of channels to ensure that USDWs are not endangered.

(4) Tubing and Packer

(a) Tubing and packer materials used in the construction of each Class VI well must be compatible with fluids that the materials may be expected to come into contact with and must meet or exceed standards developed for such materials by the American Petroleum Institute, ASTM International, or comparable standards acceptable to the division.

(b) Injection into a Class VI well must be through tubing with a packer set within an interval of cemented casing, at a distance no more than 100' from the top of the approved injection interval, at a depth approved by the division. Any exception to the packer depth requirement must be approved by the division.

(c) In order for the division to determine and specify requirements for tubing and packer, the operator must submit the following information:

(i) Depth of setting;

(ii) Characteristics of the carbon dioxide stream, such as chemical content, corrosiveness, temperature, and density, and formation fluids;

(iii) Maximum proposed injection pressure;

(iv) Maximum proposed annular pressure;

(v) Proposed intermittent or continuous injection rate, volume, and mass of the carbon dioxide stream;

(vi) Size of tubing and casing;

(vii) Tubing tensile, burst, and collapse strengths; and

(viii) Tubing manufacturer roughness factor.

**R644-9-2. Logging, Sampling, and Testing Prior to Injection Well Operation.**

(1) During the drilling and construction of a Class VI well, appropriate logs, surveys, and tests must be run to determine or verify the depth, thickness, porosity, permeability, and lithology of, and the salinity of formation fluids in, each relevant geologic formation to ensure conformance with the injection well construction requirements of Rule R644-9 and to establish accurate baseline data against which future measurements may be compared. The well operator must submit to the division a descriptive report prepared by a knowledgeable log analyst that includes an interpretation of the results of such logs and tests. At a minimum, such logs and tests must include:

(a) Deviation checks during drilling when a wellbore is constructed by drilling a pilot hole that is enlarged by reaming or another method. Such checks must be at sufficiently frequent intervals to determine the location of the borehole and to ensure that diverging holes are not created during drilling, to prevent avenues for vertical fluid movement;

(b) Before and upon installation of the surface casing:

(i) Resistivity, spontaneous potential, and caliper logs before the casing is installed; and

(ii) A cement bond and variable density log to evaluate cement quality radially, and a temperature log after the casing is set and cemented;

(c) Before and upon installation of intermediate and long string casing:

(i) Gamma ray, resistivity, spontaneous potential, porosity, caliper, fracture finder logs, and any other logs the division requires for the given geology before the casing is installed; and

(ii) A cement bond and variable density log, and a temperature log after the casing is set and cemented;

(d) A series of tests designed to demonstrate the internal and external mechanical integrity of injection wells, that may include:

(i) A pressure test with liquid or gas;

(ii) A tracer-type survey to detect fluid movement behind casing, such as a radioactive tracer, oxygen-activation logging, or similar tool;

(iii) A temperature or noise log;

(iv) A casing inspection log;

(e) Any alternative methods that provide equivalent or better information and that are required and approved by the division.

(2) The operator must take whole cores or sidewall cores of each injection zone and confining system and formation fluid samples from each injection zone and must submit to the division a detailed report prepared by a log analyst that includes: well log analysis and associated well logs, core analysis, and formation fluid sample information. The division may accept information on cores from nearby wells if the operator can demonstrate that core retrieval is not possible and that such cores are representative of conditions at the well. The division may require the operator to core other formations in the borehole.

(3) The operator must record the fluid temperature, pH, conductivity, reservoir pressure, and static fluid level of each injection zone.

(4) At a minimum, the operator must determine or calculate the following information concerning each injection zone and confining zone:

(a) Fracture pressure;

(b) Other physical and chemical characteristics of each injection and confining zone; and

(c) Physical and chemical characteristics of the formation fluids in each injection zone.

(5) Upon completion, but before operating, the operator must conduct the following tests to verify hydrogeologic characteristics of each injection zone:

(a) A pressure fall-off test; and

(b) A pump test; or

(c) Injectivity tests.

(6) The operator must provide the division with the opportunity to witness all logging and testing described in this section. The operator must submit a schedule of such activities to the division 30 days prior to conducting each log and test.

(a) The operator must notify the division at least 48 hours before conducting any wireline logs, well tests, or reservoir tests.

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