California
Department of Conservation
Oil, Gas, and Geothermal Resources

REQUIREMENTS OF COMPREHENSIVE SAFETY REVIEW OF THE ALISO CANYON NATURAL GAS STORAGE FACILITY

California Department of Conservation, Division of Oil, Gas and Geothermal Resources

Since October 25, no natural gas has been injected into the Aliso Canyon Gas Storage Facility. Pursuant to the Governor's Order of January 6, 2016, all injection activity into the Aliso Canyon facility remains suspended until a "comprehensive review, utilizing independent experts, of the safety of the storage wells" is completed. This document summarizes the requirements of this comprehensive safety review.

The Department of Conservation, Division of Oil, Gas, and Geothermal Resources (Division) has consulted with independent technical experts from the Lawrence Berkeley, Lawrence Livermore, and Sandia National Laboratories ("National Labs") to develop the requirements of this facility safety review. The National Labs experts independently reviewed and concurred with the testing requirements for the safety review detailed below. The Division will continue to consult with these experts throughout the Division's supervision of the implementation and completion of the comprehensive safety review.

This comprehensive safety review requires that each of the 114 active wells in the Aliso Canyon facility either pass a thorough battery of tests in order to resume gas injection or be taken out of operation and isolated from the underground gas reservoir. Several steps, detailed below, are required in this safety review.

REQUIRED TESTS FOR EACH WELL IN THE FACILITY

Step 1: Southern California Gas (operator) shall perform casing assessment on the well consisting of temperature and noise logs.

a. Temperature Log:
A sensor will be lowered down the depth of the well to measure the temperature of the material inside the metal tubing in the well. If the casing in the well is not intact, gas leaking out of the casing will expand and cool, and reduce temperatures within the well. A temperature test that verifies no cooling is taking place in any part of the well indicates that the casing has maintained integrity and no leaks exist.

b. Noise Log
A highly sensitive acoustic sensor capable of detecting the sound of gas flowing will be lowered down the length of the well above the gas reservoir. This sensor will listen for any gas escaping from the well bore. If the well has a leak, gas will escape from the well bore causing a sound that can be detected by the sensor. The absence of sound above the reservoir indicates an effective seal of the well.

Step 2: The results of the Temperature Logs and Noise Logs will be independently reviewed by Division engineers. Any abnormal findings in this set of tests are required to be addressed immediately. For example, if a temperature decrease is noted on a temperature log and further investigation reveals a leak in the external casing of a well, the repair of the well casing must take place immediately. Necessary actions to remediate any abnormalities revealed by these tests will be reviewed by Division engineers. Once repairs or mitigations are completed, the Temperature Log and Noise Log must then be repeated on the well and then once again be reviewed by Division engineers to ensure no additional abnormal test results.

Step 3: After these tests are completed on the well, and any required remediation of the well completed, the operator will either:

a. conduct a battery of additional required tests and evaluations on the well, outlined below, in order to gain approval for injecting gas through that well; or
b. Remove the well from operation and isolate it from the underground gas reservoir.

REQUIRED TESTS IF A WELL IS INTENDED TO RESUME NORMAL OPERATIONS

If, after the Temperature and Noise Logs are complete, the operator designates a well to return to normal operations, the operator shall perform several additional tests that will be independently reviewed by Division engineers and posted publicly.

Step 4a: The operator will conduct a **Casing Wall Thickness Inspection.**
The Thickness Inspection of the well that measures the thickness of the external casing of a well, as well as the amount of any corrosion that has occurred to that casing. For this test to be conducted, the interior metal tubing is removed from entire depth of the well, and measurements are taken directly from the inside wall of the casing. If the inspection reveals thinning of the casing, the current strength of the casing will be calculated. If the current strength of the casing has diminished to the point that it cannot withstand authorized operating pressures for the well plus a built-in additional safety factor of pressure, the well has failed this test. *A passing test for a Casing Wall Thickness Inspection would show no thinning of the casing that diminishes the casing's ability to contain at least 115% of the well's maximum allowable operating pressure.*

Step 5a: The operator will conduct a **Cement Bond Log** for the well.
The Cement Bond Log is a sonic test that measures the adherence between cement and the external casing of the well, and also the contact between the cement anchor of the well and the underground gas reservoir. Cement should be solidly bonded to both the well's external casing and the geologic formation to ensure a seal that prevents fluids or gases from migrating up or down the outside of the well. The interior metal tubing for the entire well must be pulled to conduct this test. *A passing test*

for a cement bond log shows no significant spaces between cement and casing, or between cement and the gas storage formation and cap rock.

Step 6a: The operator will conduct a **Multi-Arm Caliper Inspection** of the well.
This Inspection measures any internal degradation or significant changes to the well's geometry. In this inspection, metallic sensors or "arms" radiate out from a central wire that runs down the inside of the well's exterior casing to measure the shape of the casing. If the inspection reveals a thinning or deformity of the casing, the current strength of the casing will be calculated. If the current strength of the casing has diminished, such that it cannot withstand authorized operating pressures plus a built-in safety factor of additional pressure, the well fails this inspection. *A passing test for a Multi-Arm Caliper Inspection would show no deformation or thinning of the casing that diminishes the casing from being able to properly contain at least 115% of each well's maximum operating pressure.*

Step 7a: The operator will conduct a **Pressure Test** of the well.
Pressure tests increase the pressure within the interior metal tubing of the well, and in the annular space between this interior tubing and the well's outer casing, to determine the well's ability to withstand normal operating pressures. The interior tubing is isolated and then pressure tested. Next the annular space between tubing and casing is pressure tested. This testing also evaluates the integrity of any packers, which seal the annular space between the tubing and casing. *A passing test for a pressure test would show a minimum pressure loss when the pressure is raised to a level of 115% of the maximum operating pressure.*

After conducting the above tests, the operator will conduct any indicated remediation so that the well can pass these tests. For instance, if a test indicates casing degradation, the operator could install a metal sleeve inside the casing, with cement between the sleeve and casing. The well would then be required to undergo the tests once again to demonstrate well integrity. Any remediation will be subject to the review of Division engineers.

If the well passes the Casing Wall Thickness Inspection, the Cement Bond Log, the Multi-Arm Caliper Extension and the Pressure Test, the Division may approve the well for upcoming gas injections and withdrawal. As noted below, wells approved for operation will only be permitted to inject or withdraw gas through the interior tubing.

<u>Required Actions if the Well is Intended to be Taken Out of Operation and Isolated from the Formation::</u>

Step 4b: Confirm the presence of cement outside the well's external casing in the section of the well that prevents the movement of gas from the underground gas reservoir to shallower geologic zones above the reservoir. Existing cement bond logs and well construction records provide this information. This confirmation requires compliance with Division regulations and concurrence of Division engineers.

Step 5b: Install a mechanical seal or "packer" within the well's external casing and install a mechanical plug within the well's interior metal tubing, if applicable. These seals will be set in place near the bottom of the well, within the portion of the well surrounded by cement. This kind of seal is an industry standard practice for isolating a well from reservoir gases or fluids and will further protect the casing from internal gas pressure.

Step 6b: Fill the well with fluid to the well's surface in order to create appropriate downward pressure in the well that further contributes to the integrity of the well seal.

These measures will isolate a well from the underground gas reservoir, as confirmed by National Labs experts. Each of the above actions is subject to review and approval by Division Engineers.

Step 7b: Once the operator has completed steps 4b, 5b, and 6b, and the seal is in place at the bottom of the well and the well is filled with fluid above the seal, the operator shall:

a. Conduct daily gas monitoring at the surface of the non-operational well, including monitoring the area around the well perimeter and in the annular space between the plugged casing string and the outmost casing.
b. Install and operate real-time pressure monitors that provide immediate notification to the operator when pressures deviate from normal in the well's interior tubing and its annular space.
c. Conduct noise log, temperature log and positive pressure test every six months.

The above monitoring shall be reported to Division engineers and maintained as a part of the well file. Division engineers will review all submitted information for evaluation on a regular basis to ensure that the well taken out of service has maintained safety.

Any well taken out of operation cannot be approved to resume operations and gas injection until the successful completion of the battery of tests described above in 4a-7a (Casing Wall Thickness Inspection, the Cement Bond Log, the Multi-Arm Caliper Extension and the Pressure Test) is completed. Those tests must be completed within a year of the well being taken out of operation. If a well cannot successfully complete all necessary steps required in this safety review after one year of being removed from normal operations, the well shall be permanently taken out of service.

REQUIREMENTS FOR WELLS RESUMING OPERATIONS IN ALISO CANYON

In order for gas injections to resume in the Aliso Canyon Storage Facility, the Division Supervisor must confirm in writing that all wells in the facility have either completed and passed the full battery of tests required in the safety review or have been taken out of service and isolated from the underground gas reservoir.

At whatever future point reinjection is allowed to occur, under Order of the Supervisor, all wells that are allowed to inject gas into the Aliso Canyon facility will now be required to:

1. Install and operate real-time pressure monitors that provide immediate notification to the operator when pressures deviate from normal in the well's interior tubing and its annular space.
2. Operate with lowest possible operating pressure on the tubing-casing annulus.
3. Inject and withdrawal only through interior metal tubing; under no circumstances will dual (tubing and casing) injection and withdrawal be approved for any wells.
4. Undergo testing of any downhole devices (e.g., valves, diverters) after the device has been installed and prior to the well resuming operation.
5. Undergo testing of any downhole devices every six months.
6. Comply with of the state's Underground Injection Control regulations.
7. Establish a facility-wide emergency response plan and a safety and spill prevention plan.