SENATE NATURAL RESOURCES AND WATER COMMITTEE
INFORMATIONAL HEARING

ENSURING THE SAFETY OF CALIFORNIA'S NATURAL GAS STORAGE WELLS

BACKGROUND

Overview

The recent massive leak of gas from the Aliso Canyon natural gas storage facility has increased scrutiny of safety measures in place to protect public and environmental health and safety from uncontrolled emissions from natural gas storage wells. Although the California Public Utilities Commission (CPUC) has overall jurisdiction over gas storage facilities, the Department of Conservation's Division of Oil, Gas and Geothermal Resources (DOGGR) has responsibility for gas storage wells. The DOGGR supervisor has very broad authority to regulate oil and gas wells, and DOGGR has recently begun efforts to update its gas storage well regulations. The goal of this hearing is to review existing requirements and explore how best to ensure gas storage well safety in the future.

This background paper will briefly:

- Recap the Aliso Canyon leak and response,
- Provide an overview of natural gas storage in California,
- Review DOGGR's existing and planned regulations and its comprehensive safety review criteria for Aliso Canyon,
- Review recent guidance on gas storage wells, and
- Identify considerations for improving storage well safety.

Aliso Canyon leak

On October 23, 2015, efforts started to stop a significant natural gas leak from the "Standard Sesnon 25" gas storage well located at the Southern California Gas Company's (SoCal Gas') Aliso Canyon gas storage well facility. This well was originally drilled in 1954 for oil and gas production and was subsequently converted to a natural gas storage well. SoCal Gas was aware of increasing well integrity problems at Aliso Canyon and had proposed a (still pending before the CPUC) Storage Integrity Management Program (SIMP) to address it. However, the leaking well was not one of those designated for the SIMP program. The 18 wells proposed for SIMP were all originally drilled from 1943 – 1955 and later converted in the 1970s to gas storage wells.

The Aliso Canyon gas storage facility is located adjacent to the community of Porter Ranch in Los Angeles County. Some wells at the Aliso Canyon facility appear to be less than one mile away from homes, although the well that failed was approximately 1-1/2 miles away from the nearest home. The local air quality management district began

receiving complaints about the smell (from added odorants) on October 24th. Several days passed before SoCal Gas acknowledged to the community that a significant uncontrolled leak was occurring.

While SoCal Gas called in DOGGR and contracted with experts to stop the leak quickly, contemporaneous news reports indicate considerable missteps in public communication and initial efforts to relocate members of the community (at SoCal Gas' expense). Over 8,000 households were eventually relocated due to the leak and two public schools were moved.

After seven failed well kill attempts, the drilling of a relief well, instituting an injection moratorium and reducing the pressure in the gas storage reservoir, the leak was finally officially declared controlled on February 18, 2016, about 4 months after it started. In addition to the hundreds of health complaints reported to the Los Angeles County Department of Public Health, about 100,000 metric tons of natural gas, a potent greenhouse gas and short-lived climate pollutant, were released to the atmosphere during the leak -- fully 20% of the entire state's methane emissions during the time period.

Investigations by DOGGR and the CPUC are underway of the Aliso Canyon leak and results are not likely before 2017.

Gas storage facilities in California

There are fourteen active gas storage facilities throughout the state. There are approximately 400 gas storage wells serving these facilities and some additional observation wells. SoCal Gas and Pacific Gas and Electric own 7 of the facilities and the others are owned by various independent gas storage facility operators[1].

SoCal Gas has four facilities (Aliso Canyon (Los Angeles County), Honor Rancho (near Santa Clarita), Playa del Rey (in Marina del Rey) and La Goleta (Santa Barbara)). SoCal Gas has approximately 230 gas storage wells of which Aliso Canyon (with 114) has the most. Aliso Canyon has the largest working gas capacity at 86 billion cubic feet (bcf) of gas followed by Honor Rancho (26 bcf), La Goleta (21.5 bcf) and Playa del Rey (2.4 bcf). In 2014, SoCal Gas reported that the mean age of its wells is 52 years with wells as old as 80 years in operation[2]. Pacific Gas and Electric (PG&E) owns three facilities -- McDonald Island (in the Delta, 82 bcf), Los Medanos (Contra Costa county, 17.9 bcf), and Pleasant Valley (Yolo county, 2.3 bcf). Many of PG&E's approximately 110 active wells were originally drilled in the 1970s and the early 1990s.

Wild Goose, Gill Ranch Storage, Lodi Gas and Central Valley Gas Storage operate the other 7 gas storage facilities. These facilities are located in central and northern

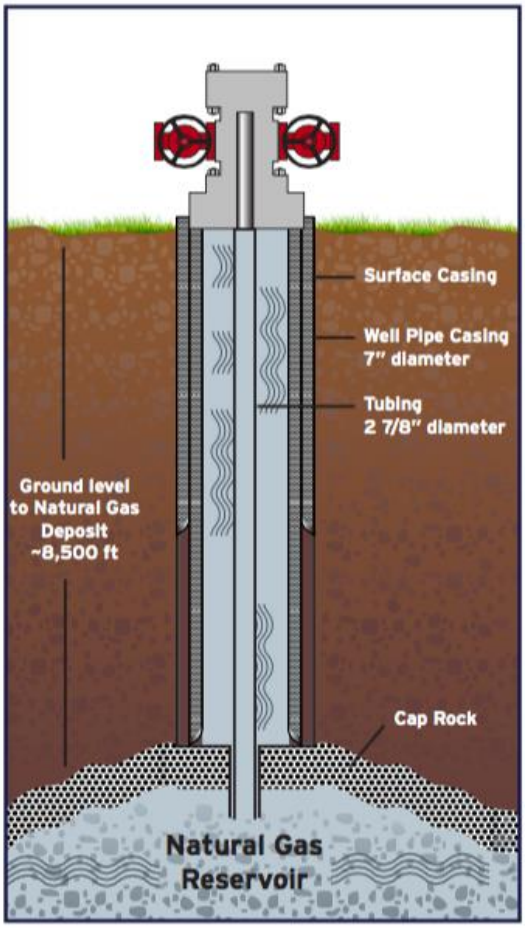
[1] Note, however, that PG&E recently reported owning 25% of one of the independents.
[2] See Philip Baker's testimony to the CPUC in November 2014.

California (from Madera to Colusa and Butte counties). These facilities and the wells serving the facilities are, in general, newer, located in rural locations and built solely for gas storage operations in existing dry gas reservoirs. For example, Wild Goose was built in 1999, uses 17 wells for injection/withdrawal and has 75 bcf working gas capacity.

Gas storage well diagram

During the Aliso Canyon leak, SoCal Gas released a diagram of a gas storage well which is included here to review the general components of a well. Metal casing "strings" of various sizes are cemented into a drilled wellbore. While the diagram shows cement from the bottom of the well to the surface, older wells – cemented to earlier standards – generally do not have as much cement. The presence of cement can help to resist corrosion to the outside of the casing as well as limit fluid migration along the wellbore. Smaller diameter tubing is placed within the casing. Unlike other injection wells, it is not unusual for both the annulus between the casing and tubing and the tubing to both be used for withdrawal. Other injection wells generally have a "packer" installed near the bottom of the casing to limit fluid flow to inside the tubing[3] only (no packer is shown in this diagram). The tubing/packer combination helps to protect the casing from the fluid being injected into or produced from the well. The wellhead has valves and associated piping and connections to the storage facility.

[3] This presumes the tubing has continuous solid walls which is not always the case.



DOGGR regulations for gas storage wells

At the start of the leak at Aliso Canyon, DOGGR's regulations for gas storage wells were largely unchanged since the late 1970s. Gas storage wells are part of California's Underground Injection Control (UIC) injection well program, although not regulated as UIC wells at the federal level[4]. Starting with the FY 2010/11 budget, the Legislature has repeatedly provided additional funding and personnel to DOGGR to increase oversight of and update regulations related to its UIC program. Some progress has very lately been made, and draft regulations specific to some aspects of the UIC program have recently been released. However, the focus prior to the Aliso Canyon leak was not on gas storage wells. While DOGGR has acknowledged long-standing implementation problems with its UIC program, such as improperly approving injection wells into aquifers with good quality groundwater and missing data, those issues are not the subjects of this hearing.

[4] The federal UIC program was developed following the passage of the federal Safe Drinking Water Act in the early 1970s. In 1980 the Safe Drinking Water Act was amended to specifically exclude natural gas storage wells from the definition of underground injection. DOGGR had already included gas storage wells within its own UIC program. Its 1981 application to the US EPA for primacy to regulate Class II UIC wells in California excluded the existing state regulation specific to gas storage wells. DOGGR has since retained gas storage wells within its UIC program. There are thus no national standards for gas storage wells through the federal UIC program. Recently, however, the federal Pipeline and Hazardous Materials Safety Administration has announced plans to revisit the issue of gas storage standards and the Obama Administration announced a federal regulatory task force to address national standards as well.

Anyone interested in developing a gas storage facility has to receive approval from DOGGR for the project under its UIC program. Data must be provided to DOGGR describing the geology, planned wells and anticipated operations for approval. Generally for UIC wells, the requirements include:

- Fluid flow restricted to tubing/packers (except for gas storage wells), and
- Mechanical integrity tests to verify the absence of leaks, although the testing interval may vary. These tests are generally a pressure test to ensure no leaks in the annulus between the tubing and casing, although additional testing may be required.

In addition, cementing and casing requirements common to all wells help to ensure zonal isolation of oil and gas bearing and freshwater zones in the subsurface. "Critical" wells (e.g. within 300 feet of a dwelling) are required to have safety valves as specified by the supervisor. Spill contingency plans are also required, although the information currently required seems more specific to oil spills. These plans are not specific to the type of equipment required to be kept on-site, but include a list of available equipment and potential sources of equipment.

Specific to gas storage wells, information on the gas storage reservoir (for example, the extent of the caprock to keep the gas in the storage reservoir), and a list of proposed safety devices, among other required data must be provided to DOGGR.

If a project is approved, DOGGR issues a "project approval letter" setting specific requirements (e.g. maximum storage pressure) for the wells. The 14 current project approval letters for natural gas storage facilities in California include a wide variety of requirements and are not generally available online to the public. While there is a good argument that each storage facility has unique, site-specific issues that must be flexibly addressed, it is not clear from the letters themselves why certain additional requirements (for example, soil monitoring) are needed at some sites as opposed to others. Additionally, while required by regulation, it is not clear – as the dates of the letters span decades – what further review, absent litigation, the project approval conditions received after initial issuance. Following approval of a project, each well must be individually permitted by DOGGR.

DOGGR's emergency regulations for gas storage wells

The Governor's Emergency Order on January 6, 2016 called for increasing the oversight of gas storage facilities, including wells, with additional requirements for monitoring and regular testing of safety valves. Some of these were clarification of existing requirements. DOGGR issued emergency regulations shortly thereafter which went into effect in early February. These emergency regulations:

- Add additional geologic data requirements to the required data submissions including the location and characteristics of faults and fractures,
- Clarify that a project approval letter will include the maximum and minimum reservoir pressure,
- Require annular pressure measurements and annular gas flow measurements made at least once/day with additional reporting requirements,
- Require regular testing of valves including, where installed, function tests of all surface and subsurface safety valves systems, as specified,
- Require an inspection and leak detection protocol to be reviewed by DOGGR with the Air Resources Board's assistance that includes at least daily aboveground inspection around a well, and
- Require a risk management plan be developed and provided to DOGGR for approval.

The requirements for the risk management plan are extensive and include an identification of potential threats to well and reservoir integrity and an evaluation of the resulting risks. These include, among others, prevention of the loss of well and storage reservoir integrity, monitoring of the mechanical integrity of the well, an assessment of reservoir integrity, corrosion monitoring and evaluation, and an erosion assessment.

DOGGR's pre-rulemaking discussion draft for natural gas storage well regulation

DOGGR's emergency regulations may be extended but remain in effect for a limited amount of time. DOGGR released a follow-on pre-rulemaking discussion document for gas storage operations in mid-February 2016. Four regulatory goals and questions were identified. They are:

1. Clarify standards for gas storage project data requirements
    - *e.g. What other data should DOGGR ask for? Is monthly injection/withdrawal information sufficient?*
2. Clarify well construction standards for gas storage wells
    - *e.g. Should there be cementing requirements specific to gas storage wells? Should safety valves be required? If so, where? Should injection and withdrawal be limited to tubing only?*
3. Clarify testing and monitoring standards and other risk mitigation protocols to ensure safe operations
    - *e.g. What types of tests should be required? How often? What are appropriate risk mitigation protocols?*
4. Clarify emergency response plans standards to ensure rapid and safe response when emergency situations arise
    - *e.g.What should notification standards be? How often should plans be reviewed?*

API Recommended Practice 1171 "Functional Integrity of Natural Gas Storage in Depleted Hydrocarbon Reservoirs and Aquifer Reservoirs

In September 2015, the American Petroleum Institute (API) released a guidance document for natural gas storage applicable to California's gas storage reservoirs. Recommendations include:

- Operation and maintenance safeguards to assure the long-term viability and functional integrity of the well,
- Extensive operator record-keeping of activities performed on and evaluations of the well,
- Baseline assessments to confirm functional integrity of the gas storage reservoir and wells (including mechanical integrity tests, use of observation wells, tests to assess where gas is located),
- Lateral and vertical buffer zones surrounding the reservoir,
- Training, and
- Risk management.

The risk management section clearly informed DOGGR's recent regulations and pre-rulemaking discussion draft. Text from the API RP risk management section is repeated verbatim by DOGGR. The risk management section is extensive and includes tables of threats/hazards, potential consequences and preventive measures. However, specific readily-implementable guidance is not provided. For example, while corrosion monitoring and evaluation of a well includes an identification of defects in the well's tubing, there is no recommendation for how often that assessment should be made.

DOGGR's comprehensive well review criteria for Aliso Canyon wells

In early March, DOGGR ordered SoCal Gas to perform a multi-step review on the 114 remaining wells that service the Aliso Canyon storage facility. The review criteria must be satisfied before injections can resume at the facility. For wells returning to service, the criteria are:

- All wells must not be leaking and must pass temperature and noise logs.
- After passing the first two tests, each well must then pass four additional tests. The cement bond log, casing inspection log and multi-caliper arm tests are used to assess the robustness of the cementing and defects in and deformation of the casing. Identified problems that might prevent the well from passing the subsequent pressure test have to be fixed. A pressure test is the final test.
- Future injection and withdrawal at the facility will be through tubing/packer only.

Temperature and noise logs serve to indicate the presence of existing leaks. Some of the other tests are more proactive and help to identify where problems may occur before they do so. While some of these tests can be performed with a well's tubing left in place, many of these types of tests require that well tubing be pulled from the casing

which requires a workover rig, more time and expense and raises the risk that the casing could be damaged by the tubing as it is removed. The criteria for returning wells to service is very similar to the proposed SoCal Gas SIMP mentioned earlier.

SoCal Gas' proposed its SIMP as part of its rate case before the CPUC as a risk mitigation strategy in view of observations of increasing issues with well integrity at its four active gas storage facilities[5]. The goal of the SIMP was proactive identification of storage well safety issues in order to address them before a leak occurs. Reasons for the program included the age of its wells, high pressure operation, proximity to residential locations and cite the likelihood of corrosion and erosion. Recent ultrasonic surveys of some wells indicate corrosion and mechanical damage due, in part, to waterflood activities for enhanced oil recovery in pools overlying the storage reservoir. In addition to temperature and noise logs (to detect leaks), pressure tests, visual camera tests and casing inspection logs via a variety of techniques were proposed.

Issues to consider

In general, for other injection wells, there are regular tests performed to identify leaks from the casing and then every 5 years or so a pressure test is performed. Other proactive measures (e.g. casing inspection logs) are generally not regularly required (with the limited exception of Class VI (carbon dioxide sequestration) and Class I (hazardous material) UIC wells).

- *What is the appropriate interval for mechanical integrity tests for gas storage wells?*
- *Does this interval depend upon the type of the test?*
- *How often should proactive tests be required?*
- *What are the best proactive well testing methods?*
- *How should risk interact with the testing interval?*

The removal decades ago of a subsurface safety valve on the SS-25 well created considerable controversy during the Aliso Canyon leak. Many gas storage wells in California, however, currently have subsurface safety valves installed. These valves require extra maintenance, and have to be replaced regularly. Public comments to DOGGR indicate support for subsurface safety valves.

- *Should subsurface safety valves be required for all gas storage wells?*
- *If yes, where should they be located?*
- *Should there be a retrofit requirement to add subsurface safety valves?*
- *What is the best way to protect against a gas containment failure near the reservoir (far down hole)?*
- *Should the definition of "critical well" be re-evaluated in view of the widespread public health impacts from Aliso Canyon?*

[5] Description of the SIMP based on Philip Baker's testimony to the CPUC in November 2014.

Given a risk-based approach to leak prevention and ensuring well and reservoir integrity:

- *How should the baseline to assess risk for new wells be established? Should this be different from establishing a baseline for existing wells?*
- *How can the risk assessment process be standardized so the same risk at different facilities is treated the same?*
- *How can public transparency be provided to the risk assessment process?*
- *How frequently should the risk assessment be reviewed and updated?*
- *Do the federal regulations instituting Pipeline Integrity Management Plans provide any insight for storage well safety?*
- *Should there be specific reporting requirements to DOGGR assessing gas lost from storage reservoirs?*

Some storage wells in the state use cathodic protection to help prevent corrosion. Other wells use corrosion and/or erosion monitoring probes. Virtually all wells produce some water at some point. The corrosion potential for a well will vary based on a variety of factors.

- *How should corrosion and/or erosion and associated risks be consistently and transparently addressed by DOGGR?*
- *Does DOGGR plan on consulting outside experts on corrosion and erosion to inform its regulations?*
- *What level of corrosion or erosion should trigger remediation requirements?*
- *What data regarding corrosion and erosion monitoring should be regularly reported to DOGGR?*

API RP 1171 repeatedly emphasizes the importance of lateral and vertical buffers surrounding gas storage reservoirs to ensure safe operation.

- *Should there be standardized ongoing monitoring by observation wells around and above all storage reservoirs?*
- *Should storage facility operators be allowed to participate in the decision of whether or not an oil and gas production or injection well is approved that may impact operations of the storage reservoir?*
- *Should DOGGR's rulemaking include explicit requirements for lateral and vertical buffers surrounding gas storage reservoirs?*

API RP 1171 emphasizes appropriate personnel training, emergency response plans and operation and maintenance of storage wells.

- *How can appropriate safety training be assured for personnel?*
- *Are there mentoring programs for personnel?*
- *How can emergency response plans, particularly community notification, be improved upon to address issues raised by the Aliso Canyon response?*
- *Is there a role for DOGGR to audit training, emergency response plans or operation and maintenance manuals?*

Odorants added to the natural gas have been associated with at least some of the health impacts reported by neighbors of the Aliso Canyon facility. DOGGR does not require tracking of the odorants used.

- *Should there be additional reporting requirements to ensure data are gathered useful to addressing public health impacts from a leak?*
- *What other information not currently reported to DOGGR should be in order to improve transparency and accountability?*