ABSTRACT

The Underground Gas Storage (UGS) Industry may be wondering, “What can we expect in 2018 and beyond?” The industry is already facing adherence to new regulations, and compliance with the integrated API RP’s 1170 and 1171 into those regulations. The question may be, how will the new regulations be implemented and addressed by the Pipeline and Hazardous Materials Safety Administration (PHMSA) in the coming months and years and the effects on the industry.

Since the incident at the Aliso Canyon storage facility, the integrity of injection and withdrawal wells at UGS facilities has been at the forefront of operators and regulators minds and agendas. PHMSA has now been given jurisdiction over UGS Facilities to fill the regulatory gap for the interstate facilities. This makes sense from the facility and pipeline point of view, but what about the wells which require different skill sets and expertise. Two (2) new American Petroleum Institute (API) documents have been incorporated into the Code of Federal Regulations (CFR’s), but is that enough and are they understood? The industry could also question if the current UGS operators have employees with the competencies to manage all the Well Integrity requirements or will there be assistance needed to implement and meet these new requirements.

This paper will explore the history and current status of UGS in the United States (U.S.), the new API RP requirements, and how PHMSA is handling the implementation of the new regulations. Well Integrity will also be discussed to explore its progress in recent years due to other major upstream incidents that have occurred and the current status of Well Integrity. It will close with a look forward to potential future developments for the industry.
INTRODUCTION

Natural gas is a versatile, widely-used energy source in the U.S. with about half of U.S. homes being heated by natural gas, along with its many other uses, such as, cooking, fueling vehicles, and generating electricity. Approximately 20% of all natural gas that is consumed during the winter heating season is supplied by UGS facilities. The U.S. has more UGS facilities than any other country.

Underground Natural Gas storage plays an important role in the supply system of natural gas in the United States; however, recent incidents have brought to the forefront integrity and safety concerns. Approximately 80% of the wells in the U.S. used for UGS were completed in the 1970’s or earlier. Many were previously production wells converted to use for UGS and have been exposed to decades of physical and mechanical stresses. They were also constructed with materials that pre-date our current technology and standards, and are less likely to have been constructed with redundant barriers. Per PHMSA data, there are approximately 124 U.S. operators of UGS facilities, with approximately 17,000 wells serving those facilities.

In response to the Aliso Canyon incident that occurred in October of 2015 PHMSA has been given authority to issue increased regulations related to UGS facilities. The need to prevent incidents like Aliso Canyon will require operators to upgrade and document the integrity of these wells. It should be noted that although major incidents at U.S. UGS facilities occur at a low rate, the consequences of those incidents are significant.

UNDERGROUND GAS STORAGE – PAST

The first gas storage field in the U.S. was developed in 1916 in the Zoar Field, which was a depleted reservoir, near Buffalo, New York. In 1942 the U.S. Government started UGS as a war initiative to ensure a dependable source of energy was available in uncertain times. Natural gas distribution is a seasonal business. Natural gas is typically injected for storage during the off months (April through October) and withdrawn for use in the winter months (November through March).

In order to store natural gas, it is injected down a wellbore into a subsurface geological formation which may be a salt cavern, a depleted oil and gas reservoir, or an aquifer. As the gas is injected the pressure builds in the formation. Higher reservoir pressure will allow for a higher flow volume during withdrawal, within the defined maximum pressure limits based on the formation specifications. A portion of the initial gas injected will remain permanently in the reservoir; this is known as a “base” or “cushion” gas. This gas is intended to remain as permanent inventory in the storage reservoir to maintain adequate pressure, minimize water produced water with the gas, and maintain adequate deliverability rates.

In the U.S. most existing natural gas storage facilities are depleted natural gas or oil fields. Utilizing these types of assets and converting them from production to storage takes advantage of existing wells, gathering systems, and pipelines. There are many considerations for the applicability of an asset to be used for UGS, such as, porosity, permeability, and retention capability.
Each of the reservoirs utilized to store natural gas has its own distinct geographic and geologic characteristics that determine its suitability for use. The differences between the types of depleted reservoirs are as follows:

- **Depleted natural gas or oil fields**: These are porous and permeable formations that have produced most of their economic reserves. This is the predominant type of gas storage in the U.S. Of the approximate 400 storage facilities in the U.S., about 80% are created from depleted reservoirs, allowing the operator to take advantage of the existing infrastructure, such as wells, gathering systems, and pipelines. The depleted reservoir UGS facilities are serviced by a large number of production and injection wells that existed for the original facility.

- **Salt caverns**: These are typically man-made caverns in salt formations created through the planned solutioning or dissolving of portions of naturally occurring salt formations. These make up approximately 10% of U.S. UGS facilities. They are primarily located in the Gulf Coast States. Salt cavern UGS facilities are typically only served by one (1) well per cavern, as opposed to the depleted reservoir facilities.

- **Aquifers**: These are similar to depleted hydrocarbon reservoirs due to the nature of the porous rock used to contain the gas, as well as the methods used for accessing the reservoir. These reservoirs were originally filled with water and did not contain oil or gas. Natural aquifers need to be determined for suitability to determine if a non-permeable cap rock exists to maintain containment. They make up approximately 10% of all U.S. UGS facilities in the U.S.

---

**Figure 1**: Types of UGS Reservoirs Utilized (Underground Natural Gas Storage – Integrity and Safe Operations paper, reference 10)
Below is a summary of the type and number of UGS sites worldwide.

<table>
<thead>
<tr>
<th>AREA</th>
<th>GAS/OIL DEPLETED</th>
<th>AQUIFERS</th>
<th>SALT CAVERNS</th>
<th>OTHER</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>5</td>
<td>23</td>
<td>27</td>
<td>3</td>
<td>117</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>36</td>
<td>13</td>
<td>1</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>USA</td>
<td>320</td>
<td>44</td>
<td>30</td>
<td>0</td>
<td>394</td>
</tr>
<tr>
<td>Canada</td>
<td>44</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td>South America</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Asia</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Australaia</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>478</td>
<td>80</td>
<td>66</td>
<td>3</td>
<td>627</td>
</tr>
</tbody>
</table>

Figure 2: Type and number of UGS Sites Worldwide (Source: HSE 2008 Report)

UGS has become an important part of the U.S. energy system. It enables utilities companies the ability to offer consumers natural gas all year with reliable service and pricing. Without the ability to store natural gas many customers, including residential users, transportation and power generation operators and others, could be faced with shortages and higher prices.

The majority of UGS facilities are owned or operated by interstate pipeline companies, intrastate pipeline companies, local distribution companies or independent storage service providers. The owners and operators of the UGS facilities are not always the owners of the gas that is held in the storage facilities; such entities as shippers, local distribution companies, or end users may own the gas and lease the storage space.

In the 1990’s there were some key Federal Energy Regulatory Commission (FERC) rulings that allowed for open access storage capacity, among other things. Order 636 required gas pipelines to provide interstate transportation on an open access basis. Operators were required to separate the offering and pricing of gas sales from the transportation and making capacity available for lease to third parties on a nondiscriminatory basis. Order 888 accomplished the same for the interstate transmission of power.

Figure 3: Number of Gas Storage Wells by State (Source: Interagency Task Force Final Report, October 2016)
INCIDENTS

Major incidents at UGS facilities occur at a relatively low rate, however their consequences are high. Also, as the industry faces aging assets it is important to understand root causes of past incidents and the current integrity status of existing facilities in the U.S. to increase safety and decrease the potential for future incidents.

According to the white paper written by the American Petroleum Institute (API), American Gas Association (AGA) and Interstate Natural Gas Association of America (INGAA) titled, Underground Natural Gas Storage: Integrity & Safe Operations, a literature search and informal industry survey was conducted in 2013 of natural gas storage incidents which determined that on average one major incident occurred per decade and less severe events occurred intermittently. This data would indicate that the likelihood of a major incident is low. The objectives of the API RP’s are to further drive down any potential risks.

Based on the Health and Safety Executive UK (HSE) research report (2008) the majority of incidents that have occurred have been due to equipment/mechanical (man-made infrastructure) or human error failures, not geological failures of the reservoirs. Data from the Pipeline and Hazardous Materials Safety Administration (PHMSA) notes that the major causes of underground storage incidents are corrosion (37%), equipment failure (17%), and material and/or weld failures (11%).

One of the recent and most notable UGS incidents is Aliso Canyon which occurred on October 23, 2015 when Southern California Gas Company’s (SoCal Gas) Aliso Canyon Well SS25 failed. The leak took four (4) months to contain. This was finally accomplished by the drilling of a relief well to intercept the SS25 well and permanently seal it off. As a result of the Aliso Canyon incident the California Department of Oil, Gas and Geothermal Resources (DOGGR) issued an order for SoCal Gas requiring them to stop operations at Aliso Canyon until all 114 wells at the facility (representing approximately one-fourth of all UGS in California) had integrity tests conducted to prove isolation and containment integrity. The DOGGR also issued requirements to all UGS facilities in the state to conduct the same integrity tests to verify safe operations at their facilities. Part of the mandate required, at a minimum, a daily inspection of all gas storage wellheads using gas leak detection technology, on-going verification of mechanical integrity of well bores, on-going measurement of annular gas pressure or annular gas flow of wells, regular testing of safety valves used in the wells, establishment of minimum and maximum pressure limits for all UGS in the State of California, and the development of a Risk Management Plan (RMP). The RMP’s have been submitted and are being evaluated by the DOGGR.

It is interesting to note that a 2014 testimony included for reference in the 2016 General Rate Case for SoCal Gas recommended that SoCal Gas implement Storage Integrity Management Plans (SIMP’s) at their facilities. It was recommended that they be modeled after the Transmission Integrity Management Plans (TIMP’s) they already had in place, but the SIMP would be specific to the UGS wells. It is not known if this recommendation was implemented.

In response to the Aliso Canyon incident the U.S. Department of Energy (DOE), Department of Transportation (DOT) and the Pipeline and Hazardous Materials Safety Administration (PHMSA) established an Interagency Task Force to study Natural Gas Storage safety. This was followed by Federal requirements and recommendations issued from the final report of the appointed task force, an Interim Final Rule (IFR), and the integration by reference of API RP documents into the Code of Federal Regulations (CFR’s).

Effective January 2017 Senate Bill 887 mandates additional requirements for California UGS facilities. All state agencies that propose major regulations in California are required to complete a Standardized Regulatory Impact Assessment (SRIA) to evaluate the economic impact associated with the proposed regulations to operators. This SRIA is available for public review and noted in the reference section of this paper.

Other notable incidents include:

The Moss Bluff storage facility, located in Liberty County, Texas, experienced two (2) incidents that occurred on August 19, 2004. One of the incidents was a well control incident and the other was a natural gas fire at their Cavern #1. The cause of the well control incident is reported as an emergency shut off valve that failed during a cavern de-watering operation. The gas blow out caused an ignition and the consequent fire destroying a single wellhead.

In December of 2003 a casing leak developed at Entergy-Koch’s Magnolia salt cavern facility near Napoleonville, LA. Which resulted in gas being vented to the atmosphere and residents were evacuated until they were able to contain the leak.

On January 17th and 18th of 2001 the Yaggy Underground Natural Gas Storage Facility salt cavern operated by Kansas Gas Service had an incident where gas leaked from the storage field well production casing and migrated approximately nine (9) miles underground. It eventually traveled to the surface through old brine or salt wells in Hutchinson Kansas area. This led to a series of gas explosions which led to physical damages and two (2) fatalities.
At the Brenham Salt Cavern storage facility outside of Houston, Texas in April of 1992, an explosion and fire occurred when a storage cavern was over-filled and leaked liquid petroleum gas (LPG).

In November of 1985 a fire and explosion occurred at the Mont Belvieu storage complex prompting the evacuation of over 2,000 residents. Mont Belvieu had another incident in October of 1984 that cost millions of dollars in property damage to the facility.

In 1980 a Liquid Petroleum Gas (LPG) leak that was caused by a corroded casing string resulted in an explosion and a fire at a salt cavern facility located at the Barber Hill salt dome which is home to several salt domes, comprising Mont Belvieu salt cavern storage complex in Texas, not far from Moss Bluff.

On September 21, 1978 a packer failure on an oil storage well at a salt dome reservoir storage facility located in West Hackberry in South Louisiana caused a release of approximately 72,000 bbls of crude oil, which caused a fire that burned for nearly 6 days and one fatality.

**UNDERGROUND GAS STORAGE – PRESENT**

Recent incidents have prompted regulatory response and a stronger focus on UGS in the U.S.

The UGS industry is regulated by multiple bodies at the state and federal levels, such as, the Federal Energy Regulatory Commission (FERC), the Pipeline and Hazardous Materials Safety Administration (PHMSA), and various state government agencies.

FERC is responsible for the permitting authority of projects that are connected to interstate pipelines and for authorizing the construction or expansion of storage facilities. PHMSA regulates the safety of natural gas transportation and storage. State regulatory agencies have authority over intrastate storage and pipelines, depending on the state.

Recent regulatory changes in response to the Aliso Canyon incident include the Protecting Our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act of 2016 which charged PHMSA to establish regulations and inspection requirements of all underground natural gas storage facilities. The Interim Final Rule (IFR) published on December 19, 2016 is the document that incorporated the API RP 1170 and 1171 documents into the CFR.

On February 5, 2016 PHMSA issued an Advisory Bulletin ADB-2016-02 (81 FR 6334) that recommended operators of UGS facilities review their operating and emergency response plans to assure the integrity of their assets. Operators were advised to take all necessary precautions to ensure the safety of their facilities.

There were other associated recommendations made in the Bulletin to address the assurance of integrity.

Per the FAQ’s posted to the PHMSA web site, it is the expectation for operators to address the risk analysis and threats requirements, described in API RP 1170, Section 10 and API RP 1171, Section 8. PHMSA notes they expect that operators would complete a risk assessment, including preventative and mitigative measures for all wells within three (3) to eight (8) years from the effective date of the rule (December 19, 2016). It is also their expectation that operators would prioritize the implementation of preventative and mitigative measures for the wells with higher risks. Baseline assessments are expected to start within two (2) years of the effective date of the rule, with priority placed on the higher risk wells as determined in the risk analysis process. Operators have indicated that conformance to the API documents in their estimation would take approximately seven (7) to ten (10) years from the date of final rule making to complete.

The initial PHMSA inspections are planned to start in 2018 and are expected to focus on reviewing written procedures and implementation plans to assure technical adequacy to comply with the API RP’s and CFR 192.12. If an operator requests a deviation from a requirement PHMSA will review their justifications for deviations employed under the CFR 192.12(f) section. PHMSA is in the process of developing the inspection criteria and inspector training for both the federal and state inspectors.

Operators will be allowed to take credit for previously completed integrity risk assessments (prior to the effective date of the rule) if a technically acceptable justification is documented and maintained in the facilities records. The prior assessment must also meet the requirements of the API RP 1170 and 1171 documents and be valid for the current operating conditions and environment. If the operator uses a prior assessment that does not meet all the requirements then they must document a deviation as required per CFR 192.12(f).

From a State regulatory perspective several, but not all, of the states with UGS facilities have regulations to address Well Integrity, which would include wells located at UGS facilities. As of August 2016, only California, Kansas and Pennsylvania have regulations to address Well Integrity at all life cycle phases of the well, basis of design to abandonment. Other states, such as Kentucky, Iowa, Indiana, Michigan, New York, Oklahoma, Texas, West Virginia, and Colorado address Well Integrity in their state regulations, but they do not address it in all the well life cycle phases.
Underground Gas Storage – Past, Present, and Future

Well Integrity has been a key topic in the Oil and Gas industry since the Deepwater Horizon incident in 2010. Prior to that there were Well Integrity documents that existed in the industry (NORSOK D-010, OLF 117) but mainly in Norway and Europe. Strides have been made in the discipline of Well Integrity in several visible ways in recent years, such as:

- Development or update of several Well Integrity documents (NORSOK D-010 (Updated); ISO 16530 (Developed and issued); UK Oil & Gas (Updated)).
- Common for operators to have Well Integrity Management Systems (WIMS) and staff dedicated to Well Integrity.
- Better communication about Well Integrity. This is obvious through the number of conferences, the involvement and interest of the Society of Petroleum Engineers (SPE) and other industry societies.

Well Integrity has many facets from design to construction to production/operations and ending in abandonment. The practice of Well Integrity should be viewed as a “complete well life cycle” process, not specific to any one phase of the wells life. However, for each lifecycle phase there are specific considerations.

The ISO 16530 Well Integrity for the Lifecycle document notes the lifecycle phases of a well to be:

- Basis of Design
- Design
- Construction
- Operational
- Intervention
- Abandonment

It should be noted that although the ISO 16530 document was not written specifically for UGS wells, it was written to address the principle Well Integrity guidelines for all wells all over the world.
Basis of Design” and Design Phase:
The “Basis of Design” and “Design” Phase considerations include the identification of safety and environmental exposure and risks that can be encountered during the wells life cycle. Controls, such as barriers, are to be incorporated into the well design to manage the hazards identified.

Several of the new regulations have addressed UGS well design and construction, both from a federal level and a state level. The regulations that have addressed these topics include, but are not limited to the following:

- 2016-30045 IFR (References API RP documents 1170 and 1171)
- California Senate Bill No. 887 (References API RP 1170 and 1171)
- Mississippi State Oil and Gas Board
- Department of Natural Resources Illinois Register, Title 62 in the Illinois Oil and Gas Act

Not all of the mentioned regulations are recently enacted; several were in place prior to the Aliso Canyon incident in 2015. The Aliso Canyon incident has brought the UGS industry to regulators attention and placed more focus on the wells at these facilities and their overall integrity. Regulations moving forward will likely be more stringent with stronger oversight both at the State and Federal levels.

In relation to the UGS well designs, there has been a lot of discussion after Aliso Canyon regarding Emergency Shutdown (ESD) Valve systems. There are two (2) main types of Emergency Safety Valves (ESV’s), those installed above ground, Surface Safety Valves (SSV) and those installed in the well below ground level, Subsurface Safety Valves (SSSV). Based on industry surveys as of 2016 it is estimated that only about three (3) to five (5) percent of UGS wells have subsurface safety valves (SSSV).

ESV systems do act as a physical barrier; however both SSV’s and SSSV’s have known reliability and safety concerns or considerations. Dependent on the operators and their standards these systems may or may not be included in their consideration of their well barrier systems. API RP 1170 requires the use of surface ESV systems in salt cavern storage wells. API 1171 requires that a risk assessment be completed to determine the need for an ESV system to be installed specific to the well and location. The document notes the risk elements to be considered as:

- Distance to dwellings
- Potential dwellings
- Outside areas where people gather or congregate
- Fluid composition
- Maximum flow potential
- Distance from wellheads to other surface equipment
- Proximity to public transportation or industrial facilities
- Current and future plans for development in the area
- Topography
- Drainage
- Environmental considerations
- Determination if risk is added due to the installation of an ESV system or equipment

The decision to install an SSSV should take into consideration the operational impacts, risk factors, inspection, testing and maintenance requirements for the valves. Currently to the knowledge of the author, there are no state regulations requiring the use of downhole safety valves for onshore wells. Surface safety systems are required for storage operations in a number of states. Offshore, there are regulations requiring the use of both surface and subsurface systems.
**Construction Phase:**

Defines the elements to be constructed and the verification tasks to be performed to assure the intended design is achieved. This phase should place a strong emphasis on barrier verification to assure integrity in the future. Such considerations are: wellhead movement and fatigue, cement, casing shoe testing, tubular connections and casing wear.

**Operational Phase:**

The longest active phase of the wells life, yet often neglected from the risk perspective. This phase includes the requirements and methods used to manage the wells integrity during operations. This phase addresses inspection, testing and maintenance, monitoring and surveillance, data tracking, well operating limits, and setting operational parameters. It is important to have a consistent and standard data collection system in place to allow for determination of anomalies that can lead to integrity issues.

**Intervention Phase:**

This phase defines the requirements for assessing well barriers prior to, during and after well intervention activities. It addresses instances when it is necessary to break containment on the well to conduct an activity or operation. These activities should be conducted in accordance with an approved program that addresses intervention requirements, mitigation and control measures required for the identified hazards and risks.

**Abandonment Phase:**

Abandonment is the final activity performed on the well and its purpose is to establish permanent barriers with no intention of future entry. Typically there are strong regulations associated with well abandonment. Well abandonment requirements should be considered throughout the life cycle of the well, beginning at the “Basis of Design” phase.

**REGULATIONS AND STANDARDS**

Aside from the Well Integrity industry documents mentioned above, API developed documents specific to UGS that also address Well Integrity. Those Recommended Practices are API RP 1170 and 1171.

In preparation for the development and implementation of PHMSA’s inspection program associated with the enforcement of the modified CFR’s that now include the API RP 1170 and 1171 documents, PHMSA and other subject matter experts conducted safety site inspections on a sampling of eight (8) UGS operators between May and July of 2017. These were not official inspections and no deficiencies or citations were enforced, since it was prior to the January 2018 enforcement date. The main purpose of these site visits was to obtain information from the operators to compile UGS Industry Best Practices data, to gather feedback from the operators, and assess the status of the operators and industry as a whole. The results are being used in the development of the PHMSA inspection guidelines and the development of the overall UGS program. The topics focused on for the site visits were:

- Procedures and training
- HSSE and Emergency Response
- Integrity
- Risk Management

Submission of the Operator’s first PHMSA UGS Annual report was originally due in 2017. However, due to a delay in the release of the approved form, PHMSA revised the submittal date of the report to March 15, 2018. Below is an overview of the Federal Regulations, State Regulations, and the API RP documents now incorporated through reference into the CFR.
Federal Regulations: Protecting our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act of 2016:

The PIPES Act of 2016 ensures that the agency completes the original 2011 Act requirements, reforms PHMA to be a more data-driven regulator, assure regulatory certainty for citizens, the safety community and the industry. It became law on June 22, 2016.

Section 31 of the PIPES Act of 2016 stated that the Secretary of Energy was to establish a task force to produce a final report about the Aliso Canyon incident noting cause and contributing factors and providing recommendations for the UGS industry. The Task Force had three (3) sections:

- Well Integrity
- Reliability
- Health and Environment

The Well Integrity group was led by the Department of Energy’s (DOE’s) Fossil Energy group and participants from four (4) DOE National Labs. (The National Energy Technology Laboratory, Lawrence Berkeley National Laboratory, Sandia National Laboratories, and PHMSA).

The reliability group was led by the DOE’s Office of Electrical Delivery and Energy Reliability along with DOE’s Argonne National Laboratory, Energy Information Administration and FERC.

The Health and Environment group was led by the Environmental Protection Agency (EPA) and Department of Health and Human Services (HHS’s) Center for Disease Control and Prevention. Contributions were also made by the Department of Commerce (DOC) National Oceanographic and Atmospheric Administration and PHMSA.

The report was issued in October 2016, titled, “Ensuring Safe and Reliable Underground Natural Gas Storage – Final Report of the Interagency Task Force on Natural Gas Storage Safety.” The task force report made more than forty (40) recommendations, the “key” recommendations of the task force include:

- Gas storage operators should begin a rigorous evaluation program to baseline the status of their wells, establish risk management planning and to phase out old wells that were designed with only one (1) barrier.
- Prepare response plans in advance for possible natural gas leaks to manage and mitigate the impact to health, safety, and environmental concerns.
- Train power system Planners and operators to better understand the risks that potential gas storage disruptions create for the electrical system grid.

49 CFR 191 and 192 UGS Interim Final Rule Overview:

In response to the Aliso Canyon incident that occurred on October 23, 2015, PHMSA published an interim final rule (IFR) on December 19, 2016 to address safety issues related to downhole facilities, including wells, wellbore tubing and casing at UGS facilities.

The IFR was drafted to meet the requirements of Section 12 of the “Protecting our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act of 2016”. That act became law on June 22, 2016. Section 12 of the PIPES Act required that no later than two (2) years after the date of enactment of the PIPES Act of 2016 that the Secretary, in consultation with other Federal Agency heads, would issue minimum safety standards for UGS facilities downhole assets.

The IFR also incorporates by reference, two (2) API recommended practice documents, API RP 1170 (Design and Operation of Solution-mined Salt Caverns used for Natural Gas Storage) and API RP 1171 (Functional Integrity of Natural Gas Storage in Depleted Hydrocarbon Reservoirs and Aquifer Reservoirs), both issued in September of 2015. Both RP’s apply to new and existing UGS facilities. Per the IFR, Operators are required to be in compliance by January 2018. Inspections to confirm compliance are scheduled to begin later in 2018. Operators can request a special permit under 49 CFR 190.341 that allows them to waive a requirement or to be granted an extension to a given requirement given they can provide sufficient cause for the request.

PHMSA considered regulating wells and downhole equipment for more than twenty (20) years before the Aliso Canyon incident. Previous meetings had been held to review the status of UGS facilities and the need for further regulation, but it was determined not to be an immediate need during previous discussions.

PHMSA has a 60105 Certification which allows for the State entity that has safety authority over their intra-state gas storage to inspect and enforce the federal regulations in addition to the state regulations. PHMSA also has a 60106 agreement which allows the state entities to conduct inspections of the intrastate UGS facilities for compliance with the federal regulations, but PHMSA maintains responsibility for the enforcement.

The Interim Final Rule (IFR) revised the Federal Pipeline Safety Regulations 49 CFR 191 and 192. It was written to address safety issues for downhole facilities at Underground Natural Gas Storage facilities. The IFR was effective as of January 1, 2018 and the comment period for the IFR closed in November of 2017. The final rule is anticipated to be released by the summer 2018.

Prior to this IFR the intrastate facilities may have been regulated for downhole assets dependent on the state regulations, but of the approximate four-hundred (400) facilities, there are one-hundred
and ninety-seven (197) that are interstate facilities that fell under no regulation. While the surface piping at these facilities is covered in the federal regulations, they did not cover any downhole facilities. The development of minimum federal standards is the first time that safety standards have been established under the 49 CFR parts 191 and 192 legislation for the downhole facilities at UGS facilities. Also, under the IFR all intrastate UGS facilities are subject to the minimum federal safety standards and will be inspected by PHMSA or a state entity that will regulate the facilities with a PHMSA certification.

Therefore, similar to the current pipeline PHMSA regulations, the UGS regulations will set the baseline fitness for service requirements but still allow the state regulations to go above and beyond the minimum federal requirements.

The IFR requires that if an operator fails to meet the requirements of API RP 1170 or 1171 then they must justify the decision that was made in their documents and written procedures.

Another addition to the requirements for UGS per 49 CFR 191 is reporting requirements as follows:

- Annual Reports,
- Safety-related condition reports, and
- Incident Reports,
- National Registry information.

Prior to the IFR there were no annual submittal requirements for UGS facilities. The “annual report” collects general operator and facility information, as well as, specific data on rates, pressures and facility status.

**State Regulations:**

In addition to the federal PHMSA regulations each state also has the allowance to implement additional requirements for UGS facilities. For instance, in California the DOGGR Bill 887 was passed as emergency regulation after Aliso Canyon. This Bill set the requirements to be adopted to provide assurance of the integrity of the assets at California UGS facilities with time frame requirements.

Other states have also implemented UGS regulations or incorporated them into their Oil & Gas Regulations.

**STATE** | **AGENCY** | **WEBSITE/LOCATIONS OF UGS REGULATIONS**
---|---|---
California | Division of Oil, Gas, and Geothermal Resources (DOGGR) | [http://www.conservation.ca.gov/dog/pubs_stats/Pages/law_regulations.aspx](http://www.conservation.ca.gov/dog/pubs_stats/Pages/law_regulations.aspx)
Illinois | Illinois Department of Natural Resources | [https://www.dnr.illinois.gov/landgas/pages/programandregulations.aspx](https://www.dnr.illinois.gov/landgas/pages/programandregulations.aspx)
Michigan | Department of Environmental Quality | [http://www.michigan.gov/deq/0,4561,7-135-3311_4231---,00.html](http://www.michigan.gov/deq/0,4561,7-135-3311_4231---,00.html)
Ohio | Ohio DNR Division of Oil and Gas | [http://oilandgas.ohiodnr.gov/well-information/oil-gas-well-locator](http://oilandgas.ohiodnr.gov/well-information/oil-gas-well-locator)
Texas | Texas Railroad Commission | [http://www.rrc.state.tx.us/](http://www.rrc.state.tx.us/)
Iowa | Iowa Department of Natural Resources | [http://www.iowadnr.gov/Conservation/Geology/Oil-Gas-Regulation](http://www.iowadnr.gov/Conservation/Geology/Oil-Gas-Regulation)
Mississippi | State of Mississippi (Judiciary) | [https://advance.lexis.com/container?config=00lAAzANzYhOTYsNC0wZj1lLTQzNzA5YjJlYS1lNjExZGYzNzFlMGYkAFBvZENhGzFsb2caMlIwWjMzIH7HoaTHBEPO&crid=5fc2cc5e-6b13-4789-8217-1c80b36f62f&prid=1123lf78-82b9-442d-950a-74ab37875f6e](https://advance.lexis.com/container?config=00lAAzANzYhOTYsNC0wZj1lLTQzNzA5YjJlYS1lNjExZGYzNzFlMGYkAFBvZENhGzFsb2caMlIwWjMzIH7HoaTHBEPO&crid=5fc2cc5e-6b13-4789-8217-1c80b36f62f&prid=1123lf78-82b9-442d-950a-74ab37875f6e)

Figure 5: States with UGS Regulations as of August 2016

The annual report will typically be due by March 15th of each year; the due date for 2018 was modified due to it being the first reporting year.

The “incident report” is a tool for operators to report an event that could include a release of gas or gas loss, safety incident involving injuries, or property damage.

The “safety related condition report” purpose is to report conditions that affect the integrity of the assets, such as, corrosion, cracks, defects, natural occurrences (earthquakes, etc.).

The “National Registry” information is used for PHMSA to identify those operators with responsibility for operating UGS through their assigned Operator Identification Number (OPID).

As part of the implementation of the IFR, PHMSA has conducted a regulatory impact analysis (RIA) to estimate the potential costs associated with meeting the IFR requirements. Under the “Paperwork Reduction Act” (5 CFR 1320.8(d)) PHMSA is also required to evaluate the paperwork requirements it is imposing on operators with the new regulations, the RIA fulfills that requirement.
American Petroleum Institute (API):

The API documents became part of the CFR’s through a petition filed by the Interstate Natural Gas Association of America (INGAA). The INGAA is an industry trade association that represents a majority of interstate natural gas pipeline transmission companies. They were also involved in the development of the API documents. In January of 2016 they filed a petition for the documents to be incorporated into 49 CFR. Interstate facilities account for approximately 59% of the working gas capacity, compared to the 41% for the intrastate facilities.

Due to the fact that API choose to issue the documents 1170 and 1171 as Recommended Practices (RP’s) rather than Standards, PHMSA adopted the non-mandatory provision in a manner that would make them mandatory. This means that where there is verbiage such as “should” rather than “shall”, it will be considered mandatory, unless the operator can provide sufficient technical or safety justification in their programs or procedures as to why the requirement is not necessary.

Summary of API RP 1170 (Design and Operation of Solution-mined Salt Caverns Used for Natural Gas Storage):

API RP 1170 was written to focus on the Design and Operation of Solution-mined Salt Caverns that are used for Natural Gas Storage. The document covers such topics as, geo-mechanical considerations and assessments, cavern well design and drilling, solution mining techniques and operations, and monitoring and maintenance. This RP does not apply to UGS facilities for liquid, brine, or waste disposals, or to caverns that are mechanically mined or for the depleted hydrocarbon or aquifer systems.

The operation of creating gas storage from salt caverns dates back to the 1950s and started in Canada. The first U.S. operation was in Mississippi in the late 1960s by Transcontinental Gas Pipe Line.

The caverns are created by the drilling of a well into a salt formation and then dissolving the salt through the circulation of fresh or low-salinity water into the wellbore and returning the fluids to the surface, thus dissolving the salt and creating the cavern.

The topics highlighted in the document include, but are not limited to:

- Overview of Underground Natural Gas Storage
- Geological and Geo-mechanical
- Well design
- Drilling
- Cavern solution mining
- Gas storage operations
- Cavern integrity monitoring
- Cavern abandonment

Summary of API RP 1171 (Functional Integrity of Natural Gas Storage in Depleted Hydrocarbon Reservoirs and Aquifer Reservoirs):

API RP 1171 was written to focus on gas storage facilities that are in depleted oil and gas reservoirs and aquifer reservoirs. The RP applies to new and existing UGS facilities.

Depleted oil and gas reservoirs have been used to store natural gas since 1916; the first facility was located in western New York. Today there are more than 350 facilities in the U.S. and more than 14,200 wells across those facilities.
Aquifer reservoirs were used to store natural gas starting in 1946. Today there are approximately 50 of these facilities with about 2,600 wells across those assets.

The topics highlighted in the document include, but are not limited to:

- General principle of UGS in the types of reservoirs noted.
- Functional integrity in the design of UGS reservoirs.
- Functional integrity in the design and construction of natural gas storage wells.
- Functional integrity of the reservoir and wells established and demonstrated through initial attainment of maximum reservoir pressure and total inventory.
- Risk management for gas storage operations.
- Integrity demonstration, verification and monitoring practices.
- Site security and Safety, Site inspections, and Emergency Preparedness and response.
- Procedures and training.

There have been many changes to the UGS industry in recent years and more are anticipated for the future. It is important to understand these changes and how they impact owners and operators of these facilities, consumers, and the general public as we move forward in the discussion of the industry’s future.

**UNDERGROUND GAS STORAGE – FUTURE**

The IFR comment period has closed and PHMSA is preparing to issue the Final Rule in the Summer of 2018. The anticipated timeline for operators to be in full compliance with the CFR and the referenced API RP documents ranges from three (3) to eight (8) years. There is no anticipation, at this time, of additional regulations to be imposed above those that have been discussed in this paper. It is noted on the Federal Register website that after the issuance of the final Rule PHMSA will further evaluate the need for any additional regulatory requirements as compliance progresses.

Based on communications with PHMSA regarding the potential for an external Well Integrity UGS advisory committee, there was no indication for plans to form such a committee. However, PHMSA does have a designated UGS team of Subject Matter Experts on staff to address and assist the UGS industry.

The future of the UGS industry remains to be seen. Several of the recommendations that have come from recent studies indicate the following is to be expected:

- Operators to phase out wells with only a single barrier.
- Operators to develop and implement rigorous integrity programs.
- Operators to prioritize integrity testing on high risk wells as determined by risk assessments.
- Operators to prioritize integrity tests on those that provide the most valuable data for well performance.
- Operators to deploy continuous monitoring for wells and critical equipment.
- Operators to implement standardized and improved data management systems. This should also address data gathering gaps.
- Operators to develop plans to reach their goals for full compliance with the regulations. This should include a schedule of the planned activities required to reach that goal, prioritized by risk, considering impacts to consumers and reliability.
- DOE and DOT have the potential to conduct studies regarding key issues, such as: downhole safety valves, casing wall thickness assessment.
- Develop an expert advisory group.
- Better collection of environmental data for analysis.
- Development of new technologies.

These are just some of the potential developments to watch for in the UGS industry as we move forward.
CONCLUSION

UGS facilities are an essential component in the United States ability to provide efficient and consistent delivery of natural gas to consumers and although their overall major incident rates are relatively low; the consequence of an incident is high.

Given the current environment they can no longer remain low priority for regulatory oversight. The events that have occurred in the past few years have started a wave of change that is sure to continue for the foreseeable future of the UGS industry.

These changes bring many positives, such as, improved safety assurance, improved awareness and oversight of the UGS facilities, and improved reliability for consumers. Other potential effects could be increased fees to consumers to accommodate for the increased regulatory requirements, a decreased number of UGS facilities for those who are unable or unwilling to meet the increased regulatory requirements, and a shortage of qualified personnel to manage and operate facilities.

Whatever the future holds for the UGS industry the goals remain the same: improved Safety, improved Reliability, and improved Environmental Consciousness long into the future.

Questions? Email CRS@AIG.com
REFERENCES


11. Legislative Counsel of California, Senate Bill No. 887, Chapter 673. September 26, 2016.


Important note and disclaimers:

The views expressed in this work by the author are his own and do not necessarily represent those of American International Group, Inc. (AIG) or any of its subsidiaries, business units or affiliates. Persons should always seek the advice of counsel or a professional insurance broker before purchasing any insurance product or services.

This document is for general informational purposes only, and has been compiled from sources believed to be reliable. AIG accepts no legal responsibility for the correctness or completeness of this material or its application to specific factual situations. Reliance upon, or compliance with, any recommendation herein in no way guarantees any result, including without limitation the fulfillment of your obligations under your insurance policy or as may otherwise be required by any laws, rules or regulations. No responsibility is assumed for the discovery and/or elimination of any hazards that could cause accidents, injury or damage. This document should not be construed as financial, accounting, tax or legal advice and does not create an attorney-client relationship.

AIG is a leading global insurance organization. Founded in 1919, today AIG member companies provide a wide range of property casualty insurance, life insurance, retirement products, and other financial services to customers in more than 80 countries and jurisdictions. These diverse offerings include products and services that help businesses and individuals protect their assets, manage risks and provide for retirement security. AIG common stock is listed on the New York Stock Exchange and the Tokyo Stock Exchange.

Additional information about AIG can be found at www.aig.com and www.aig.com/strategyupdate | YouTube: www.youtube.com/aig | Twitter: @AIGinsurance | LinkedIn: www.linkedin.com/company/aig. These references with additional information about AIG have been provided as a convenience, and the information contained on such websites is not incorporated by reference into this document.

AIG is the marketing name for the worldwide property-casualty, life and retirement, and general insurance operations of American International Group, Inc. For additional information, please visit our website at www.aig.com. All products and services are written or provided by subsidiaries or affiliates of American International Group, Inc. Products or services may not be available in all countries, and coverage is subject to actual policy language. Non-insurance products and services may be provided by independent third parties. Certain property-casualty coverages may be provided by a surplus lines insurer. Surplus lines insurers do not generally participate in state guaranty funds, and insureds are therefore not protected by such funds.

© American International Group, Inc. All rights reserved.