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Application:	A.21-01-XXX
Witness:	T. McMahon

Application of Southern California Gas Company (U 904 G) for to Recover Costs Recorded in the Storage Integrity Management Program Balancing Account from January 1, 2016 to December 31, 2018	A.21-01-XXX

CHAPTER II

PREPARED DIRECT TESTIMONY OF

THOMAS D. MCMAHON

(TECHNICAL – WELL INSPECTION AND MITIGATION)

ON BEHALF OF SOUTHERN CALIFORNIA GAS COMPANY

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

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CHAPTER II

PREPARED DIRECT TESTIMONY OF THOMAS D. MCMAHON

(Technical – Well Inspection and Mitigation)

I. PURPOSE AND OVERVIEW OF TESTIMONY

The purpose of my testimony is to describe Southern California Gas Company's ("SoCalGas") judicious project execution of the well inspection, workover, and mitigation component of the Storage Integrity Management Program ("SIMP"); specifically, the "Well Inspection and Mitigation" cost category. This cost category comprises of 80 SIMP capital well workovers and 160 operations and maintenance ("O&M") well inspections driving the $113.2 million in capital additions and $14.2 million in O&M expenditures, which are presented for reasonableness review and rate recovery in this testimony. The costs and associated activities described in this chapter provide the basis for determining the revenue requirements recorded in SoCalGas' Storage Integrity Management Program Balancing Account ("SIMPBA").

My testimony compares the 2016 Test Year ("TY") General Rate Case ("GRC") forecasted Underground Storage well activities to actual work completed for well inspections and workovers for the 2016-2018 period. The testimony is laid out mostly chronologically to reflect the impacts of developing and ongoing regulatory changes to the actual work performed in the storage fields, as well as improvements made to the program as SIMP progressed (particularly in well workover practices, well integrity, and associated cost savings) to enhance public safety, comply with the directives of state and federal regulators, minimize customer impacts, and maximize cost-effectiveness.

As demonstrated in my testimony and the accompanying workpapers, these SIMP costs were reasonably incurred and the associated revenue requirements are justified for rate recovery.

II. SIMP BACKGROUND

A. Technical

In SoCalGas's TY 2016 GRC Application, SoCalGas proposed to implement a SIMP to identify and mitigate potential storage well safety and/or integrity issues.[1] SoCalGas forecasted 40 SIMP storage well inspections and 28 SIMP capital storage well workovers per year. The Commission approved SoCalGas's proposal in D.16-06-054, finding that the program would enable SoCalGas to proactively detect and mitigate potential safety integrity issues with its facilities, and maintain, replace and upgrade various components which make up the underground gas storage facilities.[2]

As described in the Prepared Direct Testimony of Amy Kitson (Chapter I), significant regulatory changes came from the California Division of Oil, Gas, and Geothermal Resources ("DOGGR") after SoCalGas filed its 2016 TY GRC. DOGGR issued Emergency Regulations in the Requirements for Underground Gas Storage Projects in February 2016 and Final Text of Regulations in the Requirements for Underground Gas Storage Projects in October 2018. In addition to DOGGR's regulations, the federal Pipeline and Hazardous Materials Safety Administration's ("PHMSA") advisory bulletin and new Interim Final Rules ("IFR"), which incorporated American Petroleum Institute ("API") Recommended Practice ("RP") 1171 by reference in December 2016, broadened PHMSA's authority to regulate downhole portions of underground gas storage. Subsequent to these mandated requirements and additional direction from DOGGR in the form of Order No. 1109,[3] SIMP was accelerated, expanded, and enhanced to comply with these regulatory requirements.

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[1] A.14-11-004, Direct Testimony of Phillip E. Baker at PEB-17.
[2] D.16-06-054 at pp. 247-249.
[3] Order to Take Specified Actions RE: Aliso Canyon Gas Storage Facility, Order No. 1109, March 4, 2016.

DOGGR Order 1109 played a determining role in the planning and procedures for SIMP inspections and final well configurations (i.e., construction standards) at all SoCalGas storage fields. DOGGR Order 1109 was specific to Aliso Canyon; however, SoCalGas proactively implemented the same testing requirements at Honor Rancho, La Goleta, and Playa del Rey storage facilities for consistency in well integrity management. DOGGR Order 1109 prescribed specific processes, tests, and logs, which became requirements included in the Final Text of Regulations in the Requirements for Underground Gas Storage ("UGS") Projects starting on October 1, 2018, thereby superseding prior mandates.

Under DOGGR Order 1109 and subsequently under SIMP, a storage well that did not pass all tests had to be repaired and successfully retested or plugged and abandoned. Each well identified as being open to, or passing through, the storage zone had to be categorized as one of the following: 1) passed all inspection tests[4] and approved to "Return to Service," 2) rig currently on well, or 3) a successful isolation pressure test of the casing to ensure no communication between the annulus and the reservoir.

SIMP work was driven by the need to comply with new regulations and provide for well integrity for the safety and reliability of the storage fields. Regulatory guidance and prescriptive mandates from DOGGR created a need to scale SIMP activities to meet compliance requirements, including the conversion of wells to tubing flow only. These accelerated SIMP activities increased costs above the amounts initially forecasted for the program.

While implementing new DOGGR and PHMSA well assessment requirements, SoCalGas developed a more stringent emissions avoidance protocol for each Aliso Canyon well. This protocol was immediately implemented on all wells with active rig work after January 1, 2018 to

[4] Based on DOGGR Order No. 1109, Attachment 1, Safety Review Testing Regime.

minimize natural gas vented to atmosphere. This practice became a mandatory step in planning work for remaining wells.

B. Organizational Framework

Well integrity is a multidisciplinary approach with technical and operational solutions to determine the remaining life of SoCalGas's storage fields. This approach was applied to the wells in SoCalGas's four underground storage fields: Aliso Canyon, La Goleta, Honor Rancho, and Playa del Rey. Furthermore, industry standards and regulatory agencies issued specific requirements addressing well inspection, risk management, testing, monitoring, data and records management, which are all part of well integrity management systems.

SoCalGas's Storage Risk Management department supports this multi-faceted effort of well integrity management and overarching regulatory compliance. The Risk Management team is responsible for organizing and analyzing the records and data pertinent to the storage fields – including wells and reservoirs. Proper data and records management is instrumental in demonstrating that all well work was completed to sufficiently meet regulatory requirements.[5] An example of appropriate data management is the process of updating and standardizing well bore diagrams using historical records to adequately plan well work. The Risk Management team also aligned Gas Standards with API RP 1171[6] to guide best practices for the many aspects of storage field management. These well- and field-based processes for documentation, organization, and analysis were critical for the required field-specific Storage Risk Management Plans ("SRMP") that were developed by analyzing all available records and data.

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[5] Supported by the Data Management team.

[6] American Petroleum Institute (API) Recommended Practice (RP) 1171, Functional Integrity of Natural Gas Storage in Depleted Hydrocarbon Reservoirs and Aquifer Reservoirs.

As described in the Prepared Direct Testimony of Amy Kitson, the SIMP organizational framework is designed to promote effective and timely implementation of SIMP field activities, while managing a large volume of work, employees, and contractors. SoCalGas follows a governance and management strategy to comply with regulatory requirements, works with different agencies to manage the program and field activities, seeks cost avoidance opportunities where practicable, and implements cost tracking, controls and management practices.

III. SUMMARY OF SIMP WELL INSPECTION AND MITIGATION

A. Activities

The primary assets of the SIMP are the underground gas storage ("UGS") wells. For the TY 2016 GRC, SoCalGas' SIMP program identified a system-wide total of 226 UGS wells across the four underground gas storage fields that were subject to different levels of regulatory and program compliance.[7] Wells underwent in-depth integrity inspections, well design and construction enhancement efforts, and/or permanent abandonment.

1. SIMP Workover Planning and Procedures

An initial assessment of the well profile was performed by reviewing well history, available directional surveys, inspection logs, and existing wellbore configuration (e.g. casing sizes, restrictions, perforations, liner). A well workover plan was created to implement well integrity elements and determine final well status by following industry standards[8] on: well

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[7] 49 CFR Parts 191 and 192, PHMSA Interim Final Rule, Pipeline Safety: Safety of Underground Natural Gas Storage Facilities; DOGGR 14 CCR §1724.9 Requirements for Underground Gas Storage Projects (DOGGR UGS Emergency Regulations 14 CCR §1724.9); DOGGR 14 CCR §1726 Requirements for California Underground Gas Storage Projects (DOGGR UGS Regulations 14 CCR §1726).

[8] American Petroleum Institute (API), Recommended Practice (RP) 17-series Subsea Production System; API RP 54 Occupational Safety and Health for Oil and Gas Well Drilling and Servicing Operations; API RP 59 Recommended Practice Well Control Operations; API RP 1171 Functional Integrity of Natural Gas Storage in Depleted Hydrocarbon Reservoirs and Aquifer Reservoirs

intervention, well control, gas standards,[9, 10] and regulatory requirements.[11] A workover program and field activities were then initiated across SoCalGas's UGS fields.

2. Well Workovers

After the results and data from the integrity tests were analyzed, SIMP Engineers determined whether to move forward with recompletion or identify a remediation method. If the integrity logs identified anomalies which required some form of remediation, the SIMP Engineers were required to submit a Supplemental Notice of Intent ("NOI") to DOGGR. The process of initiating the remediation (i.e., composing the Supplemental NOI, submitting to DOGGR, and waiting for approval and receipt of the new permit) extended the workover timeline, often increasing costs. In some instances, while waiting for permits and materials, wells were isolated to allow for resource optimization; SoCalGas would redeploy them to perform integrity inspections on other wells.

Once approved, remediation projects included installation of new components in the existing wellbore, requiring re-inspections for validation and regulatory approvals before completion. In some cases, well performance standards[12] set by DOGGR would dictate additional work, such as perforating and cement squeezing areas of interest before new materials were installed. Consequently, additional time, material, and service equipment were sometimes required. Steel liner and inner string installations were two types of remediations performed. These installation projects required additional equipment and bottom hole assemblies, beyond a

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[9] SIMP 3, Threat Identification and Risk Assessment
[10] Gas Standard 224.104 – Blowout Contingency Plan
[11] 49 CFR Parts 191 and 192, PHMSA Interim Final Rule, Pipeline Safety: Safety of Underground Natural Gas Storage Facilities; DOGGR UGS Emergency Regulations 14 CCR §1724.9; DOGGR UGS Regulations 14 CCR §1726
[12] DOGGR UGS Regulations 14 CCR §1726.5, Well Construction Requirements

standard recompletion, to run and set in the well. Inner strings also required the use of cement to be set in place.

B. Costs

Well Inspection and Mitigation costs are attributable to safety enhancement and well integrity management activities at the storage fields. Under SoCalGas's accelerated plan to conduct comprehensive baseline assessments, all wells were subject to a suite of integrity inspections and either remediated and returned to service or abandoned.[13] Wells that returned to service incurred costs attributable to isolation, decompletion, integrity testing, mitigation (if necessary), validation, installation of new completion, final installation integrity test, and unloading of workover fluids.

For wells that were returned to service, the increase in incurred costs above initial forecasts was driven by the accelerated pace of well work and additional integrity management activities discussed in the Prepared Direct Testimony of. Amy Kitson (Chapter I). Both field work and program support work were needed to meet state and federal regulatory requirements.[14, 15] These costs are summarized in Table TM-1.

TABLE TM-1

SIMP – Well Inspection and Mitigation Costs (2016-2018)

SIMP – Well Inspection and Mitigation Costs				
(Direct + V&S Recorded, $000s)	**2016**	**2017**	**2018**	Total
O&M	$6,115	$7,909	$4,257	$18,281
Capital Additions	$33,425	$49,079	$30,695	$113,198

[13] Plug and abandonment costs are not included in this application (see the Prepared Direct Testimony of Amy Kitson, Section VI for further details).
[14] DOGGR UGS Emergency Regulations 14 CCR §1724.9; DOGGR UGS Regulations 14 CCR §1726.
[15] 49 CFR Parts 191 and 192, PHMSA Interim Final Rule, Pipeline Safety: Safety of Underground Natural Gas Storage Facilities; American Petroleum Institute (API), Recommended Practice (RP) 1171 Functional Integrity of Natural Gas Storage in Depleted Hydrocarbon Reservoirs and Aquifer Reservoirs.

SIMP O&M expenditures and capital additions were primarily attributable to the following rig work activities and corresponding increased labor:

- Preparing the gas storage well for integrity inspection logs and tests;
- Performing well remediations (such as the installation of inner strings or steel liner, if applicable);
- Completing follow-up inspection logs and tests;
- Installing new steel tubing to operate on tubing flow only;
- Returning the well to service;
- Plugging and abandoning wells.[16]

1. Well Recompletion Costs (Wells Returned to Service)

Costs for wells that were inspected and returned to service were a combination of O&M expenditures and capital additions to remediate wells with methods of standard recompletion, installation of an inner string, installation of a steel liner, and installation of an inner string with a liner. These costs are summarized in Table TM-2.

TABLE TM-2

Summary SIMP Costs for Well Recompletion Activities (2016-2018)

(Direct + V&S Recorded, $000s)		
Description	**Capital Additions**	**O&M**
Steel Liner recompletion	$14,379	$654
Inner string recompletion	$48,964	$1,955
Inner string/liner recompletion	$2,359	$555
SIMP recompletion	$47,497	$3,053
Total	$113,198	$6,217

[16] This SIMP application seeks the reasonableness review and revenue requirement recovery of the equivalent O&M and capital additions within the SIMPBA, and excludes SIMP-related capital removal (costs of plug and abandonments), as these dollars are recovered through the GRC approved depreciation mechanism outside of this recovery filing.

2. Well Costs (for Wells Isolated or Abandoned)

Prior to determining if a well had to be repaired, retested, or plugged and abandoned, completion of certain tests and/or logs was required.[17] In addition, wells with rig work that could not be completed were isolated and required regular surveys to confirm safe isolation.

IV. WELL WORK PROCESS: DEVELOPMENT AND EXECUTION

This section describes SoCalGas's process to validate well integrity to meet federal and state regulations. SoCalGas follows guidance contained within published gas standards when performing integrity assessments.

A. Pre-Assessment

Pre-assessment is a process in which Storage personnel collect and review as much information from digital and print records as practicable regarding the well to be assessed. Gathering this information enables Storage personnel to verify that the inspection methods selected are appropriate and address well integrity beyond casing and tubing inspection.

Pre-assessment includes a review of data elements of the selected well, which typically include, but are not limited to:

- Design records
- Drilling records
- Geological and reservoir records
- Completion records
- Well work records
- Wellbore diagrams

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[17] Order to Take Specified Actions RE: Aliso Canyon Gas Storage Facility, Order No. 1109, March 4, 2016 (DOGGR Order 1109).

- Wellhead configuration
- Downhole inspection records
- Well pressure monitoring and testing
- Gas sampling results

Storage personnel examine the results of the pre-assessment data, including Noise and Temperature Surveys, to prepare for the inspection portion of the SIMP work, or to proceed to abandonment.

B. Inspection

Following pre-assessment, the initial SIMP work begins with well inspections, which require DOGGR approval before commencement of such work. An inspection method is selected when the review demonstrates that a suitable method can verify well mechanical integrity and the well records do not show any incompatibility with the known design characteristics of the well casing or completion configuration.

1. Mechanical Integrity Testing

A Mechanical Integrity Test ("MIT") is conducted as an initial well inspection and is primarily accomplished by running noise and temperature surveys.[18] A temperature survey that demonstrates no unexplained anomalous temperature changes in the well is one indication of casing integrity; similarly, the absence of anomalous sound is an indication of well integrity. As part of the inspection process, any anomalies found on inspection surveys from any of the four fields are reviewed and analyzed internally by SoCalGas Engineers.

[18] Noise and temperature survey costs incremental to historical requirements described by DOGGR Project Approval letters are a sub-category of SIMP "Regulatory Compliance" activities.

For Aliso Canyon specific wells, noise and temperature surveys were required prior to rig intervention. A consultant participated in the review of each MIT log and collaborated with the SIMP team to discuss results with the DOGGR Safety Review Team.[19] Honor Rancho, La Goleta, and Playa Del Rey perform noise and temperature surveys on a recurring basis as a part of the non-SIMP O&M activities required by their project approval letters issued by DOGGR. The noise and temperature surveys were the initial method of performing casing assessment on a well; results were used as preliminary reference points prior to rig work and determined next steps of SIMP work.

2. Integrity Inspection Logs and Pressure Tests

Additional inspections to complete the SIMP work required rig intervention and removal of completion equipment. These inspections were conducted from the bottom of the gas storage reservoir caprock to surface and included two casing inspection logs – Magnetic Flux Leakage ("MFL") and Ultrasonic Testing ("UT") – where the thickness of the production casing is measured; a Cement Bond Log ("CBL") that measures the bonding between cement and the production casing outside diameter; a Multi-Arm Caliper ("MAC") log that measures internal geometry of production casing; and a pressure integrity test. The result of these inspections demonstrated the ability of the production casing to withstand above-normal operating pressures. Additionally, the completion equipment was tested to demonstrate successful installation and the well's capability to safely operate once returned to service. The DOGGR District offices reviewed inspection results and witnessed pressure tests at all four storage fields. Furthermore,

[19] DOGGR Order 1109 specified a Safety Review undertaken by DOGGR (or the "Division") staff (Action 1 and 2) which were known as the "Safety Review Team".

the DOGGR Safety Review Team oversaw inspections at Aliso Canyon, ensuring all requirements of Order 1109[20] had been met.

C. Validation and Approval Process

Validation is the process of making a final determination of the well condition after inspection. Based on results and regulatory performance standards,[21] a well would be assigned a category, such as: recompletion, remediation, or abandonment. When the inspection results determined that a well could be recompleted, the well was returned to service. This step involved installing new completion equipment, converting the well to tubing flow only, and performing a final installation test. Wells that were not suitable for remediation were prepared for plugging and abandonment. If the well required remediation, the method was selected based on the defect detection results, identified threats, well records, and design characteristics of the well casing or tubing configuration. The DOGGR District offices provided final validation on the results at all four storage fields and the DOGGR Safety Review Team also provided final validation on the results at Aliso Canyon.

1. Remediation

After conducting inspections and determining that the well required remediation, additional work was performed to enhance wellbore integrity, and meet regulatory performance standards.[22]

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[20] Order to Take Specified Actions RE: Aliso Canyon Gas Storage Facility, Order No. 1109, March 4, 2016.
[21] Id.; DOGGR UGS Regulations 14 CCR §1726.5, Well Construction Requirements.
[22] Id.

a) Production Casing

Remediation methods available for production casing included installing a steel liner across the affected area of the casing or running and cementing an inner string. Any remedial work required new integrity inspections. In some instances, regulatory requirements[23] and DOGGR District offices dictated additional work, including perforating and cement squeezing in the existing wellbore at geologic zones of interest before running inner strings or steel liners.

b) Well Casing

Remediation methods available for well casing included installing and cementing a new casing inner string or a steel liner across the affected area of the well casing. Once the inner string was installed, the suite of inspections (MFL, MAC, CBL, UT, and pressure integrity test) were performed again. Once the well met regulatory performance standards,[24] new completion equipment was installed, converting the well to tubing flow only, and a final installation test was performed.

If remediation resources were not available, the well casing was pressure tested to demonstrate integrity with no communication between the reservoir and the tubing-casing annulus. This test indicated that the well was safely isolated from the reservoir until all remediation could be performed.

2. Well Isolation

A well may be isolated prior to a planned abandonment or a scheduled activity, such as a rework or recompletion. A well may be isolated prior to rig work for a planned abandonment or scheduled activity, such as a rework or recompletion; or a well can be isolated due to an

[23] Id.
[24] Id.

incomplete SIMP well workover. Isolating a well confirms there is no communication between the storage zone and the casing annulus and is usually done with cement or mechanical barriers. For Aliso Canyon, all wells that had not undergone the suite of tests or did not have a rig on them were required to be isolated and categorized as "taken out of operation" per DOGGR Order 1109. To achieve this, isolation pressure tests were required and witnessed by the DOGGR Safety Review Team; this was not required for other fields, so other fields' wells were only isolated prior to the scheduled rig work. Isolated wells were also required to have bi-annual isolation pressure tests and noise and temperature surveys, at a minimum, as well as fluid level and well pressure monitoring.[25]

Isolations were found to be a significant effort for the SIMP team at Aliso Canyon. Simple isolations were performed by setting a tubing plug, filling tubing and casing with workover fluid using a pump truck, and then pressure testing both. When this process could not be followed, additional well intervention with a rig was required to perform downhole work which tended to be more involved than a simple isolation. To achieve isolation, SIMP had to demonstrate an adequate cement bond behind the casing at the chosen depth for a mechanical barrier, then pressure test to confirm the well was safely isolated from the reservoir. This was documented and submitted to DOGGR by either showing evidence of historical CBL or running a new CBL.

3. Abandonment[26]

Some inspections resulted in well abandonments based on required remedial work, well characteristics, and operational limitations. When a well was categorized for abandonment,

[25] Based on DOGGR Order No. 1109, Attachment 1, Safety Review Testing Regime, Step 7b.
[26] This SIMP application seeks the revenue requirement recovery of the equivalent O&M and capital additions within the SIMPBA and excludes SIMP-related capital removal (costs of plug and

additional work was performed to permanently plug and abandon the wellbore following industry procedures, DOGGR District requirements, and federal and local government approvals, if applicable. These wells were selected for abandonment under SIMP after completing the inspection.

D. Post-Assessment

Once a well passed integrity logs, pressure tests, and received approvals from the local DOGGR District,[27] the well was deemed ready to return to service. At Aliso Canyon, a DOGGR Safety Review Team approval was also required prior to returning a well to service; this approval released the well from DOGGR Order 1109 requirements, allowing the DOGGR District office to provide oversight and enforcement over well work thereafter. Once rig work is completed, the well is unloaded, the above ground instrumentation and laterals are installed, the site is restored to operating conditions, and the well is turned over to SoCalGas Operations so it can be used for natural gas injection and withdrawal, thereby returning the well to service.

Wells with completed workovers at Aliso Canyon which received DOGGR Safety Review team approval could not return to service until after July 31, 2017, when Aliso Canyon was approved to resume injection and withdrawal activities.[28] Once wells were returned to service and resumed injection and withdrawal, annular pressures developed in some wells and resulted in remedial work. This remedial work involved placing packer fluid to a calculated

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abandonments), as these dollars are recovered through the GRC approved depreciation mechanism outside of this recovery filing.

[27] DOGGR UGS Regulations 14 CCR §1726.6, Mechanical Integrity Testing and § 1726.6.1, Pressure Testing Parameters

[28] Joint Open Letter from DOGGR and CPUC to SoCalGas, "SB 380 Findings and Concurrence Regarding the Safety of Aliso Canyon Gas Storage Facility," July 19, 2017.

depth without taking the well out of service. In other instances, additional rig work was required and involved taking the well out of service prior to returning the well to service once again.

E. Post-Workover Data Management

The Post-Assessment step utilized data collected from the Pre-assessment, Inspection, and Validation steps to evaluate the effectiveness of the assessment process, establish a re-assessment interval, and provide feedback for ongoing development and improvement of preventative and mitigative measures. Information obtained during execution of the SIMP is used to validate existing asset data and is used to complete recordkeeping and documentation requirements for the assessment. This data management was integral when responding to regulatory data requests and other mandatory submittals.[29]

V. SIMP COST DRIVERS AND MANAGEMENT MEASURES

A. Accelerated and Expanded Well Work

SIMP activities were originally planned to be implemented over a six-year period to secure efficient and effective resources specific to gas storage wells and associated operations. [30] With acceleration and expansion of activities (i.e., completion of baseline well assessments within an approximate four-year period and enhancement of preventative and mitigative measures) to comply with emerging and new federal and state regulatory mandates,[31] reasonable efforts were made to manage costs as SIMP activities were significantly ramped up.

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[29] Activities supported by the SIMP Program Management and Support: Data Management team.

[30] Workpapers to Prepared Direct Testimony of Phillip E. Baker, SCG-06-WP, 2US002.000, UNDERGROUND STORAGE – RSIMP.

[31] 49 CFR Parts 191 and 192, PHMSA Interim Final Rule, Pipeline Safety: Safety of Underground Natural Gas Storage Facilities; DOGGR UGS Emergency Regulations 14 CCR §1724.9; DOGGR UGS Regulations 14 CCR §1726.

1. Accelerated (Increased) Units of Work

The following (Table TM-4) provides a simplified comparison of the TY 2016 GRC unit forecast versus actual inspections and workovers for the 2016-2018 period. In the TY 2016 GRC, SoCalGas forecasted conducting 40 SIMP storage well inspections per year, with work continuing over an additional three years. The actual activity level was 50 SIMP well inspections in 2016[32]; 60 SIMP well inspections in 2017[33]; and 50 SIMP well inspections in 2018 at all storage fields.

SoCalGas also forecasted 28 SIMP capital storage well workovers in the TY 2016 GRC. The actual activity level was 29 SIMP well workovers in 2016 (all at Aliso Canyon); 31 SIMP well workovers in 2017 at all storage fields; and 20 well workovers in 2018 at all storage fields.

TABLE TM-4
Comparison of GRC-Authorized vs Actual Units of Well Work

		# of units			
Description		**2016**	**2017**	**2018**	**Total**
2016 GRC SIMP Forecast	Well Inspections	40	40	40	120
	Well Workovers	28	--	--	28
SIMP Actual	Well Inspections	50	60	50	160
	Well Workovers	29	31	20	80

2. High Variability and Expanded Scope of Well Work

As addressed in the Prepared Direct Testimony of Amy Kitson, enhanced preventative and mitigative measures (e.g., tubing flow only, new tubing) driven by new regulatory requirements expanded the scope of well work activities and associated costs. Additionally, the very nature of workover activities is highly variable, attributed to uncertainty surrounding the volume and degree of repair work to be performed, the variable cost of consulting experts when

[32] DOGGR Order 1109 directed SIMP activities at Aliso Canyon in 2016. SIMP was expanded to all fields in 2017.
[33] Includes Aliso Canyon, Honor Rancho, Playa del Rey, and La Goleta gas storage fields.

required, specialty equipment and skillful operators to be procured, and field conditions encountered once inspection work is initiated.[34] Table TM-5 describes the SIMP Well Inspection and Mitigation costs and number of wells completed for each of SoCalGas's storage fields during the 2016-2018 period.

TABLE TM-5
Well Inspection and Mitigation SIMP Recompletion Costs by Storage Field

		Direct + V&S Recorded ($000s)				Well Count
		2016	2017	2018	Total Cost	
Aliso Canyon	O&M	$2,475	$1,567	$635	$4,678	61
	Capital Additions	$33,425	$34,915	$16,400	$84,740	
Honor Rancho	O&M	$0	$691	$254	$945	12
	Capital Additions	$0	$8,408	$10,559	$18,967	
La Goleta	O&M	$0	$162	$67	$229	2
	Capital Additions	$0	$2,503	$1,008	$3,511	
Playa Del Rey	O&M	$0	$248	$118	$365	5
	Capital Additions	$0	$3,253	$2,728	$5,981	
Total O&M		$2,475	$2,668	$1,074	$6,217	80
Total Capital Additions		$33,425	$49,079	$30,695	$113,198	

B. Market Driven Costs

As discussed in the TY 2016 GRC, costs for the well rigs required for SIMP are dependent on broader supply and demand activities throughout the oil and gas industry ("economic rig availability and quality supervision are highly dependent on overall demands of the industry").[35] Costs for well work were subject to market forces and the availability of specialty equipment and crews. Available resources from material and service companies fluctuated according to commodity prices and demand for services. The ability to secure equipment and associated prices are dependent on energy demand and rig availability worldwide.

[34] A.14-11-004, Direct Testimony of Phillip E. Baker at PEB-21.
[35] A.14-11-004, Direct Testimony of Phillip E. Baker at PEB-21.

Financial outlays to secure rigs and oil/gas field services can vary greatly over time due to domestic and foreign developments related to energy.[36]

For example, at the end of 2014, a downturn in commodity prices and total industry rig counts caused large service companies such as Baker Hughes, Weatherford, Schlumberger, and Halliburton to either cease or reduce operations in local offices such as Ventura and Bakersfield. This caused a reduction of available services and materials, which in some cases (e.g. wellheads), are manufactured by only one regional vendor.

Conversely, as the demand for well components and services rebounded, the large service companies ramped back up to provide a variety of logging tools for casing inspection and physical supplies needed for workover and abandonment such as trucking (vacuum, flatbed, crane), packers, and cementing services. This allowed SoCalGas to spread work across the service companies and, at times, negotiate prices.

C. Cost Management

1. Well Procedure Developments

As part of strategic cost and resource management, internal processes were developed to control well work costs, including strict invoice oversight. After the pre-assessment phase was completed, rig and rigless plans were produced to perform SIMP inspections to return the well to

[36] A.14-11-004, Direct Testimony of Phillip E. Baker at PEB-41.

service following industry standards,[37] well intervention, well control, safety,[38] gas standards,[39] and regulatory requirements.[40]

The integrity inspections plan includes well control, safety precautions, material selection, company standards, well integrity inspections procedures, and return to service plans. Additionally, current and proposed diagrams are created to visualize downhole conditions. The plan was submitted to the pertinent regulators and local agencies for approvals and a permit issued for rig intervention. Once scope and reach of plan was determined, a budget was generated, and an updated work order authorization (WOA) was created.

2. Contractor Support

SIMP field activities require extensive knowledge and training in oil and gas well operations, including well construction. SoCalGas requires workers who have downhole knowledge and experience to operate in a safe, appropriate, and efficient manner while handling well control and rig operations. As such, SoCalGas relied on highly skilled and experienced contractors and service companies to assist in the completion of most well work activities. Contractors and vendors were also utilized in order to meet the growing list of specialized activities required by new and expanding regulatory mandates.[41] Preceding well intervention and

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[37] API RP 17-series Subsea Production System; API RP 54 Occupational Safety and Health for Oil and Gas Well Drilling and Servicing Operations; API RP 59 Recommended Practice Well Control Operations; API RP 1171 Functional Integrity of Natural Gas Storage in Depleted Hydrocarbon Reservoirs and Aquifer Reservoirs

[38] SIMP 3, Threat Identification and Risk Assessment

[39] Gas Standard 224.104 – Blowout Contingency Plan

[40] 49 CFR Parts 191 and 192, PHMSA Interim Final Rule, Pipeline Safety: Safety of Underground Natural Gas Storage Facilities; DOGGR UGS Emergency Regulations 14 CCR §1724.9;DOGGR UGS Regulations 14 CCR §1726.

[41] DOGGR Order 1109; 49 CFR Parts 191 and 192, PHMSA Interim Final Rule, Pipeline Safety: Safety of Underground Natural Gas Storage Facilities; DOGGR UGS Emergency Regulations 14 CCR §1724.9; DOGGR UGS Regulations 14 CCR §1726.

during execution, services and materials were selected and prepared with vendors following industry standards[42] to optimize available resources.

The storage fields have utilized vendors for various GRC O&M and capital activities in Underground Storage, prior to SIMP's inception. Many of these vendors are service companies associated with the broader oil and gas industry in California and the western states. In 2016, SIMP utilized each vendor for a specific activity; however, as the program progressed, the SIMP team worked with Supply Management to negotiate additional vendor contracts to distribute expenditures for similar activities amongst multiple vendors. This activity promoted vendor competition and fair market share, reducing overall costs.

For new activities or those with unknown costs, SoCalGas utilized a competitive bidding process in accordance with SoCalGas's Supply Management standards to determine the discernable market level costs; this allowed for competitive bids from service providers. SoCalGas also leveraged the amount of well work to drive competitive contracted rates.

3. Material Selection

Materials and components installed during well workover operations were subject to industry standards in order to achieve regulatory compliance.[43] SIMP engineers select materials and components to ensure proper performance for use in gas storage wells. Specific sizes and the proper application for each component used were evaluated and chosen for each well. In addition, applications such as tubing, packers, wellheads, bottom hole assemblies with flow

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[42] API RP 17-series Subsea Production System; API RP 54 Occupational Safety and Health for Oil and Gas Well Drilling and Servicing Operations; API RP 59 Recommended Practice Well Control Operations.

[43] API Specifications: API 5CT, Specification for Casing and Tubing; API 10A, Specification for Cements and Materials for Well Cementing; API 6A Specification for Wellhead and Tree Equipment; American Society for Testing and Materials (ASTM) C150/C150M Standard Specification for Portland Cement

control components, liners, inner strings, steel liners, thread type, and cement required service companies to design, plan, and run equipment engineering analysis were overseen by SIMP Engineers.

This concludes my prepared direct testimony.

VI. WITNESS QUALIFICATIONS

My name is Thomas D. McMahon. I am employed by Southern California Gas Company as the Manager of the SIMP. My business address is 12801 Tampa Avenue, Northridge, California 91326-1045.

I graduated from the University of Southern California in 1996 with a Master of Science degree in Petroleum Engineering and from Boston College 1980 with Bachelor of Science degrees in Geology and Geophysics. I am a Professional Geologist in the State of California. My employment with Southern California Gas Company began in 1990 with the title of Drilling Engineer in Underground Storage. Since that initial assignment, I have held numerous positions with increasing levels of responsibility including Environmental Project Manager, Gas Distribution Project Manager, Customer Services Team Leader, and Gas Distribution Compliance and Maintenance & Inspection Manager. In my current position of SIMP Manager, my responsibilities include overseeing workover rig activities for the purposes of inspecting well casings and determining if each well can be returned to service or must be abandoned. Additionally, I evaluate third-party vendor costs associated with this well activity, examine vendor related invoices, work closely with Supply Management to implement or extend contracts for these vendors, and oversee an Engineering Team and Support Staff, all related to downhole well work.

Prior to joining Southern California Gas Company, I was employed by Halliburton Energy Services. While there, I held several positions including Field Engineer, Senior Field Engineer, and Master Field Engineer.

I have not previously testified before the Commission.

GLOSSARY

SoCalGas provides this glossary of terms used in testimony and in workpapers. Terms are defined by either the oil and gas industry, SoCalGas staff or regulatory agencies such as DOGGR or PHMSA. Note that terms marked (*) derived from the Schlumberger Oilfield Glossary at: https://www.glossary.oilfield.slb.com/.[44]

Annular and Tubing Pressure Tests: Two pressure tests which are conducted after setting a production packer and converting a well to tubing flow. (Also known as *Installation Integrity Test*.)

Annular Pressure Test: A pressure test in which approximately 500 psi to 1000 psi of pressure (depending on the field) is applied in an annular space between tubing and casing to ensure production packer integrity and to confirm isolated annular space between the tubing and casing. (See also *Annular and Tubing Pressure Tests*.)

Back Pressure Valve (BPV): A type of check valve, typically installed in the tubing hanger, to isolate the production tubing. The back-pressure valve is designed to hold pressure from below yet enable fluids to be pumped from above.*

BH/BHI/BHGE: Baker Hughes Incorporated, then became BHGE, later it became BH (Baker Hughes)

Blowout Preventer Equipment (BOPE): A large valve at the top of a well that may be closed if a drilling crew loses control of formation fluids. By closing this valve (usually operated remotely via hydraulic actuators), it is intended to regain control of the reservoir, and procedures can then

[44] Note that certain definitions that originated from the Schlumberger Oilfield Glossary have been modified herein to better match the activities of SoCalGas.

be initiated to increase the mud density until it is possible to open the BOPE and retain pressure control of the formation.*

Bottom Hole Assembly (BHA): The lower portion of a drillstring, consisting of (from the bottom up in a vertical well) the bit, bit sub, stabilizers, drill collar, jarring devices ("jars") and crossovers for various threadforms.*

Bridge Plug: A downhole tool that is located and set to isolate the lower part of the wellbore. Bridge plugs may be permanent or retrievable, enabling the lower wellbore to be permanently sealed from production or temporarily isolated from a treatment conducted on an upper zone.*

Caliper Log: (See also Multi-arm inspection)

Casing: Steel pipe cemented in place during the construction process to stabilize the wellbore. The casing forms a major structural component of the wellbore and serves several important functions: preventing the formation wall from caving into the wellbore, isolating the different formations to prevent the flow or crossflow of formation fluid, and providing a means of maintaining control of formation fluids and pressure as the well is drilled. The casing string provides a means of securing surface pressure control equipment and downhole production equipment, such as the drilling blowout preventer (BOPE) or production packer. Casing is available in a range of sizes and material grades.*

Casing Pressure Integrity Test (Block Test): A pressure test performed on production casing from caprock to surface at maximum allowable operational pressure (MAOP x 1.15) by not exceeding production casing internal yield as determined by hydrostatic pressure and applied surface pressure (can be done in multiple blocks or steps).

Casing Shoe: The bottom of the casing string, including the cement around it, or the equipment run at the bottom of the casing string.*

Casing String: An assembled length of steel pipe configured to suit a specific wellbore. The sections of pipe are connected and lowered into a wellbore, then cemented in place. The pipe joints are typically approximately 40 ft [12 m] in length, male threaded on each end and connected with short lengths of double-female threaded pipe called couplings. Lower portions of the string may be assembled with casing of a greater wall thickness to withstand the extreme pressures likely at depth. Casing is run to protect or isolate formations adjacent to the wellbore.*

Cement Bond Log (CBL): This inspection log uses sound waves to verify bond or adhesion between casing and cement.

Cement Squeeze (CMT SQZ'D): A remedial cementing operation designed to force cement into leak paths in wellbore tubulars. The required squeeze pressure is achieved by carefully controlling pump pressure.*

> For SoCalGas operations, the applied and hydrostatic pressure does not exceed the fracture gradient at the zone of interest.

Christmas Tree: An assembly of valves, spools, pressure gauges and chokes fitted to the wellhead of a completed well to control production.*

Clean out: To remove wellbore fill material such as sand, scale or organic materials, and other debris from the wellbore.*

Collar: A threaded coupling used to join two lengths of pipe such as production tubing, casing or liner. The type of thread and style of collar varies with the specifications and manufacturer of the tubular. *

Completion: A generic term used to describe the assembly of downhole tubulars and equipment required to enable safe and efficient production from an oil or gas well. The point at which the completion process begins may depend on the type and design of well.* (A typical SIMP completion consists of tubing, packer, sliding sleeve and nipple where a tubing plug can be set for testing proposes.)

Decompletion (Removing Completion Equipment): The action of removing previous production equipment (besides milling and fishing operations) including but not limited to production tubing, packers, sliding sleeve, nipples, gas lift mandrels, steel liners, uncemented casing/liners.

Dip tube: A tube that is located inside of a blow down valve (BDV) which is required when the BDV is extended on large gate valves. This dip tube extends through the bonnet to the bottom of the body cavity.* (This technique is used to minimize gas reaching to pump.)

Drift: To guarantee the inside diameter of a pipe or other cylindrical tool by pulling a cylinder or pipe (often called a rabbit) of known outside diameter through it. The drift diameter is the inside diameter (ID) that the pipe manufacturer guarantees per specifications. Note that the nominal inside diameter is not the same as the drift diameter but is always slightly larger. The drift diameter is used by the well planner to determine what size tools or casing strings can later be run through the casing, whereas the nominal inside diameter is used for fluid volume calculations such as mud circulating times and cement slurry placement calculations.*

Fish (Noun) or Junk: Anything left in a wellbore. It does not matter whether the fish consists of junk metal, a hand tool, a length of drillpipe or drill collars, or an expensive measurements-while-drilling tool and directional drilling package. Once the component is lost, it is properly referred to as simply "the fish." Typically, anything put into the hole is accurately measured and sketched, so that appropriate fishing tools can be selected if the item must be fished out of the hole.*

Fish (verb): To attempt to retrieve a fish from a wellbore. Where available, specialists, aptly called fishermen, are called onto location to direct and assist with the fishing operations.*

Gamma Ray (GR): A log of the total natural radioactivity, measured in API units. The measurement can be made in both openhole and through casing. The depth of investigation is a few inches, so that the log normally measures the flushed zone. Shales and clays are responsible for most natural radioactivity, so the gamma ray log often is a good indicator of such rocks. However, other rocks are also radioactive, notably some carbonates and feldspar-rich rocks. The log is also used for correlation between wells, for depth correlation between open and cased hole, and for depth correlation between logging runs.*

Gyroscopic (Gyro) Survey: A survey used to measure the change in orientation of the tool (gyro), when following a wellpath, relative to the original spin axis orientation at the start of the survey. Gyro surveys are taken within existing/cased wells every 25 ft – 100 ft from total depth to surface by obtaining measured depth (ft), inclination (angle of deviation from vertical view) and azimuth (well direction). Conventional gyro tools are used in casing to confirm magnetic surveys taken.

HES: Halliburton Energy Services

Inner liner: A cemented casing string installed inside original production casing that does not extend to surface in wellbore.

Inner string: An additional casing string installed inside the original production casing. The inner string casing covers the original production casing to surface. Prior to installing an inner string, perforation and cement squeeze operations could be performed on the original production casing at hydrocarbon and water zones areas to ensure well has proper zonal isolation. Inner strings become the new production casing, requiring the area between the original casing and inner string to be cemented with a calculated cement volume.

Isolation: The status of a well when there is no communication between the well and the storage zone and/or reservoir. The installation of a mechanical device (i.e. retrievable bridge plug, packer, etc.) is required to achieve this.

Isolation Pressure Tests: A test in which pressure is applied in a well in the range of 500 psi to 1000 psi, depending on well construction and field characteristics. This test is performed after setting a tubing mechanical plug, installing a mechanical barrier and /or confirming cement presence, or setting a cement plug to prevent gas migration from the reservoir. (These tests are conducted every six months for wells taken out of operation at Aliso Canyon and require Safety Review Team [DOGGR] approval).

Kill (Well Kill): To stop a well from flowing or having the ability to flow into the wellbore. Kill procedures typically involve circulating reservoir fluids out of the wellbore or pumping higher density mud into the wellbore, or both. In the case of an induced kick, where the mud density is sufficient to kill the well but the reservoir has flowed as a result of pipe movement, the driller must circulate the influx out of the wellbore. In the case of an underbalanced kick, the driller must circulate the influx out and increase the density of the drilling fluid. In the case of a producing well, a kill fluid with sufficient density to overcome production of formation fluid is pumped into the well to stop the flow of reservoir fluids.*

Kill String: A kill string is used to kill a well, and it made up of an open-ended tubing installed to a calculated depth to achieve well control.

Liner: Any string of casing in which the top does not extend to the surface but instead is suspended from inside the previous casing string.*

Liner Top: The upper area of a suspended casing string (liner) in the bottom of a well which usually covers a small area of original production casing at the bottom of a well.

Magnetic Flux Leakage (MFL): A distortion of the magnetic flux that has been introduced into a casing by a low-frequency electromagnet or permanent magnet. The principle of flux leakage is used to detect casing corrosion, since flux leakage is caused by rapid changes in the thickness of the casing and by pits and holes in either the internal or external wall. Flux leakage distorts the magnetic-flux lines and induces a signal into an electric coil moving past it. In-situ flux-leakage measurements make use of this effect by placing coils on or close to the casing wall, azimuthally distributed to cover the entire wall. The results are often combined with a high-frequency, eddy-current measurement, designed to detect flaws only on the inner wall.* This data is used to calculate remaining burst pressures (MAOP x 1.15).

Type of MFL Logs:

Electromagnetic Thickness Log: A measurement of the thickness of casing, giving an estimate of metal loss and detecting corrosion

High Resolution Vertilog: The log uses magnetic flux measurements to identify and quantify internal and external corrosion defects. The multiaxial sensors (flux-leakage and discriminator sensors) provide circumferential inspection of the casing.

MicroVertilog: This tool creates a magnetic field to measure for any pitting in the steel casing and thickness of the steel.

Pipe Analysis Log: Measures magnetic flux leakage anomalies on the casing wall.

Vertilog: Measures magnetic flux leakage anomalies on the casing wall.

Maximum Allowable Operating Pressure (MAOP): Based on discovery pressure for each storage field, this is the maximum pressure which the well casings must be able to contain as demonstrated by casing integrity logs and pressure testing.

Mechanical Integrity Tests (MIT): Tests conducted to ensure casing integrity/zonal isolation. These tests may include but are not limited to Noise/Temperature surveys, Tracer surveys, Ultrasonic, Magnetic Flux Leakage, Multi Arm Caliper, Cement Bond Log and Block Pressure test.

Multi-Arm Caliper (MAC) or Multifinger Caliper: This tool measures the inside diameter of the casing, while searching for changes in the wall integrity issues related to interior casing features.

Notice of Intent (NOI): A DOGGR (now CalGEM) form filed by an Oil and Gas operator for well operations. The NOI contains the plans for well operations such as a well workover or abandonment. An NOI must be approved by DOGGR which then issues a permit to conduct the NOI plan.

Noise Log/Survey: A record of the sound measured at different positions in the borehole. Since fluid turbulence generates sound, high noise amplitudes indicate locations of greater turbulence such as leaks, channels and perforations. Noise logging is used primarily for channel detection, but has also been used to measure flow rates, identify open perforations, detect sand production and locate gas-liquid interfaces. The log may be either a continuous record against depth or a series of stationary readings. The log may indicate the total signal over all frequencies, the signal at a single frequency, or consist of a set of logs for different frequency ranges. Different frequency ranges can be tied to different sources of noise or different flow regimes.* This survey is conducted every six months for taken out of operation wells and annually for wells in service after receiving official approval from DOGGR.

Notice of Operation (NOP): The date of operation in which an asset becomes available for safe use.

NOP for wells under Order 1109: The well was deemed ready for NOP submittal once approval from the Safety Review Team was received confirming accepted integrity inspections and well conversion to tubing flow; or completing the abandonment operation and receiving an official approval abandonment letter (DOGGR Coastal District approval)

NOP for wells excluded from Order 1109: The date of returning the well to Above Ground Storage team after integrity inspections and conversion of well to tubing flow (well not necessarily in service), or the date of welding steel plate on top of casing at surface for abandoned wells.

Perforate (Perf - Abandonment /Pre-Abandonment-inner string): The creation of openings in casings/liners at hydrocarbon zones, water zones and/or areas of interest which lack sufficient cement bond. A perforating gun is used with specific length, count and phasing. Cement is injected through these openings to establish zonal isolation.

Perforate (Perf - Well Completion): The creation of openings on the bottom of the well casings/liners at production and/or pay zone (reservoir) to establish a path between reservoir formation fluids and the wellbore.

Perforating Gun: A device used to perforate (create openings) oil and gas well casings/liners in preparation for production or cement squeeze.*

Periodic Wellsite Inspections:

Daily Well Site: Observations of the equipment and conditions for each active well at the facility are conducted daily to check for signs of gas or liquid leaks. The operator uses visual, audible, and olfactory methods to detect leaks or abnormal conditions**.**

Monthly Well Site Inspection: This inspection includes the inspections performed under the "Daily Well Site Inspections." In addition, the cellar floor, structural components, access roads, and general condition of the well site are inspected.

Annual Surface Area Inspection: Surface area leak inspections of wells using gas detection equipment are conducted annually.

Plug and abandon (P&A): To prepare a wellbore to be shut in and permanently isolated.* The action includes removing flow control equipment, cleaning out the well bore, performing fishing operations, and pumping cement from the bottom of the well to the surface to isolate the reservoir. This includes, but is not limited to, isolating hydrocarbon and water zones.

Plugged: The action of setting a mechanical or cement plug to isolate reservoir after determining casing and cement integrity.

Pressure integrity test (See also *Casing Pressure Integrity Test*)

Production liner: A casing string that does not extend to the top of the wellbore, but instead is anchored or suspended from the lower portion of the previous casing string. There is no difference between the casing joints themselves.* A liner located at bottom of a well (below original production casing) that has access to production zones which minimize formation damage and provide sand control.

Production Tubing: A wellbore tubular used to produce reservoir fluids. Production tubing is assembled with other completion components to make up the production string. The production tubing selected for any completion should be compatible with the wellbore geometry, reservoir production characteristics and the reservoir fluids. *

Redress: The replacement or repair of items on a well as determined in manufacturer's specifications after quality assurance and testing.

Retrievable Bridge Plug (RBP) (See also *Bridge Plug*)

Return To Service (RTS): The date SoCalGas injects and/or withdraws gas after inspecting and converting well to tubing flow only, and after completing rigless, surface and site related operations.

Rig (Workover): A mobile apparatus with specialized equipment used to perform one or more remedial operations, such as deepening, plugging back, pulling and resetting liners, on a producing well to try to restore or increase the well's production. This can also be known as a *Workover Rig*.

Rigless Operation: A well-intervention operation conducted with equipment and support facilities that precludes the requirement for a rig over the wellbore. Coiled tubing, slickline and snubbing activities are commonly conducted as rigless operations.*

Scab liner: An un-cemented casing repair to isolate a specific zone using a dual packer system to avoid pressure increase in a specific zone.

Stage collar: A collar with open ports that allows cement operation to be performed in multiple stages.

Steel Liner: A repair or remediation method used to cover depths in original production casing with identified anomalies. This method is conducted by placing an expandable liner inside the production casing which seals and expands in the area of interest to restore integrity. May also be known as a *MetalSkin®*[45] *or Metal Skin Liner*.

Steel liner/casing patch (See also *Steel Line*r)

Subsurface safety valve (SSSV): A safety device installed in the upper wellbore to provide emergency closure of the producing conduits in the event of an emergency. Two types of subsurface safety valve are available: surface-controlled and subsurface controlled. In each case, the safety-valve system is designed to be fail-safe, so that the wellbore is isolated in the event of any system failure or damage to the surface production-control facilities.*

Surface Emergency Shutdown Valves: Injection/withdrawal wells are equipped with surface emergency shutdown valves (ESD) that will shut the well in automatically if pressures exceed pre-determined set points, excessive sand production occurs, or there is a fire in close proximity to the wellhead.

Taken Out of Operation (TOOO): A well that has been temporarily isolated and is not used for injection or withdrawal activities. The well is isolated with a mechanical device or cement plug located within the caprock that must be pressure tested and followed by a noise/temperature survey. TOOO wells must be filled with fluid and pressure monitored. Reservoir and identified casing anomalies must be isolated and followed by DOGGR approval every six months.

Temperature Survey: Temperature surveys monitor the mechanical integrity of a gas storage well and are used for leak detection. A temperature survey is a record of the temperature gradient in a well and is interpreted by looking for anomalies, or departures, from the reference gradient. This survey is conducted every six months for taken out of operation wells and annually for wells in service after receiving official approval from DOGGR.

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[45] MetalSkin is a registered trademark of Weatherford International.

TSH (Tenaris Hydril): A connection that withstands high tension, compression, temperature and pressure where connection outside diameter can be the same as pipe outside diameter or slightly larger.

Texas Coupling Premium Connection (TCPC): A type of connection with deep/long threads for additional tension capacity and 90° torque shoulder, negative pin to nose angle.

Tie back: A short piece of casing string or liner used to connect to another casing string below surface.*

Tubing: (See also *Production Tubing*.)

Tubing Pressure Test: Applying pressure (MAOP x 1.15) to an isolated production tubing in a well to determine the well's capability to withstand normal operating pressures during injection and withdrawal activities. (See also *Annular and Tubing Pressure Tests*.)

Tracer Survey: Tracer surveys monitor the mechanical integrity of a gas storage well and are used for leak detection. The well is placed on a small amount of injection and a tracer element is introduced to the injection gas. A tool is lowered down the wellbore that detects and follows the tracer element to ensure that injected gas is moving into the formation.

Ultrasonic (UT) Inspection: A nondestructive evaluation (NDE) inspection procedure that uses high-frequency sound waves to detect voids and imperfections of metal parts.*

> **Cast/Cast-V Log:** Circumferential acoustic scanning tool where ultrasonic pipe inspection (thickness and diameter) and cement evaluation are obtained simultaneously.

Weekly Pressures: Weekly pressure readings are used to monitor the mechanical integrity of a gas storage well and are used for leak detection. Pressures are measured and recorded weekly on each well using a calibrated pressure gauge.

Wellhead: The surface termination of a wellbore that incorporates facilities for installing casing hangers during the well construction phase. The wellhead also incorporates a means of hanging the production tubing and installing the Christmas tree and surface flow-control facilities in preparation for the production phase of the well.*

WFT (aka WEA): Weatherford International

Workover: The process of performing major maintenance or remedial treatments on an oil or gas well. In many cases, workover implies the removal and replacement of the production tubing string after the well has been killed and a workover rig has been placed on location.*

Workover fluid: A well-control fluid, typically a brine, that is used during workover operations* Fluid must be suitable to minimize damage to the reservoir or other productive zones.

Additional Field Notes:

I. MAOP x 1.15:
   a. Aliso Canyon (MAOP x 1.15) = 3625 psi;
   b. Honor Rancho (MAOP x 1.15) = 4450 psi;
   c. La Goleta (MAOP x 1.15) = 2140 psi;
   d. Playa Del Rey (MAOP x 1.15) = 1806 psi

II. Isolation pressure requirements:
   a. 1000 psi for Aliso Canyon and Honor Rancho;
   b. 500 psi for La Goleta and Playa Del Rey.