BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Rita Boppana, Complainant, vs. Southern California Gas Company, Defendant.	Case 00-05-010 (Filed May 11, 2000)
And Related Matters.	Case 00-05-011 (Filed May 11, 2000) Case 00-05-012 (Filed May 11, 2000)

THE PLAYA DEL REY GAS STORAGE FACILITY GAS MIGRATION HAZARDS; AND THE DUTIES IMPOSED TO MONITOR AND MITIGATE THESE DANGEROUS CONDITIONS

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I. <u>EXECUTIVE SUMMARY OF THE PLAYA DEL REY GAS STORAGE FACILITY GAS MIGRATION HAZARDS</u>:

A. FOR MANY YEARS SOCALGAS HAS KNOWN OF THE EXACT MANNER IN WHICH GAS LEAKS INTO THE NEAR-SURFACE SOILS, AQUIFERS AND INTO THE AIR AT PDR:

In an engineering report prepared by Rick Lorio, Associate Petroleum Engineer of Underground Storage for Southern California Gas Company ("SOCALGAS"), the manner in which gas leaks to the surface at Playa Del Rey ("PDR") is described in detail (see Exhibit 1). This engineering analysis report was prepared, and is dated April 25, 1985. Extensive additional engineering reports and measurement data prepared by SOCALGAS reveal that large quantities of gas migrate upward into the surface casings of the old well bores at PDR. These surface casings were initially drilled and cemented to the rock formation at a typical depth of 700 feet below the surface. This is illustrated in the Exhibit 1 Attachments that diagram the well casings, and the paths of gas migration.

Effectively, the surface casings – and the annular volumes that exist between the main casing and the surface casings – serve as collection "containers" for the upward migrating gases, as illustrated in Exhibit 1. SOCALGAS has monitored the gas pressures and the gas composition in these surface casings continuously over many years. These data reveal the <u>central</u> <u>defects</u> existing in the old well bores, in allowing gas to migrate into the near-surface soils and aquifers.

Exhibit 1 identifies these defects, and describes what mitigation measures need to be taken. In summary, these are described in the report as follows (emphasis added):

> <u>Problem</u>:
>
> All wells have some uncemented segments. <u>Few wells have any cement above 2000</u>. Formation sloughing may have filled in some of these wellbores <u>but most remain the most permeable upward path for gas migration</u>.

Solution:

Noise and TDT monitor active wells to find areas of increasing activity. Continually produce shallow zones. Vent to atmosphere all gas coming from surface casing shoe aquifer.

This description is provided in Exhibit 1 under the caption "Uncemented Wellbore Leaks: Type 3." Under the caption "Casing Shoe Leaks: Type 2," the following is described:

Problem:

Casing shoe leaks due to poor, deteriorated cement or to leakage through wso holes in active or abandoned wells.

Solution, Abandoned Wells:

Collect all free gas from overlying zones. Repair work not possible.

In summary, the "Solutions" set forth above by SOCALGAS include:

1. "Continually produce shallow zones."

2. "Collect all free gas from overlying zones."

Under the caption "Abandonment Plug Leaks: Type 4," two types of abandonment are described:

Problem, Type A Abandonment:

Cement plugs inside casing allow some gas to migrate upwards. Because its casing was cut off below the surface string, water will continue to fill casing as gas leaks out. Leak will therefore be sporadic and low rate.

Problem, Type B Abandonment:

Cement plugs inside casing allow some gas to migrate upwards. Because the casing stub is cut off within 100' of surface, the entire surface casing fills with gas. No liquid enters the well. The gas leak unloads fluid from the well and the rate increases with time. Eventually all of the fluid unloads and the leak rate stabilizes at a near constant daily rate.

Problems, Both Type Abandonments:

1. Casing cap, surface casing and casing shoe cement competent. Gas will build up inside surface casing and force its way into shallow aquifer sand. Gas will surface at a non-leaking well that has the following problems.

2. Casing cap not competent. Gas will surface near well.

3. Surface casing or shoe cement not competent. Gas will spread over large area as it rises to surface lethargically.

Solution, Problem 1:

Direct repair of leaking well not possible because source well is unknown. Other wells where gas appears are continually vented to surface.

Solution, Problem 2:

Unearth well and recap or place collection funnel over it. Rig work not required. Vent all gas to atmosphere.

Solution, Problem 3:

Unearth well, move in rig, attempt to enter and repair old casing. Produce gas through casing into low pressure system. Vent surface annulus to atmosphere.

In summary, the "Problems" and "Solutions" identified under the caption "Abandonment Plug Leaks: Type 4" reveal the true nature of how the abandoned wells at PDR cause the near-surface aquifers to be continually recharged with the leaking gas:

1. "Gas will build up inside surface casing and force its way into shallow aquifer sand."

2. "... the [leak] rate increases with time ... and the leak rate stabilizes at a near constant daily rate."

3. "Gas will spread over large area as it rises to the surface lethargically."

The central issue addressed by SOCALGAS in the above topic is the manner in which "gas will surface at a non-leaking well." This issue was addressed, and corroborated the above finds, in a report prepared by Babson and Sheppard, petroleum engineers, dated July 23, 1985. Their findings included the following (emphasis added):

1. "Leakage of natural gas from underground gas storage reservoirs is not unusual."

2. "The sustained high pressures at which such projects frequently operate tend to develop pockets or channels of gas saturation which are outside the confines of the normal storage reservoir."

3. "The Storage Reservoir is particularly susceptible to occurrences of this nature because of the large number of oil wells drilled into the field's reservoirs prior to initiation of the storage operations." [Exhibit 2 is attached herein to identify the oil wells that were drilled into the PDR Storage Reservoir prior to initiation of the storage operations.]

4. "Each of those wellbores provides a potential channel for the uncontrolled migration of fluid."

5. "Gas could migrate from the storage reservoir through one wellbore to an upper formation, then through a second wellbore to yet higher formation.

6. "Such upward flows could be expected to occur naturally over time even without the presence of the storage operation."

7. "Gas remaining in depleted, abandoned reservoirs will naturally tend to seek a route to a site of lower-pressure – a shallower formation."

8. "It could even be driven toward the available flow channels by the entry of edgewater into the reservoir seeking to replace the depleted hydrocarbon saturation.

9. "The Gas Company's storage project tends to emphasize this potential for upward migration because of the high pressures necessary for its operation."

SOCALGAS has long recognized these problems at PDR, including by way of entering into contractual agreements that purport to allow "storage" of their gas as close to the surface as 500 feet. Namely, quoting from the SOCALGAS report described above:

- "Gas will build up inside surface casing and force its way into shallow aquifer sand."
- "Gas will spread over large area as it rises to surface lethargically."

The corresponding language in contractual legal documents filed with the Los Angeles County Recorders Office by SOCALGAS typically reads as follows:

- FOR A VALUABLE CONSIDERATION, receipt of which is hereby acknowledged, HUGHES TOOL COMPANY, a corporation organized under the laws of the State of Delaware, hereby conveys to SOUTHERN CALIFORNIA GAS COMPANY, a corporation, the exclusive right to use subsurface mineral, oil and/or gas zones for injecting, storing and withdrawing natural gas (whether produced from such or other property) therein and therefrom and for repressuring the same; but with no right to use the surface or to carry on such operation except between a depth of -500 feet to -7000 feet from the surface thereof in the following described property:
- Hughes Tool Company hereby convenants and agrees to prohibit exploration for mineral, oil, gas or other hydrocarbons between depths of -500 feet to -7000 feet from the surface of the above described property.

Clearly, the "exclusive right to use subsurface mineral, oil and/or gas zones for injecting, storing and withdrawing natural gas (whether produced from such or other property) therein and therefrom and for repressuring the same," would be inclusive of the shallower migration zones described in the Babson and Sheppard report quoted above.

Furthermore, the geographic extent of the property [viz., "the following described property:"], as described in the documents recorded with the County Recorder's Office, establish the true boundaries over which SOCALGAS has direct legal responsibility regarding gas leaking to the surface. These boundaries need to be carefully identified regarding the legal issues that are to be addressed regarding this proceeding.

In summary, the legal analysis regarding SOCALGAS responsibilities relating to the leaking gases at PDR must consider the above foundational material critical in this determination. The above factual foundation is essential in establishing the true nature of the legal undertaking of SOCALGAS in operating an underground gas storage field in a partially depleted oilfield under high pressure, where a large number of oil wells were drilled into the field's reservoirs prior to initiation of the storage operation. The controlling legal issues regarding this undertaking will be discussed below.

B. SOCALGAS DEVELOPED PROCEDURES FOR MONITORING AND COLLECTING LEAKING GASES, BUT FAILED TO IMPLEMENT THESE PROCEDURES AT PDR

In a document prepared by SOCALGAS titled, "Gas Inventory Monitoring, Verification, and Reporting Procedures," (see Exhibit 3), the following procedures are described for the monitoring and collection of the leaking gases, as detailed in the Rick Lorio report titled, "The Playa Del Rey Monitoring Program," (see Exhibit 1), under the caption Non-Storage Zone Wells, at page 5 of 18, the following is described (emphasis added):

Non-storage zone wells monitored include both Company wells and wells owned by others in overlying and underlying zones and in other fields within two miles of the storage reservoir boundary, where applicable. These wells are categorized as follows:

i. Pressure observation wells are located in overlying and underlying permeable formations, or adjacent to the storage reservoir but across assumed confining boundaries, such as faults, permeability pinchouts, below the gas-liquid contact or beyond the spill point of the storage zone's confining structure. Although normally static, these wells may have artificial lift mechanisms for removal of gas and fluids.

ii. Gas collection wells are located where known gas migration from the storage zone is intercepted and collected. These wells are normally equipped with operating artificial lift mechanisms so that both liquids and gas can be produced, causing a pressure sink in the reservoir near the wellbore.

iii. In some fields, shallow water observation wells have been drilled into aquifer zones existing in the first permeable sand above the shoe of the surface casing. These wells are closed in at the surface and gas concentrations in the wellbore are measured weekly.

It is important to recognize that Rick Lorio addressed these same issues with the following relevant language (see previous discussion herein) (emphasis added):

- "Gas will build up inside surface casing and force its way into shallow aquifer sand."

Clearly, the monitoring and collection procedures highlighted above are critical in dealing with shoe leaks occurring at the bottom of the surface casing, located at a typical depth of 700 feet, as illustrated in Exhibit 1. Succinctly, these procedures are described as follows (emphasis added):

> ". . . shallow water observation wells have been drilled into aquifer zones existing in the first permeable sand above the shoe of the surface casing."

At PDR there are permeable sands extending to a depth of at least 500 feet. Accordingly, it is critical that the cement shoes on the active and abandoned wells at PDR be evaluated for integrity using the shallow water observation wells design procedure developed by SOCALGAS. In particular, Rick Lorio of SOCALGAS, in Exhibit 1, warns that if the surface casing or shoe cement is not competent "gas will spread over large area as it rises to surface lethargically."

More importantly, is the high pressure gas that has been extensively measured by third parties in the "50 Foot Gravel," which is a shallow sand and gravel aquifer that overlies the legal boundaries that SOCALGAS claims to have the contractual legal authority to store gas as close to the surface as 500 feet. However, SOCALGAS has consistently denied any legal responsibility over this pressurized gas, and has failed to monitor or collect these gases at PDR in their efforts to shirk their responsibility for the leaking gases.

In a document prepared by the Consumer Protection and Safety Division of the California Public Utilities Commission, dated August 20, 2002 and revised on November 18, 2004 titled, "Complaint Case Facts and Findings (Playa Del Rey Storage Field)" the following facts and findings were set forth:

- Three Types of Natural Gas in PDR:

  "There is evidence of surface detection of three types of natural gas in PDR, namely: Biogenic gas, Native PDR Thermogenic gas and Storage Reservoir Thermogenic gas."

- 133 PPM Helium from Bar-Hole Samples near Big Ben Well:

  "SoCalGas internal office memorandum, dated November 20, 1991 revealed that gas samples collected from bar-holes around Big Ben Well contained 30,000 PPM to 620,000 PPM natural gas and these samples contained 133 PPM to 188 PPM Helium. A close examination of the memo reveled that three samples were collected on 1/11/91, at bar-holes #12, 13 & 14. Isotopic analysis of these samples indicated with high probability the signature of Storage Reservoir gas (meaning that the gas migrated from Storage Reservoir). In addition, the memo did not indicate any more sampling at these bar-holes or subsequent remedial action. On 8/23/91 and subsequent dates, samples were collected from bar-hole H instead of bar-holes 12, 13 & 14. The isotopic analyses of the new samples did not reveal the storage gas signature and subsequent discussion on the memo ignored the initial sample data, its significance and if there was any remedial action."

- 22 PPM Helium from a Shallow Probe Sample by John Sepich and Associates:

  "Isotech Laboratory performed an isotopic analysis of a gas sample submitted by Sepich & Associates on 3/25/99. Sepich and Associates was working for Playa Vista developers (developers of residential and business properties around the PDR Storage field. The isotopic analysis report indicates the gas sample was collected from Playa Vista Project Area-D. The analysis report also revealed presence of Ethane and 22 PPM Helium in the gas sample. The significance of this isotopic analysis report is the presence Storage Reservoir gas or Native PDR gas signature and the location where the gas sample was collected (Area-D of Playa Vista Project). My opinion is that the probability of Storage Reservoir gas sample from PDR area containing Ethane and 22 PPM Helium is greater than 50 percent (>50%). Furthermore, the location where the sample was collected should be of major concern" (emphasis added).

- 100 PPM-1000 PPM Helium from Groundwater Samples Collected and Analyzed by Exploration Technologies, Inc. (ETI):

  "City of Los Angeles Building and Safety Department retained ETI to conduct test, analyze and provide advice on Playa Vista project. Groundwater samples were collected in 2000 from Playa Vista Project Area, and dissolved gases were extracted and analyzed by ETI in addition to other scientific sampling and testing. Several groundwater samples revealed presence of high Helium concentrations and Methane dissolved in the groundwater. The origin of this Helium in the groundwater is not clear. However, some people have postulated that the groundwater absorbs or strips the Helium from the Storage Reservoir gas or Native PDR gas as it migrates through the aquifer to the ground surface. Hence, Thermogenic gas is detected in soil-gas without Helium.

Although this postulation seems plausible, I have not seen any scientific paper on this absorption theory and the kinetics."

- Dr. Victor Jones of ETI detected Thermogenic gas components at the Surface and detected H2S in Soil Gas during his investigation in 2000:

  "ETI conducted an extensive soil gas investigation in Playa Vista area for the City of Los Angeles in 2000. The isotopic analysis report of the samples collected revealed presence of Methane, Ethane, Helium, H2S, Toluene and other volatile organic compounds (voc). The presence of numerous Thermogenic gas components in the shallow soil gas samples analyzed indicates a deeper source for this gas."

- Previous Reservoir Inventory Verification Analysis by SCG indicated gas migration loss (8/22/80):

  "A Reservoir Inventory Verification Analysis conducted by Theodoros Georgakopoulos on August 22, 1980 for SoCalGas indicated gas migration loss. The migration pathways to the Townsite area (separate geologic zone) is unknown. The report estimated storage reservoir gas loss between January 1961 and December 1979 to be 0.10 B.c.f. Subsequent reports estimated the gas loss to have decreased."

- Presence of Methane gas around Troxel Well:

  "As part of Energy Division (ED) initial preliminary investigation, ED retained MHA, who subcontracted Giroux & Associates to conduct site investigations at the Troxel and Lor Mar well site locations in 2001. These recent studies found very high methane concentrations (greater than 50,000 ppm) at the Troxel site and low methane concentrations (1 to 6 ppm) at the Lor Mar site" (emphasis added).

Investigation reports, including reports prepared on behalf of SOCALGAS, reveal the common occurrence of gas leaking to the surface at the location of the surface casing. Namely, leaking from the annular space, and volume, existing between the surface casing and the primary oilwell casing. This is especially true for the many abandoned wells that were found to be leaking gas to the surface, and required reabandonment. These include wells Troxel, Townsite 2, Block 11 and others. This would reveal the urgent need to carefully evaluate the shoe leak and cement conditions at each of the abandoned wells within the PDR field, using the procedures previously described herein, as developed by SOCALGAS.

Regarding operational wells, SOCALGAS has been monitoring the surface casing volumes for gas pressures, rate of pressure build-up, gas constituents – including Helium, and other leakage conditions for many years. These data are very important regarding identifying the manner in which gas is migrating up the wellbores, and entering the aquifer zones at the shoe leak locations.

The above report by the Consumer Protection and Safety Division of the PUC has not included these important field measurement data gathered by SOCALGAS over many years. It is important to note that these data, including Helium counts, have been used by SOCALGAS to determine the extent of storage gas leakage into the geologically connected permeable reservoirs that surround the PDR "primary" gas storage area.

This migration of storage gas into the surrounding geologically connected reservoirs has been <u>continuously</u> ongoing since the primary storage reservoir pressure was raised above 750 pounds per square inch, beginning in the early 1940's. This storage gas has <u>commingled</u> with the billions of cubic feet of native gas that has existed within PDR oilfield, before its conversion to an underground storage facility.

For the foregoing reasons, the gas samples that have been collected from the oilwell surface casings, from surface seeps, and from dissolved and free gases in the 50 Foot Gravel zone, contain a mixture of storage gas (including Helium), Native gas, and <u>Carcinogens</u> that are carried to the surface by the upward migrating gases.

It is important to note that the surface casings, and the gas pressure build-up therein are routinely vented to the atmosphere in accordance with the "Solutions" recommended by Rick Lorio, in the report discussed above. Namely these included (emphasis added):

> "Vent to atmosphere all gas coming from surface casing shoe aquifer,"

Accordingly, this intentional venting of gas to the atmosphere – in which the gas has been confirmed to contain carcinogens – is of great concern. Many of these wells are located in close proximity to homes and apartments in the PDR area, and such venting presents a serious health hazard.

C. SOCALGAS HAS CATEGORICALLY DENIED ANY VERTICAL GAS MIGRATION AT PDR, CLAIMING THAT THE FIELD ACTS AS A CLOSED CONTAINER, AND DENIES ANY RESPONSIBILITY FOR THE FOREGOING DESCRIBED CONDITIONS:

The first attempt that SOCALGAS made to deny responsibility was to hire Dr. Kaplan, a geochemist, to evaluate the surface gas seeps for chemical composition. His results in the 1992 and 1993 time period were proclaimed by SOCALGAS, including in the newspapers, to prove that the surface gas seeps at PDR were biogenic gas (commonly described as swamp gas). These findings were later totally discredited by the soil gas investigations carried out by Exploration Technologies, Inc. (ETI) of Houston, Texas on behalf of the City of Los Angeles.

As summarized above by the Consumer Protection and Safety Division, of the California Public Utilities Commission, the surface seeps were determined to be thermogenic in gas composition, and originating from a deep source (viz., not swamp gas). Furthermore, the so-called John Sepich probe – that extended to a depth of 20 feet, for the first time – revealed significant levels of helium in the seeping gases (viz., 22 ppm helium from his 20-foot deep soil gas probe).

A much more detailed analysis of the seeping gases was performed by Victor Jones of ETI, in which his findings are summarized above in the identified Consumer Protection and Safety Division report. His gas samples were collected using, for the first time, much deeper soil gas probes that extended into the "50 Foot Gravel," with samples collected from depths exceeding 50 feet.

Water samples were also collected from these much deeper sampling depths, and analyzed for the dissolved gas chemical compositions. These samples further confirmed the thermogenic character of the seeping gases, in that they contained methane, ethane, helium, H2S, toluene (a carcinogen) and other volatile organic compounds (VOC's) consisting of propane, butane and xylenes. These gases are especially characteristic of thermogenic oilfield gas. These compositions are also typical of those gases leaking from the abandoned wellheads, that have required reabandonment throughout the PDR field.

Most noteworthy of the <u>deep</u> soil gas samples (viz., below 50 feet) collected by Victor Jones of ETI were the very high helium count levels of between 100 ppm and 1000 ppm, as reported in the Consumer Protection and Safety Division.

A further attempt was made by SOCALGAS to conceal the true dangers of the leaking abandoned wells by claiming that the wellhead leaks were biogenic gas, and not having anything to do with their storage operations. However, the true chemical analysis of the leaking cases contained methane, ethane, propane, butane and other higher order hydrocarbons, entirely consistent with thermogenic gas, that was leaking from a deep source.

Furthermore, senior technical personnel from SOCALGAS have proclaimed before City of Los Angeles hearings on the PDR field, that there is no vertical gas migration out of the field, and the storage reservoir acts as a closed container. It is important to note that the PDR facility operates under a Conditional Use Permit ("CUP") issued by the City of Los Angeles. An important condition of this CUP is as follows:

> "That the underground gas pressure shall be kept sufficiently low so that there will be no escape of gases into the air above the ground."

All of the above described factual issues relate directly to the "Scoping Memo" dated March 7, 2005 which stated the issues that are in controversy regarding the subject adversary proceeding:

> "If the SoCalGas Playa Del Rey gas storage facility is venting or leaking gas or depositing carcinogens into the air or soil to the detriment of the health or safety of the neighboring community" (emphasis added).

The above factual framework is essential in identifying the legal duties imposed upon SOCALGAS as a consequence of undertaking a gas storage operation in the partially depleted oilfield of Playa Del Rey.

D. SOCALGAS HAS THE DUTY TO MONITOR AND PROTECT AGAINST THE GAS MIGRATION HAZARDS AT THE PDR FACILITY BECAUSE THEY UNDERTOOK TO OPERATE A GAS STORAGE FACILITY IN A PARTIALLY DEPLETED OILFIELD, CONTAINING MANY PREVIOUSLY DRILLED WELLS; CREATING A KNOWN DANGEROUS CONDITION:

The controlling principle of law imposed upon SOCALGAS regarding the PDR facility is set forth in Restatement Second of Torts Section 321:

§321. Duty to Act When Prior Conduct is Found to be Dangerous

(1) If the actor does an act, and subsequently realizes or should realize that it has created an unreasonable risk of causing physical harm to another, he is under a duty to exercise reasonable care to prevent the risk from taking effect.

(2) The rule stated in Subsection (1) applies even though at the time of the act the actor has no reason to believe that it will involve such a risk.

Within the meaning of "actor" regarding the PDR facility would be the "act" of undertaking a gas storage operation in the partially depleted Playa Del Rey oilfield by SOCALGAS.

SOCALGAS subsequently realized, or should have realized, that the many old oilwells drilled into Playa Del Rey oilfield – before they began their operations – would serve as conduits for both storage gas and native oilfield gas to escape and migrate to the surface.

There was a duty imposed to exercise reasonable care to prevent the risk from taking effect. In fact, SOCALGAS developed written policies and procedures (viz., as described above) to monitor and mitigate against the risks created by the upward migration of gases into shallow zones. However, these policies and procedures were not implemented at the PDR facility. They are believed to have been implemented at other underground gas storage facilities operated by SOCALGAS, at least in part.

Accordingly, the appropriate standard of care to be employed at the PDR facility is established by these written policies and procedures. In summary, these include:

1. Monitoring of both Company wells and wells owned by others in overlying and underlying zones and in other fields within two miles of the storage reservoir boundary.

2. Drill shallow water observation wells into the aquifer zones existing in the permeable sand zones above the shoe of the surface casing.

3. Locate pressure observation wells in overlying and underlying permeable formations, or adjacent to the boundaries, such as faults, permeability pinchouts, below the gas-liquid contact or beyond the spill point of the storage zone's confining structure.

4. Install artificial lift mechanisms for removal of gas and fluids, within the above described offending areas.

For the foregoing reasons, it is essential to establish the legal boundaries of the true extent of the storage reservoir. SOCALGAS claims to have storage rights provided presumably by the relevant documents on file with the Los Angeles County Recorder's Office. These documents need to be carefully identified, primarily to establish the true "legal" boundaries of the PDR facility.

The established boundaries of the PDR facility would then allow determining the monitoring program needed within "two miles of the storage reservoir boundary," as described in paragraph (1) above.

In summary, the PDR facility must conform to an appropriate standard of care, commensurate with the extreme hazards posed by storing billions of cubic feet of flammable and explosive gas under a highly urbanized residential community. T.his extreme hazard is exacerbated by the hundreds of old oilwells that were drilled into the Playa Del Rey oilfield, many years before the gas storage operations began, thereby severely compromising the rock formations sealing capacity.

Furthermore, it is a well known characteristic of all gas storage fields that the gas leakage losses are directly proportional to the reservoir pressure. The Babson and Sheppard Report, discussed above, identified this hazard in the following way:

> "The Gas Company's storage project <u>tends to emphasize this potential for upward migration because of the high pressures necessary for its operation</u>."

SOCALGAS studies have confirmed that the primary storage area of the PDR field begins to leak when the reservoir is pressurized <u>above 750 pounds</u> per square inch. In contrast, the primary storage reservoir pressure frequently reaches 1700 pounds per square inch, more than double the pressure that precipitates the gas leakage

E. SOCALGAS IS RESPONSIBLE FOR THE LEAKING GAS CONDITIONS AT PLAYA DEL REY BECAUSE THEY EXERCISED <u>EXCLUSIVE CONTROL</u> OVER THE OLD OILWELLS, AND THE DANGEROUS CONDITIONS CREATED BY THEIR DETERIORATED CONDITIONS:

SOCALGAS acquired exclusive control over hundreds of old oilwells that had been drilled, and many of them abandoned, <u>prior</u> to SOCALGAS undertaking gas storage operations in the PDR field. As previously discussed, the Rick Lorio Report itemized the central defects in these old wells, including:

1. All wells have some uncemented segments. Few wells have any cement above 2000 feet. . . . <u>but most remain the most permeable upward path for gas migration</u>.

2. Casing shoe leaks due to <u>poor deteriorated cement</u> or to leakage through <u>water shut-off holes</u> in <u>active or abandoned wells</u>.

3. Surface casing and surface casing shoe cement (viz., at a typical depth of 700 feet) are not competent. <u>Gas will build up inside surface casing and force its way into shallow aquifer sand</u>.

4. Gas will surface at a <u>non-leaking well</u>, including at wells where the surface casing or shoe cement is not competent. <u>Gas will spread over large area</u> as it rises to surface lethargically.

Surface casing leaks, especially in old abandoned wells, have been documented repeatedly at PDR over many years. The issues raised in paragraph 4, above, are especially important regarding the degree of care and soil gas monitoring necessary to identify which of the old wells are truly leaking. Namely, gas will surface at a non-leaking well. Accordingly, even if the well is reabandoned at the location where the gas is surfacing, this will not cure the leaking well problems.

This problem is especially serious at PDR because of the very extensive sand and gravel permeable zone that was laid down over geologic time by the original river channel flow of the Los Angeles River. This shallow, highly permeable zone, is commonly known as the "50 Foot Gravel." However, other permeable zones exist extending to a depth of approximately 600 feet.

In fact, the surface casing depth requirements (viz., typically 700 feet) are dictated by State of California law, mandating that the surface casing be protective of the fresh water zones overlying the oilfield. Namely, the very conditions described in the Rick Lorio Report identify violations of State Law:

> "Gas will build up inside surface casing and force its way into shallow aquifer sand."

In short, the sealing integrity of the old surface casings, especially including the cement shoe at a typical depth of 700 feet, is pivotal regarding the operations and maintenance of the PDR field.

Historical drilling records reveal serious problems with achieving a competent cement seal when the surface casing was being cemented to the surrounding rock formation. This was especially serious for the Townlot Wells that were closer to the Pacific Ocean beach. The drill hole would often collapse during the drilling operation, preventing a proper cement squeeze at the shoe location of the surface casing.

Furthermore, saltwater intrusion from the nearby Pacific Ocean is also highly corrosive to the steel surface casing, and is known to cause significant deterioration of the concrete shoe materials.

These wells were drilled in the 1920's and 1930's, as identified herein in Exhibit 2. Certainly, when they were drilled in this early time period, there was no contemplation that the oilfield would ever be used for storing high pressure. The technology for storing natural gas in a partially depleted oilfield had not yet been invented in the 1920's/1930's. Also, the technology for performing well completions and cementing operations were still within their infancy.

The history of the oilwell acquisitions by SOCALGAS at PDR were largely dictated by the large volumes of storage gas that were leaking out of the primary storage area. Once the storage pressure was raised above 750 pounds per square inch, storage gas began leaking into oilwells operated by Union Oil Company. Initially, Union Oil Company and SOCALGAS entered into an agreement regarding how much SOCALGAS would pay Union Oil Company for the return of the lost gas, plus any additional native gas produced by Union Oil from their wells. Eventually, all right title and interest to these wells were conveyed to SOCALGAS, with legal title conveyed pursuant to documents on file with the Los Angeles County Recorder's Office.

It was also discovered by SOCALGAS that storage gas was leaking into the area known as the Townlot Wells, and migrating as far north as the Troxel well location. For this reason, SOCALGAS acquired all legal interests to these wells, as documented in records on file with the Los Angeles County Recorder's Office.

For the foregoing reasons, SOCALGAS has a direct legal ownership interest in these wells. The mere abandonment of these wells does not extinguish the responsibility of SOCALGAS over the proper monitoring and the maintaining of these wells in a safe condition.

The basic public policy of California if that every person is responsible for an injury, to property or person, caused by his or her lack of ordinary care or skill in the management of his or her property. See Civil Code Section 1714(a), and the numerous Appellate and Supreme Court decisions that have interpreted its application to ownership interests, such as are involved herein.

It is important to recognize that the surface casings of the abandoned wells extend into the surface rights area located above 500 feet. Rick Lorio points out in his report, as discussed above, the gas migration hazards created by this condition:

1. Because the casing stub is cut off within 100 feet of the surface, the entire surface casing fills with gas.

2. The gas leak unloads fluid from the well and the rate increases with time.

3. Eventually all of the fluid unloads and the leak rate stabilizes at a near constant daily rate.

These facts establish that there is an ongoing trespass to the surface property ownership interests, especially since the gas is leaking at a depth of approximately 100 feet. Furthermore, as described by Rick Lorio, the gas will spread over large areas as it rises to the surface lethargically. Accordingly, there are violations of trespass laws on adjoining surface properties as well.

These violations would also constitute nuances because of the explosive and carcinogenic character of the migrating gases.

The Public Utility Code mandates by statute that all utility property be maintained in a safe condition. Accordingly, the legal ownership of the above-described wells by SOCALGAS imposes an obligation upon them to properly monitor and mitigate the hazards associated with these wells, as described above.

Furthermore, there is a need to provide proper warning to the surface owners regarding the need to take preventative measures to protect themselves and their property from the above-described leaking gases.

II. THE QUESTION BEING SUBMITTED TO THE COMMISSION, WHICH WAS "FRAMED" BY SOCALGAS, MAKES NO LOGICAL OR LEGAL SENSE IN THE CONTEXT OF THE TRUE FACTUAL ISSUES, AS SET FORTH ABOVE:

A. THE LEGAL ARGUMENTS ADVANCED BY SOCALGAS ARE MISPLACED, AND LACK FOUNDATION:

The specific question that has been "framed" by SOCALGAS, and not agreed to in that context by Grassroots Coalition, for submittal to the Commission by briefs is as follows:

> "Does SOCALGAS have responsibility for any non? storage and non? pipeline gas that migrates through an area where SOCALGAS owns the mineral rights but does not use SOCALGAS? active or abandoned wells as a conduit to migrate to the surface or from one underground reservoir or zone to another?"

Even if any scientific or legal sense can be made of this convoluted description, it still is objectionable because it lacks foundation regarding the issues relevant to this adversary proceeding.

S M

As previously stated, the "scoping memo" identifies the relevant issues as follows:

> "If the SoCalGas Playa Del Rey gas storage facility is venting or leaking gas or depositing carcinogens into the air or soil to the detriment of the health or safety of the neighboring community" (emphasis added).

> "Does SOCALGAS have responsibility for any non? storage and non? pipeline gas that migrates through an area where SOCALGAS owns the mineral rights but does not use SOCALGAS? active or abandoned wells as a conduit to migrate to the surface or from one underground reservoir or zone to another?"

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> "If the SoCalGas Playa Del Rey gas storage facility is venting or leaking gas or depositing carcinogens into the air or soil to the detriment of the health or safety of the neighboring community" (emphasis added).

Section I. of this report has addressed the factual foundation upon which this Scoping Memo addresses. The question posed above, as framed by SOCALGAS, goes far afield of this Scoping Memo by creating its own technical jargon.

First of all, it is not possible to scientifically define the term "non storage gas," and SOCALGAS has made no attempt to define this term. Fundamentally, when the natural gas is injected into the partially depleted PDR oilfield by SOCALGAS under extremely high pressures, this gas commingles with the native oilfield gases existing in the reservoir. Furthermore, these high-pressure conditions cause the commingled gases to migrate into numerous geologically connected oilfield reservoirs that contain even larger quantities of native gases. This multiple commingling constitutes the gases that become available to migrate up the old well bores and faults, as described in the SOCALGAS Rick Lorio report detailed above. This would also be the nature of the venting or leaking gases set forth in the Scoping Memo.

Secondly, even if there were so-called "non storage" and/or "non pipeline" gas migrating through the mineral rights territory of SOCALGAS, this gas would become commingled with the storage gas and the native gases, already commingled in mineral rights territories of SOCALGAS. In short, once the hypothetical gas migration occurred, it would automatically lose whatever unique identity it was presumed to have.

SOCALGAS has failed to give any clue as to how this identity is to be carried out scientifically.

Thirdly, the issue as framed by SOCALGAS, expressly excludes a determination by the Commission of responsibility for gas that migrates and uses SOCALGAS active or abandoned wells. As set forth in Part I. of this report, the central gas migration hazards at the PDR facility are the active or abandoned wells serving as conduits for the commingled gases to reach the surface, and into the near-surface permeable zones, including freshwater aquifers.

Accordingly, any determination of the responsibility issues, as framed by SOCALGAS, would be <u>meaningless</u> within the context of the Scoping Memo.

B. SOCALGAS HAS MISUNDERSTOOD THE STANDARD OF CARE IMPOSED UPON THEIR UNDERGROUND GAS STORAGE OPERATIONS AT THE PDR FACILITY:

The fundamental premise of responsibilities imposed by negligence law, is the duty to act reasonably under the circumstances. This is established by determining the standard of care required. Conduct falling below this standard of care, can be found to be negligent conduct. The appropriate responsibilities, under the instant set of facts, are established by this standard of care.

Accordingly, it is meaningless herein to focus upon the single issue of mineral rights and/or storage. Although these become one aspect of the overall issues, they, in themselves, misdirect attention away from the central issues identified in the Scoping Memo. The totality of contractual documents, and their specific languages need to be evaluated.

The Conditional Use Permit issued by the City of Los Angeles, and the contractual obligations imposed upon SOCALGAS regarding the prohibition of operating the gas storage facility at pressures that would cause gases to leak into the air, must be considered in establishing SOCALGAS responsibilities.

Various California Administrative Codes prohibit the leakage of gas from surface casings into adjoining permeable aquifers, and must be considered in determining SOCALGAS responsibilities. Violations of the Regulations could be deemed negligence per se under a negligence standard of care legal responsibility analysis.

SOCALGAS has ignored these central issues in their legal analysis. In addition, they have ignored any legal issues related to strict liability. An entire body of law exists related to operating an abnormally dangerous activity, in which responsibility, or legal liability is imposed irrespective of the degree of care that is used in carrying out the operation. Namely, liability can be imposed even if SOCALGAS was able to show that they operated the PDR facility with utmost care.

The test to be used for determining if the PDR facility constitutes an abnormally dangerous activity is set forth in Restatement Second of Torts § 520:

> In determining whether an activity is abnormally dangerous, the following factors are to be considered:
>
> (a) existence of a high degree of risk of some harm to the person, land or chattels of others;
>
> (b) likelihood that the harm that results from it will be great;
>
> (c) inability to eliminate the risk by the exercise of reasonable care;

(d) extent to which the activity is not a matter of common usage;

(e) inappropriateness of the activity to the place where it is carried on; and

(f) extent to which its value to the community is outweighed by its dangerous attributes.

Central to this evaluation are items (d) and (e). Regarding (d), the extent to which the activity of storing gas under high pressure in a partially depleted oilfield, in an urban setting, is certainly an activity that is not a matter of common usage. Regarding (e), the above-described activity is certainly an inappropriate activity to be carried out in a high-density residential location.

Regarding item (c), the "inability to eliminate the risk by the exercise of reasonable care," is pivotal and central to this entire adversary proceeding, SOCALGAS has attempted to frame the legal issues in a context that would require them to make as few changes as possible to their current practices and procedures. The upshot of this nonaction by SOCALGAS to deal with the true gas migration hazards at the PDR facility would be the strong inference that there is an inability to eliminate the risk by the exercise of reasonable care.

In summary, the nonaction by SOCALGAS to deal with these gas migration hazards – during this adversary proceeding – is tantamount to "inviting" a strict liability level of responsibility upon SOCALGAS.

CONCLUSIONS

There is a paramount need for SOCALGAS to set forth the specific policies and procedures that will allow proper monitoring and mitigation of the gas migration hazards at the PDR facility.

These policies and procedures should use as a primary framework the "Gas Inventory Monitoring, Verification, and Reporting Procedures" set forth in Exhibit 3 herein. Particular focus should be upon the shallow monitoring wells, and the gas collection wells detailed above in Section I. of this report.

In addition, these policies and procedures should focus on the surface casing leaks, including shoe leaks, that are enumerated in the SOCALGAS Rick Lorio Report, detailed above in Section I. of this report. This needs to include both active and abandoned wells.

Finally, a determination of responsibility by the Commission of the statement of issues as framed by SOCALGAS (see above) would be of no value in resolving the central issues of this Adversary Proceeding, as articulated in the Scoping Memo, as described above. In addition, to the extent that SOCALGAS is requesting the Commission to make a determination of legal ownership interests, including property rights involving the oil and gas mineral rights and/or storage, these property right determinations are under the jurisdiction of the Superior Court.

DATED: February 26, 2007

Respectfully submitted,

By: ______________________

Patricia McPherson
President, Grassroots Coalition

EXHIBIT 1

THE PLAYA DEL REY

MONITORING PROGRAM

Rick Lorio
Associate Petroleum Engineer
Underground Storage
Southern California Gas Co.
April 25, 1985

TABLE OF CONTENTS

APPENDICES

I. Storage Zone Problems

A. Possible source of gas migration to surface

There are at least five different possible sources of gas to the surface at Playa del Rey:

1. Casing leaks due to tubing/drill pipe wear, corrosion, stage collars, squeeze holes or metal failure.

2. Casing shoe leaks in active and abandoned wells.

3. Leaks from lower to upper zones outside the casing through uncemented or poorly cemented well bore in either active or abandoned wells.

4. Abandonment plug leaks inside the casings of abandoned wells.

5. Wellhead seal leaks.

B. Three incidents of shallow casing leaks at Playa del Rey

Since Playa del Rey was converted to gas storage in 1942 for the war effort, there have been three incidents of shallow casing leaks. Two of these leaks had surface shows of gas and oil:, 12-1 and 24-2, respectively.

1. In 1964, a casing leak was reported in Big Ben at about 150'. Repaired leak in 6-5/8" casing with Baash Ross casing bowl to 269'. The leak was determined to be at a depth of 269'.

2. On August 9, 1974, a gas leak was reported in the 13-1 block. The well 12-1 was determined to have a casing leak at between 700 and 800 feet. Bar hole surveys around the well and over the pipelines in the area indicated gas was appearing at the surface. The well was killed on August 15, 1974. From this time on, no gas was injected into the 13-1 block.

3. On April 30, 1975 at about 11:00 a.m., oil and gas surfaced on the east side of cellar wall. The well was producing through a leak in 7" casing at an unknown depth. They found corrosion in the

casing from 108' - 157'. Six weeks later well was returned to service. Currently, this well has an Otis subsurface safety valve located at 92'.

II. Overview of Field

A. Introduction

Playa del Rey oil field is about eleven miles west of Los Angeles, between Venice and Playa del Rey. Wildcatting was carried on in the vicinity of Playa del Rey for over eight years before the field was finally discovered. Drilling activities in the vicinity of Playa del Rey date back to May 14, 1921, at which time Del Rey 1 was spudded. This well was drilled to depth of 2785' without encountering any oil or gas showings, and was abandoned because of mechanical problems.

The first well drilled into the storage zone was on August 2, 1929. The Ohio Oil Company spudded the "Recreation Gun Club" 1. This well was drilled to a depth deeper than 6200'. A poorly sorted conglomerate, showing gas and oil, from 6114 to 6199 was discovered. While preparing to run a "water witch" to determine the nature and point of entry of the fluid, the well suddenly came in December 18, 1929, and flowed through the casing at an estimated rate of 2500 barrels of oil and 1,500,000 cubic feet of gas per day with the oil having an API of 21.6°.

On August 4, 1942, the Commission decided that Playa del Rey appeared feasible for Underground Storage from an engineering and economic standpoint. The goverment decided that Union Oil Company of California was to act as the operating contractor for Defense Plants Corporation, and the Southern California Gas Company as the gas utility to store and withdraw gas. From that time, the storage zone has increased from a field deliverability of approximately 10 MMcf/hr to about 25 MMcf/hr. Currently, Southern California Gas Company has 72 active wells in Playa del Rey.

B. Well Lists

There are 72 active wells in this field. These wells are divided into four groups:

1.	Injection/withdrawal wells Storage wells	28
2.	Flowing wells migration Return	2
3.	Pumping wells:	10
	a. Fluid removal	
	b. Pressure relief	
4.	Observation wells	32

These wells comprise the Playa del Rey storage operation.

C. Storage Areas

There are five distinct areas in the Playa del Rey storage field. Each of these areas has distinct operating functions.

1. 13-1 Fault Block
2. 24-1 Fault Block
3. Del Rey Main Area
4. Del Rey Gas Cap
5. Venice Townlot area

13-1 Fault Block

The 13-1 fault block has not been used for injection/withdrawal operations since 1974 when a shallow leak at well 12-1 brought gas to the surface at nearby houses. This block includes wells 12-1, 13-1, Colly 2, Colly 10, Harper, Hisey, Kelly and Merrill. Should this block be determined feasible to return to operations, other factors need to be considered. All of the wells in this block are in a residential area and will require subsurface safety valves with which they are already equipped. These wells have not been operated for some time; and thus the question is whether or not the neighbors will tolerate the increased noise level required to operate these wells.

The 13-1 fault block is geologically connected but not pressure connected. This block is an upthrown fault block, gas can migrate in, but the block holds pressure indicating that gas accumulates.

24-1 Fault Block

This fault block is used in tandem with the main storage area. It has no other purpose other than to remove fluid from this east flank.

Del Rey Main Area

This is the storage zone area. The operating guidelines are to withdraw from low structure wells first and work towards the higher structures. There are twenty-eight injection/withdrawal wells located in this area.

Del Rey Gas Cap

The wells located in this area of the field are primarily used for observation. Two of these wells are also used for gas migration return Del Rey 15 and Del Rey 18.

Venice Townlot Area

The wells in this area have a dual purpose: pressure relief (fluid removal) and gas migration (observation).

Early in the usage of Playa del Rey as a gas storage reservoir, it was discovered that certain oil productive areas, previously considered to be structurally separate deposits were really pressure connected. The areas in question were the Del Rey Gas Cap, Del Rey Hills Area, Del Rey Main Area and the Venice Townlot area. Parts of this reservoir are apparently geologically connected but not pressure connected.

Block 10R, Block 11, Townsite 2, Townsite 3, Townsite 11 and Troxel are located in this part of the field. Troxel, however, is on the other side of a fault block. Helium tests have indicated storage gas production from this area of the field.

III. Monitoring Program

A. Temperature, Noise and Tracer Surveys

All of the wells at Playa del Rey with the exception of tire pumping wells have temperature surveys are run on a quarterly basis. These surveys provide the information needed to determine well leaks. When a well leaks, the expanding gas from the leak cools both the pipe and surrounding formation. On a temperature survey, the leak appears as a cooling anomaly on a temperature survey.

Gas storage technicians run temperature surveys quarterly using company-owned wireline units. If a cooling anomaly appears on the temperature survey, a noise survey is run to verify the leak. If indicated, a radioaoctive tracer survey (R/A) is run which pinpoints the exact location of the leak and provides data necessary to estimate the rate of gas loss. During the 1st five years, only two R/A tracer surveys were run. They were on Big Ben and 12-1. Big Ben had a casing leak at 1065', and well 12-1 had a leak between 168' and 230'.

B. Surface Observation

All active well cellar areas are inspected each month for indications of near surface gas migration by station personnel. Any bubbles are analyzed for hydrocarbon and helium content. The resident reservoir engineer requests the analysis, and reviews and maintains records of the results. If storage gas is forced, the senior petroleum engineer is notified.

Once a month at Playa del Rey, the station personnel survey the four permanent bar holes that are near all active wells with a gas scope or flame ionization unit.

Twice a year, the station surveys the bar holes in the vicinity of abandoned wells with the flame ionization unit to detect any near surface gas migration under the direction of the South Basin Pipeline Superintendent.

Once a year, all storage field pipelines are surveyed using the flame ionization unit to detect any near surface gas migration.

C. Storage Zone

1. Surface pressures in each well are measured and recorded weekly using a calibrated test gauge. The data recorded for each well are:

   Tubing pressure
   Casing pressure
   Annuli pressure
   Safety valve control-line pressure
   Mode of operation

2. A plot of weekly surface casing and innerstring annuli pressures versus time is maintained for each well.

3. Wellhead inspections are performed once a month.

4. Subsurface temperature survey are performed on a quarterly basis.

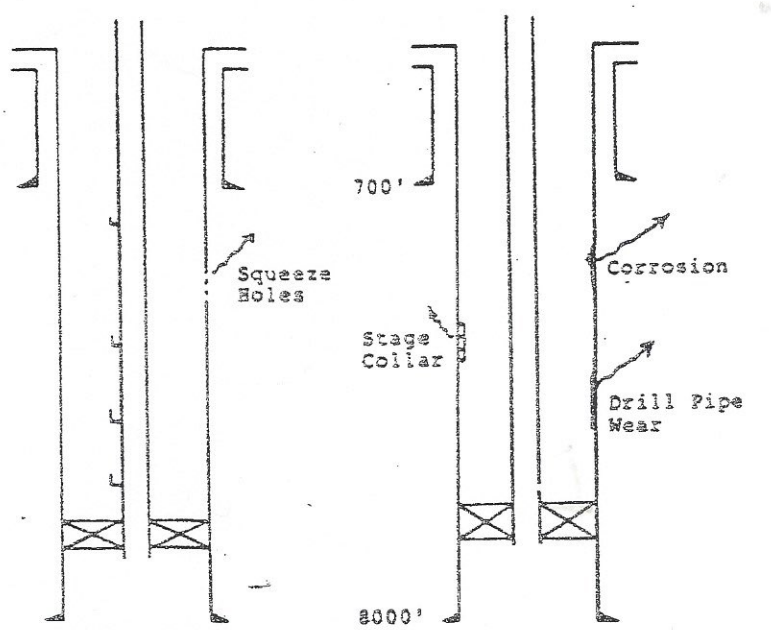
D. Gas Cap Observation Well

Vidor 6 is Playa del Rey's GCOW used to observe gas bubble pressures. This well is not used for injection and is used for withdrawal only for peak load conditions. The surface pressure measurements on the tubing and casing of Vidor 6 is recorded and plotted daily.

RMM:mm
April 25, 1985

EXHIBIT I

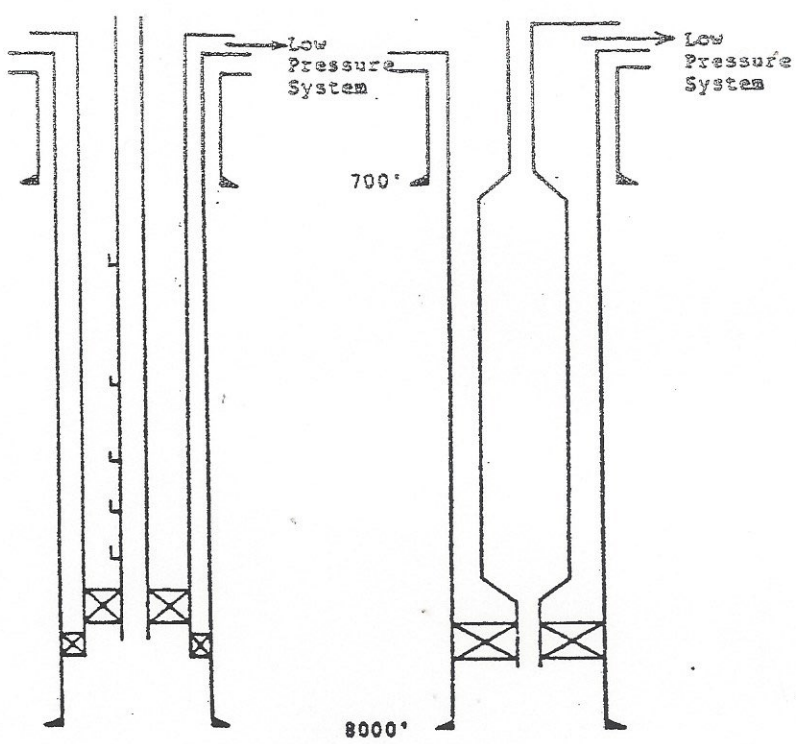
CASING LEAKS: TYPE 1



Current Gas Lift Well   FLOWING WELL

PROBLEM:

Casing leaks that allow high pressure gas into low pressure, shallow zones.



PROPOSED

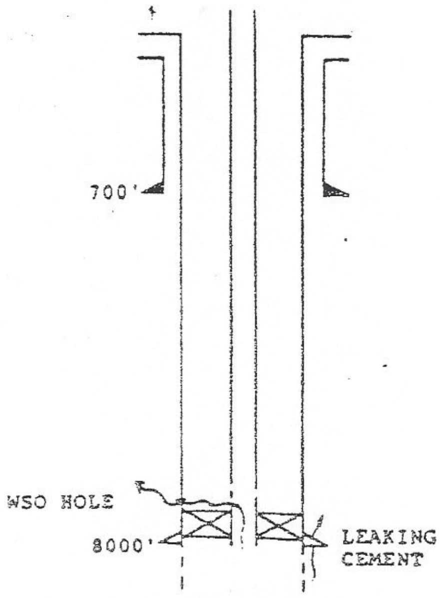
SOLUTION:

Use innerstrings and/or tubing to confine all high gas pressure. Keep innerstring or tubing annulus pressure lower than that required to force gas into acquifer sand at shoe of surface casing by venting gas to atmosphere or to low pressure system. Withdrawal wells' deliverability can be kept high by using large tubing.

JWT:hs
2/9/84

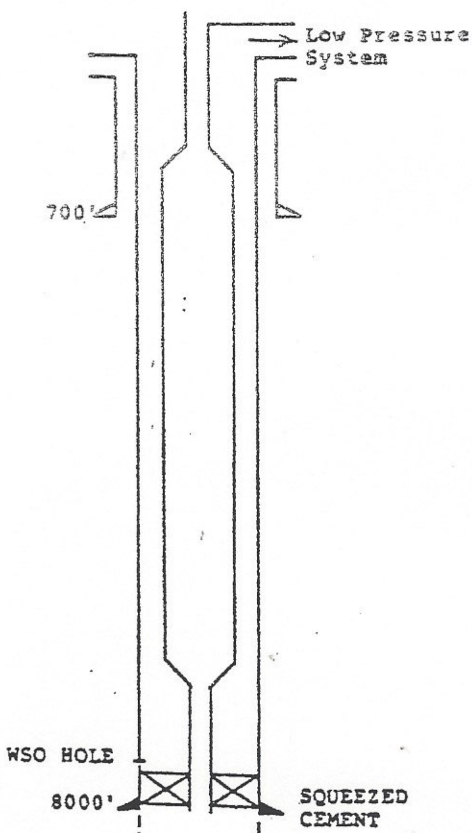
EXHIBIT I

CASING SHOE LEAKS: TYPE 2



Current Annular Flow Well

PROBLEM:
Casing shoe leaks due to poor, deteriorated cement or to leakage through WSO holes in active or abandoned wells.



PROPOSED

SOLUTION, ACTIVE WELLS:
Squeeze cement into shoe area. Place tubing packer below WSO holes where possible.

ALTERNATE SOLUTION, ACTIVE WELLS:
Do not repair if leak is into 7th zone but no higher. Collect all free gas from the 7th zone by activating more collection wells.

SOLUTION, ABANDONED WELLS:
Collect all free gas from overlying zones. Repair work not possible.

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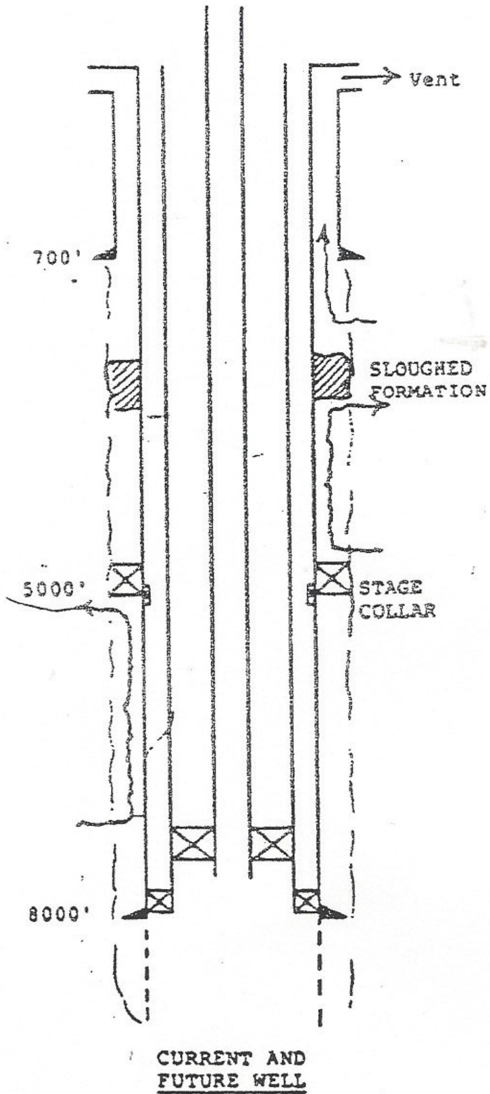
EXHIBIT I

UNCEMENTED WELLBORE LEAKS: TYPE 3



PROBLEM:
All wells have some uncemented segments. Few wells have any cement above 2000'. Formation sloughing may have filled in some of these wellbores but most remain the most permeable upward path for gas migration.

SOLUTION:
Noise and TDT monitor active wells to find areas of increasing activity. Continually produce shallow zones. Vent to atmosphere all gas coming from surface casing shoe aquifer.

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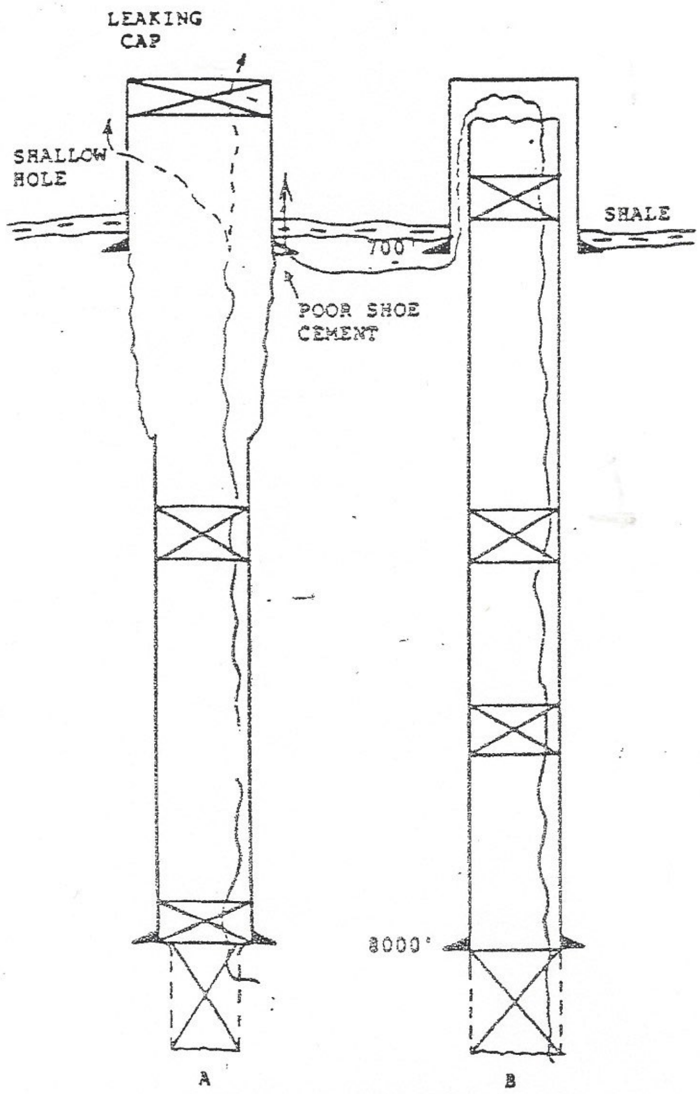
2/9/84

EXHIBIT I

ABANDONMENT PLUG LEAKS: TYPE 4



EXISTING ABANDONED WELL TYPES

PROBLEM, TYPE A ABANDONMENT:
Cement plugs inside casing allow some gas to migrate upwards. Because its casing was cut off below the surface string, water will continue to fill casing as gas leaks out. Leak will therefore be sporadic and low rate.

PROBLEM, TYPE B ABANDONMENT:
Cement plugs inside casing allow some gas to migrate upwards. Because the casing stub is cut off within 100' of surface, the entire surface casing fills with gas. No liquid enters the well. The gas leak unloads fluid from the well and the rate increases with time. Eventually all of the fluid unloads and the leak rate stabilizes at a near constant daily rate.

PROBLEMS, BOTH TYPE ABANDONMENTS:

1. Casing cap, surface casing and casing shoe cement competent. Gas will build up inside surface casing and force its way into shallow aquifer sand. Gas will surface at a non-leaking well that has the following problems.
2. Casing cap not competent. Gas will surface near well.
3. Surface casing or shoe cement not competent. Gas will spread over large area as it rises to surface lethargically.

SOLUTION, PROBLEM 1:
Direct repair of leaking well not possible because source well is unknown. Other wells where gas appears are continually vented to surface.

SOLUTION, PROBLEM 2:
Unearth well and recap or place collection funnel over it. Rig work not required. Vent all gas to atmosphere.

SOLUTION, PROBLEM 3:
Unearth well, move in rig, attempt to enter and repair old casing. Produce gas through casing into low pressure system. Vent surface annulus to atmosphere.

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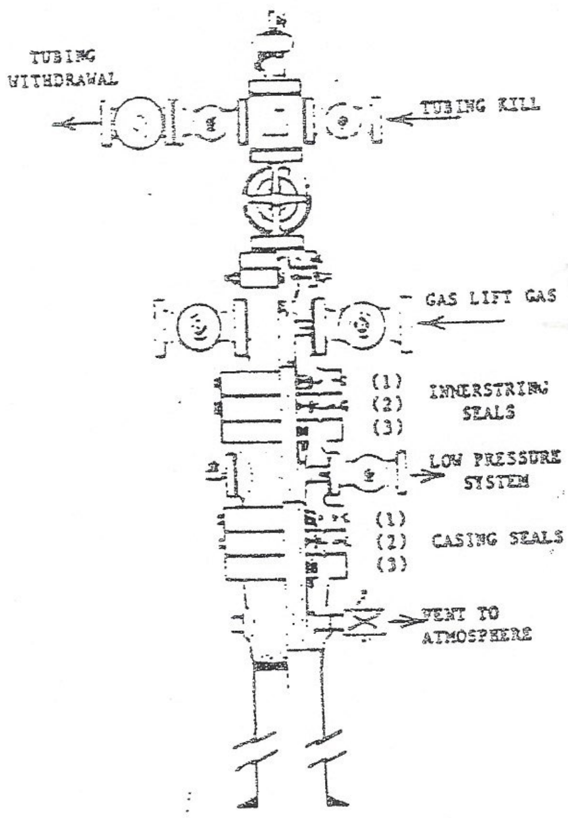
2/9/84

EXHIBIT I

WELLHEAD LEAKS: TYPE 5



CURRENT AND PROPOSED WELLHEAD FOR WELLS WITH INNERSTRINGS

PROBLEM:
Wellhead seal leaks allow high pressure gas to leak into the innerstring, tubing or surface casing annulus. Gas then enters shallow zones at the surface casing shoe or through casing holes.

SOLUTION:
Keep all annular pressures below that required to force gas into shallow zones either by connecting them to low pressure system or venting them to atmosphere. Install new wellheads with triple seals (as illustrated) on wells with obsclete equipment when other well work is performing or when wellhead is leaking badly.

(1) Inject sealant to energize seal in head

(2) Inject sealant to energize seal in sealing flange

(3) Set down weight on slips to energize seal

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2/9/84

EXHIBIT 3

APPENDIX A

GAS INVENTORY MONITORING, VERIFICATION, AND REPORTING PROCEDURES

I. GENERAL

Gas Storage Operations require monitoring and inventory verification for safe long-term management of underground gas storage operations. While no single method can be used to precisely monitor and verify the gas inventory in underground storage reservoirs, the three engineering methods in general use are summarized below. Gas volume verification can be obtained only by combining and analyzing available field data. Based on this analysis, gas volume changes or losses are recognized, estimated and reported.

II. DEFINITIONS

When gas storage operations are initiated in an oil or gas reservoir, there is an initial gas content in the reservoir prior to injection. Initial gas content is generally composed of both free gas and solution gas. Additional gas is added to the initial gas content by injection, and the combination comprises the Total Storage Volume. This volume is categorized as follows:

A. Cushion Gas

The base gas is that quantity of gas which must be in the reservoir to maintain the minimum pressure required to exclude fluids from the gas cap and to provide the energy required to deliver the minimum required rate of gas withdrawal at the end of the withdrawal season.

B. Recoverable Cushion Gas

This is defined as the volume of gas that can be economically recovered from the reservoir below the base gas pressure. This volume varies, depending upon economic conditions.

C. Non-Recoverable "Cushion Gas"

This is the volume of gas left in the reservoir after all recoverable gas volumes are removed and is not considered a part of Total Storage Inventory. This gas is capitalized and depreciated over the life of the project.

D. Working Gas

This volume is defined as the gas content which is held in the reservoir between maximum reservoir pressure and the base gas pressure.

E. Effective Working Gas

This volume is defined as the working gas which is withdrawn and re-injected in a complete injection and withdrawal cycle. Ideally, the effective working gas volume is synonymous with the working gas volume. However, limitations by wells, compression facilities, or gas availability may limit effective working gas volume.

F. Total Storage Inventory

This is the sum of all working and recoverable cushion gas volumes.

III. RESPONSIBILITY

The responsibilities for shut-ins, along with analyzing data, verifying gas inventory, and reporting changes or losses are specified in System Instruction 224.0020.

IV. MONITORING

A. Monitoring of the storage reservoir is required to ensure reservoir integrity and field deliverability. The performance review ensures the reservoir functions according to expectations, and integrity tests verify the gas inventory is present and available for delivery. Effective monitoring requires a thorough understanding of the reservoir system. This system is defined as the reservoir rock and wellbores which respond to pressure changes as a result of gas injection and withdrawal. To better understand the system, see System Instruction 224.0035, *Gas Inventory - Summary of Reservoir System*. A successful monitoring program reduces risk of injury, property damage and gas migration.

B. Monitoring of the reservoir system is conducted in both storage and non-storage zone wells and at surface observation points.

1. Storage Zone Wells

a. Performance reviews utilize information collected during individual well and reservoir tests. Back pressure curve shifts, changes in deliverability and field performance are investigated.

b. Tests are conducted on individual wells to prove both well and reservoir integrity.

i. Surface pressures on each well are measured and recorded weekly using a calibrated test gauge. Pressures measured and recorded include tubing pressure, casing pressure, annuli pressures, and, if applicable, safety valve control line pressure. The mode of well operation (injection, withdrawal or shut-in) at the time of pressure measurement is also recorded. Note that the *C.D.O.G.G.R. (California Division Of Oil Gas and Geothermal Resources)* requires a monthly average casing and tubing pressure recorded and submitted as part of the monthly production report.

ii. A plot of the weekly surface casing and the innerstring annuli pressures versus time is maintained or periodically produced for each well. Hardcopy plots are created, marked and filed when an abnormal pressure is encountered. A pressure is considered abnormal when it may be large enough to force gas into a normally pressured water sand, either at the surface casing shoe or through any other known casing holes or leak-paths.

iii. When abnormally high annular pressures are detected, diagnostic steps are taken to determine the source of pressure build up. This includes tests to eliminate surface valves and downhole tubing as possible sources of leakage. Zero pressure is abnormal in a well that has had a history of annular pressure and is investigated for the possibility of a closed valve.

iv. All wells with continuing zero-pressure readings are checked quarterly for closed valves and noted on the pressure plot. Blowdowns are also noted when they occur.

v. Wellhead inspections are performed on a monthly basis. Any leaks from wellhead flanges and valves are reported and corrected.

vi. Subsurface temperature surveys are conducted on each well in according to the following schedule: semi-annually in La Goleta, Montebello, and Playa del Rey storage fields and annually in the Aliso Canyon, and Honor Rancho Storage fields.

vii. Surveys are done in accordance with System Instruction 224.0025, *Standardized Subsurface Temperature and Pressure Surveys*. Wells that have been killed are not exempt from this requirement and must be surveyed according to the schedule. Results of surveys are reported according to Recommended Method 224.001, *Standardized Daily Well Operations Report.*

viii. Additional surveys will be run without regard to this schedule at the first indication of unusual or abnormal well conditions, i.e., anomalous pressure, surface gas emissions or other indications of well problems.

ix. Wireline retrievable tubing obstructions such as tubing plugs, subsurface safety valves, subsurface chokes or tubing stops are removed once each year to perform a temperature survey of the casing shoe and cap rock seal. Ideally, this is done at high reservoir pressure when shoe leaks are most noticeable on temperature surveys.

Under certain conditions it may not be possible or advisable to remove the wireline retrievable obstruction.

x. Subsurface surveys using wireline conductor cable equipment are made to investigate anomalies discovered by temperature surveys.

xi. Conductor cable surveys include temperature surveys, noise logs, spinner surveys, and radioactive tracer surveys.

xii. In the case of well casing leaks above the shoe, radioactive tracer surveys are typically used to verify the location of gas movement through the leak. In the case of shoe or cap rock leaks, these additional surveys are used to verify that a leak exists and as an aid to qualitatively estimate leakage rate.

c. Reservoir integrity tests include:

i. Gas cap observation wells are used to monitor reservoir pressure. If possible one or more wells completed in the gas cap are selected for observation purposes. These wells are not used for injection and are put on withdrawal only for peak load conditions. Surface pressure measurements on the tubing and casing of each gas cap observation well are made and recorded weekly.

ii. A plot of these pressures versus inventory is kept in the office of the Storage Field Engineer and is updated weekly. Anomalous well pressures or behavior are reported to Storage Engineering Staff.

iii. Reservoir shut-ins are generally on a schedule stated in System Instruction 224.0020 or when determined as necessary by the Storage Field Engineer. The

2. Non-storage Zone Wells

a. Non-storage zone wells monitored include both Company wells and wells owned by others in overlying and underlying zones and in other fields within two miles of the storage reservoir boundary, where applicable. These wells are categorized as follows:

i. Pressure observation wells are located in overlying and underlying permeable formations, or adjacent to the storage reservoir but across assumed confining boundaries, such as faults, permeability pinchouts, below the gas-liquid contact or beyond the spill point of the storage zone's confining structure. Although normally static, these wells may have artificial lift mechanisms for removal of gas and fluids.

ii. Gas collection wells are located where known gas migration from the storage zone is intercepted and collected. These wells are normally equipped with operating artificial lift mechanisms so that both liquids and gas can be produced, causing a pressure sink in the reservoir near the wellbore.

iii. In some fields, shallow water observation wells have been drilled into aquifer zones existing in the first permeable sand above the shoe of the surface casing. These wells are closed in at the surface and gas concentrations in the wellbore are measured weekly.

iv. If gas loss is expected, performance reviews of wells operated by other producers in either overlying zones or in adjacent fields may be made by reviewing production reports from these operators.

v. Performance of Company-owned observation and collection wells are also closely monitored. Wellhead inspections and temperature surveys are performed on the pressure observation wells and the gas collection wells.

vi. Pressure observation wells

a. Surface pressures on all tubing and casing strings are measured weekly using a calibrated test gauge.

b. A plot of pressure versus time for each well is kept by the Storage Field Engineer. Bottom-hole pressure surveys are run as needed on pressure observation wells.

c. If a substantial increase in reservoir pressure is noted or a significant gas buildup occurs, an attempt is made to produce the well. Produced gas is sampled and analyzed for both hydrocarbon and helium content.

vii. Gas collection wells

a. Surface pressures on all casing strings and safety valve control lines are measured weekly using a calibrated test-gauge. The mode of well operation (producing, shut-in) at the time of pressure measurement is also recorded.

b. A plot of pressure vs. time for each surface casing and innerstring annulus is kept by the Storage Field Engineer.

c. Bottom-hole pressure surveys are run on gas collection wells as needed. These surveys follow a shut-in period to allow pressure stabilization after production. If the well is equipped with a standing valve, the valve is pulled prior to the bottom-hole pressure survey and is reinstalled upon completion of the survey.

d. Production schedules are developed by the Storage Field Engineer. The Storage Field Engineer maintains plots of bottomhole pressure versus time and records of produced gas, oil and water.

viii. Shallow water observation wells

a. Shallow water observation wells are closed-in at the surface and gas concentrations in the wellbore measured periodically.

ix. Surface Observations

a. Active well cellar areas are inspected by station personnel each month for indications of near surface gas migration. The Storage Field Engineer requests the analysis if needed and reviews and maintains records of the results.

b. Region personnel survey the location perimeter of four permanent bar holes near all active wells with a gas scope or flame ionization unit. The surveys are performed monthly at Montebello, quarterly at La Goleta, and semi-annually at Aliso Canyon, East Whittier, Honor Rancho and Playa del Rey.

c. The areas in the vicinity of abandoned wells are examined with a flame ionization unit to detect any near surface gas migration under the direction of the Storage Operations Manager. Surveys are performed semi-annually at Montebello, and annually at Aliso Canyon, East Whittier, Honor Rancho, La Goleta and Playa del Rey.

d. Flame ionization surveys to detect any near surface gas migration are performed on all storage field pipelines under the direction of the Storage Operations Manager. These surveys are performed annually at La Goleta, Montebello, and Playa del Rey and every two years at Aliso Canyon, East Whittier and Honor Rancho.

V. BOTTOM-HOLE PRESSURE DETERMINATION

A. Each of the three major methods used to verify gas storage inventory, as explained in Section V, requires the determination of bottom-hole pressures in the field wells. The method used to determine bottom-hole pressure must be consistent from year to year. The most accurate method to determine bottom-hole pressure is to measure the pressure with a pressure bomb. In certain applications the bottom-hole pressure can be calculated from the shut-in wellhead pressure. For wells completed in the gas cap and having full gas columns, the bottom-hole pressure is calculated from the equation:

$$P_{BHP} = P_{WH} \exp\left(\frac{0.01875 \times SG \times D}{Z_{avg} T_{avg}}\right)$$

Where:

P_{BHP} = Bottom-hole pressure, psia.

P_{WH} = Wellhead pressure, psia.

SG = Gas specific gravity.

D = True vertical depth in feet.

T_{avg} = Average wellbore temperature between surface and bottom-hole, degrees Rankin.

Z_{avg} = Average gas compressibility factor from charts, tables or computer programs (dependent on P_{avg}, T_{avg} and gas gravity).

P_{avg} = Average pressure between surface and bottom-hole, psia or

$$P_{avg} = (P_{BHP} + P_{WH}) / 2$$

NOTE: The above equation could yield incorrect results if the well exhibits abnormally high surface pressure or high fluid levels.

VI. INVENTORY VERIFICATION – SHUT IN

A. Three primary methods for inventory verification of Gas Storage Fields are referenced and summarized below:

1. Calculation of gas content based on volumetric data and average reservoir pressure; Volumetric Determination is explained in Applied Petroleum Reservoir Engineering; by Craft, B. C. and Hawkins, M. F.: Englewood Cliffs, N.J.: Prentice- Hall, 1959.

2. Calculation of effective gas content using the simple gas material balance, hysteresis curve, and P/Z curve methods; Material Balance is explained in Natural Gas Engineering by Ikoku, C. V.; Tulsa. Oklahoma: Penn Well Publishing. 1980.

3. Verification of storage inventory by comparing measured reservoir pressures with calculated pressures obtained using the single cell material balance or reservoir simulation methods; Numerical Simulation or Reservoir Modeling is explained in *Modern Reservoir Engineering —A Simulation Approach* by *Crichlow, H. B.*; Englewood Cliffs, N.J.: Prentice- Hall, 1977 and the *Intercomp Beta II User Manual.*

B. The most common inventory verification method used in mature gas storage projects that are known to have effective geologic closure is the hysteresis curve or P/Z versus inventory plot. Typically, it is adjusted annually for known gas losses and liquid production. Any shift between points plotted at similar pressures following a shut-in is further investigated.

1. Tracking known gas losses and transfers as they occur assist with inventory verification.

2. Recommended Shut-in time durations for effective reservoir stabilization are listed below

- Aliso Canyon -14 days
- Honor Rancho -12 days
- Goleta- 5 days
- Montebello -12 days

C. Data collected during a shut-in period includes accurate measurements of reservoir pressure on each available well. Bottom-hole pressures can be calculated from surface pressures or measured directly. Gas gravity is determined using gas samples from individual, representative wells.

D. The Storage Field Engineer chooses the type and frequency of data to be collected during shut-ins.

E. Calculation of gas content based on volumetric data and average reservoir pressure from shut-in.

1. Average reservoir pressures used in this calculation are obtained during shut-in periods required for reservoir pressure stabilization. Reservoir pore volumes available for gas storage are calculated from either geologic information, material balances using production and pressure information obtained during primary field production, or in some cases from pressure and production data obtained during gas storage operations. Elements of these calculations are described below:

2. Average reservoir pressures are calculated in an appropriate way for each storage reservoir. To be reliable, the method for each field should stay consistent for all years. Various methods of calculation include the following:

a. The average reservoir pressure for Honor Rancho, La Goleta, and Playa del Rey are determined by calculating the arithmetic average of the bottom-hole pressure in the gas cap wells. In these fields the pressure of each well is measured or computed at a specified subsea datum approximately at the midpoint of the zone. The datum and reservoir temperature used for these fields are as follows:

i. Honor Rancho - 8,300 feet subsea, 190°F

ii. La Goleta - 4,200 feet subsea, 150°F

iii. Playa del Rey - 6,100 feet subsea, 210°F

iv. Montebello: An average reservoir pressure is obtained. The pressure points for the average reservoir pressure are generated by converting the bottom-hole pressure to a datum at the top of the 8-2 zone using a reservoir temperature of 187°F.

v. A volumetrically weighted average reservoir pressure is used for Aliso Canyon. The pressures in this field is computed at a specified subsea depth approximately at the midpoint of the zone. The datum depth for this field and the reservoir temperature is as follows:

a. Aliso Canyon - 5,400 feet subsea, 180°F

3. Reservoir pore volume calculated from geologic information utilizes data obtained during the drilling and completion of the well such as electric logs or core information to calculate the total pore volume of the reservoir. These calculations are based on the following equations:

a. Gas reservoirs

i. Equation: $V = Ah\phi\,(1-S_w)$

Where:

V = Reservoir gas pore volume in cubic feet

A = Gas zone area in square feet

h = Average gas zone thickness in feet determined from electric logs or cores

ø = Porosity fraction determined from porosity logs or well test analysis

S_w = Water saturation from log, core, or well test analysis

b. Oil reservoirs

i. Equation: $V = Ah\phi(1-S_w) + A_1 h_1 \phi\,(1-2_w-s_o)$

Where:

A = Primary gas cap area in square feet

A_1 = Secondary gas cap area in square feet

h_1 = Average secondary gas zone thickness in feet

s_o = Residual oil saturation

ii. In most portions of an oil zone storage reservoir, oil saturation is determined from core analysis or can be considered equivalent to residual oil saturation and can be estimated from the 16" normal resistivity curve using the following relationships.

Equation: Residual oil saturation = $(1-s_{xo})$

$$S_{xo} = \sqrt{\frac{Rmf}{R_{xo}ø2}}$$

Where:

R_{xo} = Resistivity of 16" normal or resistivity of flushed zone.

S_{xo} = Water saturation of mud filtrate within the flushed zone.

ø = Porosity

Rmf = Resistivity of mud filtrate.

4. Gas Reservoir pore volume calculated using material balance equations:

These calculations utilize production and pressure data in the following equations:

a. Equation for constant volume gas reservoirs using primary production:

$$V = \frac{P_{SC} G_P T}{T_{SC}} \left(\frac{1}{P_i / Z_i - P_f / Z_F} \right)$$

Where water production and influx are assumed negligible and where:

V = Gas pore volume in reservoir cubic feet.

P_{sc} = 14.7 psia

G_p = Gas produced in standard cubic feet.

T = Reservoir temperature in degrees Rankin (°R).

R_{sc} = 520°R

P_i = Initial pressure, psia.

P_f = Final pressure, psia.

Z_i = Initial gas compressibility factor.

Z_f = Final gas compressibility factor.

b. Equation for constant volume gas reservoirs using storage production

$$V = \frac{P_{SC} G_P T}{T_{SP}} \left(\frac{1}{P_1 / Z_1 - P_2 / Z_2} \right)$$

Where water production and influx are assumed negligible

G_p = SCF of gas produced or injected between pressure points P1 and P2.

P_1 and P_2 = The first and second stabilized average reservoir pressures bounding the production or injection period considered.

Z_1 and Z_2 = Gas compressibility factors for P1 and P2.

T = Reservoir temperature in degrees Rankin

5. Oil reservoirs pore volume calculations

a. Equation: The 'Reservoir Gas Pore Volume' is equal to the 'Original Gas Cap Pore Volume' plus the 'Secondary Gas Cap Pore Volume' plus the 'Space created by Water Production'.

Or:

$$V = GB_{gi} = \left(NB_{oi} - \left(N - N_p\right)B_o\right) + W_p B_w$$

Where:

G = Original gas pore volume, standard cubic feet (determined from either geologic data or an appropriate form of the material balance equation).

B_{gi} = Gas formation volume factor in reservoir cubic feet per standard cubic feet at discovery pressure.

N = Initial oil in place in stock tank barrels (determined from either geologic data or an appropriated form of the material balance equation).

N_p = Cumulative oil production in stock tank barrels.

B_{oi} = Oil formation volume factor in reservoir cubic feet per stock tank barrel at discovery pressure.

Bo = Oil formation volume factor at existing pressure in reservoir cubic feet per stock tank barrel.

W_p = Water production in stock tank barrels.

B_w = Water formation volume factor, reservoir cubic feet per stock tank barrel (approximates 5.615).

b. Simplifying assumptions used in the above equation are that no storage gas goes into solution in the oil and that there is no water influx into the storage reservoir. These simplifying assumptions are seldom true. However, the equation can be modified based on a judgment of the volume of gas which may go into solution in the reservoir oil and a judgment of aquifer activity surrounding the storage reservoir. When modified by these judgment factors, the equation provides a method for approximating a limit for the reservoir gas pore volume available for storage operations. An upper limit is established when it is assumed that all the residual oil is resaturated with gas. Generally, only a fraction of the oil becomes saturated and so the calculation has little usage beyond setting limits.

c. The values of G and N are not generally expected to be obtained with an accuracy greater than + 20%. However, this is not a major drawback since the methods are used to establish guidelines and set limits.

6. Calculation of gas content.

a. After the gas pore volume has been calculated, or approximated, by one of the methods indicated above, the gas content at the measured reservoir pressure is determined using the gas law as follows:

$$PV = ZNRT$$

Where:

P = Average reservoir pressure, psia

V = Gas pore volume in reservoir cubic feet

T = Temperature of reservoir, (°F + 460) degrees Rankin

Z = Compressibility factor, dependent on P, T, and gas gravity, from charts or tables.

N = pound moles (where one pound mole = 379.41 cubic feet @ 60°F and 14.7 psia).

R = 10.735 universal gas constant for above units.

Solving for gas content;

$$Volume(mscf) = \frac{(0.03533)PV}{ZT}$$

PV = ZNRT

Where:

P = Average reservoir pressure, psia

V = Gas pore volume in reservoir cubic feet

T = Temperature of reservoir, (°F + 460) degrees Rankin

Z = Compressibility factor, dependent on P, T, and gas gravity, from charts or tables.

N = pound moles (where one pound mole = 379.41 cubic feet @ 60°F and 14.7 psia).

R = 10.735 universal gas constant for above units.

Solving for gas content;

$$Volume(mscf) = \frac{(0.03533)PV}{ZT}$$

F. Calculation of effective gas content using the simple gas material balance and hysteresis curve(P/Z curve) methods

1. Pressure changes with rapid gas injection or withdrawal during selected operating periods can show the relationship between effective gas content and the storage inventory. Effective gas content is the gas which, within a given time, causes a measurable pressure response to injection or withdrawal operations. Not all gas in the reservoir yields such a response within the given time interval. The difference between

effective gas content at a given pressure (P_1) and the metered inventory is non-effective gas. Part of this non-effective gas can be due to the lack of pressure equilibrium within the reservoir. Any gas migration out of the storage reservoir also contributes to the non-effective gas. Either one of the two equations, or the graphical solutions presented below are used to calculate the effective gas content.

a. Calculations with negligible water movement are made using the following equation:

$$\text{Effective Gas Content at P1, Q1} = \left(\frac{\Delta Q}{\frac{P_1}{Z_1} - \frac{P_2}{Z_2}}\right)\left(\frac{P_1}{Z_1}\right)$$

Where:

P_1 = Pressure at the first operational point considered.

P_2 = Pressure at the second operational point considered.

Q_1 = Net storage volume at the first operational point considered.

ΔQ = The net change in gas inventory between the two operational points considered.

b. Calculations with significant water movement of a known rate are made using the following equations:

$$Q_1 = \left(\Delta Q - \left(We \times \frac{P_2}{14.7} \times \frac{520}{T_R} \times \frac{1}{Z_R}\right)\right)\frac{\frac{P_1}{Z_1}}{\left(\frac{P_1}{Z_1} - \frac{P_2}{Z_2}\right)}$$

Where terms are defined as above, and where:

We = Water influx in cubic feet.

T_R = Reservoir temperature, degrees Rankin.

Z_R = Z at T_R and P_2.

G. Graphical solutions

1. The hysteresis curve is a plot of reservoir pressure versus storage inventory. This curve utilizes the compressibility factor of non-ideal gas.

It is most effective in a constant volume reservoir since it assumes no water movement into or away from the storage reservoir; and no movement of gas into or out of solution in the reservoir oil. Actually, after sufficient storage history, the hysteresis curve becomes a qualitative tool for inventory verification since with constant operating procedures and a relatively constant storage cycling volume, aquifer movement and movement of gas into and out of solution is relatively constant and effectively drops from the equation.

VII. REPORTING GAS INVENTORY LOSSES

A. Calculated operational losses

1. Gas losses due to compressor, piping system or well blowdowns and wireline surveys are calculated by Storage Field personnel and reported to Measurement monthly. These reports are review by the Storage Field Engineer.

2. Estimates of losses related to workovers and well blowdowns are prepared by the Storage Field Engineer after a well has been killed. These estimated losses are reported monthly to Gas Measurement.

B. Losses from known well and surface facility leaks

1. Some small losses from valves, compressors, field piping, threaded well casing connections and well casing mechanical devices such as cementing stage collars, and some small casing leaks are inherent to Storage Field Operations. These leaks are estimated and reported as follows:

   a. Minor surface facility leakage is surveyed in each storage field periodically. Leakage surveys include wellhead valves and fittings, instrumentation, well piping, field piping, surface production facilities and the compressor station. Surveys are made more frequently if facility modifications are made which might change leakage rates.

   b. During these surveys, measurements are obtained on representative minor atmospheric leaks and then extrapolated to an estimated annual leakage rate for the field.

2. Subsurface leakage from wells is estimated by the Storage Field Engineer and reported to Storage Engineering Staff.

   a. Leakage from well casings is estimated by establishing a leakage rate using the radioactive tracer survey. The number of days of leakage is estimated by using subsurface temperature survey data. Casing shoe or Water Shut-Off (WSO) leakage is estimated by reviewing temperature, noise and radioactive tracer surveys, pressure draw-down and the overlying wells' gas production during the time of the leak.

b. In cases where leakage rates are not quantifiable, an average rate of 30 Mcf/d may be used. Engineering judgment is then applied and an average daily loss rate selected. The number of days the leak was occurring is determined by taking one-half the difference in the number of days between the last normal and the first abnormal temperature survey.

3. Surface facility leakage and subsurface leakage are quantified annually by the Storage Field Engineer who reports the results to the Storage Engineering Manager and Gas Management.

C. Reservoir losses

1. Reservoir losses are categorized as those associated with Company-operated wells completed in the storage reservoir and general reservoir losses.

a. Losses associated with the Company-operated wells include losses through failures in the cement between the cap rock and well casing. These losses are also known as "shoe leaks," "WSO" leaks and "stage collar" leaks.

b. General reservoir losses include losses through abandoned wells or breakdown of some portion of the trapping mechanism. This type of loss is not directly detected by surveys of Company-operated wells in the storage zone.

c. Quantification of reservoir losses utilizes industry accepted methods of inventory verification.

2. Reservoir losses are quantified annually by the Storage Field Engineer who reports results to the Storage Engineering Manager and Gas Measurement.

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PC DOCS FCD PROFILE SUMMARY	
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Author's Brief/Summary of Changes:

This FCD was revised by the Storage Engineer Peer Team. The title of the FCD was changed to Gas Inventory - Monitoring, Verification, and Reporting. It was merged with FCD 224.0045 and FCD 224.020 and changed to a Recommended Method.

Circulation Code	Filing Instructions
TRAN	File numerically in Volume II, behind Underground Storage Tab.

EXHIBIT 2