Issuing Department: GAS SYSTEM TECHNICAL SUPPORT

Effective Date: 10/17/86

Gas Supply Officer: W. R. MAZOTTI

SUBJECT:

ANNUAL STORAGE WELL LEAK SURVEYS

GENERAL NOTE:

This Gas Supply Interim Standard replaces existing PG&E Standard Practice 456-1. Minor editing has been done to reflect organizational changes, but the requirements of the original Standard Practice have not been changed. The interim standard will be reviewed and revised in the near future. Comments on or suggested revisions to this interim standard should be sent to the Director, System Standards Management (SYC3), in the Gas System Technical Support Department.

POLICY

All wells in PG&E's McDonald Island, Los Medanos, and Pleasant Creek Underground Gas Storage Fields must be surveyed for downhole leakage at least once every year as required by the California Department of Conservation, Division of Oil and Gas.

PURPOSE

Leak-surveys are conducted to verify the gas pressure integrity of all wells for regulatory compliance, safety, and conservation of storage gas.

DEFINITIONS

"Wells" is defined herein as all injection, injection-withdrawal, withdrawal, pressure observation, production, temporarily abandoned, waste injection, or other types of wells that penetrate any part of a PG&E underground gas storage reservoir.

RESPONSIBILITY

Responsibility	Action
Gas System Maintenance (GSM)	1. Prepares cost estimate of survey program. Budget and prepare work orders. 2. Selects qualified contractor and provides contractor with all required technical information for performance of job. 3. Consults with the Gas System Operations Department to schedule the survey program to avoid unnecessary interference with storage field withdrawal and injection schedules. 4. Provides scheduling and physical assistance to the

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contractor (see supplement for details).

5. Provides engineering supervision and planning, and works with the contractor through all phases of the survey. Evaluates the survey results, plans and directs follow up testing of wells with suspected leaks, and develops plans of actions if any leaks are discovered

SUPPLEMENT

A general explanation of the theory and a detailed survey procedure begin on Page 3 of this Standard.

EXHIBITS

1. Exhibit 1: Example of typical temperature and noise survey logs.
2. Exhibit 2: Example of temperature and noise logs indicating a gas leak.
3. Exhibit 3: Example of bid specifications for survey contractor.
4. Exhibit 4: Example of well specifications for survey contractor.

REFERENCE

California Administrative Code, Title 15, Natural Resources, Division 2, Department of Conservation, Chapter 4, Division of Oil and Gas, Section 1724.10.

APPROVED BY

W. R. MAZOTTI
VICE PRESIDENT - GAS SERVICES & OPERATIONS

[redacted]

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SUPPLEMENT

THEORY

1. A well shut in for 72 hours or more assumes the uniform temperature gradient of approximately 1°F per 100' of the adjacent earth surrounding its well bore path as shown in Exhibit 1.
2. When gas leaks through a hole or crack in the production casing, the expanding gas cools the orifice and generates acoustic noise. Thus, this type of leak is recorded as a temperature and noise anomaly by the survey instrument.
3. Gas leakage around the bottom of the casing (i.e., casing shoe) is most easily detected by the noise survey.
4. If needed, a radioactive tracer survey is performed to verify a suspected leak. This type of survey can be used to measure gas leakage rates inside of the casing and confirm gas leakage past the outside of the casing.

PROCEDURE

Responsibility	Action
GSM Engineer	1. Makes certain that each well has been shut in for a minimum of 72 hours prior to commencement of leak survey.
GSM Operator-Mechanic	2. Opens downhole safety valve using hand pump, and carefully monitors the valve's hydraulic pressure to make certain that it remains 100% open at all times during the survey. 3. Closes wellhead master valve and bleeds off pressure above, and then removes the Guiberson union and assists in installing contractor's lubricator connection and safety blowout prevention to union connection.
Contractor	4. Rigs up logging truck with surface recording temperature and Squires-Whitehouse noise recording instruments to be run in tandem on wireline.
GSM Operator-Mechanic	5. Assists contractor, in connecting lubricator with survey tools to top of wellhead, and then opens

[redacted]

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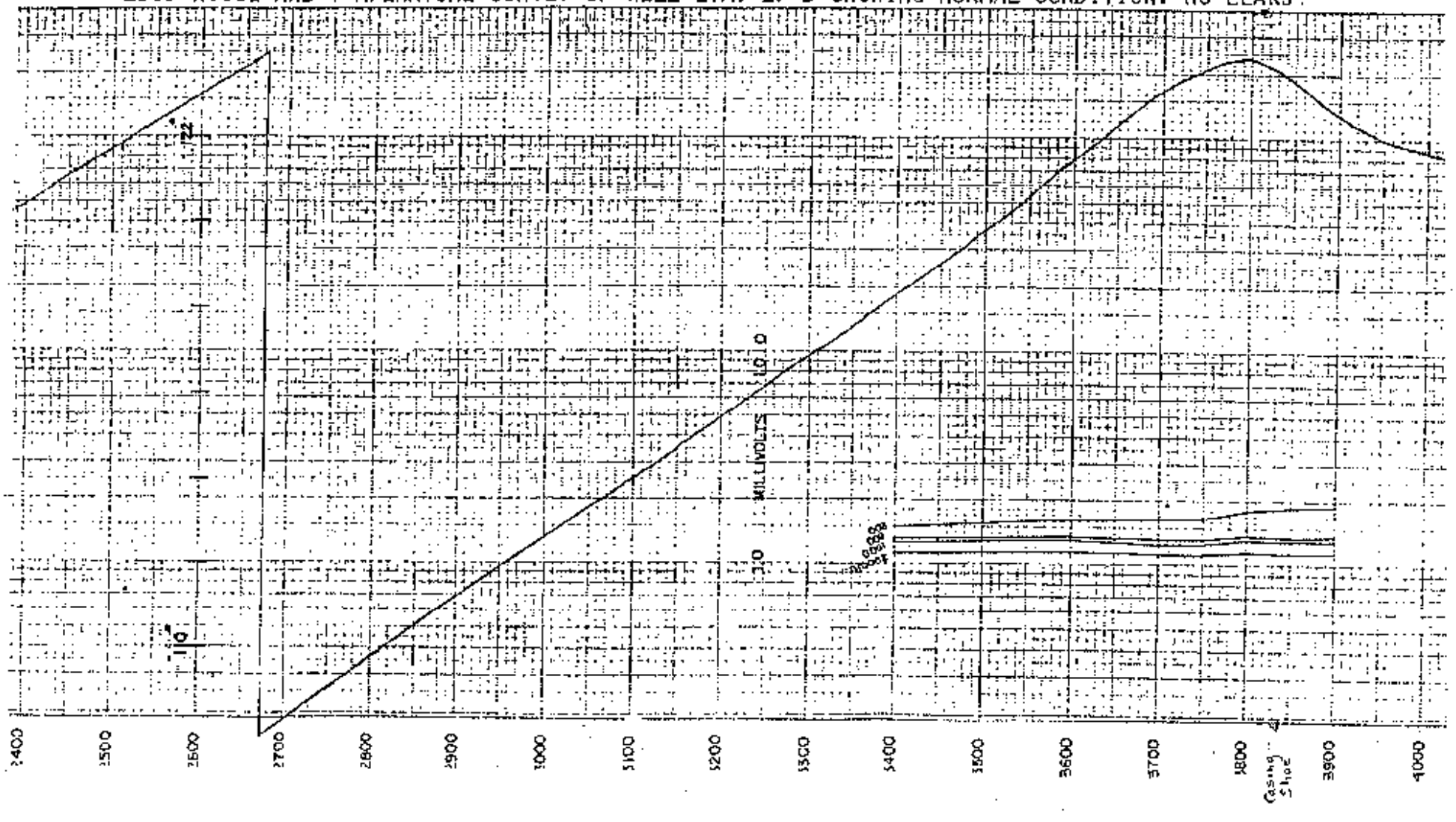
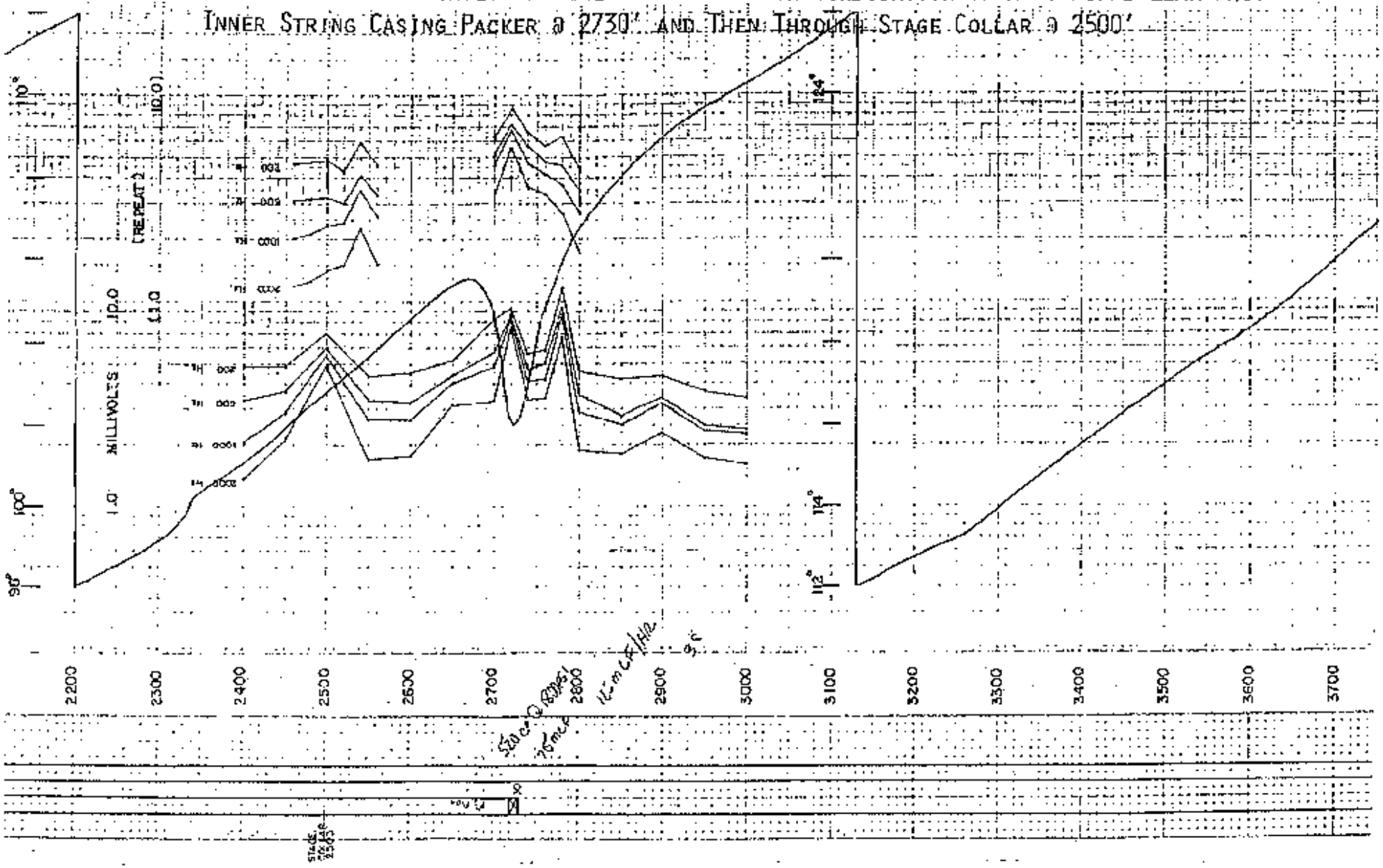
	master valve and listens for any surface leaks.
Contractor	6. Logs the temperature profile of well bore at a maximum speed of 100 ft /min. to a point 10' above bottom of tubing or to point where passage is restricted by tubing size. 7. Takes noise amplitude readings at 20' intervals: a. From the bottom of tubing through the storage zone to 200' above the casing shoe. b. 100' on each side of any potential or suspected leak area on casing. 8. Examines and verifies recorded temperature and noise log data, and checks for any instrument malfunctions. Highlights any anomalous data on field copy of recorded log. 9. Records additional noise amplitude readings in the vicinity of apparent anomalies at intervals of 20' or less as directed by the GSM representative. 10. Pulls tools up into lubricator.
GSM Operator-Mechanic	11. Closes wellhead master valve.
Contractor	12. Removes lubricator and equipment from wellhead.
GSM Operator-Mechanic	13. Reinstalls Guiberson union cap and closes downhole safety valve (if appropriate). Checks that all valves and fittings are secured.
GSM Engineer	14. Analyzes survey logs for indications of gas leakage and compares field copy and final drafted copy of logs for accuracy of reproduction. 15. Plans, arranges, and supervises radioactive tracer surveys when justified by evidence of gas leakage found on noise and temperature surveys.

[redacted]

1985 NOISE AND T-MPERATURE SURVEY OF WELL L.M. 17-D SHOWING NORMAL CONDITION: NO LEAKS.



1985 NOISE AND TEMPERATURE SURVEY OF WELL WS 12-W SHOWING INDICATION OF A 50 MCF/D LEAK PAST INNER STRING CASING PACKER @ 2730' AND THEN THROUGH STAGE COLLAR @ 2500'



1985 NOISE AND TEMPERATURE SURVEY OF WELL L.M. 15-C SHOWING INDICATION OF A CASING SHOE LEAK

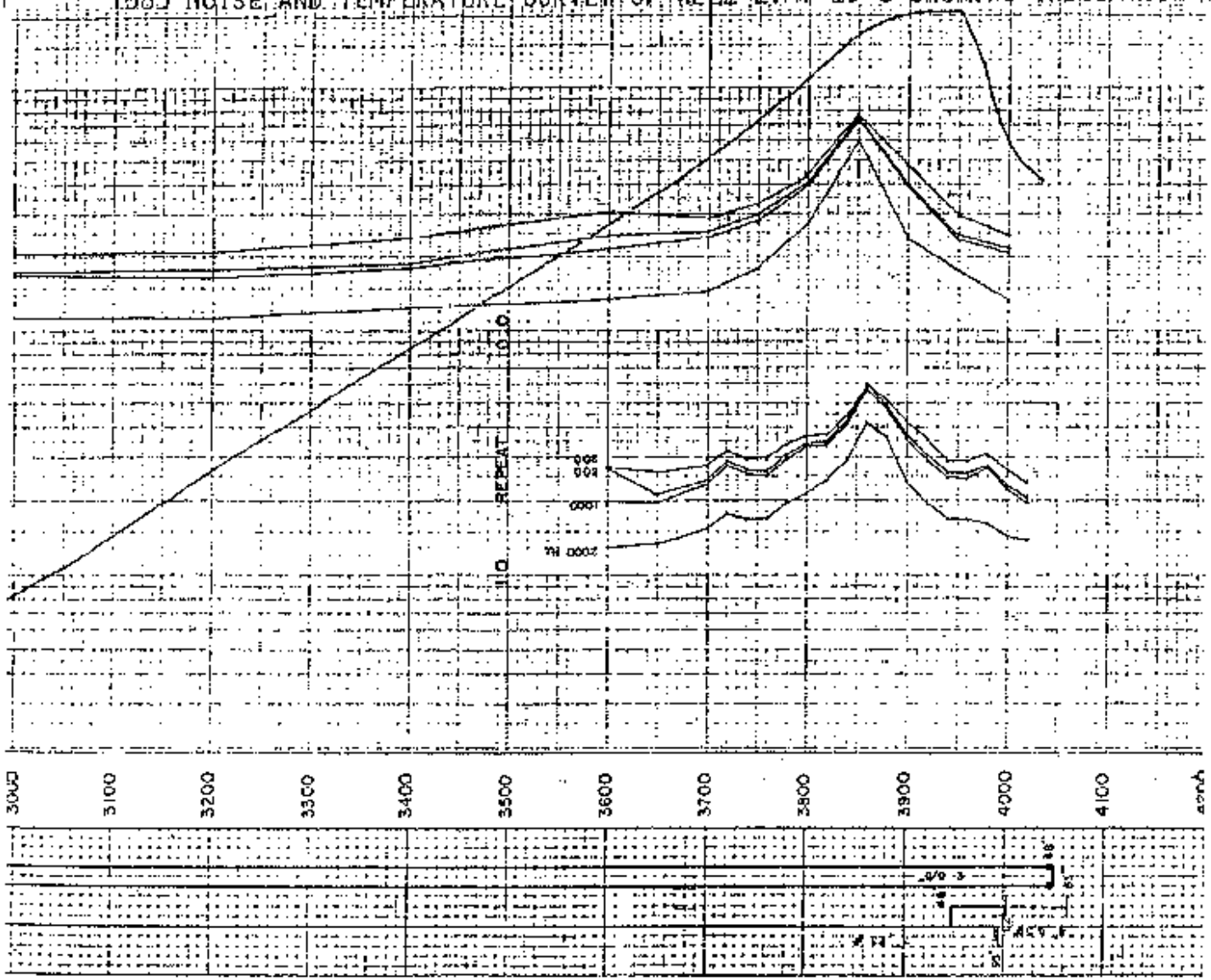


EXHIBIT 5

PACIFIC GAS AND ELECTRIC CO. STANDARD PRACTICE 456-1 SPECIFICATION NO. 8691 2/4/8(

GAS PRODUCTION AND STORAGE DEPARTMENT

1986 STORAGE WELL LEAK SURVEY PROGRAM
SPECIFIC CONDITIONS AND PRICE QUOTATION FORM

Name of Bidder (herein called "The Contractor"): FLO-LOG, Inc.

I. SCOPE OF WORK PROPOSED FOR 1986

A. The Contractor will perform surveys as specified in the following 100 gas storage wells:

1. 79 wells (average measured depth of 5500' and pressure of 1900 psig) at McDonald Island Gas Storage Field (near Stockton).

2. 6 wells (average measured depth of 2600' and pressure of 1200 psig) at the Pleasant Creek Storage Field (near Winters).

3. 15 wells (average measured depth of 4000' and pressure of 1400 psig) at the Los Medanos Gas Storage Field (near Concord).

B. Using surface recording equipment, the Contractor shall log the temperature profile at a tool speed of 100 fpm (or less) and take noise amplitude readings at 20' intervals in each well:

1. from the bottom of the tubing, through the storage zone, to 200' above the casing shoe.

2. for 100' on each side of any stage cementing collar or casing patch packer.

C. PG&E intends to rework several wells at McDonald Island and Los Medanos in 1986. The Contractor may have the opportunity to perform surveys on these wells before and/or after the reworks.

II. PRICE QUOTATION

A. The Contractor shall quote his prices in the blank spaces provided below.

1. Price quotations shall include all charges for each survey, including charges for labor, equipment, mileage, crew per diem expenses, fuel for truck, drafting of survey results, maintenance of equipment, etc.

2. The Contractor shall adhere to all specifications and conditions set forth in this document. Any exception(s) must be noted on a separate attached sheet and will be considered as a part of the price quotation.

3. The Contractor will perform survey work on 100 wells, as specified in Section I, Parts A and B, for the sum of $ 42500.00 ($ 425.00 per well).

4. The Contractor will run 1" diameter ~~noise and~~ temperature tools, where needed, for additional charges of $ N/A and $ 150.00 per well, respectively.

Bidder Please Initial Here: [redacted]

[redacted]

B. The Contractor will perform the following survey work concurrently with this well survey program at the option of PG&E Co.

1. While on location, the Contractor will take additional noise readings or will perform a partial or complete re-survey on any of the 100 storage wells for noise or temperature data at the rate of $ 300.00 per hour, including time for rigging up and down on a well.

2. The Contractor will perform a radioactive tracer survey on any of the 100 wells, providing at least a 50 MC concentration of radioactive tracer material and all tools and equipment surface injection or downhole ejection for the sum of $ 2300 per well and an overtime charge of $ 95 per hour for survey work beyond a 5 hour period.

C. At the option of PG&E, the Contractor will perform surveys separate from the specified survey program.

1. The contractor will perform surveys as in Section I, Part B for the price of $ * per well. The contractor will take additional noise readings or perform a repeat survey for the price of $ 300.00 per hour.

2. The Contractor will perform a radioactive tracer survey providing at least 50 MC concentration of radioactive tracer material and all tools and equipment for the sum of $ 2300 per well and an overtime charge of $ 95 per hour for survey work beyond a 5 hour period.

3. If these surveys cannot be performed concurrent with other survey work, a charge of $ 2.00 per mile will be levied for round trip mileage from Paramount, CA (location), though this condition may be waived if more than 3 days of work are made available.

III. DETAILS and CONDITIONS

A. A PG&E operator-mechanic will be provided to open and close all well head valves, to assist in connecting the lubricator, and to control the downhole safety valve. All rigging up and rigging down must be done under the supervision of a PG&E representative.

B. A complete well specification sheet that details all critical well parameters and past leak survey history for each well will be provided to the contractor.

1. The Contractor shall be responsible for reading the well specification carefully to get correct well information. PG&E will not be responsible for costs incurred if tools are lost or damaged because of Contractor's negligence.

2. Any questions regarding well specifications or conditions should be referred to Mr. Tom Wilson or his assistants.

* $ 1900 per well when one well is available per trip
$ 1000 per well when two " " "
$ 700 per well when three " " "
$ 500 per well when four " " "
$ 425 per well when more than four wells are available

Bidder Please Initial Here: [redacted]

[redacted]

C. Limiting Conditions

1. The Contractor understands that he shall not receive any credit for survey work producing obviously erroneous data.

2. The Contractor understands that occasional storage field operating conditions may limit the number of surveys possible on a particular day.

3. If it is not possible to survey all 100 wells, then the Contractor's compensation shall be pro-rated, at the specified per well price, on the basis of the work accomplished.

D. The Contractor may invoice PG&E on a weekly or monthly basis for 100% of charges for work performed.

IV. STANDARDS

A. The Contractor should keep the same personnel on this job as long as possible, avoiding unnecessary rotation of personnel.

B. The Contractor is to begin this job with all equipment in good operating condition. All equipment is to be inspected, tested, and maintained regularly to assure accuracy and reliability.

C. The Contractor shall provide drafted surveys as follows:

1. Scales and time constants used for the logging truck plotter should be chosen to obtain optimum detail. Drafted final survey must use scales acceptable to PG&E.

2. Drafted final well surveys shall be provided at no extra charge and not later than 20 days after completion of survey.

3. A field copy of the survey results should be provided to PG&E within two days after completion of each survey.

D. The Contractor's noise log and radioactive tracer log interpretation specialist(s) shall review all surveys before drafted copies are forwarded to PG&E. Specialist(s) shall be reasonably available to aid PG&E engineers with interpretation of survey results.

E. The Contractor's log interpretation specialist shall visit PG&E's headquarters in San Francisco at least twice (tentatively after completion of surveys at McDonald Island and after completion of surveys at Los Medanos) to review survey results with Gas Production and Storage Department engineers.

Bidder Please Initial Here: [redacted]

[redacted]

F. The Contractor should provide the following equipment and meet the following specifications:

1. Survey tool size should be 1-3/8" diameter or less. Some storage wells have a 1.51" I.D. restriction in the downhole safety valve at ~250'+/-. One well has a 1.125" restriction and will require 1" tools.

2. B.O.P. wireline rams must be placed between lubricator and wellhead, and must adapt to 2" and 3" Guiberson Sealamatic unions on top of trees. Contractor must provide crossovers if needed. (Note that all of the well heads have a 3" Guiberson Seal-A-Matic union except two well heads at McDonald Island which have 2" unions).

3. All contractor-supplied equipment must have a pressure rating of 2000 psig or greater.

4. Current calibration chart for temperature element covering temperature range from 60°F to 150°F.

5. Wireline truck capable of logging to 6,220'.

6. Back-up equipment including extra temperature tool and extra noise tool.

7. The contractor should use the Squire-Whitehouse brand noise logging instrumentation (except for 1" diameter tool).

G. Work Schedule:

1. Work Monday through Friday, excluding holidays.

2. The Contractor should rig up promptly on a well starting at 7:15 A.M., under supervision of PG&E operator-mechanic. (Contractor may set up and adjust equipment at well site prior to this time providing no contact is made with well head).

3. Work should terminate at approximately 4 to 5 PM daily. (Work beyond this time is permissible to complete a survey.)

4. Survey program should commence on or about March 11, 1986. Surveys at Pleasant Creek and McDonald Island should finish no later than June 15, 1986. The surveys at Los Medanos are to be run in November or December when the field is dormant at the end of the injection season.

We accept all terms and conditions in these Specific Conditions and the attached General Conditions with exceptions (if [redacted]) as stated on the attached sheet(s).

Signed, [redacted] 3-6-86 (Date)

[redacted] (Print Name, Title)

Representative for FLO-LOG, Inc. (Company)

14101 Orange Ave. (Address)

Paramount, CA 90723

[redacted] (Telephone)

File: SRVSPC.86

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WELL SPECIFICATION SHEET

McDONALD ISLAND GAS STORAGE FIELD WELL DATA
TURNER CUT NORTH

As of September 24, 1986

Well No.	TUBING Size*	From Depth	To Depth	CASING Size	Shoe Depth	INNER CSG/SCAB Size	From	To	PRODUCTION LINER Size	Packer Depth	Shoe Depth	STAGE COLLAR Depth	SSSV Bore (")	Depth @ Top	K.B. to Top of Tbg Head	MSD Holes Depth	NOTES
1-N	2-3/8"	Hngr	5544'	13-3/8"	904'	7"	Tree	5017'	5-1/2"	5439'	5551' (5204'TVD)	---	2"	262'	16.8'	5460'	Baker F Nipple at 302'.
				8-5/8"	5523'												
2-N	2-2/3"	Hngr	239'	13-3/8"	882'	---	---	---	5-1/2"	5239'	5331' (5204'TVD)	4460'	2"	269'	18.3'	840' 5250'	Baker F at 292'.
	2-3/8"	239'	5328'	8-5/8"	5301'												
3-N	2-3/8"	Hngr	5313'	13-3/8"	901'	7"	Tree	4220'	5-1/2"	5243'	5380' (5166'TVD)	---	2"	262'	15.9'	5275'	Baker F at 284'.
				8-5/8"	5328'												
4-N	2-3/8"	Hngr	5307'	13-3/8"	937'	7"	Tree	3315'	5-1/2"	5176'	5313' (5210'TVD)	---	2"	260'	16.1'	5285'	Baker F at 301'.
				8-5/8"	5256'												
5-N	2-3/8"	Hngr	5607'	13-3/8"	616'	---	---	---	5-1/2"	5567'	5694' (5208'TVD)	5437'	2"	265'	17.8'	5590'	Baker F at 305'.
				8-5/8"	5637'												
6-N	2-3/8"	Hngr	5220'	13-3/8"	898'	---	---	---	5-1/2"	5183'	5222'	4333'	2"	250'	19.0'	5160'	Baker F at 60'
				8-5/8"	5195'												
7-N	3-1/2"	Hngr	5648'	13-3/8"	605'	6-5/8"	4609'	4780'	5-1/2"	5499'	5693' (5211'TVD)	4674'	1.51"	258'	17.6'	5618'	Warning: Tbg. parted at top of liner. Camco No-Go at 271
	2-3/8"	5468'	5670'	8-5/8"	5644'												
8-N	3-1/2"	Hngr	332'	13-3/8"	865'	---	---	---	5-1/2"	5332'	5432' (5249'TVD)	---	2.61"	266'	17.5'	5344'	Baker F at 312'.
	2-3/8"	332'	5427'	8-5/8"	5375'												
9-N	3-1/2"	Hngr	DHSV	13-3/8"	897'	7"	4562'	4677'	4-1/2"	5334'	5507' ($220'TVD)	4626'	1.51"	258'	18.2'	5430'	Camco No-Go at 272'.
	2-3/8"	DHSV	5702'	8-5/8"	5660'												
	1.9"	5102'	5692'														

*Tubing Types: 3-1/2" 9.3# EUE; 2-2/3" 6.4# EUE; 2-3/8" 4.7# EUE and 6.6# VAM; 1.9" 2.75# NUE
**DHSV TYPES: 2" bore = Page DHSV with full bore 1.9"; 1.51" bore = Camco Wireline Retrievable DHSV; 2.61" bore = Otis Tubing Retrievable DHSV