

PUNA GEOTHERMAL VENTURE

A Hawaii Partnership

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DIV. OF WATER &
LAND DEVELOPMENT

October 16, 1991

Mr. Paul Aki
Chief, Clean Air Branch
State Department of Health
P.O. Box 3378
Honolulu, Hawaii 96801

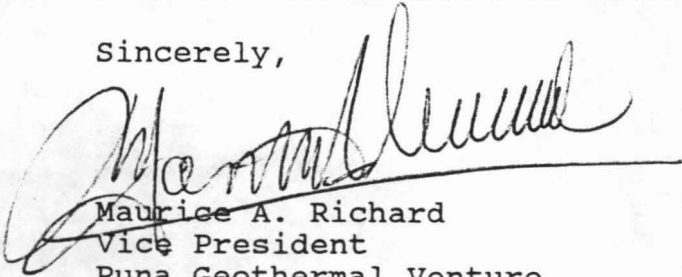
Dear Mr. Aki:

Subject: Authority of Construct (ATC) No. A-833-795
Fourteen (14) Geothermal Exploratory/Development
Wells Located at Kilauea Lower East Rift Zone,
Puna, Hawaii

Pursuant to your letter of October 1, 1991, please find enclosed Puna Geothermal Venture's submittal regarding the hydrogen sulfide abatement program for your review. We believe this document will address the concerns and satisfy your request as set forth in your October 1, 1991 letter.

If there are any questions regarding this document, please feel free to contact me in the Hilo office at 961-2184.

Sincerely,



Maurice A. Richard
Vice President
Puna Geothermal Venture

Enclosure

cc:
N. Hirai, DOH w/enclosure
W. Nagamine, DOH w/enclosure
D. Nakano, DLNR w/enclosure
M. Tagamori, DLNR w/enclosure

91142.011

H₂S ABATEMENT PLAN DURING DRILLING OPERATIONS

I. INTRODUCTION

In the event that an unplanned venting of geothermal steam occurs during drilling operations, a plan has been established to abate the resulting H₂S emissions.

If a surge of geothermal fluid occurs during drilling, a rupture disc in the blowout prevention stack will break at between 150 psi and 175 psi, allowing the steam, gas, and fluid to flow through a vent line to an atmospheric separator (Figure 1).

The flow of geothermal steam, fluid, and gas will be treated by injecting an aqueous solution of sodium hydroxide into the vent line. In the event that the flow of geothermal fluid is dry steam or nearly so, additional water can be injected into the vent line using the rig pumps.

In order to determine the concentration of H₂S emitted to the atmosphere, discrete samples of the steam will be withdrawn from the top of the atmospheric separator and analyzed using an accurate chemical test.

II. STEAM SAMPLING

To measure the H₂S concentration of steam emitted to the atmosphere, steam samples are taken directly from the atmospheric separator.

A sampling probe is mounted inside the separator stack. Steam is withdrawn by a vacuum pump, condensed, and collected in an impinger. The sample is analyzed for H₂S according to the method described in Section III.

III. H₂S TESTING

Discrete samples of steam are withdrawn at regular intervals. The samples are then immediately analyzed for H₂S concentration using a proven analytical method. The test method employed is the Silver Nitrate Potentiometric Determination. (See Appendix A for test procedure.)

To determine H₂S concentration, the steam sample is condensed and

Sodium hydroxide is delivered to the vent line through a teflon lined stainless steel braided hose.

V. ABATEMENT PROCEDURE

- 1.0 If the well begins to flow through the vent line, immediately begin injecting sodium hydroxide at 260 gallons per hour, the pumping unit's maximum discharge rate. Also, begin injecting additional water using the rig pumps if the geothermal flow is dry or nearly so.
- 2.0 Withdraw a steam sample from the atmospheric separator as soon as possible and analyze it immediately for H_2S concentration. Adjust sodium hydroxide and water injection rate to optimize abatement while maintaining the minimum possible H_2S emission rate. Continue sampling as frequently as possible (approximately every 30 minutes) until H_2S emissions stabilize at minimum level. Continue sampling on an hourly basis thereafter.
- 3.0 Take unabated samples of the geothermal flow and analyze them for H_2S concentration as required by item 4.0, Record Keeping.
- 4.0 Record Keeping
 - a. Records will be written in ink, using a permanently bound notebook. All pages will be numbered.
 - b. An entry will be made into the record book documenting each H_2S test. These tests will be numbered sequentially.
 - c. Data in the record book will include:
 - Date
 - Time
 - Steam flow rate (pounds per hour)
 - H_2S concentration (ppm) upstream and downstream of chemical injection
 - H_2S concentration (ppm) and flow rate (pounds per hour) downstream of chemical injection
 - Sodium hydroxide injection rate
 - Sodium hydroxide storage volume on location
 - A check box to acknowledge that the H_2S detector has been checked for zero and span
 - comments and operators initials

bubbled through a solution of sodium hydroxide. The H_2S is chemically trapped in the hydroxide solution. The sample bottle is weighed before and after the sampling procedure, allowing the precise weight of condensed steam to be determined. The weight of H_2S in the sample is determined by a chemical titration. Silver nitrate of a known concentration is slowly added to the sample. The silver nitrate removes H_2S from the solution by reacting with it to form an insoluble salt. An electrode placed in the solution alerts the technician when excess silver ions are present, indicating that all of the H_2S has been removed. Since the reaction between silver ions and H_2S is well understood, the amount of silver nitrate used during the titration can be related to the amount of H_2S removed. The ratio of H_2S to total sample is equal to the concentration of H_2S in the steam.

IV. H_2S ABATEMENT

A. Abatement Method

H_2S is removed from the steam by adding an aqueous solution of sodium hydroxide. The reaction is as follows:



The sodium hydroxide solution is injected into the flow line using chemical metering pumps, which allow the operator to precisely control the injection rate.

The reaction only takes place in the presence of water. Up to 360 gallons of water per minute will be injected into the flow line along with the sodium hydroxide.

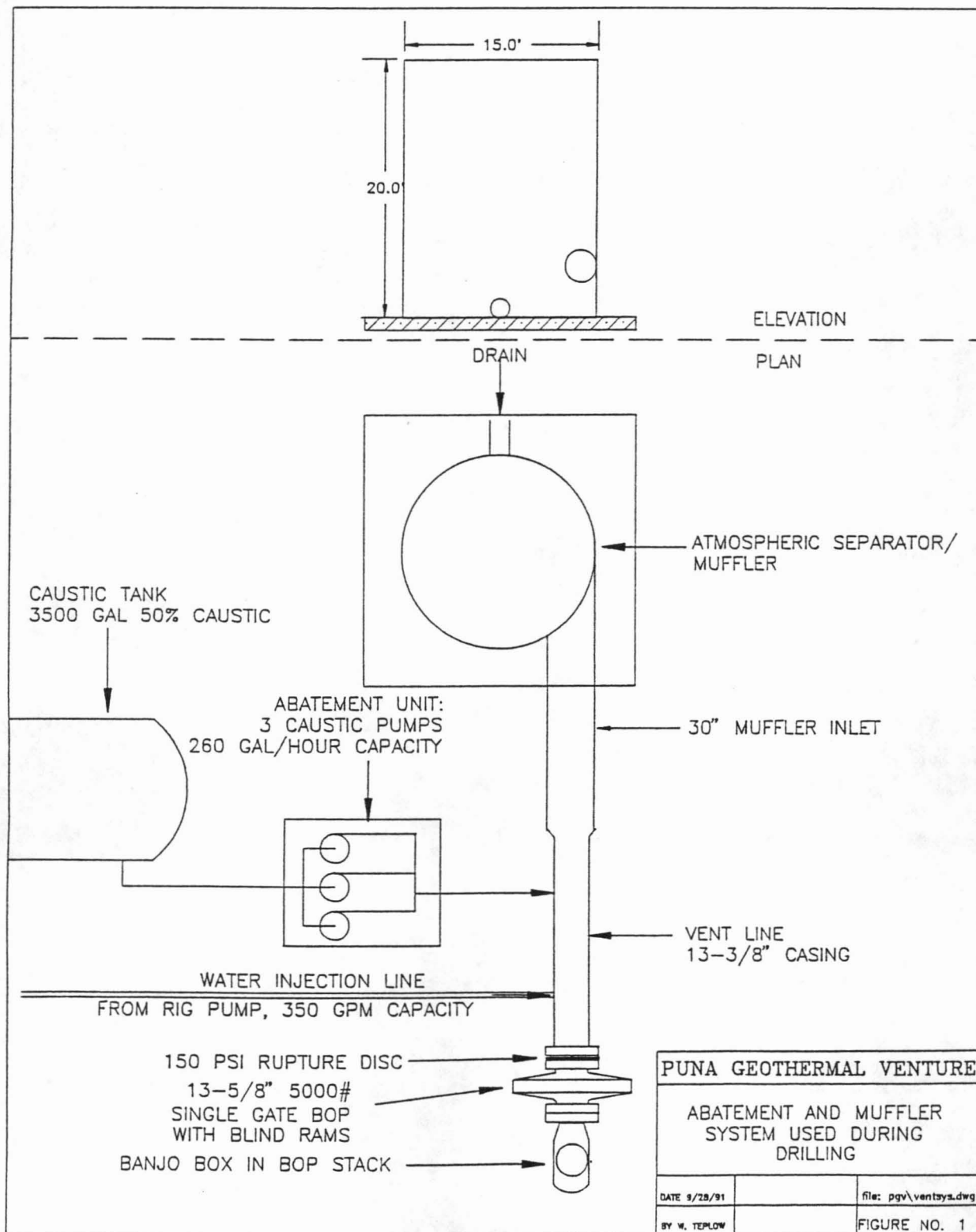
B. Description of Equipment

Sodium hydroxide is injected using Pulsafeeder chemical metering pumps. The pumps are positive displacement piston pumps which deliver a precise amount of chemical with each pump stroke. By controlling the stroke length, the dosage can be varied incrementally from zero to the pump's maximum discharge rate.

Three pumps are mounted on a skid (Figure 1). The three intakes of the pumps are connected in an intake manifold. The discharges are connected similarly. The pumps can be used singly, or together in any combination. The combined maximum discharge rate is 260 gallons per hour. Approximately 3500 gallons of sodium hydroxide is stored at the drill site and connected to the pump intake manifold.

5.0 Reporting

Report H₂S emissions to Hawaii Department of Health (HDOH) representative on site or report via telephone to HDOH after completion of each analysis. A written report summarizing all H₂S analyses and abatement history for the event will be submitted to HDOH after cessation of flow.



Appendex A
TOTAL SULFIDE DETERMINATION

USING THE SILVER ELECTRODE POTENTIOMETRIC METHOD

INTRODUCTION

This method of sulfide determination absorbs the H_2S in the steam condensate into an aqueous sodium hydroxide solution. Silver Nitrate is then used as a titrant to precipitate the sulfide ion as Ag_2S . The end point is readily determined by the sharp potential shift due to excess silver ion in the solution after all of the sulfide has precipitated. Silver ion concentration is measured using an ion specific electrode.

PROCEDURE

A. Sampling

1. Weigh dry gas wash bottle (A).
2. Add approximately 50 ml NaOH to completely submerge the gas bubbler tip and weigh the bottle again (B).
3. Collect approximately 80 ml condensate and weigh the bottle again (C).

B. Titration

1. Weigh a dry 150 ml beaker.
2. Add approximately 50 ml of sample and weigh the beaker again.
3. Dilute the sample with approximately 50 ml distilled water.
4. Record the initial buret reading.
5. Titrate the sample using the $AgNO_3$ solution until the end point is reached.

Since the endpoint to this titration is a sharp potential change (see figure 1) it will be necessary to add the $AgNO_3$ slowly (about 1 ml/min) until the potential rises slightly. After this rise in potential, record the potential readings after adding each 0.1 ml of $AgNO_3$. Continue adding the $AgNO_3$ until there is a sharp rise in the potential; this is the end point. It is good practice to go beyond the end point to observe the flat part of the curve (see figure 1).

6. Record the final buret reading.

REAGENTS

NaOH 7%

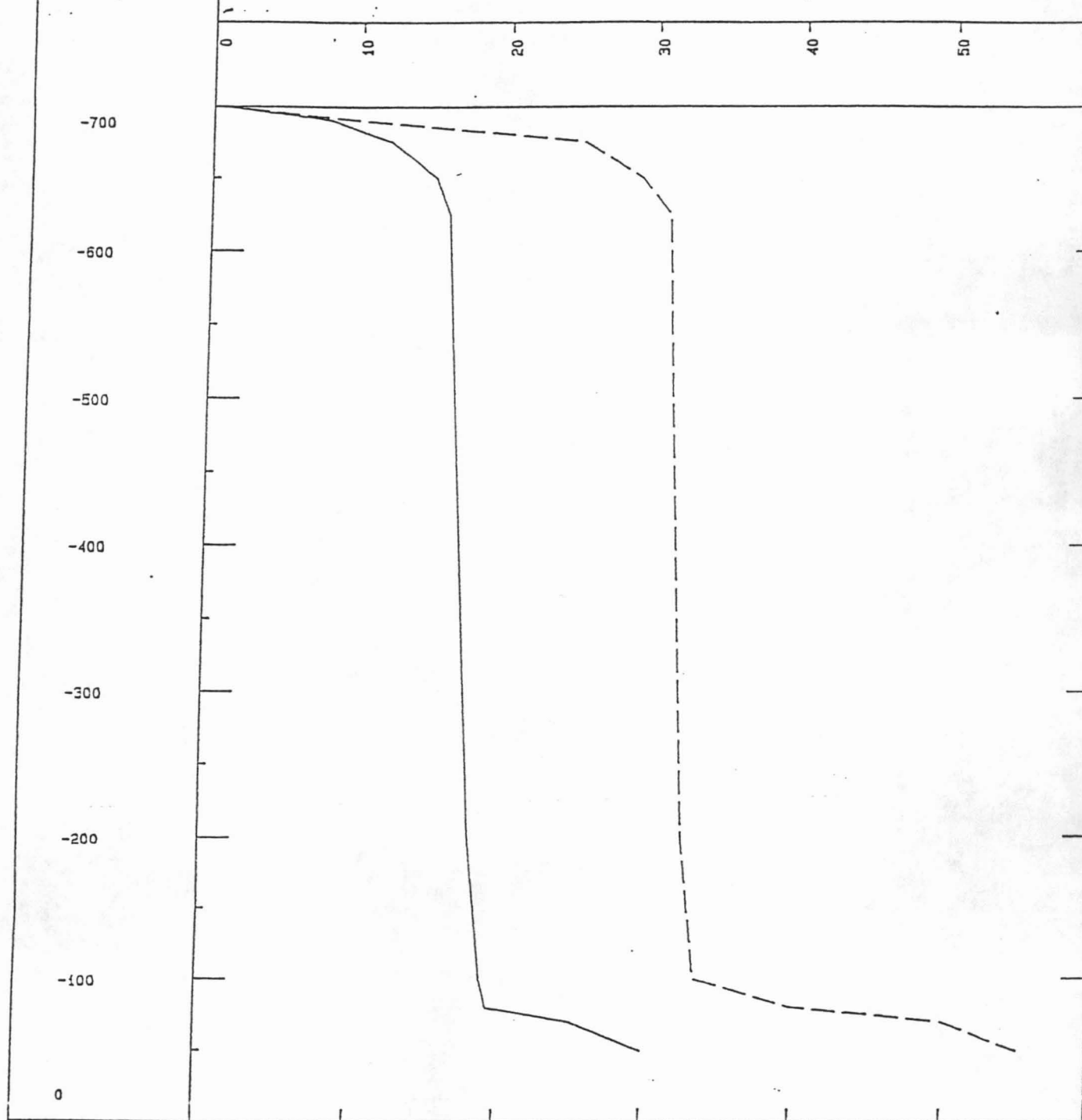
$AgNO_3$ 10 g/liter

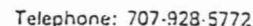
MILLILITERS NITRATE SOLUTION

SAMPLE A

SAMPLE B

POTENTIAL



[illegible]

DATA FOR H₂S DETERMINATION

CALCULATIONS:

$$\text{H}_2\text{S (ppm}_w) = \frac{\text{ml. AgNO}_3 \cdot \frac{10^{-3} \text{ g. H}_2\text{S}}{1 \text{ ml. AgNO}_3} \cdot \frac{\text{Grams of Codensate} + \text{NH}_4\text{OH} \cdot 10^6 \text{ ppm}_w}{\text{Grams of Codensate} \cdot 1}}{\text{Grams of Titrated Sample}}$$

$$\text{H}_2\text{S (ppm}_w) = \frac{(\text{Volume AgNO}_3 \cdot 10^3) \cdot \frac{(C-A)}{(C-B)}}{\text{Weight of Sample Titrated}}$$

SAMPLE #1 H₂S = _____ = _____ (ppm_w)

SAMPLE #2 H₂S = _____ = _____ (ppm_w)

SAMPLE #3 H₂S = _____ = _____ (ppm_w)

Average H₂S = _____ (ppm_w)
