# TREATMENT AND UTILIZATION OF LANDFILL GAS

## Mountain View Project Feasibility Study

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## ABSTRACT

The production, treating, transportation and utilization of landfill gas are discussed in this report. The economics of these steps are also covered. The analysis is performed from the perspective of the Pacific Gas and Electric Company, one of the partners in the Mountain View Landfill Gas Recovery Demonstration Project, scheduled to be operating by early 1977. The U.S. Environmental Protection Agency is supporting the City of Mountain View in this demonstration under Grant No. S-803396-01.

## INTRODUCTION

In California, the recovery of landfill gas was initiated by the Sanitation Districts of Los Angeles County at their Palos Verdes Sanitary Landfill.

In 1971, eighteen wells were constructed on the perimeter of the landfill to prevent gas migration into adjacent properties. The wells were connected by a collection pipeline which terminated in a suction blower and gas burner station. The obvious potential of landfill gas as a source of energy resulted in a successful test program to determine the steady-state gas composition and withdrawal rate.

NRG NuFUEL (now Reserve Synthetic Fuels Inc.) and the Sanitation Districts entered into a contract in October 1973, to produce and purify the landfill gas for a minimum of five years. Since then, a facility to process about two MMSCFD (million standard cubic feet per day) of landfill gas was built and has been in operation since the summer of 1975.

Also in the Los Angeles area, the Department of Water and Power of the City of Los Angeles, as an outgrowth of its gas migration control program at the Sheldon-Arleta Landfill, has successfully demonstrated the feasibility of generating electricity from landfill gas. A combustion engine-generator set was started in April 1974 and ran until February 1975. Since then, the Department of Water and Power has completed the design of a system to compress, dehydrate and transport the full gas production of the Sheldon-Arleta site to its Valley Steam Power Plant.

Encouraged by the success of the Los Angeles programs, PGandE surveyed, in the summer of 1974, the 32 existing landfills in the San Francisco Bay Area as potential producers of gas. This survey concluded that fourteen of these sites had good potential and that the Mountain View Landfill operated by the City of Mountain View was the most promising for an initial demonstration project.[5]

Also in the summer of 1974, PGandE agreed to assist the City of Mountain View on an EPA-sponsored study of gas recovery from the shallow Mountain View Landfill.

This report is the result of the collaboration between PGandE and the City of Mountain View on the landfill gas recovery project. It discusses, in detail, the following topics:

- Landfill gas quality and production rates
- Treatment processes for upgrading landfill gas
    a) Dehydration
    b) $CO_2$ and $H_2S$ removal
    c) $O_2$ and $N_2$ removal
    d) Propane addition
- Economics of treating landfill gas
- Transportation of landfill gas
- Other uses of landfill gas
    a) Generation of electricity
    b) Production of Methanol
- The Mountain View Landfill Gas Recovery Project-A Case History

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## LANDFILL GAS QUALITY AND PRODUCTION RATES

Measured landfill gas composition at Mountain View is as given in Table 1 (1, 2).

TABLE 1

MEASURED GAS COMPOSITION

| CONSTITUENT | VOLUME % | | |
|---|---|---|---|
| | Avg. | High | Low |
| Methane | 44.03 | 46.49 | 41.38 |
| Carbon Dioxide | 34.20 | 36.80 | 30.73 |
| Nitrogen | 20.81 | 23.51 | 19.98 |
| Oxygen and Argon ≠ | 0.96 | 1.69 | 0.48 |
| Water | Saturated at 14.7 psia and 90°F grains per 100 ft.$^3$* | | |
| Hydrogen Sulfide | | 0.40 - 0.91 | |
| Mercaptan Sulfur | | 0.00 - 0.33 | |
| Sulfides | | 0.41 - 1.80 | |
| Disulfides and Residuals | | 0.93 - 1.65 | |

≠ Ar represents at least 50% of the total

* To convert to ppm multiply by 17, 7.63, 6.44 and 4.75 for $H_2S$, mercaptan, sulfides and disulfides respectively

The composition for the major constituents is based on data taken for a continuous run at a 50 CFM withdrawal rate, lasting from May 22 to June 30, 1975. The data for the impurities is based on more limited runs at a 75 CFM withdrawal rate.

Test results at both Palos Verdes and Sheldon-Arleta show a relatively stable composition of 50-56% methane, 40-45% $CO_2$, about 1% $N_2$, 0.1% $O_2$, some heavy hydrocarbons and a hydrogen sulfide

content ranging from 0.5 ppm at Sheldon-Arleta to 45 ppm maximum at Palos Verdes. (3,4)

The substantial nitrogen and oxygen content at Mountain View indicates a high air leakage rate resulting from the shallowness of this landfill (40 ft.) as contrasted with the Los Angeles sites where depth ranges from 100 to 140 feet. The high hydrogen sulfide content measured at Palos Verdes may result from its being a Class I site that receives large quantities of toxic wastes of municipal, industrial, and agricultural origin (ashes, refinery spent brines, drilling muds, pesticides and fertilizers, etc.).

Optimum production rates of about one CFM and three CFM per foot of well were measured at Sheldon-Arleta and Palos Verdes respectively. It is difficult to explain the difference between the two figures except by reiterating that the Palos Verdes Landfill is a Class I site as opposed to the Class II Sheldon-Arleta site which contains mostly household refuse.

At Mountain View, a production rate of one CFM per foot of well was corroborated.

In general, landfill gas production (wet basis) can be expressed by the following equation: (5)

$$SCFD = 18.77 \times 10^6 \ (Ah/R^2) \quad (1)$$

Where SCFD is the production rate in standard cubic feet per day, A is the area of the landfill in acres, h is its depth in feet, and R the radius of influence of the wells in feet.

The estimated life of a production well is given by the following equation:

$$t = 2.49 \times 10^{-3} \ C \ R^2 \quad (2)$$

Where t is the life in years, C the fraction of carbon in SMW converted to methane and carbon dioxide, and R is as defined above.

Derivation of these equations is given in Appendix I. They are based on the following assumptions:

1. Landfill gas has the composition given in Table 1.
2. The optimum gas withdrawal rate is one CFM per foot of well.

At Mountain View, the area influenced by the 20 wells of the demonstration project covers about 30 acres. Using equation (1), an average depth of 35 feet and a radius of influence of 130 feet, the gas production rate is about 1.166 MMSCFD. The proposed pipe layout for the Mountain View project is shown on Figure 1 [7].

Selection of a radius of influence of 130 feet was made on the basis of tests carried out at Mountain View where pressure drop as a function of distance from wellhead, elevation within the cell, and gas withdrawal rate was investigated. [1]

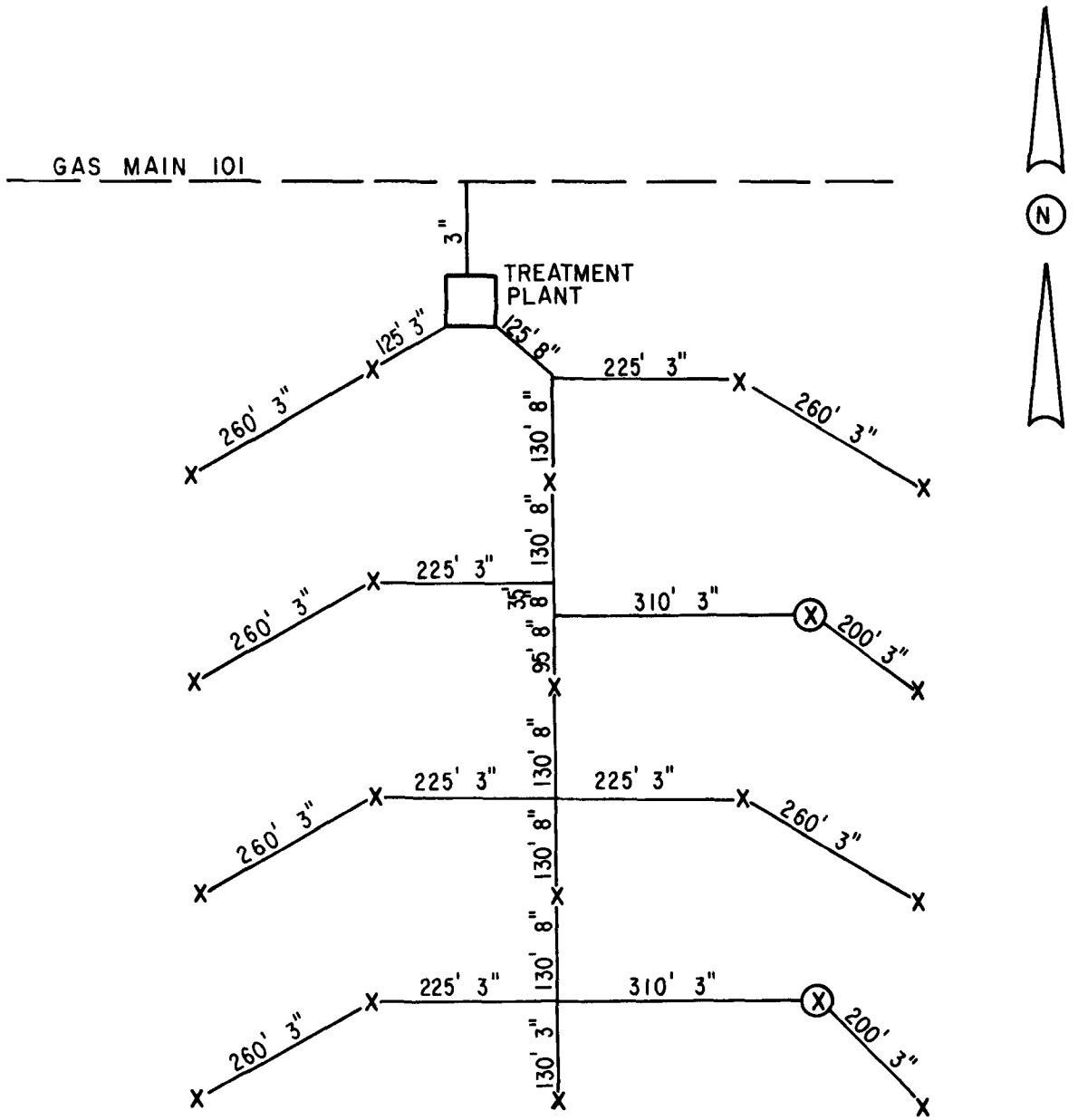
Using equation (2), a reasonable fractional conversion of carbon to methane and carbon dioxide of 0.24 corresponds to a 10-year project life. A 10-year project life was used in the economic analyses to be discussed in another section of this report.

## TREATMENT PROCESSES FOR UPGRADING LANDFILL GAS

When compared to natural gas, landfill gas is deficient in several respects.

First, due to the presence of carbon dioxide and nitrogen, landfill gas has a lower heating value (about 450 Btu/scf versus 1000+ for natural gas). This relatively low heating value of land-

# GAS COLLECTION NETWORK
# MOUNTAIN VIEW SANITARY LANDFILL




⊗ EXISTING TEST WELLS

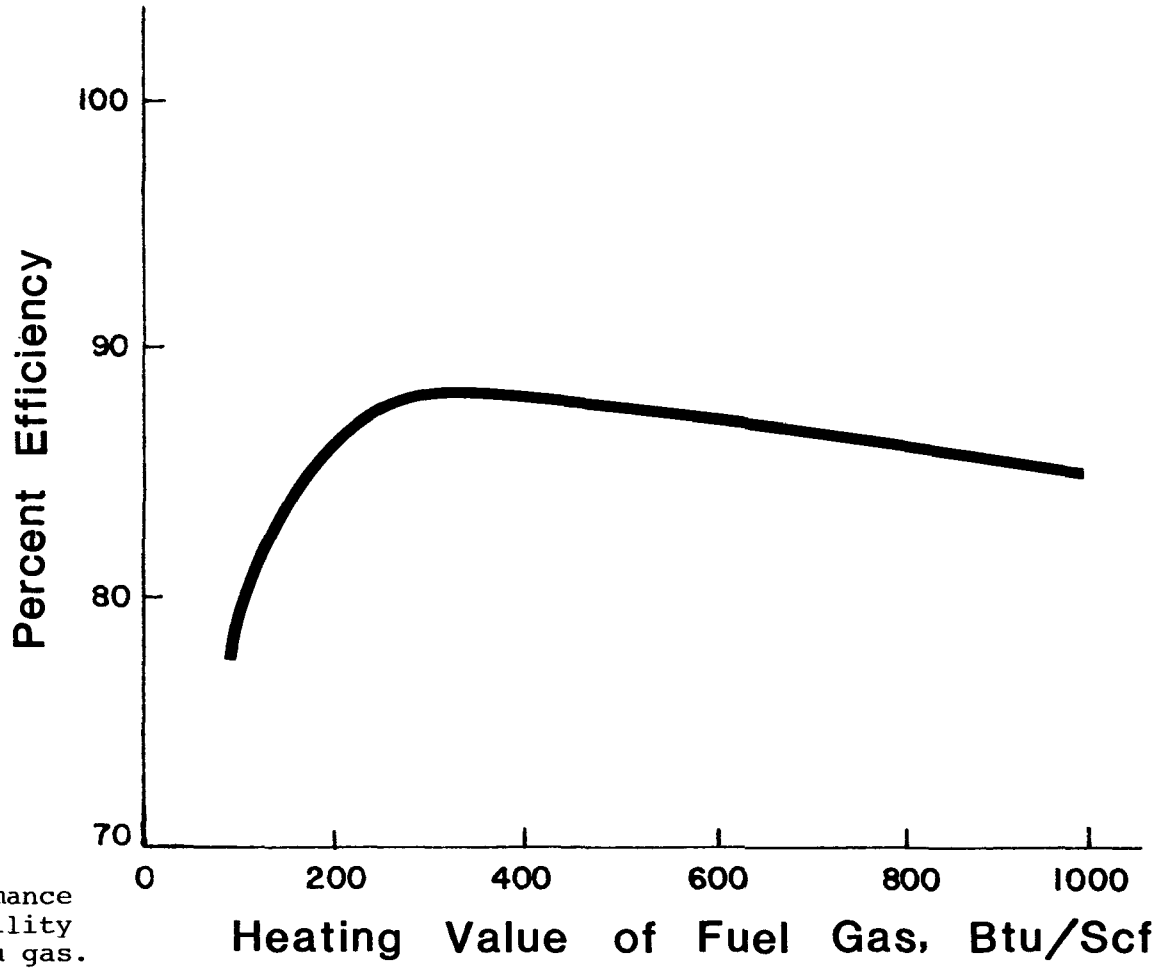
| PIPE SUMMARY | |
|---|---|
| 3" = | 3,950' |
| 8" = | 905' |
| TOTAL | 4,855' |

FIGURE NO. 1

fill gas poses different problems depending upon the way it is used. If used alone in a boiler originally designed to burn natural gas or fuel oil, some retrofitting of the equipment may be required. Retrofitting requires the replacement and/or modification of burners and fuel lines to accommodate the higher gas flows. A thorough review of the utilization of this kind of gas in existing boilers is discussed by A. M. Frenberg [8]. It must be stressed that the efficiency of an existing unit is not expected to decrease with the firing of landfill gas, as illustrated in Figure 2. This results principally from the fact that the amount of flue gas per unit of heat input is about the same as in the case of firing with natural gas, as shown in Figure 3.

If mixed with natural gas, as can be achieved, for example, by injection of landfill gas into a utility's transmission line, the heating value of the mixed gases must be kept above 975 Btu/scf in PGandE's service area. This specification is set so as to save PGandE the expense of having to reset all appliances in the area receiving the mixed gases. Another difficulty with the mixing of landfill gas with pipeline gas has to do with the specification requiring that the heating value of the gas sold to a customer be on the average within $\pm$ 2 Btu/scf of that shown on the customer's utility bill. Meeting this specification is particularly difficult in situations where a constant flow of landfill gas is injected into a grid in which the flow of gas varies hourly, daily, and seasonally. It may very well be that the way to deal with that last problem is to get a variance from the regulatory agency that has jurisdiction over the project, whenever possible. In any event, these heating value specifications

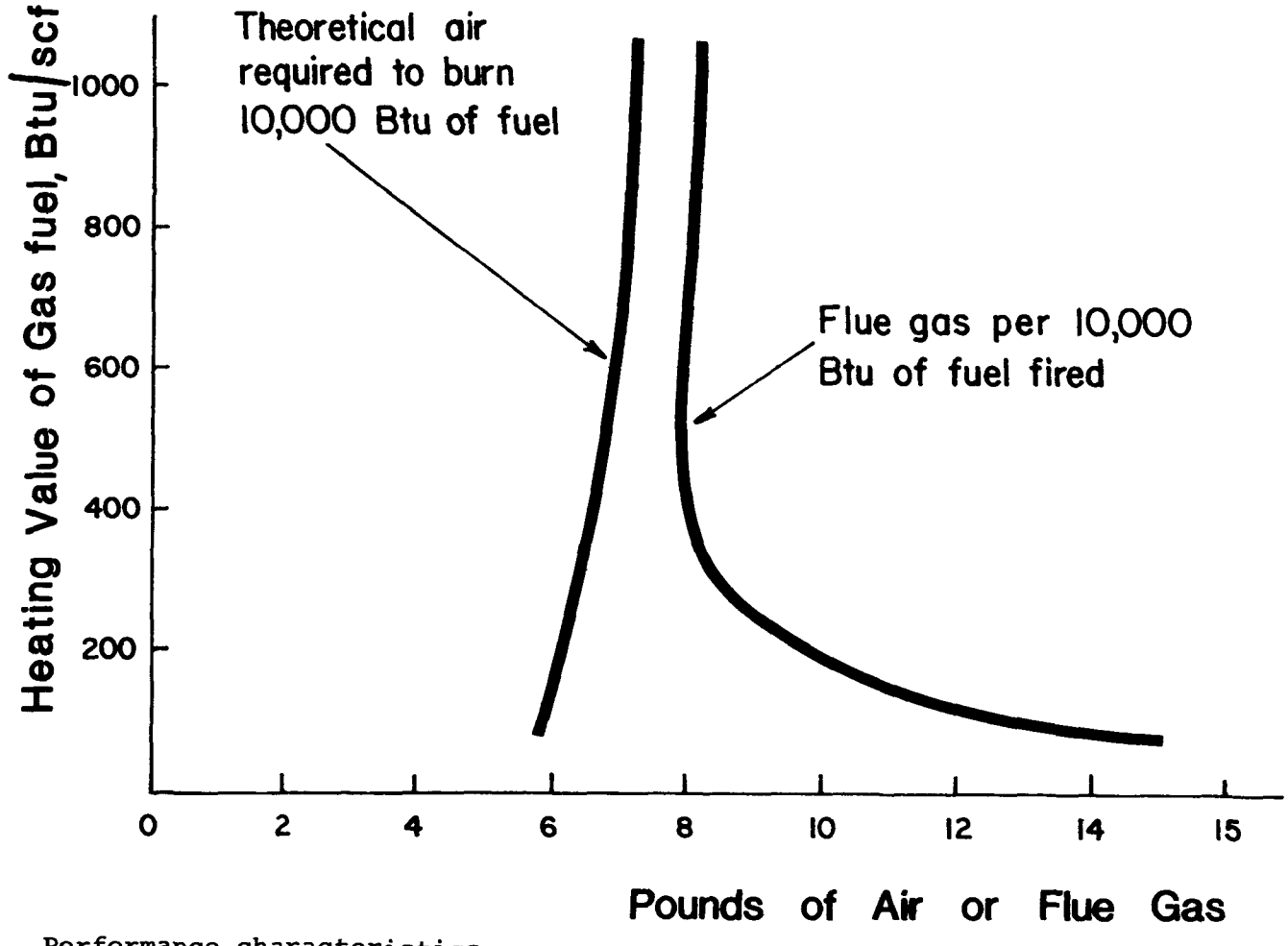
## UNIT THERMAL EFFICIENCY VERSUS HEATING VALUE OF FUEL GAS*




*Frendberg, A. M. Performance characteristics of existing utility boilers when fired with low Btu gas. Presented at Electric Power Research Institute Symposium "Power Generation--Clean Fuels Today," Monterey, Calif., Apr. 8-10, 1974. [28 p.]

FIGURE NO. 2

## POUNDS OF AIR OR FLUE GAS VERSUS HEATING VALUE OF FUEL GAS*




*Frendberg, A. M. Performance characteristics of existing utility boilers when fired with low Btu gas. Presented at Electric Power Research Institute Symposium "Power Generation--Clean Fuels Today," Monterey, Calif., Apr. 8-10, 1974. [28 p.]

FIGURE NO. 3

limit the mixing ratio of landfill gas with natural gas.

Second, landfill gas, as it comes out of the ground, is saturated with water. The water content is about 3,500 lbs of water per MMSCF of gas, as compared to a specified water content of 7 lbs per MMSCF for pipeline quality gas. This water specification is set so as to eliminate corrosion and hydrate formation problems that would result from a high water content.

Third, the presence of oxygen in landfill gas is undesirable as oxygen causes corrosion and tends to react with the odorants introduced in pipeline gas to facilitate the detection of leaks. For this last reason, PGandE deems it necessary to limit the oxygen content in the mixed gases to about 40 ppm.

Finally, the presence of sulfur compounds in landfill gas is of concern as the trend has been to limit the content of these compounds to about 4 ppm in pipeline gas.

In order to deal effectively with the deficiencies described above, landfill gas must be treated so as to improve its quality.

Many schemes for treating landfill gas were investigated by PGandE as part of its involvement in the Mountain View Project. They are described below:

Dehydration of Landfill Gas with Molecular Sieves

Molecular sieves are crystalline aluminosilicates, honey-combed with cavities which are interconnected by pores varying from about 3 to 10 angstron units in diameter depending upon the particular crystal. Molecular sieves have the largest surface area per unit volume of any solid absorbent. In addition, molecular sieves have highly localized polar charges. These localized charges explain the

very strong absorption of polar or polarizable compounds on molecular sieves. This also results in much higher absorptive capacities for these materials by molecular sieves than by other absorbents, particularly in the lower concentration ranges.

The flow scheme for molecular sieve dehydration is shown in Figure 4. Landfill gas is compressed to about 400 psig, then cooled, and condensed water and organic liquids are separated from the gas in a knock-out drum. The gas then flows to a molecular sieve dryer, which reduces the water vapor content to less that 7 lb/MMSCF. Two dryers are required so that one can be regenerated while the other is in use. In the scheme shown, regeneration is accomplished by taking a slip-stream of the dry product gas, approximately 15% of the total flow, reducing its pressure, flowing the stream through the dryer to be regenerated and recyling it to the compressor inlet. The water vapor picked up is condensed in the air cooler and separated from the gas in the knock-out drum.

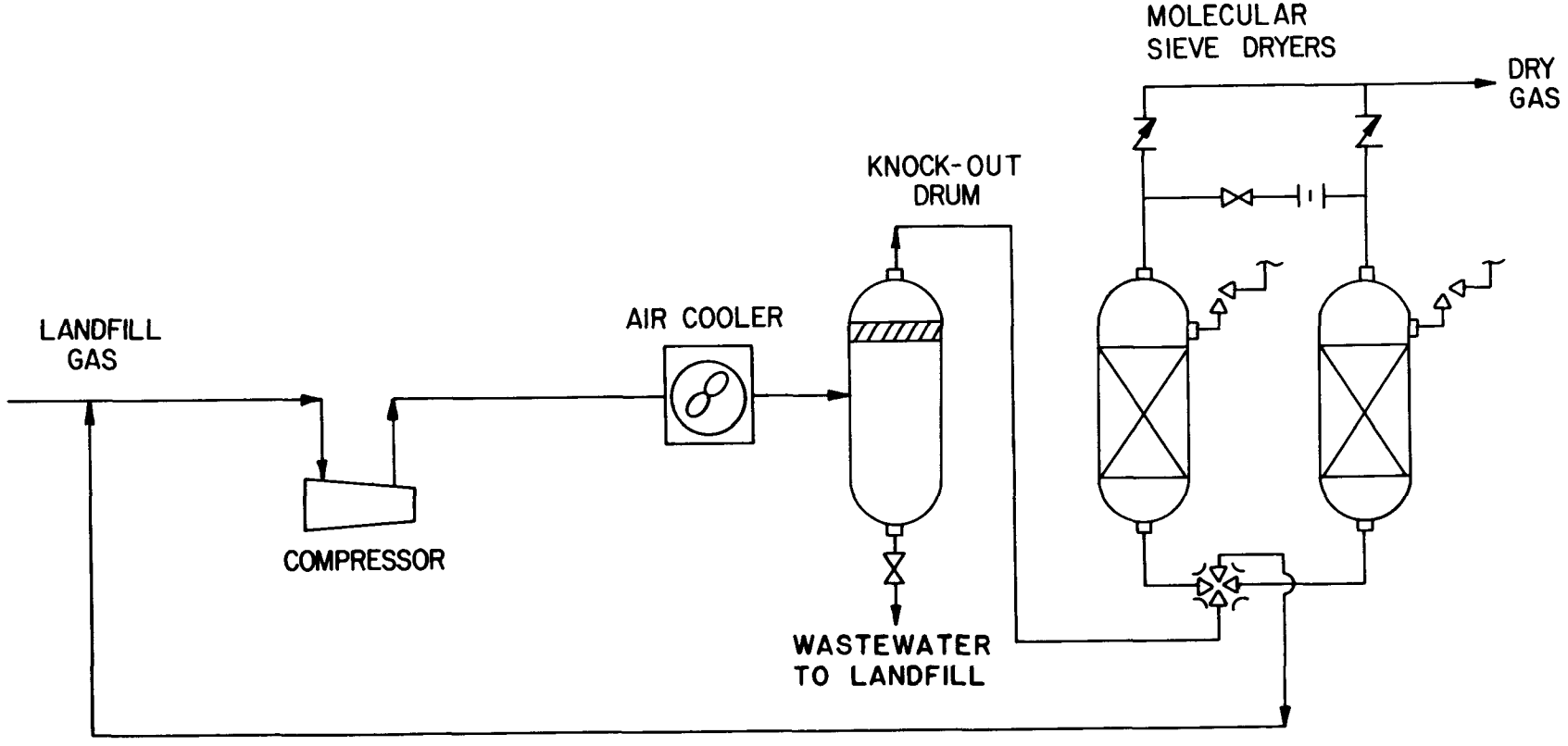
The water which this process and the following ones remove can be injected back into the landfill unless there is already an excess of leachate.

Dehydration of Landfill Gas With Triethylene Gycol

A triethylene glycol (TEG) system can also be used to dehydrate landfill gas to normal pipeline specifications of 6-7 lbs $H_2O$/MMSCF gas.

The factors which have led to the widespread use of glycols for gas dehydration are their unusual hygroscopicity, excellent thermal and chemical stability, low vapor pressures, and ready

# SIMPLIFIED PROCESS FLOW DIAGRAM
# MOLECULAR SIEVE DEHYDRATION OF LANDFILL GAS
FIGURE NO. 4



availability at moderate cost. Of the available glycols, triethylene glycol is generally the preferred absorbent where maximum dew-point depression is required. The principle reason for this is its greater stability at the high temperature required for adequate regeneration.

A flow diagram for this process is provided in Figure 5. A knock-out drum is placed in the compressor suction line to remove bulk contaminants (solid and condensed liquids). After compression and cooling (during which most of the water is removed), the gas stream enters the TEG absorber/separator tower. The lower part of the tower is a separator which removes any free liquids in the gas stream prior to its entering the absorber section. The remaining water-saturated gas then enters the absorber section of the tower where it counter-currently contacts lean triethylene glycol on bubble-cap trays.

The glycol stream containing from 1 to 5% water contacts the gas in a short, counter-current column. The water which is absorbed dilutes the glycol somewhat, and the dilute solution must be reconcentrated before it can be reused in the absorber. The reconcentration is accomplished by distilling water out of the solution in a regenerator. Because of the large difference in the boiling points of water and glycol, a very sharp separation can be accomplished with a relatively short column. Some water reflux must be provided at the top of this column to effect rectification of the vapors and minimize glycol losses. Excessive decomposition of the glycols may occur if the temperature reaches too high a level. A recommended maximum temperature is about 400°F for TEG.

# SIMPLIFIED PROCESS FLOW DIAGRAM
# TEG DEHYDRATION OF LANDFILL GAS

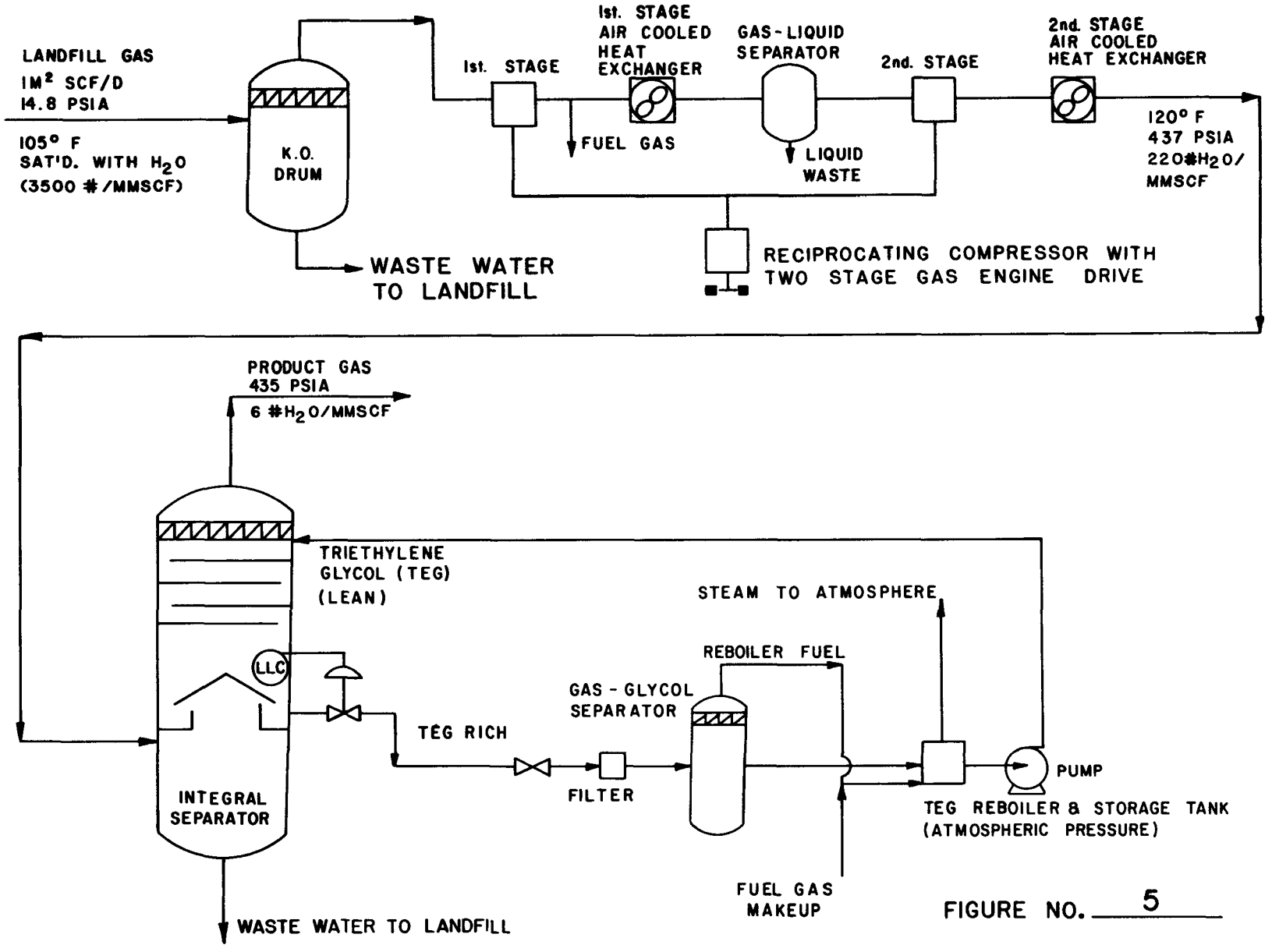



FIGURE NO. 5

Dehydration and Carbon Dioxide Removal With Molecular Sieves

A molecular sieve system similar to the one described in the Dehydration section can be also used to remove carbon dioxide and/or hydrogen sulfide. The only basic change is in the quantity and pore size of the sieve pellets used.

Dehydration and Carbon Dioxide Removal With TEG and Hot Potassium Carbonate

Coupling the TEG dehydration system described previously with a hot potassium carbonate scrubbing system would allow the removal of carbon dioxide and hydrogen sulfide as well as dehydration. A typical flow sheet for a hot carbonate $CO_2$ and $H_2S$ removal (sweetening) process is shown in Figure 6.

Landfill gas containing $CO_2$ and $H_2S$ (sour gas) flows through a separator (not shown in Figure 6) and a gas-to-gas exchanger. Heated sour gas enters the absorber in which it is contacted counter-currently with lean hot potassium carbonate. The absorber in a hot carbonate plant normally operates at about 230°F and 400 psig. $CO_2$ and $H_2S$ are absorbed by the lean carbonate solution.

The sweetened gas leaves the top of the absorber (with a high water content) and passes through the gas-to-gas exchanger. Because of the sweetened gas' water content, dehydration is normally required. The TEG system described previously can accomplish the required dehydration.

Rich carbonate solution leaves the bottom of the absorber and flows to the stripper which operates in the range of 2 to 10 psig. The sudden release in pressure flashes a large portion of the acid gases on the top tray. The partially stripped solution then flows down the stripper for further regeneration with steam from

# SIMPLIFIED PROCESS FLOW DIAGRAM
# HOT CARBONATE PROCESS

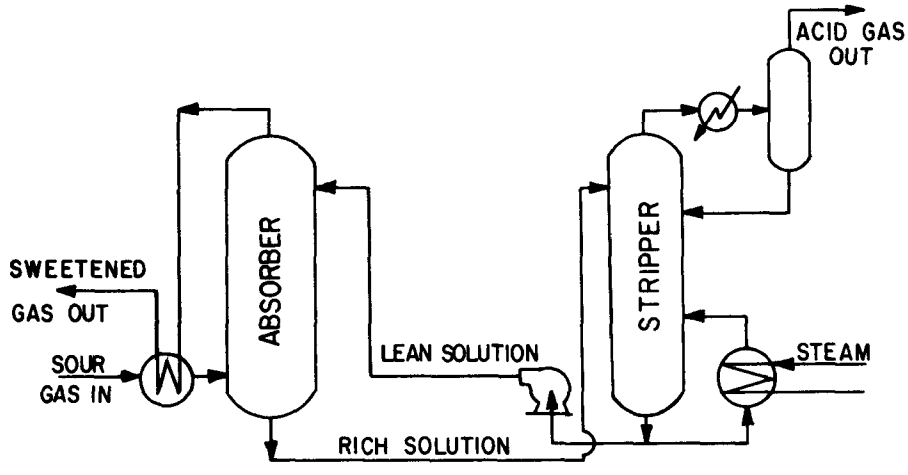



FIGURE NO. 6

the reboiler.

The acid gases, together with some water vapor, pass overhead and through the condenser. Steam is condensed and separated from the acid gases in the reflux accumulator. From the accumlator water is returned to the stripper as reflux and the acid gases are flared or further processed.

Lean solution from the bottom of the stripper is pumped to the top of the absorber for reuse. Temperature at the bottom of the stripper will normally run in the 240-250$^{o}$F range.

Dehydration and Carbon Dioxide Removal With The DMPEG Process

The DMPEG process, which dehydrates landfill gas as well as removes carbon dioxide and hydrogen sulfide, is shown in the simplified process flow diagram of Figure 7.

Landfill gas is compressed and cooled by exchange with the treated gas. Condensed water is separated prior to contact with the solvent which physically absorbs carbon dioxide. The solvent is the dimethyl ether of polyethylene glycol (DMPEG).

The cold lean solvent entering the top of the absorber reduces the temperature of the treated gas enough to condense sufficient water to meet the product gas water vapor content specification.

DMPEG having significantly greater solubility for hydrogen sulfide than for carbon dioxide, some selectivity for hydrogen sulfide can be designed into the absorption system.

No reboiler heat is required for solvent regeneration. The solvent is chilled prior to two flash separations. The first flash separation releases dissolved methane which is recirculated. The second flash generation vents carbon dioxide, hydrogen sulfide and water vapor to the atmosphere. The product gas has a water content less

# SIMPLIFIED PROCESS FLOW DIAGRAM - DMPEG PROCESS

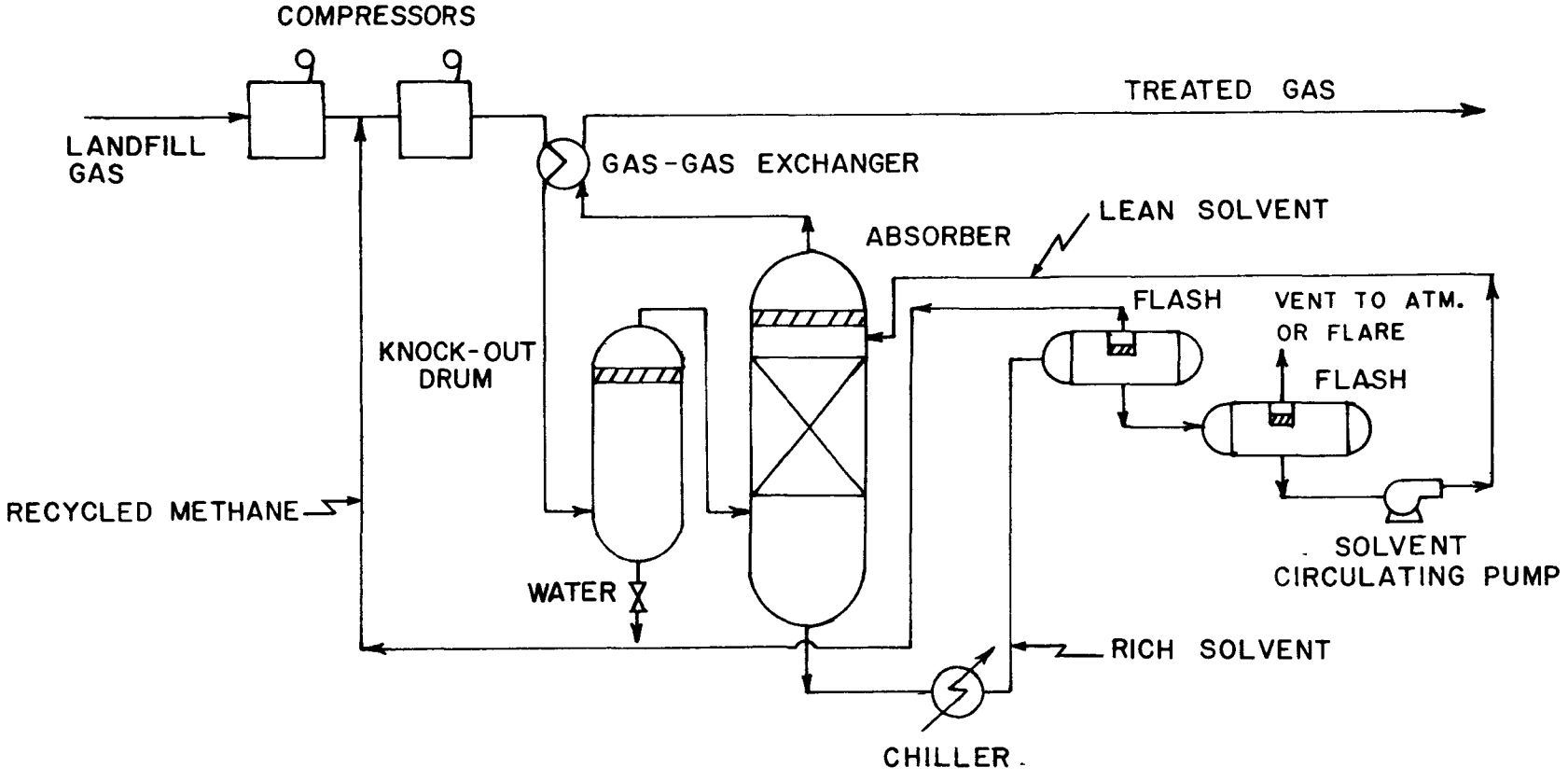



FIGURE NO. 7

than 7 lbs/MMSCF and contains less than 5% carbon dioxide. In some instances, particularly when treating for hydrogen sulfide removal, gas stripping or vacuum regeneration will be required.

Liquefied Natural Gas Manufacture

To remove other impurities from the landfill gas such as oxygen and nitrogen, cryogenic methods would have to be employed. Essentially, these methods are similar to those used in the production of liquefied natural gas, and involve compression, dehydration, $CO_2$ removal, and refrigeration to liquefy methane. The cost of this approach is prohibitive for volumes of gas in the 1-5 MMSCFD range. This is shown in Table 2 of the section on Economics of Treating Landfill Gas.

Propane Addition

This is a method of increasing the heating value of landfill gas by blending this gas with propane which has a very high heating value (2,517 Btu/scf). A typical flow diagram for this blending process is shown in Figure 8.

Three separate cases were considered. In Case A, dehydrated landfill gas (~450 Btu/scf) is blended with propane to produce a 1,000 Btu/scf gas. If treated gas from the dehydrator is available at a minimum pressure of 50-100 psig, the compressor shown in Figure 8 would not be required. A process outlet pressure of 75 psig should be adequate to deliver the gas to most customers without further compression. Injection into a gas transmission grid will, however, require much higher pressures.

Case B is similar to Case A except that the landfill gas has a heating value of 700 Btu/scf which corresponds to landfill gas

# SIMPLIFIED EQUIPMENT FLOW DIAGRAM FOR PROPANE – LANDFILL GAS MIXING

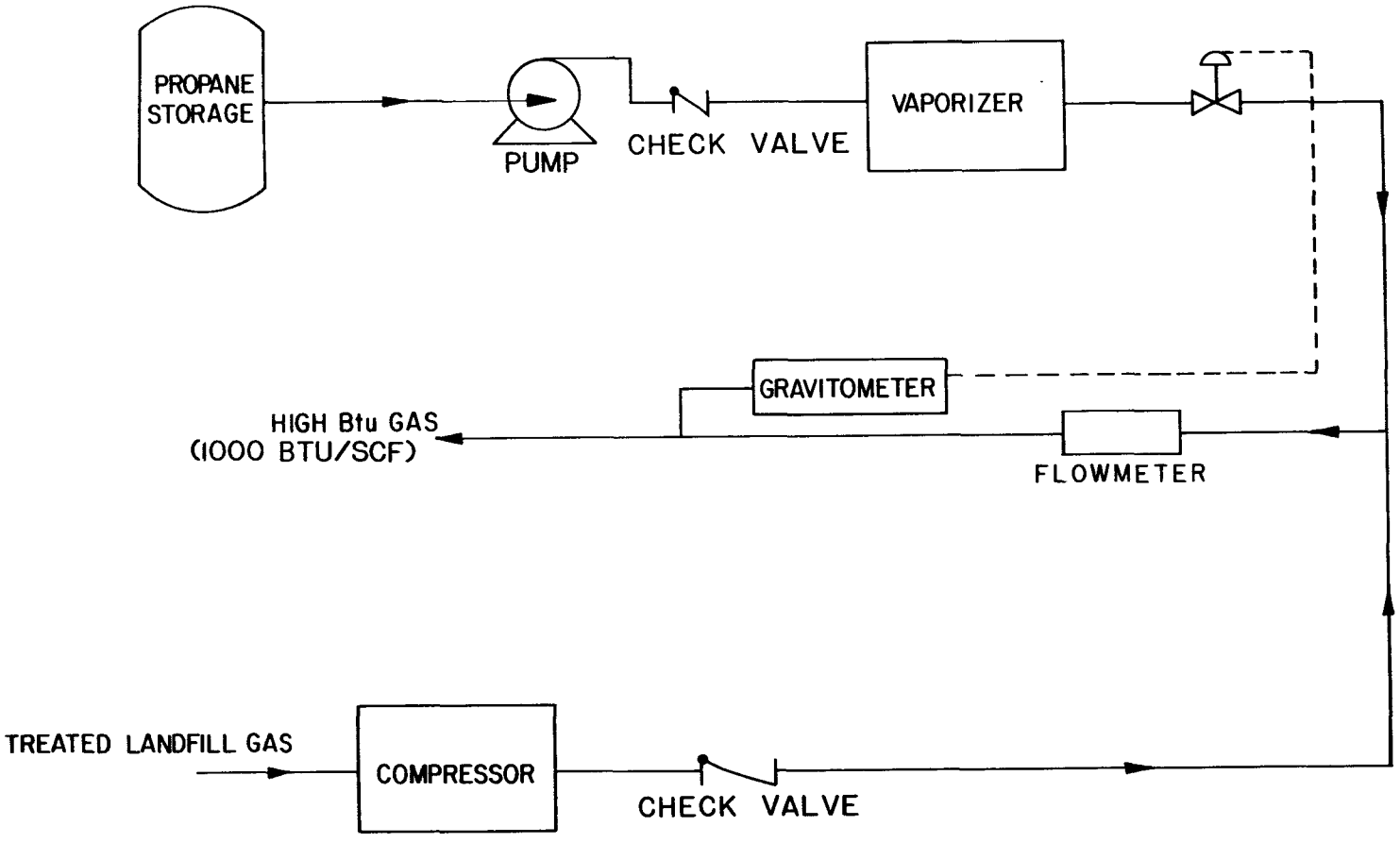



FIGURE NO. 8

with water, and carbon dioxide removed.

Case C uses 975 Btu/scf which corresponds to landfill gas which has had water, carbon dioxide, oxygen, and nitrogen removed.

Economics of Treating Landfill Gas

The economics of landfill gas treatment are presented in Tables 2 and 3.

The data in Table 2 is preliminary and comes from a screening analysis performed in the spring of 1975. Consequently, this data is in mid - 1975 dollars, and is based on vendor estimates rather than firm quotes.

The economics are for a raw landfill gas flow rate of 1 to 5 MMSCFD. When completed, the Mountain View Landfill is expected to produce approximately 5 MMSCFD of raw gas so a flow rate of 1 to 5 MMSCFD was used for preliminary evaluation.

As can be seen from Table 2, costs of treating landfill gas increase as a higher quality gas is produced. For simple dehydration (500 Btu/scf product) estimated costs are $0.31 to $0.50/MMBtu (Options I and II). For dehydration plus $CO_2$ removal (700 Btu/scf product) the treating costs increase to $0.62 to $1.00/MMBtu (Option III). The cost of removing all impurities (975 Btu/scf product) is $1.93/MMBtu.

The propane addition cases are based on maximum gas flow rates of about 4.5, 3.0 and 1.5 MMSCFD respectively. As propane addition would take place downstream of landfill gas treating, these gas rates match well with the maximum outlet rates corresponding to the three levels of treating considered (dehydration, dehydration plus $CO_2$ removal and removal of all impurities). For

instance, the cost of treating and upgrading landfill gas using molecular sieves in Option III is $0.62 plus $1.45 for propane addition for a total of $2.07 per MMBtu. This includes both the cost and the heating value of propane, with the cost in this case amounting to approximately 1.6 million dollars per year on the basis of a propane cost of $0.30 per gallon. Excluding both the cost and the heating value of propane itself, the capital, operating and maintenance costs for propane upgrading are approximately 0.13, 0.07 and 0.04 $/MMBtu for the three levels of treatment respectively.

The preliminary economics of Table 2 do not include a payment to the landfill operator for purchase of the gas or the costs of installing the necessary wells and collection system.

On the basis of the preliminary treating economics of Table 2, a decision was made to proceed with the Mountain View Demonstration Project using Option III gas treatment (700 Btu/scf product), with injection of the treated gas directly into a nearby PGandE natural gas transmission line. This decision was taken for the following reasons:

1. The experimental nature of the project made it impractical to attempt sale of the gas to nearby industrial gas customers (not a sufficiently reliable supply).
2. Other uses of the landfill gas production or on-site electrical generation are costly and necessitate a larger capital investment for a small scale demonstration project which may not have a long enough life to be economically viable.

TABLE 2

PRELIMINARY COSTS FOR COMPRESSION AND TREATMENT OF LANDFILL GAS
BASIS: 5 MMSCD OF RAW LANDFILL GAS (450 Btu/Scf)
Mid-1975 $

| | A Process Cost $ | B Compression Cost $ | C 1) Installed Cost $ | D 2) Annual Fixed Charges $ | E 3) Annual Maintenance $ | F Annual Manpower Cost-$ | G Total Annual Cost-$ | H Overall Efficiency % | I 4) Thermal Output MMBtu/Yr | J $/MMBtu |
|---|---|---|---|---|---|---|---|---|---|---|
| Option I - Dehydrate to 6# H2O/MMscf and Compress to 100 Psig, HHV = 500 Btu/Scf | | | | | | | | | | |
| 1) Molecular Sieves | 146,500 | 248,500 | 654,500 | 162,500 | 26,000 | 30,000 | 218,500 | 92 | 641,700 | 0.34 |
| 2) TEG | 80,000 | 248,500 | 555,000 | 137,500 | 24,000 | 30,000 | 191,500 | 89 | 620,800 | 0.31 |
| Option II - Same as Option I, Except for Pressure which is now 400 Psig | | | | | | | | | | |
| 1) Molecular Sieves | 146,500 | 428,500 | 969,500 | 240,500 | 42,000 | 30,000 | 312,500 | 89 | 620,800 | 0.50 |
| 2) TEG | 45,000 | 409,000 | 783,000 | 194,000 | 37,000 | 30,000 | 261,000 | 89 | 620,800 | 0.42 |
| Option III - Dehydrate to 6#H2O/MMScf, Remove CO2 and Compress to 400 Psig HHV = 700 Btu/Scf | | | | | | | | | | |
| 1) Molecular Sieves | 405,000 | 370,000 | 1,255,000 | 311,000 | 44,500 | 30,000 | 385,500 | 89 | 620,800 | 0.62 |
| 2) TEG for Dehydration and hot Carbonate for CO2 removal | 577,500 | 409,000 | 1,582,000 | 392,500 | 53,000 | 30,000 | 475,500 | 68 | 474,300 | 1.00 |
| 3) DMPEG for both Dehydration and CO2 removal | 376,000 | 409,000 | 1,280,000 | 317,500 | 47,000 | 30,000 | 394,500 | 87 | 606,800 | 0.65 |
| Option IV - Remove all impurities from Methane, HHV=975 Btu/Scf, molecular sieves for H2O & CO2 removal and LNG process for removal of N2 and O2 | 1,235,000 | 740,000 | 3,148,000 | 780,500 | 102,000 | 60,000 | 942,500 | 70 | 488,300 | 1.93 |

TABLE 2
(Continued)

| Propane Addition | A | B 5) | C | D | E | F 6) Propane Cost-$/Yr | G | H | I 7) | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1) Case A, Dehydrated Landfill Gas, 1.5 -4.5 MMSCFD | 124,000 | 297,000 | 483,000 | 120,000 | 6,700 | 3,786,500 | 3,913,200 | 100 | 1,780,000 | 2.20 |
| 2) Case B, 700 Btu/Scf treated landfill gas 1.0-3.0 MMSCFD | 46,000 | 135,000 | 204,000 | 50,500 | 2,700 | 1,514,500 | 1,567,700 | 100 | 1,084,000 | 1.45 |
| 3) Case C, 975 Btu/Scf treated landfill gas 1.5 MMSCFD | 32,000 | 27,000 | 75,000 | 18,500 | 1,200 | 63,000 | 82,700 | 100 | 507,500 | 0.16 |

1) C = 1.5A + 1.75 B; for propane upgrading C = 1.5A + B

2) D = 0.248C, the factor is based on a 10 year project life, a salvage value of 30.0% and a 12% cost of capital. A breakdown of this factor is as follows: CRF, 16%, Federal & State income taxes 5.7% ad valorem tax 3%, insurance 0.10%

3) E = 0.03A + 0.0875B; for propane addition E = 0.03A + .01B

4) Based on a 0.85 stream factor

5) Installed cost of one week storage

6) The cost of propane is $0.3/gallon

7) Includes the heating value of propane. Also includes the heating value of the treated landfill gas as follows:

Case A and B: 620,800 MMBtu/Yr
Case C: 488,300 MMBtu/Yr

GAS RESOURCES DEPARTMENT
September 15, 1976

3. The proximity of a large transmission line which does not depend on landfill source gas makes pipeline injection an economical and low risk approach.
4. Option I (simple dehydration) would depress the heating value of the mixed landfill and natural gas too much during periods of minimum flow in the transmission line.
5. Option IV (removal of all impurities) and propane addition are both expensive and unnecessary if the landfill gas is injected into the high flow transmission line.

Table 3 presents final design economics for treating landfill gas by dehydration and $CO_2$ removal (Option III). It is based on a landfill gas flow rate of 1 MMSCFD. This flow rate was selected because it is large enough to demonstrate the economic viability of the concept but holds capital risk to a minimum. The data in Table 3 is expressed in early 1976 dollars, and is the result of analysis of firm vendor bids received in conjunction with the final design for the Mountain View Demonstration Project.

In addition to the information contained in Table 2, the data in Table 3 includes the cost of wells, gathering system and analytical equipment. The cost of these items amounts to between 0.18 and 0.23 dollars per MMBtu delivered to the treating plant.

Table 3 shows the molecular sieves to have a substantial advantage over the other processes considered. This is largely the result of its higher thermal efficiency. In addition, there

TABLE 3

REVISED COST ESTIMATE FOR COMPRESSION AND TREATMENT OF LANDFILL GAS
BASIS: 1 MMSCFD of RAW LANDFILL GAS (450 Btu/scf)
0.85 Stream Factor
Early 1976 $

| | A | B[1] | C | D[2] | E[3] | F | G[4] | H | I[5] | J[6] |
|---|---|---|---|---|---|---|---|---|---|---|
| | Process Cost $ | Compression Cost $ | 18 Wells & Gathering System $ | Total Installed Cost $ | Process Efficiency % | Overall Efficiency % (Process & Compression) | Maintenance Cost $/Year | Manpower Cost $/Year | Fixed Charges $/Year | $/MMBtu |
| DMPEG | 600,000 | 200,000 | 70,000 | 1,320,000 | 78 | 64 | 35,500 | 30,000 | 327,500 | 4.40 |
| Molecular Sieves | 245,000 | 200,000 | 70,000 | 788,000 | 85 | 70 | 24,900 | 30,000 | 195,500 | 2.56 |
| Diglycolamine[7)] | 250,000 | 200,000 | 70,000 | 795,000 | 69 | 54 | 25,000 | 30,000 | 197,000 | 3.35 |

Notes: 1 Based on pressure of 400 psig at the plant gate

2 Total installed cost = 1.5 A + 1.75 B + C

3 Energy outputs: DMPEG 89,280 MMBtu/Year
Molecular Sieves 97,650 MMBtu/Year
Diglycolamine 75,330 MMBtu/Year

4 Maintenance = 0.03 A + 0.0875 B

5 Fixed charges = 0.248 D on the basis of a 10-year life (See Table 2)

6 $/MMBtu = (G + H + I)/Energy Outputs

7 This process removes both $CO_2$ and $H_2O$. It is not discussed in Table 2

GAS RESOURCES DEPARTMENT
September 13, 1976

are indications that operation at reduced gas flow rates favor molecular sieves over DMPEG. With the molecular sieves process, the cost of treating landfill gas at 5 MMSCFD to produce 700 Btu/scf gas is estimated at $1.9/MMBtu.

Neither Table 2 or Table 3 includes long distance landfill gas transportation costs, as such transportation is not required for the demonstration project. Generalized landfill gas transportation costs are discussed in the next section.

In all cases, except for those relating to propane addition, the fixed charges constitute the largest fraction of the total investment. In this analysis a fixed charge factor 0.248 was used. It is broken down as follows:

| | |
|---|---|
| Capital Recovery Factor | 0.160 |
| Federal and State Income Taxes | 0.057 |
| Ad Valorem Tax | 0.030 |
| Insurance | 0.001 |
| Total | 0.248 |

The factor is based on a 12% cost of capital, a 10-year life and a salvage value of 30%. The use of such factors is standard practice in the utility business. Private, non-regulated companies can use the capital and operating cost data to perform their own discounted cash flow computations.

Gas Transportation

Two nomographs (Figures 9 and 10) have been developed which provide generalized cost data for the transportation of landfill gas as a function of: distance to the point of utilization, flow rate, available supply pressure and heating value. The delivery pressure in each case is assumed to be 25 psig. The cost to transport the gas is given in cents per million Btu and is based on 1975 dollars. Pipeline construction costs are intermediate for terrain between difficult and normal. The pipeline facility in each case is assumed to have a 10-year life.

Other Uses of Landfill Gas

Electric Generation

As discussed previously, on-site electrical generation has already been shown to be a viable use for landfill gas by the City of Los Angeles Department of Water and Power. They have successfully operated a 200-kilowatt generating unit for over a year at their Sheldon-Arleta Landfill.

The types of electrical generating equipment investigated were: 1) engine-generators, 2) gas turbine-generators and 3) fuel cells.

1) Engine-Generators

Of the manufacturers contacted by PGandE, the engine-generator suppliers showed the most interest. This is probably due to the present application of their engines to the generation of power from sewage plant off-gas which has about the same heating value as landfill gas.

# LANDFILL GAS TRANSPORTATION COST

## DEHYDRATED GAS (~500 BTU/SCF)

### COST BASED ON 1975 DOLLARS AND 25 PSIG DELIVERY PRESSURE

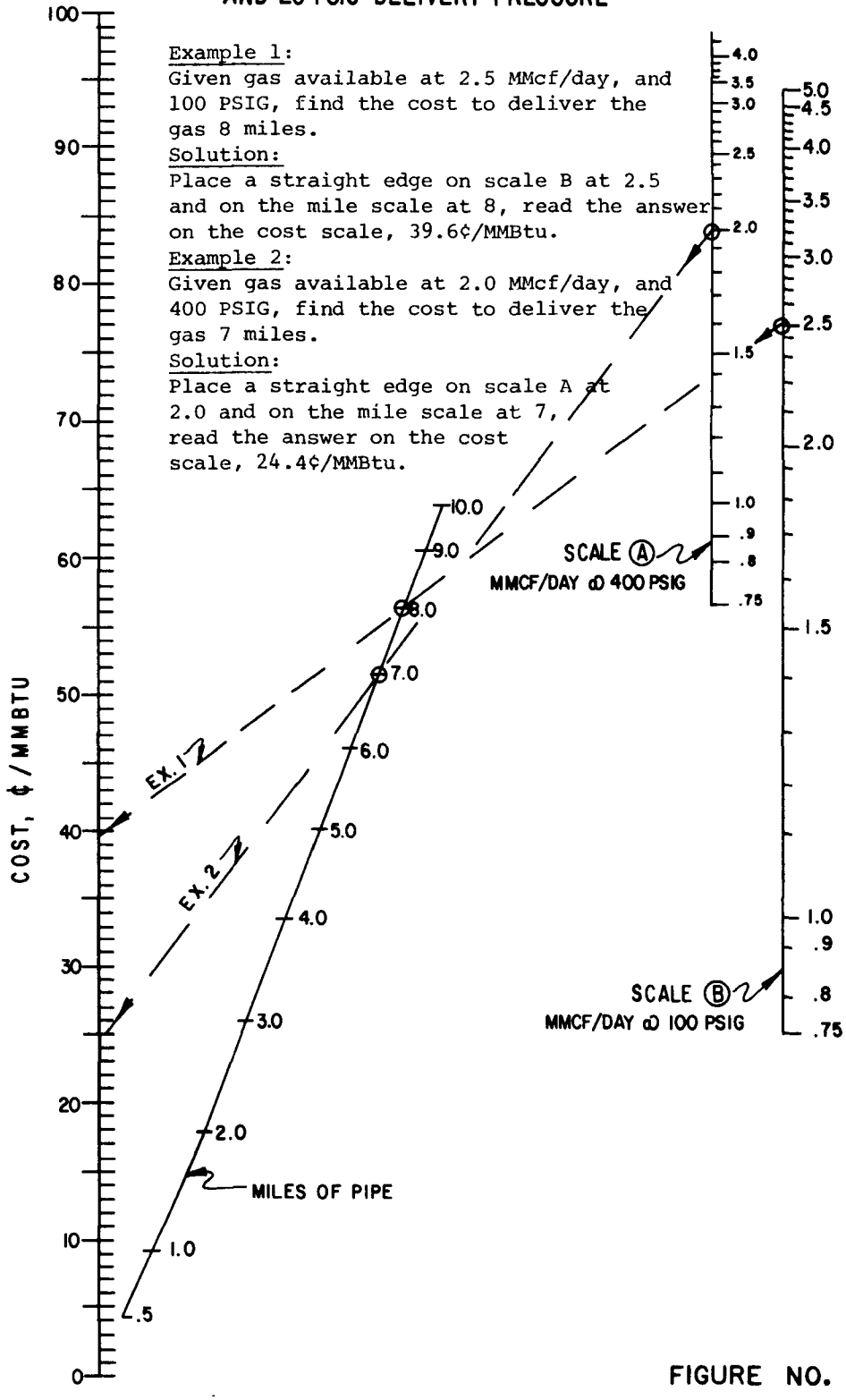



FIGURE NO. 9

# LANDFILL GAS TRANSPORTATION COST

## DEHYDRATED GAS WITH CARBON DIOXIDE REMOVED & SUBSTITUTE NATURAL GAS (700 OR 975 BTU/SGF)

### COST BASED ON 1975 DOLLARS AND 25 PSIG DELIVERY PRESSURE.

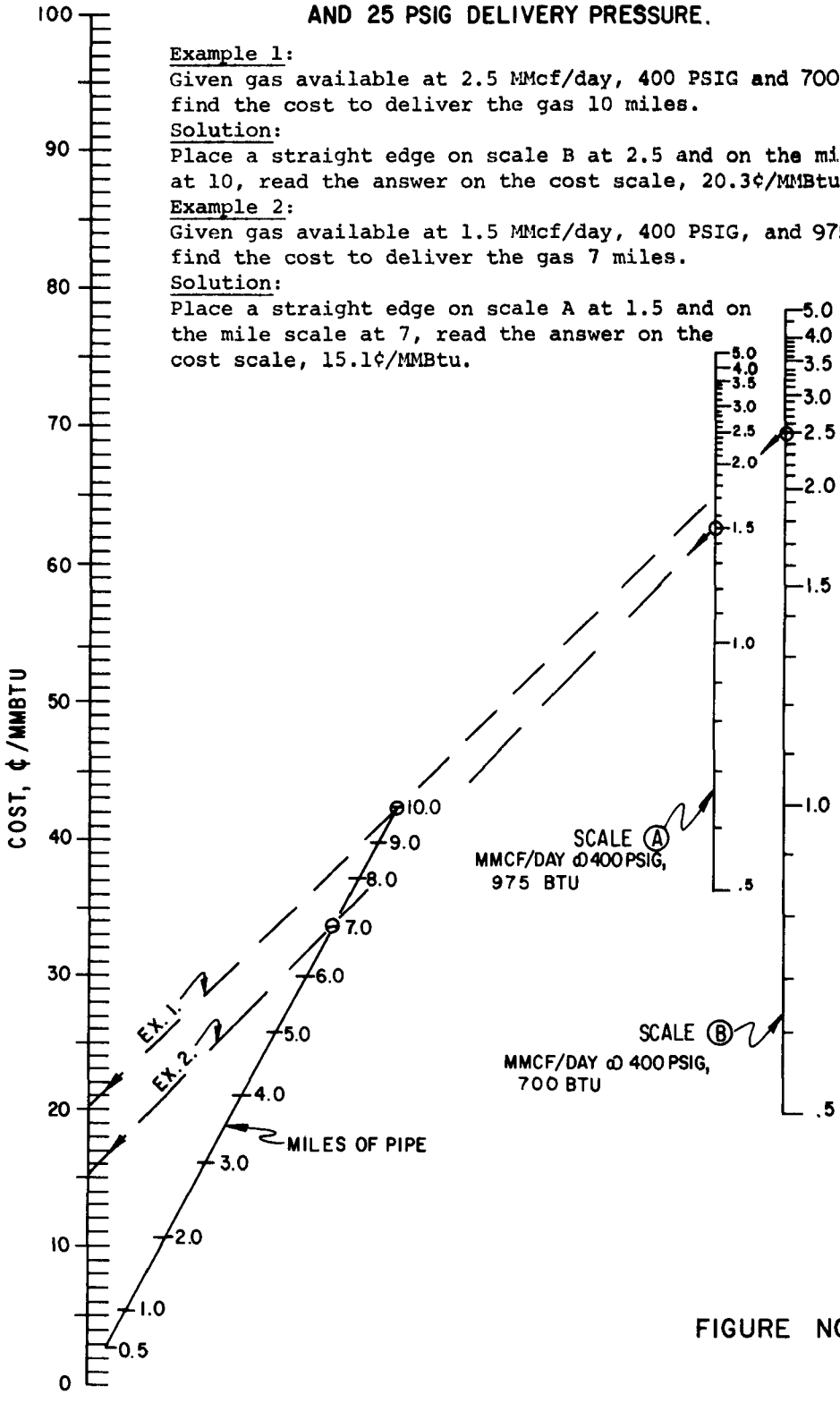



FIGURE NO. 10

2) Gas Turbines

In general, the gas turbines seemed to be of the wrong size for landfill field capacities investigated (0.2 - 5 MMSCFD). They were either too small with the result that a number would be installed in parallel or too large with the consequence that they could not efficiently burn the fuel.

3) Fuel Cells

As fuel cells are still in the early developmental stages, the suppliers could not respond in any detail. However, this option should be kept in mind as a possible future means of generating electric power from landfill gas. One supplier confirmed that the gas composition is suitable for use in its fuel cell and estimated that the heat rates would be 9,660 Btu/kwh. Fuel gas supply pressure would need to be about 35 psig which would not impose a large auxiliary power requirement.

The engine-generator appears, at this time, to be the economical choice. Its first cost is slightly less than the gas turbine-generator, its net heat rate is better, maintenance costs are about the same, and it requires less compression of the fuel gas before injection into the engine. (Gas pressures of 5 to 10 psig are satisfactory for the spark type engine, and about 50 psig required for the diesel, whereas gas turbines require 250 to 300 psig).

A generating plant would consist of one spark type engine-generator for a 0.2 MMSCFD gas supply and three units for a 1.0 MMSCFD gas field. A field whose capacity exceeds a 1 MMSCFD but is under 5 MMSCFD would be served by one low-speed, diesel-generator unit.

Figure 11 of this report shows a simplified equipment diagram for on-site power generation. Figures 12 and 13 are graphs showing gross electric power generation versus landfill gas field capacity for various higher heating values of the gas, and capital cost (in February 1975 dollars) versus generating capacity respectively.

Since PGandE does not have a great deal of experience in the operation or maintenance of engine-generator units, it has relied on the suppliers for estimates of the costs involved. An operating and maintenance cost of 3.0 mils/kwh should be representative for the spark type engines and 1.5 mils/kwh for the low-speed, diesel engines.

Figures 13 shows the estimated installed plant costs in February 1975 dollars versus electric output for a unit burning 500 Btu/scf gas. The cost includes indirect and overhead charges and is based on purchasing new equipment with engineering and construction done by PGandE personnel. No provision was made for a gas collection grid, land, or the purchase of the landfill gas. The curve shows a general decrease of plant cost in $/kw as the generating capacity increases as would be expected, but it also indicates the high cost of this type of generation. For example, a 10 mw generating facility would cost about 300 $/kw.

The generating equipment is skid-mounted and factory-piped and wired wherever possible to minimize installation time and to provide for easy relocation of the facility in the future. All pieces of equipment with the exception of the gas compressors, step-up transformer(s), high voltage breaker(s) and high voltage

# SIMPLIFIED EQUIPMENT DIAGRAM
# ON-SITE ELECTRICAL GENERATION

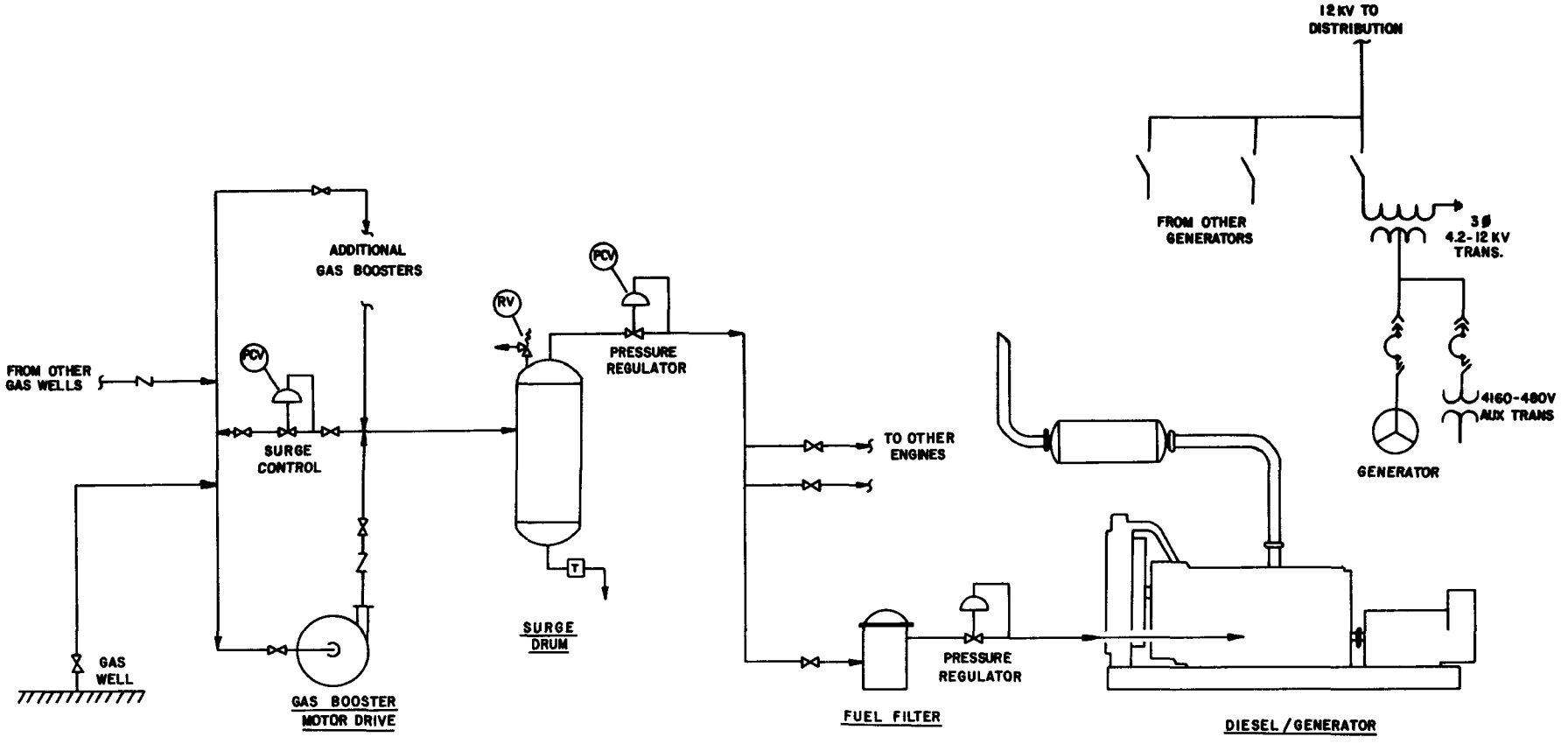



FIGURE NO. II

# ELECTRIC POWER GENERATION VS GAS FIELD CAPACITY

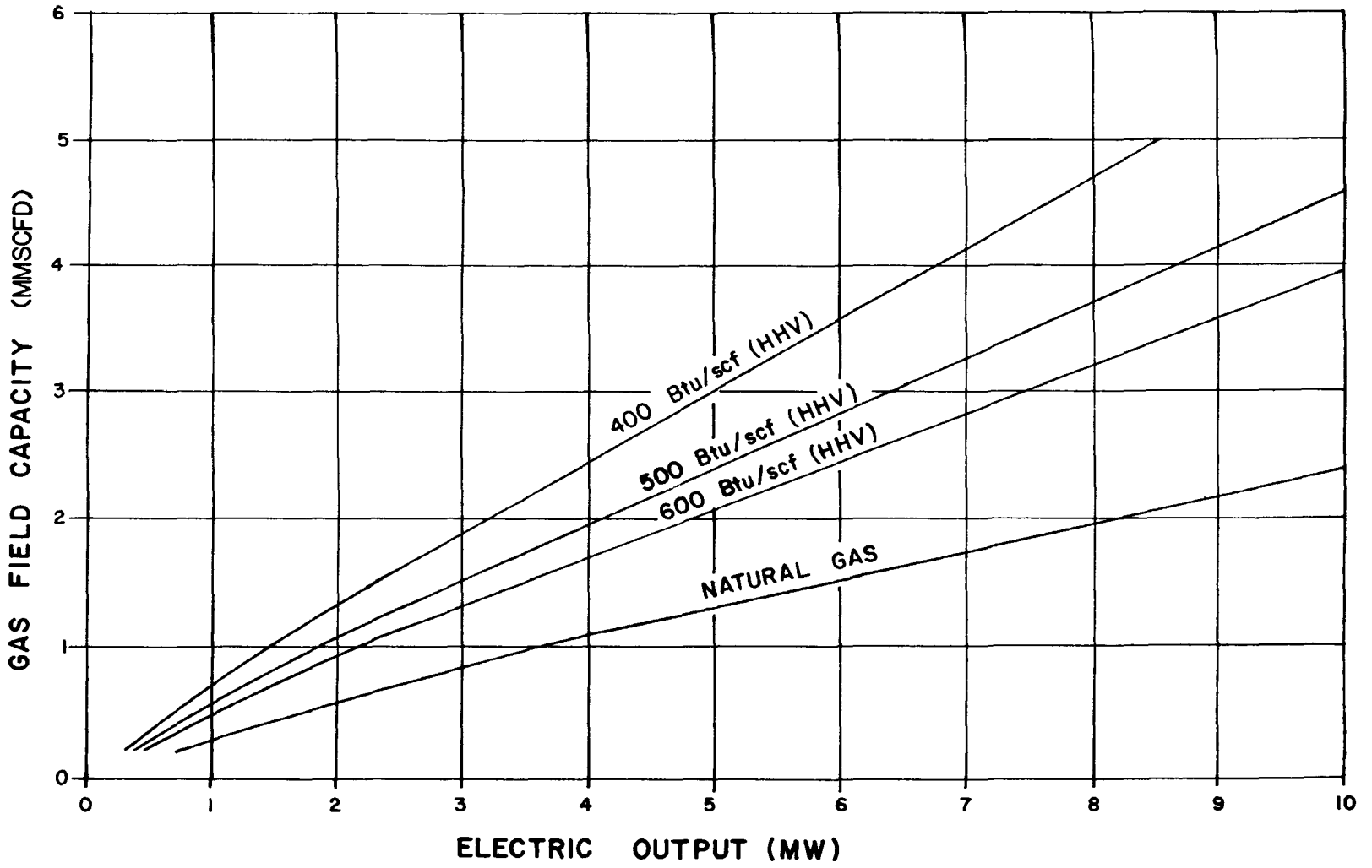



FIGURE NO. 12

PLANT COST (in Feb. 1975 $) VS
ELECTRIC OUTPUT (with 500 Btu/scf gas)

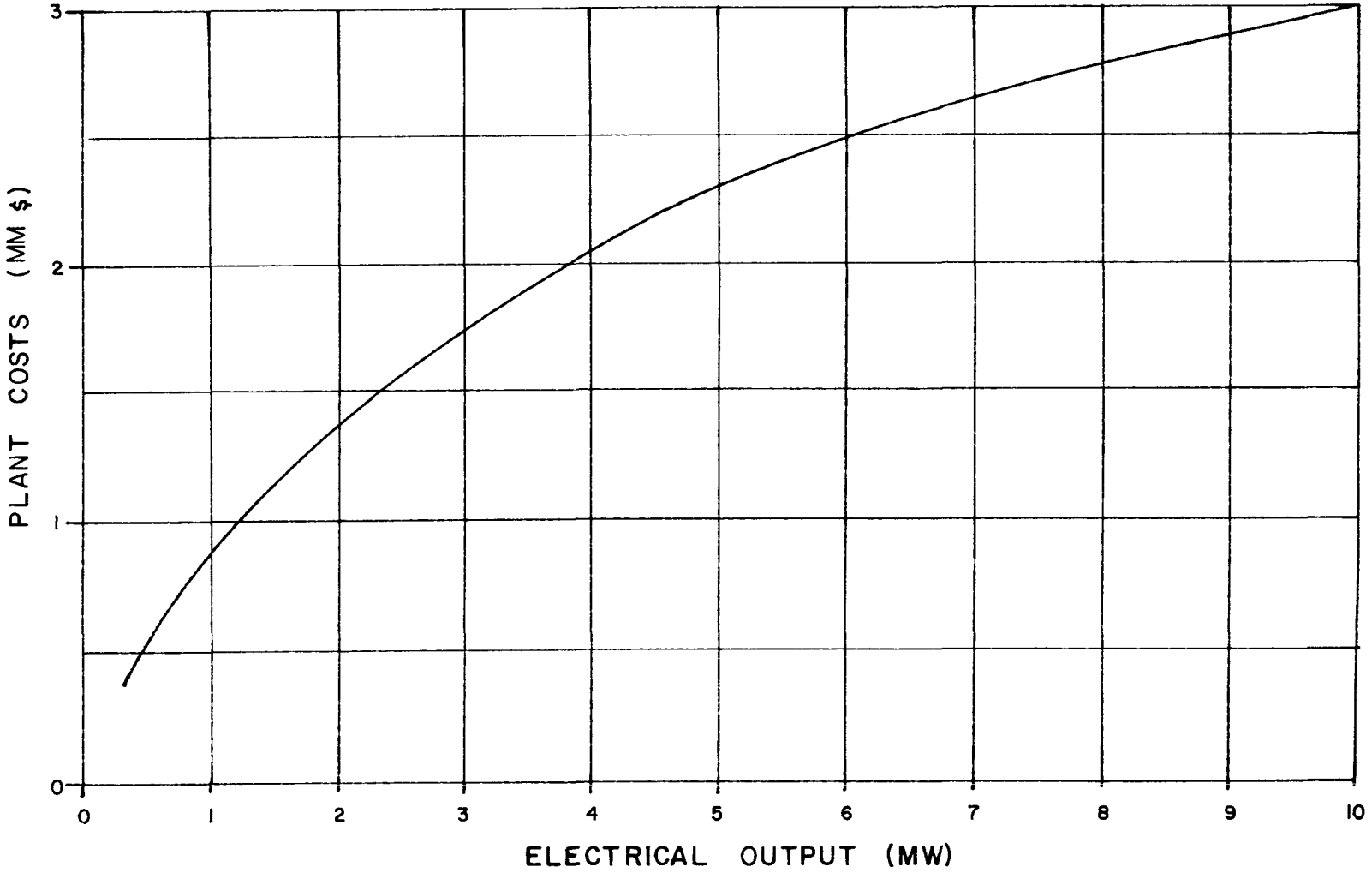



FIGURE NO. 13

bus are contained within a building to provide weather protection and sound attenuation. Air-cooled heat exchangers are used throughout so that make-up water is kept to a minimum.

The generator output voltage is 4.2 kv with step-up transformers provided to raise the voltage to 12 kv, which is typical for PGandE's distribution. The auxiliary power supply is stepped down to 480 V. A simplified single line diagram is included in Figure 11.

The injection of a small quantity of pilot oil into the fuel gas is recommended by the supplier for the diesel-generator unit. This would provide a better fuel composition for ignition by the heat of compression within the engine cylinders. Typical pilot oil would be No. 2 diesel fuel oil, kerosine, etc.

The emission of atmospheric pollutants is not expected to be a problem. When firing a gas with a composition shown in the landfill gas quality and production rate section, they should be well within the applicable State and local regulations.

Assuming that a centralized generating complex would be provided, the following minimum space requirements would be needed:

| Field Capacity | Plot Length | Plot Width |
|---|---|---|
| 0.2 MMSCFD | 140 ft. | 80 ft. |
| 1.0 MMSCFD | 150 ft. | 110 ft. |
| 2.0 MMSCFD | 155 ft. | 80 ft. |
| 3.0 MMSCFD | 160 ft. | 80 ft. |
| 5.0 MMSCFD | 165 ft. | 80 ft. |

Due to the successful utilization of sewage plant intermediate Btu off-gas as a fuel for diesel and spark type engines, it can be concluded that it is technically feasible to fire landfill gas in these engines. Compression of the gas to the 5 to 50 psig level is required, but this does not impose a significant auxiliary power load on the generation capabilities. Plant heat rates should be about 9,800 Btu/kwh for the spark type engine and about 9,300 Btu/kwh for the diesel engine. About 26% of the heat available in the fuel is rejected in the exhaust gases at about 1,050°F, and the remaining heat is lost to the jacket cooling medium, the lubricating oil and by radiation. Part of the exhaust gas heat could be easily converted into low pressure steam which may be of some value at or near the site. In the sewage plant applications, this heat is used to heat sewage sludge digesters.

The economics of generating electricity from landfill gas are shown in Table 4. At a landfill gas rate of 1 MMSCFD, 1.8 mw of capacity can be sustained at a cost of $0.037 per kwhr. This would make electricity from landfill gas competitive with power to be generated in new coal-fired or nuclear plants.

Conversion To Methanol

Another use of landfill gas is its conversion to methanol. For the small capacity plants that would be used in this type of operation, the low-pressure process for producing methanol is far more economical than the high pressure one.

For this particular use of landfill gas, the presence of carbon dioxide in the gas could prove to be advantageous. The stoichiometric ratio of hydrogen to carbon required to produce

TABLE 4

PRELIMINARY ECONOMICS OF GENERATING ELECTRICITY FROM LANDFILL GAS

| | |
|---|---|
| Raw Landfill Gas Rate, MMSCFD | 1.0 |
| Generating Capacity, kw | 1,800 |
| Electric Output, Kwhr/yr 1) | 13,400,000 |
| Total Installed Cost of Generating Equipment, $ | 1,600,000 |
| Fixed Charges, $/yr 2) | 397,800 |
| Operation and Maintenance at $.003/kwhr, $/yr | 40,200 |
| Fuel Costs at $0.45/MMBtu 3) and 9,800 Btu/kwhr | 59,100 |
| Total Costs, $/yr | 496,100 |
| Cost of Electricity Generated, $/kwhr | 0.037 |

1) Based on 310 days of operation per year

2) Based on factor of 0.248 (see Table 2 for details)

3) Represents what it would cost PGandE to install the equipment to extract, gather and compress the gas to about 5 psig. Also includes what PGandE might pay for the gas.

methanol is 2:1. This is shown by the overall reaction which is:

$$CH_2 + H_2O \longrightarrow CO + 2H_2 \longrightarrow CH_3OH$$

Methane with its 4:1 hydrogen to carbon ratio would produce, after reforming, a synthesis gas with an excess of hydrogen. Carbon dioxide in the feed stream would add the needed extra carbon atoms. A survey of samples taken from Shoreline Regional Park, however, has shown that the composition of landfill gas is such that there is still an excess of carbon dioxide present which may or may not have to be removed, depending on the economics of the particular process chosen. Preliminary clean-up costs have been taken into account in our sample economics. Any sulfur contained in the gas would also have to be removed in order not to poison the catalyst in the converter later in the process.

The feed stream (see Figure 14) is reacted in the primary reformer to form synthesis gas:

$$CH_4 + H_2O \longrightarrow CO + 3H_2$$

$$CO_2 + H_2 \rightleftharpoons CO + H_2O$$

The synthesis gas is then compressed to between 50 and 100 atomospheres depending on the size of the plant. The gas enters the methanol converter where it is reacted over a copper oxide catalyst at temperatures in the range of 480 - 520°F. The methanol is separated from the unreacted gas by cooling and the unreacted gas is recycled through the process.

The low pressure process produces a crude methanol of higher purity than does the high pressure process, but distillation is still required to remove the impurities. The distillation process employs two columns, the first of which strips volatile impurities

# SIMPLIFIED PROCESS FLOW DIAGRAM
# LOW PRESSURE METHANOL SYNTHESIS PROCESS

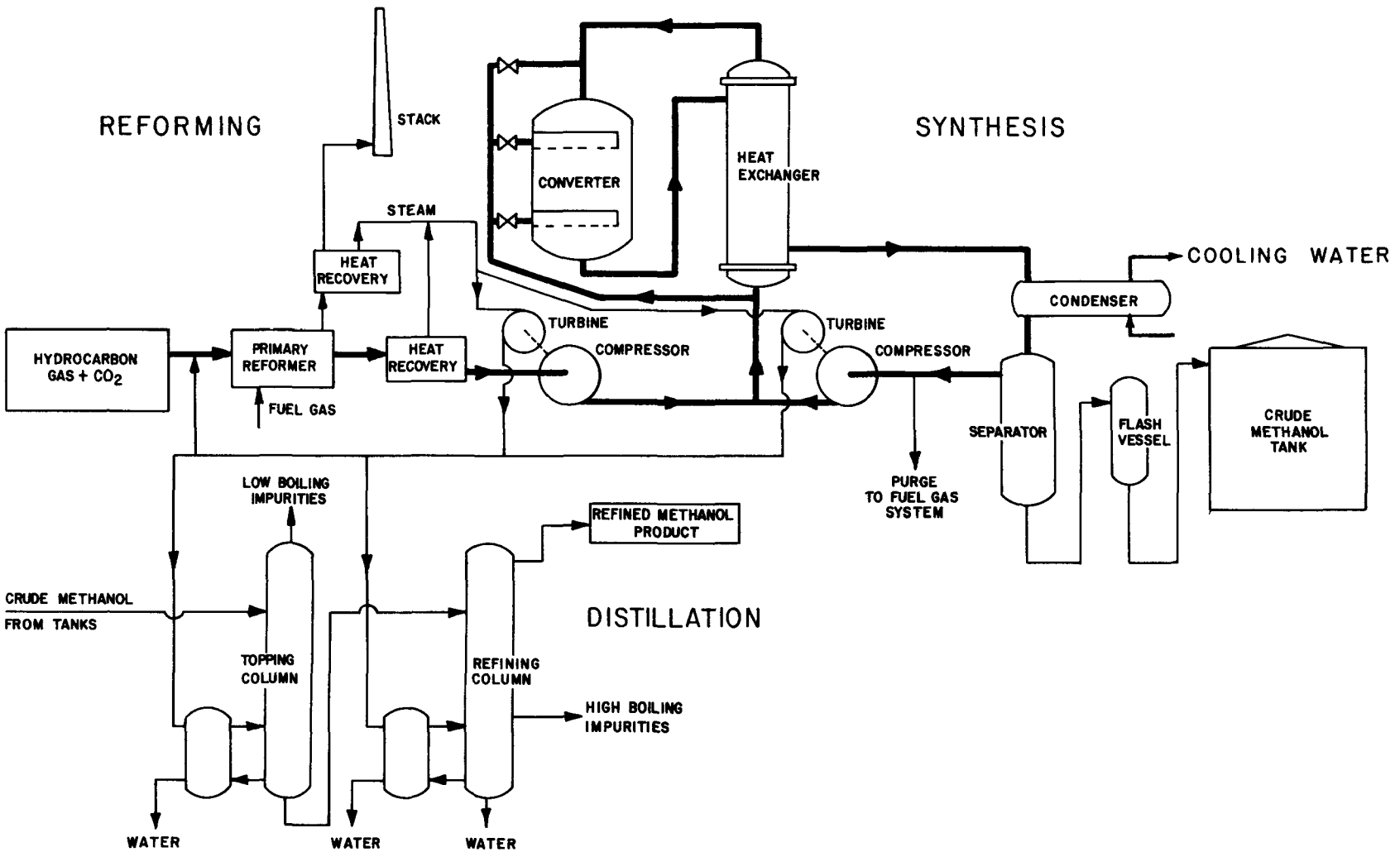



FIGURE NO. 14

(dimethyl ether, esters, ketones, and iron carbonyl) and the second removes water and higher alcohols. If the methanol is to be used as a fuel rather than as a petrochemical feedstock, the higher alcohols need not be separated form the methanol and thus only one column would be necessary.

Some sample economics for methanol production are shown in Table 5. Since methanol production is uneconomical for small volumes of gas, plant throughputs of 5 and 10 MMscfd were chosen. It is possible for some of the larger landfills or a group of landfills to produce this volume of gas. The economics are based on January 1975 dollars. No provision has been made for wells, collection grid, land, or purchase of the gas.

Table 5

Investment Costs For Methanol Production

| LANDFILL GAS FLOW | 5 MMSCFD | 10 MMSCFD |
|---|---|---|
| Process Investment, M$ | 5,000 | 7,500 |
| Product, Short tons/day | 68.5 | 137 |
| Product Cost, $/MMBtu | 4.01 | 2.55 |
| $/gallon | 0.26 | 0.17 |

The Mountain View Landfill Gas Recovery Project - A Case History

In the summer of 1974, following a survey of the 32 existing landfills in the San Francisco Bay Area which showed fourteen of these sites to have good potential as gas producers, PGandE agreed to assist the City of Mountain View on an EPA-sponsored study of gas recovery in shallow landfills at the Mountain View site.

In the summer of 1975, the project was expanded to include a demonstration facility to extract and treat one MMSCFD of

landfill gas. The EPA agreed to contribute $200,000 to the project. PGandE agreed to pay for the balance of the project cost, estimated at $416,000.

In the fall of 1975, a contract was successfully negotiated by PGandE and the City of Mountain View that sets forth the price to be paid for the gas and the conditions under which the facility will be designed, built and operated. The contract also discusses the procedure to be followed for expanding the project to recover gas from the rest of the landfill. A copy of the contract is attached in the Appendix.

As part of the screening analysis carried out in order to get management approval for the expanded demonstration project, the following decisions were made regarding the scope of the project:

1. Production was limited to 1 MMSCFD of landfill gas at the wellhead. This production rate is representative of what the fourteen promising sites in the San Francisco Bay Area can sustain. It limits, to an extent, the risk capital tied down in the project. Finally, it is large enough that it produces gas which is competitive with what PGandE pays for gas imported from Canadian sources, providing EPA's contribution is deducted from the total investment.
2. The concept of distributing dehydrated landfill gas to industrial interruptible customers located in the vicinity of the landfill was rejected as the landfill gas was not considered a sufficiently reliable source and the few

customers that could use the gas showed an erratic demand pattern which would require frequent shutdown of the facility. In addition, the construction of a low-Btu gas distribution grid would have required prior approval of the Public Utility Commission of the State of California.

3. Injection of the treated gas (700 Btu/scf) into transmission line 101 was chosen over injection into the local distribution system at Mountain View in order to meet the two specifications relating to heating value (mixed gas heating value of 975 Btu/scf, and fluctuations within +2 Btu/scf) that are discussed previously. The fact that transmission line 101 runs across the Mountain View Landfill favored injection into the transmission system. Figure 15 locates the Mountain View project with regard to PGandE's transmission system on the San Francisco Peninsula.

Late in the fall of 1975, specifications were prepared for the compressor and the treating unit that were sent out for bids. A copy of these specifications is included in the Appendix. Bids were received in January of 1976. Following review of these bids, revised economics were prepared and form the basis of Table 3 in the section on economics.

The process using molecular sieves has since then been selected and orders have been placed for the equipment. A new round of bids have been requested for a somewhat modified compression scheme involving compression to some intermediate pressure,

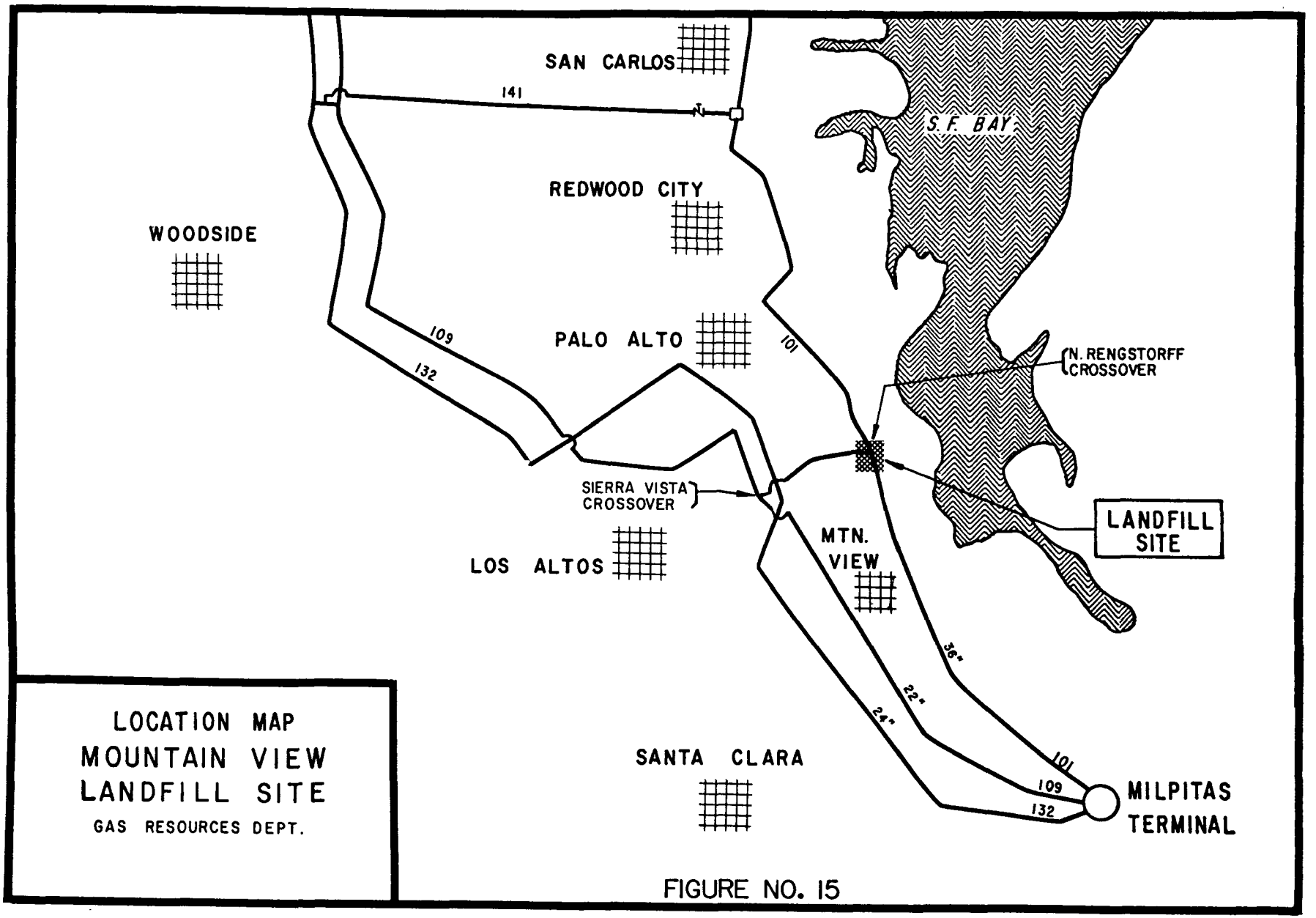
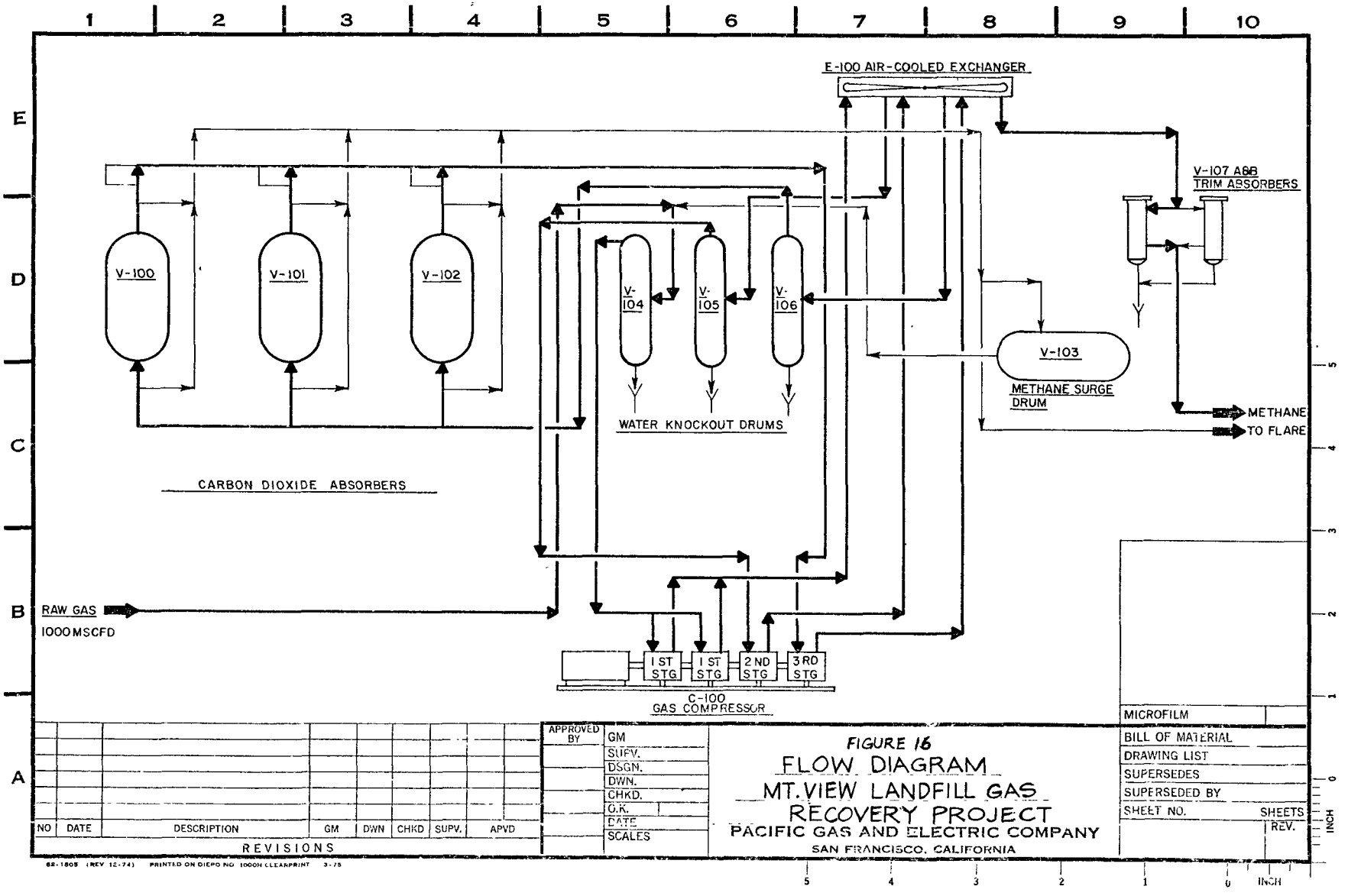

SAN CARLOS
141
S.F. BAY
REDWOOD CITY
WOODSIDE
109
132
PALO ALTO
101
N. RENGSTORFF
CROSSOVER
SIERRA VISTA
CROSSOVER
LANDFILL
SITE
MTN.
VIEW
LOS ALTOS
36"
22"
24"
101
109
132
MILPITAS
TERMINAL
SANTA CLARA
LOCATION MAP
MOUNTAIN VIEW
LANDFILL SITE
GAS RESOURCES DEPT.

FIGURE NO. 15

followed by treating and subsequent compression to 400 psig. The process is illustrated in Figure 16.

The facility is expected to be in operation by the early 1977.




| NO | DATE | DESCRIPTION | GM | DWN | CHKD | SUPV. | APVD |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

REVISIONS

| APPROVED BY | |
|---|---|
| GM | |
| SUPV. | |
| DSGN. | |
| DWN. | |
| CHKD. | |
| O.K. | |
| DATE | |
| SCALES | |

FIGURE 16

# FLOW DIAGRAM MT. VIEW LANDFILL GAS RECOVERY PROJECT

PACIFIC GAS AND ELECTRIC COMPANY

SAN FRANCISCO, CALIFORNIA

| | |
|---|---|
| MICROFILM | |
| BILL OF MATERIAL | |
| DRAWING LIST | |
| SUPERSEDES | |
| SUPERSEDED BY | |
| SHEET NO. | SHEETS |
| | REV. |

62-1805 (REV 12-74) PRINTED ON DIEPO NO 1000H CLEARPRINT 3-75

# APPENDIX

I. Derivation of Working Equations

Quantity of gas produced per ton of SMW

Tonnage in place as a function of area and depth

Volume and time calcuation

II. Specifications for Landfill Gas Compressor and Purification Unit for Mountain View Landfill Project

III. Agreement between the City of Mountain View and PGandE relating to the Mountain View Landfill Project

## I. Derivation of Working Equations

### Quantity of Gas Produced per Ton of SMW

Assuming that one lb mole of carbon yields one lb mole of gas, then the volume of gas produced per ton of SMW is:

$$V = 16{,}540 \text{ scf/ton of SMW} \quad (3)$$

This number assumes 100% conversion of carbon and a carbon content of the as-received SMW of 26% by weight[6].

Correcting for air leakage and assuming, in addition, that this gas has the composition shown in Table 1, the volume at the wellhead would be on a wet basis:

$$VREC = 21135\ C, \text{ scf/ton} \quad (4)$$

Where C represents the fractional conversion of carbon to gas.

### Tonnage In-Place as a Function of Area and Depth

The tonnage of refuse in-place is related to landfill area and depth as follows:

$$W = 0.807\ Ah\ p \quad (5)$$

where W = tons of SMW in-place
A = landfill area, acres
h = landfill depth, feet
p = in-place density of SMW, $lb/yd^3$

Assuming that p = 1,000 $lb/yd^3$, the equation becomes:

$$W = 807\ Ah \quad (6)$$

### Volume/Time Calculations

The City of Los Angeles Water and Power Department and the City of Mountain View have, on the basis of their testing of the methane from landfill concept at the Sheldon-Arleta and Mountain View sites, established an optimum production rate of one CFM per foot of well depth.

On this basis, the production rate of a site is given by the following equation:

$$Q = 19.97 \times 10^6 \quad (Ah/R^2) \quad (7)$$

Where:

Q = production rate at wellhead conditions, CFD

R = well radius of influence, feet

A and h are as defined above

Under standard conditions of temperature and pressure, the production rate equation becomes:

$$SCFD = (Q) \frac{(Tsc)}{(Twh)} \frac{(Pwh)}{(Psc)} \quad (8)$$
$$= 0.94Q$$

Where:

Tsc = 520 $^oR$

Twh = 550 $^oR$

Pwh = 14.6 psia

Psc = 14.7 psia

Combining (8) and (7), the following equation is obtained:

$$SCFD = 18.77 \times 10^6 \quad (Ah/R^2) \quad (1)$$

This equation was used to generate the graph on Figure 17.

It is obvious that:

$$(VREC) \quad (W) = 365 \quad (SCFD) \quad (t) \quad (9)$$

Where:

t = time, year

Combining (1), (6), (4) with (9), the latter equation becomes:

$$t = 2.49 \times 10^{-3} \quad CR^2 \quad (2)$$

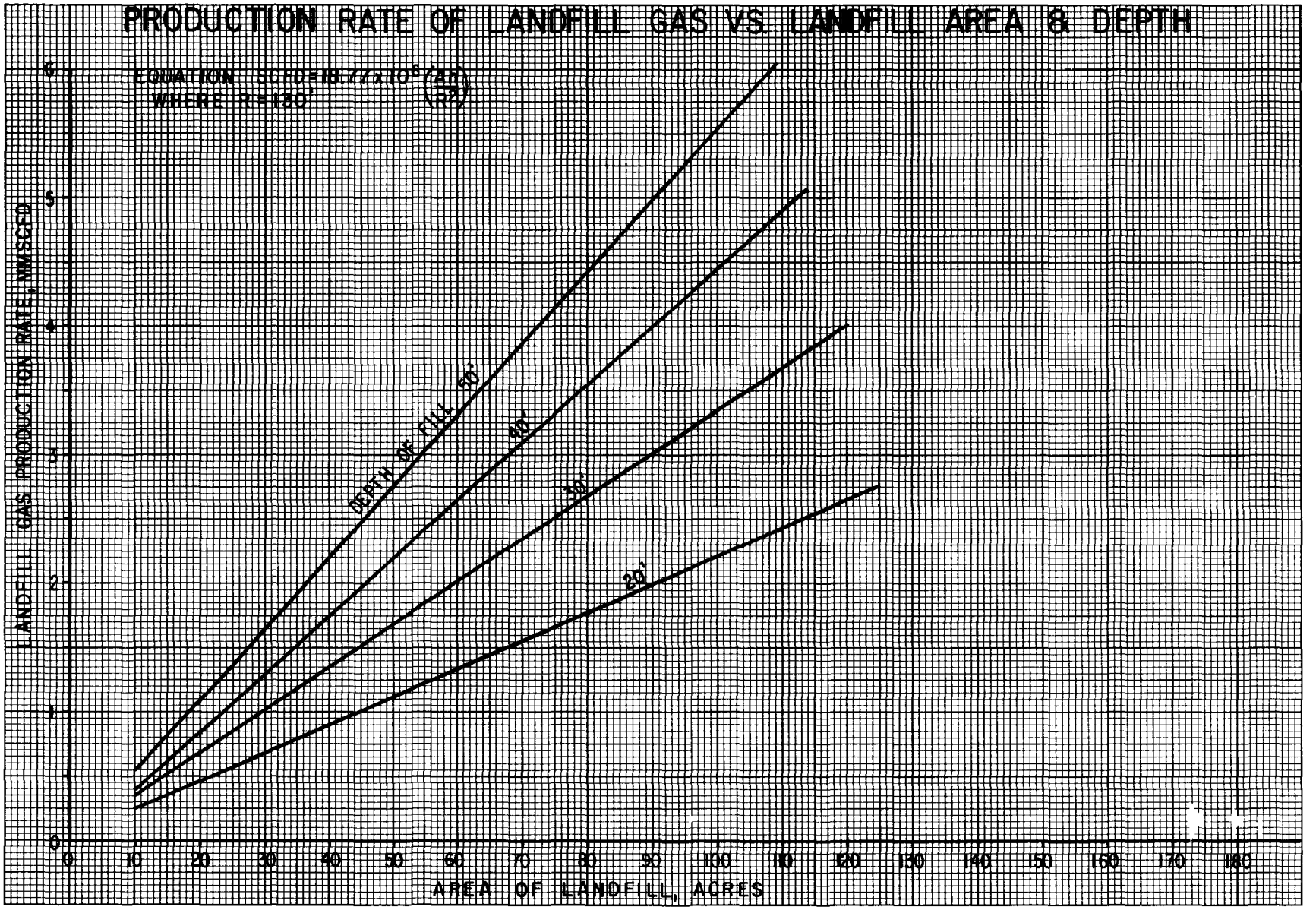

PRODUCTION RATE OF LANDFILL GAS VS. LANDFILL AREA & DEPTH
EQUATION SCFD=18.77x10^5(AD)(R^2)
WHERE R=1.30
LANDFILL GAS PRODUCTION RATE, MMSCFD
AREA OF LANDFILL, ACRES
DEPTH OF FILL, 60'
40'
30'
20'
0
1
2
3
4
5
6
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

FIGURE NO. 17

Specification No. 2785

| GM | LOC. DIV. | ACC. | ACTIVITY NO. | ITEM LOC. |
|---|---|---|---|---|
| 184662 | 8 | 1125 | | 211 |

II

# SPECIFICATIONS

For

FURNISHING AND DELIVERY

OF A

COMPRESSOR FOR LANDFILL GAS

AT THE

CITY OF MOUNTAIN VIEW LANDFILL FACILITY

PACIFIC GAS AND ELECTRIC COMPANY
San Francisco, California

BIDDER—SIGN HERE TO INDICATE
THIS HAS BEEN USED IN PREPARING PROPOSAL

SIGNATURE.....

DATE.....

APPROVED BY C. J. TATEOSIAN
Manager, Gas System Design

DATE: September 23, 1975

ADDENDUM

Specification No. 2785

1. Bidder shall quote as an alternate the additional cost of furnishing all gas piping, valves, fittings, pressure vessels (excluding cylinders), heat exchangers, etc., for 600 psig working pressure at 300°F in lieu of the 400 psig working pressure at 300°F requested in the attached specification section 7.1. Operating conditions will remain the same.

2. The second sentence of Paragraph 7.1 should read as follows:

> All gas piping shall be in accordance with the requirements of Paragraph 192.111 of CPUC G.O. 112-C.

# SPECIFICATION 2785
# COMPRESSOR FOR LANDFILL GAS UTILIZATION

## 1.0 GENERAL

This Specification covers furnishing one (1) heavy-duty compressor plant to be located on the San Francisco Bay shore. The plant will consist of a reciprocating compressor with heavy-duty gas engine, gas scrubbers, gas cooler, and necessary appurtenances for a self-contained unit, all mounted on a rigid structural steel skid. Electric drive shall be quoted as an alternate. The unit service will be compressing landfill gas from approximately atmospheric pressure to 400 psig (maximum). Normal operating exit pressure will be 350-400 psig. Unit is to be fully automatic except for manual start and capable of operating unattended except for daily servicing. Design emphasis should be placed on reliability of operation and low maintenance cost. Compressor should be able to operate 72 hours without attendance.

All requirements of this Specification are to be met by the supplier unless specifically noted otherwise.

1.1 Attached data sheets and General Conditions Specification (F-D) (MF) are a part of this Specification.

## 2.0 OPERATION CONDITIONS

2.1 The gas to be compressed and also used for fuel in the engine (if gas driven) is landfill gas of the following composition:

| Constituent | Percent |
|---|---|
| $CH_4$ | 40-45 |
| $CO_2$ | 30-35 |
| $O_2$ | 0.5-2.0 |
| $N_2$ | 19-24 |
| $H_2$ | 0-0.02 |
| CO | 0-.01 |
| $H_2S$ | 0.02 |
| $H_2O$ | Sat'd @ 4" W.C @ 100°F |

2.1.1 The compressor is to be automatically controlled to hold a pre-set pressure on the suction side by varying engine speed, loading and unloading cylinders, and/or opening or closing pneumatically operated pockets. Bidder should give full data on recommended unloading steps and maximum and minimum continuous engine speeds. All information is to be indicated on the attached data sheets.

3.0 The bidder shall furnish the following accessories with each engine:

3.1 Engine Starter

3.1.1 A reliable and complete starting system. (A pneumatic starter suitable for operation on 100 psig landfill gas and natural gas is preferred.)

3.2 Sensing devices for a safety shutdown system with first unsafe indication which covers the following:

3.2.1 Overspeed.

3.2.2 Low lube oil pressure.

3.2.3 High lube oil temperature.

3.2.4 High jacket-water temperature.

3.2.5 Vibration.

3.2.6 High liquid level in suction and discharge scrubbers.

A pneumatic shutdown and enunciation system is preferred.

3.3 Complete safety shutoff valves, pilot valves, regulating valves, and all engine piping and manifolding necessary for a landfill gas fuel system.

3.4 All foundation bolts, nuts, washers, jackscrews and soleplates.

3.5 Oil pumps, gauges, and integral piping for a complete, automatic lubrication system.

3.6 One complete set of special tools.

3.7 A Peco Full Flow Oil Filter.

3.8 Mechanical tachometer with clutch mounted on engine.

3.9 A suitable residential exhaust silencer.

3.10 A silenced intake air filter; American Air Filter Cycoil or equal.

3.11 Automatic temperature control of the engine and compressor jacket water and lube oil, both by direct acting temperature controlled three-way bypass valves.

3.12 A fuel gas heater with bypass connected to the jacket water system.

3.13 An automatic governor and speed control which works through the governor spring and not by a throttle actuating device - a governor whose setting can be controlled by a 3-15# signal. (Controller is to be furnished by Purchaser.) Bidder is requested to include in his quote the manufacturer model and type of governor to be used along with a drawing which shows how the remote speed control device operates. No bid will be considered that does not have this information.

4.0 The bidder shall furnish the following with each compressor:

4.1 Compressor cylinders shall be designed for 400 psig operating pressure and hydrostatically tested to 600 psig.

4.2 Compressor shall be furnished with oversized 72 hour capacity cylinder forced feed lubricators.

4.3 Compressor cylinder rod shall have vented flurocarbon packing.

4.4 Compressor cylinders shall have pneumatically operated suction valve and clearance pocket unloaders as required suitable for operation with digester gas at a maximum pressure of 50 psi.

4.5 Compressor cylinders will be piped for cooling.

Note: Purchaser will furnish the unloader and speed control system controls.

## 5.0 COOLING EQUIPMENT FOR EACH UNIT

### 5.1 General

Cooling for jacket water, lube oil, compressor cylinders, and gas shall be accomplished with a forced draft air cooled heat exchanger.

Cooling equipment shall be designed to provide sufficient cooling at minimum engine speed and full engine BMEP. The design operating conditions are as follows:

5.1.1 The gas cooling coils shall be designed for the lower of the maximum cylinder pressure or 400 psig at 300°F.

5.1.2 The water cooling coils shall be designed for 100 psig at 250°F.

5.1.3 The design ambient air temperature is 30-100°F.

5.1.4 The minimum net tube side fouling factor shall be 0.004 for the gas cooling coils, 0.001 for the engine/compressor water cooling coils.

5.1.5 Elevation of the location is sea level.

5.1.6 Maximum gas discharge temperature leaving cooler shall be 120°F.

5.2 Cooling Coils

All coils used in the air cooled heat exchanger shall consist of tubes with either continuous helical fins or extruded fins and adequate supporting framework. The design shall be such that the tubes are individually removable for replacement and repair without disconnecting piping. All coils shall be hydrostatically tested at one and one-half times their design working pressure.

5.3 Headers

5.3.1 Headers shall be preferably of the box type design with brass plugs opposite each tube end. Tube holes shall be drilled, reamed and grooved in accordance with standard heat exchanger practice for rolled tube joints. Headers shall be either cast steel or welded steel.

5.3.2 Gas headers shall comply with the provisions of the ASME Code for Unfired Pressure Vessels and be Code stamped. The Manufacturer shall supply appropriate code certificates.

5.3.3 All headers shall be supplied with vents and drains and all nozzles shall have at least one 3/4-inch plugged connection.

5.4 Fans and Driving Mechanisms

5.4.1 Fans shall be adjustable pitch with a minimum of four blades. Fan tip speeds shall not exceed 9,000 feet per minute.

5.4.2 The cooler fan shall be driven from the engine through a heavy-duty mechanism, suitable for the variable speed operation of the engine.

5.4.3 Safety Guards

The bidder shall furnish individual guards for the mechanical drive equipment and the fan of the cooler. Guards shall comply with the provisions of the Safety Orders issued by the State of California, Division of Industrial Safety and OSHA.

5.4.4 Bidder shall completely fill out and return the attached data sheets.

## 6.0 SCRUBBERS

Baffle drip type scrubbers with reflex type liquid level gauges, high level automatic shutdown and automatic drains shall be installed on both inlet, outlet, and interstage sides of the compressor.

## 7.0 PIPING

### 7.1 General

All gas piping, valves, fittings and pressure vessels shall be designed for 400 psig working pressure at 300°F. All gas piping shall be in accordance with the latest edition of the American Standard Code for Pressure Piping. All pressure vessels, heat-exchangers, etc., shall comply with the ASME Code for Unfired Pressure Vessels.

7.2 The necessary fuel gas piping, valves, relief valves, and regulators shall be provided by the bidder. PG&E will furnish the gas meter.

7.3 All drains from various headers, drips, and automatic liquid dumps shall be piped to a common location on the skid.

7.4 Removable screens mounted in frames shall be installed on the inlet flange of each compressor cylinder. These screens will be removed after the unit has been placed in operation long enough to determine that no further dirt is going into the compressor.

7.5 Instrument and control piping shall be seamless stainless steel tubing. In addition, the suction valve unloaders and clearance pockets shall be connected and piped to a single point on the skid to be designated later. These lines will connect to a separate panel to be mounted adjacent to the skid. (This panel will be supplied by Purchaser.)

## 8.0 GAUGE BOARD AND INSTRUMENTS FOR EACH UNIT

8.1 A gauge board shall be installed in a convenient place on the skid, in such a manner for ease in reading and shall include the following instruments:

8.1.1 Main gas suction pressure to each stage of compression.

8.1.2 Main gas discharge pressure from each stage of compression.

8.2 The bidder shall include the following Rochester 3" radial dial type temperature indicators:

8.2.1 Main gas suction to each stage of compression.

8.2.2 Main gas discharge from each stage of compression.

8.2.3 Gas discharge from the gas cooler. (All temperature indicators to have stainless steel thermometer wells.)

## 9.0 STRUCTURAL DETAILS FOR EACH UNIT

9.1 Bidder shall provide a structural steel skid so that it can be bolted and grouted in the conventional "stationary plant" manner. The main skid base shall be built from "I" beams with adequate cross bracing and channels on top of the beams forming a sub-base for mounting the compressor. The size of base and "I" beams shall be stated on the attached data sheet. An adequate number of holes shall be provided through the skid to allow bolting down the skid on a concrete pad in the field. The entire structure shall be rigid to provide safe stability and operation of the compressor.

Lifting bars shall be built into the ends of the skids.

## 10.0 PREVENTION OF RUST-PAINTING-GALVANIZING

### 10.1 Exterior Surface Preparation

10.1.1 Cleaning - All surfaces of ferrous metal, except machined surfaces, shall be cleaned, dried, and free of oil and grease. All heavy slag accumulations, metal leaves or blisters, weld splatter, or other irregularities shall be removed by appropriate mechanical means after which all mill scale, rust and old paint shall be removed by blast

cleaning in accordance with the latest edition of the Steel Structures Painting Standard SSPC SP 10 for Neat-White Blast Cleaning. Anchor depth of surface profile shall not exceed .002 inches (2 mils).

10.1.2 Priming - Within twenty-four (24) hours after blast cleaning or before reoxidation can take place, one or more coats of one of the following approved primers listed below shall be applied to these surfaces. A total dry thickness of between 2 and 3 mils is required. Coating thickness shall be maintained over welds, edges of plates, or other sharp projections or rough areas. All painting shall be done in accordance with the Steel Structures Painting Council Standard SSPC-PA-1-64 Paint Application Specifications.

10.1.3 Approved Primers

| Manufacturer | Manufacturer No. | Brand or Name |
|---|---|---|
| Mobil Chemical | #7 | Mobilzinc |
| Ameron | #6 | Dimetcote |
| Carboline | #11 | Carbo-Zince |

10.1.4 Finish Coat - A finish coat is not required.

10.1.5 Machined Surfaces - Machined surfaces shall be protected with a suitable rust-inhibitive coating.

11.0 Bidder shall pipe and arrange all equipment in such a manner as to provide accessibility for maintenance. The completed unit assembled on the skid shall be portable over California State Highways without special permit.

12.0 Bidder shall provide the services of a competent serviceman for five days for supervising the installation of the unit and placing it in operation.

13.0 PURGING AND CLEANING

Bidder shall clean all piping of dust, dirt, weld beads, etc., prior to shipment. All openings shall be closed prior to shipment.

14.0 TESTING

When the skid mounted unit is complete, the bidder will make an operating test in his shop by starting up the engine and running it long enough to check the following applicable items:

14.1 Cylinder alignment.

14.2 Proper operation of the oil and water cooling equipment, including pressure and temperature control.

14.3 Proper operation of all liquid level controls.

14.4 Proper operation of all engine or motor shutdown devices.

14.5 Proper operation of all pressure and temperature indicating devices.

In addition, the bidder will test all piping and equipment in accordance with the ASME and ASA Codes (see Paragraph 3.2).

Bidder shall notify purchaser in sufficient time, prior to testing, to permit having a PG&E inspector present during testing, if so desired.

## 15.0 INFORMATION

15.1 Six copies of an operating manual for each complete unit shall be provided when the equipment is shipped. These manuals shall include the following:

15.1.1 Operating and maintenance instructions and parts lists for all equipment. (When general manufacturer's bulletins are supplied, the specific item used shall be marked.)

15.1.2 A listing in one place of operating specifications and instrument and control settings for levels, temperatures, pressures, speeds, etc., for all equipment.

15.1.3 A set of performance curves showing horsepower and capacity versus suction pressure for the compressor, throughout its operating range. (Assume 400 psig discharge.)

15.1.4 Operating instructions for the unit as a whole, prepared by the bidder, and showing proper startup, running, and shutdown procedures.

15.1.5 One complete set of construction drawings.

15.2 Shipping instructions shall be furnished by PG&E at a later date.

15.3 The correspondence pertaining to the specifications, drawings, and job may be addressed to:

Mr. C. J. Tateosian
Pacific Gas and Electric Company
77 Beale Street, Room 2857
San Francisco, CA 94106

All telephone calls may be made to:

Mr. R. A. Holden
(415) 781-4211, Extention 1448
or
Mr. R. W. Headrick
(415) 781-4211, Extention 3706

15.4 Bidder will sign below to indicate that his quotation covers equipment in accordance with the above specification, and, that if exception is taken to any provision above, it is specifically stated to be an exception in the quotation.

_____
Bidder

## GENERAL CONDITIONS

### 1.0 DEFINITIONS

1.1 "PG&E": Pacific Gas and Electric Company.

1.2 "Supplier": Party or parties making a contract with PG&E for this work.

1.3 "Bidder": Party or parties submitting a proposal for this work.

1.4 "Specification": Refers to and indicates the General and Specific Conditions of PG&E and any addenda to these.

1.5 "Supplier Specifications": Refers to and indicates the General and Specific Conditions of Supplier and any addenda to these.

1.6 "As directed", "as required", "as permitted", "approved", "acceptable", "satisfactory", means by or to PG&E.

1.7 "Work": Includes labor, materials, or equipment or all as required hereunder.

1.8 "Engineer": PG&E's Vice President-Engineering or his representative.

1.9 "Buyer": PG&E's Manager, Materials Department, or his representative.

### 2.0 PROPOSAL

2.1 General: The proposal shall be enclosed in a sealed envelope, distinctly marked "Proposal" with the title of work as given, and delivered to Buyer, 77 Beale Street, San Francisco, CA 94106. The proposal shall be signed with the full name and local address of Bidder by a responsible member of the firm. PG&E reserves the right to reject any and all proposals, and to accept other than the lowest proposal. The design, description, and performance capabilities of the equipment and/or materials set forth in the accepted proposal, subject to modifications mutually agreed to, shall become a part of the purchase order or contract.

2.2 Quotations: Quotations shall be (1) fob vessel, car, or other vehicle, point of shipment; and (2) fob vessel, car, or other vehicle, point of shipment with freight allowed to shipping destination. Quotations shall be exclusive of applicable sales, use, or other excise taxes, and PG&E will reimburse Supplier therefor. The proposal shall include, for excise tax and other purposes, a statement showing separately the amount included in the quotation to cover delivery charges and supervision of installation charges, if any. Delivery charges shall include cost of freight, cartage, dunnage, and insurance. The total shipping weight and dimensions shall be stated in the proposal.

### 3.0 DELIVERY

3.1 Fabrication and Shipment Time: The time quoted for fabrication and shipment will be an important consideration and condition in making the award. Construction schedules and contracts between PG&E and third parties are or will be based upon receipt of the equipment and/or material which is the subject of this Specification by the promised delivery date. The facility in which the subject equipment and/or material is to be used is required as scheduled to meet the demands upon PG&E by the public which it serves with gas and/or electricity for light, heat, and power. Time is of the essence hereof. Supplier shall give immediate written notice to PG&E of each shipment as made, accompanied with full information as to routing, car numbers, and other necessary matters. If a delivery schedule is specified, the general order in which the equipment and/or material shall be delivered shall be in accordance with the delivery schedule. Changes in this schedule may be directed by Buyer and these changes shall be complied with by Supplier insofar as possible.

3.2 Suspension of Work or Delivery: PG&E may suspend work or delivery by extension of time to Supplier. Supplier shall not be liable for delays in delivery or failure to manufacture or delivery due to causes beyond its reasonable control. The date of delivery, in the event of such delay, shall be postponed by the number of calendar days over which such cause or event extended, provided Supplier submits to PG&E a claim in writing for extension of time within seven (7) days from the date of the start of delay. In the event Supplier is late in delivery, there shall be no escalation or price adjustment beyond the contract shipment date, except where such late delivery is requested or caused solely by PG&E.

### 4.0 LAWS AND REGULATIONS

4.1 Equipment and/or material furnished hereunder shall be so designed and constructed that when installed it will comply with the applicable laws, rules, and regulations, including, without limitation, all "Occupational Safety and Health Standards" promulgated by the U.S. Secretary of Labor and all Safety Orders of the Division of Industrial Safety, Department of Industrial Relations, State of California, which must be complied with before the equipment and/or material may lawfully be used by PG&E in California. All expenses incurred in complying with these requirements are understood to be included in the contract price.

## 5.0 TITLE

5.1 Title to the equipment and/or material furnished hereunder shall pass to PG&E, "fob vessel, car, or other vehicle, point of shipment". Should the equipment and/or material be received at destination by PG&E in a damaged condition and any claim for damage during shipment be declined by the carrier or carriers with the inference that damage was the result of the act of the shipper or some inherent defect in the equipment and/or material, Supplier, upon the request of PG&E, shall assume the responsibility of processing any claim or claims against the carrier or carriers and shall reimburse PG&E for the cost of repairing or replacing the damaged equipment and/or material. In any event, Supplier shall assist PG&E in establishing carrier liability by supplying evidence that the equipment and/or material was properly constructed, manufactured, packaged, and secured to withstand normal transportation conditions.

## 6.0 SPECIFICATION AND DRAWINGS

6.1 General: This Specification and the accompanying drawings, if any, are complementary and shall be taken in conjunction. Supplier shall report to Engineer in writing any discrepancy or errors which come to its attention. Necessary work implied as included in the contract shall be included without extra cost to PG&E. Figured dimensions shall be followed in preference to scaled dimensions. PG&E's Specification shall govern in cases of conflict with Supplier's specification unless otherwise provided.

6.2 Approved Drawings: Unless otherwise provided Supplier shall make any necessary detailed drawings, subject to the approval of Engineer and shall be responsible for their practicability. Approval of such drawings by Engineer shall be general only and shall not relieve Supplier of responsibility for correct construction and compliance with the purchase order or contract, which shall include this Specification. Supplier shall pay for any alternations made necessary by its errors. All work shall be done in accordance with such approved drawings in compliance with the intent of this Specification. Calling Supplier's attention to certain errors does not place responsibility upon PG&E for the correctness of other features not mentioned.

## 7.0 INTENT OF SPECIFICATION

7.1 This Specification and the accompanying drawings are intended to cover all the work to be performed, and unless expressly excluded, all labor and materials not specified or indicated but which are necessary to complete the work in a proper, substantial, and workmanlike manner shall be furnished by Supplier. In consideration of and as a condition of PG&E offering to consider and considering a proposal submitted by Bidder, it is agreed and understood by Bidder, by submitting a bid, that if Bidder's proposed specification, drawings or general terms of sale conflict with this Specification, this Specification shall govern and such conflicting portions of Bidder's proposal shall not become a part of the contract. In addition to Bidder's base proposal, which shall comply with this Specification, Bidder may submit an alternate proposal resulting in cost saving to PG&E. The base proposal shall be labeled "Base Proposal", and any alternate proposal shall be designated "Alternate Proposal". In such alternate proposal or proposals, any and all exceptions to this Specification must be stated or listed as exceptions in writing in the alternate proposal or proposals in a separate paragraph entitled "Exceptions", and it is agreed and understood that in all other particulars this Specification shall govern.

## 8.0 INFRINGEMENT PROTECTION

8.1 All royalties or other charges for any patent, trademark, or copyright to be used in the work shall be considered as included in the contract price. Supplier shall indemnify and save harmless PG&E against any and all judgments, costs, damages, and expenses which may be awarded against PG&E in any suit, action, or proceeding brought against PG&E for infringement or alleged infringement of any patent, trademark, or copyright by a court of competent jurisdiction, arising out of the use by PG&E of the equipment and/or material furnished hereunder in the ordinary course of their use for the purposes hereunder intended. If any suit or suits for infringement of any patent, trademark, or copyright be instituted against PG&E as above specified on account of the use of said equipment and/or material furnished hereunder, and if promptly notified, Supplier shall assume the defense of such suit or suits and all expenses incident to the defense thereof; but it is expressly understood that in assuming the defense of such suit or suits Supplier shall have control of same, and PG&E shall be kept fully informed as to the progress thereof and have the right to confer about and give advice and assistance regarding same.

## 9.0 MATERIALS AND WORKMANSHIP

9.1 Materials: All materials used shall be suitable for the work, the best of their respective kinds, and shall be subject to the approval of Engineer. Articles or materials may be substituted for those specified only with the consent of Engineer. The methods used by Supplier shall be such as will produce satisfactory work, and in accordance with the best trade practice.

9.2 Standards: Unless specified otherwise, equipment and/or material furnished hereunder shall be constructed and tested in accordance with the latest edition of applicable NEMA, IEEE, ANSI, ASME, AISC, AISI, AWS, THEMA, and ASTM standards.

10.0 CANCELLATION PROVISION

10.1 If PG&E shall be required or deems it advisable as a direct or indirect consequence of any governmental action, or for other good and sufficient reason, to suspend or terminate the work being performed pursuant to this Specification, PG&E may do so by written notice. Supplier thereupon shall take whatever action with respect to work in process as will tend to minimize its claim against PG&E. PG&E will pay Supplier a reasonable suspension or termination charge, excluding any allowance for anticipated profits on the unperformed portion of the work. Supplier shall, to the extent practicable, include in subcontracts made pursuant to this contract a termination provision substantially similar to the foregoing provision.

11.0 INSPECTIONS AND TESTS

11.1 Shop Tests: Shop tests as specified shall be performed by Supplier and it shall furnish all facilities necessary for the performance of these tests.

11.2 Access to Shop and Tests: For the purpose of witnessing tests, making inspections, and preparing progress reports, PG&E's inspector shall be notified well in advance of the starting of the work and he shall be given full access to the shop at all times during working hours during the period of manufacture, as well as full access to all shop tests performed by Supplier. On request, Supplier shall provide PG&E's inspector with a list of principal production tests and inspection points. Supplier shall provide reasonable advance notice of the time of those tests and inspections which PG&E's inspector indicates he intends to witness. If certain tests are specified to be witnessed by PG&E's inspector, it shall not be construed to limit access to other shop tests. PG&E's inspector shall have access to all test and inspection records pertinent to this contract. Supplier shall require subcontractors and suppliers performing work pursuant to this contract to conform to the requirements of this Paragraph.

11.3 Material Tests: Should material tests be required by Engineer, Supplier will be advised in ample time so that test specimens can be provided during the shop manufacture. Unless otherwise provided, such tests shall be made in accordance with requirements of the applicable ASTM standards.

11.4 Certified Test Reports: Supplier shall furnish to Engineer certified copies of all test reports. The number of copies required shall be as specified in the Specific Conditions hereof. These test reports, in addition to being certified, shall be approved by PG&E's inspector in the vicinity before being sent to Engineer.

11.5 Field Tests: Field tests shall be made at the expense of PG&E except that the expense of Supplier's representatives, if any, shall be borne by Supplier. If for any reason whatsoever the equipment and/or material does not meet the guarantees agreed upon in any respect and it is necessary for Supplier to make alterations for the purpose of meeting these guarantees, additional tests required to show the effects of such alterations shall be performed by Supplier at its own expense.

11.6 Location of PG&E's Inspector: The location of the headquarters of PG&E's inspector may be obtained from PG&E's Department of Engineering Services, Inspection Section, 77 Beale Street, San Francisco, CA 94106.

11.7 Inspections and Tests Not Deemed Waiver: The witnessing of such tests and the receipt of reports of such tests by Engineer, and Supplier's compliance with all provisions of this section concerning inspections and tests shall not constitute a waiver by PG&E of any warranty concerning the equipment and/or material, nor relieve Supplier of any warranty concerning said equipment and/or material.

12.0 SHIPMENT

12.1 Carload Shipments: Thirty (30) days prior to shipment, routings on carload shipments, together with an outlined sketch showing shipping dimensions and weights, shall be forwarded for approval to PG&E's Traffic Bureau, 77 Beale Street, San Francisco, CA 94106. Supplier shall be responsible for assuring that equipment and/or material is properly prepared for shipment and loaded so as to prevent damage during shipment. At or prior to the time of shipment, Supplier shall forward to PG&E's Traffic Bureau complete details, including any diagrams or sketches prepared, concerning the method and technique of preparing the equipment and/or material for shipment and loading, including those utilized to prevent both external and internal damage during shipment, loading, and unloading.

12.2 Material List: A complete list of all material shipped shall be mailed to the work site.

12.3 Bills of Lading: Bills of lading shall be mailed to PG&E as follows:

12.31 General Construction Department, 77 Beale Street, San Francisco, CA 94106.

12.32 Materials Department, Traffic Bureau, 77 Beale Street, San Francisco, CA 94106.

12.33 To the work site.

12.34 PG&E's inspector in the vicinity. The location of the headquarters of this inspector may be obtained from PG&E's Department of Engineering Services, Inspection Section, 77 Beale Street, San Francisco, CA 94106.

12.4 Identification: All routings, sketches, material lists, and bills of lading shall be identified with PG&E's purchase order number, specification number, and plant name.

13.0 *INDEMNITY*

13.1 Supplier shall indemnify PG&E, its officers, agents, and employees, against all loss, damage, expense, and liability resulting from injury to or death of person, including, but not limited to, employees of PG&E and/or Supplier, or injury to property, including but not limited to, property of PG&E and/or Supplier, arising out of or in any way connected with the technical direction of installation, inspection, or construction performed by Supplier's representatives at PG&E's work site in conjunction with the equipment and/or material furnished hereunder, excepting only such injury or death as may be caused by the sole negligence or willful misconduct of PG&E. Supplier shall, on PG&E's request, defend any suit asserting a claim covered by this indemnity. Supplier shall pay all costs that may be incurred by PG&E in enforcing the indemnity, including reasonable attorney's fees.

14.0 WARRANTIES

14.1 Workmanship and Materials: Supplier shall warrant that the equipment and/or material and all parts thereof furnished by Supplier, whether or not manufactured by Supplier, shall be of the kind and quality described in the purchase order or contract (which shall include this Specification) will be free of defects in workmanship, material, and title, shall perform in the manner hereinafter set forth in Paragraph 14.2, shall be of good and merchantable quality and shall be fit for its intended purpose.

14.2 Performance: Supplier shall warrant that when the equipment and/or material is placed in operation or used it will perform in the manner set forth in the purchase order or contract, which shall include this Specification.

14.3 Remedies: Supplier shall agree that if it shall appear within twelve (12) months from the date of shipment, that the equipment and/or material delivered hereunder does not meet the warranties specified above and PG&E notifies Supplier promptly upon the discovery of the defect or nonconformity, Supplier shall acknowledge receipt of such notice of defect or nonconformity and shall inform PG&E in writing within five (5) days of receipt of such notice as to whether:

(a) Supplier will, at its expense, immediately repair or replace the equipment and/or material or otherwise correct it so that it will meet and conform to the warranties specified above, provided, however, that if Supplier should elect to repair said equipment and/or material, such repair shall be effected in such a manner as not to interfere with construction and operations conducted by PG&E, and in such a manner as not to interfere or breach any labor agreements between PG&E or its contractors or subcontractors and labor unions performing work for PG&E, its contractors or subcontractors; or

(b) Supplier authorizes PG&E to repair the equipment and/or material, or have it repaired, or otherwise correct the nonconformity, or have it corrected, so that the equipment and/or material will meet and conform to the warranty specified above, and agrees to pay PG&E the cost of such repair, replacement, or correction.

14.31 All freight charges incurred in connection with any such repair or replacement shall be borne by Supplier.

14.32 If Supplier is obliged to correct defects as herein provided, the warranty period for the repaired or replacement part shall extend for one year from completion of repair or installation of such part provided the same is not unreasonably delayed by PG&E.

14.4 Limitation of Liability: It shall be agreed that if Supplier shall so replace, repair, or otherwise correct the defect or nonconformity, or so authorize PG&E to repair, replace, or otherwise correct the defect or nonconformity and pays or agrees in writing to pay the cost of such repair, replacement, or other correction, such shall constitute fulfillment of all liabilities of Supplier to PG&E for any claim based upon such defect or nonconformity, and in such event, except as to title and except as provided in the paragraphs entitled "Infringement Protection" and "Indemnity," Supplier shall not be liable for special or consequential damages. If Supplier so replaces, repairs, or otherwise corrects the defect or nonconformity, or so authorizes PG&E to repair, replace, or otherwise correct the defect or nonconformity and pays the cost of such repair, replacement, or other correction, and it subsequently is determined either by agreement between Supplier and PG&E or any court of competent jurisdiction that Supplier is not liable for such defect or nonconformity, PG&E will repay or refund the sum so paid by Supplier. In any event, Supplier's liability for any claim based upon such defect, nonconformity, or noncompliance shall not exceed the total price of the equipment and/or material furnished under this Specification except as provided in the paragraphs entitled "Warranties," "Infringement Protection," and "Indemnity."

15.0 PAYMENTS

15.1 Approval of Payments: Payments will be made only upon the approval of PG&E and in accordance with the terms of the agreement.

15.2 Invoices: Supplier shall render all invoices in quadruplicate for payment when due. Invoices shall be mailed to: Pacific Gas and Electric Company, Post Office Box 7760, San Francisco, CA 94119. Invoices shall indicate delivery charges, supervision of installation charges, if any, and excise taxes as single separate items apart from the cost fob vessel, car, or other vehicle, point of shipment. PG&E's specification number, purchase order number, and plant name shall appear on all invoices.

15.3 Supplier's Responsibility: Full payment by PG&E shall not release Supplier of its responsibilty to fully carry out its contract obligations.

15.4 Release: The acceptance by Supplier of final payment made under the terms hereof shall operate as and be a release of PG&E and every office and agent thereof, of and from all claims of Supplier for any and all things done or omitted by or on behalf of PG&E in connection with, relating to, or growing out of this contract for the work done hereunder.

16.0 METHOD OF PAYMENT

16.1 Preferred Method: Payments on the purchase price shall be made as follows:

16.11 Ninety-five percent (95%) of the component price thirty (30) days after invoice date and receipt of supporting bill of lading evidencing shipment, provided the equipment and/or material is received at work site and no apparent defects or damage is observed. The invoice date shall be the date of delivery to the carrier.

16.12 Five percent (5%) thirty (30) days after passing the acceptance tests described in this Specification. In the event such tests are delayed more than seven (7) months after the date of operation set forth in this Specification and deliveries have not been delayed and the equipment does not appear damaged, defective, or nonconforming with the contract, the final payment will then become payable. Unless otherwise agreed, no payment shall be deemed to constitute an acceptance of the equipment or any component part thereof or a release of any responsibility or obligation of Supplier.

16.2 Alternate Method: Bidder may present an alternate scheme of payment in addition to Bidder's basic proposal which shall comply with this Specification, but PG&E reserves the right to adhere to the method outlined above. The basic proposal shall be labeled "Basic Proposal," and any alternate designated "Alternate Proposal."

Specification No. 2774

| GM | LOC. DIV. | ACC. | ACTIVITY ITEM | ITEM LOC. |
|---|---|---|---|---|
| 184662 | 8 | 1125 | | 211 |

II (Continued)

SPECIFICATIONS

For

FURNISHING AND DELIVERY

OF A

LANDFILL GAS PURIFICATION UNIT

FOR THE

CITY OF MOUNTAIN VIEW LANDFILL FACILITY

PACIFIC GAS AND ELECTRIC COMPANY
San Francisco, California

BIDDER—SIGN HERE TO INDICATE
THIS HAS BEEN USED IN PREPARING PROPOSAL

SIGNATURE.....

DATE.....

APPROVED BY C. J. TATEOSIAN
Manager, Gas System Design

DATE: September 15, 1975

ADDENDUM

Specification No. 2774

1. Bidder shall quote as an alternate the additional cost of furnishing all gas piping, valves, fittings, pressure vessels, heat exchangers, etc., for 600 psig working pressure in lieu of the 400 psig working pressure requested in the attached specification. The applicable ASME and ANSI Codes shall be adhered to.

# SPECIFICATION FOR ACID GAS REMOVAL UNIT FOR LANDFILL GAS UTILIZATION

## 1.0 SCOPE

1.1 This Specification covers the supplying of one (1) completely packaged $H_2O$, $CO_2$, and $H_2S$ removal plant to be installed at the Mountain View Landfill in Mountain View, California.

1.2 The entire plant shall be supplied complete with all equipment and accessories necessary for automatic and unattended operation, testing, and routine maintenance unless specific exemption is made below.

1.3 Refrigeration processes are not covered in detail in this specification. However, Sections 2, 3 and 6-13 remain applicable for any proposed processes. If a refrigeration process is proposed, bidder shall submit, with quote, a detailed equipment bill of materials which includes metallurgy, for PG&E evaluation. A control schematic shall also be submitted.

1.4 Bidder must quote on specifications but may quote on as many alternates as desired.

1.5 General Conditions Specification (F-D)(MF) is attached hereto and made a part hereof.

1.6 Specification 2785 (attached) shall be used for compression equipment. Bidders who elect to submit proposals for both specifications, may wish to optimize the pressure level for acid gas removal at some intermediate pressure. If so, please so specify and include a description on your flow sheet. However, each specification shall be adhered to so far as is practicable and all exceptions shall be specifically stated. In addition, each bidder shall submit a detailed equipment specification sheet including proposed metallurgy, a control schematic, and applicable codes and standards under which this would be designed and constructed if different from the ones listed herein.

## 2. GENERAL DESIGN CONDITIONS

2.1 Wind load - 20 psf on 2/3 of projected area.

2.2 Earthquake - 0.50g Horizontal Loading.

2.3 All pressure vessels shall be fabricated, inspected, tested, and found acceptable in accordance with the latest edition of the ASME Code for Unfired Pressure Vessels. This shall include in all instances, even if not required by the Code, 100 percent X-ray of all welded joints. Radiograph films shall be made available to the Pacific Gas and Electric Company inspector.

2.4 Perform Charpy V-notch impact test on at least three specimens of material used which will average 15 ft-lb at $-20^{\circ}F$, with no single specimen below 10 ft-lb at $-20^{\circ}F$. Specimen size shall be 10 mm x 10 mm x 55 mm. If cryogenic processes are proposed ($<0^{\circ}F$), the transition temperature shall be determined for the designated metallurgy and submitted to PG&E for approval.

2.5 All the fabrication shall be done by welders qualified in accordance with Section IX, Welding Qualifications, of the ASME Boiler and Pressure Vessel Code and conform to Appendix D of Section VIII, "Suggested Good Practice Regarding Internal Structures." Prior to fabrication, the manufacturer shall submit a description of welding procedure and type of welding and welding electrodes to be used.

2.6 After fabrication and in every instance, even if not required by the Code, post weld heat treatment of the vessel (as outlined by Section VIII of the ASME Boiler and Pressure Vessel Code) is required by Pacific Gas and Electric Company. Vessel shall be code-stamped. All welds, internal and external, shall be continuous and equal to the parent material strength and ductility.

2.7 Weld defects shall be removed by chipping, grinding, or arc-gouging to sound metal. Repairs to welds shall be done in such a manner as not to gouge, groove, or reduce the base metal thickness. If the repair is in a section requiring radiography, it shall be re-radiographed.

2.8 All piping shall be designed to a 0.5 Design factor, in accordance with the requirements of Paragraph 192.111 of CPUC G.O. 112-C. All piping requiring field installation shall be flanged or beveled for welding.

2.9 All plant controls and accessories shall be so designed that copper and alloys having more than 70 percent copper do not contact landfill gas or natural gas. Stainless steel tubing or steel piping shall be used exclusively to supply gas to all instrumentation equipment. A filter shall be installed on the instrument supply immediately upstream of each individual control device.

2.10 All connections 2 inches and larger shall be flanged. All flanges shall meet the appropriate ANSI Service Rating. Flanges with higher than ANSI 150 rating shall be raised face weld neck suitable to O-ring type seals manufactured by Parker Gask-O-Seal. Where required, Gask-O-seals shall be supplied.

2.11 Connections less than 2 inches shall be minimum 2,000-pound couplings and fittings. Only steel piping or stainless steel tubing and Gyrolok fittings shall be used.

2.12 All threaded connections shall be assembled using Teflon tape. In addition, all threaded solvent piping shall be seal welded.

## 3. DESIGN AND OPERATING CONDITIONS

3.1 Landfill gas may be supplied to the process at 300-400 psig and 120°F ~~100°F~~. (See compressor spec. 2785.) For cryogenic processes bidder may wish to combine compressor spec. 2785 with cryogenic compressor.

3.2 Inlet Digester Gas Analysis

| Compressor | % by Volume |
|---|---|
| $CH_4$ | 40 - 45 |
| $CO_2$ | 30 - 35 |
| $H_2S$ | 0.02 (Max) |
| $H_2O$ | Sat'd @ 4 in W.C. 100°F |
| $O_2$ | 0.5 - 2.0 |
| $N_2$ | 19 - 24 |
| $H_2$ | 0 - 0.02 |
| CO | 0 - 0.01 |
| AR | Trace |

3.3 After compression, landfill gas will be saturated with $H_2O$ at 300-400 psig, 120°F.

3.4 Product Gas shall have <3% $CO_2$ and <4 ppm $H_2S$. $H_2O$ content would preferably meet our current pipeline specification of 7#/MMSCF; however 20-30#/MMSCF could be tolerated. Sensitivity of cost (both operating and capital) to the amount of $H_2O$ removed shall be indicated for the range 7-30#$H_2O$/MMSCF product gas.

3.5 Design flow — 1 MMSCF/D landfill gas (Total Feed)

3.6 Ambient air temperature — 30°F - 100°F

3.7 Percent of design flow at which unit is capable of meeting exit gas specifications — ~~10~~ 35 - 100%

4. ABSORBER-DESIGN CONDITIONS

4.1 Normal ASME design pressure (at 120°F inlet). — 400 psig

If gas purification is accomplished at lower pressure, please state new proposed ASME design pressure.

4.2 Maximum gas pressure drop across plant at design flow conditions (include heat exchangers and outlet piping) — 2 psid

4.3 Absorbers shall be supplied complete with all internals, all exterior connections and nozzles, suitable liquid level controls (Fisher 2500 series liquid level controls and Fisher dump valves shall be used) and all other accessories required for unattended and automated operation. Unit shall also have the following:

4.3.1 1/2" pressure taps across each tray (if used).

4.3.2 3/4" drain connection for each tray (if used).

4.3.3 System shall be properly protected against overpressure according to ASME Codes utilizing relief valves with relief valve isolators having a pressure connection for testing the relief valve in place.

4.4 Provision shall be made for access to all trays and all inside parts. Two manholes shall be provided, one at the top and one at the bottom of the unit(s).

4.5 Where possible, equipment shall be skid mounted.

5. SOLVENT REGENERATION [If applicable]

5.1 If possible, a direct fired solvent regenerator shall be used. Other methods of solvent regeneration may be quoted as an exception.

5.2 Landfill gas at 100 psig (≈400-450 Btu/$ft^3$) will be supplied to the regenerator skid by PG&E.

5.3 All heat exchangers, refrigeration units included, shall be designed and constructed in such a manner as to allow easy maintenance.

5.4 All valves except fuel gas valves shall be OS&Y with removable seats. Appropriate materials shall be used to sustain long valve life.

5.5 Insulation shall be accomplished in the manufacturer's shop wherever possible.

5.6 A pressure indicating gauge shall be provided on the output of each controller or pressure control valve.

5.7 Two fuel gas control valves, in series shall be provided. Each shall have an individual thermostat. Main burner(s) shall have automatic shutoff if pilot outage occurs. Pilot shall be equipped with a completely automatic electric igniter assembly. Igniter shall be capable of re-ignition on pilot outage and re-sequencing main burner; if pilot re-ignition is unsuccessful after three (3) tries unit shall shut off pilot and main burner(s) and one (1) set of SPDT alarm contacts shall be operated.

6. DETAILED INFORMATION THAT MUST BE SUPPLIED WITH BID (SIX COPIES OR ONE REPRODUCIBLE)

6.1 A flow diagram showing the type of equipment, process cycle, and material and heat balances where appropriate, e.g., absorbers, heat exchangers, and regenerator.

6.2 An itemized list of all equipment and its cost, fob destination, separately tabulated along with its related instruments, controls, and accessories. The latter three shall be identified by the service they accomplish. (Show amount of freight allowed.)

6.3 Dimensions, typical outline, arrangement, and sectional drawings, or cuts of each type of major equipment.

6.4 Operating requirements, e.g., fuel (gas), steam, water, electric power (pumps), solvent makeup, etc.

7. SUCCESSFUL BIDDER SHALL FURNISH

7.1 Six copies or 2 reproducibles of preliminary design drawings for approval, earliest possible date. Upon final approval by PG&E, two (2) copies and one (1) reproducible of all drawings shall be furnished.

7.2 Ten copies of an operating manual that shall contain:

7.2.1 Mill test reports on plate material.

7.2.2 Manufacturer's data report, Form U-1, for unfired pressure vessels.

7.2.3 Post weld treatment charts.

7.2.4 Hydrostatic test charts for vessel(s).

7.2.5 Schematic on 17-inch by 11-inch sheets - one covering solvent flow and one covering fuel and instrumentation circuits.

7.2.6 Final, as built, dimensional drawings for contactor, reboiler, exchangers, and all other pressure vessels, stamped and certified by signature.

7.2.7 Complete specification of all materials, assemblies, and equipment not covered by Section 7.0.

7.2.8 A set of three (3) Charpy V-notch impact specimens.

7.2.9 Complete operating instructions and maintenance recommendations.

7.3 Pacific Gas and Electric Company GM number and purchase order number and date on tower and reboiler nameplate.

7.4 At no extra charge, a serviceman to set controls and "start up" plant.

Note: Mail Items 7.1, 7.2 and 7.3 to:

Mr. C. J. Tateosian
Manager, Gas System Design Department
Pacific Gas and Electric Company
77 Beale Street, Room 2857
San Francisco, CA 94106

8. LADDER AND PLATFORM

8.1 A suitable working space and caged access ladder shall be provided to facilitate testing and maintenance requirements of the relief valve and the bursting disc assemblies. Note Item 4 in General Conditions (F-D)(MF), Laws and Regulations, attached.

9. PREVENTION OF RUST - PAINTING - GALVANIZING

9.1 Painting Surface Preparation: All surfaces of ferrous metal, including interior surfaces from which the rain is excluded by continuous welds except lubricated parts and machined surfaces and parts listed in the galvanizing paragraph below, shall be dry and cleaned and free of oil and grease. Heavy slag accumulations, all metal leaves or blisters, weld splatter, or other irregularities shall be removed by appropriate mechanical means after which all mill scale, rust, and paint shall be removed by blast cleaning in accordance with the latest edition of the Steel Structures Painting Council Standard SSPC SP6 for Commercial Blast Cleaning. Anchor depth of surface profile shall not exceed .002" (2 mils).

9.2 Priming: Within eight hours after blast cleaning and before rusting can take place, one or more coats of one of the approved primers listed below shall be applied to these surfaces. Additional primer shall be applied as necessary to obtain a minimum total dry thickness of not less than .0015 inches (1-1/2 mils). Coating thickness shall be maintained over welds, bolts, rivets, edges of plates, or other sharp projections or rough areas.

9.3 Approved Primers:

9.3.1 For contactor tower, use

| | |
|---|---|
| Mobil Chemical | Mobilzinc No. 7 |
| Porter Coatings | Zinclook 350 |
| Napko Corp. | Napko 5Z |

9.3.2 For reboiler and all equipment on skid that will be subjected to high temperatures, use PG&E Inorganic Zinc No. 55 or Mobil Zinc No. 7.

9.4 Machined Surfaces: Machined surfaces and lubricated parts shall be protected with a suitable rust-inhibitive coating, such as Rocket Distribution Company's (San Francisco) No. WD-40.

9.5 Galvanizing: All ladder, ladder guard handrails, checked floor plates, and gratings shall be protected by hot-dip galvanizing in accordance with the current ASTM Standard A-386, Specifications for Hot-Dip Zinc Coatings on Assembled Steel Products.

9.6 All openings shall be covered before shipment to protect from weather and impact damage.

10. VESSEL INTERNALS

10.1 All vessel internals and bolting materials shall be furnished and installed by the manufacturer, prior to shipment or at the jobsite unless otherwise specified.

11. HYDROSTATIC TESTING

11.1 Vessels shall be hydrostatically tested at 1.5 times the specified maximum operating pressure. Certification of the hydrostatic testing of the vessel(s) in accordance with the latest ASME code shall be furnished. (See Item 7.24.)

12. INSPECTION

12.1 At all times, while work on Purchaser's contract is being performed, the Purchaser's inspector shall have free entry to all parts of the manufacturer's works that concern the materials ordered. The manufacturer shall afford the inspector all reasonable facilities without charge to satisfy him that materials are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacturer prior to shipment, unless otherwise specified.

12.2 Welder specifications shall be made available to the inspector.

12.3 The manufacturer shall provide PG&E a shop schedule for both vessels and reboiler and shall inform PG&E the exact time of the installation of the ends of contactor vessel to enable the inspection of the completed tower.

Note: Unless Bidder takes exception in his quote to above specifications, it will be understood that equipment will meet specifications.

13. INFORMATION

13.1 The correspondence pertaining to the specifications, drawings, and job may be addressed to:

Mr. C. J. Tateosian
Manager, Gas System Design
Pacific Gas and Electric Company
77 Beale Street, Room 2857
San Francisco, CA 94106

Telephone calls regarding engineering details may be made to Mr. R. Holden (415) 781-4211, Extension 1448 or Mr. R. Headrick, Extension 3706.

R. W. HEADRICK
cc RPBenton - 15
Joe Pirtz - 4
MCBlanchet - 2
WForbes - 3
ATSchmidt - 2
RAHolden - 1
RWHeadrick - 5

GENERAL CONDITIONS



## 1.0 DEFINITIONS

1.1 "PG&E": Pacific Gas and Electric Company.

1.2 "Supplier": Party or parties making a contract with PG&E for this work.

1.3 "Bidder": Party or parties submitting a proposal for this work.

1.4 "Specification": Refers to and indicates the General and Specific Conditions of PG&E and any addenda to these.

1.5 "Supplier Specifications": Refers to and indicates the General and Specific Conditions of Supplier and any addenda to these.

1.6 "As directed", "as required", "as permitted", "approved", "acceptable", "satisfactory", means by or to PG&E.

1.7 "Work": Includes labor, materials, or equipment or all as required hereunder.

1.8 "Engineer": PG&E's Vice President-Engineering or his representative.

1.9 "Buyer": PG&E's Manager, Materials Department, or his representative.

## 2.0 PROPOSAL

2.1 General: The proposal shall be enclosed in a sealed envelope, distinctly marked "Proposal" with the title of work as given, and delivered to Buyer, 77 Beale Street, San Francisco, CA 94106. The proposal shall be signed with the full name and local address of Bidder by a responsible member of the firm. PG&E reserves the right to reject any and all proposals, and to accept other than the lowest proposal. The design, description, and performance capabilities of the equipment and/or materials set forth in the accepted proposal, subject to modifications mutually agreed to, shall become a part of the purchase order or contract.

2.2 Quotations: Quotations shall be (1) fob vessel, car, or other vehicle, point of shipment; and (2) fob vessel, car, or other vehicle, point of shipment with freight allowed to shipping destination. Quotations shall be exclusive of applicable sales, use, or other excise taxes, and PG&E will reimburse Supplier therefor. The proposal shall include, for excise tax and other purposes, a statement showing separately the amount included in the quotation to cover delivery charges and supervision of installation charges, if any. Delivery charges shall include cost of freight, cartage, dunnage, and insurance. The total shipping weight and dimensions shall be stated in the proposal.

## 3.0 DELIVERY

3.1 Fabrication and Shipment Time: The time quoted for fabrication and shipment will be an important consideration and condition in making the award. Construction schedules and contracts between PG&E and third parties are or will be based upon receipt of the equipment and/or material which is the subject of this Specification by the promised delivery date. The facility in which the subject equipment and/or material is to be used is required as scheduled to meet the demands upon PG&E by the public which it serves with gas and/or electricity for light, heat, and power. Time is of the essence hereof. Supplier shall give immediate written notice to PG&E of each shipment as made, accompanied with full information as to routing, car numbers, and other necessary matters. If a delivery schedule is specified, the general order in which the equipment and/or material shall be delivered shall be in accordance with the delivery schedule. Changes in this schedule may be directed by Buyer and these changes shall be complied with by Supplier insofar as possible.

3.2 Suspension of Work or Delivery: PG&E may suspend work or delivery by extension of time to Supplier. Supplier shall not be liable for delays in delivery or failure to manufacture or delivery due to causes beyond its reasonable control. The date of delivery, in the event of such delay, shall be postponed by the number of calendar days over which such cause or event extended, provided Supplier submits to PG&E a claim in writing for extension of time within seven (7) days from the date of the start of delay. In the event Supplier is late in delivery, there shall be no escalation or price adjustment beyond the contract shipment date, except where such late delivery is requested or caused solely by PG&E.

## 4.0 LAWS AND REGULATIONS

4.1 Equipment and/or material furnished hereunder shall be so designed and constructed that when installed it will comply with the applicable laws, rules, and regulations, including, without limitation, all "Occupational Safety and Health Standards" promulgated by the U.S. Secretary of Labor and all Safety Orders of the Division of Industrial Safety, Department of Industrial Relations, State of California, which must be complied with before the equipment and/or material may lawfully be used by PG&E in California. All expenses incurred in complying with these requirements are understood to be included in the contract price.

## 5.0 TITLE

5.1 Title to the equipment and/or material furnished hereunder shall pass to PG&E, "fob vessel, car, or other vehicle, point of shipment". Should the equipment and/or material be received at destination by PG&E in a damaged condition and any claim for damage during shipment be declined by the carrier or carriers with the inference that damage was the result of the act of the shipper or some inherent defect in the equipment and/or material, Supplier, upon the request of PG&E, shall assume the responsibility of processing any claim or claims against the carrier or carriers and shall reimburse PG&E for the cost of repairing or replacing the damaged equipment and/or material. In any event, Supplier shall assist PG&E in establishing carrier liability by supplying evidence that the equipment and/or material was properly constructed, manufactured, packaged, and secured to withstand normal transportation conditions.

## 6.0 SPECIFICATION AND DRAWINGS

6.1 General: This Specification and the accompanying drawings, if any, are complementary and shall be taken in conjunction. Supplier shall report to Engineer in writing any discrepancy or errors which come to its attention. Necessary work implied as included in the contract shall be included without extra cost to PG&E. Figured dimensions shall be followed in preference to scaled dimensions. PG&E's Specification shall govern in cases of conflict with Supplier's specification unless otherwise provided.

6.2 Approved Drawings: Unless otherwise provided Supplier shall make any necessary detailed drawings, subject to the approval of Engineer and shall be responsible for their practicability. Approval of such drawings by Engineer shall be general only and shall not relieve Supplier of responsibility for correct construction and compliance with the purchase order or contract, which shall include this Specification. Supplier shall pay for any alternations made necessary by its errors. All work shall be done in accordance with such approved drawings in compliance with the intent of this Specification. Calling Supplier's attention to certain errors does not place responsibility upon PG&E for the correctness of other features not mentioned.

## 7.0 INTENT OF SPECIFICATION

7.1 This Specification and the accompanying drawings are intended to cover all the work to be performed, and unless expressly excluded, all labor and materials not specified or indicated but which are necessary to complete the work in a proper, substantial, and workmanlike manner shall be furnished by Supplier. In consideration of and as a condition of PG&E offering to consider and considering a proposal submitted by Bidder, it is agreed and understood by Bidder, by submitting a bid, that if Bidder's proposed specification, drawings or general terms of sale conflict with this Specification, this Specification shall govern and such conflicting portions of Bidder's proposal shall not become a part of the contract. In addition to Bidder's base proposal, which shall comply with this Specification, Bidder may submit an alternate proposal resulting in cost saving to PG&E. The base proposal shall be labeled "Base Proposal", and any alternate proposal shall be designated "Alternate Proposal". In such alternate proposal or proposals, any and all exceptions to this Specification must be stated or listed as exceptions in writing in the alternate proposal or proposals in a separate paragraph entitled "Exceptions", and it is agreed and understood that in all other particulars this Specification shall govern.

## 8.0 INFRINGEMENT PROTECTION

8.1 All royalties or other charges for any patent, trademark, or copyright to be used in the work shall be considered as included in the contract price. Supplier shall indemnify and save harmless PG&E against any and all judgments, costs, damages, and expenses which may be awarded against PG&E in any suit, action, or proceeding brought against PG&E for infringement or alleged infringement of any patent, trademark, or copyright by a court of competent jurisdiction, arising out of the use by PG&E of the equipment and/or material furnished hereunder in the ordinary course of their use for the purposes hereunder intended. If any suit or suits for infringement of any patent, trademark, or copyright be instituted against PG&E as above specified on account of the use of said equipment and/or material furnished hereunder, and if promptly notified, Supplier shall assume the defense of such suit or suits and all expenses incident to the defense thereof; but it is expressly understood that in assuming the defense of such suit or suits Supplier shall have control of same, and PG&E shall be kept fully informed as to the progress thereof and have the right to confer about and give advice and assistance regarding same.

## 9.0 MATERIALS AND WORKMANSHIP

9.1 Materials: All materials used shall be suitable for the work, the best of their respective kinds, and shall be subject to the approval of Engineer. Articles or materials may be substituted for those specified only with the consent of Engineer. The methods used by Supplier shall be such as will produce satisfactory work, and in accordance with the best trade practice.

9.2 Standards: Unless specified otherwise, equipment and/or material furnished hereunder shall be constructed and tested in accordance with the latest edition of applicable NEMA, IEEE, ANSI, ASME, AISC, AISI, AWS, THEMA, and ASTM standards.

10.0 CANCELLATION PROVISION

10.1 If PG&E shall be required or deems it advisable as a direct or indirect consequence of any governmental action, or for other good and sufficient reason, to suspend or terminate the work being performed pursuant to this Specification, PG&E may do so by written notice. Supplier thereupon shall take whatever action with respect to work in process as will tend to minimize its claim against PG&E. PG&E will pay Supplier a reasonable suspension or termination charge, excluding any allowance for anticipated profits on the unperformed portion of the work. Supplier shall, to the extent practicable, include in subcontracts made pursuant to this contract a termination provision substantially similar to the foregoing provision.

11.0 INSPECTIONS AND TESTS

11.1 Shop Tests: Shop tests as specified shall be performed by Supplier and it shall furnish all facilities necessary for the performance of these tests.

11.2 Access to Shop and Tests: For the purpose of witnessing tests, making inspections, and preparing progress reports, PG&E's inspector shall be notified well in advance of the starting of the work and he shall be given full access to the shop at all times during working hours during the period of manufacture, as well as full access to all shop tests performed by Supplier. On request, Supplier shall provide PG&E's inspector with a list of principal production tests and inspection points. Supplier shall provide reasonable advance notice of the time of those tests and inspections which PG&E's inspector indicates he intends to witness. If certain tests are specified to be witnessed by PG&E's inspector, it shall not be construed to limit access to other shop tests. PG&E's inspector shall have access to all test and inspection records pertinent to this contract. Supplier shall require subcontractors and suppliers performing work pursuant to this contract to conform to the requirements of this Paragraph.

11.3 Material Tests: Should material tests be required by Engineer, Supplier will be advised in ample time so that test specimens can be provided during the shop manufacture. Unless otherwise provided, such tests shall be made in accordance with requirements of the applicable ASTM standards.

11.4 Certified Test Reports: Supplier shall furnish to Engineer certified copies of all test reports. The number of copies required shall be as specified in the Specific Conditions hereof. These test reports, in addition to being certified, shall be approved by PG&E's inspector in the vicinity before being sent to Engineer.

11.5 Field Tests: Field tests shall be made at the expense of PG&E except that the expense of Supplier's representatives, if any, shall be borne by Supplier. If for any reason whatsoever the equipment and/or material does not meet the guarantees agreed upon in any respect and it is necessary for Supplier to make alterations for the purpose of meeting these guarantees, additional tests required to show the effects of such alterations shall be performed by Supplier at its own expense.

11.6 Location of PG&E's Inspector: The location of the headquarters of PG&E's inspector may be obtained from PG&E's Department of Engineering Services, Inspection Section, 77 Beale Street, San Francisco, CA 94106.

11.7 Inspections and Tests Not Deemed Waiver: The witnessing of such tests and the receipt of reports of such tests by Engineer, and Supplier's compliance with all provisions of this section concerning inspections and tests shall not constitute a waiver by PG&E of any warranty concerning the equipment and/or material, nor relieve Supplier of any warranty concerning said equipment and/or material.

12.0 SHIPMENT

12.1 Carload Shipments: Thirty (30) days prior to shipment, routings on carload shipments, together with an outlined sketch showing shipping dimensions and weights, shall be forwarded for approval to PG&E's Traffic Bureau, 77 Beale Street, San Francisco, CA 94106. Supplier shall be responsible for assuring that equipment and/or material is properly prepared for shipment and loaded so as to prevent damage during shipment. At or prior to the time of shipment, Supplier shall forward to PG&E's Traffic Bureau complete details, including any diagrams or sketches prepared, concerning the method and technique of preparing the equipment and/or material for shipment and loading, including those utilized to prevent both external and internal damage during shipment, loading, and unloading.

12.2 Material List: A complete list of all material shipped shall be mailed to the work site.

12.3 Bills of Lading: Bills of lading shall be mailed to PG&E as follows:

12.31 General Construction Department, 77 Beale Street, San Francisco, CA 94106.

12.32 Materials Department, Traffic Bureau, 77 Beale Street, San Francisco, CA 94106.

12.33 To the work site.

12.34 PG&E's Inspector in the vicinity. The location of the headquarters of this inspector may be obtained from PG&E's Department of Engineering Services, Inspection Section, 77 Beale Street, San Francisco, CA 94106.

12.4 Identification: All routings, sketches, material lists, and bills of lading shall be identified with PG&E's purchase order number, specification number, and plant name.

13.0 INDEMNITY

13.1 Supplier shall indemnify PG&E, its officers, agents, and employees, against all loss, damage, expense, and liability resulting from injury to or death of person, including, but not limited to, employees of PG&E and/or Supplier, or injury to property, including but not limited to, property of PG&E and/or Supplier, arising out of or in any way connected with the technical direction of installation, inspection, or construction performed by Supplier's representatives at PG&E's work site in conjunction with the equipment and/or material furnished hereunder, excepting only such injury or death as may be caused by the sole negligence or willful misconduct of PG&E. Supplier shall, on PG&E's request, defend any suit asserting a claim covered by this indemnity. Supplier shall pay all costs that may be incurred by PG&E in enforcing the indemnity, including reasonable attorney's fees.

14.0 WARRANTIES

14.1 Workmanship and Materials: Supplier shall warrant that the equipment and/or material and all parts thereof furnished by Supplier, whether or not manufactured by Supplier, shall be of the kind and quality described in the purchase order or contract (which shall include this Specification) will be free of defects in workmanship, material, and title, shall perform in the manner hereinafter set forth in Paragraph 14.2, shall be of good and merchantable quality and shall be fit for its intended purpose.

14.2 Performance: Supplier shall warrant that when the equipment and/or material is placed in operation or used it will perform in the manner set forth in the purchase order or contract, which shall include this Specification.

14.3 Remedies: Supplier shall agree that if it shall appear within twelve (12) months from the date of shipment, that the equipment and/or material delivered hereunder does not meet the warranties specified above and PG&E notifies Supplier promptly upon the discovery of the defect or nonconformity, Supplier shall acknowledge receipt of such notice of defect or nonconformity and shall inform PG&E in writing within five (5) days of receipt of such notice as to whether:

(a) Supplier will, at its expense, immediately repair or replace the equipment and/or material or otherwise correct it so that it will meet and conform to the warranties specified above, provided, however, that if Supplier should elect to repair said equipment and/or material, such repair shall be effected in such a manner as not to interfere with construction and operations conducted by PG&E, and in such a manner as not to interfere or breach any labor agreements between PG&E or its contractors or subcontractors and labor unions performing work for PG&E, its contractors or subcontractors; or

(b) Supplier authorizes PG&E to repair the equipment and/or material, or have it repaired, or otherwise correct the nonconformity, or have it corrected, so that the equipment and/or material will meet and conform to the warranty specified above, and agrees to pay PG&E the cost of such repair, replacement, or correction.

14.31 All freight charges incurred in connection with any such repair or replacement shall be borne by Supplier.

14.32 If Supplier is obliged to correct defects as herein provided, the warranty period for the repaired or replacement part shall extend for one year from completion of repair or installation of such part provided the same is not unreasonably delayed by PG&E.

14.4 Limitation of Liability: It shall be agreed that if Supplier shall so replace, repair, or otherwise correct the defect or nonconformity, or so authorize PG&E to repair, replace, or otherwise correct the defect or nonconformity and pays or agrees in writing to pay the cost of such repair, replacement, or other correction, such shall constitute fulfillment of all liabilities of Supplier to PG&E for any claim based upon such defect or nonconformity, and in such event, except as to title and except as provided in the paragraphs entitled "Infringement Protection" and "Indemnity," Supplier shall not be liable for special or consequential damages. If Supplier so replaces, repairs, or otherwise corrects the defect or nonconformity, or so authorizes PG&E to repair, replace, or otherwise correct the defect or nonconformity and pays the cost of such repair, replacement, or other correction, and it subsequently is determined either by agreement between Supplier and PG&E or any court of competent jurisdiction that Supplier is not liable for such defect or nonconformity, PG&E will repay or refund the sum so paid by Supplier. In any event, Supplier's liability for any claim based upon such defect, nonconformity, or noncompliance shall not exceed the total price of the equipment and/or material furnished under this Specification except as provided in the paragraphs entitled "Warranties," "Infringement Protection," and "Indemnity."

15.0 PAYMENTS

15.1 Approval of Payments: Payments will be made only upon the approval of PG&E and in accordance with the terms of the agreement.

15.2 Invoices: Supplier shall render all invoices in quadruplicate for payment when due. Invoices shall be mailed to: Pacific Gas and Electric Company, Post Office Box 7760, San Francisco, CA 94119. Invoices shall indicate delivery charges, supervision of installation charges, if any, and excise taxes as single separate items apart from the cost fob vessel, car, or other vehicle, point of shipment. PG&E's specification number, purchase order number, and plant name shall appear on all invoices.

15.3 Supplier's Responsibility: Full payment by PG&E shall not release Supplier of its responsibilty to fully carry out its contract obligations.

15.4 Release: The acceptance by Supplier of final payment made under the terms hereof shall operate as and be a release of PG&E and every office and agent thereof, of and from all claims of Supplier for any and all things done or omitted by or on behalf of PG&E in connection with, relating to, or growing out of this contract for the work done hereunder.

16.0 METHOD OF PAYMENT

16.1 Preferred Method: Payments on the purchase price shall be made as follows:

16.11 Ninety-five percent (95%) of the component price thirty (30) days after invoice date and receipt of supporting bill of lading evidencing shipment, provided the equipment and/or material is received at work site and no apparent defects or damage is observed. The invoice date shall be the date of delivery to the carrier.

16.12 Five percent (5%) thirty (30) days after passing the acceptance tests described in this Specification. In the event such tests are delayed more than seven (7) months after the date of operation set forth in this Specification and deliveries have not been delayed and the equipment does not appear damaged, defective, or nonconforming with the contract, the final payment will then become payable. Unless otherwise agreed, no payment shall be deemed to constitute an acceptance of the equipment or any component part thereof or a release of any responsibility or obligation of Supplier.

16.2 Alternate Method: Bidder may present an alternate scheme of payment in addition to Bidder's basic proposal which shall comply with this Specification, but PG&E reserves the right to adhere to the method outlined above. The basic proposal shall be labeled "Basic Proposal," and any alternate designated "Alternate Proposal."

CITY OF MOUNTAIN VIEW

AGREEMENT

THIS AGREEMENT, made and entered into this 26th day of November, 1975, by and between PACIFIC GAS AND ELECTRIC COMPANY, a California corporation (hereinafter called "Pacific"), and the CITY OF MOUNTAIN VIEW, a municipal corporation (hereinafter called "City"):

WITNESSETH:

WHEREAS, City owns and operates a landfill refuse disposal site (hereinafter called "site") as referred to in Exhibit A which produces as a by-product of the natural refuse decomposition process certain amounts of gas containing methane (hereinafter referred to as "raw gas"); and

WHEREAS, Pacific has represented to City that this raw gas is of substantially lower heating value than natural gas purchased from other sources and distributed by Pacific, and such raw gas contains water vapor, oxygen, nitrogen, carbon dioxide and possibly sulfur compounds, in excess of Pacific's usual maximum limitations of such dilutents; and

WHEREAS, Pacific has represented to City that it is possible to construct and operate a facility to process and treat this raw gas (hereinafter, when so processed and treated, referred to as "processed gas") in order to improve its quality; and

WHEREAS, City, under a grant from the Environmental Protection Agency, is currently investigating among other things the optimum raw gas withdrawal rate from the site and the effect of moisture on raw gas production; and

WHEREAS, City has applied to the Environmental Protection Agency for a grant modification (Grant No. S803396-01-0) in the amount of $200,000 for the purpose of facilitating a Demonstration Project for the recovery of one million (1,000,000) standard cubic feet (MMscf) per day of raw gas from site; and

WHEREAS, this agreement covers the Demonstration Project, funded jointly by EPA and Pacific, and the Production Project which will begin at the end of the Demonstration Project; and

WHEREAS, Pacific is willing to provide sufficient funds necessary to the Demonstration Project in order to facilitate the raw gas recovery and to develop the withdrawal and processing facilities required for its utilization, and

WHEREAS, City is willing and desirous, upon approval of the City Council, to apply for additional grants, if and when available, upon successful conclusion of the Demonstration Project for the purpose of facilitating the recovery of additional raw gas from site, and

WHEREAS, Pacific is willing and desirous to enter into the Production Project by expanding the landfill gas recovery effort to the entire site in a timely fashion upon the successful conclusion of the Demonstration Project; and

WHEREAS, City desires to sell the raw gas produced from site to Pacific; and

WHEREAS, Pacific desires to purchase the raw gas produced from site.

NOW THEREFORE, IT IS AGREED UPON AS FOLLOWS:

1. Effective Date and Term

This agreement shall become effective on the date hereof, and shall continue in effect until the date raw gas production from

the site is determined in Pacific's judgment to be technically or economically non-feasible, or if in City's judgment, processing the gas is deemed incompatible with the use of the Shoreline Regional Park by the public. This agreement may be terminated at any time after twenty (20) years after the end of the Demonstration Project provided that either party hereto has tendered written notice of termination at least one (1) year preceding date of such termination. In the event notice of termination is given pursuant to this paragraph of this agreement prior to the expiration of the 20 year period, Pacific shall pay to City or City shall pay to Pacific, as the case may be, within 90 days after receipt of an invoice therefor, any unamortized expenditures accrued to the date of termination by the party receiving notice of termination. Such expenditures shall be amortized over a ten year period subject to California Public Utilities Commission approval.

2. Obligation to Purchase and Sell

A. Pacific shall have the exclusive right to purchase and process all raw gas from said site.

B. Pacific shall purchase and City shall sell all raw gas produced from site that meets the conditions set forth in this agreement.

C. Pacific shall not be required to take raw gas hereunder at rates of flow or with a composition which will result in damage to its facilities or in utilization or operational problems in the area where such raw gas so processed is marketed.

3. Price

A. Pacific shall pay to City on a monthly basis, subject to (B.) below for all raw gas received monthly, an initial unit price equal to seven and two-tenth cents ($.072) per thousand (1,000) standard cubic

feet (Mscf). This unit price shall be recalculated and revised eighteen (18) months from the date of the initiation of the Production Project and each twelve (12) months thereafter in conformance with the following formula:

$$P_R = \$.072/\text{Mscf}\left[(0.25)\left(\frac{WPI_C}{WPI_B} + \frac{HE_C}{HE_B}\right) + (0.50)\left(\frac{RR_C}{RR_B}\right)\right]$$

$P_R$ = Revised price of raw gas rounded to the nearest one-tenth of one cent.

$WPI_C$ = The most recent value, as published by the U.S. Department of Labor, Bureau of Labor Statistics (BLS), of the Wholesale Price Index for Industrial Commodities (1967 = 100) as of the date of revision.

$WPI_B$ = The value of the Wholesale Price Index for Industrial Commodities (1967 = 100) as published by the BLS twelve (12) months from the month of the signing of this agreement.

$HE_C$ = The most recent value, as published by the State of California, Employment Development Department, of the Average Hourly Earning for Electric, Gas and Sanitary Services in effect at the date of revision.

$HE_B$ = The value of the Average Hourly Earning for Electric Gas and Sanitary Services as published by the State of California, Employment Development Department twelve (12) months from the date of the signing of this agreement.

$RR_C$ = The rate in effect for the first 100 therms sold to customers on PGandE General Natural Gas Service Schedule No. G-2, or its revised equivalent, for residential customers in the Peninsula/San Jose rate area at the date of revision.

$RR_B$ = The rate in effect for the first 100 therms sold to customers on PGandE General Natural Gas Service Schedule G-2, or its equivalent, for residential customers in the Peninsula/San Jose rate area twelve (12) months from the date of the signing of this agreement.

B. Payment by Pacific, pursuant to A. above, shall not begin until after a 12-month demonstration phase operation of the treatment facilities. The demonstration phase shall begin upon the completion of the planned Demonstration Project facilities and the injection of processed gas into Pacific's natural gas system. If upon the completion of the 12-month demonstration phase both parties agree that the concept of landfill gas recovery and utilization has not yet been sufficiently demonstrated to warrant expansion of the Demonstration Project into the Production Project, yet that the concept is nevertheless potentially viable, the parties may agree that the Demonstration Project shall continue for an additional 12-month period or some part thereof. Payments for the raw gas shall not begin until after the expiration of the agreed upon extension of the demonstration phase.

4. Facilities

A. Demonstration Project:

1) Pacific shall be responsible for the location, design, engineering, and construction of the gas wells, the raw gas collection net-work, the treatment equipment, and the processed gas pipeline and associated facilities within the area shown in Exhibit "B". If a raw gas flow of one million (1,000,000) standard cubic feet (MMscf) per day cannot be obtained from the initially designated area, then City and Pacific shall mutually agree upon installation of additional wells and/or the designation of more landfill area to allow production of said volume of raw gas. All of the foregoing shall be subject to City's rights pursuant to paragraph 4.C.3, infra.

2) City shall exercise due diligence in administering the EPA Grant and in endeavoring to secure all necessary permits, priorities, rights-of-way and approvals of governmental bodies having jurisdiction over the Project for the operation herein contemplated, but City shall not be required to accept or comply with any unreasonable condition to such permit, priority, or rights-of-ways. City shall pay the cost of obtaining and satisfying the requirements of all necessary permits, priorities, rights-of-way, and approvals of governmental bodies having jurisdiction over the project.

3) Pacific shall proceed in good faith and with reasonable diligence with the design, engineering,

acquisition and construction of the facilities necessary to implement the Demonstration Project.

4) In no event shall the City's cost liability under any provision of this agreement, except for any termination payment, exceed the lesser of the amount of federal funding received by the City for the Demonstration Project, or $200,000. Pacific's cost liability is limited to the amount set forth in Pacific's GM No. 184,662 but not to exceed $416,688.

5) City shall administer the disbursal of EPA funding as required by the EPA and Pacific shall furnish City appropriate material substantiating expenditures of non-EPA funding. Pacific may consult with City in advance of costs being incurred, regarding all expenditure proposals for EPA Grant funds. City shall use its best efforts to minimize the administrative costs associated with the EPA Grant. Nothing in this agreement shall be construed to prevent City from making expenditures in Pacific's areas of responsibility.

B. Production Project:

1) Pacific shall have the exclusive right to expand the landfill gas recovery project to those areas shown on Exhibit "A". Pacific shall exercise due diligence to implement such expansion upon approval of such additional areas by City. Such expansion shall be pursuant to the terms and conditions contained herein.

2) City shall exercise due diligence in endeavoring to secure all necessary permits, priorities, rights-of-way and approvals of governmental bodies having jurisdiction over the project for the operation herein contemplated, but City shall not be required to accept or comply with any unreasonable condition to such permit, priority, or rights-of-ways. Pacific shall pay the cost of obtaining and satisfying the requirements of all necessary permits, priorities, rights-of-way, and approvals of governmental bodies having jurisdiction over the project, including payment of City's administration costs as reported to and found reasonable by Pacific.

3) Pacific shall have the right of prior review and approval of and shall reimburse City for all costs City may incur in the Production Project.

4) Pacific shall administer and be responsible for all costs incurred in the Production Project.

C. Both Projects:

1) Pacific shall secure all materials needed for installing and maintaining facilities required for Pacific's performance hereunder, and following receipt of said in form and substance satisfactory to Pacific, Pacific shall proceed with due diligence to install such facilities.

2) Pacific shall be responsible for the maintenance and operation of the facilities and shall pay for such costs of maintenance and operation incurred therefore.

3) Facilities shall be located in a manner that maximizes the economical recovery and utilization of raw gas within the selected area, and minimizes the potential impact upon subsequent landfill operations and the development of the Shoreline Regional Park. City may review and approve the location, planning, design, engineering, safety, construction and operation of the facilities in order to assure compatibility with construction and use of Shoreline Regional Park. City shall have the right to inspect and approve the installation of all the aforementioned facilities to assure such compatibility.

4) The parties agree that when it becomes necessary to expand the capacity of the facilities or to improve or provide a higher degree of treatment of the raw gas, Pacific shall cause to have prepared the necessary engineering studies and to make the necessary acquisitions and improvements.

5) The City shall act as the "Grant Administrator" for the purpose of compliance with EPA requirements.

6) The Demonstration Project shall not be required to obtain a conditional use permit from City but such a permit shall be required for the Production Project. The location, design engineering, construction and operation of the facilities shall adhere to the requirements of the City Code and all other applicable laws and regulations and shall not materially affect the aesthetics or use of the Shoreline Regional Park.

7) Nothing in this agreement shall be construed to prevent Pacific from having full right to accept all gas developed in the Demonstration and Production Projects if additional landfill gas development is technically or economically non-feasible, provided Pacific pays City for all such gas at the rate provided in Paragraph 3.

5. Performance

A. Pacific shall operate and maintain the raw gas collection and processing facilities required for the Projects described herein.

B. Each party shall use its best efforts to deliver raw gas in conformance with the provisions of Paragraphs 2.1 and 2.2 of Section 2 of the General Conditions appended hereto.

C. The requirements of California Public Utilities Commission General Order 112-C shall be applicable (where required) to the Projects herein.

D. In order to maintain gas recovery and to assure the health and safety of the public, City, at its own expense, shall comply with its current sanitary landfill practice, including maintenance of seals. City shall take no action to damage the gas reserves, except where reasonably necessary for development or use of the site. Except in the case of an emergency, City shall notify Pacific prior to taking action to break the seal of any garbage cell. In cases of emergency, notice shall be given to Pacific as soon as possible. Pacific shall have the right to suspend

raw gas receipt and payment therefor if the raw gas, prior to treatment, fails to conform to the quality standards set forth in Paragraph 2.2 of Section 2 of the General Conditions appended hereto.

E. Pacific may maintain suspension of raw gas receipt until the aforesaid quality standards are restored.

F. In the event that landfill gas recovery and utilitization becomes technically or economically non-feasible in Pacific's judgment, and Pacific elects to terminate this agreement, Pacific shall pay City all amounts due and owing up to and including the date of termination of this agreement, and Pacific shall have the right to salvage facilities installed in conjunction with this agreement, except that City may retain the underground plastic piping system for the sole purpose of venting the gas for safety purposes.

6. Notices

Any notice to be given hereunder by either Pacific or City to the other shall be respectively addressed as follows:

to Pacific: Pacific Gas and Electric Company
Attention: Manager, Gas Resources Dept.
245 Market Street, Room 1344
San Francisco, California 94106

to City: City Manager
City of Mountain View
P.O. Box 10
Mountain View, California 94042

7. General Conditions

The documents entitled "General Conditions" attached hereto and containing eleven sections is hereby incorporated in and

made a part hereof.

IN WITNESS WHEREOF, each of the parties has caused this agreement to be executed as of the day and year above written.

PACIFIC GAS AND ELECTRIC COMPANY

ATTEST:

By: _____
Vice President - Gas Supply

_____
Secretary

CITY OF MOUNTAIN VIEW

ATTEST:

By: _____
City Manager

_____

APPROVAL AS TO FORM

_____
City Attorney

APPROVAL AS TO CONTENT

_____
Director of Public Works

APPROVAL AS TO FORM

_____
Attorney, Pacific Gas and Electric Company

Section 1. MEASUREMENT OF GAS

(1.1) For the purpose of this agreement one standard cubic foot of gas (scF) shall be that quantity of gas containable in a volume of one cubic foot at a pressure of 14.73 pounds per square inch absolute at a temperature of 60 degrees Fahrenheit, one thousand (1,000) cubic feet of gas is referred to as a "MscF", and one million (1,000,000) cubic feet of gas is referred to as a "MMscF".

(1.2) Raw gas rate at the inlet of Pacific's facilities shall be measured in cubic feet in accordance with the provisions of the American Gas Association Measurement Committee Report Number Three or any subsequent revision thereof acceptable to the parties hereto.

(1.3) Pacific shall, at its own cost and expense, install and maintain a suitable meter as generally adopted and used in the Natural Gas industry at the inlet of its treating facility for the purpose of measuring the gas delivered hereunder.

(1.4) City shall have access to said meter at any reasonable time, and shall be allowed to inspect and check or test same, and also all gauges, charts and records of measurement, at such time as it may desire. City shall give Pacific an opportunity to have a representative present when any check or test is made, and if an inaccuracy is discovered, then the amount of gas which shall have been delivered shall be recalculated and corrected where the magnitude of the inaccuracy can be determined, for any period definitely known or agreed upon, or if the duration of the inaccuracy in measurement is not so known or agreed upon, such dispute may be arbitrated as set forth in Section 5 infra.

Section 2. CONDITIONS OF DELIVERY

(2.1) Pacific need not accept raw gas at so low a rate of flow that, in Pacific's judgment, such rate might be detrimental to the proper operation of its facilities. In the event Pacific is not able to take raw gas due to temporary shutdown of its facilities or difficulties that may be experienced at times of low load in its marketing area, extraction of raw gas shall be stopped.

(2.2) Raw gas received hereunder by Pacific shall be as free of oxygen, nitrogen, carbon dioxide, and hydrogen sulfide as City and Pacific can keep it through the exercise of all reasonable precautions within their respective areas of responsibility and shall not in any event contain more of these impurities than Pacific can reasonably accept, as determined during the Demonstration Project.

Section 3. PAYMENT

On or before the 12th day of each calendar month during the term hereof Pacific will render a written statement to City showing the quantity of gas delivered hereunder during the last preceding calendar month. Said statement, unless objected to by either Pacific or City within 15 days after being rendered, shall be accepted by all parties hereto as a correct statement of the gas delivered during such calendar month. City shall render an invoice therefor as soon as practicable after receipt of Pacific's statement. Payment shall be made by Pacific to City at City's office on or before the 25th day of each month, or the 15th day after receipt of such City's invoice, whichever shall occur later.

Section 4. FORCE MAJEURE

If either party to this agreement shall fail to perform any obligation hereby imposed upon it, and such failure shall be caused, or materially contributed to, by act of God; a public enemy; strikes; lockouts; riots; rebellions; injunctions or interference through legal proceedings, Municipal, State or Federal laws or regulations; the failure to obtain necessary governmental permits and approvals; the requisitions or necessity of any governmental or acting authority; breakage, vandalism or accident to machinery, equipment, or lines of pipe; washouts; earthquakes; storms; freezing of lines; or any cause or causes of whatsoever nature (whether like or unlike those herein enumerated) not due to the fault or neglect of any such party and beyond its reasonable control, or shall be occasioned by the necessity for making repairs to or reconditioning machinery, equipment or lines of pipe not resulting from the fault or neglect of such party, such failure shall not be deemed to be a violation of the obligations of such party hereunder. Breakage of the top clay seal cover by root growth shall be considered an act of God. Such party shall, however, use reasonable diligence to put itself again in a position to carry out its obligations hereunder, and in the event such party does not or cannot within a reasonable time put itself again in a position so to do, the other party may, at its option terminate this agreement by written notice. Nothing herein contained shall be construed to require either party to settle a strike or lockout by acceding against its judgment to the demands of opposing parties.

Section 5. ARBITRATION

In addition to those disputes which are required to be arbitrated under the provisions hereof, any other dispute arising between City and Pacific under any provision hereof which cannot be settled by the parties within a reasonable time may be submitted by either party to arbitration. All disputes to be arbitrated shall be submitted to and decided by a board of three arbitrators, one to be appointed by City, one by Pacific, each of which may be an employee, and a third by the two so appointed. If either party shall fail or refuse to appoint an arbitrator within 30 days after written notice has been given to it by the other party naming the latter's arbitrator, the party giving such notice shall have the right to request the Presiding Judge of the Superior Court of the State of California in and for the County of Santa Clara to appoint an arbitrator for the other party so in default. If the two arbitrators thus chosen are unable to agree upon the third arbitrator, such arbitrator shall be appointed, upon application of either party, by the Presiding Judge of the Superior Court of the State of California in and for the County of Santa Clara. The decision of a majority of the board of arbitrators after a hearing at which both parties shall have the opportunity to be heard and to introduce evidence, shall be binding upon the parties hereto. The cost of the arbitrator appointed by City shall be paid by City; the cost of the arbitrator appointed by Pacific shall be paid by Pacific; and the cost of the third arbitrator shall be borne equally by City and by Pacific.

Except as otherwise specifically provided in this Section, any arbitration shall be subject to the provisions of Title 9 of Part 3 of the Code of Civil Procedure of the State of California.

Any controversy which can be determined by an engineer's or other expert's findings and which under this paragraph could be submitted to arbitration may, if the parties thereto elect to do so, be submitted to a mutually agreed upon engineer or expert who shall be the sole arbitrator. Any such engineer shall be a duly licensed professional engineer of the State of California. Such engineer or expert shall be disinterested as hereinbefore in this paragraph required of arbitrators on an arbitration board. He shall proceed in the same manner and shall make findings, conclusions, and an award in the manner provided herein for an arbitration board. The decision of such expert shall be binding upon the parties. The cost of the expert shall be borne equally by City and Pacific.

Section 6. PACIFIC'S USE OF CITY'S LANDS

Insofar as it has the authority so to do, City hereby grants Pacific, throughout the life of this agreement and without charge, permission to use and occupy site for Pacific's treatment plant, measuring stations, pipelines, and other facilities used for the performance hereof, subject to the terms of this agreement. Pacific shall remain the owner of any such facilities installed upon site. Pacific shall remove all above ground facilities with reasonable diligence after the termination of this agreement. Pacific shall restore the ground to substantially its original condition and replace any landscaping promptly after the removal of any such facilities.

Section 7. TAXES

Pacific shall pay all taxes before delinquency on all pipelines and equipment owned by it on site.

Section 8. CITY'S REPRESENTATIONS AND TITLE

(8.1) City represents that its raw gas to be produced from site and its right to deliver said gas are free and clear of encumbrances or other obligations. City hereby guarantees its title to all raw gas delivered hereunder.

City shall indemnify and hold Pacific harmless from all loss, damage, or liability which Pacific may sustain by reason of breach or failure of any of the representations or guarantees above set forth, but City's liability hereunder shall not exceed payment of the amount necessary to reimburse Pacific for its capital costs, less revenues derived by Pacific from the Projects.

(8.2) Title to all gas delivered to Pacific shall pass at the point of delivery of such gas into the facilities of Pacific, and risk shall follow title.

Section 9. ASSIGNMENT

This agreement shall bind and inure to the benefit of the successors and assigns of the respective parties hereto. Neither Pacific nor City shall assign this agreement or any interest therein without first obtaining the written consent of the other. No assignment shall be effective until the assignee shall in writing agree to assume and fully perform the terms of this agreement, whereupon the assignor shall be released from further liability.

Section 10. INDEMNITY

City and Pacific, respectively, as indemnitor, will indemnify the other as indemnitee and save it harmless from any and

all loss, damage, expense and liability resulting from injuries to or death of persons, including but not limited to employees of either party hereto, and damage to or destruction of property, including but not limited to the property of either party hereto, arising out of, or in any way connected with, the performance of this agreement, or any operations hereunder, by indemnitor, its agents, or employees, excepting only such injury, death, damage, or destruction as may be caused by the sole negligence or willful misconduct of the indemnitee, its agent, or employees. Indemnitee shall, upon indemnitor's request, defend any suit asserting a claim covered by this indemnity and indemnitor shall pay all costs that may be incurred by indemnitee in enforcing this indemnity, including reasonable attorney's fees.

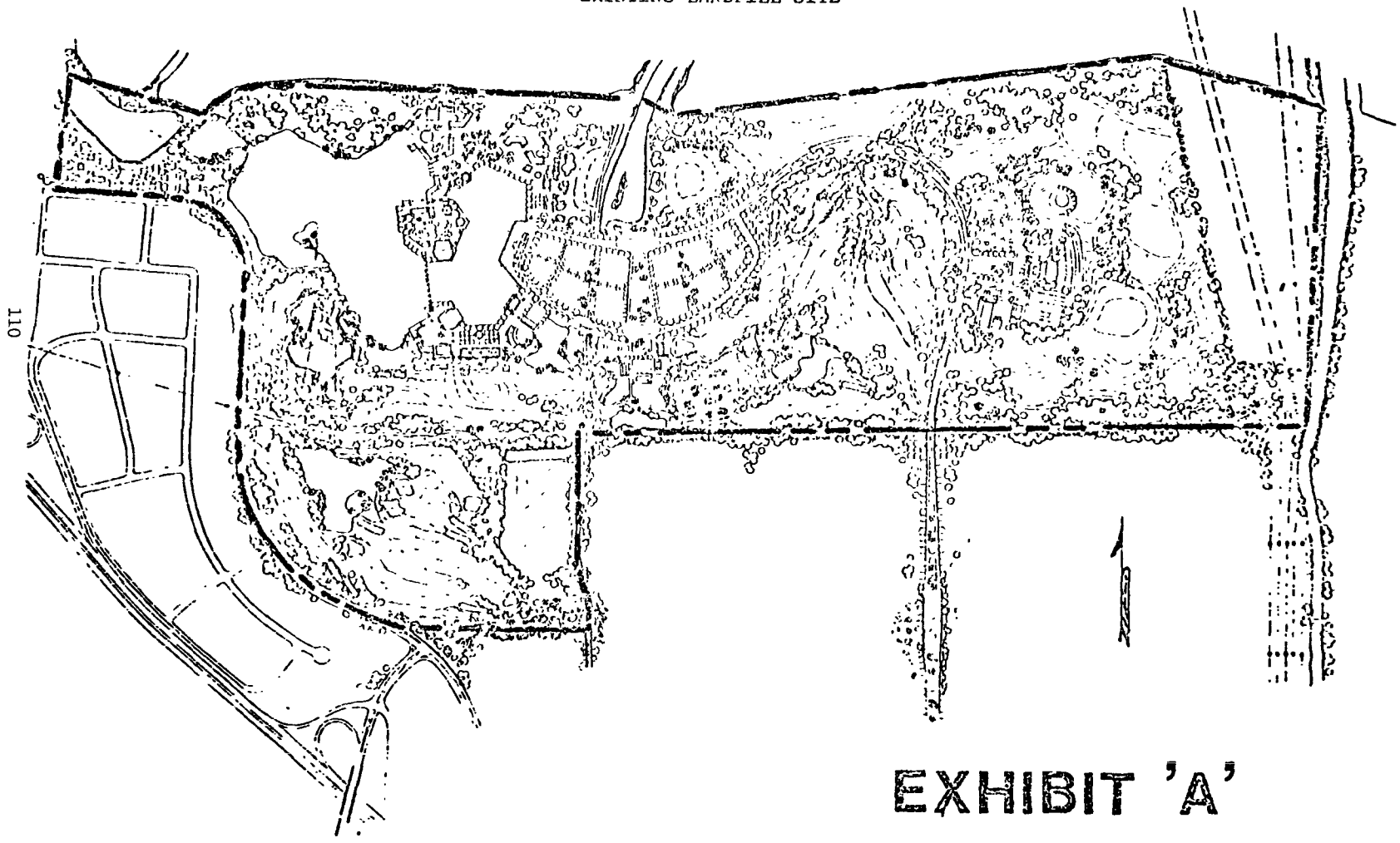
Section 11. MISCELLANEOUS PROVISIONS

(11.1) The books, records, and accounts of the parties hereto relating to the subject matter of this agreement shall be open at all reasonable times for the inspection and copying by the other party.

(11.2) No waiver by either party of any failure or failures on the part of the other to perform any of the terms or conditions of this agreement shall ever be construed as a waiver of any future or continuing failure or failures whether similar or dissimilar thereto.

# SHORELINE
# REGIONAL PARK

EXISTING LANDFILL SITE




## EXHIBIT 'A'

CITY OF MOUNTAIN VIEW

Parcel 1

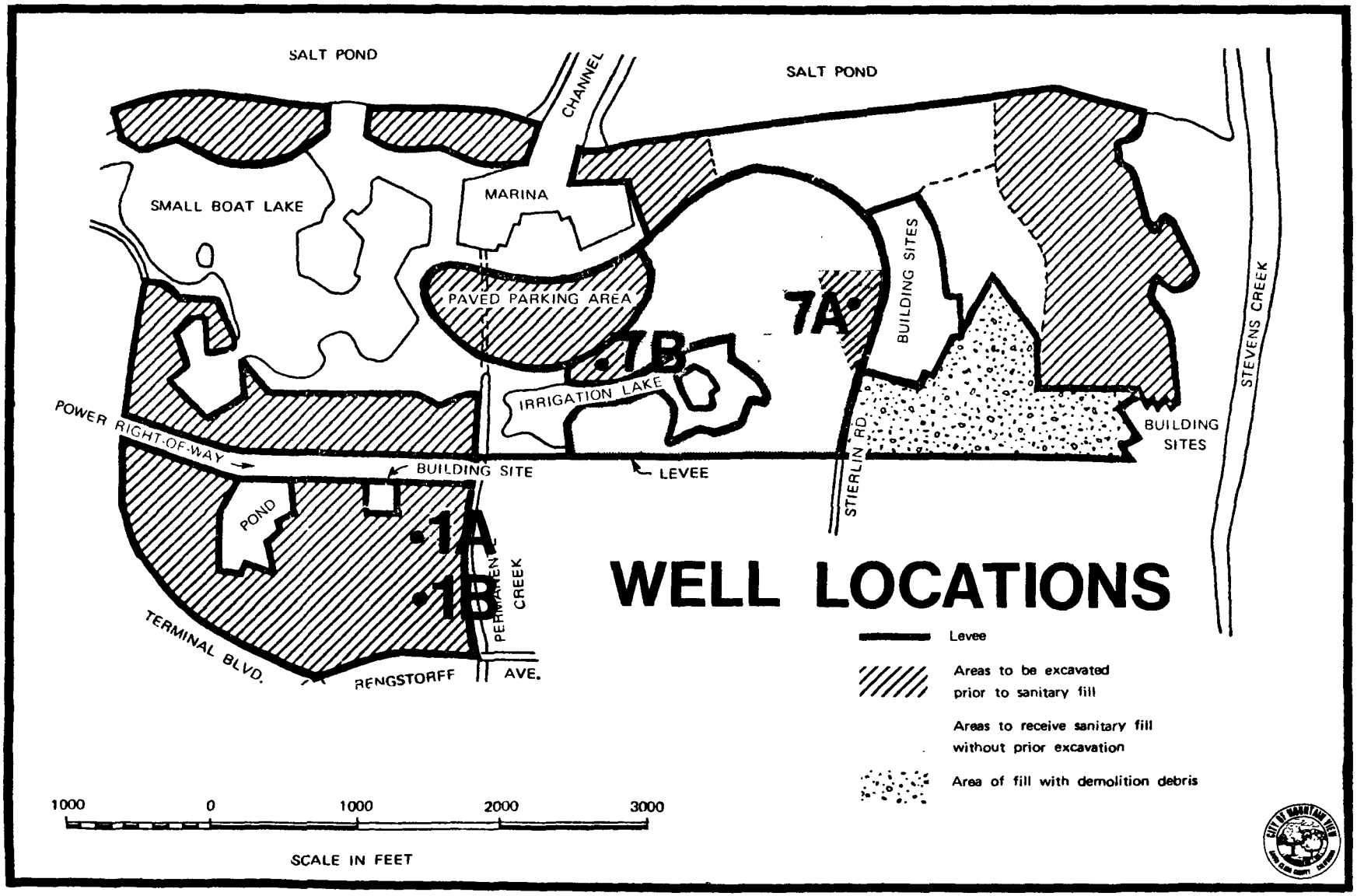
Exhibit A

All that certain real property situate in the city of Mountain View, county of Santa Clara, state of California, being more particularly described as follows:

COMMENCING at a 3/4" iron pipe at the intersection of Stierlin Road and Argenta Avenue, as said 3/4" iron pipe, intersection, Road, and Avenue are shown on that certain map entitled, "RECORD OF SURVEY OF LANDS OF CITY OF MOUNTAIN VIEW IN RANCHO RINCON DE SAN FRANCISQUITO AND IN SECTION 9, TOWNSHIP 6 SOUTH, RANGE 2 WEST, M.D.B.& M., SANTA CLARA COUNTY, CALIFORNIA," filed for record on August 6, 1959 in Book 110 of Maps at Page 18, Santa Clara County Records; thence from said Point of Commencement northerly along the centerline of said Stierlin Road N 01° 09' 51" E 716.90 feet to a point thereon; thence leaving said centerline N 88° 55' 09" W. 25.00 feet to the TRUE POINT OF BEGINNING of the Parcel to be described herein; thence from said TRUE POINT OF BEGINNING the following courses: N 88° 54' 19" W 2,560.26 feet, S 08° 23' 32" W 179.50 feet, S 81° 36' 28" E 15.00 feet, S 08° 23' 32" W 221.07 feet, tangent to the preceding course along the arc of a curve to the left having a radius of 559.97 feet and a central angle of 09° 48' 03", an arc length of 95.79 feet, tangent to the preceding curve S 01° 24' 31" E 193.38 feet, N 88° 35' 21" E 5.00 feet, S 01° 24' 31" E 220.80 feet, S 05° 07' 46" W 469.91 feet, N 88° 16' 51" W 315.00 feet, N 88° 16' 51" W 693.88 feet, tangent to the preceding course along the arc of a curve to the right having a radius of 1,449.92 feet and a central angle of 92° 42' 58", an arc length of 2,346.26 feet, tangent to the preceding curve N 04° 26' 07" E 50.10 feet, N 04° 26' 07" E 99.95 feet, N 04° 26' 07" E 956.04 feet, tangent to the preceding course along the arc of a curve to the left having a radius of 449.97 feet and a central angle of 87° 30' 56", an arc length of 687.30 feet, tangent to the preceding curve N 83° 04' 49" W 9.10 feet, N 06° 55' 11" E 90.00 feet, N 83° 04' 49" W 1,028.94 feet, N 06° 55' 11" E 563.55 feet, N 44° 34' 49" W 55.17 feet, N 70° 24' 11" E 177.99 feet, N 03° 11' 11" E 119.54 feet, N 57° 25' 11" E 160.75 feet, S 63° 34' 49" E 924.95 feet, N 50° 07' 26" E 185.38 feet, N 59° 25' 53" E 68.57 feet, N 71° 40' 01" E 71.07 feet, N 79° 45' 41" E 144.61 feet, N 86° 46' 56" E 247.82 feet, N 89° 58' 49" E 299.98 feet, S 84° 28' 03" E 501.28 feet, S 84° 28' 03" E 1,425.87 feet, S 89° 09' 01" E 133.44 feet, S 69° 35' 59" E 438.64 feet, S 89° 25' 09" E 97.73 feet, N 83° 31' 44" E 1,201.43 feet, N 84° 21' 21" E 277.01 feet, N 83° 31' 44" E 1,533.91 feet N 85° 10' 03" E 381.66 feet, S 72° 35' 43" E 1,151.62 feet, S 03° 35' 16" E 67.08 feet, N 86° 24' 44" E 15.00 feet, S 03° 35' 16" E 445.82 feet, tangent to the preceding course along the arc of a curve to the right having a radius of 824.95 feet and a central angle of 11° 25' 00", an arc length of 164.38 feet, tangent to preceding curve S 07° 49' 14" W 586.41 feet, S 82° 10' 16" E 55.00 feet, S 07° 49' 44" W 692.15 feet, S 82° 10' 16" E 15.00 feet, S 07° 49' 44" W 66.48 feet, tangent to the preceding course along the arc of a curve to the right having a radius of 894.95 feet and a central angle of 04° 43' 11", an arc length of 73.73 feet, tangent to the preceding curve S 12° 32' 55" W 445.36 feet. N 50° 20' 09" W 189.12 feet, S 80° 32' 01" W 307.07 feet,

N 88° 55' 09" W 2,103.11 feet, and N 88° 55' 09" W 50.00 feet to the TRUE POINT OF BEGINNING and containing 550.407 acres of land, more or less..

EXHIBIT 'B'


SALT POND
CHANNEL
SALT POND
SMALL BOAT LAKE
MARINA
PAVED PARKING AREA
7A
7B
BUILDING SITES
STEVENS CREEK
IRRIGATION LAKE
POWER RIGHT-OF-WAY
BUILDING SITE
LEVEE
STIERLIN RD.
BUILDING SITES
POND
1A
1B
PERMANENTE CREEK
TERMINAL BLVD.
RENGSTORFF
AVE.
WELL LOCATIONS
Levee
Areas to be excavated prior to sanitary fill
Areas to receive sanitary fill without prior excavation
Area of fill with demolition debris
1000
0
1000
2000
3000
SCALE IN FEET

DUPLICATE ORIGINAL

CITY OF MOUNTAIN VIEW

ADDENDUM TO THE METHANE GAS RECOVERY AGREEMENT DATED NOVEMBER 26, 1975 BETWEEN THE CITY OF MOUNTAIN VIEW AND PACIFIC GAS AND ELECTRIC COMPANY

WHEREAS, the Environmental Protection Agency requires that an "Access to Records" clause required by the Environmental Protection Agency Grant Regulations and Procedures (Federal Register, Volume 40, Number 90, Part III, Thursday, May 8, 1975), §30.505 "Access", be a part of the City of Mountain View, Pacific Gas and Electric Methane Gas Recovery Agreement, dated November 26, 1975.

IT IS HEREBY AGREED that said Agreement be amended by the addition thereto of Paragraph 8 titled "Access to Records" to read as follows:

The CITY and PACIFIC shall ensure that the Project Officer and any authorized representative of EPA, the Controller General of the United States or the Department of Labor, shall at all reasonable times during the period of EPA grant support and until three years following final settlement have access to the facilities, premises, and records related to the project as defined in §30.805 of the Federal Register, Volume 40, Number 90, Part III, dated Thursday, May 8, 1975 entitled "Environmental Protection Agency Grant Regulations and Procedures."

AND

Attest

JAN 16 1976 Secretary

Pacific Gas & Electric Company

By: Vice President - Gas Supply

Attest

City of Mountain View

By: City Manager

Approved as to Form

City Attorney

Approved as to Form

Attorney, Pacific Gas & Electric

Approved as to Content

Director of Public Works

☆ U. S GOVERNMENT PRINTING OFFICE : 1977 720-116/5711

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