SULFUR COMPOUND EMISSIONS OF THE PETROLEUM PRODUCTION INDUSTRY

TASK NO. 26 FINAL REPORT

SUBMITTED TO

U.S. ENVIRONMENTAL PROTECTION AGENCY
CONTROL SYSTEMS LABORATORY
NATIONAL ENVIRONMENTAL RESEARCH CENTER

CONTRACT NO. 68-02-1308

DECEMBER, 1974

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Subsidiary of Core Laboratories, Inc.

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EPA CONTRACT NO. 68-02-1308
TASK NO. 26
TASK CHANGE NO. 1

DECEMBER, 1974

EPA PROJECT OFFICER: GARY FOLEY

A Report To: Environmental Protection Agency
Control Systems Laboratory
National Environmental Research Center
Research Triangle Park
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AUTHORIZATION

This work was performed as part of Contract 68-02-1308, Task No. 26, change 1 and was subcontracted by M.W. Kellogg Co. to Ecology Audits Inc. The main objectives of this study were:

- To determine the optimum way to obtain data on emissions of sulfur compounds by gas producing and processing, and the oil production industry in the U.S.

- Perform an investigation of existing sources whereby the quantity and disposition of hydrogen sulfide contained in natural gas produced in the year 1973 from the Permian Basin and the Smackover Formation will be estimated.

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Formation

A strata or series of associated earth materials having similar conditions of origin. A single petroleum well will often produce from several formations in a vertical sequence, and the fluids found in each may be significantly different chemically. As a result, the composition of the produced fluid may change with time.

Gasoline Plant

A gas processing plant that separates natural gasoline (pentanes and hexanes-and-heavier) from natural gas streams. These plants also often produce ethane, propane and butane. By definition, these plants produce either natural gasoline or blends from which gasoline can be separated.

Grains per 100 std. cu. ft. (Gr./100 $ft.^3$)

Standard term for reporting H_2S concentration in natural gas. 1 Gr./100 $ft.^3$ is equivalent to 16 ppm (parts per million) of H_2S in natural gas.

Sour Gas

Natural gas containing hydrogen sulfide in concentrations of 4 to 16 ppm or greater.

Sulfur Recovery Plants

A plant which recovers elemental sulfur from a charge gas stream composed principally of a mixture of H_2S and CO_2. Where the acid gas stream is sufficient, an operator will elect to install a sulfur recovery plant. Sometimes these plants are operated in conjunction with gasoline plants, and at other times they are built independently of any additional gas processing facilities.

Sweet Gas

Natural gas whose hydrogen sulfide content is less than approximately 4 ppm.

GLOSSARY

Acid Gas

A blend of hydrogen sulfide (H_2S) and carbon dioxide (CO_2) that is separated by the amine process from raw natural gas. Most plants meter their total acid gas.

Amine Process

A process using one of the amines in which raw natural gas is bubbled through the solution which absorbs essentially all CO_2 and H_2S (acid gas). The solution is regenerated by boiling and the acid gas sent on for further processing.

Casinghead Gas

The term used to denote that the gas is principally solution gas produced in association with crude oil.

Drilling Mud

A fluid system containing clay materials and weighting agents and circulated in a drilling well to cool and lubricate the drill bit and to conduct the drilled materials to the surface.

Field

A single well or group of wells that penetrate and produce from one or more petroleum-bearing formations.

Flare Stack

One common way to dispose of acid gas is to mix it with some raw natural gas and burn it at the end of a flare stack. The combustion takes place in the natural atmosphere and in virtually all the studies done by Ecology Audits, the combustion of H_2S to SO_2 is over 98 percent complete. Sometimes a strong wind will extinguish a flare causing emissions of hydrogen sulfide until the flare is re-ignited.

Sweetening Plant

A plant which processes a sour natural gas charge stream, selectively recovers the H_2S and CO_2 content and yields a sweet natural gas stream and an acid gas (H_2S and CO_2) stream as products.

I. INTRODUCTION

A. SOURCES OF SULFUR EMISSIONS IN THE PETROLEUM AND NATURAL GAS PRODUCTION INDUSTRY

The most common volatile sulfur compound found in petroleum and encountered in petroleum and natural gas production is hydrogen sulfide. Natural gas is considered to be sour if the hydrogen sulfide content exceeds a certain level which varies from 4 ppm to 16 ppm, depending on the company or government body. The Texas Air Control Board considers crude oil to be sour if it emits a sour gas.[1]

Other sulfur compounds found in petroleum include mercaptans, organic sulfur complexes and dissolved elemental sulfur. Sour natural gas contains hydrogen sulfide in widely varying concentrations, plus trace amounts of organic sulfur compounds such as mercaptans, carbonyl sulfide (COS) and carbon disulfide (CS_2). Gases processed as part of refinery operations often contain much larger quantities of organic sulfur compounds, but these contribute insignificant amounts in the field production operations.

Nearly all of the dissolved hydrogen sulfide in crude oil volatilizes in field storage. For example, while the well stream in the Jay Field is 8 to 10 percent hydrogen sulfide, the concentration of hydrogen

[1] Definitions 1.31 and 1.32, General Rules, Texas Air Control Board, November 1, 1973.

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sulfide in the crude going to a refinery is less than 50 ppm. Other compounds, minor in quantity, remain in the crude oil and are part of the feedstock in a refinery.

1. Location of Sour Gas and Oil

The petroleum industry uses special terminology to describe the locations of petroleum. A well is drilled through several formations. Near the surface there are often fresh water aquifers. At greater depths there are saline aquifers and, hopefully, one or more petroleum bearing formations. In some locations a single well can extract petroleum from several formations, each at different depths. The extent of the petroleum bearing formation is found by drilling a series of wells. The series of wells is called a field.

One formation from which the petroleum production is nearly always sour is the "Smackover". It runs in a large arc from south of San Antonio, Texas, northeasterly along the southern boundary of Arkansas to Jackson, Mississippi, to Pensacola, Florida. Geologists anticipate that the drilling proposed for offshore Florida will produce sour gas and oil.

Another area in which sour production is often found is the Permian Basin. Between 10 and 20 percent of the wells in this area of West Texas and Southeastern New Mexico produce sour petroleum. There are also some sour fields in Wyoming, Michigan, Oklahoma, California, Ohio, Montana, Colorado, Arizona and North Dakota. However, it is estimated that the production from the Smackover formation and Permian Basin represents about 80 percent of total sour petroleum production in the United States.

Petroleum found in other areas is usually sweet. This includes the present production of coastal and offshore areas of Texas, much of Louisiana, and all of Alaska.

2. Drilling and Testing Operations

When a well is drilled, the bit is lubricated and cooled with "drilling muds". These muds are circulated to the surface to remove the cuttings. Most operators monitor the muds for the presence of hydrocarbons, and if it is expected, hydrogen sulfide.

When a well is to be "completed" the petroleum is allowed to flow freely and push the mud and cuttings out of the hole. Natural gas is flared during this operation while the muds and oil flow into a settling basin or temporary tanks. The oil, too, is often flared. The particulates arising from these fires are a worse problem than sulfur dioxide. Well completions generally require no more than portions of a day or two and represent only a minor fraction of sulfur emissions.

Some states require that all wells be tested periodically, usually annually. When this is done, the well is allowed to flow freely for up to several hours to determine its productivity. The gas produced during this test is frequently flared.

During the life of a well, it is likely that between 0.001 and 0.1 percent of production is emitted to the atmosphere during drilling and testing.

3. Production of Oil

Gas, and frequently saline water, is produced along with crude oil. When the mixture gets to the surface it flows through separator units. The oil then flows to a tank battery, the water is reinjected or disposed of otherwise, and the gas is disposed of in one of several ways.

One common way to break down a crude oil/water emulsion is to heat it. Thus, some of the produced gas or oil is used at the well site as fuel to furnish heat in a "heater-treater". Sulfur dioxide will be emitted if the fuel for the heater-treater is sour.

Produced gas (called casinghead gas if found associated in essentially solution ratio proportions with oil) is usually collected in a gathering system and sent to a processing plant. In some instances where there are no gathering or sweetening facilities, flaring is authorized by the petroleum regulatory agency on a temporary basis. In other cases, the petroleum regulatory agency will force a field to be closed until facilities are available to handle the gas to prevent its loss.

Crude oil is usually stored in a tank battery for several days, and this permits most of the gases such as hydrogen sulfide and carbon dioxide to escape. The vapors from sour crude oil contain hydrogen sulfide. Many states, including Texas, New Mexico, and Mississippi, regulate the quantities of hydrogen sulfide that can be present in ambient air. As a result, many tank batteries located near residences have vapor recovery systems. The vapors from stored crude can be quite valuable so, aside from any air pollution interests, many firms install vapor recovery systems as an economic investment. Additional investment in vapor recovery systems can be expected as the price of natural gas and natural-gas liquids increases. The recovered vapors are collected in a gathering system. On rare occasions where the purpose of the recovery system is to reduce hydrogen sulfide emissions to the atmosphere and there is no economical way to treat the gas, it is burned in a flare.

4. Production of Gas

Natural gas is found in reservoirs sometimes with and sometimes without oil. If found with oil, it is called "casinghead" gas. The majority of gas production, both from gas wells and casinghead gas, is collected and sent to processing plants. In Texas, for example, reports show that 1.8 percent of casinghead gas is vented or flared while only 0.016 percent of gas well gas is vented or flared.[2] The gas moves through gathering systems and normally none escapes except for leaks in valves or at compressor stations. Occasionally some will be flared because of a processing plant malfunction or as a safety device.

[2] Annual Report of the Oil and Gas Division, 1973, The Railroad Commission of Texas.

5. Processing of Gas

All processing of gas is done either to provide a product which conforms to customer standards or to maximize financial profit while conforming to regulatory requirements.

a. Customer Standards

Gas pipelines have standards which set minimum values for heat content and maximum values for contaminants such as sulfur compounds and water. Heat content can be improved by removal of nitrogen and carbon dioxide. Hydrogen sulfide, the principal sulfur compound, and carbon dioxide are most frequently removed by an amine scrubbing system. When sour gas is found some distance from a processing plant, producers may install small packaged units to remove acid gases (carbon dioxide and hydrogen sulfide) prior to sending it on via pipeline. The tail gases from these small units are either burned in an incinerator, burned in a flare or vented.

b. Maximize Profits

The processing of lease separator gases can be very profitable. The most common processing involves separation of the heavier, easily liquified hydrocarbons from ethane and methane, the light gaseous components. Methane (CH_4) is the principal component of natural gas, but it has the lowest heat value per unit volume and the lowest relative price. Propane (C_3H_8) and butane (C_4H_{10}) are familiar bottled gases and have higher heat values and command higher prices. Heavier hydrocarbons such as pentane, hexanes and heavier are generally processed to make motor fuel.

c. Gasoline Plants

The definition of gasoline plants varies. Plants that produce a blend of natural gas liquids (NGL) are frequently called natural gas plants. The Texas Railroad Commission reserves the term for those plants which produce gasoline (pentane and hexane-and-heavier fractions). An increasing portion of new plants produce natural gas liquids which are sent to existing gasoline plants for fractionation.

These types of plants are expensive to construct and costly to operate. Unless a stream has a flow of at least a few million cubic feet per day, a processing plant may not be financially attractive. As a result, many smaller fields sell gas to pipelines without processing to remove heavier hydrocarbons.

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There are numerous existing gas processing installations in the Permian Basin area of West Texas and Southeastern New Mexico. As a result, there is more complexity associated with processing in this area. Plant operators try to maximize profit by keeping their plants operating at capacity. As a result, some operators do only partial processing. For example, in one location, the producer sells the gas to gas pipeline Company A who compresses the gas and sells it to oil Company B who extracts the propanes and heavier components and sells the still sour gas stream back to A who sweetens it at a plant some twenty miles away. Oil Company B flares the amine regenerator stream resulting from the sweetening of its products. Both firms emit to the atmosphere sulfur compounds from the same original gas stream.

In the other areas studied, there was far less complexity because plants are built to serve the needs of a particular field or area.

To minimize corrosion in the plant, most operators sweeten plant charge streams in which the hydrogen sulfide content exceeds 1/4 grain/100 SCF (4 ppm). The tail gases from the sweetening plant are used in several ways. If there is a sufficient quantity of sulfur, usually more than 5 long tons per day, a sulfuric acid plant or a sulfur recovery plant will be built. In most cases, the tail gases from sulfur recovery and sulfuric acid plants are incinerated, vented or flared, although occasionally they are reinjected to maintain reservoir pressure.

d. Cycling Plants

In a number of fields the produced gas is processed to remove the heavier components and the gas is reinjected into the formation to maintain pressure and increase ultimate recovery. These are called cycling operations. The produced gas is often first sweetened prior to processing and reinjection.

e. Other

Another market for sour natural gas is carbon black manufacturers where the sulfur content in the raw material is not detrimental to the end product.

Another minor market is in power plants which have been equipped to burn sour gas.

6. Shipment of Natural Gas

The great bulk of the approximately 21 trillion cubic feet of[3] natural gas consumed in the United States annually is transported between the gas producing areas and gas distribution utilities by about 20 major gas transmission companies. Each firm sets its own purchasing standards which typically are the same as those in the tariffs filed with the Federal Power Commission.

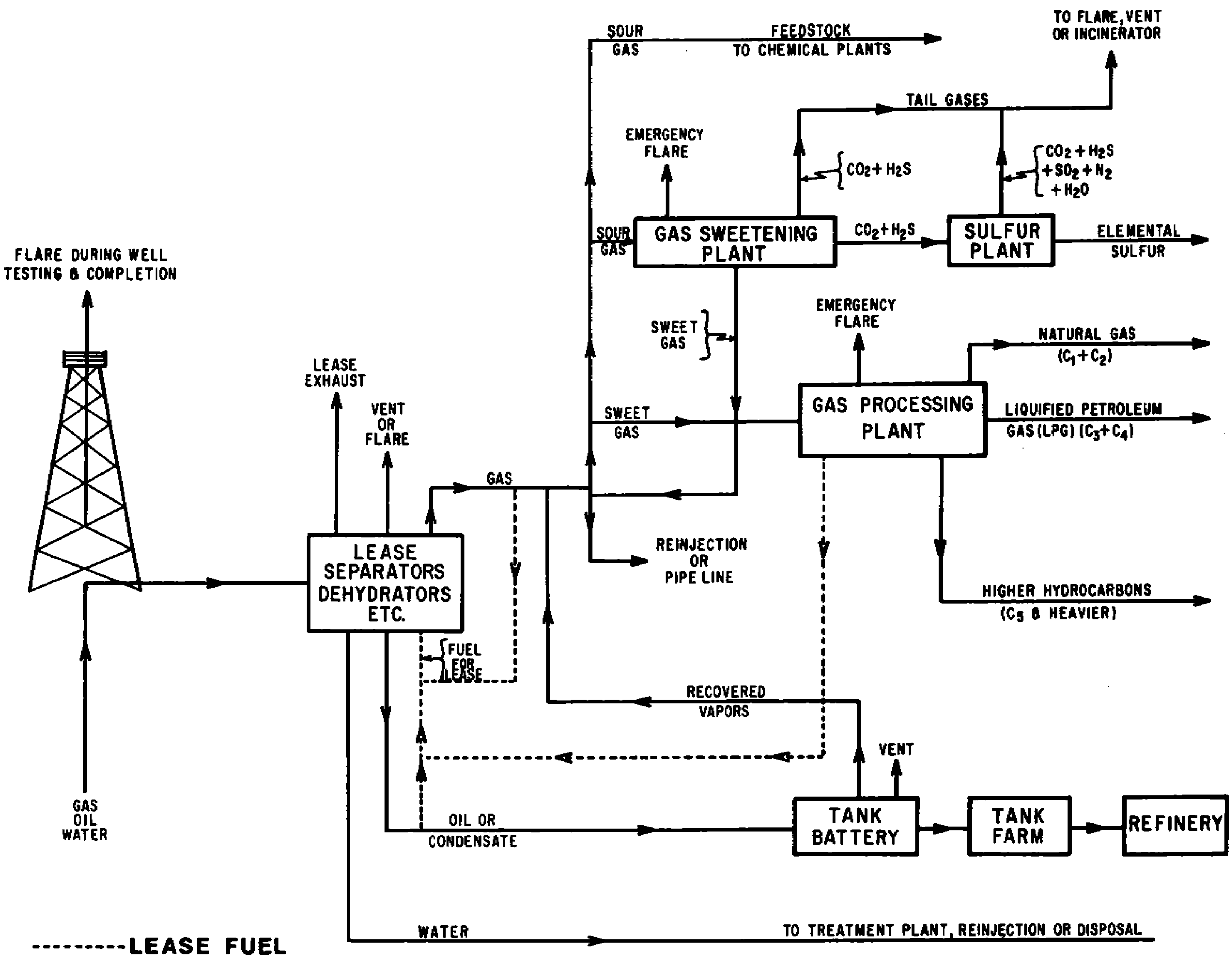
The most common standard for hydrogen sulfide is a maximum 0.25 grains per 100 standard cubic feet or about 4 parts per million. It has been found that gas containing more hydrogen sulfide than this not only presents health hazards to pipeline workers, but causes excessive corrosion damage, particularly in compressors. Because of the general shortage of natural gas at current prices, transmission companies will consider the purchase of gas with hydrogen sulfide levels up to 1 gr/100 SCF if it will not result, upon dilution with gas in their system, in concentrations exceeding 0.25 gr/100 SCF.

[3] U.S. Department of Commerce, Statistical Abstract of the United States 1971, p. 645.

Another common standard for natural gas is 20 grains of total sulfur per 100 standard cubic feet of gas. One exception to this is Transwestern Pipeline Company which specifies only a 0.5 gr/100 SCF tariff with Southern California Gas. As a practical matter, hydrogen sulfide is rarely less than 95 percent of the total sulfur content. The reason for the total sulfur standard has to do with the end users. Sulfur can "poison" catalysts in petrochemical plants using natural gas feedstocks and cause discoloration or embrittlement of certain metals during heat treating. Sulfur can also cause discoloration of glass used to make engineered products such as light bulbs and television picture tubes.

The mercaptans used to odorize natural gas are usually added by the distribution utility unless local laws require the transmission companies to do this.

The accompanying schematic flow sheet, Fig. 1, illustrates the various sources and channels of disposition of gaseous materials which are encountered in the production of petroleum and natural gas.



SOURCE & DISPOSITION OF GAS IN PETROLEUM PRODUCTION OPERATIONS

B. GENERAL SOURCES OF PERTINENT DATA

Some, but not all, petroleum producing states have well established petroleum regulatory agencies to which production data are reported on a periodic basis, usually monthly. The forms required for reporting in the different states vary widely, and some are much more nearly complete than others. Also, many states now have active air pollution control agencies, and much data on sulfur production and sulfur emissions from petroleum production operations are available from this source. Other general sources of data include trade organizations, manufacturers of equipment or chemicals industry publications and commercial data sources, independent consultants and private correspondence, in addition to the petroleum producers and the gas pipeline companies themselves.

II. OVERALL SUMMARY AND CONCLUSIONS

A preliminary survey of data sources indicated the feasibility of obtaining meaningful data on sulfur emissions in the United States by the natural gas production industry. This preliminary survey also indicated that there were serious discrepancies as well as wide differences in the total U.S. sulfur emission values for the petroleum production industry as reported in two earlier studies made for the U.S. Environmental Protection Agency.

The major portion of natural gas production industry emissions of sulfur compounds is contributed by natural gas sweetening processes in which hydrogen sulfide is removed from the natural gas. Two large producing areas, the Permian Basin in West Texas and Southeastern New Mexico and the Smackover Formation which runs in a large arc starting south of San Antonio, Texas and following northeasterly along Southern Arkansas and then southeasterly to Jackson, Mississippi and Pensacola, Florida, account for approximately 80 percent of the sulfur emissions from natural gas production operations in the United States. The detailed study was limited to these two areas.

A study of the available data indicates that the emissions of sulfur compounds by the natural gas producing industry from the areas studied were equivalent to 304,000 long tons (309,000 metric tons) of sulfur in 1973. This resulted in emissions to the atmosphere of 664,000 short tons (602,000 metric tons) of sulfur dioxide and 9,000 short tons (8,000 metric tons) of hydrogen sulfide. These results are summarized below: (see Table 5, p. 77 for more detail)

	Total Emissions Reported As Elemental Sulfur	Actual Emissions	
		Sulfur Dioxide	Hydrogen Sulfide
long tons/year	304,000	593,000	8,000
metric tons/year	309,000	603,000	8,000
short tons/year	340,000	664,000	9,000
95 percent confidence limits	± 15%	± 15%	± 15%

Total emissions by the natural gas producing industry in the United States in 1973 are estimated to be equivalent to 408,000 long tons of sulfur (415,000 metric tons) which are equal to 914,000 short tons (829,000 metric tons) of sulfur dioxide. The accuracy of this estimate is plus or minus 24 percent, indicating a range of 695,000 short tons (630,000 metric tons) to 1,133,000 short tons (1,028,000 metric tons). A comparison of the emissions value resulting from the present study with values from the two previous studies is presented on the following page:

Estimated Total Annual Emissions of Sulfur From
Natural Gas Producing Operations in the United States

	Reported As Sulfur		Reported As Sulfur Dioxide	
	Long Tons	Metric Tons	Short Tons	Metric Tons
EAI Study	408,000 ± 24%	415,000 ± 24%	914,000 ± 24%	829,000 ± 24%
Battelle Study	48,400	50,000	108,000	100,000
Process Research, Inc.				
Study #1			3,400,000	3,084,000
Study #2			7,340,000	6,659,000

The present study indicates that the weighted average efficiency of the 55 sulfur recovery plants operating in the study area is 85.3 percent. The weighted average was calculated by summing the product of the inlet gas charge to each sweetening plant and its recovery efficiency and dividing the sum by the total amount of gas sweetened. Recovery efficiency drops rapidly as the ratio of hydrogen sulfide to carbon dioxide in the acid gas stream decreases. It will be difficult to maintain a 90 percent recovery efficiency, even with new plants operating on acid gas streams of 80 percent and greater hydrogen sulfide content.

III. PART I - A STUDY TO ASSESS THE OPTIMUM METHOD TO COLLECT DATA

(This section was submitted in August, 1974, at the conclusion of the initial study phase.)

A. SUMMARY

This study was conducted by contacting over thirty organizations including state petroleum and air quality regulatory agencies, trade associations, publications, manufacturers, service companies for the petroleum production industry, petroleum production companies and gas transmission companies. The purpose was to determine an optimum way to obtain data on the emissions of hydrogen sulfide and sulfur dioxide by the petroleum production industry.

The major share of petroleum production industry emissions of sulfur compounds arises from the natural gas sweetening process in which hydrogen sulfide is removed from natural gas. The hydrogen sulfide is vented, flared, reinjected or further processed to make elemental sulfur or commercial products. The 1972 emissions inventory of the petroleum production industry for Texas showed a total of about 300,000 short tons (272,000 metric tons) of sulfur dioxide emissions, virtually all of which result from the combustion of hydrogen sulfide. Based on approximate data, the emissions in Texas are probably between 50 and 65 percent of the total United States emissions by this industry.

There are several other less important sources of sulfur emissions, such as hydrogen sulfide vapors at field crude oil storage tanks, the use of unprocessed gas and the combustion of processed gas. Based on information developed to date, these sources are probably less than 10 percent of those associated with gas treating plants.

The availability of data varies greatly by state. Fortunately, Texas and Wyoming, which probably have over 65 percent of U.S. emissions, have excellent records at both the petroleum and environmental regulatory agencies. Available data for the other states can be compiled and then a telephone survey conducted to resolve discrepancies and fill gaps in information.

B. PURPOSE OF THE STUDY

This section of the report describes the purpose of the study and the methods that were employed.

1. Purpose

The purpose of this study was to investigate existing sources of information to determine the optimum way to obtain data on the emissions of sulfur compounds by the natural gas producing and processing and the oil production industries.

2. Methods

Personal interviews were conducted with nearly all individuals contacted. Not only were data obtained, but opinions were solicited on the optimum way to collect data. Below is a listing of the organizations contacted. Detailed contact reports are included in Appendix 8 of this report.

Petroleum Regulatory Agencies

Federal Power Commission
Colorado Oil and Gas Conservation Commission
Louisiana Department of Conservation
Mississippi State Oil & Gas Board
Texas Railroad Commission
Wyoming Oil and Gas Conservation Commission

Air Pollution Control Agencies

Colorado Air Pollution Control Division
Louisiana Air Control Commission
Mississippi Air and Water Pollution Control Commission
Texas Air Control Board
Wyoming Department of Environmental Quality

Trade Organizations

American Gas Association
Gas Producers Association
Texas Mid-Continent Oil and Gas Association

Manufacturers of Equipment or Chemicals

C-E Natco Company
Ford, Bacon and Davis
Jefferson Chemical (interview refused)
John Zink Company

Publications and Commercial Data Sources

Bureau of Mines, Department of Interior
R. W. Byram & Co.
Oil and Gas Journal
Petroleum Information Corporation

Petroleum Producers and Gas Pipeline Companies

Amoco Production Co.
Arkansas Louisiana Gas Co.
Cities Service Oil Co.
Exxon Corporation, U.S.A.
Lone Star Gas
Phillips Petroleum Co.
Shell Oil Co.
Transcontinental Gas Pipeline Corp.
Transwestern Pipeline Co.
Trunkline Gas Co.
United Gas Pipeline
Warren Petroleum Company

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C. EVALUATION OF INFORMATION SOURCES

Visits were made to organizations within eight categories of information sources. Below is an evaluation of each:

1. State Oil and Gas Regulatory Agencies

All states require operators of gas processing plants to file monthly reports. The plant operator provides data on the source of incoming natural gas, the sales or shipments of products and processed gas and the disposition of the remainder or "Residue Gas". These reports are typically filed by the accounting section of the processor's company.

Texas asks for data on hydrogen sulfide and production of sulfur while Wyoming and Mississippi only ask for sulfur production. Louisiana and Colorado have no such requirement because sour gas is either rare or non-existent in these states. Sample report forms are included in the Appendix.

Texas accumulates data on all types of gas processing plants including gasoline, cycling and "other" plants. "Gasoline Plants" are defined as those that produce gasoline (natural gasoline) along with natural gas and other products such as butane, propane and ethane. "Cycling Plants" are associated with gas condensate reservoirs. The produced well stream is separated at relatively high pressure and the vapors are processed for sweetening, if necessary, and removal of normal liquid components. The processed gas is then reinjected to maintain reservoir pressure as near the original pressure as possible. "Other Plants" are those where compression condensate, line drips and similar unfractionated feedstocks for gasoline plants or refineries are separated from wet-gas streams and collected.

In 1972 the Texas Railroad Commission[1] reported the following:

Type of Plant	Total Number of Plants	Annual Sulfur Production (long tons)
Gasoline	340	193,000
Cycling	30	217,000
Other	600	46,000
	970	456,000
Oil & Gas Journal[2]	369	403,000

1 Annual Report of the Oil and Gas Division, 1972. The Railroad Commission of Texas.

2 "1973 Survey of Gas-Processing Plant", Oil and Gas Journal July 9, 1973, for Texas.

It appears that the Oil & Gas Journal survey includes only the gasoline and cycling plants and omits the "other" plants.

None of the other four states surveyed required reports on the "other" category of plants.

No state collects data on the use of crude oil as a fuel at well sites or in plants, or flared. Only total production data are reported. Also, there are no data collected on the hydrogen sulfide content of crude oil.

2. State Air Control Agencies

All states were required by the Environmental Protection Agency to have emissions inventories prepared as part of their implementation plans. Of the five states surveyed, only Texas has a regular emissions inventory requirement.

Each source is required in Texas to submit data annually on its emissions. The data are processed in a variety of ways, and complete data on 1973 emissions by the petroleum production industry in Texas should be available in October, 1974. (These data are still not available at the completion of the second phase of the study, December, 1974.)

The 1972 inventory as reported to the Texas Air Control Board shows that the emissions of the petroleum production industry total about 300,000 short tons (272,000 metric tons) per year of sulfur dioxide.

There are inconsistencies between the data filed with the Texas Air Control Board (TACB), data filed with the Railroad Commission (RRC) and some of the source testing work done by Ecology Audits, Inc. One reason for the inconsistency between the two state agencies is that the reports are generally prepared by two different individuals in the company. Reports for the TACB are usually prepared by the environmental manager while the RRC reports are furnished by the processor's accounting department.

Many clients of Ecology Audits have been surprised by the higher than expected emissions in stack tests. They relied on plant balances prior to the general usage of stack testing which began in 1973. Sulfur production is easy to measure, but apparently small errors occur in measuring the large volumes of incoming gas or its hydrogen sulfide content. There are several possible explanations.

Sour gas is quite corrosive, and it may damage the orifice plate measuring incoming flow. This would result in erroneously low values of inlet gas flow and indicate high recovery efficiency. Another possible source of error may be that hydrogen sulfide is so chemically active it reacts with the sampling and analytical devices such as sample bombs and tubing in chromatographs. This would also result in understated hydrogen sulfide content of the incoming gas, boost apparent plant efficiency, and understate tail gas incinerator emissions.

Several conclusions may be made. The errors in measuring produced hydrogen sulfide and in estimating the emissions from a sweetening plant without sulfur recovery are likely to be small -- generally less than a five percent underestimation. The errors in estimating the stack emissions from sulfur recovery plants by material balance are likely to be much greater, perhaps on the order of underestimating by 15 to 30 percent.

None of the other states surveyed had, in their opinion, reliable and current emission inventories.

3. Trade Organizations

No data collection or processing is done in the industry by the three organizations visited. Hydrogen sulfide has not been studied by the American Gas Association except from the standpoint of corrosion and safety. The Gas Processors Association generally is involved with phase equilibria and enthalpy properties for process design, but it does not accumulate statistical data on production. The Mid-Continent Oil and Gas Association acts as a coordinating body for industry committees and does not accumulate statistical production data.

4. Manufacturers of Equipment and Chemicals

Companies in this group were very reluctant to discuss any aspect of their business. By disclosing information about customers, they run two risks: 1) that competitors will find out who their customers are and 2) that their customers may be subjected to an Environmental Protection Agency inquiry. Neither risk has offsetting commercial advantages.

One maker of chemicals said that there was no easy way to get a list of plant operators. The sales manager said that the published directories were of limited help, and that he relied on his long-term relationships with most gas processors to tell him where and when they were planning their next plants. In short, he confirmed the essence of this study, that there is no easy or simple way to find out by whom and where gas sweetening is taking place.

5. Publications/Commerical Data Sources

The Oil & Gas Journal does an annual survey of gas-processing plants. This survey is voluntary and most firms respond. Below is a tabulation of the plants reported to the petroleum regulatory agencies and the Oil & Gas Journal:

State	Gas Processing Plants Reported To: Petroleum Regulatory Agency	Gas Processing Plants Reported To: Oil & Gas Journal
Colorado	17	12
Louisiana	169	132
Mississippi	14	10
Texas*	370	369
Wyoming	33	27
Other States	358**	236
Texas "Other"	600	--
U.S. Total	1561	786

* Includes only gasoline and cycling plants. "Other" plants are excluded.

** Estimates based on ratio of underreporting in Colorado, Louisiana, Mississippi and Wyoming.

It appears that the coverage for Texas is good if only because the format of the Oil & Gas Journal report is similar to that of the Texas Railroad Commission. Data for the other states shows that the Oil & Gas Journal survey covers 75 to 80 percent of the gasoline plants. If this ratio applies elsewhere then there should be about 358 plants in these states. This and the 600 "other" Texas plants suggests a U.S. total of 1561 plants.

Starting in 1974, the Oil & Gas Journal modified their questionnaire specifically to request data on sulfur production. Until then many, but not all, sulfur producers voluntarily listed sulfur production in the "other" category.

The Bureau of Mines, U.S. Department of the Interior, publishes a monthly and annual report of sulfur production as part of its Mineral Industry Surveys. Their mailing list for sulfur recovery plants is derived from the Oil & Gas Journal report. This survey covers only sulfur recovery plants, and no data on individual plants can be made available because of departmental disclosure rules. The Bureau of Mines list of plants can provide a useful check to verify data obtained from state regulatory agencies.

Below is a comparison of the Bureau of Mines report and the Oil & Gas Journal Report. It shows that many firms responding to the Oil & Gas Journal survey did not include their sulfur production.

Comparison of Data - Gas Processing Plants
Recovering Sulfur, 1972 Shipments and Capacity

State	Bureau of Mines		Oil & Gas Journal	
	Number of Plants**	Shipments (1000 long tons)* 1972	Number of Plants	Capacity (1000 long tons)
Alabama	1	*	--	--
Arkansas	2	*	1	2
Florida	1	92	--	--
Mississippi	2	*	2	80
New Mexico	6	35	2	11
North Dakota	2	*	1	42
Oklahoma	1	1	--	--
Texas	36	*	20	403
Wyoming	4	40	2	37
	55		28	575

* Data only reported for those states where all recovered sulfur is made in gas processing plants.

** The number of plants is based on the current Bureau of Mines list of plants which was annotated on about June 15, 1974, by Roland W. Merwin and sent to the author.

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Several firms summarize data filed with the oil and gas regulatory agencies and make it available on a fee basis. Petroleum Information, a subsidiary of A. C. Nielson Company, has some of the data computerized, but there are gaps in material extracted from the reports.

6. Petroleum Production and Gas Transmission Companies

All of the major petroleum companies were anxious to cooperate. In general, they are not enthusiastic over additional reports so they want all existing data currently available to the public to be summarized. All expressed a desire to cooperate with a survey of facilities in states where there is limited public data available.

The gas transmission firms fell into two categories: those that were cooperative and several that almost refused to answer any question. It appears that their reluctance to provide information stems from their tight regulation by the Federal Power Commission and by the barrage of surveys and reports resulting from the energy crisis.

7. Service Company Data

a. Compositions of Oil and Gas Well Production

Generalized data on approximately 2,000 reports of reservoir fluids studied over a 35 month period were examined. Samples from wells in the United States numbered 856 and of these 158 (18.5 percent) showed hydrogen sulfide, ranging between 0.01 and 49.0 mol percent. The lower limit of the content reported is 0.01 mol percent (approximately 6 grains per 100 cubic feet), which is governed by the analytical accuracy of the instruments. No data are contained in these reports on the potential or current production rate of the wells.

Generally, sour reservoirs are tested much more extensively than sweet reservoirs because of the problems associated with handling hydrogen sulfide. It is not correct, therefore, to conclude that 18 percent of new reservoirs contain sour gases.

It also appears that after testing, some well owners have sold their interests to others or found the wells uneconomical to produce. Data more than 10 years old, therefore, is probably of limited value in identifying owners of sour production.

Similar data may be obtained for an additional 4,000 to 4,500 studies made during the past ten years, of which about 350 to 400 may be expected to contain sour gas. There will be significant duplication since well owners frequently have the original well and nearby development wells tested.

All of the specific well data are confidential, but the generalized data can be used to identify areas where hydrogen sulfide exists.

b. Ambient Air and Stack Monitoring

Since its founding in 1967, Ecology Audits has conducted ambient air studies at 43 sites at or near petroleum production facilities. In addition, it has conducted 34 stack tests on sulfur recovery plant incinerators for sulfur dioxide and, in some cases, for hydrogen sulfide.

Much of these data were obtained to aid firms in determining their compliance status and, in many cases, new equipment has been installed to control emissions. Another trend is the reduction in emissions as operators learn more about the operating characteristics of their plants.

All the specific data are confidential, but the generalized summaries may be used to identify areas where emissions of sulfur compounds exist.

D. RECOMMENDATIONS FOR ESTIMATING EMISSIONS FROM THE PETROLEUM PRODUCTION INDUSTRY

Based on analysis of the information that is available, Ecology Audits proposes to carry out a study as presented below:

1. Scope of Work

Ecology Audits proposes to conduct a study whereby the quantity and disposition of hydrogen sulfide contained in natural gas produced in the year 1973 from the Permian Basin and the Smackover Formation will be estimated. Information provided on the disposition of this hydrogen sulfide will include data on venting, flaring, incinerating, conversion into elemental sulfur, and reinjection.

2. Methods

a. Source of Emissions

Emissions of hydrogen sulfide and sulfur dioxide can come from a variety of sources. The letter by each source indicates the section to be found in the next following pages in which these emissions are discussed.

Hydrogen Sulfide	b.	vented from gas sweetening plants
	b.	emitted by low-temperature (700-1200°F) tail gas incinerators operating on sulfur recovery plants
	d.	emitted by carbon black plants using sour gas as a feedstock
	c.	vented unprocessed natural gas
		released by sour crude stored in tanks without vapor recovery (not included in this study)
Sulfur Dioxide	b.	released by flares and/or incinerators at gas sweetening plants
	b.	released by flares or incinerators fed by tail gases from sulfur recovery plants or plants making chemicals containing sulfur
	d.	released by users of sour gas such as power plants
	c.	flared or burned unprocessed natural gas
		released by the burning of sour crude in heaters located at plant and well sites (not included in this study)
		released by users of commercial grade natural gas (not included in this study)

In rare cases hydrogen sulfide is reinjected with other gases to maintain reservoir pressure. The difficulties in handling hydrogen sulfide preclude widespread reinjection if any other gases are available.

b. Emissions of Gas Sweetening and Sulfur Recovery Plants

This group of sources is probably responsible for over 90 percent of the total emissions. All available data will be assembled on a county basis.

Analysis sheets will be prepared for each county known to produce sour gas. All available information from state agencies, publications and service company sources will be compared and analyzed. Inconsistencies will be identified and phone calls made to the producer to resolve these. Some personal visits will be required to both Austin and Santa Fe and possibly other state capitols.

Special attention will be given sulfur recovery plants, injection systems and producers selling tail gases to chemical companies for further processing.

c. Emissions From Flaring, Burning or Venting of Unprocessed Sour Natural Gas

The amount of gas reported to the state agencies as vented or flared is less than 0.5% of total gas production. Data on the emissions from the burning or venting of unprocessed

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sour natural gas only will be obtained to determine the accuracy of these values. The following procedure will be used:

The gross production into each gathering system will be determined along with the receipts by gas plants. The difference is assumed to be used, in an unprocessed state, on the lease and will be considered to be as sour as the average produced gas in the county.

d. Miscellaneous Sources of Sulfur Dioxide and Hydrogen Sulfide

For many years sour natural gas has been used as a feedstock for carbon black plants. The process results in the emissions of some hydrogen sulfide which will be estimated as part of the study.

There is also at least one power plant that has been reported that burns sour natural gas. This plant and other industrial users of sour natural gas will be studied.

Excellent data are available in Texas where it has been estimated that between 50 and 65 percent of the emissions occur. Field survey work will probably be required in some other states.

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3. Report

A draft report will be prepared discussing the industry, the sources of emissions and the methods used to collect the data. Tabular summaries of data collected for the Permian Basin and the Smackover Formation will be broken down by County, AQCR and State. The summaries will show:

a. Production of hydrogen sulfide along with natural gas by county in the study areas.

b. Production of elemental sulfur and other products in sulfur equivalents from plants using by-products of gas processing plants as feedstock.

c. Emissions of hydrogen sulfide and sulfur dioxide occurring at field operations including:

1.) use or venting of unprocessed gas

2.) disposal of tail gases from sweetening operations

3.) tail gas incineration associated with sulfur recovery and sulfur products production operations

4.) operation of non-petroleum facilities using natural gas not meeting usual pipeline standards

d. Shipment of hydrogen sulfide along with sweetened natural gas to pipeline customers.

e. Typical range of hydrogen sulfide content of natural gas by county in the areas studied and calculated average concentrations by county based on the hydrogen sulfide analyses.

f. Estimate of the degree of accuracy of the data reported on a county-by-county basis.

Detailed information will be provided on the data sources and the methods used to estimate data.

The final report will include:

I. Summary

II. Purpose and Methods

III. Description of Facilities and Processes, Including a Flow Sheet

IV. Statistical Summaries of Data for the Two Study Areas

V. Summary of Information in Other Areas

Appendices

A. Contact Reports
B. Copies of Important Statistical Source Material
C. Glossary of Terms

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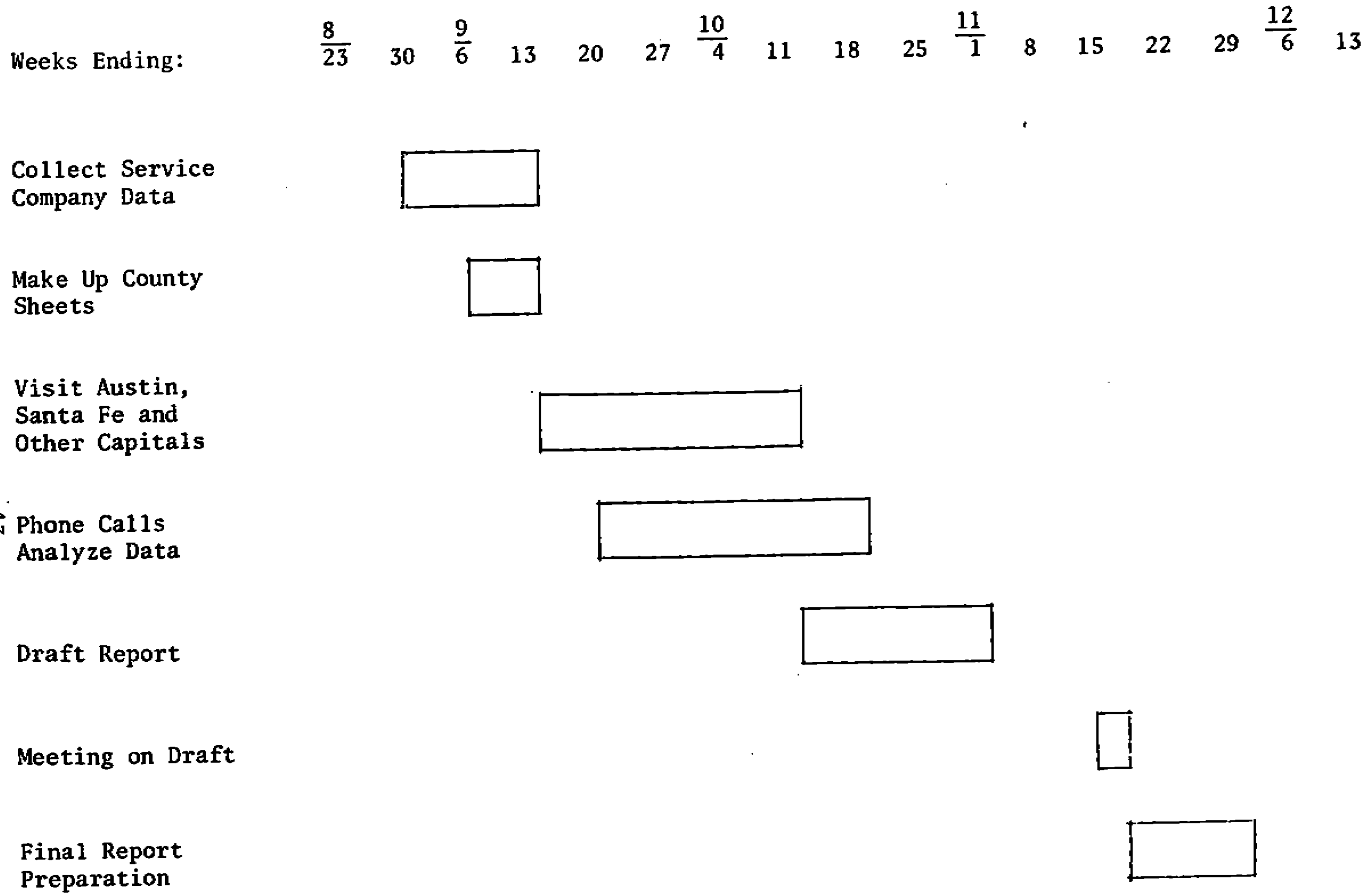
4. Time Schedule for Project

The accompanying bar chart indicates the approximate time allocation and the dates for completion of the various phases of the proposed study.

SCHEDULE OF WORK



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IV. PART II - COLLECTION OF DATA AND EVALUATION OF SULFUR COMPOUND EMISSIONS

A. SUMMARY AND CONCLUSIONS

1. The emissions of sulfur compounds by the natural gas producing industry from the Permian Basin and Smackover Formation in 1973 were equivalent to 304,000 long tons of sulfur. This resulted in emissions to the atmosphere of 664,000 short tons of sulfur dioxide and 9,000 short tons of hydrogen sulfide. These data are estimated to be accurate to within plus or minus 15 percent.

2. The emissions by the natural gas producing industry in the United States but outside of the study area are estimated to be equivalent to 104,000 long tons of sulfur. The accuracy of this estimate is plus or minus 50 percent.

3. The emissions by the natural gas producing industry in the United States in 1973 are estimated to be equivalent to 408,000 long tons of sulfur which is equal to 914,000 short tons of sulfur dioxide. The accuracy of this estimate is plus or minus 24 percent. Emissions could be as high as 1,133,000 or as low as 695,000 short tons of sulfur dioxide in 1973.

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4. In the study area about 33 percent of all gas produced was processed for the removal of hydrogen sulfide. This volume represents about 14.4 percent of total U.S. production of natural gas. It is likely that about 19 percent of all U.S. gas production is treated for hydrogen sulfide removal. The gas production in the study area, therefore, represents approximately 76 percent of the natural gas which is processed in the U.S. for the removal of hydrogen sulfide.

5. The weighted average recovery efficiency of the 55 sulfur recovery plants fed by natural gas in the study area is 85.3 percent. Even the newest three stage plants have difficulty maintaining 90 percent recovery efficiency on acid gas streams containing over 80 percent hydrogen sulfide. Recovery efficiency drops rapidly as the ratio of hydrogen sulfide to carbon dioxide in the acid gas stream decreases.

6. The reports of the Texas Railroad Commission show that 9.6 billion cubic feet of produced sour gas was either vented or used as lease fuel in 1973. This activity resulted in minor emissions: 1233 long tons of sulfur per year, or less than one-third of one percent of total sulfur intake to sweetening plants. The data for other states, had they been available, are likely to show a similar ratio.

B. PURPOSE AND METHODS

1. Purpose of the Study

The purpose of the study was to perform an investigation of existing sources whereby the quantity and disposition of hydrogen sulfide contained in natural gas produced in the year 1973 from the Permian Basin and the Smackover Formation will be estimated. Information provided on the disposition of this hydrogen sulfide will include data on reinjection, recovery as elemental sulfur and emissions from venting, flaring, and incinerating.

2. Sources of Information

This section describes the sources of public information concerning the oil and gas production industry. The first subsection discusses the data collected by national organizations. Subsequent parts discuss the data available in each state.

a. General Sources

1.) Oil & Gas Journal

The Oil & Gas Journal (Petroleum Publishing Company, Tulsa, Oklahoma) makes an annual survey of natural gas processing plants. The survey is voluntary and most firms respond.

Table 1 presents comparative data on the number of plants that reported data to the Oil & Gas Journal with plants reporting to the respective petroleum regulatory agencies for the states studied.

Because of the different reporting rules among the states, data in Table 1 should be used only as an approximate guide. In Texas, for example, some gas processing plants do not make reports to the state agency because they produce no hydrocarbon liquids. Reports of the gas sweetening plants in the Jay Field of Florida were made to the state agency, even though the recovered liquids are recombined with field crude. These plants were not included in the Oil & Gas Journal survey.

TABLE 1

State	Gas Processing Plants Reported To Petroleum Regulatory Agency	Oil & Gas Journal
Alabama	3	1
Arkansas	4	3
Florida	5	1
Louisiana*	147	124
Mississippi	14	9
Southeastern New Mexico	33	24
Texas**	366	301
(Texas)	(575)	(70)

*The Petroleum Regulatory Agency column contains 37 plants not responding to the Oil & Gas Journal survey while the Oil & Gas Journal column includes 14 plants not on the state mailing list.

**Includes gasoline and cycling plants. "Other" plants are indicated by parenthesis ( ) and include sulfur recovery plants, drip stations and plants that produce an unseparated blend of natural gas liquids.

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The Oil & Gas Journal data for states covers about 75 to 80 percent of the gasoline plants, but only a small fraction of other gas processing units such as sweetening and dehydration facilities. Although the questionnaire requested data on sulfur production, only about 33 of the plants provided this information. No data is provided on the hydrogen sulfide gas losses of each plant.

2.) Bureau of Mines

The Bureau of Mines of the Department of the Interior collects and reports United States sulfur production. The data is reported by state, but several states are combined where necessary to avoid disclosing the production of individual operators.

Mr. Roland Merwin (703/557-0495) provided Ecology Audits a list of all sulfur recovery plants in the United States and indicated which of these were at sites of natural gas processing plants.

Under departmental rules, the data furnished by companies is treated in confidence except that it may be disclosed to Federal Defense Agencies.

3.) Service Company Data

a.) Well Stream Data

Data contained in 5981 reports of reservoir fluid studies made by a world-wide service company during a 10-year period from 1964 to 1973 were examined. Of these, 2304 reports represent reservoirs in all of the major producing areas in the United States, including 265 reports (11.5 percent) on petroleum containing some hydrogen sulfide.

Since all of the reservoir study data are confidential, the generalized qualitative data were used only to identify areas where hydrogen sulfide exists. No data are contained in these reports on the potential or current production rate of the wells.

The lower limit of content reported is 0.01 mol percent (approximately 6 grains per 100 standard cubic feet) which is governed by the analytical accuracy of the instruments. Any content below 0.01 mol percent is reported as a trace or zero.

Generally, sour reservoirs are tested more extensively than sweet reservoirs because of the problems associated with handling hydrogen sulfide. In addition, there tended to be more samples analyzed in the case of sour petroleum reservoirs per report; therefore, a conclusion that 11.5 percent of reservoirs contain hydrogen sulfide would not be correct.

b.) Ambient Air and Stack Monitoring

Since its founding in 1967, Ecology Audits has conducted ambient air studies at 43 sites at or near petroleum production facilities. In addition, it has conducted 35 stack tests on sulfur recovery plants and acid gas incinerators.

Most of this data was used by clients to determine their compliance status. In many cases new equipment has been installed to control emissions. As in the case of reservoir studies, all test data is confidential, but it can be used to identify areas where sulfur dioxide and hydrogen sulfide emissions occur.

b. New Mexico

1.) New Mexico Oil Conservation Commission

Monthly reports are made by all gas processing plant operators on Form C-111 (See Appendix). No data is collected on acid gas or hydrogen sulfide. Information on the 33 facilities, including 30 extraction plants, located in Southeastern New Mexico was obtained from the New Mexico Oil and Gas Engineering Committee, P. O. Box 127, Hobbs, New Mexico.

The data includes plant intake, plant fuel use, lease use, sales, reinjection, shrinkage and vented gas.

2.) New Mexico Environmental Improvement Agency

The Air Quality Section provided a listing of plants with estimated emissions of sulfur dioxide of 25 tons per year or more. The list was compiled in 1971 for the year 1970 by an EPA contractor assisting the state in the preparation of its implementation plan. State officials expressed their reservations regarding the list, and Ecology Audits confirmed that there were some omissions. Subsequently, the state provided data on selected plants for which emissions data had been submitted by plant operators.

c. Texas

1.) The Railroad Commission of Texas, Oil and Gas Division
All operators of gasoline plants, cycling plants or any facility which produces or collects liquids is required to file information monthly on Form GP-1. Data is collected on hydrogen sulfide, although many operators report total acid gas (hydrogen sulfide and carbon dioxide) as hydrogen sulfide.

Where operators do provide information on the composition of acid gas, it is from ratios given to the operator's accounting department by process engineers. Unfortunately, the engineers sometimes do not keep the accountants up-to-date on changes in acid gas composition which occur as new wells are drilled and old wells cease production.

All reports for 1973 were reviewed, and if hydrogen sulfide loss was reported, the following data were collected:

-- hydrogen sulfide loss

-- sulfur production

-- total plant intake

-- unprocessed gas used in the fuel system or on a lease

-- vented unprocessed gas

A total of 99 facilities have some reported hydrogen sulfide out of a total of 941 facilities (10.5 percent). This is not a complete list of all potential sources of sulfur compound emissions because plants which do not collect liquids, such as sweetening facilities or sulfur recovery plants, are not required to report to the Commission.

2.) The Texas Air Control Board

For the past three years the Texas Air Control Board has sent out questionnaires to all plants in the state which emit 50 or more tons of pollutants annually. The data for 1973 was extracted from their working papers for 173 facilities, many of which have emissions less than 50 tons per year of sulfur dioxide. Although these data are more comprehensive, the emission reports are estimates which are subject to possible error in calculation methods.

3.) Texas Comptrollers Office

Texas has a severence tax on sulfur, and this office furnished copies of quarterly production reports by the 35 sulfur plants in the state paying taxes. There are six more plants in the state that apparently are not aware of their potential tax liability.

d. Arkansas

1.) State of Arkansas Oil and Gas Commission

Mr. Lynn Fite of this agency provided production and operating statistics on the four gas processing plants located in Arkansas. No data is collected on acid gas or hydrogen sulfide. Mr. Fite also commented on some specific sour gas wells by indicating that these had been plugged or that production was initiated from sweet zones.

Arkansas is a leading producer of elemental Bromine. The feedstock for these plants is from saline aquifers which are tapped in the same manner as petroleum reservoirs. These aquifers often contain high levels of hydrogen sulfide. No attempt was made to assess the emissions from these facilities because it is outside the scope of the study.

2.) Arkansas Department of Pollution Control and Ecology
Several requests have been made of this agency, but no letter has been received as of the date of this report. The Department did confirm that the data developed in this study for Arkansas is essentially correct.

e. Louisiana

1.) Louisiana Department of Conservation
Monthly reports are required of all gasoline and cycling plants on Form R-6. No data is collected on either acid gas or hydrogen sulfide. Officials with the agency said there may be isolated sour gas flares in Louisiana, but only the regional directors would have information. The agency furnished a copy of their mailing list of

firms submitting monthly reports. Contact was made will all six district managers and the only sour gas flares were located in the Southeastern part of the state, several hundred miles from the Smackover Formation.

2.) Louisiana Air Control Commission

The technical secretary of the Commission knew of no amine treating units in the state. He provided the names of individuals in industry who might provide some assistance. It was his opinion that the problems associated with the natural gas industry are very minor compared to the other problems in the state.

f. Mississippi

1.) Mississippi State Oil and Gas Board

Monthly reports are made by all gas processing plant operators on Form 11-10CC G-9 (See Appendix 3.) Data is required on acid gas in section III of this report. Copies of reports furnished by the four plants that report acid gas losses were obtained and summarized.

2.) Mississippi Air and Water Pollution Control Commission

Several requests have been made of this agency, but no letter has been received as of the date of this report.

3.) Region IV Environmental Protection Agency

This region has been requesting firms to submit information on emissions. Ms. Carolyn Heller (404/526-3286) provided copies of reports furnished by seven operators in Mississippi. This program is relatively new and not all sources have been asked to submit data as of the date of this report.

g. Alabama

1.) State Oil and Gas Board

Mr. Donald B. Moore provided copies of the monthly data on petroleum activities in Alabama. During 1973, one gasoline plant and one gas sweetening plant operated in Alabama. Three more plants commenced operations in 1974. Although no data are collected on hydrogen sulfide, it did furnish test reports in their files on two sour gas fields.

Gas produced on the Alabama side of the Jay and Little Escambia Creek Fields is treated at the Wiggin's Lake facility located just across the state line in Florida.

2.) Alabama Air Pollution Control Commission

Mr. James W. Cooper, Director, provided data on the emissions of the two plants in the state, only one of which operated in 1973.

h. Florida

1.) Division of Interior Resources, Bureau of Geology

Mr. Charles Hendly provided copies of monthly reports for the four gas treating plants located in Northwestern Florida. These plants remove the hydrogen sulfide from the casinghead gas. A gasoline plant is currently under construction. No data are collected on hydrogen sulfide, but most producers do show their recovered sulfur production.

2.) Department of Pollution Control

Mr. Henry Sobala, Regional Manager of far Northwest Florida, sent copies of all test reports furnished to his department by the Jay Field plant operators.

3. <u>Analysis of Data</u>

a. Data Analysis Sheets

All available data from public sources were entered on a data sheet. A copy of the type of data sheet used in tabulating the data is included in Appendix 5 as sheet No. 1.

The heading shows the state and the counties within the state. The left stub provides information on the company and field and/or plant as appropriate.

Service Company information was used to provide an indication of the presence of sour gas. G/O is an indication that the analysis is for Gas or Oil. W/S indicated a well stream analysis. The hydrogen sulfide content of sour gas varies with the pressure in the separator, so only in general terms could the reservoir fluid analysis be used to indicate the hydrogen sulfide content of the gas stream going to a processing plant.

Air Agency refers to information provided by the State Air Control Agency. All reported emissions were reduced to long tons of sulfur.

$$SO_2 \text{ tons per year} \times \underbrace{\frac{32}{64} \times \frac{2000}{2240}}_{(.4464)} - \text{long tons sulfur per year}$$

$$H_2S \text{ tons per year} \times \underbrace{\frac{32}{34} \times \frac{2000}{2240}}_{(.8403)} = \text{long tons sulfur per year}$$

Only Texas had up-to-date emissions information on this industry.

Oil and Gas Journal data was extracted from their 1973 report. The daily "capacity" in long tons per day was multiplied by 365 to obtain annual data. Comparisons of the data indicate that "production" rather than "capacity" was reported in many cases.

The Bureau of Mines provided a list of all known sulfur plants. A plant on their list is indicated by an "X". In the lower space data reported to the Texas Comptroller's office in long tons of sulfur per year is recorded.

Data for Gas Processing Plants were obtained from each state agency. The first column shows the total plant throughput in millions of cubic feet for the year. Where reported, the "hydrogen sulfide" extraction loss appears in the next column. In many cases the "hydrogen sulfide" number is actually the metered acid gas volume from the amine regenerator and includes carbon dioxide and some hydrocarbons.

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The "hydrogen sulfide" loss is reduced to long tons of sulfur as follows:

1 lb. mol = 359.05 cubic feet at 32°F, 14.7 psia

Molecular weight of hydrogen sulfide = 34

Molecular weight of sulfur = 32

Standard reporting conditions to Texas Railroad Commission: 60°F, 14.65 psia

One long ton = 2240 pounds

Calculate the cubic feet per pound under TRRC conditions:

$$\frac{359.05}{34} \times \frac{460 + 60}{460 + 32} \times \frac{14.70}{14.65} = 11.21 \text{ cubic feet per pound of hydrogen sulfide}$$

Calculate the tons of sulfur per million cubic feet of hydrogen sulfide:

$$\frac{1,000,000}{11.20} \times \frac{1}{2240} \times \frac{32}{34} = 37.48 \text{ long tons sulfur per } MMCFH_2S$$

Some operators reported the H_2S content of their produced gas in terms of grains per 100 standard cubic feet. To calculate the tons of sulfur per million cubic feet of gas containing one grain of H_2S per 100 standard cubic feet, the following calculation is used:

1MMCF = 10,000 grains of hydrogen sulfide

7,000 grains = 1 pound

$$\frac{10,000}{7,000} \times \frac{32}{34} \times \frac{1}{2240} = .000600 \text{ long tons sulfur per MMCF with 1 grain } H_2S \text{ content}$$

The average "H_2S" content is calculated by dividing the "H_2S loss" by the total plant intake.

Sulfur production is based on data reported to the petroleum regulatory agency.

Data on unprocessed gas obtained from the state regulatory agency are recorded in the next column. Both fuel use and vented gas are reported. Then, using the same average hydrogen sulfide content as the inlet gas to the plant, the hydrogen sulfide losses are calculated and converted into emissions of long tons of sulfur.

The data were then transferred to another data sheet, one for each facility. This data form is included in Appendix 5, Sheet No. 2. These sheets were mailed to the operators of several plants for their comments. Those who operate only one or two plants were contacted by telephone to verify the data.

Included in Appendix 7 is M. W. Kellogg's Evaluation of the Assumptions, Methods, and Results used in this section of the report.

b. Analytical Methods

There are several methods that can be used to analyze a gas treating facility. Below are some methods used in the preparation of this report.

1.) Sulfur recovered analysis

Calculate the ratio between plant intake and recovered sulfur. If the plant is fed by a single field of similar gas wells, the ratio should remain constant. Typically, the gas plant intake will show a reasonably uniform monthly flow except for periodic dips. The recovery rate will usually show declines each month until the plant is shut down (the reason for the dip in monthly intake) and the catalyst bed in the sulfur recovery unit is renewed after which the recovery rate peaks again. Below is data for a sulfur recovery plant which illustrates this:

TABLE 2

Month	Gas Production MMCF	Sulfur Recovered LT/mo.	Ratio LT/mo. per MMCF
January	339	712	2.10
February	234	813	3.47
March	720	2,576	3.58
April	685	2,451	3.58
May	712	2,307	3.24
June	786	2,247	2.86
July	800	1,705	2.13
August	696	979	1.41
September	680	514	.76
October	0	0	--
November	781	2,785	3.57
December	897	1,997	2.23
TOTAL	7,330	19,086	2.60

One can readily see that catalyst beds were changed in January and early February and again in October. The decrease in catalyst efficiency is clearly observed in the ratio column. If the plant claims it is 95 percent efficient, one can set the ratio of the best or second-best month equal to 95 and then get a rough idea of the efficiency for the other months. In this case assume that 3.57 is 95 percent, then the annual average efficiency is 69.2%.

$$\text{Annual average efficiency} = \frac{2.60}{3.57}(.95) = 69.2\%$$

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The efficiency for each month can also be calculated. This method is only valid if the incoming well stream is uniform.

2.) Unknown acid gas stream

For some plants data on sales gas is known but the amount of hydrogen sulfide in the incoming gas stream is not available. If the operator has furnished a plant material balance based on actual experience, calculations can be made to determine the mols of acid gas in the plant inlet gas stream. The mols of water are subtracted and dry mols of acid gas determined. Since mols are directly proportional to volume, the hydrogen sulfide can be calculated on a dry basis for the incoming gas stream. Below is an illustration of the method :

TABLE 3

SAMPLE MATERIAL BALANCE

	Acid Gas lbs.	Acid Gas mols	Sweet Gas
H_2S	276,828	8,142	--
CO_2	80,696	1,834	--
H_2O	12,546	697	--
CH_4	224	14	
C_2H_6	151	5	
C_3H_8	176	4	
Total Wet Basis	370,621	10,696	1,039,949
Total Dry Basis		9,999	
Volume (MMCF)	4,072		17,335
Volume (dry)	3,807		

$$\text{Acid gas is } \frac{3,807}{3,807 + 17,335} = 18.0\%$$

$$H_2S \text{ in feed is } \left(\frac{3,807}{3,807 + 17,335}\right)\left(\frac{8,142}{9,999}\right) = 14.7\%$$

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c. Survey Information

There were far more public data available on plants located in Texas than on plants located in the other six states. Plants in Texas accounted for about 75 percent of the facilities studied.

When all public data was assembled for Texas plants, there were discrepancies in the great majority. The discrepancies for other states were significantly less, if only for the fact that less data were publicly available.

Copies of the individual data sheets on each plant were mailed to most multi-plant operators. A copy of the letter and form are included in Appendix 4. Then all operators, both single and multi-plant, were contacted by telephone and asked to comment on the data and verify the emissions data. Confirming information was obtained from more than 99 percent of the more than 200 plant operators contacted.

Among the reasons for the discrepancies are:

- The Railroad Commission data were incorrect because some operators reported their acid gas loss as "H_2S loss". In other cases, the operator's accounting department was using a stream analysis made several years ago to divide the metered acid gas stream into H_2S and CO_2 components. As reservoir pressure changes and as new wells feed a plant, significant compositional changes occur in acid gas. In some cases, operators merely neglected to fill in some data, such as sulfur produced, for some months.

- The Air Control Board data was in error frequently because of various reporting practices. Some operators merely annualized their stack test data. This is a poor practice because most operators "tune" their plants and take special operating precautions to "pass" stack tests. After the test is complete, these standards are relaxed. As a result, stack tests are rarely indicative of long-term emission levels.

  Other operators merely assumed that their plant was 95 or 96 percent efficient and reported emissions as 5 or 4 percent, respectively, of their elemental sulfur recovery. There appear to be some cases where operators figured out their allowable emissions and reported actual emissions at some arbitrary, slightly smaller number.

There were also operators who simply confessed that they had made mathematical errors in their calculations.

In discussing the reports with the operators, Ecology Audits sometimes felt that some operators reaffirmed emission data that was much too low. This often occurred where there have been or are currently court suits or hearings. In about 10 percent of the cases the operator did not care to take the time to investigate the discrepancies. In these cases, Ecology Audits tabulated both the operator's estimate and then made its own estimate, based on what, in some cases, is confidential data.

One of the conclusions of this study is that the use of infrequent stack test data to show annualized plant efficiency has limited value if used alone. Much more reliable data can be obtained by analyzing and developing a material balance for the incoming gas, the acid gas, the sales gas streams and sulfur recovery. Meters are almost always installed on these vapor lines to measure flow continuously. Daily data are also obtained on sulfur recovered. Periodic checks of stream compositions by on-site analytical techniques and sulfur recovery, together with occasional stack tests, provide data for both optimum and long-term emissions evaluation.

4. Other Reports for EPA on this Subject

The Environmental Protection Agency has purchased two prior studies on the industry. During 1972 a study was made by Processes Research, Inc., and during 1974 a study was conducted by Battelle Columbus Laboratories.

a. Processes Research, Inc. Study

The results of this work were reported in two publications:

"Sulfur Dioxide from Natural Gas Fields," July 21, 1972 conducted under Task Order No. 20 Contract No. CPA 70-1.

"Screening Report Crude Oil and Natural Gas Production Processes," December 27, 1972 conducted under Task Order No. 13, Contract No. 68-02-0242.

The first report comments on the fact that very little data is available in the public records on the sulfur content of natural gas. The author assumes that the emissions come from three sources: sulfur recovery plants were assumed to emit sulfur (as sulfur dioxide) in an amount equal to 10 percent of sulfur recovered. Then it was assumed that about 20 percent of all gas produced was sour and contained 400 grains per 100 scf (0.64 mol percent). The acid gases from these plants were assumed to be flared. Finally, it was assumed that the balance of natural gas contained 20 grains of sulfur per 100 standard cubic feet of gas.

All three assumptions are considerably in error. First, most sulfur recovery plants do not operate, or at least did not operate in 1970, at 90 percent recovery efficiency. Second, the occurrence of sour natural gas varies widely but in no instance is it as high as was assumed. Finally, it was found in the first phase of this study that well over 95 percent of the total sulfur in natural gas occurs as hydrogen sulfide and this compound is usually limited by the pipelines to 0.25 grains per 100 scf. The reported conclusion that total sulfur dioxide emissions from natural gas producing operations totals 3.4 million tons is a vast overstatement and is unsupported by data of either industry or regulatory bodies.

The second report uses a slightly different set of assumptions. It assumes that all the 20.7 trillion cubic feet of gas marketed contained, when produced, 0.5 mol percent of sulfur. It was estimated that of the 3.88 million long tons of sulfur produced, 686,000 long tons are recovered. The remainder is emitted, some as hydrogen sulfide and the major portion as sulfur dioxide from the burning of natural gas. The report arrives at the conclusion that annual emissions of sulfur are 7.34 million short tons as sulfur dioxide. This includes 7.15 million short tons related to marketed gas and 190,000 short tons from vented and flared gas.

The assumption concerning the sulfur contet of natural gas fails to recognize that most natural gas contains no sulfur. The assumptions are also at variance with a tabulation of gas processing plants contained on pages 32 to 42 in their report.

b. Battelle Columbus Laboratories Study

The results of this work were reported in "Characterization of Sulfur Recovery in Oil and Natural Gas Production", August 28, 1974, under Task 6, Contract No. 68-02-0611.

The report relies heavily on the data in the Oil and Gas Journal survey for 1972. It assumes that sulfur recovery plants have an efficiency of 95 percent and that the annual emissions of sulfur is 50,000 metric tons per year (100,000 metric tons of sulfur dioxide). The author noted the availability of data from the Railroad Commission in Texas, but did not attempt to analyze it because so many firms report acid gas as "H_2S loss".

The conclusions of this report greatly understate emissions. First, the Oil & Gas Journal reported on only 20 of the 40 plants in Texas. Further, the results of the present study indicate sulfur recovery efficiency of approximately 85.3 percent rather than the 95 percent assumed in the report. The report also does not analyze the emissions from numerous plants where the acid gas is flared and sulfur not recovered.

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C. SUMMARY OF EMISSIONS FOR STUDY AREA

1. Study Areas

The study covers all or parts of seven states where gas production from the Permian Basin and the Smackover Formation is encountered. These include Texas, Arkansas, Louisiana, Mississippi and Alabama, and parts of Southeastern New Mexico and Western Florida. No sour gas was located in Northern Louisiana, so this state will be excluded. Also excluded were air quality control regions (AQCR) where there were no reported sour gas production. Table 4 summarizes the AQCRs where emissions of sulfur compounds were found. Appendix 6 contains data and methods of computing values for Table 4.

Table 4 shows that in the study area 1,304,000 long tons of sulfur was produced in 1973 in the form of hydrogen sulfide along with natural gas. Of this amount 1,000,000 long tons were recovered and 304,000 long tons were emitted to the atmosphere, normally in the form of sulfur dioxide. All of the sulfur recovery plants .incinerate their tail gas streams and virtually all gas sweetening plants burn their acid gas streams through either flaring or incineration. Many firms that burn their acid gas (hydrogen sulfide and carbon dioxide) streams erroneously report the total as emissions of hydrogen sulfide. Ecology Audits estimates the emissions and their accuracy in Table 5.

TABLE 4

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	No. of Plants	Total Intake MMCF/YR	Gas Sweetening Plant Intake MMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR: Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
155 (NM)	Pecos Permian Basin	30	590	587	100	0.49%	0.49%	108	48	60
218 (TX)	Midland-Odessa San Angelo	81	2726	1801	66**	0.35%	0.23%	236	126	110
211 (TX)	Amarillo Lubbock	23	1359	530	39**	0.20%	0.08%	40	22	18
217 (TX)	San Antonio	8	159	76	48	1.65%	0.79%	47	34	13
215 210 212 214 (TX)	Dallas-Ft. Worth Abilene-Wichita Falls-Austin-Waco-Corpus Christi	10	2456	56	2	3.63%	0.08%	77	62	15
213 216 (TX)	Brownsville-Laredo-Houston Galveston SE Texas	--	2213	--	0			--	--	--
22 (TX) (AR)	Shreveport-Texarkana-Tyler	14	459	129	28	7.50%	2.10%	362	314	48
5 (MS,AL FL)	Mobile-Pensacola Panama City Southern Miss.	14	165	71	43	16.2%	7.03%	434	394	40
Total (excluding "other Texas")		180	7914	3250	41**	1.07 %	0.44%	1304	1000	304
Total Study Area			10127		32**		0.34%			

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.
**Approximation - see text

Table 5

Emissions of Sulfur Compounds in the Study Area

	Total Emissions Reported As Elemental Sulfur	Actual Emissions: Sulfur Dioxide	Actual Emissions: Hydrogen Sulfide
long tons/year	304,000	593,000	8,000
metric tons/year	309,000	603,000	8,000
short tons/year	340,000	664,000	9,000
95 percent confidence limits	± 15%	± 15%	± 50%

(Emissions from Claus plant tail gasses are approximately 172,000 long tons per year of elemental sulfur or 344 long tons per year of SO_2 [see Table 6, p. 83] and this is included in these totals.)

The Texas Railroad Commission publishes data monthly and annually on the disposition of produced natural gas. Based on this study, hydrogen sulfide is about 11 percent of the acid gas loss as reported in Table 8 of their recent annual reports (see Appendix 3). This is equal to 20 billion cubic feet per year, or about 750,000 long tons of sulfur, equivalent to 58 percent of the hydrogen sulfide produced in the study area.

2. Facilities Studied

A total of 261 plants were studied, of which 180 plants are believed to emit more than 50 short tons of sulfur dioxide per year in the study area. Also, approximately another 40 to 50 plants were identified, but no data were recorded due to their extremely small size.

It was not possible to obtain data on plant intake for all plants. Some firms, particularly pipeline companies, did not wish to disclose annual volumes. In other cases, the same gas may be processed by more than one facility. Not all "Gas Sweetening Plant Intake" as shown in Table 4 and Appendix 6 is sour. Some sweet gas often by-passes the sweetening unit, but many operators did not have complete data available and reported total gas processed as sweetening plant intake. Thus, the data on the share of gas production that is treated should be used only as a rough approximation.

It is common practice in West Texas for the same gas to be processed several times. One operator of a major plant which processes over 100 billion cubic feet per year, sweetens gas to each individual customer's specifications. Obviously this process greatly complicates calculations of emissions for the operator. Not all gas leaving the plant is of regular pipeline quality. That gas which is not sweetened by the processor is sweetened by the customer down the line either in his own plant or in a contractor's "line straddle" plant. In other instances, gasoline plants operate on sour gas. These gasoline plants sweeten their gasoline product and, at times, their fuel. They sell their still unsweetened residue "gas" to a gas pipeline company who sweetens it.

Because much of the gas in West Texas is only slightly sour, up to about 200 grains of H_2S/100 scf (0.32 mol percent), a great deal of partial processing of gas takes place. In the Smackover area, the gas is generally more sour, and so each plant there does a complete job of sweetening the gas up to pipeline standards.

The variations in hydrogen sulfide content also affect the use of sour gas within gas treating plants and for heating purposes at the lease operations. A total of 30 plants in Texas reporting hydrogen sulfide losses sent some unprocessed gas back to lease operations or vented unprocessed gas. Of these, 28 were in West Texas. Since many West Texas plants are fed by several streams, only one or two of which may be sour, the unprocessed gas can, and often may, be sweet. Further details on the use of unprocessed gas are contained in Item C.6 of this report (p. 89).

Another factor, which does not affect total emissions, is the use of sour gas as boiler and compressor fuel. Some companies always use sweet fuel because of the corrosive effect of sour fuel. Other companies have learned to cope with corrosion and hence use sour fuel for in-plant purposes. Since the point of emission of exhaust gases from these facilities is generally lower than a flare stack, emissions will result in somewhat higher ground level concentrations of sulfur oxides closer to the plant.

3. Sulfur Recovery Plants

In the study area, there are 55 plants that recover sulfur or sulfur products. These plants have an average production of 50 long tons per day of sulfur and recover an average of 85.3 percent of the sulfur in the acid gas feed.

Several factors affect the efficiency of sulfur recovery plants:

- Percent of capacity. Newer plants tend to achieve higher efficiencies because they are operated closer to designed conditions than older plants which serve partially depleted fields.

- Carbon dioxide content of acid gas. The presence of carbon dioxide in the acid gas can have dramatic effects on efficiency, a factor not present in Claus sulfur recovery plants located at refineries. Recovery efficiency varies directly with the percent of hydrogen sulfide in the acid gas stream. For pure or nearly pure hydrogen sulfide streams, efficiencies of three stage new plants are designed to reach in the range of 95 percent, but if the stream is only 5 to 10 percent hydrogen sulfide, recoveries of sulfur may be as low as 10 to 20 percent.

- Number of stages. Some older sulfur recovery plants have only one stage, but most of those in the survey have two stages. New plants with large capacities often have three stages. Practical recovery efficiency of plants processing pure hydrogen sulfide streams rises from about 75 percent with one stage to about 90 percent with two stages and 95 percent with three stages.

- Measurement accuracy. Nearly all gas treating plants have an acid gas meter. The corrosiveness of hydrogen sulfide tends to enlarge the orifice hole, reducing the apparent pressure drop. Another common practice is to analyze acid gas streams by taking a sample in a pressure container back to a laboratory. Hydrogen sulfide tends to react with the container resulting in erroneously low analyses, especially in streams containing less than 0.1 mol percent. Thus, both metering and stream analysis errors tend to understate the amount of acid gas and overstate apparent plant efficiency.

Table 6 summarizes the data on the 55 sulfur recovery plants. These plants:

- process 37 percent of all gas sweetened.
- process 89.9 percent of all sulfur produced from the ground as hydrogen sulfide.
- emit 57 percent of the sulfur dioxide emissions resulting from gas sweetening.

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TABLE 6

Plants Recovering Sulfur and Sulfur Products From Natural Gas
In Air Quality Control Regions in the Study Area

AQCR	Location	No. of Plants	Gas Sweetening Plant Intake MMMCF/YR	% of Sweetened Gas Processed In Plants With Sulfur Recovery	Quantities in Thousand LT/Yr			Average Recovery Efficiency %
					Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted *	
155 (N.M.)	Pecos Permian Basin	5	116	20	61	48	13	78
218 (TX)	Midland-Odessa San Angelo	19	584	32	175	126	49	72
211 (TX)	Amarillo Lubbock	5	252	47	27	22	5	80
217 (TX)	San Antonio	6	71	93	46	34	11	75
215 210 212 214 (TX)	Dallas-Ft. Worth Abilene-Wichita Falls-Austin-Waco-Corpus Christi	3	34	32	75	62	13	82
22 (TX&AR)	Shreveport-Texarkana-Tyler	10	114	88	358	314	44	88
5 (MS,AL FL)	Mobile-Pensacola Panama City Southern Miss.	7	63	88	430	394	36	92
TOTAL		55	1234	37	1172	1000	172	85.3

*As estimated by Ecology Audits.
Emitted principally as sulfur dioxide from tail gas incineration.

Appendix 1 contains a list of sulfur recovery plants in the study area.

In at least three cases, the sulfur plant makes sulfuric acid instead of sulfur when it is profitable to do so. Two plants bubble hydrogen sulfide through an ammonia solution. The remaining plants produce elemental sulfur.

Of the 55 plants, only one does not utilize the Claus process. A Stretford unit has been in the start-up stages for over a year to remove hydrogen sulfide from an acid gas stream with a very high carbon dioxide content. To date, the Stretford unit has not yet consistently met even the very low recovery efficiency of the Claus plant it replaced.

Many sulfur recovery plants, particularly smaller units, operate unattended. It would be a major error to compare these plants with Claus plants at refineries because the refinery units rarely have carbon dioxide, which markedly reduces the operating efficiency, and they do have 24 hour on-site availability of chemical engineers, instrumentation specialists and maintenance personnel. Many of the small and medium-sized sulfur plants operate with semi-skilled personnel. Engineers and maintenance personnel often only visit the plants periodically. As a result, Ecology Audits believes that, considering the operating handicaps, the state of the art limits three-stage plant efficiency to about 90 percent on a long-term basis, with reductions for increases in carbon dioxide content in the acid gas.

4. Gas Sweetening Facilities

There were 125 facilities studied in this survey, each of which appeared to emit more than 50 tons of sulfur dioxide annually. It is likely that there may be another 10 or 15 facilities which were not included because, based on preliminary review of reported data, they produced less than the 50 tons per year used as a minimum in the study.

Many of these plants were associated with gasoline plants, but a surprising number, about one-third, are not included in petroleum regulatory agency records. Petroleum regulatory agencies are concerned principally with liquids and if a gas sweetening plant collects no liquids, and many do not, then there is no need to furnish reports. The only way these facilities have been identified is through the survey work of field personnel of the various state air control agencies and the reports furnished by the plant operators.

The gas sweetening plants:

- process 63 percent of all gas sweetened.
- process 10.1 percent of all sulfur produced from the ground.
- emit 43 percent of sulfur dioxide emissions resulting from gas sweetening.

5. Estimates for Balance of United States

The Natural Gas Industry marketed approximately 21,000 billion cubic feet of natural gas in 1973. By using the ratio of production to sales in Texas of 1.1:1, U.S. production is estimated to be about 23,000 billion cubic feet annually.

Table 7 provides details on the estimated natural gas production of other states and the estimates of sulfur dioxide emissions. It shows that the study area includes 87 percent of all sulfur production, 92 percent of recovered sulfur and about 74 percent of the sulfur emissions. Below are comments on the sulfur content of production of the states:

- Alaska - all gas is sweet.
- Arkansas - all production in the northern half of the state is sweet.

TABLE 7

U.S. NATURAL GAS AND SULFUR DATA NOT INCLUDED IN SURVEY

State	Estimated 1973 Natural Gas Production Billions of Cubic Feet	Quantities in Thousand LT/YR: Estimated Sulfur Production	Estimated Sulfur Recovered	Estimated Sulfur Emissions
Arkansas (N)	121*	--	--	--
California	504*	6	1	5
Colorado	130*	1*	--	1*
Kansas	900	5	--	5
Kentucky	90	--	--	--
Louisiana (S)	8,000	2*	--	2*
Michigan	44*	5	--	5
Montana	58*	3	--	3
North Dakota	30*	62*	42*	20
New Mexico (NW)	480*	10	--	10
Ohio	50	1	--	1
Oklahoma	1,800	30	3	27
Pennsylvania	70	--	--	--
Utah	50	--	--	--
West Virginia	250	--	--	--
Wyoming	370*	72	47*	25
Other States	75	--	--	--
		197	93	104
95 percent confidence limits		± 35%	± 20%	± 50%

*Based on information provided by various state agencies. Other data is estimated based on knowledge of the area.

- California - most California production is sweet, with the exception of some in the Santa Barbara area and offshore.
- Colorado - all production is sweet except for some small fields on the western slope.
- Kansas - some sour gas may exist in the southwestern part of the state.
- Kentucky - no known sour gas production.
- Louisiana - there are fewer than 10 fields that have sour production. All are within 100 miles of New Orleans and flare their acid gas. With this exception, all gas in the state and offshore is sweet.
- Michigan - many of the newer discoveries are sour.
- Montana - some sour production occurs in this state although there are no known sulfur recovery plants.
- New Mexico - there is some sour production in the northwest part of the state.
- North Dakota - some gas in North Dakota is sour and at least one sulfur recovery plant operates in this state.
- Ohio - there is some minor sour gas production.

- Oklahoma - most gas produced in this state will have the same characteristics as that of the Texas Panhandle. One sulfur plant operates in this state.
- Pennsylvania - no known major sources of sour gas.
- Utah - no known major sources of sour gas.
- West Virginia - no known major sources of sour gas.
- Wyoming - a significant portion of Wyoming gas is sour. Four sulfur recovery plants are operated in the state.

All data marked with asteriks (*) in Table 7 were furnished by state agencies and is considered accurate. All other data have been estimated by Ecology Audits and, as indicated in Table 7, are subject to a considerable degree of uncertainty, especially in the estimates of emissions.

6. <u>Fuel Use and Venting of Gas Prior to Processing</u>

The venting and fuel use of gas can take place either within a plant or at other locations in the field.

The data collected by most agencies concentrates on the emissions by plants and large identified facilities. In this report data are compiled on total plant intake, the average sulfur content of gas, sulfur recovery and the balance which is assumed to be flared or vented. From an emissions standpoint, it made no difference whether an operator used sour or sweet gas in his plant process heaters so long as the gas was part of total plant intake.

Some gathering systems do not deliver all of their gas to a plant. The gas not delivered to a plant is often used in field process heaters, or it is vented or flared. For example, if the gathering system develops a leak, the gas in the system will be flared in the field to purge the lines.

The reports for Texas were careful to distinguish whether the venting and fuel use took place after (Section III, lines 4 and 13 of GP-1) or before (Section II, lines 1 and 9 of GP-1) it became part of a plant's intake. No other state compiled this type of data.

Ecology Audits compiled data on 30 gathering systems associated with plants known to process sour gas. It was assumed that the gathering system gas had the same hydrogen sulfide content as the gas entering the plant served by the system. This is a conservative assumption since many gas plants have several feed streams and often only one or two will be sour. The available data does not indicate whether the gas used or vented outside the plant was sweet or sour. All but two of these 30 systems are in West Texas. Table 8 summarizes the data on this venting and field use. The emissions from this are included in Table 4.

In summary, over 99 percent of the emissions of sulfur compounds take place after the gas has entered the plant. Only a minor portion is emitted from produced gas in the field. Furthermore, the venting and fuel use of unprocessed gas generally takes place only in areas where the hydrogen sulfide content of the gas is relatively low.

Table 8

Disposition of Sour Unprocessed Gas
From Gathering Systems in Texas

Fuel System and Lease Use	9084 MMCF/year
Vented	561 MMCF/year
Total	9647 MMCF/year*
Sulfur emissions	1233 long tons/year
Average hydrogen sulfide content of unprocessed gas	0.34 percent
Portion of all Texas emissions represented by unprocessed gas	0.60 percent
Portion of Texas field vented and fuel gas to total gas sweetening plant intake	0.29 percent

*The numbers are probably under-reported because some lease fuel is used before metering. However, this is negligible.

APPENDICES

1. List of Plants Studied
2. Production of Sulfur by Counties
3. Report Forms Used by Several State Petroleum Regulatory Agencies
4. Copy of Letter Sent to Multi-plant Operators
5. Ecology Audits, Inc. Data Forms
6. Tabular Data for Plants Studied
7. M. W. Kellogg's Evaluation of the Assumptions, Methods and Results in IV.
8. Call Reports Made in Connection with a Study of Sulfur Compound Emissions of the Petroleum Production Industry

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1. LIST OF PLANTS STUDIED

1. LIST OF PLANTS STUDIED

(Texas)

AQCR	COUNTY	FIRM	PLANT NAME	SULFUR RECOVERED
215	Hunt	Quinlan Processing	Quinlan	
	Kaufman	Belco Petroleum	Tawakoni Gas	
	Navarro	Gulf Energy Development Co.	Powell Gas Treating	X
217	Atascosa	Atlantic Richfield Co.	Fashing	X
	"	Elcor Chemical Co.[1]	"	X
	"	Lone Star Gas Co.	"	
	"	Warren Petroleum Co.	"	X
	"	Exxon Company, USA	Jourdonton	X
	Gonzales	HNG Petrochemicals	DuBose	
	Karnes	LoVaca Gathering Co.	Persons	X
	"	Shell Oil Co.	Person	X
22	Camp	Texas Oil & Gas Co.	Gilmer	X
	Cass	Shell Oil Co.	Bryan's Mill	X
	Franklin	Getty Oil Co.	New Hope	X
	"	Texas Oil & Gas Co.	Chitsey	
	Gregg	Cities Service Oil Co.	East Texas	
	Hopkins	Burmah Oil & Gas	Birthright	X
	"	Schneider, Josey & Corey	Nelta	
	"	Warren Petroleum Co.	Como	X
	Upshur	Arkansas Louisiana Gas Co.	Gilmer	
	Van Zandt	Amoco Production Co.	Edgewood	X
	"	Cities Service Oil Co.	Myrtle Springs	X
	Wood	Amoco Production Co.	West Yantis	X
210	Fisher	Continental Oil	Hamlin	
	Scurry	Monsanto Co.	Diamond M	
211	Carson	Shell Oil Co.	Bryan	
	"	Skelly Oil Co.	Crawford	
	"	"	Schafer	

1] Bought acid gas stream from Lone Star Gas Co. Plant has been shut down.

1. LIST OF PLANTS STUDIED

(Texas)

AQCR	COUNTY	FIRM	PLANT NAME	SULFUR RECOVERED
211	Cochran	Cities Service Oil Co.	Lehman	X
	Gray	Skelly Oil Co.	King's Mill	
	Hansford	Phillips Petroleum Co.	Sherman	
	Hockley	Amoco Production Co.	Slaughter	X
	"	" " "	Levelland	
	"	" " "	Anton Irish	
	"	P-C Gas Systems	Levelland	
	Hutchinson	Colorado Interstate	Sanford	
	"	Phillips Petroleum Co.	Candiam	
	"	Texas Sulfur Products 2]	"	X
	"	Skelly Oil Co.	Watkins	
	Moore	Colorado Interstate	Bivins	
	"	Diamond-Shamrock	McKee	X
	"	Phillips Petroleum Co.	Sneed	
	"	" " "	Dumas	
	"	Texas Sulfur Products 2]	Dumas	X
	"	Panhandle Eastern	Cabot Booster	
	Wheeler	Natural Gas Pipeline	Plant #163 (Briscoe)	
	Yoakum	Amoco Production Co.	Prentice	
	"	Shell Oil Co.	Wasson	
212	Freestone	Getty Oil Co.	Teas	X
	Limestone	Lone Star Production Co.	Box Church	
214	Bee	Coastal States Gas Co.	Pawnee	
	McMullen	Transcontinental Gas Pipeline Co.	Tilden	X
	Kenedy	Exxon Company, USA	Sarita	
218	Andrews	Amoco Production Co.	Midland Farms	X
	"	" " "	South Fullerton	X
	"	El Paso Natural Gas Co.	Fullerton	
	"	Phillips Petroleum Co.	Fullerton	
	"	" " "	Andrews	X
	"	Union Oil Co.	Bakke	
	"	" " "	Dollarhide	
	"	Texaco, Inc.	Mabee	

2] Buys acid gas from nearby Phillips plants.

1. LIST OF PLANTS STUDIED

(Texas)

AQCR	COUNTY	FIRM	PLANT NAME	SULFUR RECOVERED
218	Crane	El Paso Natural Gas	McElroy	
	"	Mobil Oil Corp.	Sand Hills	
	"	Phillips Petroleum Co.	Crane	X
	"	Warren Petroleum Co.	Waddell	X
	"	" " "	Sand Hills	X
	"	Atlantic Richfield Co.	Block 31	
	"	Exxon Company, USA	Sand Hills	X
	Crockett	El Paso Natural Gas co.	Midway Line	
	"	Ozona Gas Processing	Ozona	
	"	Permian Corp.	Todd	
	"	Perry Gas Processors	N. Tippett	
	"	Texas Oil & Gas Co.	MPI	
	Dawson	Cities Service Oil Co.	Welch	X
	Ector	Amarillo Oil Co.	Andector	X
	"	Amoco Production Co.	N. Cowden	X
	"	El Paso Natural Gas Co.	Goldsmith	
	"	Getty Oil Co.	Headlee	
	"	Phillips Petroleum Co.	Goldsmith	X
	"	Shell Oil Co.	TXL	
	"	Odessa Natural Gasoline	Texas	X
	Gaines	Amoco Production Co.	Cedar Lake	
	"	Phillips Petroleum Co.	Seminole	
	"	Cities Service Oil Co.	West Seminole	
	"	" " " "	Sulfur Plant No. 67	X
	Howard	Skelly Oil Co.	East Vealmoor	
	Irion	CRA, Inc.	Mertzon	
	Midland	Mobil Oil Co.	Pegasus	
	Pecos	El Paso Natural Gas Co.	Santa Rosa	
	"	Hassie Hunt Trust	N. Puckett	
	"	Intratex Gas. Co.	W. Gomez	
	"	Mobil Oil Co.	Waha	
	"	" " "	Coyanasa	X
	"	Northern Natural Gas. Co.	Pikes Peak	
	"	" " " "	Jasper	
	"	Texas Oil & Gas	Coyanasa	
	"	LoVaca Gathering Co.	Gomez	

1. LIST OF PLANTS STUDIED

(Texas)

AQCR	COUNTY	FIRM	PLANT NAME	SULFUR RECOVERED
218	Pecos	LoVaca Gathering Co.	W. Gomez	
	"	" " "	Petco	
	"	Marathon Oil Co.	Yates	X
	"	Transwestern Pipeline Co.	Chenot-Putnam	
	"	Atlantic Richfield Co.	Imperial	
	Reagan	Dorchester Gas Co.	Texon	X
	"	Pecos Co.	Barnhart	X
	Reeves	Pioneer Natural Gas Co.	Barstow	
	"	El Paso Natural Gas Co.	Waha	
	"	LoVaca Gathering Co.	Greasewood	
	"	Texaco, Inc.	Knight	
	Schleicher	Atlantic Richfield Co.	El Dorado	
	Tom Green	Beacon Gasoline	H. J. Strawn	
	" "	Marathon Oil	Suzan Peak	
	Upton	El Paso Natural Gas Co.	Wilshire	
	"	Atlantic Richfield Co.	Crane	
	Ward	Cabot Corp.	Estes	
	"	Intratex Gas	MiVida	X
	"	Natural Gas Pipeline	Plant #160 (Pyote)	
	"	Northern Natural Gas Co.	Lockridge	
	"	Perry Gas Processors	Pyote	
	"	Warren Petroleum Co.	Monohans	
	"	LoVaca Gathering Co.	MiVida	
	"	" " "	Pyote	
	"	" " "	Block 21	
	"	Transwestern Pipeline Co.	Pyote	
	"	" " "	Estes	
	Winkler	Amoco Production Co.	Monohans	
	"	Perry R. Bass	Halley	
	"	Cabot Corp.	Walton	
	"	Northern Natural Gas	Kermit	
	"	Transwestern Pipeline Co.	Halley	
	"	" " "	Walton	
	"	" " "	Plant #164 (Kermit)	
	"	" " "	Keystone	
	"	Natural Gas Pipeline	Kermit	
	"	Texaco, Inc.	South Kermit	

1. LIST OF PLANTS STUDIED

(New Mexico)

AQCR	COUNTY	FIRM	PLANT NAME	SULFUR RECOVERED
155	Eddy	Amoco Production	Empire Abo	X
	"	Yates Gasoline (operated by Transwestern)	Artesia	
	"	Southern Union Gas	Indian Hills	
	"	Marathon Oil Co.	Indian Basin	X
	"	Phillips Petroleum Co.	Artesia	X
	"	" " "	Lusk	
	Lea	Climax Chemical	Hobbs	X
	"	Continental Oil	Maljamar	
	"	El Paso Natural Gas	Monument 3]	
	"	" " "	Jal No.1	
	"	" " "	Jal No.3	
	"	" " "	Jal No. 4	
	"	" " "	Eunice 4]	
	"	Northern Natural Gas	Hobbs	
	"	Perry Gas Processors	Antelope Ridge	
	"	Tipperary-Resources	Denton-Lovington	
	"	Warren Petroleum Co.	Monument 3]	
	"	" " "	Saunders	
	"	" " "	Eunice	
	"	" " "	Tatum	
	"	Texaco, Inc.	Buckeye	
	"	Skelly Oil Co.	Eunice No. 1	
	"	" " "	Eunice No. 2	
	"	Phillips Petroleum Co.	Wilson 4]	
	"	" " "	Lovington	
	"	" " "	Eunice 4]	
	"	" " "	Hobbs	
	"	" " "	Buckeye	
	"	Transwestern Pipeline Co.	Belle Lake	
	Roosevelt	Cities Service Oil Co.	Bluitt	X

3] Acid gas from these plants is sold to Climax Chemical, Hobbs.

4] Wilson and Eunice plants of Phillips are adjacent. Eunice acid gas stream goes to El Paso Eunice plant.

1. LIST OF PLANTS STUDIED

(Arkansas, Mississippi, Alabama and Florida)

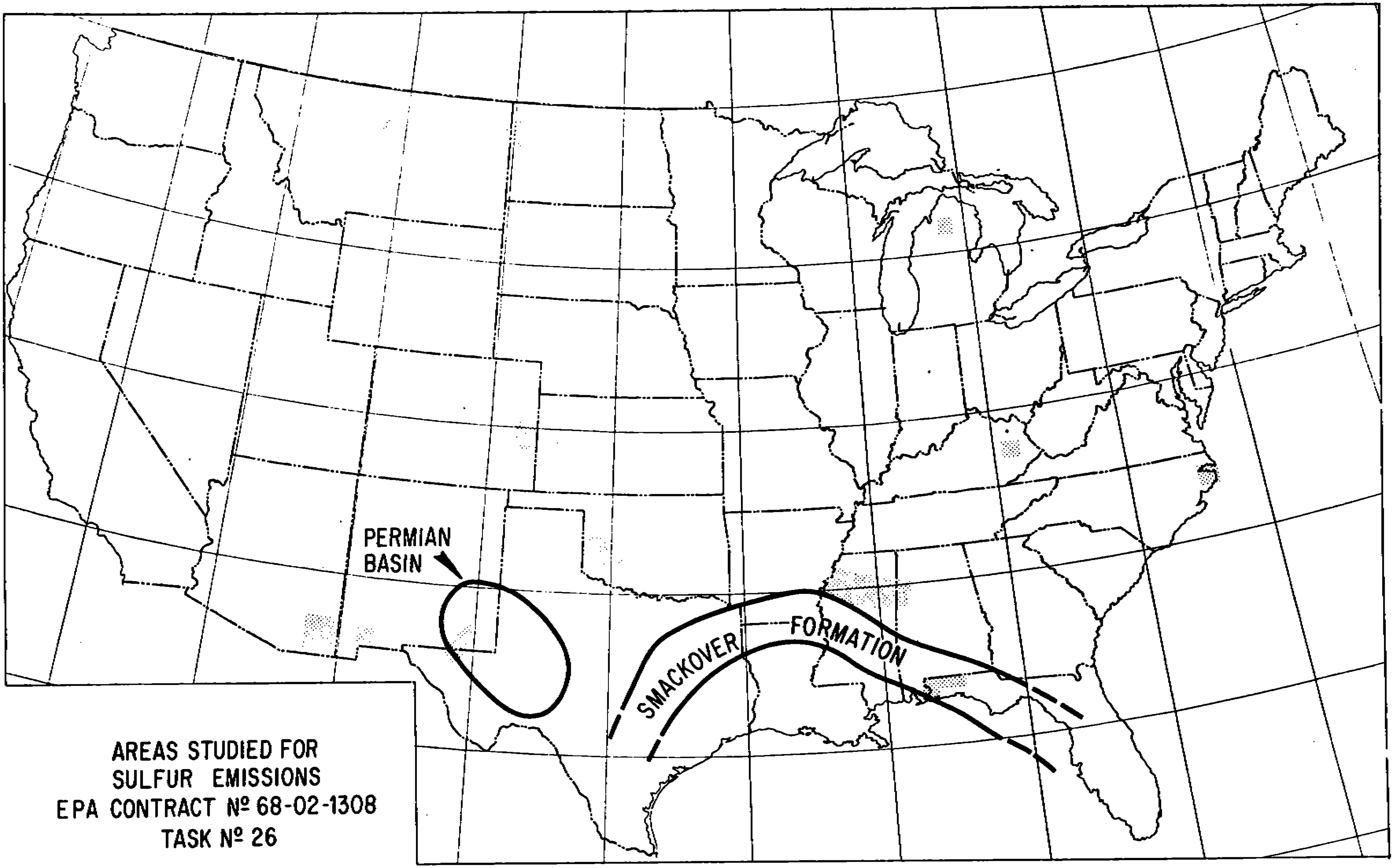
AQCR	COUNTY	FIRM	PLANT NAME	SULFUR RECOVERED
22 Arkansas	Columbia	Arkansas-Louisiana Gas	Hamilton	X
	Lafayette	Phillips Petroleum Co.	McCamey	X
5 Mississippi	Clarke	Shell Oil Co.	Goodwater	X
	"	Tonkawa Gas Co.	Harmony	
	"	Continental Oil Co.	Pachuta Creek & West Nancy	
	"	Getty Oil Co.	Pachuta Creek Area	
	"	Amerada-Hess	Eucutta Station	
	Smith	Shell Oil Co.	Tallahala Creek	
	Rankin	" " "	Thomasville	X
	Wayne	Amerada-Hess	Quitmon & Cypress Creek	
	"	Mobil Oil	S. Cypress Creek	
5 Alabama	Escambia	Exxon Co. USA	Flomaton	X
5 Florida	Escambia	Louisiana Land & Exploration Co.	Wiggins Lake	X
	"	Exxon Co. USA	Jay	X
	"	Amerada-Hess (Mississippi-Florida)	Jay	X
	"	Sun Oil Co.	Jay	X

2. PRODUCTION OF SULFUR BY COUNTIES

ECOLOGY AUDITS, INC.
9995 Monroe Dr. · Dallas, Texas 75220

2. PRODUCTION OF SULFUR BY COUNTIES

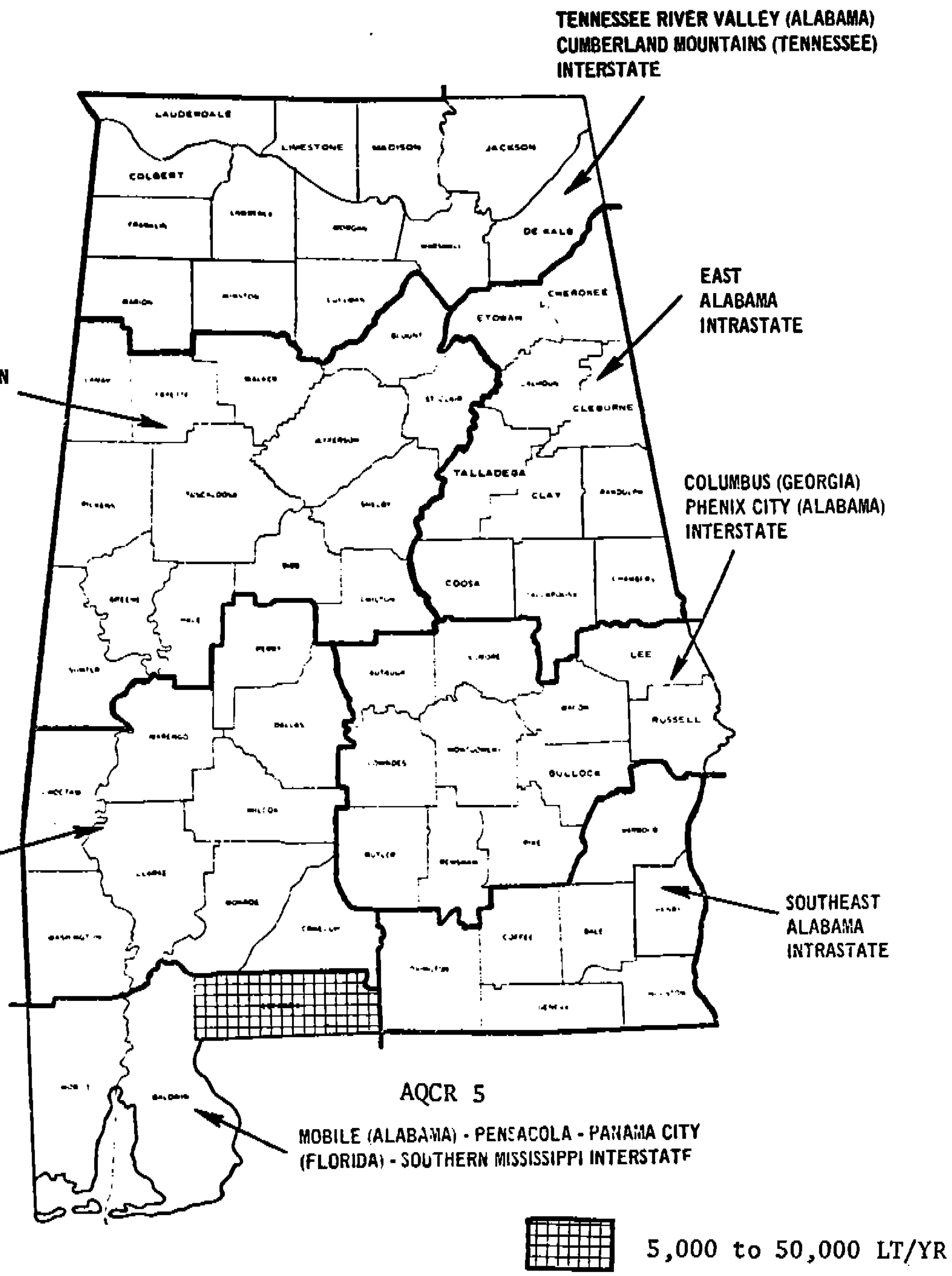
STATE	50,000 or more LT/YR	5,000 to 50,000 LT/YR	500 to 5,000 LT/YR	less than 500 LT/YR
New Mexico	Lea	Eddy Roosevelt		
Alabama		Escambia		
Florida	Escambia			
Mississippi	Rankin	Clarke	Wayne	Smith
Arkansas		Lafayette	Columbia	
Texas	Cass Van Zandt Crane Ector	Franklin Hopkins Wood Andrews Gaines Pecos Reeves Ward Winkler Atascosa Karnes Hockley Moore Yoakum McMullen Freestone	Crockett Dawson Reagan Gonzales Carson Cochran Hutchinson Wheeler Hunt Navarro	Gregg Upshur Howard Midland Schleicher Irion Tom Green Upton Hansford Bee Limestone Fisher Scurry Kaufman Gray



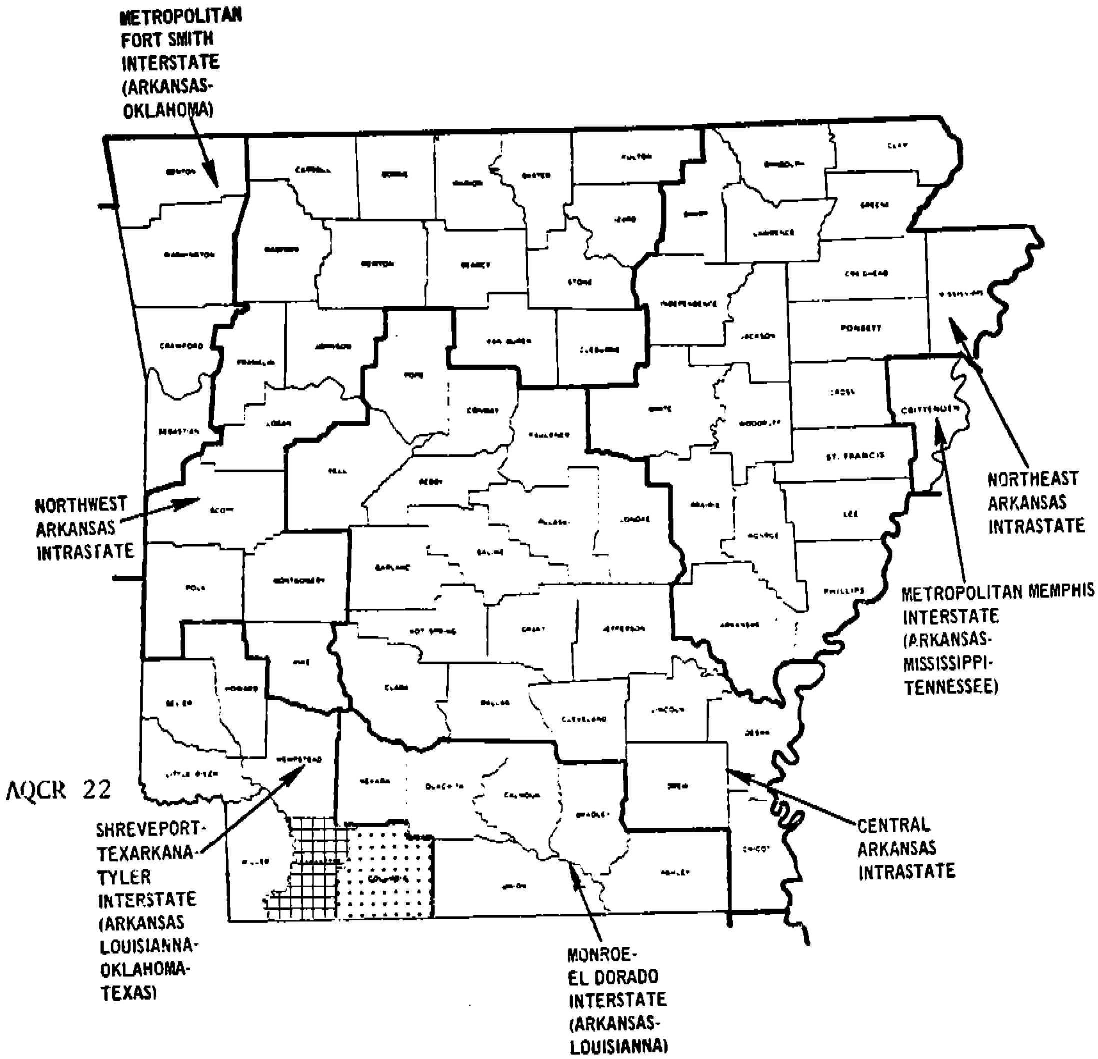
AREAS STUDIED FOR
SULFUR EMISSIONS
EPA CONTRACT № 68-02-1308
TASK № 26

ECOLOGY AUDITS, INC.
Subsidiary of Core Laboratories, Inc.
9995 Monroe Dr. · Dallas, Texas 75220
(214) 350-7893

PRODUCTION OF SULFUR BY COUNTY IN ALABAMA



PRODUCTION OF SULFUR BY COUNTY IN ARKANSAS

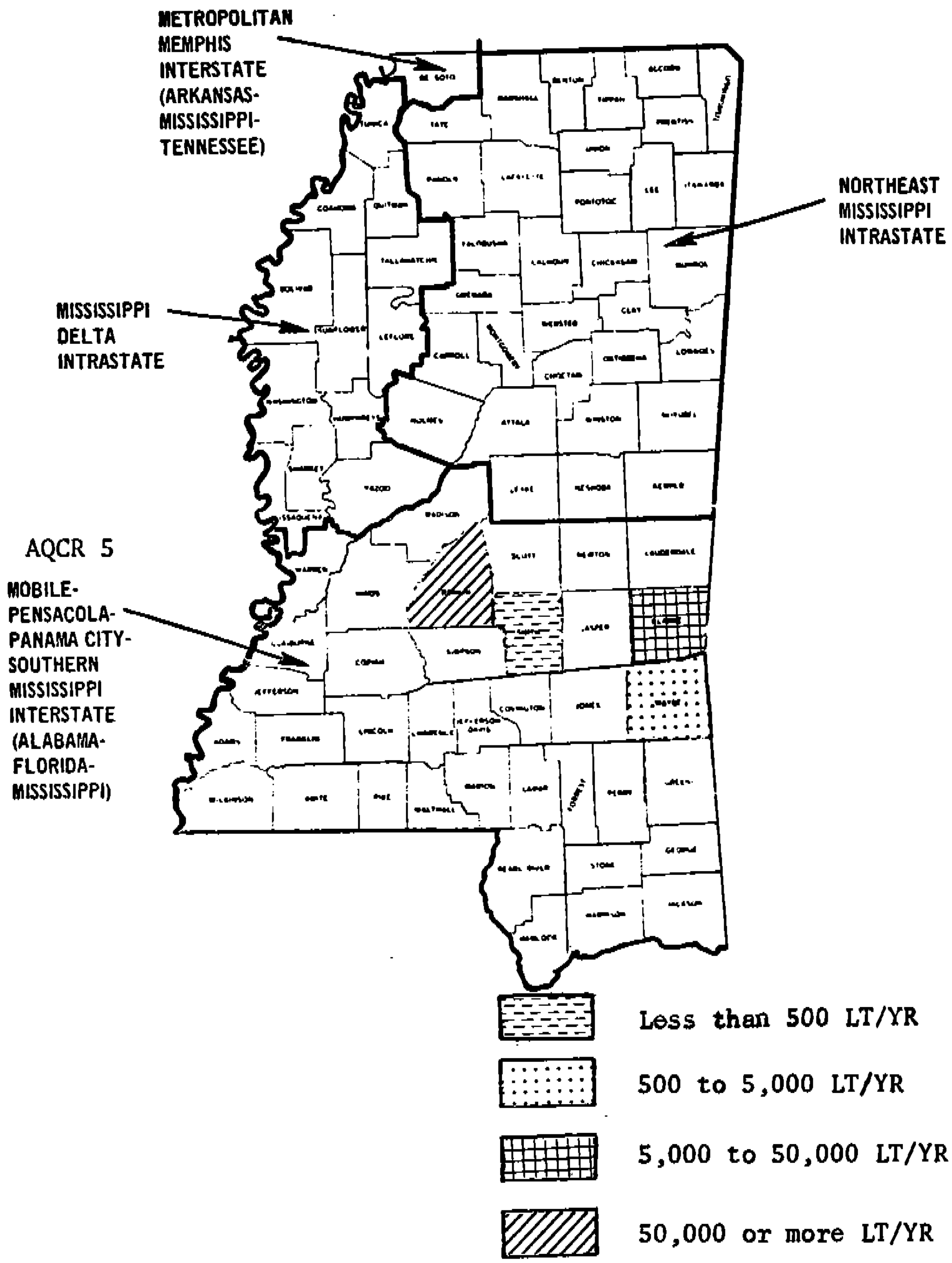


500 to 5,000 LT/YR

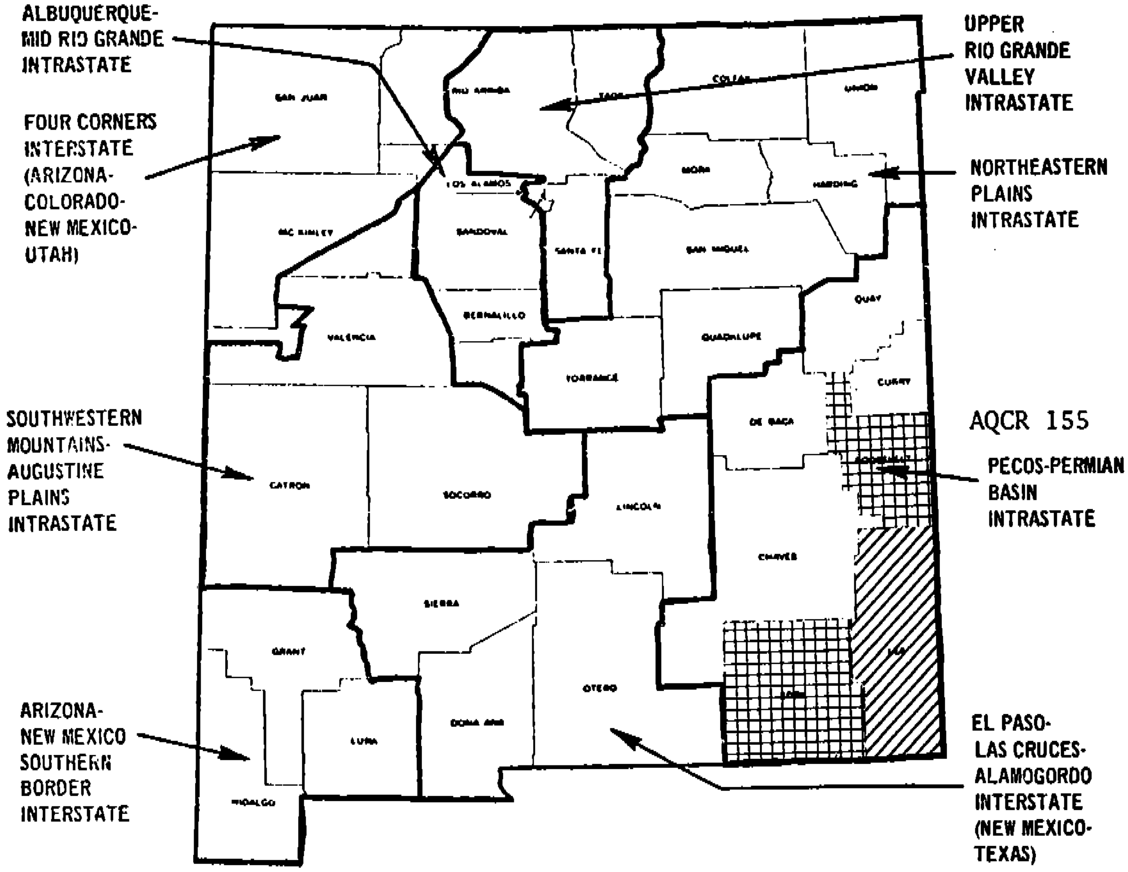
5,000 to 50,000 LT/YR

PRODUCTION OF SULFUR BY COUNTY IN FLORIDA

PRODUCTION OF SULFUR BY COUNTY IN MISSISSIPPI



PRODUCTION OF SULFUR BY COUNTY IN NEW MEXICO

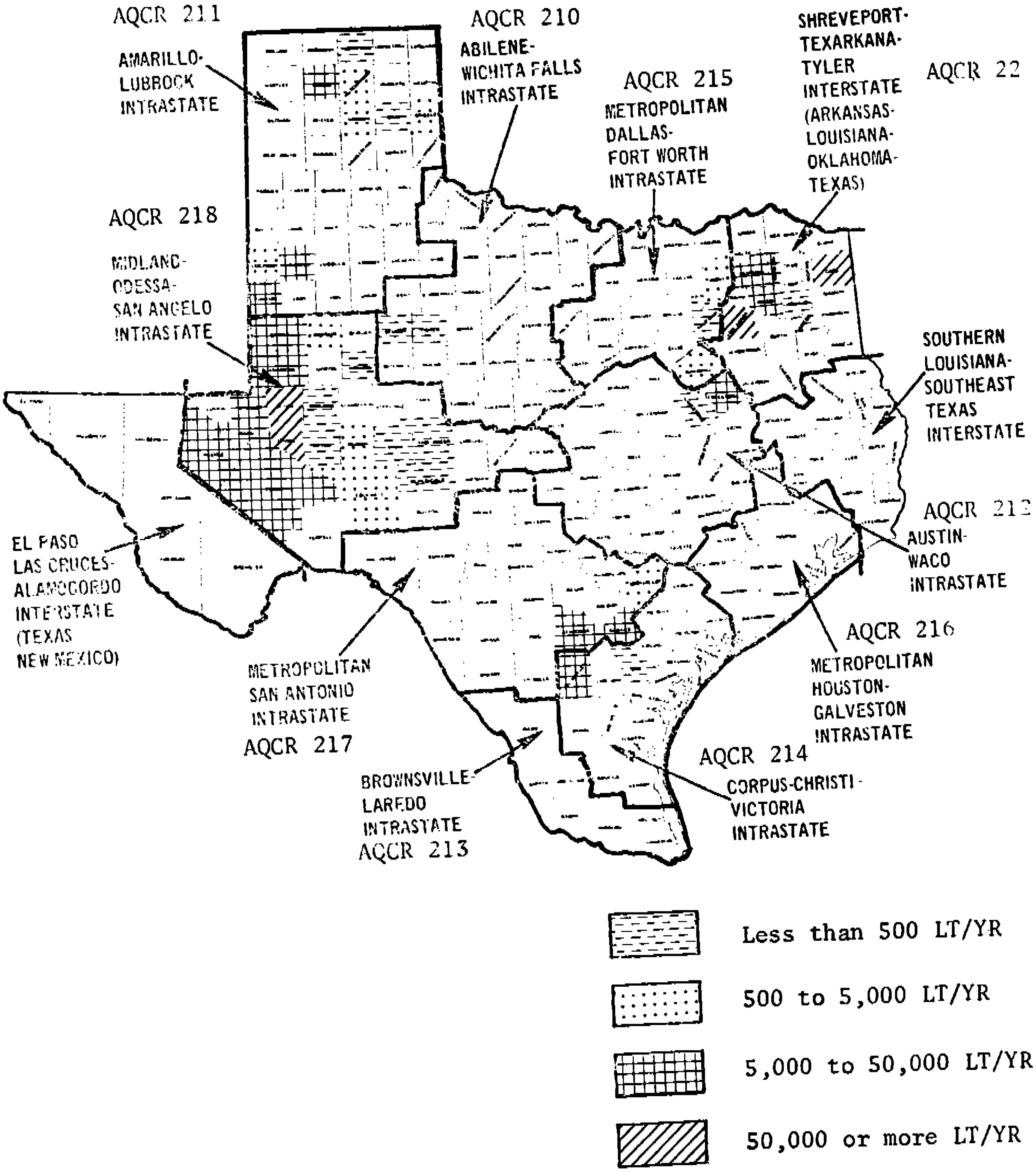


5,000 to 50,000 LT/YR

50,000 or more LT/YR

ECOLOGY AUDITS, INC.
9995 Monroe Dr. · Dallas, Texas 75220

PRODUCTION OF SULFUR BY COUNTY IN TEXAS



3. REPORT FORMS USED BY SEVERAL STATE PETROLEUM REGULATORY AGENCIES

Form A-18
Sheet 1

ALABAMA OIL AND GAS BOARD

GASOLINE OR OTHER EXTRACTION PLANT MONTHLY REPORT

Report of .... for the month of ...., 19..........

Address ....
(Main Office) (Plant)

Report all Volumes in M. C. F. at 14.4 lbs. plus 4 oz. pressure

INTAKE VOLUME		M. C. F.
Total Gas From Oil Wells	(Detail on Sheet 2)	
Total Gas From Gas Wells	(Detail on Sheet 2)	
Total Gas from Other Sources	(Detail on Sheet 2)	
TOTAL		

DISPOSITION OF RESIDUE	M. C. F.
Plant Fuel	
Returned for Lease Fuel	
Sold or Other Disposition (Detail Below)	
Returned to Earth	
Vented	
Shrinkage	
TOTAL	

Detail of Sale or Other Disposition of Residue

NAME OF PURCHASER OR USER	ADDRESS	USED FOR	M. C. F.
TOTAL			

Plant Production, Receipts, Deliveries and Stock, in Barrels of 42 U. S. Gallons

PRODUCE	OPENING STOCK	RECEIPTS	PRODUCTION	DELIVERIES	CLOSING STOCK
Crude Oil					
Condensate					
Gasoline					
Butane					
Propane					
Kerosene					
Other					
TOTAL					

Remarks ....

AFFIDAVIT

STATE OF ....
COUNTY OF ....

Before me, the undersigned authority, on this day personally appeared .... known to me to be the person whose name is subscribed to this report, who after being by me duly sworn on oath or affirmation states that he is authorized to make and execute this report, that this report, including sheet 2, is a true and correct reflection of the record of the operations reported herein, and that no pertinent matter inquired about in this report has been omitted therefrom.

Sworn to and subscribed before me this .... day of .... 19..........

....
Name of Operator

....
(Signature) (Title)

....
Notary Public in and for ....

(Follow instructions on reverse side)

INSTRUCTIONS

The addresses, as required on this report, shall be clear and definite as to street number, city and state.

A report on this form, including sheet 2, shall be made by each operator of a gasoline plant, cycling plant, or any other plant, at which gasoline, butane, propane, condensate, kerosene, oil or other liquid products are extracted from natural gas.

This report shall be filed on or before the 25th day of each calendar month and shall be complete as to data covering the calendar month next preceding the date of filing. An executed copy shall be filed with the Alabama Oil and Gas Board.

NOTE: "Deliveries"—show under "REMARKS" the name of the Transporter and the quantity delivered to each, except deliveries to trucks may be reported in Total only.

On Sheet 2 of this form, group and report by lease the volumes of "Gas from Oil Wells," and the total thereof; group and report by well the volume of "Gas from Gas Wells" and the total thereof; report by each source the volume of "Gas From Other Sources" and the Total thereof; and report the Total Intake Volume from All Sources.

Make a separate report for each plant.

If any space does not apply, fill in the word "none".

Please use the typewriter if possible.

Form A-18
Sheet 2

ALABAMA OIL AND GAS BOARD

GASOLINE OR OTHER EXTRACTION PLANT MONTHLY REPORT

Report of...for the month of..

Report all Volumes in M. C. F. at 14.4 lbs. plus 4 oz. pressure

Detail of Intake Volume

NAME OF PRODUCER	Lease Name	Location			County	Kind of Well	Well No.	Allowable M. C. F.	Take M. C. F.
		S.	T.	R.					
TOTAL									

AOGC-7-(64)

Arkansas Oil and Gas Commission

EL DORADO, ARKANSAS

MONTHLY GAS REPORT

Field__________ County__________

Report of__________ (Name of Initial Taker) For the Month of__________, 19____

Address__________ (Main Office) (Local or Field Office)

Report All Volumes in M. C. F. at 14.4 Lbs. Plus 4 Oz. Pressure

ACQUISITION

Name of Producer	Lease Name	Well No.	Allowable M. C. F.	Production M. C. F.	Over/Under M. C. F.	Accumulated Over/Under M. C. F.
TOTAL						

DISPOSITION

Used For	Name of Company	Address	Volume
Fuel System			
Lease Use			
Transmission System			
Other Disposition (Detail)			
TOTAL			

Remarks:__________

(If space herewith is inadequate—please write letter and attach hereto)

CERTIFICATE

I declare under the penalties of perjury that this report has been examined by me and to the best of my knowledge is true, correct and complete.

INSTRUCTIONS

The addresses, as required on this report, shall be clear and definite as to street number, city and state.

Report on this form all gas taken into a fuel system, transmission system, or any other system, except gas taken into a gasoline, cycling, or other extraction plant gathering system which is required to be reported on Gasoline or Other Extraction Plant Monthly Report, Form AOGC 8-(56). In case the gas from any well is taken by any person other than the producer, then such person taking the gas shall make and file said report. Where such gas is taken from an oil or gas well by the producer, then the producer shall make and file said report.

This report shall be filed on or before the 15th day of each calendar month and shall be complete as to data covering the calendar month next preceding the date of filing. An executed copy shall be filed with the Arkansas Oil and Gas Commission, El Dorado, Arkansas.

Report the volume of gas taken from each gas well separately. Report the volume of gas taken from oil wells by leases. All volumes shall be reported in M. C. F. at 14.4 Lbs. plus 4 Oz. pressure.

AOGC—8—(56)
Sheet 1

ARKANSAS OIL AND GAS COMMISSION

EL DORADO, ARKANSAS

Gasoline or Other Extraction Plant Monthly Report

Report of ______________________ For the Month of ______________________, 19____

Address ______________________ (Main Office) ______________________ (Plant)

Report All Volumes in M. C. F. at 14.4 Lbs. Plus 4 Oz. Pressure

Intake Volume		M. C. F.
TOTAL GAS FROM OIL WELLS	(Detail on Sheet 2)	
TOTAL GAS FROM GAS WELLS	(Detail on Sheet 2)	
TOTAL GAS FROM OTHER SOURCES	(Detail on Sheet 2)	
TOTAL		

Disposition of Residue	M. C. F.
PLANT FUEL	
RETURNED FOR LEASE FUEL	
SOLD OR OTHER DISPOSITION (Detail Below)	
RETURNED TO EARTH	
VENTED	
SHRINKAGE	
TOTAL	

Detail of Sale or Other Disposition of Residue

Name of Purchaser or User	Address	Used For	M. C. F.
TOTAL			

Plant Production, Receipts, Deliveries and Stock, in Barrels of 42 U. S. Gallons

Product	Opening Stock	Receipts	Production	Deliveries	Closing Stock
CRUDE OIL					
CONDENSATE					
GASOLINE					
BUTANE					
PROPANE					
KEROSENE					
OTHER					
TOTAL					

Remarks: ______________________

CERTIFICATE

I declare under the penalties of perjury that this report has been examined by me and to the best of my knowledge is true, correct and complete.

____

INSTRUCTIONS

The addresses, as required on this report, shall be clear and definite as to street number, city and state.

A report on this form, including Sheet 2, shall be made by each operator of a Gasoline Plant, Cycling Plant, or any other Plant, at which Gasoline, Butane, Propane, Condensate, Kerosene, Oil or Other Liquid Products are extracted from Natural Gas.

This report shall be filed on or before the 15th day of each calendar month and shall be complete as to data covering the calendar month next preceding the date of filing. An executed copy shall be filed with the Arkansas Oil and Gas Commission.

NOTE: "DELIVERIES"—show under "REMARKS" the name of the Transporter and the quantity delivered to each, except deliveries to trucks may be reported in Total only.

On Sheet 2 of this form, group and report by lease the volumes of "Gas From Oil Wells," and the total thereof; group and report by well the volume of "Gas From Gas Wells" and the total thereof; report by each source the volume of "Gas From Other Sources" and the total thereof; and report the Total Intake Volume From All Sources.

Make a separate report for each plant.

If any space does not apply, fill in the word "NONE."

Please use typewriter if possible.

Form 8

DEPARTMENT OF NATURAL RESOURCES
STATE OF FLORIDA

MONTHLY PRODUCER'S NATURAL GAS REPORT

Field JAY

Report of CHEVRON (Name of Producer) Month of AUGUST, 1973

[illegible] Blvd., Metairie, La. (Address of Main Office) (Address of Local or Field Office)

REPORT ALL VOLUMES IN M.C.F. AT 14.4 LBS. PLUS 4 OZ. PRESSURE AND 60 F.

PRODUCTION

ZONE—LEASE NAME	Well No.	County	LOCATION Survey	LOCATION Section	Allowable M.C.F.	Production M.C.F.
Foutwell Ut	22-3	Santa Rosa				652
		Purchased Gas for fuel: from Florida Gas Trans. Co.				0
GRAND TOTAL						65?

DISPOSITIONS

UTILIZATION	M. C. F.
Producer's Field Operations (Sun Jay Oil Facility) fuel	[illegible]
Reserved by Lessors	
Vented to Atmosphere from Gas Wells	
Vented to Atmosphere from Oil Wells (Sun-Jay Oil Facility Flare)	26
Others (denote) Plant Shrinkage	120
Sales or Deliveries	

NAME OF COMPANY	ADDRESS	M. C. F.
Florida Gas Transmission Company 1100 Southwest Tower Houston, Texas 77002		443
TOTAL		65?

RECEIVED
SEP 1973
DIV. OF INTERIOR RESOURCES
BUREAU OF GEOLOGY
TALLAHASSEE, FLORIDA

AFFIDAVIT

STATE OF FLORIDA

GASOLINE PLANT OR PRESSURE MAINTENANCE PLANT MONTHLY REPORT

Operator		Address			
Plant Name		Field		County	
Month of	Type of plant	Av. intake capacity MCF	Av. intake pressure PSIA	Av. tested gpm	Recovered gpm

SECTION I—INTAKE VOLUMES (MCF MONTHLY)

	Gas wells	Casinghead	Total
1. No. of wells produced			
2. Gas into gathering system			
3. Deliveries from gathering system. (Total of section II)			
4. Gathering system to plant for processing			
5. Plant intake—from plant meters			
6. Loss or gain—Diff between lines 4 & 5			
7. Gas from other sources (Detail in Remarks)			
8. Refinery and storage vapors			
9. Net gas to plant for processing			

SECTION II—DISPOSITION OF UNPROCESSED GAS FROM GATHERING SYSTEM (MCF MONTHLY)

	Gas wells	Casinghead	Total
1. Fuel system & lease use			
2. Gas lift			
3. Repressuring & pressure maintenance			
4. Transmission line			
5. Vented			
6. Other processing plants or carbon black plants			
7. Total			

SECTION III—DISPOSITION OF RESIDUE GAS (MCF MONTHLY)

1. Extraction loss	2. Acid gas	3. Plant fuel	4. Lease fuel	5. Gas lift	6. Repressuring & press. maint.

7. Carbon black pl.	8. Other proc. pl.	9. Transmiss. line	10. Vented	11. Total

SECTION IV—PLANT PRODUCTION, RECEIPTS, DELIVERIES, FLARE AND STOCK IN 42-GAL. BBLS.

Product	Open'g stock	Receipts	Production	Deliveries	Flare	Clos'g stock
Crude Oil						
Condensate						
Gasoline						
Kerosene						
Butane						
Propane						
Plant Loss						
Total						

Continued on Reverse Side

MISSISSIPPI STATE OIL AND GAS BOARD

Gasoline Plant or Pressure Maintenance Report

FORM 11 - IOCC G-9

Authorized by Order No. 118-58 **Effective November 1, 1958**

SECTION V—DETAIL OF DISPOSITION—DETAIL OF 3, 4, 6 SECTION II, 6, 7, 8, 9 SECTION III

Company	Use	Processed	Unprocessed

1. Reason for venting unprocessed gas

2. Reason for venting residue gas

3.

SECTION VI—DETAIL OF MONTHLY GAS INTAKE (USE FORM ENTITLED "DETAIL OF INTAKE VOLUME" WHEN NECESSARY)

Well owner	Name of lease	Kind of gas	Well number	Take M. C. F.

NOTE: All volumes must be corrected to a pressure of ________ psia and to a temperature of ________ °F.

Executed this the ______ day of ____________, 19____

State of ____________ }
County of ____________ }

____
Signature of Affiant

Before me, the undersigned authority, on this day personally appeared ________________ known to me to be the person whose name is subscribed to the above instrument, who being by me dully sworn on oath states, that he is duly authorized to make the above report and that he has knowledge of the facts stated therein, and that said report is true and correct.

Subscribed and sworn to before me this ______ day of ____________, 19____

SEAL

My commission expires ____________

____
Notary Public in and for ____________
County, ____________

STATEWIDE FORM C-115 (REV 12-1-72)
SUBMIT: ORIGINAL TO OCC SANTA FE
ONE COPY TO OCC DIST. OFFICE
ONE COPY TO TRANSPORTER

NEW MEXICO OIL CONSERVATION COMMISSION

BOX 2088 SANTA FE, NEW MEXICO

OPERATOR'S MONTHLY REPORT

(Company or Operator) ____________ (Address) ____________ FOR MONTH ____________ Page ____ of ____

POOL NAME (Underline) *LEASE NAME WELL NO. UNIT SEC. TWP. RNG.	WELL STATUS	TOTAL LIQUIDS PRODUCED			GAS PRODUCED MCF	DAYS PROD.	DISPOSITION OF GAS						DISPOSITION OF OIL					
		MONTHLY OIL ALLOWABLE	ACTUAL BARRELS PRODUCED	BARRELS OF WATER PRODUCED			VENTED	USED ON LEASE	SOLD	PURCH.	OTHER	CODE	OIL ON HAND BEG. OF MONTH	BARRELS TO TRANS-PORTER	OTHER	CODE	TRANS-PORTER	OIL ON HAND END OF MONTH

*LEASE NAME – Include State Land Lease Number or Federal Lease Number

STATUS CODE
F ..... FLOWING
P ..... PUMPING
G ..... GAS LIFT
S ..... SHUT IN
T ..... TEMP. ABANDONED
I ..... INJECTION

"OTHER" GAS DISPOSITION CODE
X ..... USED OFF LEASE } (DESTINATION MUST BE SHOWN ON FORM C-111)
D ..... USED FOR DRILLING }
G ..... GAS LIFT
L ..... LOST (MCF ESTIMATED)
E ..... EXPLANATION ATTACHED
R ..... REPRESSURING OR PRESSURE MAINTENANCE

"OTHER" OIL DISPOSITION CODE
C ..... CIRCULATING OIL
L ..... LOST
S ..... SEDIMENTATION (BS&W)
E ..... EXPLANATION ATTACHED

I HEREBY CERTIFY THAT THE INFORMATION GIVEN IS TRUE AND COMPLETE TO THE BEST OF MY KNOWLEDGE.

____________ (SIGNATURE) ____________ (DATE)

____________ (POSITION)

NEW MEXICO OIL CONSERVATION COMMISSION
GAS PURCHASERS MONTHLY REPORT

Form C-111 Sheet No. 1
Supersedes old Form C-111 & C-114
Effective 1-1-65

Operator and Address	Plant	Month

REPORT ALL VOLUMES OF GAS IN MCF AT 15.025 PSIA AND 60°F

SECTION I — Volume of Gas Taken	VOLUME — MCF
Total Gas From Oil Wells (Detail on Sheet 2)	
Total Gas From Gas Wells (Detail on Sheet 2)	
Total Gas From Other Sources (Detail on Sheet 2)	
TOTAL TAKES	
Gasoline or Other Extraction Plant Only:	
Deduct Volume That By-Passed Plant and Was Not Processed	
TOTAL PLANT INPUT	

SECTION II — Disposition		ITEM	UNPROCESSED GAS VOLUME MCF	ITEM	PLANT RESIDUE VOLUME MCF
Lease Use	Detail Below	a.		h.	
Gas Drilling Operation	" "	b.		i.	
Gas Lift	" "	c.		j.	
Fuel System	" "	d.		k.	
Returned to Lease For Fuel	" "	e.		l.	
Returned to Earth	" "	f.		m.	
Sold or Other Disposition	" "	g.		n.	
Plant Fuel					
Vented					
Shrinkage					
Totals					
GRAND TOTAL — ALL DISPOSITION					

SECTION III — Detail of Disposition *(Show each individual disposition of items above.) (Attach additional sheets if necessary)*

ITEM	NAME AND ADDRESS OF PURCHASER OR USER	USED FOR	VOLUME — MCF

SECTION IV — Plant Production, Receipts, Deliveries, and Stock in Barrels of 42 U.S. Gallons.

PRODUCT	OPENING STOCK	RECEIPTS	PRODUCTION	DELIVERIES	CLOSING STOCK
Oil					
Condensate					
Gasoline					
Butane					
Propane					
Kerosene					
Other					
TOTAL					

Remarks: ____

____

____

Signature ______________________ Title ______________ Date ______________

RAILROAD COMMISSION OF TEXAS

OIL AND GAS DIVISION

AUSTIN, TEXAS

MEMORANDUM TO: All Plant Operators

SUBJECT: Reporting Facilities on Form GP-1, Monthly Report for Gas Processing Plants

Form GP-1, revised October, 1968, is now available at all District Offices. This form is required to be used by plant operators in filing reports for January, 1969, which are due in the District Office on or before February 25, 1969.

Please note that the new Form GP-1 is designed to facilitate the reporting of a whole plant system (including drips, scrubbers, compressors, etc.) on one report at the option of the operator. Attached are instructions and examples concerning the filing of revised Form GP-1. If further information is needed, please contact the Railroad Commission of Texas, Oil & Gas Division, Production and Proration Section, P. O. Drawer EE, Austin, Texas, 78711.

James C. Bouldin

James C. Bouldin, Director
of Production and Proration

FORM GP-1

MONTHLY REPORT FOR GAS PROCESSING PLANTS AND/OR OTHER FACILITIES REPORTED ON GP-1

GENERAL INSTRUCTIONS

This report shall be filed in four (4) duplicate originals with the District Director of the Railroad Commission of Texas for the District in which the plant is located as soon after the first of the month as possible for the preceding month, and never later than the twenty-fifth of the month.

Form GP-1 is required for all plants processing natural gas. Processing includes recovering liquid hydrocarbons and/or treating gas for H_2S and CO_2. All gas volumes must be reported at a Base Pressure of 14.65 pounds per square inch absolute and a Base Temperature of 60 degrees Fahrenheit. All liquid quantities shown on this report shall be in barrels of 42 U. S. Gallons based on actual physical gauges computed from 100% U. S. Tank Tables or other method of measurement approved by the Commission and corrected from the temperature at the time of measurement to a standard temperature of 60 degrees Fahrenheit.

Do not use fractions of thousands of cubic feet of gas or fractions of barrels of liquid on this report.

CERTIFICATE OF COMPLIANCE

In accordance with Statewide Rule 61, no gasoline plant shall be operated without a Certificate of Compliance approved by the Commission which shall be in effect for a twelve-month period, and is to be renewed each year.

In accordance with Statewide Rule 62, no cycling plant shall be operated without a Certificate of Compliance. Application for Certificate of Compliance shall be filed each year for renewal, August 1. After "Statement of Inspection" on Application has been approved at the District Office, a Certificate of Compliance for Cycling will be issued from the Austin Office.

A Certificate of Compliance for Cycling (where gas is injected into a reservoir for credit to gas wells) is sufficient compliance for all products that may be recovered at the plant.

The Certificate of Compliance for Gasoline Plants and Application for Certificate of Compliance for Cycling Plants, are to be filed in triplicate with the District Director of The Railroad Commission in which District the plant is located.

No Certificate of Compliance is required for other type plants (Drips, Scrubbers, Separators, Dehydrators, etc.) when only condensate or unprocessed liquid hydrocarbons are recovered.

SEMI-ANNUAL CASINGHEAD GAS CONNECTIONS

A semi-annual list of casinghead gas connections is required from all plant operators that gather casinghead gas from oil wells. These lists are to be filed in duplicate with the District Director of the Commission District in which the plant is located on or

before January 15, and July 15, of each year and are to show the connections as of January 1, and July 1, respectively. The list should be arranged by field, operator, lease, RRC lease number, and each well number.

FORM GP-1 INSTRUCTIONS

HEADING

District Number - Railroad Commission District in which the plant is located.

Serial Number - Assigned by District Director of District in which the plant is located.

Plant Name - Name of plant being reported. Several Facilities (Drips, Scrubbers, Compressors, Central Separation Facilities, etc.) may be reported on one Form GP-1 if the plants serve a main system where gas is delivered for final processing and disposition. (See attached examples.)

System Name - Name of system that plant serves, if any.

Fields - Source of Gas Supply

County - Location of Plant

Daily Average Intake Capacity of Plant - The maximum Daily MCF that plant was constructed to process.

SECTION I: INTAKE VOLUMES

When filing a system report, this and all appropriate sections should include, the wells and volumes from all wells connected to the whole system.

1. Number of Wells Produced:

Gas Wells - Total number of sweet, sour, non-associated and/or associated gas wells produced.

Oil Wells - For the purpose of this report, a producing oil well is one that is producing or has an assigned allowable which may be transferred and produced by another well or wells for injection or efficiency purposes.

2. Gas Into Gathering System:

Initial reporting of gas production from wells connected to plant for processing regardless of the ownership and/or operation of the gathering system. The volumes shown as "Gas Into the Gathering System" should be the volumes measured at the well for gas well gas and on the lease for casinghead gas, or these well and/or lease volumes adjusted by a central point delivery meter volume.

Do not include any gas volume into the gathering system that has been previously reported on Form GP-1 for another facility. Gas received from other facilities is correctly reported on Line 8 as "Gas From Other Processing Plants."

3. Deliveries From Gathering System:

Any delivery or use of gas that is not processed for recovery of liquid hydrocarbons.

4. Gathering System to Plant for Processing:

Difference between lines 2 and 3.

5. Plant Intake - From Plant Meters:

Plant intake meter volumes of gas produced by wells connected to gathering system and reported in lines above. Gas volumes reported on Lines 7 through 11 should not be included. Complete Line 5 whether a Loss or Gain from plant is shown.

6. Loss or Gain:

Difference between Lines 4 and 5

7. Refinery and Storage Vapors:

8. Gas from Other Processing Plants:

Gas that is received for further processing from another processing plant or facility being reported on Form GP-1. Show name of plant that gas is received from on this line and the amount of gas in Total Column.

9. Gas From Main Transmission Line:

10. Gas Withdrawn From Storage:

11. Gas Imported From Other States:

Report all gas imported from other States that is received into plant for processing or further disposition. Show name of State on this line and the amount of gas in the Total Column.

12. Net Gas to Plant for Processing:

Total of Lines 5 and Lines 7 through 11.

SECTION II: DISPOSITION OF UNPROCESSED GAS FROM GATHERING SYSTEM

Total disposition must balance and total must agree with volume reported on Line 3, Section I.

Definition of dispositions applicable to this section shown in Section III.

SECTION III: DISPOSITION OF RESIDUE GAS

Extraction Loss

Loss in volume due to removal of liquid hydrocarbons. The volumetric equivalent must be reported for liquids recovered from any type facility when gas volumes are reported. Do not include any H_2S or CO_2 losses in this disposition. Use lines 2 and/ or 3.

Lease Fuel and Use

Gas used, sold, or given for field operations, lease drilling fuel, compressor fuel, etc.

Gas Lift

Gas used, sold, or given for injection into oil wells to lift oil.

Repressuring & Pressure Maintenance

Gas used, sold, or given to maintain or build up reservoir pressure through an injection well in an oil reservoir. Oil wells receive credit for gas injected and reported as "Repressuring and Pressure Maintenance."

Cycling

Normally gas returned to gas cycling projects (gas reservoir or gas cap of associated reservoir) after extraction of hydrocarbon liquids. Gas wells receive credit for gas injected and reported as "Cycled".

Underground Storage

Gas injected into underground storage.

Carbon Black Plant

Gas delivered to a gas Carbon Black Plant.

Other Processing Plants

Gas that is delivered to another gas processing plant or facility being reported on Form GP-1. Gas delivered to Industrial Plants (not reported on Form GP-1) should be reported to Transmission Line.

Transmission Line

Gas used for industrial purposes, irrigation fuel, refinery fuel, etc.

Meter Difference

Difference that occurs within the plants.

Total

Total disposition must balance and agree with total reported on Line 12, Section I.

SECTION IV: SULFUR AND CO_2 RECOVERY

Report in Long Tons and/or Standard Barrels.

You are reminded to complete all sections of Form GP-1 for treating plants whether or not liquid hydrocarbons are recovered. This information is needed for statistical purposes.

SECTION V: PLANT LIQUID HYDROCARBON PRODUCTION

Report all liquid production in this Section and Section VII. The "Total" (Line 9) should reflect total liquid recovery of the system, and production reported as "Condensate From Gas Well Gas" and "Drip and/or Scrubber Oil From Casinghead Gas" must be included. Total on Line 9, Section V, must balance and agree with total reported on Line 5, Section VII. Consider allocated scrubber oil a detail sub-total of the amount of scrubber oil shown on the line above.

Condensate From Gas Well Gas

Drip and/or condensate production from gas well gas when Form GP-1 is used for reporting liquids. Do not report any condensate production on Form P-2 that is reported on Form GP-1.

Drip and/or Scrubber Oil From Casinghead Gas

Scrubber oil recovered in excess of 0.75 barrel per well per month (Statewide Rule 56) is not allowable free and must be allocated back to the oil leases where produced and reported as production by the operator on Form P-1. Disposition of scrubber oil allocated back to leases may be made in the "Other Column" on Form P-1 with 5* as the code. Explanation of 5* (Lost in Casinghead Gas System) should be shown on Form. Furnish this office with an original and one copy of your allocation of excess scrubber oil. List field, operator, lease name, RRC lease number, and number of barrels allocated.

"Drip and/or Scrubber Oil produced in excess of Statewide Rule 56 and allocated back to leases for operator to report on Form P-1" is only a sub-total or detail amount and the liquids shown as such should be included under"Drip and/or Scrubber Oil From Casinghead Gas" in the line above.

Plant Condensate

Report in this category only under conditions approved by the Commission.

"Plant Condensate" and"Condensate From Gas Well Gas"may be combined as production and deliveries in Section VII.

Hydrocarbon Mixtures

For statistical purposes, report the components of any Hydrocarbon or LPG mixes in Section V and Section VII. You may state that product is delivered as a mix in Section VIII.

SECTION VI: DETAIL OF DRIP OR SCRUBBER RECOVERY

This section is to be used to show the detailed scrubber recovery when filing a "System" report.

The name of drip or scrubber, wells, and barrels of liquid recovered from these facilities must be reported in this section, and the wells and liquid production will also be included in Sections I and V above. See examples for proper reporting of these facilities.

SECTION VII AND SECTION VIII: LIQUID OPERATIONS (RECEIPTS, PRODUCTION, AND DELIVERIES)

Report actual product received in Section VIII. If product received is fractionated, the components may be reported on Line 4, Section VII, and included in "Deliveries".

Do not include any products received in the production sections (Section V and Section VII). Production should be only those products extracted from natural gas taken into the plant for processing.

Do not include LPG in underground storage in your plant opening and closing inventories. You may report the initial production of product and include the amount to storage in "Deliveries". Any further Storage Tabulation (Injection, withdrawals, and accumulated balances should be reported on a supplemental sheet.

SECTION IX: REPORT OF GAS INJECTED - REPRESSURING, PRESSURE MAINTENANCE, CYCLING AND UNDERGROUND STORAGE

Report volume of gas returned to reservoirs for each injection well.

If more space is needed, use Form GP-3.

SECTION X: DETAIL OF DELIVERY OF GAS-EXCEPT FUEL SYSTEM AND LEASE USE

Use the proper column for reporting delivery of gas. "Unprocessed Gas" column should be used for dispostion reported in Section II and "Residue Gas" column for disposition reported in Section III.

Complete section even though no delivery or sale of transmission line gas is made.

SECTION XI: REMARKS

State the reason for venting unprocessed and residue gas.

Whenever a report is final, show "Final Report". Do not state report is final if there is a closing inventory of stock reported in Section VII. Form GP-1 must be continued until stock has been disposed of.

Also, note any change in the plant operating name and show the effective date of change.

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MONTHLY REPORT FOR GAS PROCESSING PLANTS

RAILROAD COMMISSION OF TEXAS

OIL AND GAS DIVISION

FORM GP-1
Rev. 10/68

SERIAL NO. 3-1501

DISTRICT NO. 3

FOR THE MONTH OF January, 1969

OPERATOR Total Production Company

ADDRESS P.O. Box 1340-Austin, Texas 78720

PLANT NAME Blanche

SYSTEM NAME Blanche

FIELDS ABC & Blanche

COUNTY Orange

TYPE OF PLANT Gasoline

DAILY AVERAGE INTAKE CAPACITY OF PLANT 170,000

AVG. INTAKE PRESSURE 800 P.S.I.A. AVG. TESTED GPM 1.420 RECOVERED GPM 1.649

REPORT ALL GAS VOLUMES IN MCF AT 14.65 PSIA PRESSURE AND 60° FAHRENHEIT IN ACCORDANCE WITH GAS MEASUREMENT LAW.

Section I: Intake Volumes (MCF monthly)	GAS WELL GAS	CASINGHEAD	TOTAL
1. NO. OF WELLS PRODUCED	80	750	830
2. GAS INTO GATHERING SYSTEM	2,500,025	1,201,419	3,701,444
3. DELIVERIES FROM GATHERING SYSTEM	150,725	30,900	181,625
4. GATHERING SYSTEM TO PLANT FOR PROCESSING	2,349,300	1,170,519	3,519,819
5. PLANT INTAKE – FROM PLANT METERS	2,345,409	1,172,043	3,517,452
6. LOSS OR GAIN – DIFF. BETWEEN LINES 4 & 5	3,891	1,524	2,367
7. REFINERY AND STORAGE VAPORS			
8. GAS FROM OTHER PROCESSING PLANTS J & J Gas Company - Plant No. 3			204,671
9. GAS FROM MAIN TRANSMISSION LINE M & W Pipeline Company			300,960
10. GAS WITHDRAWN FROM STORAGE			
11. GAS IMPORTED FROM OTHER STATES Louisiana			10,009
12. NET GAS TO PLANT FOR PROCESSING			4,033,092

SECTION II: Disposition of Unprocessed Gas from Gathering System (MCF monthly)	GAS WELL GAS	CASINGHEAD	TOTAL
1. FUEL SYSTEM AND LEASE USE	20,450	1,982	22,432
2. GAS LIFT	10,465	12,563	23,028
3. REPRESSURING & PRESSURE MAINTENANCE	22,040	15,071	37,111
4. CYCLED			
5. UNDERGROUND STORAGE			
6. OTHER PROCESSING PLANTS	97,770		97,770
7. CARBON BLACK PLANTS			
8. TRANSMISSION LINE			
9. VENTED		1,284	1,284
10. TOTAL	150,725	30,900	181,625

SECTION III: Disposition of Residue Gas (MCF monthly)

1. EXTRACTION LOSS	173,539	6. GAS LIFT	24,455	11. OTHER PROCESS. PLANTS	
2. H_2S LOSS	11,025	7. REPRESS & PRESS MAINT		12. TRANSMISSION LINE	3,637,461
3. CO_2 LOSS		8. CYCLED		13. VENTED	
4. PLANT FUEL	150,193	9. UNDERGROUND STORAGE		14. METER DIFFERENCE	7,491
5. LEASE FUEL & USE	28,928	10. CARBON BLACK PLANTS		15. TOTAL	4,033,092

SECTION IV: Sulfur and CO2 Recovery

PRODUCTION OF SULFUR FROM PROCESSING NATURAL GAS 100 (Long) TONS. CO_2 - BBLS. TONS

SECTION V. Plant Liquid Hydrocarbon Production (barrels monthly)

CONDENSATE FROM GAS WELL GAS 195 DRIP AND/OR SCRUBBER OIL FROM CASINGHEAD GAS 335

Drip and/or Scrubber Oil produced in excess of Statewide Rule 56 and allocated back to leases for operator to report on Form P-1. 94

1. PLANT CONDENSATE	1,044	4. PROPANE	38,000	7. ETHANE	41,258
2. GASOLINE	50,550	5. BUTANE-PROPANE MIX.		8.	
3. BUTANE	25,133	6. ISO-BUTANE	2,345	9. TOTAL	158,860

SECTION VI: Detail of Drip or Scrubber Recovery (Production included above)

NAME OF DRIP OR SCRUBBER	NO. OF GAS WELLS	NO. OF OIL WELLS	BARRELS
Jameson Compressor Station	10	415	324
Larimore Compressor Plant	0	21	110
Scrubber No. 1	12	4	36
Scrubber No. 2	10	0	60
		TOTAL	530

(Use Attachment If Necessary)

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SECTION VII: Barrels

	Condensate	Drip and/or Scrubber Oil	Gasoline	Butane	Propane	Ethane	Other ~~ISO-Butane~~	Total
1. OPENING BALANCE	201	15	10,019	6,045	3,041	2,055	0	21,376
2. FROZEN STOCK	0	0	0	0	0	0	0	0
3. TOTAL OPENING STOCK	201	15	10,019	6,045	3,041	2,055	0	21,376
4. RECEIVED	52	0	3,015	5,038	3,049	1,151	0	12,305
5. PRODUCED	1239	335	50,550	25,133	38,000	41,258	2,345	158,860
6. DELIVERED	1442	330	56,989	31,952	38,054	39,767	2,345	170,879
7. LOSS	0	0	0	0	0	0	0	0
8. TOTAL CLOSING STOCK	50	20	6,595	4,264	6,036	4,697	0	21,662
9. FROZEN STOCK	0	0	0	0	0	0	0	0
10. CLOSING BALANCE	50	20	6,595	4,264	6,036	4,697	0	21,662

SECTION VIII: Liquid Operations Statement

RECEIPTS			DELIVERIES		
Received from	Commodity	Barrels Received	Delivered to	Commodity	Barrels Delivered
E & S Gas Co.	Hydrocarbon Mix	12,305	L & D Oil Co.	Ethane	39,767
			DXL Oil Company	Condensate	1,442
			do	Scrubber oil	330
			T & P Oil Company	Gasoline	56,989
			do	Butane	31,952
			do	Pro & Iso But Mix	40,399
TOTALS					170,879

SECTION IX: Report of Gas Injected – Repressuring, Pressure Maintenance, Cycling, and Underground Storage

Field and Reservoir	Well Owner	Lease	Well No.	Injection Pressure	MCF Monthly
Blanche /A-1/	Total Production Co.	Ward "A"	1	2600	37,111
		Total		xxxxxxx	37,111

SECTION X: Detail of Delivery of Gas – Except Fuel System and Lease Use (MCF monthly)

Delivered to Whom	Use or Disposition	Unprocessed Gas (Sec. II)	Residue Gas (Sec. III)
J & J Gas Company (Day Plant)	Processing	97,770	
B & H Transmission Co.	Transmission Line		3,623,363
Farmers' Co-OP	Irrigation		14,098

SECTION XI: Remarks

1. REASON FOR VENTING UNPROCESSED GAS Compressor Down
2. REASON FOR VENTING RESIDUE GAS
3.

CERTIFICATE: I, the undersigned, state that I am the Plant Superintendent (TITLE) of the Total Production Co. (COMPANY AND PLANT) and that I am authorized by said company to make this report; and that this report was prepared under my supervision and direction and that the facts stated therein are true, correct and complete to the best of my knowledge.

2-20-69 — Date

T.P. Vitek T. P. Vitek — Signature

512-475-3803 — Area Code and Telephone Number

INSTRUCTIONS:

1. This report shall be filed in four (4) duplicate originals with the District Director of the Railroad Commission of Texas for the District in which the Plant is located as soon after the first of the Month as possible for the preceding Month, and never later than the Twenty-Fifth of the month.
2. This report is required of all Plants processing Natural Gas. All Gas Volumes must be reported at a Base Pressure of 14.65 pounds per square inch absolute and a Base Temperature of 60 degrees Fahrenheit. All liquid quantities shown on this report shall be in barrels of 42 U.S. Gallons based on actual physical gauges computed from 100% U.S. Tank Tables or other method of measurement approved by the Commission and corrected from the temperature at the time of measurement to a standard temperature of 60 degrees Fahrenheit. Do not use fractions of thousands of cubic feet of gas, or fractions of barrels of liquid on this report.
3. Detailed instructions available from Railroad Commission of Texas, Oil & Gas Division, Production & Proration Section, P.O. Drawer EE, Austin, Texas 78711.

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MONTHLY REPORT FOR GAS PROCESSING PLANTS

RAILROAD COMMISSION OF TEXAS

OIL AND GAS DIVISION

FORM GP-1
Rev. 10/68

SERIAL NO. 3-100

DISTRICT NO. 3

FOR THE MONTH OF January, 19 69

OPERATOR Total Production Co.

ADDRESS P.O.Box 1340-Austin, Texas 78720

PLANT NAME Val

SYSTEM NAME T & P Oil Co. Plant #1

FIELDS Val

COUNTY Brazoria

TYPE OF PLANT Compressor Station

DAILY AVERAGE INTAKE CAPACITY OF PLANT 35,000

AVG. INTAKE PRESSURE ______ P.S.I.A. AVG. TESTED GPM ______ RECOVERED GPM ______

REPORT ALL GAS VOLUMES IN MCF AT 14.65 PSIA PRESSURE AND 60° FAHRENHEIT IN ACCORDANCE WITH GAS MEASUREMENT LAW.

Section I: Intake Volumes (MCF monthly)	GAS WELL GAS	CASINGHEAD	TOTAL
1. NO. OF WELLS PRODUCED	10	130	140
2. GAS INTO GATHERING SYSTEM	325,096	500,045	825,141
3. DELIVERIES FROM GATHERING SYSTEM	5,230	25,093	30,323
4. GATHERING SYSTEM TO PLANT FOR PROCESSING	319,866	474,952	794,818
5. PLANT INTAKE – FROM PLANT METERS	319,866	474,952	794,818
6. LOSS OR GAIN – DIFF. BETWEEN LINES 4 & 5			
7. REFINERY AND STORAGE VAPORS			
8. GAS FROM OTHER PROCESSING PLANTS			
9. GAS FROM MAIN TRANSMISSION LINE			
10. GAS WITHDRAWN FROM STORAGE			
11. GAS IMPORTED FROM OTHER STATES			
12. NET GAS TO PLANT FOR PROCESSING			794,818

SECTION II: Disposition of Unprocessed Gas from Gathering System (MCF monthly)	GAS WELL GAS	CASINGHEAD	TOTAL
1. FUEL SYSTEM AND LEASE USE	5,230	5,090	10,320
2. GAS LIFT		4,950	4,950
3. REPRESSURING & PRESSURE MAINTENANCE			
4. CYCLED			
5. UNDERGROUND STORAGE			
6. OTHER PROCESSING PLANTS		15,053	15,053
7. CARBON BLACK PLANTS			
8. TRANSMISSION LINE			
9. VENTED			
10. TOTAL	5,230	25,093	30,323

SECTION III: Disposition of Residue Gas (MCF monthly)

1. EXTRACTION LOSS	282	6. GAS LIFT		11. OTHER PROCESS. PLANTS	150,666
2. H_2S LOSS		7. REPRESS & PRESS MAINT		12. TRANSMISSION LINE	566,893
3. CO_2 LOSS		8. CYCLED		13. VENTED	
4. PLANT FUEL	22,090	9. UNDERGROUND STORAGE		14. METER DIFFERENCE	(-),547
5. LEASE FUEL & USE	55,434	10. CARBON BLACK PLANTS		15. TOTAL	794,818

SECTION IV: Sulfur and CO2 Recovery

PRODUCTION OF SULFUR FROM PROCESSING NATURAL GAS ______ TONS. CO_2 ______ BBLS. TONS

SECTION V. Plant Liquid Hydrocarbon Production (barrels monthly)

CONDENSATE FROM GAS WELL GAS 110 DRIP AND/OR SCRUBBER OIL FROM CASINGHEAD GAS 165

Drip and/or Scrubber Oil produced in excess of Statewide Rule 56 and allocated back to leases for operator to report on Form P-1. 67

1. PLANT CONDENSATE		4. PROPANE		7. ETHANE	
2. GASOLINE		5. BUTANE-PROPANE MIX.		8.	
3. BUTANE		6. ISO-BUTANE		9. TOTAL	275

SECTION VI: Detail of Drip or Scrubber Recovery (Production included above)

NAME OF DRIP OR SCRUBBER	NO. OF GAS WELLS	NO. OF OIL WELLS	BARRELS
(Use Attachment if Necessary)		TOTAL	

SECTION VII: Barrels

	Condensate	Drip and/or Scrubber Oil	Gasoline	Butane	Propane	Ethane	Other	Total
1. OPENING BALANCE	100	50						150
2. FROZEN STOCK	0	0						0
3. TOTAL OPENING STOCK	100	50						150
4. RECEIVED	0	0						0
5. PRODUCED	110	165						275
6. DELIVERED	150	140						290
7. LOSS	0	0						0
8. TOTAL CLOSING STOCK	60	75						135
9. FROZEN STOCK	0	0						0
10. CLOSING BALANCE	60	75						135

SECTION VIII: Liquid Operations Statement

RECEIPTS			DELIVERIES		
Received from	Commodity	Barrels Received	Delivered to	Commodity	Barrels Delivered
			DXL Oil Co.	Condensate	150
			do	Scrubber Oil	140
TOTALS					290

SECTION IX: Report of Gas Injected – Repressuring, Pressure Maintenance, Cycling, and Underground Storage

Field and Reservoir	Well Owner	Lease	Well No.	Injection Pressure	MCF Monthly
		Total		xxxxxxx	

SECTION X: Detail of Delivery of Gas – Except Fuel System and Lease Use (MCF monthly)

Delivered to Whom	Use or Disposition	Unprocessed Gas (Sec. II)	Residue Gas (Sec. III)
J & W Gas Co.-Bexar Plant	Processing Plant	15,053	
T & P Oil Company-Plant #1	Processing Plant		150,666
D & L Pipeline Co.	TransmissionLine		566,893

SECTION XI: Remarks

1. REASON FOR VENTING UNPROCESSED GAS ________
2. REASON FOR VENTING RESIDUE GAS ________
3. ________

CERTIFICATE: I, the undersigned, state that I am the Plant Superintendent (TITLE) of the Total Production Co. (COMPANY AND PLANT) and that I am authorized by said company to make this report; and that this report was prepared under my supervision and direction and that the facts stated therein are true, correct and complete to the best of my knowledge.

2-20-69 — T. P. Vitek — 512-475-3803

Date — Signature — Area Code and Telephone Number

INSTRUCTIONS:

1. This report shall be filed in four (4) duplicate originals with the District Director of the Railroad Commission of Texas for the District in which the Plant is located as soon after the first of the Month as possible for the preceding Month, and never later than the Twenty-Fifth of the month.
2. This report is required of all Plants processing Natural Gas. All Gas Volumes must be reported at a Base Pressure of 14.65 pounds per square inch absolute and a Base Temperature of 60 degrees Fahrenheit. All liquid quantities shown on this report shall be in barrels of 42 U.S. Gallons based on actual physical gauges computed from 100% U.S. Tank Tables or other method of measurement approved by the Commission and corrected from the temperature at the time of measurement to a standard temperature of 60 degrees Fahrenheit. Do not use fractions of thousands of cubic feet of gas, or fractions of barrels of liquid on this report.
3. Detailed instructions available from Railroad Commission of Texas, Oil & Gas Division, Production & Proration Section, P.O. Drawer EE, Austin, Texas 78711.

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MONTHLY REPORT FOR GAS PROCESSING PLANTS

RAILROAD COMMISSION OF TEXAS
OIL AND GAS DIVISION

FORM GP-1
Rev. 10/68

SERIAL NO. 3-409

DISTRICT NO. 3

FOR THE MONTH OF January, 19 69

OPERATOR Total Pipe Line Company

ADDRESS P.O.Box 1340-Austin, Texas 78720

PLANT NAME Main Transmission Line Drip Stations

SYSTEM NAME Arkansas Delivery

FIELDS

COUNTY

TYPE OF PLANT Mainline Drips

DAILY AVERAGE INTAKE CAPACITY OF PLANT

AVG. INTAKE PRESSURE ______ P.S.I.A. AVG. TESTED GPM ______ RECOVERED GPM ______

REPORT ALL GAS VOLUMES IN MCF AT 14.65 PSIA PRESSURE AND 60° FAHRENHEIT IN ACCORDANCE WITH GAS MEASUREMENT LAW.

Section I: Intake Volumes (MCF monthly)	GAS WELL GAS	CASINGHEAD	TOTAL
1. NO. OF WELLS PRODUCED			
2. GAS INTO GATHERING SYSTEM			
3. DELIVERIES FROM GATHERING SYSTEM			
4. GATHERING SYSTEM TO PLANT FOR PROCESSING			
5. PLANT INTAKE – FROM PLANT METERS			
6. LOSS OR GAIN – DIFF. BETWEEN LINES 4 & 5			
7. REFINERY AND STORAGE VAPORS			
8. GAS FROM OTHER PROCESSING PLANTS			
9. GAS FROM MAIN TRANSMISSION LINE			
10. GAS WITHDRAWN FROM STORAGE			
11. GAS IMPORTED FROM OTHER STATES			
12. NET GAS TO PLANT FOR PROCESSING			

SECTION II: Disposition of Unprocessed Gas from Gathering System (MCF monthly)	GAS WELL GAS	CASINGHEAD	TOTAL
1. FUEL SYSTEM AND LEASE USE			
2. GAS LIFT			
3. REPRESSURING & PRESSURE MAINTENANCE			
4. CYCLED			
5. UNDERGROUND STORAGE			
6. OTHER PROCESSING PLANTS			
7. CARBON BLACK PLANTS			
8. TRANSMISSION LINE			
9. VENTED			
10. TOTAL			

SECTION III: Disposition of Residue Gas (MCF monthly)

1. EXTRACTION LOSS		6. GAS LIFT		11. OTHER PROCESS. PLANTS	
2. H_2S LOSS		7. REPRESS & PRESS MAINT		12. TRANSMISSION LINE	
3. CO_2 LOSS		8. CYCLED		13. VENTED	
4. PLANT FUEL		9. UNDERGROUND STORAGE		14. METER DIFFERENCE	
5. LEASE FUEL & USE		10. CARBON BLACK PLANTS		15. TOTAL	

SECTION IV: Sulfur and CO2 Recovery

PRODUCTION OF SULFUR FROM PROCESSING NATURAL GAS ______ TONS. CO_2 ______ BBLS. TONS

SECTION V. Plant Liquid Hydrocarbon Production (barrels monthly)

CONDENSATE FROM GAS WELL GAS Mainline DRIP AND/OR SCRUBBER OIL ~~XXXXXXXXXXXXXX~~ 645

Drip and/or Scrubber Oil produced in excess of Statewide Rule 56 and allocated back to leases for operator to report on Form P-1.

1. PLANT CONDENSATE		4. PROPANE		7. ETHANE	
2. GASOLINE		5. BUTANE-PROPANE MIX.		8.	
3. BUTANE		6. ISO-BUTANE		9. TOTAL	645

SECTION VI: Detail of Drip or Scrubber Recovery (Production included above)

NAME OF DRIP OR SCRUBBER	NO. OF GAS WELLS	NO. OF OIL WELLS	BARRELS
Main Line Drip No. 1			245
Main Line Drip No. 2			290
Main Line Drip No. 3			110
		TOTAL	645

(Use Attachment If Necessary)

SECTION VII: Barrels

	Drip Condensate	Drip and/or Scrubber Oil	Gasoline	Butane	Propane	Ethane	Other	Total
1. OPENING BALANCE	75							75
2. FROZEN STOCK	0							0
3. TOTAL OPENING STOCK	75							75
4. RECEIVED	0							0
5. PRODUCED	645							645
6. DELIVERED	573							573
7. LOSS	0							0
8. TOTAL CLOSING STOCK	147							147
9. FROZEN STOCK	0							0
10. CLOSING BALANCE	147							147

SECTION VIII: Liquid Operations Statement

RECEIPTS			DELIVERIES		
Received from	Commodity	Barrels Received	Delivered to	Commodity	Barrels Delivered
			DXL Oil Company	Drip Condensate	573
TOTALS					573

SECTION IX: Report of Gas Injected – Repressuring, Pressure Maintenance, Cycling, and Underground Storage

Field and Reservoir	Well Owner	Lease	Well No.	Injection Pressure	MCF Monthly
		Total		xxxxxxx	

SECTION X: Detail of Delivery of Gas – Except Fuel System and Lease Use (MCF monthly)

Delivered to Whom	Use or Disposition	Unprocessed Gas (Sec. II)	Residue Gas (Sec. III)

SECTION XI: Remarks

1. REASON FOR VENTING UNPROCESSED GAS
2. REASON FOR VENTING RESIDUE GAS
3.

CERTIFICATE: I, the undersigned, state that I am the Superintendent (TITLE) of the Total Pipe Line Co. (COMPANY AND PLANT) and that I am authorized by said company to make this report; and that this report was prepared under my supervision and direction and that the facts stated therein are true, correct and complete to the best of my knowledge.

2-20-69 — Date

T. P. Vitek — Signature

512-475-3803 — Area Code and Telephone Number

INSTRUCTIONS:

1. This report shall be filed in four (4) duplicate originals with the District Director of the Railroad Commission of Texas for the District in which the Plant is located as soon after the first of the Month as possible for the preceding Month, and never later than the Twenty-Fifth of the month.
2. This report is required of all Plants processing Natural Gas. All Gas Volumes must be reported at a Base Pressure of 14.65 pounds per square inch absolute and a Base Temperature of 60 degrees Fahrenheit. All liquid quantities shown on this report shall be in barrels of 42 U.S. Gallons based on actual physical gauges computed from 100% U.S. Tank Tables or other method of measurement approved by the Commission and corrected from the temperature at the time of measurement to a standard temperature of 60 degrees Fahrenheit. Do not use fractions of thousands of cubic feet of gas, or fractions of barrels of liquid on this report.
3. Detailed instructions available from Railroad Commission of Texas, Oil & Gas Division, Production & Proration Section, P.O. Drawer EE, Austin, Texas 78711.

TABLE NO. 8

ULTIMATE DISPOSITION OF ALL GAS PRODUCTION

ALL GAS VOLUMES REPORTED AT A STANDARD BASE PRESSURE OF 14.65 P. S. I. ABSOLUTE AND A STANDARD BASE PRESSURE OF 60° F.

YEAR 1972

Month	Extraction Loss*	Acid Gas H_2S & CO_2	Plant Fuel & Lease Use	Pressure Maint. & Repres'g	Transmission Lines	Cycled	Carbon Black	Under-ground Storage	Vented or Flared	Plant Meter Difference	Total Gas Produced▲	Marketed Production⊕
January	38,114,452	15,504,425	49,700,167	38,736,122	635,534,249	33,174,044	1,816,850	589,941	5,418,894	2,256,722	820,845,866	687,051,266
February	37,447,606	14,471,379	47,308,265	36,311,949	604,577,782	31,734,208	1,616,217	178,676	4,950,100	3,213,726	781,809,908	653,502,264
March	40,987,871	13,957,616	49,845,209	39,690,974	626,846,173	33,117,591	1,776,921	2,602,804	5,487,332	3,470,880	817,783,371	678,468,303
April	39,163,207	13,450,660	48,021,966	40,734,120	608,432,611	30,890,796	1,690,837	3,526,118	5,470,126	4,414,678	795,795,119	658,145,414
May	41,061,892	13,816,664	49,544,871	43,694,854	609,308,677	30,865,693	1,744,284	2,777,998	5,108,004	3,721,393	801,644,330	660,597,832
June	39,148,724	13,962,106	47,767,291	40,933,159	595,429,950	28,754,956	1,589,956	1,378,580	5,407,045	4,759,223	779,130,990	644,787,197
July	40,693,071	15,490,181	49,709,046	39,842,497	622,081,173	29,341,099	1,758,238	2,054,569	5,136,865	5,234,965	811,341,704	673,548,457
August	39,958,511	15,225,391	50,314,496	39,225,747	615,685,794	29,758,757	1,723,305	1,149,521	5,405,631	5,186,515	803,633,668	667,723,595
September	38,862,447	15,127,762	47,944,534	39,447,510	599,580,965	29,645,395	1,532,433	1,106,350	4,653,850	4,186,313	782,087,559	649,057,932
October	40,143,319	15,395,970	49,285,339	39,038,318	621,345,064	31,017,916	1,694,587	2,119,746	4,701,868	2,277,115	807,019,242	672,324,990
November	38,531,630	15,689,858	48,701,671	36,086,303	611,306,547	28,576,004	1,764,982	427,844	4,206,066	2,047,270	787,338,175	661,773,200
December	38,560,262	15,948,219	50,544,262	36,842,037	635,353,277	29,896,890	1,626,268	345,076	4,202,206	881,200	814,199,697	687,523,807
TOTAL	472,672,992	178,040,231	588,687,117	470,583,590	7,385,482,262	366,773,349	20,334,878	18,257,223	60,147,987	41,650,000	9,602,629,629	7,994,504,260
Percent of Total	4.92	1.86	6.13	4.90	76.91	3.82	0.21	0.19	0.63	0.43		

* Extraction Loss is shrinkage in Gas Volumes due to removal of Liquefiable Hydrocarbons.

⊕ Marketed Production is the total gas to Transmission Lines, Carbon Black, and Plant Fuel and Lease Use.

▲ Disposition Volumes not adjusted for corrected reports.

TABLE NO. 8

ULTIMATE DISPOSITION OF ALL GAS PRODUCTION

ALL GAS VOLUMES REPORTED AT A STANDARD BASE PRESSURE OF 14.65 P. S. I. ABSOLUTE AND A STANDARD BASE TEMPERATURE OF 60° F.

YEAR 1973

Month	Extraction Loss	Acid Gas H_2S & CO_2	Plant Fuel & Lease Use	Pressure Maint. & Repressuring	Transmission Lines	Cycled	Carbon Black	Under-ground Storage	Vented or Flared	Plant Meter Difference	Total Gas Produced▲	Marketed Production ⊕
January	37,697,524	15,777,164	49,335,153	35,505,601	635,661,881	28,470,078	1,478,334	421,859	4,104,446	3,274,904	811,726,944	686,475,368
February	35,304,766	14,349,999	45,276,423	32,991,150	574,207,298	25,421,154	1,438,657	879,127	3,403,545	3,349,114	736,621,233	620,922,378
March	39,805,353	14,579,654	49,286,303	36,608,088	617,793,864	28,195,645	1,607,403	3,097,865	3,953,192	5,129,672	800,057,039	668,687,570
April	37,698,091	14,256,181	47,543,559	35,942,933	590,810,955	28,627,598	1,543,825	4,280,032	3,696,334	3,008,205	767,407,713	639,898,339
May	40,575,118	15,150,519	49,131,933	36,560,534	599,620,372	28,069,830	1,753,922	6,210,885	3,864,398	6,385,259	787,322,770	650,506,227
June	38,372,458	14,976,282	46,629,823	34,999,058	585,315,798	26,768,542	1,675,424	5,536,299	3,519,646	6,163,282	763,956,612	633,621,045
July	39,833,978	15,736,969	48,486,979	35,380,707	613,504,373	26,890,889	1,542,090	4,054,529	3,544,681	6,592,618	795,567,813	663,533,442
August	39,302,092	15,801,873	48,498,697	35,859,414	612,661,673	26,544,922	1,541,353	3,662,547	3,338,991	7,764,674	794,976,236	662,701,723
September	38,991,005	15,096,559	46,855,424	34,105,038	583,389,464	26,468,785	1,636,029	4,002,624	3,190,387	5,364,184	759,099,499	631,880,917
October	40,188,312	15,192,628	47,941,408	34,496,083	599,783,095	27,581,986	1,631,127	3,552,615	3,092,190	3,453,065	776,912,509	649,355,630
November	39,066,656	15,105,615	46,894,236	33,412,900	589,194,096	25,580,270	1,268,326	3,152,396	2,984,905	2,778,730	759,438,130	637,356,658
December	39,307,601	15,378,879	48,807,982	33,569,934	616,478,377	25,951,832	1,469,291	853,291	3,199,202	2,580,100	787,596,489	666,755,650
TOTAL	466,142,954	181,402,322	574,687,920	419,431,440	7,218,421,246	324,571,531	18,585,781	39,704,069	41,891,917	55,843,807	9,340,682,987	7,811,694,947
Percent of Total	4.99	1.94	6.15	4.49	77.28	3.47	0.20	0.43	0.45	0.60		

* Extraction Loss is shrinkage in Gas Volumes due to removal of Liquefiable Hydrocarbons.

⊕ Marketed Production is the total gas to Transmission Lines, Carbon Black, and Plant Fuel and Lease Use.

▲ Disposition Volumes not adjusted for corrected reports.

OIL & GAS JOURNAL

P. O. Box 1260
Tulsa, Oklahoma 74101

1974 ANNUAL GAS-PROCESSING PLANT SURVEY

COMPANY ______________ YOUR NAME ______________ YOUR TITLE ______________

YOUR OFFICE ADDRESS ______________ CITY ______________ STATE ______________

List all plants processing natural gas and short-cycle adsorption units, including dehydrators from which hydrocarbons are recovered. List partnership plants only if you're the operator. Report only individual streams which you make in your plant.

EXISTING PLANTS

LOCATION (For legal description give section-township-range or section-block-survey.)	GAS CAPACITY (MMcf daily)	GAS THROUGH PUT (MMcf daily)	CYCL-ING Yes or No	PROCESS METHOD 1–Absorp. only 2–Refrig.–abs. 3–Refrig. only 4–Compress. only 5–Adsorption	PRODUCTION – Gallons per day: Ethane	Propane	Iso-butane	Normal or unsplit butane	Base average on production the past 12 months: Ethane–Propane mix (give % of each)	Report only if produced as such: LP–gas mix	RawNGL mix	Debut. nat. gaso.*	Other 1. Isopentane 2. Upgraded motor fuel 3. Diesel 4. Kerosine . List others
Plant name: Field: County: State: Legal de- scription:				1– 2– 3– 4– 5–						:			1– 2– 12. Sulfur (LT/d) 3– 4– –
Plant name: Field: County: State: Legal de- scription:				1– 2– 3– 4– 5–						:			1– 2– 3– 4– –
Plant name: Field: County: State: Legal de- scription:				1– 2– 3– 4– 5–						:			1– 2– 3– 4– –

* Pentanes plus

NEW PLANTS OR EXPANSIONS UNDER CONSTRUCTION OR PLANNED

LOCATION	STATUS	NEW CAPACITY BEING ADDED (MMcfd)	PRODUCTS & CAPACITIES Gallons per day	COMPLETION month–year	CONTRACTOR	PROCESS METHOD	REMARKS: Cost etc.

(Use back side if more space is needed for new construction)

(New plant or expansion continued....)

LOCATION	STATUS	NEW CAPACITY BEING ADDED (MMcfd)	PRODUCTS & CAPACITIES Gallons per day	COMPLETION month–year	CONTRACTOR	PROCESS METHOD	REMARKS: Cost etc.

PLEASE LIST SHUT DOWN PLANTS HERE (note if sold and to whom)

Plant name: ________
Field: ________
County: ________
State: ______ Legal description: ________

New owner ________
Address ________

Plant name: ________
Field: ________
County: ________
State: ______ Legal description: ________

New owner ________
Address ________

Plant name: ________
Field: ________
County: ________
State: ______ Legal description: ________

New owner ________
Address ________

4. COPY OF LETTER SENT TO MULTI-PLANT OPERATORS

ECOLOGY AUDITS, INC.

Subsidiary of Core Laboratories, Inc.

9995 Monroe Dr. · Dallas, Texas 75220
(214) 350-7893

We are in the process of conducting a study to determine the emissions of sulfur dioxide and hydrogen sulfide by the petroleum production industry. As you may know, there has been a great deal of misinformation about the industry. One 1971 study for EPA singled out the natural gas industry as contributing 7 million tons of sulfur dioxide per year to the atmosphere; between 20 and 25 percent of the total by all industry in the United States. Another more recent study by Battelle suggests that there is but 110,000 tons per year of sulfur oxides.

Both of these studies have been done by people unfamiliar with the industry. Both reports have significant deficiencies and it is important to both the petroleum industry and the general public that accurate data be compiled on the industry.

Our approach has been to attempt to correlate the data reported to the Texas Air Control Board with that reported to the Railroad Commission. We have also attempted to correlate Railroad Commission data with that reported to the Texas Comptrollers office for sulfur and the Oil and Gas Journal data.

Attached are forms which summarize the data reported for the year 1973. All data has been reduced to long tons annually of elemental sulfur. Total sulfur emissions from plants have been calculated by adding the H_2S loss in both processed and unprocessed gas and subtracting recovered sulfur, if any (as reported to the Texas Railroad Commission).

There are several reasons why many discrepancies exist:

1. The Texas Air Control Board does not mail questionnaires to plants if their emissions are less than 50 tons per year.

2. The Railroad Commission regulates only the production and/or collection of liquids. If you have a gas sweetening plant only or handle dry natural gas, you may not be required to make reports.

3. Some operators report total acid gas on the H_2S loss line (Section III line 2) of the GP-1, thus overstating H_2S production.

4. Some operators sell the amine regenerator stream to another operator; thus not all the reported H_2S loss is flared or vented.

5. Poor arithmetic.

We shall appreciate your reviewing the reported data to determine reasons for the discrepancies. I shall call you within a few days to discuss your findings regarding these differences. If you wish additional information, please feel free to call at my personal telephone 214/233-7998.

The results of the survey will be summarized by county. When disclosure of an individual plant would occur, then data will be shown by groups of counties. This survey is being made for the EPA as a part of a study of total sulfur oxides emissions in the United States. The results will be made available to interested firms as well as publications and the requesting agency.

Sincerely yours,

Richard H. Schulze
Project Manager

RHS:pjp
Enc.

5. ECOLOGY AUDITS, INC. DATA FORMS

No. 1

STATE ______ / 1. ______ COUNTY 2. ______ 3. ______ 4. ______

ECOLOGY AUDITS, INC.
9995 Monroe Dr. - Dallas, Texas 75220
(214) 350-7893
Subsidiary of Core Laboratories, Inc.

			SERVICE CO.		AIR AGENCY YEAR ______ EMISSIONS				PETROLEUM REG AGENCY								
									GAS PROCESSING PLANTS				UNPROCESSED GAS				
COMPANY	FIELD	PLANT	G/O	$\%H_2S$	SO_2 T/Y S T/Y	H_2S T/Y S T/Y	OIL & GAS JOURNAL SULFUR CAPACITY TONS/DAY T/Y	BUREAU OF MINES SULFUR CAPACITY TONS/DAY T/Y	TOTAL PLANT INTAKE MMCF	H_2S LOSS MMCF S T/Y	AV H_2S CONTENT %	SULFUR PRODUCTION T/Y	FUEL USE MMCF	EST H_2S MMCF S T/Y	VENTED MMCF	EST H_2S MMCF S T/Y	REMARKS

No. 2

COMPANY ______________________ PLANT ______________________

long tons sulfur/year

Oil & Gas Journal reported capacity long tons/day ________ X 365 ________

GP-1 Data - 12 mos. 1973 - Sulfur Production ________

Gas Plant Intake MMCF ________

H_2S Loss MMCF ________ X 37.48 long tons/MMCF= ________

H_2S as mol % of Intake ________

Apparent Sulfur Recovery ________ %

Unprocessed Gas

Fuel Use MMCF ________

Vented MMCF ________

Total ________

Assumed H_2S mol% ________

H_2S Loss: MMCF ________ X 37.48 long tons/MMCF= ________

Total Apparent Emissions - Processed and unprocessed Gas ________

Texas Air Control Board Data - 1973

SO_2 Emissions ________ tons/year x .4464 long tons/ton SO_2 emission ________

H_2S Emissions ________ tons/year x .8403 long tons/ton H_2S emission ________

Total atmospheric emission - sulfur compounds ··········› ________

No. 3

STATE / 1. ______ COUNTY 2. ______ COUNTY 3. ______

AQCR

* A = ± 10%
B = ± 25%
C = +200% 50%

COMPANY	PLANT	INTAKE MMCF/Y	RANGE OF H_2S %	RANGE OF SULFUR PRODUCED LT/YR	SULFUR RECOVERED LT/YR	SULFUR EMITTED AS REPORTED TO STATE	AS RE-ESTIMATED IN SURVEY	AS ESTIMATED BY ECOLOGY AUDIT		
TOTAL										
COUNTY DATA										

SULFUR PLANTS

6. TABULAR DATA FOR PLANTS STUDIED

The following tables in Appendix 6 show total values only, rather than values for individual plants in the columns for "Total Intake", "% of Gas Sweetened", "H_2S in Sour Natural Gas as Produced" and "H_2S in all Natural Gas Produced." Individual plant data would identify specific plants in many cases and violate the confidentiality of some of the information provided for the study. Much of the H_2S content data were obtained from individual operators in varying terms of percentages of H_2S and SO_2 in an acid gas stream, percent H_2S in a plant charge stream, grains of H_2S per 100 std. cu. ft. of gas plant charge or pipeline receipt, ppm of H_2S in a stream, etc. Since the objective of the present study is to evaluate total emissions of sulfur, a complete itemization of data by plant is not called for. Further, plant processing varies widely from day to day in some areas (see pages 78-80) which may make individual plant numbers misleading. As an example of cooperative operation, plants No. 2 and No. 10 of AQCR 155 send all or most of their sour gas stream to plant No. 12 for sulfur recovery. Data for these three plants should provide a balance on sulfur produced, recovered and emitted.

The average value of "H_2S in Sour Natural Gas as Produced" was calculated for each AQCR by converting the total quantity of sulfur produced to MMSCF of H_2S and dividing this value by the total gas sweetening plant intake. Take AQCR 155 as an example:

$$\frac{108{,}100 \text{ LT/yr}}{37.48 \text{ LT/MMCF } H_2S} = 2884.2 \text{ MMCF } H_2S\text{/yr}$$ (Refer to Page 62 for explanation)

$$\frac{2884.2 \times 100}{586{,}800} = 0.49\% \ H_2S \text{ in Gas Sweetening Plant Intake}$$

The percentage of "H_2S in all Natural Gas Produced" is obtained by considering "Total Intake" rather than "Gas Sweetening Plant Intake."

Similar calculations can be made for each plant if such data are desired. As examples:

Plant No. 2, AQCR 155

$$\frac{17{,}100 \times 100}{37.48 \times 28{,}700} = 1.59\% \ H_2S \text{ in Gas Sweetening Plant Intake}$$

Plant No. 7, AQCR 155

$$\frac{6{,}600 \times 100}{37.48 \times 63{,}400} = 0.28\% \ H_2S \text{ in Gas Sweetening Plant Intake}$$

Plant No. 9, AQCR 155

$$\frac{1{,}900 \times 100}{37.48 \times 70{,}200} = 0.073\% \ H_2S \text{ in Gas Sweetening Plant Intake}$$

H_2S concentrations range from a few grains per 100 cubic feet to 16 or 18 percent of the sweetening plant intake gas to the various plants, but the total values provide the weighted average, which is the significant quantity in the present study.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR		
								Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
155	Pecos Permian Basin	1		11.6				.1		.1
		2		28.7				17.1		--
		3		2.0				.1		.1
		4		3.9				<.1		<.1
		5		88.0				5.8		5.8
		6		--				7.1		7.1
		7		63.4				6.6		6.6
		8		62.2				1.5		1.5
		9		70.2				1.9		1.9
		10		2.0				13.1		9.5
		11		6.9				2.0		2.0
		12		--				--	18.3	2.5
		13		8.3				.3		.3
		14		24.1				.8		.8
No. of plants studied with small or no sulfur emissions										
	Total									

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR		
								Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
155	Pecos Permian Basin	15		12.2				.9		.9
		16		25.3				1.7		1.7
		17		1.9				.8		.8
		18		2.8				.2		.2
		19		26.3				.9		.4
		20		13.9				1.3		1.3
		21		7.0				1.2		1.2
		22		2.6				1.0		1.0
		23		20.1				1.2		1.2
		24		12.5				1.6		1.6
		25		6.6				10.2	4.6	5.5
		26		3.1				.5		.5
		27		9.3				5.8	3.3	2.5
		28		.3				.1		.1
No. of plants studied with small or no sulfur emissions										
Total										

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR: Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
155	Pecos Permian Basin	29		63.0				11.9	10.6	1.3
		30		8.6				12.4	10.9	1.5
No. of plants studied with small or no sulfur emissions - 7										
Total		30	590	586.8	100	.49	.49	108.1	47.7	59.9

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR		
								Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
218	Midland-Odessa San Angelo	1		11.0				.4		.4
		2		24.1				2.2		2.2
		3		33.4				1.1		1.1
		4		7.3				.3		.3
		5		7.9				.7		.7
		6		19.3				.9		.9
		7		12.2				.8		.8
		8		11.0				1.0		1.0
		9		15.3				.1		.1
		10		1.6				.1		.1
		11		18.9				.2		.2
		12		5.5				.7		.7
		13		3.0				.7		.7
		14		104.7				3.5		3.5
No. of plants studied with small or no sulfur emissions										
Total										

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR		
								Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
218	Midland-Odessa San Angelo	15		30.1				.9		.9
		16		35.6				2.6		2.6
		17		23.0				1.6		1.6
		18		70.3				1.4		1.4
		19		unknown				.5		.5
		20		147.6				9.1	5.0	4.1
		21		3.8				1.1		1.1
		22		5.1				<.1		<.1
		23		5.0				.4		.4
		24		.7				<.1		<.1
		25		.9				<.1		<.1
		26		14.0				<.1		<.1
		27		19.7				2.6		2.6
		28		35.9				3.4		3.4
No. of plants studied with small or no sulfur emissions										
	Total									

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
218	Midland-Odessa San Angelo	29		unknown				2.0		2.0
		30		unknown				.1		.1
		31		.9				1.8	1.0	.9
		32		2.1				.6	.5	.1
		33		3.1				.2		.2
		34		5.3				1.5		1.5
		35		1.3				.2		.2
		36		3.4				5.2	3.7	1.6
		37		120.5				.2		.2
		38		93.9				.3		.3
		39		26.3				5.7		5.7
		40		5.4				.6		.6
		41		unknown				.3		.3
		42		112.2				4.7	.7	4.0
No. of plants studied with small or no sulfur emissions										
Total										

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR		
								Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
218	Midland-Odessa San Angelo	43		77.1				3.7		3.7
		44		126.7				.6		.6
		45		5.2				.7		.7
		46		7.4				1.2		1.2
		47		30.2				.1		.1
		48		.2				<.1		<.1
		49		18.8				.3		.3
		50		10.4				4.5		1.2
		51		10.5				9.4		1.6
		52		--					8.3	2.8
		53		.1				3		.3
		54		7.1				6.5	4.5	2.0
		55		25.2				3.3		3.3
		56		85.8				23.1	16.5	6.6
No. of plants studied with small or no sulfur emissions										
Total										

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR		
								Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
218	Midland-Odessa San Angelo	57		57.8				.1		.1
		58		unknown				.3		.3
		59		28.8				15.3	8.7	6.5
		60		unknown				1.1	1.0	.1
		61		.8				1.4	.5	.8
		62		.3				.1		.1
		63		1.0				1.9		1.9
		64		11.7				.1		.1
		65		unknown				.9		.9
		66		26.6				9.7	6.1	3.6
		67		38.4				.7		.4**
		68		55.7				18.6	14.8	3.8
		69		38.5				29.6	25.9	3.7
		70		15.8				20.2	18.2	2.0
No. of plants studied with small or no sulfur emissions										
Total										

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.
** Some is sold sour.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR		
								Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
218	Midland-Odessa San Angelo	71		6.9				2.1		2.1
		72		unknown				.7		.7
		73		7.6				2.7	1.4	1.2
		74		20.7				.8		.8
		75		3.1				.4		.4
		76		12.6				7.3	5.3	2.1
		77		11.7				4.2		1.1**
		78		unknown				--		3.2
		79		5.9				1.9	1.6	.3
		80		11.3				2.7	2.5	.2
		81		unknown				<.1		<.1
No. of plants studied with small or no sulfur emissions - 40										
	Total	81	2726.1	1801.2	66	0.35	0.23	236.4	126.2	110.0

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.
** Sells some sour gas.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR: Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
211	Amarillo/Lubbock	1		70.1				5.1		5.1
		2		2.5				.7		.7
		3		unknown				.1		.1
		4		--				--	2.0	1.0
		5		104.5				3.5		.5
		6		13.8				.9		.9
		7		122.3				6.7	5.5	1.1
		8		7.3				.2		.2
		9		5.3				1.2		1.2
		10		--				--	.8	.3
		11		4.2				1.1		--
		12		unknown				.5		.5
		13		.9				.2		.2
		14		3.0				.3		.3
No. of plants studied with small or no sulfur emissions										
Total										

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR		
								Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
211	Amarillo/Lubbock	15		8.8				.9		.9
		16		16.2				14.8	13.7	1.1
		17		73.6				.4		.4
		18		70.0				1.2		1.2
		19		6.9				.2		.2
		20		4.5				1.4	.4	1.0
		21		6.8				.3		.3
		22		7.3				.6		.6
		23		2.3				.1		.1
No. of plants studied with small or no sulfur emissions		-12								
	Total	23	1,358.8	530.3	39	0.20	0.08	40.4	22.4	17.9

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR: Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
217	San Antonio	1		16.2				10.5	7.0	3.5
		2		2.0				1.0	1.0	--
		3		5.0				1.4	--	1.4
		4		8.3				7.1	4.6	2.6
		5		20.3				13.0	9.8	3.2
		6		19.3				10.6	--	.5
		7		--				--	9.3	.7
		8		5.0				3.5	2.6	.9
No. of plants studied with small or no sulfur emissions - 1										
	Total	8	159.0	76.1	47.9	1.65	0.79	47.1	34.3	12.8

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
215	Dallas-Ft. Worth	1		3.0				2.6	.3	2.3
		2		.1				.1		.1
		3		.7				.7		.7
210	Abilene-Wichita Falls	4		5.0				.1		.1
		5		13.9				.3		.3
212	Austin-Waco	6		.9				.3		.3
		7		4.2				39.7	33.0	6.7
214	Corpus Christi	8		0.6				<.1		<.1
		9		26.8				32.6	28.4	4.2
		10		1.1				.3		.3
No. of plants studied with small or no sulfur emissions -12										
	Total	10	2455.7	56.3	2	3.63	0.008	76.7	61.7	15.0

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR: Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
22	Shreveport-Texarkana-Tyler	1		6.3				13.3	12.0	1.3
		2		7.1				77.0	67.4	9.6
		3		28.1				114.6	106.6	8.0
		4		3.6				.4		.4
		5		4.5				12.4	10.1	2.4
		6		2.6				2.7		2.7
		7		3.8				5.4	4.5	.9
		8		7.8				.4		.4
		9		.9				.7		.7
		10		17.1				40.1	36.6	3.5
		11		21.7				79.9	64.8	15.1
		12		2.7				2.9	2.1	.8
		13		16.0				10.9	9.6	1.4
		14		6.6				1.4	.4	1.0
No. of plants studied with small or no sulfur emissions - 4										
	Total	14	459.1	128.8	28	7.5	2.1	362.1	314.1	48.2

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

Natural Gas and Sulfur Production for Air Quality Control Regions in the Study Area

AQCR	Location	Plant No.	Total Intake MMMCF/YR	Gas Sweetening Plant Intake MMMCF/YR	% of Gas Sweetened	H_2S in Sour Natural Gas as Produced	H_2S in all Natural Gas produced	Quantities in Thousand LT/YR Sulfur Produced	Sulfur Recovered	Elemental Sulfur Emitted*
5	Mobile-Pensacola Panama City-So. Miss	1		.2				.4		.4
		2		.2				.7		.7
		3		.2				.2		.2
		4		.1				.1		.1
		5		.2				.1		.1
		6		10.5				153.4	150.3	3.1
		7		2.9				.1		.1
		8		4.9				2.6		2.6
		9		2.6				4.9	4.2	.7
		10		22.7				127.3	112.7	14.6
		11		13.6				77.5	73.4	4.1
		12		2.9				17.2	16.1	1.1
		13		3.1				19.7	18.4	1.4
		14		7.3				29.9	19.1	10.8
No. of plants studied with small or no sulfur emissions - 5										
	Total	14	164.6	71.4	43	16.2	7.03	434.1	394.2	40.0

*As estimated by Ecology Audits. Emitted principally as sulfur dioxide from tail gas incineration.

7. M. W. KELLOGG'S EVALUATION OF THE ASSUMPTIONS, METHODS AND RESULTS IN IV.

KELLOGG'S ROLE IN THIS STUDY

This study was authorized by EPA as part of Contract 68-02-1308, Task No. 26, change 1. The actual work was performed by Ecology Audits, Inc. During the course of the subject study Kellogg worked closely with the EPA and Ecology Audits, Inc. and reviewed the work being done.

A detailed discussion of Kellogg's evaluation of the work done under this task is presented in this section of the Appendix.

In Kellogg's opinion the methods used and the results obtained are satisfactory.

Kellogg's Evaluation of the Assumptions, Results and Methods in IV.

Kellogg's Review of Ecology Audits' Assumptions On Source and Disposition of Gas in Production Operations

The basis for the determination of how much emission of sulfur compounds occur from petroleum production has been shown in the flowsheet (Figure 1) used by Ecology Audits Inc. and is part of this report. M.W. Kellogg and the EPA had agreed for this to be the basis for the entire study. A similar flowsheet has been discussed in greater detail by Harold R. Jones (1).

The approach taken by Ecology Audits to estimate the total sulfur emissions has been:

"The total sulfur emissions from a plant to the atmosphere is the difference between the amount of hydrogen sulfide produced from the ground less what is recovered. The total emitted by the entire study area or an AQCR region is the sum of the emissions from the individual plants within that region."

There is further breakdown possible for how this sulfur is disposed off (vented, flared or emitted as SO_2). As far as the computation of the total amount of sulfur emission is concerned this approach is valid when the data for the total plant intake and the amount of S recovered are available.

The various sources of information that are available as public data do not contain sufficient information to compute the percentage of H_2S in the gas produced. In certain cases the data available do not appear to be reasonable. There are a number of ways in which the data have been reported to different agencies depending upon the requirements of the agency. Also, where data were missing and had to be gathered by personal contact, the data reported by the operators were in terms of grains per 100 standard cubic feet.

Different methods used for computing the various quantities are discussed and evaluated in the following pages.

Sample Calculations When Gas Analysis is Reported in Grain Per 100 Standard Cubic Feet

1 MMCF = 10,000 grains of H_2S

7,000 grains - 1 lb.

$$\frac{10,000}{7,000} \times \frac{32}{34} \times \frac{1}{2240} =$$ 0.000600 long tons of S per MMCF with 1 grain H_2S content.

Sample Calculations Performed by Kellogg To Evaluate Figures Obtained By Ecology Audits

Input Data

(assumed available either from public data or from the survey)

Plant Name, County, State, Plant 1 - Any County, Any State

Source GP-1 Data

Gas plant Intake	MMCF 927
H_2S Loss	MMCF 48.8
H_2S as % of Intake	

$$\frac{(48.8)}{927} \times 100 = 5.26\%$$

Converting H_2S Loss to Long Tons of Sulfur

1 lb. mol @ 32°F, 14.7 Psia	= 359.05
Molecular weight of H_2S	= 34
Molecular weight of S	= 32
Texas railroad Commission reporting condition	= 60°F, 14.6 psia

cft/lb of H_2S

$$= \frac{359.05}{34} \times \frac{460 + 60}{460 + 32} \times \frac{14.70}{14.65} = 11.21 \text{ cft/lb of } H_2S$$

Sulfur per million cubic feet of H_2S

$$\frac{1,000,000}{11.20} \times \frac{1}{2240} \times \frac{32}{34} = 37.48 \text{ LT/MMCF of } H_2S$$

Total sulfur in long tons produced = 37.48 x 48.8
= 1830 LT/Yr.

Apparent sulfur recovery (based on the data available from the same source as above or by survey) - 54.4%

Total sulfur recovered from this plant
(.54 x 1830) = 990 Long Tons/Year

Sulfur emitted by plant (including flaring)
1830-990 = 840 LT/Yr.

This is the figure that must go into the summary of the county or the AQCR's total emissions and is entered into the work sheet 2 and work sheet 3 in their respective columns.

If the data on emissions are available from an other source for example in this case - the total apparent emissions - (processed and unprocessed gas) is reported as 852 L. tons. The two figures are close enough and either one of them could be used.

Whenever a large discrepancy occurs between the reported values then certain discretion has to be used. The values used in this study are those in the column labelled - "As estimated by Ecology Audits." One of the major objectives of this study was to resolve such differences in data.

Example   Plant of Any County, Any State

Input data 46 grains/100 SCF

Plant Intake 70184 MMCF

Long Tons of Sulfur = 70184 x 46 x .0006

= 1937

Apparent sulfur recovery 55%

Amount Recovered = .55 x 1937

= 1065.0

Amount Emitted = 872 Tons/Yr.

This figure is entered in County totals on Work sheet W 2

Compute percentage of H_2S-Given the SO_2 Emissions by the Agency.

S(Long Tons) = SO_2 in tons/year x .4464

1 MMCF of H_2S = 37.48 Long Tons

Amount of H_2S IMMCF)

$$= \frac{SO_2 \text{ Emissions} \times .4464}{37.48} = 0.0119 \times (SO_2 \text{ emissions})$$

Example - SO_2 emissions (T/Yr.) = 21311

S emissions (LT/Y) = .4464 x 21311

= 9513 Long Tons

Plant Intake = 2026 MMCF

Amount of H_2S (MMCF) = .0119 x 9513

= 113.2

Assuming an apparent sulfur recovery = 55%

$$\text{Total amount of } H_2S \text{ (MMCF)} = \frac{113.2}{.45} = 251$$

$$H_2S \text{ \% in Gas Stream} = \frac{251}{2026} \times 100$$

= 12.4%

NOTE: The apparent sulfur recovery along with the SO_2 emissions (reported in tons/year) can be used to find out gas intake analysis.

STATISTICAL ANALYSIS ON DATA

General Approach in the Evaluation of Data used by Ecology Audits In Cases where Data were Missing.

General Approach To Evaluate the Data

As pointed out earlier in this evaluation the Ecology Audits survey had to gather information from some of the plants on their H_2S percentages, plant intake and the amount of sulfur recovered. This information, in some cases where it was not publicly available had to be obtained from the data gathered by a worldwide service company as part of their (service company) contracts with the individual plants. These data are confidential and are not disclosed.

However, in order to evaluate how good the figures used by Ecology Audits are, Kellogg has taken the following approach.

1. Tabulate data for a given AQCR or a county (if county has a large number of plants) - in a table as shown in (MWK W 2)

2. Obtain figures for different columns from the data sheets supplied by Ecology Audits and get averages for public data.

3. Compare these averages with the values substituted or supplied by Ecology Audits.

4. Determine the amount of deviations between data available and perform other statistical analysis on the data used by Ecology Audits Inc. for the purpose of this study.

The conclusions drawn on the validity of the data and the confidence that can be placed on the overall figures is based on the above steps. This will give a fairly good idea of the accuracy of the measurements made by the Service company and the data gathered by the Ecology Audits' survey.

Analysis of Data on County/AQCR Basis

To illustrate the approach described above and show the step by step calculations in arriving at the conclusion on the validity of the data for a given county or AQCR the following worksheets have been used by Kellogg.

Worksheet 1) MWK-W 1 - (Statistical Analysis by County)
Worksheet 2) MWK-W 2 - (Summary of Data by County)

where necessary the source of data and calculations have been indicated.

Some of the plants do vent some of the gas and to determine what % of the intake is vented and establish the overall % of the gas that is vented a breakdown for this quantity is also computed.

Based on the analysis of the data supplied for missing values of H_2S for a particular region the following conclusions are drawn.

1. The values substituted for missing data for a few of the plants with missing data in the AQCR regions reviewed by Kellogg the data fell within the 95% confidence limits.

2. Whenever the % of H_2S appeared to be exceptionally high, the cause for it was determined by reviewing the raw data supplied. This was generally due to the fact that the plant was a recycling plant and H_2S %

was not a true figure. This has been discussed in greater detail in Section IV of this report.

With regard to the % of unprocessed gas vented the following conclusion is drawn.

The % in most of the plants is less than 1% of the intake gas and only in a few plants is this % higher.

For an explanation of this, the raw data and the operators' comments have to be referred to for that particular plant. Section IV outlines some of the possible reasons for this discrepancy.

References -

(1) "Pollution Control in the Petroleum Industry", Jones, H.R., Noyes data Corporation, 1973.

(WORKSHEET MWK-W 1)

STATISTICAL ANALYSIS (MWK-W6.2) BY COUNTY/AQCR

Refer to Worksheet (MWK-W6.2) for the corresponding State, and County.

State :
AQCR Region :
County(s) :
Number of plants in this Region :
Number of plants with complete Data:
Number of plants with missing percentage of H_2S :
Number of plants with public Data on H_2S percentages :
Average % of H_2S in the gas in this area :
Average of Values % of H_2S used by Ecology Audits based on their data :
% of vented gas computation :
Average % of gas vented using Public Data :
Average % of gas vented using Ecology Data :

Statistical Analysis of Above Data

95% Confidence Limit on the % H_2S for this region --
95% Confidence Limit on the % of gas vented in this region --

THE M. W. KELLOGG COMPANY
A DIVISION OF PULLMAN INCORPORATED

WORKSHEET (MWK-W 2)

DESCRIPTION

CUSTOMER

DATE 12/6/74
BY H.A. Khan

EST NO.
JOB NO. 4118-26

STATE/AQCR/COUNTY	PLANT NO.	% H_2S GAS PRODUCED		DIFFERENCE		PLANT INTAKE (MMCF)			S.EMISSIONS (T/YR.)		DIFFERENCE		DATA ON VENTING		
		PUBLIC DATA	ECOLOGY AUDITS	ABS.	%	PUBLIC DATA	ECOLOGY AUDITS	REPORTED	PUBLIC DATA	ECOLOGY AUDITS	ABS.	%	MMCF INTAKE % OF		
	01														
	02														
	03														
	04														
	05														
	06														
	07														
	08														
	09														
	10														
	11														
	12														
TOTAL															

COOA 11 11-64

8. CALL REPORTS MADE IN CONNECTION WITH A STUDY OF SULFUR COMPOUND EMISSIONS OF THE PETROLEUM PRODUCTION INDUSTRY

CONTACT REPORT

PERSON - Louis J. Engel
TITLE - Bureau of Natural Gas
COMPANY - Federal Power Commission
ADDRESS - 825 N. Capitol, N.E.
Washington, D.C.

DATE - June 5, 1974

PHONE - 202/386-5237

- -

Mr. Engel said that buyer and seller of gas negotiate the levels of H_2S, CO_2, water and total sulfur contents. It is his understanding that standards of 1 gr/100 CF H_2S and 20 gr/100 CF for total sulfur are common contract terms.

If a seller sought to obtain the ceiling price for gas not meeting these specifications, then the FPC would require a lower price to offset the cost of processing the gas.

In practice, however, the FPC has no power and does not inspect the actual gas quality moving between buyer and seller.

CONTACT REPORT

PERSON	- James A. McKee	DATE	- June 12, 1974
TITLE	- Associate Petroleum Engineer		
COMPANY	- Oil and Gas Conservation Commission	PHONE	- 303/892-3531
ADDRESS	- 1845 Sherman Street Denver, Colorado 80203		

Monthly reports are filed by all gas processing plants and by all oil and gas producers. Samples of forms and reports were obtained.

Mr. McKee said no Colorado production is sour, and to his knowledge, no sweetening plants exist.

The 1972 report of the commission was obtained. A 1973 report is due to be published in a few weeks. The changes in number of plants are shown below:

Year	Plants Closed	New Plants	Operating at year end
1972			17
1973	2	5	20
1974	1	3	22 (as of 7/74)

The new and closed plants since 12/31/72 are as follows:

Date of Startup	Plant Name	Operating Company	Location
1/73	Latigo	Darenco, Inc.	
1/73	Third Creek	Amoco	Brighton
1/73	West Douglas Creek	Western Slope Gas	Rangeley
6/73	Irondale	Halliburton Reservoir Mgt.	Strausburg
10/73	Spindle	Amoco	Ft. Lupton
1/74	Denver Central	Sun Oil	
3/74	Lowry	Texaco	
7/74	Watkins	Amoco	Watkins
	Plants Closed		
12/73	Bombing Range	Sun Oil	
12/73	Comanche Creek	Sun Oil	
3/74	Dragoon	Sun Oil	

CONTACT REPORT

Fred Peterson - Assistant Chief Engineer
John Aldridge - Petroleum Reservoir Engineer

PERSON - Lucille Magee DATE - July 11, 1974
TITLE - Supervisor R-6 Forms
COMPANY - Louisiana Department of Conservation PHONE - 504/389-5161
ADDRESS - Baton Rouge, Louisiana

- -

None of the above people know of any H_2S or sour gas production in the state. The data is not required on any of their forms and they have had no reason to collect it.

It is known that there are isolated sour gas flares in Louisiana, but one would have to contact the directors of the six regional offices to see if they personally knew of anything.

The plant which vents the largest amount of gas in Louisiana is the Henry plant of Texaco.

CONTACT REPORT

Floor		June 27 & 28, 1974
10	Jim C. Langdon, Chairman	512/475-3365
3	Larry C. Willimack, Chief of Staff Services	475-3081
6	Bob Harris, Research and Inspection Section	475-4519
7	Dorothy Locks, Clerk - GP-1 reports	
2	Lee Wheelus, Clerk - Microfilm Department	

Railroad Commission of Texas
Oil and Gas Division
10th and Colorado
Austin, Texas

The Texas Railroad Commission has an extensive reporting system for oil and gas production. Unfortunately, it does not record any data on sulfur except on the GP-1 report. This report is submitted by about 950 plant operators in Texas each month. Data are shown for H_2S processed and sulfur recovered. Unfortunately, the statistical clerks combine H_2S and CO_2 as "acid gas" so that one will have to go through 950 reports for 12 months to get H_2S data and sulfur production data by plant.

These 950 plants fall into the following categories:

gasoline plants	344	(produce natural gas liquids and gasoline)
cycling plants	30	(cycle dry gas back into a reservoir)
other plants	584	(produce compression and drip condensate or other, non-gasoline products such as CO_2 or sulfur)

The Railroad Commission recently set a new Rule 36 which states that a producer of gas which could have ambient air concentrations of hydrogen sulfide in excess of 20 ppm is required to file an emergency contingency plan. So far only about 30 of these have been received.

CONTACT REPORT

PERSON - Donald B. Basko
TITLE - Secretary
COMPANY - The Wyoming Oil & Gas Conservation Comm.
ADDRESS - 202 East Second Street
Casper, Wyoming 82601

DATE - June 14, 1974
PHONE - 307/234-7147

- -

Mr. Basko said that sour gas was found in only four fields in Wyoming and these each have sulfur recovery plants. He also said that some small quantities of sour gas were being flared from the S. Frisbee (Union Oil), Rattlesnake (Tenneco), Golden Eagle (Phillips) and Waugh fields (Phillips). The total amount flared totals less than 1.5 million cubic feet per day. He also said there may be a few scattered flares at Big Horn.

Since 1973 there have been no new gas treating plants put into operation or shut down. The sulfur plant at E. Riverton ceased sulfur production in March, 1973, although the plant continues to produce condensate.

The well reports show no sulfur production or flaring, yet other data for Unit #19 show the gas to be sour. The production from this unit is all used in the company's own pipeline.

All of Arco's production is processed by the Riverton plant which shows no sulfur production, but probably disposes of sour gas through incineration or flaring.

The Tenneco Production at USA Faure Number 1 is at Rattlesnake field, not Cottonwood Creek and apparently it is used on the lease and/or flared.

CONTACT REPORT

PERSON -	Lonnie Lantz John V. Speigel	DATE -	June 12, 1974
TITLE -	Air Pollution Control Division		
COMPANY -	Colorado Department of Health	PHONE -	303/388-6111
ADDRESS -	4210 East 11th Avenue Denver, Colorado 80220		

- -

The Colorado Air Pollution Control Division has no data on gas processing plants. They were unaware of the existence of such data until I discussed the Oil and Gas Commission report with them.

As for well-site operations - Common Provisions - Regulation IV A 13a do not require reporting data nor do they require a permit prior to construction of heater-treaters.

They expressed strong interest in the results of the current survey effort.

CONTACT REPORT

PERSON -	Vernon Parker	DATE -	July 12, 1974
TITLE -	Technical Secretary		
COMPANY -	Louisiana Air Control Commission	PHONE -	504/575-5115
ADDRESS -	317 Loyola Blvd. New Orleans, La.		

- -

The state has an emissions inventory and it asks sources to revise the emissions if there is a change of 10 percent or more.

Mr. Parker was unaware of any gas treating plants in Louisiana with Amine treating units. He suggested that I call the industry association and three companies who might have information:

Getty Oil	T. Ed Griffith	713/228-9361
Gulf Oil	Red Thomas	504/524-4282
Texaco	Hoyt Ambrosious	504/562-3541
Mid-Continent Oil & Gas Assn.	Vernon Dowdy	504/348-2236

He concluded by saying that either there was a problem he wasn't aware of, or more likely, this was a very minor problem compared to the others in his state.

CONTACT REPORT

PERSON - Wayne B. Anderson | DATE - July 11, 1974
TITLE - Chief, Engineering Section
COMPANY - Mississippi Air and Water Pollution Control Commission | PHONE - 601/354-6783
ADDRESS - Box 827
Jackson, Mississippi 39205

Mississippi has a poor emissions inventory. It was done about three years ago as part of their implementation plan. They have put some of the information on the NEDS format but there are many important gaps.

Mr. Anderson cited the key areas and the operators with sour gas problems as:

Shell Oil Company	Thomasville
Shell Oil Company	Clark Co. (Goodwater Plant)
Texas Oil & Gas Company	Toukawa, Harmony
Amerada-Hess (Miss. Fla.)	Quitman & Cypress Creek
Amerada-Hess Pipeline	Eucutta Station
Continental Oil Company	Scott Co. (office in Forrest)
Getty Oil Company	E. Nancy, W. Nancy & Vossberg
Mobil Oil Company	Waynesboro
(unknown)	Heidelberg

CONTACT REPORT

PERSON - Mr. Spurge Baskin
TITLE -
COMPANY - Texas Air Control Board
ADDRESS - Shoal Creek Blvd.
Austin, Texas

DATE - June 27, 1974
PHONE -

- -

Mr. Baskin is the petroleum specialist in the emissions inventory section of TACB.

He showed data for 1972 which was copied. He said he had no data on well flaring and such limited data on crude oil storage that it was not useful. The information from the 1973 reports is now being put on the computer and should be available about September or October.

A cursory view of the data suggests that there are many possible ways for sour gas to be treated. Some of the options are as follows:

- treat gas at the wellhead before sending it to a processing plant.
- treat gas at a gasoline plant.
- treat gas at a cycling plant where dry gas (methane and ethane) are reinjected.
- use in a carbon black plant.
- use in a power generation station built at the wellhead.
- use in a refinery built near the wellheads.
- use in petrochemical plants such as ammonia or butadiene plants located at or near wellheads.

There is also some question as to the accuracy of the emissions data. This is especially true at sulfur recovery plants where the reporting firm will often report the result of stack tests which have been made during the best possible operating conditions.

CONTACT REPORT

PERSON - Randolph Wood   DATE - June 14, 1974
TITLE - Administrator - Division of Air Quality
COMPANY - Wyoming Dept. of Environmental Quality   PHONE - 307/777-7391
ADDRESS - Cheyenne, Wyoming 82002

The State has no sulfur dioxide regulations on stack emissions - only ambient air quality. They are priority III for sulfur dioxide so have not addressed the problem in their implementation plan.

They have an emissions inventory compiled following the NEDS format. The bulk of the work on this inventory was done by a contractor, and EPA Denver has the original copy.

The inventory was not available for review. It is a stack of 11" x 17" sheets about 2" thick. His department has just moved into new quarters and the inventory was still packed up in the library. The man in charge of the inventory is Bernie Dailey.

Mr. Wood was not too confident of the inventory. He said that he is constantly finding new sources. He also said changes in the inventory are not always made, especially with the oil and gas industry.

He was aware that one gasoline plant had ceased making sulfur. He also was not much concerned over the oil and gas industry. Instead, his focus is on the major State projects: 4 power plants, 4 trona plants and about a dozen coal/energy projects.

CONTACT REPORT

PERSON -	James Halder Richard Schollhammer	DATE -	June 5, 1974
TITLE -	Manager Pipeline Research		
COMPANY -	American Gas Association	PHONE -	703/524-2000
ADDRESS -	1515 Wilson Blvd. Arlington, Virginia 22209		

- -

Mr. Halder and Schollhammer both stated that there are no standards that they know of governing the quality of purchased gas. It is strictly a matter between buyer and seller.

CONTACT REPORT

PERSON - Carl B. Sutton
TITLE - Secretary
COMPANY - Gas Processors Assn.
ADDRESS - 1812 First Place
Tulsa, Oklahoma 74103

DATE - May 22, 1974

PHONE - 918/582-5112

- -

This organization consists of 105 company members, nearly all of them in the natural gas processing field. Gas Processors Association does not compile any statistical summaries. The bulk of its work is funding research on gas phase behavior and thermodynamic data by four organizations:

University of Alberta
University of Utah
Rice University
PVT, Inc. (A subsidiary of Core Lab)

Suggested buying a book:
"Gas and Liquid Sweetening"
Dr. R. N. Maddox
Published by John M. Cambell
121 Collier Drive
Norman, Oklahoma 73069

CONTACT REPORT

PERSON - Warren Richards*, Jack Deetz, Steve Brusso DATE - May 22, 1974
TITLE - *Engineer - Gas Processing Facilities
COMPANY - C-E Natco PHONE - 918/584-5511
ADDRESS - 5330 E. 31st Street
Tulsa, Oklahoma 74101

- -

Mr. Richards was contacted in the absence of Leon Wehmeyer, Product Engineering Supervisor, Gas Processing Facilities, who was out of town.

Standards for pipeline quality gas are generally set at less than 2% CO_2 and less than 1/4 grain H_2S per 100 SCF (about 4 ppm). The firm has built about 35 sweetening plants in the past decade, and only four of these have sulfur recovery. Well over two-thirds of the installed sulfur recovery capacity built by this firm is at one plant: Sun Oil Company - Jay, Florida.

Most plants are designed to treat gas with an H_2S concentration greater than 100 ppm (0.01 mol percent). It was estimated that 60% of the plants designed are for H_2S concentrations between 40 and 80 grains (0.07 mol percent to 0.14 mol percent). In sweetening plants without sulfur recovery the acid gas from the sweetening unit is usually flared.

The firm would not give me a customer list since they felt it was confidential.

Natco only makes treating units. It is up to the buyer to specify and buy stacks and incinerators. Among the suppliers of this equipment are:

National Airoil
John Zink (Tulsa)
Coen (New Jersey)
Russell Engineering (representatives for an Oklahoma City firm)

Among the competitors of Natco are:

Maloney-Crawford	Tulsa
Smith Industries	Houston
Trend Construction	Tulsa
R. L. Fraley	Perry, Oklahoma
Olsen Engineering	Houston
Delta Engineering	Houston
Weatherby Engineering	Houston
Fish Engineering	Houston (larger jobs only)
Hudson Engineering	Houston (larger jobs only)

CONTACT REPORT

PERSON - C. Donald Swain, Jr.
TITLE - Vice President
COMPANY - Ford, Bacon & Davis
ADDRESS - Box 38209
Dallas, Texas 75238

DATE - May 20, 1974
PHONE - 214/278-8121

- -

Mr. Swain provided a list of sulfur recovery plants built by Ford, Bacon & Davis. Ford, Bacon & Davis generally focuses on the refinery market in which gas treating and sulfur recovery plants are only a small part of the total project. Refinery plants are generally built to more rigid specifications than "gas patch" plants. The field plants generally are only required to have a useful life of 10 to 15 years, but refinery plants often last twice as long.

The primary suppliers of solvents - monoethanolamine and diethanolamine are:

Jefferson Chemical	Jack Dingman (713/529-4471)
Ashland Chemical	Columbus, Ohio
Shell Chemical	
Phillips	

Sulfanol is a proprietary product of Shell Chemical. Dow and Union Carbide also make diisopropanolamine.

The principal competitors to Ford, Bacon & Davis include:

Ortloff Engineers	Midland, Texas	
Hudson Engineering	Houston, Texas	
Delta Engineering	Houston, Texas	
Olsen Engineering	Houston, Texas	
Fish Engineering	Houston, Texas	
C-E Natco	Tulsa, Oklahoma	
Black, Sivals & Bryson	Kansas City	
Trentham	Houston, Texas	
Ralph M. Parsons	Los Angeles, Calif.	(mostly refineries)
Pritchard	Kansas City	(mostly refineries)

Some of the above list were characterized as "Shade tree operators" who can be very competitive on price.

Among the makers of solvents are:

Jefferson Chemical Co. (the largest)
Union Carbide
Monsanto
Dow
Allied
DuPont
Ashland
Shell Chemical

Iron Sponge for gas sweetening is a problem, especially in disposing of the iron sulfide saturated wood chips. The only current source of these wood chips is the Connelly Company, Chicago.

June 19, 1974

Mr. Jack Dingman
Sales Manager, Gas Treating Chemicals
Jefferson Chemical Co.
3336 Richmond Avenue
Houston, Texas 77052

Dear Mr. Dingman:

I enjoyed the opportunity to talk with you regarding the survey we are doing for the Environmental Protection Agency. I am doing the field study portion of the work for the contractors, M. W. Kellogg and Core Laboratories..

The study is being done for the research planning division of EPA which is seeking to assess how much of a problem is represented by sulfur dioxide emissions of the petroleum production industry. The data will be used to help set research priorities for EPA is terms of sulfur dioxide control technology.

Among the items I would like to discuss are:

1. The products you make for this industry and comments on the problems created by sulfur compounds other than hydrogen sulfide.

2. The ways in which you develop list of sales prospects, the existence of directories or lists of prospects, and the firms specializing in the construction of gas treating plants.

3. The existence of industry sales data showing its use on a geographical basis.

I might add that we at Core Laboratories debated whether we should undertake this project we concluded that it was better that, since someone would do it, it had better be done by someone who knew and understood the petroleum production industry.

Sincerely yours,

Richard H. Schulze

RHS/mk

CONTACT REPORT

PERSON - Dr. Robert Schwartz
TITLE - Flare Gas Specialist
PERSON - Gene McGill
TITLE - Incinerator Designer
COMPANY - John Zink Company
ADDRESS - 4401 S. Peoria
Tulsa, Oklahoma 74105

DATE - May 23, 1974

PHONE - 918/747-1371

- -

John Zink is a licensee of Parsons' Stretford process, but apparently has not built any of this type plant. It was suggested that Parsons in Los Angeles at 213/629-2484 be called for a list of customers for their process. For the most part, the installations to date have been small capacity units.

Mr. McGill refused to release data on customers without their written permission. It is Zink's policy not to identify specific customers.

Mr. McGill served on an EPA industry steering committee for the chemical industry. He was very enthusiastic for the way in which Leslie B. Evans and Air Products obtained data on the chemicals industry. He provided copies of the correspondence that accompanied the questionnaire.

Mr. McGill then relented and provided some information relating to the customer list. Ecology Audits has tested about 10 of the 15 units sold to the natural gas industry. One surprise was a tail gas-incinerator sold to Montana Dakota Utilities at Slick Run, Colorado.

CONTACT REPORT

PERSON -	Chuck Christensen	DATE -	June 28, 1974
TITLE -			
COMPANY -	R. W. Byram & Co.	PHONE -	512/478-2551
ADDRESS -	Drawer 1867 Austin, Texas 78767		

- -

This firm publishes a guide to the reporting requirements of the Railroad Commission. A copy was purchased.

They also perform statistical services. For example, they felt that they could extract the data from the Texas GP-1 form for one year for both H_2S and sulfur for no more than $500.00.

CONTACT REPORT

PERSON - Don Wilson & Ailleen Cantrell
TITLE - Directories Manager
COMPANY - Oil and Gas Journal
ADDRESS - Box 1260
Tulsa, Oklahoma 74101

DATE - May 22, 1974

PHONE - 918/584-4411

- -

Miss Cantrell provided a copy of their questionnaire. The response is strictly voluntary, and some companies elect to provide no information. Amerada seldom responds to mail surveys. Phillips usually tells capacity only, not actual production.

The sulfur data for past years was strictly a matter of being volunteered. For the 1974 survey, due out in July, a short listing was attached specifically suggesting sulfur.

We should keep the Journal posted on the progress of our work, and as soon as it becomes public we should get them copies in the event they desire to feature a story.

CONTACT REPORT

PERSON -	Ross Nichols	DATE -	June 24, 1974
TITLE -	Vice President		
COMPANY -	Petroleum Information Corporation	PHONE -	713/526-1381
ADDRESS -	2600 Southwest Freeway Houston, Texas 77006		

- -

This firm collects copies of all petroleum reports filed with regulatory agencies and summarizes them.

They offered to sell the 1973 Texas Summary of Gasoline Plants for $286.

A listing of all the state agencies is available from the Interstate Oil Compact Commission in Oklahoma City. Incidentally, this group has its annual meeting at Vail, Colorado starting July 1, so all senior personnel will be out of town.

The states with the best data systems are Texas, Mississippi, North Dakota and New Mexico. All the rest rank a long step behind these.

The names of the organizations in the various states are as follows:

Mississippi, Oil & Gas Board, Jack Meyers, Jackson, Miss.
New Mexico, Dick Stamets, Santa Fe, New Mexico
Oklahoma, Corporation Commission, Oklahoma City, Okla.
Arkansas, Oil & Gas Commission, El Dorado, Arkansas

CONTACT REPORT

PERSON - Jack McWilliams
TITLE -
COMPANY - Amoco Production Co.
ADDRESS - 600 W. Jefferson
Houston, Texas 77002

DATE - June 26, 1974

PHONE - 713/227-4371

- -

Jack is the Chairman of the Technical Subcommittee of the Environmental Protection Committee of the Texas - Mid-Continent Oil and Gas Association. As such, he is a frequent spokesman for the oil and gas industry on technical matters.

Amoco (a subsidiary of Standard Oil Company of Indiana) operates about 40 gas processing plants. In their Houston Division there are 18 processing plants - of these 12 have sweetening units: in 5 cases there is no sulfur recovery - just a flare; in 7 cases there is sulfur recovery. In 4 cases there is a tail gas incinerator and in 3 cases a flare for tail gases.

Jack also said that there was little, if any, data on the hydrogen sulfide emissions of tank batteries. He agreed that H_2S oxidizes in the atmosphere to form sulfur dioxide.

The most common standard for pipelines is 1/4 grain per 100 SCF, but a few contracts permit higher levels. Generally the pipelines are so anxious to get gas now that they will buy poorer quality gas if the gas in their lines is sweet and the sour gas will not cause problems when diluted.

Texas Air Control Board defines sour gas as any gas with more than 1.5 gr. H_2S per 100 SCF or more than 30 grains per 100 SCF of total sulfur. Sour crude is defined as a crude which will emit a sour gas.

He also said that Amoco has about eight or ten skid-mounted sweetening units located near wells. These units sweeten produced gas so that it can be shipped some distance to a processing plant. He showed me a 2" thick book of materials he sent to Keshva Murthy of Battelle who is doing a study for Stan Cuffe of EPA. One article in this book described the special precautions necessary and great difficulties experienced in transporting gas as sour as 15 to 30 grains H_2S/100 SCF (250 to 500 ppm) some 60 miles to a processing plant. The gas is from Buffalo Wallow Field, Hemphill County, Texas and the sweetening plant is at Aledo, Oklahoma. Another set of comments in this book dealt with the reasons for pipeline standards for natural gas.

Amoco does not report the emissions from the skid-mounted units because, according to Texas regulations, they are only required to submit data when requested. They haven't been asked - so no data has been supplied. Jack suggested that the Railroad Commission may have some data on this, however.

The Executive Secretary of the Interstate Oil Compact Commission is Vernon Dowdy. His office is in Oklahoma City and his phone is 405/525-3556.

CONTACT REPORT

PERSON - J. G. Herring
TITLE - Measurement Manager
COMPANY - Arkansas-Louisiana Gas Co.
ADDRESS - Box 1734
Shreveport, Louisiana 71151

DATE - July 9, 1974

PHONE - 318/425-1271

- -

This firm is an integrated producer, transporter and distributor of natural gas. Mr. Herring said that they generally don't measure deliveries, just the gas delivered to the system. About 20 to 25 percent of their total volume is purchased from gas sweetening plants whose average output is less than 0.1 grains/100 SCF hydrogen sulfide.

Mr. Herring estimated that the ratio of other sulfur compounds such as mercaptans and carbonyl sulfide is one-tenth to one-hundredth that of hydrogen sulfide.

The firm's internal standard is 1/4 grain/100 SCF.

CONTACT REPORT

PERSON - A. E. Straub
DATE - May 29, 1974 (phone)
TITLE - Environmental Control, Production Division
COMPANY - Cities Service Oil Co.
PHONE - 918/586-2743
ADDRESS - Box 300
Tulsa, Oklahoma 74102

Crude oil delivered to a pipeline is supposed to be stable; that is, all gas is to be removed prior to putting it in a pipeline. Most pipeline companies insist on adequate storage capacity to insure that enough time elapses for the oil to stabilize. As a result, the great majority of dissolved H_2S is removed in the field.

The American Petroleum Institute has a series of formulas which are used to help estimate the gas left in solution after crude leaves the low pressure heater-treater.

Cities Service now has a project underway to measure the H_2S in the space above the liquids in all its stock tanks. This information, coupled with the API formula will be used to estimate the emissions of H_2S. The survey will be complete in August or September. This work is limited to situations where the gas is vented or flared from the stock tanks.

To date the information suggests that the vapors above the liquid level in tank batteries is rich in wet gases (C_3 and heavier), as well as H_2S, when compared to the gas sent from a separator to a gas processing plant.

Mr. Straub promised full cooperation with his data, especially in trying to develop correlations so that emissions could be estimated on an oil field or county basis.

CONTACT REPORT

PERSON - W. J. Templeton DATE - May 23, 1974
TITLE - Supervisor of Measurement & Env'l. Affairs
COMPANY - Cities Service Oil Co. PHONE - 918/586-2641
ADDRESS - Box 300
Tulsa, Oklahoma 74102

- -

Both Texas and New Mexico require very detailed reports on gasoline plants, including data on H_2S loss. The Texas report is called GP-1. Both Texas and New Mexico have good (and complicated) reporting systems for emissions to the atmosphere. Other states such as Louisiana, Oklahoma, Arkansas and Mississippi do not require annual reports of emissions.

The typical specifications for pipeline quality gas are 1/4 grain per 100 SCF. Each gas contract is negotiated individually. The 1/4 grain standard is just commonly used. There is no standard or standards guidelines.

Cities Service operates 40 gas plants. Of these, 8 have sweetening and 5 of the 8 have sulfur recovery. Mr. Templeton would have no objection to assembling data by county, but he urged that the format of the report take into account population density of the county. He felt that there is no problem on disclosure if there is only one plant in a county, since the state has the data anyway.

The Texas Oil and Gas Handbook contains samples and explanations of all the forms required by the Texas Railroad Commission. It costs $10.00 and is available from:

R. W. Byram & Company
Drawer 1867
Austin, Texas 78767
512/478-2551

CONTACT REPORT

PERSON -	J. G. Herring	DATE -	July 9, 1974
TITLE -	Measurement Manager		
COMPANY -	Arkansas-Louisiana Gas Co.	PHONE -	318/425-1271
ADDRESS -	Box 1734 Shreveport, Louisiana 71151		

- -

This firm is an integrated producer, transporter and distributor of natural gas. Mr. Herring said that they generally don't measure deliveries, just the gas delivered to the system. About 20 to 25 percent of their total volume is purchased from gas sweetening plants whose average output is less than 0.1 grains/100 SCF hydrogen sulfide.

Mr. Herring estimated that the ratio of other sulfur compounds such as mercaptans and carbonyl sulfide is one-tenth to one-hundredth that of hydrogen sulfide.

The firm's internal standard is 1/4 grain/100 SCF.

CONTACT REPORT

PERSON - Carl T. Hester
TITLE -
COMPANY - Exxon Corporation
ADDRESS - Houston, Texas

DATE - June 24, 1974
PHONE - 713/221-3563

- -

Mr. Hester saw two ways to obtain data: 1) via the emissions inventory at the air pollution agencies and 2) by the GP-1 or similar reports filed with each oil and gas commission.

In Austin, there are two statistical services that specialize in Railroad Commission data: R.W. Byram & Company (512/478-2551) and Mason Map Service (512/472-4646).

Mr. Hester was not sure what made crude oil sour. The usual definition is crude that emits hydrogen sulfide, but he thought there were other compounds, too.

He confirmed that the Jay Field has been unitized by Exxon, and Steve Joens in New Orleans is the person to contact regarding data.

He expressed doubt that anyone was not submitting emissions data honestly. He stated that it is a law and that fraudulent or fabricated data submission is subject to severe penalties.

He agreed that data on sulfur recovery plants is relatively easy to get and suggested that a random sample be made of all plants without sulfur recovery to see what their emissions of sulfur dioxide are.

Among the contacts he suggested at the Railroad Commission were Larry Willimack (512/475-3081) and Bob Harris.

CONTACT REPORT

PERSON - Dr. Paul Petro
TITLE - Director - Product Development
COMPANY - Lone Star Gas
ADDRESS - 301 S. Harwood
Dallas, Texas 75201

DATE - May 29, 1974 (phone)

PHONE - 214/741-3711

- -

Dr. Petro said that the 1/4 grain/100 SCF standard is traditional in the industry. New contracts are being written as high as one grain. Lone Star has also become more lax in enforcing the 1/4 grain standard because of the shortage of gas. Sometimes it reroutes the gas in the pipelines to one of its dozen or so processing plants for clean-up prior to delivery.

The H_2S standard has usually been adequate, but much of the new gas being found in West Texas contains mercaptans and other organic sulfur compounds.

Only two of the 12 gas processing plants of Lone Star have sulfur recovery, Fashing and a new plant, Warwink (starting up 7/74).

CONTACT REPORT

PERSON - R. M. Cook
TITLE - Mechanical Engineer
COMPANY - New Orleans Public Service
ADDRESS - New Orleans, La.

DATE - July 12, 1974

PHONE - 504/

- -

The typical H_2S content of the gas purchased by NOPSI from United Gas is between 0.01 and 0.09 grains/100 SCF.

CONTACT REPORT

PERSON - Elmer R. Leisure
TITLE -
COMPANY - Phillips Petroleum Engineer
ADDRESS - Bartlesville, Oklahoma

DATE - June 20, 1974
PHONE - 918/661-6600

- -

Phillips generally tries to keep a slight positive pressure on its crude oil storage tanks. In this way gas dissolved in crude oil is delivered to the refinery where it is processed.

Mr. Leisure said that the sulfur in crude oil is almost always hydrogen sulfide. He disputed the fact that H_2S converts to SO_2 in the atmosphere. He cited some large produced water storage vessels in Kansas Arbuckle Field. This water contained H_2S and air passing over it would cause elemental sulfur to form on the surface.

He was not aware of any studies that had been made comparing the composition of crude as produced to that as shipped.

CONTACT REPORT

PERSON - B. F. (Ben) Ballard
TITLE - Manager Environmental Control
COMPANY - Phillips Petroleum Co.
ADDRESS - Bartlesville, Oklahoma 74004

DATE - May 23, 1974

PHONE - 918/661-5330

Phillips operates about 40 gas processing plants; about ten have some sweetening, but only three of these have sulfur recovery. More than half of Phillips' plants are located in Texas.

Mr. Ballard would fill out a questionnaire, but would want it limited to states where Phillips does not now make reports. He said that both Texas and New Mexico have extensive report requirements.

He stressed that Phillips often sells its tail gas from sweetening units, therefore, the questionnaire should include questions on disposal of the sulfur rich tail gas on:

flared
vented
Recovered as elemental sulfur
Sold (to whom - name and address)

As with the other petroleum companies, Mr. Ballard stressed cooperation, but also he wanted to avoid needless paper work if the data are available elsewhere.

CONTACT REPORT

PERSON - Billy D. Freeman
TITLE -
COMPANY - Shell Oil Company
ADDRESS - Houston, Texas

DATE - June 24, 1974

PHONE - 713/220-1650

- -

Bill reported that Shell operates five gas processing plants in their Mid-Continent Division and more in the other Division headquartered in New Orleans. Of the five, three have sweetening units and none has sulfur recovery. These three are TXL, Wassom and Bryan.

Shell is building about six sweetening plants in Michigan which will emit 200 to 300 pounds of sulfur dioxide per day. The plants employ Shell's sulfinol process and are small package units. There are several reasons for this type of plant. First, the wells are spread out over an area 100 miles in length, hence the gas must be sweetened prior to being sent to the gas processing plant for recovery of the natural gas liquids (propane and heavier). Second, several small plants avoid the problems of a single major facility.

Bill said that sour crudes contain organic sulfur complexes which breakdown to form hydrogen sulfide. This disassociation can be quite difficult, as shown by the rather high cost of desulfurization units at refineries.

It may be of interest to note that not all produced sulfur goes to the atmosphere. Shell's TXL plant only flares residue gas from the production of natural gas liquids and in-plant fuel. The sour natural gas stream is sent to El Paso Natural Gas Co. who cleans up the gas and sends the acid gas stream (70% CO_2 and 30% H_2S) to ARCO who reinjects it to maintain reservoir pressure.

CONTACT REPORT

PERSON -	James P. Aviati James E. Sirois	DATE -	June 25, 1974
TITLE -			
COMPANY -	Transcontinental Gas Pipe Line Corp.	PHONE -	713/626-8100
ADDRESS -	Box 1396 Houston, Texas 77001		

- -

When gathering gas from areas known to be sour, Transco has monitors on the line and ceases acceptance of gas if it is found to be in violation of contract. Thus only small amounts of off-specification gas ever get into the system.

The pipeline companies have a very practical reason for keeping concentrations of hydrogen sulfide low. Not only is it corrosive to the pipeline, but it is especially bad in compressors. Hence they are very careful about what they accept.

One tariff on file with the FPC shows that the maximum contaminants permitted to be delivered to gas utilities and distribution networks is 0.3 grains H_2S and 9 grains total sulfur per 100 cubic feet. Although there are some variations, the quality of the gas delivered to customers generally contains 0.1 grain H_2S and no other detectable sulfur per one hundred cubic feet.

In general gas is odorized, usually with sulfur mercaptans, by the distribution utility.

It was also mentioned that reactivity of hydrogen sulfide along the length of the pipeline is not a problem. There is little difference between gas quality entering and leaving a pipeline system. This means that the reaction with metals in the pipe are apparently not important.

Transco, like other gas pipeline companies, is having a difficult time buying gas. In one case they have built a gas treating and sulfur recovery plant, a task they used to be able to require their supplier to do. They will also buy limited quantities of higher H_2S gas - up to 1 grain - provided the existing gas in the line will keep it diluted enough to prevent problems.

CONTACT REPORT

	Mr. Hendricks - Measurement Manager	DATE -	July 9, 1974
PERSON -	Paul Fisher		
TITLE -	General Superintendent	PHONE -	318/424-0331
COMPANY -	Transwestern Pipeline Company		
ADDRESS -	500 Milam Street Shreveport, Louisiana		

Mr. Hendricks referred me to Mr. Fisher who was generally reluctant to answer any questions. They feel that they have been victimized by other "information gatherers" in the past and were highly suspect of my motives.

All that Mr. Fisher would say is that their tariffs call for delivery of gas which is less than 1/2 grain/100 SCF total sulfur of which no more than a 1/4 grain is hydrogen sulfide. This utility has two major customers: Southern California Gas and Cities Service. Mr. Fisher did not wish to reveal the sulfur content of the gas being delivered. He said it varied too much and he could not give a range of values.

CONTACT REPORT

PERSON - Robert Castle
TITLE - Supervisor Gas Measurement
COMPANY - Trunkline Gas Co.
ADDRESS - Box 1642
Houston, Texas 77001

DATE - June 26, 1974

PHONE - 713/664-3401

- -

Trunkline's Collection system covers the coastal areas of Texas and Louisiana and the offshore area of Louisiana. All gas goes to a major junction point in Southwestern Louisiana where it is shipped north to Central Illinois.

Because all the gas comes from sweet areas, sulfur is rarely of concern. One test at the junction point showed the following:

.0056 gr./100 SCF	Onshore Louisiana
.0056 gr./100 SCF	Onshore Texas
.0028 gr./100 SCF	Offshore Louisiana
.0042 - average (about)	

total average daily throughput of the line is 1.1 x 10^{12} CF/day.

So far as is known Trunkline buys no gas from any gas processing plant that has a sulfur recovery plant. He said that the firm with the largest problem was Transwestern (a subsidiary of Texas Eastern). Much of their gas comes from West Texas and Eastern New Mexico - where it is quite sour when produced. California has very strict regulations on the sulfur content of gas.

In summary - he just felt lucky that he had such clean gas.

CONTACT REPORT

PERSON - George A. Loker, Jr.
TITLE - Pipeline Operations Coordinator
COMPANY - United Gas Pipeline
ADDRESS - Box 1407
Shreveport, La. 71158

DATE - July 9, 1974

PHONE - 318/222-8631

- -

Most of United's gas is from offshore areas and it generally analyzes at 0.01 gr/100 SCF H_2S. United buys gas from three gas treating plants. Two in Mississippi supply gas between .10 and .40 grains; one in South Texas also has some sweetening. The total output of these three plants accounts for less than 0.2 percent of the entire system capacity.

The above data is based on scanning about 50 analyses.

Deliveries of gas were all reported to be 0.01 grains or less for total sulfur. It was Mr. Loker's opinion that hydrogen sulfide constitutes well over ninety percent of the total sulfur reported.

CONTACT REPORT

PERSON - (Ed) E. T. Horton
TITLE - Director of Technical Services
COMPANY - Warren Petroleum Co.
ADDRESS - Box 1589
Tulsa, Oklahoma 74102

DATE - May 23, 1974

PHONE - 918/584-7121

- -

Warren is a division of Gulf Oil that handles all of their gasoline plants. They operate 25 plants as follows:

16	Texas (4 of these have sulfur recovery)
5	New Mexico
3	Oklahoma
1	Louisiana
25	

Of these plants, about 12 have some sort of treating facility where the off gases are either flared, vented or reinjected. Mr. Horton said that if they had 2 grain gas, they would normally clean it up prior to selling to a pipeline. They would not just dilute it in the pipeline.

The pipeline customer, whoever he is, sets the standards on maximum H_2S, water and CO_2.

Mr. Horton said that the API is preparing a copy of a brochure telling the public about gasoline plants and how environmentally clean they are.

He had no objection to a data format that would show emissions by county. He would favor filling out a form, but only for those states which do not require information e.g. not Texas or New Mexico. He commented that these two states required the most detailed reports.

Since Warren is strictly a gas processor, he did not have any data on H_2S emissions from crude oil storage.