

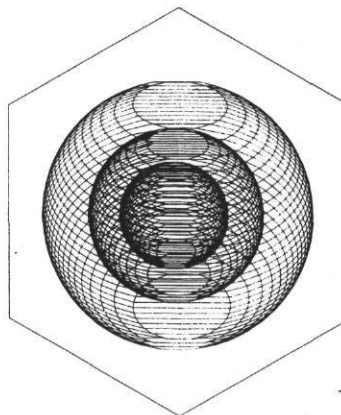
Task #3: Audit of Lone Star Gas Invoices and Billing Procedures

Submitted to
the Texas A&M University Power Plant
in partial fulfillment of Contract No. C97-00228

Submitted by
Energy Systems Laboratory

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September 1997



ENERGY SYSTEMS LABORATORY

**Department of Mechanical Engineering
Texas Engineering Experiment Station
Texas A&M University System**

EXECUTIVE SUMMARY

At the request of the TAMU Power Plant, the ESL staff audited the 1995 Lone Star Gas Company invoices. Gas consumption is measured and the measured volume is converted to standard volume (at T=60 °F, P=14.65 psia) to determine the energy content and cost. This audit was performed to determine if the bills from Lone Star Gas Company had correctly converted the measured volumes to standard volumes, and had charged the proper amounts.

Lone Star Gas Company uses standard methods to convert measured gas volumes to standard volumes by assuming constant gas CO₂ content (2.8%), N₂ content (0.79%) and gas specific gravity value (0.647). In 1995, the gravity value measured varied from 0.601 to 0.627, which is lower than the assumed value. Hence, Lone Star Gas Company overcharged TAMU Power Plant by 0.17% to 0.39% depending on the actual specific gravity values (see the chart below). The impact of assuming constant CO₂ and N₂ levels on the bills is negligible.

After a joint meeting with ESL and TAMU Physical Plant personnel, Lone Star Gas Company agreed to update the gas specific gravity value every four months in the future and to reconcile gas bills back to 1994 with measured specific gravity values. This reconciliation will result in a credit to Texas A&M University of approximately \$20,000 for 1995. Results of the reconciliation for other years will depend on the measured specific gravity values.

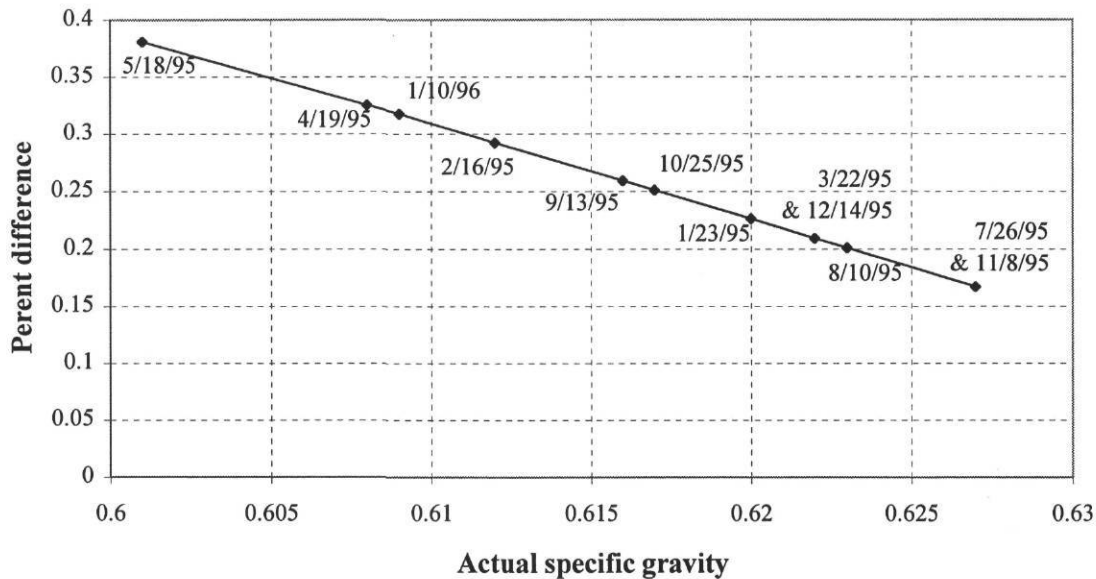


Figure 1. The percent overcharge due to incorrect specific gravity (0.647) used in the volume correction.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
TABLE OF CONTENTS	ii
1. INTRODUCTION.....	1
2. METHODOLOGY	1
2.1 INTRODUCTION.....	1
2.2 SUPERCOMPRESSIBILITY FACTOR.....	2
2.3 DETERMINATION OF SUPERCOMPRESSIBILITY FACTOR (F_{pv}).....	3
3. RESULTS.....	5
4. CONCLUSIONS AND RECOMMENDATIONS	6
ATTACHMENT A GAS TRANSPORTATION CONTRACT BETWEEN LONE STAR GAS COMPANY AND TEXAS A&M UNIVERSITY	8
ATTACHMENT B AGA MANUAL FOR THE DETERMINATION OF SUPERCOMPRESSIBILITY FACTORS FOR NATURAL GAS	9
ATTACHMENT C MONTHLY AND PARTIAL HOURLY GAS MEASUREMENT FOR MAY 1997	10
ATTACHMENT D SPREADSHEET OF GAS VOLUME CORRECTION	11
ATTACHMENT E GAS ANALYSIS DATA FOR 1995.....	12

Task #3: Audit Lone Star Gas Invoices and Billing Procedures.

1. INTRODUCTION

With the help of Sheryl Russell from the physical plant, the ESL staff audited the Lone Star Gas invoices and verified the calculation of the gas volumes applied by the Lone Star Gas Company. This report presents the method of verification and the results.

2. METHODOLOGY

2.1 INTRODUCTION

Gas is measured by volume which is expressed in cubic feet at a specified reference pressure and temperature, as measured by a meter or computed from a meter record. Since gas volumes vary according to pressure and temperature, it is necessary to express volumes in accordance with some standard set of conditions. The American Gas Association (A.G.A.) endorses the adoption of 14.73 psia and 60 °F as the standard base conditions of pressure and temperature to be used in gas volume measurement. However, these standard pressure and temperature values vary from state to state in the United States. The gas transportation contract between Lone Star Gas Company and Texas A&M University (refer to Attachment A) specifies that a pressure base of 14.65 psia and a temperature base of 60 °F will be the standard conditions.

The absolute pressure of the gas at the point of measurement is the sum of the gage pressure and the atmospheric pressure. The atmospheric pressure depends on the location, altitude and barometric conditions. Normally, an average atmospheric pressure of 14.4 psia is assumed regardless of the actual location or elevation of the delivery point or variation in actual barometric pressure from time to time. The gas transportation contract between Lone Star Gas Company and Texas A&M University uses 14.4 psia as the average atmospheric pressure, which is called zone pressure in its gas bill.

2.2 SUPERCOMPRESSIBILITY FACTOR

For an ideal gas, the relationship of the gas volume at different pressures and temperatures is expressed by the perfect gas law:

$$\frac{P_m V_m}{RT_m} = \frac{P_s V_s}{RT_s} \quad (1)$$

$$V_s = V_m \cdot \frac{P_m}{P_s} \cdot \frac{T_s}{T_m} \quad (2)$$

Where subscript m indicates actual measured values, s indicates values under base conditions.

For a real gas, its volume at high pressure is less than the theoretical value. This deviation is called “supercompressibility”. A supercompressibility factor should be taken into account in gas measurement. This factor may be expressed by the following equation:

$$F_{pv} = (RT/PV)^{0.5} = (1/Z_f)^{0.5} \quad (3)$$

where

F_{pv} = supercompressibility factor;

R = universal gas constant;

T = gas temperature;

P = gas pressure;

V = molar gas volume;

Z_f = compressibility of a particular gas

$$= \frac{V_{\text{actual}}}{V_{\text{ideal}}};$$

V_{actual} = actual gas specific volume;

V_{ideal} = ideal gas specific volume.

Therefore, under high pressure,

$$F_{pv} = \left(\frac{1}{Z_f} \right)^{0.5} = \left(\frac{V_{\text{ideal}}}{V_{\text{actual}}} \right)^{0.5} \quad (4)$$

we have:

$$V_{\text{ideal}} = V_{\text{actual}} \times F_{pv}^2 \quad (5)$$

Thus, V_m should be corrected by a factor of $(F_{pv})^2$:

$$V_s = V_m \cdot \frac{P_m}{P_s} \cdot \frac{T_s}{T_m} \cdot F_{pv}^2 \quad (6)$$

2.3 DETERMINATION OF SUPERCOMPRESSIBILITY FACTOR (F_{pv})

The formulas used to calculate this factor were found in an A.G.A. report from December 1962 entitled "AGA Manual for the Determination of Supercompressibility Factors for Natural Gas." It was produced as a result of Research Project NX-19, whose goal was "Extension of Range of Supercompressibility Tables." (refer to Attachment B).

The carbon dioxide (CO_2) and nitrogen (N_2) contents and the gas specific gravity¹, in conjunction with the gage pressure and absolute flowing temperature, are required to determine F_{pv} . The required information and the detailed procedures for the determination of F_{pv} is presented below.

Inputs:

G = specific gravity of flowing gas

M_c = mol percent carbon dioxide

M_n = mol percent nitrogen

P = gage pressure, psig

t = flowing temperature, °F

The detailed step-by-step calculation of F_{pv} is as follows:

The base equation for determining F_{pv} is expressed as:

Step 1. Calculate K_p .

$$K_p = M_c - 0.392M_n \quad (7)$$

Step 2. Calculate F_p , pressure adjusting factor

$$F_p = \frac{156.47}{160.8 - 7.22G + K_p} \quad (8)$$

¹ Also known as relative density. It is the ratio of the weight of one cubic foot of natural gas to the weight of one cubic foot of dry air, under the same pressure and temperature conditions. It depends on the constituents of gas.

Step 3. Calculate K_T .

$$K_T = Mc + 1.681M_n \quad (9)$$

Step 4. Calculate F_T .

$$F_T = \frac{226.29}{99.15 + 211.9G - K_T} \quad (10)$$

Step 5. Calculate the adjusted pressure.

$$P_{adj.} = P \times F_p \quad (11)$$

Step 6. Calculate the adjusted temperature.

$$t_{adj.} = (t + 460) \times F_T - 460 \quad (12)$$

Step 7. Calculate the pi factor.

$$\pi = \frac{P_{adj.} + 14.7}{1000} \quad (13)$$

Step 8. Calculate the tau factor.

$$\tau = \frac{t_{adj.} + 460}{500} \quad (14)$$

Step 9. Calculate the m factor.

$$m = 0.0330378 (\tau)^{-2} - 0.0221323 (\tau)^{-3} + 0.0161353 (\tau)^{-5} \quad (15)$$

Step 10. Calculate the n factor.

$$n = \frac{0.265827(\tau)^{-2} + 0.0457697(\tau)^{-4} - 0.133185(\tau)^{-1}}{m} \quad (16)$$

Step 11. Calculate the B factor.

$$B = \frac{3 - mn^2}{9m\pi^2} \quad (17)$$

Step 12. Look up the E factor.

The E factor depends on pressure and temperature. It can be linearly interpolated from Table 4 in Attachment B. For typical values of temperature and pressure found at the TAMU power plant, the E factor is 1.0

Step 13. Calculate the b factor.

$$b = \frac{9n - 2mn^3}{54m\pi^3} - \frac{E}{2m\pi^2} \quad (18)$$

Step 14. Calculate the D factor.

$$D = \left(b + \sqrt{b^2 + B^3} \right)^{1/3} \quad (19)$$

Step 15. Calculate the F_{pv} factor.

$$F_{pv} = \frac{\sqrt{\frac{B}{D} - D + \frac{n}{3\pi}}}{1 + \left(\frac{0.00132}{\tau^{3.25}} \right)} \quad (20)$$

3. RESULTS

Although the gas transportation contract specifies that the measured gas volumes should be corrected based on daily average meter pressure, specific gravity and flowing temperature, Lone Star Gas Company actually makes the gas volume correction on an hourly basis. The corrections are added to obtain daily and monthly totals and the power plant is billed for the monthly total.

One month of hourly gas measurement printouts for the power plant were obtained from Sheryl Russell at the Physical Plant (refer to Attachment C for part of the printouts). These printouts show hourly uncorrected and corrected gas volumes and average gas pressure and temperature. The equations discussed in Section 2 were applied to compute the corrected gas volume based on gas pressures and temperatures shown in the printouts and assuming constant CO_2 , N_2 , and specific gravity values of 2.8%, 0.79%, and 0.647, respectively. Hourly values for CO_2 , N_2 , and specific gravity values are not available. The impact of this assumption will be examined later. The computed gas volumes at standard conditions were compared with the corrected values shown in the printouts. The difference (defined as

$\frac{V_{\text{bill_corrected}} - V_{\text{calculated}}}{V_{\text{calculated}}} \times 100\%$) varied from -0.10% to 0.05% (minus sign is in favor of the power plant), and the average difference is 0.01% (refer to Attachment D for part of the spreadsheet).

4. CONCLUSIONS AND RECOMMENDATIONS

The result shows that the gas volumes calculated by Lone Star Gas Company were correct. However, there are two items that need to be noted.

First, the gas transportation contract between Lone Star Gas Company and Texas A&M University does not indicate the use of some gas constituent values (CO₂ and N₂ contents) for the correction of gas volume. Constant CO₂, N₂, and specific gravity values of 2.8%, 0.79%, and 0.647, respectively, appeared in all gas bills. It was then assumed that these were the values used in the calculation of standard gas volume. This was verified during the meeting with Lone Star Gas Company representatives on August 28, 1997. The impact of the variation of these values is small, however, as can be seen from Table 1. The differences were evaluated by holding all other parameters at the assumed constant values while varying one item to its minimum and maximum values. Minimum and maximum values of CO₂, N₂, and specific gravity were based on historical monthly gas analysis data obtained from Lone Star Gas Company for the year 1995 (refer to Attachment E).

Table 1. Impacts of gas content and specific gravity variations on the difference of corrected gas volume calculated by Lone Star Gas and using the standard procedures.

	Contents	Percent Difference Range	Percent Difference (average)
CO ₂	1.65% (minimum)	-0.17 ~ -0.01	-0.07
	2.80% (assumed)	-0.10 ~ 0.05	-0.01
	3.18% (maximum)	-0.08 ~ 0.07	0.02
N ₂	0.40% (minimum)	-0.13 ~ 0.03	-0.03
	0.79% (assumed)	-0.10 ~ 0.05	-0.01
	0.85% (maximum)	-0.10 ~ 0.06	0
Specific Gravity	0.601 (minimum)	0.28 ~ 0.44	0.39
	0.627 (maximum)	0.07 ~ 0.23	0.17
	0.647 (assumed)	-0.10 ~ 0.05	-0.01

It can be seen that the gas specific gravity has a greater impact on the volume correction than CO₂ and N₂ contents do. Note that the assumed CO₂ and N₂ contents used in the bills are within the normal range of variations based on the monthly gas analysis in 1995. However, the specific gravity value used is out of the range. This will result in the power plant be overcharged by 0.39% when the

specific gravity value of 0.647 is used while the actual value is 0.601. Figure 1 presents the resulting gas volume differences if a constant specific gravity of 0.647 was used when the actual specific gravity varies from 0.601 to 0.627. The average of the 11 monthly values of specific gravity recorded in attachment E is 0.618. If differences in monthly consumption are ignored, Texas A&M University was overcharged by 0.24% for gas during 1995, or by approximately \$20,000 for the \$8,329,058 spent for gas used at the main power plant. After a joint meeting with ESL and TAMU Physical Plant personnel, Lone Star Gas Company agreed to update the gas specific gravity value every four months in the future and to reconcile gas bills back to 1994 with measured specific gravity values. This reconciliation will result in a credit to Texas A&M University of approximately \$20,000 for 1995. Results of the reconciliation for other years will depend on the measured specific gravity values.

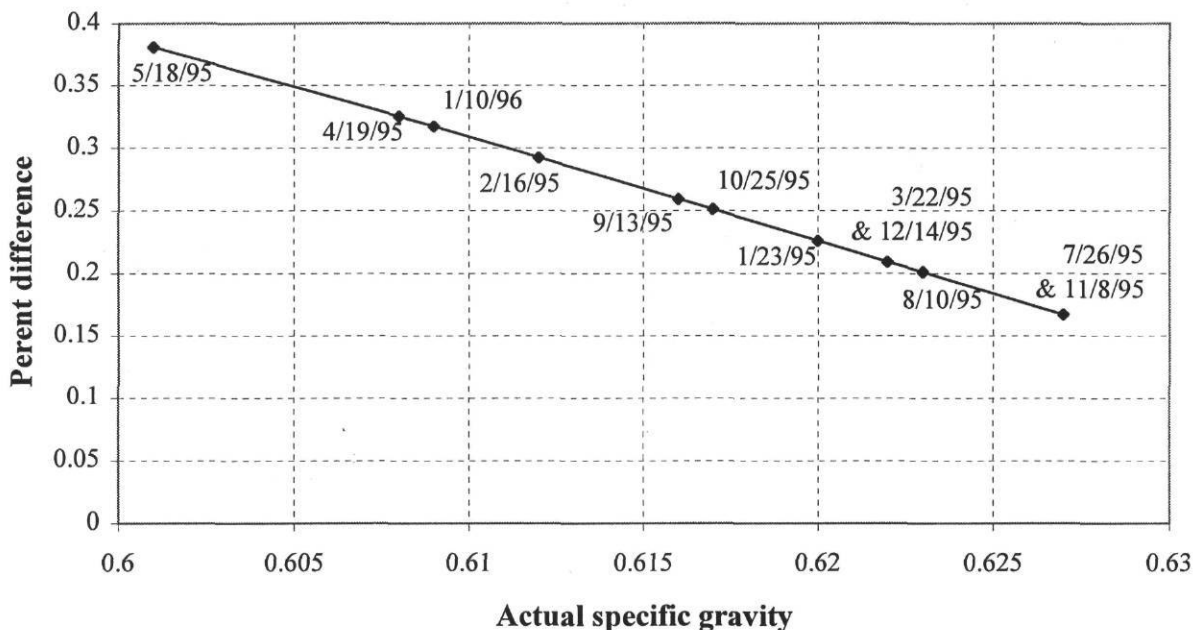


Figure 1. The percent overcharge due to incorrect specific gravity (0.647) used in the volume correction.

Second, Lone Star Gas Company currently checks the meter accuracy once a year (according to a personal communication). TAMU receives no report or record of the activities. It is recommended that Lone Star Gas Company calibrate the meter every six months and submit the calibration report to TAMU.

ATTACHMENT A

**GAS TRANSPORTATION CONTRACT BETWEEN LONE STAR GAS
COMPANY AND TEXAS A&M UNIVERSITY**



Lone Star Gas Company

WILLIAM Z. RANKIN
Associate Gas Transportation Representative
(214) 573-5194

301 S. Harwood St. • Dallas, Texas 75201-5696

November 15, 1994

Texas A & M University
Physical Plant Department
Agronomy Road
College Station, Texas 77843-1371

Attn: Executive Director

Re: LS-MC-#782
Gas Transportation Agreement
between Lone Star Gas Company and
Texas A & M University

Dear Gentlemen:

Enclosed please find an executed copy of the Gas Transportation Agreement between Lone Star Gas Company and Texas A & M University, dated September 30, 1994, for your files. If further assistance is needed, please call me at 214/573-5194.

Very truly yours,

William Z. Rankin

WZR:pb

Enclosure

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AMENDMENT OF GAS TRANSPORTATION AGREEMENT

THIS AMENDATORY AGREEMENT, made and entered into this 30 day of September 1994, by and between TEXAS A & M UNIVERSITY, herein referred to as "Shipper", and LONE STAR GAS COMPANY, a Division of ENSERCH Corporation, a Texas corporation, hereinafter referred to as "Transporter".

W I T N E S S E T H:

WHEREAS, Shipper and Transporter made and entered into a Gas Transportation Agreement dated September 20, 1990, as amended (the "Agreement") covering the transportation of gas from Point(s) of Receipt set forth in said Agreement, more particularly described in Exhibit "A" thereto, to which Agreement, being unrecorded, reference is hereby made for all purposes; and

WHEREAS, the parties hereto, as Shipper and Transporter, desire to modify and amend the Agreement as hereinafter indicated,

NOW THEREFORE, in consideration of the mutual covenants and agreements herein contained, Shipper and Transporter hereby contract and agree as follows:

I.

Effective Septemer, 1994, all terms and provisions of the Agreement shall be deleted in their entirety and replaced by the attached terms and provisions, which by reference are made part hereof and of the Agreement; provided, however, any obligations incurred by either party under the Agreement prior to the effective date of this Amendment shall not be extinguished hereby.

IN WITNESS WHEREOF, this Amendment of Gas Transportation Agreement has been executed in duplicate originals by the parties hereto as of the day and year first hereinabove written.

ATTEST:

By: Melvin M. Ricard

TEXAS A & M UNIVERSITY

By: [Signature] MK
Title: Senior VP - Finance & Administration

ATTEST:

By: Not Required

LONE STAR GAS COMPANY, a
Division of ENSERCH Corporation

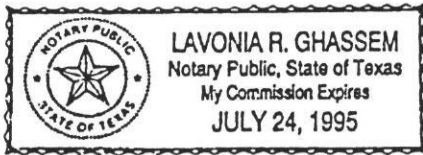
By: [Signature]
Title: Secretary in Fact

STATE OF TEXAS

COUNTY OF BRAZOS

BEFORE ME, the undersigned authority, a Notary Public in and for said County and State, on this day personally appeared Jerry Gaston, Interim V.P. for, Finance & Admin., of TEXAS A & M UNIVERSITY, known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he executed the same for the purposes and consideration therein expressed, in the capacity therein stated.

GIVEN UNDER MY HAND AND SEAL OF OFFICE, this the 30th day of September, A.D., 1994



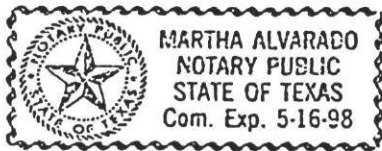
Lavonia R. Ghassem
Notary Public in and for
Brazos County, Texas
My commission expires the 24th
day of July, 1995

STATE OF TEXAS

COUNTY OF DALLAS

BEFORE ME, the undersigned authority, a Notary Public in and for the State of Texas, on this day personally appeared Richard A. Frank Attorney-in-Fact for LONE STAR GAS COMPANY, a Division of ENSERCH Corporation, a Texas corporation, known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he executed the same for the purposes and consideration therein expressed, in the capacity therein stated, and as the act and deed of said corporation.

GIVEN UNDER MY HAND AND SEAL OF OFFICE, this the 1st day of November, A.D. 1994.



Martha Alvarado
Notary Public in and for
the State of Texas

GAS TRANSPORTATION AGREEMENT

THIS AGREEMENT, made and entered into the 20th day of September, 1990, to be effective September 1, 1990, by and between LONE STAR GAS COMPANY, a Division of ENSERCH Corporation, a Texas corporation, hereinafter referred to as "Transporter" and TEXAS A & M UNIVERSITY, hereinafter referred to as "Shipper";

W I T N E S S E T H:

WHEREAS, Shipper owns or controls certain quantities of natural gas which are not subject to the jurisdiction of the Federal Energy Regulatory Commission (the "FERC") under either the Natural Gas Act of 1938, as amended, (the "NGA"), or the Natural Gas Policy Act of 1978, as amended, (the "NGPA"), and Shipper desires that Transporter (a) receive gas from Shipper (or its designee) at the Point(s) of Receipt hereinafter set forth and (b) redeliver gas to the Point(s) of Delivery hereinafter set forth; and

WHEREAS, Transporter owns and operates a pipeline system and is willing to transport gas for Shipper under the terms and conditions hereinafter set forth and pursuant to Section 5.02(b) of the Texas Gas Utility Regulatory Act;

NOW, THEREFORE, for and in consideration of the mutual covenants and conditions herein contained, the adequacy and sufficiency of which are hereby acknowledged, Transporter and Shipper hereby agree as follows:

ARTICLE I.

QUANTITY

1.1 (a) Shipper hereby agrees to transport under this Agreement one hundred percent (100%) of Shipper's facilities' (as listed on Exhibit "A" attached hereto and incorporated herein) (hereinafter referred to as "Shipper's facilities") entire natural gas requirements, except for any purchases under (i) that certain Contract for Special Commercial Standby Gas Service between Shipper and Transporter dated September 30, 1994 (hereinafter referred to as the "Contract for Special Commercial Standby Service") or (ii), if applicable, that certain Contract for Industrial Gas Service between Shipper and Transporter dated September 30, 1994 (hereinafter referred to as the "Contract for Industrial Gas Service"). It is agreed that the volume of gas to be transported under this Agreement will not exceed a maximum daily volume of 20,000 Mcf for the Industrial Power Plant Delivery Point and a combined total maximum daily volume of 5,000 Mcf for all other delivery points hereunder. It is further hereby agreed that if Shipper ever fails to transport at least a daily average of 10,000 Mcf to Shipper's Industrial Power Plant for two consecutive months, then Transporter reserves the right, upon 60 days' prior written notice, to re-negotiate and/or terminate this Agreement and all related agreements (as specified on Exhibit "B" attached hereto and incorporated herein) within ninety (90) days of such occurrence. It is further hereby agreed that the calculation of all quantities of gas received and delivered hereunder shall, for all purposes, including, but not limited to, payment and determination of imbalance and retention volumes, be on an MMBtu basis.

(b) Transporter's receipt and delivery of such gas volumes, up to 5,000 Mcf/d, will be considered "Priority" and shall not be curtailed, interrupted, or discontinued by Transporter for any

reason except for: (i) an event of force majeure, as defined herein including but not limited to compliance with laws, regulations or governmental orders, (ii) failure or refusal of Shipper (or its designee) to receive/deliver or cause to be received/delivered gas hereunder in accordance with the terms of this Agreement, (iii) available pipeline capacity necessary to maintain Transporter's sales service to its residential and commercial customers and higher priorities of sales service under tariffs filed with applicable regulatory authorities, and (iv) any other terms and conditions herein.

(c) Transporter's receipt and delivery of such gas volumes, up to an additional 20,000 Mcf/d, will be considered "Non-Priority" and may be curtailed, interrupted, or discontinued by Transporter for the following reasons: (i) the most operationally efficient utilization of Transporter's pipeline capacity (provided, however, the foregoing shall not be interpreted to allow Transporter to prioritize transportation service based upon the fees paid for such service), (ii) an event of force majeure, as defined herein including but not limited to compliance with laws, regulations or governmental orders, (iii) failure or refusal of Shipper (or its designee) to receive/deliver or cause to be received/delivered gas hereunder in accordance with the terms of this Agreement, (iv) available pipeline capacity necessary to maintain Transporter's sales service to its residential and commercial customers and higher priorities of sales service under tariffs filed with applicable regulatory authorities, and (v) any other terms and conditions herein.

(d) It is understood and agreed by the parties that if in the future Transporter establishes a queuing system for prioritizing intrastate transportation, the date of initial delivery under this Agreement shall be considered September 1, 1990 for the Receipt Points and Delivery Points established hereunder as of the September 20, 1990 execution date of this Agreement.

1.2 (a) It is recognized that a day-to-day balance of gas received by Transporter and delivered to Shipper may not be possible due to the inability of the parties to control precisely such receipts or deliveries. However, Transporter, to the extent practicable, will deliver to Shipper each day a quantity of gas equivalent to the quantity received from Shipper (or its designee) that day, in addition to any quantities of gas nominated by Shipper and approved by Transporter to correct an imbalance hereunder; provided, however, Transporter shall deliver to Shipper's Industrial Power Plant Delivery Point only ninety nine and one quarter percent (99.25%), and to Shipper's other facilities (as set forth herein) only ninety nine percent (99%), of the quantity of gas received by Transporter from Shipper (or its designee) and Transporter shall retain, respectively, the three quarters of one percent (.75%) and one percent (1%) balance of the quantity of gas received as normal gas lost, gas used as fuel and gas used in day-to-day pipeline operations (the "Retention Volume").

(b) It shall be the responsibility of Shipper to monitor, to the best of its ability, and if necessary, adjust, or cause to be adjusted, (i) deliveries of gas to Transporter for transportation and (ii) receipts of transportation gas from Transporter, in order to maintain a daily balance of receipts and deliveries. Transporter shall not be obligated to receive or deliver quantities of gas in excess of those quantities nominated by Shipper, in accordance with Section 1.3 hereof, for transportation hereunder, nor shall Transporter be obligated to deliver to Shipper at the Delivery Point(s) quantities of gas in excess of those quantities received from Shipper at the Receipt Point(s) and any quantities of gas nominated by Shipper and approved by Transporter to correct an imbalance hereunder, less the Retention Volume. Shipper shall monitor, to the best of its ability, receipts and deliveries hereunder and shall advise Transporter of any situation wherein an imbalance has occurred or may occur unless corrective action is taken. Shipper shall be obligated to adjust its receipts and/or deliveries of transportation gas to the extent necessary to correct or avoid any imbalance and to notify Transporter of such adjustments. Any adjustments to receipts and/or deliveries by Shipper, whether or not pursuant to notification from either party, shall be coordinated with Transporter's

gas control personnel. The foregoing paragraph shall not be construed to obligate Shipper to upgrade existing metering equipment, except as provided in Section 2 of the General Terms and Conditions attached hereto.

(c) An imbalance shall exist hereunder where, during any month of the term hereof, there is a numerical difference between the quantity of gas, exclusive of the total of those volumes of gas delivered under the Contract for Special Commercial Standby Service and the Retention Volume, delivered by Transporter to Shipper and the quantity of gas received by Transporter from Shipper (or its designee) during such month and any such imbalance shall be corrected insofar as practicable during the month following Transporter's initial notice to Shipper (verbally or in writing) of such imbalance. In the event Shipper ever fails during any month of the term hereof to make up a prior month's imbalance, then (i) in the case of any cumulative imbalance, as hereinafter defined, due Transporter ("underdeliveries by Shipper"), Shipper shall purchase such cumulative imbalance volume(s), in accordance with and pursuant to the terms of the Contract for Special Commercial Standby Service or (ii) in the case of any cumulative imbalance, as hereinafter defined, due Shipper ("overdeliveries by Shipper"), Transporter shall have the right with notice given to Shipper or its designee, on or before four (4) business days prior to any month, to restrict, interrupt, or reduce the quantity of gas Transporter will accept at any and/or all the Receipt Point(s) until such time as the imbalance is corrected. In the event Shipper is required to purchase from Transporter any cumulative imbalance(s), as provided in (i) above, Transporter agrees to credit Shipper for transportation fees paid by Shipper to Transporter hereunder on such cumulative imbalance volume(s). For the purposes of this paragraph, the term "cumulative imbalance" shall mean the sum of (1) any imbalance carried forward from an immediately preceding month to the next succeeding month, plus (2) any imbalance based on the delivery and receipt of gas hereunder during such succeeding month. Notwithstanding the foregoing, Shipper shall not attempt to utilize the imbalance provisions hereunder to provide back-up service for its facilities in the event its third party supplier(s) fail to deliver gas to Transporter for redelivery hereunder to Shipper's facilities, or to provide facilities protection gas for its facilities. In the event Transporter, in its reasonable opinion, ever determines that Shipper has intentionally done so, Shipper agrees that Transporter shall have the right to suspend and/or terminate this Agreement upon reasonable prior notice.

(d) Notwithstanding anything contained herein which might be construed to the contrary, either party may restrict, interrupt, or reduce its receipt and/or delivery of gas hereunder in order to maintain a daily balance or to correct an imbalance hereunder.

1.3 At least three (3) business days prior to the first calendar day of each month during the term hereof, Shipper shall notify Transporter of the volumes of gas Shipper nominates for transportation at the Receipt and Delivery Points under this Agreement. Each such transportation nomination shall contain Shipper's nominated quantities for the Receipt and Delivery Points, designation of the appropriate contract(s) covering such gas, and the identity by name and telephone number of individual(s) who have authority to confirm the nominated gas volumes at each Receipt and Delivery Point. Timely nominations may be given by verbal notice; provided, however, Shipper shall furnish written confirmation thereof within five (5) business days of the date of such verbal notice. Shipper may change nominated quantities, receipt points or delivery points on any business day upon verbal notice and Transporter's prior approval of any such change, but such verbal notice must be received by Transporter prior to 12:00 noon Central time of any business day to be effective the next succeeding business day. If Shipper fails to furnish transportation nominations as required herein for any month during the term hereof, Transporter may interrupt transportation service during such month hereunder for the same number of days that the nomination is late for such month, and such interruption of service shall not prevent enforcement by Transporter of any other

of its legal rights or remedies nor be construed as a breach of Transporter's obligations hereunder.

1.4 Shipper agrees to transport under this Agreement to each of the Delivery Points set forth herein a volume of 500 Mcf of gas or more per year. In the event such volumes do not reach at least 500 Mcf for any Contract Year of the term of this Agreement, the applicable Delivery Point(s) shall not be eligible to receive gas transportation hereunder during the next succeeding Contract Year of the term of this Agreement; however, should such Delivery Point(s) subsequently achieve a volume of at least 500 Mcf per year, then it shall again become eligible for gas transportation service under this Agreement for the next succeeding Contract Year of the term of this Agreement, but in no event beyond the term of this Agreement.

ARTICLE II.

LOCATIONS OF POINTS OF RECEIPT AND DELIVERY

2.1 Receipt Point: Gas delivered by Shipper (or its designee) to Transporter hereunder shall be delivered at points which are sometimes herein referred to as the "Transporter Receipt Point(s)" or "Point(s) of Receipt" and located at mutually agreeable points on Transporter's pipeline transmission system, and any such mutually agreeable points shall be specifically set forth and identified in writing signed by both Transporter and Shipper. It is agreed that all Transporter Receipt Point(s) to be established hereunder will be subject to Transporter's prior approval.

2.2 Delivery Point: Gas transported by Transporter hereunder shall be delivered to Shipper where gas first passes from Transporter's metering equipment into Shipper's facilities, as specified in Exhibit "A" attached hereto.

2.3 Additional Points: It is understood by both parties that Shipper and Transporter may mutually agree in writing to establish other Receipt Points hereunder. In the event Shipper desires that Transporter receive gas at a proposed point(s), Shipper shall notify Transporter in writing or verbally, to be promptly followed in writing, of such proposed point(s), including in such notice estimated daily delivery volume(s) at such point(s) and the location(s) thereof and Shipper shall therein warrant that the quality of gas to be received at such proposed point(s) meets the quality specifications as defined herein and all other applicable terms and conditions contained in this Agreement. Transporter will promptly evaluate each point and, by five o'clock (5:00) pm (CST) on the business day immediately following Transporter's receipt of Shipper's notice, for such proposed point, notify Shipper whether or not Transporter is able to accept gas from Shipper's proposed new Receipt Point(s). Failure to respond by such following business day shall not be construed as Transporter's acceptance of any proposed new point(s). If Transporter agrees to establish any additional Receipt Point(s) pursuant hereto, such agreement shall be evidenced in writing signed by both Shipper and Transporter. Shipper's requested receipt points shall not be unreasonably denied by Transporter. It is further understood by both parties that Shipper and Transporter may mutually agree in writing to establish other Delivery Points hereunder.

ARTICLE III.

PRESSURES AT POINTS OF RECEIPT AND DELIVERY

3.1 Shipper (or its designee) shall deliver gas to Transporter at the Receipt Point(s) at pressures sufficient to enter Transporter's pipeline system at such point; provided, however, that Shipper's delivery pressure into Transporter's system at the Receipt Point(s) shall not exceed Transporter's maximum allowable operating pressure at any such point.

3.2 Transporter shall deliver gas to Shipper at Transporter's operating pressure at the Delivery Point(s). Should Transporter's operating pressure at the Delivery Point(s) be insufficient to serve the Delivery Point(s), Shipper shall have the option to terminate this Agreement upon sixty (60) days' prior written notice to Transporter.

ARTICLE IV.

RATES

4.1 (a) Beginning September 1, 1994, Shipper shall pay Transporter for the services rendered hereunder each month an amount equal to:

- (1) 5¢ for each MMBtu delivered hereunder to the Industrial Power Plant Delivery Point,
- (2) 38¢ for each MMBtu delivered hereunder to the West Utility I Delivery Point,
- (3) \$1.25 for each MMBtu delivered hereunder to any Delivery Point(s) having a commercial load less than 15,000 Mcf per year, but greater than 500 Mcf/yr,
- (4) 85¢ for each MMBtu delivered hereunder to any Delivery Point(s) having a commercial load greater than 15,000 Mcf per year,
- (5) 58¢/MMBtu for Rate I, 43.5¢/MMBtu for Rate II, or 37.5¢/MMBtu for Rate III, whichever is applicable at the time of the applicable deliveries of gas, for any Delivery Point(s) having an industrial load other than the Industrial Power Plant Delivery Point.

(b) It is understood and agreed by the parties that competition existed, with regard to Shipper's natural gas requirements, between Transporter and another gas utility or other supplier of gas or alternative fuel, as set forth in Section 5.02(b)(3) of the Gas Utility Regulatory Act. However, should the appropriate regulatory agency find such rates to be unreasonable for any reason or in any way in violation of any provision of law, and determine a rate lower than that provided for herein, Transporter may terminate this Agreement by giving Shipper sixty (60) days' prior written notice of such termination. Should the agency determine a rate higher than that provided for herein, Shipper may terminate this Agreement by giving Transporter sixty (60) days' prior written notice of such termination.

(c) It is agreed by the parties hereto that rate charged in paragraph (a) above for deliveries to the Industrial Power Plant Delivery Point shall escalate one half cent ($\frac{1}{2}$ ¢) per MMBtu beginning on September 1, 1999, and annually thereafter during the term of this Agreement. It is further agreed that all other rates recited in paragraph (a) above shall escalate one cent (1¢) per MMBtu beginning on September 1, 1999 and annually thereafter during the term of this Agreement.

(d) In addition to the rates provided herein, Shipper also agrees to reimburse Transporter

for any Taxes as defined in Section 5 of GENERAL TERMS AND CONDITIONS attached hereto as APPENDIX "A".

ARTICLE V.

TERM

5.1 This Agreement shall be effective as of September 1, 1990, hereunder and shall remain in full force and effect, subject to the terms and provisions hereof, for a primary term until September 1, 1999 and year to year thereafter until cancelled by either party giving the other party sixty (60) days' prior written notice; provided, however, notwithstanding anything contained herein to the contrary, Transporter shall have the right to terminate this Agreement effective on the same date as the date of termination or cancellation of the Contract for Special Commercial Standby Service or the Contract for Industrial Gas Service. Notwithstanding the above, if an imbalance in deliveries exists on the date of termination hereof between the quantities theretofore delivered at the Receipt Point(s) and Delivery Point(s), or if Shipper has working gas remaining in Transporter's storage facilities pursuant to that Certain Gas Storage Agreement between the parties dated September 1, 1990, the term of this Agreement shall be extended for a period sufficient to allow the party whose deliveries are in arrears to promptly eliminate any imbalance. Provided further, any termination, cancellation, or expiration of this Agreement shall never operate to extinguish the obligation to make payment for monies due hereunder.

ARTICLE VI.

LAWS AND REGULATIONS

6.1 This Agreement shall be subject to all applicable State and Federal laws, orders, directives, rules and regulations of any governmental body, official or agency having jurisdiction; therefore, Transporter's and Shipper's obligations and liabilities hereunder shall be limited accordingly.

6.2 To the full extent allowed by law, each party warrants to the other that its or its agent's facilities utilized for the delivery and acceptance of gas hereunder are not subject to the NGA. As a material representation, without which both parties would not have been willing to execute this Agreement, each party warrants to the other party that it and its agents will take no action nor commit any act of omission which will subject this transaction or the other party's facilities to jurisdiction of the FERC or its successor governmental agency under the terms of the NGA or the NGPA. The gas delivered and accepted hereunder shall not have been nor shall be sold, transported, or otherwise utilized in a manner which will subject either party to the terms of the NGA or the NGPA. In addition to and without excluding any remedy the aggrieved party may have at law or in equity, the party who knowingly breaches the above warranties and representations shall be liable to the aggrieved party for all damages, injury and reasonable expense the aggrieved party may sustain by reason of any breach hereof. Further, should either party or its agents perform any act, or cause any action to be performed, at any time, that results in any gas covered hereunder becoming regulated by or subject to jurisdictional authority of the FERC, or successor governmental authority, under the terms of the NGA or NGPA contrary to this Agreement, this Agreement shall be deemed of its own terms to terminate on the day before the date of such occurrence; provided, however such termination shall never be construed to impair any right under this Article. Shipper hereby waives any defense for breach of this paragraph that Transporter could avoid NGA jurisdiction under the

provisions of Section 1(c) of such Act.

ARTICLE VII.

GENERAL TERMS AND CONDITIONS

7.1 The GENERAL TERMS AND CONDITIONS attached hereto as APPENDIX "A" are incorporated herein and made a part hereof by this reference.

ARTICLE VIII.

MISCELLANEOUS

8.1 This Agreement shall be binding upon and inure to the benefit of the parties hereto and their respective successors and assigns; provided, however, that this Agreement shall not be transferred or assigned by Shipper without the prior written consent of Transporter, and any purported transfer or assignment without such consent shall be null and void and shall not operate to release Shipper obligations hereunder.

8.2 Any notice, request, demand, statement or payment provided for in this Agreement may be given in writing directed to the party to whom given and mailed or delivered at such party's address as follows:

(Notices)

Texas A & M University
Physical Plant Department
Agronomy Road
College Station, Texas 77843-1371
Attn: Executive Director
FAX: (409) 845-0051

(Invoices)

Texas A & M University
Physical Plant Department
Agronomy Road
College Station, Texas 77843-1371
Attn: Accounting Section
FAX: (409) 845-8187

(Notices)

Lone Star Gas Company
301 S. Harwood Street
Dallas, Texas 75201
Attn: Transportation Contract
Administration FAX: (214) 573-5134

(Invoices)

Lone Star Gas Company
P.O. Box 910255
Dallas, Texas 75391-0255

or at such address as each party may by like notice give to the other. Such mailed notices shall be deemed to have been given when deposited in the United States mail (first class, registered or certified), postage prepaid, or in the case of hand delivery, when accepted by a representative of either party from a representative of the other party; provided, however, except for payments of amounts due hereunder, either party may provide such notices by electronic mail or facsimile to the other party at the telephone numbers listed in paragraph 8.2 above to be deemed given when received, and further provided the original copy of such notice shall be sent to the other party within two (2) business days.

8.3 This Agreement, and all related agreements as set forth in Exhibit "B" hereof and that certain Release Agreement between the parties dated ~~Sept. 30~~, 1994, constitute the entire agreement between the parties covering the subject matter hereof, and there are no agreements, modifications, conditions or understandings, written or oral, express or implied, pertaining to the subject matter hereof which are not contained herein.

8.4 Modifications of this Agreement shall be or become effective only upon the mutual execution of appropriate letter agreements and amendments hereto by duly authorized representatives of the respective parties.

8.5 Transporter and Shipper acknowledge, agree and intend that this Agreement is entered into solely for the respective benefit of Transporter and Shipper and nothing contained in this Agreement, either express or implied, shall be interpreted or construed as conferring any rights, remedies or claims under or in respect to this Agreement or any provision hereof upon any person or entity not a Party hereto, other than the successors or assigns of the Parties hereto.

8.6 This Agreement was drafted by both Transporter and Shipper, and, accordingly, no court construing this Agreement shall construe it more stringently against one party than against the other.

8.7 If any provision hereof shall be held to be illegal, void or unenforceable, such provision shall be of no force and effect, but the illegality or unenforceability shall have no effect upon and shall not impair the enforceability of any other provision of this Agreement.

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APPENDIX "A"

GAS TRANSPORTATION AGREEMENT

GENERAL TERMS AND CONDITIONS1. Definitions

(a) "Gas" shall mean natural gas produced from gas wells, vaporized natural gas liquids, gas produced in association with oil (casinghead gas) and/or the residue gas resulting from processing casinghead gas and/or gas well gas.

(b) "Day" shall mean the 24-hour period beginning at 7:00 a.m., Central time, on one calendar day and ending at 7:00 a.m., Central time, on the following calendar day.

(c) "Month" shall mean the period beginning at 7:00 a.m., Central time on the first day of a calendar month and ending at 7:00 a.m., Central time, on the first day of the succeeding calendar month.

(d) "Year" shall mean a period of twelve (12) consecutive months beginning at 7:00 a.m., Central time, on the first day of a calendar month and ending at 7:00 a.m., Central time, on the same date of each succeeding year during the term hereof.

(e) "Mcf" shall mean one thousand (1,000) cubic feet.

(f) The term "Btu" as used herein shall mean British Thermal Unit and, where appropriate, the plural thereof. The term "MMBtu" shall mean one million (1,000,000) Btu.

(g) "Heating Value" or "Heat Content" shall mean the total heating value expressed in Btu per cubic foot (gross heating value) of the gas delivered hereunder, and shall be determined at a temperature of sixty (60) degrees Fahrenheit, saturated with water vapor and under a pressure equivalent to that of thirty (30) inches of mercury at thirty-two (32) degrees Fahrenheit converted to base conditions of sixty (60) degrees Fahrenheit and an absolute pressure of fourteen and sixty-five one hundredths (14.65) pounds per square inch and adjusted to reflect actual water vapor content.

(h) "Psia" shall mean pounds per square inch absolute.

(i) "Psig" shall mean pounds per square inch gauge.

(j) "Point of Receipt" or "Receipt Point" shall mean the point(s) where Transporter receives gas delivered to it by Shipper or by the designee of Shipper for Shipper's account.

(k) "Point of Delivery" or "Delivery Point" shall mean the point where Transporter delivers gas to Shipper.

2. Measuring Equipment and Testing

(a) The gas delivered to Transporter at the Receipt Point(s) shall be measured by means of measuring devices of standard type which shall be installed, operated and maintained by Transporter (or its designee) and gas delivered to Shipper at the Delivery Point(s) shall be measured by meters of standard type which shall be installed, operated and maintained by Transporter (or its designee). Measurement devices and equipment shall be tested and adjusted for accuracy on a regular schedule by the party metering the gas (the "metering party").

(b) Both parties recognize and agree that if adequate metering facilities are not in place at a proposed Receipt Point or Delivery Point, neither party will be obligated to install such facilities nor shall Transporter be obligated in any way to accept a Receipt Point or Delivery Point hereunder

until adequate metering facilities are in place.

(c) It is understood and agreed that it will be necessary for Transporter to install an automatic meter reading system for each Delivery Point meter hereunder in order to comply with the various measurement and monitoring provisions herein. As reimbursement for the installation cost of such system(s), Shipper will pay to Transporter (in addition to all other rates, fees, or other charges under this Agreement) a metering fee of 1¢/MMBtu on all gas transported hereunder until all such costs are repaid. As of the execution hereof, Transporter and Shipper estimate that the total cost of the automatic meter reading systems will be \$ 80,000. Any costs above the estimated cost will be subject to Shipper's prior approval. Additionally, Shipper agrees to provide and maintain, at Shipper's expense, a telephone connection to, and a compatible and operational telephone line for, Transporter's automatic meter reading system(s). Such automatic meter reading system(s) shall be the sole property of Transporter and shall be operated and maintained by Transporter at Transporter's expense.

(d) In addition, Shipper agrees to reimburse Transporter, subject to Shipper's prior approval of costs, within thirty (30) days from the date of receipt of Transporter's invoice, for any tap valves, metering facilities (other than automatic meter reading systems) and associated equipment and all labor and overhead expenses, attributable to the installation of such equipment, incurred by Transporter in effectuating the receipt and delivery of gas hereunder. If the invoiced amount is not paid when due, interest on all unpaid amounts shall accrue at the rate of one and one-half percent (1½%) per month, or the highest rate allowed by law, whichever is less, from the date such amount is due Transporter. Failure of Transporter to receive total reimbursement within thirty (30) days of Shipper's receipt of Transporter's invoice will allow Transporter to suspend and/or terminate this Agreement. It is understood that although Shipper shall reimburse Transporter for any tap valves, metering facilities and all associated costs incurred by Transporter in establishing any Receipt and/or Delivery Point(s), Shipper shall receive ownership of only the metering facilities (excluding any automatic meter reading system(s)) and Transporter will be solely responsible for all activities in connection with said metering facilities, including, but not limited to, operation, testing, calibration, adjusting, repair and replacement (both at Shipper's expense), and maintenance, necessary for performance hereunder until Transporter disconnects and removes the metering facilities after termination of this Agreement. After said disconnection and removal, Shipper will have the right within a reasonable period of time thereafter to pick up the metering facilities (excluding any automatic meter reading system(s)) from Transporter. Shipper's failure to so claim the metering facilities within ninety (90) days of Transporter's disconnection and removal thereof, shall constitute a waiver by Shipper of any right, title or interest in and to such metering facilities and all right, title and interest therein shall thereafter vest in Transporter. Transporter shall retain ownership of all equipment associated with the tap and tap valve installation and the automatic meter reading system(s). Notwithstanding the above, if adequate metering facilities are already in existence at the Receipt and/or Delivery Points hereunder, such existing metering facilities shall be used and the party having title to such facilities shall retain title to such facilities.

(e) The other party shall have access to the metering party's metering equipment at all times, but the maintenance, calibration and adjustment thereof shall be done only by the employees or agents of the metering party. Records from such metering equipment shall remain the property of the metering party and shall be kept on file by said party for a period of not less than two (2) years. However, upon request of the other party, the metering party shall make available to the other party volume records from its metering equipment, together with calculations therefrom, for inspection and verification, subject to return by the other party to the metering party within thirty (30) days after receipt thereof. Transporter shall provide Shipper direct access to automatic meter reading systems installed at the Delivery Points for the sole purpose of retrieving information on a

"real-time" basis. Any such systems so installed shall be compatible with Shipper's SCADA system to the extent possible.

(f) The other party may, at its option and expense, install and operate meters, instruments and equipment, in a manner which will not interfere with the metering party's equipment, to check the metering party's meters, instruments and equipment, but the measurement of gas for the purpose of this Agreement shall be by the metering party's meter only, except as hereinafter specifically provided. The meters, check meters, instruments and equipment installed by each party shall be subject at all reasonable times to inspection or examination by the other party, but the calibration and adjustment thereof shall be done only by the installing party.

(g) Each party shall give to the other party notice of the time of all tests of meters sufficiently in advance of such tests so that the other party may conveniently have its representatives present; provided, however, that if either party has given such notice to the other party and such other party is not present at the time specified, then the party giving the notice may proceed with the test as though the other party were present.

(h) Meter measurements computed by the metering party shall be deemed to be correct except where the meter is found to be inaccurate by as much as one percent (1%), fast or slow, or to have failed to register, in either of which cases the metering party shall repair or replace the meter. The quantity of gas delivered while the meter was inaccurate or failed to register shall be determined by the readings of the other party's check meter, if installed and in good operating condition, or by correcting the error if the percentage of error is ascertainable by calibration or mathematical calculation. If not so ascertainable, then it shall be determined by estimating the quantity on a basis of deliveries under similar conditions when the meter was registering accurately. Such adjustments or correction shall be made only for one-half ($\frac{1}{2}$) of the period which has elapsed since the previous test.

3. Measurements

(a) In gas measurement computations, the metering party may use the findings and rules of the Railroad Commission; with respect to flowing temperature, the metering party may at its expense properly install and operate a device of standard make to continuously determine or record flowing temperature. With respect to specific gravity, such shall be determined by "on-site" sampling and laboratory analysis or any other mutually agreeable method which is of standard industry practice (provided, however, that either party may at its expense properly install and operate a recording specific gravity instrument of standard make and in this event the specific gravity as recorded shall be used).

(b) The meters for measurement of volumes at the Receipt Point(s) and Delivery Point hereunder shall be installed and operated, and computations shall be made, in accordance with current industry standards. The unit of measurement of gas shall be one thousand (1,000) cubic feet at a pressure base of fourteen and sixty-five one hundredths (14.65) pounds per square inch absolute and at a temperature base of sixty (60) degrees Fahrenheit. Meter measurements shall be computed by the measuring party into such units in accordance with the Ideal Gas Laws for volume variations due to metered pressure and corrected for deviation using daily averages of recorded specific gravity and flowing temperature, or by using the calculated specific gravity determined by the method mentioned in paragraph (c) below.

(c) The daily average heating value and specific gravity of the gas delivered hereunder by either party may be determined by the use of BTU recording instruments of standard type, which may be installed and operated by the metering party at the metering point, or at such other point or points as are mutually agreeable to both parties; provided, however, if there is no BTU recording

instrument at a particular Receipt or Delivery Point specified herein or agreed upon hereunder, then the heating value and specific gravity of the gas at such point may be determined by "on-site" sampling and laboratory analysis or any other mutually agreeable method which is of standard industry practice.

(d) The daily average meter pressure, specific gravity, flowing temperature and heating value shall be determined only during periods of time when the gas is actually flowing.

4. Quality

(a) Each party shall deliver to the other party hereto natural gas which is of merchantable quality and is commercially free from water, hazardous substances, hydrocarbon liquids, bacteria, and other objectionable liquids, solids or gas components. In addition, the gas delivered by each party shall specifically contain (i) not more than five one hundredths of one percent (.05%) oxygen, (ii) not more than five (5) grains of total sulphur consisting of not more than one quarter (¼) grain of hydrogen sulphide and one (1) grain of mercaptan sulphur per one hundred (100) cubic feet of gas, (iii) not more than three percent (3%) by volume of carbon dioxide, (iv) not more than six percent (6%) by volume total non-hydrocarbon and inert gases (including carbon dioxide, nitrogen, oxygen, helium, etc.), and (v) not more than seven pounds (7#) of water vapor per one million (1,000,000) cubic feet of gas; provided, however, if Shipper tenders gas for transportation upstream of a dehydration plant, Transporter may waive Shipper's obligation to deliver dehydrated gas, subject to Transporter's continuing right to withdraw such waiver at any time in the future. The gas shall be at temperatures not in excess of one hundred twenty (120) degrees Fahrenheit or less than forty (40) degrees Fahrenheit, provided that the gas shall have a hydrocarbon dew point not to exceed forty (40) degrees Fahrenheit at the delivery pressure, and shall have a heat content of not less than nine hundred fifty (950) or more than eleven hundred (1,100) British Thermal Units per cubic foot under the conditions of measurement contained herein; provided, however, if Shipper tenders gas for transport on Transporter's gathering system, such gas shall in addition to meeting the other quality specifications described herein, have a minimum BTU content of one thousand (1,000) British Thermal Units under the conditions of measurement contained herein, but there shall not be a maximum BTU content or a minimum hydrocarbon dewpoint requirement for such gas. Transporter shall not be obligated to accept any gas delivered by Shipper (or its designee) hereunder which is not interchangeable with other gas in Transporter's pipeline at the Point of Receipt hereunder. Transporter's determination of such interchangeability shall be based upon a factor which is equivalent to the quotient obtained by dividing the total heating value of such gas, expressed in BTU's, by the square root of the specific gravity of such gas. Such factor must be within $\pm 7\%$ of the interchange factor established by Transporter for its system at the Receipt Point hereunder; provided, however, if Shipper tenders gas for transport on Transporter's gathering system, Transporter may waive Shipper's obligation to meet these interchangeability conditions, subject to Transporter's right to withdraw such waiver at any time in the future.

(b) If at any time the gas fails to meet the quality specifications enumerated herein, the party receiving such gas shall notify the party delivering such gas, and the delivering party shall immediately correct such failure. If the delivering party is unable or unwilling to deliver gas according to such specifications, the party receiving such gas may refuse to accept delivery of gas hereunder for so long as such condition exists.

5. Taxes

(a) Shipper agrees to pay Transporter, by way of reimbursement, all Taxes paid by

Transporter with respect to the transport of gas and associated facilities related to the performance of this Agreement. If any such Taxes paid by Transporter to any governmental authority are calculated based upon the value of or price paid for the gas transported hereunder, Shipper shall disclose or caused to be disclosed to the designated representative of Transporter responsible for the payment of Taxes, no later than the tenth (10th) day of the month following any month in which gas is transported, the purchase price of such gas to enable Transporter to calculate and pay all such fees and taxes to appropriate governmental authorities in a timely manner. If Shipper fails or refuses to disclose the purchase price of such gas, Transporter will provide Shipper written notice of such nondisclosure with at least a ten (10) day opportunity to provide such information, and if Shipper fails to provide such information during the allotted period, then Transporter shall have the right to suspend this Agreement by giving Shipper ten (10) days prior written notice and Shipper hereby agrees to indemnify and hold Transporter harmless from and against any and all claims, demands, losses or expenses, including attorneys' fees, which Transporter may incur as a result of Shipper's failure or refusal to disclose the purchase price of gas transported hereunder. Transporter acknowledges that Shipper considers that the volume of the gas it delivers to Transporter and the price that Shipper pays for such gas as competitively sensitive information to Shipper and its gas supplier(s). Transporter agrees that it and its employees shall treat any such value or pricing information as confidential and shall prevent the dissemination of such value or pricing information to any persons, including directors, employees or representatives of Transporter, or of Transporter's parent or affiliated producing or marketing organizations, who do not have direct responsibilities for either the calculation, invoicing or payment of such Taxes to the appropriate governmental authorities. Prior to commencement of Shipper's gas pricing reports to Transporter, Transporter shall notify Shipper of the name and mailing address of the employee designated to receive and control such pricing information; subsequent changes in Transporter's employee designation will be made in writing to Shipper by at least the first (1st) day of the month in which this designation is to be effective.

(b) The term "Taxes" as used herein, shall mean all taxes and fees levied upon and/or paid by Transporter (other than ad valorem, capital stock, income or excess profit taxes, except as provided herein, general franchise taxes imposed on corporations on account of their corporate existence or on their right to do business within the state as a foreign corporation and similar taxes), including, but not limited to, gas utility tax, street and alley rental fees agreed upon in franchise ordinances, licenses, fees and other charges levied, assessed or made by any governmental authority on the act, right or privilege of transporting, handling or delivering gas, which taxes or fees are based upon the volume, heat content, value or sales/purchase price of the gas, or transportation fee payable hereunder.

(c) As of the execution hereof, Transporter and Shipper believe that the only Taxes applicable to this Agreement are the Texas Utilities Gross Receipts Tax, the Street and Alley Tax and the State Occupation Tax. In the event the aforementioned Taxes are increased, or there are in fact other Taxes, or new Taxes are imposed, each party will in good faith endeavor to advise the other party in writing of such increase or any new Taxes as soon as possible after the party becomes aware of such Taxes or any increase in such Taxes. In the event that any new or increased Taxes are imposed, then Shipper shall have the right within thirty (30) days thereafter to request renegotiation concerning the future reimbursement of the new or increased Taxes. Transporter and Shipper shall then begin good faith negotiations; however, should Transporter and Shipper be unable to reach a mutual agreement within thirty (30) days from Shipper's request, then either party shall have the right to terminate this Agreement by giving the other party sixty (60) days' prior written notice within thirty (30) days thereafter. Notwithstanding the foregoing, Shipper shall reimburse Transporter the full amount of any and all Taxes until the parties otherwise specifically agree in

writing to the contrary.

6. Billing, Accounting and Reports

(a) On approximately the 15th day of each month, Transporter shall render to Shipper a statement for the preceding month showing the Mcf and MMBtu delivered at the Receipt Point(s) and Delivery Point(s); the amount of compensation due to Transporter hereunder, including the tax reimbursement; and other reasonable and pertinent information which is necessary to explain and support same and any adjustments made by Transporter in determining the amount billed.

(b) Shipper shall pay Transporter within thirty (30) days from the date of receipt of Transporter's statement for gas transported hereunder during the preceding month, or as to payment which is otherwise due hereunder, according to the measurements, computations and rates herein provided. Transporter hereby agrees, however, that Shipper may pay any such statement by bank wire transfer by directing the bank wire transfer to Lone Star Gas Company at Texas Commerce Bank, Dallas, Texas, ABA No. 111001150, for deposit to Lone Star Gas Company Account No. 08805016795. To assure proper credit, Shipper should designate the company name, invoice number and amount being paid in the Fedwire Text Section. If the invoiced amount of any payment due is not paid when due, interest on all unpaid amounts shall accrue at the rate of one and one half percent (1½%) per month, or the highest rate allowed by law, whichever is less, from the date such amount is due Transporter; provided, however no interest shall accrue on unpaid amounts when failure to make payment is the result of a bona fide dispute between the parties hereto regarding such amounts and Shipper timely pays all amounts not in dispute.

(c) Each party hereto shall have the right at all reasonable times to examine the measurement records and charts of the other party to the extent necessary to verify the accuracy of any statement, charge, computation or demand made under or pursuant to any of the provisions in this Agreement. If any such examinations reveal any inaccuracy in such billing theretofore made, the necessary adjustments in such billing and payment shall be made; provided, that no adjustments for any billing or payment shall be made for any inaccuracy claimed after the lapse of twenty five (25) months from the rendition of the invoice relating thereto.

7. Responsibility

Shipper shall be deemed to be in control and possession of the gas until such gas shall have been delivered to Transporter at the Receipt Point(s) and after such gas shall have been delivered at the Delivery Point. Transporter shall be deemed to be in control and possession of the gas after receipt of the gas at the Receipt Point(s) and until such gas shall have been delivered to Shipper (or for its account) at the Delivery Point. Each party shall have responsibility for gas handled hereunder, or for anything which may be done, happen or arise with respect to such gas, only when such gas is in its control and possession as aforesaid. Each party shall be responsible for any damage or injuries caused thereby until the same shall have been delivered to the other party at the Receipt Point(s) or Delivery Point, except injuries and damages which shall be occasioned by the negligence of the receiving party.

8. Warranty

To the full extent allowed by law, Shipper warrants to the Transporter that at the time of delivery of gas hereunder it will have good title or the right to deliver such gas, and that such gas shall be free and clear of all liens and adverse claims; and Shipper agrees to indemnify Transporter,

to the full extent allowed by law, against all suits, actions, debts, accounts, damages, costs (including attorneys' fees), losses and expenses arising from or out of any adverse claims of any and all persons to or against said gas.

9. Force Majeure

(a) In the event either party is rendered unable, wholly or in part, by force majeure to carry out its obligations under this Agreement, except the obligation to pay monies due hereunder, it is agreed that, on such party's giving notice and reasonably full particulars of such force majeure, in writing or by telecopy, to the other party within a reasonable time after the occurrence of the cause relied on, the obligations of the party giving such notice, so far as they are affected by such force majeure, shall be suspended during the continuance of any inability so caused, but for no longer period, and such cause shall, so far as possible, be remedied with all reasonable dispatch.

(b) The term "force majeure", as employed herein, shall mean acts of God; strikes, lockouts or other industrial disturbances; acts of the public enemy, wars, blockades, insurrections, civil disturbances and riots, and epidemics; landslides, lightning, earthquakes, fires, storms, floods and washouts; arrests, orders, directives, restraints and requirements of the government and governmental agencies, either federal or state, civil and military; and application of governmental conservation rules and regulations; explosions, breakage or accident to machinery or lines of pipe; outages (shutdowns) of power plant equipment or lines of pipe for inspection, maintenance or repair; freezing of wells or lines of pipe; and any other causes, whether of the kind enumerated or otherwise, not reasonably within the control of the party claiming suspension. It is understood and agreed that the settlement of strikes or lockouts shall be entirely within the discretion of the party having the difficulty, and that the above reasonable dispatch shall not require the settlement of strikes or lockouts by acceding to the demand of the opposing party when such course is or is deemed to be inadvisable or inappropriate in the discretion of the party having the difficulty. "Force Majeure" shall not include the failure of Shipper to cause gas to be delivered to the Industrial Power Plant Delivery Point because of any failure of Shipper's gas suppliers or any other party acting on behalf of Shipper, unless such failure is due to a bona fide event of Force Majeure, as described herein, affecting Shipper's gas suppliers.

(c) Notwithstanding the foregoing, it is specifically understood and agreed by the Parties that an event of Force Majeure shall in no way terminate any either party's obligation to balance volumes of gas hereunder or Shipper's obligation to make payment for volumes delivered prior to such force majeure.

(d) Both parties recognize and agree that if Transporter totally and completely fails to deliver gas to Shipper by reason of force majeure on the part of Transporter (and due to no fault of Shipper or its agents, suppliers or designees) for fourteen (14) consecutive days, Shipper shall have the right to terminate this Agreement by providing written notice to Transporter within thirty (30) days of such occurrence and such cancellation shall be effective sixty (60) days from and after the date of such occurrence.

10. Waiver of Breaches, Defaults or Rights

No waiver by either party hereto of any one or more breaches, defaults or rights under any provisions of this Agreement shall operate or be construed as a waiver of any other breaches, defaults or rights, whether of a like or of a different character. By providing written notice to the other party, either party may assert any right not previously asserted hereunder or may assert its right to object to a default not previously protested. Except as specifically provided herein, in the

event of any dispute under this Agreement, the parties shall, notwithstanding the pendency of such dispute, diligently proceed with the performance of this Agreement without prejudice to the rights of either party.

11. Remedy for Breach

Except as otherwise specifically provided herein, if either party shall fail to perform any of the covenants or obligations imposed upon it in this Agreement (except where such failure shall be excused under the provisions of Section 9 hereof), then, and in that event, the other party may, at its option (without waiving any other remedy for breach hereof), by notice in writing specifying wherein the default has occurred, indicate such party's election to terminate this Agreement by reason thereof; provided, however, that Shipper's failure to pay Transporter within a period of thirty (30) days following Shipper's receipt of written notice from Transporter advising of such failure to make payment in full within the time specified in Section 6 hereof, shall be a default which shall give Transporter the right to immediately terminate this Agreement, unless such failure to pay such amounts is the result of a bona fide dispute between the parties hereto regarding such amounts hereunder and Shipper timely pays all amounts not in dispute. With respect to any other matters, the party in default shall have thirty (30) days from receipt of such notice to remedy such default, and upon failure to do so, this Agreement shall terminate from and after the expiration of such thirty (30) day period. Such termination shall be an additional remedy and shall not prejudice the right of the party not in default to collect any amounts due it hereunder for any damage or loss suffered by it and shall not waive any other remedy to which the party not in default may be entitled for breach of this Agreement.

12. Applicable Law

THE PARTIES HERETO HEREBY AGREE AND CONFIRM THAT THIS AGREEMENT AND THE RIGHTS OF THE PARTIES HEREUNDER SHALL BE CONSTRUED AND ENFORCED ACCORDING TO THE LAWS OF THE STATE OF TEXAS, WITHOUT REGARD TO ITS LAWS CONCERNING THE CONFLICT OF LAWS.

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EXHIBIT "A"
 GAS TRANSPORTATION AGREEMENT
 BETWEEN
 LONE STAR GAS COMPANY
 AND
 TEXAS A & M UNIVERSITY

Delivery Points

<u>Name</u>	<u>MDQ (Mcf/d)*</u>	<u>Meter Number</u>
Industrial Power Plant	20,000	17-1489-00
West Utility I	600	93-0001-00

Commercial Points:

TAMU West Campus Sat. Pl. Bldg. 1499	150	93-0002-00
Southside Utility Plant Turk Rd. Bldg. 377	100	93-0003-00
USDA Toxicology Lab FB Rd.	100	93-0004-00
Texas A & M Annex RW 14-500	100	93-0005-00
Vet. Hospital Bldg. 508	50	93-0006-00
Vet. Hospital Bldg. 508	50	93-0007-00
Animal Research and Res. Agronomy Rd.	30	93-0008-00
TAMU Bldg. 4126	25	93-0009-00
A & M Greenhse. Agron.	20	93-0010-00
Poultry Science Center Bldg. 1201	20	93-0011-00
Bio Chem - Bio Physics Agronomy & Hort.	20	93-0012-00
TAMU Bldg. 1197 Vet. Med. Center	20	93-0013-00

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To Rick Floyd	From Sheryl Owens
Co.	Co.
Dept.	Phone # 7-9206

TAMU Exhibit "A" p. 2

<u>Name</u>	<u>MDQ (Mcf/d)*</u>	<u>Meter Number</u>
TAMU New Bakery Bldg. 450	20	93-0014-00
TAMU Bldg. 1156	20	93-0015-00
Deware Field House Bldg. 452	20	93-0016-00
Horticulture Science Bldg. 1506	20	93-0017-00
TAMU Bldg. 440	20	93-0018-00
Purchasing and Storage	20	93-0019-00
TAMU Bldg. 495	20	93-0020-00
TAMU Med. Sc. Bldg. 1504 Hwy. 60	15	93-0021-00
TAMU Meat Sc. Lab	15	93-0022-00
Phys. Res. and Cond. Lab Bldg. 360	15	93-0023-00
TAMU Bldg. 1299	15	93-0024-00
Food Services Center Bldg. 454	15	93-0025-00
Vet. Science Bldg.	15	93-0026-00
TAMU Tarrow	15	93-0027-00
Food Services Comm. Bldg. 971	15	93-0028-00
Clinical Science	15	93-0029-00
Educational T. V. Bldg. 519	10	93-0030-00
Plant Bio-Tech Bldg. Joe Routt Blvd.	10	93-0031-00
Horticulture Farm Bldg. 699	10	93-0032-00
Phys. Plant Grounds Maint. Dept. Bldg. 829	10	93-0033-00
Food Protein R & D Center Bldg. 1503	10	93-0034-00
Offshore Tech. Res. Bldg. 1604 Mariner Blvd.	10	93-0035-00
Soil and Crop Sciences Agronomy Rd.	10	93-0036-00

TAMU Exhibit "A" p. 3

<u>Name</u>	<u>MDQ (Mcf/d)*</u>	<u>Meter Number</u>
TAMU Discovery	10	93-0037-00
Transportation Bldg. Bldg. 958	10	93-0038-00
FA&MU Crops and Soil Fertility	10	93-0039-00
Soil Crop Bldg. 955	10	93-0040-00
Horticulture Greenhouse Bldg. 793	10	93-0041-00
U.S. Dept. of Agriculture Bldg. 253	10	93-0042-00
U.S.D.A. A&M Univ.	10	93-0043-00
Entomology Greenhouse Bldg. 815	10	93-0044-00
Plant Sciences Form.	10	93-0045-00
TAMU Bus Operations Agronomy Rd.	10	93-0046-00
Dept. of Horticulture Bldg. 510	10	93-0047-00
Entomological Res. Lab Bldg. 815	10	93-0048-00
TAMU Greenhouse Bldg. 1045	10	93-0049-00
Texas A&M Medical Center	10	93-0050-00
TAMU Ocean Drilling Bldg. 1601	10	93-0051-00
Civil Engin. Bldg. 740	10	93-0052-00
TAMU Press Bldg.	10	93-0053-00
Agri. Eng. Dept. Power Mac. Bldg. 1034	10	93-0054-00
Tex. Med. Vet. Diagnostic Lab. Bldg. 1041	10	93-0055-00
Civil Engineering Bldg. 492	10	93-0056-00
Vet. Microbiology	10	93-0057-00
TAMU Bldg. 1051	10	93-0058-00
Woffard Cain Ath. Dorm Bldg. 439	10	93-0059-00

<u>Name</u>	<u>MDQ (Mcf/d)*</u>	<u>Meter Number</u>
USDA ARS Bldg. 1046	10	93-0060-00
TAMU Research Foundation	10	93-0061-00
Farm Service Dept. Bldg. 1003	10	93-0062-00
TAMU Bldg. 448	10	93-0063-00

* Notwithstanding anything contained herein, in no event shall the total daily volumes transported under the Agreement to each Delivery Point ever exceed the total maximum daily quantity for such point as set forth above or the maximum daily volume set forth in Article I,1.1(a), unless mutually agreed to by both parties.

EXHIBIT "B"
GAS TRANSPORTATION AGREEMENT
BETWEEN
LONE STAR GAS COMPANY
AND
TEXAS A & M UNIVERSITY

Related Agreements

		<u>Date</u>
1)	LS-MC-#787 Gas Storage Agreement	September 1, 1990
2)	(Contract #11248) Contract for Special Commercial Standby Service	September 30, 1994
3)	(Contract #11251) Contract for Industrial Gas Service	September 30, 1994

ATTACHMENT B

**AGA MANUAL FOR THE DETERMINATION OF
SUPERCOMPRESSIBILITY FACTORS FOR NATURAL GAS**

A.G.A. MANUAL FOR THE DETERMINATION OF
SUPERCOMPRESSIBILITY FACTORS FOR NATURAL GAS

PAR RESEARCH PROJECT NX-19
"Extension of Range of Supercompressibility Tables"

Completed
December 1962

AMERICAN GAS ASSOCIATION

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TABLE OF CONTENTS

	Page
Personnel	iv
Preface	vi
Range and Applicability	vii
Introduction	1
Standard Method	2
Determining F_{pv} Factors by Table	3
Table 1, Pressure Adjusting Factors, F_p	5
Table 2, Temperature Adjusting Factors, F_T	29
Table 3, Supercompressibility Factors, F_{pv}	115
Determining F_{pv} Factors By Equation	397
Table 4, Parameter E	398
Appendix	401
Alternate Methods	401
Table 5, Critical Pressures and Temperatures	402
Equations of Parameter E	403
Figure 1, Range of Applicability of Parameter E	405
Figure 2, Graph of F_{pv} Factors	407

PREFACE

This manual is based on the findings of PAR Research Project NX-19 initiated by the Pipeline Research Committee in 1956 upon the recommendation of the Gas Measurement Committee. The initial purpose was to extend the range of the A.G.A. Supercompressibility Factor Tables published in 1955, 1956. However, a significant outcome of the project was that in addition to providing the basic data for extending the range, a base equation for calculation of supercompressibility factors was developed.

The research and development work required in the project was accomplished by Professor Richard H. Zimmerman and assistants at the Ohio State University serving as agency under the guidance of the Supervising Committee for Project NX-19.

Upon completion of their assignment in April 1961, the research agency submitted reports containing the complete details of the source data analysis, development of mathematical expressions, general observations, and recommendations to A.G.A.

Subsequently the NX-19 Report Review Subcommittee was assigned to review the agency's reportings and from these prepare a practical and accurate extended range supercompressibility table applicable to existing procedures. Also they were to present the basic mathematical expression in a form suitable for industry wide electronic computer computation.

This manual, which constitutes the final report of said Report Review Subcommittee, is the culmination of the efforts of all those associated with PAR Research Project NX-19.

A.G.A. SUPERCOMPRESSIBILITY FACTORS

Range & Applicability

Pressure, psig	0 to 5000
Temperature, °F	- 40 to 240
Specific Gravity	0.554 to 1.000
Carbon Dioxide mol %	0 to 15
Nitrogen mol %	0 to 15

While the F_{pv} factors obtainable herein from Table 3 or from the Equation (page 397), are to be used directly in gas measurement with orifice meters and in gas pipeline flow computation, the factor $(F_{pv})^2$ is applicable to gas volumes meas-

red with displacement type meters and storage volume calculations.

Formula for orifice meter flow calculation:

$$Q_h = F_b \times F_c \times Y \times F_{pb} \times F_{tb} \times F_{tl} \times F_g \\ \times F_{pv} \times F_m \sqrt{h_w p_t}$$

Formula for displacement meter volume calculations:

$$V = q \times \frac{p_t}{p_b} \times \frac{T_b}{T_t} \times (F_{pv})^2$$

q = cubic feet registered by meter

INTRODUCTION

The methods, tables and equation presented in this manual provide extended ranges of coverage, simplification of use and a broadening of the applicability of the supercompressibility factor determination procedures as published with A.G.A. Gas Measurement Committee Report No. 3*, "Orifice Metering of Natural Gas" 1955, 1956. The procedures offered are the same as or compatible with those of Report No. 3 and the same accuracy tolerances are maintained.

In using this manual it must be borne in mind that it is intended to be a condensed factual working tool. General information concerning the theory of supercompressibility has been purposely omitted. The theory of supercompressibility may be found in the A.G.A. Gas Measurement Manual.

The basic technique of determining a supercompressibility factor of natural gas by the A.G.A. method involves evaluation of its pseudo-critical pressure and temperature. These pseudo

values are employed in the determination of pressure and temperature adjusting factors which are used to adjust the flowing gas pressure and temperature values to correspond to a pressure and temperature of the chosen standard 0.600 specific gravity hydrocarbon gas. With the adjusted pressures and temperatures the supercompressibility factors can be determined directly from the F_{pv} table or by applying the definitive equation. The most practical method of determining pressure and temperature adjusting factors for normal mixtures of natural gas is by application of the specific gravity relationship. Consequently, the specific gravity method is presented as the standard method. For less common natural gas mixtures up to 1.000 specific gravity alternate methods employing other relationships of natural gas are offered in the appendix. The table of F_{pv} factors and the supercompressibility equations presented are applicable regardless of the method employed to adjust the pressure and temperature of the flowing gas.

* Revised 1969

A.G.A. Standard Method of Calculating Supercompressibility Factors

The standard method is applicable to natural gas that does not exceed 0.750 specific gravity and/or diluent contents of 15 mol percent carbon dioxide and/or 15 mol percent nitrogen. Consequently, this method is limited to natural gas mixtures that do not contain large concentrations of heavier hydrocarbons.

The specific gravity, and the carbon dioxide and nitrogen contents in conjunction with the gage pressure and absolute flowing temperature, are required to determine the adjusted pressures and temperatures.

The adjusted pressure is obtained by multiplying the gage pressure of the flowing gas by the pressure adjusting factor F_p furnished in Table 1. The equation for the pressure adjusting factor is:

$$F_p = \frac{156.47}{160.8 - 7.22G + K_p} \quad (1)$$

where:

$$K_p = M_c - 0.392 M_n \quad (2)$$

and

G = specific gravity of flowing gas

M_c = mol percent carbon dioxide

M_n = mol percent nitrogen

The adjusted absolute temperature is obtained by multiplying the absolute temperature of the flowing gas by the temperature adjusting factor F_T furnished in Table 2. The equation for the temperature adjusting factor is:

$$F_T = \frac{226.29}{99.15 + 211.9G - K_T} \quad (3)$$

where:

$$K_T = M_c + 1.681 M_n \quad (4)$$

A simple calculation is required to establish constants K_p and K_T using equations (2) and (4).

After the adjusted pressures and temperatures are determined the supercompressibility factor F_{pv} can be found in Table 3 or determined by use of the supercompressibility equation on page 397.

NOTE: All tables in this manual can be interpolated.

Determining F_{pv} Factors by Table

Table 1, Pressure Adjusting Factors F_p : The applicable pressure adjusting factor F_p is chosen from this table by using the appropriate values of specific gravity and the constant K_p . The adjusted pressure is obtained by multiplying the gage pressure P_t of the flowing gas by F_p . The F_p table has been so designed that any error in F_{pv} resulting from its use will be within acceptable tolerance without interpolating the F_p values.

Table 2, Temperature Adjusting Factors F_T : The applicable temperature adjusting factor F_T is chosen from this table using the appropriate values of specific gravity and the constant K_T . The adjusted temperature is obtained by multiplying the absolute temperature T_t of the flowing gas by F_T and subtracting 460. The F_T table has been so designed that any error in F_{pv} resulting from its use will be within acceptable tolerance without interpolating the F_T value.

EXAMPLE 1 Conditions:

Specific gravity	= 0.573
Carbon dioxide content (M_c)	= 0 mol percent
Nitrogen content (M_n)	= 0 mol percent
Gage pressure (P_t)	= 683 psig
Flowing temperature (t_t)	= 12 F
Calculate K_p and K_T	
$K_p = M_c - 0.392 M_n$	
= 0 - 0.392 (0)	
= 0	
$K_T = M_c + 1.681 M_n$	
= 0 + 1.681 (0)	
= 0	

From Tables 1 and 2 find pressure and temperature adjusting factors F_p and F_T for:

Specific gravity	= 0.573
K_p	= 0
K_T	= 0

By direct table-look-up:

F_p	= 0.9988	Page 12
F_T	= 1.0259	Page 31

Calculate the adjusted pressure and temperature:

Adjusted pressure	= $P_t F_p$
	= 683 (0.9988)
	= 682 psig
Adjusted temperature	= $T_t F_T - 460$
	= (12 + 460) 1.0259 - 460
	= 484.2 - 460
	= 24.2 F

From Table 3 find F_{pv} factor for:

Adjusted pressure	= 682 psig
Adjusted temperature	= 24.2 F
F_{pv} (without interpolation)	= 1.0767
F_{pv} (with interpolation)	= 1.0768

Page 151

The K_p and K_T values can be calculated and recorded when the diluent content of a natural gas is determined. Such K_p and K_T values can be applied until the diluent content is redetermined.

At lower specific gravities in certain parts of the pressure and temperature adjusting factor tables, the F_p and F_T values are omitted. This is where the stated magnitude of the diluents content make it impossible for such specific gravities to occur.

Table 3, Supercompressibility Factors F_{pv} : After adjusting the pressure and temperature of the flowing gas the adjusted values can be used to obtain the F_{pv} factor directly from Table 3.

To illustrate the procedure of determining the supercompressibility factor F_{pv} by use of tables in this volume the following examples are given:

EXAMPLE 2

Conditions:

Specific gravity	= 0.731
Carbon dioxide content (M_c)	= 2.75 mol percent
Nitrogen content (M_n)	= 8.18 mol percent
Gage pressure (P_t)	= 1344 psig
Flowing temperature (t_f)	= 87 F
Calculate K_p and K_T	
$K_p = M_c - 0.392 M_n$	
= 2.75 - 0.392 (8.18)	
= 2.75 - 3.21	
= -0.46	
$K_T = M_c + 1.681 M_n$	
= 2.75 + 1.681 (8.18)	
= 2.75 + 13.751	
= 16.501	

From Tables 1 and 2 find pressure and temperature adjusting factors F_p and F_T for:

Specific gravity	= 0.731
K_p	= -0.46
K_T	= 16.501

By direct table lookup:

F_p	= 1.0093
F_T	= 0.9530

Page 12
Page 102

Calculate the adjusted pressure and temperature:

Adjusted pressure	= $P_t F_p$
	= 1344 (1.0093)
	= 1356 psi
Adjusted temperature	= $T_f F_T - 460$
	= (87 + 460) 0.9530 - 460
	= 521.3 - 460
	= 61.3 F

From Table 3 find F_{pv} factor for:

Adjusted pressure	= 1356 psig
Adjusted temperature	= 61.3 F
F_{pv} (without interpolation)	= 1.1126
F_{pv} (with interpolation)	= 1.1120

Page 183

TABLE 1
PRESSURE ADJUSTING FACTORS

F_p

All tables in this manual can be interpolated

At lower specific gravities in certain parts of the pressure adjusting factor tables, F_p values are omitted. This is where the stated magnitude of the diluents content make it impossible for such specific gravities to occur.

Determining F_{pv} Factors by Equation

The base equation for determining the F_{pv} Factor is expressed as:

$$F_{pv} = \frac{\sqrt{\frac{B}{D} - D + \frac{n}{3\pi}}}{1 + \left(\frac{0.00132}{\tau^{3.25}}\right)} \quad (5)$$

where:

$$B = \frac{3 - mn^2}{9m\pi^2} \quad (6)$$

$$m = 0.0330378(\tau)^{-2} - 0.0221323(\tau)^{-3} + 0.0161353(\tau)^{-5} \quad (7)$$

$$n = \frac{0.265827(\tau)^{-2} + 0.0457697(\tau)^{-4} - 0.133185(\tau)^{-1}}{m} \quad (8)$$

$$\pi = \frac{P_{adj.} + 14.7}{1000} \quad (9)$$

$$\tau = \frac{t_{adj.} + 460}{500} \quad (10)$$

$$P_{adj.} = P \times F_p \quad (11)$$

$$t_{adj.} = [(t + 460) F_T] - 460 \quad (12)$$

P = gauge pressure, psig

t = flowing temperature, °F

$$D = [b + \sqrt{b^2 + B^3}]^{1/3} \quad (13)$$

$$b = \frac{9n - 2mn^3}{54m\pi^2} - \frac{E}{2m\pi^2} \quad (14)$$

E = as linearly interpolated from Table 4

The equations used for developing Table 4 for Parameter E values are given in the Appendix.

TABLE 4
PARAMETER E
TO BE USED IN
A.G.A. SUPERCOMPRESSIBILITY FACTOR EQUATION

	Adjusted Temperature °F.						
	- 40	- 35	- 30	- 25	- 20	- 10	0
0	.9999	.9999	.9999	.9999	.9999	1.0000	1.0000
100	.9990	.9991	.9993	.9994	.9995	.9997	.9998
200	.9981	.9984	.9987	.9989	.9991	.9994	.9996
300	.9973	.9977	.9981	.9984	.9986	.9990	.9993
400	.9966	.9971	.9975	.9979	.9982	.9987	.9991
500	.9959	.9965	.9970	.9974	.9978	.9984	.9989
600	.9954	.9960	.9965	.9970	.9974	.9981	.9986
700	.9950	.9956	.9962	.9967	.9972	.9979	.9984
800	.9948	.9954	.9960	.9965	.9969	.9976	.9982
900	.9948	.9954	.9959	.9964	.9968	.9975	.9979
1000	.9950	.9955	.9960	.9964	.9967	.9973	.9977
1100	.9955	.9959	.9962	.9965	.9968	.9972	.9976
1200	.9963	.9965	.9967	.9969	.9970	.9972	.9974
1225	.9966	.9967	.9969	.9970	.9971	.9972	.9974
1250	.9968	.9969	.9970	.9971	.9972	.9973	.9973
1300	.9981	.9979	.9977	.9975	.9974	.9973	.9973
1350	1.0008	.9997	.9989	.9983	.9979	.9975	.9973
1400	1.0032	1.0013	.9999	.9990	.9983	.9976	.9972
1450	1.0052	1.0026	1.0007	.9995	.9986	.9976	.9971
1500	1.0069	1.0036	1.0013	.9998	.9988	.9975	.9970
1550	1.0081	1.0043	1.0017	1.0000	.9988	.9974	.9968
1600	1.0089	1.0047	1.0018	.9999	.9987	.9972	.9965
1650	1.0093	1.0047	1.0017	.9997	.9984	.9969	.9962
1700	1.0092	1.0044	1.0013	.9993	.9980	.9965	.9959
1750	1.0086	1.0038	1.0007	.9987	.9975	.9961	.9955
1800	1.0076	1.0027	.9997	.9979	.9968	.9956	.9950
1850	1.0061	1.0013	.9985	.9969	.9959	.9949	.9945
1900	1.0040	.9995	.9970	.9956	.9949	.9942	.9939
1950	1.0014	.9973	.9952	.9941	.9937	.9934	.9933
2000	.9981	.9945	.9928	.9921	.9920	.9922	.9923
2100	.9903	.9873	.9862	.9862	.9866	.9877	.9887
2200	.9818	.9794	.9790	.9795	.9805	.9826	.9846
2400	.9630	.9620	.9628	.9645	.9666	.9708	.9746
2650	.9375	.9381	.9404	.9435	.9470	.9538	.9598
2850	.9165	.9182	.9216	.9257	.9302	.9389	.9467
3150	.8853	.8884	.8932	.8987	.9045	.9156	.9258
3350	.8654	.8692	.8747	.8810	.8875	.9000	.9114
3500	.8511	.8554	.8614	.8681	.8750	.8884	.9007
3700	.8331	.8379	.8443	.8515	.8589	.8733	.8865
3800	.8246	.8296	.8362	.8435	.8512	.8659	.8795
4150	.7972	.8025	.8095	.8173	.8253	.8410	.8556
4300	.7864	.7918	.7989	.8067	.8149	.8308	.8458
4650	.7623	.7678	.7750	.7831	.7915	.8079	.8234
5000	.7375	.7434	.7509	.7593	.7680	.7850	.8013

Adjusted Pressure — psig

TABLE 4
PARAMETER E
TO BE USED IN
A.G.A. SUPERCOMPRESSIBILITY FACTOR EQUATION

		Adjusted Temperature °F.							
		0	10	20	30	40	50	60	70
Adjusted Pressure — psig	0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	250	.9995	.9996	.9998	.9999	.9999	.9999	.9999	.9999
	500	.9989	.9992	.9994	.9996	.9996	.9997	.9997	.9998
	750	.9983	.9986	.9989	.9991	.9992	.9993	.9993	.9994
	1000	.9977	.9980	.9983	.9984	.9985	.9986	.9987	.9989
	1250	.9973	.9974	.9975	.9975	.9976	.9977	.9979	.9981
	1500	.9970	.9968	.9968	.9969	.9970	.9970	.9971	.9972
	1750	.9955	.9953	.9953	.9954	.9955	.9956	.9958	.9961
	2000	.9923	.9925	.9926	.9929	.9931	.9935	.9939	.9946
	2250	.9823	.9844	.9862	.9879	.9893	.9906	.9918	.9931
	2500	.9690	.9731	.9768	.9800	.9828	.9852	.9874	.9895
	2750	.9534	.9596	.9651	.9699	.9741	.9778	.9811	.9841
	3000	.9364	.9445	.9517	.9581	.9638	.9688	.9732	.9772
	3250	.9186	.9284	.9372	.9451	.9521	.9584	.9640	.9691
	3500	.9007	.9119	.9221	.9313	.9395	.9470	.9537	.9599
	3750	.8830	.8953	.9066	.9169	.9263	.9349	.9427	.9499
	4000	.8657	.8789	.8911	.9024	.9128	.9223	.9311	.9392
	4250	.8490	.8629	.8758	.8879	.8990	.9094	.9190	.9280
	4500	.8329	.8473	.8608	.8734	.8853	.8963	.9067	.9165
	4750	.8171	.8319	.8459	.8591	.8716	.8833	.8943	.9048
5000	.8013	.8167	.8312	.8450	.8580	.8703	.8819	.8930	

		Adjusted Temperature °F.						
		80	90	100	110	120	130	140
Adjusted Pressure — psig	0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	250	1.0000	.9999	.9999	.9999	.9999	.9999	.9999
	500	.9998	.9998	.9997	.9997	.9996	.9996	.9995
	750	.9995	.9995	.9995	.9994	.9994	.9993	.9992
	1000	.9991	.9992	.9992	.9992	.9991	.9990	.9989
	1250	.9985	.9988	.9989	.9989	.9989	.9989	.9988
	1500	.9977	.9982	.9986	.9988	.9988	.9988	.9987
	1750	.9967	.9976	.9982	.9986	.9988	.9988	.9988
	2000	.9956	.9969	.9978	.9984	.9987	.9989	.9990
	2250	.9945	.9960	.9971	.9977	.9980	.9981	.9981
	2500	.9915	.9935	.9950	.9958	.9963	.9966	.9967
	2750	.9869	.9896	.9916	.9930	.9938	.9944	.9948
	3000	.9810	.9845	.9872	.9891	.9905	.9916	.9923
	3250	.9738	.9782	.9817	.9844	.9865	.9881	.9893
	3500	.9656	.9710	.9754	.9789	.9816	.9839	.9857
	3750	.9566	.9629	.9682	.9725	.9761	.9791	.9815
	4000	.9469	.9541	.9603	.9655	.9699	.9736	.9767
	4250	.9366	.9447	.9518	.9578	.9630	.9674	.9713
	4500	.9259	.9348	.9426	.9495	.9554	.9606	.9651
	4750	.9149	.9245	.9330	.9406	.9472	.9531	.9582
5000	.9037	.9139	.9230	.9311	.9384	.9448	.9506	

APPENDIX

Alternate Methods

The system of determining F_p Factors presented in the body of this manual is the standard method based on adjusting pressures and temperatures using the specific gravity relationship of gas. Alternate methods are presented below which in special cases are more applicable. These methods are based on molal analysis, methane content and heating value relationships of gas for the determination of adjusting factors F_p and F_T . The Table of Supercompressibility Factors is applicable regardless of which method of adjustment is used.

Analysis Method: This method of adjusting pressures and temperatures provides the most precise results over a comparatively wide range of natural gas composition. A complete fractional analysis of the flowing gas is required. The analysis method is the method most applicable when a natural gas has a specific gravity higher than 0.750. It is the best method when appreciable percentages of components as hydrogen sulphide, oxygen and helium occur in the gas.

The pseudocritical pressure of a natural gas mixture can be defined as the sum of the products of the mol fraction and the critical pressure of each component gas:

$$P_c = \sum P_i X_i \quad (15)$$

where:

P_c = pseudocritical pressure of the gas mixture

P_i = critical pressure of any component gas

X_i = mol fraction of the respective component gas

The pressure adjusting factor F_p is:

$$F_p = \frac{671.4}{P_c} \quad (16)$$

where:

P_c is defined by equation (15):
similarly:

$$T_c = \sum T_i X_i \quad (17)$$

where:

T_c = absolute pseudocritical temperature of gas mixture

T_i = absolute critical temperature of any component gas

X_i = mol fraction of any corresponding component gas

The temperature adjusting factor F_T is:

$$F_T = \frac{359.46}{T_c} \quad (18)$$

where:

T_c is defined by equation (17)

The critical pressures and temperatures of the component gases of natural gas are shown in Table 5.

Methane-Gravity Method: The methane-gravity method is especially applicable where a natural gas has a specific gravity higher than 0.750 due to the heavier hydrocarbon components. This method requires only the methane content of the gas in addition to the five variables required in the standard method. The equations for the determination of the pseudocritical pressure and temperature are:

$$P_c = 891.11 - 172.56G + 443.04 X_c - \dots - 232.23 X_n - 122.52 X_m \quad (19)$$

$$T_c = 327.77 + 214.82G - 144.12 X_c - \dots - 319.52 X_n - 102.78 X_m \quad (20)$$

where:

G = specific gravity of the natural gas

X_c = mol fraction carbon dioxide

X_n = mol fraction nitrogen

X_m = mol fraction methane

The pressure and temperature adjusting Factors F_p and F_T are determined by equations (16) and (18) respectively with P_c and T_c defined by equations (19) and (20) respectively.

Heating Value Method: This method is inherently the same as the Standard Method since an exact linear relationship exists between the heating value and the specific gravity of the hydrocarbon components of a natural gas. Any difference between the two methods can be attributed to normal uncertainties in determining specific gravity, heating value and diluent content of gas. This method is limited to natural gases of specific gravity less than 0.750.

The equations for the determination of the pseudocritical pressure and temperatures are:

$$P_c = 693 - 0.02029 H + 379.0 X_c - 201.0 X_n \quad (21)$$

$$T_c = 124.7 + 0.2203 H + 384.99 X_c + 91.11 X_n \quad (22)$$

where:

H = heating value (wet basis) B.T.U. per cubic foot, 14.73 psia and 60°F.

X_c = mol fraction carbon dioxide

X_n = mol fraction nitrogen

The pressure and temperature adjusting factors F_p and F_T are determined by equations (16) and (18) respectively with P_c and T_c defined by equations (21) and (22) respectively.

Actual Test Method: Before extending the use of these data and methods beyond the recommended range of conditions, their applicability to any such extended condition should first be properly verified by actual test.

TABLE 5

Gas	Critical Pressure psia	Critical Temperature °Rankine	Ideal Specific Gravity	Ideal Gas Total Heating Value ⁽¹⁾
Methane	673	344	0.554	994
Ethane	712	550	1.038	1742
Propane	617	666	1.523	2479
Iso-Butane	529	734	2.006	3203
n-Butane	551	766	2.006	3213
Iso-Pentane	483	830	2.490	3939
n-Pentane	485	846	2.490	3948
n-Hexane	440	911	2.973	4684
n-Heptane	400	972	3.460	5420
n-Octane	361	1025	3.943	6153
Carbon Dioxide	1072	510 ⁽¹⁾	1.519	—
Nitrogen	492	216 ⁽¹⁾	0.967	—
Air	547	239	1.000	—
Oxygen	731	278	1.105	—
Helium	33	10	0.138	—
Hydrogen	188	60	0.070	319
Hydrogen Sulfide	1306	678	1.176	630 ⁽²⁾

(1) Adjusted critical temperatures

(2) For combustion to gaseous SO₂

(3) Approximate BTU/SCF — 60° F., 30" Hg., sat.

Equations of Parameter *E*

The base equation on page 397 using the *E* values from Table 4 was employed to generate Table 3 Supercompressibility Factors F_{sc} through the full range of pressure and temperature. The base equation differs in eight range groups due to the variation of the parameter *E*. Parameter *E* appears in equation (14) which is a definitive relation of the base equation. The following are the equations of *E* based on the respective ranges of applicability for pressure and temperature as indicated in Figure 1 on page 405.

$$E_1 = 1 - 0.00075 (\pi)^{2.3} e^{-20(\tau-1.09)} - \dots - 0.0011 (\tau - 1.09)^{0.5} (\pi)^2 [2.17 + 1.4 (\tau - 1.09)^{0.5} - \pi]^2 \quad (23)$$

PRESSURE RANGE:
 π , 0 to 2, or p , 0 to 2000 psia
TEMPERATURE RANGE:
 τ , 1.09 to 1.4, or t , 85°F to 240°F

$$E_2 = 1 - 0.00075 (\pi)^{2.3} [2 - e^{-20(1.09-\tau)}] - \dots - 1.317(1.09 - \tau)^1 (\pi) (1.69 - \pi^2) \quad (24)$$

PRESSURE RANGE:
 π , 0 to 1.3, or p , 0 to 1300 psia
TEMPERATURE RANGE:
 τ , 0.84 to 1.09, or t , -40°F to 85°F

$$E_3 = 1 - 0.00075 (\pi)^{2.3} [2 - e^{-20(1.09-\tau)}] + \dots + 0.455 [200(1.09 - \tau)^6 - \dots - 0.03249(1.09 - \tau) + \dots + 2.0167(1.09 - \tau)^2 - \dots - 18.028(1.09 - \tau)^2 + 42.844(1.09 - \tau)^4] (\pi - 1.3) [1.69(2)^{1.25} - \pi^2] \quad (25)$$

PRESSURE RANGE:
 π , 1.3 to 2.0, or p , 1300 to 2000 psia
TEMPERATURE RANGE:
 τ , 0.88 to 1.09, or t , -20°F to 85°F

$$E_4 = \text{same as } E_3 \text{ except the exponent 1.25 is changed to } 1.25 + 80(0.88 - \tau)^2 \quad (26)$$

PRESSURE RANGE:
 π , 1.3 to 2.0, or p , 1300 to 2000 psia
TEMPERATURE RANGE:
 τ , 0.84 to 0.88, or t , -40°F to -20°F

$$E_{5a} = E_4 - Y \quad (27) \quad *$$

PRESSURE RANGE:
 π , 2.0 to 5.0, or p , 2000 to 5000 psia
TEMPERATURE RANGE:
 τ , 0.84 to 0.88, or t , -40°F to -20°F

$$E_{5b} = E_5 - Y \quad (28) \quad *$$

PRESSURE RANGE:
 π , 2.0 to 5.0, or p , 2000 to 5000 psia
TEMPERATURE RANGE:
 τ , 0.88 to 1.09, or t , -20°F to 85°F

$$E_{5c} = E_1 - Y \quad (29) \quad *$$

PRESSURE RANGE:
 π , 2.0 to 5.0, or p , 2000 to 5000 psia
TEMPERATURE RANGE:
 τ , 1.09 to 1.32, or t , 85°F to 200°F

$$E_6 = E_{5c} - U \quad (30)$$

PRESSURE RANGE:
 π , 2.0 to 5.0, or p , 2000 to 5000 psia
TEMPERATURE RANGE:
 τ , 1.32 to 1.40, or t , 200°F to 240°F

$$Y = A(\pi - 2) + A_1(\pi - 2)^2 + A_2(\pi - 2)^3 + \dots + A_3(\pi - 2)^4 \quad (31)$$

where:

$$A = 1.71720 - 2.33123(\tau) - 1.56796(\tau)^2 + \dots + 3.47644(\tau)^3 - 1.28603(\tau)^4 \quad (32)$$

$$A_1 = 0.016299 - 0.028094(\tau) + 0.48782(\tau)^2 - \dots - 0.728221(\tau)^3 + 0.27839(\tau)^4 \quad (33)$$

$$A_2 = -0.35978 + 0.51419(\tau) + 0.16453(\tau)^2 - \dots - 0.52216(\tau)^3 + 0.19687(\tau)^4 \quad (34)$$

$$A_3 = 0.075255 - 0.10573(\tau) - 0.058598(\tau)^2 + \dots + 0.14416(\tau)^3 - 0.054533(\tau)^4 \quad (35)$$

where:

$$U = (\tau - 1.32)^2 (\pi - 2) [3 - 1.483(\pi - 2) - \dots - 0.10(\pi - 2)^2 + 0.0833(\pi - 2)^3] \quad (36)$$

NOTE: π and τ are defined on page 397. The Napierian constant e was carried to eight significant digits 2.7182818 in developing the table of *E* constants. The computer program used a floating decimal system.

*In equations 27-29 if the value of π is in excess of 2.0, then use 2.0. However, in equations 31 and 36 use the actual value of π as computed from equation 9 on Page 397.

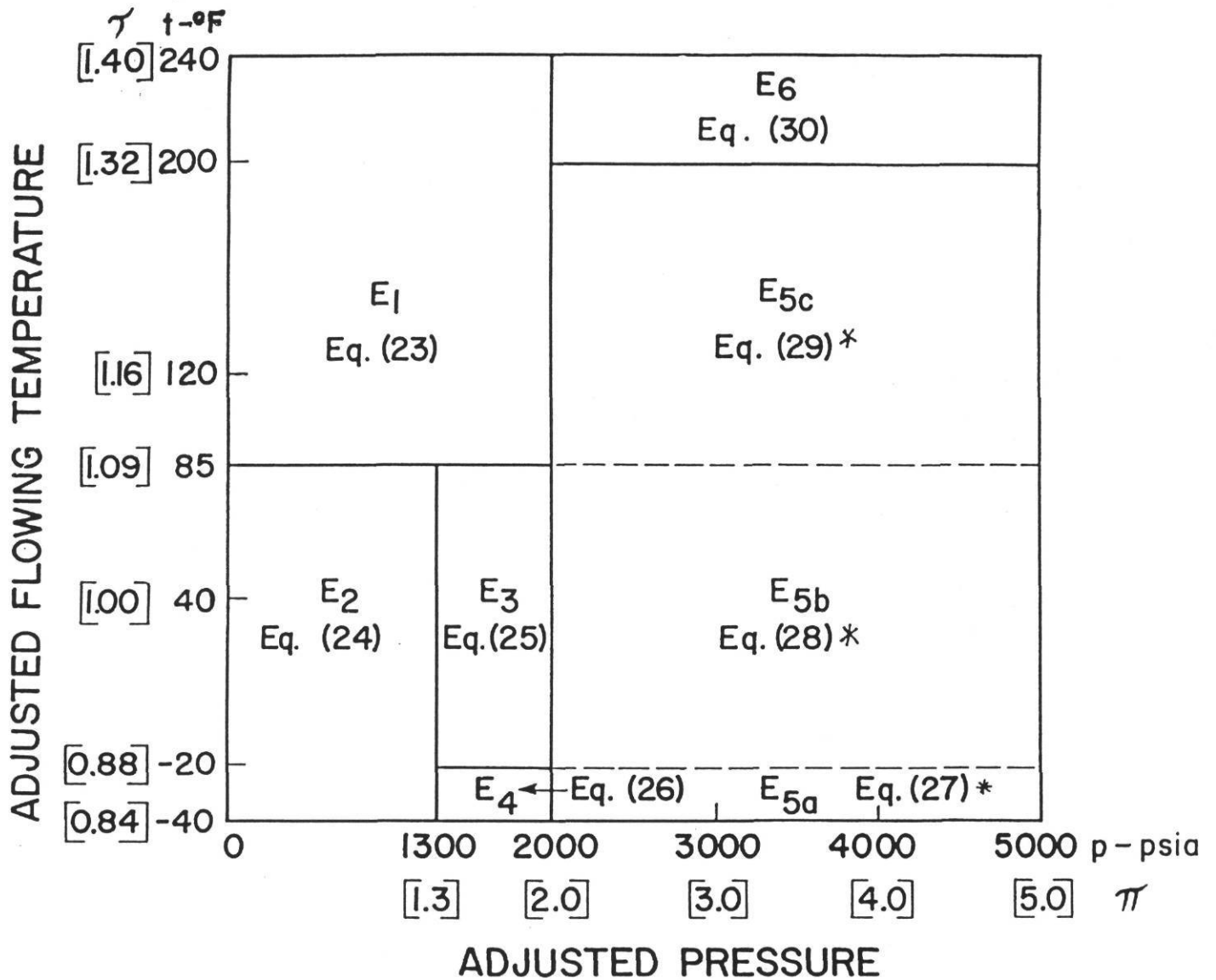
For ordinary use the system analyst by examining the equation can easily see ways of implementing them on almost any computer. Three systems are available for programming the parameter E in the equation for computer calculation:

1. Parameter E selected from Table 4.
2. Parameter E computed directly from equations.
3. Selective use of equations and tables of Parameter E .

The selection of the most suitable system for determining the supercompressibility factor F_{pv} by the computer method will ultimately depend upon the pressure and temperature ranges of the flowing gas and the capabilities of the electronic data processing equipment available to the user.

Figure 2 on page 407 shows a graphic representation of the F_{pv} factors at four temperatures taken directly from the Table of Supercompressibility Factors. These values are for the 0.600 specific gravity hydrocarbon natural gas.

RANGE OF APPLICABILITY OF THE PARAMETER E



* Reference footnote on Page 403

FIGURE 1

PURE HYDROCARBON GAS 0.600 SPECIFIC GRAVITY

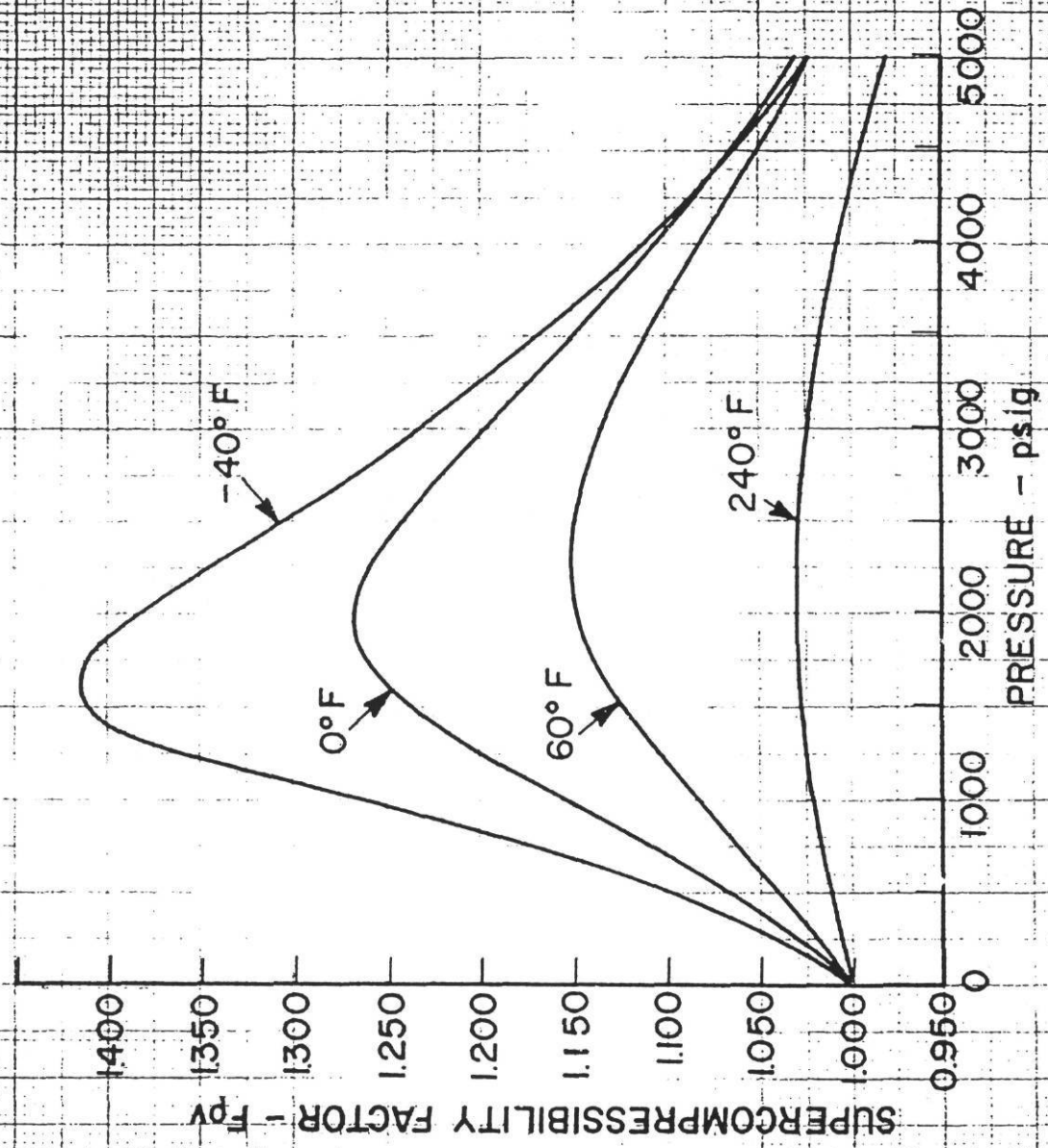


FIGURE 2

ATTACHMENT C

MONTHLY AND PARTIAL HOURLY GAS MEASUREMENT

FOR MAY 1997

SHERYL OWENS
 AVC 3.22
 Monthly Summary SN: 84302378

TAMU POWER PLANT
 IRELAND STREET
 COLLEGE STATION TX.

07:00 Thursday 01 May 1997

Day	Cor Vol ft ³ X 100	UnCor Vol ft ³ X 100	Avg Pres PSIG	Avg Temp Degrees F
01 Th	166455	13250	165.51	62.6
02 Fr	168229	13410	165.36	62.9
03 Sa	163911	13030	165.83	62.9
04 Su	164046	13050	165.81	63.2
05 Mo	167323	13350	165.37	63.3
06 Tu	171012	13670	165.15	63.7
07 We	171811	13750	165.05	63.9
08 Th	171292	13720	165.00	64.2
09 Fr	167083	13340	165.48	64.0
10 Sa	162542	12960	165.82	64.3
11 Su	159867	12740	166.03	64.6
12 Mo	158520	12630	166.09	64.6
13 Tu	156721	12490	166.12	64.9
14 We	156000	12440	166.09	65.1
15 Th	156057	12450	166.08	65.3
16 Fr	155950	12450	166.04	65.5
17 Sa	158122	12650	165.78	65.8
18 Su	157520	12600	165.92	66.1
19 Mo	162619	13080	165.08	66.5
20 Tu	161037	12910	165.59	66.3
21 We	163166	13100	165.41	66.5
22 Th	158572	12700	165.89	66.5
23 Fr	152991	12250	166.13	66.8
24 Sa	161084	12920	165.68	66.7
25 Su	159443	12800	165.70	67.2
26 Mo	165627	13350	165.10	67.5
27 Tu	163485	13170	165.24	67.6
28 We	161635	13000	165.50	67.6
29 Th	161653	13010	165.50	67.9
30 Fr	163195	13150	165.36	68.1
31 Sa	158628	12750	165.83	68.1
-----		-----	-----	-----
	5025596	402170	165.63	65.5
-----		-----	-----	-----

Max Cor Vol	ft ³	X 100	=	171811	Wed 7 May 97
Min Cor Vol	ft ³	X 100	=	152991	Fri 23 May 97
Max UnCor Vol	ft ³	X 100	=	13750	Wed 7 May 97
Min UnCor Vol	ft ³	X 100	=	12250	Fri 23 May 97
Max Avg Pres	PSIG		=	167.88	Fri 23 May 97
Min Avg Pres	PSIG		=	163.99	Fri 2 May 97
Max Avg Temp	Degrees F		=	68.4	Sat 31 May 97
Min Avg Temp	Degrees F		=	62.2	Thu 1 May 97

SHERYL OWENS
 AVC 3.22
 Daily Summary SN: 84302378

TAMU POWER PLANT
 IRELAND STREET
 COLLEGE STATION TX.

07:00 Thursday 01 May 1997

Time	Cor Vol ft ³ X 100	UnCor Vol ft ³ X 100	Avg Pres PSIG	Avg Temp Degrees F
07:00	6796	540	165.70	62.2
08:00	6918	550	165.57	62.3
09:00	6911	550	165.44	62.4
10:00	6905	550	165.34	62.6
11:00	7028	560	165.31	62.6
12:00	7242	580	164.45	62.7
13:00	7143	570	165.13	62.7
14:00	7013	560	165.01	62.7
15:00	7135	570	164.92	62.9
16:00	7003	560	164.82	63.0
17:00	7147	570	165.26	63.0
18:00	7023	560	165.28	62.8
19:00	6906	550	165.45	62.8
20:00	7031	560	165.46	62.8
21:00	6800	540	165.98	62.7
22:00	6803	540	165.96	62.6
23:00	6803	540	165.98	62.6
00:00	6812	540	166.21	62.6
01:00	6807	540	166.05	62.5
02:00	6806	540	166.08	62.5
03:00	6811	540	166.21	62.5
04:00	6810	540	166.11	62.5
05:00	6786	540	165.61	62.6
06:00	7016	560	165.02	62.7
07:00	7137	570	164.96	62.8
08:00	7136	570	164.94	62.8
09:00	7247	580	164.59	62.7
10:00	7139	570	165.00	62.7
11:00	7348	590	164.09	62.9
12:00	7467	600	163.99	62.9
13:00	7482	600	164.38	63.1
14:00	7347	590	164.08	63.1
15:00	7146	570	165.27	63.1
16:00	7133	570	165.00	63.1
17:00	6989	560	164.53	63.2
18:00	7140	570	165.20	63.3
19:00	7153	570	165.46	63.2
20:00	7019	560	165.28	63.1
21:00	7147	570	165.27	63.0
22:00	6813	540	166.33	62.9
23:00	6566	520	166.41	62.7
00:00	6694	530	166.44	62.6
01:00	6564	520	166.34	62.6
02:00	6698	530	166.55	62.6
03:00	6692	530	166.34	62.5
04:00	6688	530	166.19	62.5
05:00	6678	530	165.96	62.5

06:00

6806

540

166.02

62.5

Printed: 11:23 Wednesday 16 July 1997

File: 84302378.PRF

Page: 1

SHERYL OWENS
AVC 3.22
Daily Summary

SN: 84302378

TAMU POWER PLANT
IRELAND STREET
COLLEGE STATION TX.

07:00 Saturday 03 May 1997

Time	Cor Vol ft ³ X 100	UnCor Vol ft ³ X 100	Avg Pres PSIG	Avg Temp Degrees F
07:00	6804	540	165.98	62.6
08:00	6890	550	165.08	62.7
09:00	7021	560	165.22	62.9
10:00	6902	550	165.43	62.9
11:00	7029	560	165.44	62.9
12:00	6787	540	165.72	63.0
13:00	6907	550	165.57	63.1
14:00	6895	550	165.33	63.2
15:00	6780	540	165.62	63.3
16:00	6782	540	165.68	63.2
17:00	6783	540	165.70	63.2
18:00	6902	550	165.50	63.2
19:00	6788	540	165.78	63.1
20:00	6799	540	165.99	62.9
21:00	6798	540	165.97	62.9
22:00	6807	540	166.17	62.8
23:00	6808	540	166.21	62.8
00:00	6688	530	166.30	62.8
01:00	6822	540	166.47	62.7
02:00	6816	540	166.33	62.6
03:00	6682	530	166.11	62.6
04:00	6814	540	166.25	62.6
05:00	6810	540	166.11	62.6
06:00	6797	540	165.84	62.6
07:00	6915	550	165.66	62.6
08:00	6892	550	165.18	63.0
09:00	7025	560	165.44	63.1
10:00	6904	550	165.49	63.0
11:00	6903	550	165.52	63.1
12:00	6913	550	165.80	63.2
13:00	6788	540	165.81	63.3
14:00	6787	540	165.82	63.3
15:00	6788	540	165.91	63.4
16:00	6783	540	165.80	63.4
17:00	6780	540	165.75	63.4
18:00	6779	540	165.65	63.5
19:00	6789	540	165.93	63.4
20:00	6789	540	165.83	63.3
21:00	6786	540	165.77	63.2
22:00	6919	550	165.96	63.2
23:00	6795	540	166.01	63.2
00:00	6800	540	166.07	63.1
01:00	6806	540	166.22	63.1
02:00	6801	540	166.07	63.0
03:00	6806	540	166.25	63.0
04:00	6800	540	166.04	63.0
05:00	6796	540	165.90	63.0

06:00

6902

550

165.47

63.0

Printed: 11:23 Wednesday 16 July 1997

File: 84302378.PRF

Page: 2

SHERYL OWENS
AVC 3.22
Daily Summary

SN: 84302378

TAMU POWER PLANT
IRELAND STREET
COLLEGE STATION TX.

07:00 Monday 05 May 1997

Time	Cor Vol ft ³ X 100	UnCor Vol ft ³ X 100	Avg Pres PSIG	Avg Temp Degrees F
07:00	6904	550	165.55	63.2
08:00	7034	560	165.63	63.1
09:00	6886	550	165.12	63.2
10:00	7108	570	164.47	63.3
11:00	7249	580	164.96	63.4
12:00	7014	560	165.24	63.3
13:00	7127	570	165.01	63.4
14:00	7223	580	164.33	63.6
15:00	6883	550	165.05	63.4
16:00	7125	570	164.93	63.5
17:00	7109	570	164.62	63.6
18:00	6888	550	165.33	63.6
19:00	6901	550	165.58	63.4
20:00	6899	550	165.58	63.4
21:00	6894	550	165.42	63.4
22:00	6792	540	165.94	63.3
23:00	6907	550	165.70	63.3
00:00	6918	550	165.91	63.3
01:00	6924	550	166.12	63.2
02:00	6788	540	165.81	63.2
03:00	6910	550	165.74	63.3
04:00	6916	550	165.87	63.2
05:00	6904	550	165.58	63.2
06:00	7020	560	165.38	63.3
07:00	7018	560	165.33	63.4
08:00	7148	570	165.44	63.4
09:00	7115	570	164.75	63.6
10:00	7013	560	165.32	63.6
11:00	7117	570	164.83	63.6
12:00	7227	580	164.51	63.7
13:00	7119	570	164.87	63.8
14:00	7341	590	164.28	63.9
15:00	7118	570	164.95	63.9
16:00	7248	580	165.03	63.9
17:00	7003	560	165.17	64.0
18:00	7113	570	164.87	64.0
19:00	7119	570	164.95	64.0
20:00	7133	570	165.25	63.8
21:00	7137	570	165.32	63.7
22:00	7013	560	165.30	63.7
23:00	7151	570	165.60	63.7
00:00	7030	560	165.71	63.6
01:00	7150	570	165.56	63.5
02:00	7021	560	165.50	63.5
03:00	7148	570	165.47	63.5
04:00	7269	580	165.42	63.5
05:00	7145	570	165.42	63.5

06:00

7116

570

164.74

63.5

Printed: 11:23 Wednesday 16 July 1997

File: 84302378.PRF

Page: 3

ATTACHMENT D

SPREADSHEET OF GAS VOLUME CORRECTION

Time	Vol.	P	t	Mc	Mn	G	Kp	Fp	Kt	Ft	Padj	tadj	pi	tau	m	n	B	E	b	D	Fpv	Volume	Volume	Difference
	(uncor)	(psig)	(F)	(mol% CO2)	(mol% N2)	(sp. gr.)					(psi)	(F)										(calc'd)	(meter)	(%)
7	540	165.7	62	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.46	49.1	0.1782	1.018	0.026	6.559	258.9	1.000	5075.3	22.7	1.0141	6798	6796	-0.03%
8	550	165.6	62	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.33	49.2	0.1780	1.018	0.026	6.558	259.5	1.000	5090.5	22.7	1.0141	6917	6918	0.01%
9	550	165.4	62	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.20	49.3	0.1779	1.019	0.026	6.558	260.2	1.000	5105.6	22.7	1.0140	6911	6911	0.00%
10	550	165.3	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.10	49.5	0.1778	1.019	0.026	6.557	260.9	1.000	5121.9	22.7	1.0140	6904	6905	0.02%
11	560	165.3	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.07	49.5	0.1778	1.019	0.026	6.557	261.0	1.000	5124.6	22.7	1.0140	7028	7028	0.00%
12	580	164.5	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.22	49.6	0.1769	1.019	0.026	6.556	263.8	1.000	5205.5	22.9	1.0139	7242	7242	0.00%
13	570	165.1	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.89	49.6	0.1776	1.019	0.026	6.556	261.8	1.000	5144.4	22.8	1.0140	7145	7143	-0.02%
14	560	165	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.77	49.6	0.1775	1.019	0.026	6.556	262.2	1.000	5155.1	22.8	1.0140	7015	7013	-0.02%
15	570	164.9	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.69	49.8	0.1774	1.020	0.026	6.555	262.9	1.000	5170.6	22.8	1.0139	7133	7135	0.03%
16	560	164.8	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.59	49.9	0.1773	1.020	0.026	6.555	263.5	1.000	5183.4	22.8	1.0139	7003	7003	0.01%
17	570	165.3	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.02	49.9	0.1777	1.020	0.026	6.555	262.2	1.000	5144.0	22.8	1.0140	7146	7147	0.02%
18	560	165.3	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.04	49.7	0.1777	1.019	0.026	6.556	261.6	1.000	5134.7	22.8	1.0140	7024	7023	-0.01%
19	550	165.5	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.21	49.7	0.1779	1.019	0.026	6.556	261.1	1.000	5119.7	22.7	1.0140	6905	6906	0.01%
20	560	165.5	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.22	49.7	0.1779	1.019	0.026	6.556	261.1	1.000	5118.8	22.7	1.0140	7031	7031	0.00%
21	540	166	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.73	49.6	0.1784	1.019	0.026	6.556	259.3	1.000	5069.3	22.7	1.0141	6802	6800	-0.03%
22	540	166	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.71	49.5	0.1784	1.019	0.026	6.557	259.2	1.000	5067.3	22.7	1.0141	6802	6803	0.01%
23	540	166	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.73	49.5	0.1784	1.019	0.026	6.557	259.1	1.000	5065.6	22.7	1.0141	6803	6803	0.00%
0	540	166.2	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.96	49.5	0.1787	1.019	0.026	6.557	258.4	1.000	5045.5	22.6	1.0141	6812	6812	0.00%
1	540	166.1	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.80	49.4	0.1785	1.019	0.026	6.557	258.7	1.000	5055.8	22.6	1.0141	6807	6807	0.00%
2	540	166.1	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.83	49.4	0.1785	1.019	0.026	6.557	258.6	1.000	5053.2	22.6	1.0141	6809	6806	-0.04%
3	540	166.2	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.96	49.4	0.1787	1.019	0.026	6.557	258.2	1.000	5041.9	22.6	1.0141	6814	6811	-0.04%
4	540	166.1	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.86	49.4	0.1786	1.019	0.026	6.557	258.5	1.000	5050.6	22.6	1.0141	6810	6810	0.00%
5	540	165.6	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.37	49.5	0.1781	1.019	0.026	6.557	260.2	1.000	5098.1	22.7	1.0140	6789	6786	-0.04%
6	560	165	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.78	49.6	0.1775	1.019	0.026	6.556	262.1	1.000	5154.2	22.8	1.0140	7015	7016	0.01%
7	570	165	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.73	49.7	0.1774	1.019	0.026	6.556	262.6	1.000	5163.3	22.8	1.0140	7136	7137	0.01%
8	570	164.9	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.71	49.7	0.1774	1.019	0.026	6.556	262.6	1.000	5165.1	22.8	1.0140	7135	7136	0.01%
9	580	164.6	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.36	49.6	0.1771	1.019	0.026	6.556	263.4	1.000	5192.8	22.8	1.0139	7248	7247	-0.01%
10	570	165	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.76	49.6	0.1775	1.019	0.026	6.556	262.2	1.000	5156.0	22.8	1.0140	7139	7139	-0.01%
11	590	164.1	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	161.87	49.8	0.1766	1.020	0.026	6.555	265.4	1.000	5245.8	22.9	1.0139	7348	7348	0.00%
12	600	164	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	161.77	49.8	0.1765	1.020	0.026	6.555	265.7	1.000	5255.0	22.9	1.0139	7468	7467	-0.02%
13	600	164.4	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.15	50.0	0.1769	1.020	0.026	6.554	265.0	1.000	5227.0	22.9	1.0139	7482	7482	0.00%
14	590	164.1	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	161.86	50.0	0.1766	1.020	0.026	6.554	265.9	1.000	5254.4	22.9	1.0139	7345	7347	0.03%
15	570	165.3	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.03	50.0	0.1777	1.020	0.026	6.554	262.4	1.000	5146.8	22.8	1.0140	7145	7146	0.02%
16	570	165	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.76	50.0	0.1775	1.020	0.026	6.554	263.2	1.000	5171.0	22.8	1.0139	7133	7133	-0.01%
17	560	164.5	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.30	50.1	0.1770	1.020	0.026	6.554	264.8	1.000	5217.1	22.9	1.0139	6988	6989	0.02%
18	570	165.2	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	162.96	50.2	0.1777	1.020	0.025	6.553	263.1	1.000	5160.6	22.8	1.0139	7139	7140	0.02%
19	570	165.5	63	2.8	0.79	0.6470	2.490	0.9865	4.128	0.975	163.22	50.1	0.1779	1.020	0.026	6.554	262.1	1.000	5133.7	22.8	1.0140	7151	7153	0.03%

ATTACHMENT E

GAS ANALYSIS DATA FOR 1995

REPORT: GANB155-01
 JOB: GAN6030

GAS ANALYSIS
 MASTER FILE WITH ANALYSIS HISTORY
 STW: 16122201 199501 THRU 199601

PAGE: 1
 DATE: 01/24/96
 TIME: 10:26:07

COMPOSITE CONTRACT QUALITY REQUIREMENTS
 MINIMUM MAXIMUM

STATION NO: 16-1222-01

STATUS.....: ACTIVE
 PL COMPANY....: 107 LSG - GENERAL DIV

BTU
 RELATIVE DENSITY
 INTERCHANGE
 WATER VAPOR (LBS/MMCF)
 CARBON DIOXIDE (%)
 OXYGEN (%)
 NITROGEN (%)
 CO2 + N2 (%)
 TOTAL INERTS (%)
 HYDROGEN SULFIDE (GR/CCF)
 HYDROCARBON DEW PT (F)

STATION NAME...: COLLEGE STA LINE 1 (C&G)
 OPERATOR.....: BRYAN CITY OF
 COUNTY.....: BRAZOS STATE.....: TX
 FIELD.....: MAIN LINE.....: L8-C-1
 FIELD EQUIP...: GB200-THERMTITRATOR

GAN REGION...: 800 SOUTH (EAST) TX
 AREA.....: 28 SPOT SAMPLES-BRYAN
 RPT DSTB CODE: 019 WACO DISTRICT
 PURPOSE.....: BTU-DEVICE
 PREVIOUS STA.:
 FREQUENCY....: MONTHLY
 PRIORITY.....: 5
 BEGINNING MO.: JAN CCCCCCCCCCCC

ANALYSIS TEST HISTORY

TEST NUMBER.....	212446	211326	209915	209678	208516	207345	206120	204951	203665	202439	201123	199921
SEQUENCE NUMBER..												
SAMPLE TO DATE...:	1/10/1996	12/14/1995	11/08/1995	10/25/1995	9/13/1995	8/10/1995	7/26/1995	6/30/1995	5/18/1995	4/19/1995	3/22/1995	2/16/1995
VALIDATED DATE...:	1/19/1996	1/03/1996	11/29/1995	11/02/1995	10/04/1995	9/05/1995	8/02/1995	7/03/1995	5/31/1995	4/28/1995	3/31/1995	3/01/1995
BTU @ 14.696 DRY....	1031	1038	1049	1036	1028	1038	1042		1034	1029	1029	1023
BTU @ 14.65 SAT....	1009	1017	1027	1015	1007	1016	1021		1012	1008	1008	1002
REL DENSITY (R)....	.609	.622	.627	.617	.616	.623	.627		.601	.608	.622	.612
I/C FACTOR.....	1301	1297	1304	1299	1290	1295	1297		1313	1299	1285	1287
TOTAL INERTS.....	2.870	3.320	3.320	3.130	3.370	3.430	3.450	.000	2.190	2.790	3.700	3.370
HELIUM.....												
CARBON DIOXIDE....	2.20	2.74	2.47	2.47	2.76	2.83	2.89	.00	1.65	2.39	3.17	2.71
OXYGEN.....												
NITROGEN.....	.67	.58	.85	.66	.61	.60	.56	.00	.54	.40	.53	.66
METHANE.....	91.28	89.60	88.94	90.15	90.47	89.19	88.65	.00	92.41	91.57	89.60	91.03
ETHANE.....	5.47	6.44	6.48	6.18	5.80	6.85	7.26	.00	5.06	5.30	6.22	5.29
PROPANE.....	.35	.54	1.02	.49	.32	.51	.60	.00	.33	.34	.45	.31
ISO-BUTANE.....	.01	.03	.09	.02	.01	.00	.02	.00	.00	.00	.01	.00
N-BUTANE.....	.01	.05	.13	.02	.01	.02	.02	.00	.00	.00	.02	.00
ISO-PENTANE.....	.00	.01	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00
N-PENTANE.....	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
HEXANES.....	.01	.01	.00	.01	.02	.00	.00	.00	.01	.00	.00	.00
H2S (PPH).....		NIL	ND	ND	NIL	NIL	ND		NIL	NIL	NIL	ND
STATIC PRESSURE...:	245	254	250	246	255	255	260		275	260	250	250
FLOWING TEMP.....:	56	61	67	74	78	80	77		65	65	60	53
HCDP @ DEL PR (F):												
CHEMIST INITIALS...:	RL	RL	RL	RL	RL	RL	RL	JH	RL	RL	RL	RL
CHANGE AUTH. BY...:												
VALID FOR PAYMENT..:	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES

JAN-07-0000 00:21 FROM LONE STAR PIPELINE LAB TO 914098622418 P.01

REPORT: GANB155-01
JOB: GAN6030

GAS ANALYSIS
MASTER FILE WITH ANALYSIS HISTORY
STTN: 16122201 199501 THRU 199601

PAGE: 2
DATE: 01/24/96
TIME: 10:26:07
COMPOSITE CONTRACT QUALITY REQUIREMENTS
MINIMUM MAXIMUM

STATION NO: 16-1222-01
STATION NAME: COLLEGE STA LINE 1 (C&G)
OPERATOR: BRYAN CITY OF
COUNTY: BRAZOS
FIELD: TX
FIELD EQUIP: GB200-THERMITRATOR
STATE: TX
MAIN LINE: L8-C-1

STATUS: ACTIVE
PL COMPANY: 107 LSG - GENERAL DIV
GAN REGION: 800 SOUTH (EAST) TX
AREA: 28 SPOT SAMPLES-BRYAN
RPT DSTB CODE: 019 WACO DISTRICT
PURPOSE: BTU-DEVICE
PREVIOUS STA.:
FREQUENCY: MONTHLY
PRIORITY: 5
BEGINNING MO.: JAN CCCCCCCCCCCC

BTU
RELATIVE DENSITY
INTERCHANGE
WATER VAPOR (LBS/MMCF)
CARBON DIOXIDE (%)
OXYGEN (%)
NITROGEN (%)
CO2 + H2 (%)
TOTAL INERTS (%)
HYDROGEN SULFIDE (GR/CCF)
HYDROCARBON DEN PT (F)

A N A L Y S I S T E S T H I S T O R Y

TEST NUMBER: 198799
SEQUENCE NUMBER:
SAMPLE TO DATE: 1/23/1995
VALIDATED DATE: 2/01/1995

BTU 014,696 DRY: 1024
BTU 014,65 SAT: 1002
REL DENSITY (R): .620
I/C FACTOR: 1280
TOTAL INERTS: 3.840

HELIUM: 3.18
CARBON DIOXIDE: .66
OXYGEN: 90.05
NITROGEN: 5.66
METHANE: .39
ETHANE: .02
PROPANE: .03
ISO-BUTANE: .00
N-BUTANE: .01
ISO-PENTANE: .01
N-PENTANE: .01
HEXANES: NIL
K2S (PPM): 250

STATIC PRESSURE: 57
FLOWING TEMP: RL
HDDP @ DEL PR (F):
CHEMIST INITIALS:
CHARGE AUTH. BY: YES
VALID FOR PAYMENT: YES