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NATURAL GAS DEPARTMENT

JUDD MILLER, JR
VICE PRESIDENT

February 28, 1995

Gas Quality Task Force Members:

Gas Quality Task Force Final Report Draft

Attached for your review and comment is a draft of the final report of the Grid Integration Project Gas Quality Task Force. It summarizes the work performed by the Task Force during our efforts to further investigate tariff data and find occurrences where quality problems have affected gas movements across the grid. You will note that the attachments (INGAA tariff survey, pipeline survey results, etc.) are not included at this time since they are between 200-250 pages long.

As you know, we established four sub-teams during our November 16, 1994 meeting with the objective of further investigating the 13 "across-the-grid" problems identified through the gas quality problems survey. The problems affected about 0.8 BCF/D of gas. Were they all to occur simultaneously, their volume represents less than 1.5% of the average volume of gas carried on interstate pipelines in recent years. After review, the general sense of the four teams is that the problems do not require the efforts of the Gas Quality Task Force and are best resolved by the parties involved. As such, Task Force work efforts have ended with the exception of the final report.

Please provide any comments you have to Roger Huffaker (Phone: 713-656-8369, Fax: 713-656-4144) by Wednesday, March 15, 1995. Unless major revisions are indicated, the report will be issued soon thereafter.

For myself and on behalf of the Grid project, I thank you for the time and energy that you and your organizations have contributed. It has been enjoyable working with you.

Judd

RWH:ap

******** FINAL DRAFT - FEBRUARY 27, 1995 *******

Grid Integration Project
Gas Quality Task Force Report

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1. SUMMARY

The Grid Integration Project Gas Quality Task Force was charged with identifying pipeline gas quality specifications which unnecessarily inhibit the flow of gas across the interstate pipeline grid or create inefficiencies. The Task Force was chaired by Mr. Judd Miller, Jr., Exxon Company USA. Through a series of meetings and smaller work group efforts during the period September 1994 through January 1995, the Task Force assessed the impact of gas quality as it affects current operations to move gas across the interstate grid.

The Task Force surveyed interstate pipelines for reasons behind existing tariff specifications. The Task Force also developed and sent to producers, interstate pipelines, marketers, LDCs and gas industry trade associations a survey designed to identify occurrences during the past 12 months where gas quality had affected movements across the interstate grid. Conclusions of the effort are:

- There do not appear to be widespread problems or inefficiencies moving gas across the interstate grid due that are due to gas quality. Reported gas quality problems affected less than 0.8 BCFD, of which 0.5 BCFD involved 2 companies. Even if all the problems occurred simultaneously, the total volume represents less than 1.5% of gas moved across interstate pipelines in 1993 (21 TCF).

- For the significant majority of the gas, "blending" across the interstate grid produces flowstreams that are within quality tolerances at pipeline to pipeline and pipeline to end-user interconnects.

- From a transportation tariff standpoint, the quality characteristics that are the most significant to pipeline operations are BTU, carbon dioxide, oxygen, hydrogen sulfide, and water content. Other characteristics have lesser impact on operations but may affect production (e.g. nitrogen), pipeline economics (e.g. inerts transportation), end-use (e.g. sulfur, inerts) or cause environmental concerns (e.g. trace contaminants)

- There do not appear to be any significant reasons from a transportation standpoint to change existing pipeline gas quality tariffs. Any changes not related to pipeline operations should be dictated by the market.

- Setting transportation issues aside, proposals for wide-spread gas quality specification adjustments ultimately become the question "Who benefits from the adjusted quality, who suffers, and who pays?" On the end-use side, wide-spread adjustments to gas quality might benefit some segments (e.g. natural gas vehicles) but may be unnecessary for other segments (e.g. residential & commercial heating). On the production side, wide-spread adjustments to gas quality might affect gas flow into the grid and/or increase production costs without a corresponding benefit. This issue was beyond the charter of the Gas Quality Task Force.

- There are alternate methods of defining gas quality specifications which may more efficiently integrate the needs of the production, pipeline and end-use segments than do existing methods. For example, to specify gas heating value and liquefiables one could limit hydrocarbon dew point and Wobbe Index instead of limiting maximum / minimum BTU, inert gas, and liquefiables. Both approaches have advantages and disadvantages. Identification and evaluation of alternate methods to specify gas quality was beyond the scope of the Gas Quality Task Force.

- The Gas Quality Task Force recommends no changes.

2. GAS QUALITY TASK FORCE OVERVIEW

2.1 BACKGROUND

The Grid Integration Project began in the first half of 1994 as an industry-wide effort to increase system reliability and ease gas movement across pipelines by addressing barriers impeding interstate gas flow. As a starting point, the Project commissioned the Interstate Natural Gas Association (INGAA) to survey interstate pipelines for tariff information regarding gas quality specifications, nomination procedures, and balancing and allocations procedures.

Results of the INGAA survey (Attachment 1) were presented to assembled Grid Integration Project members on July 29, 1994. The survey highlighted numerous tariff differences across pipelines. After discussion, three task forces were established to determine which tariff specifications actually impeded gas flow vs. those which on paper appeared to impede flow but in reality did not.

The three task forces were Nominations and Capacity Release, Balancing and Allocations, and Gas Quality. The charge to the Nominations and Capacity Release Task Force, chaired by Mr. Craig Matthews of Brooklyn Union, was to identify specific concerns due to different pipeline nomination procedures and determine if the differences unnecessarily affected the flow of gas across the interstate grid. The charge to the Balancing and Allocations Task Force, chaired by Mr. Dennis Hendrix of Panhandle Eastern, was to (i) determine if any allocation procedures at interconnects unnecessarily affected the flow of gas across the interstate grid, and (ii) determine how balancing requirements affected the ability of shippers to move gas across the grid. Final results of these two task forces will be reported separately.

2.2 GAS QUALITY TASK FORCE CHARTER AND SCOPE

The Gas Quality Task Force was chaired by Mr. Judd Miller, Jr., Vice President - Natural Gas, Exxon Company USA. The charter of the Gas Quality Task Force was to identify pipeline gas quality specifications which unnecessarily inhibit the flow of gas across the interstate pipeline grid or create inefficiencies, including:

- Consideration of the set of gas quality content specifications that pipelines generally include in their tariffs, and understanding, if possible, reasons for any wide variances in tariff provisions across pipelines:
    - minimum and maximum BTU content;
    - oxygen;
    - water vapor;
    - hydrogen sulfide & total sulfur;
    - carbon dioxide;
    - dust, gums, and solid matter;
    - total inert substances;
    - temperature;
    - other extraneous substances which may be limited by tariffs.
- Identification of any gas quality problems affecting the movement of gas across multiple pipelines in sufficient detail to distinguish significant recurring events from unique situations. Differentiation between gas quality specifications that affect pipeline operations from those which, though different from pipeline to pipeline, are innocuous from a transportation perspective.

- If problems were found, identification of standards or ranges of standards that might be agreeable to a broader base of pipelines.
- Coordination with the AGA task force examining gas quality specifications.
- Recommended changes, as appropriate, to gas quality specifications with such recommended changes supported by:
  - (a) cost/benefit assessments for interested parties;
  - (b) estimates of the extent to which changes impact transportation or end-use markets;
  - (c) consideration of any settlement process involving the pipeline and its broad customer base which may have produced the specification

The Task Force's effort was directed at gas movement across the interstate grid, not at problems associated with gas entering or leaving the grid.

2.3 GAS QUALITY TASK FORCE MEMBERSHIP

The Task Force sought to include in its membership representatives from each sector of the gas industry that might be affected by recommendations, if any, that were made. Membership was open to anyone desiring to participate. The initial mailing list (Table 1) was developed using attendance at the July 29, 1994 Grid Integration Project meeting. A total of 60 people from 41 different organizations and trade associations were invited to the Gas Quality Task Force kick-off meeting, held September 16, 1994 in Houston.

Persons/Organizations Invited to Gas Quality Task Force Kick-Off Meeting

	No. Individuals	No. Organizations
Total	60	41
- LDCs	8	6
- Marketers	7	6
- Pipelines	18	13
- Producers	11	7
- Trade Associations	16	9

The final mailing/fax list (Table 2) of the Gas Quality Task Force consisted of 53 people from 36 different organizations.

Gas Quality Task Force Fax / Mailing List

	No. Individuals	No. Organizations
Total	53	36
- LDCs	6	5
- Marketers	5	4
- Pipelines	19	12
- Producers	11	7
- Trade Associations	12	8

Given that the representation spanned the gas industry, the Task Force believes that the results obtained are credible and provide comfort that all interested parties had opportunity to participate.

2.4 GAS QUALITY TASK FORCE ORGANIZATION

From a timing and organization standpoint, the Task Force broke the effort into 3 phases over a 7-1/2 month period.

Gas Quality Task Force Timeline

	Planned Action	Timing
Phase 1	Understand Variations in Pipeline Quality Tariffs and Identify Actual "Across-the-Grid" Problems	(Sep - Dec 1994)
Phase 2	Explore Solutions and Costs	(Jan - Feb 1995)
Phase 3	Prepare Recommendations and Reports	(April 15, 1995)

Phase 1: The objectives of Phase 1 work were twofold: (i) to further understand the reasoning behind existing pipeline tariff specifications, and (ii) to identify occurrences where gas had affected gas movements across the grid. Two teams were established to achieve these objectives. The first team, Pipeline Tariff Investigation and Analysis, was charged with gaining a better understanding of the reasoning behind pipeline tariffs, and to develop an appreciation of the potential problems and issues should changes to gas quality specifications be recommended. The second team, Gas Quality Problems , was charged with identifying specific instances and interconnects where gas quality had interfered with the movement of gas across the interstate pipeline grid.

Participation on either of the two teams was voluntary. Membership spanned the industry, although the majority of participants represented interstate pipelines.

Phase 1 Team Breakdown

	Tariff Team	Problems Team
Total Participants	14	12
- LDCs	1	1
- Marketers	1	1
- Pipelines	12	4
- Producers	1	5
- Trade Associations	0	1

Phases 2 and 3: Phases 2 and 3 depended on the results of Phase 1 work. As it turned out, the lack of widespread gas quality problems eliminated Phase 2 and reduced Phase 3 to documentation of Phase 1 work and results.

2.5 COORDINATION WITH AGA

While organizing the Task Force, discussions were held with Mr. John Erickson of the American Gas Association (AGA) to ensure that work performed by the Gas Quality Task Force complemented AGA efforts on gas quality. The discussion indicated that AGA efforts would build on results of the Gas Quality Task Force.

3. PIPELINE TARIFF INVESTIGATION AND ANALYSIS

3.1 OVERVIEW

The Pipeline Tariff Investigation and Analysis team was charged with gaining a better understanding of the reasons behind pipeline tariffs, and to develop an appreciation of the potential problems and issues should recommendations be made to change gas quality specifications. The team was chaired by Ms. Dottie Anderson of Panhandle Eastern. Mr. Brad Holmes of Transco was Vice-Chair. Other team members were:

- Leon Bowdoin, Algonquin Transmission
- Kristi Brown, Rep. United Distribution Companies
- Wade Church, Tenneco Gas Transmission
- Scott Coburn, Northern Border Pipeline
- Philip Dusek, Natural Gas Pipeline
- James Flanagan, Amoco Production
- John Kelly, Panhandle Eastern
- Henry Poelnitz, Southern Natural Gas
- Ken Purgason, Tejas Power
- Thomas Staats, Consolidated Natural Gas
- Lawrence Thummel, Williams Energy Ventures
- Rosie Villanueva, El Paso Natural Gas

3.2 APPROACH

After reviewing the INGAA data, the Tariff Team decided to survey each member and several other pipelines not represented on the team for answers to the following questions:

1. What are the reasons for gas quality specifications in the pipeline's tariff and how do they affect pipeline operations and transportation?

2. What are specific tariff provisions governing gas that is out of specification? How is notification to affected shippers accomplished? Are notification procedures stated in the tariff?

3. From a transportation standpoint, should other specifications be included and would changes cause pipeline operational or transportation problems?

4. Is the geographic region of production a driver for specifications for specific pipelines?

5. How often does pipeline test for gas quality? What are the sampling frequencies and techniques utilized?

Sixteen interstate pipelines responded to the survey:

- ANR Pipeline Company
- El Paso Natural Gas
- Kern River Gas Transmission Company
- Natural Gas Pipeline Company
- Northern Border Pipeline Company
- Northern Natural Gas Company
- Northwest Central Pipeline Corporation.
- Northwest Pipeline Company
- Panhandle Eastern Pipeline Company
- Southern Natural Gas Company
- Tennessee Gas Pipeline Company
- Texas Eastern Transmission Company
- Texas Gas Transmission Company
- Transcontinental Gas Pipeline Corporation
- Transwestern Pipeline Company
- Transcontinental Pipeline Company

3.3 REASONS BEHIND SPECIFICATIONS

Gas quality specifications have their basis in industry studies conducted during and prior to the 1930's. Specifications adopted by each pipeline reflected the gas being supplied to, transported on and delivered from the pipeline. As might be expected, each pipeline tended to be slightly different. End-users (LDCs, manufacturers, etc.) designed, built, and calibrated equipment and processes to the gas delivered by their pipelines. The gas quality tariff specifications evolved over time, reflecting an ever-changing understanding of factors that affect pipeline operations, gas supply, and end-use needs. With the grid becoming increasingly integrated in recent years, tariff specification differences have been highlighted.

Concurrent with tariff evolution has been the development of numerous methods, or indices , used to determine the interchangeability of other fuel gases with natural gas as well as to judge the suitability of a specific natural gas flowstream for a given application. Examples include the "Wobbe Index" and the "Weaver Flame Speed Factor"[1]. The indices, in turn, are used in designing various natural gas-fired equipment and end-use processes. It is beyond the scope of this report to explore the effects of interstate pipeline gas quality tariffs on gas interchangeability factors, however, the reader should note that end-use applications may be significantly affected by gas quality adjustments which have the side-effect of moving interchangeability indices beyond the application's design parameters.

3.3.1 BTU CONTENT

BTU content specifications have been based on the content of the gas supply, end-use needs, and/or contractual commitments between the pipelines and its customers. Besides gas supply characteristics, minimum BTU content specifications have been established for multiple reasons, including:

- Transportation rates are on a "Per BTU Basis". Low BTU gas reduces the economic efficiency of the pipeline.
- Changes in gas quality (particularly heating value) can cause gas to perform poorly in a given piece of equipment which is often times calibrated for a specific BTU content or Wobbe Index. A heating value that is too low can cause unstable, potentially dangerous conditions. For example, a serious accident could occur should a burner-tip flame-out due to low BTU gas and subsequently re-light.
- Heating efficiency is critical for many industrial customers. In timed processes, (e.g. food fryers, pizza ovens, and continuous process steamers) changes in heating value can result in an under-or-over heated product (e.g. raw chicken, burned pizza).
- Variations in heating quality and gas specific gravity can upset continuous melting processes (e.g. glass manufacturing) while trace contaminants can alter the composition of the finished product (e.g. glass strength, color, and clarity).

All of the 42 pipelines that provided gas quality tariff information to INGAA had a minimum BTU limit. As shown below, most of the limits were between 950 - 970 Btu/SCF. The majority were one of two values, either 950 or 967 Btu/SCF.

Tariff Ranges for Minimum BTU Content

Min Btu Accepted (Btu/SCF)	No. Pipelines
930	1
950-960	18
961-970	17
971-980	3
981-1000	3
1000+	1

Note: One pipeline has dual limits depending on geographic location

Other than "tradition", the Task Force was unable to pinpoint why specific minimum BTU values were chosen for tariff specifications. It is interesting to note that 950 Btu/SCF on a "wet" basis converts to 967 Btu/SCF on a "dry" basis. One speculation is that most tariffs started out on a "wet" basis (950 Btu/SCF). Over the years, and many tariff revisions, some were changed to a "dry" basis (967 Btu/SCF) with the "wet"/"dry" distinction slowly being lost over time.

[1] Further descriptions and definitions of indices are available in Gas Research Institute Report #96/0021, "Catalogue of Existing Interchangeability Prediction Methods"

Maximum BTU Content: Maximum BTU content appears to be established primarily to prevent liquefiable hydrocarbons from condensing in pipelines. Slugs of hydrocarbon liquids, or water, can damage compressors, filter separators, and gas distribution systems. Hydrocarbon liquefiable flow-through to the end-user, or large fluctuations in BTU content, can lead to serious process upsets, burner fouling or plugging, and potentially dangerous situations.

Twenty-six (26) of the 42 pipelines that provided tariff quality information for INGAA's survey limited maximum BTU limit. Of the 26, 19 established limits via a specified maximum while 7 limited either hydrocarbon dew point or liquid hydrocarbon content.

Tariff Ranges for Maximum BTU Content

Max Btu Accepted (Btu/Ft^3)	No. Pipelines
950	1
1050-1100	9
1101-1150	2
1151-1200	5
1201+	2
HC dew point/Liquid HC Limit	7

3.3.2 HYDROGEN SULFIDE

Hydrogen sulfide (H_2S) is a naturally existing gas contaminant. When combined with water it forms sulfuric acid which can corrode steel, generally via an aggressive pitting attack. The steel can be rapidly perforated. In addition, the corrosion product, iron sulfide as scale or a black powder, is cathodic to steel and can cause deep pitting if water is present. H_2S can cause stress cracking and blistering in some metals. H_2S is readily oxidizable to elemental sulfur, resulting in suspended solids and potentially causing sulfur related problems. H_2S corrosion is synergistic if other contaminants are present, especially carbon dioxide and/or oxygen.

On the end-use side, H_2S can contaminate catalysts at processing or manufacturing plants. When burned, it produces sulfur dioxide which at high concentrations can be toxic and environmentally harmful. It can also form particulates in copper piping commonly used by some LDCs and end-users.

Current tariff limits for H_2S are between 1/4 and 1 grain/100 SCF (4 to 16 ppm). All of the 42 pipelines that provided tariff quality information for INGAA's survey limited H_2S, as follows:

Tariff Ranges for Maximum H_2S Content

H_2S Limit (Grains Per/100 SCF)	No. Pipelines
1/4 Grain	23
3/10 Grain	3
1/2 Grain	1
1 Grain	16

Note: One pipeline has dual limits depending on geographic location

AGA Report 4A (August 1971) recommended a maximum level of 1 grain/100 SCF (16 ppm) and many pipelines incorporated this into their tariffs. In the years following the report, several pipelines have lowered their tariff limits to 1/4 grain per 100 SCF (4 ppm).

3.3.3 TOTAL SULFUR

Natural gas frequently contains varying concentrations of hydrogen sulfide, mercaptans, sulfides, and disulfides. Sulfur has multiple impacts on gas transmission and end-use. With water, sulfur at concentrations above 20 grains/100 SCF can corrode the internal wall of a pipeline by creating a dissimilar metal condition. Excessive sulfur can foul equipment and cause unwanted reactions or by-products. It can also damage some plastic and non-ferric materials used in distribution and utilization equipment. Federal, state, and local agencies may restrict total sulfur emissions.

When excess sulfur compounds are present, residential and commercial customers may detect the smell and report a gas leak to their LDC. The LDC, in turn, must investigate the leak reports and confirm whether or not the gas fired equipment is operating safely. Customers may notice the smell when sulphur concentrations, including any LDC-added odorants, are as low as 1 grain/100 SCF.

Current tariff limits for sulfur are between 1/2 - 20 grains/100 SCF. All of the 42 pipelines that provided tariff quality information for INGAA's survey had a sulfur limit, as follows:

Tariff Ranges for Maximum Sulfur Content

Sulfur Limit *(Per/100 SCF)*	No. Pipelines
1/2 Grain	1
3/4 Grain	1
1	1
2 Grains	2
5 Grains	7
10 Grains	4
20 Grains	26

AGA Report 4A (August 1971) recommended a maximum level of 20 grains/100 SCF and many pipelines incorporated this into their tariffs. Pipeline survey data suggests lower limits were adopted over time to meet customer requirements and/or reduce corrosion potential.

3.3.4 CARBON DIOXIDE

Carbon Dioxide (CO_2) is a naturally occurring gas contaminant. CO_2 is non-corrosive in the absence of free water. When CO_2 dissolves in water, it forms carbonic acid, decreases the pH of the water and increases its corrosivity. It reacts synergistically with oxygen and H_2S to increase overall corrosion attack. CO_2 also reduces the BTU content of the flowstream through volumetric dilution.

In natural gas vehicles (NGVs), water vapor and CO_2 can cause corrosion in the onboard storage tanks at the high pressures normally used. Shifts in heating value and octane rating can upset engine tuning and cooling parameters and subsequently damage the engine.

At an LNG peak-shaving plant, the front end of the liquefier is basically a gas treating and chemical processing plant. Carbon dioxide is the principle contaminant and must be removed. Excess levels, over 1%, severely restrict the liquefaction rate of most plants. High levels can also cause icing/ freezing. Other contaminants in the gas flowstream have been known to poison the Mol sieve used to remove carbon dioxide.

Current tariff limits for CO_2 are generally between 1 - 3%. Of the 42 pipelines that provided tariff quality information for INGAA's survey, 38 had CO_2 limits, as follows:

Tariff Ranges for Maximum CO_2 Content

CO_2 Limit *(% Volume)*	No. Pipelines
1%	1
2%	22
3%	15

Tariff limits for CO_2 appear to be based primarily on corrosion considerations, with secondary consideration to end-user needs and the cost of removal.

3.3.5 OXYGEN

Oxygen is not a natural contaminant in any gas supply. Oxygen enters the flowstream in low pressure and vacuum service locations through leaks in piping, packing, and operational malfunctions.

Oxygen increases both the effects and rate of other corrosion mechanisms. Corrosion reactions generally polarize as the reaction progresses. Polarization slows the reaction rate, thus slowing the corrosion rate. Oxygen is a depolarizer in corrosion reactions, however, and causes the reaction to continue at the same or greater rate. Oxygen enhanced corrosion can be very harmful in pipeline dips and sags, separation vessels, and wet gas gathering systems. Corrosion often occurs along the "line" formed by water along the bottom of the pipeline, resulting in "long-line" corrosion. Corrosion products may also become moving solids that foul or plug downstream equipment.

Very small amounts of oxygen can support colonies of sulfate reducing bacteria. Once established, the steel under the bacteria can rapidly corrode. In addition, the bacteria can produce H_2S.

As oxygen percentage increases to a range of 5% to 15%, the gas is considered explosive. In the presence of pyrophoric iron, the mixture can explode without an external ignition source.

Some pipelines responding the survey reported that there is no economical process to remove oxygen from a gas flowstream. They suggested that the best control method is to prevent it from initially entering the flowstream.

Current tariff limits for oxygen are between 10 ppm (.001%) and 10,000 ppm (1%). Of the various gas quality specifications, oxygen has the greatest range of values. Of the 42 pipelines that provided tariff quality information for INGAA's survey, 39 had oxygen limits, as follows:

Tariff Ranges for Maximum Oxygen Content

Oxygen Limit (% Vol)	Oxygen Limit (PPM)	No. Pipelines
0.001	10	8
0.002	20	2
0.005	50	3
0.05	500	1
0.1	1,000	1
0.2	2,000	11
0.25	2,500	1
0.4	4,000	6
1.0	10,000	6

AGA Report 4A (August 1971) recommended a maximum level of 0.2% (2,000 ppm) and many pipelines incorporated this into their tariffs. In all cases, the permissible level is well below the 5% to 15% required to make the flowstream an explosive mixture.

3.3.6 WATER VAPOR

Water vapor is generally limited to 7 lbs. per million SCF, although several pipelines surveyed have lower limits. Liquid water encourages corrosion by acting as an electrolyte during the corrosion process. Accumulations of water in pipeline dips and sags where oxygen, CO_2, and/or H_2S are present can produce significantly higher corrosion rates. Liquid water reduces pipeline capacity and efficiency, makes measurement more difficult, and can cause operational problems via "slugging". At low temperatures, liquid water may also freeze-up in control valves, metering equipment, and so-forth.

Water vapor is also limited to prevent condensation and reduce hydrate formation potential. Hydrates are an ice-like mixture of water and hydrocarbons. Hydrates can form at gas temperatures up to 60°F in a high pressure pipeline containing free or liquid water and hydrocarbons. Hydrates can block or cause problems in metering equipment, pressure regulators, the pipeline itself, and other production & transportation equipment. Hydrates are of special concern in offshore pipeline systems since sea floor temperatures are less than 60°F year-round.

Of the 42 pipelines that provided tariff quality information for INGAA's survey, 40 limited water vapor as follows:

Tariff Ranges for Maximum Water Content

Vapor Limit (Lbs. Per Million SCF)	No. Pipelines
4	8
5	5
6	2
7	27

Note: 2 pipelines have dual limits depending on geographic location

The use of 7 lbs. water vapor / million SCF by the majority of the pipelines appears to be based on the dew point of natural gas at common pipeline operating pressures and low-end temperatures. At 1000 psia, gas with 7 lbs water vapor / million SCF has a dew point of 32°F. Pipelines operating in colder areas (e.g. Canadian pipelines, Northern Border) have a lower water content specification to prevent water drop-out at lower operating temperatures.

3.3.7 HYDROCARBON LIQUEFIABLES

Hydrocarbon liquefiables are the heavy ends of natural gas and are commonly referred to as natural gasoline. Hydrocarbon liquefiables can condense and collect in sag areas of pipelines, causing restrictions, decreasing pipeline efficiency, and resulting in periodic "slugging". Separation is often needed upstream of compressor stations to remove condensed liquids and prevent damage to the compressor units.

High propane and butane content have a masking effect on odorants generally used and thus reduce their effectiveness. ABS plastic, though not commonly used in distribution systems, is sensitive to some hydrocarbon liquids.

Transmission pipelines typically limit the heavy ends to two-tenths (0.2) gallons per thousand cubic feet of natural gas. Some pipelines specify a maximum hydrocarbon dew point rather than specifying gallons/thousand SCF. The hydrocarbon dew point is selected to prevent the formation of liquid hydrocarbons in the pipeline and at the delivery points to the customers. In either case, limiting hydrocarbon liquefiables also limits the heating value of the gas.

3.3.8 TEMPERATURE

Maximum temperature limits (generally 120°F) appear to be in place primarily to protect external coatings and secondarily to protect downstream compression and gas handling equipment. Coatings exposed to high operating temperatures gradually lose their effectiveness and eventually require that either additional cathodic protection be applied or that the coating be removed and re-applied. External pipeline corrosion begins if the coating degenerates sufficiently.

All external pipeline coatings have a maximum acceptable operating temperature. As a general rule, older coatings have lower maximum operating temperatures before the coating begins to degenerate. Coal tar enamels, asphalts, and mastics generally will degrade at temperatures greater than 120 degrees. New coatings generally have a greater resistance to higher temperatures. Coal tar epoxies and fusion bond epoxies can withstand temperatures to 190 degrees.

Maximum limits also appear to exist as a means of corrosion control. A rough rule of thumb supplied by one pipeline is that the rate of most chemical reactions (e.g. corrosion) doubles with each 10^{o} Celsius increase in temperature. Thus, limiting temperature helps limit corrosion rates.

Of the 42 pipelines that provided tariff quality information for INGAA's survey , 38 limit maximum temperature, as follows:

Tariff Ranges for Maximum Temperature

Max. Temperature (^{o}F)	No. Pipelines
100-119	2
120	33
121-140	3

Minimum Temperature: A minimum temperature limit serves several purposes. First, it helps ensure that all components of the flowstream stay in a gaseous state, thus limiting liquids drop-out and their subsequent problems. Second, low gas temperatures result in low external pipeline temperatures which can cause water to condense on the pipeline's exterior. During cold months, the condensed water may freeze and damage the coating or cause the pipeline to shift (i.e. "frost-heaving").

Of the 42 pipelines that provided tariff quality information for INGAA's survey . 16 limited minimum temperature, generally in the 35-40 ^{o}F range.

3.3.9 TOTAL INERTS

"Total Inerts" generally refers to the combined nitrogen and carbon dioxide content of the flowstream, but some tariffs may also include oxygen, carbon monoxide, and any other gas that does not have a heating value.

The major reason for limiting total inerts is to ensure that the gas flowstream consists mainly of methane and has a consistent heating value. High levels of inerts affect the economic efficiency of the pipeline since transportation rates are generally on a BTU basis. Total inerts can also cause or enhance other problems such as sooting (yellowtipping), lowered operating or process efficiency, increased emissions, appliance damage; flame instability (flashback). and possible flame extinguishment or delayed ignition.

Of the 42 pipelines providing gas quality information for INGAA's survey, 19 limited total inerts in some manner, generally in the range of 3% - 5% for combined CO_2 and nitrogen.

3.3.10 DUST, GUM, DIRT

The majority of the tariffs specify that the gas be "commercially free" of dust, gum and dirt etc. These substances can collect on moving parts of compressors, valves, and pipe walls to cause inefficiencies and malfunctions. They can plug customer's burners, extinguish pilot lights, and interfere with process equipment. They can provide a "safe-haven" for corrosion to occur under them, and can reduce the efficiency of corrosion inhibitors injected into the flowstream.

3.3.11 OTHER

"Other" provisions in pipeline tariffs are generally a catch-all for unwanted impurities that may flow down a pipeline. There are many trace constituents that are undesirable but are generally not present in gas. The trace constituents include, among others, microbiological agents (e.g. bacteria), PCB's, mercury, and arsenic. It can be costly to decontaminate a system once it has be contaminated with a toxic or hazardous substance. Contaminants in gas may have, among others, the following effects:

- Bacteria in the flowstream can adhere to equipment surfaces and cause severe, localized corrosion through several mechanisms.

- In glass manufacturing, combustion products are used for the blanket atmosphere. Trace contaminants can cause oxidation and discoloration of the finished product.
- In heat treating applications, trace contaminants can adversely affect machined metal surfaces. Small changes in the H-C ratio can alter the surface hardening parameter. Some heat treatable alloys are also significantly affected by oxygen and nitrogen content in the gas.
- In chemical manufacturing, gas feedstocks for producing a wide range of chemicals based on the methane molecule must be relatively free of contamination, including sulfur, carbon dioxide and most trace compounds. Variations of composition can cause overloading of front end clean-up equipment, drastically reduce production rates, upset process parameters, and lead to complete shutdown.
- In underground storage, trace contaminants can cause environmental problems if they move beyond the storage formation and into aquifers.
- Small amounts of mercury can damage aluminum parts and is environmentally undesirable.
- Oxides of nitrogen introduced in some amine sweetening processes can severely reduce odorant effectiveness and can damage epoxy based elastomers.

Given the wide range of gas supply, end-use, and environmental regulation, it is likely that "other" tariff provisions will continue to differ from pipeline to pipeline.

3.4 NOTIFICATION

All pipelines reserve the right to refuse gas that is outside tariff quality limits. To understand the notification process for gas that is outside quality limits, the Tariff Team asked: (a) what the notification procedure was; (b) how the notification was performed; and (c) are the notification procedures in the tariff.

The tariffs reviewed by the team generally all have language which can be summarized as:

> "Company shall notify Shipper of such failure, and Company may suspend receipt of all or part of such gas. Shipper shall make a diligent effort to correct such failure".

The tariff language provides remedies for out of specification gas but it does not provide specific, formal, notification procedures. Generally, notification is performed on an informal basis by telephone, letter, or fax when the problem is identified. In many cases, both the Shipper and Pipeline are aware that the gas may be at or near specification limits and are already engaged in an ongoing dialogue. Gas that is slightly beyond specification limits is often blended with other pipeline quality gas to produce a flowstream of acceptable quality.

3.5 EFFECTS OF CHANGING SPECIFICATIONS

The third question asked by the Tariff team of pipelines was "From a transportation standpoint, should other quality specifications be included in the tariff and would changes in any of the above specifications cause the pipeline operational or transportation problems?"

Changing existing specifications was not favored. The current specifications represent in many cases a compromise between the needs and economics of production, transportation, and end-use segments. Blending gas across the grid provides the flexibility to accept gas of varying quality and still meet end-use requirements.

Responses indicated that specification changes allowing increased contaminant levels would likely increase maintenance costs and reduce transportation reliability. End-users would be affected by the increased contaminants and might bear additional costs. On the other side, specification changes which decrease contaminant levels could result in higher pipeline operating costs or capital expenditures for treating equipment. At the production level, operating costs for some gas would become economically unattractive and the production would be shut-in and prematurely abandoned.

3.5.1 SINGLE GAS QUALITY SPECIFICATION DISCUSSION

At one point, the Task Force discussed whether it should develop and recommend a single gas quality specification that could be used as a model, or goal, for the industry to implement. Some postulated that a single "reasonable" quality specification, achieved in practice perhaps over the next 10-30 years, would help move the industry forward and grow the market for natural gas. Another pointed out that pipelines currently accept out-of-specification gas, so that adoption of a single specification might not exclude gas per se, but only result in more "out of specification" gas being accepted or delivered. Further, given the small number of problems moving gas across the grid, it was suggested that the industry has a "de facto specification" in place and that recommending a single specification simply acknowledged the situation.

Counterpoints were raised that while gas quality meets market needs at any point along the grid, the composition of the gas itself differs across the grid due to changes in supply, pipeline gas blending, and pipeline-to-pipeline gas blending. Rather than a single "de-facto specification", the grid has a range of specifications. Each market region has developed infrastructure and end-uses based on the gas that has been, and still is, being delivered. Implementing a single grid-wide gas quality specification might impact large investments and infrastructures already in place. After further discussion, the sense of the Task Force was that a single quality specification was neither necessary nor readily attainable.

3.5.2 HYDROCARBON DEW POINT / WOBBE INDEX DISCUSSION

Another area studied by the Task Force was the use of a hydrocarbon dew point and Wobbe Index in place of maximum / minimum BTU, total inert gas, and hydrocarbon liquefiables to specify the energy content and composition of the gas. The hydrocarbon dew point is the highest temperature at which any of the hydrocarbon vapors in a particular gas composition condense into liquids; increasing BTU content increases the temperature at which hydrocarbon liquids condense in the pipeline. Thus, limiting hydrocarbon dew point limits the BTU content and liquefiable hydrocarbon content of the gas.

The Wobbe Index is calculated using the heating value and specific gravity of the gas[2]. It is widely used in equipment design, particularly burners. Typically, the equipment can accept gas with a Wobbe Index between +/- 8-10% of the design value. Since the specific gravity of the gas depends on the composition, the Wobbe Index reflects the relative percentage of methane and other light hydrocarbon gases to inert gases and hydrocarbon liquefiables. Thus, specification of hydrocarbon dew point and Wobbe Index limits the composition of the gas in terms of BTU content, inert gases, and hydrocarbon liquefiables. It also helps ensures that flowstreams stays within design limits used for gas equipment / processes.

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2 $\text{Wobbe Number} = \dfrac{\text{Heating Value}}{\sqrt{\text{Specific Gravity}}}$; For Example, $\text{Wobbe Number} = \dfrac{1020\ \text{BTU}}{\sqrt{0.61\ \text{S.G.}}} = 1306$

There could be several advantages if tariff specifications for maximum / minimum BTU content, total inerts, and liquefiable hydrocarbons were replaced with a hydrocarbon dew point and Wobbe Index specification. First, it further integrates end-use needs into the production / transmission system by explicitly incorporating an interchangeability index. Second, it may be more efficient than individual specifications in meeting the operating "envelope" for heating value / inert gas / hydrocarbon liquids. Finally, it reduces tariff specifications from 4 to 2. The most significant disadvantage is that there is no driving reason to change - the existing system works and meets needs.

As a side note, Wobbe Index considerations are one reason why pipelines may not accept gas with a high BTU / high inert gas composition. Although the overall BTU content of the flowstream may be within acceptable limits, the changes in specific gravity due to the "heavy" hydrocarbons and inert gases may move the Wobbe Index beyond acceptable limits.

3.6 GEOGRAPHIC PRODUCTION REGION

The fourth question asked "Is the geographic region in which production is gathered a driver for the specifications for the specific pipeline?".

In general, the pipelines responded that the geographic region is not an important factor in setting their specification. The primary drivers are pipeline safety and operations, followed by customer requirements. However, geographic region may affect the choice of a particular specification value. For example, one pipeline reported that decreasing their CO_2 specification from 3% to 2% would eliminate some gas currently available to them in Northern Louisiana. A second reported that changes to their sulfur specification could curtail deliveries into them from one of their largest suppliers. A third reported that their nitrogen limits are high to reflect the nitrogen content of gas available to them from a specific production basin. Others report that gas within a region is blended via gathering systems and intrastate pipelines to interstate pipeline quality specifications prior to entering the grid.

Some pipelines have different receipt and delivery specifications based on the ability of the pipeline to blend the gas to meet customer needs. For example, Southern California customers require lower total sulfur, etc. than other parts of the country. To meet this need, Kern River's delivery tariff has more stringent quality requirements than their receipt tariff. The less stringent receipt tariff is conditional based on Kern River's ability to blend to flowstream prior to delivery. El Paso, serving the same market, has a similar tariff structure.

3.7 PIPELINE QUALITY TESTING AND FREQUENCY

The last question posed in the Tariff Survey was "How often does the pipeline test for quality? What are the sampling frequency and techniques used to test for quality?".

Based on the responses, it appears that gas chromatographs are generally located at most major receipt and delivery points. They run continuously with cycle times ranging from about 5 minutes to 15 minutes. In the cases where the chromatograph samples several flowstreams, the sampling time increases proportionately. Results are generally transmitted electronically to a central location. The data is used for both quality control and accounting purposes. The analyses allows determination of heating value, inerts, and hydrocarbon dew point. Some locations may also have continuous water analyzers with electronic data transmission.

Mainline pipe appears to be tested quarterly for total sulfur and hydrogen sulfide. Testing may include spot sampling using titrators or by commercial laboratories. Smaller receipt points may be tested monthly for water, CO_2, and H_2S by drawing a sample of gas through a packed, chemically treated disposable tube (a "stain-tube"). The tube is then compared with a color chart and gas quality estimated. Finally, locations with frequent or past quality problems may have specific monitoring equipment to detect out-of-specification gas before it can cause problems in the grid.

3.8 CONCLUSIONS

The Tariff Investigation and Analysis reached the following conclusions:

- The drivers for specific gas quality specification limits are generally related to safety, operational reliability, geographic area where the gas is produced, or the needs of the end-use customers. Pipelines may include tariff specifications that contain slightly less restrictive specifications to accommodate the delivery of large gas volumes in certain regions.

- Responding pipelines use informal procedures (i.e. not specifically outlined in tariff language) to notify parties when gas is out of specification. Gas that is slightly out of tolerance is often accepted via temporary waivers and blended with other gas to pipeline quality specifications.

- The flexibility to blend gas as it moves across the interstate grid plays a significant role in ensuring that flowstreams of various quality entering the grid meet end-use needs. The ability of a pipeline to "blend gas" allows some out-of-specification gas to flow economically. Were blending eliminated, some gas would be shut-in for economic reasons.

- Gas quality differs across the grid, resulting in a range of specifications along the grid which appear to meet the varied needs of the production, transportation, and end-use segments. A single gas quality specification is not required and is probably not readily attainable.

- There are alternate methods of defining gas quality specifications which may more efficiently integrate the needs of the production, pipeline and end-use segments than do existing methods. For example, to specify gas heating value and liquefiables one could limit hydrocarbon dew point and Wobbe Index instead of limiting maximum / minimum BTU, inert gas, and liquefiables. Both approaches have advantages and disadvantages. Identification and evaluation of alternate methods to specify gas quality was beyond the scope of the Gas Quality Task Force.

4. GAS QUALITY PROBLEMS SURVEY

4.1 OVERVIEW

The Gas Quality Problems Team was charged with identifying specific occurrences and interconnects where gas quality had interfered with the movement of gas across the pipeline grid. The goal of the team was to capture (i) where and how often the problem occurred, (ii) what caused the problem, (iii) who had the problem, and (iv) solutions recommended by affected party(ies)

The team was chaired by Mr. Mike Keller of Anadarko with Mr. Ira Feinberg of Brooklyn Union as Vice-Chair. Other members of the team were:

- Ron Beaty, Amoco
- Mike Brey, Panhandle Eastern
- Wade Church, Tenneco Gas Transmission
- Kristine Delkus, rep. United Distribution Companies
- Wayne Lake, Amoco
- Kathy Patton, Rep. NG Clearinghouse, Aquila, Chevron
- Jerry Peterson, Southern Natural Gas
- Bill Ryan, El Paso Natural Gas
- Virgil Spurgeon, Phillips Petroleum
- Alan Wiggins, Conoco

4.2 APPROACH:

During the Task Force's kick-off meeting, a survey was proposed and accepted as the best way for the team to gather information related to actual gas quality problems. The Task Force felt that the survey would provide a vehicle to identify "real" gas quality problems on an interconnect specific basis, and thus move away from "theoretical" problems appearing to exist due to tariff differences. If only a few problems were found, resolving them on a case-by case basis would be more efficient that trying to change all pipeline tariffs. On the other hand, if a significant number of interconnect problems were identified, then a more general gas quality specification change across pipelines might be required.

After discussion, the team developed the survey shown in Figure 1. The questionnaire was intended to provide an insight into gas quality characteristics which have caused inefficiencies during the past 12 months in moving gas across multiple pipelines. While its primary emphasis was on gas movement across the grid, participants were invited to relate problems associated with gas entering or leaving the grid (i.e. production & end-use).

The survey was sent to a total of 49 organizations, including 9 trade associations. Of the 9 trade associations, 6 disseminated the survey further to their members. Twenty-six companies responded to the survey. Table 3 shows the distribution list and responding companies. Given this distribution, the Task Force feels that the survey provided opportunity for interested parties to identify problem areas, and believes that the results are credible.

4.3 RESULTS

Results of the survey show only 35 problems reported overall for gas entering, moving across, or leaving the pipeline grid. Of the 35, 9% were reported by LDCs/End-Users, 9% by Marketers, 49% by Pipelines, and 34% by producers. Directionally, this suggests that gas quality affects the production and transmission segments more than the end-use segment. This is consistent with the Tariff Team's findings that "blending" across the grid results in delivered gas that meets end-use needs most of the time. Attachment 3 contains the survey responses , including problems reported with gas entering or leaving the interstate grid. The problems are summarized in the following table:

Gas Quality Survey Distribution And Response

	Surveys Sent	Companies Responding	Quality Problems Reported: Into Grid	Across Grid	Out of Grid	Total
Total	49	26	16	13	6	35
- LDC/End-Use	9	7	1	1	1	3
- Marketer	4	2	0	1	2	3
- Pipeline	15	8	6	9	2	17
- Producer	12	9	9	2	1	12
- Trade Associations	9	6 Distributed to Members	N/A	N/A	N/A	

The survey identified only 13 across the grid problems, affecting ~775 Million SCFD, categorized as follows:

"Across-the-Grid" Gas Quality Problem Break-Down

Basic Problem	Total	Volume Affected *(Million SCFD)*
Carbon Dioxide	4	462
Water/Condensate	4	225
Hydrogen Sulfide	1	9
Oxygen	3	56
PCBs	1	15
Total	13	767

Further analysis shows that 400 Million SCFD of the carbon dioxide problems involved one company , and 100 Million SCFD of "water/condensate" problems involved another company. On a volumetric basis, then, 500 million SCFD (66%) of the problems reported involved only 2 companies.

For 1993, INGAA reported that total gas delivered by interstate pipelines (carriage for market plus sales) was 21 TCF (57.5 BCFD)[3] . Were all the "across-the-grid" problems to occur concurrently, they would affect less than 1.5% of the gas. The Task Force does not consider this to be significant.

4.4 CONCLUSIONS

Based on the survey results, the Task Force concluded that gas quality does not significantly interfere with or cause inefficiencies moving gas across the interstate grid. Due to the small number of problems identified, the consensus of the group is that they should be worked by the parties involved and do not require a larger group effort.

3 "INGAA's Annual Pipeline Survey Shows Continuing Decline in Pipeline Sales as Demand for Carriage Grows", Foster Natural Gas Report, No. 1985, 30 June 1994, Pgs. 22-23.

Table 1
Gas Quality Task Force
Initial Mailing List for Kick-Off Meeting
(Sorted by company type, company name, last name)

Name		Company	Type
Craig	Matthews	Brooklyn Union	LDC
Dolores	Chezar	Brooklyn Union	LDC
Helmut	Peters	Brooklyn Union	LDC
Robert	Rock	Comgas-AGD	LDC
Stephen	Salese	Consolidated-Edison	LDC
Jim	Robins	Pacific Gas	LDC
George	Rieger	Peoples Gas	LDC
William	Penniman	PGC/AISI	LDC
Mike	Fadden	Abtech Resources	Marketer
Jerry	Fogarty	Aquila Energy	Marketer
Julie	Gomez	Enron	Marketer
Theresa	Hess	Enron	Marketer
Harlan	Murphy	Natural Gas Clearinghouse	Marketer
Guy	Hunte	Tejas Power	Marketer
Larua	Murrell	Tenneco Gas Marketing	Marketer
Clancy	Aschbrenner	Colorado Interstate Gas	Pipeline
Anne	Bomar	CNG Transmission	Pipeline
Gary	Sypolt	CNG Transmission	Pipeline
Jack	Salmons	Columbia Gas	Pipeline
Kevin	Moran	Columbia Gas	Pipeline
Nancy	Gardiner	Enron Pipeline	Pipeline
Wayne	St. Germaine	Koch Gateway	Pipeline
Richard	Kitchens	NGPL	Pipeline
Pat	Blox	Nova	Pipeline
Dennis	Hendrix	Panhandle Eastern	Pipeline
Mike	Bray	Panhandle Eastern	Pipeline
Richard	Kruse	Panhandle Eastern	Pipeline
Wayne	Christian	Southern Natural Gas	Pipeline
Byron	Wright	Tenneco Gas	Pipeline
Rae	McQuade	Tenneco Gas	Pipeline
Doug	Church	Texas Eastern	Pipeline
Jim	Avioli	Transco Gas Pipeline	Pipeline
Larry	Thummel	Williams Energy	Pipeline
Jim	Flanagan	Amoco	Producer
Ron	Beaty	Amoco	Producer
Phyllis	Morris	Anadarko	Producer
Richard	Sharples	Anadarko Petroleum	Producer
Paula	Cavallo	Destec Energy	Producer
Judd	Miller, Jr.	Exxon Company, USA	Producer
Roger	Huffaker	Exxon Company, USA	Producer
Larry	Wall	Mobil Natural Gas	Producer
Marge	O'Connor	Mobil Natural Gas	Producer
Virgil	Spurgeon	Phillips Petroleum	Producer
Randy	McCrea	Shell	Producer
Brian	White	American Gas Association	Trade Assn
John	Erickson	American Gas Association	Trade Assn
Mike	Baly	American Gas Association	Trade Assn
Fred	Moring	American Gas Distributors	Trade Assn
Bob	Cave	American Public Gas Assn.	Trade Assn
Myron	Gottlieb	Gas Research Institute	Trade Assn
Steve	Takagishi	Gas Research Institute	Trade Assn
Anne	Roland	Interstate Natural Gas Assn.	Trade Assn
Samir	Salama	Interstate Natural Gas Assn.	Trade Assn
Skip	Horvath	Interstate Natural Gas Assn.	Trade Assn
Denise	Bode	Independent Producers Assn.	Trade Assn
Nick	Bush	Natural Gas Suppliers Assn	Trade Assn
Philip	Budzik	Natural Gas Suppliers Assn	Trade Assn
Patrick	Nugent	Texas Intrastate Pipeline Assn	Trade Assn
Ron	Jones	United Distribution Companies	Trade Assn
Kristine	Delkus	United Distribution Companies	Trade Assn
	No. Persons		No. Organizations
Total	60		41
- LDC	*8*		*6*
- Marketers	*7*		*6*
- Pipeline	*18*		*13*
- Producers	*11*		*7*
- Trade Assn.	*16*		*9*

Table 2

Persons/Companies Receiving Gas Quality Task Force Mailings / Faxes

(Sorted by Company Type, Company Name, Last Name)

First	Last	Company	Type	Tariff Team	Survey Team
Tony	Amurgis	Columbia Gas of Ohio	LDC		
Krisd	Brown	Columbia Gas Distribution	LDC	YES	
Craig	Matthews	Brooklyn Union	LDC		
Ira	Feinberg	Brooklyn Union Gas	LDC		V.CHAIR
Jonathan	Pfister	Commonwealth Gas/New England LDC's	LDC		
Jim	Robins	Pacific Gas	LDC		
Michael T.	Fadden	Abtech Resource	Marketer		
Kathy	Patton	Attorney Rep. NGCH, Chevron, et al.	Marketer		YES
C. Terry	Callender	Natural Gas Clearinghouse	Marketer		
Glenn R.	Etienne	Natural Gas Clearinghouse	Marketer		
Ken	Purgason	Tejas Power	Marketer	YES	
Leon	Bowdoin	Algonquin Gas Transmission	Pipeline	YES	
Ken	Opland	ANR Pipeline	Pipeline		
David	Noss	CNG Transmission	Pipeline		
Thomas C.	Staats	CNG Transmission	Pipeline	YES	
Rosa P.	Jackson	El Paso Natural Gas	Pipeline		
Bill	Ryan	El Paso Natural Gas	Pipeline		YES
Rosie B.	Villanueva	El Paso Natural Gas	Pipeline	YES	
Philip J.	Dusek	Natural Gas Pipeline	Pipeline	YES	
Scott	Coburn	Northern Border / Enron	Pipeline	YES	
Dennis	Hendrix	Panhandle Eastern	Pipeline		
Mike	Bray	Panhandle Eastern	Pipeline		YES
John	Kelly	Panhandle Eastern	Pipeline	YES	
Jerry	Peterson	Southern Natural Gas	Pipeline		YES
Henry W.	Poelnitz	Southern Natural Gas	Pipeline	YES	
Wade	Church	Tenneco	Pipeline	YES	YES
Dorothea	Anderson	Texas Eastern Transmission	Pipeline	CHAIR	
Jim	Aviok	Transcontinental Gas Pipeline	Pipeline		
Brad	Holmes	Transcontinental Gas Pipeline	Pipeline	V.CHAIR	
Lawrence K.	Thummel	Williams Energy Ventures, Inc.	Pipeline	YES	
Ron E.	Beaty	Amoco	Producer		YES
James J.	Flanagan	Amoco	Producer	YES	
Wayne	Lake	Amoco	Producer		YES
Michael F.	Keller	Anadarko Petroleum Corp.	Producer		CHAIR
Alan	Wiggins	Conoco	Producer		YES
Roger	Huffaker	Exxon Company USA	Producer		
Judd	Miller, Jr.	Exxon Company USA	Producer		
Les	Bamburg	Mobil Natural Gas	Producer		
Virgil R.	Spurgeon	Phillips Petroleum Co.	Producer		YES
Terry	Hancock	Texaco	Producer		
Brian	Weeks	Texaco	Producer		
Mike	Baly	American Gas Association	Trade Assn		
John	Erickson	American Gas Association	Trade Assn		
Fred	Moring	American Gas Distributors	Trade Assn		
Myron	Gottlieb	Gas Research Institute	Trade Assn		
John	Gregor	Gas Research Institute	Trade Assn		
Irvina J.	Solomon	Gas Research Institute	Trade Assn		
Mark	Sutton	Gas Processors Association	Trade Assn		
Denise	Bode	Independent Producers Assn of America	Trade Assn		
Samir Y.	Salama	Interstate Natural Gas Assn. America	Trade Assn		
Kristine	Delkus	Morgan, Lewis & Bockius / United Dist.	Trade Assn		YES
Philip M.	Budzik	Natural Gas Supply Association	Trade Assn		
Jeff	Hannan	Natural Gas Supply Association	Trade Assn		
		Total Persons	53	14	12
		- LDC	6	1	1
		- Marketer	5	1	1
		- Pipeline	19	11	4
		- Producer	11	1	5
		- Trade Association	12	0	1
		Total Organizations	36	14	12
		- LDC	5	1	1
		- Marketer	4	1	1
		- Pipeline	12	11	4
		- Producer	7	1	5
		- Trade Association	8	0	1

Table 3

Gas Quality Task Force

COMPANIES & ORGANIZATIONS RECEIVING AND RESPONDING TO GAS QUALITY SURVEY

(Sorted by Company Type, Company Name)

Company	Type	Status	Grid Problems Reported: Entering	Across	Leaving	Total
Brooklyn Union	LDC	Responded	0	1	0	1
Commonwealth Gas/New England LDC's	LDC					
Consumers Gas	LDC	Responded	0	0	0	
Consumers Power	LDC	Responded	1	0	0	1
National Fuel Gas	LDC	Responded	0	0	0	
Northwestern Utilities	LDC	Responded	0	0	0	
Pacific Gas & Electric	LDC					
Peoples Gas	LDC	Responded	0	0	1	1
UGI Utilities	LDC	Responded	0	0	0	
Abtech Resources, Inc.	Marketer					
Laclede Gas Company	Marketer	Responded	0	0	2	2
Natural Gas Clearinghouse	Marketer	Responded	0	1	0	1
Tejas Power	Marketer					
Algonquin Gas Transmission Company	Pipeline					
ANR Pipeline	Pipeline					
CNG Transmission Corp.	Pipeline	Responded	0	0	0	
Columbia Gas	Pipeline	Responded	0	0	0	
El Paso Natural Gas	Pipeline					
Florida Gas Transmission	Pipeline	Responded	1	0	0	1
Great Lakes Gas Transmission	Pipeline	Responded	NA	NA	NA	
Natural Gas Pipeline Co.	Pipeline					
Northern Border / Enron	Pipeline	Responded	2	2	0	4
Panhandle Eastern	Pipeline	Responded	3	7	2	12
Southern Natural Gas Co.	Pipeline	Responded	0	0	0	
Tenneco	Pipeline					
Texas Eastern Transmission	Pipeline					
Transcontinental Gas Pipeline	Pipeline					
Williams Energy (Northwest Pipeline)	Pipeline	Responded	0	0	0	
Amoco	Producer					
Anadarko Petroleum Corp.	Producer	Responded	2	0	0	2
Cabot Oil & Gas	Producer	Responded	0	0	0	
Conoco Inc.	Producer	Responded	0	0	0	
Dorchester Hugoton	Producer	Responded	7	0	0	7
Exxon Company USA	Producer	Responded	0	0	0	
Kerr McGee Corp	Producer	Responded	0	0	0	
Mobil Natural Gas	Producer					
Oxy USA	Producer	Responded	0	0	0	
Phillips Petroleum Co.	Producer					
Texaco Natural Gas	Producer	Responded	0	0	0	
Williams Natural Gas	Producer	Responded	0	2	1	3
American Gas Association	Trade Assn	Distributed				
American Gas Distrubutors	Trade Assn	Distrubuted				
American Public Gas Association	Trade Assn	Did Not Distribute				
Gas Research Institute	Trade Assn	Did Not Distribute				
GPA	Trade Assn	Distributed				
Independent Producers Assn of America	Trade Assn	Did Not Distribute				
INGAA	Trade Assn	Distributed				
Morgan, Lewis & Bockius / UDC	Trade Assn	Distributed				
Natural Gas Supply Association	Trade Assn	Distributed				
Grand Total RECIPIENTS	49	28	16	13	6	35
- LDC	9	7	1	1	1	3
- Marketer	4	2	0	1	2	3
- Pipeline	15	8	6	9	2	17
- Producer	12	9	9	2	1	12
- Trade Association	9	*(6 Distributed)*	*N/A*	*N/A*	*N/A*	*N/A*

2/14/95

Figure 1

GAS QUALITY CHARACTERISTICS - SURVEY OF PROBLEM AREAS

This questionnaire is intended to provide an insight into gas quality characteristics which have caused inefficiencies in moving gas across multiple pipelines. While its primary emphasis is on gas movement across the grid, participants may also relate problems associated with gas entering or leaving the grid (i.e. production & end-use). Based on your actual experiences in the last 12 months, please indicate where problems have occurred, the basic nature of the problem, and how often the problem has occurred. Please use one form per problem. **WHILE ALL INFORMATION REQUESTED WOULD BE APPRECIATED PLEASE TREAT EACH ITEM AS OPTIONAL IF THAT WOULD ENSURE YOUR RESPONSE TO THIS QUESTIONNAIRE.**

Company: ______ Company Type: ______ Pipeline, LDC, Marketer, etc.)

Contact: ______ Telephone: ______ FAX: ______

INTERCONNECT INFORMATION:

Delivering Pipeline: ______ Receiving Pipeline: ______

Name/Location: ______ PI Grid No: ______ Volume: ______ x 1000 SCFD

BRIEF PROBLEM DESCRIPTION:

__ Entering Grid __ Across Grid __ Leaving Grid ______

______

Problem Frequency: One Time __ Reoccurring __ Other: ______

GAS QUALITY PROBLEMS:

	Problem? NO	Problem? YES	If Yes, please complete the following: Pipeline Limits Delivering	Pipeline Limits Receiving	Your Actual at Interconnect (as possible)	How Often Avg/Month	Comments
1. Heating Value (BTU/CF): __ Maximum __ Minimum __ Dry __ Actual __ Sat.	__	__	__	__	__	__	__
2. Reactive & Inert Contaminants							
Hydrogen Sulfide __ PPM __ Grains/100 SCF	__	__	__	__	__	__	__
Total Sulfur __ PPM __ Grains/100 SCF	__	__	__	__	__	__	__
Carbon Dioxide (%)	__	__	__	__	__	__	__
Oxygen (%)	__	__	__	__	__	__	__
Nitrogen (%)	__	__	__	__	__	__	__
3. Other Inert Contaminants (Describe)	__	__	__	__	__	__	__
4. Water Content (lbs/MMcf)	__	__	__	__	__	__	__
5. Temperature (OF) __ Maximum __ Minimum	__	__	__	__	__	__	__
6. Dust, Gums, Misc. Solid Matter	__	__	__	__	__	__	__

7. Other: ______

8. Resolution: Temp. Waiver __ Perm. Waiver __ Transp. Curtailed __ Other: ______

9. Your Recommended Solution: ______

______

Please return questionnaire to: Mr. Ira J. Feinberg Brooklyn Union FAX: (718) 488-1761