



**Dominion
Energy[®]**

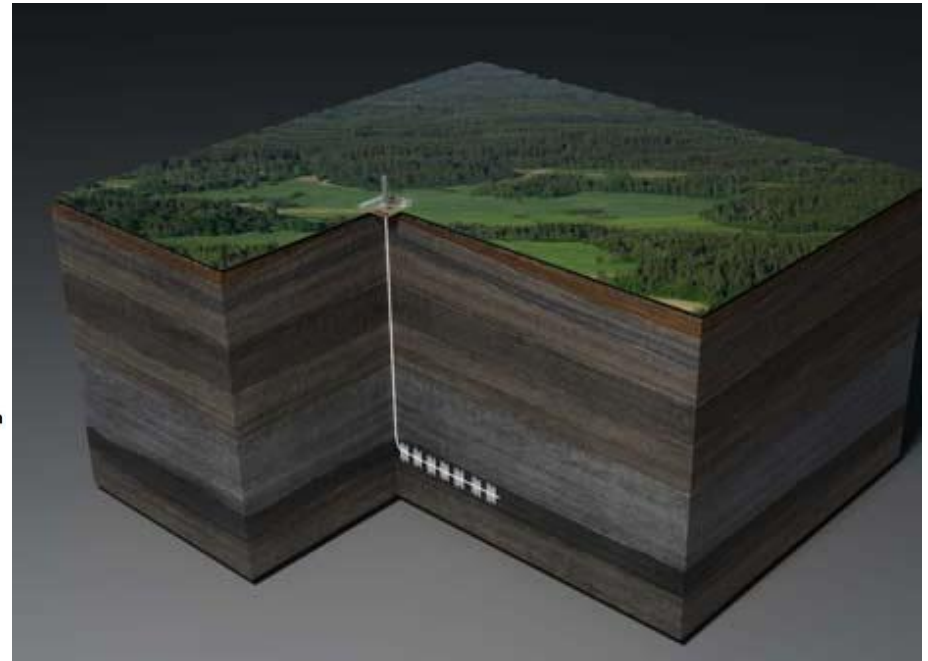
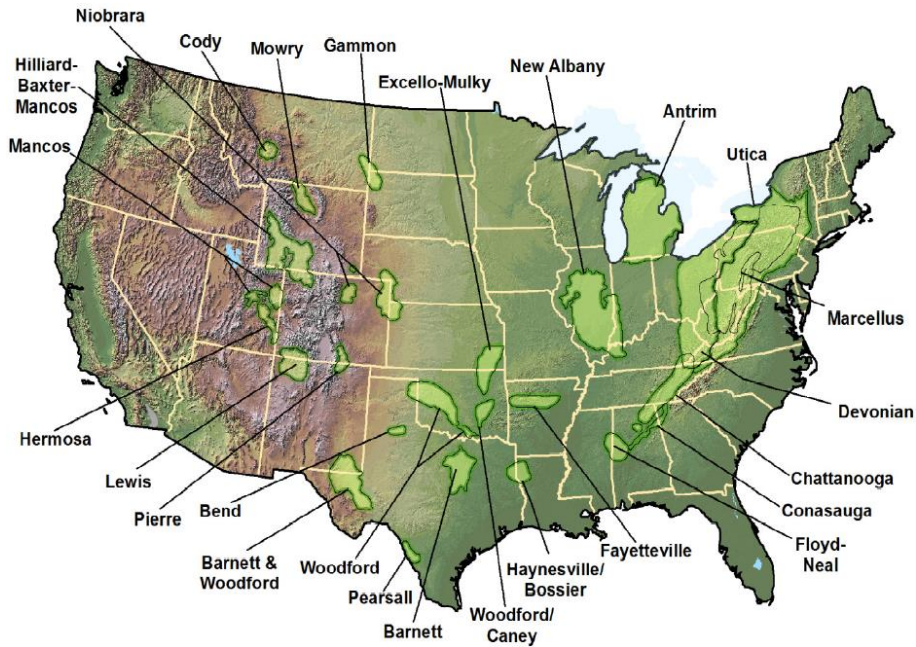
2019 AUCSC Natural Gas Quality

Michael Fouts

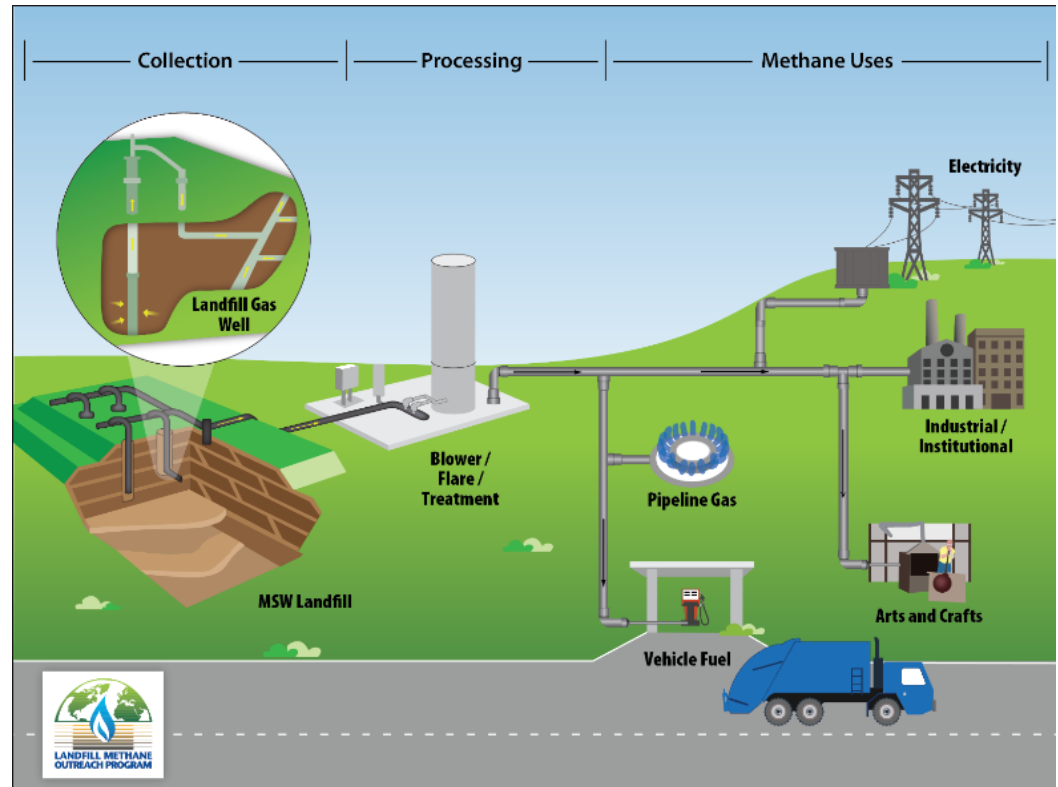
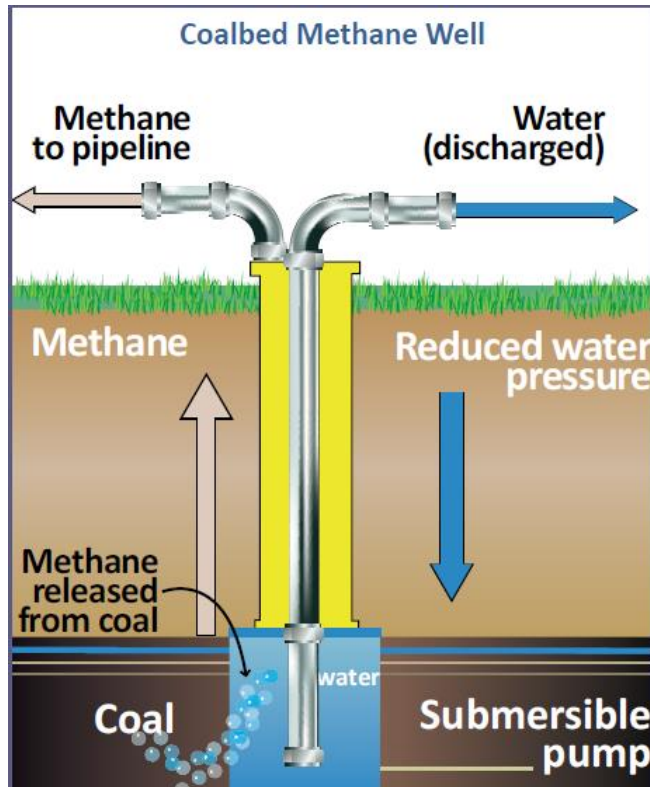
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Shale Gas



Nontraditional Natural Gas Sources



1. https://www.energy.gov/sites/prod/files/coalbed_methane_factcard.pdf
2. <https://www.epa.gov/lmop/basic-information-about-landfill-gas>

Glossary

Natural Gas Quality

- **Composition (C1 to C6+, N₂, CO₂)**
- **BTU/scf**
- **N₂**
- **CO₂**
- **O₂**

Glossary

Natural Gas Quality (continued)

- **Gravity**
- **Water Content**
- **H₂S and S**
- **Dirts and Gums**

Glossary

Dry BTU

- Assumed to have no H₂O Content
- < 7 #/MMSCF H₂O Content Limit
- 967 to 1100 BTU/SCF
- Marketable

Wet BTU

- >1100 BTU/SCF
- No free liquids preferred
- Going to Extraction

Shale Gas Details

- Ethane (C_2H_6) values can range from 12-14%, as compared to typical values of 1.8-5.1%
- Higher C_2+ Values
- Higher Wobbe Values

Gas Composition Examples

Component	Wet Gas (mole %)	Dry Gas (mole %)
Methane	80.4567	86.33
Ethane	11.1350	11.85
Propane	4.1112	0.3944
Isobutane	0.6150	0.01450
n-Butane	1.1253	0.02499
Isopentane	0.3455	0.005724
n-Pentane	0.2736	0.007140
Hexane+	0.3377	0.008027
Carbon Dioxide	0.5000	0.09600
Nitrogen	1.100	1.274
<u>TOTAL</u>	<u>100</u>	<u>100</u>

Gas Quality

- **Gas Quality Tariffs**
 - Due to the increase in non-conventional gas streams, the current trend is for Gas Transmission Companies to update/modify their Gas Quality Tariffs.
- **Large Volumes of New Gas Sources.**
 - The below table shows a comparison of new gas streams to conventional natural gas.

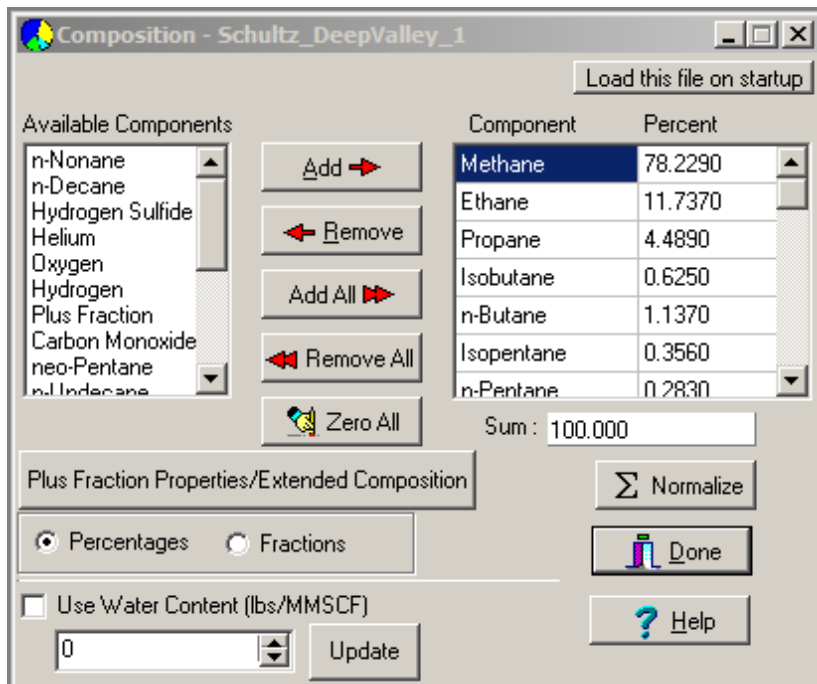
Type	BTU	Wobbe	N ₂	CO ₂	O ₂	C ₂ +
CBM	↓	↓	↑	↑	↑	↓
Shale	↑	↑	—	—	—	↑
LNG	↑	—	—	↓	↓	↓

Throttling Processes

- **Joule-Thompson Effect**

- Ratio in change of temperature to the change in temperature to the change in pressure when a real gas is throttled.
- 100 psig \rightarrow 7°F

Hydrocarbon Dewpoint



Enter Gas Analyses

C6+ vs. C9+

Peng-Robinson Equation

Phase Envelope

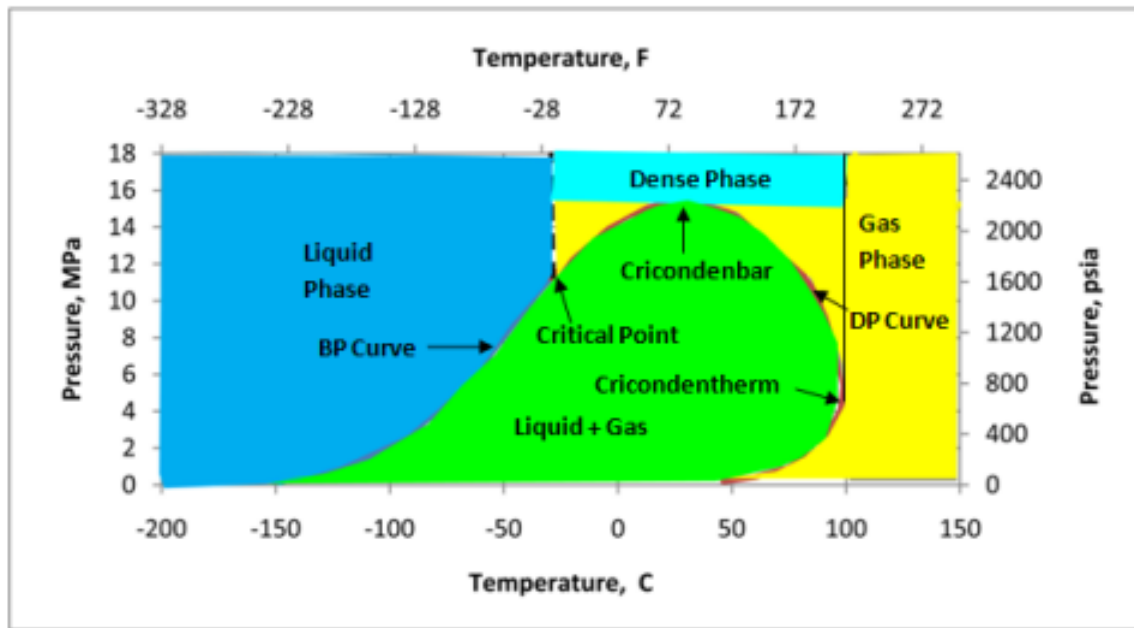


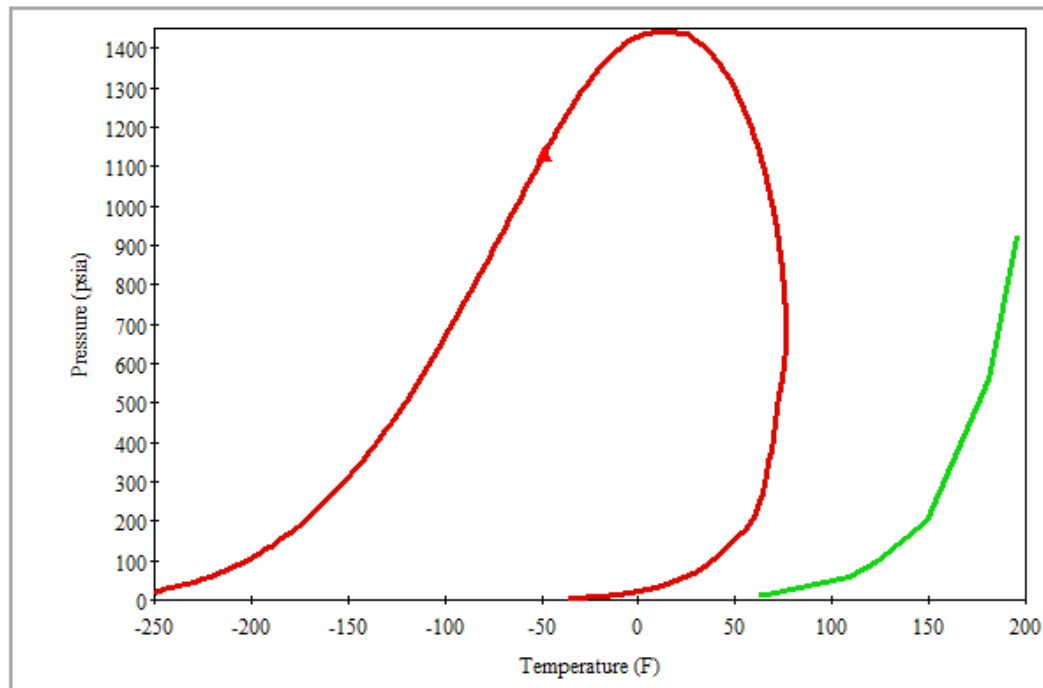
Figure 1. Identifying different phases for a typical natural gas

Phase Envelope
Dewpoint
Critical Point
Cricondetherm
Cricondenbar

3. <http://www.jmcampbell.com/tip-of-the-month/2010/01/variation-of-properties-in-the-dense-phase-region-part-2-%E2%80%93-natural-gas/>

Phase Envelope

Using Peng-Robinson Equation



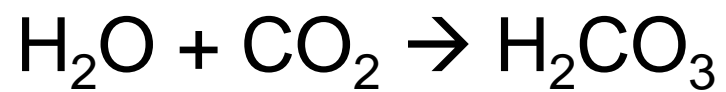
— Phase Envelope
▲ Critical Point
— Water Dew Points for water = 824.644549763033 lbs/MMSCF

Water Dew Point

Peng-Robinson Equation	
Water Dew Points for water = 824.644549	
Temperature	Pressure
(F)	(psia)
62.33	11.9946
65.93	14.7068
109.13	60.0021
123.53	100.0035
148.73	200.007
181.13	560.0197
195.53	920.0324

**Relationship of Pressure
to Dewpoint
Temperature**

Carbonic Acid



4. <https://www.slideshare.net/Siduyy/2228-5547435>

Sulfuric Acid



4. <https://www.slideshare.net/Siduyy/2228-5547435>

AGA Report No. 4A

Sample contract measurement and gas quality clauses and definitions currently under review by the Transmission Measurement Committee of the American Gas Association (AGA) include references to the general concept of merchantability, and to the specific obligation to provide natural gas of a quality that is commercially free of contaminants and objectionable materials. For example, see drafts of:

AGA Report No. 4A, Appendix A-1 (Definitions and Industry Publications, Standards, and References): “Merchantability” – See Commercially Free. “Commercially Free” – a contract term used to qualify objectionable material to the extent the gas is reasonably free of contaminants or constituents that would otherwise interfere or cause harm to the pipeline or would preclude utilization of a gas supply in the ordinary course of business.

AGA Report No. 4A, Appendix B, (Sample Contract Measurement and Gas Quality Clauses), 3. Absence of Impurities: XYZ recognizes its obligation to provide gas in accordance with the specification hereunder: (a) shall be commercially free of objectionable constituents such as, but not limited to, dirt, dust, gums, gum forming constituents, iron particles, liquid water, and other solid, liquid or gaseous matter that might interfere, cause injury to, or interference with proper operation of lines, regulators, meters or other equipment.

Tariff Example

PIPELINE	HEAT VALUE BTU/SCF: MIN/MAX	WOBBE NUMBER MIN/MAX	OXYGEN: MAX%	INERTS: TOTAL MAX %	CARBON DIOXIDE MAX%	NITROGEN MAX %	LIQUEFIABLE HYDROCARBON DEW POINT / NON-METHANE HYDROCARBONS	H2O: HYDROGEN SULFIDE MAX GR/100 CF	TOTAL SULFUR: MAX GR/100 CF
DETI	Dry Gas: 987/1100	-----	.20%	5.00%	3.00%	4.00%	Free of hydrocarbons in liquid form	.25 Gr.	20 Gr.
Company A	967/1110	1298/1400	.10%	4.00% (carbon dioxide and nitrogen)	3.00%	3.00%	Max .05 GPM of C6+ hydrocarbons	.25 Gr.	20 Gr.
Company B	970/-	-----	.20%	4.00% total inerts .10% (carbon monoxide)	2.50%	-----	Free of hydrocarbons in liquid form	.30 Gr.	10 Gr.

AGA Report No. 4A

DETI Tariff Language:

The gas delivered by Pipeline to Customer shall be commercially free from objectionable odors, dust, or other solid or liquid matters which might interfere with the merchantability of the gas or cause injury to or interference with proper operation of the lines, regulators, meters, or other appliances through which the gas flows.

Dust, Gums, etc.: The gas shall be free of objectionable odors, dust, gum, dirt, impurities and other solid or liquid or hazardous matter which might interfere with its merchantability or cause injury to or interfere with proper operation of the facilities, lines, regulators, meters or other appliances through which it flows.

Moisture (H₂O) Analyzers

- Approved On-line Equipment
 - SpectraSensor SS500(e)
 - GE Aurora
- Approved Portable Equipment
 - SpectraSensor SS1000
 - Draeger/Sensidyne
- Saturated vs. Dry
 - >7 lb/mmscf
- Moisture Standard
 - Verification of both portable and on-line equipment.
- Dew Point Testing & Monitoring
 - Available by a pressure input (4-20mA) from the GE Aurora
 - ZEGAZ



Oxygen (O₂) Analyzer

- Approved Equipment
 - SpectraSensor Oxy440
 - Requires a certified nitrogen (N₂) gas.
 - AMI 2010BR
 - Requires an electrochemical cell.
 - AMI 1000RS (Portable)
 - Requires an electrochemical cell.
- Tariff Limits and Pipeline Integrity
 - Current DTI Tariff Limit: 2,000 ppm
 - Corrosion concern at 100ppm



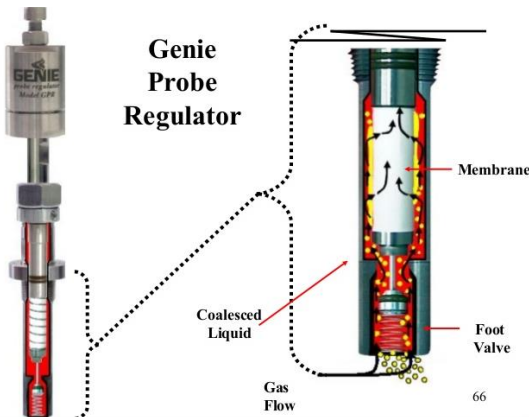
Hydrogen Sulfide Analyzer

- Approved Equipment
 - SpectraSensors SS3000 (H₂S)
 - Draeger/Sensidyne
 - Energy MEDOR
- Tariff Limits
 - > 0.25 gr./100cf



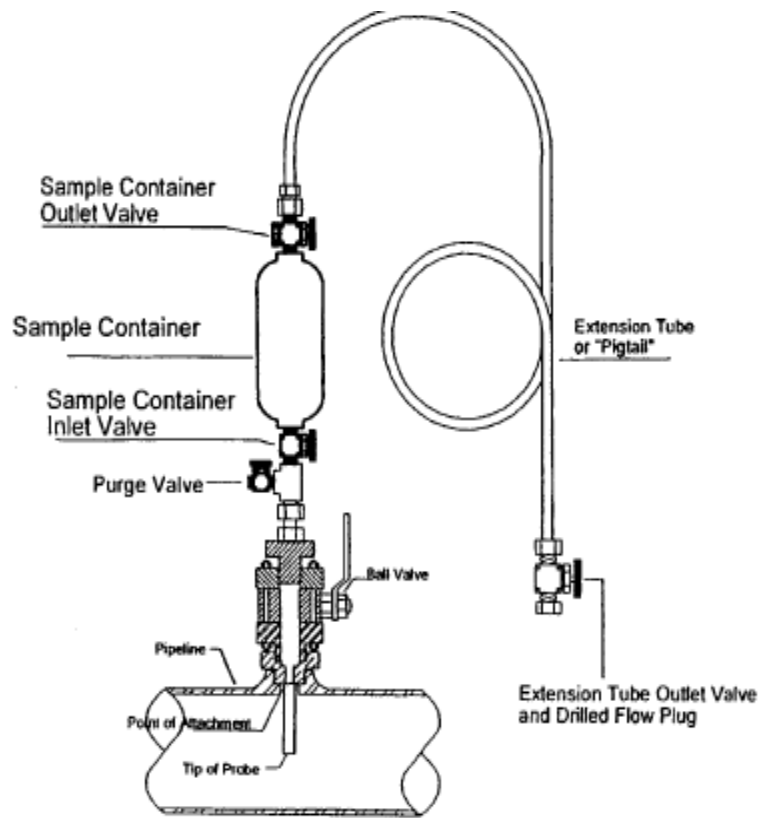
Chromatograph

- C_1 - C_6 +, N_2 , CO_2
- Daniels 500 Series
- ABB NGC 8206
- Portable Chromatographs



Gas Samples

- Bottle Samples sent to Laboratory



Other Considerations

- Velocity of Gas
- Microorganisms
- Mercury

QUESTIONS?

Michael Fouts

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Other Sources

1. <http://trimeric.com/assets/oxygen-removal-in-natural-gas-systems-Irgcc-paper.pdf>
2. <https://www.omicsonline.org/open-access/corrosion-in-oil-and-gas-industry-a-perspective-on-corrosion-inhibitors-2169-0022.1000e110.php?aid=33566>