



RNG WORKS



RNG QUALITY: Laboratory Perspective

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HIGHLIGHT

Importance of RNG quality as pipeline natural gas

Differences of RNG Quality and raw source gases

Common specifications of RNG quality

On-line and/or Laboratory testing

Representativeness of RNG samples for laboratory testing

Laboratory testing for detailed gas quality monitoring

Selected testing methods

RNG QUALITY SHOULD BE SUITABLE TO BE USED AS CONVENTIONAL PIPELINE NG

Considerations

- **Gas processing**
- **Custody transfer (tariff)**
- **Gas operation and transportation (corrosion)**
- **Gas odorization (odorant fading, odor masking)**
- **Gas utilization as a supplemental NG (suitability and interchangeability)**

SPECIFICATIONS OF CONVENTIONAL NATURAL GAS QUALITY

RECOMMENDED GAS QUALITY SPECIFICATIONS

| <u>PARAMETER</u> | <u>RECOMMENDED LIMIT</u> |
|---|---|
| Oxygen, % | - 0.2 |
| Carbon dioxide, % | - 3.0 |
| Total inerts (CO ₂ +O ₂ +N ₂ etc.),% | - 4.0 |
| Hydrogen Sulfide, gr H ₂ S/100scf ⁽¹⁾ | - 0.25 |
| Mercaptan Sulfur, gr S/100scf | - 0.3 |
| Total Sulfur, gr TS/100scf ⁽²⁾ | - 0.75 (12 ppmv) |
| Water Vapor | |
| for delivery pressures ≤ 1000 psig | - 71lbs/MMSCF (144 ppmv) |
| for delivery pressures > 1000 psig | - 32°F dewpoint at delivery pressure |
| Hydrocarbons | |
| for delivery pressures ≤ 400 psig | - 45°F dewpoint at delivery pressure |
| for delivery pressures > 400 psig | - 45°F dewpoint at 400 psig |
| Dust, gum and solid matter | - Commercially free of |
| Hazardous Substances ⁽³⁾ | - Concentrations must not be hazardous to health, injurious to pipeline facilities or be a limit to marketability |
| Heating value, Btu/SCF (gross) | - 970 minimum, dry basis |
| Delivery Temperature | - 50°F - 105°F |

RNG SPECIFICATIONS COVER A WIDER ARRAY OF COMPONENTS OR PARAMETERS

RNG quality requirements are different and more extensive because raw source gas is complex

Raw biogas contains unique components

Source raw gas varies;

- **Different LFG locations with varying wastes and maturity**
- **Digester gases from various solid waste sources**
- **Presence of different residential and commercial products**

A TYPICAL RNG QUALITY SPECIFICATIONS - 1

| | | | |
|-------------------|---|------|--------------|
| | | | |
| HHV, Minimum | < | 950 | Btu/SCF |
| Maximum | < | 1050 | Btu/SCF |
| Wobbe No. Minimum | < | 1230 | |
| Maximum | < | 1400 | |
| Moisture content | < | 5 | Lb/MMSCF |
| H ₂ S | < | 0.25 | Grain/100SCF |
| Total sulfur | < | 1 | Grain/100SCF |
| CO ₂ | < | 3.0 | % |
| O ₂ | < | 0.5 | % |

A TYPICAL RNG QUALITY SPECIFICATIONS - 2

| | | | |
|---------------------------------------|---|-------------|-------------------|
| Total halogenated hydrocarbons | < | 5 | ppmv |
| Pentane | < | 600 | ppmv |
| Hexane | < | 50 | ppmv |
| Nonane | < | 200 | ppmv |
| Benzene | < | 10 | ppmv |
| Toluene | < | 100 | ppmv |
| Ethyl benzene | < | 100 | ppmv |
| m,p-Xylenes | < | 100 | ppmv |
| o-Xylene | < | 100 | ppmv |
| Cumene (Isopropyl benzene) | < | 50 | ppmv |
| Naphthalene | < | 10 | ppmv |
| Siloxanes | < | 0.4 | mg/M ³ |
| Mercury | < | 0.05 | µg/M ³ |

ADDITIONAL RNG QUALITY PARAMETERS

Other common RNG quality concerns

- Hydrogen
- Ammonia
- Hydrocarbon dew point

California rule 21 section J

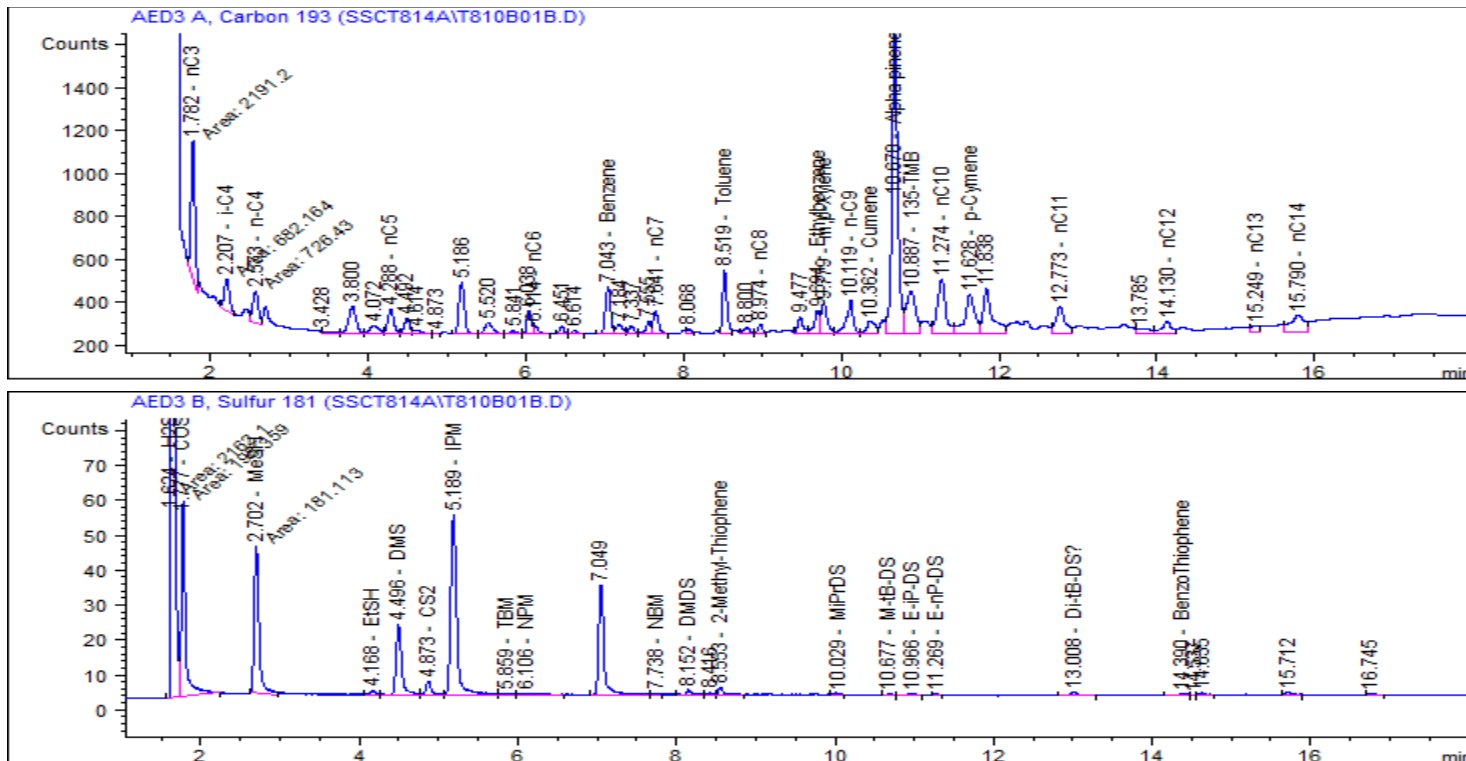
- Arsenic, Antimony, Copper, Lead
- p-Dichlorobenzene, Vinyl chloride
- Methacrolein
- N-Nitroso-di-N-propylamine
- Biologicals

RAW BIOGAS COMPOSITION

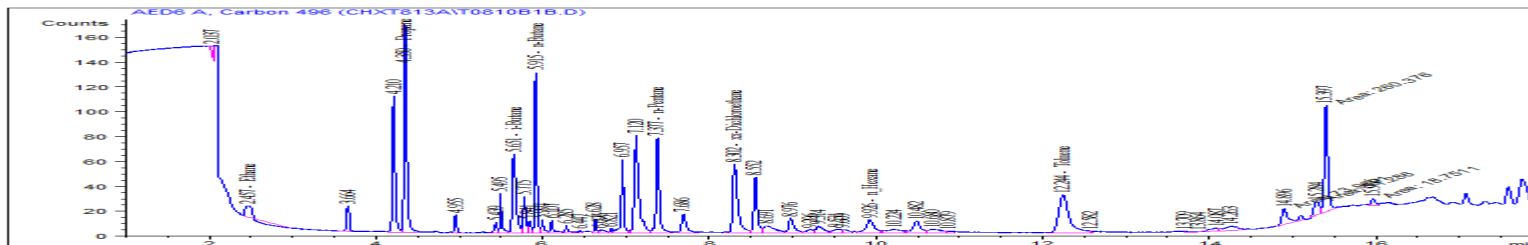
It is Largely different from raw natural gas and is a complex mixture of fuel gas.

- Lower methane, higher CO₂ & N₂, O₂ enriched
- Unique hydrocarbons (branched, cyclic and aromatic compounds)
- High H₂S and Mercaptans
- Oxygenated compounds (Alcohols, Ketones & Esters)
- Halogenated compounds (Cl & F)
- Siloxanes (Organic silicon compounds)
- Ammonia & Others to be verified

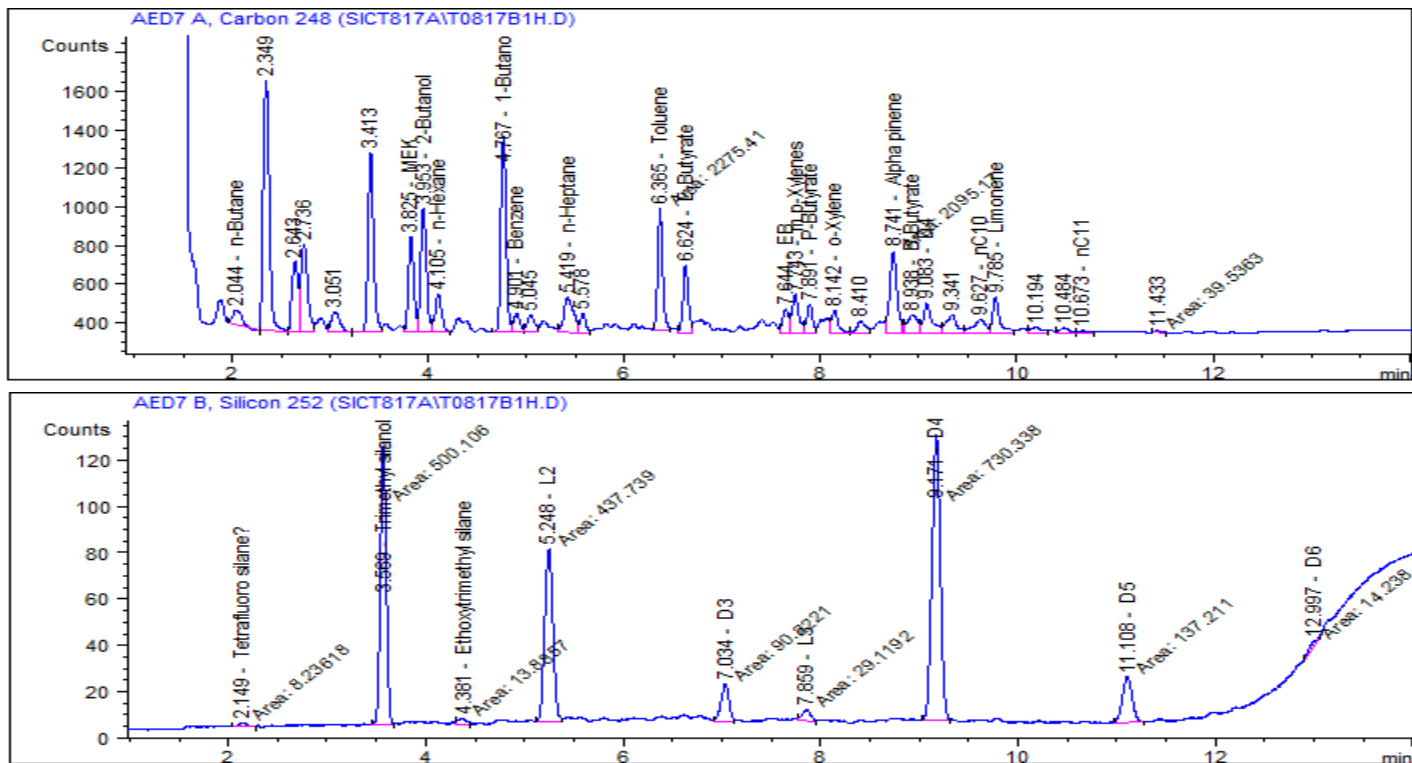
HYDROCARBONS AND SULFURS IN A LFG



HALOGENATED COMPOUNDS IN A LFG



ORGANIC SILICON COMPOUNDS IN A LFG



ON-LINE OR LABORATORY TESTING

On-line Testing

- **Representative sampling means accuracy (low moisture & oxygen)**
- **Quick results for feed back**
- **Some tests cannot be done in laboratory (dust, gum & solid matters)**

Laboratory Testing

- **Sampling problem exist**
- **Time delayed analysis**
- **More sophisticated analysis for multiple component testing (speciation)**
- **Validation of on-line testing**
- **Higher reliability ?**

SAMPLES FOR LABORATORY TESTING

Representative sampling

- **Bad samples leads to bad results and misinformation, if not wasting time**

A variety of **samplers**, Which is better?

- **Double ended cylinder (typical for natural gas sampling, Vacuum-fill and purging possible, internally coated for sulfur testing)**
- **Tedlar bags (leak prove?, light sensitivity? Easy to break/explode if filled too much, sampling technique dependable)**
- **Summa canister (normally for environmental sampling, good for traces, internally silica coated preferred)**

SAMPLES FOR LABORATORY TESTING

Holding time for gaseous fuel samples must be determined

- **Gaseous fuel samples are different from air emission samples. Do not apply EPA emission rules without verification.**
- **Holding time can vary depending on maturity and stability of raw RNG at different producing locations**

Shipping of dangerous goods is not easy task and must be in a time fashion

- **DG combustible gas by priority air shipping with declarations**
- **Combustible gas in limited quantity by Ground (49 CFR 173.306)**
- **Dilution by Helium to make the sample as non-combustible**

GAS SAMPLERS



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SAMPLING TECHNIQUE IS ESSENTIAL

Representative sampling & Avoid air invasion



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Too much sample may blow up Tedlar bag or make it difficult to exit the can.

IN LINE SAMPLING



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SHIPPING CONTAINERS

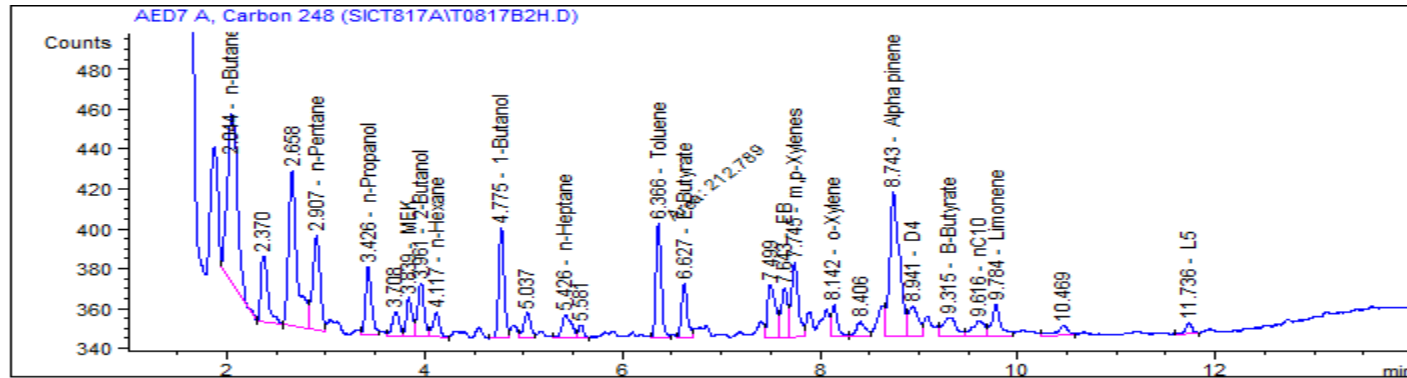
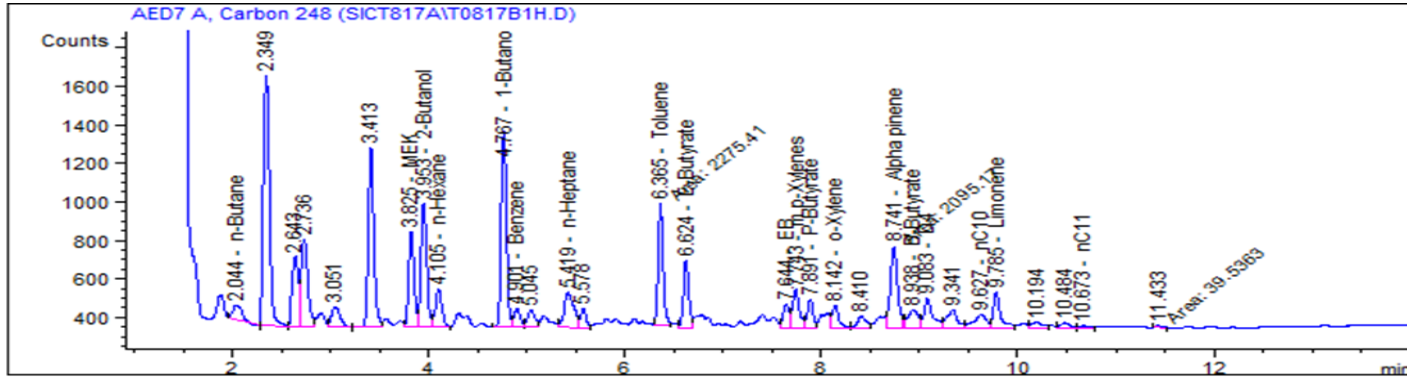


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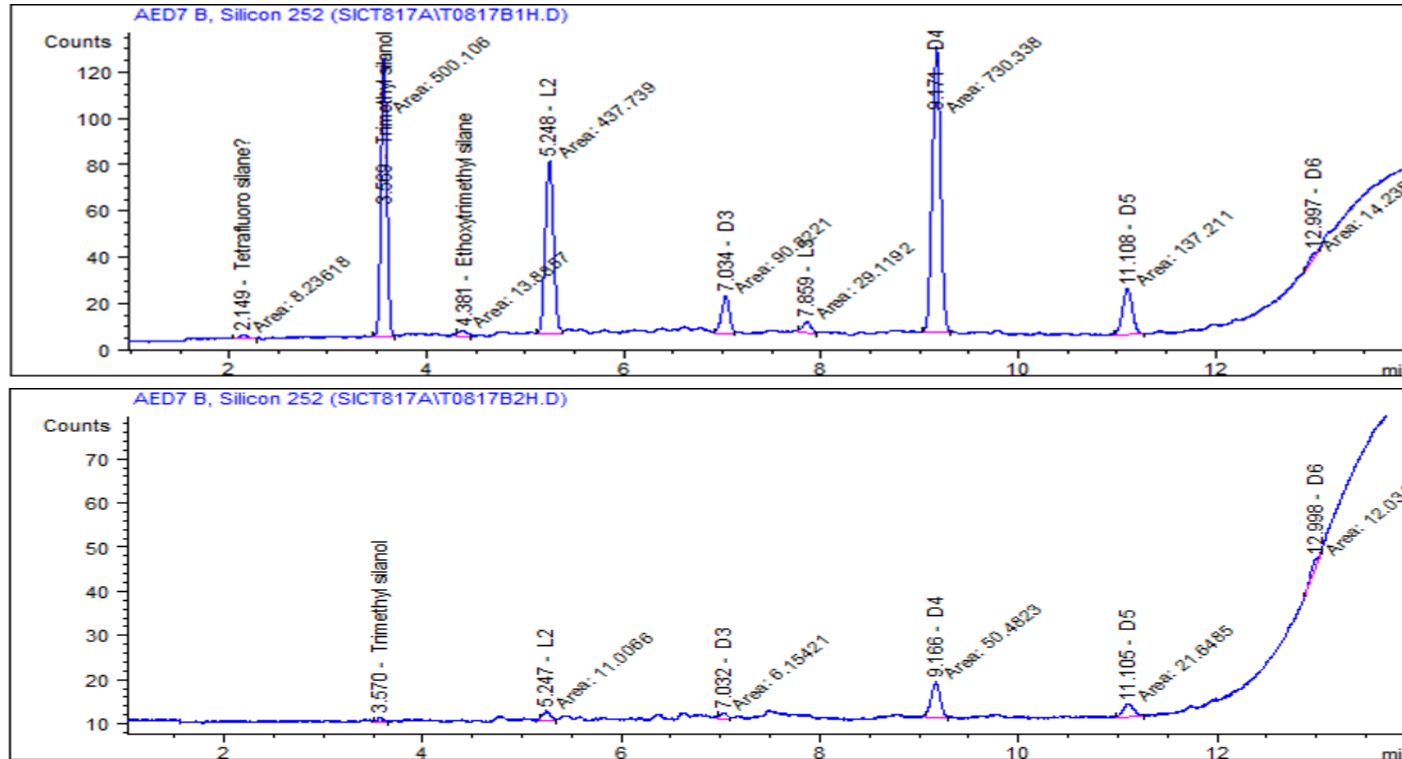
TESTING FOR RNG QUALITY

- **Sample integrity**
- **Holding time**
- **Target components and parameters**
- **Detection limit required**
- **Selection of right methods for intended purposes**

LABORATORY TESTING FOR GAS PROCESSING EFFICIENCY



LABORATORY TESTING FOR GAS PROCESSING EFFICIENCY



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LABORATORY TESTS - 1

Major and minor components (ASTM D1945, EPA3C)

HV & RD (ASTM D3588) and Wobbe number

Hydrogen (GC-TCD with MS 5-A column)

Trace Oxygen (on-line preferred, ASTM D7607 – Electrochemical sensor)

Moisture (on-line preferred, ASTM D5454, GC methods)

High H₂S (EPA 15/16)

H₂S and sulfur compounds speciation (ASTM D6968, D5504, D6228)

LABORATORY TESTS -2

Extended hydrocarbon analysis (ASTM D6968, D7833)

Hydrocarbon dew point

- *Chilled mirror dewpoint meter*
- *Equation of state calculation from extended composition analysis by GC)*

Target VOC component analysis (TO 14A or TO15 methods does not cover all components. The results cannot be used for total VOCs, total organic chlorine and fluorine)

TNMOG (GC-FID or GC-AED for total VOCs as methane, EPA 25)

LABORATORY TESTS - 3

Total halogens (Cl, F) (EPA 9073 – Oxidative combustion and microcoulometry, or combustion ion chromatography, GC-AED)

Halogenated compounds (Total and speciated analysis by GC-AED, GC-MS)

Siloxanes (ASTM D8230 -Direct gas analysis or sorbent extraction with GC-AED or GC-MS analysis)

Mercury (ASTM D5954, D6350)

Arsenic compounds (GC-AED)

Alkali and alkaline earth metals ?? (ASTM D7550)

CONCLUSION

Laboratory testing to examine, confirm and validate the complete quality of RNG for NG use

Laboratory testing is aiming at detailed, complete and possible unique components

Sample representativeness is most important and sampling must be done correctly with appropriate containers

Many standard test methods are available. Test methods may be modified to deal all gas matrices

The selection of tests and test methods is dictated by the raw RNG quality

Test results should be repeatable, reliable and accurate, and useful for intended purpose

RNG quality measurement can be challenging and is the key to the success of production and utilization of RNG – A green energy