



RNG WORKS



BIOGAS CONSTITUENTS & TESTING





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RNG WORKS

Presented by Adam Klaas

Presenter comments are noted in red on each slide.



UNISON
SOLUTIONS

UNISON SOLUTIONS, INC.

- Based in Dubuque, Iowa
- Operating since 2000
- Design, engineering, fabrication, start up and service at one location
- Over 325 biogas conditioning and upgrading projects



STEP 1 - BIOGAS TESTING

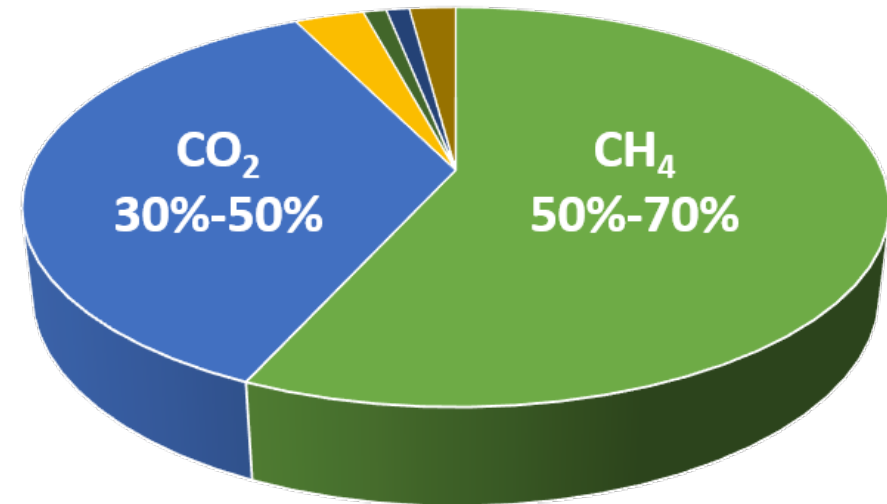
bi·o·gas, 'bīōˌgas/, *noun*, gaseous fuel, especially methane, produced by the fermentation of organic matter.

- Methane, CH₄
- Carbon Dioxide, CO₂
- Nitrogen, N₂
- Oxygen, O₂

Vary by site, but remain fairly consistent from a specific biogas source

- Hydrogen Sulfide, H₂S
- Moisture
- Particulates
- Siloxanes
- Volatile Organic Compounds

Vary by site, and can vary significantly within a specific biogas source



All constituents should be tested at least 2 times to determine gas consistency

RNG FUEL QUALITY SPECIFICATIONS

Biogas Constituents	Raw Biogas	SAE J1616 CNG Fuel Quality Specification	Natural Gas Pipeline Fuel Quality*
Methane	50-80%	88% or greater	
Wobbe Index		1,250 – 1,420 BTU/ft ³	1,400 BTU/ft ³ max
Higher Heating Value (HHV)			950-990 BTU/ft ³
Carbon Dioxide (CO ₂) and Nitrogen (N ₂)	20-50%		<2%
Oxygen (O ₂)	0-1%		6 ppm to 0.2%
Hydrogen Sulfide (H ₂ S)	<1,000 ppm	≤4 ppm	≤4 ppm
Water Content		PWDP 10°F below lowest recorded temp	3-7#/MMcf
Siloxanes and Volatile Organic Compounds	<2,000 ppm	ND (Silicon)	ND to 1 ppm
Pressure	0-2 psig	3,000-3,600 psig	50 to 900+ psig

RNG requirements vary depending on the utility

BIOGAS QUALITY_WWTP EXAMPLES

	Site 1	Site 2	Site 3
Methane (%)	61	62	66
Hydrogen Sulfide (ppmv)	3,500	11,000	150
Siloxanes (ppbv as sum of the compounds)	604	2,433	86
Acetone (ppbv)	34	80	55
MEK (ppbv)	61	ND	13
Benzene (ppbv)	8	13	ND
Toluene (ppbv)	250	245	21
Ethylbenzene (ppbv)	27	49	ND
Xylene (ppbv)	55	24	ND

Note the varying concentrations of impurities. There is no such thing as “typical” or average biogas quality!

BIOGAS QUALITY_INDUSTRIAL DIGESTER EXAMPLES

	Food & Green Waste	Dairy Processing	Ingredient Mfr	Brewery
Methane (%)	63	62	88	65
Hydrogen Sulfide (ppmv)	415	1,800	4,300	2,840
Siloxanes	234	294	ND	258
Acetone (ppbv)	6,610	40	ND	131
MEK (ppbv)	17,400	23	240	89
Benzene (ppbv)	27	7	ND	ND
Toluene (ppbv)	233	245	100	18
Ethylbenzene (ppbv)	88	5	22	5
Xylene (ppbv)	64	10	17	2

Industrial waste streams also have a wide range of biogas constituents and concentrations

Hydrogen Sulfide (H₂S)

- Where does H₂S come from?
 - Landfills – break down of calcium sulfate used in building materials
 - Digesters - sulfate-reducing bacteria (SRB's) convert the sulfate ion to sulfide
- Equipment damage from corrosion (hydrosulfuric acid)
- SO_x emissions
- Health and safety issues
- Odor control
- **Causes fouling of siloxane removal media**
- Measure levels with either lab testing, colorimetric tubes, or onsite meter



HYDROGEN SULFIDE REMOVAL SYSTEMS

H₂S levels and moisture content of the gas help determine the best removal method and media type



Ferric Hydroxide

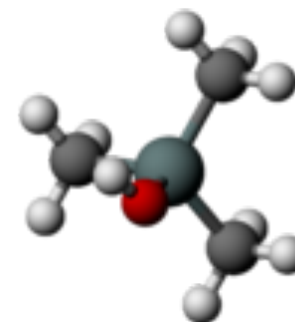


Wood

- Filtration medias (Ferric oxide coated)
 - Low replacement cost – high changeout costs
 - Wood based
 - Clay based
- Biological systems for sites with high H₂S
- Chemical systems for high flow/high H₂S
- Reaction Process
 - Ferric Hydroxide pellets
 - Potassium iodide, KI impregnated
 - Coal or coconut substrate
- Adsorption
 - Wood or coal based carbon

WHAT IS A SILOXANE?

- Silica and organic compounds are combined (Organosilicon)
- Used in many industrial products and consumer products
 - Laundry detergent
 - Shampoo/conditioner
 - Deicing fluid/ Windshield Cleaning Products
 - Silicone caulks
 - Food additives
 - Commercial products for washing fruits and vegetables
- Siloxanes break down in landfills and digesters, and combine with the methane gas



SILOXANE IMPACT ON EQUIPMENT

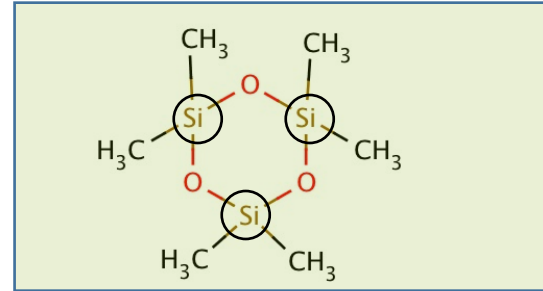
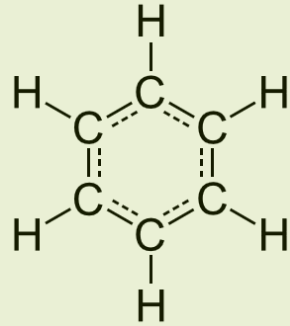


- When methane gas is used as a fuel, the siloxanes form SiO_2 Silicon Dioxide, and precipitate to a hard deposit on surfaces
- Significant impact on electrical generation systems
 - Increased down time for maintaining equipment
 - Increased costs for components, i.e. spark plugs, valve seats
 - Engine rebuild time is more frequent

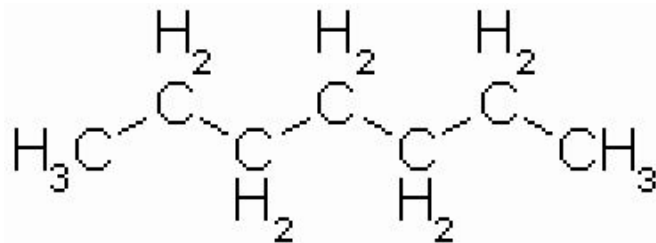


SUITABILITY FACTORS FOR MEDIA SYSTEMS: SILOXANES, HYDROCARBONS AND VOC'S

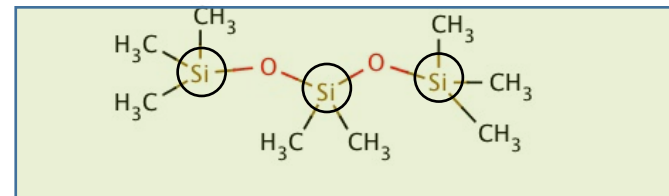
Benzene
 C_6H_6



D3, Hexamethylcyclotrisiloxane



Heptane
 C_7H_{16}



L3, Octamethyltrisiloxane

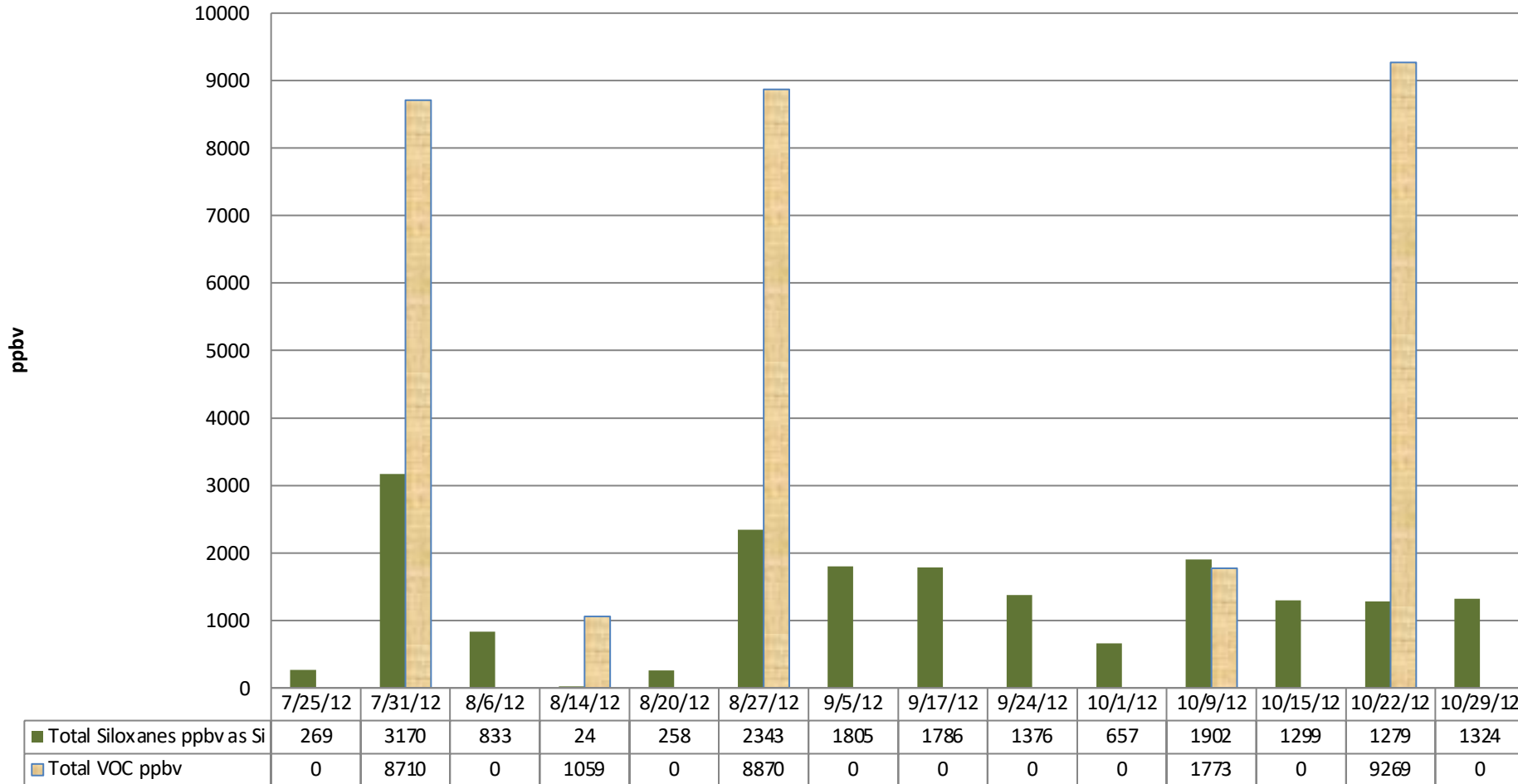
Siloxanes precipitate from the gas under combustion and form silica on the surface of engines. So they need to be removed from the gas.

The structure of siloxanes and other VOC's are so similar, the removal media's can not always differentiate various compounds.

Testing for both siloxanes and VOC's by species is needed in order to calculate a media life estimate

SILOXANE AND VOC RESULTS - RAW GAS TESTING

Wastewater Treatment Plant



This site participated in media testing and tested siloxanes and VOC's every week for several months. The variability of both types of compounds was significant!

Multiple gas samples should be tested before a project begins.

SILOXANE/VOC REMOVAL MEDIA

Coal



Coconut shell



Wood



Extruded pellets



4 x 8 mesh chips

Silica gel - spheres



Silica gel – irregular shaped



Different media types can be used for the removal of siloxanes and VOC's and are determined by the specific compounds present in the gas

Laboratory biogas testing is needed to determine concentrations for both siloxanes and VOC's compounds.



LABORATORY GAS TESTING — TEDLAR BAG OR SUMMA CANISTER SAMPLING



Tedlar Bags: Fairly short hold time depending on the compounds being tested. However, it's a quick and simple set up for gas sampling and can be used for sites that are close to the lab.



Summa Canisters: Longer hold time, with more equipment required for sampling. Canisters are under vacuum.

LABORATORY GAS TESTING – FIELD INSTRUMENTATION



There are many handheld monitors available on the market that can measure major gases and H₂S.

Siloxanes and VOC's must be tested in a laboratory set up for vapor phase testing at low detection levels. Testing should provide speciated results by compound.

FIELD MONITORING - COLORIMETRIC TUBES



Colorimetric tubes for measuring the following:

- H₂S
- Moisture

Brands include

- Draeger
- Sensidyne
- Honeywell

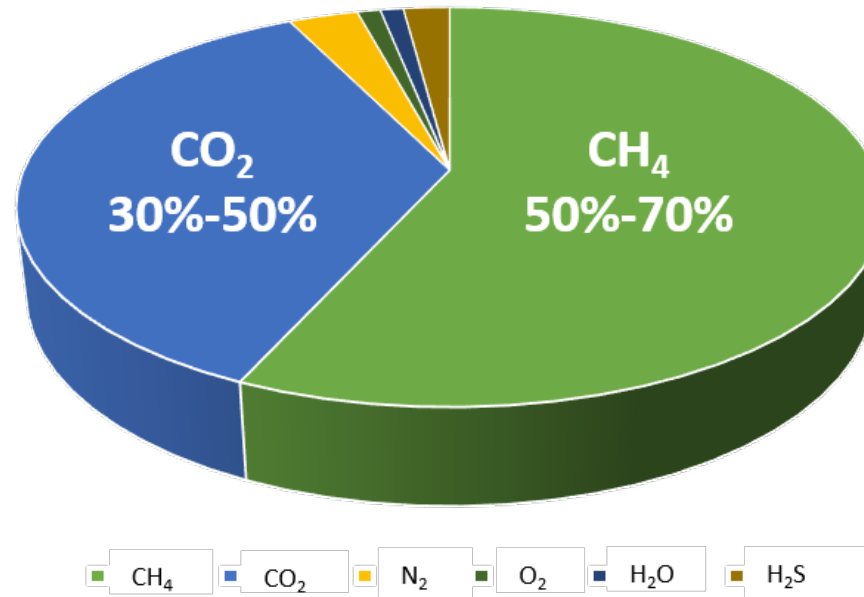
These tubes are an inexpensive option to determine H₂S and moisture levels from biogas.

The system consists of a pump and single use tubes.

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- Volatile Organic Compounds



All constituents should be tested at least 2 times to determine gas consistency

Before beginning a biogas to RNG or CHP project, gas testing should be done at the beginning of the project.

We recommend that gas be tested at least 2 times, preferably at different times of the year or at least at different stages in the digestion process.

THANK YOU!

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If you have any questions on biogas testing or steps to begin a biogas conditioning or upgrading project, please feel free to contact us for assistance.