Elemental Instruments®
A DIVISION OF OHIO LUMEX

OHIO LUMEX

WORLDWIDE LEADER
Gaseous Fuels, Emissions &
Process Monitoring
Sampling & Laboratory Analysis

Biogas/RNG
Onsite Sampling & Laboratory Analysis

One-Stop-Shop for
Gaseous Fuels Analysis

Biogas and RNG Gas Composition Analysis

Applications

- Digester Design
- Upgrading Skid Design
- Process Control
- Compliance
  - Pipeline/Utility RNG Gas Quality Specifications
  - EPA Renewable Fuel Standard (RFS)
  - 45Z Production Tax Credit (ASTM D8080)

Analytes & Methods Summary

Gas Component		Sample Type	Test Method
Major Gases	CH4, CO2, O2, N2, CO, H2, C6+ Hydrocarbons	Passivated High-Pressure Cylinder	ASTM D1945, D1946
Heating Value & Relative Density		Calculated	ASTM D3588
Hydrocarbon Dewpoint		Calculated	Peng-Robinson Equation of State
Total & Speciated Sulfur Compounds	H2S, COS, Mercaptans, Others	Passivated High-Pressure Cylinder	ASTM D6228, D5504
Halocarbons	Organic Chlorine/Fluorine	Passivated SUMMA Canister	EPA TO-15
Inorganic Chlorine & Fluorine		Sorbent Trap	EPA 9056A
Volatile Organic Compounds (VOCs)		Passivated SUMMA Canister	EPA TO-15
Non-Methane Organic Compounds (NMOCs)		Passivated SUMMA Canister	EPA TO-25C
Terpenes		Passivated SUMMA Canister	EPA TO-15
N-nitroso-di-N-propylamine (NDPA)		Sorbent Trap	EPA 0010 & 8270E
Mercury	Hg	Sorbent Trap	ASTM D5954
Siloxanes	TMSOL, L2, L3, L4, L5, D3, D4, D5, D6	Sorbent Trap	ASTM D8230
HCL/HF	Inorganic Chlorine & Fluorine	Sorbent Trap	EPA 9056A
Aldehydes & Ketones		Sorbent Trap	EPA TO-11A
Ammonia	NH3	Sorbent Trap	NIOSH 6016, OSHA ID-188
PCBs & Pesticides	Organochlorine	Sorbent Trap	EPA TO-10A
Radiological	Gross Alpha and Beta Particles	Filter	EPA 900.0
	Radon Gas	Sorbent Trap	Gamma Spectrometry
Metals	Antimony, Arsenic, Lead, Copper, Others	Impinger Train	EPA Method 29
		Sorbent Trap	OL-21G & EPA 6020B (ASTM WK91049)
Bacteria	APB, SRB, IOB, Total Bacteria	Custom Sampling Apparatus	qPCR
Temperature	Performed Onsite	Inline Thermocouple	
Odors, Dust, Liquids	Performed Onsite	Sorbent Trap	OL-71
Water Dewpoint	Performed Onsite	Chilled Mirror Hygrometer	ASTM D1142
	Performed Onsite	Metal Oxide Hygrometer	ASTM D5454
	Performed Onsite	Length of Stain Tubes	ASTM D4888
Particulates		High-Pressure Filter	ASTM D7651
Compressor Oil		Sorbent Trap	ASTM D8251
VFCs and PFAS		Passivated SUMMA Canister	EPA OTM-50

NELAP ACCREDITED TNI LABORATORY

ISO 17025

EPA RFS – Added a Layer of Complexity

Required Methods for Analysis

EPA Method 3C	Methane, Carbon Dioxide, Nitrogen, Oxygen
EPA Method 18	Hydrocarbon Analysis
ASTM D3588	Heating Value, Relative Density
ASTM D5504	Hydrogen Sulfide, Total Sulfur
ASTM D8230	Siloxanes
ASTM D4888	Moisture
ASTM D6866	Carbon-14
Pipeline Specified	Additional Components required by Pipeline Gas Quality Specifications

Requires Analysis of Raw Biogas

- Specific components and methods required (see above)
- Additional components required by Pipeline Gas Quality Specifications

Methods Not Ideal for Gaseous Fuels Applications

EPA did not consult with the Industry

- Methods selected not ideal for gaseous fuel applications
  - EPA Method 3C, 18
- Methods selected not industry accepted methods
  - Requires redundant testing
- Methods selected reduce accuracy and increase risk
  - ASTM D4888
- Needlessly increases costs
  - Requires testing Raw Biogas to same requirements as RNG
- Lengthens lead times
  - ASTM D6866

Requested EPA Add Alternative Methods

ASTM D03 Gaseous Fuels Committee

- Long-term active member
  - Chair, D03.01 – Collection and Measurement of Gaseous Samples
  - Vice-Chair, D03.06 – Analysis of Constituents in Gaseous Fuels

- Ohio Lumex and ASTM D03 submitted Alternative Measurement Protocol (AMP) to EPA on behalf of Industry to approve other methods
  - ASTM D1945, D1946, D7833 Major Gases, Hydrocarbons
  - ASTM D6228, D6968 Total & Speciated Sulfur
  - ASTM D1142, D5454 Moisture

- EPA RFS Final Rule Changes (published April 1, 2026)
  - Added all of the above requested methods
  - Effective 2026 and 2027

45Z Production Tax Credit

Required Methods for Analysis

Major Gases & Hydrocarbons	ASTM D1945, D1946
Calculated Methane Number	ASTM D8221
Higher Heating Value	ISO 6976
Lower Heating Value	ASTM D3588
Total & Speciated Sulfur	ASTM D6228
Siloxanes	ASTM D8230
Moisture	ASTM D1142
Maximum Particulates	ASTM D7651
Compressor Oil	ASTM D8251

Pipeline, EPA RFS, ASTM D8080 Comparison

Analyte	Method	RNG			Raw Biogas		
		Tariff	EPA RFS*	ASTM D8080	Tariff	EPA RFS**	ASTM D8080
Major Gases & Hydrocarbons	ASTM D1945, D1946	✓		✓			
	EPA 3C, 18[1]	·	✓		·	✓	
Calculated Methane Number	ASTM D8221	·	·	✓	·	·	
Higher Heating Value	ISO 6976	·	·	✓	·	·	
Lower Heating Value	ASTM D3588	✓	✓	✓	·	✓	
Hydrocarbon Dewpoint	Peng-Robinson Equation of State	✓	·	✓	·	·	
Total & Speciated Sulfur	ASTM D5504[3]	·	✓	·	·	✓	
	ASTM D6228	✓	·	✓	·	·	
Siloxanes	ASTM D8230	✓	✓	✓	·	✓	
Moisture	ASTM D1142 (Chilled Mirror)	✓		✓			
	ASTM D4888 (Length of Stain Tubes)[2]	·	✓		·	✓	
Maximum Particulates	ASTM D7651	·	·	✓	·	·	
Compressor Oil	ASTM D8251			✓	·	·	
Carbon-14[4]	ASTM D6866	·	✓	·	·	✓	

* EPA requires seven (7) tests for RNG and Raw Biogas, and specifies the methods for sampling and analysis

** EPA requires Raw Biogas to be tested to the same requirements the Tariff/Pipeline Gas Quality Specifications require for RNG

Ohio Lumex and ASTM have requested the EPA approve alternate methods to address limitations of their selections

1 EPA Method 3C &18 developed for emissions, and includes only Methane, Carbon Dioxide, Nitrogen and Oxygen, requiring additional testing

2 Length of Stain Tubes are highly inaccurate and could cause failure to comply with Pipeline Gas Quality Specifications for RNG

3 ASTM D6228 not included, but used by most gaseous fuels laboratories

4 Measures biogenic carbon (credits applied only for new carbon)

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Halocarbons	Organic Chlorine/Fluorine	Passivated SUMMA Canister	EPA TO-15
Inorganic Chlorine & Fluorine		Sorbent Trap	EPA 9056A
Volatile Organic Compounds (VOCs)		Passivated SUMMA Canister	EPA TO-15
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Aldehydes & Ketones		Sorbent Trap	EPA TO-11A
Ammonia	NH3	Sorbent Trap	NIOSH 6016, OSHA ID-188
PCBs & Pesticides	Organochlorine	Sorbent Trap	EPA TO-10A
Radiological	Gross Alpha and Beta Particles	Filter	EPA 900.0
	Radon Gas	Sorbent Trap	Gamma Spectrometry
Metals	Antimony, Arsenic, Lead, Copper, Others	Impinger Train	EPA Method 29
		Sorbent Trap	OL-21G & EPA 6020B (ASTM WK91049)
Bacteria	APB, SRB, IOB, Total Bacteria	Custom Sampling Apparatus	qPCR
Temperature	Performed Onsite	Inline Thermocouple	
Odors, Dust, Liquids	Performed Onsite	Sorbent Trap	OL-71
Water Dewpoint	Performed Onsite	Chilled Mirror Hygrometer	ASTM D1142
	Performed Onsite	Metal Oxide Hygrometer	ASTM D5454
	Performed Onsite	Length of Stain Tubes	ASTM D4888
Particulates		High-Pressure Filter	ASTM D7651
Compressor Oil		Sorbent Trap	ASTM D8251
VFCs and PFAS		Passivated SUMMA Canister	EPA OTM-50

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Preparing For The Field

Sample Points

- Location(s)
  - Selected in advance by local personnel
  - Recommend marking or labeling
  - Request photos
- Valve Size
- Valve Connections
- Pressure

Available Power (if required)

- Inverter (car)

Locally Sourced

- Table
- Tent (weather related)
- Ice (if required)

Preparing For The Field (cont'd)

Safety

- Location specific safety requirements
  - Equipment
  - Tests, Certifications, Insurance, etc.

FedEx

- Nearest location
- Confirm HAZMAT accepted
- Hours of operation

Equipment & Supplies

- Verify versus Project Scope
- Accessories Kit
- HAZMAT Labels and Cartons

Chains of Custody

Sample must be accompanied by a *Chain of Custody*

- Record of the handling, transfer and storage of the sample from collection to analysis
  - Project ID
  - Sample start and end date/time
  - Source description
  - Sample train used
  - Dry Gas Meter (DGM) temperature
  - Barometric pressure
  - Flow rate
  - DGM correction coefficient
  - DGM volume (initial/final)
  - Corrected volume

Sampling Equipment

Sampling Console

- Calibrated Dry Gas Meters (DGM)
  - Provide volume measurements
    - Correction coefficient
    - Accuracy relative to NIST traceable reference
  - Corrected to standard temperature & pressure
    - Barometric pressure
    - DGM temperature
- Two sampling trains
  - Two samples collected simultaneously

Sample Probe

- A+ Genie passivated stainless steel probe
- PTFE (Teflon) line inserted into gas pipe

Types of Sampling Containers & Media

General Categories

- Tedlar Bags
- High-Pressure Cylinders
- SUMMA Canisters
- Sorbent Traps
- Impingers
- Filters
- Foil Bags
- HAZMAT Shipping

Types of Sampling Containers & Media

Tedlar Bags

- Not recommended as default collection container
- Limited Sample Stability
- Limited Sensitivity
- Potential for Valve Contamination
- Hydrogen passes through bag
- Connect bag to gas source, reducing pressure if necessary

Types of Sampling Containers & Media

High-Pressure Cylinders

- Passivated – Inert Wetted Surfaces
- Recommended as default collection container
  - Major Gases
  - Total & Speciated Sulfur
  - Halocarbons
- Internal pressure equilibrated with source pressure gas
  - For sample pressure < 20 psi, a pump is recommended

Types of Sampling Containers & Media

SUMMA Canisters

- Passivated – Inert Wetted Surfaces
- Recommended as default collection container
  - Volatile Organic Compound (VOCs)
  - Total & Speciated Sulfur (Raw Biogas)
- Sampled from Bypass to an Atmospheric Dump
  - Filled to -4 to -7 “Hg

Types of Sampling Containers & Media

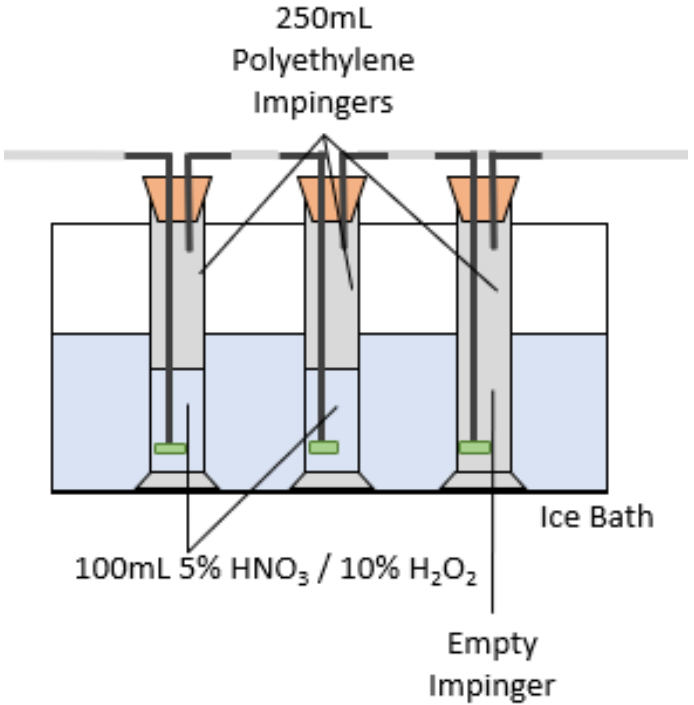
Sorbent Traps

- Highly Recommended
  - Extremely Stable & Sensitive
  - Non-Hazardous Shipment
- Default collection container
  - Mercury (Hg)
  - Siloxanes
  - Inorganic Chlorine & Fluorine
  - Aldehydes & Ketones
  - Ammonia (NH3)
  - Nitroso-n-di-propylamine (NPDA)
  - PCBs & Pesticides
  - Metals (Arsenic, Lead, Antimony, Copper, Cadmium, Chromium, others)
  - Odors, Dust & Liquids
  - Radon
  - Compressor Oil
- Sample for 30 minutes @ 0.5 LPM (Hg)

Types of Sampling Containers & Media

Impingers

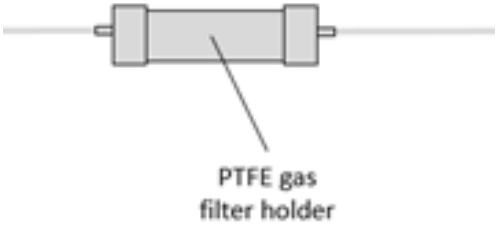
- Required for EPA Method 29 (Metals)
- Complex setup
  - Hazardous chemicals mixed onsite
  - Three impingers in ice bath
  - Polyethylene Bottle preparation
    - Sample
    - Blank
  - Hazardous shipment
- Sample for 60 minutes @ 1 LPM
- Recommend Sorbent Trap alternative

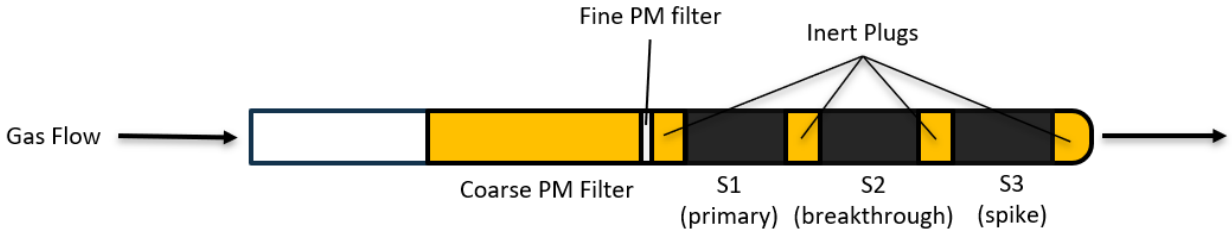


Types of Sampling Containers & Media

Filters

- Required to capture analytes bound to particulate matter, including:
  - Particulates
  - Alpha & Beta particles
  - Bacteria
  - Metals





Types of Sampling Containers & Media

Foil Bag

- Mylar Bag
- Recommended collection container
  - Carbon-14
- Connect bag to gas source, reducing pressure if necessary

HAZMAT Shipping

Federal Regulations are Confusing

Hazardous rating depends on the combination of three factors:

- Gas Flammability
- Gas Pressure
- Container Volume

HAZMAT Shipping

HAZMAT Fundamentals

- Regardless of the container volume, a ***flammable gas under pressur***e is considered hazardous and must be shipped HAZMAT
- A ***non-flammable gas under pressure*** can be shipped as non-hazardous if the Container Pressure is less than 29 psi, and the Container Volume is less than 5 liters
  - We ship HPC (500cc) and SUMMA Canisters (3 liters) to sites filled with nitrogen with a pressure of less than 29 psi to avoid HAZMAT

HAZMAT Shipping

A ***flammable gas not under pressur***e can be shipped as non-hazardous if the container volume is less than the 5-liter limit

- The shipment must go via Ground, as regardless of the pressure, flammable gases are not allowed on aircraft
  - Eliminates this alternative for relatively unstable compounds such as sulfur
- Lab analysis would require pressurizing the sample with Helium to extract the sample gas.
  - Eliminates ability to report Hydrogen concentration
  - Reduces sensitivity

HAZMAT Shipping

Ohio Lumex suggests the following process to quickly certify an employee to ship hazardous materials

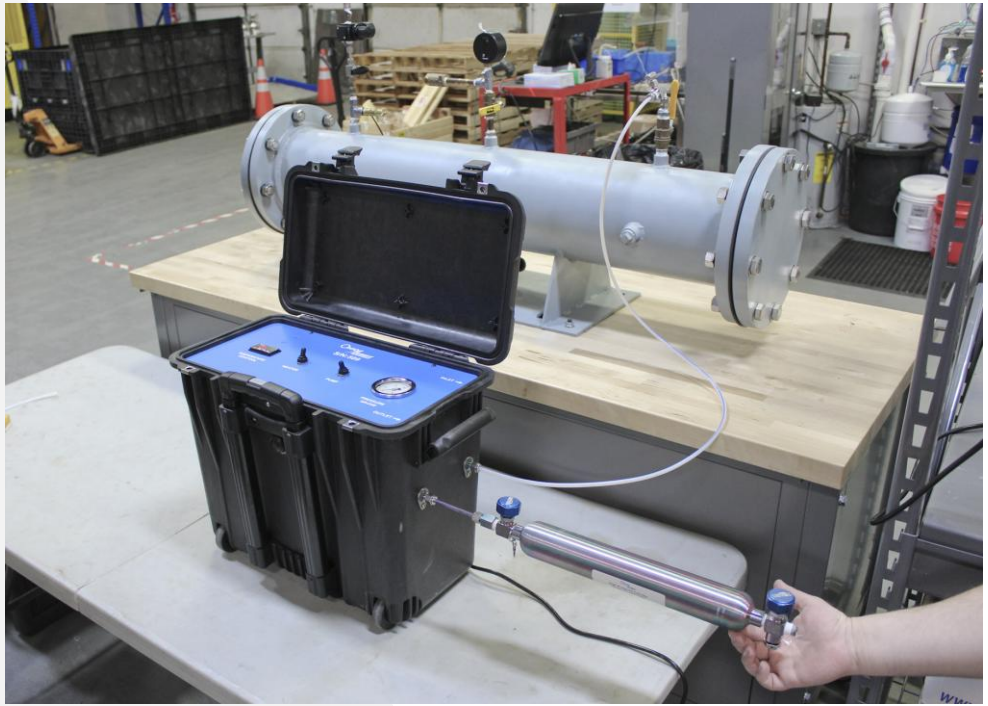
On-Line Course: FedEx Ground On-Line 49 CFR Shipping Course
Web Address: https://www.shipsafeshipsmart.com/ProductDetails.aspx?ProductID=206
Time Needed: Approximately 2 hours

Long-term, transitioning methods to Ohio Lumex Sorbent Traps

- Eliminates the need for hazardous shipments
- Increases sample stability
- Improves sensitivity
- Lowers cost

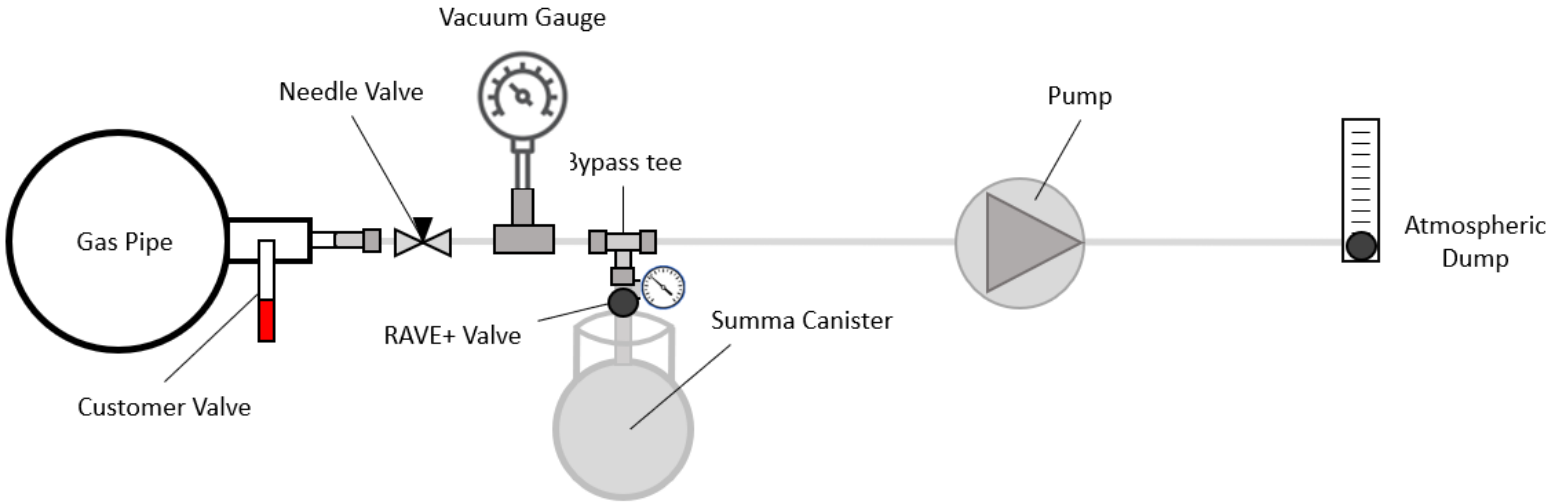
High-Pressure Cylinder

High-Pressure Cylinder (Raw Biogas)



SUMMA Canister

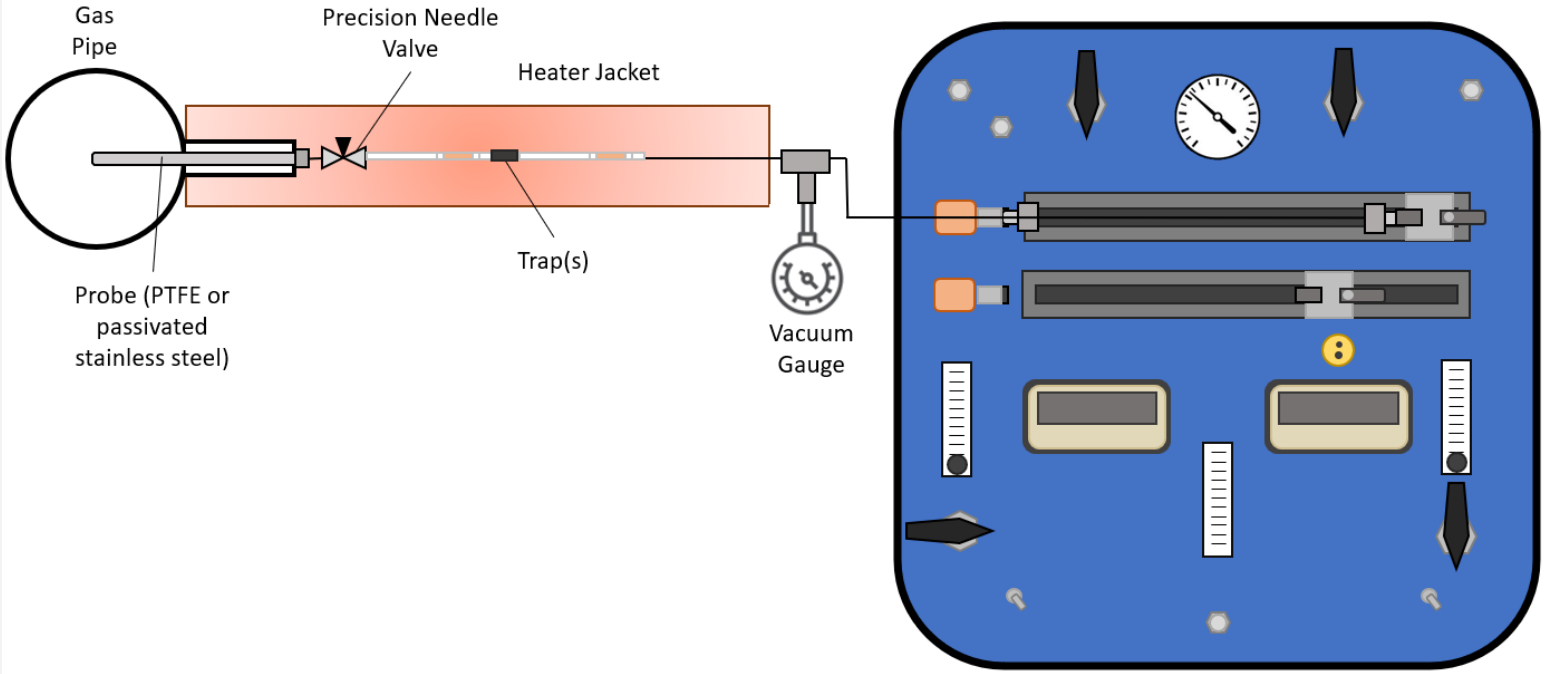
SUMMA Canister (Raw Biogas)



Sorbent Traps

Sorbent Traps (Raw Biogas)

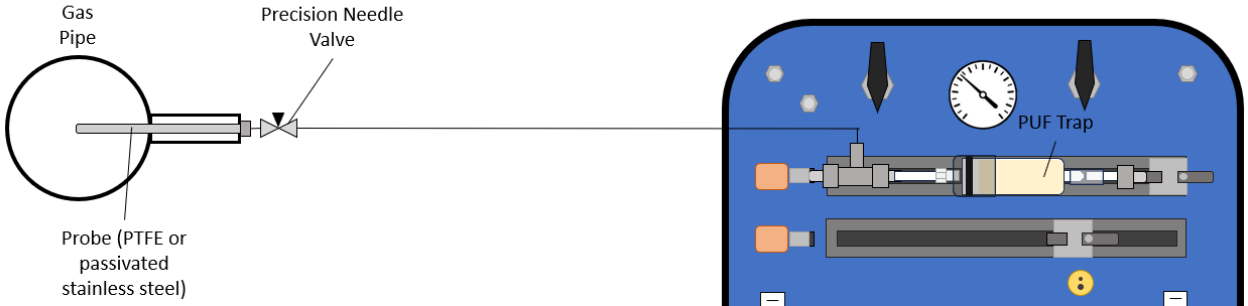
Scenario – Low Pressure, High Moisture



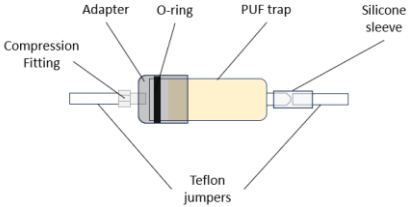
Impingers (Metals via EPA Method 29)

PCBs & Pesticides (PUF Trap)

PCBs and Pesticides Sampling

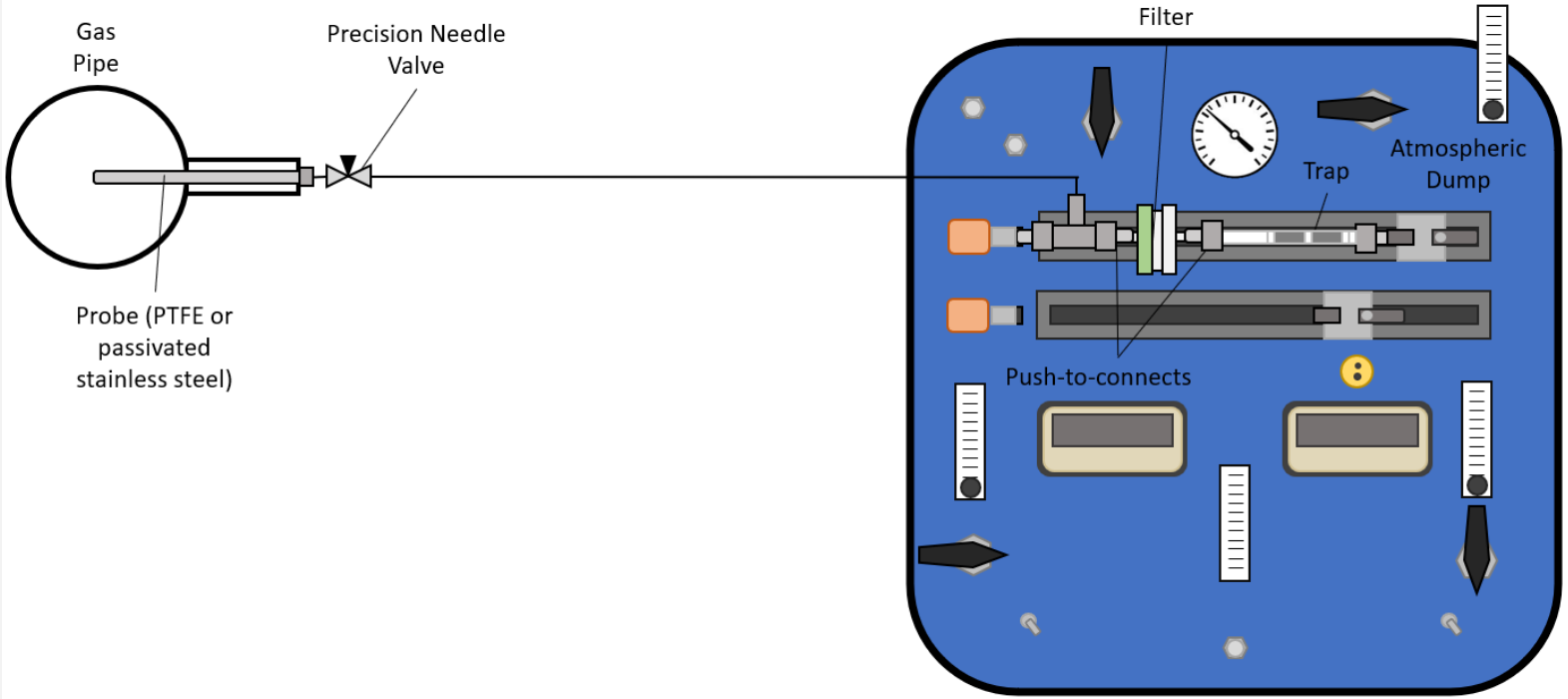


PCBs and Pesticides PUF Trap Assembly



Radiological Testing

Radiological Testing – Filter + Trap



Types of Sampling Containers & Media

Onsite Measurements

- Gas Temperature
- Moisture
  - Length of Stain Tubes (ASTM D4888)
  - Metal Oxide Hygrometer (ASTM D5454)
  - Chilled Mirror Analyzer (ASTM D1142)
- Odors, Dust & Liquids

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Particulates		High-Pressure Filter	ASTM D7651
Compressor Oil		Sorbent Trap	ASTM D8251
VFCs and PFAS		Passivated SUMMA Canister	EPA OTM-50

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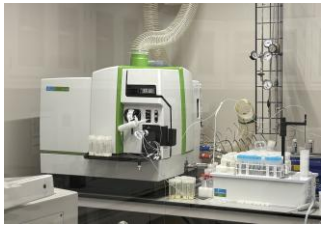
Types of Laboratory Instrumentation

Analytical Laboratory

GC Lab	GC-MS, GC-PFPD, GC-SCD
IC Lab	Ion Chromatograph
Mercury Lab	Spectrometer
Metals Lab	ICP-MS
Microbiology Lab	qPCR
Gravimetric Lab	Glove Box





Continuous Monitoring Summary

Ei2200					
Ei800 & Ei2800				Ei2300	RA915-AMNG
Major Gases	**Hydrocarbons**	**Sulfur**	**BTEX**	**Siloxanes**	**Mercury**
CH4	Methane	Hydrogen Sulfide (H2S)	Benzene	TMSOL	Mercury (Hg)
CO2	Ethane	Carbonyl Sulfide (COS)	Toluene	L2	
CO	Propane	Dimethyl Sulfide	Ethyl Benzene	L3	
H2	i-Butane	Methyl Ethyl Sulfide	Xylenes	L4	
N2	n-Butane	Diethyl Sulfide		L5	
O2	i-Pentane	Methyl Mercaptan		D3	
H2O	n-Pentane	Ethyl Mercaptan		D4	
H2S	C6+	Tertiary Butyl Mercaptan		D5	
Btu	Hexane	Propyl Mercaptan		D6	
	Heptane	Thiophene		Total Si	
	Octane	Isobutyl Mercaptan			
	C9+	Tetrahydrothiophene (THT)			
		Butyl Mercaptan			

One-Stop-Shop for Gaseous Fuels Analysis

- **Analyzers and Equipment**
  - Ei800/2800 Biogas/RNG/NG Monitoring System
  - Ei2300 Siloxane Monitoring System
  - Ei2200 RNG Monitoring System
  - RA915-AMNG Mercury Monitor
  - Sampling Equipment, Supplies and Guides
- **Analytical Laboratory (NELAP, ISO Accredited)**
  - Laboratory Analysis
  - Methods Development
- **Onsite Field Services**
  - Onsite Sample Collection (Certified Field Technicians)
  - Commissioning & Start Up
  - Training, Support & Service

Experience Matters

Trust the Experts

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ASTM D03 Gaseous Fuels Committee
- Chair D03.01
  Collection and Measurement of Gaseous Samples
- Vice Chair D03.06
  Analysis of Constituents in Gaseous Fuels

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