ONE GAS (OGS) BIOMETHANE SPECIFICATION AND QUALITY MANAGEMENT PROGRAM

Effective Date: 11/15/2022

1. SCOPE

1.1. The purpose of this document is to establish contract requirements for Biomethane quality, limits on constituents of concern, properties, testing requirements, and procedures for biomethane sourced deliveries into ONE Gas (OGS) Receipt Points.

2. DEFINITIONS

2.1. **ASTM**: American Society for Testing Materials.

2.2. **QUALITY ASSURANCE PROGRAM ADMINISTRATOR (Administrator)**: The Administrator will verify compliance with OGS Biomethane gas quality specification. The Administrator may be an employee of OGS, or a representative contracted by OGS.

2.3. **BIOGAS**: Biogas refers to gas that is produced from the anaerobic decomposition of organic material. Biogas can be produced by a landfill gas management facility, wastewater treatment plant, anaerobic digester, or by other methods and sources. Biogas is a mixture of methane, carbon dioxide, and other Constituents, and must be conditioned into Biomethane prior to receipt into the natural gas pipeline system.

2.4. **BIOMETHANE**: Biomethane refers to Biogas that has been conditioned and conforms to the specifications contained herein for receipt into a common carrier pipeline. Biomethane must be free from bacteria, pathogens, and any other substance injurious to utility facilities, or other Constituents that would cause the Biogas to be unmarketable. Biomethane must conform to all other tariffs and standard utility operating practices and guidelines.

2.5. **BIOMETHANE SUPPLIER (Supplier)**: A Supplier of Biomethane seeking to deliver Biogas to the OGS Receipt Point.

2.6. **BRITISH THERMAL UNIT (Btu)**: The standard unit for measuring a quantity of thermal energy.

2.7. **Ccf**: The standard unit for a volume of gas equivalent to one hundred cubic feet of gas under Standard Conditions.

2.8. **CONSTITUENT**: A chemical or compound that may impact the merchantability of gas.

2.9. **CONTINUOUS TESTING**: The use of onsite instruments and analyzers for the measurement of Constituents of concern, operating conditions, flow rates and gas properties, performed in short term intervals without manual intervention.

2.10. **EPA**: United States Environmental Protection Agency.

2.11. **FEEDSTOCK**: Raw material supply used to produce Biogas.

2.12. **GRAIN**: The standard unit of weight equivalent to one seven-thousandth of one pound.

2.13. **HAZARDOUS WASTE LANDFILL**: All contiguous land and structures, and other appurtenances and improvements, on the land used for the treatment, transfer, storage, resource recovery, disposal, or recycling of hazardous waste. The facility may consist of one or more treatment, transfer, storage, resource recovery, disposal, or recycling hazardous waste management units, or combinations of these units.

2.14. **Maximum Daily Quantity (MDQ)**: The maximum daily quantity of Biomethane that may be delivered by the Supplier and accepted by OGS at the Receipt Point. OGS may interrupt delivery and will not be required to accept delivery of Biomethane up to the MDQ if operational conditions or lack of customer demand and consumption exist that would restrict the amount of Biomethane that OGS's Receipt Point can accept.

2.15. **Mcf**: The standard unit for a volume of gas equivalent to one thousand (1,000) cubic feet of gas under Standard Conditions.

2.16. **PPB (Parts per Billion)**: Standard unit for the concentration of a Constituent relative to one billion parts.

2.17. **PPM (Parts per Million)**: Standard unit for the concentration of a Constituent relative to one million parts.

2.18. **PHF (Peak Hourly Flow)**: The maximum hourly flow rate of RNG that may be delivered by Supplier and accepted by OGS at the Receipt Point. OGS may interrupt delivery and will not be required to accept delivery of RNG up to the PHF if operational conditions or lack of customer demand and consumption exist that would restrict the amount of RNG that OGS's Receipt Point can accept.

2.19. **RECEIPT POINT**: The place where OGS receives natural gas from a Supplier.

2.20. **RENEWABLE NATURAL GAS (RNG)**: Renewable natural gas is any pipeline compatible gaseous fuel derived from biogenic or other renewable sources that has lower lifecycle $CO2_e$ emissions than geological natural gas. Biomethane is one category of gases considered RNG.

2.21. **SHUT-IN**: The action of not allowing the Supplier to deliver Biomethane into the OGS Receipt Point.

2.22. **STANDARD CONDITIONS**: Conditions of temperature and pressure that are used as a basis for volumetric measurement of a gas equivalent to 60 degrees Fahrenheit and 14.73 pounds per square inch atmosphere (PSIA).

3. TESTING ACTION LEVELS:

3.1. **INITIAL ALERT OR TRIGGER LEVEL**: The concentration or measured value of a Constituent requiring additional periodic testing and analysis.

3.2. **LOWER ACTION LEVEL**: The concentration or measured value of a Constituent, used to screen Biomethane during the initial gas quality review and ongoing periodic testing, requiring a shut-off of RNG supply if exceeded three times in a 12-month period.

3.3. **UPPER ACTION LEVEL**: The concentration or measured value of a Constituent requiring an immediate shut-off of Biomethane supply.

4. QUALITY OF GAS

4.1. Gas delivered to OGS conform to the Quality specifications in Tables 1 and 2. Acceptable Values for Constituents or parameters is defined as values either at, or between the minimum and maximum values in Table 1; and Constituents in Table 2 must be less than, or equal to the Lower Action Level values.

4.2. Carbon dioxide (CO_2): The gas shall contain no more than two percent (2%) by volume basis of carbon dioxide.

4.3. Oxygen: The gas shall contain no more than 2000 ppm of oxygen if the CO_2 level is less than or equal to one percent (≤ 1%) by volume. Additionally, the gas shall contain no more than 10 ppm of oxygen if the CO_2 level is greater than one percent (1%) and less than or equal to two percent (2%) by volume (1% < CO_2 level ≤ 2%).

4.4. Hydrogen sulfide: The gas shall contain more than 4 ppm by volume basis of hydrogen sulfide.

4.5. Total Sulfur: The gas shall contain no more than twenty (20) grains of total sulfur, measured as sulfur, per one hundred (100) standard cubic feet.

4.6. Water vapor: The gas shall contain no more than 7 pounds per million standard cubic feet (lbs/MMSCF) of water vapor.

4.7. Hydrocarbon dew point: The gas shall have a hydrocarbon dew point of no more than minus 25 degrees Fahrenheit.

4.8. Liquids: The gas shall contain no liquids at the Receipt Point.

4.9. Merchantability: The gas shall not contain objectionable odors, solid matter, dust, gums and gum-forming Constituents, biologicals, heavy metals, or any other substance which might interfere with the marketability of the gas, or cause injury to or interference with proper operation of the lines, meters, regulators, or other appliances through which it flows.

4.10. Pressure: The gas pressure at the Receipt Point will be determined on an application basis and shall be sufficient to enter OGS's pipeline system, but in no event in excess of the maximum allowable operating pressure of OGS's meter setting.

4.11. Temperature: The maximum gas temperature at the Receipt Point shall be determined on an application specific basis. Typical temperature limits are approximately 80 degrees Fahrenheit for gas entering polyethylene mains and approximately 120 degrees Fahrenheit for gas entering steel mains.

4.12. Flow Rate: The flowrate of the gas shall be uniform without significant swings in flow. At no time will the flowrate of the gas exceed the Peak Hourly Flow (PHF).

4.13. Heating value: The gas shall have a gross heating value range of greater than or equal to 980 btu/scf and less than or equal to 1,100 btu/scf (980 btu/scf ≤ heating value ≤ 1100 btu/scf).

4.14. The Biomethane shall be tested for the Quality specifications at the Supplier's location after processing and before it reaches OGS's facilities.

4.15. The gas quality and measurement of the Biomethane delivered by Supplier shall be based on the analytical instruments recorded by both the Supplier and OGS. The measurement shall be based on the Supplier's meter. OGS will have check measurement.

4.16. Any gas quality testing conducted by OGS shall control over any disputed variation from and similar or duplicative tested conducted by the Supplier.

4.17. Tables 1 and 2 show testing methodology and frequency of testing. Supplier may offer alternative testing methodology and frequency for OGS to consider, but OGS reserves the right to make the final decision.

4.18. OGS reserves the right to approve and adopt other gas quality testing requirements, testing methods, frequency of tests, and testing equipment, now or as may be changed from time to time in the future. Approving and adopting changes to this quality specifications are within the sole discretion of OGS. OGS may approve and adopt changes to the specifications for reasons including but not limited to the following:

4.18.1. Regulatory mandates

4.18.2. Constituents of concern that either are new to the Biomethane industry or have been found to present increased risks to natural gas infrastructure or customers; and/or

4.18.3. Gas quality standards or best practices developed by the Natural Gas Industry associations or groups and adopted by OGS.

4.19. OGS will communicate the effective date of such prospective changes, if any, to Supplier. In addition, OGS will coordinate with Supplier in an effort to reduce any negative impact of any imposed change to gas quality testing requirements, testing methods, testing frequency, and testing equipment, on Supplier's existing operations. The cost of any additional equipment needed by Supplier to implement revised testing requirements, testing methods, frequency of testing, and testing equipment shall be borne by Supplier.

4.20. OGS reserves the right to Shut-In a Supplier whose Biomethane repeatedly violates this specification until such time Supplier can provide evidence that the Biomethane consistently meets this specification.

4.21. OGS will not accept Biomethane from a Hazardous Waste Landfill or from a Supplier using production methods that create an environmental, pipeline or safety hazard.

5. TESTING

5.1. Supplier Responsibility for Testing

5.1.1. Supplier will be responsible for owning, operating, calibrating, maintaining, and replacing- (when necessary), gas quality monitoring & measurement equipment, i.e., gas chromatograph, moisture analyzer, H_2S analyzer, btu analyzer, flow measurement, remote terminal unit (RTU), pressure transducer(s) and temperature transducer(s). A siloxane analyzer will be required for only landfill and sewage Feedstock, if requested by OGS. Gas quality monitoring & measurement equipment to be approved by OGS. At a minimum, equipment will be calibrated and tested to the manufacturer's specifications, at prescribed intervals. All equipment calibration and test documentation to be shared with OGS. Supplier is responsible for the associated costs.

5.1.2. Supplier shall provide OGS access to the results of the Continuous Testing. Results will be made available to OGS via a read only data connection(s) provided at the Supplier's metering point. Supplier is responsible for providing all parts, labor, equipment and electrical supply associated with accessing this data connection for OGS's use.

5.1.3. Supplier shall select a certified Test Lab capable of testing the Biomethane for all Constituents identified in these specifications. Prior to pre-delivery testing, Supplier shall provide the name and contact information to the Administrator. The certified Test Lab must be approved by OGS.

5.1.4. Supplier shall grant the Test Lab permission to share the results of the Biomethane testing directly with the Administrator and OGS.

5.1.5. Supplier shall provide the Administrator details on the sampling location on the Biomethane process piping used for compliance with this specification for review and approval by OGS.

5.1.6. Supplier will provide the Administrator gas sampling procedures and ensure proper gas sampling techniques and shipping procedures are followed.

5.1.7. Supplier will notify the Administrator a minimum of 48 hours prior to collecting a gas sample so the Administrator or OGS has the ability to schedule a representative to observe and/or audit the collection of the gas sample.

5.1.8. Supplier is responsible for all labor and costs associated with collecting, shipping, and laboratory analysis of the gas samples.

5.1.9. Sampling must be conducted on a day such that no more than two days pass before the samples are received by the Test Lab.

5.1.10. Supplier must contact the Administrator immediately if the shipping procedure cannot be completed per Section 5.1.9.

5.1.11. The date, time, and name of individual collecting the gas sample must be documented.

5.1.12. Supplier will notify the Administrator in writing of any changes in Feedstock that may significantly affect the concentrations of Constituents of concern a minimum of 30 days prior to producing Biomethane from the new Feedstock and a written explanation of the expected impact to the quality.

5.1.13. Supplier will notify the Administrator in writing of any changes in operating conditions and/or processes that may significantly affect the quality of the Biomethane and a written explanation of the expected impact to the quality.

5.1.14. If the Feedstock is from a landfill, it is the responsibility of the Supplier to disclose whether such landfill is a site of hazardous waste, or has ever been a site of hazardous waste, contains hazardous waste, or ever accepted hazardous waste. Supplier shall demonstrate verification from an approved company that Biomethane does not originate from hazardous waste before gas flows into ONE Gas' pipeline system. Supplier will be

responsible for the cost of the environmental due diligence assessment prior to the execution of the interconnect agreement.

5.1.15. If either party Shuts-in the other, that party shall immediately notify the other.

5.1.16. Prior to delivering to the OGS Receipt Point, whether initially or a restart, Supplier must request and receive written consent from ONE Gas Control.

5.1.17. Supplier will be responsible for all Biomethane received being within the parameters stated in Table 1. Supplier will be responsible for measuring, calculating, and reporting the actual values listed in Table 1, on a continuous basis, or at a frequency based on the normal cycle time of the applicable instrument(s), but not less frequent than once every eight (8) minutes.

5.1.18. Additionally, Supplier will be responsible for meeting Biomethane Constituent levels/parameters identified in Table 2, depending on the Feedstock.

5.1.19. In the event OGS rejects Biomethane for being outside of any specified gas quality range, it is the Supplier's responsibility to accept the rejected Biomethane from the Receipt Point.

5.1.20. Supplier shall provide thirty (30) days advance written notice to OGS before changing its RNG Feedstock, Feedstock source, or Biomethane conditioning process.

5.1.21. OGS shall have the right to share testing information received or taken by OGS, with appropriate parties.

5.1.22. OGS reserves the right to revise the testing guidelines in these specifications by OG as needed.

5.2. Pre-Delivery Raw Biogas Testing

5.2.1. If required by OGS, Supplier will conduct testing on the raw Biogas for all Constituents listed in Table 3. These gas quality tests will be performed using the Test Lab and results shared directly with the Administrator and the Supplier.

5.3. Pre-Delivery Biomethane Testing Procedure

5.3.1. Supplier will conduct testing on the Biomethane for all Constituents listed in Table 1. These gas quality tests will be performed using the Test Lab and results shared directly with the Administrator and the Supplier.

5.3.2. Pre-delivery Biomethane testing must yield Acceptable Values in order to advance to Start-up; Constituents in Table 1 must be at, or between the minimum and maximum values; and Constituents in Table 2 must be less than, or equal to the Lower Action Level values.

5.3.3. If any of the Constituent concentrations are outside the Acceptable Values defined above, then Supplier shall make necessary modifications to maintain the Constituent concentrations at the Acceptable Values.

5.4. Biomethane Periodic Testing

5.4.1. Supplier will conduct testing on the Biomethane for all Constituents listed in Tables 1 and 2. These gas quality tests will be performed per the indicated frequency and using the Test Lab. The results will be shared directly with the Administrator and the Supplier.

5.4.2. Supplier shall make necessary modifications to maintain Constituent concentration within the Acceptable Values.

5.4.3. All PASS/FAIL decisions points are determined by a simple comparison of the Test Lab results to OGS's defined Acceptable Values from Tables 1 and 2.

5.4.4. If the tested Constituents are within the Accepted Values, the sample(s) is considered a PASS. The Administrator will provide a report per the approved communication protocols with concentrations and comparisons to the Acceptable Values.

5.5. Relaxation of Periodic Testing

5.5.1. Supplier must first submit a written request to the Administrator and then receive approval from OGS prior to relaxation of any periodic testing requirements.

5.5.2. OGS may reduce the frequency of periodic laboratory-based gas quality testing from monthly to quarterly (but not to exceed 100 days) provided:

5.5.3. Supplier's Biomethane facility has been in service for a minimum of one year.

5.5.4. Periodic laboratory tests from the previous year are within the Acceptable Values.

5.5.5. OGS may reduce the frequency of the laboratory gas quality testing for biologicals from monthly to once per calendar year (but not to exceed 14 months) provided:

5.5.6. Supplier installs a product gas filter to prevent biologicals from entering the OGS system.

5.5.7. The filter must have normal efficiency of 99.98% at 0.2 micron.

5.5.8. The piping configuration does not allow for bypassing the filter.

5.5.9. OGS may remove the laboratory-based biological testing requirements for Supplier provided the conditions of the section above are met and the filter is monitored to detect filter failure, or the filter element is replaced annually.

5.5.10. OGS may remove the laboratory-based biological testing requirements for Suppliers using membrane gas separation processes.

5.5.11. OGS may remove the laboratory-based gas quality testing requirements for Constituents of concern that are not present in the raw biogas at concentrations greater than twenty percent (20%) of the gas quality specification limits provided:

5.5.12. Raw biogas is tested once per calendar year not to exceed 14 months.

5.5.13. This provision does not apply to siloxane testing.

5.5.14. OGS may remove Hydrocarbon Dew Point testing if less than two percent (2%) of the energy content of the Biomethane is from a non-methane source, based gross heating value.

5.6. Biomethane Start-Up Procedure

5.6.1. The Biomethane start-up shall be scheduled with the Administrator and OGS.

a) OGS Gas Control and Engineering shall be notified a minimum of forty-eight (48) hours prior to delivery of the Biomethane into OGS's facilities.

5.6.2. Supplier shall have performed pre-delivery testing no more than thirty (30) days prior to start-up.

5.6.3. Supplier will conduct Continuous Testing on the Biomethane. All quality specifications shall be within the Acceptable Values for a minimum of two (2) readings or ten (10) minutes prior to accepting delivery of the Biomethane into OGS's system. OGS's on-site analytical equipment will be used to check the Supplier's readings.

5.7. Biomethane Re-Start

5.7.1. If Shut-In of the Biomethane was caused by Constituent concentration that is tested on a continuous basis being outside of the Acceptable Values, then:

a) Supplier shall make necessary modifications to maintain Constituent concentration within the Acceptable Values.

b) The Constituent concentration must be within the Acceptable Values for two (2) subsequent tests of a minimum of ten (10) minutes before Biomethane delivery into OGS's system will be allowed to resume.

5.7.2. If Shut-In of the Biomethane was caused by Constituent concentration that is tested on a periodic basis being outside the Acceptable Values, then:

a) Supplier shall make necessary modifications to maintain Constituent concentration within the Acceptable Values.

b) The Constituent concentrations that are tested on periodic basis must be tested no more than 30 days prior and all Constituent concentrations shall within the "Acceptable Values" before Biomethane delivery can resume.

c) The Constituent concentrations that are tested on a continuous basis must be within the Acceptable Values for two (2) subsequent tests or a minimum of ten (10) minutes before Biomethane delivery can resume.

5.7.3. If a Shut-In of the Biomethane was caused by any other issue not related to the quality specifications, then:

a) The Constituent concentrations that are tested on a continuous basis must be tested no more than the periodic testing interval prior and all Constituent concentrations shall be within the Acceptable Values before the Biomethane can resume.

b) The Constituent concentrations that are tested on a continuous basis must be within the Acceptable Values for two (2) subsequent tests or a minimum of ten (10) minutes before Biomethane delivery can resume.

5.8. Communication Protocol

5.8.1. It is imperative that good communication pathways are established and maintained between all parties involved in the testing process.

a) Supplier will provide a phone number and email address that is monitored 24/7/365.

b) OGS will provide contact info for Gas Control, Engineering, Pressure, Control, and Operations.

c) Test Lab will provide appropriate contact information.

d) The Administrator will provide appropriate contact information.

5.8.2. OGS Continuous & Monthly Testing

a) Supplier must notify OGS immediately of substantive expected changes to the raw gas quality or upgrading process that have the potential to impact Biomethane quality and an explanation of the expected impact.

b) OGS will notify Supplier immediately that Shut-In of the Biomethane has occurred. The notification may be provided via the data connection used to share the results of OGS's testing. If Shut-In occurs due to Supplier testing, Supplier will notify OGS Gas Control and Pressure Control & Operations immediately.

Table 1 - ONE Gas Quality Specifications

CONSTITUENT/PARAMETER	INITIAL ALERT or TRIGGER LEVEL	MIN VALUE LEVEL	MAX VALUE LEVEL	UPPER ACTION LEVEL	TEST METHOD	FREQUENCY
Methane (CH4 %)	≤ 95	97		94	Gas Chromatograph	Continuous
Heating Value (btu/scf)	≤ 965	980	1100	≤ 960 or ≥ 1115	Gas Chromatograph	Continuous
Wobbe Number	≤ 1269 or ≥ 1401	1270	1400	≤ 1268 or ≥ 1402	On-site analytical instrument	Continuous
Temperature (°F)	≤ 35 or ≥ 90	40	86	≤ 30 or ≥ 95	On-site analytical instrument	Continuous
Carbon Dioxide (CO2 %)	≥ 1.8		2	> 2.1	On-site analytical instrument Laboratory testing per ASTM D1946	Continuous
Nitrogen (N2 %)	≥ 1.8		2	> 2.1	Gas Chromatograph	Continuous
Oxygen (O2 ppm) if CO2 at 1% Oxygen (O2 ppm) if CO2 at 2%	≥ 0.18 0.0009		2000 10	2100 50	On-site analytical instrument	Continuous
Total Inerts (%)	≥ 3.5		4	> 4.1	Gas Chromatograph	Continuous
Hydrogen Sulfide (H2S grain/ccf)	≥ 0.20		0.25	> 0.26	Sulfur Analyzer	Continuous
Total Sulfur (grain/ccf)	≥ 0.80		1	≥ 1.5	Sulfur Analyzer	Continuous
Moisture (lbs /MMSCF)	≥ 5		7	> 7.1	Moisture Analyzer	Continuous
Hydrocarbon Dew Point (°F)	– 15	– 25	– 10	≥ – 9	Calculation based on Laboratory analysis	Monthly

Table 2-ONEGas Constituent Concentrations for Biomethane – RNG

Constituent	Initial Alert or Trigger Level mg/m³ (ppmv)	Lower Action Level mg/m³ (ppmv)	Upper Action Level mg/m³ (ppmv)	Landfill	WWTP	Dairies or Food Waste	SOME POSSIBLE TEST METHODS	FREQUENCY
Biomethane – RNG Quality Specification				x	x	x		
Health Protective Constituents - Carcinogenic								
Arsenic	0.019 (0.006)	0.19 (0.06)	0.48 (0.15)	x			ICP-MS (EPA Meth. 29, EPA Comp. Meth. IO-3.5) GC-AED	Monthly
P-Dichlorobenzene (VOC)	5.7 (0.95)	57 (9.5)	140 (24)	x	x		GC/MS, EPA Compendium Methods TO-15 or TO-14A or GC-AED	Monthly
Ethylbenzene (VOC)	26 (6.0)	260 (60)	650 (150)	x	x	x	GC/MS, EPA Compendium Methods TO-15 or TO-14A or GC-AED	Monthly
n-Nitroso-di-n-propylamine (VOC)	0.033 (0.006)	0.33 (0.06)	0.81 (0.15)	x		x	Solvent extraction (EPA Method 3542) & GC-MS (EPA 8270)	Monthly
Vinyl Chloride	0.84 (0.33)	8.4 (3.3)	21 (8.3)	x	x		GC/MS, EPA Compendium Methods TO-15 or TO-14A or GC-AED	Monthly
PCB's/Pesticides	0.8 ppbv	0.9 ppbv	1 ppbv	x	x		PUF/XAD sorbent tube sampling-EPA Methods 8082 or TO-10A	Monthly
Health Protective Constituents – Non-Carcinogenic								
Antimony (*volatile metal*)	0.60 (0.12)	6.0 (1.2)	30 (6.1)	x			Inductively Coupled Plasma-MS (EPA 29, EPA Comp. Meth IO-3.5)	Monthly
Copper	0.060 (0.02)	0.60 (0.23)	3.0 (1.2)	x			Inductively Coupled Plasma-MS (EPA 29, EPA Comp. Meth IO-3.5)	Monthly
Lead (non-*volatile metal*)	0.075 (0.009)	0.75 (0.09)	3.8 (0.44)	x	x		ICP-AES (NIOSH Method 7303)	Monthly
Other Volatile Metals (includes, but not limited to Zn, Cr and Mn)	19 µg/m³	20 µg/m³	30 µg/m³	x	x		Inductively Coupled Plasma-MS (EPA 29, EPA Comp. Meth IO-3.5)	Monthly
Methacrolein	1.1 (0.37)	11 (3.7)	53 (18)	x			Extraction with acetonitrile and HPLC, EPA Comp. Meth. TO-11A)	Monthly
Alkyl Thiols (Mercaptans)	N/A (12)	N/A (120)	N/A (610)	x	x	x	GC-SCD (ASTM Meth. D5504) or GC FPD/GC PFPD (ASTM D6228)	Monthly
Toluene	904 (240)	9,000 (2,400)	45,000 (12,000)	x	x	x	Laboratory testing per TO15	Monthly
Pipeline Integrity Protective Constituents								
Ammonia	(9)	(10)	(11)	x	x	x	Laboratory testing per ASTM D1945/D1946, NIOSH 6015	Monthly
Total Biologicals	$4x10^4$/scf and free of < 0.2-micron filter			x	x	x	Use of a ≤ 0.2-micron filter to assess the presence of total bacteria/spores	Monthly
Hydrogen	0.1%	0.2%	0.3%	x	x	x	Laboratory testing per ASTM D1945/D1946	Monthly
Mercury (includes Mercury and Mercury-based derivatives)	0.05 µg/m³	0.08 µg/m³	0.1 µg/m³	x	x	x	ASTM D5954, D6350 (gold sorbent, on-line and off-line)	Monthly
Siloxanes	0.01 mg Si/m³	0.1 mg Si/m³	0.5 mg Si/m³	x	x		ASTM D8230, gas chromatography (off-line canister collection) with atomic emission detection (GC-AED) or mass spectral detection (GC-MS) or siloxane analyzer	Monthly or Daily
Aldehydes and Ketones	80 ppbv	100 ppbv	120 ppbv	x			EPA TO-14 (off-line DNPH sorbent) or EPA TO-11	Monthly
Terpenes.	0.8 ppmv	1 ppmv	2 ppmv	x	x	x	TDS-GC-MS µGC-TCD	Monthly
Environmental								
Halocarbons (includes, but not limited to freons and chloroethane)	0.9 ppmv	0.1 ppmv	0.15 ppmv	x	x		EPA TO-14, TO-15 (off-line canister collection)	Monthly

Note: The first number is in milligrams per cubic of air (mg/m³), while the second number in parenthesis is in parts per million (ppmv), unless otherwise specified.

Table 3- RAW GAS CONSTITUENT TESTING AND METHOD

CONSTITUENT	POSSIBLE TEST METHOD
Hydrogen	Laboratory testing per ASTM D1946
Oxygen	Laboratory testing per ASTM D1946
Nitrogen	Laboratory testing per ASTM D1946
Carbon Dioxide	Laboratory testing per ASTM D1946
Methane	Laboratory testing per ASTM D1946
Heating Value	Calculated per ASTM D3588
Relative Density	Calculated per ASTM D3588
Hydrogen Sulfide	Laboratory testing per ASTM D6228
Total Sulfur	Laboratory testing per ASTM D6288
Trace Halocarbons and VOCs	Laboratory testing per EPA TO-15
Total Organic Silicon	Laboratory testing per ASTM D8230

1. Raw gas testing may be required to startup and commissioning, then once per calendar year not to exceed 14 months.
2. Raw gas testing may be required for reducing the periodic testing frequency.
3. It is assumed that all raw gas will be saturated with water and contain bacteria.

REFERENCES

Aldehydes- An organic compound which incorporates a carbonyl functional group, C=O, bonded on one side to a hydrogen atom and on the other side to a hydrocarbon group. Aldehydes and ketones are chemically similar. They can be found in waste streams containing building materials such as OSB (oriented strand board), MDF (medium-density fiberboard), carpet and linoleum/vinyl flooring, other pressed wood products, hardwood and plywood paneling, upholstery fabrics, latex-backed fabrics, fiberglass, and urea formaldehyde foam insulation.

Ammonia- Ammonia is a colorless inorganic compound of nitrogen and hydrogen with the formula NH3, usually in gaseous form with a characteristic pungent odor. Ammonia is potentially encountered in anaerobic digestion of organic waste.

Antimony- is a lustrous gray metalloid and is found in nature mainly as the sulfide mineral stibnite (Sb_2S_3). It can be harmful to the eyes and skin. Antimony can also cause problems with the lungs, heart, and stomach.

Arsenic- Arsenic is a natural element that can be found in rocks and soil, water, air, and in plants and animals. People can also be exposed to arsenic in the environment from some agricultural and industrial sources.

Copper- Copper toxicity (or Copperiedus) is a type of metal poisoning caused by an excess of copper in the body.

Ethylbenzene-is an aromatic hydrocarbon that belongs to the group volatile organic compounds (VOC). It is a very flammable, colorless liquid with a gasoline-like odor.

Halocarbons – Organic compounds containing the elements fluorine (F), chlorine (Cl), bromine (Br), and iodine (I), which make up the seventh period in the periodic table of the elements. They are a class of organic compounds containing carbon, one or more halogens, and sometimes hydrogen used as an aerosol and refrigerant, and polymerized to make plastics. Compounds which consist of these elements are often used in disinfectant solutions, or as refrigerant gases in air conditioning and other cooling equipment. Upon degradation, the elements may be released as gases. For example, these constituents include Freons, chloroethane and vinyl chloride.

Heating Value- Gross heating value, also known as Higher Heating Value (HHV), is defined as the amount of energy transferred as heat from the complete, ideal combustion of the gas with air, at a standard temperature, in which all the water formed by the reaction condenses to liquid. Another commonly seen heating value parameter is net heating value, or Lower Heating Value (LHV). The difference between HHV and LHV is that the water produced by combustion remains in the vapor state when determining the LHV. The energy gained by the condensation of the water vapor is not realized so the heating value is lower. Heating values are also often reported as wet or dry. Wet gas refers to gas that is completely saturated with water vapor. A wet gas has a lower heating value per volume than a dry gas because some of the gas volume is occupied by the water vapor, so the absolute amount of combustible gas is less. The North American Energy Standards Board recommends utilizing the HHV expressed on a dry basis.

Hydrocarbon Dewpoint Temperature- The hydrocarbon dew point temperature (HDP) is the temperature of the corresponding state condition at which the non-methane hydrocarbon components of natural gas begin to condense into the liquid phase.

Hydrogen- Hydrogen is a clean fuel that, when consumed in a fuel cell, produces only water. Hydrogen can be produced from a variety of domestic resources, such as natural gas, nuclear power, biomass, and renewable power like solar and wind. Hydrogen is the chemical element with the symbol H and atomic number 1. Hydrogen is the lightest element. At standard conditions hydrogen is a gas of diatomic molecules having the formula H_2. It is colorless, odorless, tasteless, non-toxic, and highly combustible. Hydrogen is the most abundant chemical substance in the universe, constituting roughly 75% of all normal matter.

Ketone- An organic compound which incorporates a carbonyl functional group, C=O, bonded on both sides to a hydrocarbon group. Aldehydes and ketones are chemically similar. They can be found in waste streams containing building materials such as OSB (oriented strand board), MDF (medium-density fiberboard), carpet and linoleum/vinyl flooring, other pressed wood products, hardwood and plywood paneling, upholstery fabrics, latex-backed fabrics, fiberglass, and urea formaldehyde foam insulation.

Lead- Lead is a naturally occurring element found in small amounts in the earth's crust. While it has some beneficial uses, it can be toxic to humans and animals, causing health effects. Lead can affect almost every organ and system in your body. Children six years old and younger are most susceptible to the effects of lead.

Mercaptans (Alkyl Thiols)- Mercaptans, commonly referred to as thiols, are organosulfur molecules composed of carbon, hydrogen, and sulfur that are known for having a pungent odor like rotten cabbage or garlic. In nature, these compounds can be found in living organisms as a waste product of metabolism, and in oil and gas. While their odor is usually a nuisance, it can be used for gas detection purposes. For example, in natural gas, non-corrosive mercaptans are added to it to detect it.

Mercury- Mercury poisoning is a type of metal poisoning due to exposure to mercury. Symptoms depend upon the type, dose, method, and duration of exposure. They may include muscle weakness, poor coordination, numbness in the hands and feet, skin rashes, anxiety, memory problems, trouble speaking, trouble hearing, or trouble seeing.

Methacrolein- Methacrolein, or methacrylaldehyde, is an unsaturated aldehyde. It is a clear, colorless, flammable liquid. Exposure to methacrolein is highly irritating to the eyes, nose, throat, and lungs.

n-Nitroso-di-n-propylamine-is a chemical produced by industry in small amounts for research. It is a yellow liquid at room temperature.

PCBs- Polychlorinated Biphenyls are synthetic chlorinated chemicals that were produced for approximately 50 years between the 1920's and the 1970's. The mixtures were sold under the registered trademark of "Aroclor" followed by a 4-digit code. PCB oils used to be used as compressor lubricants for natural gas pipeline transmission lines. In 1976 Congress passed the Toxic Substances Control Act (TSCA) which banned their use.

p-Dichlorobenzene (PDCB)- is a chlorinated volatile organic compound (VOC) that can be encountered at high concentrations in buildings due to its use as pest repellent and deodorant.

Siloxanes- Any chemical compound composed of units of the form R2SiO2, where R is a hydrogen atom or a hydrocarbon group. A siloxane has a branched or unbranched backbone of alternating silicon and oxygen atoms, -Si-O-Si-O-Si, with side chain R groups attached to the silicon atoms. The word siloxane is derived from silicon, oxygen, and alkane. Siloxanes can be found in products such as cosmetics, deodorants, water repelling windshield coatings, food additives and soaps. When combusted, the siloxane molecules are reduced to silica dust; this is extremely abrasive and damaging to internal engine components. The combustion process can cause a build up around burner tips and on the tubes of heat exchangers.

Terpenes (α and β pinenes, p-cymene, 3-carene, limonene)- Derived from feedstocks and depending on their composition, terpenes (odorant compounds) may mask the odorant of biomethane (THT).

Total Biologicals- Bacteria are microbes with a cell structure simpler than that of many other organisms. Bacteria are classified into five groups according to their basic shapes: spherical (cocci), rod (bacilli), spiral (spirilla), comma (vibrio's) or corkscrew (spirochaetes). They can exist as single cells, in pairs, chains or clusters.

Toluene ($C_6H_5CH_3$)- is a colorless liquid with a sweet, pungent odor. Exposure to toluene can cause eye and nose irritation, tiredness, confusion, euphoria, dizziness, headache, dilated pupils, tears, anxiety, muscle fatigue, insomnia, nerve damage, inflammation of the skin, and liver and kidney damage. Workers may be harmed from exposure to toluene. The level of exposure depends upon the dose, duration, and work being done.

Vinyl Chloride- is a colorless gas that burns easily. It does not occur naturally and must be produced industrially for its commercial uses. Extremely high levels of vinyl chloride can damage the liver, lungs, and kidneys.

Volatile and Semi-volatile Organic Compounds- Biogas produced from landfill biomass sources typically consists of methane and other major components but can also contain hundreds of other chemicals - most of which are known as "non-methane organic compounds" or volatile or semi-volatile organic compounds (VOCs and SVOCs). These are typically compounds containing carbon, hydrogen, and sometimes oxygen. Many non-halogenated VOCs and SVOCs are present in natural gas as well, originating from the geological basin from which the gas was extracted.

Volatile Metals- Volatile metals refers to a group of mostly toxic metals that have high atomic weights. Some are always toxic (e.g., lead, mercury, cadmium, arsenic, chromium) and others are toxic at high concentrations (e.g., zinc, copper). They are found everywhere in the environment because they are naturally part of the earth's crust or are concentrated in waste streams due to the use of a compound that incorporates a heavy metal element. When a compound that contains a heavy metal is degraded, the element can be released as a toxic gas.

Wobbe Number- An interchangeability parameter that takes both the higher heating value and the relative density of the gas into consideration and accounts for both heat content and gas flow through a fixed orifice. The Wobbe Number is calculated by dividing the HHV by the square root of the relative density. Differences in the relative density, and by extrapolation the Wobbe Number, generally come from the presence of other hydrocarbons or diluent and inert gases such as carbon dioxide or air (nitrogen plus oxygen).

RNG SPECIFICATIONS COMPARISON CHART

Constituent	ONE GAS	NGA/GTI LIMITS	CENTER POINT	NORTHERN NATURAL	NO.WEST NATURAL	CALIFORNIA UTILITIES-(1)	SO. STAR CENTRAL	BLACK HILLS	SPIRE	ATMOS ENERGY	BALTIMORE GAS & ELEC.
Methane (CH4 %)	97 %								94 %		95 %
Heating Value (btu/scf)	980 - 1100	970 - 1110	975 - 1100	950 ≤	985 - 1155	990 - 1150	950 - 1125	950 ≤	950 - 1100	950 - 1100	970 - 1070
Wobbe Number	1270 - 1400	1270 - 1400	1290 - 1400		1290 - 1400				1290 - 1370		1270 - 1400
Temperature (°F)	40 - 86 °F		50 - 115 °F	≤ 120 °F	35 - 120 °F		≤ 120 °F	≤ 80°F PE mains & ≤ 120°F steel	40 - 120 °F	40 - 120 °F	50 – 120 °F
Carbon Dioxide (CO2 %)	2 %	2 %	3 %	2 %	2 %	3 %	2 %	2 %	2 %	2 %	
Nitrogen (N2 %)	2 %	2 %			2 %				2.5 %		3 %
Oxygen (O2 %)		0.4%		0.2%	0.2 %	0.2 %		0.2 %	0.05 %	0.05 %	0.3 %
Oxygen (O2 ppm) if CO2 at 2%	10 ppm						10 ppm				
Oxygen (O2 ppm) if CO2 at 1%	2000 ppm						2000 ppm				
Total Inerts (%)	≤ 4 %		≤ 4 %		≤ 3 %	≤ 4 %	≤ 5 %		4.5 %	4 %	4 %
Hydrogen Sulfide (H2S grain/ccf)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	4 ppm	0.25	0.25	4 ppm
Total Sulfur (grain/ccf)	1 grain/ccf	1 grain/ccf	5 grain/ccf	20 grain/ccf	5 grain/ccf		20 grain/ccf	20 grain/ccf	5 grains/ccf	5 grains/ccf	16 ppm
Moisture (lb./MMSCF)	7	7	7	6	7	7	7	128 ppm	7	7	
Hydrocarbon Dew Point (°F)	≤ -25 °F	≤ 15 °F	≤ 45 °F		≤ 15 °F		≤ 40 °F	≤ -40 °F	20 °F	≤ 40 °F	≤ 15 °F
Arsenic	0.19 (0.06)		0.19 (0.06)	0.06 ppmv	0.19 (0.06)	0.19 (0.06)	0.15 ppmv		0.48		0.19 mg/m³
P-Dichlorobenzene (VOC)	57 (9.5)		57 (9.5)	9.5 ppm	57 (9.5)	57 (9.5)					
Ethylbenzene (VOC)	260 (60)		260 (60)	60 ppm	260 (60)	260 (60)					
n-Nitroso-di-n-propylamine (VOC)	0.33 (0.06)		0.33 (0.06)	0.06 ppm	0.33 (0.06)	0.33 (0.06)					
Vinyl Chloride	8.4 (3.3)		8.4 (3.3)	3.3 ppm	8.4 (3.3)	8.4 (3.3)	≤ 8.3 mg/m³		21 mg/m³		
PCB's/Pesticides	0.9 ppbv	1 ppbv									
Antimony	6.0 (1.2)		6.0 (1.2)	1.2 ppm	6.0 (1.2)	6.0 (1.2)					
Copper	0.60 (0.23)		0.60 (0.23)	0.23 ppm	0.60 (0.23)	0.60 (0.23)	< 0.60 mg/m³				< 0.60 mg/m³
Lead	0.75 (0.09)		0.75 (0.09)	0.09 ppm	0.75 (0.09)	0.75 (0.09)					
Other Volatile Metals (includes, but not limited to Zn, Cr and Mn)	20 µg/m³	213 µg/m³					< 20 µg/m³				
Methacrolein	11 (3.7)		11 (3.7)	3.7 ppm	11 (3.7)						
Mercaptans (Alkyl Thiols)	N/A (120)		N/A (120)	120 ppmv	N/A (120)	120 ppmv				1 grain/ccf	
Toluene	9,000 (2,400)		9,000 (2,400)	2400 ppm	9,000 (2,400)	9,000 (2,400)		≤ 5000 ppmv			
Ammonia	(10)	10 ppmv	0.001vol%	10 ppm	5 grains/ccf		< 10 ppmv	≤ 10 ppmv			0.001 %
Total Biologicals	$4x10^4$/scf and free of < 0.2-micron filter	< 0.2-micron filter	$4x10^4$/scf and free of < 0.2-micron filter	$4x10^4$/scf and free of < 0.2-micron filter	$4x10^4$/scf	$4x10^4$/scf and free of < 0.2-micron filter	≤ 0.2-micron filter	$4x10^4$/scf			
Hydrogen	0.2 %		0.1 %	1000 ppm	0.1 %			1000 ppmv	400 ppm		0.1 %
Mercury (includes Mercury and Mercury-based derivatives)	0.08 µg/m³	0.08 µg/m³	0.08 µg/m³	0.00008 ppm	0.08 µg/m³		< 0.1 µg/m³				0.08 µg/m³
Siloxanes	0.1 mg Si/m³	0.5 mg Si/m³	0.1 mg Si/m³	1 ppm	0.1 mg Si/m³	0.1 mg Si/m³	≤ 0.1 mg Si/m³		1 ppm		0.5 mg Si/m³
Aldehydes and Ketones	100 ppbv	100 ppbv					100 ppbv				
Terpenes	1 ppmv										
Halocarbons (includes, but not limited to freons and chloroethane)	0.1 ppmv	0.1 ppmv					< 0.1 ppmv	4 ppmv	0.1 ppmv		

Units unless specified otherwise: mg/m³ (ppmv) (1)-California Public Utilities Commission Rules (CPUC) covers: Pacific Gas & Electric; Southern California Gas Cal; Southwest Gas and San Diego Gas & Electric