QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PLAN

FOR

AURORA RIDGE DAIRY LLC

BIOLOGICAL SCRUBBER SYSTEM

Agreement # 42049

June 5, 2015

Submitted to:

New York State Energy Research and Development Authority
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Introduction

Aurora Ridge Dairy, LLC, is a 2,000 acre family owned dairy farm, located in Aurora, NY part of Cayuga County. The farm maintains a herd of more than 1,800 milking cows as well as 1,200 calves and heifers. The animals produce between 65,000 and 75,000 gallons of manure per day. In 2009, Aurora Ridge Dairy installed a plug flow anaerobic digester designed by DVO and a biogas based electrical generation system to treat manure produced by the cows as well as the leachate from corn silage and to utilize the waste gas produced by digestion to generate electricity. The biogas from the digester is used to fuel a 600 kW Guascor model MGG-950 CHO system. Until 2012, the digester incorporated a DVO air injection system that reduces the H_2S (hydrogen sulfide) to levels below the engine manufacturer's warranty levels. However, this approach resulted in significant corrosion of the digester heating system, and a two month outage to repair and replace the heating pipes. The DVO system then modified the air injection system, to inject the air into the digester gas space above the slurry. This approach has not been able to reduce the H_2S levels below 1,500 ppm. The high H_2S levels has resulted in increased downtime and maintenance, as well as reduced power output due to high cylinder temperatures in the Combined Heat and Power (CHP) unit.

This plan describes the approach to monitor the performance of the biological scrubber system that has been installed by Aurora Ridge Dairy, LLC to lower the level of H_2S in the biogas to reduce downtime, maintenance and increase the CHP power output. A monitoring system is installed to measure and collect pre and post biological scrubber H_2S levels to quantify the H_2S removal by the biological scrubber. The data will serve as the basis for payment of a capacity incentive to help offset the capital expenses associated with the procurement of the new biological scrubber equipment and ten (10) years of performance incentive payments, which Aurora Ridge Dairy, LLC has applied for under a Standard Performance Contract with NYSERDA.

Biological Scrubber System Description

The biological scrubber system at the farm was designed by American Biogas Conditioning LLC. The scrubber is designed for a biogas flow rate of 350 standard cubic feet per minute (scfm) to address Aurora Ridge Dairy's interest for future expansion of the digester and the power generation equipment. The sulfur loading has been designed for biogas with 4,000 parts per million by volume (ppmv) of H_2S.

Figure 1, includes photographs of the biological scrubber system. Figure 2, schematically shows the biological scrubber system.

The biological scrubber consists of the following major components:

1. ***Bioreactor*** – a large cylindrical insulated tower with conical roof and flat bottom made of corrosion proof fiberglass material. The tower also incorporates the following components:

    a. Randomly packed polypropylene fill material designed for low pressure drop and maximum surface area;

b. Internal grating made of synthetic material that supports the packing material;

c. PVC piping system for transferring and distributing the nutrient liquid over the packing material and washing the packing material;

d. Corrosion proof PEX piping for heating;

e. Hydraulic mixing system to maintain the suspension of elemental sulfur in the process liquid; and

f. Internal wash system for rinsing the packing material and the heating system.

2. ***Mist-Eliminator*** – this unit will be installed as a complementary part of the bioreactor. This cylindrical vessel downstream of the bioreactor, will remove moisture droplets in the biogas after it is treated in the scrubber. The design captures the droplets and returns them as condensate to the bioreactor.

3. ***Technical Building*** – is a lighted, climate controlled walk-in space with ventilation, heating and lockable door. This building houses the process power and control switch board (PLC), nutrient storage tote, and all process instrumentation and control equipment. The process instrumentation and control equipment consists of the following components:

   a. One (1) acid-resistant magnetically coupled synthetic material recirculation pumps, with dry protection to convey the nutrient solution over the fill material, and to routinely flush the packing material with process liquid;

   b. One (1) air blower with variable frequency drive (VFD) to provide the required dosage of air to the process. ;

   c. An automated dosing pump with dosage control for providing nutrient solution to the tower;

   d. One (1) heating pump with electro-magnetic valve to regulate the supply of hot water from cogeneration system to the bioreactor;

   e. Plant instrumentation and controls that monitor process variables and enable fully automatic operation of the equipment;

   f. A4-channel biogas analyzer to provide discrete measurements of :

      i. H_2S (inlet and outlet) 0 – 10,000 ppm (± 150 ppm)

      ii. O_2 (inlet and outlet) 0 – 20% Vol.

      iii. CH_4 (inlet and outlet) 0 – 100% Vol.

   g. One (1) Ex-sensor to monitor the concentration of combustible gases in the technical building. When unsafe levels of combustible gas is detected in the technical building, the central processing unit (CPU) will shut down the entire plant until such time the gas leak has been fixed and the lower explosive limit (LEL) levels have dropped below acceptable levels. Farm staff will also be notified of the upset condition through the generator alarm.

h. Climate control system to maintain the room temperature within acceptable levels (50°F to 90°F) and to ventilate the room if combustible gas is detected in the technical building.

i. Human Machine Interface (HMI), which is the user interface with the process control system, provides a graphics-based visualization of the controls and monitoring system

4. ***Process Power and Control Switchboard (PLC)*** – the PLC is installed on the exterior wall of the Technical Building. This box incorporates the I/O bus, controls and the CPU that controls the internal functions and regulates the automatic operation of the scrubber. The CPU can also communicate the process parameters to the main control system for the biogas plant through Ethernet TCP/IP as communication medium. This also makes it possible to directly connect the scrubber to the "PC realm" for remote administration and management of the process.

Table 1. Biological Scrubber Systems at Aurora Ridge Dairy, LLC

Biological Scrubber	American Biogas Conditioning LLC Cylindrical Tower w/ conical roof and flat bottom with randomly packed polypropylene fill material
Biogas Flow Rate	Inlet : 200 to 350 scfm Outlet: 420 scfm
Gas Temperature	Inlet: 50° to 100°F Outlet: 85° to 95°F
Gas Pressure	Inlet: -2" to +20" W.C. Outlet (Max): >-6" W.C.
Gas Composition*	
CH_4	Inlet: 55% to 58% Outlet: 48% to 50%
O_2	Inlet: <1% Outlet: <2.2%
H_2S	Inlet (Max): 4,000 ppmv Outlet: <200 ppmv

*These are projected specifications when the scrubber treats the gas.

Bioreactor Tower

Mist-Eliminator

Gas Analyzer (1)

Gas Analyzer (2)

Figure 1a. Photos of System Components

Air Blower

Air Flow Meter

Nutrient Tote

Nutrient Dosing Pump

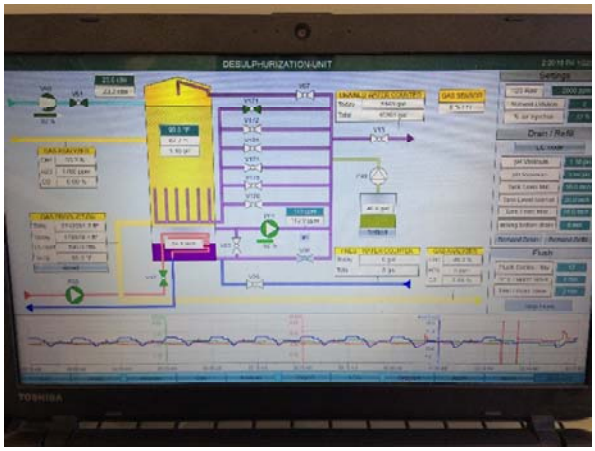
Figure 1b. Photos of System Components

Process Liquid Pump

Upper and Lower Spray Lines

Polypropylene Fill Material

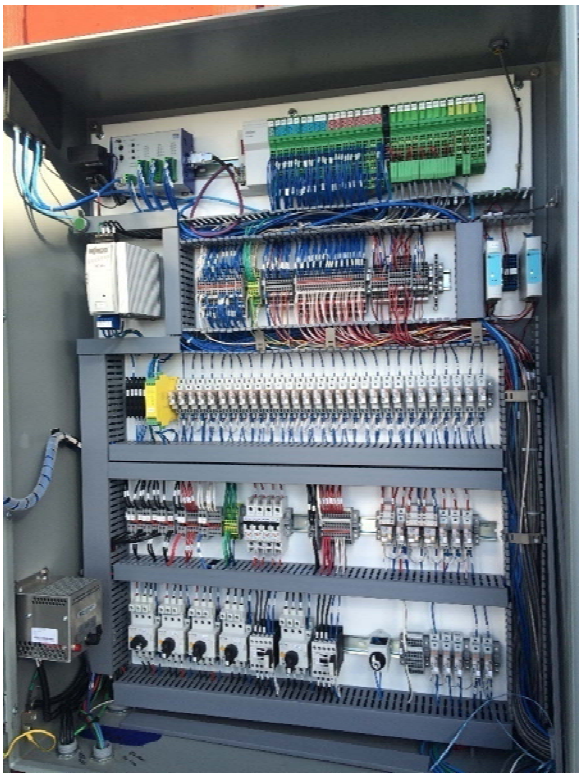
Hot Water Piping



HMI

Figure 1c. Photos of System Components

Air Gap between Bioreactor and Technical Building



PLC

Figure 1d. Photos of System Components

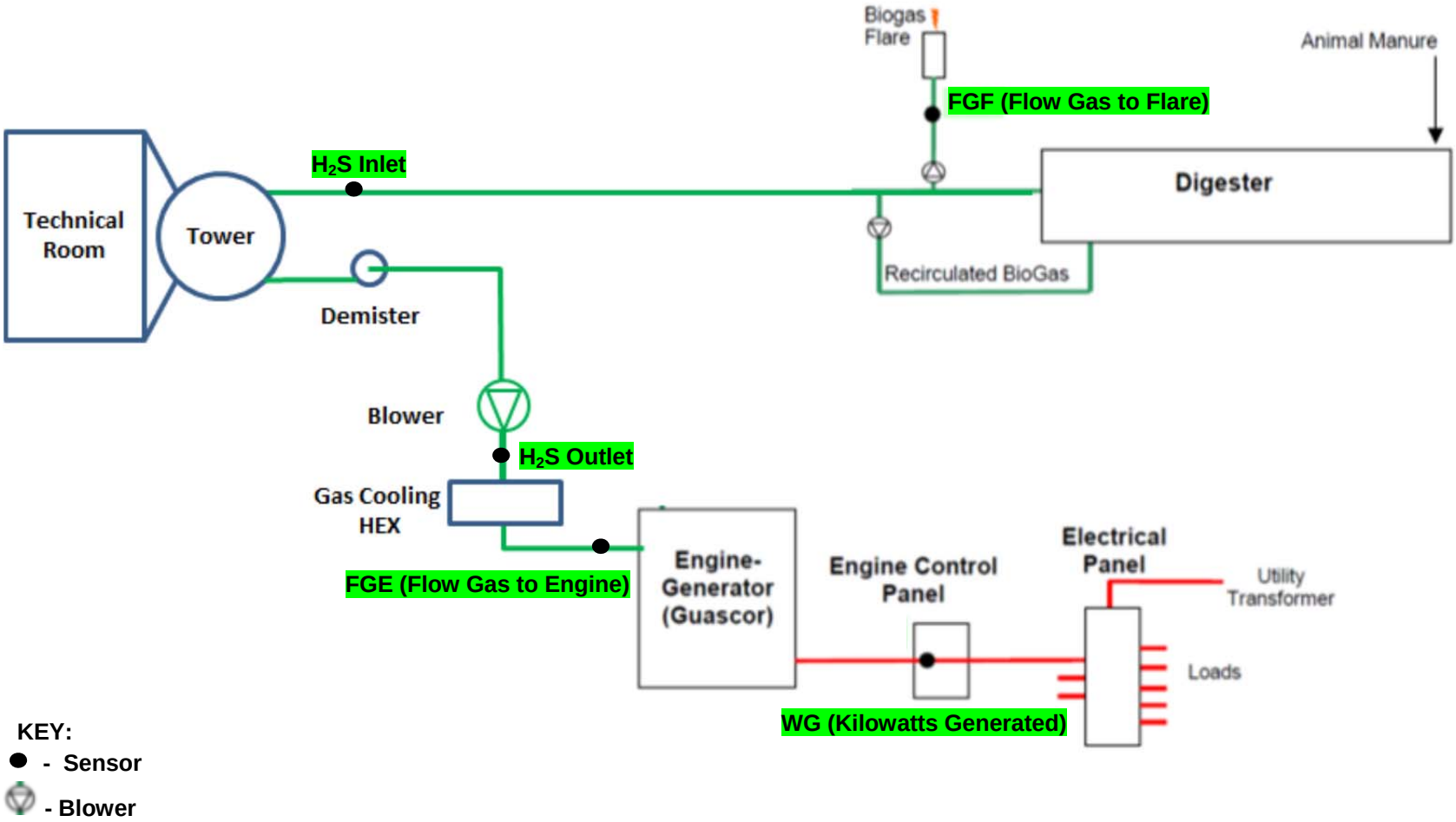


Figure 2. Schematic of System

Biological Scrubber System Capacity Payment Descriptions

This Section describes the Capacity Incentive Payments included in the Agreement, the payment milestones to be achieved in order to receive payment, and the deliverables to be provided in achieving these milestones. For a biological scrubber system, the available Capacity Payments are Capacity Payments 1, 4, 5, and 6, which are presented below.

Capacity Payment #1: Up to 15% of Total Capacity Incentive is payable for reimbursement of project costs once the Contractor provides evidence sufficient to demonstrate payments for major equipment (e.g. power generation system, anaerobic digester system, biogas clean-up and handling systems etc.) and/or engineering design.

Capacity Payment #4: Up to 45% of the Project Enhancement Component of the Total Capacity Incentive is payable once NYSERDA's designated technical consultant has verified that construction/installation of the Project Enhancement has been completed or the required documentation for the Project Enhancement, according to applicable sections of *Using the Incentive Calculation Tool* of Exhibit D has been submitted to NYSERDA. The Contractor may request payment at this time for any Project Enhancements that have been completed and verified. Payment for Project Enhancements completed and verified after the request for Capacity Payment #4 had been made may be requested with the Capacity Payment #6.

Capacity Payment #5: 20% of Total Capacity Incentive is payable once documentation has been provided to NYSERDA that sufficiently verifies successful operation of the newly installed system and completion of interconnection, if applicable (e.g. interconnection acceptance test documentation from the utility.).

Capacity Payment #6: Up to 100% of the Total Capacity Incentive is payable once the newly installed system is successfully commissioned. Commissioning includes operating the ADG-fueled energy generation system at a minimum of 75% average capacity factor over seven (7) consecutive days, and demonstrating the ability to upload data generated by the system to NYSERDA's CHP website, if applicable. A project Commissioning Report must also be completed detailing the installation and commissioning activities and include design updates and as-built diagrams. Any project Enhancements payments that were not made with the Capacity Payment #4 may be requested with this payment.

Monitoring System Equipment, Installation, Operation, and Maintenance

Payment for this incentive shall ultimately be based on adequate measurements of the ability of the biological scrubber to reduce H_2S levels to less than 400 ppmv. Measurements will be made with continuous automatic gas sampling and analysis, or by other methods found acceptable to NYSERDA. For this project Union Instruments GmbH INCA4003, a biogas analyzer, will be used to measure the H_2S concentrations. A link to the specification for the gas analyzer can be found in Appendix A. This system is in-line and can measure H_2S from 0 to 5,000 ppm. Readings of H_2S will be taken every 15 minutes and then averaged over each hour period.

Figure 2 also shows the locations of the two (2) new H_2S data monitoring points which will be used to measure system performance. The gas analyzer measures H_2S levels prior to the biological scrubber (**H_2S Inlet**) and H_2S levels after the biological scrubber (**H_2S Outlet**). Information on these data points is shown in Table 2.

Table 2. Monitored Points for Biological Scrubber System

Point Type	Point Name	Description	Instrument	Engineering Units	Expected Range
Pulse	H_2S Inlet	H_2S Level	Union Instruments GmbH INCA4003	ppm	0-5000 ppm (±150 ppm)
Pulse	H_2S Outlet	H_2S Level	Union Instruments GmbH INCA4003	ppm	0-5000 ppm (±150 ppm)

The H_2S levels in both the inlet (**H_2S Inlet**) and outlet (**H_2S Outlet**) gas flows from the biological scrubber are measured using the Union Instruments GmbH INCA4003 biogas analyzer. This system includes an LCD display and is installed in the electrical room of the generator building. The system has the capability to measure ppm data for H_2S in 15 minute intervals. Maintenance activities will be performed in accordance with the instructions in the O&M manual. A log of maintenance activities for the meter will be maintained at the site.

The existing data logger currently used for tracking electrical and biogas production from the digester may be used for transferring H_2S reduction data to NYSERDA's Integrated Data System website. The data logger is programmed to average or totalize data for each monitoring point for each 15-minute interval as appropriate. A record of all multipliers and data logger settings will be maintained. The data logger will be connected to an uninterruptible power supply (UPS) to ensure the data logger retains its settings and data in the event of a power outage. The UPS is capable of powering the data logger for at least one day. The farm will provide a dedicated phone line (or an Ethernet connection with fixed IP address) that will be used to communicate with the data logger. The NYSERDA CHP website contractor (CDH Energy Corp.) will communicate with the data logger nightly to extract monitored data from the data logger and transfer the data to the NYSERDA Integrated Data System website. If communications are lost, the data logger is capable of holding at least 15 days of 15-minute interval data.

The worksheet in Appendix B will be used as a template for documenting the capabilities of the biological scrubber system. Biogas flow and H_2S input to and output from the biological scrubber will be documented for each hour of the year that samples are taken. The percentage of cumulative outlet H_2S samples (up to a maximum of 90% of the hours in a year) with 399 ppm H_2S and below will be submitted to document adequate compliance with the requirement for payment. The summary of samples will show the percentage of cumulative samples with 399 ppm H_2S and below as well as the percentage of cumulative samples with 400 ppm H_2S and above. To satisfy requirements for the 6th Capacity Incentive payment, a minimum of 75% of the samples taken in a 7 day period must be below 400 ppm. The H_2S reduction component of the annual Performance Incentive payment is determined by multiplying the Contract Capacity (600kW), times the factor 75%/90%, times the verified hourly samples below the minimum H_2S threshold, times the H_2S Performance Incentive variable for a biological scrubber ($0.0023/kWh). NYSERDA will consider other formulations for calculating the Performance Incentive, in the event that the biological scrubber is unable to operate due to reasons outside of the operation of the scrubber itself. NYSERDA may direct its technical contractors to sample the biogas, determine H_2S removal efficiency, and compare the results to the data originally provided by the operator.

Management of Monitoring System Data (Farm Responsibilities)

The Aurora Ridge Dairy, LLC staff will perform the following quality assurance and quality control measures to ensure the data produced from the monitoring system accurately describes system performance.

On a daily basis, the Aurora Ridge Dairy, LLC equipment manager (or other specified employee) will perform inspections of the biological scrubber equipment and record findings into the project log.

On a weekly basis, the Aurora Ridge Dairy, LLC equipment manager (or other specified employee) will perform inspections of the QA/QC biogas analyzer installations and complete the routine maintenance on the analyzer, noting any abnormalities or unexpected readings.

On a weekly basis, the Aurora Ridge Dairy, LLC staff will review the data stored on the NYSERDA Integrated Data System website (chp.nyserda.org) to ensure it is consistent with their observed performance of the biological scrubber system and logged readings. Aurora Ridge Dairy, LLC will review the data using the reporting features at the website, including:

- Monitored Data – Plots and Graphs
- RPS: Customer-Sited Tier Anaerobic Digester Gas-to-Electricity Program NYSERDA Incentive Program Reports

In addition, the Aurora Ridge Dairy, LLC staff will also setup and use the email reports that are available at the Integrated Data System website to help the track system performance, including:

- A periodic email report summarizing performance and the estimated incentive,
- An email report will be sent out if data are not received at web site or do not pass the quality checks.

The website will automatically take the data collected from the data logger and evaluate the quality of the data for each interval using range and relational checks. The expected ranges for the sensors (see Table 2) will be used for the range checks. The relational check will compare the H_2S ppm data for each 15-minute interval to ensure both analyzers always provide non-zero readings at the same time (e.g., to detect if a meter has failed). Only data that passes the range and relational quality checks are used in the incentive reports listed above. However, all hourly data are available from the NYSERDA Integrated Data System website using the "Download (CSV file)" reporting option.

In the event of a communications or analyzer failure, Aurora Ridge Dairy, LLC personnel will work with CDH to resolve the issue.

If unanticipated loss of data occurs when the biological scrubber is operational, Aurora Ridge Dairy, LLC will follow the procedures outlined in Exhibit D of their contract, i.e. using data from similar periods – either just before or after the outage – to replace the lost data. Aurora Ridge Dairy, LLC personnel understand that they can use this approach for up to two (2) 36-hour

periods within each 12-month performance reporting period. If more than two (2) such data outages occur, Aurora Ridge Dairy, LLC personnel will provide information from other acceptable data sources (e.g., weekly recorded logs) to definitively determine the H_2S levels of the biogas during the period in question.

APPENDIX A

Cut Sheets and Manuals-

Union Instruments INCA4003 Gas Analyzer Specifications:

http://engl.union-instruments.com/inca-4000s/product/inca4003-txxx.html

APPENDIX B

Worksheet to Document Ability of Biological Scrubber to Produce Measured H_2S Concentrations Less then 400 ppmv for 75% of Samples									
Data to be Completed by Operator					Analysis which can be done by Technical Consultant				
A	B	C	D		E	F	G	H	I
Hour	Date of Sample	H_2S in Biogas Before Cleanup (ppm)	H_2S in Biogas After Cleanup (ppm)		Sorted H_2S Data	Range of H_2S Concentrations (ppm)	Number of Samples in Each Range	Cumulative Number of Samples less than Range Maximum	Percentage of Cumulative Samples Less than Range Maximum
12:00:00 AM	1	1,500	50			0 to 399	18	18	75%
1:00:00 AM	1	1,600	50			400 or higher	6	24	100%
2:00:00 AM	1	2,000	250				Total Samples:	24	
3:00:00 AM	1	1,600	250						
4:00:00 AM	1	1,400	400						
5:00:00 AM	1	1,250	150						
6:00:00 AM	1	1,300	150						
7:00:00 AM	1	1,500	150						
8:00:00 AM	1	2,000	200						
9:00:00 AM	1	1,500	250						
10:00:00 AM	1	1,500	250						
11:00:00 AM	1	1,600	150						
12:00:00 PM	1	800	250						
1:00:00 PM	1	800	350						
2:00:00 PM	1	1,200	350						
3:00:00 PM	1	1,100	450						
4:00:00 PM	1	1,300	350						
5:00:00 PM	1	1,400	350						
6:00:00 PM	1	1,500	350						
7:00:00 PM	1	1,400	550						
8:00:00 PM	1	1,300	550						
9:00:00 PM	1	1,500	350						
10:00:00 PM	1	2,000	950						
11:00:00 PM	1	800	550						

NOTE: This is an example for 1 days worth of data. This table will need to be extended to 7 days for the 6th Capacity Payment and 365 days for the Annual Performance Payments.