
DEMONSTRATION OF A COMPACT SCR™ SYSTEM MEETING 0.07 LB/MWH NO_x IN A BIOGAS ENGINE

FINAL REPORT

June 24, 2014

**Submitted to:
San Joaquin Valley Unified Air Pollution Control District**



**Demonstration of a Compact SCR™ System
Meeting 0.07 lb/MWH NOx in a Biogas Engine**

Final Report

Submitted to
Technology Advancement Program
San Joaquin Valley Unified Air Pollution Control District
1990 East Gettysburg Ave.
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EXECUTIVE SUMMARY

Engine, Fuel, and Emissions Engineering, Inc. (EF&EE) received a grant from the San Joaquin Valley Air Unified Air Pollution Control District under the District's Technology Advancement Program. The purpose of this grant was to develop and demonstrate a compact selective catalytic reduction (SCR) system capable of meeting the California Air Resources Board (ARB) standard for distributed generation systems of 0.07 pounds of NOx per megawatt-hour of useful energy output (lb/MWH). This goal has been achieved, with NOx emissions of 0.028 lb/MWH (equivalent to 0.69 ppmvd or 0.009 g/BHP-hr) measured by independent source testing. Ammonia slip was 3.0 ppmvd, which is well below the limit of 10 ppmvd considered BACT.

It should be noted that the achieved value of 0.028 pounds of NOx per MWH was calculated with respect to only the electrical output of the engine-generator. For cogeneration systems, ARB rules allow the calculation to be made against the sum of the electrical and useful thermal outputs. Depending on the cogeneration system design, useful thermal output from a lean-burn engine is typically between 50% and 120% of the electrical output. This would result in NOx emissions between 0.013 and 0.019 lb/MWH.

The SCR system developed under this grant was installed on a lean-burn, spark-ignition biogas engine at the Joseph Gallo Cheese Company plant near Atwater, CA. Two different SCR catalyst types were tested. One type was provided with a platinum coating on the downstream end to control emissions of excess ammonia reductant from the SCR system (ammonia slip). This coating also helped to oxidize carbon monoxide emissions from the engine. The second catalyst type was similar in composition but lacked the platinum coating on the downstream end.

The effects of each catalyst type on NOx and ammonia emissions were determined as functions of exhaust temperature, engine power output, and reductant flow rate. The second catalyst type was found to give better NOx control efficiency, and was the one used to demonstrate compliance with the ARB standard. The platinum slip catalyst on the first catalyst type was found to oxidize ammonia to NOx, resulting in higher minimum NOx levels than for the second type. Only the second type was found capable of meeting the 0.07 lb/MWH NOx standard.

The performance of both SCR catalyst types is affected by exhaust temperature. Minimum NOx levels were similar from 320 to 410 C, but increased significantly at 440 C. The independent source testing was conducted at a catalyst exit temperature of 405 C. Higher temperatures will result in lower NOx control efficiency and/or higher ammonia emissions. The high temperature limit for meeting the 0.07 lb/MWH standard is probably between 410 and 440 C. Equivalent or improved performance is expected at lower temperatures, down to at least 320 C.

The second catalyst type gives lower NOx emissions, but lacks CO oxidation activity. Thus, to provide adequate compliance margin, a separate CO oxidation catalyst is recommended to be installed upstream of the urea injection point. The added cost of the CO oxidation catalyst is estimated at less than \$3,000.

At the time of testing, the catalyst elements of the second type had accumulated about 740 operating hours. Catalyst efficiency is expected to degrade slowly with increased operating time. Based on experience with the SCR control system at the Fiscalini Dairy, the useful life of the SCR catalyst is estimated to be 30,000 to 40,000 hours before it can no longer maintain the target levels of NOx control. EF&EE plans to perform follow-up measurements at approximately annual intervals in order to monitor catalyst performance over time. The results of these follow-up measurements will be submitted to the District as addenda to this report.

In addition to optimizing NOx reduction efficiency, operating the SCR catalyst at the moderate temperature employed here would help to protect the catalyst from degradation due to siloxanes in the fuel. Siloxanes are silicon compounds commonly found as contaminants in biogas from landfills and sewage digesters, and can damage catalytic converters. Siloxanes burn in the engine to form silicon dioxide in the exhaust. At these moderate exhaust temperatures, silicon dioxide is expected to form solid particles, rather than depositing on the catalyst. If so, then this SCR technology should be highly tolerant of siloxane contamination of the fuel. Additional testing is recommended using these catalysts with exhaust streams from internal-combustion engines burning sewage gas or landfill gas in order to assess this possibility.

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1. INTRODUCTION

Engine, Fuel, and Emissions Engineering, Inc. (EF&EE) received a grant from the San Joaquin Valley Air Unified Air Pollution Control District under the District's Technology Advancement Program. The purpose of this grant was to develop and demonstrate a selective catalytic reduction (SCR) system capable of meeting the California Air Resources Board (ARB) standard for oxides of nitrogen (NOx) emissions from distributed generation systems. The ARB standard limits distributed generation systems to a maximum of 0.07 pounds of NOx emissions per megawatt-hour of useful energy output (lb/MWH).

The SCR system developed under this grant was installed on a lean-burn, spark-ignition biogas engine at the Joseph Gallo Cheese Company plant near Atwater, CA. That engine produces electric power for use by the cheese plant and for export. Biogas fuel for the engine is supplied by covered-lagoon digesters processing manure from the Joseph Gallo and Santa Rita dairies. Waste heat in the engine exhaust is captured in a heat recovery steam generator. The resulting steam is supplied to the cheese plant for process use.

The demonstration project assessed the capabilities of two different SCR catalyst types. One catalyst type was provided with a platinum coating on downstream end to control emissions of excess ammonia reductant from the SCR system (ammonia slip). This coating also helped to oxidize carbon monoxide emissions from the engine. The second catalyst type was similar in composition but lacked the platinum coating on the downstream end. The effects of each catalyst type on NOx and ammonia emissions were determined as functions of exhaust temperature, engine power output, and reductant flow rate.

The project comprised the following tasks:

1. System design
2. Procurement and assembly
3. Installation and startup
4. Emissions optimization with the platinum slip catalyst
5. Emissions optimization without platinum slip catalyst
6. Independent source testing of the engine fitted with the optimized system
7. Final report

Work on the project began in January, 2011; and was completed in April, 2014. This final report responds to Air District comments on the draft report submitted in April 2014.

2. BACKGROUND

2.1 BIOGAS DISTRIBUTED GENERATION

The use of biogas produced from animal manure in combined heat-and-power (CHP) systems offers many environmental benefits. The biogas digestion process reduces odors, VOC, methane, and ammonia emissions from the manure, while the digester effluent retains most of the plant nutrients and can safely be used as fertilizer. The resulting biogas can be used in an internal-combustion engine to produce electricity – thus displacing fossil fuels – while the waste heat from the engine exhaust and cooling jacket is recovered as steam and hot water for heating, sterilization and process uses. This heat would otherwise have to be produced by burning fossil fuels. Thus, the process eliminates a waste disposal and water pollution problem while reducing consumption of fossil fuels and emissions of methane, CO₂, odor, ammonia, and VOC.

Lean-burn, spark-ignition reciprocating engines can burn biogas with only minimal processing to remove excess water vapor. These engines have proven durable, reliable, and efficient in this application. Capital and operating costs are also low compared to many distributed generation technologies. Their main drawback is relatively high pollutant emissions, especially of oxides of nitrogen (NO_x).

2.2 ARB DISTRIBUTED GENERATION STANDARDS

The California Air Resources Board (ARB) has established pollutant emission standards for distributed generation systems (CCR 17, §94203). Since 2007, these standards have limited NO_x emissions to a maximum of 0.07 lb/MWH of useful energy output. That standard was based on the estimated emissions from a state-of-the-art combined-cycle central power plant, equipped with selective catalytic reduction. Carbon monoxide (CO) emissions are limited to 0.10 lb/MWH, and volatile organic compounds (VOC) to 0.02 lb/MWH.

The ARB distributed generation standards do not apply to distributed generation systems that are subject to the local air quality district permitting process. That process is complex, but most local air district permits mandate the application of “best available control technology” or BACT. For spark-ignition engines in practice, the requirement for BACT has been less restrictive than the ARB standard. However, the ARB standard remains relevant to those engines, as it controls eligibility for certain incentive grants and other programs.

California SB 412 of 2009 restored the eligibility of reciprocating engine-based CHP systems for the Small Generator Incentive Program (SGIP), but limits it to engines meeting the 0.07 lb/MWH standard. Incentive payments for biogas engines under the SGIP program could amount to as much as \$2,500 per kilowatt of electric capacity; or more than half of the capital cost of the system.

Separately, in Rule 1110.2, the South Coast AQMD has established the same 0.07 lb/MWH NO_x limit for new engines driving electric generators. This rule includes an exception for biogas engines (which remain subject to BACT), but would apply to natural gas engines in combined heat-and-power applications.

2.3 BEST AVAILABLE CONTROL TECHNOLOGY

BACT for control of NOx emissions from natural gas engines has long been considered as being 0.15 g/BHP-hr, which has been calculated as equivalent to between 9 and 12 parts per million NOx, (calculated on a dry basis and corrected to 15% oxygen, and abbreviated ppmvd). This has been based on the use of SCR in a lean-burn engine. This is generally complimented by a limit of 10 ppmvd for ammonia slip from the SCR system.

Until recently, BACT for biogas engines was considered to be 0.60 g/BHP-hr. This was based on the use of a lean air-fuel ratio and retarded spark timing. It was not considered practical to apply SCR to these engines due to the variability in the composition of the biogas. This variable composition affects the air-fuel ratio, causing engine-out NOx concentrations to vary widely. In addition, biogas from non-agricultural sources is often contaminated with siloxanes, which burn in the engine to produce silicon dioxide. The resulting silicon dioxide dust can foul the SCR catalyst.

In a project at the Fiscalini Dairy in Modesto, it was demonstrated that a lean-burn engine burning dairy biogas, and equipped with EF&EE's Compact SCR™ and exhaust NOx sensors could consistently meet the natural gas engine BACT limit. This has led to the acceptance of 0.15 g/BHP-hr NOx as BACT for biogas engines as well.

The present IC engine BACT limit is equivalent to about 0.35 lb/MWH with no heat recovery, or to about 0.15 to 0.20 lb/MWH assuming typical heat-recovery rates for CHP systems. To meet the 0.07 lb/MWH standard, therefore, would require catalyst-out NOx levels around 0.03 to 0.05 g/BHP-hr, equivalent to 2 to 4 ppmvd.

3. SYSTEM DESIGN, INSTALLATION, STARTUP, AND OPERATIONS

The demonstration SCR system was installed on a Guascor SFGLD 480 engine-generator set located in a covered shed adjacent to the Joseph Gallo Cheese Company plant. The generating set is rated at 800 kW electric, but the plant operators have limited maximum power output to 750 kW for reasons of reliability and durability.

Since Tasks 4 and 5 of this contract required us to optimize the exhaust temperature going into the SCR catalyst, it was necessary to design a system for varying that temperature. The design approach selected in consultation with the Joseph Gallo Project Engineer is diagrammed in Figure 1.

As Figure 1 shows, a pair of dampers split the exhaust flow from the engine into two streams, A and B. Stream B flows through the first pass of a three-pass firetube-type heat-recovery boiler. This exhaust stream transfers heat to the water in the boiler, forming steam. Upon exit from the boiler, the two exhaust streams are recombined. The temperature of the recombined exhaust stream may range from about 330 to 440 C, depending on the position of the dampers and the engine power output. In the original design, a thermocouple transmitted the recombined exhaust temperature to the control PLC, which adjusted the damper positions to bring it to the desired setpoint. Following the failure of the pneumatic damper actuator, this was replaced by a simpler system in which the damper position was set by hand.

Urea is injected into and mixes with the recombined exhaust stream before it enters the SCR catalyst, where the reactions take place to convert NOx to N₂ and water. After leaving the SCR catalyst, the exhaust passes through a second set of dampers, from which it either passes back through the second pass of the boiler or directly to the stack. The design allows the boiler to be bypassed completely when there is no demand for steam, or to allow cleaning of the boiler tubes.

The operation of the Optimin™ urea metering and control system is diagrammed in Figure 2. Sensors communicate the temperature, pressure, and NOx concentration upstream and the temperature and NOx concentration downstream of the SCR catalyst to the PLC control unit. An analog signal from the engine controller communicates the engine load. The controller calculates the NOx flow rate from the engine load and upstream NOx concentration, then calculates the urea injection rate required to fully react with that quantity of NOx. This injection rate is communicated to the metering pump, which mixes the required amount of urea solution with the compressed air stream flowing to the nozzle.

The downstream NOx sensor supplies feedback to the urea metering system. To optimize the urea injection rate, the Optimin™ control algorithm slightly varies the ratio of urea injected to estimated NOx flow, while observing the effect on downstream NOx concentrations. If a change results in lower average NOx concentrations downstream, change continues in the same direction. If average NOx concentrations increase, the direction of change is reversed. This is the same hardware and control approach that was successfully applied in the Fiscalini Dairy demonstration.

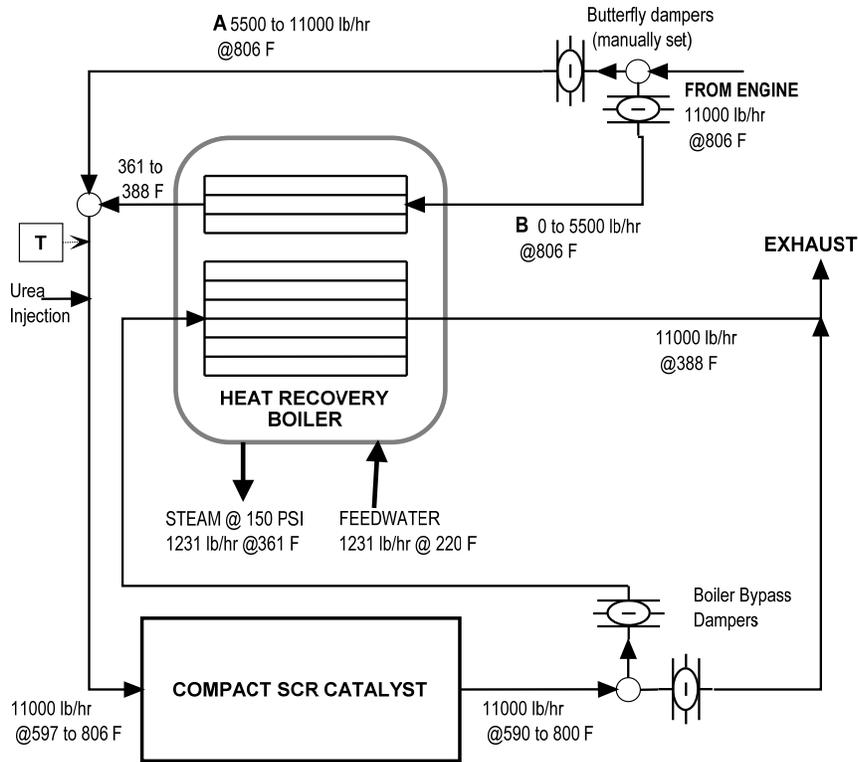


Figure 1: System flow diagram for heat recovery system

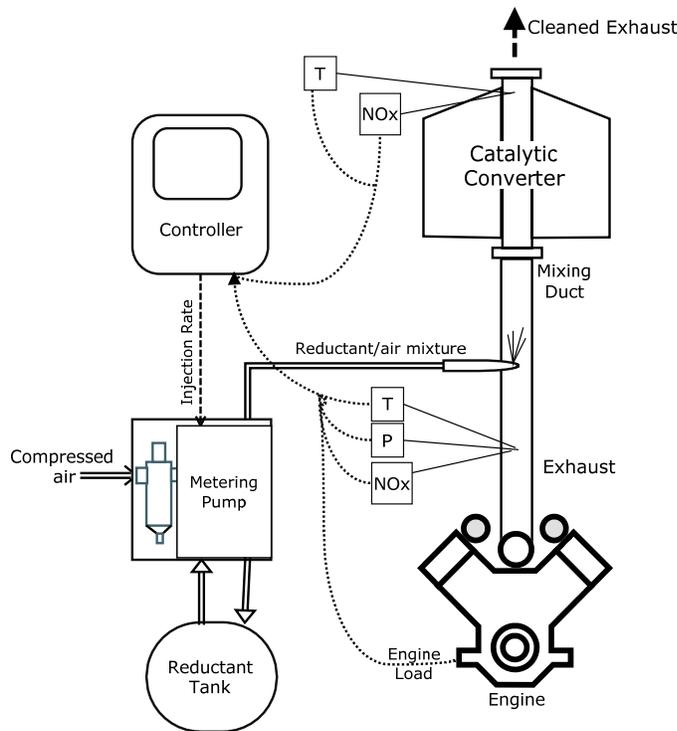


Figure 2: Diagram of the urea metering and control system

The SCR catalyst selected for this project is an EF&EE CM12CA catalyst assembly, comprising twelve round cellular ceramic catalyst modules of 14.9 liters each. This is also the same design used at Fiscalini Dairy. Figure 3 shows the overall dimensions and structure of this assembly. The Joseph Gallo Project Engineer designed a supporting structure for the SCR catalyst assembly. EF&EE was responsible for design of the junction pipe to recombine the two outlet streams from the SCR catalyst. This junction pipe is shown in Figure 4.

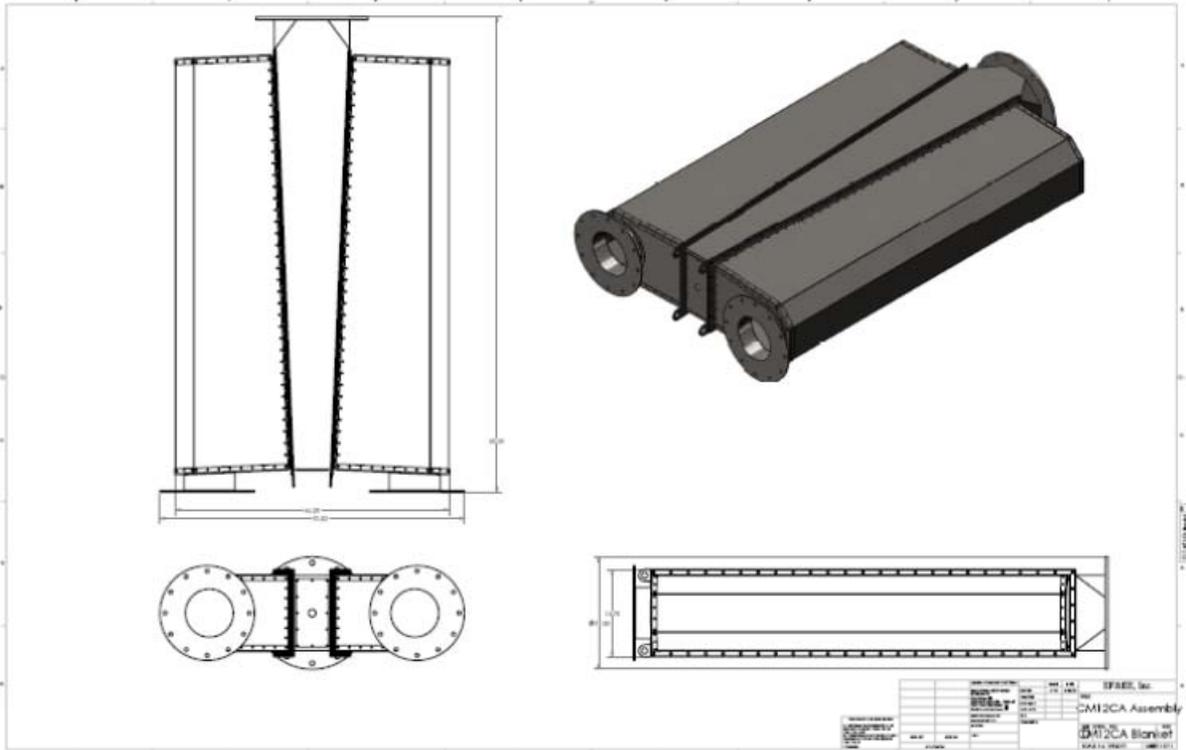


Figure 3: SCR catalyst assembly - installation drawing

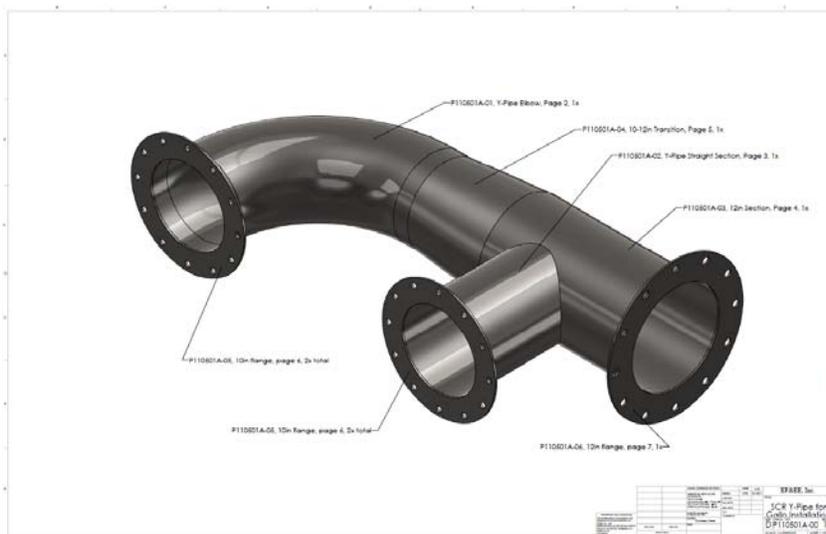


Figure 4: SCR catalyst assembly outlet junction pipe

Construction at the host site was largely completed and the SCR system was installed in January, 2012. The engine was test-run in February, 2012 with the SCR catalyst in place. Figure 5 shows the complete SCR catalyst assembly installed in the exhaust system.

Figure 5: SCR catalyst assembly installed in exhaust pipe, without insulation



Due to supplier delays, the heat-recovery steam generator was not delivered until August, 2012. Commissioning of the SCR system and source-testing for the operating permit finally took place after the HRSG was installed and insulation was applied to the exhaust piping and the boiler. Figure 6 shows the boiler and insulated exhaust piping. The SCR catalyst assembly is under the insulating blankets at the upper left. Figure 7 shows the control unit and urea metering pump.

Figure 6: SCR catalyst assembly and waste heat boiler, after insulation



Figure 7: SCR system controller and urea metering pump assembly



Conditions for the proposed air quality permit were negotiated between Joseph Gallo Farms and the District, with technical input from EF&EE. The resulting conditions are shown in Table 1. These corresponded to the District’s present definition of BACT for engines fueled by natural gas and biogas. The goal of the project was to demonstrate NOx levels well below 0.15 g/BHP-hr, but the ability to do so over the long term had not yet been demonstrated. Thus, it was considered inappropriate to include these lower emission levels as a condition of the permit.

Table 1: Air quality permit conditions and source test results

Pollutant	Permit Condition		Source Test Result	
	ppmvd	g/BHP-hr	ppmvd	g/BHP-hr
NOx	9	0.15	4.66	0.052
Ammonia	10	--	1.50	--
CO	123	0.95	17.3	0.12
VOC	48.2	0.20	<0.20	<0.001
PM	--	0.04	--	0.023

Source testing was conducted on September 25th, 2012, and the results are also shown in Table 1. These results were obtained with the platinum slip catalyst, the then-standard version of the Optimin self-tuning algorithm, and with the exhaust bypass valve fully closed to give a temperature of about 325 C downstream of the catalyst.

4. EMISSIONS OPTIMIZATION WITH PLATINUM SLIP CATALYST

The SCR catalyst assembly was initially loaded with catalyst modules that included the platinum slip catalyst on the downstream end. The emissions optimization study with this initial catalyst charge was conducted on February 27 and 28, 2014. At that point, the SCR system had accumulated about 9,030 operating hours, out of an estimated operating life of at least 40,000 hours. This is substantially more than the operating time normally considered necessary to stabilize the catalyst. The delay was due to difficulty in securing a suitable Fourier-transform infrared (FTIR) analyzer to measure ammonia and nitrous oxide (N₂O) emissions.

4.1 INSTRUMENTATION AND SAMPLING

Exhaust gas was sampled from a port immediately downstream of the HRSG, and conducted to the gas analyzers via a heated sample line. NO_x emissions in the raw exhaust were measured “wet” (without removing water vapor) by a California Analytical Instruments (CAI) 600 HCLD heated chemiluminescent analyzer. Total hydrocarbons (THC) were also measured “wet”, using a CAI 600 HFID heated flame ionization detector. CO and CO₂ were measured “dry” using a CAI 603 NDIR non-dispersive infrared analyzer. Water vapor removal for the dry measurements was accomplished by a Nafion™ moisture exchanger arranged in counterflow. The moisture sink was a stream of atmospheric air that had been passed through a silica-gel dessicant bed. The analyzers were calibrated using an NTIS-traceable multi-gas calibration mixture.

We were ultimately unable to secure an FTIR analyzer for ammonia measurements. We therefore fell back on the downstream NO_x sensor of the SCR control system instead. This sensor responds to both NO_x and ammonia. The sensor was calibrated to agree with the chemiluminescent analyzer under conditions of zero urea injection. (In the absence of urea injection, there would be no ammonia slip, and the NO_x sensor should thus agree with the NO_x measurement). By subtracting the chemiluminescent NO_x value from the NO_x sensor reading, it was possible to calculate the ammonia concentration.

4.2 TEST MATRIX

As described earlier, the SCR catalyst is located in the exhaust flow between the first and second passes through the fire-tube boiler. The bypass valve can be set to allow a varying percentage of the exhaust flow to bypass the initial boiler pass. With the bypass valve fully closed, the exhaust temperature at the SCR catalyst ranged from 312 to 337 C, depending on engine power output. When fully open, the temperature ranged from 432 to 440 C.

The test matrix was defined with exhaust bypass settings of fully-closed, 1/3 open, 2/3 open, and fully open; and with engine power output levels of 400, 600, and 750 kW. This gave a total of 12 test conditions: four temperatures at each of three exhaust flow rates. The exhaust bypass

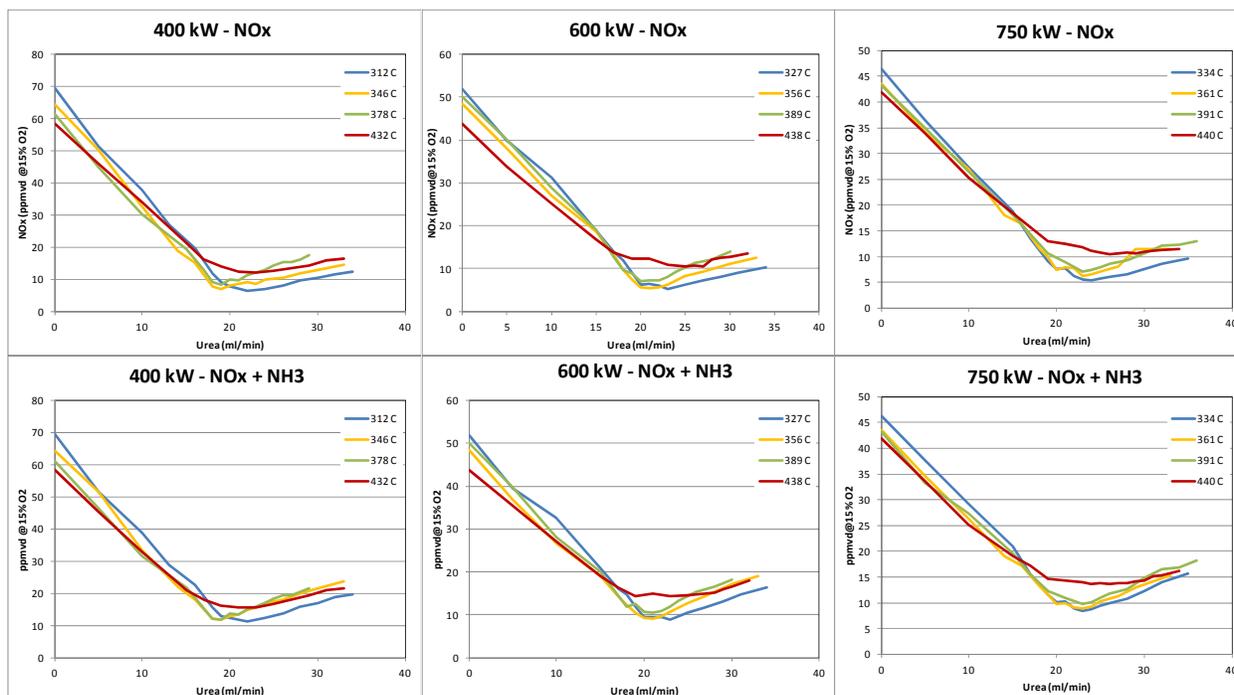
valve was positioned first, and the electrical power output of the generator was then set to 400, 600, and 750 kW in turn.

For each combination of power output and bypass valve setting, emissions were recorded at 12 to 17 separate urea flow settings, beginning with zero and increasing up to between 30 and 36 milliliters per minute. Each urea flow setting was maintained for approximately 200 seconds. The emission results for each setting were calculated as the average over the last 60 seconds of that period. The period of ~140 seconds before averaging started was included to allow the level of ammonia adsorption onto the catalyst to stabilize at each setting.

4.3 TEST RESULTS

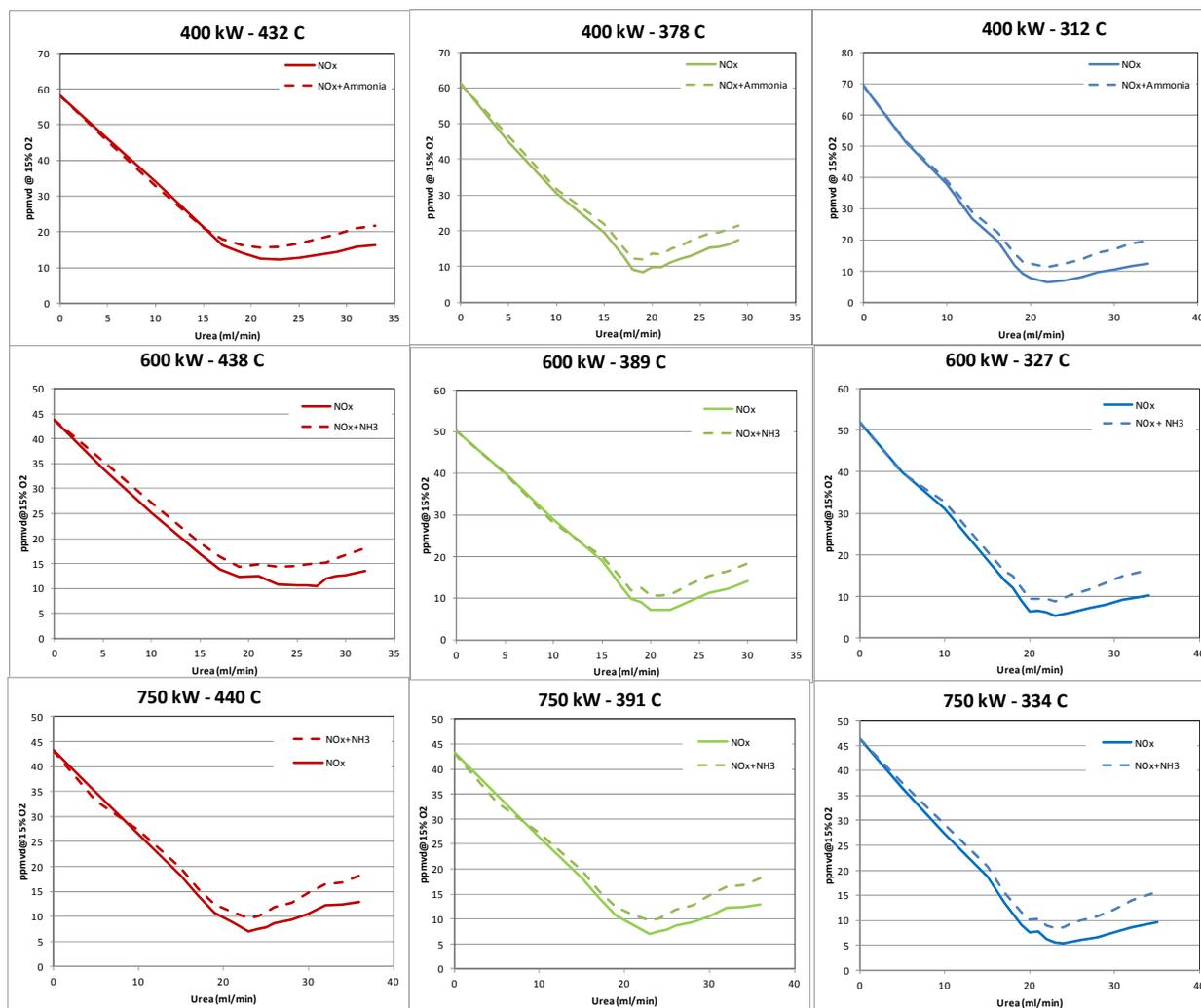
The measured concentrations of NOx (from the chemiluminescent analyzer) and NOx + ammonia (from the NOx sensor) are plotted below. Both sets of measurements are corrected to 15% O₂ dry basis, so that the values are directly comparable to the permit limits. At low rates of urea injection, the NOx concentration goes down linearly as the urea injection rate goes up. In this regime, there is too little ammonia present to react with all of the NOx, so the levels of ammonia slip are low. At high rates of urea injection, the NOx concentration increases more-or-less linearly with the urea injection rate. Here, there is excess ammonia present, and some of the excess reacts on the platinum slip catalyst to form NOx. The fraction of the ammonia that reacts in this way increases with temperature. The area of greatest interest is in the transition between these two regimes, where the NOx concentration reaches a minimum. For exhaust temperatures below 360 C, this minimum is about 5 to 6 ppmvd, but it increases to about 10-11 ppmvd at 432 to 440 C.

Figure 8: NOx and NOx + ammonia concentrations vs. urea flow rate and temperature for SCR with platinum slip catalyst



The plots below compare the measured values for NOx plus ammonia (from the NOx sensor) to the NOx measured by the chemiluminescent analyzer. The distance between the two lines is the ammonia concentration. As these plots show, the ammonia concentrations are well below the 10 ppmvd limit, even where the amounts of urea injected are significantly greater than optimal. This is because the platinum slip catalyst is converting much of the excess ammonia to NOx.

Figure 9: NOx and NOx + ammonia concentrations compared for SCR with platinum slip catalyst



The existing Optimin™ self-tuning algorithm takes the NOx + ammonia signal from the downstream NOx sensor, and is designed to adjust the urea injection rate to a small range centered on the minimum in the NOx + ammonia curves shown Figure 9. Comparing the NOx and NOx + ammonia curves, it can be seen that the urea injection rate that produces a minimum in the latter is also very close to that giving the minimum value in the former.

5. EMISSIONS OPTIMIZATION WITHOUT PLATINUM SLIP CATALYST

Once the emissions optimization study was completed, the SCR catalyst modules with the platinum slip catalyst were exchanged for new modules without the slip catalyst. The change was made on March 5th, 2014. Emissions optimization studies on the new catalyst modules were carried out on April 9 and 10, 2014. At that point, the new catalyst modules had accumulated about 740 operating hours.

5.1 INSTRUMENTATION AND SAMPLING

The sampling and instrumentation for these measurements were the same as those for Task 4, described in the preceding section. The downstream NOx sensor on the SCR control system was used to measure the sum of NOx and ammonia emissions. Simultaneously, NOx emissions were measured separately from ammonia using the CAI 600 HCLD analyzer. With no urea being injected, and sufficient time allowed for any urea present to have decomposed, both the upstream and downstream NOx sensors agreed with the chemiluminescent analyzer within a few ppm. This was as-expected – in the absence of urea injection, there would be no ammonia slip, and the NOx+NH₃ signal should thus agree with the NOx measurement.

5.2 TEST MATRIX

The test matrix was defined with exhaust bypass settings of fully-closed, 2/3 open, ~85% open, and fully open; and with engine power output levels of 400, 600, and 750 kW. This gave a total of 12 test conditions: four temperatures at each of three exhaust flow rates. The exhaust bypass valve was positioned first, and the electrical power output of the generator was then set to 400, 600, and 750 kW in turn.

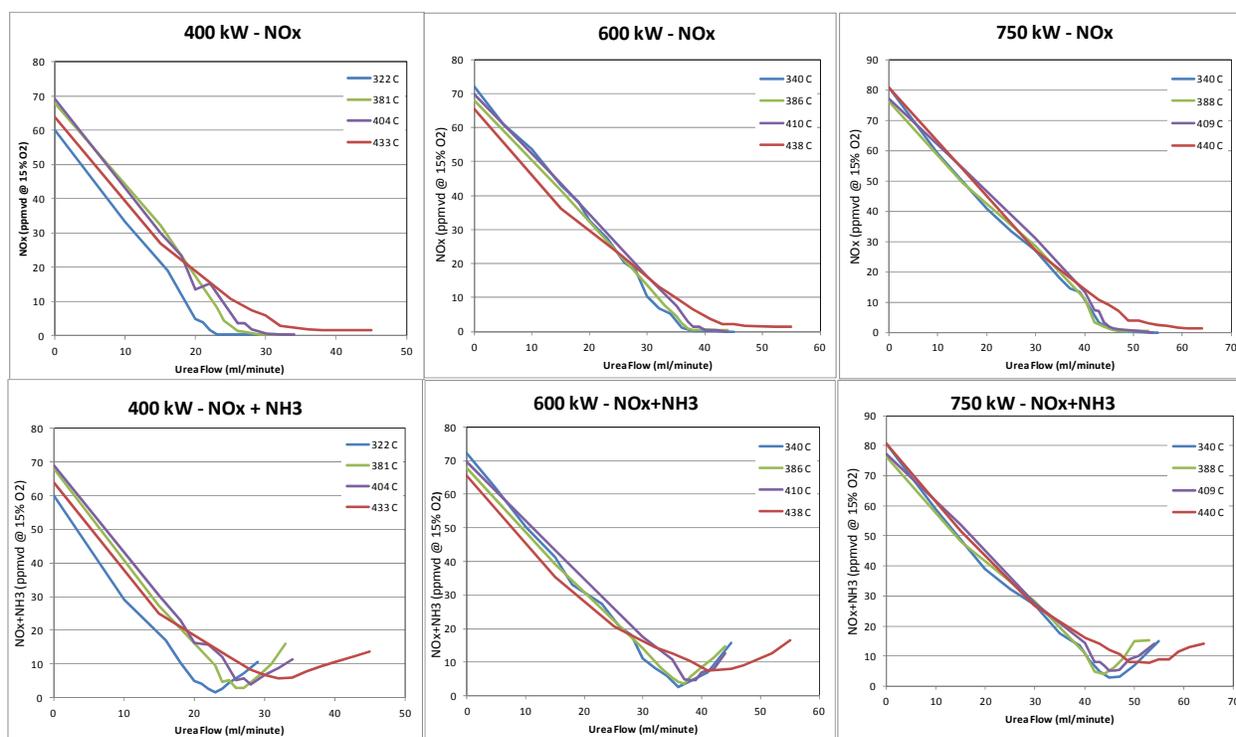
The ~85% open position of the exhaust bypass valve represents a change from the testing done in Task 4. The Task 4 testing showed little difference in catalyst performance between the closed, 1/3 open, and 2/3 open positions, but a substantial change between the 2/3 open and full-open conditions. The 85% open position was therefore substituted for the 1/3 open condition, in order to provide more detail on the transitional region. This position gave an exhaust temperature of about 410 C downstream of the SCR catalyst assembly.

For each combination of power output and bypass valve setting, emissions were recorded at 10 to 16 separate urea flow settings, beginning with zero and increasing up to between 33 and 64 milliliters per minute. Each urea flow setting was maintained for approximately 200 seconds, of which only the last 60 seconds were included in the analysis. This allowed the level of ammonia adsorption onto the catalyst to stabilize at each setting.

5.3 TEST RESULTS

The results of the chemiluminescent NOx measurements and the NOx+ammonia measurements made with the NOx sensor are plotted in Figure 10. All results have been corrected to conditions of dry gas with 15% O₂, to match the District's normal permit conditions. At low rates of urea injection, the NOx concentration goes down linearly as the urea injection rate goes up. In this regime, there is too little ammonia present to react with all of the NOx, so the levels of ammonia slip are low. It is notable that the engine-out exhaust NOx concentrations were substantially higher for these tests than for the earlier testing in Task 4. At 750 kW, the NOx concentration was around 80 ppmvd, compared to around 40-45 ppmvd in the earlier testing. At 600 kW, the NOx concentration was about 70 ppmvd, compared to 45-50 ppmvd in Task 4. This difference was not observed at 400 kW, where the NOx concentrations were similar in Task 4 and Task 5.

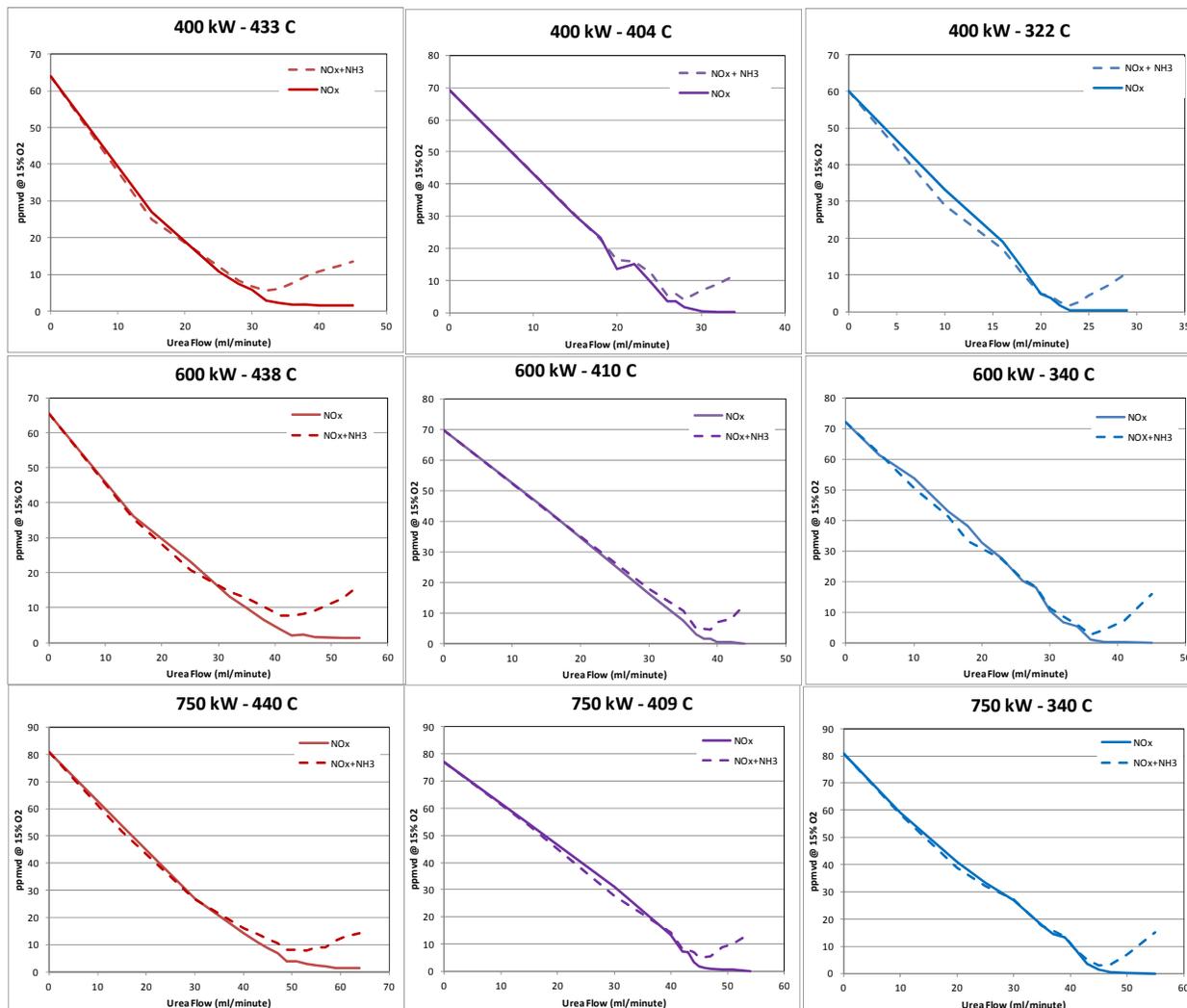
Figure 10: NOx and NOx + ammonia concentrations vs. urea flow rate and temperature for SCR without slip catalyst



As Figure 10 shows, both NOx and NOx+ammonia concentrations go down more-or-less linearly as the rate of urea injection increases, until an inflection point is reached. From that point, further increases in urea injection give only small reductions in NOx, but increasing amounts of ammonia slip. The NOx + ammonia plot reaches a minimum near the NOx inflection point, and subsequently increases with the urea injection rate. The minimum NOx and NOx+ammonia concentrations increase with increasing exhaust temperature. The minimum NOx concentration is near zero for temperatures up to 410 C, and about 1.3 ppmvd at 440 C.

The plots in Figure 11 compare the measured values for NOx+ammonia (from the NOx sensor) to the NOx measured by the chemiluminescent analyzer. To allow a more precise comparison, the NOx data were adjusted to be equal to the NOx + ammonia values at zero urea flow.

Figure 11: NOx and NOx + ammonia concentrations compared for SCR without slip catalyst



As discussed earlier, EF&EE’s existing Optimin™ self-tuning algorithm was designed to adjust the urea injection rate to approximately the minimum in the NOx + ammonia plot. In practice, the actual urea injection rate varies within a band of about +/- 6% around the minimum. This is shown schematically as the gray rectangle in Figure 12. The resulting average NOx values are well within the District’s current BACT guidelines, but do not meet the goal of this project except at the lowest temperature.

To achieve even lower NOx emissions, the self-tuning algorithm was modified. Instead of seeking the minimum value of the NOx+ammonia plot, the modified algorithm adjusts the urea injection rate to lie within a range of values to the right of the minimum, but to the left of the point where ammonia emissions would approach the District’s limit of 10 ppmvd. This is shown schematically by the blue rectangle in Figure 12. This new algorithm results in higher NOx + ammonia concentrations, on average, but average NOx concentration is much lower.

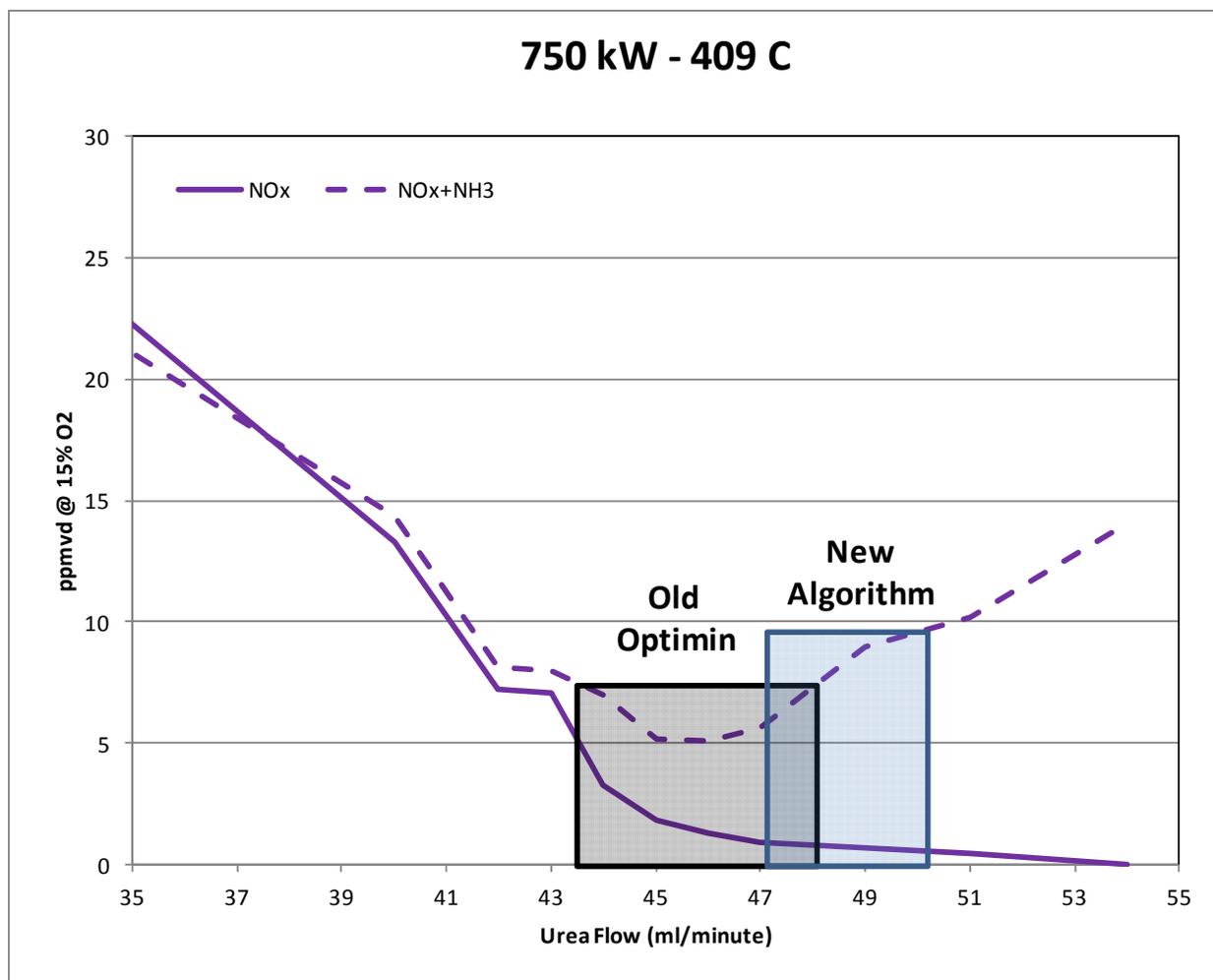


Figure 12: Range of urea injection rates for the old Optimin vs. new self-tuning algorithm

From the data shown in Figure 11, the new algorithm is feasible up to an exhaust temperature of 433 C at 400 kW output, and to 410 C at 750 kW. At the highest temperature and at high power output, there is too little room between the minimum NOx + ammonia value and 10 ppmvd for this algorithm to be workable.

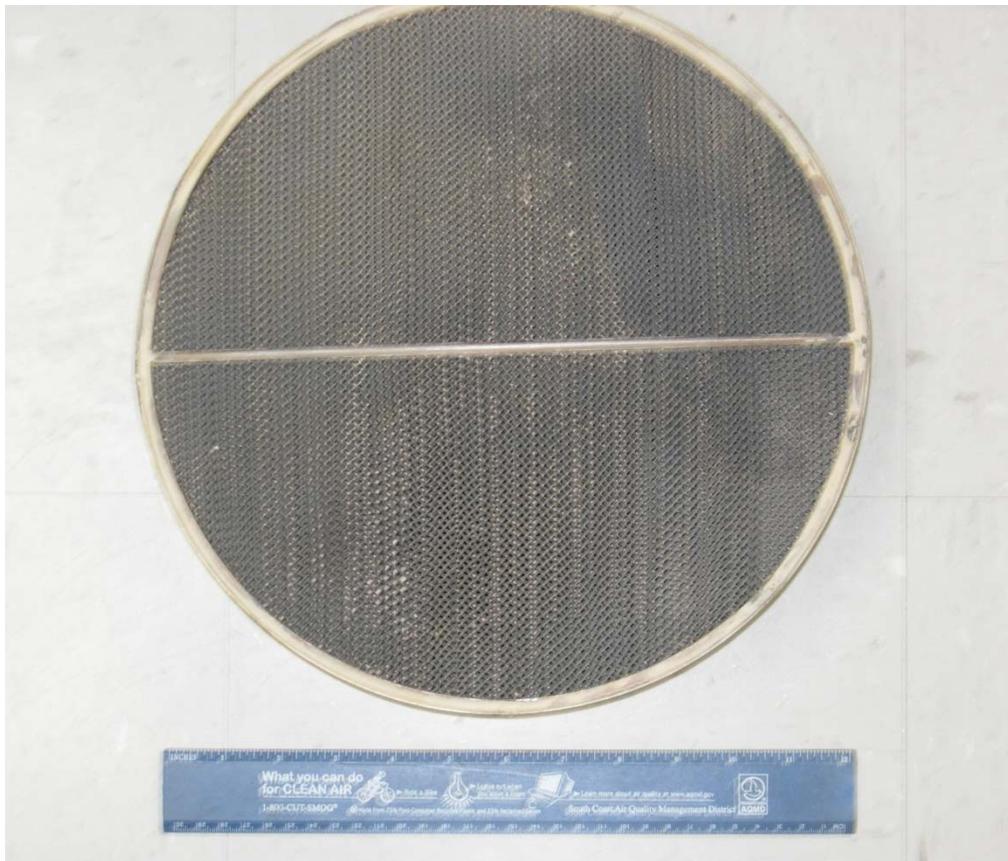
The new algorithm was tested for several days to confirm that it gave stable results. The Task 6 source testing was then conducted with the modified self-tuning algorithm active, and with the exhaust bypass valve adjusted to give 404 C at the outlet of the SCR catalyst. This testing was carried out by Best Environmental, and completed on April 17. At that time, the new SCR catalyst modules had accumulated about 900 operating hours.

With the new catalyst and self-tuning algorithm, the source testing showed average NOx emissions of 0.69 ppmvd, or 0.021 lb/hr, with mean ammonia emissions of 3.03 ppmvd. At 0.75 MW(e) output, this gives 0.028 pounds of NOx per megawatt-hour, which is comfortably less than the project goal of 0.07 lb/MWH. It should be noted that this lb/MWH value is calculated with respect to the electrical output alone. For this cogeneration system, ARB rules allow the calculation to be made against the sum of electrical and useful thermal output. That would result in a value less than 0.02 lb/MWH.

The source test results showed CO emissions of 123 ppmvd, barely meeting the permit requirement for this pollutant. In the absence of the platinum end-coat, the SCR catalyst does not promote the oxidation of CO. The catalyst does promote the oxidation of VOC to CO, however, so that the exhaust CO concentration typically increases slightly in going through the catalyst. To assure adequate compliance margin, a separate CO oxidation catalyst is needed upstream of the urea injection point.

Figure 13 shows a CO oxidation catalyst suitable for this application. The round catalyst element is specified to fit inside the exhaust pipe, thus minimizing installation cost. EF&EE has ordered a similar catalyst element sized for the 14” ID exhaust pipe used in this installation. The estimated retail cost of the oxidation catalyst element is less than \$3,000.

Figure 13: Typical CO oxidation catalyst element



6. CONCLUSIONS AND PLANS FOR FURTHER WORK

The goal of this project was to develop and demonstrate a Compact SCR™ system to allow typical lean-burn, biogas stationary engines to meet the ARB distributed generation standard of 0.07 pounds of NOx per MWH. This goal has been achieved, with actual measured NOx emissions of 0.028 lb/MWH (equivalent to 0.69 ppmvd or 0.009 g/BHP-hr). Ammonia slip was 3.0 ppmvd, which is well below the limit of 10 ppmvd considered BACT.

It should be noted that the achieved value of 0.028 pounds of NOx per MWH was calculated with respect to only the electrical output of the engine-generator. For cogeneration systems, ARB rules allow the calculation to be made against the sum of the electrical and useful thermal outputs. Depending on the cogeneration system design, useful thermal output from a lean-burn engine is typically between 50% and 120% of the electrical output. This would result in NOx emissions between 0.013 and 0.019 lb/MWH.

Two different SCR catalyst types were tested. One type was provided with a platinum coating on the downstream end to control emissions of excess ammonia reductant from the SCR system (ammonia slip). This coating also helped to oxidize carbon monoxide emissions from the engine. The second catalyst type was similar in composition but lacked the platinum coating on the downstream end.

The effects of each catalyst type on NOx and ammonia emissions were determined as functions of exhaust temperature, engine power output, and reductant flow rate. The second catalyst type was found to give better NOx control efficiency, and was the one used to demonstrate compliance with the ARB standard. The platinum slip catalyst on the first catalyst type was found to oxidize ammonia to NOx, resulting in higher minimum NOx levels than for the second type. Only the second type was found capable of meeting the 0.07 lb/MWH NOx standard.

The performance of both SCR catalyst types is affected by exhaust temperature. Minimum NOx levels were similar from 320 to 410 C, but increased significantly at 440 C. The independent source testing was conducted at 405 C. Higher temperatures will result in lower NOx control efficiency and/or higher ammonia emissions. The high temperature limit for meeting the 0.07 lb/MWH standard is probably between 410 and 440 C. Equivalent or improved performance is expected at lower temperatures, down to at least 320 C.

The second catalyst type lacks CO oxidation activity. Thus, to provide adequate compliance margin for that pollutant, a separate, inexpensive CO oxidation catalyst is recommended to be installed upstream of the urea injection point. The added cost of the CO oxidation catalyst is estimated at less than \$3,000.

At the time of testing, the catalyst elements of the second type had accumulated about 740 operating hours. Catalyst efficiency is expected to degrade slowly with increased operating time. Based on experience with the SCR control system at the Fiscalini Dairy, the useful life of the SCR catalyst is estimated to be 30,000 to 40,000 hours before it can no longer maintain the target levels of NOx control. EF&EE plans to perform follow-up measurements at approximately

annual intervals in order to monitor catalyst performance over time. The results of these follow-up measurements will be submitted to the District as addenda to this report.

In addition to optimizing NOx reduction efficiency, operating the SCR catalyst at the moderate temperature employed here would help to protect the catalyst from degradation due to siloxanes in the fuel. Siloxanes are silicon compounds commonly found as contaminants in biogas from landfills and sewage digesters, and can damage catalytic converters. Siloxanes burn in the engine to form silicon dioxide in the exhaust. At these moderate exhaust temperatures, silicon dioxide is expected to form solid particles, rather than depositing on the catalyst. If so, then this SCR technology should be highly tolerant of siloxane contamination of the fuel. Additional testing is recommended using these catalysts with exhaust streams from internal-combustion engines burning sewage gas or landfill gas in order to assess this possibility.

APPENDIX A: SOURCE TEST REPORT

**Joseph Gallo Farms
GALLO CATTLE COMPANY
Atwater, CA**

Emissions Test Report
One 750KW Digester Gas Fired Engine
NO_x, CO, VOC & NH₃ Emission Results
[N-1660-10-0]

Test Date(s): April 17, 2014

Report Date: May 1, 2014

Performed and Reported by:

BEST ENVIRONMENTAL
339 Stealth Court
Livermore, CA 94551
Phone: (925) 455-9474
Fax: (925) 455-9479
Email: bestair@sbcglobal.net

Test Location:

Joseph Gallo Farms-Gallo Cattle Company
10561 W Highway 140
Atwater, CA 95301

Prepared For:

Engine, Fuel and Emissions Engineering, Inc.
8614 Unsworth Avenue, Suite 100
Sacramento, CA 95828
Attn: Mr. Christopher S. Weaver

REVIEW AND CERTIFICATIONTeam Leader:

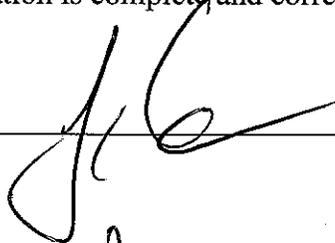
The work performed herein was conducted under my supervision, and I certify that the details and results contained within this report are to the best of my knowledge an authentic and accurate representation of the test program. If this report is submitted for compliance purposes it should only be reproduced in its entirety. If there are any questions concerning this report, please call the Team Leader or Reviewer at (925) 455-9474.



Suhail Asfour
Project Manager

Reviewer:

I have reviewed this report for presentation and accuracy of content, and hereby certify that to the best of my knowledge the information is complete and correct.



Regan Best
Source Test Manager

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SECTION 1. INTRODUCTION

1.1. Test Purpose

Best Environmental was contracted by Joseph Gallo Farms to perform NO_x, CO, VOC and NH₃ outlet emissions testing on one digester gas fired engines to comply with San Joaquin Valley Air Pollution Control District (SJVAPCD) and the Permit to Operate (PTO # N-1660-10-0). A copy of the permits is included in the appendices.

1.2. Test Location

The testing was conducted on one digester-gas fired I.C. engines located at Gallo Cattle Company, 10561 W Highway 140, Atwater, California 95301.

1.3. Test Date(s)

Testing was conducted on April 17, 2014.

1.4. Pollutants Tested

The following emission parameters were measured:

Parameter	Monitoring & Analytical Protocols
NO _x , CO & O ₂	EPA Methods 7E, 10 & 3A
VOC	EPA Method 18
NH ₃	BAAQMD ST-1B
Volumetric Flow Rate	EPA Method 19

1.5. Sampling and Observing Personnel

Sampling was performed by Suhail Asfour and Burt Kusich of BEST ENVIRONMENTAL (BE).

SECTION 2. SUMMARY OF RESULTS

2.1. Emission Results

Table 2.1: 750 KW Engine (N-1660-10-0)

Parameter	Average	Limits
NH ₃ , ppm @ 15% O ₂	3.03	10
NO _x , ppm @ 15% O ₂	0.69	9
CO, ppm @ 15% O ₂	122.37	123
VOC, ppm @ 15% O ₂	<0.20	48.2

A more extensive summary of the emissions is presented in Table 1 following the text.

2.2. Process Data

The engine was operated at 750KW throughout the test program.

2.3. Allowable Emissions

See Table 2.1 above. The test results show that all emissions are in compliance with the emissions limits shown in the ATC. Although CO exceeded the emission limit for Run 1, the average CO ppm results were within the SJVAPCD imposed limit.

2.4. Description of Collected Samples

Following testing, all samples are recovered and/or sealed onsite and placed into pre-labeled containers for shipment. The ST-1B impinger samples were recovered onsite following each test run.

A Chain of Custody (COC) was filled out for all samples to ensure proper handling and analysis.

2.5. Comments: Discussion of Quality Assurance and Errors

Quality assurance procedures listed in the above referenced test methods and referenced in the Source Test Plan were performed and documented. The QA/QC procedures are described in Section 4.3 of the report. Documentation of the QA/QC is provided in Appendix A, B, D & E.

Method 19 flow rates were used to calculate the emission rate and factors for all gaseous emissions. VOC is assumed equal to total non-methane non-ethane hydrocarbons.

SECTION 3. SOURCE OPERATION

3.1. Process Description

Joseph Gallo Farms (Gallo Cattle Company) operates an 800 KW Guascor model SFGLD-480 I.C. engine to provide power for the facility. The lean burn engine is exclusively fired on digester gas generated from the facilities cattle farm. The engine is equipped with a selective catalytic reduction system and a heat recovery system used for boiler water pre-heating.

3.2. Stack Diagram

A diagram of the stack is contained in Appendix F.

3.3. Process and Control Operating Parameters During Testing

The 1,152 HP engine was operated normally at 750kW, approximately 94% of rated capacity. Load was determined from the readout on the unit control panel.

The fuel usage for the engine was recorded at 14.6MSCFH from the dedicated fuel meter.

3.4. Testing or Process Interruptions and Changes

There were no process or testing delays on the day of the test.

SECTION 4. SAMPLING AND ANALYSIS PROCEDURES

4.1. Port Location

Emissions from the engines were sampled via two 3.0-inch ports 90° apart from each other 8 stack diameters downstream and 2 stack diameter upstream from the nearest disturbance. The sample ports were accessed on the roof of the engine housing.

The dimensional cross-section of each stack is 14.0 inches (Area SQFT = 1.069).

4.2. Point Description/Labeling – Ports/Stack

A 12-point traverse check was performed during the first run. No stratification was found therefore a single point in the stack was selected on the remaining test run.

4.3. Method Description, Equipment, Sampling, Analysis and QA/QC

Sampling and analytical procedures of the methods were followed as published in the BAAQMD Manual of Procedures, CARB Stationary Source Test Methods Volume I and the EPA "Quality Assurance Handbook for Air Pollution Measurement Systems" Volume III, US EPA 600/4-77-027b.

The following is an overview of the Testing Performed

Parameter	Location	Method(s)	Duration	# of Runs
NO _x , CO & O ₂	Exhaust	EPA Method 7E, 10 & 3A	30 mins	3
VOC	Exhaust	EPA Method 18	30 mins	1
NH ₃	Exhaust	BAAQMD ST-1B	30 mins	3
Flow Rate, DSCFM	Exhaust	EPA Method 19	30 mins	3

EPA Method 1. This method is used to determine the duct or stack area and appropriate traverse points that represent equal areas of the duct for sampling and velocity measurements. The point selection is made based on the type of test (particulate or velocity), the stack diameter and port location distance from flow disturbance.

EPA Method 7E, 10 & 3A are all continuous monitoring techniques using instrumental analyzers. Sampling is performed by extracting exhaust flue gas from the stack, conditioning the sample and analyzing the flue gas using continuous monitoring gas analyzers in a CEM test van. The sampling system consists of a stainless steel sample probe, teflon sample line, glass-fiber particulate filter, glass moisture-knockout condensers in ice, teflon sample transfer tubing, diaphragm pump and a stainless steel/teflon manifold and flow control/delivery system. A constant sample and calibration gas supply pressure of 5 PSI was provided to each analyzer to avoid pressure variable response differences. The entire sampling system was leak checked prior to and at the end of the sampling program. The BE sampling and analytical system was checked for linearity with zero, mid and high level span calibration gases, and was checked for system bias at the beginning of the test day. System bias was determined by pulling calibration gas through the entire sampling system. Individual test run calibrations used the calibration gas, which most closely matches the stack gas effluent. The calibration gases were selected to fall approximately within the following instrument ranges; 80 to 100 percent for the high calibration, 40 to 60 percent for the mid range and zero. Zero and calibration drift values were determined for each test.

EPA Method 7E, 10 & 3A met the following criteria:**System Criteria**

Instrument Linearity	± 2% Calibration Span or 0.5 difference
Instrument Bias	± 5% Calibration Span or 0.5 difference
Calibration Gas	± 2% Value
NO ₂ converter efficiency	>90%

Test Criteria

Instrument Zero Drift	± 3% Calibration Span or 0.5 difference
Instrument Span Drift	± 3% Calibration Span or 0.5 difference

The following continuous monitoring analyzers were used:

<u>Parameter</u>	<u>Make</u>	<u>Model</u>	<u>Principle</u>
O ₂	CAI	110P	Paramagnetic
NO _x	TECO	42C	Chemiluminescence
CO	TECO	48C	GFC IR analyzer

All BE calibration gases are EPA Protocol # 1. The analyzer data recording system consists of BE's Data Acquisition System (DAS).

EPA Method 18 is used to determine carbon speciated hydrocarbons (C₁, C₂ & C₃+) emissions by gas chromatograph / Flame Ionization Detection (GC/FID). Gaseous emissions are drawn through a Teflon sample line to a tedlar bag located in a rigid leak proof bag container. Sample is drawn into the bag by evacuating the container to stack gas pressure to allow sample flow without using a pump to avoid contamination. Negative pressure is adjusted to maintain an integrated sample flow between 20 to 60 minutes. The bag samples are taken to a laboratory and analyzed within 72 hours. The results are reported as methane with a detection limit of 0.5 ppm for non-methane non-ethane organic compounds (C₃+).

Ammonia by BAAQMD Method ST-1B. This method was used to determine the ammonia content in the gas stream by extracting a sample via a Teflon® or stainless steel probe and condensing/adsorbing the ammonia in two Greenburg-Smith impingers containing 200ml of 0.1N HCl, followed by an empty knock-out impinger and a fourth impinger containing 200g of pre-weighed silica gel. The moisture gained is determined volumetrically and gravimetrically. A minimum of 20 cubic feet of sample is pulled using a leak tight pump and sampling assembly and the volume is measured with a calibrated dry gas meter. Ammonia is determined at the laboratory by analysis using specific Ion Electrode. Results are recorded on the field data sheet. Sampling QA/QC consists of performing sampling system leak checks before and after each test run. Reagent blanks were collected onsite. All the sampling equipment is calibrated according to CARB schedules and documentation is included in the report. Analytical QA/QC consisted of a reagent blank, and laboratory blanks, and duplicates.

EPA Method 19 is used to determine stack gas volumetric flow rates using oxygen based F-factors. F-factors are ratios of combustion gas volumes generated from heat input. The heating value of the fuel in Btu per cubic foot is determined from the analysis of fuel gas samples using gas chromatography (GC). Dedicated fuel meters monitor total fuel consumption for the source. The

total cubic feet per hour of fuel multiplied times the Btu/CF provides million Btu per hour (MMBTU) heat input. The heat input in MMBTU/hr is multiplied by the F-factor (DSCF/MMBTU) and adjusted for the measured oxygen content of the source to determine volumetric flow rate. This procedure is proposed for pollutants whose compliance standards are based on emission rates (lb/day) or emission factors (lb/MMBtu).

TABLE #1
Joseph Gallo Farms
NOx & CO Emission Results
800KW Biogen (N-1660-10-0)
Normal Load

TEST	1	2	3	AVERAGE	LIMIT
Test Location	Outlet	Outlet	Outlet		
Test Date	4/17/2014	4/17/2014	4/17/2014		
Test Time	1045-1118	1134-1204	1219-1249		
Standard Temp., °F	60	60	60		
Exhaust Flow Rate, DSCFM	1,621	1,625	1,612	1,620	
Engine kw	750	750	750	750	
Engine, bhp	1,058	1,058	1,058	1,058	
O ₂ , %	5.94	5.87	5.91	5.91	
NH ₃ , ppm	5.80	7.75	9.57	7.71	
NH₃, ppm @ 15% O₂	2.29	3.04	3.77	3.03	10
NO _x , ppm	1.75	1.70	1.82	1.75	
NO_x, ppm @ 15% O₂	0.69	0.67	0.71	0.69	9
NO _x , lbs/hr	0.021	0.020	0.021	0.021	
NO _x , lbs/day	0.49	0.48	0.51	0.50	
NO _x , g/bhp-hr	0.009	0.009	0.009	0.009	
NO _x , lbs/MMBtu	0.0029	0.0028	0.0030	0.0029	
CO, ppm	313.59	310.53	308.81	310.98	
CO, ppm @ 15% O₂	123.68	121.90	121.52	122.37	123
CO, lbs/hr	2.25	2.23	2.20	2.23	
CO, lbs/day	54.03	53.64	52.89	53.52	
CO, g/bhp-hr	0.96	0.96	0.94	0.96	
CO, lbs/MMBtu	0.3133	0.3088	0.3079	0.3100	
VOC, ppm	<0.50	<0.50	<0.50	<0.50	
VOC, ppm @ 15% O₂	<0.20	<0.20	<0.20	<0.20	48.2
VOC, lbs/hr	<0.002	<0.002	<0.002	<0.002	
VOC, lbs/day	<0.05	<0.05	<0.05	<0.05	
VOC, g/bhp-hr	<0.001	<0.001	<0.001	<0.001	
VOC, lbs/MMBtu	<0.0003	<0.0003	<0.0003	<0.0003	

WHERE:NO_x = Oxides of Nitrogen (MW=46)

CO = Carbon Monoxide (MW=28)

O₂ = Oxygen

ppm = Parts Per Million Concentration

kW-hr = kilowatt hour

BHp-hr = Brake Horsepower hour

DSCFM = Dry Standard Cubic Feet per Minute

lbs/MMBtu = Pounds per Million Btu

Fd = 8710 (EPA F Factor for Natural Gas)

Tstd. = Standard Temp.; °R = °F + 460

VOC = Total Non-methane non-ethane Hydrocarbons as CH₄ (MW = 16)**CALCULATIONS:**15%O₂ correction = ppm of pollutant * 5.9 / (20.9 - %O₂)lbs/MMBtu = Fd * MW * ppm * 2.59E-9 * 20.9 / (20.9 - %O₂)

BHp-hr = kW-hr * 1.411

lbs/hr = ppm * DSCFM * MW * 60 / 379 x 106 (@ 60°F)

g/BHp-hr = lbs/hr * 453.6 / horsepower

Fd = 9862

APPENDICES

APPENDIX A - CALCULATIONS & NOMENCLATURE

APPENDIX B - LABORATORY REPORTS

APPENDIX C - FIELD DATA SHEETS

APPENDIX D - CALIBRATION GAS CERTIFICATES

APPENDIX E - EQUIPMENT CALIBRATION RECORDS

APPENDIX F - STACK DIAGRAMS

APPENDIX G - SAMPLING SYSTEM DIAGRAMS

APPENDIX H - SOURCE TEST PLAN

APPENDIX I - PERMIT TO OPERATE

APPENDIX A
CALCULATIONS & NOMENCLATURE

Standard Abbreviations for Reports

Unit	Abbreviation	Unit	Abbreviation
billion	G	microgram	µg
Brake horsepower	bhp	milligram	mg
Brake horsepower hour	bhp-hr	milliliter	ml
British Thermal Unit	Btu	million	MM
capture efficiency	CE	minute	min
destruction efficiency	DE	Molecular Weight	M
Dry Standard Cubic Feet	DSCF	nanogram	ng
Dry Standard Cubic Feet per Minute	DSCFM	Parts per Billion	ppb
Dry Standard Cubic Meter	DSCM	Parts per Million	ppm
Dry Standard Cubic Meter per Minute	DSCMM	pennyweight per firkin	pw/fkn
grains per dry standard cubic foot	gr/DSCF	pound	lb
gram	g	pounds per hour	lbs/hr
grams per Brake horsepower hour	g/bhp-hr	pounds per million Btu	lbs/MMBtu
kilowatt	kW	second	sec
liter	l	Specific Volume, ft ³ /lb-mole	SV
Megawatts	MW	Thousand	k
meter	m	watt	W

Common Conversions / Calculations / Constants

1 gram = 15.432 grains

1 pound = 7000 grains

grams per pound = 453.6

bhp = 1.411 * Engine kW, (where Engine kW = Generator kW output / 0.95) @ 95% efficiency

g/bhp-hr = 453*ppm*(MW / (385E6))* 0.00848 * f-factor * (20.9 / (20.9-O₂)); CARB

g/bhp-hr = lbs/hr * 453.6 / bhp

2.59E-9 = Conversion factor for ppm to lbs/scf; EPA 40CFR60.45

Correction Multiplier for Standard Temperature = (460 + T_{std.} °F) / 528

dscf / MMBTU = 8710 for Natural gas; EPA Method 19

Btu/ft³ = 1040 for Natural Gas; EPA Method 19

lb/hr Part. Emission Rate = 0.00857 * gr/dscf * dscfm; EPA Method 5

lbs/hr = ppm / SV x dscfm x M * 60; CARB Method 100; where SV ≈ 385E⁶ @ 68°F or ≈ 379E⁶ @ 60°F or ≈ 386E⁶ @ 70°F.

Correction to 12% CO₂ = gr/dscf * 12% / stack CO₂%; EPA Method 5

Correction to 3% O₂ = ppm * 17.9 / (20.9 - stack O₂ %); CARB Method 100

Correction to 15% O₂ = ppm * 5.9 / (20.9 - stack O₂ %); CARB Method 100

dscfm = Gas Fd * MMBtu/min * 20.9 / (20.9 - stack O₂ %); EPA Method 19

lb/MMBtu = Fd * M * ppm * 2.59E-9 * 20.9 / (20.9 - stack O₂ %); EPA Method 19

Standard Temperatures by District

EPA	68 °F	NSAPCD - Northern Sonoma	68 °F
CARB	68 °F	PCAPCD - Placer	68 °F
BAAQMD - Bay Area	70 °F	SLOCAPCD - San Luis Obispo	60 °F
SJVUAPCD - San Joaquin	60 °F	SMAQMD - Sacramento	68°F de facto
SCAQMD - South Coast	60 °F	SCAQMD - Shasta County	68 °F
MBUAPCD - Monterey Bay	68 °F	YSAPCD - Yolo-Solano	68 °F
FRAQMD - Feather River	68 °F	AADBAPC - Amador County	68 °F

CEM BIAS SYSTEM TEST SUMMARY SHEET

Facility: Joseph Gallo Farms Date: 4/17/2014 Personnel: SA/BK
 Location: 800KW Biogen (N-1660-10-0)

	O ₂	CO ₂	NOx	CO	THC	CH ₄	Comments
Analyzer	110P		42C	48C			
Range	10		50	500			
Zero Value (low)	0.00		0.00	0.00			Drift Cales per
Cal Value (mid)	4.49		22.1	250			
Cyl. #	CC83596		CC17028	CC134979			
Cal Value (Hi)	8.43		45.90	428			Calibration Span
Cyl. #	CC200475		CC155626	SA17938			

CALIBRATIC CALIBRATION ERROR CHECK

zero (int)	-0.01		0.00	0.84			
% Linearity	-0.12		0.00	0.20			Limit (±2%) or ±0.5diff.
mid cal (int)	4.50		22.47	248.55			
% Linearity	0.12		0.81	-0.34			Limit (±2%) or ±0.5diff.
high cal (int)	8.49		46.06	426.93			
% Linearity	0.71		0.35	-0.25			Limit (±2%) or ±0.5diff.

SYSTEM BIAS & DEM BIAS & DRIFT

Zero (int)	-0.01		0.00	0.84			
Zero (ext)	0.07		0.11	-0.11			
Cal (int)	4.50		22.47	248.55			
Cal (ext)	4.47		22.01	242.44			
Zero (int) 1(f)	0.02		0.14	-0.90			1045-1118
Cal (int) 1(f)	4.44		21.49	240.08			Run 1
Zero % Drift	-0.54		0.07	-0.18			Limit (±3%) or ±0.5diff.
Zero % Bias	0.40		0.31	-0.41			Limit (±5%) or ±0.5diff.
Cal % Drift	-0.34		-1.13	-0.55			Limit (±3%) or ±0.5diff.
Cal % Bias	-0.67		-2.13	-1.98			Limit (±5%) or ±0.5diff.
Average	5.88		1.83	302.75			
Corr. Average	5.94		1.75	313.59			
Zero (int) 2(f)	0.01		0.07	-0.43			1134-1204
Cal (int) 2(f)	4.44		20.92	234.36			Run 2
Zero % Drift	-0.11		-0.16	0.11			Limit (±3%) or ±0.5diff.
Zero % Bias	0.29		0.14	-0.30			Limit (±5%) or ±0.5diff.
Cal % Drift	0.00		-1.24	-1.34			Limit (±3%) or ±0.5diff.
Cal % Bias	-0.67		-3.37	-3.32			Limit (±5%) or ±0.5diff.
Average	5.80		1.72	294.82			
Corr. Average	5.87		1.70	310.53			
Zero (int) 3(f)	0.00		0.07	-0.28			1219-1249
Cal (int) 3(f)	4.43		20.39	238.07			Run 3
Zero % Drift	-0.13		0.01	0.04			Limit (±3%) or ±0.5diff.
Zero % Bias	0.17		0.15	-0.26			Limit (±5%) or ±0.5diff.
Cal % Drift	-0.20		-1.17	0.87			Limit (±3%) or ±0.5diff.
Cal % Bias	-0.87		-4.54	-2.45			Limit (±5%) or ±0.5diff.
Average	5.83		1.76	291.87			
Corr. Average	5.91		1.82	308.81			

SYSTEM RESPONSE TIME = 70 sec

System Drift (Limit ± 3%) = $100 * \frac{\text{External final cal} - \text{External Initial cal}}{\text{Calibration Span}}$

System Bias (Limit ± 5%) = $100 * \frac{\text{External cal} - \text{Internal cal}}{\text{Calibration Span}}$

% Linearity (Limit ± 2%) = $100 * \frac{\text{Span Value} - \text{Internal cal}}{\text{Calibration Span}}$

Corrected Average = $[\text{Test Avg.} - ((Z_i + Z_f) / 2)] * \text{Span Gas Value} / [((S_i + S_f) / 2) - ((Z_i + Z_f) / 2)]$

STACK GAS FLOW RATE DETERMINATION -- FUEL USAGE

EPA Method 19

Facility: Joseph Gallo Farms
 Unit: 800KW Biogen (N-1660-10-0)
 Condition: Normal Load
 Date: 4/17/2014

	1045-1118 Run 1	1134-1204 Run 2	1219-1249 Run3	
# standard cubic feet	275	277	274	ft ³
# of seconds	60.00	60.00	60.00	seconds
Gas Line Pressure(PSIG)	0.0	0.0	0.0	PSI Gauge
Gas Line Pressure(PSIA)	14.70	14.70	14.70	PSI Absolute
Gross Calorific Value @ 68°F	427.9	427.9	427.9	Btu / ft ³
Stack Oxygen	5.94	5.87	5.91	%
Gas Fd-Factor @ 68°F	9862	9862	9862	DSCF/MMBtu
Gas Temperature (°F)	60	60	60	°F
Standard Temperature (°F)	60	60	60	°F

Realtime Fuel Rate (CFM)	275.0	277.0	274.0	CFM
Corrected Fuel Rate (SCFM) @ 68°F	279.2	281.3	278.2	SCFM
Fuel Flowrate (SCFH)	16,754	16,876	16,693	SCFH
Million Btu per minute	0.119	0.120	0.119	MMBtu/min
Heat Input (MMBtu/hour)	7.2	7.2	7.1	MMBtu/Hr

Stack Gas Flow Rate	1,621	1,625	1,612	DSCFM
----------------------------	--------------	--------------	--------------	--------------

WHERE:

Gas Fd-Factor = Fuel conversion factor (ratio of combustion gas volumes to heat inputs)
 MMBtu = Million Btu

CALCULATIONS:

SCFM = CFM * 528 * (gas line PSIA) / 14.7 / (gas °F + 460)
 MMBtu/min = (SCFM * Btu/ft³) / 1,000,000
 DSCFM = Gas Fd-Factor * MMBtu/min * 20.9 / (20.9 - stack oxygen%)
 SCFH = SCFM * 60
 Heat Input = MMBtu/min * 60

**STACK AMMONIA DETERMINATION
BAAQMD METHOD ST-1B**

Facility: Joseph Gallo Farms
 Unit: 800KW Biogen (N-1660-10-0)
 Condition: Normal Load
 Date: 4/17/14

	NH ₃	NH ₃	NH ₃
Run:	1	2	3
Time:	1045-1115	1134-1204	1219-1249

- 1. Uncorrected Meter Volume (Vm)
- 2. Meter Factor (Yd)
- 3. Barometric Pressure (Pb)
- 4. Meter Pressure (ΔH)
- 5. Meter Temperature (Tm)
- 6. Std. Temperature (Tstd)
- 7. Impinger H₂O Gain (Vw imp)
- 8. Silica Gel Wt. Gain (Vw sg)
- 9. Total H₂O Gain (Vw)
- 10. Moisture Vapor (Vw std)

16.680	21.067	17.829	ft ³
0.9969	0.9969	0.9969	
29.90	29.90	29.90	"Hg
0.00	0.00	0.00	"H ₂ O
81.75	82.17	84.33	°F
60	60	60	°F
36.0	38.0	38.0	g
5.0	6.0	5.0	g
41.0	44.0	43.0	g
1.903	2.042	1.995	SCF

Ammonia, mg/sample
Std. Meter Volume (Vm std)
Ammonia, ppm
Percent of H₂O in Stack

1.88	3.17	3.30	
15.950	20.129	16.968	DSCF
5.80	7.75	9.57	
10.7	9.2	10.5	%

WHERE:

- ft³ = Cubic Feet
- H₂O = Water
- Hg = Mercury
- °F = Fahrenheit
- ml = milliliters
- g = grams
- % = Percent

CALCULATIONS:

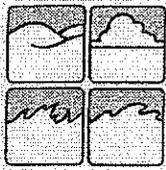
$$Vw\ std = 0.00267 * Vw * (Tstd + 460) / 29.92$$

$$Vm\ std = Vm * Yd * (Tstd+460) * (Pb+(\Delta H/13.6)) / (Tm+460) / 29.92$$

$$Ammonia\ ppm = 1.6085 * (mg / Vm\ std) * (Tstd + 460) / 17$$

$$Stack\ Moisture\ H_2O\ \% = 100 * Vw\ std / (Vw\ std + Vm\ std)$$

APPENDIX B
LABORATORY REPORTS



CHIPS
Environmental
Consultants, Inc.

10815 Foothill Avenue
Gilroy, CA 95020

(408) 847-8850
FAX (408) 847-8853

Best Environmental
339 Stealth Court
Livermore, CA 94550

D88 2807A.rtf
page 1 of 1

4-1-14

ATTN: Bobby Asfour (925) 455-9474, bestair@sbcglobal.net
RE: Gas Bag Analysis EPA Method 18, JGF Engine #3, 3-28-14

Engineering Test

Sample Run 1 Exhaust Gas
Time: 1330. All values Calculated as Methane
Methane: 522 PPMv
C-2: 21.3 PPMv
C-3+: ND

ND: Less than 0.5 PPMv

Analysis: HP 5890A Gas Chromatograph w/FID detection. Component separation on a six foot glass column of SP-1000 on Carbopak. Temperature programming was employed. Chromatographic data was recorded on an HP 3393A reporting integrator. Methane in Nitrogen and C2 to C6 n-alkanes in Nitrogen standards.

Sincerely,

Mark Chips
Laboratory Director
for Chips Environmental Consultants, Inc.



Project ID: *NGP - Engineering* SAMPLE CHAIN OF CUSTODY BE PROJECT MANAGER: BA
 Analytical Lab: *abips*

#	DATE	TIME	SAMPLE ID Run/Method/Fraction/Source	CONTAINER size / type	Volume	Storage Temp. of	SAMPLE DESCRIPTION	ANALYSIS	TAT
1	3-28-14	1330	Run / Engine #3	100 / Reddy	70%	AMB	Exhaust Gas	M/S	Normal
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

SPECIAL INSTRUCTIONS: Record & Report all liquid sample volumes.
Engineering - Please report separately

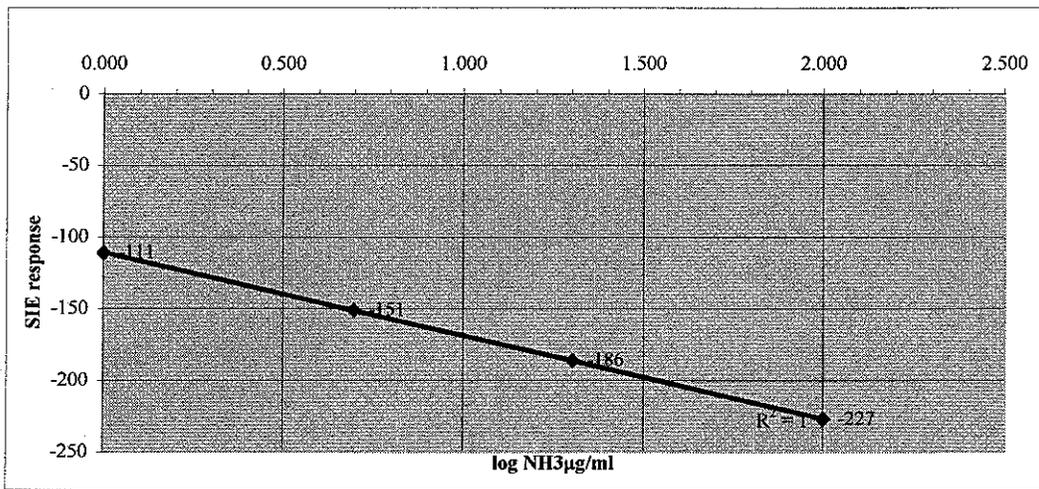
Submit Results to: Attn: *Bobby Astor* Received by: *[Signature]* Date: *3-29-14* Time: *1810*
 Relinquished by: *[Signature]* Received by: _____ Date: _____ Time: _____
 Relinquished by: _____ Received by: _____ Date: _____ Time: _____
 Relinquished by: _____ Received by: _____ Date: _____ Time: _____

AMMONIA by Specific Ion Electrode (SIE)

Facility: JGF
 Location: Engine #3 Outlet
 Sample Date: 4/17/2014
 Analysis Date: 4/18/2014

Request by: R. Best/ S. Asfour
 Analysts: R. Mariano *R. Mariano*
 Signature:

SIE millivolts (y)	NH ₃ µg/ml (x)	log (x)
-111	1.0	0.000
-151	5.0	0.699
-186	20.0	1.301
-227	100.0	2.000
Slope (m)		-58.011
Y Intercept (b)		-110.739



Sample µg/ml = 10^(| SIE - Intercept | / Slope)

Total mg/sample = (Sample µg/ml - Blank µg/ml) / 1000 * Total sample volume * Dilution

RUN	Total sample ml	Dilution	(y) SIE - millivolts	Temp. (F)	(x) Sample µg/ml	Total mg/sample
Run 1	236	1	-163	68	7.96	1.88
Run 2	238	1	-176	68	13.33	3.17
Run 3	238	1	-177	68	13.87	3.30
Blank	100	1	1	68	0.01	0.00

Project ID: J G F / Engine #3 Outlet
 Analytical Lab: Best Environmental
 SAMPLE CHAIN OF CUSTODY BE PROJECT MANAGER: SA

#	DATE	TIME	SAMPLE ID Run#/Method/Fraction/Source	CONTAINER size / type	Volume	Storage Temp °F	SAMPLE DESCRIPTION	ANALYSIS	TAT
1	4/17/2014	10:45	RUN 1 M ST-1B / B.H. IMP.	500ML / HDPE	236 ML		0.1N HCL	AMMONIA	NORMAL
2	4/17/2014	11:34	RUN 2 M ST-1B / B.H. IMP.	500ML / HDPE	238 ML		0.1N HCL	AMMONIA	NORMAL
3	4/17/2014	12:19	RUN 3 M ST-1B / B.H. IMP.	500ML / HDPE	238 ML		0.1N HCL	AMMONIA	NORMAL
4									
5	4/17/2014		BLANK HCL	500ML / HDPE			0.1N HCL	AMMONIA	NORMAL
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

SPECIAL INSTRUCTIONS: Record & Report all liquid sample volumes.

Submit Results to: Atri: BEST ENVIRONMENTAL 339 STEALTH COURT LIVERMORE CA 94551
 Relinquished by: Subal 4/18/14 Received by: Alan Date: 7-18-14 Time: 11:55 AM
 Relinquished by: _____ Received by: _____ Date: _____ Time: _____
 Relinquished by: _____ Received by: _____ Date: _____ Time: _____

SAMPLE CONDITION AS RECEIVED: OK or not OK

APPENDIX C
FIELD DATA SHEETS

CEM SYSTEM TEST SUMMARY SHEET (EPA)

Facility: JGF Date: 4-17-14 Personnel: SA, BK
 Location: ENS

	O ₂	CO ₂	NO _x	CO	THC	SO ₂	Comments
Analyzer	110P		42C	42C			
Range	10		50	500			
Zero Value (N ₂)	0		0	0			
Cyl. #	CC124475	→	→	→			
Cal Value (mid)	4.49		22.1	250			
Cyl. #	CC83596		CC17028	CC134979			
Exp. Date	11-01-21		1-21-17	5-3-15			
Cal Value (Hi)	8.43		45.9	428			Calibration Span
Cyl. #	CC200475		CC155626	SA17938			
Exp. Date	7-11-21		1-17-19	6-17-19			

CALIBRATION ERROR CHECK

Zero (int)	0.01		0	0.84		
Abs. Difference	0.01		0	0.84		
% Linearity	0.12		0	0.20		(< or = 2%) or (< or = .5diff.)
mid cal (int)	4.50		22.47	248.55		set at mid
Abs. Difference	0.01		0.37	1.95		
% Linearity	0.12		0.81	0.34		(< or = 2%) or (< or = .5diff.)
high cal (int)	8.49		46.96	426.93		
Abs. Difference	0.06		0.16	1.07		
% Linearity	0.71		0.35	0.25		(< or = 2%) or (< or = .5diff.)

Initial SYSTEM BIAS Check

Zero (int)	0.01		0	0.84		
Zero (ext)	0.07		0.11	-0.11		
Abs. Difference	0.08		0.11	0.95		
bias, % range	0.95		0.24	0.22		(< or = 5%) or (< or = .5diff.)
Cal (int)	4.50		22.47	248.55		
Cal (ext)	4.47		22.01	242.44		
Abs. Difference	0.03		0.46	6.11		
bias, % range	0.36		1.00	1.43		(< or = 5%) or (< or = .5diff.)

SYSTEM RESPONSE TIME (secs) - time from ext. zero to ext. cal, or ext. cal to ext. zero (95% response) -

zero to cal.	cal. to zero
70	70

NO₂ CONVERTER TEST

NO ₂ Cal value =	4.172	Final Value =	3.86	% Efficiency =	92.52	Cyl # =	CC500295
-----------------------------	-------	---------------	------	----------------	-------	---------	----------

System Calibration Bias = 100 * $\frac{\text{External cal} - \text{Internal cal}}{\text{Calibration Span}}$

% Linearity = 100 * $\frac{\text{Span Value} - \text{Internal cal}}{\text{Calibration Span}}$

% Converter Efficiency (Limit 90%) = 100 * $\frac{\text{Internal cal}}{\text{Cal Value}}$

DAS CONTINUOUS EMISSIONS MONITORING DATA SHEET

Facility: Joseph Gallo Farms
 Location: 800KW Biogen (N-1660-10-0)
 Observers: _____
 Expected Run Time = 30 min

Run #: _____ CEC
 Barometric: 29.90
 Personnel: SA/BK
 Std. Temp: 60

Date: 04/17/14
 Leak ✓ : OK
 Strat. ✓ : OK

Cylinder #s: _____

Analyte	O2	CO2	NOx	CO	THC	SO2		
Analyzer	110P	702D	42C	48C				
Range	10		50	500				
Span Value	4.49		22.10	250.00				

Time		Comments:						
9:54	-0.01		0.02	0.86				
9:55	-0.01		0.00	0.84	Zero O2, NOx & CO			Unit #
9:56	-0.01		0.01	0.61				
9:57	-0.01		0.00	0.52				
9:58	-0.01		0.00	0.54				Operating Conditions
9:59	3.49		2.02	117.30				
10:00	4.49		13.43	245.18				
10:01	4.50		21.07	248.58				Fuel
10:02	4.50		23.65	248.55	Mid O2 & CO			
10:03	4.50		22.67	248.51				
10:04	7.05		22.47	351.40	Mid NOx			
10:05	8.49		22.43	426.29				
10:06	8.49		22.47	426.93	High O2 & CO			
10:07	8.49		29.51	426.67				
10:08	7.42		42.05	426.72				
10:09	0.03		45.92	131.57				
10:10	-0.01		46.05	30.27				
10:11	-0.01		46.09	11.30				
10:12	-0.01		46.02	-0.18				
10:13	-0.01		46.06	0.20	High NOx			
10:14	-0.01		13.52	-0.03				
10:15	-0.01		1.53	0.07				
10:16	-0.01		2.29	0.35				
10:17	-0.01		3.33	0.16				
10:18	-0.01		3.49	0.19				
10:19	-0.01		3.70	0.07				
10:20	-0.01		3.85	0.32				
10:21	-0.02		3.86	0.17				
10:22	-0.01		3.86	0.45	NO2			
10:23	1.59		0.06	5.29				

Corrected Average = [Test Avg. - ((Zi+Zf) / 2)] * Span Gas Value / [((Si+Sf) / 2) - ((Zi+Zf) / 2)]

Zero Drift % = 100 * (Zf - Zi) / Instrument Range

Span Drift % = 100 * (Sf - Si) / Instrument Range

DAS CONTINUOUS EMISSIONS MONITORING DATA SHEET

Facility: Joseph Gallo Farms
 Location: 800KW Biogen (N-1660-10-0)
 Observers: _____
 Expected Run Time = 30 min
 Cylinder #s: _____

Run #: 1
 Barometric: 29.90
 Personnel: SA/BK
 Std. Temp: 60

Date: 04/17/14
 Leak ✓: OK
 Strat. ✓: OK

Analyte	O2	CO2	NOx	CO	THC	SO2			
Analyzer	110P	702D	42C	48C					
Range	10		50	500					
Span Value	4.49		22.10	250.00					
Time									
									Comments:
	10:45	5.93		1.91	304.00				
	10:46	5.93		1.98	303.92				Unit #
	10:47	5.93		2.21	303.97				
	10:48	5.92		1.97	304.39				
	10:49	5.90		1.84	304.86				Operating Conditions
	10:50	5.92		1.96	304.46				
	10:51	5.92		2.13	304.04				
	10:52	5.94		2.36	303.69				Fuel
	10:53	5.89		1.93	303.98				
	10:54	5.92		2.09	304.04				
	10:55	5.92		2.07	303.99				
	10:56	5.91		1.96	303.60				
	10:57	5.92		1.76	303.32				
	10:58	5.89		1.68	303.75				
	10:59	5.87		1.94	303.60				
	11:00					O2	NOx	CO	
	11:01					1.12	1.95	291.27	Port Change
	11:02	5.91		1.87	299.37	7.27	1.49	241.62	
	11:03	5.88		1.93	302.44				
	11:04	5.86		1.84	302.12				
	11:05	5.87		1.78	302.37				
	11:06	5.85		1.79	302.06				
	11:07	5.86		1.71	302.77				
	11:08	5.85		1.69	302.08				
	11:09	5.84		1.83	301.69				
	11:10	5.84		1.78	301.41				
	11:11	5.86		1.58	301.37				
	11:12	5.86		1.52	301.44				
	11:13	5.84		1.49	301.50				
	11:14	5.83		1.55	301.26				
	11:15	5.84		1.59	301.30				
	11:16	5.86		1.59	301.09				
	11:17	5.84		1.54	301.33				
ZERO I	10:35	0.07		0.11	-0.11				
SPAN I	10:37	4.47		22.01	242.44				
Average		5.88		1.83	302.75				
ZERO I	11:27	0.02		0.14	-0.90				
SPAN I	11:25	4.44		21.49	240.08				
Zero Drift %		-0.5%		0.1%	-0.2%				
Span Drift %		-0.3%		-1.0%	-0.5%				
Corr. Avg.		5.94		1.75	313.59				

Corrected Average = [Test Avg. - ((Zi+Zf) / 2)] * Span Gas Value / [((Si+Sf) / 2) - ((Zi+Zf) / 2)]
 Zero Drift % = 100 * (Zf - Zi) / Instrument Range
 Span Drift % = 100 * (Sf - Si) / Instrument Range

DAS CONTINUOUS EMISSIONS MONITORING DATA SHEET

Facility:	Joseph Gallo Farms	Run #:	2	Date:	04/17/14
Location:	800KW Biogen (N-1660-10-0)	Barometric:	29.90	Leak ✓:	OK
Observers:		Personnel:	SA/BK	Strat. ✓:	OK
Expected Run Time =	30 min	Std. Temp:	60		
Cylinder #s:					

Analyte	O2	CO2	NOx	CO	THC	SO2			
Analyzer	110P	702D	42C	48C					
Range	10		50	500					
Span Value	4.49		22.10	250.00					
Time		Comments:							
	11:34	5.84		1.67	297.35				
	11:35	5.83		1.69	296.72				Unit #
	11:36	5.83		1.74	296.47				
	11:37	5.82		1.79	296.08				
	11:38	5.81		1.71	295.70				Operating Conditions
	11:39	5.81		1.76	296.33				
	11:40	5.82		1.63	295.90				
	11:41	5.80		1.64	295.64				Fuel
	11:42	5.77		1.76	295.60				
	11:43	5.80		1.79	295.17				
	11:44	5.80		1.78	295.32				
	11:45	5.79		1.81	296.47				
	11:46	5.80		1.85	295.16				
	11:47	5.79		1.64	294.56				
	11:48	5.82		1.56	294.41				
	11:49	5.82		1.47	293.37				
	11:50	5.79		1.48	294.18				
	11:51	5.80		1.65	294.76				
	11:52	5.80		1.72	295.54				
	11:53	5.84		1.89	294.16				
	11:54	5.83		1.59	293.56				
	11:55	5.78		1.81	292.83				
	11:56	5.75		1.93	293.44				
	11:57	5.76		2.00	293.87				
	11:58	5.79		1.89	294.83				
	11:59	5.80		1.75	294.20				
	12:00	5.82		1.71	293.87				
	12:01	5.80		1.62	292.95				
	12:02	5.79		1.65	292.93				
	12:03	5.80		1.66	293.16				
ZERO I	11:27	0.02		0.14	-0.90				
SPAN I	11:25	4.44		21.49	240.08				
Average		5.80		1.72	294.82				
ZERO f	12:12	0.01		0.1	-0.4				
SPAN f	12:14	4.44		20.9	234.4				
Zero Drift %		-0.1%		-0.1%	0.1%				
Span Drift %		0.0%		-1.1%	-1.1%				
Corr. Avg.		5.87		1.70	310.53				

Corrected Average = [Test Avg. - ((Zi+Zf) / 2)] * Span Gas Value / [((Si+Sf) / 2) - ((Zi+Zf) / 2)]

Zero Drift % = 100 * (Zf - Zi) / Instrument Range

Span Drift % = 100 * (Sf - Si) / Instrument Range

DAS CONTINUOUS EMISSIONS MONITORING DATA SHEET

Facility: Joseph Gallo Farms
 Location: 800KW Biogen (N-1660-10-0)
 Observers: _____
 Expected Run Time = 30 min

Run #: 3
 Barometric: 29.90
 Personnel: SA/BK
 Std. Temp: 60

Date: 04/17/14
 Leak ✓: OK
 Strat. ✓: OK

Cylinder #s: _____

Analyte	O2	CO2	NOx	CO	THC	SO2			
Analyzer	110P	702D	42C	48C					
Range	10		50	500					
Span Value	4.49		22.10	250.00					
Time		Comments:							
	12:19	5.84		1.69	292.76				
	12:20	5.83		1.72	292.43				Unit #
	12:21	5.87		1.81	293.14				
	12:22	5.84		1.69	292.80				
	12:23	5.84		1.69	292.80				Operating Conditions
	12:24	5.86		1.74	292.07				
	12:25	5.82		1.69	292.55				
	12:26	5.80		1.79	292.60				Fuel
	12:27	5.81		1.88	292.59				
	12:28	5.82		1.85	292.22				
	12:29	5.83		1.81	291.83				
	12:30	5.83		1.89	292.24				
	12:31	5.82		1.86	291.94				
	12:32	5.81		2.09	292.49				
	12:33	5.82		2.01	292.04				
	12:34	5.84		1.95	292.17				
	12:35	5.85		1.85	291.54				
	12:36	5.84		1.59	290.99				
	12:37	5.84		1.61	291.94				
	12:38	5.84		1.70	291.22				
	12:39	5.84		1.75	291.35				
	12:40	5.84		1.74	291.84				
	12:41	5.83		1.67	290.96				
	12:42	5.83		1.76	291.76				
	12:43	5.85		1.81	290.98				
	12:44	5.82		1.66	291.42				
	12:45	5.83		1.67	291.49				
	12:46	5.83		1.63	291.54				
	12:47	5.83		1.62	290.92				
	12:48	5.83		1.58	289.36				
ZERO I	12:12	0.01		0.1	-0.4				
SPAN I	12:14	4.44		20.9	234.4				
Average		5.83		1.76	291.87				
ZERO f	12:59	0.00		0.07	-0.28				
SPAN f	12:58	4.43		20.39	238.07				
Zero Drift %		-0.1%		0.0%	0.0%				
Span Drift %		-0.2%		-1.1%	0.7%				
Corr. Avg.		5.91		1.82	308.81				

Corrected Average = [Test Avg. - ((Zi+Zf) / 2)] * Span Gas Value / [((Si+Sf) / 2) - ((Zi+Zf) / 2)]

Zero Drift % = 100 * (Zf - Zi) / Instrument Range

Span Drift % = 100 * (Sf - Si) / Instrument Range

DATE: 9-17-14		FACILITY: JGF		UNIT: #3		Serial No. :	
UNITS	Check or Record Data	PROCEDURE					
		Leak Check CEM system (set sample to 6 PSI then close off all but one rotameter and watch drop to zero)					
		Determine Traverse Points (4, 6, or 8 per diameter use Figure 1-2 in CARB 1) & mark the CEM Probe					
		All zero's and cal's must show straight line for reasonable length of time (i.e., 3-5 mins)					
		Now is a good time to do your NO2 converter check					
		Linearity Check - set internal zero (Ca) and cal gas (Ca) closest to stack gas, then check other cal gas					
		Bias Check - external zero (Cib) and cal gas (Cib) closest to stack gas - no analyzer adjustments allowed					
secs	70	Response Time (RT) Check (time from ext zero to ext cal 95% response for slowest analyzer)					
Time	10:45	Start Run #1 30 or 40 min Stratification Check - monitor all traverse points for 1 min + RT					
"Hg	29.96	Record	Barometric Pressure				
VOLTS	117	Record	Supply Voltage to the Van				
°F	276	Record	Heated Line Temp >248°F				
°F	49	Record	Knock-Out exit Temp <60°F or 20°F less than ambient				
°F	80	Record	Ambient Temp (Ta)				
°F		Record	Stack Temp (Ts)			1801 RPM	
°F		Record	Windbox Temp (Tw)				
NO		Record	Stack Gas NO2 (if >5% of NOx must show Converter Efficiency performed once per month)				
secs/ cf	275 SCFM	Record	Fuel meter - seconds/revolution				
PSI A or G		Record	Fuel Pressure			750 kW	
°F		Record	Fuel Temp				
	11:18	End Run #1 ≥30 min					
		Perform Ext zero & cal (Cfb) - make no analyzer adjustments					
		Determine Drift & Bias					
		If < 3 or 5% can start Run #2					
		If > 3 or 5% must re-do Linearity & Bias					
		If you fear next run will be > 3 or 5% then re-do Linearity & Bias					
Time	11:34	Start Run #2 30 or 40 min + RT if no stratification (Use Single Point)					
VOLTS	117	Record	Supply Voltage to the Van				
°F	274	Record	Heated Line Temp >248°F				
°F	36	Record	Knock-Out exit Temp <60°F or 20°F less than ambient				
°F	85	Record	Ambient Temp (Ta)				
°F		Record	Stack Temp (Ts)			1800 RPM	
°F		Record	Windbox Temp (Tw)				
secs/ cf	277 SCFM	Record	Fuel meter - seconds/revolution			744 kW	
PSI A or G		Record	Fuel Pressure				
°F		Record	Fuel Temp				
	12:04	End Run #2 ≥30 min					
		Perform Ext zero & cal (Cfb) - make no analyzer adjustments					
		Determine Drift & Bias					
		If < 3 or 5% can start Run #2					
		If > 3 or 5% must re-do Linearity & Bias					
		If you fear next run will be > 3 or 5% then re-do Linearity & Bias					
Time	12:19	Start Run #3 30 or 40 min + RT if no stratification					
VOLTS	117	Record	Supply Voltage to the Van				
°F	275	Record	Heated Line Temp >248°F				
°F	56	Record	Knock-Out exit Temp <60°F or 20°F less than ambient				
°F	86	Record	Ambient Temp (Ta)				
°F		Record	Stack Temp (Ts)			1800 RPM	
°F		Record	Windbox Temp (Tw)				
secs/ cf	274 SCFM	Record	Fuel meter - seconds/revolution			749 kW	
PSI A or G		Record	Fuel Pressure				
°F		Record	Fuel Temp				
	12:49	End Run #3 ≥30 min					
		Perform Ext zero & cal (Cfb) - make no analyzer adjustments					
		Determine Drift & Bias					
		Repeat any Runs that exceed Drift or Bias limits					
		Have you done your NO2 Converter Check??					

(CARB/EPA Method 4) Moisture Sampling Data Sheet

Facility: <u>Gallo Cattle Co</u>	Meter #: <u>29049</u>	Pbar: <u>29.90</u>
Location: <u>outlet</u>	Yd: <u>.4469</u>	% O ₂ : _____
Date: <u>4-17-14</u>	Pyrometer #: _____	% CO ₂ : _____
Personnel: <u>SKBK</u>		% H ₂ O: _____

Point	Time	Meter Vol, Ft ³	Temperature, °F			Vacuum, "Hg	
			Meter In	Meter Out	Imp.		
1	10:45	053.250	80	80	150	6	
2	5	055.9	84	80	"	"	
3	10	058.6	84	80	"	6.5	
4	15	061.4	84	80	"	"	
5	20	064.2	84	80	"	"	
6	25	067.1	85	80	"	"	
Stop	30	069.930					
	10:45						
TOTAL/AVG		16.680	81.75				

Initial Leak Check	<u>.005</u> CFM	<u>27</u> "Hg
Final Leak Check	<u>.002</u> CFM	<u>15</u> "Hg

	Initial	Final	Net
Impinger #1:	100	136	36
Impinger #2:	100	100	0
Impinger #3:			
Silica Gel:	714	124	5
Total Net:			41
% Moisture			

Point	Time	Meter Vol, Ft ³	Temperature, °F			Vacuum, "Hg	
			Meter In	Meter Out	Imp.		
1	11:15	070.223	82	80	150	7	
2	5	073.9	84	80	"	"	
3	10	077.4	84	80	"	"	
4	15	080.8	84	80	"	"	
5	20	084.3	85	80	"	7.1	
6	25	087.7	86	81	"	"	
Stop	30	091.290					
	12:04						
TOTAL/AVG		21.067	82.17				

Initial Leak Check	<u>.002</u> CFM	<u>15</u> "Hg
Final Leak Check	CFM	"Hg

	Initial	Final	Net
Impinger #1:	100	138	38
Impinger #2:	100	100	0
Impinger #3:			
Silica Gel:	524	232	6
Total Net:			44
% Moisture			

Point	Time	Meter Vol, Ft ³	Temperature, °F			Vacuum, "Hg	
			Meter In	Meter Out	Imp.		
1	12:18	091.321	84	82	150	7	
2	5	094.2	86	82	"	"	
3	10	097.2	86	82	"	"	
4	15	100.2	88	82	"	"	
5	20	103.2	88	82	"	"	
6	25	106.11	88	82	"	"	
Stop	30	109.150					
	12:49						
TOTAL/AVG		17.829	84.33				

Initial Leak Check	CFM	"Hg
Final Leak Check	CFM	"Hg

	Initial	Final	Net
Impinger #1:	100	138	38
Impinger #2:	100	100	0
Impinger #3:			
Silica Gel:	730	535	5
Total Net:			43
% Moisture			

Comments: _____

APPENDIX D
CALIBRATION GAS CERTIFICATES



Praxair
 5700 South Alameda Street
 Los Angeles, CA 90058
 Tel: (323) 585-2154 Fax: (714) 542-6689
 PGVPID: F22013

DocNumber: 000060196

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS

Customer & Order Information:

PRAXAIR WHSE PITTSBURG CA
 1930 LOVERIDGE RD
 PITTSBURG CA 945650

Praxair Order Number: 25416482
 Customer P. O. Number: 04649226
 Customer Reference Number:

Fill Date: 10/30/2013
 Part Number: NI CD8.5CO1E-AS
 Lot Number: 109330308
 Cylinder Style & Outlet: AS CGA 350
 Cylinder Pressure & Volume: 2000 psig 140 cu. ft.

Certified Concentration:

Expiration Date:	11/4/2021	NIST Traceable
Cylinder Number:	CC83596	Analytical Uncertainty:
45.4 ppm	CARBON MONOXIDE	± 1.1 %
8.43 %	CARBON DIOXIDE	± 1 %
4.49 %	OXYGEN	± 1 %
Balance	NITROGEN	

Certification Information: Certification Date: 11/4/2013 Term: 96 Months Expiration Date: 11/4/2021

This cylinder was certified according to the 2012 EPA Traceability Protocol, Document #EPA-600/R-12/531, using Procedure G1. Do Not Use this Standard if Pressure is less than 100 PSIG.

[CO] has been corrected for [CO2] interference.

Analytical Data:

(R=Reference Standard, Z=Zero Gas, C=Gas Candidate)

1. Component: CARBON MONOXIDE

Requested Concentration: 45 ppm
 Certified Concentration: 45.4 ppm
 Instrument Used: Horiba VIA-510, S/N 577172043
 Analytical Method: NDIR
 Last Multipoint Calibration: 10/24/2013

Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC272592
 Ref. Std. Conc: 50.6 ppm
 Ref. Std. Traceable to SRM #: 1678c
 SRM Sample #: 4-J-21
 SRM Cylinder #: XF001068B

First Analysis Data:		Date: 11/4/2013	
Z: 0	R: 50.6	C: 45.4	Conc: 45.4
R: 50.6	Z: 0	C: 45.3	Conc: 45.3
Z: 0	C: 45.4	R: 50.6	Conc: 45.4
UOM: ppm	Mean Test Assay:		45.367 ppm

Second Analysis Data:		Date:	
Z: 0	R: 0	C: 0	Conc: 0
R: 0	Z: 0	C: 0	Conc: 0
Z: 0	C: 0	R: 0	Conc: 0
UOM: ppm	Mean Test Assay:		0 ppm

2. Component: CARBON DIOXIDE

Requested Concentration: 8.5 %
 Certified Concentration: 8.43 %
 Instrument Used: Horiba VIA-510 S/N 2807014
 Analytical Method: NDIR
 Last Multipoint Calibration: 10/24/2013

Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC207040
 Ref. Std. Conc: 9.96%
 Ref. Std. Traceable to SRM #: vs. 1674b
 SRM Sample #: 7-F-32
 SRM Cylinder #: CAL014645

First Analysis Data:		Date: 11/4/2013	
Z: 0	R: 9.96	C: 8.43	Conc: 8.43
R: 9.96	Z: 0	C: 8.43	Conc: 8.43
Z: 0	C: 8.43	R: 9.96	Conc: 8.43
UOM: %	Mean Test Assay:		8.43 %

Second Analysis Data:		Date:	
Z: 0	R: 0	C: 0	Conc: 0
R: 0	Z: 0	C: 0	Conc: 0
Z: 0	C: 0	R: 0	Conc: 0
UOM: %	Mean Test Assay:		0 %

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DocNumber: 000060196

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS**3. Component: OXYGEN**
 Requested Concentration: 4.5 %
 Certified Concentration: 4.49 %
 Instrument Used: OXYMAT SE
 Analytical Method: PARAMAGNETIC
 Last Multipoint Calibration: 10/24/2013

 Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC245878
 Ref. Std. Conc: 5.02 %
 Ref. Std. Traceable to SRM #: 2658a
 SRM Sample #: 72-28-B
 SRM Cylinder #: CLM-006896

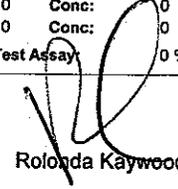
First Analysis Data:				Date:			
Z:	0	R:	5.02	C:	4.49	Conc:	4.49
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Z:	0	C:	4.49	R:	5.02	Conc:	4.49
UOM:	%	Mean Test Assay:		4.49 %			

Second Analysis Data:				Date:			
Z:	0	R:	0	C:	0	Conc:	0
R:	0	Z:	0	C:	0	Conc:	0
Z:	0	C:	0	R:	0	Conc:	0
UOM:	%	Mean Test Assay:		0 %			

Analyzed by:


 Jacquelyne Fiero

Certified by:


 Rolonda Kaywood



Praxair
 5700 South Alameda Street
 Los Angeles, CA 90058
 Tel: (323) 585-2154 Fax: (714) 542-6689
 PGPVID: F22013

DocNumber: 000055940

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS

Customer & Order Information:

BEST ENVIRONMENTAL SERVICE
 339 STEALTH CT
 LIVERMORE CA 945510

Praxair Order Number: 24172365
 Customer P. O. Number: 8210
 Customer Reference Number:

Fill Date: 6/26/2013
 Part Number: NI CD12.5CO3EAS
 Lot Number: 109317709
 Cylinder Style & Outlet: AS CGA 590
 Cylinder Pressure & Volume: 2000 psig 140 cu. ft.

Certified Concentration:

Expiration Date:	7/11/2021	NIST Traceable
Cylinder Number:	CC200475	Analytical Uncertainty:
91.3 ppm	CARBON MONOXIDE	± 0.6 %
12.3 %	CARBON DIOXIDE	± 1 %
8.43 %	OXYGEN	± 1 %
Balance	NITROGEN	

Certification Information: Certification Date: 7/11/2013 Term: 96 Months Expiration Date: 7/11/2021
 This cylinder was certified according to the 2012 EPA Traceability Protocol, Document #EPA-600/R-12/531, using Procedure G1. Do Not Use this Standard if Pressure is less than 100 PSIG.

CO response have been corrected for CO2 interference.

Analytical Data: (R=Reference Standard, Z=Zero Gas, C=Gas Candidate)

1. Component: CARBON MONOXIDE

Requested Concentration: 90 ppm
 Certified Concentration: 91.3 ppm
 Instrument Used: Horiba VIA-S10, S/N 577172043
 Analytical Method: NDIR
 Last Multipoint Calibration: 6/25/2013

First Analysis Data:		Date: 7/11/2013	
Z: 0	R: 100.6	C: 91.4	Conc: 91.4
R: 100.6	Z: 0	C: 91.3	Conc: 91.3
Z: 0	C: 91.2	R: 100.6	Conc: 91.2
UOM: ppm	Mean Test Assay:		91.3 ppm

Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC141663
 Ref. Std. Conc: 100.6 ppm
 Ref. Std. Traceable to SRM #: vs. 1679c
 SRM Sample #: 3-I-45
 SRM Cylinder #: FF26593

Second Analysis Data:		Date:	
Z: 0	R: 0	C: 0	Conc: 0
R: 0	Z: 0	C: 0	Conc: 0
Z: 0	C: 0	R: 0	Conc: 0
UOM: ppm	Mean Test Assay:		0 ppm

2. Component: CARBON DIOXIDE

Requested Concentration: 12.5 %
 Certified Concentration: 12.3 %
 Instrument Used: Horiba VIA-510 S/N 2807014
 Analytical Method: NDIR
 Last Multipoint Calibration: 6/20/2013

First Analysis Data:		Date: 7/11/2013	
Z: 0	R: 19.71	C: 12.3	Conc: 12.3
R: 19.71	Z: 0	C: 12.31	Conc: 12.31
Z: 0	C: 12.32	R: 19.71	Conc: 12.32
UOM: %	Mean Test Assay:		12.31 %

Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC74850
 Ref. Std. Conc: 19.71 %
 Ref. Std. Traceable to SRM #: vs. 1674b
 SRM Sample #: 7-F-32
 SRM Cylinder #: CAL014645

Second Analysis Data:		Date:	
Z: 0	R: 0	C: 0	Conc: 0
R: 0	Z: 0	C: 0	Conc: 0
Z: 0	C: 0	R: 0	Conc: 0
UOM: %	Mean Test Assay:		0 %

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DocNumber: 000055940

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS

3. Component: OXYGEN

Requested Concentration: 8.5 %
Certified Concentration: 8.43 %
Instrument Used: OXYMAT 5E
Analytical Method: PARAMAGNETIC
Last Multipoint Calibration: 6/20/2013

Reference Standard Type: GMIS
Ref. Std. Cylinder #: CC92651
Ref. Std. Conc: 15.09 %
Ref. Std. Traceable to SRM #: 2659a
SRM Sample #: 71-37-B
SRM Cylinder #: CLM-006734

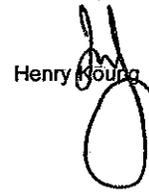
First Analysis Data:				Date:			
Z:	0	R:	15.08	C:	8.42	Conc:	8.426
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Z:	0	C:	8.44	R:	15.08	Conc:	8.446
UOM:	%	Mean Test Assay:		8.439 %			

Second Analysis Data:				Date:			
Z:	0	R:	0	C:	0	Conc:	0
R:	0	Z:	0	C:	0	Conc:	0
Z:	0	C:	0	R:	0	Conc:	0
UOM:	%	Mean Test Assay:		0 %			

Analyzed by:


King Yu

Certified by:


Henry Young

Information contained herein has been prepared at your request by qualified experts within Praxair Distribution, Inc. While we believe that the information is accurate within the limits of the analytical methods employed and is complete to the extent of the specific analyses performed, we make no warranty or representation as to the suitability of the use of the information for any purpose. The information is offered with the understanding that any use of the information is at the sole discretion and risk of the user. In no event shall the liability of Praxair Distribution, Inc., arising out of the use of the information contained herein exceed the fee established for providing such information.



Praxair
 5700 South Alameda Street
 Los Angeles, CA 90058
 Tel: (323) 585-2154 Fax: (714) 542-6689
 PGVPID: F22014

DocNumber: 000062709

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS

Customer & Order Information:

PRAXAIR WHSE PITTSBURG CA
 1930 LOVERIDGE RD
 PITTSBURG CA 945650

Praxair Order Number: 26050820
 Customer P. O. Number: 04740690
 Customer Reference Number:

Fill Date: 1/9/2014
 Part Number: NI NO22ME-AS
 Lot Number: 109400904
 Cylinder Style & Outlet: AS CGA 660
 Cylinder Pressure & Volume: 2000 psig 140 cu. ft.

Certified Concentration:

Expiration Date:	1/21/2017	NIST Traceable
Cylinder Number:	CC17028	Analytical Uncertainty:
22.0 ppm	NITRIC OXIDE	± 1 %
Balance	NITROGEN	

NOx = 22.1 ppm

NOx for Reference Only

Certification Information: Certification Date: 1/21/2014 Term: 36 Months Expiration Date: 1/21/2017

This cylinder was certified according to the 2012 EPA Traceability Protocol, Document #EPA-600/R-12/531, using Procedure G1. Do Not Use this Standard if Pressure is less than 100 PSIG.

Analytical Data:

(R=Reference Standard, Z=Zero Gas, C=Gas Candidate)

1. Component: NITRIC OXIDE

Requested Concentration: 22 ppm
 Certified Concentration: 22.0 ppm
 Instrument Used: Thermo Electron 42C S/N 518112467
 Analytical Method: Chemiluminescence
 Last Multipoint Calibration: 12/21/2013

Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC362481
 Ref. Std. Conc: 19.9 ppm
 Ref. Std. Traceable to SRM #: 2629a
 SRM Sample #: 50-G-109
 SRM Cylinder #: FF31631

First Analysis Data:		Date: 1/14/2014	
Z: 0	R: 19.9	C: 22.1	Conc: 22.1
R: 19.9	Z: 0	C: 22.1	Conc: 22.1
Z: 0	C: 22.1	R: 19.9	Conc: 22.1
UOM: ppm	Mean Test Assay:		22.1 ppm

Second Analysis Data:		Date: 1/21/2014	
Z: 0	R: 19.9	C: 22	Conc: 22
R: 19.9	Z: 0	C: 21.9	Conc: 21.9
Z: 0	C: 22	R: 19.9	Conc: 22
UOM: ppm	Mean Test Assay:		21.967 ppm

Analyzed by:


 Diego Mestanza

Certified by:


 Jack Fu



Praxair
 5700 South Alameda Street
 Los Angeles, CA 90058
 Tel: (323) 585-2154 Fax: (714) 542-6689
 PGVPID: F22014

DocNumber: 000062563

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS

Customer & Order Information:

PRAXAIR WHSE PITTSBURG CA
 1930 LOVERIDGE RD
 PITTSBURG CA 945650

Praxair Order Number: 26050867
 Customer P. O. Number: 04740701
 Customer Reference Number:

Fill Date: 1/6/2014
 Part Number: NI NO45ME-AS
 Lot Number: 109400610
 Cylinder Style & Outlet: AS CGA 660
 Cylinder Pressure & Volume: 2000 psig 140 cu. ft.

Certified Concentration:

Expiration Date:	1/17/2017	NIST Traceable
Cylinder Number:	CC155626	Analytical Uncertainty:
45.7 ppm	NITRIC OXIDE	± 0.7 %
Balance	NITROGEN	

NOx = 45.9 ppm

NOx for Reference Only

Certification Information: Certification Date: 1/17/2014 Term: 36 Months Expiration Date: 1/17/2017

This cylinder was certified according to the 2012 EPA Traceability Protocol; Document #EPA-600/R-12/531, using Procedure G1. Do Not Use this Standard if Pressure is less than 100 PSIG.

Analytical Data:

(R=Reference Standard, Z=Zero Gas, C=Gas Candidate)

1. Component: NITRIC OXIDE

Requested Concentration: 45 ppm
 Certified Concentration: 45.7 ppm
 Instrument Used: Thermo Electron 42C S/N 518112467
 Analytical Method: Chemiluminescence
 Last Multipoint Calibration: 12/21/2013

Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC362460
 Ref. Std. Conc: 50.0 ppm
 Ref. Std. Traceable to SRM #: 1683b
 SRM Sample #: 45-U-37
 SRM Cylinder #: CAL015617

First Analysis Data:				Date:			
Z:	0	R:	50	C:	45.6	Conc:	45.6
R:	50	Z:	0	C:	45.7	Conc:	45.7
Z:	0	C:	45.7	R:	50	Conc:	45.7
UOM:	ppm	Mean Test Assay:	45.667 ppm				

Second Analysis Data:				Date:			
Z:	0	R:	50	C:	45.7	Conc:	45.7
R:	50	Z:	0	C:	45.8	Conc:	45.8
Z:	0	C:	45.6	R:	50	Conc:	45.6
UOM:	ppm	Mean Test Assay:	45.7 ppm				

Analyzed by:

Diego Mestanza

Certified by:

Jack Fu

DocNumber: 000037964

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS**Customer & Order Information:**

PRAXAIR WHSE MODESTO CA
 420 RIVER RD
 MODESTO CA 953510

Praxair Order Number: 20027681
 Customer P. O. Number: 03851396
 Customer Reference Number:

Fill Date: 4/19/2012
 Part Number: NI CO250E-AS
 Lot Number: 109211013
 Cylinder Style & Outlet: AS CGA 350
 Cylinder Pressure & Volume: 2000 psig 140 cu. ft.

Certified Concentration:

Expiration Date:	5/3/2015	NIST Traceable
Cylinder Number:	CC134979	Analytical Uncertainty:
250 ppm	CARBON MONOXIDE	± 1 %
Balance	NITROGEN	

Certification Information: Certification Date: 5/3/2012 Term: 36 Months Expiration Date: 5/3/2015

This cylinder was certified according to the 1997 EPA Traceability Protocol, Document #EPA-600/R-97/121, using Procedure G1
 Do Not Use this Standard if Pressure is less than 150 PSIG

PGVP I.D.# F22012

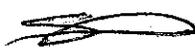
Analytical Data: (R=Reference Standard, Z=Zero Gas, C=Gas Candidate)

1. Component: CARBON MONOXIDE

Requested Concentration: 250 ppm
 Certified Concentration: 250 ppm
 Instrument Used: Horiba VIA-510, S/N 577172043
 Analytical Method: NDIR
 Last Multipoint Calibration: 4/11/2012

First Analysis Data:				Date:			
Date:	4/25/2012						
Z:	0	R:	253.1	C:	249.5	Conc:	250
R:	253.1	Z:	0	C:	249.6	Conc:	250
Z:	0	C:	249.7	R:	253.1	Conc:	250
UOM:	ppm	Mean Test Assay:	250 ppm				

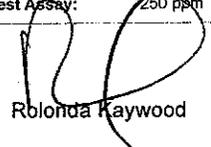
Analyzed by:


 Shameela Jiffrey

Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC272957
 Ref. Std. Conc: 253.1 ppm
 Ref. Std. Traceable to SRM #: 2636a
 SRM Sample #: 57-9-C
 SRM Cylinder #: CLM-004482

Second Analysis Data:				Date:			
Date:	5/2/2012						
Z:	0	R:	253.1	C:	249.4	Conc:	249
R:	253.1	Z:	0	C:	249.5	Conc:	250
Z:	0	C:	249.6	R:	253.1	Conc:	250
UOM:	ppm	Mean Test Assay:	250 ppm				

Certified by:


 Rolonda Kaywood



Praxair
 5700 South Alameda Street
 Los Angeles, CA 90058
 Tel: (323) 585-2154 Fax: (714) 542-6689
 PGVP ID: F22011

DocNumber: 000025243

CERTIFICATE OF ANALYSIS - EPA PROTOCOL GAS

Customer & Order Information:

BEST ENVIRONMENTAL SERVICES *MM
 6261 SOUTHFRONT RD
 LIVERMORE CA 945510000

Praxair Order Number: 16946682
 Customer PO Number: 7982

Customer Reference Number:

Fill Date: 5/27/2011
 Part Number: EV NICONOE160AS
 Lot Number: 109114708
 Cylinder Style and Outlet: A8 CGA 660
 Cylinder Pressure and Volume: 2000 psia 140 cu. ft.

Certified Concentration:

Expiration Date:	06/17/2019	NIST Traceable
Cylinder Number:	SA17938	Analytical Uncertainty:
428 ppm	CARBON MONOXIDE	± 1 %
83.6 ppm	NITRIC OXIDE	± 1 %
Balance	NITROGEN	

NOx ppm = 83.9 ppm

NOX for Reference Only

Certification Information: Certification Date: 6/17/2011 Term: 96 Months Expiration Date: 06/17/2019

This cylinder was certified according to the 1997 EPA Traceability Protocol, Document #EPA-600/R-97/121, using Procedure G1. Do Not Use this Standard if Pressure is less than 150 PSIG.

PGVP I.D.# F22011. First analysis for [NO] was done using 99.8 ppm GMIS.

Analytical Data:

(R=Reference Standard, Z=Zero Gas, C=Gas Candidate)

1. Component: CARBON MONOXIDE
 Requested Concentration: 415 ppm
 Certified Concentration: 428 ppm
 Instrument Used: HORIBA, VIA-910 5/6 878 015
 Analytical Method: NDIR
 Last Multipoint Calibration: 06/02/2011

Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC115192
 Ref. Std. Conc: 508 ppm
 Ref. Std. traceable to SRM #: vs. 1880b
 SRM Sample #: 2-7-G
 SRM Cylinder #: FF-35980

First Analysis Data:		Date: 06/10/2011	
Z:	0 R: 508 C: 427.7	Conc:	428
R:	508 Z: 0 C: 428	Conc:	428
Z:	0 C: 428 R: 508	Conc:	428
UOM:	ppm	Mean Test Assay:	428 ppm

Second Analysis Data:		Date: 09/17/2011	
Z:	0 R: 508 C: 426.4	Conc:	428
R:	508 Z: 0 C: 427.4	Conc:	427
Z:	0 C: 427.4 R: 508	Conc:	428
UOM:	ppm	Mean Test Assay:	427 ppm

2. Component: NITRIC OXIDE
 Requested Concentration: 83 ppm
 Certified Concentration: 83.6 ppm
 Instrument Used: Thermo Electron 42i SN 072802432C
 Analytical Method: Chemiluminescence
 Last Multipoint Calibration: 06/02/2011

Reference Standard Type: GMIS
 Ref. Std. Cylinder #: CC244651
 Ref. Std. Conc: 96.2 ppm
 Ref. Std. traceable to SRM #: vs. 1654b
 SRM Sample #: 44-S-81
 SRM Cylinder #: CAL015484

First Analysis Data:		Date: 06/10/2011	
Z:	0 R: 99.8 C: 83.9	Conc:	83.9
R:	99.8 Z: 0 C: 83.9	Conc:	83.9
Z:	0 C: 83.9 R: 99.8	Conc:	83.9
UOM:	ppm	Mean Test Assay:	83.9 ppm

Second Analysis Data:		Date: 06/17/2011	
Z:	0 R: 97.4 C: 83.4	Conc:	83.4
R:	97.4 Z: 0 C: 83	Conc:	83
Z:	0 C: 83 R: 97.4	Conc:	83.1
UOM:	ppm	Mean Test Assay:	83.2 ppm

Analyzed by:
 Nelson Ma

Certified by:
 Diego Mestanza

Information contained herein has been prepared at your request by qualified experts within Praxair Distribution, Inc. While we believe that the information is accurate within the limits of the analytical methods employed and is complete to the extent of the specified analyses performed, we make no warranty or representation as to the suitability of the use of the information for any purpose. The information is offered with the understanding that any use of the information is at the sole discretion and risk of the user. In no event shall the liability of Praxair Distribution, Inc. arising out of the use of the information contained herein exceed the fee established for providing such information.

APPENDIX E
EQUIPMENT CALIBRATION RECORDS

METER BOX FULL TEST CALIBRATION

Meter #: 29049
 Meter Office ID: #2.11/64
 Standard Meter: Wet Gas Meter
 Test Vacuum "Hg: 3"
 Bar. Pressure (Pb): 29.60
 Leak Checked: 18, 8.2

Date: 7 26 13

Operator: BOB GALLAGHER

Signature: *[Signature]*

QAQC Officer: *[Signature]*

Yd ΔH@
 Current 0.9969 2.120

Previous 0.9855 2.107

ΔH	ΔP	Yds	Standard Meter Gas Volume (ft³)			Meter Box Gas Volume (ft³)			Std. Meter Temp. (T _{mb}) Avg.	Meter Box Temperature				Time (Min.)	Q	Yd	ΔH@		
			Initial	Final	(V _{ds}) Net	Initial	Final	(V _d) Net		(T _i) Inlet Inlt. End	(T _o) Outlet Inlt. End	(T _b) Avg.	Ø						
0.50	-0.060	1.000	0.000	5.062	5.062	5.062	114.254	119.275	5.021	75.0	73	75	74	74	74.0	14.00	0.353	1.0049	2.195
0.50	-0.060	1.000	5.062	10.260	5.198	119.275	124.435	5.160	75.0	75	75	74	74	74.5	14.30	0.355	1.0050	2.170	
0.50	-0.055	1.000	10.260	15.500	5.240	124.435	129.654	5.219	75.0	75	76	74	75	75.0	14.23	0.360	1.0026	2.113	
1.50	-0.075	1.000	0.000	10.165	10.165	10.165	130.330	140.420	10.090	76.0	76	81	75	76	77.0	15.53	0.638	1.0054	2.006
1.50	-0.070	1.000	10.165	20.230	10.065	140.420	150.524	10.104	76.0	81	82	76	76	78.8	15.40	0.637	0.9974	2.005	
1.50	-0.070	1.000	20.230	34.000	13.770	150.524	164.391	13.867	76.0	82	84	77	78	80.3	21.11	0.636	0.9970	2.008	
3.00	-0.090	1.000	0.000	10.000	10.000	10.000	165.887	176.018	10.131	77.0	80	84	79	80	80.8	11.33	0.859	0.9864	2.199
3.00	-0.085	1.000	10.000	23.550	13.550	176.018	189.755	13.737	77.0	84	89	80	80	83.3	15.38	0.857	0.9903	2.197	
3.00	-0.085	1.000	23.550	34.000	10.450	189.755	200.463	10.708	77.0	89	90	81	81	85.3	11.85	0.858	0.9834	2.185	

Comments: this is the calib. Cert.

Variables:

- Q = Flow rate (cfm)
- ΔH = Orifice pressure differential (in. H₂O)
- ΔP = Inlet pressure differential standard meter (in. H₂O)
- Y_{ds} = Standard meter correction factor (Unitless)
- Y_d = Meter box correction factor (Unitless)
- ΔH@ = Orifice pressure differential that gives 0.75 DSCFM of air at 68°F and 29.92 in. Hg (in. H₂O)

$$Y_d = (Y_{ds}) \left(\frac{V_{ds}}{V_d} \right) \left(\frac{T_d + 460}{T_{ds} + 460} \right) \left(\frac{P_b + \Delta P / 13.6}{P_b + \Delta H / 13.6} \right)$$

$$\Delta H@ = \frac{0.0317 \times \Delta H}{P_b (T_o + 460)} \left[\frac{T_{ds} + 460}{Y_{ds} \times Y_{ds}} \right]^2$$

$$Q = \frac{17.64 \times V_{ds} \times P_b}{(T_{ds} + 460)\theta}$$

1. Yd Tolerance: (Yd_{aver}-Yd) ±0.02 ref. Fig 5.6 in EPA method 5
 2. ΔH@ Tolerance: (ΔH@_{aver}-ΔH@) ±0.20 ref. fig 5.6 in EPA method 5.

Spring Type Thermometer Calibration

Calibrated By: *R. Benlaf*

Date Calibrated: 1-8-14

Calibration Due: 7-8-14

Thermometer ID	Test Thermometer Temp (°F)	Reference Thermocouple (°F)	Temp Difference	% Difference	Notes
14A inlet	34	32.4	+1.6		PASS
	58	60.8	-2.8		PASS
	120	120.6	-1.6		PASS
14B outlet	33	32.4	+1.6		PASS
	59	60.8	-2.8		PASS
	118	120.9	-2.9		PASS

NIST Pyrometer: T 223406 T/Couple: 950306

ASTM Thermometer: 3304 RM

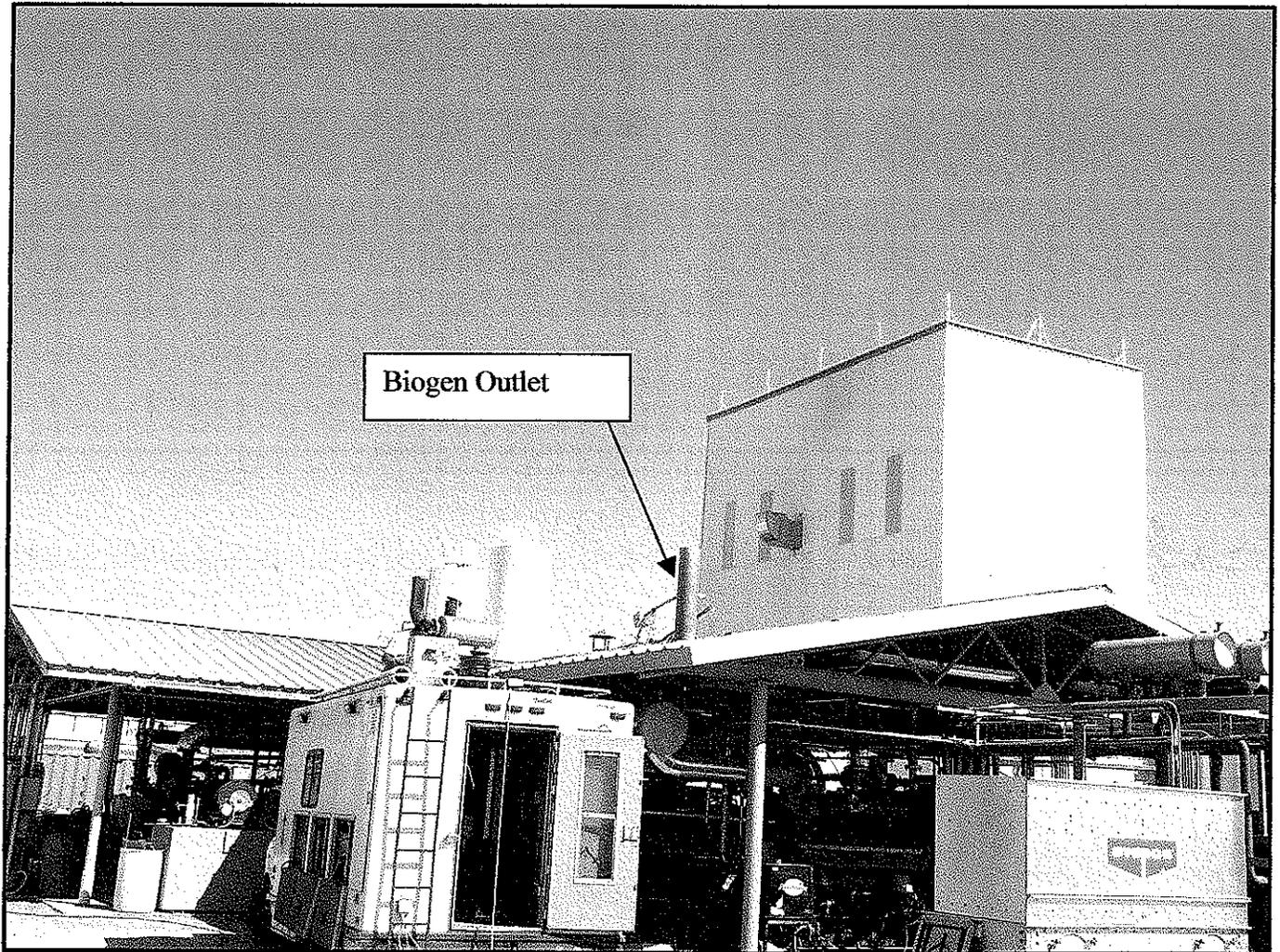
Comments: _____

Reference Thermometer: ASTM mercury in glass.
 Method Reference: EPA QA Handbook Vol. III: Stationary Source Specific Methods, sect. 3.5.2.2
 Tolerance Limits: ± 5.4 °F at ambient temperature and in hot water bath.
 Calibration Frequency – 6 months

APPENDIX F
STACK DIAGRAMS

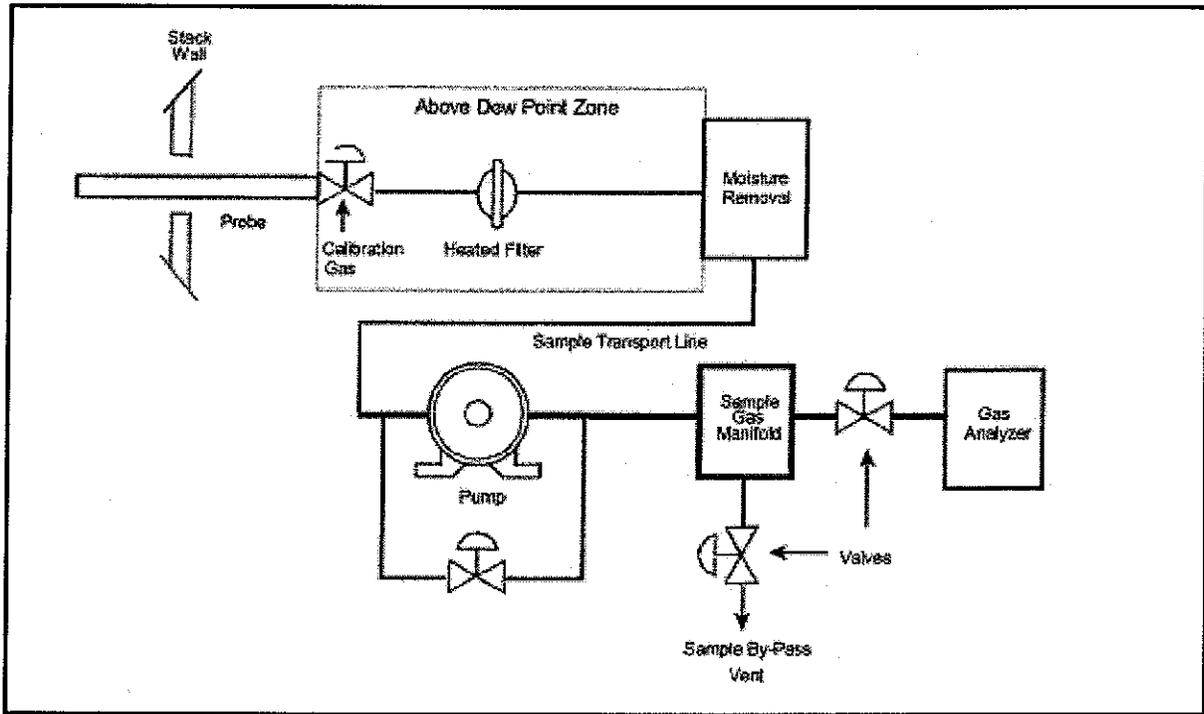
Joseph Gallo Farms
Atwater, CA

800KW Biogen (N-1660-10-0)



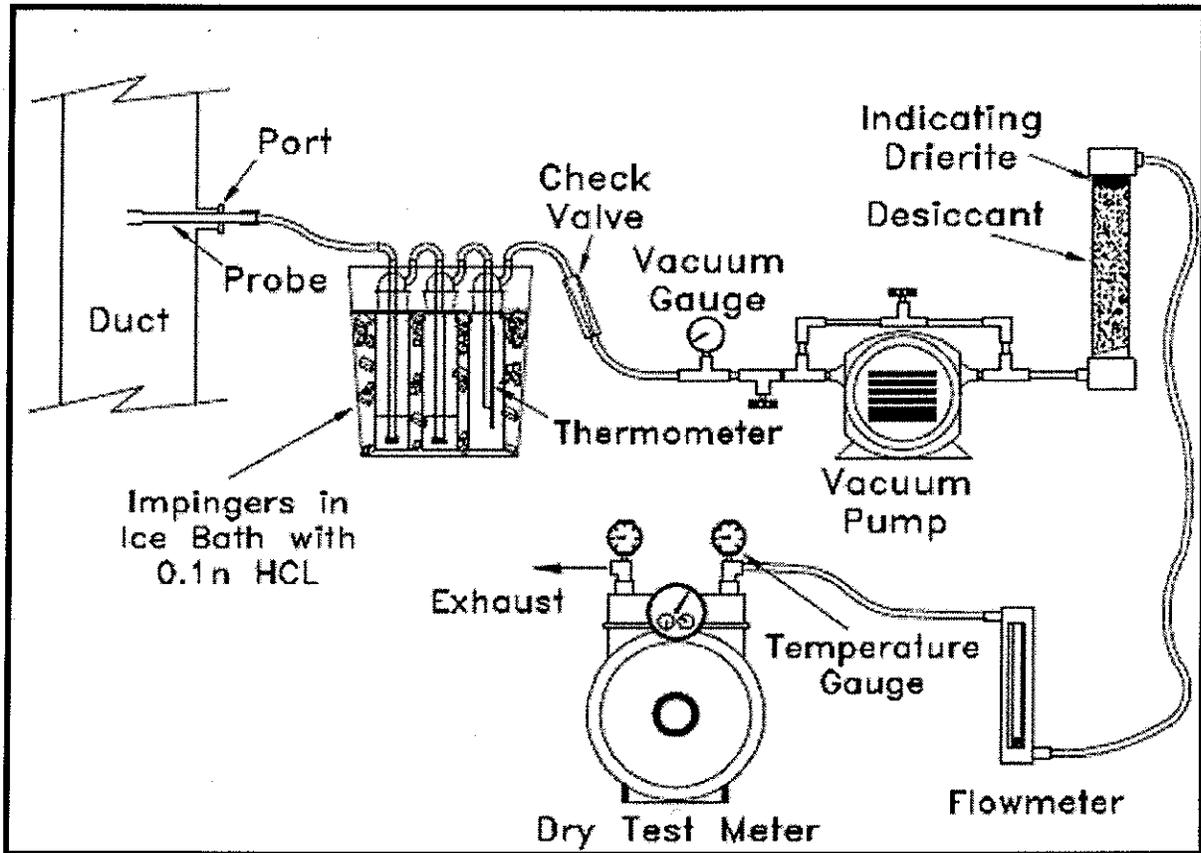
APPENDIX G
SAMPLING SYSTEM DIAGRAMS

EPA Methods 3A, 6C, 7E & 10



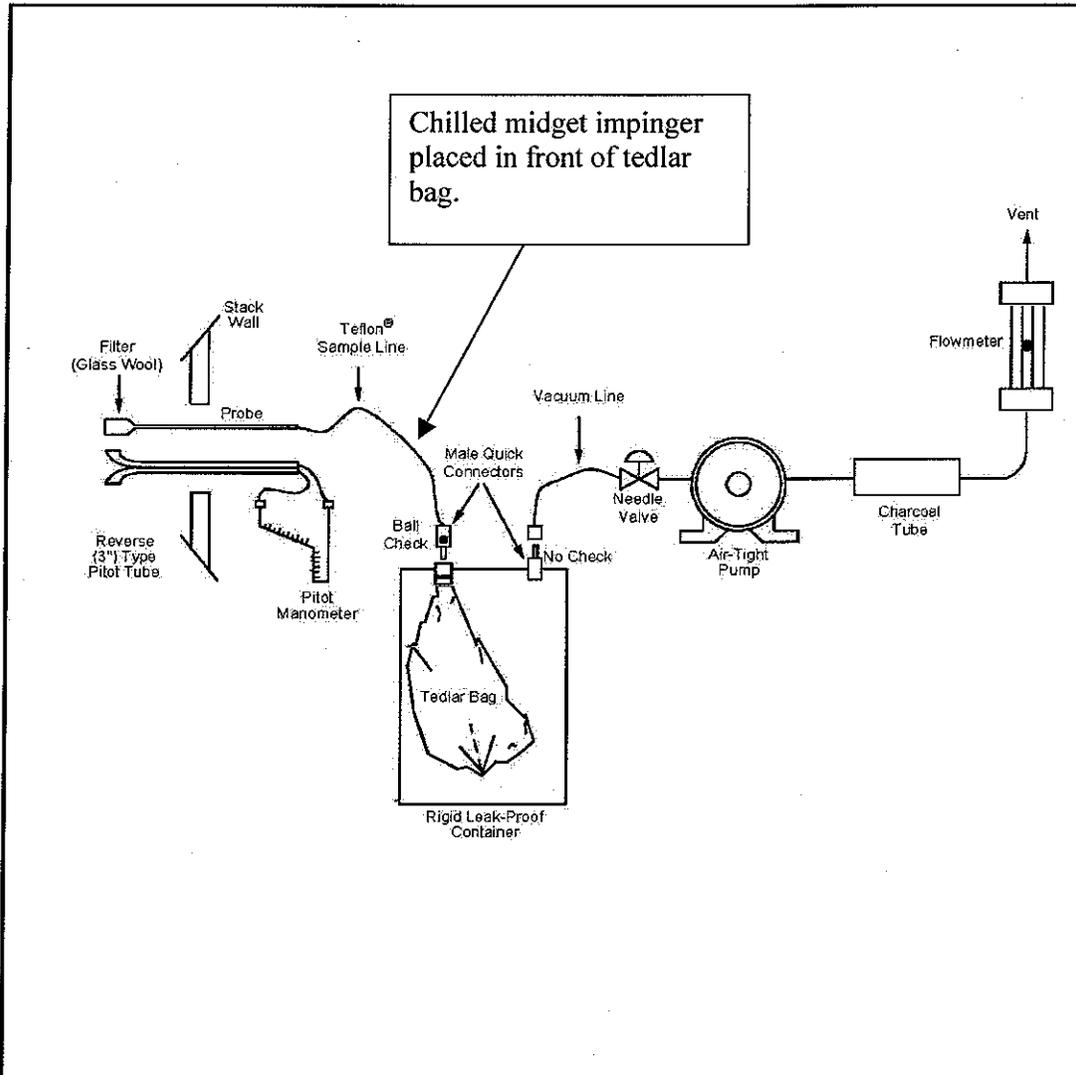
CEM Sampling Train

BAAQMD Method ST-1B



Ammonia Sampling Train

EPA Method 18 (Modified)



EPA Method 18. Integrated Bag Sampling Train

APPENDIX H
SOURCE TEST PLAN

This Section is Not Applicable

APPENDIX I
PERMIT TO OPERATE



COPY

AUTHORITY TO CONSTRUCT

PERMIT NO: N-1660-10-0

ISSUANCE DATE: 07/25/2011

LEGAL OWNER OR OPERATOR: GALLO CATTLE COMPANY
MAILING ADDRESS: PO BOX 775
ATWATER, CA 95301-0775

LOCATION: 10561 W HIGHWAY 140
ATWATER, CA 95301

EQUIPMENT DESCRIPTION:

1,152 BHP GUASCOR MODEL SFGLD-480 LEAN-BURN DIGESTER GAS-FIRED INTERNAL COMBUSTION ENGINE SERVED BY AN ENGINE FUEL EMISSIONS ENGINEERING INC'S SELECTIVE CATALYST REDUCTION SYSTEM. THIS ENGINE POWERS AN 800 KW ELECTRICAL GENERATOR

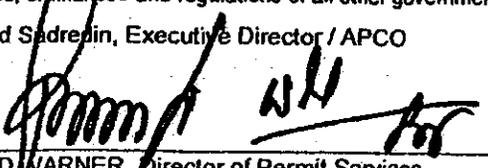
CONDITIONS

1. Particulate matter emissions shall not exceed 0.1 grains/dscf in concentration. [District Rule 4201]
2. No air contaminant shall be discharged into the atmosphere for a period or periods aggregating more than three minutes in any one hour which is as dark as, or darker than, Ringelmann 1 or 20% opacity. [District Rule 4101]
3. No air contaminant shall be released into the atmosphere which causes a public nuisance. [District Rule 4102]
4. This engine shall be equipped with either a positive crankcase ventilation (PCV) system that recirculates crankcase emissions into the air intake system for combustion, or a crankcase emissions control device of at least 90% control efficiency. [District Rule 2201]
5. The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction. [District Rule 4102]
6. This engine shall only be fired on digester gas. [District Rule 2201]
7. The permittee shall utilize and maintain a non-resettable elapsed operating time meter. In lieu of a non-resettable operating time meter, the owner/operator may use an alternative device, method, or technique for determining operating time. [District Rule 4702]
8. Sampling ports adequate for hydrogen sulfide (H₂S) testing shall be provided in the fuel line. [District Rule 2201]

CONDITIONS CONTINUE ON NEXT PAGE

YOU MUST NOTIFY THE DISTRICT COMPLIANCE DIVISION AT (209) 557-6400 WHEN CONSTRUCTION IS COMPLETED AND PRIOR TO OPERATING THE EQUIPMENT OR MODIFICATIONS AUTHORIZED BY THIS AUTHORITY TO CONSTRUCT. This is NOT a PERMIT TO OPERATE. Approval or denial of a PERMIT TO OPERATE will be made after an inspection to verify that the equipment has been constructed in accordance with the approved plans, specifications and conditions of this Authority to Construct, and to determine if the equipment can be operated in compliance with all Rules and Regulations of the San Joaquin Valley Unified Air Pollution Control District. Unless construction has commenced pursuant to Rule 2050, this Authority to Construct shall expire and application shall be cancelled two years from the date of issuance. The applicant is responsible for complying with all laws, ordinances and regulations of all other governmental agencies which may pertain to the above equipment.

Seyed Sadrejin, Executive Director / APCO


DAVID WARNER, Director of Permit Services
N-1660-10-0 25 2011 8 22AM - KAH:DNJ Joint Inspection NOT Required

9. Sampling facilities for source testing shall be provided in accordance with the provisions of Rule 1081 (Source Sampling). [District Rule 1081]
10. NO_x emissions shall not exceed 9.0 ppmvd @ 15% O₂ or 0.15 g/bhp-hr referenced as NO₂. [District Rules 2201, 4701 and 4702]
11. CO emissions shall not exceed 123 ppmvd @ 15% O₂. [District Rules 2201, 4701 and 4702]
12. VOC emissions shall not exceed 48.2 ppmvd @ 15% O₂ referenced as methane. [District Rules 2201, 4701 and 4702]
13. PM₁₀ emissions (filterable and condensable) shall not exceed 0.04 g/bhp-hr. [District Rule 2201]
14. Ammonia (NH₃) emissions from the SCR system shall not exceed 10 ppmvd @ 15% O₂. [District Rule 2201]
15. H₂S concentration in the digester gas used as a fuel in the engine shall not exceed 59 ppmv in any one day. [District Rules 2201 and 4801]
16. H₂S concentration in the digester gas used as a fuel in the engine shall not exceed 40 ppmv in any 12 consecutive month rolling period. The monthly H₂S readings shall be taken using Draeger tubes or a District approved equivalent method at the time of monitoring and recording NO_x, CO, NH₃ and O₂ concentrations. These readings shall be used to demonstrate compliance with this condition. [District Rule 2201]
17. Testing to demonstrate compliance with the fuel H₂S content limit of this permit shall be conducted weekly. Once eight consecutive weekly tests show compliance, the fuel H₂S content testing frequency may be reduced to once every calendar quarter. If a quarterly test shows a violation of the H₂S content limit of this permit, then weekly testing shall resume and continue until eight consecutive tests show compliance. Once compliance is shown on eight consecutive weekly tests, then testing may return to quarterly. The permittee shall keep records of the date and time of H₂S measurements, measured H₂S concentrations (ppmv) to demonstrate compliance with the permit limit. [District Rule 2201]
18. Source testing to demonstrate compliance with the permitted NO_x, CO, VOC, PM₁₀ and NH₃ emission limits shall be conducted within 60 days of initial startup. [District Rules 2201, 4701 and 4702]
19. Source testing to demonstrate compliance with the permitted NO_x, CO, VOC and NH₃ emission limits shall be conducted at least once every 24-months after the previous test. [District Rules 4701 and 4702]
20. Emissions source testing shall be conducted with the engine operating either at conditions representative of normal operations or conditions specified in the Permit to Operate. [District Rules 4701 and 4702]
21. For emissions source testing, the arithmetic average of three 30-consecutive-minute test runs shall apply. If two of three runs are above an applicable limit the test cannot be used to demonstrate compliance with an applicable limit. [District Rules 4701 and 4702]
22. Testing to measure the H₂S content of the fuel shall be conducted using either EPA Method 15 or ASTM Method D1072, D4084, D3246, D5504 or with the use of the Testo 350 XL portable analyzer. [District Rule 2201]
23. The following test methods shall be used for testing: NO_x (ppmv) - EPA Method 7E or ARB Method 100; CO (ppmv) - EPA Method 10 or ARB Method 100; VOC (ppmv) - EPA Method 18, 25A or 25B, or CARB Method 100; NH₃ - BAAQMD ST-1B; PM₁₀ (filterable and condensable) - EPA Method 201 or 201A and 202, CARB Method 5 in combination with 501, and stack gas oxygen - EPA Method 3 or 3A or ARB Method 100. EPA approved alternative test methods as approved by the District may also be used to address the source testing requirements of this permit. [District Rules 1081, 4701 and 4702]
24. The District must be notified at least 30 days prior to any compliance source test, and a source test plan must be submitted for approval at least 15 days prior to testing. [District Rule 1081]
25. The results of each source test shall be submitted to the District within 60 days thereafter. [District Rule 1081]

26. The permittee shall monitor and record the stack concentration of NO_x, CO, NH₃, and O₂ at least once every month (in which a source test is not performed). NO_x, CO and O₂ monitoring shall be conducted utilizing a portable analyzer that meets District specifications. NH₃ monitoring shall be conducted utilizing gas detection tubes (Dräger brand or District approved equivalent). The monthly monitoring shall not be required if the engine is not in operation, i.e. the engine need not be started solely to perform monitoring. Furthermore, the monthly monitoring shall be performed within 5 days of restarting the engine unless monitoring has been performed within the last month. Records must be maintained of the dates of non-operation to validate extended monitoring frequencies. [District Rules 2201, 4701 and 4702]
27. All alternate monitoring parameter emission readings shall be taken with the unit operating either at conditions representative of normal operations or conditions specified in the permit-to-operate. The analyzer shall be calibrated, maintained, and operated in accordance with the manufacturer's specifications and recommendations or a protocol approved by the APCO. Emission readings taken shall be averaged over a 15 consecutive-minute period by either taking a cumulative 15 consecutive-minute sample reading or by taking at least five (5) readings, evenly spaced out over the 15 consecutive-minute period. [District Rules 2201, 4701 and 4702]
28. If either the NO_x, CO, or NH₃ concentrations corrected to 15% O₂, as measured by the portable analyzer or the District approved ammonia monitoring equipment, exceed the allowable emission concentration, the permittee shall return the emissions to within the acceptable range as soon as possible, but no longer than 8 hours after detection. If the readings continue to exceed the allowable emissions concentration after 8 hours, the permittee shall notify the District within the following 1 hour, and conduct a certified source test within 60 days of the first exceedance. In lieu of conducting a source test, the permittee may stipulate a violation has occurred, subject to enforcement action. The permittee must then correct the violation, show compliance has been re-established, and resume monitoring procedures. If the deviations are the result of a qualifying breakdown condition pursuant to Rule 1100, the permittee may fully comply with Rule 1100 in lieu of performing the notification and testing required by this condition. [District Rules 2201, 4701 and 4702]
29. The permittee shall maintain records of: (1) the date and time of NO_x, CO, NH₃, H₂S and O₂ measurements, (2) the O₂ concentration in percent and the measured NO_x, CO, and NH₃ concentrations corrected to 15% O₂, (3) make and model of exhaust gas analyzer, (4) exhaust gas analyzer calibration records, and (6) a description of any corrective action taken to maintain the emissions within the acceptable range. [District Rules 2201, 4701 and 4702]
30. The permittee shall maintain records, on a monthly basis, that contain the following information: (1) total hours of operation; (2) type of fuel used; (3) maintenance or modifications performed; (4) monitoring data; and (5) compliance source test results. [District Rules 4701 and 4702]
31. This engine shall be operated and maintained in proper operating condition per the manufacturer's requirements as specified on the Inspection and Monitoring (I&M) plan submitted to the District. [District Rule 4702]
32. This engine shall be operated within the ranges that the source testing has shown result in pollution concentrations within the emissions limits as specified on this permit. [District Rule 4702]
33. The permittee shall update the I&M plan for this engine prior to any planned change in operation. The permittee must notify the District no later than seven days after changing the I&M plan and must submit an updated I&M plan to the APCO for approval no later than 14 days after the change. The date and time of the change to the I&M plan shall be recorded in the engine's operating log. For modifications, the revised I&M plan shall be submitted to and approved by the APCO prior to issuance of the Permit to Operate. The permittee may request a change to the I&M plan at any time. [District Rule 4702]
34. All records shall be maintained and retained on-site for a minimum of five (5) years, and shall be made available for District inspection upon request. [District Rules 4701 and 4702]
35. This engine is subject to the requirements of 40 CFR Part 63 Subpart ZZZZ - National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines. Currently, the U.S. EPA administers the requirements of this subpart. The owner or operator shall comply with the applicable emission and operating limitations, testing requirements, initial and continuous compliance requirements as specified in this subpart. [District Rule 4002]