Derenzo and Associates, Inc.
Environmental Consultants

AIR EMISSION TEST REPORT

Title	AIR EMISSION TEST REPORT FOR THE INTERNAL COMBUSTION ENGINE – GENERATOR SETS OPERATED AT FREMONT COMMUNITY DIGESTER
Report Date	May 5, 2014
Test Dates	April 23, 2014

Facility Information	
Name	Fremont Community Digester, LLC
Street Address	1634 Locust St.
City, County	Fremont, Newaygo

Facility Permit and Emission Unit Information			
Facility SRN:	N8210	Permit No. :	378-08A
Emission Unit	EUICENGINE1	Serial No.	1046813
Emission Unit	EUICENGINE2	Serial No.	1046825

Testing Contractor	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1402019

AIR EMISSION TEST REPORT
FOR THE
BIOGAS FUELED INTERNAL COMBUSTION
ENGINE – GENERATOR SETS
OPERATED AT
FREMONT COMMUNITY DIGESTER

1.0 INTRODUCTION

Fremont Community Digester, LLC (FCD) operates two (2) General Electric (GE) Jenbacher Model No. J420 GS B82 biogas fueled reciprocating internal combustion engines (RICE) at the FCD facility (Facility SRN: N8210) in Fremont, Newaygo County, Michigan. The facility has been issued Permit to Install No. 378-08A by the Michigan Department of Environmental Quality (MDEQ).

The GE Jenbacher Model No. J420 GS B82 engines are identified in Permit to Install No. 378-08A as Emission Unit ID: EUICENGINE1 and EUICENGINE2.

Air emission compliance testing was performed to demonstrate ongoing compliance with 40 CFR 60, Subpart JJJJ and Permit No. 378-08A which states:

> *...the permittee shall conduct an initial performance test for each engine in FGICENGINES within one year after startup of the engine and every 8,760 hours of operation (as determined through the use of a non-resettable hour meter) or three years, whichever occurs first, to demonstrate compliance with the emission limits in 40 CFR 60.4233(e)...*

The compliance testing was performed by Derenzo and Associates, Inc. (Derenzo and Associates), a Michigan-based environmental consulting and testing company. Derenzo and Associates representatives Daniel Wilson, and Patrick Triscari performed the field sampling and measurements April 23, 2014.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated March 18, 2014 that was reviewed and approved by the MDEQ in the March 31, 2014 test plan approval letter. MDEQ representatives Mr. David Patterson and Mr. Erin Grinstern observed portions of the testing project.

Questions regarding this emission test report should be directed to:

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Mr. Bryan Heiss
Plant Manager
Fremont Community Digester
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Report Certification

This test report was prepared by Derenzo, Associates, Inc. based on field sampling data collected by Derenzo and Associates, Inc. Facility process data were collected and provided by Fremont Community Digester, LLC employees or representatives. This test report has been reviewed by FCD representatives and approved for submittal to the Michigan Department of Environmental Quality.

I certify that the testing was conducted in accordance with the approved test plan unless otherwise specified in this report. I believe the information provided in this report and its attachments are true, accurate, and complete.

Report Prepared By:

Patrick A. Triscari
Environmental Engineer
Derenzo and Associates, Inc.

Reviewed By:

Robert L. Harvey, P.E.
General Manager
Derenzo and Associates, Inc.

I certify that the facility operating conditions were in compliance with permit requirements or were at the maximum routine operating conditions for the facility. Based on information and belief formed after reasonable inquiry, the statements and information in this report are true, accurate and complete.

Bryan Heiss
Plant Manager
Fremont Community Digester, LLC.

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Biogas containing methane is generated at FCD from the anaerobic decomposition of disposed organic waste materials. The biogas is collected from three (3) complete-mix digester tanks and treated to remove hydrogen sulfide, prior to combustion. The treated biogas is used as fuel for the two (2) RICE. Each RICE is connected to an electricity generator that produces electricity that is transferred to the local utility. At full load the facility generates 2.85 megawatts (MW) of electrical power.

2.2 Rated Capacities and Air Emission Controls

The GE Jenbacher Model No. J420 GS B82 RICE has a rated output of 1,967 brake-horsepower (bhp) and the connected generator has a rated electricity output of 1,426 kilowatts (kW). The engine is designed to fire low-pressure, lean fuel mixtures (e.g., biogas) and is equipped with an air-to-fuel ratio controller that monitors engine performance parameters and automatically adjusts the air-to-fuel ratio and ignition timing to maintain efficient fuel combustion.

The engine/generator sets are not equipped with add-on emission control devices. Air pollutant emissions are minimized through the operation of the gas treatment system and efficient fuel combustion in the engines.

The fuel consumption rate is regulated automatically to maintain the heat input rate required to support engine operations and is dependent on the fuel heat value (methane content) of the treated biogas.

2.3 Sampling Locations

The RICE exhaust gas is directed through mufflers and is released to the atmosphere through dedicated vertical exhaust stacks and vertical release points. The two (2) GE Jenbacher Model J420 GS B82 RICE exhaust stacks are identical.

The exhaust stack sampling ports for the GE Jenbacher Model J420 GS B82 engines (EUICENGINE1 and EUICENGINE2) are located in individual exhaust stacks with an inner diameter of 19.6 inches. Each stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 96 inches (greater than 2.5 duct diameters) upstream and 120 inches (greater than 3.0 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

Individual traverse points were determined in accordance with USEPA Method 1.

Appendix 1 provides diagrams of the emission test sampling locations.

3.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

3.1 Purpose and Objective of the Tests

The conditions of Permit to Install No. 378-08A and 40 CFR Part 60 Subpart JJJJ require FCD to test each RICE (EUICENGINE1 and EUICENGINE2) for carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compounds (VOCs) every 8,760 hours of operation. Therefore, each RICE (EUICENGINE1 and EUICENGINE2) was sampled for CO, NO_X and VOC emissions and exhaust gas oxygen (O_2) and carbon dioxide (CO_2) content.

3.2 Operating Conditions During the Compliance Tests

The testing was performed while the engine/generator sets were operated at maximum operating conditions (1,426 kW electricity output +/- 10%). FCD representatives provided the kW output in 15-minute increments for each test period.

Fuel flowrate (cubic feet per minute) and fuel methane content (%) were also recorded by FCD representatives in 15-minute increments for each test period. The RICE fuel consumption rate ranged between 487 and 521 scfm and fuel methane content ranged between 52.8 and 55.4% during the test periods. Biogas fuel heating value (Btu/scf) was calculated based on the lower heating value of 910 Btu/scf for methane.

Appendix 2 provides operating records provided by FCD representatives for the test periods.

Engine output (bhp) cannot be measured directly and was calculated based on the recorded electricity output, the calculated GE Jenbacher Model J420 GS B82 generator efficiency (97.2%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp).

Engine output (bhp) = Electricity output (kW) / (0.972) / (0.7457 kW/hp)

Table 3.1 presents a summary of the average engine operating conditions during the test periods.

3.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled biogas fueled RICE were each sampled for three (3) one-hour test periods during the compliance testing performed April 23, 2014.

Table 3.2 presents the average measured CO, NO_X and VOC emission rates for the engines (average of the three test periods for each engine) and applicable emission limits.

Results of the engine performance tests demonstrate compliance with emission limits specified in 40 CFR 60, Subpart JJJJ and Permit to Install No. 378-08A.

Test results for each one hour sampling period are presented in Section 6.0 of this report.

Table 3.1 Average engine operating conditions during the test periods

Emission Unit	Gen. Output (kW)	Engine Output (bHp)	Fuel Use (scfm)	Biogas CH_4 Content (%)	Biogas Btu Content (Btu/scf)	Exhaust Temp. (°F)
EUICENGINE1	1,426	1,967	507	53.6	488	839
EUICENGINE2	1,426	1,967	508	54.4	495	787

Table 3.2 Average measured emission rates for each tested FCD RICE (three-test average)

	CO Emission Rates		NOx Emission Rates		VOC Emission Rates	
Emission Unit	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)
EUICENGINE1	11.07	2.55	1.99	0.46	0.51	0.12
EUICENGINE2	10.60	2.44	1.97	0.45	0.54	0.13
Emission Limit	--	2.6	--	0.6	--	1.0

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Test protocols for the air emission testing were reviewed and approved by the MDEQ. This section provides a summary of the sampling and analytical procedures that were used during the testing periods.

4.1 Summary of Sampling Methods

USEPA Method 2	Exhaust gas velocity pressure was determined using a Type-S Pitot tube connected to a red oil incline manometer; temperature was measured using a K-type thermocouple connected to the Pitot tube.
USEPA Method 3A	Exhaust gas O_2 and CO_2 content was determined using zirconia ion/paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 4	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 7E	Exhaust gas NOx concentration was determined using chemiluminescence instrumental analyzers.
USEPA Method 10	Exhaust gas CO concentration was measured using NDIR instrumental analyzers.
USEPA Method 25A /ALT-096	Exhaust gas VOC (as NMHC) concentration was determined using flame ionization analyzers equipped with GC columns.

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The RICE exhaust stack gas velocities and volumetric flow rates were determined using USEPA Method 2 prior to and after each test. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure at each traverse point across the stack cross section. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were periodically leak-checked to verify the integrity of the measurement system.

The absence of significant cyclonic flow for the exhaust configuration was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each velocity traverse point with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero).

Appendix 3 provides exhaust gas flowrate calculations and field data sheets.

4.3 Exhaust Gas Molecular Weight Determination (USEPA Method 3A)

CO_2 and O_2 content in the RICE exhaust gas streams were measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a Fuji California Analytical ZRF infrared gas analyzer. The O_2 content of the exhaust was monitored using a Fuji ZRF gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the IC engine exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

Prior to, and at the conclusion of each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document). Sampling times were recorded on field data sheets.

Appendix 4 provides O_2 and CO_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

4.4 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content of the RICE exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train. The moisture sampling was performed concurrently with the instrumental analyzer sampling. During each sampling period a gas sample was extracted at a constant rate from the source where moisture was removed from the sampled gas stream using impingers that were submersed in an ice bath. At the conclusion of each sampling period, the moisture gain in the impingers was determined gravimetrically by weighing each impinger to determine net weight gain.

4.5 NO_x and CO Concentration Measurements (USEPA Methods 7E and 10)

NO_X and CO pollutant concentrations in the RICE exhaust gas streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence NO_X analyzer and a Fuji Model ZRF infrared CO analyzer.

A continuous sample of the RICE exhaust gas was delivered to instrumental analyzers using the sampling and conditioning system described previously in this section. Prior to, and at the conclusion of each test, the instruments were calibrated using appropriate upscale calibration and zero gas to determine analyzer calibration error and system bias.

Appendix 4 provides CO and NO_X calculation sheets. Raw instrument response data are provided in Appendix 5.

4.6 Measurement of Volatile Organic Compounds (USEPA Method 25A / ALT-096)

VOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC) concentration in the IC engine exhaust gas. NMHC pollutant concentration was determined using a Thermo Environmental Instruments (TEI) Model 55i Methane / Nonmethane hydrocarbon analyzer. The TEI 55i analyzer contains an internal gas chromatograph column that separates methane from non-methane components and has been approved by the USEPA for measuring VOC relative to 40 CFR Part 60 Subpart JJJJ compliance test demonstrations (Alternative Test Method 096 or ALT-096). The concentration of NMHC in the sampled gas stream, after separation from methane, is determined relative to a propane standard using a flame ionization detector in accordance with USEPA Method 25A.

Samples of the exhaust gas were delivered directly to the instrumental analyzer using the Teflon® heated sample line to prevent condensation. The sample to the NHMC analyzer was not conditioned to remove moisture. Therefore, VOC measurements correspond to standard conditions with no moisture correction (wet basis).

The instrumental analyzer was calibrated using certified propane concentrations in hydrocarbon-free air to demonstrate detector linearity and determine calibration drift and zero drift error.

Appendix 4 provides VOC calculation sheets. Raw instrument response data for the NMHC analyzer is provided in Appendix 5.

5.0 QA/QC ACTIVITIES

5.1 NO_x Converter Efficiency Test

The NO_2 – NO conversion efficiency of the Model 42c analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO_2 was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO_2 concentration is within 90% of the expected value.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO_2 concentration was -6.68% of the expected value, i.e., within 10% of the expected value as required by Method 7E).

5.2 Sampling System Response Time Determination

The response time of the sampling system was determined prior to the compliance test program by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration was determined using a stopwatch.

The TEI Model 42c analyzer exhibited the longest system response time at 74 seconds. Results of the response time determinations were recorded on field data sheets. For each test period, test data were collected once the sample probe was in position for at least twice the maximum system response time.

5.3 Gas Divider Certification (USEPA Method 205)

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The ten-step STEC gas divider was NIST certified (on December 20, 2013) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivered calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

5.4 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NO_X, CO, O_2 and CO_2 have had an interference response test preformed prior to their use in the field (July 26, 2006, June 21, 2011 and April 3, 2012), pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e., gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 3.0% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

5.5 Instrument Calibration and System Bias Checks

At the beginning of each day of the testing program, initial three-point instrument calibrations were performed for the NO_x, CO, CO_2 and O_2 analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

At the beginning of each test day, appropriate high-range, mid-range, and low-range span gases followed by a zero gas were introduced to the NMHC analyzer, in series at a tee connection, which is installed between the sample probe and the particulate filter, through a poppet check valve. After each one hour test period, mid-range and zero gases were re-introduced in series at the tee connection in the sampling system to check against the method's performance specifications for calibration drift and zero drift error.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, NO_x, and CO in nitrogen and zeroed using hydrocarbon free nitrogen. The NMHC (VOC) instrument was calibrated with USEPA Protocol 1 certified concentrations of propane in air and zeroed using hydrocarbon-free air. A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

5.6 Determination of Exhaust Gas Stratification

A stratification test for each RICE exhaust stack was performed during the performance test sampling periods. The stainless steel sample probe was positioned at sample points correlating to 16.7, 50.0 (centroid) and 83.3% of the stack diameter. Pollutant concentration data were recorded at each sample point for a minimum of twice the maximum system response time.

The recorded data for each RICE exhaust stack gas indicate that the measured CO, O_2 and CO_2 concentrations did not vary by more than 5% of the mean across the stack diameter. Therefore, the stack gas of each IC engine was considered to be unstratified and the compliance test sampling was performed at a single sampling location within each IC engine exhaust stack.

5.7 Meter Box Calibrations

The Air Control Model 2010 sampling console, which was used for exhaust gas moisture content sampling, was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5. The metering console calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

The digital pyrometer in the Clean Air metering consoles were calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Appendix 6 presents test equipment quality assurance data (NO_2 – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results, meter box calibration records, stratification checks, cyclonic flow determinations sheets, Pitot tube and probe assembly calibration records).

6.0 RESULTS

6.1 Test Results and Allowable Emission Limits

Engine operating data and air pollutant emission measurement results for each one hour test period are presented in Tables 6.1 through 6.2.

The measured air pollutant concentrations and emission rates for Engine Nos. 1 and 2 (EUICENGINE1 and EUICENGINE2) are less than the allowable limits specified in Permit to Install No. 378-08A for the engines:

- 2.6 grams per brake-horsepower hour (g/bhp-hr) CO;
- 0.6 g/bhp-hr NOx;
- 1.0 g/bhp-hr VOC.

6.2 Variations from Normal Sampling Procedures or Operating Conditions

The testing for all pollutants was performed in accordance with the approved test protocols. The engine-generator sets were operated within 10% of maximum output as required by the 40 CFR Part 60 Subpart JJJJ.

Table 6.1 Measured exhaust gas conditions and NO_x, CO and VOC air pollutant emission rates EUICENGINE1, S/N 1046813

Test No. Test date Test period (24-hr clock)	1 4/23/14 930 - 1030	2 4/23/14 1116 – 1216	3 4/23/14 1253 - 1353	Three Test Average
Fuel flowrate (scfm)	507	502	511	507
Generator output (kW)	1,426	1,426	1,426	1,426
Engine output (hp)	1,967	1,967	1,967	1,967
Biogas methane content (%)	53.2	53.9	53.7	53.6
<u>Exhaust Gas Composition</u>				
CO_2 content (% vol)	11.09	11.15	11.08	11.1
O_2 content (% vol)	8.99	8.96	8.97	8.97
Moisture (% vol)	11.8	10.7	9.4	10.7
Exhaust gas temperature (°F)	839	840	839	839
Exhaust gas flowrate (scfm)	4,984	4,908	4,901	4,931
Exhaust gas flowrate (dscfm)	4,394	4,382	4,439	4,405
<u>Nitrogen Oxides</u>				
NO_X conc. (ppmvd)*	62.5	71.4	55.7	63.2
NO_X emissions (lb/hr as NO_2)	1.97	2.24	1.77	1.99
NO_X emissions (g/bhp*hr)	0.45	0.52	0.41	0.46
*Permitted emissions (g/bhp*hr)*	-	-	-	*0.60*
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)*	574.1	570.0	583.5	575.9
CO emissions (lb/hr)	11.01	10.90	11.30	11.07
CO emissions (g/bhp*hr)	2.54	2.51	2.61	2.55
*Permitted emissions (g/bhp*hr)*	-	-	-	*2.60*
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv C_3)*	15.8	13.7	15.4	14.9
VOC emissions (lb/hr)	0.54	0.46	0.52	0.51
VOC emissions (g/bhp*hr)	0.12	0.11	0.12	0.12
*Permitted emissions (g/bhp*hr)*	-	-	-	*1.0*

*Corrected for calibration bias.

Table 6.2 Measured exhaust gas conditions and NO_x, CO and VOC air pollutant emission rates EUICENGINE2, S/N 1046825

Test No. Test date Test period (24-hr clock)	1 4/23/14 930 - 1030	2 4/23/14 1116 – 1216	3 4/23/14 1253 - 1353	Three Test Average
Fuel flowrate (scfm)	509	503	511	508
Generator output (kW)	1,426	1,426	1,426	1,426
Engine output (hp)	1,967	1,967	1,967	1,967
Biogas methane content (%)	54.3	54.3	54.6	54.4
Exhaust Gas Composition				
CO_2 content (% vol)	10.9	11.1	11.0	11.0
O_2 content (% vol)	9.09	8.93	8.99	9.00
Moisture (% vol)	13.8	10.5	10.6	11.6
Exhaust gas temperature (°F)	790	788	784	787
Exhaust gas flowrate (scfm)	4,987	4,893	4,857	4,912
Exhaust gas flowrate (dscfm)	4,297	4,379	4,342	4,340
Nitrogen Oxides				
NO_X conc. (ppmvd)*	60.3	66.5	63.0	63.3
NO_X emissions (lb/hr as NO_2)	1.86	2.09	1.96	1.97
NO_X emissions (g/bhp*hr)	0.43	0.48	0.45	0.45
*Permitted emissions (g/bhp*hr)*	-	-	-	*0.60*
Carbon Monoxide				
CO conc. (ppmvd)*	563.8	559.6	554.5	559.3
CO emissions (lb/hr)	10.58	10.70	10.51	10.60
CO emissions (g/bhp*hr)	2.44	2.47	2.42	2.44
*Permitted emissions (g/bhp*hr)*	-	-	-	*2.60*
Volatile Organic Compounds				
VOC conc. (ppmv C_3)*	16.0	15.8	16.4	16.1
VOC emissions (lb/hr)	0.55	0.53	0.55	0.54
VOC emissions (g/bhp*hr)	0.13	0.12	0.13	0.13
*Permitted emissions (g/bhp*hr)*	-	-	-	*1.0*

*Corrected for calibration bias.