

LUNDELL ENTERPRISES, INC.

**BURN-IN TEST FOR RDF ON HURST BOILER
AT
MARSHALL MUNICIPAL UTILITIES
MARSHALL, MO**

DETERMINATION OF PM, SO₂, THC, NO_X AND CO EMISSION

January 2006

Prepared for

Lundell Enterprises, Inc.
Cherokee, Iowa

Prepared by



AeroMet
Engineering, Inc.
Solutions for a Changing Environment

I. INTRODUCTION

AeroMet Engineering, Inc., located in Jefferson City, Missouri, was retained by Lundell Enterprises Inc., (LEI) on behalf of Cherokee County Solid Waste Commission, to determine Particulate Matter (PM), Sulfur Dioxide (SO₂), Sulfur Trioxide / Acid Mist (SO₃), Nitrogen Oxide (NO_x), Total Hydrocarbons (THC) and Carbon Monoxide (CO) emission factors for (RDF) Refuse Derived Fuel. LEI used RDF as a fuel for burn-in test required by Iowa Department of Natural Resources, on a stationary Hurst boiler, Model HYB 818-150-1 located at Marshall Municipal Utilities (MMU) in Marshall, MO. Emissions were sampled over a two day period (Jan.10, 2006 & Jan.11, 2006). Nitrogen oxide (NO_x) emissions are recorded and reported as NO₂ emissions. The Hurst boiler was operating under normal operating conditions during the testing.

The boiler that underwent emissions testing was located at MMU's power plant located at 765 W. North St. in Marshall, MO. The boiler burns Refuse Derived Fuel (RDF). The paper pellets are made from the paper and cardboard products that are separated from the city's refuse. The pelletizing equipment used by the city of Marshall is supplied by Lundell Enterprises Inc. (LEI).

LEI is working with the Cherokee County Solid Waste Commission and currently exploring the possibility of the addition of a similar pelletizing plant to its Cherokee County operation. The testing program described in this report was conducted for determination of air emissions from typical fuel that would be used by Cherokee County. The purpose of this emissions testing is to supply data to be used for permitting purposes in Iowa. This testing was required by the Iowa Department of Natural Resources (IDNR) for the application of a construction permit for the Cherokee County Solid Waste Commission. The testing was required in order to verify the emission factors that are to be used in the permit application.

The fuel used for this testing was RDF comprising of paper, cardboard and plastics. A waiver was obtained from Missouri Department of Natural Resources (MDNR) to burn the fuel needed to simulate typical conditions to be used in Iowa.

The emissions were sampled at an inside location approximately eighteen feet above the boiler and approximately twenty-five feet below the stack exit.

Testing of the emissions was performed in accordance with the procedures specified in the Code of Federal Regulations (CFR), Title 40, Part 60, Appendix A, Method 5 - Determination of Particulate Matter (PM), Method 8 - Determination of Sulfur Dioxide (SO₂) and Sulfuric Acid Mist (SO₃), Method 7E -Determination of Nitrogen Oxide (NO_x), Method 10 - Determination of Carbon Monoxide-NDIR, and Method 25A - Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer (Total Hydrocarbons - THC)

The testing was coordinated through Mr. Kyle Gibbs, Plant Superintendent - Marshall Municipal Utilities, and Mr. Marion M. Brooks (Mike), Senior Project Engineer - Lundell Engineering, Inc. and Don Pitts, Manager – Cherokee Solid Waste. The test team comprised of Mr. Tom Scheppers, P.E. and Mr. Yogesh Naik, both of AeroMet Engineering, Inc.

II. TEST RESULTS

Testing of emissions from the Hurst boiler was completed under normal operating conditions. Equivalent fuel that will be used in Iowa was combusted at an equivalent throughput rate at MMU. The average results for the tested emissions and corresponding stack gas flow rates are shown in Appendix A. All results are based on the raw data shown in the Appendices of this report. As mentioned above, testing was performed under steady-state operating conditions for two days of testing.

Other than delays getting started, no equipment or process problems were encountered during the three runs for each pollutant for the entire test period. The test results were collected under normal operating conditions during a two-day period of January 10 and 11, 2006. The test results should be considered normal and representative of typical emissions.

The boiler was operated in a manner representative of operations that may contribute to normal particulate emissions. The boiler processed an average of 800 Lbs/hour of raw materials. Discussions of the process data can be found in Section IV-- Plant Operating Conditions.

During the test runs, no abnormalities were discovered to contribute to any errors in the results of the tests. The results of each test run should be accurate within the variations acceptable by each of the USEPA Reference Methods.

A. Particulate Emissions

The average particulate emission rate from the boiler was 1.766 lbs/hour. Testing for particulate emissions, velocity, moisture, CO₂, and O₂, was performed simultaneously for all three runs during the period emissions were sampled.

Visual observations of the collected samples indicated the presence of a black particulate coating on the filters for all three runs from the stack. Particulate coating on each filter was similar for each of the three runs. The reagent recovered from the first impinger was noted to be slightly brown from discoloration.

The isokinetic sampling rate compares the stack gas velocity to the nozzle velocity of the sampling probe. A rate of 100% represents a stack gas velocity equal to the nozzle velocity. The acceptable range is 90% to 110%. The USEPA has determined that sampling outside this range may cause a bias in the results based on the particle size and aerodynamic properties. All three of the test runs were conducted with an isokinetic rate within this range. The moisture content in the exhaust gas was as expected.

All process equipment was operated in a normal manner representative of operations that may contribute to normal particulate emissions at each load setting. The particulate emission results should be representative of the actual concentrations within the normal accuracies of Method 5. Although no upper limits of emissions have been established for the test method, an upper limit has not been exceeded based on acceptance of the test method on significantly higher grain loadings. The estimated accuracy of Method 5 is approximately +/- 20% based on results of collaborative tests.

B. Nitrogen Oxide

The summary of nitrogen oxides emissions is presented in Appendix A, All results are based on the raw data collected by a real time analyzer and shown in Appendix B--Raw Gaseous Emission Results.

The arithmetic mean (average) of the nitrogen oxide emission rate for the test period is 93.2 pm. This is equivalent to 1.002 lb/hour. The maximum concentration reached during the test period was 105.7 ppm.

Instrument drift averaged less than 0.16 % and never exceeded 0.35 %. All of the sample gas was analyzed in the 314 ppm range and one can assume that all of the data should fall in the same range of accuracy (less than 1 %). As specified in the EPA test method, the NO_x results should be representative of the actual concentrations within 5% accuracy.

Nitrogen Oxide values were obtained by use of a Chemiluminescent Analyzer. Data was collected on one minute averages based on continuous analysis by the analyzer and a sampling rate of 6 samples per minute by the data logger. During each minute, the 6 sample numbers are stored and averaged. The one-minute average is permanently stored as a computer file. Each one-minute average of data is displayed in Appendix B.

All process equipment was operated in a normal manner representative of operations that may contribute to normal nitrogen oxide emissions at each load setting. The nitrogen oxide results should be representative of the actual concentrations within the normal accuracies of Method 7E

C. Carbon Monoxide

The summary of carbon monoxide emissions is presented in Appendix A, All results are based on the raw data collected by a real time analyzer and shown in Appendix B--Raw Gaseous Emission Results.

The arithmetic mean (average) of the carbon monoxide emission rate for the test period is 193.9 ppm. This is equivalent to 1.270 lb/hour. The maximum concentration reached during the test period was 418.4 ppm.

Instrument drift averaged less than 0.20 % and never exceeded 0.46 %. All of the sample gas was analyzed in the 350 ppm range and one can assume that all of the data should fall in the same range of accuracy (less than 1 %). As specified in the EPA test method, the CO results should be representative of the actual concentrations within 5% accuracy.

The test program was designed to measure the Carbon Monoxide emissions concentrations up to 350 ppm span using the equipment and procedures defined in Method 10. At times, the concentration of CO exceeded the span defined by Method 10. However, the span of the instrument (500 ppm) was never changed to record the highest values. During the test program, Brian X with Iowa DNR was contacted regarding this matter. He stated that since this was a test to gather permitting information and not a compliance test, he would allow the test to continue without obtaining a higher calibration gas to verify the highest values. Since the span of the instrument was never changed and the accuracy of the analyzer, it is likely

that the data is still representative of actual emissions. The instrument read the stack gases directly from the stack in the same concentration as released to the atmosphere. EPA protocol gases were used to verify the integrity of the sample line, analyzer, and data logger, independently and as a complete system.

All process equipment was operated in a normal manner representative of operations that may contribute to normal carbon monoxide emissions at each load setting. The carbon monoxide results should be representative of the actual concentrations within the normal accuracies of Method 10.

D. Sulfur Dioxide, Sulfur Trioxide and Acid Mist Determination

The Sulfur Dioxide and Sulfur Trioxide emission results are presented in Appendix A. Data was collected as 72 minutes sampling duration at the exhaust stack.

Average sulfur dioxide emissions were determined to be 84.3 ppm or 1.25 lbs/hr.

Average sulfur trioxide / acid mist were determined to be 1 ppm or 0.023 lbs/hr. This number is an accumulation of sulfur trioxide and acid mist. Mass rates are calculated and reported based on H₂SO₄. The test results were obtained by using sample train.

All process equipment was operated in a normal manner representative of operations that may contribute to normal Sulfur Dioxide/Sulfur Trioxide emissions at each load setting. The Sulfur Dioxide/Sulfur Trioxide results should be representative of the actual concentrations within the normal accuracies of Method 8.

E. Total Hydrocarbons (THC)

The summary of Total Hydrocarbons emissions is presented in Appendix A, All results are based on the raw data collected by a real time analyzer and shown in Appendix B—Raw Gaseous Emission Results.

The arithmetic mean (average) of the carbon monoxide emission rate for the test period is 7.6 ppm. This is equivalent to 0.087 lb/hour. The maximum concentration reached during the test period was 74.6 ppm.

Instrument drift averaged less than 0.38 % and never exceeded 0.70 %. All of the sample gas was analyzed in the 100 ppm range and one can assume that all of the data should fall in the same range of accuracy (less than 1 %). As specified in the EPA test method, the CO results should be representative of the actual concentrations within 5% accuracy.

During the test program, calibrations of the instrument were performed before and after each one hour test period. After an initial repair, the test instrument performed flawlessly and required minimal adjustments after the calibration checks were made.

All process equipment was operated in a normal manner representative of operations that may contribute to normal THC emissions at each load setting. During the test runs, no abnormalities were discovered to contribute to any errors in the results of the tests. The results should be accurate within the variations acceptable by USEPA Method 25A.

III. SOURCE DESCRIPTION

Marshall Municipal Utilities owns and operates a Hurst boiler Model HYB 818-150-1. The boiler is used to generate steam that is used for space heating. The unit is stationary and is enclosed in a building. The unit is controlled from the main control room of the power plant. The boiler is rated at 5.15MMBtu/hour or 125 horsepower, and is capable of producing approximately 4,000 pounds of steam per hour. The boiler burns paper pellets for fuel. For this test the boiler was fired with the RDF fuel that was supplied by Cherokee County Solid Waste Commission. A 13.5 inch I.D exhaust stack carries emissions from the combustion chamber to the outside of the building. Steam production during the testing of the emissions from the boiler stack ranged between 3019 & 3481 lbs/hour. The boiler consumed approximately 800 pounds of RDF fuel per hour. The operating data was collected by Jim Johnson and can be found in Appendix C.

IV. PLANT OPERATING CONDITIONS

Marshall Municipal Utilities maintained normal operating conditions during the testing. The boiler operated normally and without problems. The boiler burned RDF fuel that was provided by Cherokee County Solid Waste Commission that was equivalent to the fuel that will be burned in Iowa. Therefore, the test data represents normal emissions that are generated by the Hurst Boiler. Marshall Municipal Utilities documented boiler-operating conditions. As mentioned above, operational data is provided in Appendix C. Fuel throughput was determined by counting the number of revolutions the fuel input auger made during a known amount of time. Each revolution of the fuel input auger yields 8.359 pounds of RDF moved into the combustion chamber. Operational data was recorded every fifteen minutes throughout the testing.

The boiler was down over the weekend of January 8-9, 2006. On Monday morning, the boiler was initially fired and brought online. Fuel used by Marshall Municipal Utilities was in the feed bunker at initial startup. The fuel in the feed bunker was transferred out of the bunker and replaced by fuel supplied by Cherokee County. After several hours, the transition was complete and a steady load was reached with the only new fuel as a heat source. Enough fuel was maintained in the bunker to keep normal load throughout the testing. At the end of the testing for the day, normal fuel was supplied to the bunker to run the boiler through the night. The next morning, the bunker was run low of normal fuel and new fuel was added for a smooth transition. After achieving a normal load on new fuel, testing was allowed to restart. Fuel samples were taken periodically during the test program. No additional analysis of the fuel was performed. Fuel samples will be retained for a period of time in case analysis may be needed.

V. TEST CONDITIONS

US EPA Reference Method 2, 4, 5, & 8 were combined together for testing Velocity, Moisture, PM, SO₂, and SO₃ / acid mist as H₂SO₄ on the first day of testing. Method 3 for molecular weight determination was performed simultaneously. The Method 7E, 10, & 25A test samples were drawn from a single point at the stack on the second day. All sample runs were conducted for a minimum of 60 minutes. The Method 2 test data was collected from six sample points on each of two traverses. Therefore, the exhaust gas velocity and temperature were collected from twelve points. USEPA Method 1 specified the traverse point locations.

No problems of either the boiler operations or the sampling were encountered during the tests that may lead to bias or inaccuracies in the test results. The boiler consumed RDF fuel in a steady state manner.

A cyclonic flow test and preliminary velocity traverse was performed during previous testing. Stack flow conditions were acceptable for testing. All sampling points were found to have flow angles within 3.2 degrees to 8.9 degrees. The average angle of rotation of the stack gases in the vertical plane was less than 6.0 degrees. (Average up to 20 degrees is acceptable according to the USEPA Method 1 procedures).

VI. TEST METHODS, PROCEDURES, AND EQUIPMENT

Each aspect of determining the emission concentrations and flows is described below. A copy of certain procedures and test equipment are provided in Appendix G.

A. Sampling Location

Method 1 provides a chart for reference to determine the correct number of sampling points for a given port location relative to disturbances in the stack. The minimum distance allowed is 2 stack diameters downstream from a disturbance and $\frac{1}{2}$ stack diameter upstream. Meeting this minimum distance, the minimum sampling points are 24. However, if the downstream distance is greater than 2 diameters and upstream distance is greater than $\frac{1}{2}$ diameter, then the minimum number of sampling points can be as low as 12 points for stacks with diameters of greater than 24 inches, or as low as eight points in stacks with diameters of between 12 and 24 inches. The reason for using distances from disturbances to dictate the number of sampling points is that longer distances will allow the gas flow to stabilize and have more uniform velocity profile along with a more uniform distribution. In the case of the boiler stack the port locations were not ideal thus resulting in the use of twelve sampling points. The test ports were 7.7-stack diameter downstream and <2.0 stack diameters upstream of the nearest disturbance thus resulting in the usage of twelve sampling points. Six points were located on each of two traverses.

B. Velocity Determinations

Velocity was monitored and recorded by USEPA Method 2 – “Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)”. This procedure was performed on the first day in conjunction with the Method 5 sample train.

Method 2 was performed with an S-type pitot tube at sampling points determined in Method 1. The sampling consisted of locating the pitot tube at each sampling point and recording the average velocity pressure (inches water). An inclined manometer at each of the twelve sampling points displays the velocity pressure induced by the pitot. The average of the square root values at each point make-up the average velocity pressure for one test run. The velocity pressures obtained by this method were converted to velocity and flow values by considering molecular weight, temperature and moisture of the sampled gas. Quality assurance for both procedures included system leak checks before and after the sampling periods. No problems intaking the velocity measurements were encountered throughout the entire test period.

C. CO₂ and O₂ Gas Analysis

Tedlar bag samples were collected simultaneously with the Method 5 sample train. From these samples, an analysis of the exhaust gases were performed, in triplicate, accordance with USEPA Reference Method 3 – “Gas Analysis for Carbon Dioxide, Oxygen, Excess Air, and Dry Molecular Weight”.

A separate gas sample was extracted from the stack by a multi-point, integrated sampling technique. The sample was collected in a chemically inert Tedlar Bag over the duration of the test run. The gas sample is analyzed for percent carbon dioxide (CO₂) and percent oxygen (O₂) by use of an Orsat apparatus.

The sample bags used during the test program were leak checked prior to use. No problems were encountered in performing the gas analysis during the test period.

D. Moisture Determination

Moisture determination of exhaust gas was performed in accordance with USEPA Reference Method 4 – “Determination of Moisture Content in Stack Gases”. During the Method 4 tests, a portion of the stack gases were extracted and the sample volume was recorded. Routing the sample through an ice-chilled condenser/dryer and measuring the amount of moisture collected obtained the amount of moisture in the sample volume. The temperature of the sample gas leaving the condenser was maintained below 68 degrees F. Moisture determination was performed by noting the liquid increase in the impingers and the weight gain of the silica gel. No problems were encountered in making the moisture analysis measurement. This procedure was combined with the Method 5 sample train use to collect particulate, sulfur dioxide, and sulfur trioxide / acid mist emissions.

E. Particulate, Sulfur Dioxide and Sulfur Trioxide / Acid Mist Emissions Determination

A Method 5 sample train was used to combine the procedures of US EPA Method 5 and 8 for determining particulate, sulfur dioxide and sulfur trioxide / acid mist emissions.

Particulate emissions were determined by performing an analysis of the nozzle, probe, and front half of the filter holder rinses, and the filter itself (front half) collected by the sample train. Analysis was performed according to the procedures of EPA Method 5 for particulates.

Sampling duration was 72 minutes for each of three runs at the exhaust stack. Samples were extracted isokinetically (where the nozzle inlet velocity equals the stack velocity at the sample point). All three of the test runs had isokinetic sampling rates between 90% and 110%. The sample train contained the typical four impingers with an additional filter to knock out any mist carryover between the second and third impingers. The sample train was assembled by loading the first impinger with 100 mL of 80% Isopropyl Alcohol, the second and third impinger with 100 mL of 3% Hydrogen Peroxide, and the fourth was loaded with 200-300 grams of silica gel to assure an absolute dry gas leaving the condenser section. All impingers were maintained below 68 degrees F by use of an ice bath. The first impinger contains reagents to capture SO₃ and allow SO₂ to carry through to the next impinger. The next two impingers contain reagents to adsorb SO₂. The reagents containing SO₂ are collected after each sample run, volume measured for moisture determination, and analyzed

by titration for SO₂. The reagents containing SO₃ are collected after each sample run, volume measured for moisture determination, and analyzed by titration for SO₃.

Leak checks of the entire sample trains and velocity trains were performed before, during, and after the test program. Heated probes were used throughout the Method 5 testing. No problems were encountered during the particulate / sulfates sampling. The samples were taken by USEPA Reference Method 6.

F. Carbon Monoxides

Carbon monoxide values were obtained by use of a Non-Dispersive Infrared (NDIR) continuous analyzer. Data was collected on one minute averages based on continuous analysis by the analyzer and a sampling rate of 6 samples per minute by the data logger. During each minute, the 6 sample numbers are stored and averaged. The one-minute average is permanently stored as a computer file. Each one-minute average of data is displayed in Appendix C.

The NDIR analyzer was calibrated through the entire sample train as well as leak checked before and after the test program. Method 10 requires calibration with a zero and mid level calibration gas after each run (eighteen 16-minute runs) to verify the accuracy of the previous data. Prior to the test program, the instruments were warmed up to stable operation and calibrated.

The instruments performed flawlessly and all calibrations did verify accurate data. All process equipment was operated in a normal manner representative of operations that may contribute to normal CO emissions at each load setting. During the test runs, no abnormalities were discovered to contribute to any errors in the results of the tests. The results should be accurate within the variations acceptable by USEPA Method 10.

G. Nitrogen Oxides

The results of the Nitrogen Oxides sampling and analysis are summarized in Table I. The nitrogen oxide results should be representative of the actual NO_x concentrations found in the exhaust under normal operating conditions. Method 7E uses an analyzer that display the No_x value, in real time. It requires calibration with a zero and mid level calibration gas after each test run to verify the accuracy of the previous data.

EPA protocol gases (NO in N₂) were used to verify the integrity of the sample line, analyzer, and data logger, independently and as a complete system.

All three test runs were performed at the exhaust stack on Jan.11, 2006. The equipment that vents emissions to this exhaust stack operated under normal operating conditions. Testing for nitrogen oxides, velocity, gas analysis for molecular weight, and moisture were performed simultaneously for all three runs during the period process exhaust gases were sampled. Visible emission readings were not required.

Nitrogen oxide values were obtained by use of a Chemiluminescent continuous analyzer. Data was collected on one minute averages based on continuous analysis by the analyzer and a sampling rate of 6 samples per minute by the data logger. During each minute, the 6 sample

numbers are stored and averaged. The one-minute average is permanently stored in a computer file. Each one-minute average of data is displayed in Appendix C.

The results of nitrogen oxide sampling and analysis are summarized in Table 1. Data values are expressed as a total nitrogen oxide count based on the addition of all nitric oxide (NO), nitrogen dioxide (NO₂) and all other higher levels of oxygen contained in nitrogen compounds. The data is expressed in parts per million (ppm) by volume summarized as one minute averages taken directly from the instrument. The analyzer reports the nitrogen oxide emission concentration as ppm of NO₂. A more complete description of the NO_x analyzer and its operation can be found in Appendix G. In short, the analyzer continuously draws in a sample. The NO₂ in the sample is transformed to NO. After transformation, the NO molecules enter a reaction chamber where they mix with ozone, forming NO₂. The analyzer then determines the concentration of NO₂ molecules and therefore determines the NO_x concentration.

The analyzer was calibrated through the entire sample train as well as leak checked before and after the test program. Between test runs, the analyzer was calibrated with a zero and mid level gas to verify the accuracy of the data from the previous test run. EPA protocol gases were used to verify the integrity of the sample line, analyzer, and data logger, independently and as a complete system.

EPA protocol calibration gases were used to verify accuracy of readings throughout the test program.

H. Total Hydrocarbon Compounds

The Total Hydrocarbon compounds were evaluated by application of the USEPA Method 25A - "Determination of Total Organic Concentration Using a Flame Ionization Analyzer".

Method 25A requires the use of a flame ionization detector (FID). The analyzer used for these tests was a Model 51 Heated Total Hydrocarbon Analyzer manufactured by Thermo Environmental Instruments. The instrument reads the stack gases directly from the stack in the same concentration as released to the atmosphere. All sample lines were Teflon or stainless steel. A flame ionization detector operates by ionizing volatile organic compounds using the energy of a hydrogen flame. The hydrogen flame combusts the organic compounds to generate carbon dioxide and water. In the process, carbon ions are formed. This formation occurs in an electrical field between 2 electrodes. One electrode is the jet where the hydrogen flame burns, and the other one is a cylindrical electrode surrounding the jet which is referred to as the collector electrode. A potential difference between these two electrodes causes movement of the ions to one or the other of the electrodes. When these ions arrive at the electrode, a small ion current flows. The ion current is amplified by an electrometer type amplifier and is then presented to the microprocessor system of the Model 51. The flame ionization detector responds to virtually all organic compounds. Since the response is due to the carbon ions formed, any organically bound carbon will show a response on a flame ionization detector. In this detector, a flow of the sample is mixed with the hydrogen prior to the flame. An external source of air provides the necessary oxygen for the combustion of the sample in the flame. Normally, sample flow and hydrogen flow are approximately equal and the combustion air is 5-10 times greater. The detector used in the Model 51 is designed to

have hydrogen and sample flows of approximately 25 mL/min. and airflows of approximately 150 mL/min.

Depending on the molecular structure of each hydrocarbon compound, the detector will respond differently. Actual hydrocarbon concentrations of specific compounds can be calculated based on a response factor determination.

Data was collected on one minute averages based on continuous analysis by the analyzer and a sampling rate of 6 samples per minute by the data logger. During each minute, the 6 sample numbers are stored and averaged. The one-minute average is permanently stored as a computer file. Each one-minute average of data is displayed in Appendix C. Testing was continuous during each of the three test runs.

The instrument read the stack gases directly from the stack in the same concentration as released to the atmosphere. EPA protocol gases were used to verify the integrity of the sample line, analyzer, and data logger, independently and as a complete system.

The THC analyzer was calibrated through the entire sample train as well as leak checked before and after the test program. Method 25A requires calibration with a zero and mid level calibration gas after each run (three 60-minute runs) to verify the accuracy of the previous data. Prior to the test program, the instruments were warmed up to stable operation and calibrated.

The instrument was calibrated and leak checked before and after the test period and recorded on individual calibration sheets.

VII. CONCLUSION

AeroMet Engineering, Inc., located in Jefferson City, Missouri, was retained by Lundell Enterprises Inc., (LEI) on behalf of Cherokee County Solid Waste Commission, to determine Particulate Matter (PM), Sulfur Dioxide (SO₂), Sulfur Trioxide / Acid Mist (SO₃), Nitrogen Oxide (NO_x), Total Hydrocarbons (THC) and Carbon Monoxide (CO) emission factors for (RDF) Refuse Derived Fuel. LEI used RDF as a fuel for burn-in test required by Iowa Department of Natural Resources, on a stationary Hurst boiler, Model HYB 818-150-1 located at Marshall Municipal Utilities (MMU) in Marshall, MO. Emissions were sampled over a two day period (Jan. 10, 2006 & Jan.11, 2006).

Throughout the entire testing period, the boiler was operating normally and near maximum capacity during the test period. The emissions vented through the main stack should also be representative of maximum operation. The test data represents normal emissions for the operating conditions at the time of the tests.

The average particulate emission rate, determined by use of Method 5, for the three tests run was 1.766 lbs/hour. The average sulfur dioxide emission rate, determined by use of Method 8, was 1.27 lbs/hour, while the average emission concentration was 84.3 ppm. The average sulfur trioxide / acid mist emission rate, determined by use of Method 8, was 1.27 lbs/hour, while the average emission concentration was 84.3 ppm. The average total nitrogen oxides emission rate, determined by use of Method 7E, for the three tests run was 1.002 lbs/hour, while the average emission concentration was 93.2 ppm. The average carbon monoxide emission rate determined by use of Method 10, for the three tests run was 1.270 lbs/hour, while the average emission concentration was 193.9 ppm. The average emission rate determined by use of Method 25A, for the three tests run was 0.087 lbs/hour, while the average emission concentration was 7.6 ppm. Gas flows were determined by use of Method 2, Gas Molecular weight was determined by use of Method 3, and moisture was determined by use of Method 4.

Weather was not a factor during the testing program. No testing or production equipment malfunction was encountered during the collection of data presented in this report. Therefore, results should be representative of actual emissions within the normal accuracies of USEPA Methods 5, 7E, 8, 10, and 25A.

APPENDIX - A SUMMARY OF EMISSIONS TEST

LUNDELL ENTERPRISES, INC.

**Burn –In-Test For RDF for Emissions at
MARSHALL MUNICIPAL UTILITIES
Marshall, MO**

Summary of Emission Test conducted for RDF used as fuel for Hurst Boiler

Test Results		CO (ppm)	NOx (ppm)	THC (ppm)	SO2 (ppm)	SO3 (ppm)	Particulate (grains/dscf)
Run 1		193.0	95.2	14.7	100	1	0.1325
Run 2		230.5	91.8	6.6	79	1	0.1433
Run 3		158.2	92.5	1.7	71	1	0.1359
Average Results		CO	NOx	THC	SO2	SO3	Particulate
Emission Conc	(ppm)	193.9	93.2	7.6	83.3	1.0	
Emission Conc	(lb/scf)	1.409E-05	1.112E-05	9.660E-07	1.3833E-05	2.5419E-07	1.9606E-05
Emission Rate	(lb/hr)	1.270	1.002	0.087	1.247	0.023	1.766
Emission Rate	(lb/yr)	11125.2	8781.0	762.2	10919.5	200.6	15472.1
Emission Rate*	(tpy)	5.56	4.39	0.38	5.46	0.10	7.74
DeMinimus Rate	(tpy)	100	40	40	40 as Total Sulfur Compounds		15 as PM10

* Note: Based on 24 hr/day 365 days/year