ENGINEERING REPORT
ENERGY-from-WASTE TECHNOLOGY
as found in INEZ, KENTUCKY, USA

Energy 21, LLC

Sustainable Energy for the 21st Century

August 16, 2018

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INTRODUCTION

The author of this report is a professionally licensed engineer in multiple state with over forty-seven (47) year of experience, which started with the operation of an electric power generating station, progressed to the design of plant utility and pollution control systems, followed by extensive project and company management experience. In addition to the professional licenses, the author also has B.S.-Mechanical Engineering, and M.S.- Environmental Engineering.

In 2003 the author was first introduced to the rotary kiln gasification system studied in this report and has served as a part-time advisor and consultant to the developer. In addition, the author has witnessed the rotary gasifier operate on multiple occasions and was on hand the first time the synthetic gas (syngas) produced by the gasifier was combusted in the waste heat boiler to produce steam. With this background, the author is in a unique position to present both information on the Inez rotary gasifier as well as professional personal opinions of the system.

The rotary gasifier and its ancillary systems started out in 2003$^{+/-}$ as a combination of new and used equipment with the sole goal of proving and validating the viability of this Energy-from-Waste system. Over the years changes and modifications have been made to the systems to enhance the operation and/or reliability of the equipment. Currently major improvements are underway the author believes will greatly improve the operational reliability of the system, such as: enlarging the syngas duct from the gasifier to decreasing gas velocity, eliminating the afterburner vessel in its entirety, combusting the syngas directly in the boiler's primary furnace, opening the tube spaces in the boiler's furnace to allow for ash to drop out into hoppers below, and a new spray dryer/absorber better sized to meet the operating parameters of the flue gas from the boiler.

PROJECT DESCRIPTION

This report presents an engineering overview of the patented gasification technology for converting municipal solid waste (MSW) into beneficial energy and recyclable byproducts, including:

- design and operation simplicity;
- converting syngas into useable energy;
- system safety;
- eliminating syngas pre-cleaning;
- stack emissions control; and
- ash characteristics.

As far back as the May 2010 Waste to Energy (WTE) conference contained an interesting paper titled “Status of Existing Biomass Gasification and Pyrolysis Facilities in North America (NAWTEC18-3521),” which detailed a website search for “firms in the United States and Canada identifying themselves as gasification or pyrolysis system suppliers.” The paper acknowledged three available technologies including: The Updraft Gasifier, the Downdraft Gasifier, and the Fluidized Bed Gasifier.

The gasification system described in the following pages considers a fourth technology that utilizes a rotary gasifier to convert municipal solid waste (MSW) into a synthetic gas, or syngas, to fuel a steam boiler. At the end-user’s request, the steam can be sold as the primary output or the production of electric power (through a steam turbine - electric generator) or the production of chilled water (through absorption chillers) or for the production of compressed air (through a steam turbine driven air compressor) or for the production clean water (through steam powered distillation towers).

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The intent of this engineering report is two-fold:

1) To highlight the concept that the gasifier is a piece of process equipment and not the complete system itself;
2) To introduce a rotary kiln as a fourth form of MSW gasification.

The fourth MSW gasification process, developed in Inez, Kentucky is a cost effective, environmental solution to landfill impact, greenhouse gas reduction, energy security, and rapid system implementation. To date, this gasifier has been demonstrated to reduce all the MSW fed into it to either recycled materials or syngas (synthetic gas) that has been fired in a waste heat boiler to produce steam. The author of this report is a registered professional engineer in multiple states and, as such, can testify to having witnessed this gasifier operate successfully on many occasions to generate steam in a waste heat recovery boiler while turning in-feed MSW turned into syn-gas with the steel, aluminum, and glass byproducts easily separated in a post-gasification step.

It is the opinion of the author, as well as other familiar with the generation of electric power, that the gasifier has been able to demonstrate its ability to turn MSW into a synfuel capable of producing steam. Converting that steam into electric power is simply the application of exiting know, tried and true technology. As additional proof of this statement, the State of Kentucky had licensed and permitted this gasifier to receive and reduce 440 Tons per Day (TPD) of MSW into beneficial uses.

THE ROTARY KILN AS A GASIFIER

According to a Wikipedia article, the rotary kiln technology was invented in 1873 by the Englishman Frederick Ransome and defines a rotary kiln as a pyroprocessing device used to raise materials to a high temperature (calcination) in a continuous process. Materials produced using rotary kilns include:

- Activated carbon
- Cement
- Lime
- Refractories
- Metakaolin
- Titanium dioxide
- Alumina
- Vermiculite
- Iron ore pellets

The author has observed several rotary kilns in operation at the Calgon Carbon plant in Catlettsburg, Kentucky partially gasifies bituminous coal as the first step in creating activated carbon from the infeed of raw coal. In these rotary kilns, dating back to the 1940s, the raw coal is heated just high enough to release the volatile constituents, but not so high as to gasify the fixed carbon portion, with the resulting product being the step in creating the desired activated carbon product.

However, a search of the internet does not return any results in the nearly 150 years history of rotary kilns of these process devices being employed for the gasification or pyrolysis of MSW into useful byproducts. But such a gasification system does exist.

The first rotary gasifier system, located in the Commonwealth of Kentucky, is a full scale, 440 TPD facility that has received both state and federal certification and permitting. This commercial unit has established the basic modular building block for future waste-to-energy facilities using this simple technology.

DESCRIPTION OF THE ROTARY GASIFICATION PROCESS

The rotary gasifier developed in Inez, Kentucky meets this historic definition noted above by bringing municipal solid waste into the rotary kiln and raising the material to an elevated temperature in the absence of oxygen causing the thermal separation of the organic matter from the inorganics. The organic, and other volatile matter leaves the gasifier in the form of synthetic gas (syngas) that can be combusted in a separate device (furnace/boiler) or further refined into beneficial components. The inert, inorganic matter is discharged from the gasifier and easily be separated into beneficial components in the form of metal, glass, and other mineral products with virtually zero material discharge to a landfill.

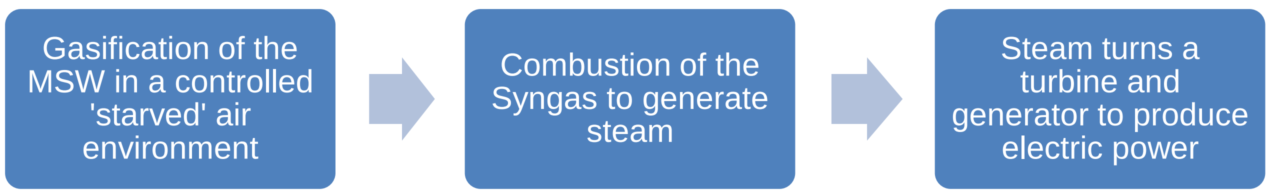
Photo 1: Gasifier diameter: 10-ft Dia.

The basic process is as follows:

- Raw, unprocessed waste is delivered to the process ram feeding the gasifier.
- The kiln is fed through a large, enclosed, and air sealed push ram, so large articles that can feed fit in this feeder box can go into the kiln with minimal or no preparation.
- The 120-foot-long gasifier dries and processes the waste as it progresses through the kiln (see Photo).
- The gasifier processes the MSW into: 1) syngas, which is sent to the furnace, and 2) solids, including sterile aluminum and steel, glass, and mineral frit.
- The syngas continues on to the furnace where fresh air is added and ignition to combust the syngas at the correct temperature and time required to destroy any undesirable components and, in doing so, raises the flue gas temperature in the furnace and the boiler.
- The boiler turns the heat in the flue gas into useful energy in the form of high-pressure, super-heated steam that can be used for several purposes.
- The combustion of the syngas in the boiler reaches temperature over 4,000^{o}F to incinerate any toxic and undesirable waste gases.
- An off-gas from the boiler is controlled by an emissions monitoring system that meters the activated charcoal and lime slurry to the spray absorber to remove any remaining undesirable components in the gas stream.
- Cooler exhaust gases are sent to the baghouse for final particulates reduction. A controlled induced draft fan sends final exhaust gas to the stack and into the atmosphere.

GASIFICATION ENERGY CONVERSION PROCESS

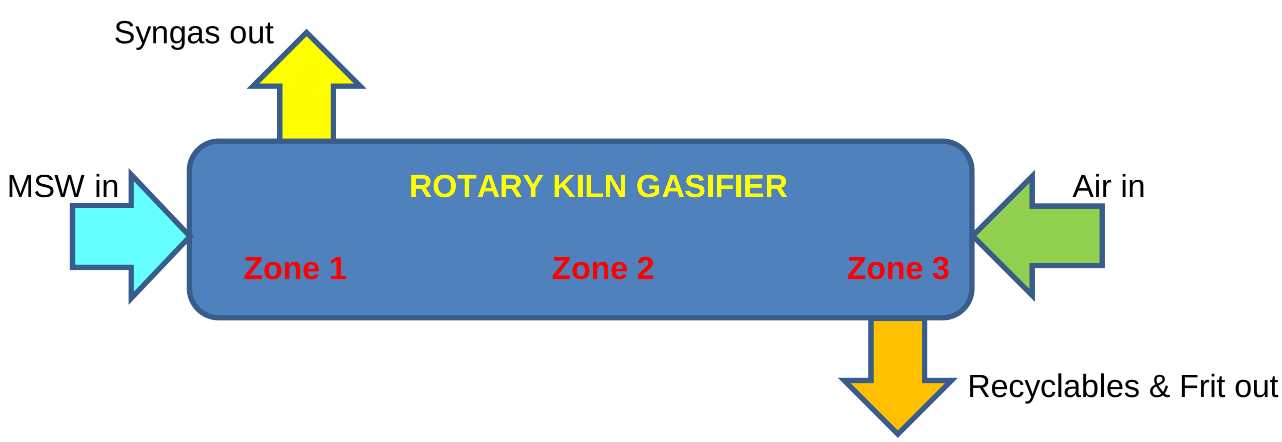
The generation of electric power from municipal solid waste is a three-step conversion process.



Combustion of the syngas to generate steam followed by the generation of electric power is an established, straight-forward and proven technology to be described in more detail later. The unique step is the gasification process, which is more difficult to explain without going into detail.

Step 1: Gasification of the Municipal Solid Waste:

First, it is important to note that this rotary kiln is a ‘counterflow type of process. The solid material flows from left to right (in the following sketch) while the gases flow from right to left. This means that the coolest gas flows over the hottest solids while the hottest air flow over the coolest solids.



Zone 1

MSW enters the gasifier at ambient temperature and full of moisture. The syngas leaves the kiln at over 1,800 ^{o}F as various gaseous elements, predominately nitrogen and with large amounts of hydrogen, oxygen, methane, and carbon monoxide. The high temperature of the syngas dries the MSW while the moisture of the MSW protects light metals, like aluminum from melting and burning.

Zone 2

Combustion of the light weight, volatile materials, like paper and plastic, occurs providing heat for the gasification process. Combustion is controlled by limiting the fresh air admitted to the kiln, essentially ‘starving’ the combustion process of all the air required for a complete burn. The heat from this controlled combustion causes a breakdown of the remaining organic matter into gaseous components and at the same time disassociates the moisture in the MSW into hydrogen and oxygen (historically called ‘water gas’).

Zone 3

The combustion/gasification step is complete, but the inorganic materials left (recyclables and frit) are extremely hot. The controlled amount of fresh air coming into the kiln to support the limited combustion passes over the hot inorganics transferring the heat to the air and at the same time cooling these rejected materials so that they can be handled by conventional material handling systems.

All the time the gases are going one direction and the solids are going the opposite direction, the rotary gasifier is slowly rotating, which has the effect of:

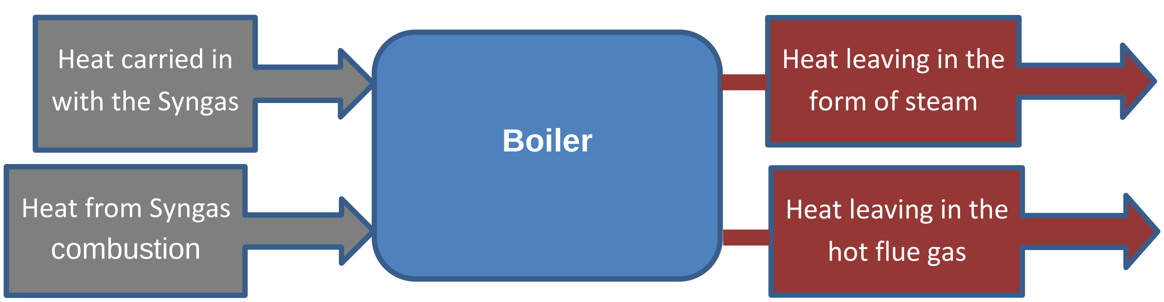
- Constantly exposing new MSW material to the hot gases, and
- Protecting the metals by moving other MSW over them, and
- Knock off any char off the solids which otherwise would prove to be an insulting layer that would slow down the gasification process.

Tests were conducted relating the syngas produced to the infeed of MSW to the gasifier to determine both the quantity and composition. It should also be noted that the characteristics of any syngas produced depends greatly on the MSW composition and whether pre-gasification recycling has occurred. While the exact composition of the syngas is considered confidential by the developer, the general, important characteristics of the syngas used in the following calculations are as follows:

- Combustibles consists of hydrogen, methane, oxygen, and carbon monoxide
- 1,000 standard cubic feet (SCF) of syngas produced per pound of MSW
- The approximate syngas temperature leaving gasifier is 1,800 ^{o}F.

Step 2: Combustion of the Syngas to Generate Steam

The calculation of the steam produced is the results of a simple heat balance calculation where heat in equals the heat out of the boiler. In a simple illustration:

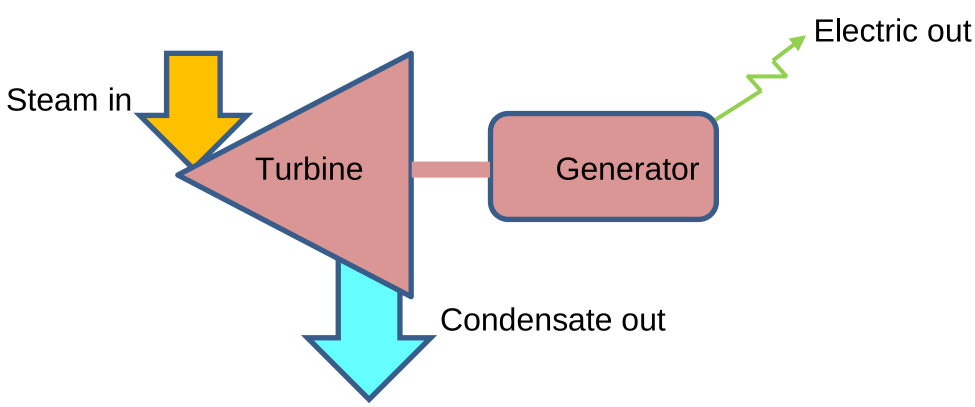


The quantity and composition of the syngas produced, based on testing of the MDGS Energy-from-Waste technology as found at the Inez, Kentucky (USA) facility with a projected increase of the MSW feed rate to 750 TPD was given to an established boiler manufacturer who calculated the predicted performance of this boiler using this syngas as its fuel. A summary of the significant parameters are listed below:

- Steam produced: 220,000 lbs/hr
- Steam conditions: 750 psi at 750 °F
- Flame temperature: 4,229 °F (note this high temperature)
- ➢ Equipment supplied: Boiler furnace & convection zone, superheater, economizer

Step 3: Steam turbine and generator produce electric power

The steam flow rate and conditions were given to an established turbine manufacturer who calculated the predicted performance of the steam produced. This manufacturer could only produce a turbine generator (T-G) set up to 12 MW, so for this study, it is assumed two T-G sets would be used as a design basis and ultimately a manufacturer could be found to provide a single unit.



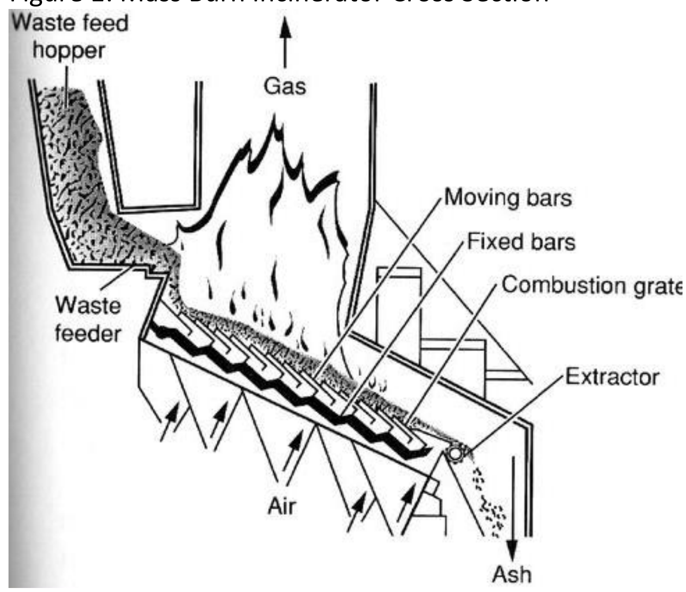
- Steam consumed: 220,000 lbs/hr
- Steam inlet conditions: 750 psi at 750 °F
- Steam outlet conditions: 2-½ "Hg
- Turbine Operating Speed: 4,500 RPM
- ➢ Equipment supplied: Turbine, speed reducer, and generator

COMPARATIVE CURRENT MASS BURN TECHNOLOGY

Mass burn technology probably originated in the early 1800s to provide as labor intensive way to burn coal and wood in an industrial application to produce steam (imagine an old-time steam locomotive). By the early 1900s, labor saving improvements included the mechanical stoker, which transformed the heavy manual labor effort into something machines could do.

As no clear definition or history of mass burn could be found on the internet, as used herein, mass burn is meant to depict the supply of the fuel in 'mass', originally coal, to a boiler's primary furnace for combustion. This mass of fuel is spread over a horizontal, or slightly inclined surface, or stoker, where fresh air is passed though the fuel bed, and ignition source is provided, and the combustion process is initiated. Orinial coal stoker types included the underfeed stoker, the traveling grate stoker, and the spreader stoker. At first, the traveling grate stoker was used to burn municipal solid waste, and eventually modified into the inclined, reciprocating stoker shown here.

Figure 1: Mass Burn Incinerator Cross Section



Since the very essence of the combustion process is the oxidation of the combustible elements in the fuel (i.e. carbon, hydrogen, and some others) with the exothermic release of the heating value contained in these elements. Gaseous fuel, like natural gas or propane, combust efficiently as it is relatively easy to position the oxygen next to the combustible element to start the combustion process. With solid fuel, coal, wood, or MSW, on the other, it is extremely difficult for the oxygen element to reach all the combustible elements. Typical combustion of any solid object typically occurs on or near the surface of the solid itself. For example, take burning wood in a fireplace. The wood needs to be constantly poked to break off the outer crust of ash to allow the air to reach the inner most, unburned wood.

There is an axiom in combustion fundamentals, good combustion requires the three Ts, these are Temperature, Time, and Turbulence.

1. Temperature is the autoignition point where each of the combustible elements can spontaneously burn,
2. Time is the period required to bring the combustible element up to the autoignition point, and
3. Turbulence is the agitation required to mix the fuel with the air to introduce oxygen to the combustible elements.

The proper design of the mass burn technology does well satisfying Points 1 and 2 above, but the quiet, slow motion of the MSW travel across the stoker grate has difficulty satisfying Point 3. As an example of this, ash from the combustion process of MSW can contain from 3 to 6 percent unburned carbon, which represents an inefficiency of the overall combustion process. In virtually all mass burn incinerators, combustion efficiency is not a concern as the 'fuel' is free, and the incinerator is meeting its goal of achieving over a 90 percent reduction in the volume of MSW that ends up going to a landfill.

ADVANTAGES OF GASIFICATION OVER CURRENT TECHNOLOGY

The following is a simple overview list of the many advantages the MDGS Energy-from-Waste technology as found at the Inez, Kentucky (USA) has over the current mass burn technology describe above,

1. Gasification systems, in general, could be considered a "carbon neutral" process because MSW that would otherwise go to landfills is used as fuel.
   a. Approximately 750 tons/day of MSW could produce 23 MW of electric power, the thermal equivalent of 7 tons/hour of coal, 1,300 gallons/hour of fuel oil, or 190,000 CF/Hr of natural gas.

2. Based on published information (US Energy Information Agency Article; Biomass Explained), "waste-to-energy plants in the US generated about 474 KW of electricity" per ton of MSW.
   a. Extrapolating the performance of the MDGS Energy-from-Waste technology as found at the Inez, Kentucky (USA) based on experience, this rotary kiln gasifier should be capable of generating over 700 KW of electricity per ton of MSW.
   b. This increase in electric production represents a 47% improvement over current mass burn technology.
3. The MSW fed into the kiln can vary in size from house trash to 4-inch chunks of wood to full car tires.
4. The slow rotation of the 'rotary' kiln (2 rpm) gently tumbles the MSW, causing the cascading of the trash on top of adjacent trash.
   a. The slow-motion tumbling action of the MSW abrades and knocks off any char surface on the trash being gasified continuously exposing fresh material beneath the char layer.

b. The exposure of the fresh material promotes the contact of oxygen with the material to be oxidized, thereby promoting the combustion process.

c. The constant attrition of the MSW infeed ensures that all combustible materials are gasified so that any material existing the gasifier is inert 'ash'.

Photo 2: Glass frit left from gasification

5. The combustion process is controlled by limiting the amount of fresh air allowed into the kiln to support the combustion process.
    a. Air introduced into the kiln is limited to the stoichiometric amount required for the limited combustion to take place, excess air is theoretically reduced to 'zero'.
    b. The heat from the limited combustion breaks the organic compounds contained in the MSW into hydrogen, methane and carbon monoxide, and because of the strict control of 'excess air', does not burn completely, thereby forming the basis of the syngas produced.
6. The temperature of the kiln is maintained at approximately 600 ^{o}F by controlling the combustion process's release of thermal energy in conjunction with the infeed of raw MSW into the kiln.
    a. The relatively low temperature ensures the valuable metals, aluminum, copper, and steel, are not oxidized, thereby available for recycling.
    b. As these various metals are not oxidized, the environmental impact of any potential metal oxides is avoided.
7. The synthetic gas (syngas) created is as the name applies, a gaseous fuel.
    a. Combustion of the syngas in the boiler that follows the rotary kiln gasifier is as efficient as a gas fired boiler can be.
    b. Combustion of the syngas in the boiler at an elevated temperature over 1,600^{o}F ensures the total destruction of dangerous emissions (like dioxins and others).

8. The MSW material that cannot be gasified is rejected from the rotary kiln gasifier for post gasification recycling.
   a. The post gasification recycled material is sterile, cleaned of any varnish, paper, or food coatings.
   b. Separation of recycled materials is much easier as the bulk of the combustibles have been eliminated.

Photo 3: Wire strands from a gasified tire

The following is a simple overview list of the few disadvantages the Inez rotary kiln gasifier has over the current mass burn technology describe above,

1. The physical size of the rotary kiln is limited by the ability of the kiln to stay rigid over its entire length. Attempts to make the kiln too long or two big a diameter could cause flexing of the kiln between its roller supports, which in turn would cause cracking, thereby destruction of the internal refractory. Such physical restraints would have a limit on the through-put of MSW into the kiln.
2. The kiln is lined with refractory to resist the thermal and chemical attack of the MSW passing through it. As with any refractory lined vessel, the rotary kiln is subject to thermal shock.
   a. Start-up of the kiln must be carefully controlled as not to be too fast as to cause harm to the refractory
   b. Starts and stops of the kiln should be reduced as much as possible; preferable to operate the kiln 24 hours per day for months at a time.
3. The internal refractory is a 'consumable' material as it will wear with the attrition of the MSW passing though it. Life expectancy is dependent on the characteristics of the MSW being processed, but should be in years, not months.

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Appendix 1

NAWTES18-3521 Technical Paper; Status of Existing Biomass Gasification and Pyrolysis Facilities in North America

Proceedings of the 18th Annual North American Waste-to-Energy Conference
NAWTEC18
May 11-13, 2010, Orlando, Florida, USA

NAWTEC18-3521

STATUS OF EXISTING BIOMASS GASIFICATION AND PYROLYSIS FACILITIES IN NORTH AMERICA

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ABSTRACT

A search of websites for firms in the United States and Canada identifying themselves as gasification or pyrolysis system suppliers indicates that there are a number of existing facilities where their technologies are installed. According to the websites, the companies' existing installations focus on processing biomass and industrial residuals, rather than mixed refuse. The biomass processed, according to the websites includes yard waste, wood, and wastewater treatment sludge. The existence of these facilities provides a potential opportunity for communities in areas with a high density of development, who experience difficulties in siting "traditional" facilities for processing these biomass wastes. Such traditional facilities include yard waste and sludge composting, wood mulching, sludge drying, chemical treatment or pelletization, and combustion-based waste-to-energy. As a result of these facility siting difficulties, these communities often resort to long-haul trucking of the biomass wastes to processing facilities or landfills. Certain potential advantages associated with gasification and pyrolysis technologies could ease the siting difficulties associated with the traditional technologies, due to smaller facility footprints, reduced odors, and the potential for energy production through combustion of syngas/synfuel to power internal combustion engines or produce steam using boilers. Lower stack emissions may result as compared to direct combustion of biomass wastes. Locally sited biomass gasification facilities could reduce the environmental impacts associated with long-haul trucking and generate an energy product to meet nearby demand.

Research has been conducted by the Author on behalf of client communities to identify gasification and pyrolysis facilities in the United States and Canada that are in actual operation in order to assess their potential for processing biomass wastes and for providing the advantages listed above. Website reviews, interviews with company representatives, and facility visits were conducted in order to assess their potential for development to meet the biomass management objectives of the communities. The information sought regarding design and operating parameters included the following:

- Year of start-up.
- Availability.
- Process description.
- Design throughput.
- Actual throughput.
- Energy product.
- Energy generation capability and technology.
- Residuals production and characteristics.
- Emissions.
- Construction and operating costs.

In addition, the system suppliers' business status was addressed in terms of their readiness and capabilities to participate in the development of new facilities.

Confidentiality requirements imposed by the system suppliers may prevent the identification of the company name or facility location and certain details regarding the system designs.

INTRODUCTION

Much of the recent years' attention regarding the potential development of gasification or pyrolysis facilities for municipal solid waste ("MSW") has focused on utilizing technologies which have been commercialized in Europe and Japan. However, several firms in the United States and Canada have developed and commercialized systems that are operating at numerous locations. Some have extensive operating histories. These existing facilities are generally relatively small scale and typically process biomass (forestry, lumber mill, or crop wastes). The operators report experience processing a wide variety of biomass, including yard wastes and sludge. One relatively new facility processes sewage sludge [1]. Research was conducted by the author in order to determine if these systems could be developed to process yard wastes, wood, or sewage sludge generated in communities where the scarcity of sites, regulatory hurdles, and local opposition have prevented or made it politically perilous to develop facilities employing other processing technologies, such as yard waste/wood composting or mulching; sludge drying, chemical treatment, pelletization, or combustion. Such difficulties sometimes force local governments to resort to long haul of these biomass wastes to processing or disposal facilities, with the attendant considerable expense and emissions from trucking.

The preferred development scenario for a biomass gasification or pyrolysis facility to serve these communities is as follows:

1. Flexibility to process each of the biomass wastes generated on a seasonal and non-seasonal basis over the course of the year, with their varying fuel characteristics. Leaves, grass clippings, brush, and wood waste are generated seasonally, while sewage sludge is generated on a relatively stable basis throughout the year. These biomass wastes exhibit a range of fuel characteristics that a processing system must be capable of handling.

2. A facility footprint that would enable development at existing biomass waste transfer stations. Existing sites where the biomass wastes are currently delivered and loaded into trailers for transport have gained a certain level of acceptance. Their use for a thermal conversion facility would avoid the need to select new sites with sufficient acreage to support a composting or treatment process facility.

3. Low profile building envelope. Avoidance of a significant visual impact would mitigate local opposition.

4. Convert syngas to mechanical or electrical energy via direct firing in internal combustion engines or combustion turbines. Direct firing would avoid the need for intermediate steam generation as required for steam driven turbine-generators. There is also familiarity and acceptance of direct firing of landfill gas at local landfill sites.

5. Favorable reception by regulatory agencies. Regulatory agencies have been reluctant to support combustion. Their attitude toward gasification or pyrolysis is uncertain. Gaining regulatory support for gasification or pyrolysis would be partially dependent upon the ability to demonstrate the ability to meet existing emissions standards and to attain the very low dioxin and furan emissions claimed for these systems. Although, such demonstration would not guarantee regulatory support.

6. Cost competitive with current management strategies. Absent a legal mandate, cash-strapped municipalities must realize a savings from the project in order to support it.

GASIFICATION SYSTEM DESIGNS

This section provides a brief review of gasification system design alternatives and issues. It does not extensively address pyrolysis systems, since they are in a minority with regard to commercially available systems. Refer to Figure 1 for an illustration of the gasification system components.

Biomass Preprocessing, Storage, Drying, and Feeding

Preprocessing and Storage

The requirements for systems handling segregated biomass will be influenced by the characteristics of the particular waste material. The systems reviewed often employ size reduction to attain consistent material and fuel characteristics, and the use of familiar solid waste management equipment for storage and feeding. Since these are processing segregated biomass, the elaborate systems associated with refuse derived fuel systems are not used.

Drying

Gasification and pyrolysis systems are differentiated from combustion systems by the need for some systems to conduct biomass drying *prior* to feeding it into the gasifier, and the need to control the introduction of air during the feeding process in order to maintain substoichiometric conditions. Specific requirements vary among commercially available pyrolysis and gasification systems. In combustion systems, the first section of the stoker is utilized for drying and the heated water vapor combines with flue gas, allowing some of the heat from the vapor to be recaptured in the boiler. As further addressed below, certain gasifiers utilize stokers, and thus have the capability for fuel drying during the gasification process. However, others which do not employ a stoker, may not provide adequate residence time in the gasification reactor for drying to occur. Excessive moisture in the biomass may also prevent or inhibit the desired thermal reactions. The presence of moisture in the biomass would reduce the reactor operating temperature, creating the potential for increasing the methane and reducing the hydrogen content of the syngas. The methane, in combination with the water vapor that would be present in the syngas could also interfere with the downstream operations. The gasification and pyrolysis systems reviewed by the author utilize a variety of drying methods, including fluidized bed and rotary mechanisms, direct exposure to flue gas, or a thermal fluid [2]. In order to avoid losing the energy used to drive off the water vapor, heat recapture would be necessary. It is not apparent from the review of these systems that this is commonly practiced, which is probably due to the added expense.

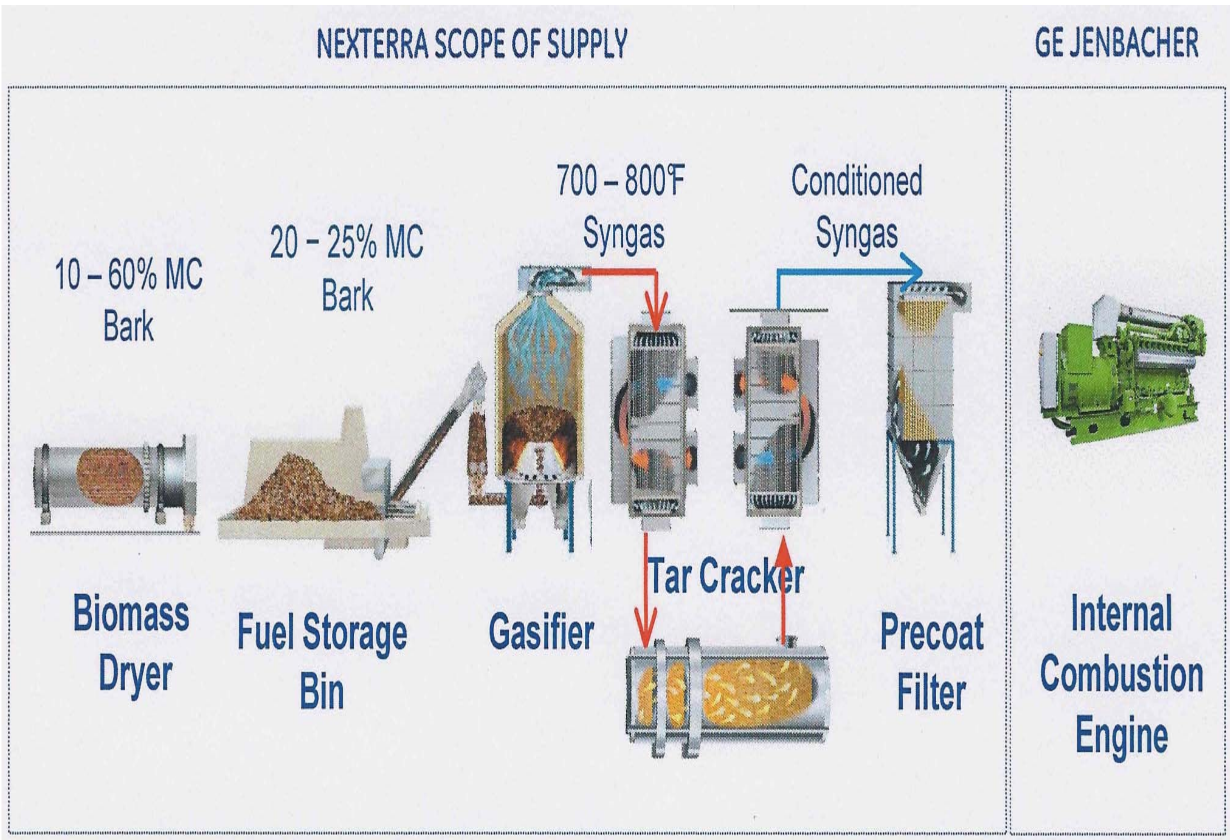

Figure 1 – Illustration of Gasification System Components (Nexterra website)

Feeding

In order to maintain the oxygen free or substoichiometric conditions necessary for pyrolysis or gasification, respectively, the air introduced during the biomass feeding process must be controlled. The companies do not generally describe how they accomplish this. A fluidized bed wood chip gasifier that operated until 2001 used nitrogen to purge the feed hopper each time wood was fed to the unit, and to purge the system prior to restart following outages. This necessitated the installation of a storage tank in order to maintain the continual supply to the gasifier during operations [3].

Gasification

Fixed bed – updraft, fixed bed – downdraft, and fluidized bed gasifiers are the three (3) primary varieties of gasification technologies. Advantages and disadvantages vary among the different designs. A description of each will help to understand the differences of these types and the inherent uses of each design [4].

Updraft Gasifier

Also referred to as a counter-current, fixed bed gasifier, an updraft gasifier's flow of gas is upward, as the name suggests. Starting from the bottom and working upward, a fixed bed of carbonaceous material reacts with the gasification agent (air, oxygen, steam, or hydrogen), which flows through the grate at the bottom of the gasifier. As it ascends, the resulting gas will pyrolyze the fed biomass. Fuel must be "non-caking" so that the bed stays permeable. Tar and methane build up is significant, in comparison with downdraft and fluidized bed designs, considering the relatively low operation temperature of this design. Due to this fact, extensive cleaning of gas is required before it is useable in other than close-coupled operation.

Downdraft Gasifier

Also referred to as a co-current fixed bed gasifier, in a downdraft system, the gasification agent (air, steam, or oxygen) is fed downward in the same direction as the fuel. Relatively high temperatures in this design help reduce tars as the evolving syngas passes through the hot bed. Differences between updraft and downdraft designs result from the direction in which the process takes place, and the effects the operational flow has on the reactions taking place during gasification.

Fluidized Bed Gasifier

In a fluidized bed gasifier, the gasification agent rises through the grate with substantial velocity where it fluidizes a heat transfer medium (sand or limestone) that meets and gasifies small particles of the fuel, and, in result, a type of "fluidized bed" is formed. This type of gasifier is most useful for fuels, such as biomass, that normally would form corrosive ash, which would damage the walls of a slagging gasifier. Since the forceful air pushes around the particles of fuel, corrosive ash may not be a problem for this design. Bubbling fluidized bed and circulating fluidized bed are variations of this design. Issues to be addressed in the design include the quality and replenishment of the heat transfer medium and erosion of the reactors due to the abrasive nature of the heat transfer medium. The circulating fluidized bed wood chip gasifier previously mentioned required sand with non-agglomeration additives. Due to the loss of the sand at the rate of approximately one (1) pound per hour, a constant supply of the treated sand was necessary [6].

Updraft and downdraft designs are less complex than fluidized bed; but generate lower energy value syngas. Fluidized bed systems are more complex and produce greater particulate. However, fluidized beds produce higher fuel value syngas and accept a wider range of biomass feedstocks [7]. In selecting a gasifer design, the advantages and disadvantages of each must be weighed with regard to the objectives of the project in terms of feedstock, energy product, cost constraints, and emissions.

A number of the commercially available updraft and downdraft units operate in a manner highly similar to the "controlled air, modular combustion units" that are familiar to the waste-to-energy industry. However, the gasification industry calls them "close-coupled gasification" [5]. These systems appear to have been developed in the lumber and food processing industries for recovery of energy from their residuals. The similarities include the use of moving stokers, gasification of the waste under substoichiometric conditions in a primary chamber, and immediate oxidation of the syngas in a secondary chamber via the introduction of air. The resulting flue gas is used to produce steam in either fire-tube or water-tube heat recovery steam generators. In discussions, gasification system representatives have indicated that this approach is dictated in part by the difficulties encountered thus far in attempting to remove impurities from the syngas as necessary for direct firing. Efforts by the vendors to market these gasifiers for managing biomass wastes from municipal sources and the desire to adapt them to direct firing of their syngas in IC engines, is hampered by their high tar production rates, as well as other contaminants in the syngas.

Syngas Conversion to Energy

In close-coupled gasifiers, syngas undergoes immediate oxidation in response to the introduction of air into the secondary chamber. The resultant flue gas is used to produce steam in either fire tube or water tube boilers. Fire tube boilers are used for lower capacity gasification units marketed to institutions (schools and hospitals) where minimizing purchase costs and unit size are key. The waste-to-energy industry has experience with fire tube boilers in controlled air modular combustion facilities. These boilers are subject to frequent fouling when exposed to the flue gas associated with waste firing. The steam produced by the existing biomass gasifiers is used to produce power via turbine-generators, or is used for heating or process applications. One (1) vendor offers steam driven piston engines for power production. However, no applications of this system in the United States or Canada are cited [8].

The direct firing of syngas from a biomass gasifier in an IC engine is rare. No examples of commercial facilities in the United States or Canada operating in this mode have been identified. One (1) firm cites a facility in Moissannes, France that fires syngas in a Caterpillar engine [9]. Another firm states that it is developing this capability and predicts near term availability for commercial applications [10]. A biomass pyrolysis system has tested firing syn-oil in a gas turbine [11].

Safety

The direct firing of syngas may pose safety hazards since syngas is hot, combustible, and poisonous gas. Air leaking into the system or syngas leaking out, downstream of the gasifer, could cause unintended oxidation resulting in explosions or fires. In addition, syngas leaking out could cause CO poisoning.

Syngas Cleaning

The syngas produced by biomass gasification can contain one (1) or more of the contaminants listed in Exhibit 1 [12]. The identity and amount of these contaminants depend on the gasification process and the type of biomass feedstock. Syngas cleaning is generally not needed for immediate oxidation or co-firing in boilers. However, cleaning is essential for direct firing in IC engines or gas turbines. Efforts by vendors and research organizations to identify cleaning technologies and reliable system designs for contaminant removal are ongoing [13]. Tars are composed of polynuclear hydrocarbons that can clog engine valves, cause deposition on turbine blades, or fouling of a turbine system. Wet scrubbing systems have been utilized for removal of tar, chlorides, ammonia, and alkaline compounds. However, scrubbing cools the gas and produces a wastewater stream. Removal of tars by catalytically cracking the larger hydrocarbons could reduce or eliminate the wastewater, avoid the loss of thermal energy due to scrubbing, and enhance gas quality and quantity. Incompletely converted biomass and ash particulate removal may be accomplished with cyclones, wet scrubbing, or high temperature filters. A cyclone can provide primary particulate control, but is not adequate to meet gas turbine specifications. A high temperature ceramic filter can avoid thermal energy losses associated with gas cooling and remove particulates [14].

Control of Stack Emissions

The pollutants contained in the stack emissions from gasification and pyrolysis systems are the same as those in combustion systems. The measured levels of emissions are influenced by the thermal conversion technology employed and the nature of the waste being processed. A 2009 report by the University of California at Riverside compiled emissions data from fifteen (15) gasification and pyrolysis facilities [15]. The data was obtained from independent source test reports, compliance reports from regulatory agencies, and peer-reviewed publications. It includes air emissions data for several pollutants from facilities employing a variety of gasification and pyrolysis technologies, and various synfuel utilization approaches. Twelve (12) of the facilities process municipal waste, two (2) process medical waste, one (1) processes circuit boards, and one (1) processes a combination of industrial and municipal waste. Eleven (11) of the sixteen (16) facilities are not in North America. The technologies include fluidized bed, fixed bed, plasma arc, high temperature gasification, and pyrolysis plus gasification. The synfuel utilization approaches include close-coupled combustion, IC engines, and gas turbines. The emissions ranges reported are summarized in Exhibit 2. Also included for comparison are emissions reported from mass burn and controlled air waste-to-energy facilities, all processing municipal waste [16, 17, 18, 19, and 20]. Given the variation in fuel-feedstocks being processed, conclusions regarding comparative emissions would be premature. However, it appears that the emissions from the gasification/pyrolysis, mass burn, and controlled air systems lie within the same ranges, with the exception of low end nitrogen oxides, mercury, and dioxin/furans from gasification/pyrolysis, which are one (1) or more orders of magnitude less than mass burn and controlled air. A closer look at the gasification/pyrolysis emissions seems to indicate that the fluidized bed and plasma arc gasification and pyrolysis systems achieve the very low dioxin/furan emissions, whereas the close-coupled gasification systems emissions lie within the same range as mass burn and controlled air combustion. The lowest dioxin/furan emissions reported are associated with a plasma gasification facility that processed circuit boards.

Due to the variety of gasification technologies, the varying waste types processed, and the relative newness of the technology, there is no industry-standard air pollution control strategy or technology. The air pollution control devices employed by gasification and pyrolysis vendors in existing facilities vary and include electrostatic precipitators and scrubbers alone and in combination, including selective non-catalytic nitrogen oxide control, scrubbers, and baghouses. The control strategy utilized in a proposed project will be dependent upon the wastes to be processed, the thermal processing and energy recovery system, and its projected emissions and requirements imposed by regulators.

Slag and Ash Handling

The slag and ash handling approaches used by various gasification system vendors are dependent upon the reactor design and their objectives regarding the recovery of byproducts. Fixed bed systems generally operate like a combustion facility and capture the slag/ash in solid form. Fluidized bed systems may employ a melting process, wherein liquid slag and ash may be tapped from the bottom of the reactor. Circulating fluidized bed systems must also incorporate a process for separating ash from the heat transfer agent that escapes the reaction chamber. Systems employing plasma arc technology often use the torches to melt the slag and ash. It is expected that these systems, like those in combustion systems, are problematic and require a large amount of ongoing attention from the operator.

Exhibit 1

SYNGAS CONTAMINANTS

Contaminant	Example	Potential Problem
Particles	Ash, char, fluid bed material	Erosion
Alkali Metals	Sodium and Potassium Compounds	Hot corrosion, catalyst poisoning
Nitrogen Compounds	NH_3 and HCN	Emissions
Tars	Refractive aromatics	Clogging of filters
Sulfur, Chlorine	H_2S and HC1	Corrosion, emissions, catalyst poisoning

Exhibit 2

COMPARISON OF EMISSIONS RANGES FROM GASIFICATION/PYROLYSIS, MASS BURN, AND CONTROLLED AIR SYSTEMS

(all units in mg/dscm@7% O_2, except as noted)

Pollutant	Gasification/ Pyrolysis	Mass Burn	Controlled Air
Particulate	<1.0 - 18.2	0.73 - 9.84	4.93 - 20.13
Hydrogen Chloride	<2.8 - 55.8	3.2 - 15.8	30.3 - 38.7
Nitrogen Oxide	10 - 254	172 - 180	200 - 206
Sulfur Dioxide	0.44 – 51.9	1.0 - 16.0	NR
Mercury	0.0001 - <0.007	0.001 - 0.007	0.0052 - 0.014
Dioxin/Furan (ng/dscm)	0.000013-0.098	0.01 - 0.04	0.072 - 0.11

The biomass gasification industry does not focus on the quantity of slag/ash generated by their systems as a percent of biomass input, or the pollutants contained therein. This probably owes to the fact that their focus is in converting harvested biomass to fuel, rather than on destroying harmful waste and minimizing the volume to be disposed. Additionally, the slag from gasification of pure biomass will be high in carbon and low in impurities, making it useful as a soil additive.

SURVEY OF EXISTING BIOMASS GASIFICATION SYSTEMS

A list of companies with operating biomass gasification and pyrolysis systems in the United States or Canada, their existing facilities, and pertinent characteristics, identified as of January 2010, is provided on Exhibit 3. The list is not complete in that there are numerous pilot scale and demonstration facilities in existence. In addition, companies offering these technologies that do not have facilities processing biomass in the United States or Canada are not listed. Facilities processing mixed refuse are also not listed. However, the Exhibit provides a sense of the large number of firms active, as is characteristic of a start-up industry. Information is presented below regarding four (4) firms that have developed biomass gasification and pyrolysis facilities, as gathered from company websites and obtained during the course of the author's project assignments for clients. Exhibit 4 summarizes the primary design characteristics and existing installations for these firms.

Ensyn

Process – Ensyn, is a United States company that has developed a fast pyrolysis technology based upon a transported bed reactor that utilizes biomass to produce a liquid pyrolysis oil [21]. The system (Figure 2) is called the Rapid Thermal Process or RTP. RTP pyrolysis technology is claimed to convert biomass to liquid in under two (2) seconds. Hot sand is used as a heat transfer medium for the feedstock fed into the reactor, wherein it is heated to 500 degrees Celsius. The company describes it as a "tornado of hot sand." After the vessel reaches the desired temperature, it is cooled within seconds. This process results in bio-oil, and the process has a yield of approximately sixty (60) to eighty (80) percent, by weight, depending upon the biomass feedstock. Along with bio-oil, by-product char and non-condensable gas are produced during the process. Both can be used to provide process energy. Biomass must be pre-dried to five (5) – six (6) percent moisture and a particle size of 0.125 – 0.25 inches. This energy can be used in the RTP process or in pre-stages of the process through use in a dryer which prepares bio-mass for the RTP process. The company's pyrolysis oil meets ASTM standards for biofuels used in industrial burners. The company does not provide details on the mode in which its pyrolysis oil is fired. However, the information provided indicates that it has experience in firing in industrial boilers, and development of gas turbine power generation is underway. In 2008, Ensyn teamed with UOP, a subsidiary of Honeywell, Inc. to form Envergent Technologies, LLC. Envergent will further develop and market the technology.

Existing Facilities – Ensyn claims that its RTP technology is the only pyrolysis technology to be proven through long-term commercial operation. Ensyn currently claims eight (8) commercial RTP plants in the United States and Canada; and have achieved over ninety (90) percent availability. The largest of these resides in Renfrew, Ontario. This plant's capacity is 100 tons of dry residual wood per day. The company has plans to scale-up the system's processing capacity in future projects.

Scope of Supply – Envergent offers to undertake a twenty (20) to twenty-seven (27) month project development process, leading to initiation of construction. Details regarding the schedule for construction and testing are not provided. Ensyn states it designed, built, and commissioned all eight (8) commercial RTP plants.

Nexterra

Feedstock – Current systems operate on wood fuel; however, future systems are being developed that will be capable of operating on coal and other low cost fuels [22].

Gasification Process – Nexterra utilizes a fixed-bed, updraft gasifier (Figure 3). Feedstock must be shredded to three (3) square inches or less and then fed into the center of the dome-shaped refractory lined gasifier. The system's fixed bed design allows it to gasify feedstocks at six (6) to sixty (60) percent moisture. Partial oxidation, pyrolysis, and gasification occur after combustion air, steam, and/or oxygen are introduced into the gasifier. The gasifier heats to 1,500 – 1,800 degrees Fahrenheit and the feedstock is converted to syngas, along with some non-combustible ash. An in-floor ash grate removes the ash from the bottom of the gasifier. The syngas is then processed according to the customer's needs in order to produce energy. According to information provided by company representatives, and in a recent submission to a county agency, Nexterra's product development effort is aiming toward progressively higher value applications for its system, including direct firing in IC engines and gas turbines and production of synthesis fuels and chemicals. At the present time, the system is operated in a close-coupled mode.

Exhibit 3

OVERVIEW OF GASIFICATION VENDORS

Firms	Existing Facilities
Alter NRG	Madison, Pennsylvania
BRI Energy	Fayetville, Arkansas.
Ensyn	Renfrew, Ontario plus seven commercial plants in the United States and Canada (unspecified locations).
Horizon Energy	Westbury, Ontario
Integrated Environmental Technologies	In Midland, MI – Development at Dow, Corning; Richland – Demonstration/testing.
International Environmental Solutions	Romoland, California.
IST Energy	Waltham, Massachusetts – Demonstration.
MaxWest Environmental Systems	Sanford, Florida. Carterville, Illinois, Northfield, Minnesota. Kingsey, Canada. Wardensville, West Virginia. Southern British Columbia. Alberta, Canada Belowna, British Columbia.
Nexterra	University of South Carolina. Tolko Heffley, British Columbia. Vancouver, British Columbia. Westminster, British Columbia.
Primenergy	Jonesboro, Arkansas. Stuttgart, Arkansas. Little Falls, Minnesota.
Alternative Energy Solutions	Wichita, Kansas.
Chiptec Wood Energy	175 installations.
Frontline Bioenergy	Benson, MN.
Community Power Corporation	Winters, California.
Thermogenics	Albuquerque, New Mexico.
PRMEnergy	Producer's Rice (location not disclosed). Archer Daniels (location not disclosed). Cargill (location not disclosed). Riceland Foods (location not disclosed).

Service: (Peterson and Haase); various company websites.

Exhibit 4

EXISTING GASIFICATION INSTALLATIONS FOR FOUR VENDORS

Firms	Technology	Commercial Facility Locations	Biomass Experience	Start-Up Date	Syngas Conversion To Energy
Ensyn	P	Renfrew, Ontario.	Residual wood from Ottawa Valley forestry industries converted to bio-oil.	2007	Fuel oil replacement
Nexterra	FBUD	Columbia, South Carolina – University of South Carolina. Victoria, British Columbia. New Westminister, British Columbia. Prince George, British Columbia. Heffley Creek near Kamloops, British Columbia.	Wood chips/residue. Wood residue. Wood residue. Local mills. Clean construction debris. Wood residue.	Q4 2007 May 2009	CC/B CC/B CC/B CC/B CC/B
MasWest	FBDD	Sanford, Florida. Kingsey Canada. Wardensville, West Virginia. Southern British Columbia. Kelowna, British Columbia. Carterville, Illinois.	Dried biosolids (sludge). Paper biosolids. Chicken litter. Cow manure. Waste wood. Multiple feedstocks.	7 months	Thermal energy via a hot oil system. Chicken coop Heating. CC/B. CC/B. CC/B.
PRM Energy	FBUD	Northfield, Minnesota. Stuttgart, Arkansas – Four Installations. Tulsa, Oklahoma Archer Daniels – Midland. Greenville, Mississippi. Joneboro, Arkansas. Little Falls, Minnesota.	Turkey litter. Rice hulls. All biomass fuel types. Cotton gin waste. Rice husks. Rice husks and straw. Wood.	1982 – 1996 1996. 1985. 1995. 1996. 2006.	Hot oil passed through turbine. CC/B. CC/B and DF. CC/B. CC/B. CC/B. CC/B.

Notes:

Technology:

P – Pyrolysis
FBDD – Fixed Bed Downdraft
FBUD – Fixed Bed Updraft
CC – Close-Coupled
FB – Fluidized Bed

Figure 2 – Ensyn Pyrolysis System (Ensyn Website)

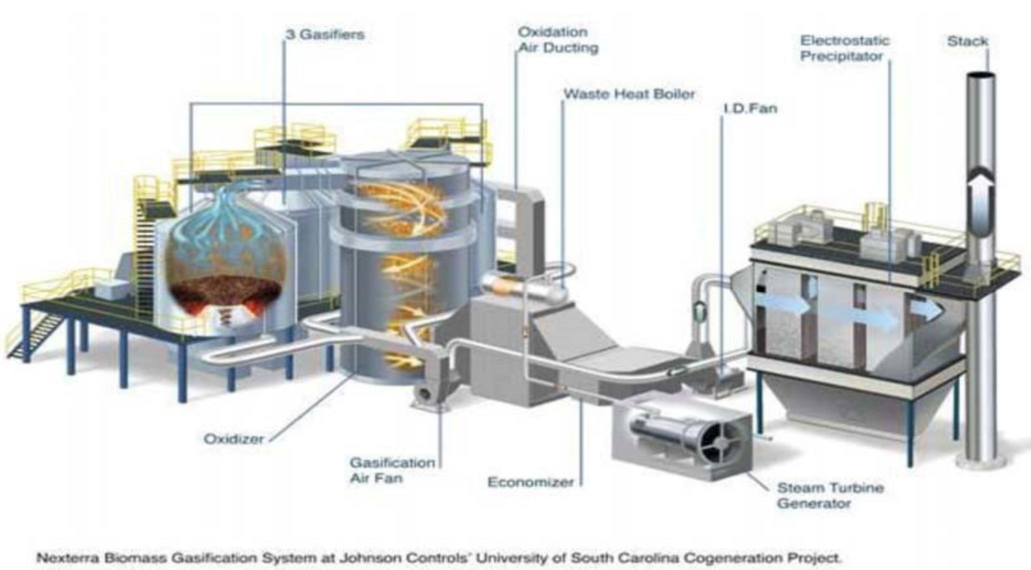

Figure 3 – Nexterra Biomass Gasification System at Johnson Controls' University of South Carolina Cogenation Project (Nexterra Website)

Existing Facilities – The company has five (5) operating facilities, a product development and test plant facility is located in Kamloops, BC; an installation at Tolko Industries in Kamloops, BC; and commercial facilities at the University of South Carolina; Kruger Paper, Westminster, BC; and Dockside Green in Vancouver, BC. The company has contracts or has been selected to construct additional facilities at the Oakridge National Laboratory, Tennessee, the University of Northern British Columbia, and Stamford, Connecticut. Dockside Green is a residential and commercial development in downtown Vancouver.

MaxWest

According to the company, the MaxWest system has been demonstrated to process biosolids and agricultural wastes, including manures and solid wastes [23]. The system is composed of five (5) components (Figure 4).

Waste Handling System – The waste handling system is designed to deliver waste to the gasifier at the correct moisture level. Typically, waste is delivered to the gasifier at fifty (50) percent moisture or lower.

Drying System – If the waste is not below fifty (50) percent moisture level, the drying system will dry it or combine it with other dryer waste to reach the desired moisture level.

Gasifier – The gasifier is a fixed bed, downdraft design (Coaltec website). Gasification units can be purchased in one (1), two (2), or three (3) cell models. These models can handle up to thirty (30) mmBtu/Hour. Feedstocks with particle size up to 1.5 cm (six (6) in) can be processed. Gasification takes place in a refractory lined, primary gasification chamber. Company representatives describe the output as a hot fuel gas and not a syngas. The fuel gas is combusted in a close-coupled, oxidation/ temperature control chamber, called the thermal oxidizer.

Thermal Oxidizer – The thermal oxidizer receives fuel gas from the gasifier and through the introduction of air, converts it into useable energy.

Energy Recovery and Power Generation System – The flue gas is utilized to create steam which can be used for heating or process application or directed through a turbine generator to produce electricity. The company is associated with Coaltec, Inc. Coaltec, Inc. operates the Carterville, Illinois test facility. Both companies have indicated that they do not intend to develop the capability to clean the fuel gas for direct firing applications.

Existing Facilities – The MaxWest technology is based upon a system developed by Westwood Fibre in Kamloops, British Columbia. The company presently has operating facilities in Sanford, Florida; Wardensville, West Virginia; southern British Columbia; and Carterville, Illinois. Facilities under construction include Northfield, Minnesota; Kingsey, Quebec; Alberta; and Kelowna, British Columbia. The Sanford, Florida facility uses the thermal energy in a hot oil system in order to dry Sanford's wastewater treatment plant sludge. Its operating size is seven (7) mmBtu/Hour and its feedstock is dried biosolids.

PRM

The PRM gasifier is a fixed bed, updraft design [24] (Figure 5). It was originally developed to process hulls produced in rice processing. The company has several operating facilities throughout the world gasifying rice hulls. They report to have also processed tree waste, saw dust and wood chip fines, biosolids, and refuse derived fuel. They have nine (9) operating facilities in the United States, with the earliest dating to 1982. The facilities primarily operate in the close-coupled mode. However, the company states that it can offer the following configurations and applications:

1. PRME Waste Gasification Fired IC Engine/Generator Systems – The combustible syngas produced from the waste is conditioned and cooled for firing IC Engines. For this application, the waste feed stock to be gasified must contain a minimum calorific value of 14.3MJ/kg (6,160 btu/lb) at a maximum moisture content of twenty (20) percent and maximum particle size of 8mm (0.3 in), delivered to the PRME Gasifier. This application is incorporated into a test/demo facility in Moissannes, France, owned by ENERIA, the Caterpillar distributor for France, Poland, Romania, Algeria, and Belgium. The application is fully supported by Caterpillar USA.

2. PRME Waste Gasification Steam Cycle Systems – The combustible syngas produced from the waste is fully combusted and fired directly into a Heat Recovery Steam Generator ("HRSG") to raise steam for a steam turbine/generator or for process steam. For this application, the waste feed stock must contain a minimum calorific value of 11.0MJ/kg (4,739 btu/lb) at a maximum moisture content of forty (40) percent and maximum particle size of 8mm, delivered to the PRME Gasifier. This application is incorporated into PRME facilities in the United States and Asia.

Figure 4 – MaxWest System
(MaxWest Website)

Figure 5 – PRM Energy System
(PRM Website)

3. PRME Waste Gasification Direct Firing Systems – The combustible syngas produced from the waste is fully combusted and fired directly into a dryer, kiln, furnace, thermal oxidizer, or into a heat exchanger to reduce the temperature of the products of combustion for drying/thermal applications. Feed stock requirements are the same as item #2 above. This application is incorporated into PRME facilities in the United States, Asia, Latin America, and United Kingdom.

4. PRME Waste Gasification for Co-Firing Utility Boilers – The combustible syngas produced from the waste is co-fired into a large pulverized coal fired utility boiler. See Co-Fire flyer. The PRME Co-Firing Technology is almost the same as firing an industrial boiler.

5. PRME Waste Gasification for conversion to liquid fuels – The combustible syngas produced from the waste is conditioned and cooled for processing into liquid fuels.

System Construction and Operations Costs

The estimation of construction and operation costs for biomass gasification and pyrolysis systems encounters difficulties in several respects, as described below.

- Many of the existing projects are privately owned by processing industries, who are reluctant to publicize their operating costs due to concerns regarding sharing information with their competition.

- Reports containing cost information do not specify the scope of the projects covered.

- Costs may be provided as dollars per million BTU output by the system, rather than daily tons of biomass processed. It is typically not specified whether system output is rated capacity or actual operations.

- Some cost quotations available to the author have been provided on a confidential basis.

Therefore, cost estimates for existing projects as presented below must be viewed as “ballpark” values providing a general idea of the cost of these systems.

Construction costs are presented in Exhibit 5 for three (3) gasification facilities. The three (3) are all-in capital costs, in that they are obtained from facilities that are operating or did operate. They include the wood chip gasification facility at the University of South Carolina, using the Nexterra system; a wood chip gasification facility at Middlebury College, Vermont, using the Chiptec system; and a circulating fluidized bed gasifier in Burlington, Vermont, using the FERCO system, that has ceased operations. The University of South Carolina and Middlebury College [25] applications supply steam and power to the campuses. The Burlington, Vermont system was co-located at a wood fired combustion power plant. The Exhibit provides the capital costs, the date of construction, and the cost per daily ton of biomass (wood) throughput. The throughput estimates assume 365 day per year operations. Since the colleges may operate under reduced load in the summer, this may understate the throughputs during peak operating periods and thus overstate the cost per daily ton of capacity.

Project Development and Operations Capabilities of the Vendors

The project development and operations capabilities of system vendors is determined by their organizational, financial, and management competence, in addition to the soundness of their technology. As indicated in Exhibit 3 above, there are many firms offering biomass gasification and pyrolysis systems at this time. Several of the firms have been active in offering proposals to the public sector. One (1) project, in Sanford, Florida, has been constructed for the public sector. As proposed, public sector projects advance, the heightened scrutiny of their proposals by engineers, attorneys, regulators, financial underwriters, and the public during the proposal review, contract negotiation, permitting, financing phases, construction, and acceptance testing phases will separate firms that have the capability to develop viable projects from those that do not.

CONCLUSIONS

The research thus far has indicated that, at present, the preferred configuration can be attained with regard to some of the criteria and may be attainable with regard to the others, as is discussed below.

Flexibility to process each of the biomass wastes generated on a seasonal and non-seasonal basis over the course of the year, with their varying fuel characteristics – Several of the vendors indicate that they have produced synfuel or pyrolysis oil from yard waste and wood. The fuel characteristics of these wastes are similar to the wood chips that are most typically processed in existing systems. Particle size would have to be controlled by preprocessing.

A facility footprint that would enable development at existing biomass waste transfer stations – The modular design of the existing systems is aimed at matching unit size to the amount of biomass to be processed and achieving a small footprint for industrial and institutional applications.

Low profile building envelope – Certain vendor gasifier designs utilize a vertically oriented reaction chamber. In addition, close-coupled systems that incorporate a boiler and air pollution control equipment, such as electrostatic precipitators, scrubbers, and baghouses will require higher building envelopes. However, certain modular close-couple systems package the feed system, gasifier, and boiler in a low profile design.

Exhibit 5

CAPITAL COSTS FOR BIOMASS GASIFICATION FACILITIES

Facility/Technology Vendor	Gasification Design	Capital Cost	Year Of Construction	Daily Biomass Throughput	Capital Cost Per Daily Ton	Debt Service Per Ton(1)
University of South Carolina/Nexterra	Fixed Bed-Updraft	$20M	2006 – 2007	155	$129,032	$28.37
Middlebury College/Chiptec	Fixed Bed-Updraft	$12M	2007 – 2008	55	$218,182	$47.97
Burlington, Vermont/FERCO	Circulating Fluidized Bed	$52M	1996 – 1998	200	$260,000	$57.16

Convert syngas to power via direct firing in internal combustion engines or gas turbines for sale to the grid – It is questionable whether this can be achieved presently. Apparent concerted efforts by several vendors may attain this goal in the next few years.

Favorable reception by regulatory agencies – The Sanford, Florida, MaxWest biosolids gasifier provides an example of the successful permitting of a municipal gasification system. Efforts underway to develop systems for municipal waste may provide additional success stories.

Cost competitive with current management strategies – Further analysis is necessary. The capital cost information in Exhibit 5 indicates that the debt service burden is not excessive; and that reasonably estimated operating costs and energy revenues could result in net operating costs in the $50 to $75 per ton range.

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ENGINEERING REPORT
MDGS ENERGY-from-WASTE TECHNOLOGY
as found in INEZ, KENTUCKY, USA

Appendix 2

Wikipedia article on Rotary Kilns

WIKIPEDIA

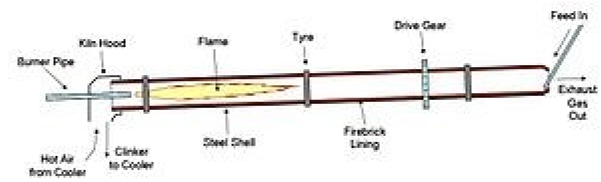
Rotary kiln

A **rotary kiln** is a pyroprocessing device used to raise materials to a high temperature (calcination) in a continuous process. Materials produced using rotary kilns include:

Rotary kiln (rust colored horizontal tube at right) at a Wyoming cement plant

- Cement
- Lime
- Refractories
- Metakaolin
- Titanium dioxide
- Alumina
- Vermiculite
- Iron ore pellets

They are also used for roasting a wide variety of sulfide ores prior to metal extraction.



General layout of a direct fired countercurrent rotary kiln used in cement manufacture

Principle of operation

The kiln is a cylindrical vessel, inclined slightly to the horizontal, which is rotated slowly about its axis. The material to be processed is fed into the upper end of the cylinder. As the kiln rotates, material gradually moves down towards the lower end, and may undergo a certain amount of stirring and mixing. Hot gases pass along the kiln, sometimes in the same direction as the process material (co-current), but usually in the opposite direction (counter-current). The hot gases may be generated in an external furnace, or may be generated by a flame inside the kiln. Such a flame is projected from a burner-pipe (or "firing pipe") which acts like a large bunsen burner. The fuel for this may be gas, oil, pulverized petroleum coke or pulverized coal.

Rotary kiln body, with drive gear and 2 tyres (riding rings)

Construction

The basic components of a rotary kiln are the shell, the refractory lining, support tyres (riding rings) and rollers, drive gear and internal heat exchangers.

History

The rotary kiln was invented in 1873 by the Englishman Frederick Ransome.[1]

Kiln shell

This is made from rolled mild steel plate, usually between 15 and 30 mm thick, welded to form a cylinder which may be up to 230 m in length and up to 6 m in diameter. This will be usually situated on an east–west axis to prevent eddy currents.

Upper limits on diameter are set by the tendency of the shell to deform under its own weight to an oval cross section, with consequent flexure during rotation. Length is not necessarily limited, but it becomes difficult to cope with changes in length on heating and cooling (typically around 0.1 to 0.5% of the length) if the kiln is very long.

Refractory lining

The purpose of the refractory lining is to insulate the steel shell from the high temperatures inside the kiln, and to protect it from the corrosive properties of the process material. It may consist of refractory bricks or cast refractory concrete, or may be absent in zones of the kiln that are below around 250 °C. The refractory selected depends upon the temperature inside the kiln and the chemical nature of the material being processed. In some processes, such as cement, the refractory life is prolonged by maintaining a coating of the processed material on the refractory surface. The thickness of the lining is generally in the range 80 to 300 mm. A typical refractory will be capable of maintaining a temperature drop of 1000 °C or more between its hot and cold faces. The shell temperature needs to be maintained below around 350 °C in order to protect the steel from damage, and continuous infrared scanners are used to give early warning of "hot-spots" indicative of refractory failure.

Tyres and rollers

Kiln tyre closeup showing typical chair arrangement

Tyres, sometimes called riding rings, usually consist of a single annular steel casting, machined to a smooth cylindrical surface, which attach loosely to the kiln shell through a variety of "chair" arrangements. These require some ingenuity of design, since the tyre must fit the shell snugly, but also allow thermal movement. The tyre rides on pairs of steel rollers, also machined to a smooth cylindrical surface, and set about half a kiln-diameter apart. The rollers must support the kiln, and allow rotation that is as nearly frictionless as possible. A well-engineered kiln, when the power is cut off, will swing pendulum-like many times before coming to rest. The mass of a typical 6 x 60 m kiln, including refractories and feed, is around 1100 tonnes, and would be carried on three tyres and sets of rollers, spaced along the length of the kiln. The longest kilns may have 8 sets of rollers, while very short kilns may have only two. Kilns usually rotate at 0.5 to 2 rpm, but sometimes as fast as 5 rpm. The Kilns of most modern cement plants are running at 4 to 5 rpm. The bearings of the rollers must be capable of withstanding the large static and live loads involved, and must be carefully protected from the heat of the kiln and the ingress of dust. In addition to support rollers, there are usually upper and lower "retaining (or thrust) rollers" bearing against the side of tyres, that prevent the kiln from slipping off the support rollers. Now rotary kiln length is 84 meters.

Drive gear

The kiln is usually turned by means of a single Girth Gear surrounding a cooler part of the kiln tube, but sometimes it is turned by driven rollers. The gear is connected through a gear train to a variable-speed electric motor. This must have high starting torque in order to start the kiln with a large eccentric load. A 6 x 60 m kiln requires around 800 kW to turn at 3 rpm. The speed of material flow through the kiln is proportional to rotation speed, and so a variable speed drive is needed in order to control this. When driving through rollers, hydraulic drives may be used. These have the advantage of developing extremely high torque. In many processes, it is dangerous to allow a hot kiln to stand still if the drive power fails. Temperature differences between the top and bottom of the kiln may cause the kiln to warp, and refractory is damaged. It is therefore normal to provide an auxiliary drive for use during power cuts. This may be a small electric motor with an independent power supply, or a diesel engine. This turns the kiln very slowly, but enough to prevent damage.

Internal heat exchangers

Heat exchange in a rotary kiln may be by conduction, convection and radiation, in descending order of efficiency. In low-temperature processes, and in the cooler parts of long kilns lacking preheaters, the kiln is often furnished with internal heat exchangers to encourage heat exchange between the gas and the feed. These may consist of scoops or "lifters" that cascade the feed through the gas stream, or may be metallic inserts that heat up in the upper part of the kiln, and impart the heat to the feed as they dip below the feed surface as the kiln rotates. The latter are favoured where lifters would cause excessive dust pick-up. The most common heat exchanger consists of chains hanging in curtains across the gas stream.

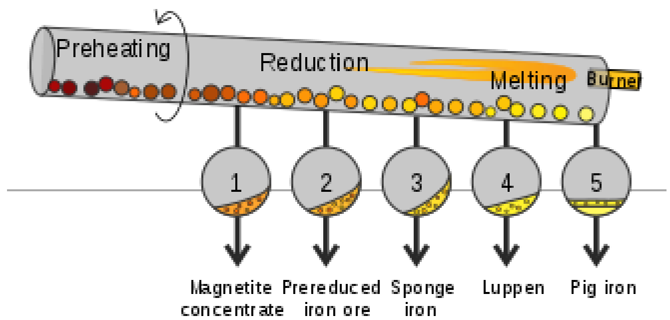
Other equipment

The kiln connects with a material exit hood at the lower end and to ducts for waste gases. This requires gas-tight seals at either end of the kiln. The exhaust gas may go to waste, or may enter a preheater which further exchanges heat with the entering feed. The gases must be drawn through the kiln, and the preheater if fitted, by a fan situated at the exhaust end. In preheater installations which may have a high pressure-drop, a lot of fan power may be needed, and the fan is often the largest drive in the kiln system. Exhaust gases contain dust and there may be undesirable constituents such as sulfur dioxide or hydrogen chloride. Equipment is installed to scrub these out before the exhaust gases pass to atmosphere.

Differences according to the process

Kilns used for DRI production

Direct reduction processes based on a rotary kiln[2]



	1	2	3a	3b	4	5
Consistancy of kiln discharge	solid				semiliquid	sol. (clinker) liq. (pig iron)
Preferred iron content of ore (% Fe)	30-60		30-60	55-63	25-45	50-67
Size of ore feed (mm)	< 20	< 20	< 10	5-25[3]	< 5	< 0.2
Influence of basicity of charge (CaO/Al_2O_3)	no influence				0.3	2.8-3.0
Maximal temperature of charge (°C)	600-900	900-1100			1200-1300	1400-1500
Oxygen removal (% O_2 extracted from Fe_2O_3)	12 %	20-70	>90			100
Examples of processes	Lurgi	Highveld Udy Larco Elkem	RN	SL/RN Krupp	Krupp-Renn	Basset

See also

- List of ovens

References

1. *The Michigan Technic* (https://books.google.com/books?id=-EriAAAAMAAJ&pg=RA3-PA45). UM Libraries. 1900. pp. 3–.
2. Grzella, Jörg; Sturm, Peter; Krüger, Joachim; Reuter, Markus A.; Kögler, Carina; Probst, Thomas (2005). "Metallurgical Furnaces" (http://web.vscht.cz/~vun/Metallurgical%20Furnaces.pdf) (PDF). John Wiley & Sons. p. 7.
3. For ilmenite and ferrous sands : size between 0.05 and 0.5 mm.

Sources and further reading

- R H Perry, C H Chilton, C W Green (Ed), *Perry's Chemical Engineers' Handbook (7th Ed)*, McGraw-Hill (1997), sections 12.56-12.60, 23.60, ISBN 978-0-07-049841-9
- K E Peray, *The Rotary Cement Kiln*, CHS Press (1998), ISBN 978-0-8206-0367-4
- Boateng, Akwasi, *Rotary kilns : transport phenomena and transport processes*. Amsterdam ; Boston : Elsevier/Butterworth-Heinemann (2008), ISBN 978-0-7506-7877-3

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Appendix 3

US Energy Information Agency Article; “Biomass Explained”

Biomass *Explained*

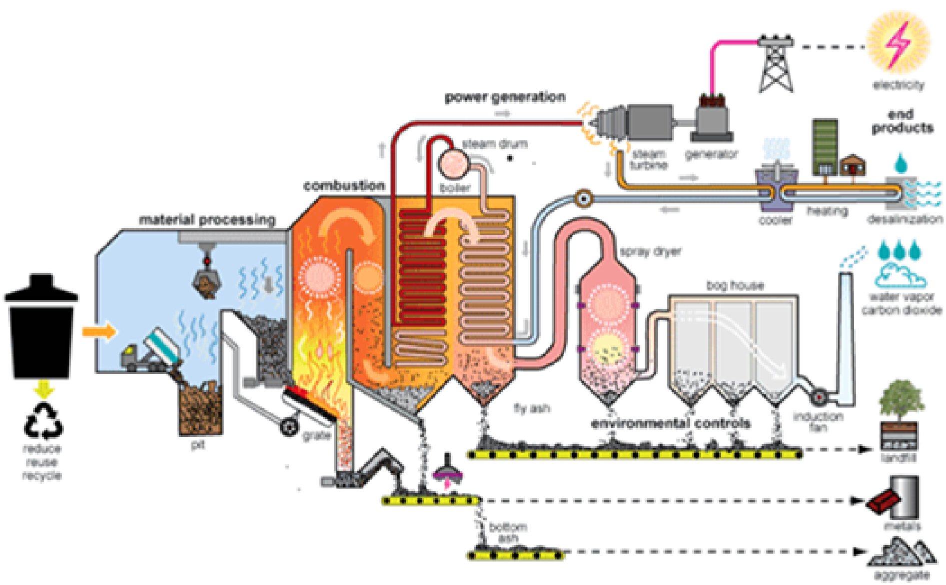
Waste-to-Energy (Municipal Solid Waste) – In Depth

How waste-to-energy plants work

Waste-to-energy plants burn municipal solid waste (MSW), often called garbage or trash, to produce steam in a boiler that is used to generate electricity.

There are different types of waste-to-energy systems or technologies. The most common type used in the United States is the mass-burn system, where unprocessed MSW is burned in a large incinerator with a boiler and a generator for producing electricity (see illustration below). Another, less common type of system processes MSW into fuel pellets that can be used in smaller power plants.

A mass burn waste-to-energy plant



Source: Adapted with permission from Deltaway Energy

The process of generating electricity in a mass-burn waste-to-energy plant has seven stages:

- Waste is dumped from garbage trucks into a large pit.
- A giant claw on a crane grabs waste and dumps it in a combustion chamber.
- The waste (fuel) is burned, releasing heat.
- The heat turns water into steam in a boiler.
- The high-pressure steam turns the blades of a turbine generator to produce electricity.
- An air pollution control system removes pollutants from the combustion gas before it is released through a smoke stack.
- Ash is collected from the boiler and the air pollution control system.

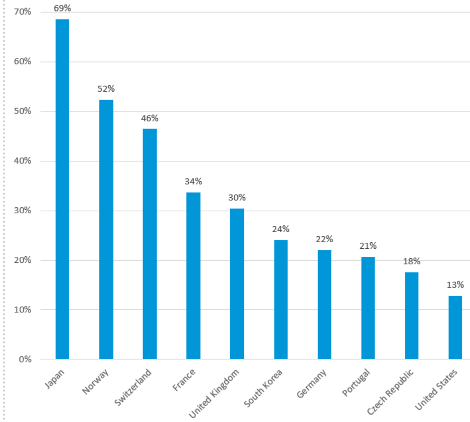
Think of municipal solid waste as a mixture of energy-rich fuels. For every 100 pounds of MSW in the United States, more than 85 pounds can be burned as fuel to generate electricity. Those fuels include paper, plastics, and yard waste. In 2016, one ton of MSW burned in waste-to-energy plants in the United States generated about 474 kilowatthours (kWh) of electricity, the amount of electricity used by about 16 U.S. households in one day.

In a waste-to-energy plant, 2,000 pounds (one ton) of garbage is reduced to 300 pounds–600 pounds of ash.

Trash burned around the world

Many countries use waste-to-energy plants to capture the energy in waste. The use of waste-to-energy plants in some European countries and Japan is relatively high, in part because those countries have little open space for landfills, and they have few energy resources.

Percent of total municipal solid waste that is burned with energy recovery in selected countries



Note: Data for Japan, Portugal, South Korea, and the United States are for 2014. Data for other countries are for 2015.
Source: Organization for Economic Cooperation and Development, November 2017

Learn More

- Sustainable materials management — https://www.epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures
- OECD data - See Environment, Waste, Municipal waste - Generation and Treatment, Incineration with energy recovery — http://stats.oecd.org/#
- Articles on waste-to-energy — /todayinenergy/index.php?tg=waste-to-energy

Independent Statistics & Analysis
U.S. Energy Information Administration

Last Updated: January 24, 2018

https://www.eia.gov/energyexplained/index.cfm?page=biomass_waste_to_energy

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Appendix 4

Preliminary Boiler Performance & Layout

CUSTOMER SPEC SHEET

Customer: Date: 10/14/2009
Reference: HRSG with Furnace Quote #:

Performance Data:		
Steam Output, superheated	220000	(lbs/h)
Fuel/Firing Conditions -		
Fuel Type	Syngas	
Excess Air	25	(%)
Flue Gas Recirc.	0	(%)
Steam/Water Conditions -		
Steam Temp. @ NRV Outlet	750	(F)
Steam Press.@ NRV Outlet	750	(psig)
Boiler Saturation Temp.	525	(F)
Boiler Drum Press.	830	(psig)
ECON. Water Outlet Temp	268	(F)
Feedwater Inlet Temp	225	(F)
Flow Quantities -		
Percent Blowdown	1	(%)
Blowdown Flow	2173	(lbs/hr)
Feedwater Flow	217342	(lbs/hr)
Fuel Flow	183340	(lbs/h/lb)
Combustion Air Flow	43521	(lbs/h/lb)
Flue Gas LVG System	226861	(lbs/h/lb)
Air/Gas Temperatures -		
Air Temp. Enter Boiler	77	(F)
Flame Temp w/ Recirc.	4229	(F)
Furnace Exit Gas Temp.	2639	(F)
Superheater Gas Inlet Temp.	1807	(F)
Superheater Gas Outlet Temp.	1164	(F)
Boiler Exit Gas Temp.	616	(F)
Gas Temp. LVG Economizer #1	458	(F)
System Efficiency -		
Dry Gas Losses	19.41	(%)
Water From Fuel Fired	10.09	(%)
Moisture in Air Losses	0.11	(%)
Radiation Loss	1	(%)
Manufactures Margin	1	(%)
Total Heat Losses	31.6	(%)
Credit of Sensible Heat in Fuel	184.46	(%)
Boiler Efficiency	252.85	(%)
HHV Heat Input By Fuel	102.59	(mmBtu/h)
Sensible Heat in Fuel	1032.1	(Btu/lb_fuel)
	189.23	(mmBtu/h)
Heat Absorbed By Steam	259.39	(mmBtu/h)
System Draft Losses -		
Burner	8	(in.WC)
Screen and Convection Zone	3.36	(in.WC)
Super Heater	0.41	(in.WC)
Economizer #1	0.94	(in.WC)

```
   Total Draft Losses                  12.71       (in.WC)

Furnace Performance-
   Liberation Rate, HHV                50898       (Btu/hr_ft^3)
   Heat Release Rate, LHV              175182.1    (Btu/h_ft^2)
   Heat Absorbed in Furnace            112.594     (mmBtu/hr)

Screen Performance-
   LMTD                                1664        (F)
   Overall U                           12.39       (Btu/ft^2_h_F)
   Heat Transfer                       58.861      (MBtu/hr)

Secondary Superheater Performance-
   Steam Flow                          220000      (lb/hr)
   Steam Outlet Temp                   751         (F)
   Steam Outlet Pressure               760         (psig)
   Tube Side Steam Pressure Drop       28.75       (psi)
   Steam Inlet Temp                    611         (F)
   Overall U                           10.91       (Btu/ft^2_h_F)
   LMTD                                963         (F)
   Heat Transfer,              Total   19.9567     (MBtu/hr)

Desuperheater Performance-
   DSH Location:                       Inlet of 2nd SH
   Water Temp.                         225         (F)
   Water Flow Rate.                    4831        (lb/h)

Primary Superheater Performance-
   Steam Flow                          215169      (lb/hr)
   Steam Outlet Temp                   647         (F)
   Steam Outlet Pressure               780         (psig)
   Tube Side Steam Pressure Drop       29.47       (psi)
   Steam Inlet Temp                    525         (F)
   Overall U                           10.22       (Btu/ft^2_h_F)
   LMTD                                747         (F)
   Heat Transfer,              Total   22.9704     (MBtu/hr)

Convection Zone Performance-
                     Section #1
   Gas outlet Temp                     978         (F)
   Gas Mass Velocity                   4283        (lb/ft^2_hr)
   Overall U                           12.46       (Btu/ft^2_h_F)
   LMTD                                541         (F)
   Heat Transfer                       11.8629     (MBtu/hr)

                     Section #2
   Gas outlet Temp                     616         (F)
   Gas Mass Velocity                   5638        (lb/ft^2_hr)
   Overall U                           12.99       (Btu/ft^2_h_F)
   LMTD                                225         (F)
   Heat Transfer                       22.2537     (MBtu/hr)

Economizer Performance-
   Gas Flow into ECON                  226861      (lb/hr)
   Gas outlet Temp                     458         (F)
   Water Flow                          217342      (lb/hr)
   Operating Pressure                  850         (psig)
```

Water Outlet Temp	268	(F)
Water Inlet Temp	225	(F)
Overall U	12.34	(Btu/ft^2_h_F)
LMTD	279	(F)
Heat Transfer	9.3379	(MBtu/hr)
Tube Side Water Pressure Drop	15.1	(psi)

Fuel and Flue Gas Data:

Fuel Analysis -

Fuel Type	Syngas	(gas)
C		(% wt)
H		(% wt)
O	Confidential	(% wt)
N		(% wt)
S		(% wt)
H2O		(% wt)
ASH		(% wt)
HHV	559.54	(Btu/lb)
LHV	512.03	(Btu/lb)

Flue Gas Analysis -

	% vol	% wt
H2O	6.67	4.02
CO2	15.7	23.11
N2	76.81	71.96
O2	0.82	0.88
SO2	0	0
Total	100	99.96

Molecular Weight of Flue Gas	29.8902	(lb/mole)
Ash in Flue Gas	0	(lb ash/lb flue gas)
Altitude Above Sea Level	500	(ft)
Ambient Temp.	77	(F)
Relative Humidity	70	(%)

Physical Design Data:

Furnace Design Data -

Furnace Volume	6048	(ft^3)
Furnace Effective Area	1608	(ft^2)

Secondary Superheater Design Data -

Total Heat Transfer Area	2111	(ft^2)
Average Gas Flow Area	84	(ft^2)
Tube OD	2	(in)
Tube Wall Thickness(min.)	0.15	(in)
Tube Specification	SB-407	

Primary Superheater Design Data -

Total Heat Transfer Area	3167	(ft^2)
Average Gas Flow Area	84	(ft^2)
Tube OD	2	(in)
Tube Wall Thickness(min.)	0.15	(in)

Tube Specification	SA-213T22	

Convection Zone Design Data -

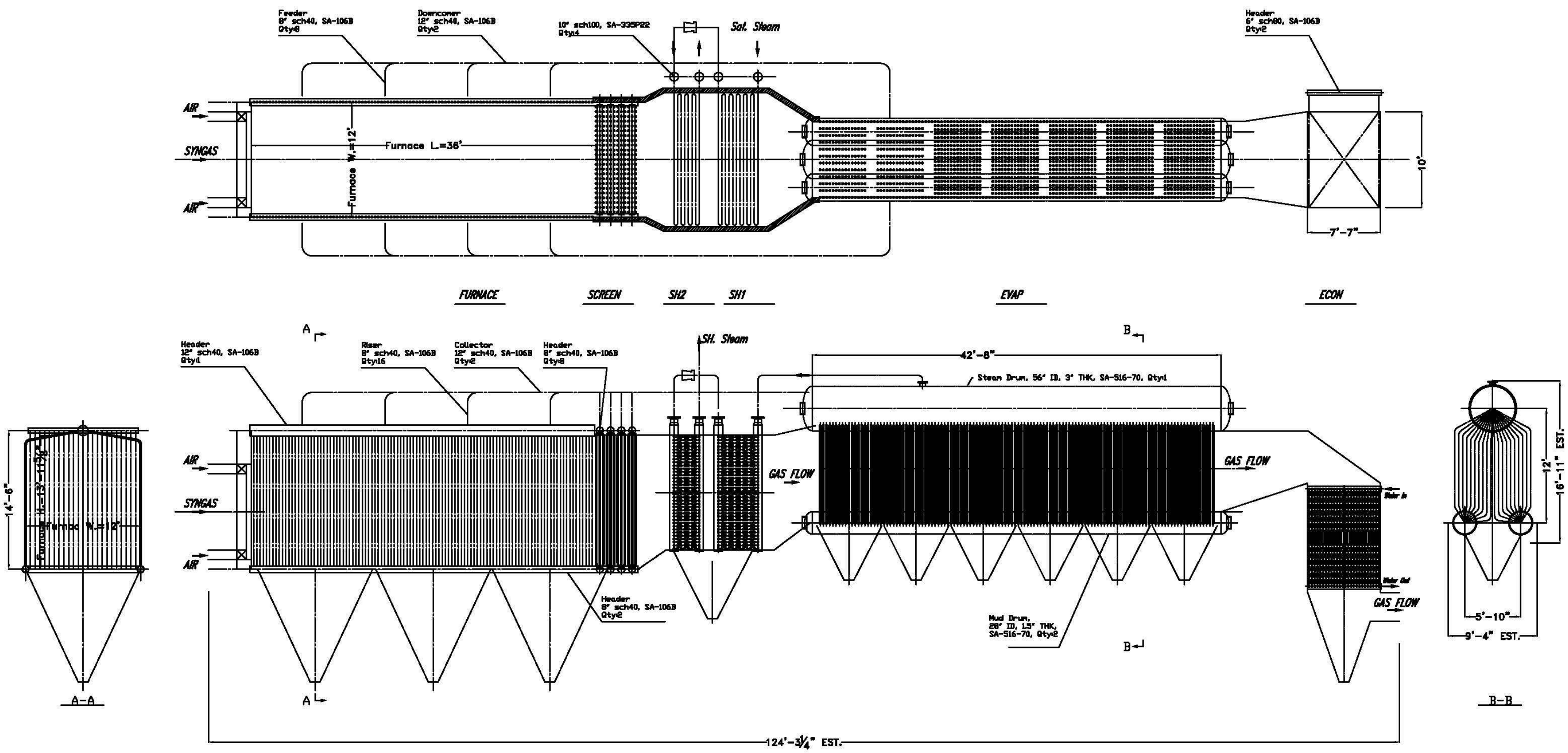
Arrangement of Surface	In-line	
Total Number of Tubes	2076	
Tube MW	0.18	(in)
Tube OD, avg.	2	(in)
Tube Specification	SA-178A	
Total Heat Transfer Area	13124	(ft^2)

Economizers Design Data -

Arrangement of Surface	In-line	
Tube OD	1.5	(in)
Tube MW	0.15	(in)
Tube Specification	SA-178	
Total Heat Transfer Area	2859	(ft^2)
Gas Flow Area	43	(ft^2)

Note:
Design Pressure: 900 psig
Design Temperature: 600 F for HRSG
900 F for SH
500 F for ECON

Corrosion Allowance: 0.0625"



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rev	by	date	chkd	date	description
6					
5					
4					
3					
2					
1					

cust:

title: MSW Syngas Boiler

by	chk'd	appd	scale	dwg. no.	rev.
date	date	date	NONE		

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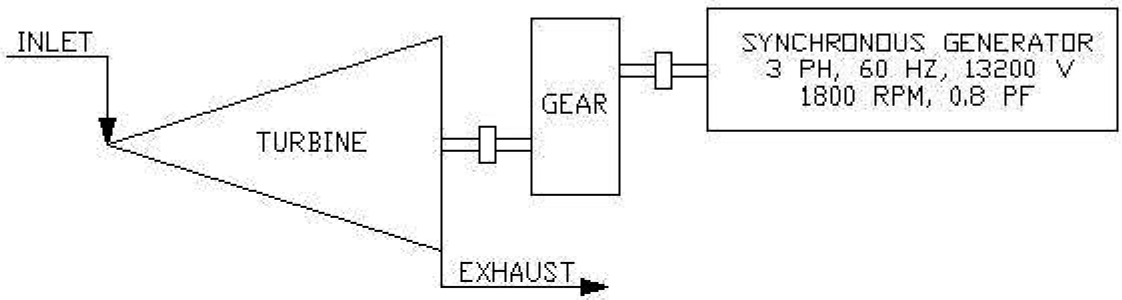
Appendix 5

Preliminary Steam Turbine – Electric Generator Performance

STEAM TURBINE GENERATOR BUDGET PROPOSAL

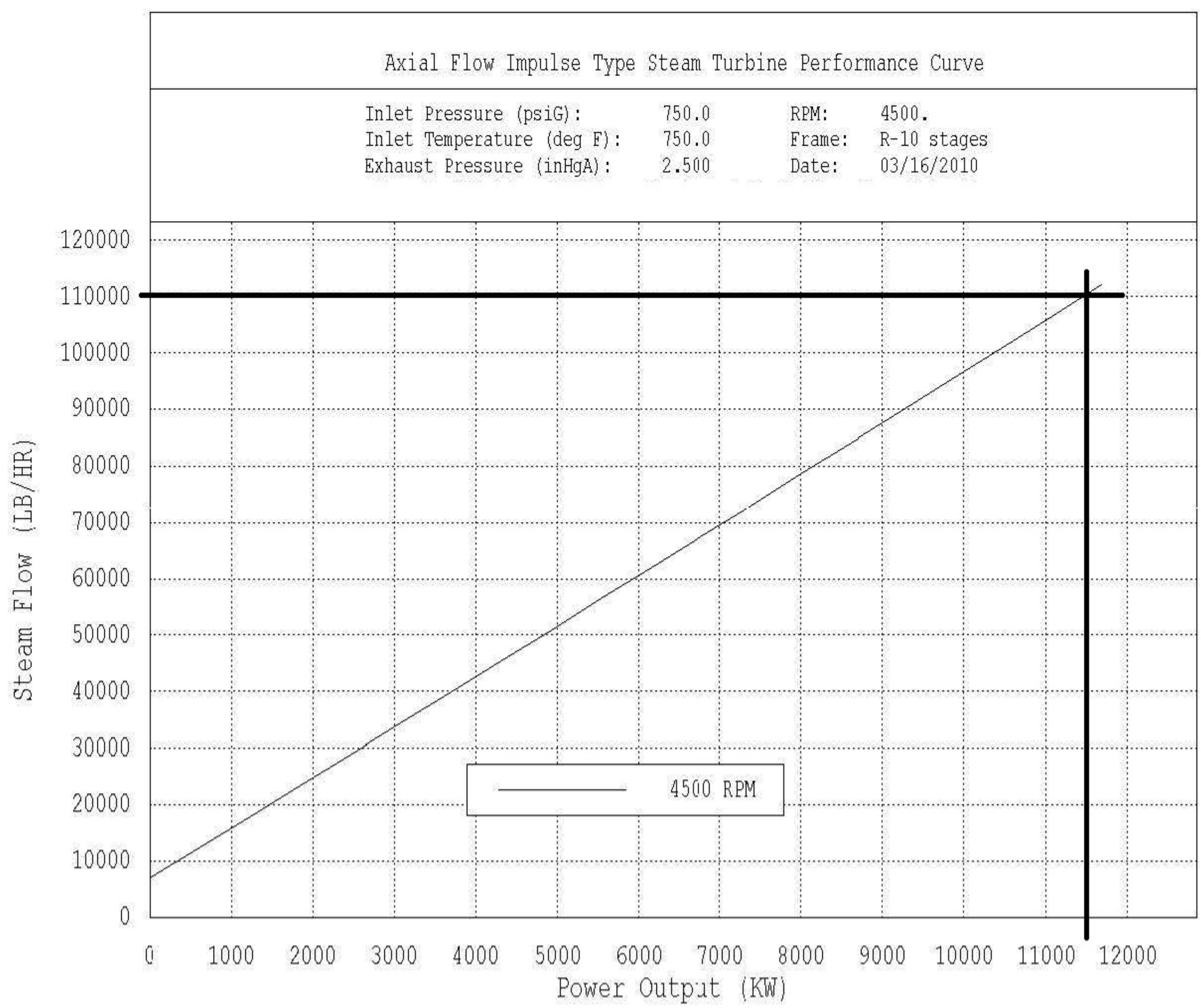
TO: ______ ATTN: ______
EMAIL: ______ DATE: April 7, 2011
SUBJECT: ______
SHEET: 1 of 2 INCLUDING THIS SHEET
SIGNED: ______ D-R REF: T26978 rev1



TURBINE DATA	
SELECTION	E
TURBINE FRAME	R
NUMBER OF STAGES	10
INLET VALVES	MULTIPLE
INLET SIZE/RATING	6"/900# Left or Right
EXTRACTION SIZE/RATING	NONE
BLEED SIZE/RATING	NONE
EXHAUST SIZE/RATING	50" x 92.5" Rect./15# Down
PERFORMANCE DATA	
INLET PRESSURE (PSIG)	750
INLET TEMPERATURE (DEG F	750
EXHAUST PRESSURE (INHGA)	2.5
TURBINE SPEED (RPM)	4,500
INLET FLOW (LB/HR)	110,000
EXHAUST TEMPERATURE (DEG F)	125
EXHAUST ENTHALPY (BTU/LB)	1001
GENERATOR OUTPUT (KW)	11,477
COMMERCIAL DATA	
SHIPMENT (WEEKS)	50
TURBINE-GEN PRICE (USD), 1st Set	
TURBINE-GEN PRICE (USD), Duplicate	

PRICES INCLUDE TURBINE, GEAR, GENERATOR, GENERATOR CONTROLS, BASEPLATE FOR TURBINE/GEAR, SEPARATE SOLEPLATES OF GENERATOR, SEPARATE LUBE SYSTEM, GLAND CONDENSER AND EJECTOR, LABYRINTH GLAND SEALS, FULLY OIL OPERATED SEPARATE COMBINED T&T VALVE, HS & LS COUPLINGS, DG505 GOVERNOR WITH HYDRAULIC ACTUATOR, ELECTRONIC OVERSPEED, STAINLESS STEEL SUPPLY & CARBON STEEL DRAIN MANIFOLD OIL PIPING, DSLC SYNCHRONIZER AND REAL POWER SENSOR, BLANKET INSULATION WITHOUT SHEET METAL LAGGING, GAUGEBOARD & TACHOMETER, TWO RTD'S PER BEARING, TWO VIBRATION PROBES PER BEARING, TWO AXIAL PROBES IN THRUST BEARING, VIBRATION AND TEMPERATURE MONITORING, VACUUM BREAKER, SARCO AUTOMATIC CASING DRAIN PUMP (UP EXHAUST ONLY), SHIPPING FCA BURLINGTON, IA.

PRICE DOES NOT INCLUDE GENERATOR SWITCHGEAR, SURFACE CONDENSER, INTERCONNECTING PIPING BETWEEN TURBINE AND LUBE SYSTEM, OR BETWEEN STEAM



TURBINE AND CONDENSER, FREIGHT, OR START-UP SUPERVISION.

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Appendix 6

State of Kentucky Environmental Operating Permit

Commonwealth of Kentucky
Energy and Environment Cabinet
Department for Environmental Protection
Division for Air Quality
200 Fair Oaks Lane, 1st Floor
Frankfort, Kentucky 40601
(502) 564-3999

Final

Worldwide rights to sell the technology as developed at Inez Power belongs to MDGS

AIR QUALITY PERMIT
Issued under 401 KAR 52:030

Permittee Name:	Inez Power, L.L.C.
Mailing Address:	P.O. Box 367, Allen, Kentucky 41601
Source Name:	Inez Power, L.L.C.
Mailing Address:	900 Middle Fork Wolf Creek Road, Debord, Kentucky 41214
Source Location:	900 Middle Fork Wolf Creek Road
Permit ID:	F-14-033
Agency Interest #:	40472
Activity ID:	APE20140002
Review Type:	Title V, Operating
Source ID:	21-159-00026
Regional Office:	Hazard Regional Office 233 Birch Street, Suite 2 Hazard, KY 41701 (606) 435-6022
County:	Martin
Application Complete Date:	June 25, 2014
Issuance Date:	November 10, 2014
Expiration Date:	November 10, 2019

Sean Alteri

Sean Alteri, Director
Division for Air Quality

Version 10/16/13

TABLE OF CONTENTS

	Permit type	**Activity#**	**Complete Date**	**Issuance Date**	**Summary of Action**
F-14-033	Renewal	APE20140002	6/25/2014	11/10/2014	Renewal and administrative amendment

SECTION A - PERMIT AUTHORIZATION

Pursuant to a duly submitted application the Kentucky Division for Air Quality (Division) hereby authorizes the operation of the equipment described herein in accordance with the terms and conditions of this permit. This permit has been issued under the provisions of Kentucky Revised Statutes (KRS) Chapter 224 and regulations promulgated pursuant thereto.

The permittee shall not construct, reconstruct, or modify any affected facilities without first submitting a complete application and receiving a permit for the planned activity from the permitting authority, except as provided in this permit or in 401 KAR 52:030, Federally-enforceable permits for non-major sources.

Issuance of this permit does not relieve the permittee from the responsibility of obtaining any other permits, licenses, or approvals required by the Kentucky Energy and Environment Cabinet (Cabinet) or any other federal, state, or local agency.

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

Emission Unit: 01 (01) Municipal Solid Waste Gasifier

Description:

The emission unit consists of a gasification kiln and a dryer unit exhausting into a reduction chamber (also known as boiler furnace chamber). The gasification kiln is equipped with a 15 million British thermal units per hour (mmBtu/hr) burner. The reduction chamber is also equipped with a 15 mmBtu/hr burner. The emission unit also contains two heat exchangers used to recover heat from the gasifier exhaust gases.

Process 001:	Municipal Solid Waste Gasifier
Type:	Shop fabricated
Maximum Capacity:	18.33 tons per hour 440 tons per day
Construction Date:	2003, new burners added in 2006
Process 002:	#1 & 2 fuel oil (primary fuel)
Construction Date:	7/29/2006
Process 003:	Natural gas (secondary fuel)
Construction Date:	7/29/2006
Process 004:	Propane (tertiary fuel)
Construction Date:	7/29/2006
Control Device:	Spray dryer absorber; baghouse (Injection of sodium bicarbonate and/or calcium oxide in the flue gas prior to the spray dryer absorber unit to reduce hydrochloric acid emissions and introduction of aqueous ammonia to the flue gas prior to the spray dryer absorber unit to reduce nitrogen oxides (NO_X) emissions)

The heat recovered from the flue gas in the indirect heat exchangers will be used to produce steam to power a 9 megaWatt (MW) steam turbine for the generation of electricity. The flue gas will then be directed to the control devices.

APPLICABLE REGULATIONS:

401 KAR 60:005, 40 C.F.R. Part 60 standards of performance for new stationary sources, incorporating by reference 40 CFR 60, Subpart Eb, Standards of Performance for Large Municipal Waste Combustors for Which Construction is Commenced After September 20, 1994 or for Which Modification or Reconstruction is Commenced After June 19, 1996.

401 KAR 59:021, New municipal solid waste incinerators.

STATE-ORIGIN REQUIREMENTS

401 KAR 63:020, Potentially hazardous matter or toxic substances.

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

NON-APPLICABLE REGULATIONS:

401 KAR 60:005, 40 C.F.R. Part 60 standards of performance for new stationary sources, incorporating by reference 40 CFR 60, Subpart Da, Standards of Performance for Electric Utility Steam Generating Units.

401 KAR 60:005, 40 C.F.R. Part 60 standards of performance for new stationary sources, incorporating by reference 40 CFR 60, Subpart Db, Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units.

401 KAR 60:005, 40 C.F.R. Part 60 standards of performance for new stationary sources, incorporating by reference 40 CFR 60, Subpart Ea, Standards of Performance for Municipal Waste Combustors for Which Construction is Commenced After December 20, 1989 and on or Before September 20, 1994.

401 KAR 60:005, 40 C.F.R. Part 60 standards of performance for new stationary sources, incorporating by reference 40 CFR 60, Subpart AAAA, Standards of Performance for Small Municipal Waste Combustion Units for Which Construction is Commenced After August 30, 1999 or for Which Modification or Reconstruction is Commenced After June 6, 2001.

401 KAR 60:005, 40 C.F.R. Part 60 standards of performance for new stationary sources, incorporating by reference 40 CFR 60, Subpart EEEE, Standards of Performance for Other Solid Waste Incineration Units for Which Construction is Commenced After December 9, 2004, or for Which Modification or Reconstruction is Commenced on or After June 16.

1. Operating Limitations:

a. For compliance with the source-wide emission limit to preclude the applicability of 401 KAR 52:020 for major sources, the maximum charging rate of municipal solid waste (MSW), as defined in 40 CFR 60.51(b), to the gasifier shall not exceed 18.3 tons per hour and 440 tons per day. Refer to Section D - Source Emission Limitations And Testing Requirements, paragraph 4.

b. The owner or operator shall not cause the facility to operate at a load level greater than 110 percent of the maximum demonstrated municipal waste combustor unit load. [40 CFR 60.53b(b)]

c. The owner or operator shall not cause the facility to operate at a temperature, measured at the particulate matter control device inlet, exceeding 17 degrees Celsius (°C) above the maximum demonstrated particulate matter control device temperature measured during the most recent dioxin/furan performance test. [40 CFR 60.53b(c)]

d. The owner or operator shall not cause or allow the facility to operate at a load level greater than 100 percent of the maximum MSWI unit load. Unit load as defined in 401 KAR 59:021, Section 1(50), means volume of steam produced expressed in kilograms per hour (pounds per hour) of steam. [401 KAR 59:021, Section 8(1)]

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e. The reduction chamber shall be maintained at a minimum temperature of 982 °C (1,800 degrees Fahrenheit (°F)). [401 KAR 59:021, Section 8(3)(a)]

f. The minimum secondary chamber residence time shall be 1.0 second. [401 KAR 59:021, Section 8(3)(b)]

g. The facility shall have interlocks or other process control devices to prevent operation of unit until the minimum temperature and residence time is assured. [401 KAR 59:021, Section 8(3)(c)]

h. The owner or operator shall not allow the temperature of the flue gases entering the particulate matter control device inlet to exceed 149 °C (300 °F) while combusting MSW. [401 KAR 59:021, Section 8(4)]

i. No unprocessed MSW or firing refuse-derived fuel (RDF), as defined in 40 CFR 60.51(b), shall be gasified in the facility. [401 KAR 59:021, Section 8(5)]

j. No yard waste or vehicle batteries shall be processed in the facility. [401 KAR 59:021, Section 8(6)]

k. Prior to initial start-up, the owner or operator shall establish a program to remove household batteries from MSW prior to gasification and the program shall be approved by the Cabinet. [401 KAR 59:021, Section 8(7)]

l. The ash removed from the gasifier shall be tested to determine the toxicity of the ash, using tests required in Title 401, Chapter 31. Ash which is determined to be a hazardous waste shall be disposed of according to the administrative regulations of the Division of Waste Management. Ash which is determined to be not hazardous waste shall be disposed of in a contained landfill. [401 KAR 59:021, Section 8(9)]

m. Since the facility will receive MSW from generators that are noncontiguous to the incineration site, it shall comply with the operating requirements for contained landfills in 401 KAR 48:090, Section 2. [401 KAR 59:021, Section 8(10)]

n. Since the facility will receive MSW from generators that are noncontiguous to the incineration site, it shall comply with the design requirements for contained landfills in 401 KAR 48:070, Section 15. [401 KAR 59:021, Section 8(11)]

o. Within 6 months after the date of startup, each chief facility operator and shift supervisor of the facility shall have completed full certification or shall have scheduled a full certification exam or shall obtain and maintain a current provisional operator certification with the American Society of Mechanical Engineers (ASME). [40 CFR 60.54b(a) and (b)]

p. The owner or operator shall not allow the facility to be operated at any time unless one of the following persons is on duty and at the affected facility: A fully certified

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chief facility operator, a provisionally certified chief facility operator who is scheduled to take the full certification exam according to the schedule specified in 40 CFR 60.54b(b), a fully certified shift supervisor, or a provisionally certified shift supervisor who is scheduled to take the full certification exam according to the schedule specified in 40 CFR 60.54b(b). [40 CFR 60.54b(c)]

q. Pursuant to 40 CFR 60.54b(c)(2), if both the certified chief facility operator and certified shift supervisor are unavailable, a provisionally certified control room operator on site at the municipal waste combustion unit may fulfill the certified operator requirement. Depending on the length of time that a certified chief facility operator and certified shift supervisor are away, the owner or operator must meet one of three criteria:

(1) When the certified chief facility operator and certified shift supervisor are both off site for 12 hours or less, and no other certified operator is on site, the provisionally certified control room operator may perform the duties of the certified chief facility operator or certified shift supervisor. [40 CFR 60.54b(c)(2)(i)]

(2) When the certified chief facility operator and certified shift supervisor are off site for more than 12 hours, but for two weeks or less, and no other certified operator is on site, the provisionally certified control room operator may perform the duties of the certified chief facility operator or certified shift supervisor without notice to, or approval by, the Administrator. However, the owner or operator must record the period when the certified chief facility operator and certified shift supervisor are off site and include that information in the annual report. [40 CFR 60.54b(c)(2)(ii)]

(3) Pursuant to 40 CFR 60.54b(c)(2)(iii), when the certified chief facility operator and certified shift supervisor are off site for more than two weeks, and no other certified operator is on site, the provisionally certified control room operator may perform the duties of the certified chief facility operator or certified shift supervisor without approval by the Administrator. However, the owner or operator must take two actions:

(i) Notify the Administrator in writing. In the notice, state what caused the absence and what actions are being taken by the owner or operator to ensure that a certified chief facility operator or certified shift supervisor is on site as expeditiously as practicable.

(ii) Submit a status report and corrective action summary to the Administrator every four weeks following the initial notification. If the Administrator provides notice that the status report or corrective action summary is disapproved, the municipal waste combustion unit may continue operation for 90 days, but then must cease operation. If corrective actions are taken in the 90-day period such that the Administrator withdraws the disapproval, the municipal waste combustion unit operation may continue.

r. All chief facility operators, shift supervisors, and control room operators at affected facilities must complete the Environmental Protection Agency (EPA) municipal

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waste combustor operator training course no later than the date six months after the date of startup of the affected facility. [40 CFR 60.54b(d)]

s. Pursuant to 40 CFR 60.54b(e), the owner or operator shall develop and update on a yearly basis a site-specific operating manual that addresses the elements of municipal waste combustor unit operation specified below:
   (1) A summary of the applicable standards under 40 CFR 60, subpart Eb;
   (2) A description of basic combustion theory applicable to a municipal waste combustor unit;
   (3) Procedures for receiving, handling, and feeding MSW;
   (4) Municipal waste combustor unit startup, shutdown, and malfunction procedures;
   (5) Procedures for maintaining proper combustion air supply levels;
   (6) Procedures for operating the municipal waste combustor unit within the standards established under 40 CFR 60, subpart Eb;
   (7) Procedures for responding to periodic upset or off-specification conditions;
   (8) Procedures for minimizing particulate matter carryover;
   (9) Procedures for handling ash;
   (10) Procedures for monitoring municipal waste combustor unit emissions; and
   (11) Reporting and recordkeeping procedures.

t. The owner or operator shall establish a training program to review the operating manual developed pursuant to 40 CFR 60.54b(e) with each person who has responsibilities affecting the operation of an affected facility including, but not limited to, chief facility operators, shift supervisors, control room operators, ash handlers, maintenance personnel, and crane/load handlers. The review will be completed within six months after the date of startup of the affected facility or the date prior to the day the person assumes responsibilities affecting municipal waste combustor unit operation; and will be repeated annually. [40 CFR 60.54b(f)]

u. The owner or operator subject to 401 KAR 47:030 shall not construct or operate the affected facility in a manner which will violate the requirements of that administrative regulation. Solid waste facilities failing to satisfy the requirements of this administrative regulation shall be considered open dumps which are prohibited by KRS 224.40-100. [401 KAR 59:021, Section 2(5)]

v. The procedures in 40 CFR 60.13 shall be followed for installation, evaluation, and operation of the continuous emission monitoring system (CEMS). [401 KAR 59:021, Section 10(8)(e)]

w. The CEMS shall conform to the applicable performance specifications in 40 CFR Part 60, appendix B or Kentucky Specification 4A. [401 KAR 59:021, Section 10(8)(f)]

x. The requirements of Kentucky Procedure 1, shall be met in the operation of the CEMS. [401 KAR 59:021, Section 10(8)(g)]

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

y. The owner or operator shall not allow any affected facility to emit potentially hazardous matter or toxic substances in such quantities or duration as to be harmful to the health and welfare of humans, animals and plants. [401 KAR 63:020, Section 3]

z. The owner or operator shall comply with the provisions of 40 CFR 60.58b(a)(1) during startup, shutdown and malfunction. [40 CFR 60.58b(a)]

Compliance Demonstration Methods:

a. As referenced by 40 CFR 60.58b(j)(1), for compliance with Operating Limitations a, the municipal waste gasifier unit capacity shall be calculated based on 24 hours of operation at the maximum charging rate. The maximum charging rate shall be determined as follows:
   (1) For combustors that are designed based on heat capacity, the maximum charging rate shall be calculated based on the maximum design heat input capacity of the unit and a heating value of 12,800 kilojoules per kilogram for combustors firing RDF and a heating value of 10,500 kilojoules per kilogram for combustors firing MSW that is not RDF.
   (2) For combustors that are not designed based on heat capacity, the maximum charging rate shall be the maximum design charging rate.

b. For compliance with Operating Limitations b, and d, the owner or operator shall determine municipal waste unit load as defined in 40 CFR 60.51b, by the procedures in 40 CFR 60.58b(i)(6) consisting of:
   (1) The owner or operator shall install, calibrate, maintain, and operate a steam flow meter or a feed water flow meter; measure steam (or feed water) flow in kilograms per hour (or pounds per hour) on a continuous basis; and record the output of the monitor. Steam (or feed water) flow shall be calculated in four-hour block arithmetic averages.
   (2) The method included in the "American Society of Mechanical Engineers Power Test Codes: Test Code for Steam Generating Units, Power Test Code 4.1—1964 (R1991)" shall be used for calculating the steam (or feed water) flow. The recommendations in "American Society of Mechanical Engineers Interim Supplement 19.5 on Instruments and Apparatus: Application, part II of Fluid Meters, 6th edition (1971)," shall be followed for design, construction, installation, calibration, and use of nozzles and orifices.
   (3) Measurement devices such as flow nozzles and orifices are not required to be recalibrated after they are installed.
   (4) All signal conversion elements associated with steam (or feed water flow) measurements must be calibrated according to the manufacturer's instructions before each dioxin/furan performance test, and at least once per year.

   Additionally, for compliance with Operating Limitations b, the owner or operator shall fulfill the requirements of 40 CFR 60.58b(i)(8).

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

c. For compliance with Operating Limitations c, and h, the owner or operator shall install, calibrate, maintain and operate a device for measuring on a continuous basis the temperature of the flue gas stream at the inlet to each particulate matter control device. Temperature shall be calculated in four-hour block arithmetic averages. [40 CFR 60.58b(i)(7) and 401 KAR 59:021, Section 10(7)(b)]

Additionally, for compliance with Operating Limitations c, and h, the owner or operator shall fulfill the requirements of 40 CFR 60.58b (i)(9).

d. For compliance with Operating Limitations e, the owner or operator shall install, calibrate, maintain, and operate a device for measuring on a continuous basis the temperature of the reduction chamber temperature. Temperature shall be calculated in four-hour block averages. [401 KAR 59:021, Section 10(7)(b)]

e. For compliance with Operating Limitations f, the owner or operator shall demonstrate compliance using the following equation:

$$T = L / V$$

Where:

T = Residence time in the chamber
L = Length of the chamber
V = Exit gas velocity as calculated in EPA Method 2

f. For compliance with Operating Limitations i, j, and k, pursuant to 401 KAR 59.021, Section 10(4), the owner or operator shall be responsible for operating the affected facility in compliance with the prohibition on combustion of unprocessed MSW, yard waste, and vehicle batteries and the implementation of a program for removal of household batteries. If another party provides processed unprocessed MSW, or removes yard waste, or vehicle or household batteries, the provider of the service may become a co-operator of the affected facility. If the party providing the off-site processing of unprocessed MSW, removal of yard waste or vehicle batteries, or removal of household batteries elects to become a co-operator for purposes of demonstrating compliance with Operating Limitations i, j, or k, the owner or operator shall submit at the time of submittal of the initial compliance demonstration the following:

(1) A copy of a validly executed contract between the owner or operator and the party providing the processing of unprocessed MSW, removal of vehicle batteries, removal of yard waste, or removal of household batteries which contains the following provisions:

(i) An undertaking by the party that is co-operator or sole operator of the affected facility regarding compliance with the requirements of Operating Limitations i, j, or k; and

(ii) An undertaking by the party to meet the requirements of Operating Limitations i, j, or k, and a description of the specific actions that will be implemented to comply with these requirements;

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

(2) A certified statement signed by an authorized official representing the party that they agree to become a cooperator, or sole operator, for the purpose of demonstrating compliance and recognizing that enforcement action, including penalties, may be taken against the party for failure to demonstrate compliance with these requirements.

g. Compliance with Operating Limitations l, is demonstrated from the maintained records of analysis for toxicity of the ash from the affected facility and records of the disposal of the ash. The owner or operator may utilize the ash for beneficial reuse if the Division of Waste Management determines that the ash meets the requirements for beneficial reuse.

h. For compliance with Operating Limitations o, p, and q, the owner or operator shall fulfill the requirements of 40 CFR 60.59b(d)(12)(i) through 40 CFR 60.59b (d)(12)(iv).

i. For compliance with Operating Limitations r, s, and t, the owner or operator shall fulfill the requirements of 40 CFR 60.59b(d)(13).

j. Compliance with Operating Limitations u, is shown when the owner or operator does not violate any requirement of 401 KAR 47:030.

k. For compliance with Operating Limitations v, w, and x, the owner or operator shall fulfill the requirements of 401 KAR 59.021, Section 11(2).

l. The source complies with 401 KAR 63:020 Operating Limitations y, based on the rates of emissions of airborne toxics provided in the application submitted by the source. If the source makes a process change, such as, but not limited to, process rates, material formulations, which would result in increased emissions of these previously evaluated airborne toxics, or in the emission of airborne toxics not previously evaluated by the Administrator, the source shall submit the appropriate application forms pursuant to 401 KAR 52:030, Section 4.

m. Refer to reporting requirements in Section F ─ Monitoring, Recordkeeping, and Reporting Requirements, paragraph 9, for compliance with Operating Limitations g, l, m, n, and y.

n. Refer to Section E ─ Source Control Equipment Requirements, for compliance with Operating Limitations z.

2. Emission Limitations:

a. For affected facilities that commenced construction, modification, or reconstruction after September 20, 1994, and on or before December 19, 2005, the emission limit for particulate emissions is 24 milligrams per dry standard cubic meter (dscm) (three-hour average), corrected to 7 percent oxygen and emissions shall not exceed ten percent opacity (six-minute average). [40 CFR 60.52b(a)(1)(i)]

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

b. On and after the date on which the initial performance test is completed, particulate emissions from the affected facility shall not exceed 34 milligrams per dscm (0.015 grains per dry standard cubic foot), corrected to seven percent oxygen (dry basis). Emissions shall not exceed ten percent opacity. [401 KAR 59:021, Section 3]

c. On and after the date on which the initial performance test is completed or is required to be completed under 40 CFR 60.8, subpart A, the owner or operator shall not cause to be discharged into the atmosphere from that affected facility any gases that contain cadmium in excess of is 20 micrograms per dscm, corrected to seven percent oxygen, based on a three-hour average. [40 CFR 60.52b(a)(3)(i)]

d. On and after the date on which the initial performance test is completed or is required to be completed under 40 CFR 60.8, subpart A, the owner or operator shall not cause to be discharged into the atmosphere from that affected facility any gases that contain lead in excess of 200 micrograms per dscm, corrected to seven percent oxygen, based on a three-hour average. [40 CFR 60.52b(a)(4)(i)]

e. On and after the date on which the initial performance test is completed or is required to be completed under 40 CFR 60.8, subpart A, the owner or operator shall not cause to be discharged into the atmosphere from that affected facility any gases that contain mercury in excess of 80 micrograms per dry dscm or 15 percent of the potential mercury emission concentration (85 percent reduction by weight), corrected to seven percent oxygen, whichever is less stringent, based on a three-hour average. [40 CFR 60.52b(a)(5)(i)]

f. On and after the date on which the initial performance test is completed or is required to be completed under 40 CFR 60.8, subpart A, the owner or operator of an affected facility for which construction, modification, or reconstruction commences after November 20, 1997 shall not cause to be discharged into the atmosphere from that affected facility any gases that contain dioxin/furan total mass emissions that exceed 13 nanograms per dscm (total mass), corrected to seven percent oxygen based on a 24-hour average. [40 CFR 60.52b(c)(2)]

g. On and after the date in which the initial performance test is completed, emissions that contain dioxin or furan shall not exceed 30 nanograms per normal cubic meter (14 grains per billion standard cubic feet), corrected to seven percent oxygen (dry basis). [401 KAR 59:021, Section 4(2)]

h. On and after the date on which the initial performance test is completed or is required to be completed under 40 CFR 60.8, subpart A, the owner or operator shall not cause to be discharged into the atmosphere from that affected facility any gases that contain Sulfur dioxide (SO_2) in excess of 30 parts per million by volume (ppmv) or 20 percent of the potential SO_2 emission concentration (80 percent reduction by weight or volume), corrected to seven percent oxygen (dry basis), whichever is less stringent; on a 24-hour daily geometric average. [40 CFR 60.52b(b)(1)]

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

i. On and after the date on which the initial performance test is completed, the owner or operator shall not cause emissions that contain SO_2 in excess of 15 percent of the uncontrolled SO_2 emission rate (85 percent reduction by weight) or 30 ppmv, corrected to seven percent oxygen (dry basis), whichever is less stringent. [401 KAR 59:021, Section 5(2)(a)]

j. On and after the date on which the initial performance test is completed or is required to be completed under 40 CFR 60.8, subpart A, the owner or operator shall not cause to be discharged into the atmosphere from that affected facility any gases that contain hydrogen chloride in excess of 25 ppmv or five percent of the potential hydrogen chloride emission concentration (95 percent reduction by weight or volume), corrected to seven percent oxygen (dry basis), whichever is less stringent, based on a three-hour average. [40 CFR 60.52b(b)(2)]

k. On and after the date on which the initial performance test is completed, the owner or operator shall not cause emissions that contain hydrogen chloride in excess of five percent of the uncontrolled hydrogen chloride emission rate (95 percent reduction by weight) or 25 ppmv, corrected to seven percent oxygen (dry basis), whichever is less stringent. [401 KAR 59:021, Section 5(2)(b)]

l. Pursuant to 40 CFR 60.52b(d), limits for NO_X are specified as:
   (1) During the first year of operation after the date on which the initial performance test is completed or is required to be completed under 40 CFR 60.8, subpart A, the owner and operator shall not cause to be discharged into the atmosphere from that affected facility any gases that contain NO_X in excess of 180 ppmv, corrected to seven percent oxygen (dry basis), based on a 24-hour daily arithmetic average.
   (2) After the first year of operation following the date on which the initial performance test is completed or is required to be completed under 40 CFR 60.8, subpart A, the owner and operator shall not cause to be discharged into the atmosphere from that affected facility any gases that contain NO_X in excess of 150 ppmv, corrected to seven percent oxygen (dry basis) based on a 24-hour daily arithmetic average.

m. On and after the date on which the initial performance test is completed, the owner and operator located within a large MSWI plant shall not cause or allow to be discharged into the atmosphere from the affected facility emissions that contain NO_X in excess of 120 ppmv, corrected to seven percent oxygen (dry basis). [401 KAR 59:021, Section 6]

n. On and after the date on which the initial performance test is completed as per 40 CFR 60.8, subpart A, the facility shall not exceed the CO standard of 50 ppmv for a modular starved air process. The measurement shall be taken at the outlet of the reduction chamber, corrected to seven percent oxygen (dry basis) using a four-hour block arithmetic average. [40 CR 60, subpart Eb]

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

o. On and after the date on which the initial performance test is completed, the facility shall not exceed the CO standard of 50 ppmv for a modular starved air process. The measurement shall be taken at the outlet of the reduction chamber, corrected to seven percent oxygen (dry basis) using a four-hour block average. [401 KAR 59:021, Section 7]

p. On and after the date on which the initial performance test is completed or is required to be completed, the owner or operator shall not cause to be discharged to the atmosphere visible emissions of combustion ash from an ash conveying system (including conveyor transfer points) in excess of five percent of the observation period (i.e., nine minutes per four-hour period), as determined by EPA Reference Method 22 observations. The emission limit does not cover visible emissions discharged inside buildings or enclosures of ash conveying systems; however it does cover visible emissions discharged to the atmosphere from buildings or enclosures of ash conveying systems. [40 CFR 60.55b]

Compliance Demonstration Methods:

a. Compliance with Emission Limitations a, and b, for particulate matter and opacity shall be determined using the following:
   (1) The procedures specified in 40 CFR 60.58b (c)(1) through (11) shall be used to determine compliance with particulate matter and opacity emission limits;
   (2) Testing Requirements b;
   (3) Specific Monitoring Requirements a, b, and e;
   (4) Specific Recordkeeping requirements b, and c; and
   (5) Specific Reporting Requirements e, f, and g.

b. Compliance with Emission Limitations c, d, and e, for cadmium, lead and mercury shall be determined as follows:
   (1) The procedures specified in 40 CFR 60.58b(d)(1) and (2) shall be used to determine compliance with cadmium, lead and mercury emission limits;
   (2) Testing Requirements c;
   (3) Specific Monitoring Requirements b, f, and g;
   (4) Specific Recordkeeping requirements b, i, k, l, and m; and
   (5) Specific Reporting Requirements d through g.

c. Compliance with Emission Limitations f, and g, for dioxin/furan emission shall be determined using the following:
   (1) The procedures specified in 40 CFR 60.58b(g)(1) through (9) shall be used to determine compliance with dioxin/furans emission limit;
   (2) Testing Requirements d;
   (3) Specific Monitoring Requirements b, f, and g;
   (4) Specific Recordkeeping requirements i, through m; and
   (5) Specific Reporting Requirements d through g.

d. Compliance with Emission Limitations h, and i, for SO_2 standards shall be determined by using the following:

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

(1) The procedures specified in 40 CFR 60.58b(e)(1) through (14) shall be used to determine compliance the SO_2 emission limit;
(2) Testing Requirements e;
(3) Specific Monitoring Requirements a, and e;
(4) Specific Recordkeeping requirements b, and c; and
(5) Specific Reporting Requirements d through g.

e. Compliance with Emission Limitations j, and k, for hydrogen chloride standards shall be determined by using the following:
(1) The procedures specified in 40 CFR 60.58b(f)(1) through (8) shall be used to determine compliance with the hydrogen chloride emission limit;
(2) Testing Requirements f;
(3) Specific Monitoring Requirements b;
(4) Specific Recordkeeping requirements h; and
(5) Specific Reporting Requirements d through g.

f. Compliance with Emission Limitations l, and m, for NO_X standards shall be determined as follows:
(1) The procedures specified in 401 KAR 59:021, Section 10(5)(a) through (e) shall be used to determine compliance the NO_X emission limit;
(2) Testing Requirements g;
(3) Specific Monitoring Requirements a, b, and e;
(4) Specific Recordkeeping requirements b, and c; and
(5) Specific Reporting Requirements d through g.

g. Compliance with Emission Limitations n, and o, for CO standards shall be determined as follows:
(1) The procedures specified in 40 CFR 60.58b(i)(1) through (5) shall be used to determine compliance with the CO emission limit;
(2) Testing Requirements h;
(3) Specific Monitoring Requirements a, b, and e;
(4) Specific Recordkeeping requirements b, and c; and
(5) Specific Reporting Requirements d through g.

h. Compliance with the Emission Limitations p, for fugitive ash emission standards shall be determined as follows:
(1) The procedures and test methods specified in 40 CFR 60.58b(k)(1) and (4) shall be used to determine compliance the fugitive ash emission limit;
(2) Testing Requirements i;
(3) Specific Recordkeeping Requirements b; and
(4) Specific Reporting Requirements e.

3. Testing Requirements:

a. The owner or operator shall conduct testing at such times as may be required by the Cabinet in accordance with 401 KAR 59:005, Section 2(2) and 50:045, Section 4.

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

b. For compliance with Emission Limitations a, and b, for particulate matter, the owner or operator shall comply with the applicable requirements of 40 CFR 60.58b(c). Following the date that the initial performance test is completed, the owner or operator shall conduct a performance test for particulate matter on a calendar year basis (no less than nine calendar months and no more than 15 calendar months following the previous performance test; and must complete five performance tests in each five year calendar period).

c. For compliance with Emission Limitations c, d, and e, for cadmium, lead and mercury, the owner or operator shall comply with the applicable requirements of 40 CFR 60.58b(d). Following the date of the initial performance test or the date on which the initial performance test is required to be completed, the owner or operator shall conduct a performance test for compliance with the emission limits for cadmium and lead on a calendar year basis (no less than nine calendar months and no more than 15 calendar months following the previous performance test; and must complete five performance tests in each five year calendar period).

d. For compliance with Emission Limitations f, and g, for dioxins/furans, the owner or operator shall comply with the applicable requirements of 40 CFR 60.58b(g). Performance tests shall be conducted on a calendar year basis (no less than nine calendar months and no more than 15 calendar months following the previous performance test; and must complete five performance tests in each five year calendar period). An average carbon mass feed rate in kilograms per hour or pounds per hour shall be estimated during the initial performance test for dioxin/furan emissions and each subsequent performance test for dioxin/furan emissions.

e. For compliance with Emission Limitations h, and i, for SO_2 standards, the owner or operator shall comply with the applicable requirements of 40 CFR 60.58b(e). Following the date that the initial performance test for SO_2 is completed or is required to be completed, compliance with the SO_2 emission limit shall be determined based on the 24-hour daily geometric average of the hourly arithmetic average emission concentrations using continuous emission monitoring system outlet data if compliance is based on an emission concentration, or continuous emission monitoring system inlet and outlet data if compliance is based on a percent reduction.

f. For compliance with Emission Limitations j, and k, for hydrogen chloride standards, the owner or operator shall comply with the applicable requirements of 40 CFR 60.58b(f). Following the date that the initial performance test for hydrogen chloride is completed or is required to be completed, the owner or operator shall conduct a performance test for hydrogen chloride emissions on an annual basis (no more than 12 calendar months following the previous performance test).

g. For compliance with Emission Limitations l, and m, for NO_X standards, the owner or operator shall comply with the applicable requirements of 401 KAR 59:021, Section 5. The owner or operator subject to the NO_X emission limit shall install, calibrate,

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

maintain, and operate, a continuous emission monitoring system for measuring NO_X discharged to the atmosphere, and record the output of the system.

h. For compliance with Emission Limitations n, and o, for CO standards, the owner or operator shall comply with the applicable requirements of 40 CFR 60.58b(i). Following the initial performance test, compliance with the CO emission limits shall be determined based on the arithmetic average of the four-hour emission rates measured using CEMS data.

i. For compliance with Emission Limitations p, for fugitive ash emission standards, the owner or operator shall comply with the applicable requirements of 40 CFR 60.58b(k). The EPA Reference Method 22 shall be used for determining compliance with the fugitive ash emission limit. The minimum observation time shall be a series of three one-hour observations. The observation period shall include times when the facility is transferring ash from the municipal waste combustor unit to the area where ash is stored or loaded into containers or trucks. The average duration of visible emissions per hour shall be calculated from the three one-hour observations. The average shall be used to determine compliance. The owner or operator shall conduct an initial performance test for fugitive ash emissions. Following the date that the initial performance test for fugitive ash emissions is completed or is required to be completed, the owner or operator shall conduct a performance test for fugitive ash emissions on an annual basis (no more than 12 calendar months following the previous performance test).

j. The initial performance evaluation shall be completed within 60 days after achieving the maximum production rate at which an affected facility will be operated, but not later than 180 days after initial start-up of the facility and at other times as may be required by the Cabinet. [401 KAR 59.021, Section 10]

4. Specific Monitoring Requirements:

a. The owner or operator shall install, calibrate, maintain, and operate a CEMS for measuring opacity (except for MSWI units equipped with a wet scrubber); and CEMS for measuring NO_X, $SO_{2,}$ and CO emissions. The output of the CEMS shall be monitored for opacity, the input and output of the CEMS shall be monitored for the SO_2 emissions, and the output of the CEMS at the incinerator outlet shall be monitored for NO_X and CO emissions. The owner or operator shall comply with the test procedures and test methods specified in 40 CFR 60.58b(b)(1) through (8). [40 CFR 60.58b(b) and 401 KAR 59:021, Section 10(1)(e), 10(3)(d), 10(5)(c) and 10(6)(b)]

b. Pursuant to 401 KAR 42:030, Section 26, for all required emissions control equipment, the owner or operator shall keep the following records:

(1) Design and manufacturer’s specifications;

(2) Preventive maintenance records related to performance of control equipment;

(3) All periods, during normal operating conditions, where emissions control equipment, required by this permit is bypassed;

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

(4) Description of operating, temperature and pressure-measuring devices (e.g., automatic strip charts, digital data acquisition systems);
(5) Data from the temperature measuring device and any temporary data logged manually as back up;
(6) Inspection reports and maintenance performed in response to recommendations in inspection reports;
(7) Monitoring system malfunctions; and
(8) Calibrations, accuracy audits and validation check records for monitoring control equipment.

c. Pursuant to 401 KAR 59:021, Section 10(7):

(1) The facility shall install, calibrate, maintain, and operate a steam flow meter, shall measure steam flow in kilograms per hour (pounds per hour) steam on a continuous basis, and shall monitor the output of the monitor. Steam flow shall be calculated in one-hour block averages.
(2) The facility shall install, calibrate, maintain, and operate a continuous monitoring system for measuring both secondary chamber temperature and the temperature of the flue gas stream at the inlet to the particulate matter air pollution control device and shall record the output of the device. Temperature shall be calculated in four hour block averages.

d. The following procedures shall be used to determine compliance with 401 KAR 59:021, Section 8(5) through (7).

(1) Compliance with the percent reduction requirement for processed MSW or RDF shall be determined by calculating the percentage difference between the weight of MSW received at the affected facility and the weight of MSW processed in the MSWI unit or the weight of separated recoverable materials. Beginning the month after the date of the initial start-up for a new MSWI, the percent reduction in MSW shall be calculated on a monthly basis using the following monthly total weights, which are required by 401 KAR 59:021, Section 11(1)(h) and (i): the amount (by weight) of MSW or RDF received on a monthly basis at the affected facility; the amount (by weight) of MSW or RDF combusted on a monthly basis; and the estimated amount (by type and weight) of recoverable materials reduced or separated for recovery on a monthly basis through an off-site or community source reduction or materials separation (recycling) program.
(2) At the end of each full calendar year (January through December), the annual average percent MSW reduction (by weight) shall be calculated by using the annual total weights. In calculating the percent MSW reduction, a maximum of 15 percent weight reduction shall be attributed to separation of yard waste. If the annual average percentage reduction requirement for processed MSW or RDF is not achieved, the MSW or RDF shall not be considered to be processed MSW or RDF.

e. Pursuant to 401 KAR 59:021, Section 10(8) or 40 CFR 60.58b:

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

(1) CEMS and continuous monitoring data shall be used to determine compliance with emission standards and operating practices.

(2) At a minimum, CEMS or continuous monitoring system data, if required, shall be obtained for 90 percent of the hours per calendar quarter and 95 percent of the hours per calendar year the unit is operated and gasifying MSW.

(3) All valid CEMS or continuous monitoring system data shall be used in calculating emission rates and percent reductions, even if the minimum CEMS or continuous monitoring system data do not meet minimum of 90 percent of the hours per calendar quarter and 95 percent of the hours per calendar year the unit is operated.

(4) If emissions data from CEMS or continuous monitoring systems are not obtained because of CEMS or monitoring system breakdown, repairs, calibration checks, and zero and span adjustments, emissions data shall be obtained by using other monitoring systems as approved by the Cabinet or Methods 6, 6A, 7, 7E, 10, and 19, as appropriate, to provide necessary emission data for a minimum of 90 percent of the hours per calendar quarter and 95 percent of the hours per calendar year the unit is operated and combusting MSW.

(5) The procedures in 40 CFR 60.13 shall be followed for installation, evaluation, and operation of the CEMS.

(6) The CEMS shall conform to the applicable performance specifications in 40 CFR Part 60, appendix B or Kentucky Specification 4A.

(7) The requirements of Kentucky Procedure 1 shall be met in the operation of the CEMS.

f. Pursuant to 40 CFR 60.58b(m)(3), the owner or operator shall monitor the total carbon usage of the plant (kilograms or pounds) for each calendar quarter by two independent methods, according to the procedures in paragraphs 40 CFR 60.58b (m)(3)(i) and (ii) and listed below:

(1) The weight of carbon delivered to the plant; and

(2) Estimate the average carbon mass feed rate in kilograms per hour or pounds per hour for each hour of operation for each affected facility based on the parameters specified in 40 CFR 60.58b(m)(1).

g. The owner or operator shall install a pneumatic injection pressure or other carbon injection system operational indicator to provide additional verification of proper carbon injection system operation. The operational indicator shall provide an instantaneous visual and/or audible alarm to alert the operator of a potential interruption in the carbon feed. The basis for selecting the indicator and operator response to the indicator alarm, shall be included in the site-specific operating manual. [40 CFR 60.58b(m)(4)]

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

5. Specific Recordkeeping Requirements:

a. Pursuant to 401 KAR 59:021, Section 9(3), a site-specific operation manual shall be developed, maintained, and updated on a yearly basis. This manual shall address the following elements:

(1) Summary of the applicable standards under 401 KAR 59:021;
(2) Description of basic gasification theory applicable to a MSWI unit;
(3) Procedures for receiving, handling, and feeding MSW;
(4) MSWI unit start-up, shutdown, and malfunction procedures;
(5) Procedures for maintaining proper combustion air supply levels;
(6) Procedures for operating a MSWI unit within the standards established in 401 KAR 59:021;
(7) Procedures for responding to periodic upset or off-specification conditions;
(8) Procedures for minimizing particulate matter carry-over;
(9) Procedures for monitoring solid waste burnout;
(10) Procedures for handling ash;
(11) Procedures for monitoring MSWI unit emissions; and
(12) Reporting and recordkeeping procedures.

This manual shall be reviewed annually with each person who has responsibilities affecting the operation of the affected facility. Documentation shall be kept showing compliance with this section. This documentation, at a minimum, shall include a description of the instruction given, the date of the instruction, the signature of the person receiving instruction, and copies of the ASME certificates issued to the chief facility operator and shift supervisor. This manual shall be available for inspection by the Cabinet upon request. [401 KAR 59:021, Section 9(4) through (7)]

b. Pursuant to 401 KAR 59:021, Section 11, and 40 CFR 60.59b(d), the following records shall be maintained for a period of at least five years:

(1) Calendar date that data from performance tests, CEMS, or continuous monitoring systems were obtained;
(2) The following measurements specified in 40 CFR 60.59b(d)(2)(i)(A) through (D) shall be recorded and be available for submittal to the Administrator or review on site by an EPA or State inspector:
    (i) All six-minute average opacity levels specified in 40 CFR 60.58b(c);
    (ii) All one-hour average SO_2 emission concentrations specified in 40 CFR 60.58b(e);
    (iii) All one-hour average NO_X emission concentrations specified in 40 CFR 60.58b(h); and
    (iv) All one-hour average CO emission concentrations, municipal waste combustor unit load measurements and particular matter control device inlet temperature specified in 40 CFR 60.58b(i);
(3) Pursuant to 40 CFR 60.59b(d)(2)(ii), the average concentrations and percent reductions, as applicable, shall be computed and recorded, and shall be available for submittal to the Division or review on site by an EPA or State inspector;

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

(i) All 24-hour daily geometric average SO_2 emission concentrations and all 24-hour daily geometric average percent reductions in SO_2 emissions as specified in 40 CFR 60.58b(e).

(ii) All 24-hour daily arithmetic average NO_X emission concentrations as specified in 40 CFR 60.58b(h).

(iii) All four-hour block or 24-hour daily arithmetic average CO emission concentrations, as applicable as specified in 40 CFR 60.58b(i).

(iv) All four-hour block arithmetic average municipal waste combustor unit load levels and particulate matter control device inlet temperatures as specified in 40 CFR 60.58b(i).

(4) Pursuant to 40 CFR 60.59b(d)(3), identification of the operating periods where the calculated NO_X, SO_2 or CO emission rates, opacity, percentage reductions or the operating parameters exceeded the applicable standards, with reasons for the exceedances and a description of corrective actions taken;

(5) Pursuant to 40 CFR 60.59b(d)(6), identification of operating periods for which valid hourly NO_X, SO_2 or CO emissions, opacity, or operational data have not been obtained, including reasons for not obtaining sufficient data and a description of corrective actions taken;

(6) Pursuant to 40 CFR 60.59b(d)(7), identification of the times that NO_X, SO_2 or CO emission concentrations, opacity, or operational data (unit load data, particulate matter control device temperature) have not been excluded from the calculation of average emissions rates or parameters excluded and the reasons for excluding the data.

(7) Pursuant to 40 CFR 60.59b(d)(8), the results of daily NO_X, SO_2 and CO CEMS drift tests and accuracy assessments;

(8) The results 40 CFR 60.59b(d)(9)(i), of the initial and all annual performance tests conducted to determine compliance with the mass particulate matter, opacity, cadmium, lead, mercury, dioxin or furan, and hydrogen chloride standards and fugitive ash emission limits;

(9) Pursuant to 40 CFR 60.59b(d)(9)(ii), the test reports documenting the results of the initial performance test and all annual performance tests to determine compliance with particulate matter, opacity, cadmium, lead, mercury, dioxins/furan, hydrogen chloride and fugitive ash emission limits and the maximum demonstrated municipal waste combustor unit load and maximum demonstrated particulate matter control device temperature shall be recorded along with supporting calculations;

(10) Pursuant to 401 KAR 59:021, Section 11(h), beginning the month after the date of the initial start-up, the amount (by weight) of MSW or RDF received on a monthly basis at the affected facility, the amount (by weight) of MSW or RDF gasified on a monthly basis, and the amount of recoverable materials (by type and weight) separated on a monthly basis;

(11) Pursuant to 401 KAR 59:021, Section 11(i), beginning the month after the date of the initial start-up, the estimated amount (by type and weight) of recoverable materials reduced or separated for recovery on a monthly basis

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

through an off-site or community source reduction or materials separation (recycling) program;

(12) Pursuant to 401 KAR 59:021, Section 11(j), beginning at the end of the first full calendar year after the date of initial start-up, the calculations of the annual average percentage of reduction in MSW achieved for the previous calendar year; and

(13) Pursuant to 401 KAR 59:021, Section 11(k), beginning the month after the date of the initial start-up and for each month thereafter, the amount (by weight) of vehicle batteries separated for recovery.

c. Records of CEMS, steam flow, and temperature data shall be maintained for at least 2 years after date of recording and shall be made available for inspection upon request.

d. The owner or operator shall maintain records of the following information for the spray dryer absorber control device:
(1) The operational procedures and preventive maintenance records; and
(2) All maintenance activities performed at the control device.

e. Backup fuels shall only be natural gas and propane with sulfur content of less than 0.50 percent. The fuel usage shall be monitored on a monthly basis and shall be used to calculate the annual emissions for any 12-month period.

f. The owner or operator shall keep track of the amount of fuel oil #2 used on a monthly basis.

g. To preclude the applicability of 401 KAR 52:020, the facility shall calculate and maintain a record of the amount of sodium bicarbonate and calcium oxide required to control hydrogen chloride emissions and aqueous ammonia injected on the upstream side of the spray dryer absorber control device to control NO_X emissions, during the initial and annual performance tests. The facility shall maintain records of the average sodium bicarbonate and calcium oxide, and aqueous ammonia flow rate (pounds per hour and gallons/hour respectively) estimated for each day of operation.

h. The owner or operator shall maintain a monthly log of the NO_X, CO and hydrogen chloride emission calculations so as to fulfill the requirements of 401 KAR 52:030, Section 1. Records shall be summarized each month and added to the previous 11 months to provide a total of actual emissions for each consecutive 12-month period and demonstrate that the source's actual emissions during each consecutive 12-month period are less than the major source thresholds and contain additional information if needed to implement and enforce applicable requirements or to determine applicability. [401 KAR 52:030, Section 10]

i. The owner or operator shall maintain record of the average carbon mass feed rate (in kilograms per hour or pounds per hour) as required in 40 CFR 60.58b(m)(1)(i)

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

during the initial mercury performance test and all subsequent annual performance tests, with supporting calculations. [40 CFR 60.59b(d)(4)(i)]

j. The owner or operator shall maintain record of the average carbon mass feed rate (in kilograms per hour (pounds per hour) as required in 40 CFR 60.58b(m)(1)(ii) estimated during the initial dioxin/furan performance test and all subsequent annual performance tests, with supporting calculations. [40 CFR 60.59b(d)(4)(ii)]

k. The owner or operator shall maintain record of the average carbon mass feed rate (in kilograms per hour or pounds per hour) estimated for each hour of operation with supporting calculations. [40 CFR 60.59b(d)(4)(iii)]

l. The owner or operator shall maintain a record of the total carbon usage for each calendar quarter pursuant to 40 CFR 60.59b(d)(4)(iv), estimated from the following:
   (1) The weight of carbon delivered to the plant; or
   (2) Estimate the average carbon mass feed rate in kilograms per hour (pounds per hour) for each hour of operation for each affected facility, and sum the results for all affected facilities at the plant for the total number of hours of operation during the calendar quarter.

m. Carbon injection system operating parameter data for the parameter(s) that are the primary indicator(s) of carbon feed rate (e.g., screw feeder speed). [40 CFR 60.59b (d)(4)(v)]

n. The owner or operator shall maintain documentation demonstrating that the ash disposal from the facility complies with 401 KAR 59.021, Section 8(9), and 401 KAR 47:080. [401 KAR 59.021, Section 11(8)]

o. Records showing the names of the municipal waste combustor chief facility operator, shift supervisors, and control room operators who have been provisionally certified by the ASME including the dates of initial and renewal certifications and documentation of current certification. [40 CFR 60.59b(12)(i)]

p. Records showing the names of the municipal waste combustor chief facility operator, shift supervisors, and control room operators who have been fully certified by the ASME including the dates of initial and renewal certifications and documentation of current certification. [40 CFR 60.59b(12)(ii)]

q. Records showing the names of persons who have completed review of the operating manual, including the date of the initial review and all subsequent annual reviews, and the documentation required by 401 KAR 59:021, Section 9(7) [which includes, at a minimum, a description of the instruction given, the date of the instruction, the signature of the person receiving the instruction, and copies of the ASME certificates issued to the chief facility operator and the shift supervisor (if ASME adopts such a certification program)], shall be maintained for at least 2 years after the date of

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

manual review and shall be made available to the Cabinet for inspection upon request. [40 CFR 60.59b(12)(iii)]

r. A description of the procedures employed for ensuring that unprocessed MSW or RDF is not combusted in an affected facility shall be maintained, along with associated records to demonstrate use of the procedures, and shall be made available for inspection upon request.

s. Records of when a certified operator is temporarily off site. Include two main items:
   (1) Pursuant to 40 CFR 60.59b(d)(12)(iv)(A), if the certified chief facility operator and certified shift supervisor are off site for more than 12 hours, but for two weeks or less, and no other certified operator is on site, record the dates that the certified chief facility operator and certified shift supervisor were off site; and
   (2) Pursuant to 40 CFR 60.59b(d)(12)(iv)(B), when all certified chief facility operators and certified shift supervisors are off site for more than two weeks and no other certified operator is on site, keep records of four items:
      (i) Time of day that all certified persons are off site;
      (ii) The conditions that cause those people to be off site;
      (iii) The corrective actions taken by the owner or operator to ensure a certified chief facility operator or certified shift supervisor is on site as soon as practicable; and
      (iv) Copies of the written reports submitted every four weeks that summarize the actions taken by the owner or operator to ensure that a certified chief facility operator or certified shift supervisor will be on site as soon as practicable.

t. The operating manual required pursuant to 40 CFR 60.54b(e) shall be kept in a readily accessible location for all persons required to undergo training.

6. <u>Specific Reporting Requirements:</u>

a. The initial demonstration of compliance with the percent reduction requirement for processed MSW or RDF; the requirements for not combusting unprocessed MSW or RDF, yard waste, or vehicle batteries in the facility; and the requirement to have an approved program for removing household batteries from the MSW prior to combustion; shall be required at the end of the second full calendar year (January through December) after the date of initial start-up of an affected facility. [401 KAR 59:021, Section 10(7)(c)1]

b. The facility may elect to achieve, either wholly or partially, the percent reduction requirement for processed MSW or RDF, the prohibition of yard waste or vehicle batteries in 401 KAR 59:021, Section 8(6), or the removal of household batteries in 401 KAR 59:021, Section 8(7), through an off site source reduction or materials separation (recycling) program. The owner or operator shall submit a separation plan which contains sufficient information to measure the performance of the off site separation program on an annual basis beginning the first full calendar year (January through December) for the initial start-up of the affected facility, except as provided in 401 KAR 59:021, Section 10(7)(c)4. The off site separation plan shall be submitted along with the initial compliance demonstration results. [401 KAR 59:021, Section 10(7)(c)3]

c. Pursuant to 401 KAR 59:021, Section 10(7)(c)4, the owner or operator shall be responsible for operating the affected facility in compliance with all standards including the prohibition on combustion of unprocessed MSW, yard waste, and vehicle batteries under 401 KAR 59:021, Section 8(5) and (6), and the implementation of a program for removal of household batteries under 401 KAR 59:021, Section 8(7). If another party provides processed MSW, or removes yard waste or vehicle batteries, or removes household batteries elects to become a co-operator for purposes of demonstrating compliance with 401 KAR 59:021, Section 8(5), (6), or (7), the owner or operator shall submit at the time of submittal of the initial compliance demonstration related to the requirements of 401 KAR 59:021, Section 8(5), (6), or (7):
   (1) Pursuant to 401 KAR 59:021, Section 10(7)(c)4(A), a copy of a validly executed contract between the owner or operator and the party providing the processing of MSW, removal of vehicle batteries, removal of yard waste, or removal of household batteries which contains the following provisions:
      (i) An undertaking that the party will comply with the requirements of 401 KAR 59:021, Section 8(5), (6), or (7); and
      (ii) An undertaking by the party to meet the requirements of 401 KAR 59:021, Section 8(5), (6), or (7), and a description of the specific action that will be implemented to comply with these requirements;
   (2) A certified statement signed by an authorized official representing the party that they agree to become a co-operator, or sole operator, for the purpose of demonstrating compliance with 401 KAR 59:021, Section 9(5), (6), or (7), and recognizing that enforcement action, including penalties, may be taken against the party for failure to demonstrate compliance with these requirements. [401 KAR 59:021, Section 10(7)(c)4(B)]

d. Pursuant to 401 KAR 59:021, Section 11, the following shall be submitted to the Cabinet.
   (1) After completion in accordance with applicable administrative regulations, the owner or operator shall submit to the Cabinet the initial performance test data, the performance evaluation of the CEMS using the applicable performance specifications in 40 CFR Part 60, appendix B or Kentucky Specification 4A, and the maximum MSWI unit load within 60 days upon completion. [401 KAR 59:021, Section 11(2)]
   (2) Pursuant to 401 KAR 59:021, Section 11(3), a plan describing the procedures for separating materials for recovery to achieve the 40 percent or greater MSW reduction requirement for processed MSW or RDF, a plan describing the procedures for ensuring that vehicle batteries are not processed in the affected facility, and a description of the program for removal of household batteries shall be provided at the time of submittal of the initial

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demonstration of compliance with the requirements of 401 KAR 59:021, Section 8(5), (6), and (7), which are as follows:

(i) Pursuant to 401 KAR 59:021, Section 8(5), except as provided under 401 KAR 59:021, Section 8(8), on and after the date of initial start-up, no owner or operator of an affected facility shall cause or allow unprocessed MSW or RDF to be combusted in the facility;

(ii) Pursuant to 401 KAR 59:021, Section 8(6), no owner or operator of an affected facility shall cause or allow yard waste or vehicle batteries to be combusted in the facility; and

(iii) Pursuant to 401 KAR 59:021, Section 8(7), prior to initial start-up, the owner or operator of an affected facility shall establish a program which has been approved by the cabinet to remove household batteries from MSW prior to combustion. On and after the date of initial start-up, the owner or operator shall comply with the approved plan for removing household batteries from MSW.

(iv) This information shall be provided by the 30^{th} day following the end of the second full calendar year after initial start-up.

(3) Pursuant to 401 KAR 59:005, Section 3(3), the owner or operator shall submit quarterly reports to the Cabinet containing the information listed in Specific Recordkeeping Requirements c, for emission unit 01 of this permit. Both printed report and computer tape or discs shall be furnished in the format specified by the Cabinet. All reports shall be postmarked by the 30^{th} day following the end of each calendar year.

(4) Documentation demonstrating that the ash disposal from an affected facility complies with 401 KAR 59:021, Section 8(9), and 401 KAR 47:080 shall be submitted to the Division of Waste Management in the frequency required by the Division of Waste Management.

e. The owner or operator shall submit the information specified in 40 CFR 60.59b(f) in the initial performance test report. [40 CFR 60.59b(f)]

(1) The initial performance test data as recorded under paragraphs 40 CFR 60.59b(d)(2)(ii)(A) through (D) for the initial performance test for NO_X, SO_2, CO, municipal waste combustor unit load level, and particulate matter control device inlet temperature.

(2) The test report documenting the initial performance test recorded as per 40 CFR 60.59b(d)(9) for particulate matter, opacity, cadmium, lead, mercury, dioxins/furans, hydrogen chloride, and fugitive ash emissions.

(3) The performance evaluation of the continuous emission monitoring system using the applicable performance specifications in 40 CFR 60, appendix B.

(4) The maximum demonstrated municipal waste combustor unit load and maximum demonstrated particulate matter control device inlet temperature(s) established during the initial dioxin/furan performance test.

(i) For affected facilities that apply activated carbon injection for mercury control, the owner or operator shall submit the average carbon mass feed rate recorded as per 40 CFR 60.59b(d)(4)(i).

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

(ii) For those affected facilities that apply activated carbon injection for dioxin/furan control, the owner or operator shall submit the average carbon mass feed rate recorded as per 40 CFR 60.59b(d)(4)(ii).

f. Pursuant to 40 CFR 60.59b(g), following the first year of municipal waste combustor operation, the owner or operator shall submit an annual report no later than February 1, of each year following the calendar year in which the data were collected. The report shall contain:

(1) A summary of data collected for all pollutants and parameters regulated;

(2) A list of the particulate matter, opacity, cadmium, lead, mercury, dioxins/furans, hydrogen chloride, and fugitive ash emission levels achieved during the performance tests recorded;

(3) A list of the highest emission level recorded for NO_X, SO_2, CO, particulate matter, cadmium, lead, mercury, hydrogen chloride, and dioxin/furan (for owners and operators who elect to continuously monitor particulate matter, cadmium, lead, mercury, hydrogen chloride, and dioxin/furan emissions instead of conducting performance testing using EPA manual test methods), municipal waste combustor unit load level, and particulate matter control device inlet temperature based on the data recorded;

(4) List the highest opacity level measured based on the data recorded;

(5) Periods when valid data were not obtained;

(6) The total number of hours per calendar quarter and hours per calendar year that valid data for NO_X, SO_2, CO, municipal waste combustor unit load, or particulate matter control device temperature data were not obtained based on the data recorded; and

(7) Periods when valid data were excluded from the calculation of average emissions concentration or parameters.

g. The owner or operator shall submit a semiannual report that includes the information specified in 40 CFR 60.59b(h)(1) through (5), according to the schedule specified in 40 CFR 60.59b(h)(6). [40 CFR 60.59b(h)]

h. All reports shall be submitted as a paper copy, postmarked on or before the submittal dates specified under these paragraphs, and maintained onsite as a paper copy for a period of 5 years. [40 CFR 60.59b(j)]

i. All records specified in 40 CFR 60.59b(d) and (e), shall be maintained onsite in either paper copy or computer-readable format, unless an alternative format is approved by the Administrator. [40 CFR 60.59b(k)]

7. Specific Control Equipment Operating Conditions:

a. The spray dryer absorber scrubber shall be operated at all times that emission unit 01 (municipal solid waste gasifier) is in operation.

b. The owner or operator shall monitor and record the following scrubber operating parameters at least once per shift:

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

(1) Flow rate of the scrubbing liquor; and

(2) Daily average of amount of infusion of sodium bicarbonate and calcium oxide, and aqueous ammonia per ton of MSW fed to the unit.

c. Refer to Specific Monitoring Requirements f, and g, for emission unit 01 of this permit, for usage of activated carbon as mercury, dioxin/furan, and hydrogen chloride emissions control.

d. The baghouse will be operated at all times emission unit 01 is in operation.

8. **Alternate Operating Scenarios:**
None

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

Emission Unit: 02 (02) Yard Area and Unpaved Haul Road

Description:
Fugitive emissions from the yard area and unpaved haul road, servicing the municipal solid waste gasifier.

APPLICABLE REGULATIONS:
401 KAR 63:010, Fugitive Emissions.

1. Operating Limitations:

a. Pursuant to 401 KAR 63:010, Section 3, reasonable precautions shall be taken to prevent particulate matter from becoming airborne. Such reasonable precautions shall include, when applicable, but not be limited to the following:
   (1) Application and maintenance of asphalt, oil, water, or suitable chemicals on roads, material stockpiles, and other surfaces which can create airborne dusts;
   (2) Covering, at all times when in motion, open bodied trucks transporting materials likely to become airborne;
   (3) The maintenance of paved roads in a clean condition; and.
   (4) The prompt removal of earth or other material from a paved street where earth or other material has been transported thereto, by trucking or earth moving equipment or erosion by water.

Compliance Demonstration Method:
Compliance with the Operation Limitations will be demonstrated by the good operating procedures listed above.

2. Emission Limitations:
Discharge of visible fugitive dust emissions beyond the property line is prohibited. [401 KAR 63:010, Section 3]

Compliance Demonstration Method:
Compliance with Emission Limitations shall be demonstrated by Operating Limitations.

3. Testing Requirements:
None

4. Specific Monitoring Requirements:
The owner or operator shall monitor the amount of raw materials, waste materials, and final products to estimate vehicle miles traveled for use in AP-42 emission calculations for paved and unpaved roadways (includes yard area). [401 KAR 52:030, Section 26]

5. Specific Recordkeeping Requirements:

a. The owner or operator shall maintain records of the calculations used to determine the fugitive emissions from paved and unpaved roads with all data used in the calculations. Emission calculations shall be based on the most current AP-42

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

emission factors for paved and unpaved roadways for that year. [401 KAR 52:030, Section 26]

b. The owner or operator shall keep records of the dates that it vacuumed, swept, and applied water or dust suppressants to roadways. [401 KAR 52:030, Section 26]

6. Specific Reporting Requirements:

None

7. Specific Control Equipment Operating Conditions:

The owner or operator shall employ a combination of the following to control fugitive dust emissions: sweeping or vacuuming for paved roads; watering; and the use of dust suppressants on roads and material stockpiles. [401 KAR 52:030, Section 26]

8. Alternate Operating Scenarios:

None

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

Emission Unit 03 **Transfer to Silos**
Construction Date: None

Descriptions:

Process 001 (06): Cement transfer to silo
Load Rate: 18 cubic yards of truck mix concrete per hour (491 lbs of cement per cubic yard of truck mix concrete, AP-42 11.12-3)
Control Device: Dust sock on silo vent

Process 001 (07): Fly ash transfer to silo
Load Rate: 18 cubic yards of truck mix concrete per hour (73 lbs cement supplement/yd^3 of truck mix concrete, AP-42 11.12-3)
Control Device: Dust sock on silo vent

APPLICABLE REGULATIONS:
401 KAR 59:010, New process operations.

1. Operating Limitations:
None

2. Emission Limitations:

a. Particulate matter emissions into the open air shall not exceed [$3.59(P)^{0.62}$] lbs/hr, where P is the processing rate in tons/hr. [401 KAR 59:010, Section 3(2)]

b. Any continuous emissions into the open air shall not equal or exceed 20 percent opacity based on a six-minute average. [401 KAR 59:010, Section 3(1)(a)]

Compliance Demonstration Method:

a. The following formula and table of emissions factors from AP-42 11.12-3, shall be used to show compliance with the particulate emission limit:

Hourly Emission Rate = Monthly processing rate x Post Control Emission factor/Hours of operation per month

Description	Post Control Emission Factor (pounds per cubic yard of truck mix concrete)
Cement Transfer to Silo	3.6×10^{-3}
Fly Ash Transfer to Silo	5.4×10^{-3}

b. For compliance with visible emissions limit, the owner or operator shall perform weekly visual inspections.

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

3. Testing Requirements:
None

4. Specific Monitoring Requirements:

a. Pursuant to 401 KAR 52:030, Section 26, The owner or operator shall perform weekly visual inspections where:
   (1) If no visible emissions are observed then no further monitoring is required.
   (2) If visible emissions are observed, then an inspection of the control equipment shall be initiated and corrective action taken. If visible emissions are present after the corrective action, the process shall be shut down and shall not be operated again until repairs have been made that result in no visible emissions from the process during operation. In lieu of shutting the process down, the owner or operator may determine the opacity using Reference Method 9. If the opacity limit is not exceeded, the process may continue to operate.

5. Specific Recordkeeping Requirements:
The owner or operator shall keep log of the weekly qualitative visible emission observations.

6. Specific Reporting Requirements:
None

7. Specific Control Equipment Operating Conditions:
All the air pollution control systems shall be maintained regularly in accordance with good engineering practices and the recommendations of the respective manufacturers. A log shall be kept of all routine and nonroutine maintenance performed on each control device.

8. Alternate Operating Scenarios:
None

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

Emission Unit 04	**Aggregate and Sand Handling**
Construction Date:	None

Descriptions:

Process 001 (03AD):	Aggregate delivery to storage
Load Rate:	18 cubic yards of truck mix concrete per hour (1865 lbs of aggregate per cubic yard of truck mix concrete, AP-42 11.12-3)
Control Device:	None

Process 002 (03AS):	Aggregate storage
Load Rate:	16.785 tons of aggregate stored per hour
Control Device:	Moisture carryover or wet suppression

Process 003 (03SD):	Sand delivery to storage
Load Rate:	18 cubic yards of truck mix concrete per hour (1428 lbs of sand per cubic yard of truck mix concrete, AP-42 11.12-3)
Control Device:	None

Process 004 (03SS):	Sand storage
Load Rate:	12.825 tons of aggregate stored per hour
Control Device:	Enclosure, moisture carryover or wet suppression

Process 005 (04):	Weigh hopper-aggregate & sand
Load Rate:	18 cubic yards of truck mix concrete per hour
Control Device:	None

Process 006 (05AT):	Aggregate transfer to conveyor
Load Rate:	18 cubic yards of truck mix concrete per hour
Control Device:	None

Process 007 (05ST):	Sand transfer to conveyor
Load Rate:	18 cubic yards of truck mix concrete per hour
Control Device:	None

Process 008 (08):	Weigh hopper-cement & fly ash
Load Rate:	18 cubic yards of truck mix concrete per hour
Control Device:	None

Process 009 (09):	Truck mix loading
Load Rate:	18 cubic yards of truck mix concrete per hour
Control Device:	None

SECTION B - EMISSION POINTS, EMISSION UNITS, APPLICABLE REGULATIONS, AND OPERATING CONDITIONS (CONTINUED)

APPLICABLE REGULATIONS:
401 KAR 63:010, Fugitive Emissions

1. Operating Limitations:
No person shall cause, suffer, or allow any material to be handled, processed, transported, or stored; a building or its appurtenances to be constructed, altered, repaired, or demolished, without taking reasonable precaution to prevent particulate matter from becoming airborne. Such reasonable precautions shall include, when applicable, but not be limited to the following: installation and use of hoods; fans; and fabric filters to enclose and vent the handling of dusty materials, or the use of water sprays or other measures to suppress the dust emissions during handling. [401 KAR 63:010, Section 3]

2. Emission Limitations:
Discharge of visible fugitive dust emissions beyond the property line is prohibited. [401 KAR 63:010, Section 3]

Compliance Demonstration Method:
Compliance with Emission Limitations shall be demonstrated by Operating Limitations.

3. Testing Requirements:
None

4. Specific Monitoring Requirements:
None

5. Specific Recordkeeping Requirements:
The owner or operator shall monitor the visible fugitive emissions on a daily basis.

6. Specific Reporting Requirements:
None

7. Specific Control Equipment Operating Conditions:
None

8. Alternate Operating Scenarios:
None

SECTION C - INSIGNIFICANT ACTIVITIES

The following listed activities have been determined to be insignificant activities for this source pursuant to 401 KAR 52:030, Section 6. Although these activities are designated as insignificant the permittee must comply with the applicable regulation. Process and emission control equipment at each insignificant activity subject to an opacity standard shall be inspected monthly and a qualitative visible emissions evaluation made. Results of the inspection, evaluation, and any corrective action shall be recorded in a log.

	Description	Generally Applicable Regulation
1.	Ash/Frit loading Silo	401 KAR 59:010
2.	Lime loading Silo	401 KAR 59:010
3.	Carbon loading Silo	401 KAR 59:010

SECTION D - SOURCE EMISSION LIMITATIONS AND TESTING REQUIREMENTS

1. As required by Section 1b of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26; compliance with annual emissions and processing limitations contained in this permit, shall be based on emissions and processing rates for any twelve (12) consecutive months.

2. Emissions of particulate matter, NOx, CO, hydrogen chloride, and dioxins/furans, measured by applicable reference methods, or an equivalent of alternative method specified in 40 C.F.R. Chapter I, or by a test method specified in the state implementation plan shall not exceed the respective limitations specified herein.

3. Testing shall be conducted at such times as may be required by the cabinet in accordance with the 401 KAR 59:005 Section 2 (2) and 401 KAR 50:045 Section 4.

4. Emissions for NO_x, CO, and hazardous air pollutant(s) (HAP), during any consecutive 12-month period for the entire source, shall not exceed the following:
   a. NO_x 90.0 tons
   b. CO 90.0 tons
   c. Single HAP 9.0 tons
   d. Combined HAP 22.5 tons

   Compliance Demonstration Method:
   The maximum charging rate of MSW to emission unit 01 (municipal solid waste gasifier) shall not exceed 18.3 tons/hr and 440 tons/day. The control equipment associated with emission unit 01 operations shall be properly operated in accordance with manufacturer's specifications and standard operating procedures at all times. The owner or operator is required to use the control equipment associated with emission unit 01 in order meet the emission limits. The owner or operator shall calculate and record the total NO_X, CO, individual HAP, and combined HAP emissions monthly and on a twelve consecutive month rolling total. Emission calculations shall be performed using data from CEMS and the most recent performance test which demonstrated compliance and the total monthly hours of operation of the emission unit 01.

SECTION E - SOURCE CONTROL EQUIPMENT REQUIREMENTS

1. Pursuant to 401 KAR 50:055, Section 2(5), at all times, including periods of startup, shutdown and malfunction, owners and operators shall, to the extent practicable, maintain and operate any affected facility including associated air pollution control equipment in a manner consistent with good air pollution control practice for minimizing emissions. Determination of whether acceptable operating and maintenance procedures are being used will be based on information available to the Division which may include, but is not limited to, monitoring results, opacity observations, review of operating and maintenance procedures, and inspection of the source.

2. Pursuant to 40 CFR 60.58b, duration of startup, shutdown, or malfunction periods are limited to three hours per occurrence, except as in 40 CFR 60.58b(a)(1)(iii). During periods of startup, shutdown, or malfunction, monitoring data shall be dismissed or excluded from compliance calculations, but shall be recorded and reported in accordance with the provisions of 40 CFR 60.59b(d)(7).

3. The startup period commences when the affected facility begins the continuous burning of MSW and does not include any warm up period when the affected facility is combusting fossil fuel or other nonmunicipal solid waste fuel, and no MSW is being fed to the combustor.

4. Continuous burning is the continuous, semi-continuous, or batch feeding of MSW for purposes of waste disposal, energy production, or providing heat to the combustion system in preparation for waste disposal or energy production. The use of MSW solely to provide thermal protection of the grate or hearth during the startup period when MSW is not being fed to the grate, is not considered to be continuous burning.

5. For the purpose of compliance with the CO emission limits, if a loss of boiler water level control (e.g., boiler waterwall tube failure) or a loss of combustion air control (e.g., loss of combustion air fan, induced draft fan, combustion grate bar failure) is determined to be a malfunction, the duration of the malfunction period is limited to 15 hours per occurrence. During such periods of malfunction, monitoring data shall be dismissed or excluded from compliance calculations, but shall be recorded and reported in accordance with the provisions of 40 CFR 60.59b(d)(7).

SECTION F - MONITORING, RECORDKEEPING, AND REPORTING REQUIREMENTS

1. Pursuant to Section 1b-IV-1 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030 Section 26, when continuing compliance is demonstrated by periodic testing or instrumental monitoring, the permittee shall compile records of required monitoring information that include:
   a. Date, place (as defined in this permit), and time of sampling or measurements;
   b. Analyses performance dates;
   c. Company or entity that performed analyses;
   d. Analytical techniques or methods used;
   e. Analyses results; and
   f. Operating conditions during time of sampling or measurement.

2. Records of all required monitoring data and support information, including calibrations, maintenance records, and original strip chart recordings, and copies of all reports required by the Division for Air Quality, shall be retained by the permittee for a period of five (5) years and shall be made available for inspection upon request by any duly authorized representative of the Division for Air Quality [401 KAR 52:030, Section 3(1)(f)1a, and Section 1a-7 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

3. In accordance with the requirements of 401 KAR 52:030, Section 3(1)f, the permittee shall allow authorized representatives of the Cabinet to perform the following during reasonable times:
   a. Enter upon the premises to inspect any facility, equipment (including air pollution control equipment), practice, or operation;
   b. To access and copy any records required by the permit;
   c. Sample or monitor, at reasonable times, substances or parameters to assure compliance with the permit or any applicable requirements.

   Reasonable times are defined as during all hours of operation, during normal office hours; or during an emergency.

4. No person shall obstruct, hamper, or interfere with any Cabinet employee or authorized representative while in the process of carrying out official duties. Refusal of entry or access may constitute grounds for permit revocation and assessment of civil penalties.

5. Summary reports of any monitoring required by this permit shall be submitted to the Regional Office listed on the front of this permit at least every six (6) months during the life of this permit, unless otherwise stated in this permit. For emission units that were still under construction or which had not commenced operation at the end of the 6-month period covered by the report and are subject to monitoring requirements in this permit, the report shall indicate that no monitoring was performed during the previous six months because the emission unit was not in operation [Sections 1b-V-1 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

SECTION F - MONITORING, RECORDKEEPING, AND REPORTING REQUIREMENTS (CONTINUED)

6. The semi-annual reports are due by January 30th and July 30th of each year. All reports shall be certified by a responsible official pursuant to 401 KAR 52:030, Section 22. If continuous emission and opacity monitors are required by regulation or this permit, data shall be reported in accordance with the requirements of 401 KAR 59:005, General Provisions, Section 3(3). All deviations from permit requirements shall be clearly identified in the reports.

7. In accordance with the provisions of 401 KAR 50:055, Section 1, the owner or operator shall notify the Regional Office listed on the front of this permit concerning startups, shutdowns, or malfunctions as follows:
   a. When emissions during any planned shutdowns and ensuing startups will exceed the standards, notification shall be made no later than three (3) days before the planned shutdown, or immediately following the decision to shut down, if the shutdown is due to events which could not have been foreseen three (3) days before the shutdown.
   b. When emissions due to malfunctions, unplanned shutdowns and ensuing startups are or may be in excess of the standards, notification shall be made as promptly as possible by telephone (or other electronic media) and shall be submitted in writing upon request.

8. The owner or operator shall report emission related exceedances from permit requirements including those attributed to upset conditions (other than emission exceedances covered by Section F.7 above) to the Regional Office listed on the front of this permit within 30 days. Deviations from permit requirements, including those previously reported under F.7 above, shall be included in the semiannual report required by F.6 [Sections 1b-V, 3 and 4 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

9. Pursuant to 401 KAR 52:030, Section 21, the permittee shall annually certify compliance with the terms and conditions contained in this permit by completing and returning a Compliance Certification Form (DEP 7007CC) (or an alternative approved by the regional office) to the Regional Office listed on the front of this permit in accordance with the following requirements:
   a. Identification of each term or condition;
   b. Compliance status of each term or condition of the permit;
   c. Whether compliance was continuous or intermittent;
   d. The method used for determining the compliance status for the source, currently and over the reporting period.
   e. For an emissions unit that was still under construction or which has not commenced operation at the end of the 12-month period covered by the annual compliance certification, the permittee shall indicate that the unit is under construction and that compliance with any applicable requirements will be demonstrated within the timeframes specified in the permit.

SECTION F - MONITORING, RECORDKEEPING, AND REPORTING REQUIREMENTS (CONTINUED)

f. The certification shall be submitted by January 30th of each year. Annual compliance certifications shall be sent to the Division for Air Quality, Hazard Regional Office, 233 Birch Street, Suite 2, Hazard, KY 41701.

10. In accordance with 401KAR 52:030, Section 3(1)(d), the permittee shall provide the Division with all information necessary to determine its subject emissions within 30 days of the date the Kentucky Emissions Inventory System (KYEIS) emissions survey is mailed to the permittee. If a KYEIS emissions survey is not mailed to the permittee, then the permittee shall comply with all other emissions reporting requirements in this permit.

11. The Cabinet may authorize the temporary use of an emission unit to replace a similar unit that is taken off-line for maintenance, if the following conditions are met:
    a. The owner or operator shall submit to the Cabinet, at least ten (10) days in advance of replacing a unit, the appropriate Forms DEP7007AI to DD that show:
        (1) The size and location of both the original and replacement units; and
        (2) Any resulting change in emissions;
    b. The potential to emit (PTE) of the replacement unit shall not exceed that of the original unit by more than twenty-five (25) percent of a major source threshold, and the emissions from the unit shall not cause the source to exceed the emissions allowable under the permit;
    c. The PTE of the replacement unit or the resulting PTE of the source shall not subject the source to a new applicable requirement;
    d. The replacement unit shall comply with all applicable requirements; and
    e. The source shall notify Regional office of all shutdowns and start-ups.
    f. Within six (6) months after installing the replacement unit, the owner or operator shall:
        (1) Re-install the original unit and remove or dismantle the replacement unit; or
        (2) Submit an application to permit the replacement unit as a permanent change.

SECTION G - GENERAL PROVISIONS

1. General Compliance Requirements

a. The permittee shall comply with all conditions of this permit. A noncompliance shall be a violation of 401 KAR 52:030, Section 3(1)(b), and a violation of Federal Statute 42 USC 7401 through 7671q (the Clean Air Act). Noncompliance with this permit is grounds for enforcement action including but not limited to the termination, revocation and reissuance, revision, or denial of a permit [Section 1a-2 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

b. The filing of a request by the permittee for any permit revision, revocation, reissuance, or termination, or of a notification of a planned change or anticipated noncompliance, shall not stay any permit condition [Section 1a-5 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

c. This permit may be revised, revoked, reopened and reissued, or terminated for cause in accordance with 401 KAR 52:030, Section 18. The permit will be reopened for cause and revised accordingly under the following circumstances:

(1) If additional applicable requirements become applicable to the source and the remaining permit term is three (3) years or longer. In this case, the reopening shall be completed no later than eighteen (18) months after promulgation of the applicable requirement. A reopening shall not be required if compliance with the applicable requirement is not required until after the date on which the permit is due to expire, unless this permit or any of its terms and conditions have been extended pursuant to 401 KAR 52:030, Section 12;3

(2) The Cabinet or the United States Environmental Protection Agency (U. S. EPA) determines that the permit must be revised or revoked to assure compliance with the applicable requirements;

(3) The Cabinet or the U. S. EPA determines that the permit contains a material mistake or that inaccurate statements were made in establishing the emissions standards or other terms or conditions of the permit.

Proceedings to reopen and reissue a permit shall follow the same procedures as apply to initial permit issuance and shall affect only those parts of the permit for which cause to reopen exists. Reopenings shall be made as expeditiously as practicable. Reopenings shall not be initiated before a notice of intent to reopen is provided to the source by the Division, at least thirty (30) days in advance of the date the permit is to be reopened, except that the Division may provide a shorter time period in the case of an emergency.

d. The permittee shall furnish information upon request of the Cabinet to determine if cause exists for modifying, revoking and reissuing, or terminating the permit; or to determine compliance with the conditions of this permit [Sections 1a- 6 and 7 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

SECTION G - GENERAL PROVISIONS (CONTINUED)

e. Emission units described in this permit shall demonstrate compliance with applicable requirements if requested by the Division [401 KAR 52:030, Section 3(1)(c)].

f. The permittee, upon becoming aware that any relevant facts were omitted or incorrect *information was submitted in the permit application, shall promptly submit such* supplementary facts or corrected information to the permitting authority [401 KAR 52:030, Section 7(1)].

g. Any condition or portion of this permit which becomes suspended or is ruled invalid as a result of any legal or other action shall not invalidate any other portion or condition of this permit [Section 1a-11 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

h. The permittee shall not use as a defense in an enforcement action the contention that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance [Section 1a-3 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

i. All emission limitations and standards contained in this permit shall be enforceable as a practical matter. All emission limitations and standards contained in this permit are enforceable by the U.S. EPA and citizens except for those specifically identified in this permit as state-origin requirements. [Section 1a-12 of the Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources incorporated by reference in 401 KAR 52:030, Section 26].

j. This permit shall be subject to suspension if the permittee fails to pay all emissions fees within 90 days after the date of notice as specified in 401 KAR 50:038, Section 3(6) [Section 1a-9 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

k. Nothing in this permit shall alter or affect the liability of the permittee for any violation of applicable requirements prior to or at the time of permit issuance [401 KAR 52:030, Section 11(3)].

l. This permit does not convey property rights or exclusive privileges [Section 1a-8 of the *Cabinet Provisions and Procedures for Issuing Federally-Enforceable Permits for Non-Major Sources* incorporated by reference in 401 KAR 52:030, Section 26].

m. Issuance of this permit does not relieve the permittee from the responsibility of obtaining any other permits, licenses, or approvals required by the Cabinet or any other federal, state, or local agency.

SECTION G - GENERAL PROVISIONS (CONTINUED)

n. Nothing in this permit shall alter or affect the authority of U.S. EPA to obtain information pursuant to Federal Statute 42 USC 7414, Inspections, monitoring, and entry.

o. Nothing in this permit shall alter or affect the authority of U.S. EPA to impose emergency orders pursuant to Federal Statute 42 USC 7603, Emergency orders.

p. This permit consolidates the authority of any previously issued PSD, NSR, or Synthetic Minor source preconstruction permit terms and conditions for various emission units and incorporates all requirements of those existing permits into one single permit for this source.

q. Pursuant to 401 KAR 52:030, Section 11, a permit shield shall not protect the owner or operator from enforcement actions for violating an applicable requirement prior to or at the time of permit issuance. Compliance with the conditions of this permit shall be considered compliance with:
   (1) Applicable requirements that are included and specifically identified in this permit; and
   (2) Non-applicable requirements expressly identified in this permit.

2. Permit Expiration and Reapplication Requirements

a. This permit shall remain in effect for a fixed term of five (5) years following the original date of issue. Permit expiration shall terminate the source's right to operate unless a timely and complete renewal application has been submitted to the Division at least six (6) months prior to the expiration date of the permit. Upon a timely and complete submittal, the authorization to operate within the terms and conditions of this permit, including any permit shield, shall remain in effect beyond the expiration date, until the renewal permit is issued or denied by the Division [401 KAR 52:030, Section 12].

b. The authority to operate granted through this permit shall cease to apply if the source fails to submit additional information requested by the Division after the completeness determination has been made on any application, by whatever deadline the Division sets [401 KAR 52:030, Section 8(2)].

3. Permit Revisions

a. Minor permit revision procedures specified in 401 KAR 52:030, Section 14(3), may be used for permit revisions involving the use of economic incentive, marketable permit, emission trading, and other similar approaches, to the extent that these minor permit revision procedures are explicitly provided for in the State Implementation Plan (SIP) or in applicable requirements and meet the relevant requirements of 401 KAR 52:030, Section 14(2).\

b. This permit is not transferable by the permittee. Future owners and operators shall obtain a new permit from the Division for Air Quality. The new permit may be

SECTION G - GENERAL PROVISIONS (CONTINUED)

processed as an administrative amendment if no other change in this permit is necessary, and provided that a written agreement containing a specific date for transfer of permit responsibility coverage and liability between the current and new permittee has been submitted to the permitting authority within ten (10) days following the transfer.

4. Construction, Start-Up, and Initial Compliance Demonstration Requirements

Pursuant to a duly submitted application the Kentucky Division for Air Quality hereby authorizes the construction of the equipment described herein, emission units 03 (Transfer to silos) and 04 (Aggregate and sand deliver, storage, loading and transfer) in accordance with the terms and conditions of this permit.

a. Construction of any process and/or air pollution control equipment authorized by this permit shall be conducted and completed only in compliance with the conditions of this permit.

b. Within thirty (30) days following commencement of construction and within fifteen (15) days following start-up and attainment of the maximum production rate specified in the permit application, or within fifteen (15) days following the issuance date of this permit, whichever is later, the permittee shall furnish to the Regional Office listed on the front of this permit in writing, with a copy to the Field Office Branch of the Frankfort Central Office, notification of the following:
   (1) The date when construction commenced.
   (2) The date of start-up of the affected facilities listed in this permit.
   (3) The date when the maximum production rate specified in the permit application was achieved.

c. Pursuant to 401 KAR 52:030, Section 3(2), unless construction is commenced within eighteen (18) months after the permit is issued, or begins but is discontinued for a period of eighteen (18) months or is not completed within a reasonable timeframe then the construction and operating authority granted by this permit for those affected facilities for which construction was not completed shall immediately become invalid. Upon written request, the Cabinet may extend these time periods if the source shows good cause.

d. For those affected facilities for which construction is authorized by this permit, a source shall be allowed to construct with the final permit. Operational or final permit approval is not granted by this permit until compliance with the applicable standards specified herein has been demonstrated pursuant to 401 KAR 50:055. If compliance is not demonstrated within the prescribed timeframe provided in 401 KAR 50:055, the source shall operate thereafter only for the purpose of demonstrating compliance, unless otherwise authorized by Section I of this permit or order of the Cabinet.

e. This permit shall allow time for the initial start-up, operation, and compliance demonstration of the affected facilities listed herein. However, within sixty (60) days after achieving the maximum production rate at which the affected facilities

SECTION G - GENERAL PROVISIONS (CONTINUED)

will be operated but not later than 180 days after initial start-up of such facilities, the permittee shall conduct a performance demonstration on the affected facilities in accordance with 401 KAR 50:055, General compliance requirements. Testing must also be conducted in accordance with General Provisions G.5 of this permit.

f. Terms and conditions in this permit established pursuant to the construction authority of 401 KAR 51:017 or 401 KAR 51:052 shall not expire.

5. Testing Requirements

a. Pursuant to 401 KAR 50:045, Section 2, a source required to conduct a performance test shall submit a completed Compliance Test Protocol form, DEP form 6028, or a test protocol a source has developed for submission to other regulatory agencies, in a format approved by the cabinet, to the Division's Frankfort Central Office a minimum of sixty (60) days prior to the scheduled test date. Pursuant to 401 KAR 50:045, Section 7, the Division shall be notified of the actual test date at least Thirty (30) days prior to the test.

b. Pursuant to 401 KAR 50:045, Section 5, in order to demonstrate that a source is capable of complying with a standard at all times, any required performance test shall be conducted under normal conditions that are representative of the source's operations and create the highest rate of emissions. If [When] the maximum production rate represents a source's highest emissions rate and a performance test is conducted at less than the maximum production rate, a source shall be limited to a production rate of no greater than 110 percent of the average production rate during the performance tests. If and when the facility is capable of operation at the rate specified in the application, the source may retest to demonstrate compliance at the new production rate. The Division for Air Quality may waive these requirements on a case-by-case basis if the source demonstrates to the Division's satisfaction that the source is in compliance with all applicable requirements.

c. Results of performance test(s) required by the permit shall be submitted to the Division by the source or its representative within forty-five days or sooner if required by an applicable standard, after the completion of the fieldwork.

6. Acid Rain Program Requirements

a. If an applicable requirement of Federal Statute 42 USC 7401 through 7671q (the Clean Air Act) is more stringent than an applicable requirement promulgated pursuant to Federal Statute 42 USC 7651 through 7651o (Title IV of the Act), both provisions shall apply, and both shall be state and federally enforceable.

7. Emergency Provisions

a. Pursuant to 401 KAR 52:030, Section 23(1), an emergency shall constitute an affirmative defense to an action brought for noncompliance with the technology-

SECTION G - GENERAL PROVISIONS (CONTINUED)

based emission limitations if the permittee demonstrates through properly signed contemporaneous operating logs or other relevant evidence that:

(1) An emergency occurred and the permittee can identify the cause of the emergency;

(2) The permitted facility was at the time being properly operated;

(3) During an emergency, the permittee took all reasonable steps to minimize levels of emissions that exceeded the emissions standards or other requirements in the permit; and,

(4) The permittee notified the Division as promptly as possible and submitted written notice of the emergency to the Division within two (2) working days of the time when emission limitations were exceeded due to an emergency. The notice shall include a description of the emergency, steps taken to mitigate emissions, and the corrective actions taken.

(5) Notification of the Division does not relieve the source of any other local, state or federal notification requirements.

b. Emergency conditions listed in General Provision G.7.a above are in addition to any emergency or upset provision(s) contained in an applicable requirement [401 KAR 52:030, Section 23(3)].

c. In an enforcement proceeding, the permittee seeking to establish the occurrence of an emergency shall have the burden of proof [401 KAR 52:030, Section 23(2)].

8. Ozone depleting substances

a. The permittee shall comply with the standards for recycling and emissions reduction pursuant to 40 CFR 82, subpart F, except as provided for Motor Vehicle Air Conditioners (MVACs) in subpart B:

(1) Persons opening appliances for maintenance, service, repair, or disposal shall comply with the required practices contained in 40 CFR 82.156.

(2) Equipment used during the maintenance, service, repair, or disposal of appliances shall comply with the standards for recycling and recovery equipment contained in 40 CFR 82.158.

(3) Persons performing maintenance, service, repair, or disposal of appliances shall be certified by an approved technician certification program pursuant to 40 CFR 82.161.

(4) Persons disposing of small appliances, MVACs, and MVAC-like appliances (as defined at 40 CFR 82.152) shall comply with the recordkeeping requirements pursuant to 40 CFR 82.166.

(5) Persons owning commercial or industrial process refrigeration equipment shall comply with the leak repair requirements pursuant to 40 CFR 82.156.

(6) Owners/operators of appliances normally containing 50 or more pounds of refrigerant shall keep records of refrigerant purchased and added to such appliances pursuant to 40 CFR 82.166.

SECTION G - GENERAL PROVISIONS (CONTINUED)

b. If the permittee performs service on motor (fleet) vehicle air conditioners containing ozone-depleting substances, the source shall comply with all applicable requirements as specified in 40 CFR 82, Subpart B, *Servicing of Motor Vehicle Air Conditioners*.

9. Risk Management Provisions

a. The permittee shall comply with all applicable requirements of 401 KAR Chapter 68, Chemical Accident Prevention, which incorporates by reference 40 CFR Part 68, Risk Management Plan provisions. If required, the permittee shall comply with the Risk Management Program and submit a Risk Management Plan to:

RMP Reporting Center
P.O. Box 10162
Fairfax, VA 22038

b. If requested, submit additional relevant information to the Division or the U.S. EPA.

SECTION H - ALTERNATE OPERATING SCENARIOS

None

SECTION I - COMPLIANCE SCHEDULE

None