Chapter 16 - Incineration System Optimization

Incinerator system optimization refers to operation and maintenance (O&M) factors that can be influenced directly by the shift and chief operators at a facility. The term does not refer to options that may be available during design of a facility, such as the type(s) of auxiliary fuel that will be used, or to factors that may be decided during a major upgrade, such as the type of emission control systems to be installed. For the most part, these factors are beyond the control of an operator facing a challenge on a given day. This chapter provides recommendations regarding the optimization of a system as constructed.

16.1 Critical Control Points / Operational Controls

The controls associated with running an incineration system as efficiently as possible vary with the many different types of equipment and combinations of equipment used today. A different list of controls should be established for each individual incineration system. The controls discussed in this chapter are divided into three major categories: controls that are general in nature and apply to any type of incineration system; controls that apply to only MHFs; and controls that apply to only FBIs.

General Controls

- Operator Training
- Record Keeping and Reporting
- Feed Characteristics
- Feed Rate

MHF Controls

- Air Entry Rate
- Hearth and Breech Temperature
- Rotational Speed of the Central Shaft
- Emergency Controls

FBI Controls

- Airflow
- Bed Material
- Bed Depth
- Bed and Freeboard Temperature
- Emergency Controls

16.2 General Controls

General controls apply to any type of incineration system. For the most part, they consist of common sense operational rules. However, because these factors are obvious, they are sometimes taken for granted and overlooked or not adequately planned for. For example, the importance of effective communication as part of an ongoing operator training program can sometimes be considered a lower priority when compared to daily challenge of managing a large incinerator or wastewater treatment facility.

16.2.1 Operator Training

> *The best designed and constructed incinerator systems will not operate to their maximum efficiency without properly trained operators*

The best designed and constructed incinerator systems will not operate to their maximum efficiency without properly trained operators. As a result, any incinerator optimization program should begin with operator training. All personnel who work around the incinerator and/or ancillary systems should be trained to know what normal operating conditions are and who to notify if an operating parameter appears to be outside of its normal range. Operators in charge of the incinerator must receive thorough training. All employees who may affect how the incinerator operates must also receive training in their specific tasks and how their work may affect the entire system. These positions include load handlers, ash handlers and maintenance personnel.

Training at a particular facility should begin with development of a thorough, and up to date, operation and maintenance (O&M) manual. An O&M manual should have been developed during construction of the incinerator system by the equipment manufacturer and design engineer. Unfortunately, these manuals often become outdated as modifications are made or as facilities refine the recommended operating procedures to meet their unique circumstances. Facility administrators should keep the O&M manual up to date and make it a useful training tool for newer employees and a valuable reference for experienced operators. While some of the writing can be completed by outside consultants, it will be necessary for key employees to play a role in maintaining the O&M manual. Consider a task force consisting of the key employees to periodically review the O&M manual, and recommend changes. This activity will serve not only to keep the manual up to date, but also will encourage discussion and review O&M procedures. The information contained in the O&M manual should be included with the agencies Environmental Management System.

The following items should be considered when developing included in an O&M manual. Other items may be added as needed for a specific site.

- A summary of requirements for the facility such. These may include self-imposed limitations such as a minimum solids content of the feed biosolids.
- An overall description of the entire system with figures that identify key components and narrative that describes the basic function of each unit process.
- A description of the basic combustion principles for the type of incinerator used.
- Procedures for receiving, handling and feeding biosolids to the incinerator.
- Procedures to be followed during startup and shutdown of the incinerator.
- Procedures for operating the incinerator and ancillary systems to maintain compliance with regulatory requirements.
- Procedures for responding to periodic upsets or malfunction of the incinerator and/or ancillary systems.
- Procedures for handling ash.
- A list of agencies and personnel to notify in case of emergency. This may include

different contacts for different unit processes.
- Procedures for record keeping and reporting.

The manual should be kept in easily accessible locations at the facility such as the control room, main office and break room.

Another useful training tool for facility administrators and key operating personnel that is often underutilized is exchanging information with similar facilities. Develop a relationship with other incinerator operators in your area. Administrative, operational and maintenance personnel should meet on a regular basis to discuss things like new regulatory initiatives and recent operational challenges. Exchange programs should be established to allow O&M personnel to learn from one another.

Graphs and moving averages are powerful tools in understanding the cause and effect relationship that exists between many operational parameters

16.2.2 Record Keeping and Reporting

Maintenance of accurate records is important for three major reasons. First, periodic review of operational records allows operators to troubleshoot and optimize system performance. Graphs and moving averages are powerful tools in understanding the cause and effect relationship that exists between many operational parameters. Second, operational records are an invaluable tool to the engineer designing improvements for the incinerator or ancillary systems. Finally, accurate record keeping and reporting are required to illustrate compliance to regulatory agencies.

Federal regulations require operators to compile and keep the data listed below for at least five years.

- Concentration of arsenic, cadmium, chromium, lead and nickel in the biosolids fed to the incinerator.
- Information showing how the requirements for beryllium and mercury in the National Emission Standards for Hazardous Pollutants (NESHAPs) are being met.
- Biosolids feed rate on a dry weight basis.
- Stack height.
- Dispersion factor.
- Control efficiency for arsenic, cadmium, chromium, lead and nickel.
- The risk specific concentration for chromium.
- The THC or CO monthly average concentration in the stack exhaust gas.
- The oxygen concentration in the stack exhaust gas.
- Information used to measure the moisture content in the stack exhaust gas.
- Combustion temperatures, including maximum daily combustion temperature.
- Measurements for required air pollution control device-operating conditions.
- Calibration and maintenance log for instruments used to measure:
  --THC of CO in stack exhaust.
  --Oxygen levels in stack exhaust.
  --Moisture content in stack exhaust.
  --Combustion temperatures in furnace.

Treatment facilities serving a population greater than 10,000 or with a design flow of greater than one million gallons per day; must provide the above listed information to the permitting authority every February 19th. Reporting requirements may be more stringent in certain states.

16.2.3 Feed Characteristics

As discussed in Chapter 16, the characteristics of the feed material can have an impact on the operation of the incinerator. The incinerator operator can influence the factors that impact the characteristics of the biosolids by maintaining close coordination with the operator of the dewatering facility, the wastewater treatment facility, the collection system and the industrial pretreatment program. Examples of activities that should be monitored by operators of the incinerator include:

- <u>Dewatering System</u>: Depending on the availability of storage, the rate that biosolids are dewatered may dictate the feed rate to the incinerator. The incinerator operator should have input on the operation of the dewatering equipment. The dewatering system must be operated to maintain a consistently high solids concentration. The impact on incinerator operations must be carefully considered if planning is being conducted to replace the major components of the dewatering system. For example, if an operator of a recessed chamber or plate and frame press changes from lime and ferric chloride as the conditioning agents to an organic polymer, the softening and fusion points of the ash may be much lower and the formation of clinkers and slag may increase.

- <u>Wastewater Treatment System</u>: Operational changes at the wastewater treatment facility can impact the characteristics of the feed biosolids and operation of the incinerator. For example, a change in the mode of operation of an activated sludge facility from a low sludge age to a higher sludge age could reduce the volatile solids content, and thus the fuel value, of the biosolids. Another example of an operational modification that would impact the incinerator is initiation of chemical phosphorus removal. The addition of aluminum or iron salts, commonly used to precipitate phosphorus, may increase the quantity of waste activated sludge produced relative to the quantity of primary solids. This in turn will increase the overall quantity of dry solids fed to the incinerator and may decrease the solids concentration of the dewatered cake.

- <u>Collection System</u>: If significant seasonal variations in the quantity of ash are observed, there is a good chance that the collection system is experiencing significant inflow and infiltration problems. The incinerator operator can support the collection system manager’s efforts to correct collection system deficiencies by identifying the cost implications of passing the inert material through the incinerator and disposing of it along with the biosolids ash.

- <u>Industrial Pretreatment</u>: Part 503 Rule places restrictions on the concentration of five metals in the biosolids to be fed to incinerators. In most instances, the only control an incinerator operator has on the concentration of these metals in the biosolids is through the industrial pretreatment program. As a result, careful coordination with the pretreatment coordinator is required.

16.2.4 Feed Rate

The feed rate is an important parameter for the incinerator operators. The rate at which biosolids are incinerated is normally dictated by the quantity of material requiring disposal. A continuous steady-state feed rate is desirable from a control standpoint. If the feed rate is to be changed, a gradual increase or decrease to allows the incinerator to change gradually as well.

The manner in which the feed rate is monitored will vary depending on the conveyance system used. Facilities that incorporate conveyor systems often include weight belts to monitor feed rate. Facilities that incorporate pump systems need to rely on solids flow rate and pre-determined unit weights to calculate feed rates.

16.3 MHF Controls

There are number of controls that should be considered when optimizing MHA Operation. They include:

- Air Entry Rate
- Hearth and Breach Temperature
- Shaft Rotational Speed
- Control Llogic

16.3.1 Air Entry Rate

Airflow into a MHF serves two major functions:

- It provides a source of oxygen for the combustion process; and
- It maintains the furnace under negative pressure to prevent injury to operators. The air is generally supplied from three separate sources: recirculated shaft cooling air; the combustion air supply fan; and the induced draft fan and associated leakage.

> *To ensure complete combustion, a MHF requires 50 to 150 percent excess air over the stoichiometric amount.*

The overall quantity of air required by the incinerator is equal to the air required by the combustion process plus a volume of excess air. The amount of oxygen and therefore quantity of air, required to incinerate the biosolids can be calculated. As a rule of thumb, 7.5 pounds of air are required to release 10,000 BTU from biosolids and supplemental fuel. In practice, incinerator operation requires air in excess of the theoretical amount for complete combustion. The excess air increases the contact between the fuel and the oxygen. To ensure complete combustion, a MHF requires 50 to 150 percent excess air over the stoichiometric amount. The quantity of excess air entering a conventional MHF plays an important role in the overall efficiency of the incinerator. If insufficient air is supplied, the combustion process will be incomplete and carbon monoxide, soot and odorous hydrocarbons will be produced. An exception is the starved air combustion (SAC) previously process described. In this process, the incomplete combustion process is carefully controlled to increase the capacity of the MHF and reduce supplemental fuel use. If too much air is introduced to the incinerator, additional energy will be needed to raise the temperature of the air to the temperature of the hottest hearth.

An assessment can be made on the adequacy of the combustion air quantity based on the oxygen content of the MHF outlet gas or the oxygen content of the gases in any given hearth. Control of the amount of excess air is necessary to minimize fuel usage and, in a conventional MHF, provide adequate oxygen for complete combustion of the biosolids. In a MHF being operated in the SAC mode, a lower oxygen content would be targeted. The typical operating target for oxygen content is 6 to 9 percent dry gas basis.

In a typical MHF, the majority of combustion air is introduced into the bottom hearth. It rises to the upper combustion hearths as it warms. In the process, it also serves to cool the ash in the bottom hearth prior to discharge. Control of the air supply from each source is summarized below.

Shaft Cooling Air

The quantity of shaft cooling air available is based on the design of the MHF. In general, it is advantageous to maximize the usage of shaft cooling air as combustion air because it has been preheated as it passed up through the shaft and rabble arms. Thus, it helps to close the energy balance and minimize the use of supplemental fuel. The shaft cooling air duct on some MHFs is equipped with a damper that is automatically controlled by the oxygen content of the outlet gas or from a lower hearth.

Induced Draft Air

A number MHFs rely on induced draft fans to supply combustion air to the incinerator. Under this scenario, the amount of air entering the MHF is normally regulated by controlling the draft, or the negative pressure, within the furnace. Typically, the induced draft fan speed is automatically controlled to maintain a negative pressure of 0.05 to 0.2 inches of water column. Control over the quantity and location of air supply is often accomplished by leaving poke and peak holes open or furnace doors ajar. The degree of control available depends on how tight the incinerator shell is.

The draft, or negative pressure, should be monitored on the top and bottom hearths. The top hearth is normally used to control the induced draft fan speed.

Combustion Air Fan

Control of excess air is easier to manage in relatively airtight MHFs. The oxygen content of the outlet gas or air from a lower hearth can be used to control the combustion airflow by adjusting the position of a damper on the combustion air fan or the speed of the fan if it is equipped with a variable frequency drive. This method of control ensures that the right amount of combustion air is being supplied. Manual controls to start, stop and adjust the airflow should also be provided.

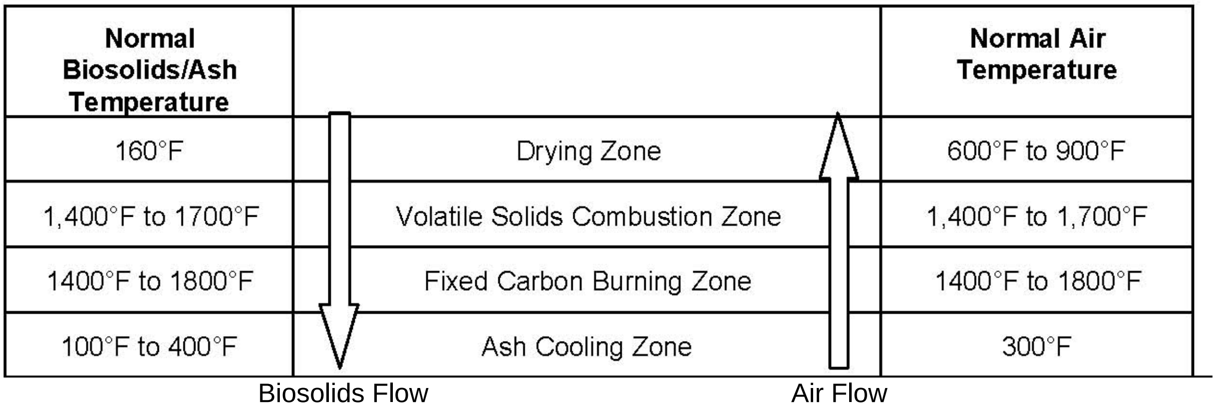
An induced draft fan is still used to ensure that the furnace is not pressurized. Keeping the furnace under negative conditions results in drawing air in through any openings in the furnace shell and not out, which could result in operator injury.

The combustion air fan should be interlocked with the emergency by-pass damper. The combustion air fan should be prevented from operating when the by-pass damper is open to prevent “fanning the fire” during an emergency.

16.3.2 Hearth and Breech Temperature

A MHF can be divided into four zones, as shown on Figure 16.1. The first zone that the biosolids are exposed to occurs in the upper hearths. It is the drying or evaporation zone where most of the water is removed. The second zone generally of the central hearths. This is the zone where the volatile solids are burned. The third zone, also in the central hearths, is the fixed carbon-burning zone, where the remaining carbon is oxidized to carbon dioxide. The fourth and final zone is the cooling zone. Incinerator ash is cooled in this zone by incoming combustion air. The sequence of these zones is always the same, but the location within the MHF varies depending on the quality of the feed, the design of the furnace and current operating conditions.

Figure 16.1 Process Zones in a MHF



Normal Biosolids/Ash Temperature		Normal Air Temperature
160°F	Drying Zone	600°F to 900°F
1,400°F to 1700°F	Volatile Solids Combustion Zone	1,400°F to 1,700°F
1400°F to 1800°F	Fixed Carbon Burning Zone	1400°F to 1800°F
100°F to 400°F	Ash Cooling Zone	300°F

Temperature should be monitored at each hearth, the outlet flue and in the emission control devices if necessary. The temperature of individual hearths is often used as control points for supplementary fuel burners. Outlet temperature is monitored and tracked to determine if the MHF is operating efficiently, and to ensure that downstream air pollution control devices are receiving an inflow that is below the maximum temperature recommended by the manufacturer. Control of the outlet temperature, is generally accomplished by regulating the entire MHF temperature.

> *For safety reasons, it is recommended that burners be ignited by the MHF operator and not by the control system.*

Control of these temperatures is primarily through operation of the auxiliary fuel burners. In the event that the biosolids are autogenous, temperature control is exerted through a combination of biosolids and combustion air feed rates. The overall control of these factors must be incorporated into the incinerator’s combustion control logic to ensure that all factors are considered when changing one variable.

The temperature of a hearth can be altered rapidly when a burner is being fired in that hearth or the one below it by changing the firing rate. Burner firing rates should be controlled by thermocouples. Controlling the burners with thermocouples located in the hearth above it produces the most stable temperature profile.

For safety reasons, it is recommended that burners be ignited by the MHF operator and not by the control system. When the combustion control logic circuit determines that a burner should be ignited, a signal will indicate which burner should be started. For safety reasons the control circuit should be able to automatically turn burners off.

When the combustion control logic circuit determines that more auxiliary fuel is required, it will signal the operators and indicate which burner to light. Once this is done, the combustion control logic circuit should adjust the fuel delivery until the desired temperature is achieved. The control circuit increases the fuel delivery by increasing the burner set point temperature on the “selected” fired hearth. When less fuel is required, the control circuit decreases the amount of auxiliary fuel being fired into the furnace. This type of control loop is commonly referred to as cascade control.

16.3.3 Shaft Rotational Speed

The center shaft rotational speed and subsequently the rabble arm speed are typically adjusted manually. Proper speed of the center shaft is important for three reasons. First, it is the mechanisms by which biosolids are conveyed through and out of the incinerator. Increases in center shaft speed increase the rate at which the rabble arms push biosolids from one hearth to the next lower hearth.

The second function of center shaft rotational speed is to enhance evaporation in the upper hearths. An optimum rabble arm speed is necessary to maximize the surface area of furrows exposed to the hot gases and radiation from the roof. If the speed is too fast, the width of the furrows will increase, reducing the exposed surface area. If the speed is too slow, the valleys between furrows will fill in with solids, again decreasing the surface area of the biosolids.

Finally, the operators can exert some control over the location of the burning zone of the furnace by adjusting the speed of the center shaft rotation. As the speed of the rotation increases, the location of the burning zone falls to lower hearths, at least initially. The amount of lowering of burning in the furnace does not always change significantly. Since the rotation speed does change the location of the burning zone, rabble arm speed has been has been eliminated by most operators and engineers as a variable from the list of parameters considered in the hearth-by-hearth heat and material balance.

16.3.4 Control Logic

The incinerator should be equipped with automatic purge and shutdown features. Emergency conditions such as high temperature at the incinerator outlet or within the incinerator itself should shut down the induced draft fan and open the emergency by-pass chamber. Controls should be provided to shut down the auxiliary fuel burners and biosolids feed equipment upon any interruption in operation of the incinerator.

A troubleshooting guide for a MHF is presented in Table 16.1 (USEPA, September 1979). The table summarizes problems that have been experienced with MHFs, probable causes and potential solutions.

Table 16.1 - MHF Troubleshooting Guide

Problem	Probable Cause	Solution
Furnace or stack gas temperature too high	Excessive fuel feed rate. Greasy feed material.	Decrease fuel feed rate. Raise air feed rate or reduce biosolids feed. Investigate cause of excessive grease with WWTF operator.
	Thermocouple faulty	Replace thermocouple
Furnace or stack gas temperature too low	Moisture content of biosolids has increased.	Increase fuel feed rate. Coordinate with dewatering system operator to increase cake solids content.
	Fuel system malfunction.	Check supplemental fuel system.
	Excessive air feed	If O2 content in stack gas is high this is the likely cause; reduce air feed rate
Oxygen content in stack gas is too high	Biosolids feed rate is too low.	Check for blockages or equipment failure and reestablish proper feed rate.
	Air feed rate is too high.	Decrease air feed rate.
	Air feed above burn zone is excessive	Check poke and peepholes and doors in upper hearths. Close as necessary
Oxygen content in stack gas is too low	Volatile solids content of grease and/or biosolids feed has increased.	Increase air feed rate and/or decrease biosolids feed rate. Investigate causes with WWTF operator.
	Air feed rate is too low	Increase air feed rate
Furnace refractories have deteriorated	Furnace has been started up and shut down too quickly	Replace refractories and review start up/shut down procedures. Conduct operator training.
Unusually high cooling effect from one hearth to another	Air leak	Check hearth doors, poke and peep holes etc. Stop leak.
Short hearth life	Uneven firing	Make sure that supplemental fuel burners are firing evenly on all sides
Center shaft shear pin failure	Rabble arms are dragging or a foreign object is caught in the furnace	Inspect and correct problem

Rabble arms drooping	Excessive hearth temperature. Loss of cooling air	Refer to high temperature problems above. Inspect and repair cooling air supply.

16.4 FBI Controls

There are a number of controls that should be considered when optimizing FBI Operation they include:

- Air Flow
- Bed Material and Bed Depth
- Bed and Freeboard Temperature
- Control Logic

16.4.1 Air Flow

Air flow is determined by two major factors: providing sufficient oxygen for combustion and fluidizing the bed.

To ensure complete combustion, a FBI requires 20 to 45 percent excess air over the stoichiometric amount

Minimum oxygen requirements must be met to assure complete oxidation of all volatile solids in the biosolids cake. The amount of oxygen and therefore quantity of air, required to incinerate the biosolids can be calculated. As a rule of thumb, 7.5 pounds of air are required to release 10,000 Btu from biosolids and supplemental fuel. In practice, incinerator operation requires air in excess of the theoretical amount for complete combustion. The excess air increases the contact between the fuel and the oxygen. To ensure complete combustion, a FBI requires 20 to 45 percent excess air over the stoichiometric amount. This represents a significant advantage of FBI as compared to MHF, which can use up 150 percent excess air. The quantity of excess air entering a conventional FBI plays an important role in the overall efficiency of the incinerator. If insufficient air is supplied, the combustion process will be incomplete and carbon monoxide, soot and odorous hydrocarbons will be produced. If too much air is introduced to the incinerator, excess bed material may be lost with the incinerator exhaust and additional energy will be needed to raise the temperature of the air to the temperature of the exhaust gas.

The size of a FBI is selected by determining the airflow required for efficient combustion at the required capacity, and then sizing the FBI such that the resulting air velocity sustains a properly fluidized bed. The design air flow rate is generally set between 2.3 and 3 feet per second. The operator can vary the airflow rate, and therefore the velocity, within a reasonable range of the design set point to increase or decrease incinerator capacity. The higher the air velocity through the FBI, the greater the combustion capacity.

Maintaining a properly fluidized bed is critical to the efficient operation of a FBI. Therefore, a basic understanding of the term “fluidized bed” is required. As air is passed upward through a bed of sand at a low rate, it percolates through the void spaces between the stationary particles. This is considered to be a fixed bed. When the air flow rate is increased, some of the particles of sand vibrate. This is an expanded bed approaching fluidization. As the airflow is increased further, a point is reached where all of the particles are suspended in the upward flowing air. The pressure drop of the air flowing through the bed is less than it was when the bed was stationary and is essentially equal to the weight of the air and the sand particles in the fluidized column. At this point, the bed is considered to be barely fluidized, minimum fluidization. With increasing airflow the bed will pass from minimum fluidization to smooth fluidization, a bed characterized by violent bubbling and channeling. This is referred to as an aggregated or bubbling fluidized bed. Further increases in airflow may cause slugging. When a bed is slugging, large gas bubbles coalesce and grow as they push upward, much like an airlift pump. Slugging is undesirable because it leads to loss of bedding material. If the airflow is increased beyond the point that slugging occurred, the bed enters lean phased fluidization and excessive amounts of bedding will be lost.

The type of bed that is desired in a biosolids incinerator is midway between smooth fluidization and slugging. This level of fluidization will result in minimum headloss, violent contact between the biosolids particles and the hot bed material and acceptable bed losses in the exhaust gas. Bed material losses in this range are normally 5 percent of the bed volume for every 300 hours of operation.

16.4.2 Bed Material and Bed Depth

Because it is normal to lose five percent of the bed volume for every 300 hours of operating time, the bed depth must be controlled to give the desired residence time this is generally measured using differential pressure devices similar to liquid level measurement. The depth of the static bed is typically 3 to 4 feet and the fluidized depth is 5 to 6 feet.

The operator has to select the appropriate material to replace the lost bedding material. Selection of the proper bedding material has a significant impact on the performance of the FBI.

Fine particles of a wide size distribution remain fluidized over a wide range of airflow rates. Conversely, beds of large uniformly sized grains tend to fluidize poorly with a high degree of slugging. The finer grained bedding tends to be carried out with the exhaust gas at a higher rate than the larger, heavier bedding material. As a result, the quality of fluidization often can be improved by adding finer grained (10 mesh) materials to act as a lubricant. The overall size range of bedding material for a FBI incinerating biosolids should be 10 to 80 mesh at bed velocity of approximately 3 feet per second.

If the grit is added to the incinerator for disposal, the bed will classify the material. It may be necessary to periodically remove the coarser grit particles from the bottom of the bed to assure good fluidization.

16.4.3 Bed and Freeboard Temperature

The biosolids must be introduced to the bed when it is at an operating temperature that exceeds the ignition temperature of the biosolids. The required temperature may vary depending on the characteristics of the biosolids and the design of the incinerator, but is generally in the range of 1500º to 1600ºF. Adjusting the supplemental fuel feed rate controls the temperature of the bed, biosolids feed rate and combustion air feed rate.

The operating temperature of the freeboard area, above the fluidized bed, runs several hundred degrees hotter than the bed temperature. This is a function of many variables, but is due at least in part to the combustion of volatilized organic matter in the area above the bed. The bed temperature typically runs between 1350º and 1400ºF while the freeboard temperature may be as hot as 1650ºF. This characteristic of FBIs results in thermal oxidation of the exhaust gas within the incinerator, eliminating the need to further thermally treat the exhaust air before discharge.

16.4.4 Emergency Controls

The FBI should be equipped with fail-safe electromechanical interlocks ensure that none of the combustion or heat recovery systems can be started or remain operational unless the various cooling elements are on-line. The safety interlocks should be placed not only on the FBI, but also on the emission control systems.

16.4.5 Troubleshooting

A troubleshooting guide for a FBI is presented in Table 16.2 (USEPA 1979). The table summarizes problems that have been experienced with FBIs, probable causes and potential solutions.

Table 16.2 FBI Troubleshooting Guide

Problem	**Probable Cause**	**Solution**
Falling bed temperature	Inadequate fuel supply.	Increase fuel feed rate or repair any fuel system malfunctions.
	Excessive biosolids feed.	Decrease biosolids feed rate.
	Excessive biosolids moisture content.	Coordinate with dewatering system operator to improve performance.
	Excessive air flow	Reduce air flow if exhaust O2 > 6%
Low O2 (<4%) in exhaust gas	Low air flow.	Increase combustion air blower speed.
	High fuel rate	Decrease fuel rate
High O2 (<6%) in exhaust gas	Biosolids feed rate too low	Adjust biosolids feed rate and fuel feed rate to maintain constant bed temperature
Erratic bed depth readings on control panel	Bed pressure taps plugged with solids	If FBI is not in operation, tap a metal rod into the tap pipe. If FBI is operating, apply compressed air to pressure tap after reviewing manufacturer’s safety instructions
Preheat burner fails and alarm sounds	Pilot flame not receiving fuel.	Open appropriate valves and establish fuel supply.

	Pilot flame not receiving spark.	Remove spark plugs and check for spark. Check transformer, or replace defective pan.
	Pressure regulators defective.	Disassemble and clean regulators.
Problem	**Probable Cause**	**Solution**
	Pilot flame ignites but flame scanner malfunctions	Clean sight glass on scanner or replace scanner
Bed temperature too high	Fuel feed rate too high. Increased fuel value in feed biosolids	Decrease fuel rate. Explore reasons for change with WWTF operator
Bed temperature reads off the scale	Faulty thermocouple	Check the entire control system. Repair as necessary
Reactor biosolids feed pump fails	Bed temperature interlock may have shut down pump. Pump is blocked	Check bed temperature. Clear blockage and dilute feed sludge if necessary
Poor bed fluidization	Sand has leaked through support plate	Shut down incinerator and clean wind box
High scrubber temperature	No water flowing. Spray nozzles plugged. Water not recirculating	Open valves. Clean nozzles and strainers. Return pump to service