SOLID WASTE DISPOSAL AND INCINERATION

INTRODUCTION

The safe disposal of solid waste remains a challenging problem for both industry and local governments in the United States. The disposal and incineration of waste offers many advantages, including:

- Conservation of valuable fossil fuels
- Dependable fuel supply to provide process steam
- Dependable steam supply to generate electric power
- Stable refuse disposal costs
- Possibility of selling excess refuse-derived fuel
- Conservation of available land
- Sales of reclaimed materials and by-products

Many refuse-processing systems were put into use during the past thirty years. Unfortunately a high percentage of them failed because of pollution problems or unprofitability. The statistics, however, are improving with advances in technology and the review of data from past successes and failures as well as concerns over landfills. Often these types of disposals when coupled with power generation are being considered more environmentally friendly.

The incineration of municipal, medical, or hazardous wastes is the major source of dioxins. Dioxins are colorless, odorless compounds containing carbon, hydrogen, oxygen, and chlorine. The EPA lists dioxin as a potential human carcinogen. Some studies conclude that dioxins produced during incineration could be released into the air we breathe, or they may be trapped in fly ash and require handling as a hazardous waste. Although small amounts of dioxins are found everywhere, the EPA considers values above 5,000 to 20,000 parts per trillion to be an amount that needs further study or possible clean-up. This document is to address the method of fuel delivery and specific burning/boiler concerns. Turbines and generators are also attached and PRC.17.12 for specific concerns with them.

PROCESSES AND HAZARDS

The two major techniques for incinerating municipal solid waste (MSW) are mass burning and burning refuse-derived fuel (RDF). The mass-burning method burns the refuse as received, except that very large objects, such as stoves and refrigerators and other large noncombustible items, are removed. The second incineration technique uses refuse-derived fuel (RDF). In this technique, municipal refuse is sorted and shredded and noncombustible materials are removed in preparation for burning in an RDF fired furnace. Although fuel preparation results in increased costs due to capital equipment, operational expenses and equipment maintenance operations, these costs are offset by the increased efficiency of the combustion and reclamation process. The overall result is more complete combustion, producing more energy per ton of waste, better reclamation of ferrous metals for resale, and vast reduction in materials going to landfill.

In addition to mass burning, this section discusses two trash-to-RDF systems:

- The semi-suspension method.
- The pyrolysis method.

Mass Burning

The mass-burning process is used predominately throughout Europe for solid waste disposal. It has been experimented with in this country for the past 90 years with marginal success by today's standards. Most MSW units shut down during the 1960's, due to the Clean Air Act and the required pollution control equipment that made the burning of trash cost prohibitive. Today, however, the reduction in available landfill areas and the associated high costs of dumping have made MSW units more cost-effective. See Figure 1.

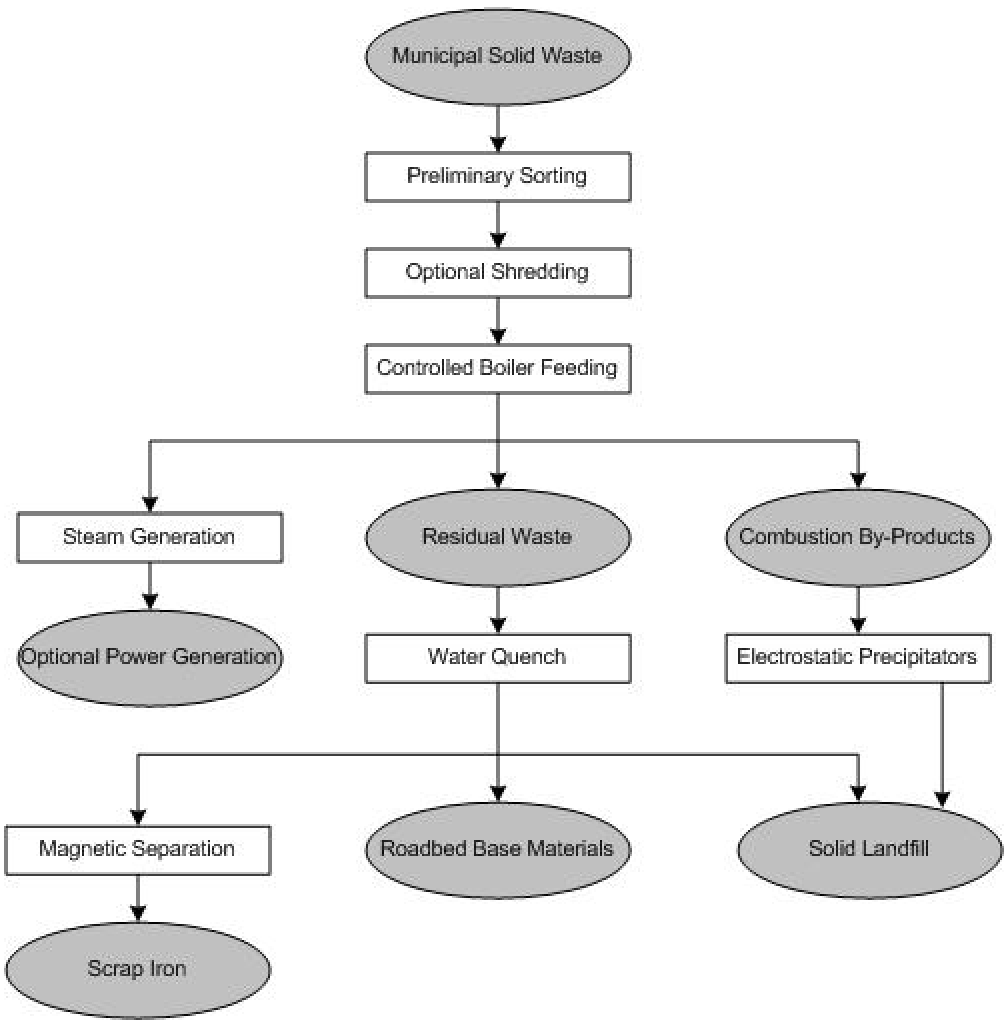

Figure 1. Mass-Burning

In the mass-burning system the trash is delivered and dumped into a deep pit. The pit acts as a storage reservoir to even out trash deliveries. The trash is then removed from the pit by crane and either dumped onto the boiler feed grate system or, if found to be too large for the boiler system, into a shredder. The crane operator must do a certain amount of sorting to ensure that large noncombustible items are not sent to the furnace.

Waste is fed to the charging hopper of the stoker and dropped to the feed chute, where it is pushed onto the boiler's movable burning grate using one or more hydraulically operated charging ram assemblies. The function of the movable grate is to move the waste through the boiler at a uniform rate. One of the problems associated with earlier mass-burning systems was that the trash entering the boiler on the movable grate got so tightly packed that it prevented proper air introduction, resulting in incomplete burning. Most new systems now use both primary and secondary air systems to overcome this problem. Primary air is introduced under the grate to produce an updraft and control the burning rate. Secondary air produces turbulence and introduces the necessary oxygen above the grate for a more complete incineration.

Wide variations in the composition of the trash not only make it difficult to control the burning process, but also lead to boiler problems like stress cracking, tube fatigue and chloride corrosion. The overall result is an inordinate amount of downtime for normal maintenance and for repairs following disruptions of the process.

When using the mass-burning method, very little material can be reclaimed. "Frit," a hard granular material produced after the ashes are water quenched, can be used in roadbed preparation as a base for paving. Otherwise, the residue goes directly to the solid waste dump. Also, if trash deliveries are suspended, there is usually no alternative fuel that can be burned. This is a major problem if the facility must make steam or electric power. The grate openings are usually too large to carry coal and operating the boiler solely by oil is usually not anticipated in the original design of the system.

Semi-Suspension Method

The first refuse-derived fuel (RDF) method of incinerating is the semi-suspension firing of refuse in a waterwall furnace. This method has gained wide acceptance throughout industry over the years for the disposal of bark, bagasse and various fibrous wastes. The main reason for success with these materials has been that they have a fairly consistent heat of combustion and, thus, a controllable flow rate. Conversely, the predominant problem with burning trash in the United States is the inconsistency and unpredictability of solid waste, but is improving every year. Recycling efforts covering separation of glass, metals, etc. is becoming more commonplace all over the world. As a result, the combustibility of the trash is more uniform, and, thus, its burning rate is easier to control because the heat of combustion is more predictable. See Figure 2.

The purpose of fuel preparation is to produce a more homogeneous fuel. In the semi-suspension system the raw waste is broken-up using primary shredders. Conveyors are very commonplace in this process. They are used to move the trash from station to station. The waste material then passes through air-classifiers, which, in combination with vibrators and a series of grates and counterflow fans, separate the heavier materials from the lighter combustibles. Much of the heavier materials, such as glass, sand and various metals, can be reclaimed by using shakers and magnets. This essentially removes the heavier materials before they are contaminated by incineration by-products, thus giving them a higher resale value. The remaining combustible waste is sent through secondary shredders to reduce the waste to a fairly uniform size and consistency for delivery to the boilers.

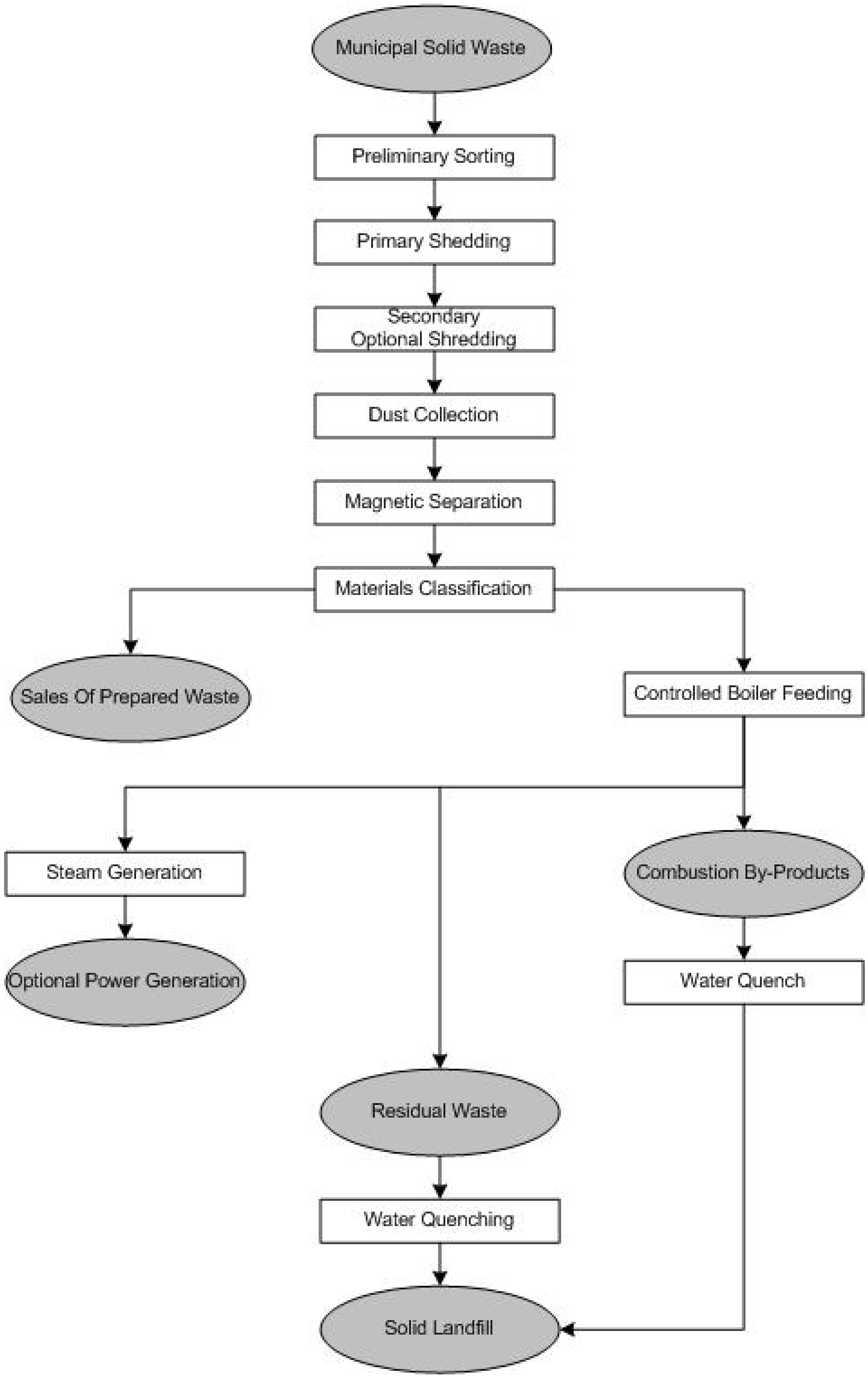

Figure 2. Semi-Suspension

The prepared wastes can also be stored and sold to utility companies or other large consumers of energy that have the equipment to burn this type of waste. Many of the prepared refuse-derived fuels can be burned on movable-grate coal burning equipment. Coal can be used as an auxiliary fuel.

Pyrolysis

The second method of incinerating refuse-derived fuel is the pyrolysis system, which burns waste in a high temperature, air-starved environment. There are three basic types of pyrolysis units; low and medium heat of combustion gas, and high heat of combustion liquid units. The by-products of pyrolysis are gases, such as hydrogen, methane, and carbon monoxide; organic chemical liquids such as oil, acetone and methanol; and carbonation char. The by-products of pyrolysis are largely dictated by the type of refuse burned, catalysts added to aid combustion and auxiliary fuels used. By-products can be further controlled by adjusting the reaction time, temperature and pressure. Oxygen may be used to raise the kiln temperatures. If the heat of combustion of the off-gases is high enough, they can be compressed and sold. In some cases, the by-product gases are recirculated and burned in the boiler. See Figure 3.

In low heat of combustion systems, the fuel is usually prepared by shredding. No. 2 fuel oil is burned with the incoming waste to provide sufficient heat for the pyrolysis reaction. The flow of waste is arranged so that a counterflow of gases and solids is present, which subjects the waste to progressively higher temperatures as it passes through the kiln. The solid residue is quenched with water, and metal separators are used to remove ferrous materials. The off-gases are burned in an after-burner, and the waste heat is passed through a waste heat boiler to generate steam. Improper operating temperatures in the after-burner could lead to the formation of metallic salts.

Some of the pyrolysis units use horizontal kilns and some use vertical kilns. The vertical type preheats the waste more efficiently as it descends into the kiln, thus achieving more complete pyrolysis.

Medium heat of combustion systems use oxygen instead of auxiliary fuel to intensify the combustion. This produces very hot gases, which pyrolyze the incoming fuel. The combustion residue is greatly reduced and is in the form of frit after quenching. The gases are passed through an electrostatic precipitator to remove oil and sent back to the furnace for incineration, an acid absorber to remove neutralized organic salts and sent to the furnace for incineration and a condenser to remove excess moisture. The resulting product is a clean fuel gas with about a 300 Btu (316,500 J) rating or about 30% of the rating of natural gas.

High heat of combustion pyrolysis systems recirculate part of the hot char with the incoming refuse to provide the energy necessary for pyrolysis. This system has some of the characteristics of the semi-suspension method. They include initial fuel preparation, shredding and the use of air-classifiers to extract the lighter combustibles from the heavier noncombustibles. The lighter weight materials are dried to reduce the moisture content. Ferrous metals and clean glass are removed before disposing of the remaining heavier materials. The dried combustibles then pass through a secondary shredder where the waste is pulverized into powder form. This process has a large dust hazard potential.

Waste is pneumatically blown into the reactor where it is mixed with burning char. An endothermic reaction takes place in the pyrolysis reactor. A cyclone separates the char from the gas-oil mixture. A portion of the char returns to the inlet of the reactor where it mixes with fresh trash. The remaining char is cooled in a quench system and trucked to landfill.

Because the reaction takes so little time, the gaseous products formed are not exposed to the high temperatures long enough to degrade. These gaseous by-products become liquid when cooled. The resulting oil has about 75% of the heat of combustion capacity of No. 6 fuel oil, and has been found to be slightly corrosive to some metals.

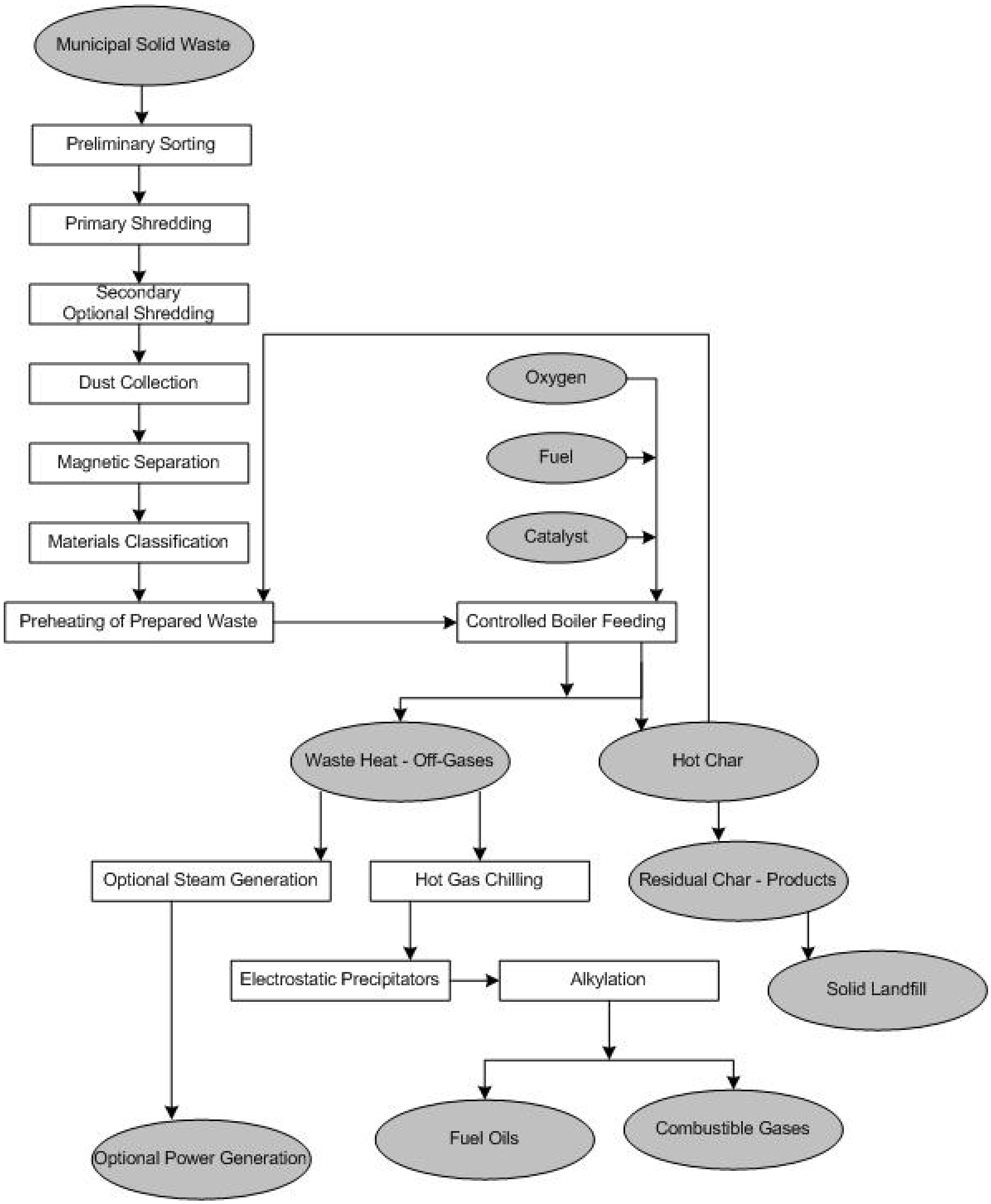

Figure 3. Pyrolysis

Solid Waste Hazards

Incineration of solid waste involves many challenges. Some important concerns include having sufficient trash to burn, preventing potentially hazardous materials from entering the facility, protecting the storage and handling of trash, and controlling combustion including pollution control for exhaust. Samplings of some of these concerns are:

Fluctuations in trash deliveries

- Expiring contracts and difficulty getting long-term agreements
- Labor problems and strikes
- Seasonal fluctuations in trash pickup

Curbside pick up of hazardous materials

- Explosives
    - Sticks of dynamite
    - Military bombs and shells
    - Propane cylinders (especially tanks form residential gas grills)
- Flammable or combustible liquids
- Aerosols
- Controlled substances
    - PCBs
    - Pesticides
    - Herbicides
    - Carcinogens
    - Biological wastes
- Pressurized containers
- Industrial waste (hazardous materials in large quantities)
- Reactive materials
- Materials discarded by pranksters
- Materials already burning

Storage of waste in various stages of processing

- Spontaneous ignition
- Moving equipment as ignition source
- Pile height control

Waste processing

- Shredding of waste - inherent explosion hazards
    - Primary shredders - flail type
    - Secondary shredders - high power pulverizers
- Vapor control
- Dust control
- Odor Control

Combustion control

- Consistency of fuel
- Fuel flow rates
- Combustion air control
- Auxiliary fuels
- Fly ash control
- By-product control
- Possible generation of dioxins
- Exhaust control for pollution (NO_x reduction)

- Corrosive degradation of the boiler
  - Frequent maintenance
  - Reduced safety of operation

Ductwork

- Various ducts are used to move air for various reasons such as combustion, odor control. Combustion air is often pulled from inside the pit, lay down areas and other places. This also helps with odor control by keeping the building as negative pressure and pulling the odors from these areas and fed to the combustion air chamber.
- Odor control is a concern for most solid waste locations especially when located in a populated area. Methods to control odors include covering, spraying with water and large air turnover rates. Most often these areas are under negative pressure (to keep odors in) and the air moved from the floor is fed to boilers for combustion. This is often done with ducts inside buildings to move large volume of air to remove odors. The ductwork must be constructed of metal with plastic not allowed (FRP is considered a plastic duct) with a substantial review of the fire protection following NFPA 13 concerning duct sizes.
- Sprinklers are the preferred method of protection in the duct due to build-up and size. Fire rated dampers are also needed to limit fire spread. These can be activated by fusible link or other methods and need to be on both sides if passing through a wall. Smoke detectors are very difficult to maintain in this environment so consideration should be given to heat detection inside ducts. With any portion of the fire protection scheme, the fans and air movers should shut down upon fire alarm activation as well as have manual emergency shut offs strategically located including in the control room.

Pollution Control

- Various concerns exist for pollution control of the effluent or any other discharge for the sites. For newer facilities, it is common to use ammonia, urea, or other chemicals in an effort to reduce nitrous oxide (NO_x) and other acidic air discharges. Ammonia can be part of a Selective Catalytic Recovery (SCR) system and the location of the bulk storage is a concern. Prevailing winds and proximity to structures need to be considered for tank placement. It is common practice to provide a deluge (or other water washing means) around the tank incase of a leak.
- Larger facilities may also have Continuous Emission Monitoring (CEM) points. These are environmental concerns as some regions may require the plant to shutdown if discharge cannot be monitored, but this varies from plant to plant and location. Gaseous fire protection may be needed due to business impact if the monitoring equipment was lost.

LOSS PREVENTION AND CONTROL

In general, protection of solid waste processing facilities is through proper construction with compartmentation and properly designed sprinkler systems. NFPA 850 has additional details.

Management Programs

Taylor management programs for loss prevention and control to address the hazards at the facility.

Operator Training Program

Educate all operators in the hazards involved and in the functions of the safety control equipment. Forbid deviations from the written procedures.

Pre-Emergency Planning

AXA XL Risk Consulting's pre-emergency plan from *OVERVIEW*, may be used to develop a customized plan for the facility.

Preventive Maintenance

Heavy attrition on key equipment, such as shredders, conveyors, and boilers, requires redundancy so that repairs and maintenance can proceed with the plant operating at full capacity. A proper preventative maintenance program is essential to the continued performance of this equipment.

Inspect and maintain process equipment with proper consideration of design and service conditions. Include all appropriate types of modern nondestructive testing, IR scanning and vibration analysis in the inspection techniques. Establish a detailed record-keeping system that includes equipment retirement forecasts.

Plant Security And Surveillance

Restrict access to the site by fencing with guards at all points of access to the property. Provide recorded watchman service in areas that are not constantly attended or equivalent electronic monitoring.

Other Management Programs

Incorporate these features into the comprehensive management program for loss prevention and control:

- Welding, cutting and other "hot work" permit programs.
- A program of supervision of impairments of fire protection equipment using AXA XL Risk Consulting's "RSVP" program. All systems should be in service before operations are started.
- Smoking regulations.
- Housekeeping that addresses potential dust build up in all areas of the site with particular attention to building structural members.

Facility Protection

Construction

Provide explosion relief in the form of light metal panel construction, designed to relieve without weakening the integrity of the structure, where an explosion potential may be present. In addition, provide blast-resistant construction to limit damage to adjacent areas and important equipment.

Detach the following areas:

- Refuse receiving (Negative pressure to prevent odor escaping)
- Refuse storage areas (Negative pressure to prevent odor escaping)
- Processing and shredding areas (Negative pressure to prevent odor escaping)

Provide parapeted freestanding fire walls of 3-h fire resistance rating, with all wall openings protected by single Class A automatic closing fire door(s) having a rated maximum temperature rise of 250°F (139°C) in 30 min, to cut off the following areas:

- Incineration buildings
- Steam generation buildings
- Fuel storage awaiting incineration or transport.

Cut off or pressurize the following areas:

- Power generation buildings. (Pressurized to prevent dust infiltration)
- Administration buildings. (Pressurized to prevent dust infiltration)

Sprinkler Protection

Provide sprinkler protection in all areas whenever possible meeting all applicable codes, standards and guidelines. In areas without heat and there are concerns for freezing, increase the design area by 30% for dry sprinkler systems. Install this protection in accordance with NFPA 13, NFPA 850 and PRC12.1.1.0.

Provide wet pipe sprinkler systems equipped with 165°F (74°C) temperature rated sprinklers in all heated areas of the handling facilities. Design the systems to provide 0.20 gpm/ft² (8.1 L/min/m²) over any, including the hydraulically most remote 3000 ft² (279 m²) of floor area with sprinkler area not exceeding 100 ft² (9.3 m²) per sprinkler in the following areas:

- Administration buildings.
- The incineration, steam generation and power generation buildings.
- Lube oil storage (in sealed drums one pallet high).

Provide sprinklers in the RDF Storage Building equipped with 286°F (138°C) temperature rated sprinklers. Design the systems to provide 0.35 gpm/ft² (14.3 L/min/m²) over 3000 ft² (279 m²) of floor area with sprinkler area not exceeding 100 ft² (9.3 m²) per sprinkler. Storage heights in excess of 20 ft (6.1 m) will require higher densities.

Provide sprinkler systems equipped with 165°F (74°C) temperature rated sprinklers for bins, hoppers, chutes and conveyors. Design the systems to provide 0.20 gpm/ft² (8.1 L/min/m²) over 2000 ft² (186 m²) with sprinkler area not exceeding 130 ft² (12 m²) per sprinkler. The RDF fuel stream should be reviewed to verify this density is adequate as it may need to be increased based on the volatility of the material.

Shredder enclosures should be provided with sprinkler systems designed to provide 0.25 gpm/ft² (10.1 L/min/m²) over 2000 ft² (186 m²) with sprinkler area not exceeding 100 ft² (9.3 m²) per sprinkler. Consideration for a foam type system should be reviewed due to potential volatile contents and location.

The Processing and Tipping/Receiving Buildings areas should have sprinklers installed designed to provide 0.25 gpm/ft² (10.1 L/min/m²) over 3000 ft² (279 m²) with sprinklers not 100 ft² (9.3 m²) per sprinkler.

The storage pit should have monitor nozzles designed so that every portion of the pit can be reached by two operating nozzles. This is in addition to sprinklers located at the roof. The nozzles should be designed for a minimum of 250 gpm (956 L/min) at 100 psi (689 kPa) at the tip. Oscillating monitor nozzles should be considered.

Sprinkler system activation should be interlocked to shut down the equipment involved. This could be conveyors, shredders, chutes, etc. and also activate a local alarm to notify site personnel.

Provide water spray extinguishing systems to protect bag and dust collection systems, designed to deliver a 0.25 gpm/ft² (10.1 L/min/m²) over 2000 ft² (186 m²)

- Provide sufficient water for both sprinklers and hose streams.
- Actuate the system by infrared flame detection as well as manually.
- Provide adequate drainage at water collection points so that the weight of the waste, which absorbs water will not overtax the design of the equipment.

Provide water spray protection in accordance with NFPA 850 and NFPA 15 for the following:

- Combustible oil-filled transformers.
- Governor housing and oil lines at turbine bearings.
- Boiler feed pump equipment.
- Hydrogen seal oil unit.
- Fuel oil ignitors in the boiler building.
- The precipitator if collecting combustibles.
- Within covered or otherwise shielded conveyors.
- Pit area beneath the receiving conveyors.

Provide 1-in. (25-mm) hose connections in all waste-handling areas, spaced so that any point can be reached with at least two streams and equipped with 100 ft (30.5 m) of 1-in. (25-mm) hard rubber hose on constant feed reels and adjustable spray nozzles. Supply hose connections from a separate valve connection to the underground water main system.

Provide adequate access for materials handling equipment so that burning materials can be removed and isolated from nonburning materials. Operator training is essential for this to be safely completed.

Provide access doors opposite yard hydrants to assist in manual firefighting.

Flammable Liquids

One of the major problems associated with solid waste processing is the possible introduction of flammable liquids and explosives into a major piece of process equipment. The primarily safeguard against such an occurrence is the action of trained people. Such action includes inspecting the trash at all workstations from the curb pickup through to incineration.

Past problems include an attempt to pass a drum of flammable liquid through the sole shredder in a mass-burning process. Extensive damage to the equipment and the building resulted. This scenario was not considered a possibility, since three or more people who “knew better” handled the drum.

In another case, numerous fiber drums filled with acetone-impregnated sawdust were the cause of a severe explosion. Vapors apparently accumulated in the conveying equipment during processing and exploded in the secondary shredder due to the presence of sparks. This points out the dangers of processing industrial waste that may have concentrated quantities of hazardous materials as opposed to strictly municipal waste with household materials.

The household materials may be just as hazardous, but they are usually in small quantities, and well enough dispersed so that they do not have the same disastrous effects. The facility’s management should:

- Specify in industrial waste pickup contracts that hazardous materials will not be tolerated.
- Support vigorous employee training in the proper recognition and handling of hazardous materials.
- Prepare and post written instructions for handling suspicious materials.

Solid Waste Storage

Storage of waste not only introduces the normal hazard of combustible storage, but also encompasses materials that may spontaneously ignite. In addition, the health hazards and explosion hazards are unknown. Often storage areas contain enough waste to continue operation through several days of meager collections and holidays.

In the prepared waste processes, piles are usually 12 ft (3.7 m) or less in height, and they are protected by closed head sprinkler systems. During meager collection periods the facility may exceed normal storage heights. The stored refuse is moved by tractor-type front-end loaders. Frequent moving of the piles reduces bulk, helps to dry the refuse before burning, and helps locate materials, such as propane cylinders, that should not be processed through the equipment. However, these vehicles can be sources of ignition if hot surfaces are exposed or if their fuel systems malfunction.

The mass-burning process uses deep refuse pits. Although pits may be 30 ft (9.1 m) deep, the piles usually extend above the finished floor. Some piles may be 70 ft (21 m) or more in total height.

Refuse pits may be protected by one of the following measures:

- Deluge sprinklers and adjustable monitor nozzles.
    - Design automatic deluge sprinkler systems to deliver 0.30 gpm/ft² (12.2 L/min/m²) over the entire pit. Activate the system by infrared flame detection and remote manual actuators at the tipping floor and the overhead crane.
    - Provide fixed, adjustable, monitor-nozzles of not less than 250 gpm (950 L/min) capacity to augment the sprinkler protection, or for use before the sprinkler system operates. Arrange the nozzles so that any point in the pit can be reached with two water streams.
- Closed head sprinklers and pre-aimed monitor nozzles.

  - Design automatic closed head sprinkler systems to deliver 0.25 gpm/ft² (10.2 L/min/m²) over 3000 ft² (279 m²).
  - Provide a system of fixed, pre-aimed, monitor-nozzles to augment the sprinkler protection, or for use before the sprinkler system operates. Arrange an adequate number of nozzles so that the entire pit is covered simultaneously. Activate the monitor-nozzle system by infrared flame detection with remote manual actuators at the tipping floor and the overhead crane.
- Closed head sprinklers, high expansion foam and adjustable monitor-nozzles.
  - Design automatic closed head sprinkler systems to deliver 0.20 gpm/ft² (8.1 L/min/m²) over 3000 ft² (279 m²).
  - Provide automatic high expansion foam system designed to fill the pit within 3 min and designed in accordance with NFPA 11A and PRC12.3.3.1. Activate the high expansion foam system by infrared flame detection with remote manual actuators at the tipping floor and the overhead crane.
  - Provide fixed, adjustable, monitor-nozzles of not less than 250 gpm (950 L/min) capacity to augment the sprinkler protection, or for use before the sprinkler system operates. Arrange the nozzles so that any point in the pit can be reached with two water streams.

Arrange the crane to self-park upon operation of the fire protection system; however, enable the operator to override this feature. The cab should also have manual activation abilities for any deluge or waterspray type systems as well as immediate communication to plant personnel.

Provide smoke exhaust equipment at the lip of the refuse pit designed to provide 10 cfm/ft² (0.3 m³/min/m²) of pit area. All ductwork should be of metal construction (no plastic) and permanently attached as needed.

Shredders

Besides making the particle size proper for incineration, shredders also:

- Reduce bulk.
- Produce homogeneous refuse with a more predictable burning rate.
- Enhance refuse drying.
- Reduce refuse odor.
- Provide more surface area for combustion.

The solid waste industry uses three types of shredders: the horizontal and vertical hammer mills and flail-type shredders. Hammermill shredders are costly to run, difficult to maintain, and are susceptible to extensive down time due to the abuse they receive during operation.

Flail shredders are used for primary shredding in the solid waste industry because their flexible-impact hammers operate relatively slowly and thus require less energy consumption. They are primarily used to open bags of trash and break large items into pieces approximately 8 in. (200 mm) across. This process results in less wear and tear on the equipment, less down time, a higher production rate, and less energy consumption. Their disadvantage is the chance of not removing potentially dangerous materials before secondary shredding takes place. Although flail shredders are relatively new, they are becoming more commonplace in the waste industry. Magnetic separators or sieve type separators are used to remove metal parts. The secondary shredders are used to pulverize the waste to a boiler-ready size.

Since all hazardous materials are not removed before they get to the shredder, explosions in shredders are common, and, as a result, most are designed to withstand moderate explosions. However, explosions can exceed these design limits. Therefore, provide explosion relief on the units. If adequate explosion relief is not possible, install an explosion suppression system. Damaging explosions are more common in the secondary shredders than the primary ones because the primary shredders are usually of fairly open construction, which allows the force of an explosion to dissipate rather than cause extensive physical damage to the unit.

The need for explosion suppression depends on the type of dust or vapor and on the presence and anticipated effectiveness of available explosion venting. The design details and extinguishing agent used depend on the geometry of the equipment being protected.

An agent used in shredder explosion suppression systems is carbon dioxide and monoammonium phosphate has also been used with great success. Because of the potential damage to the stratospheric ozone layer, AXA XL Risk Consulting does not recommend the use of halon extinguishing or explosion suppression agents. Investigate alternate agents and verify their effectiveness by tests. Explosion suppression on enclosed shredders has been quite effective. Explosion suppression has also been used on open-type flail shredders with satisfactory results.

Explosion suppression systems used in shredders are usually designed with pressure-type detectors because they are less prone to malfunction than infrared detection in this type of environment.

Arrange and protect shredders as follows:

- Duplicate shredders and separate them so that a single explosion or fire will not involve more than one unit.
- If explosion venting is insufficient to relieve the intensity of explosive forces that may be encountered, provide explosion suppression in accordance with NFPA 69.
- Due to problems experienced with pressure-type explosion detection devices from vibration forces generated during shredding, mount a pair of series-wired detectors on vibration-isolated standoffs near the top of the shredder. The use of two detectors improves response and reliability, and the vibration standoffs result in fewer false trips.

Waste Handling

Sprinklers are very effective on slower moving and residual fires, and will minimize damage especially in systems using both cyclones and bag collectors.

In addition to the moving fire problem, movement of fluidized waste through ducts presents other problems in the form of flammable vapor accumulation and combustible dust generation. These are familiar problems faced in other industries, with the added problem of not knowing what materials are being processed through the system at any particular moment.

Vapor detection with emergency exhaust capability may be helpful in some cases along with interlocks to shut down downstream shredding operations.

If vapors build up enough to create an explosion potential, it may be too late for the additional ventilation to be of any assistance. Explosion suppression systems have been very successful in dealing with such problems. Ducts that feed collection systems may be protected by spark-suppression equipment activated by infrared detection, which extinguishes burning embers before they reach collection system. Although the chance of occurrence of a fire or an explosion is greatly reduced, the potential for a sizable loss is always present. Thus, this protection does not replace the need for protection downstream of the spark-suppression-protected ductwork. Repair cost and downtime involved in explosion losses dictate the use of both spark suppression and explosion suppression systems.

Build enclosures for areas where trash is handled to minimize dust accumulations and to facilitate cleaning.

Provide access doors and stationary ladders to gain access to the ducts with hose streams for firefighting purposes. These same access doors can be used for maintenance purposes to inspect ducts when idle.

Waste Burning

Controlling combustion of fuel with variable heat capacity is usually very difficult. Auxiliary fuels are sometimes used to stabilize the burning rate or keep the boiler at proper temperatures during idle periods; however, this can be quite costly and is usually avoided. Dramatic fluctuations in burning rate can cause an alternating reducing/oxidizing atmosphere that can shorten the boiler life expectancy by corrosion. Combustion Equipment should comply with NFPA 85.

Prepared refuse-derived fuel is more uniform and has a more consistent heat of combustion than the mass-burning method. Another added advantage is that substitute fuels can be used when RDF is not available.

Along with large boiler operation comes the generation of steam for electrical power generation or steam use, and the need for clean air emission. Power generation and the protection of generating equipment, and the use and protection of scrubbers and electrostatic precipitators are covered in PRC17.12.