B.Sc. Course(Second Semester)

University of Babylon-College of Engineering

Environmental Engineering Department

<u>Hospital / Medical Waste (MED)</u>

MED.1 Classification Of Medical Waste:

Answer the following questions:

1. Describe the difference between a medical waste and an infectious waste.
2. Identify the seven classes of regulated medical wastes.
3. By what means are hospital waste disposed?
4. What steps can be taken by hospital operations to minimize occupational hazards, contamination, and infection?

Solution:

1. A medical waste is any solid waste that is generated in the diagnosis, treatment, or immunization of human beings or animals. A medical waste can be infectious or noninfectious. Infectious waste is a medical waste that contains pathogenic microorganisms that can cause disease.
2. The seven classes of regulated medical wastes are:
   a. Cultures and stocks
   b. Pathological waste
   c. Blood and blood products
   d. Sharps
   e. Animal waste
   f. Isolation wastes
   g. Unused sharps
3. The predominant means of disposing of hospital waste is incineration (almost 35% of all hospital waste is incinerated). Other means of treatment or disposal include autoclaving, sanitary landfilling, chemical disinfection, thermal inactivation, ionizing radiation, gas vapor sterilization, segregation, and bagging.
4. The steps that may be taken by hospital operations to minimize occupational hazards, contamination, and infection include:
   a. Enclose medical waste at point of generation.
   b. Construct carts and equipment that have sanitary construction.

c. Construct and operate chutes to minimize microbiological contamination.
d. Reduce dangers of medical waste handling by using personal protective equipment.
e. Require higher training and qualifications for personnel handling medical waste.
f. Improve incinerator operation through training.
g. Implement safe management of hazardous wastes.

MED.2 Infectious Waste Management Plans:

Answer the following questions:

1. What factors should be taken into consideration when designing an infectious waste management plan for an individual facility?

2. Future infectious hospital waste management plans should include procedures that will deal with emergency situations. Describe three scenarios that could use emergency response procedures.

Solution:

1. Infectious waste management plans are designed around the individual needs of a facility. Three main factors, which must be considered in the custom designing of an infectious waste management plan, are:

   a. Facility location
   b. Size of the facility
   c. Operation budget

Other factors that are important include the nature of the infectious waste, waste quantity, the availability of both onsite and offsite equipment for treatment of the waste, regulatory constraints, and operating costs.

2. Three possible scenarios include:

   a. Liquid infectious waste spills.
   b. Rupture of infectious waste containers.
   c. Failure of infectious waste treatment equipment.

MED.3 Incineration Requirements:

In many cases, medical waste can be converted to inorganic matter or changed in form by high-temperature processes in the presence of oxidizing agents. Such thermal processes can result in the partial or complete reduction in the degree of hazard of a material. The general class of such thermal processes when oxygen is the oxidizing agent is termed incineration.

What considerations must be present in an incinerator to provide successful conversion of a medical waste material?

Solution:

For incineration to be successful in the destruction of a medical waste material, the following characteristics must exist:

- ❖ Adequate free oxygen must always be available in the combustion zone.
- ❖ Sufficient turbulence must exist within the incinerator to ensure the constant mixing of waste and oxygen.
- ❖ Adequate combustion temperatures must be maintained. Exothermic combustion reactions must supply enough heat to raise the burning mixture to a sufficient temperature to destroy all of the organic components of the waste.
- ❖ The duration of exposure of the waste material to combustion temperatures must be long enough to ensure that even the slowest combustion reaction is completed. In other words, transport of the burning mixture through the high-temperature region must occur for a sufficient period of time to allow reactions to go to completion.

MED.4 Fly Ash Calculation:

An incinerator burning medical waste contains 7.8% ash. The hospital produces approximately 540 Ib waste every hour on a round-the-clock basis. How much ash needs to be disposed of annually, if the 25% of the ash "flies" during the burning process?

Solution:

The rate of ash output from the incinerator in pounds/hour is:

$(0.078)(540\ Ib/h) = 39\ Ib/h$

The rate of ash output per day would then be:

$(24)(39)(0.75) = 702\ Ib/day$

The rate of ash output per yr would be:

$(365)(702) = 256000\ Ib/yr$

MED.5 Mercury Removal:

Medical sludge containing mercury is burned in an incinerator. The mercury feed rate is 9.2 Ib/h. the resulting 500°F product (40000 Ib/h of gas; MW=32) is quenched with water to a temperature of 150°F. The resulting stream is filtered to remove all particulates. What happens to the mercury? Assume the process pressure is 14.7 psi and that the vapor pressure of Hg at 150°F is 0.005 psi.

Solution:

For the mercury to be removed by the filter, it must condense and form particles. Therefore, the question to be answered relates to the partial pressure of mercury during removal compared to its vapor pressure at 150°F:

$Molar\ flowrate\ of\ Hg = (9.2\ Ib/h)/(200.6\ Ib\ Hg/Ib\ mol) = 0.046\ Ib\ mol/h$

$Molar\ flowrate\ of\ gas = (40000\ Ibgas)/(32\ Ibgas/Ib\ mol) = 1250\ Ibmol/h$

$$y = \frac{Ib\ mol\ Hg}{Ib\ mol\ Hg + Ib\ mol\ gas} = \frac{0.046\ Ib\ mol/h}{0.046\ Ib\ mol/h + 1250\ Ibmol/h} = 3.68 \times 10^{-5}$$

$Partial\ pressure = y_i P$

$P_i = y_i(14.7\ psia) = 3.68 \times 10^{-5}(14.7\ psia) = 5.4 \times 10^{-5}\ psia$

Since the partial pressure is much less than the vapor pressure, mercury will NOT condense and thus will NOT be removed by the filter.

MED.6 Mercury Emissions:

An incinerator burns mercury-contaminated waste. The waste material has an ash content of 1%. The solid waste feed rate is 1000 Ib/h and the gas flow rate is 20000 dscfm. It is reported that the average mercury content in the particulates was 2.42 ug/g when the vapor concentration was 0.3 mg/dscm. For the case where incinerator emissions meet the particulate standard of 0.08 gr/dscf (0.1832 g/dscm) with a 99.5% efficient electrostatic precipitator (ESP), calculate:

1. The amount of mercury bound to the fly ash, which is captured in the ESP in grams/day.
2. The amount of mercury leaving the stack as a vapor and with the fly ash in grams/day.

Solution:

1. The amount of ash leaving the stack is:

$$\left(\frac{0.08\ gr}{dscf}\right)\left(\frac{1\ Ib}{7000\ gr}\right)\left(\frac{20000\ dscf}{1\ min}\right)\left(\frac{60\ min}{h}\right)\left(\frac{24\ h}{day}\right) = 329\ Ib/day$$

The amount of ash collected in the ESP is:

$(329\ Ib/day)/(1 - 0.995\ collected) = 65800\ Ib/day$

2. The amount of mercury leaving the stack with the fly ash is:

$$(329\ Ib\ ash/day)(2.42\times10^{-6}\ g\ Hg/g\ ash)=7.96\times10^{-4}\ Ib\ Hg/day$$
$$=0.361\ g\ Hg/day$$

The amount of mercury leaving the stack as vapor is:

$$\left(\frac{0.3\times10^{-3} g\ Hg}{dscm}\right)\left(\frac{20000\ dscf}{1\ min}\right)\left(\frac{1\ m^3}{35.3\ ft^3}\right)\left(\frac{60\ min}{h}\right)\left(\frac{24\ h}{day}\right)=244.8\ g/day$$

Total mercury leaving the stack=244.8+0.361=245.2 g/day

MED.7 Waste Blending:

Two hospital wastes are received and stored in separate tanks at an incineration facility. The first, a sludge with an net heating value (NHV) of 6000 Btu/Ib contains 2% Cd by weight. The second, a mercury-contaminated waste with an NHV of 8000 Btu/Ib, contains 8% Cd by weight. A minimum of 1000 Ib/h of each waste is to be incinerated. Because of pump limitations, no more than 5000 Ib/h of each waste can be utilized.

To achieve the required destruction and removal efficiency (DRE), the facility requires a minimum of 8000 Btu/Ib in the waste stream, which may be obtained by adding fuel oil with an NHV of 15000 Btu/Ib. The incinerator can operate with a heat rate between 25 and 40 million Btu/h. A graphical approach involving the plotting of the two principal variables, $\dot{m}_{sludge}\ and\ \dot{m}_{plate}$ (plating waste), may aid in the following analysis.

Determine the maximum amount of mercury-contaminated waste that can be incinerated.

Solution:

Let $\dot{m}_{plate}\ and\ \dot{m}_{sludge}$ represent the flow rates of the two wastes to the hazardous waste incinerator in pounds/hour. The restrictions on the available blending options are shown in Figure 1 using numbered lines for the constraints.

Line 1	Limit of 5000 lb/h of plating waste	$\dot{m}_{\text{plate}} < 5000$
Line 2	Minimum of 1000 lb/h of plating waste	$\dot{m}_{\text{plate}} > 1000$
Line 3	Limit of 5000 lb/h of plating waste	$\dot{m}_{\text{sludge}} < 5000$
Line 4	Minimum of 1000 lb/h of sludge	$\dot{m}_{\text{sludge}} > 1000$
Line 5	Maximum heat rate of 40 MBtu/h	$\dot{m}_{\text{sludge}} = 3890 - \left(\frac{3890}{5000}\right)\dot{m}_{\text{plate}}$
Line 6	Minimum heat rate of 25 MBtu/h	$\dot{m}_{\text{sludge}} = 2431 - \left(\frac{2431}{3125}\right)\dot{m}_{\text{plate}}$

Lines 5 and 6 are determined by relaxing all constraints and assuming that only sludge is to be incinerated.

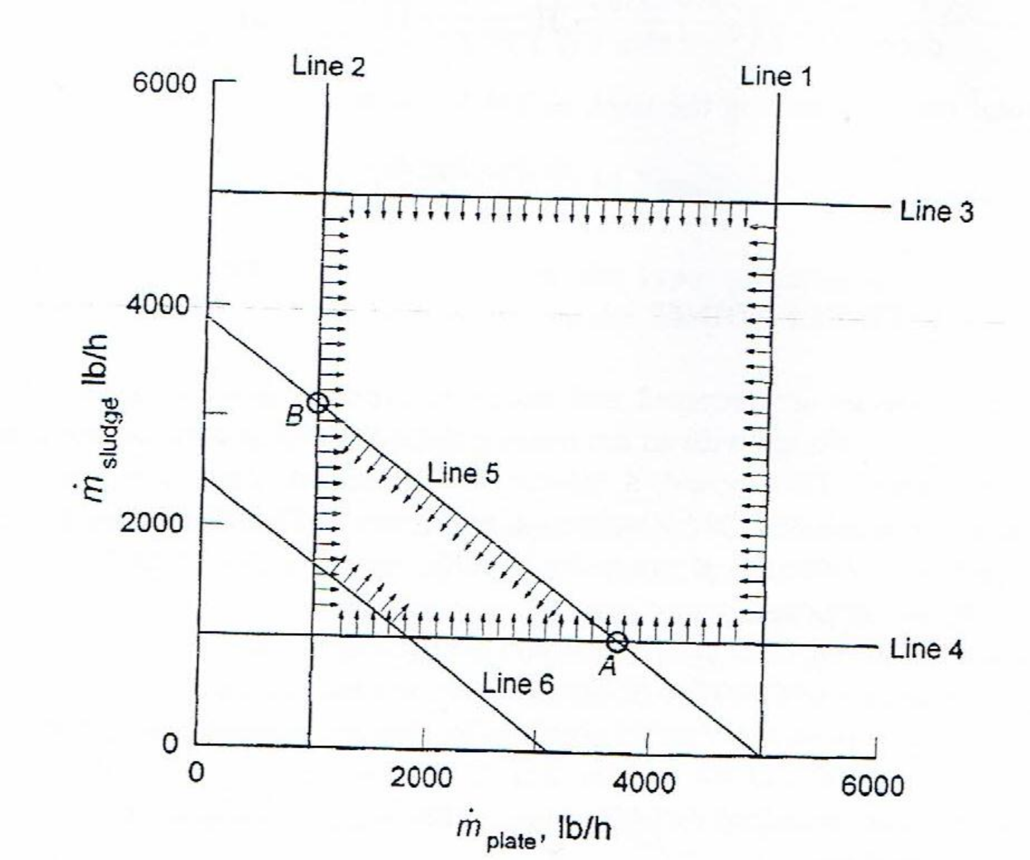

Figure 1: Diagram showing six constraints for problem MED.7

The permissible area in Figure 1 is the quadrilateral bounded by lines 2, 4, 5, and 6. The point farthest to the right (point A) represents the maximum rate at which plating waste can be burned. This occurs where constraints 4 and 5 intersect, i.e.,

$$1000\ Ib/h = 3890\ Ib/h - \left(\frac{3890\ Ib/h}{5000\ Ib/h}\right)\dot{m}_{plate}$$

$$\dot{m}_{plate} = 3715\, Ib/h$$

MED.8 Maximum Amount Of Sludge To Be Incinerated:

Refer to problem MED.7. Determine the maximum amount of sludge that can be incinerated, along with the required supplemental fuel oil necessary for this waste.

Solution:

In the permissible area in Figure1, the highest point (point B) represents the maximum rate at which the sludge can be burned. This occurs where constraints 2 and 5 intersect, i.e.:

$$\dot{m}_{sludge} = 3890\ Ib/h - \left(\frac{3890\ Ib/h}{5000\ Ib/h}\right)1000 = 3113\ Ib/h$$

To determine the fuel oil requirements at this sludge loading, the NHV of the waste is first calculated as:

$$\left(\frac{3112\ Ib/h}{3112\ Ib/h + 1000\,Ib/h}\right)\left(\frac{6000\,Btu}{Ib}\right) + \left(\frac{1000\,Ib/h}{3112\ Ib/h + 1000\,Ib/h}\right)\left(\frac{8000\,Btu}{Ib}\right)$$
$$= 6490\ Btu/Ib$$

Then the fraction of the fuel, F, required to bring the mixture to 8000 Btu/Ib is calculated as follows:

$$(6490\ Btu/Ib)(1 - F) + (15000\,Btu/Ib\,)F = 8000\,Btu/Ib \rightarrow F = 0.18$$

The supplemental fuel requirement at 40 MBtu/h is:

$$0.18(40 \times 10^6\ Btu/h)(1\,Ib/15000\,Btu) = 480\ Ib/h$$

MED.9 Maximum Amount Of Mercury-Contaminated Waste To Be Incinerated:

Refer to problem MED.7.

1. If no more than 150 Ib/h of mercury can be incinerated, what is the maximum amount of mercury-contaminated waste that can be incinerated?
2. Discuss the impact that the mercury and other constraints impose on the operation of this incineration facility.

Solution:

1. A seventh constraint is required to keep the Hg<150 Ib/h. this may be represented by:

$$0.02\,\dot{m}_{sludge} + 0.08\,\dot{m}_{plate} < 150\ Ib/h$$

This constraint is shown as line 7 in Figure2. The equation of this line is:

$$\dot{m}_{sludge} = \frac{150}{0.02} - \left(\frac{0.08}{0.02}\right)\dot{m}_{plate}$$

Given all seven constraints, the permissible area is then the quadrilateral bounded by lines 2, 5, 6, and 7. The farthest point to the right in this area (point C) on the figure is the maximum incineration rate of the plating waste. This occurs where constraints 6 and 7 intersect, i.e.,

$$7500\ Ib/h - 4\,\dot{m}_{plate} = 2431\,Ib/h - \left(\frac{2431\,Ib/h}{3125\,Ib/h}\right)\dot{m}_{plate}$$

$$\dot{m}_{plate} = 1573\ Ib/h$$

2. The shaded area on the Figure represents the permissible operating range for this unit given all seven constraints. The operating range does not allow much flexibility. The solution is deterministic, and variation in waste, operator error, waste analysis uncertainty, etc. are unaccounted for. Low-intensity burners may allow a decrease in the required NHV of the waste and permit additional flexibility.

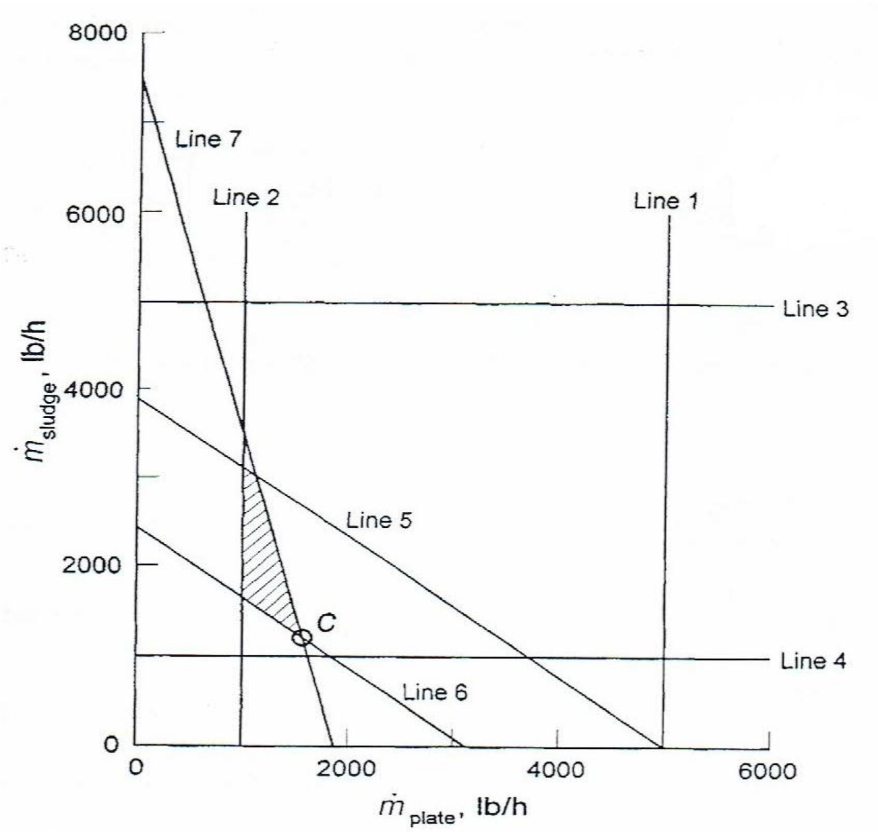

Figure 2: Diagram showing seven constraints for problem MED.9.

This graphical technique is adequate for the two variables investigated in this problem. This problem can also be solved using optimization techniques such as linear programming, a technique that can handle numerous constraints and variables and can be used, for example, to minimize supplemental fuel costs while operating within given system constraints.

MED.10 Combustion Temperature:

Estimate the combustion temperature of an incinerator contaminated with hospital alcohol, 50% ethyl alcohol+50% water and solids (may treat all as water) by weight using 40% EA. To simplify the calculations, assume an average flue gas heat capacity for N_2, CO_2, and O_2 of 0.26 and for H_2O vapor of 0.5 Btu/(Ib.°F).

Solution:

The stoichiometry for the problem is as follows:

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

Assuming a I-Ib waste basis,

$$Stoichiometic\ O_2 = (0.5)(3\ Ibmol)\left(\frac{\frac{32\ Ib}{Ibmol\ O_2}}{\frac{46\ Ib}{Ibmol\ EtOH}}\right) = 1.04\ Ib\ O_2$$

Then, the oxygen requirement at 40% excess air (EA) =1.46 Ib O_2/Ib waste.

The composition of the fluc gas is given as:

$$N_2: \left(\frac{1.46\ Ib\ O_2}{Ib\ waste}\right)\left(\frac{28\ \ Ib/Ib\ mol\ N_2}{32\ \ Ib/Ib\ mol\ O_2}\right)\left(\frac{79\ Ib\ mol\ N_2}{21\ Ib\ mol\ O_2}\right) = 4.806\ \ Ib\ N_2/Ib\ waste$$

$$CO_2: \left(\frac{0.5\ Ib\ EtOH}{Ib\ waste}\right)(2)\left(\frac{44\ \ Ib\ CO_2/Ib\ mol}{46\ \ Ib\ EtOH/Ib\ mol}\right) = 0.956\ \ Ib\ CO_2/Ib\ waste$$

$$O_2 = (0.4\ EA)(1.04) = 0.416\ \ Ib\ O_2/Ib\ waste$$

$$H_2O: \left(\frac{0.5\ Ib\ H_2O}{Ib\ waste}\right) + \left(\frac{0.5\ Ib\ EtOH}{Ib\ waste}\right)(3)\left(\frac{18\ \ Ib\ H_2O/Ib\ mol}{46\ \ Ib\ EtOH/Ib\ mol}\right)$$

$$= 1.09\ \ Ib\ H_2O/Ib\ waste, 0.5\ Ib\ of\ which\ comes\ in\ with\ waste.$$

Total $N_2 + \ CO_2 + O_2$ in the dry flue gas $= 4.806 + 0.956 + 0.416 = 6.18\,Ib/Ib\ waste$

$NHV\ for\ ethyl\ alcohol = 11.929\ \ Btu/Ib$

$The\ NHV\ for\ the\ combined\ \ water/ethyl\ alcohol\ \ waste\ is$:

$$NHV: \left(\frac{0.5\ Ib\ EtOH}{Ib\ waste}\right)\left(\frac{11.929\ Btu}{Ib\ EtOH}\right) - \left(\frac{0.5\ Ib\ H_2O}{Ib\ waste}\right)\left(\frac{1\ Btu}{Ib\ H_2O.°F}\right)(212 - 60)$$

$$- \left(\frac{0.5\ Ib\ H_2O}{Ib\ waste}\right)\left(\frac{970\ Btu}{Ib\ H_2O}\right) - \left(\frac{0.5\ Ib\ H_2O}{Ib\ waste}\right)\left(\frac{0.5\ Btu}{Ib\ H_2O.°F}\right)(T - 212)$$

$$= 5403.5\ \ Btu/Ib\ waste - 0.25(T - 212)$$

$$= 5456.5 - 0.25(T)\ Btu/Ib\ waste$$

The reader is referred to Chapter 9 for details on the following calculation. The energy of the waste is used to raise the temperature of the combustion products, and this change in enthalpy of the combustion products is calculated as:

$$\Delta H_p: \left(\frac{6.18\ Ib\ gas}{Ib\ waste}\right)\left(\frac{0.26\ Btu}{Ib\ gas.°F}\right)(T - 60) + \left(\frac{0.59\ Ib\ H_2O}{Ib\ waste}\right)\left(\frac{1\ Btu}{Ib\ gas.°F}\right)(212 - 60)$$

$$+ \left(\frac{0.59\ Ib\ H_2O}{Ib\ waste}\right)\left(\frac{970\ Btu}{Ibgas}\right) + \left(\frac{0.59\ Ib\ H_2O}{Ib\ waste}\right)\left(\frac{0.5\ Btu}{Ib\ gas.°F}\right)(T - 212)$$

$$= 1.607(T - 60) + 89.68 + 572.3 + 0.295(T - 212)$$

Equating NHV to ΔH_p yields the following relationship and solution:

$5456.5 - 0.25(T) = 1.902(T) + 503.02 \rightarrow T = 2302°F$

MED.11 Choosing An Incineration System:

A city has decided to incinerate all hospital and infectious wastes at a central location due to new stringent air emission regulations. Two hospitals, A and B, each containing 500 beds, along with a 50- bed nursing home and an animal research center, contribute their waste to the central facility. Hospital A contributes 20 Ib/bed/day of waste while hospital B contributes 15 Ib/bed /day. The nursing home contributes 10 Ib/bed/day of waste, and the animal research center provides 250 Ib/day of waste to the incineration facility. The compositions by weight of the wastes from contributing facilities are as follows:

Waste Type	Hospital A	Hospital B	Nursing Home	Animal Research
Trash	55	55	65	30
Plastic	30	15	20	15
Garbage	10	10	10	5
Pathological	5	20	5	50

Hospital A and the nursing home have a high percentage of plastics, and hospital B and the animal research facility high percentages of pathological (infectious)waste.

1. What are some considerations that are necessary before an incineration system is selected?
2. Compare controlled-air incineration and rotary kiln incineration for the central facility.
3. Would heat recovery be viable for this central facility?

Solution:

1. The total quantity of waste received must first be determined. Continuous or batch operation of the waste must be chosen. Biomedical waste incinerators are normally batch-operated, but since the quantity of waste received at this facility is large, continuous operation may make more sense.

Since the wastes from hospital A and the nursing home contain a high percentage of plastics, excessive acid gas emissions are possible. Therefore, acid gas emissions control should be considered.

The high percentage of pathological waste from hospital B and the animal research facility would result in lower waste heating values. Operations must be trained to account for variations in the heating value of the feed to the incinerator. Batch operation should still be considered an option due to the expected variation of the incinerator feed heating value.

The principal organic hazardous constituents (POHCs) of the waste must be destroyed to the required destruction and removal efficiency. HCI and particulate emissions must comply with state and federal regulations for hospital waste incinerators.

Since a high percentage of plastics occurs in the waste stream fed to the incinerator, a suitable method of treating the acid gases produced must be chosen. This may entail reacting the acid gases with an alkaline material. Therefore, a spray dryer should be considered to neutralize the acid gases.

2. Controlled-air incinerators have a lower capital cost since they do not normally require air pollution control equipment (unless acid gas emissions are excessive). But since this facility must comply with new stringent regulations and acid gas emissions may be excessive, a rotary kiln system may be more advantageous.

It is expected that the heating value of the waste fed to the incinerator may vary substantially. Therefore, a rotary kiln incinerator would be more appropriate since it can handle a large range of waste heating values. The residence time of a rotary kiln incinerator may be changed by adjusting the rotational speed of the kiln.

Since this facility is large compared to traditional hospital waste incinerators, the incinerator may be operated continuously. controlled-air incinerators are normally operated in batch mode.

All factors suggest that a rotary kiln incineration unit would be more appropriate for this facility than a controlled-air incineration system.

3. The facility operates at over 9 tons per day. While this is not large compared to municipal solid waste incineration facilities, if the facility expands in the future, heat recovery may be a viable option. But heat recovery is only economically advantageous if customers exist to purchase the recovered heat (normally steam) or if there is an onsite need for the recovered heat.

Biomedical wastes are not only generated by hospitals. Animal research facilities, research centers, universities, rest homes, and venterinary clinics also generate pathological(infectious) waste. Pathological waste includes animal carcasses, contaminated laboratory wastes, hypodermic needles, contaminated food and equipment, blood products, and even dialysis unit wastes. Normally, biomedical wastes are incinerated along with other wastes generated by the facilities such as paper and plastic.

In addition to the above, an increase in plastics in hospital waste streams has occurred during the last decade. Plastics may account for as much as 30% of a hospital waste stream. Unfortunately, incinerating plastics normally increases the chlorine content of the exiting flue gas. This creates a need for air pollution control devices to remove chlorine compounds.

In the past, controlled-air incinerators have been the most popular incinerators for biomedical waste destruction. A controlled-air incinerator is a two-chamber, hearth-burning, pyrolytic unit. The primary chamber receives the waste and burns it with less than stoichiometric air. Volatiles released in the primary chamber are burned in the secondary combustion chamber. These units result in low fly ash generation and low particulate emissions. In addition, they have a low capital cost and may be batch operated. They normally do not require air pollution control equipment unless acid gas emissions are excessive.

MED.12 Compliance Determination For A Hospital Incinerator:

A hospital in the state of Pennsylvania is currently incinerating its waste in a modular incinerator at a temperature of 1800°F and a residence time of 2s. Regulations for particulate emissions for hospital waste incinerators in Pennsylvania are as follows:

Capacity (lb/h)	Particulate Emissions Standard (gr/dscf)
$\leqslant$ 500	0.08 (corrected to 7% O_2)
500–2000	0.03 (corrected to 7% O_2)
$\geqslant$ 2000	0.015 (corrected to 7% O_2)

Hydrogen chloride (HCI) emissions must not exceed 4 Ib/h for incinerators operating at capacities of 500 Ib/h or less. For larger incinerators, HCI emissions must not exceed 30 ppmdv (corrected to 7% O_2).

The hospital generates 20Ib/bed.day of waste of which 10% is infectious(the remaining 90% is paper, cardboard, etc.) it also produces 0.056 Ib/bed.day of Resource Conservation and Recovery Act(RCRA) hazardous wastes. Two hundred beds are present in the hospital. The RCRA hazardous wastes are:

Hazardous Waste Component	Wt %
Methyl alcohol	12.5
Polyvinyl chloride (PVC)	75
Xylene	12.5

A trial burn is conducted with the waste composition in the preceding table. The designated principal organic hazardous constituents (POHCs)for the trial burn are methyl alcohol, polyvinyl chloride, and xylene. The results of the trial burn are:

Hazardous Waste Component	Outlet mass flowrate (lb/h)
Methyl alcohol	0.0001
Polyvinyl chloride (PVC)	0.0002
Xylene	0.00001
HCl	3.2
Particulates	5.64

The total stack gas flow rate is 10000 dscfm. Determine

1. The hazardous waste generation rate in pounds/month.
2. The regulations the incinerator must comply with (state hospital regulations or combined state and hospital and RCRA regulations).
3. The total incinerator capacity in pounds/hour.
4. Is the incinerator in compliance?

Solution:

1. Calculate the hazardous waste generation rate in pounds/month:

$$Hazardous\ waste\ rate = (0.056\ Ib/bed.day)(200\ beds) = 11.2\ Ib/day$$

$$= 11.2\ Ib/day\ (30\ days/mo) = 336\ Ib/mo$$

2. Determine if the incinerator must comply with RCRA regulations. Since the hazardous waste generation rate of 336 Ib/mo is greater than the 220 Ib/mo RCRA regulation, the incinerator must comply with RCRA regulations in addition to the state regulations for hospital incinerators.

3. Calculate the amount of nonhazardous waste produced in pounds/day:

$$Nonhazardous\ waste\ rate = (20\ Ib/bed.day)(200\ beds) = 4000\ Ib/day$$

Determine the total incinerator capacity in pounds/hour.

$Total\ capacity = Hazardous\ waste\ rate + Nonhazardous\ waste\ rate$

$Total\ capacity = (11.2\ Ib/day + 4000\ Ib/day)(day/24h) = 167.1\ Ib/h$

Determine the inlet mass rate of methyl alcohol to the incinerator in pounds/ hour:

$\dot{m}_{in} = (0.125)(11.2\ Ib/day)(day/24h) = 0.0583\ Ib/h$

Calculate the destruction efficiency for the hazardous component methyl alcohol (MeOH):

$DRE_{MeOH} = [(0.0583\ Ib/h - 0.0001\ Ib/h)/(0.0583\ Ib/h)](100) = 99.827\%$

Calculate the destruction efficiency for the hazardous component xylene:

$\dot{m}_{in} = (0.125)(11.2\ Ib/day)(day/24h) = 0.0583\ Ib/h$

$DRE_{xylene} = [(0.0583\ Ib/h - 0.00001\ Ib/h)/(0.0583\ Ib/h)](100) = 99.983\%$

Calculate the destruction efficiency for the hazardous component polyvinyl chloride (PVC):

$\dot{m}_{in} = (0.75)(11.2\ Ib/day)(day/24h) = 0.350\ Ib/h$

$DRE_{PVC} = [(0.350\ Ib/h - 0.0002\ Ib/h)/(0.350\ Ib/h)](100) = 99.943\%$

Since the total incineration capacity is less than $500\ Ib/h,\ the\ 4\ Ib/h$ regulation applies. The trial burn resulted in an HCI emission rate of $3.2\ Ib/h$.

Calculate the outlet loading (OL) of the particulates in gr/dscf.

$OL = [(5.64\ Ib/h)(7000)]/[(10000\ dscfm)(60)] = 0.0658\ gr/dscf$

4. Determine if the incinerator is in compliance.

POHCs: Since all of the POHCs had $DREs < 99.99\%,$ the incinerator is out of compliance.

HCI: The incinerator complies with the $4\ Ib/h$ limit on HCI emissions.

Particulates: The outlet loading of $0.0658\ gr/dscf$ is less than the $0.08\ gr/dscf$ limit for incinerators operating at a capacity less than $500\ Ib/h$

The incinerator is not in compliance.

Note that the pathological waste in the waste stream in this problem is the most difficult waste to destroy since its heating value is low. Hospital waste incinerators must be designed to destroy pathological and infectious waste, not paper waste alone. The contents of a hospital waste stream are normally more complex than shown in this problem. Other hazardous components may include pentane, diethyl ether, acetone, methyl cellosolve, and other laboratory wastes.

Each state has its own regulations concerning hospitals. Other regulations must also be complied with in addition to those stated in this problem. The pertinent state agencies should be contacted for a list of the detailed regulations for hospital waste incinerators.

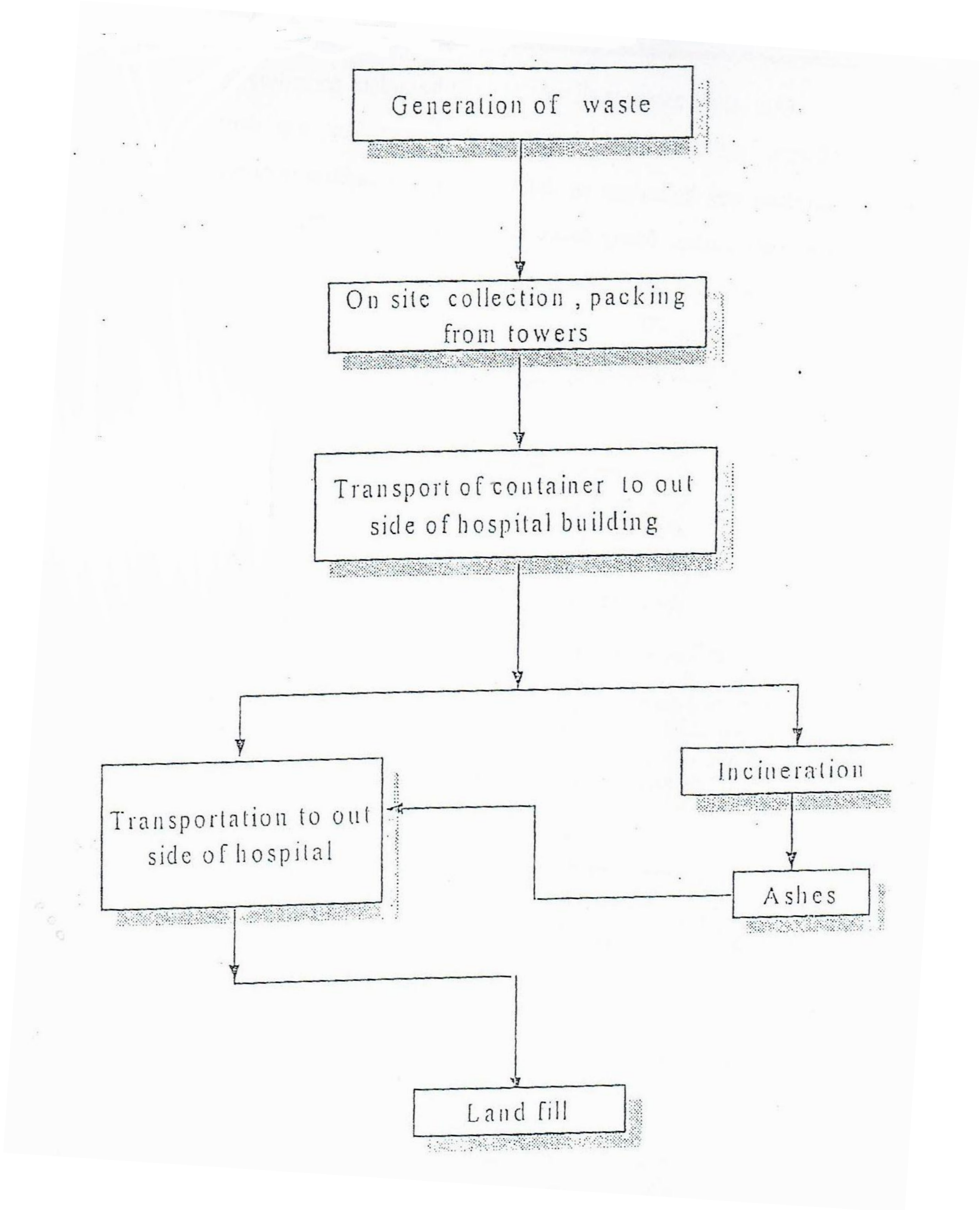

Figure3: Flow chart for the management of hospitals solid waste in Baghdad for three hospitals*.

*Source: Researcher.

Our study assumes all wastes to be hazardous according to the (EPA) Guide to pollution prevention which states: By current law, any waste mixture of non-hazardous and hazardous or infectious and hazardous wastes must be handled as a hazardous wastes. Many items that are routinely handled as infections wastes(gauze pads, gowns that are contaminated with hazardous waste)should be handled as hazardous wastes

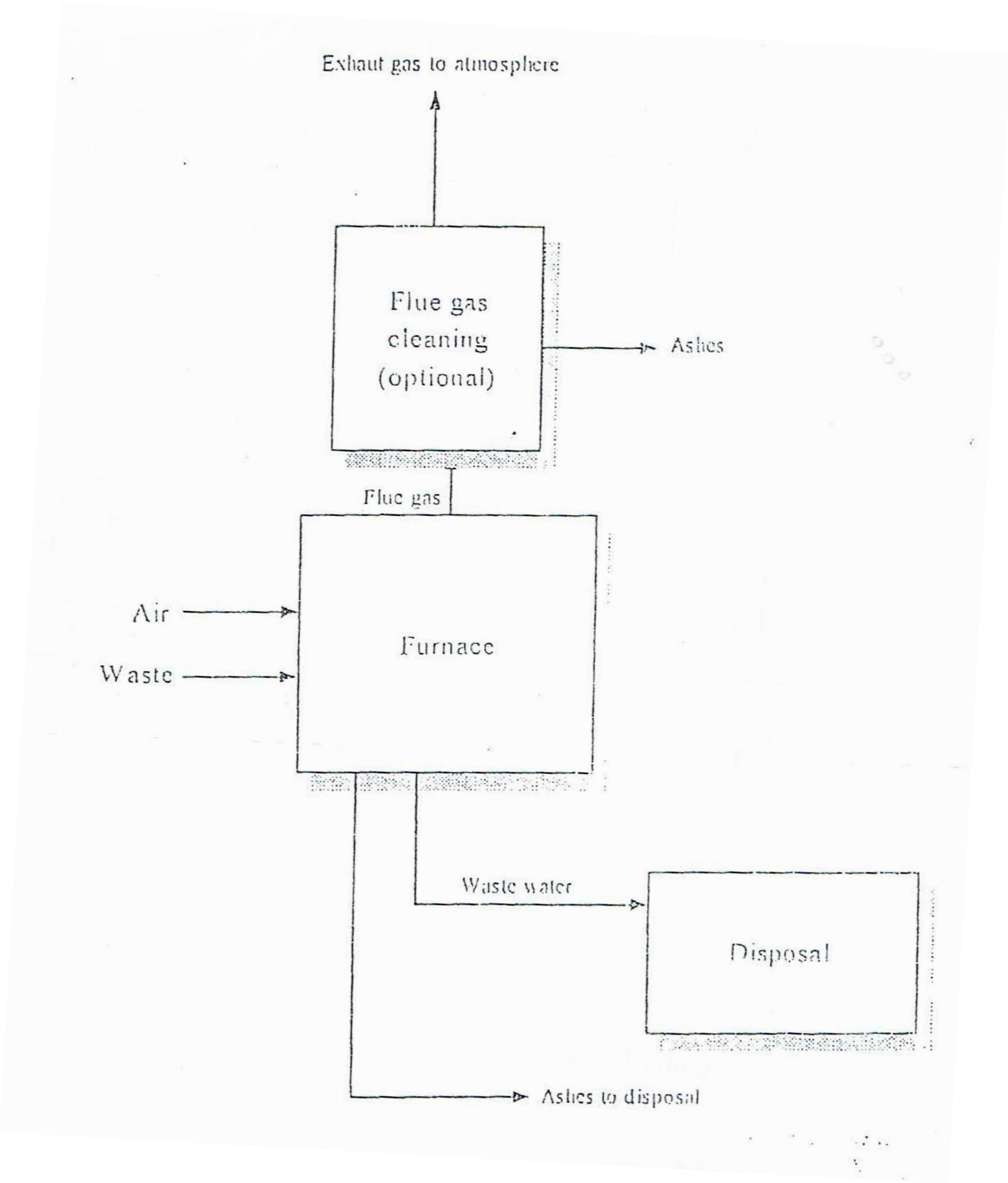

Figure4: Simplified flow scheme of incinerators.