Chapter 3

Current Technologies, Treatment, and Disposal Issues

Incineration

The incineration of medical waste has many of the same advantages and disadvantages associated with the incineration of any type of waste. That is, advantages include significant volume reduction of the wastes, while requiring little processing of wastes before treatment. Disadvantages include high costs and potential pollution risks associated with incineration processes. The discussion in this chapter will focus on issues and concerns more specific to the incineration of medical wastes.

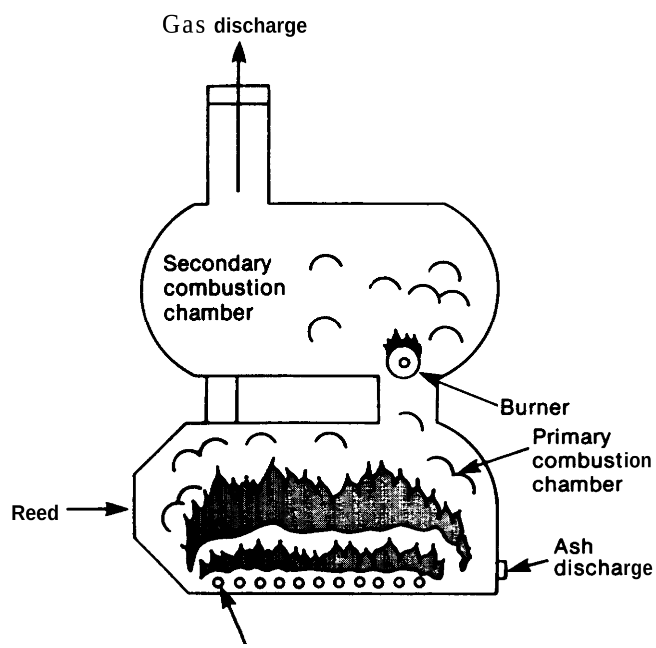
As noted earlier, hospitals generate approximately 2.1 to 4.8 million tons of medical waste per year (9,83). Of that, about 10 to 15 percent, or about 210,000 to 720,000 tons, is generally considered infectious waste. Hospitals often incinerate both infectious and non-infectious waste together. The total amount of medical waste incinerated per year is unknown.[1] In fact, the exact number of medical waste incinerators currently operating is not known.[2]

Hospital incinerators burn a much smaller volume of waste than municipal incinerators. Of the 158 million tons of municipal solid waste generated per year, approximately 15 million tons are incinerated (15). What concerns some observers is that many of the hospital incinerators are located in heavily populated areas (which could lead to greater potential exposure) and appear to have relatively high emission rates of some pollutants of concern given their size.

Limited data indicate that small, on-site incinerators can emit relatively high levels of some pollutants, but few risk assessments have been performed on these incinerators, hindering the ability to definitively evaluate the relative degree of risks from these sources compared with other sources. Most hospital incinerators have short stacks, which may allow incinerator emissions to enter hospitals through air-conditioning ducts and windows (40). One study found that the concentrations of chromium, cadmium, and 2,3,7,8 tetra-chlorinated dibenzo-p-dioxin (TCDD) equivalents were approximately two times higher in the hospital air intake than the maximum ambient ground level concentrations (13).

The three types of incinerators used most frequently for hospital waste treatment in the United States are: controlled air, multiple chamber air, and rotary kiln models (83). (See figure 2.) All three types can use primary and secondary combustion chambers to ensure maximum combustion of the

Figure 2.—Typical Controlled Air Incinerator



SOURCE: C. Brunner, "Biomedical Waste Incineration," paper presented at 80th Annual Meeting of the Air Pollution Control Association, New York, NY, June 1987.

[1]EPA estimated that the total amount of hospital waste incinerated, when including the waste incinerated off-site, is about 80 percent of the total hospital waste in the United States (42).

[2]One estimate is that over 7,000 medical waste incinerators of the most frequently used type, i.e., controlled air systems, have been installed during the past two decades (8).

waste. Many hospitals also may have small (usually older) incinerators used only for pathological wastes.[3] Most, probably over 90 percent, of the hospital incinerators installed during the last two decades have been controlled air units, which tend to be modular (8). Large municipal incineration operations are usually of a different design, since often more capacity is needed than a modular unit can provide. Consequently, there are relatively fewer modular municipal waste incinerators.

As noted above, some concerns associated with the incineration of medical wastes are not unlike those associated with the incineration of most municipal solid wastes (e. g., the effects of burning plastics). Other concerns are more specific to the medical wastestream, such as the highly mixed nature of medical wastes (e. g., infectious, hazardous, and general refuse wastes) and the potential for incomplete pathogen destruction. Both types of concerns will be discussed in this section, although limited data are available on either type of concern. First, the types of incinerators most frequently used for medical wastes will be briefly discussed and compared.

Controlled Air Incinerators

Most of the incinerators built for medical waste treatment in the last 15 to 20 years have been controlled air (sometimes referred to as starved air) incinerators. These burn waste in two or more chambers under conditions of both low and excess stoichiometric oxygen requirements. In the primary chamber, waste is dried, heated, and burned at between 40 and 80 percent of the stoichiometric oxygen requirement. Combustible gas produced by this process is mixed with excess air and burned in the secondary chamber. Excess air is introduced into the secondary chamber at usually between 100 and 150 percent of the stoichiometric requirement. A supplementary fuel burner is used to maintain elevated gas temperatures and provide for complete combustion.

Temperatures in the incinerator are controlled through adjustments in the air levels. Air in both chambers is modulated to maintain proper operating temperatures. Furnace exit temperatures are usually maintained in the normal range between 1,400 and 2,000 “F. There are also three and four stage-controlled air incinerators that feature flue gas recirculation.

One advantage of using low levels of air in the primary chamber is that there is very little entrainment of particulate matter in the flue gas. For example, multiple-chamber air incinerators have average particulate emission factors of 7 pounds per ton, compared with 1.4 pounds per ton for controlled air units. Available data indicate that many controlled air incinerators can be operated to meet existing particulate standards that are at or below 0.08 grains per dry standard cubic foot (gr/dscf) (corrected to 12 percent carbon dioxide) (3,83). Many States, however, are adopting lower standards (e.g., 0.015 gr/dscf) for incinerators, which probably would require additional control technologies. Additional controls may raise capital costs and require expansion space (which may or may not be available). Additional controls, however, would capture finer particulate and some other pollutants.

Advantages of the controlled air system include high thermal efficiency as a result of lower stoichiometric air use, higher combustion efficiencies, and low capital costs (which may increase as more controls are required). As with all types of incinerators, disadvantages include potential incomplete combustion under poor operating conditions and problems associated with achieving proper operating temperatures during startup of a batch unit.[4]

Other Types of Incinerators

Most incineration systems constructed before the early 1960s were of the multiple-chamber types (sometimes referred to as excess air types). They operated with high excess air levels and thus needed scrubbers to meet air pollution control standards (8). Few multiple-chamber incinerator units are being installed today. Instead, older units of this type are used primarily for non-infectious wastes (3,8).

A small number of rotary kiln incinerators are currently operating, although greater use of them is being promoted by some. These incineration systems feature a cylindrical, refractory-lined (usually brick) combustion primary chamber. This chamber

[3]It is not known how many of these types of incinerators are still in use.

‘In batch units, the waste is placed in the furnace in batches and allowed to burn out. Combustion of the waste first occurs in the primary (ignition) chamber, through the introduction of heat by a burner.

rotates slowly (between 1 and 3 rpm) on a slightly inclined, horizontal axis. This rotation provides excellent turbulence (i. e., mixing). Yet, the rotary kiln systems tend to be costly to operate and maintain, usually require shredding (i. e., some size reduction of wastes), and usually require emission controls (3,8,83).

Variations of all types of incineration processes and other "innovative' technologies continue to appear. At present, however, controlled air incinerators are popular due to their relatively low (capital, operating and maintenance) cost and their ability to meet ***existing*** air standards without air pollution controls. As a result, the controlled air incineration industry is healthy. It remains in a relatively constant state of change and development, although there are frequent turnovers, mergers, and company failures in the industry (8).

Air Emissions and Ash

Concentrations of Emission Constituents

As of 1987, most States recommended but did not require control of opacity and particulate emissions from hospital incinerators (83). The reported range of concentrations of constituents in hospital incinerator emissions are presented in table 5. The raw data on emissions can be analyzed by normalizing the data to the amount of waste burned. Table 6 shows that for both polychlorinated dibenzodioxins (PCDDs, commonly referred to as dioxins) and polychlorinated dibenzofurans (PCDFs, commonly referred to as furans), hospital incinerator emissions are on the average one to two orders of magnitude higher per gram of waste burned than emissions from municipal incinerators. The single exception to this is the Hampton, Virginia, facility, which in the past emitted upper bound dioxin and furan levels that are one order of magnitude higher than the upper bound levels reported for hospital incinerators.[6]

Table 5.—Concentrations of Constituents in Emissions From Hospital incinerators Without Particulate Control Devices

Constituent	Range of emissions
Arsenic	1-5 .99 gr/dscf
Cadmium	24.7-140 gr/dscf
Chromium	2.15-30.9 gr/dscf
Lead	532-1190 gddscf
Nickel	2.22-8.0 gr/dscf
TCDD	3.3-38.5 ng/Nm^3
Total dioxins	51.8-450 ng/Nm^3
TCDF	18.9-79.8 ng/Nm^3
Total furans	117.3-785 ng/Nm^3
HCI	41-2095 ppmv
SO_2	19-50 ppmv
NO_x	155-270 ppmv

abbreviations: gr/dscf = grains per dry standard cubic foot; ng/Nm^3 = nanograms per standard cubic meter; ppmv = parts per million volume.

SOURCE: U.S. Environmental Protection Agency, "Hospital Waste Combustion Study, Data Gathering Phase," final draft, October 1987.

Table 6.—Dioxin and Furan Emission Concentrations (in ng/Nm^3)

Facilities	Total dioxins	Total furans
Hospitals:[a]		
A	160-260	386-700
B	290-450	700-785
c	117-197	52-84
Municipalities:		
Hampton, NY	243-10,700	400-37,500
North Andover, Mass.	225	323
Marion Co., Oregon	1.13	
Prince Edward Island, Canada	60-125	100-160
Tulsa, Okla.	18.9	15.5
Wurzburg	22.1	27.9
Akron, Ohio	258	679

aExact locations of hospitals were not reported in the study.

SOURCE: C.C. Lee, G. Huffman, and T. Shearer, "A Review of Biomedical Waste Disposal" (U.S. Environmental Protection Agency, Feb. 19, 1988).

Thus, hospital incinerators tend to produce more dioxins and furans per gram of waste burned than municipal incinerators. Given the smaller volume of medical waste incinerated, overall emissions from all medical waste incinerators are less than those from existing incinerators. Yet, since hospital incinerators are usually located in densely populated areas, potential exposure may be greater.

'Additional data may soon be available as a result of a settlement approved by the U.S. District Court of the District of Columbia between EPA and two environmental groups. The settlement includes a requirement for EPA to study emissions of dioxins and durans from hospital incinerators, the current regulations of State and local governments, and available control technologies of such emissions by January 31, 1989. By March 3, 1989, EPA is to complete a study of operating procedures for hospital incinerators. (See *Environmental Defense Fund and National Wildlife Federation v. Thomas,* Civ. No., *85-0973* (D. D.C.))

[6]The Hampton facility has recently been retrofitted, and its emissions have been significantly reduced (46).

Possible Reasons for Higher Emission Levels of Dioxins/Furans and HCl

Higher concentrations of dioxins and furans may be associated with medical waste incineration emissions due to:

1. the frequent startups and shutdowns these incinerators undergo;
2. less stringent emission controls;
3. poorer combustion control (e. g., waste mixing and oxygen controls); and
4. differences in the waste feed composition as compared with municipal solid waste.

Studies have shown that dioxins and furans can be formed *after* leaving the furnace, by the catalysis ***at low temperatures*** of precursors (such as chlorophenol and benzene) and chlorine atoms on fly ash particles (19). This suggests that destruction of precursors in the furnace and control of temperatures in the stack are important factors in preventing formation of dioxins and furans. Disagreement exists over whether pyrolysis of PVC in hospital incinerators can produce chlorobenzene (a potential dioxin precursor). EPA has studied the phenomenon of ‘transient puffs” (referring to upset conditions) in test incinerators burning PVC and polyethylene. During waste charging, hospital incinerators often experience high carbon monoxide emissions, indicating poor combustion. These transient puffs generate large quantities of products of incomplete combustion (PICs), including dioxins (40).

Almost all hospital incinerators are operated on an intermittent basis (83). Frequent startups and shutdowns of medical waste incinerators may lead to increased dioxin formation and may volatilize certain waste components, including pathogens. A study of dioxin emissions from the Westchester municipal incinerator in New York State found that during cold starts (without auxiliary fuel), dioxin and furan emissions were at least 10 times higher than under normal operation (14,38). The study concluded that dioxins are formed in cool sections of the incinerator (between 400 and 800 ‘F). If startups and shutdowns of medical waste incinerators are undertaken without auxiliary fuel, poor combustion may allow dioxin precursors (e. g., chlorophenols) to escape up the stack, increasing catalysis of dioxins and furans on fly ash particles.

A study by the New York State Energy and Research Development Authority (NYSERDA), however, found that the presence of polyvinyl chloride (PVC) was not related to the levels of dioxins and furans in the stack of a municipal incinerator, at least under the limited set of conditions during the test. Instead, formation of these compounds was partly related to the thoroughness of the combustion process. Poor combustion, which occurred at temperatures below 1500 ‘F and which was indicated by high carbon monoxide levels, resulted in substantial increases in dioxin and furan formation in the furnace (52).[7]

Moreover, differences in waste composition may influence the formation of dioxins and furans through increased concentrations of precursors. Medical waste can contain organic solvents that may act as aromatic precursors and chemicals such as anti-neoplastic agents (classified as RCRA hazardous waste) and bactericide. In addition, cytotoxic wastes represent approximately 1 to 2 percent of all hospital wastes (71).

Laboratory studies have found that pyrolysis of various plastics produces chlorinated aromatic hydrocarbons. For example, pyrolysis of PVC has resulted in the formation of benzene, 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene (85). On this basis, it is conceivable that pyrolysis of plastics may occur in the primary combustion chamber of controlled air units, causing the formation of dioxin and furan precursors. To reduce formation of these precursors, increased turbulence (mixing), retention time, and temperature are required (7). In addition, computerized combustion controls that regulate the level of oxygen in the furnace can improve destruction of precursors (40).

The concentrations of hydrogen chloride (HCl) also appear to be consistently higher, on average, compared with municipal waste combustors. One reason for this may be higher levels of PVC in medical waste (39).[8] EPA has reported that plastics comprise approximately 20 percent (by weight) of all hospital waste, compared with 5 to 10 percent in municipal solid waste (55). Virtually all of the chlorine present in these wastes is converted to HCl dur-

[7] See refs. 2,65.

[8] It should be noted, however, that HCl is contained primarily in PVC and not other types of plastics. OTA does not have data on how much PVC is in the plastic portion of the medical wastestream.

ing the actual combustion ‘process, assuming a high combustion efficiency. The chlorinated plastics may contribute to some of the high emission rates of HCl and possibly dioxins. HCl may be controlled by monitoring waste input or through the installation of appropriate air pollution control technologies (e. g., acid gas scrubbers).

Concentrations of Constituents in Ash

Little data has been reported describing the concentrations of the constituents of medical incinerator ash. Heavy metals have been found in hospital incinerator emissions and are expected to be present in incinerator ash. Lead and cadmium, for example, are found in radioisotope shielding as well as pigments and additives in plastics (40). Limited data from one hospital showed that extractions of the fly ash sample were well above EP Toxicity limits for cadmium and lead. Extractions from the bottom ash sample were well below EP Toxicity limits (7). One study summarized dioxin and furan concentrations in fly ash from three hospital incinerators and four municipal incinerators (19). (See table 7.) The data reveal that concentrations of both dioxins and furans are considerably higher in hospital incinerator fly ash than in municipal incinerator fly ash.

Total dioxin levels in hospital incinerator fly ash samples were between 1 and 2 ppm, which is much higher than the range of 7 to 80 ppb for the municipal fly ash samples. (See table 7.) In addition, none of the fly ash samples from the hospital incinerators had concentrations of the 2,3,7,8-TCDD isomer alone that were below 1.4 ppb. A concentration of 1.4 ppb of **total 2,3,7,8-TCDD** equivalents is the figure that CDC and EPA Headquarters have used as an indicator of safe concentrations of dioxin in ash. If total toxic equivalents are calculated, hospital incinerators actually exceed the dioxin standards by about two orders of magnitude. It is important to note, however, that this comparison is based on a limited sample, and caution is required when attempting to draw any conclusions based on the reporting of so few studies.

Table 7.—Concentrations of Dioxins and Furans in Fly Ash From Municipal and Hospital Incinerators (rig/g, equivalent to parts per billion)

	Incinerator type	
Constituent	Municipal	Hospital
2,3,7,8-TCDD	**0.03-0.34**	**1.4-3.4**
Tetra CDD	0.6-7.5	94-404
Penta CDD	1.2-13,2	208-487
Hexa CDD	1.4-15.8	271-411
Hepta **CDD**	**1.8-25.6**	**189-307**
Octa CDD	**1.9-23.1**	**123-245**
Total dioxins	**6.9-80.3**	**1155-1737**
Tetra CDF	**9.0-32.1**	**199-376**
Penta CDF	**10.2-38.3**	**285-647**
Hexa CDF	**8.0-31.7**	**253-724**
Hepta CDF	**3.4-15.9**	**125-286**
Octa CDF	**0.7-4.6**	**25-134**
Total furans	**31.3-1 19,5**	**895-2140**

SOURCE: H. Hagenmaier, M. Kraft, H. Brunner, and R. Haag, “Catalytic Effects of Fly Ash From Waste Incineration Facilities on the Formation and Decomposition of Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans,” *Environment, Science and* Technology 21(1 1): 1080-1084, 1987,

Future Trends in Medical Waste Incineration

There are a number of factors (in addition to the definitional issues discussed above) which may influence the waste disposal practices of hospitals in the future. First, the stringency of the emission standards that hospital incinerators will need to meet will determine the type and cost of air pollution controls. The cost and engineering feasibility of retrofitting existing hospital incinerators with acid gas scrubbers and/or particulate matter controls, and computerized combustion controls, may force many hospitals to cease on-site incineration in favor of off-site centralized incineration. g The ***capital*** costs of larger regional incinerators are presumed to be lower per ton of waste than smaller individual hospital incinerators (6). Other costs, such as transportation, however, need to be considered. Also, generators of wastes using a regional facility rather than incinerating wastes on-site may not realize a cost savings.

Second, increased regulation of ash disposal may provide further impetus for hospitals to utilize off-site management of wastes or residuals. Even those hospitals that continue to incinerate wastes on-site may be forced to contract with a centralized ash management facility. It is unlikely that disposal of

‘See, for example, refs. 6,39); Currently, insurance is *apparently* available for hospital incinerators (e. g., refs. 27,31) and financing for construction of off-site facilities is also available (18). Future concerns in these areas do exist as well as concerns over potential siting problems and other difficulties associated with the construction of most waste facilities of any type today.

incinerator ash in existing municipal landfills will **continue to be allowed. This may result in the need** to send the ash to more stringently controlled landfills or monofills. Regardless of whether ash is regulated under either Subtitle C or as a special waste under Subtitle D, relatively short-term liability costs associated with RCRA corrective action as well as longer term liability associated with Superfund could increase insurance and other operating costs for these ash disposal facilities.

Controlled air incinerators have traditionally been popular for medical wastes. As noted above, this is apparently due to the fact that they can achieve relatively lower particulate emissions, as compared with rotary kiln incinerators (which tend to be higher priced due at least in part to the need for emission controls, such as fabric filters or electrostatic precipitators) (3). As best available control technology (BACT) emission standards below 0.08 gr/dscf for particulate matter (PM) are promulgated, however, controlled air facilities will require additional emission controls and may lose one cost advantage over rotary kiln models.

For example, New York recently proposed PM standards for new hospital incinerators of 0.01 gr/dscf for facilities processing more than 50 tons per day and 0.015 gr/dscf for facilities processing less than 50 tons per day, as well as a standard of 0.03 gr/dscf for existing facilities. In contrast, the new Pennsylvania PM standard is 0.08 gr/dscf for modular facilities, which can probably be met by many controlled air facilities without emissions controls. Mid-sized units must meet 0.03 gr/dscf and large units must meet 0.015 gr/dscf. The 0.03 and 0.015 standards will require air pollution control devices.

Alternative technologies are being studied for medical waste disposal. For example, the Department of Energy announced its participation in a demonstration project at a hospital in Pennsylvania to incinerate hospital wastes with coal in a fluidized bed boiler. The temperatures at which coal burns in these combustors is about 1,600 ‘F, which is considered sufficient to render most medical waste non-infectious. Limestone is added to the bed to absorb sulfur. Moreover, both the limestone and the coal ash itself, are chlorine-capturing agents. The fluidized bed combustion could allow hospitals to incinerate waste on-site and also to produce energy for heat, steam, or other hospital uses (64).

Autoclaving

Autoclaving, or steam sterilization, is a process to sterilize medical wastes prior to disposal in a landfill.[10] Since the mid-1970s, steam sterilization has been a preferred treatment method for microbiological laboratory cultures. Other wastes (e. g., pathological tissue, chemotherapy waste, and sharps) may not be adequately treated by some sterilization operations, however, and thus require incineration (72). OTA has no data on the total amount of medical wastes sterilized in the country.

Typically, for autoclaving, bags of infectious waste are placed in a chamber (which is sometimes pressurized). Steam is introduced into the container for roughly 15 to 30 minutes. Steam temperatures are usually maintained at 250 ‘F (63). Some hospital autoclaves, however, are operated at 270 ‘F (61). This higher temperature sterilizes waste more quickly, allowing shorter cycle times.

Several studies indicate that the type of container (e.g., plastic bags, stainless steel containers), the addition of water, and the volume and density of material have an important influence on the effectiveness of the autoclaving process (41 ,54,63). Each of these factors influences the penetration of steam to the entire load and, consequently, the extent of pathogen destruction. Autoclaving parameters (e.g., temperature and residence/cycle time) are determined by these factors.

Since there is no such thing as a “standard load” for an autoclave, adjustments need to be made by an operator based on variation in these factors. As with many technologies, proper operation of autoclaves is key to effective functioning (i. e., in this case, sufficient pathogen destruction to render wastes non-hazardous).

One method of assuring that pathogen destruction has taken place is the use of biological indicators, such as ***Bacillus stearothermophilus.*** Elimination of this organism (as measured by spore tests) from a stainless steel container requires a cycle time

[10]Ethylene oxide and other gas sterilization processes, as well as some chemical (including the use of radioactive) processes, are also used to treat wastes.

of at least 90 minutes of exposure. This is considerably longer than is currently provided by standard operating procedures (61 ,63). This conservative approach, however, may provide more pathogen destruction than is necessary to reduce microbiological contamination to non-infectious levels (63).

Chemical disinfection (e. g., with formaldehyde, xylene, alcohol) is used to sterilize reusable items. Recently, sodium hypochlorite has been used in a process to disinfect disposable products. Partial destruction of the material is achieved, but additional incineration and high capital costs are associated with the process as well.

Several factors have led some hospitals to abandon autoclaving. For example, problematic operating conditions can lead to incomplete sterilization. In addition, landfill and off-site incinerator operators are increasingly refusing to receive such wastes, questioning whether the waste has actually been treated. The refusals are partly in response to the fact that most autoclave "red bags' do not change color and thus appear no different from non-autoclaved red bags (even though they often are labeled or in some way identified as "autoclave"). This also has led to more cumbersome documentation and/or identification requirements in an effort to avoid refusals (72).

Incineration v. Autoclaving; and the Importance of Proper Operation

Autoclaves must achieve minimum temperatures and be operated according to appropriate cycle times to ensure adequate destruction of pathogens. Primary and secondary chamber temperatures of 1,400 'F and 1,600 'F, respectively, must be reached in hospital incinerators to ensure adequate combustion and minimum air emissions (83). Normally, these temperatures would ensure the destruction of pathogens in the waste, however, if an incinerator is loaded and fired-up cold, pathogens could conceivable escape from the stack. Data is not readily available to evaluate this point further. At the typical operating temperature of an autoclave (250 "F), the cycle time of 45 to 90 minutes is necessary to reduce pathogen concentrations in most hospital waste below infectious levels (63).

The proper operation of incinerators and autoclaves is critical to their effective functioning. Proper operation is dependent on at least four conditions: 1) trained operators; 2) adequate equipment (i. e., proper design, construction, controls and instrumentation); 3) regular maintenance; and 4) repair. For example, trained operators need to be knowledgeable in the operation of the incinerator and in the proper handling of medical wastes. It is not clear, however, that workers are consistently receiving adequate training in the operation of incinerators or autoclaves, and consequently that most units are operating properly. [11]

Autoclaves do provide some advantages over incinerators, which may increase their attractiveness as a disposal option, particularly if incineration regulations become much more stringent and thereby increase incineration costs. For example, operation and testing of incinerators is more complex and difficult than that for autoclaves (57). In addition, environmental releases from incinerators probably contain a broader range of constituents (e. g., dioxins, heavy metals) than autoclaves.

Autoclaves are also less costly to purchase and operate and require less space. These cost advantages, however, may be lessened if incineration is also required.

A major difficulty associated with autoclaving is the reluctance of landfill and (off-site) incinerator operators to accept medical wastes. This, along with other difficulties associated with autoclaving, such as ensuring the proper operation of the autoclaving process (e. g., sufficient residence time to ensure pathogen destruction), the more limited capacity of most autoclaves, and the time-consuming process for autoclaving compared with incineration, make it a less common waste treatment method for most facilities (53). 12

[11] EPA is preparing a training manual for the operators of hospital incinerators and an air compliance inspection guide.

[12] Recently, new technologies for autoclaving have been announced. For example, one company has introduced a large mobile autoclaving unit (moved on a semi-trailer) that can sterilize approximately 1,500 pounds of waste per hour. Materials ' 'cook' at 275 'F and are then allowed to cool. Special autoclaving bags are apparently not necessary, and the process is advertised as an economical disposal option for certain medical wastes. See announcement in *Infectious Waste News,* June 18, 1987.

Health and Environmental Risks From Treatment Technologies[13]

The few risk assessments that have been performed on individual hospital incinerators have predicted health risks (specifically, cancer risks) that are comparable to those predicted for municipal incinerators (20,47). Important differences, however, in risk assessment methodologies and the site-specific nature of these risk assessments precludes meaningful comparisons between projected cancer risks. For example, most risk assessments account for risks associated with inhalation, but not for those associated with ingestion. In addition, the age of facilities under investigation varies considerably, and older facilities tend to have less-than-optimal operating conditions and/or less air pollution control equipment.

There are two important points regarding hospital incinerator emissions: 1) hospital incinerators do not generally achieve emission levels as low as those reported for municipal incinerators; but 2) they tend to burn a much smaller volume of waste and so emit smaller quantities of toxic constituents. Yet, the closer proximity of many hospital incinerators to populations is also an important consideration. In any case, no national estimates have been developed for aggregate cancer risks from all hospital incinerators that can be compared with EPA's national estimates for municipal incinerators. Additionally, no national estimates of non-cancer effects associated with hospital incinerator emissions have been undertaken.

[13]Note, currently most of the attention here is on risks from the incineration of biomedical wastes. Additional information, as available, will be added on risks associated with autoclaving and landfilling.

The risks associated with incinerator emissions have been estimated by States for individual municipal incinerators and by EPA for all municipal incinerators (48,82). In contrast, few risk assessments have been performed for hospital incinerators. The New Jersey Department of Environmental Protection (N.J. DEP) performed a risk analysis on four hospital incinerators for seven carcinogens (four metals, two VOCs and TCDD), HCl, and criteria pollutants (20). Only TCDD was found to pose a cancer risk of greater than one in a million. The upper bound cancer risks from chromium and cadmium, the second and third most significant carcinogens, were both one order of magnitude lower than TCDD.

A risk analysis of a proposed hospital incinerator in Michigan predicted upper bound dioxin cancer risks that were one order of magnitude lower than those predicted by N.J. DEP (12). The New Jersey risk assessment only examined the tetra dioxin homolog and did not include other dioxin homologs or furans in the analysis. This may have resulted in some underestimation of the upper bound cancer risk. One review of data on dioxin and furan emissions from hospital incinerators has found emission rates of total dioxins and total furans generally higher than those from municipal incinerators (42).

The New Jersey results are consistent with the national risk assessment performed by EPA on municipal incinerators insofar as they indicate that dioxins are responsible for most of the cancer risk associated with incinerator emissions (82). EPA's analysis, which examined the risk from municipal incinerators on a national basis, found that dioxins posed the greatest risk of cancer by two orders of magnitude, compared with the second most significant carcinogen present, cadmium.