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Medical Waste Incinerators-Background Information for Proposed Standards and Guidelines: Industry Profile Report for New and Existing Facilities

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INDUSTRY PROFILE REPORT

1.0 INTRODUCTION

1.1 PURPOSE

This report presents a profile of the medical waste incinerator (MWI) source category. The purpose of this profile is to characterize the source category for use in subsequent environmental and economic analyses. Definitions of medical waste and MWI's are presented, and the industry structure associated with MWI's is described.

1.2 BACKGROUND

In recent years, public concern has grown about potential health hazards from the improper disposal of medical wastes. The washup of medical waste on beaches in 1988 heightened public awareness even further. While not all medical waste poses significant health hazards, improper disposal can lead to public exposure to infectious organisms, such as the AIDS and hepatitis B viruses, and can result in aesthetically unpleasant situations. Public exposure routes include beaches with waste washups and trash dumpsters in which medical wastes have been placed.

Because significant public concern has been raised about medical waste disposal, lawmakers and regulatory agencies have acted to ensure that medical waste generators properly treat and dispose of their waste. As a consequence of these regulatory actions, treatment by sterilization or incineration and disposal by subsequent landfilling are becoming the treatment and disposal methods of choice. Incineration is frequently preferred over sterilization because it reduces the volume of treated waste to be landfilled and generally renders the waste unrecognizable. This preference is likely to result in increased use of incineration.

1.3 ORGANIZATION

The remaining sections of this report describe the characteristics of the industry associated with medical waste incineration. In Section 2.0, a summary of the findings is

presented. Section 3.0 presents the definitions of medical waste and MWI adopted for this industry profile. This section also includes information on the characteristics of medical waste. Section 4.0 presents the alternative technologies for treatment, destruction, and disposal of medical wastes. Section 5.0 presents the available information on the medical waste generator population. Information on the existing MWI population and projected growth is presented in Section 6.0.

2.0 SUMMARY

It is estimated that approximately 3.4 million tons of waste are produced annually by medical waste generators in the United States. This total includes any solid waste generated at these facilities. Table 1 presents estimates of annual infectious waste and total waste generation for 14 categories of generators. These estimates are discussed by category in Section 5.0. As shown in Table 1, hospitals are the single largest generator, producing approximately 70 percent of the annual total.

In Table 2, the estimated U.S. population of MWI's is presented, along with statistics on the units' rated capacities. In all, about 5,000 MWI's are believed to exist. Estimates are presented for each type of facility at which MWI's are commonly found. Over half of these MWI's are found at hospitals. These estimates are discussed more fully in Section 6.0.

3.0 CHARACTERIZATION OF MEDICAL WASTE

3.1 DEFINITION OF MEDICAL WASTE

The Solid Waste Disposal Act of 1965 was amended by the Resource Conservation and Recovery Act (RCRA) of 1976. In 1988, RCRA was amended by the Medical Waste Tracking Act (MWTA). Medical waste is defined by MWTA, Section 1004 (40) as ". . . any solid waste which is generated in the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in production or testing of biologicals." ("Biologicals" refers to preparations, such as vaccines, that are made from living organisms.) Specifically excluded from this definition are hazardous waste and household waste as identified in RCRA, Subtitle C.

TABLE 1. ESTIMATED NUMBER OF U.S. FACILITIES AND QUANTITY OF WASTE GENERATED ANNUALLY BY GENERATOR CATEGORY[1]

Generator category	No. of facilities	Annual infectious waste generated, tons	Annual total waste generated, tons
Hospitals	7,000	360,000	2,400,000
Laboratories			
Medical	4,900	17,600	117,500
Research	2,300	8,300	55,500
TOTAL	7,200	25,900	173,000
Clinics (outpatient care)	41,300	26,300	175,000
Physicians' offices	180,000	35,200	235,000
Dentists' offices	98,000	8,700	58,000
Veterinarians	38,000	4,600	31,000
Long-term care facilities			
Nursing homes	18,800	29,700	198,000
Residential care	23,900	1,400	9,000
TOTAL	42,700	31,100	207,000
Free-standing blood banks	900	4,900	33,000
Funeral homes	21,000	900	6,000
Health units in industry	221,700	1,400	9,000
Fire and rescue	7,200	1,600	11,000
Corrections	4,300	3,300	22,000
Police	13,100	<100	<1,000
TOTAL	682,400	504,000	3,361,000

TABLE 2. ESTIMATED U.S. MWI POPULATION WITH RATED CAPACITY STATISTICS[1]

Facility type	Population		Rated capacity, lb/hr			
	Units	Percent of total	Range	Average	Total	Percent of total
Hospitals	3,150	63	3-2,500	274	918,000	64.5
Laboratories	500	10	3-3,000	338	169,000	11.9
Veterinary facilities	550	11	15-2,000	122	85,000	6.0
Nursing homes	500	10	3-1,300	168	50,000	3.5
Commercial facilities	150	3	100-8,000	1,179	177,000	12.4
Other/unidentified facilities	150	3	25-900	166	25,000	1.7
Total	5,000	100	3-8,000	254	1,424,000	100
Municipal waste combustors that cofire medical waste	31		20 tons/d to 375 tons/d	118 tons/d		

The definition of medical waste adopted for this industry profile includes all materials encompassed by the RCRA/MWTA statutory definition of medical waste. These materials are included regardless of their infectious properties, whether they are generated in association with humans or animals, or whether they have been used before they are discarded. Waste generated by health care providers who provide medical services to individuals in private homes is covered by the working definition when the waste is removed from the home and transported to the provider's place of business for disposal. Similarly, veterinary waste that is generated at a home or farm is also covered by the definition when the waste is transported to the veterinarian's place of business. Any mixtures of the types of medical waste discussed above with any other waste are also considered to be medical waste.

Because emissions from incineration depend greatly on the materials that are combusted, the intent of the definition of medical waste presented above is to include all the components of the medical waste stream, regardless of what they were used for prior to disposal. This approach differs from that adopted for most medical waste regulatory and guidance activities to date, which have been concerned with the potential for transmission of infectious diseases. For this purpose, the term "infectious waste" is generally, but not universally, used to refer to the subset of medical waste that is capable of transmitting an organism that causes an infectious disease. Other terms commonly used for the infectious component of medical waste include biological, biomedical, biohazardous, contaminated, red bag, pathological, and pathogenic waste. The U. S. Environmental Protection Agency (EPA) Office of Solid Waste (OSW) uses the term "regulated medical waste" in its implementation of the MWTA. Definitions of these terms generally take the format of a list of types of waste to be included based on infection hazard. Other factors that may be considered are the potential for injury (e.g., from "sharps" such as hypodermic needles and scalpels) and

aesthetic considerations (e.g., the unpleasantness of encountering recognizable body parts).

The categories of regulated medical waste, as defined by OSW, are presented in Table 3. Where "infectious agents" are mentioned, OSW has indicated that this term means infectious to humans. Thus, for example, veterinary waste (other than sharps) that has no potential for containing human pathogens is not included. As indicated above, the definition of medical waste for this industry profile has been broadened to reflect potential emissions from incineration rather than infection potential.

3.2 CHARACTERISTICS OF MEDICAL WASTE

Waste materials produced by facilities that generate medical waste, primarily hospitals, are heterogeneous mixtures of general refuse, laboratory and pharmaceutical chemicals and containers, and pathological wastes. All of these waste components may contain medical waste as defined above, as well as potentially infectious agents. In some cases, these wastes also may contain low-level radioactive wastes, wastes classified as hazardous under RCRA Subtitle C, and cytotoxic wastes.

3.2.1 Infectious Component

The fraction of medical waste that is classified as infectious waste depends on the type of generator, the activities that produce the waste, and the definition of infectious waste used. Probably the most widely used guidelines for classifying infectious waste are those issued by the Centers for Disease Control (CDC) and by EPA.[3,4] A more recent development is the "universal precaution" recommendations issued by the CDC in August 1987.[5] These recommendations were intended to reduce potential occupational exposure to the AIDS virus within the health-care setting and were not intended to affect waste management practices.[6] Nevertheless, the universal precaution recommendations apparently resulted in some hospitals classifying virtually all patient-contact waste as infectious.[7,8] Table 4, reproduced from a study conducted in 1987 and 1988, summarizes the types of medical waste designated as infectious by the CDC and EPA guidelines and by a random sample of U.S. hospitals.

TABLE 3. REGULATED MEDICAL WASTES[2]

Waste class	Description
1. Cultures and stocks	Cultures and stocks of infectious agents and associated biologicals, including: cultures from medical and pathological laboratories; cultures and stocks of infectious agents from research and industrial laboratories; wastes from the production of biologicals; discarded live and attenuated vaccines; and culture dishes and devices used to transfer, inoculate, and mix cultures.
2. Pathological wastes	Human pathological wastes, including tissues, organs, and body parts and body fluids that are removed during surgery or autopsy or other medical procedures and specimens of body fluids and their containers.
3. Human blood and blood products	(a) Liquid waste human blood; (b) products of blood; (c) items saturated and/or dripping with human blood; or (d) items that were saturated and/or dripping with human blood that are now caked with dried human blood, including serum, plasma, and other blood components and their containers, which were used or intended for use in patient care, testing and laboratory analysis, or the development of pharmaceuticals. Intravenous bags are also included in this category.
4. Sharps	Sharps that have been used in animal or human patient care or treatment or in medical, research, or industrial laboratories, including hypodermic needles, syringes (with or without the attached needle), Pasteur pipettes, scalpel blades, blood vials, needles with attached tubing, and culture dishes (regardless of presence of infectious agents). Also included are other types of broken or unbroken glassware that were in contact with infectious agents, such as used slides and cover slips.
5. Animal wastes	Contaminated animal carcasses, body parts, and bedding of animals that were known to have been exposed to infectious agents during research (including research in veterinary hospitals), production of biologicals, or testing of pharmaceuticals.
6. Isolation wastes	Biological waste and discarded materials contaminated with blood, excretion, exudates, or secretions from humans who are isolated to protect others from certain highly communicable diseases or from isolated animals known to be infected with highly communicable diseases.
7. Unused sharps	The following unused, discarded sharps: hypodermic needles, suture needles, syringes, and scalpel blades.

TABLE 4. TYPES OF MEDICAL WASTE DESIGNATED AS INFECTIOUS BY THE CDC, THE EPA, AND 441 RANDOMLY SELECTED U.S. HOSPITALS[a]

Source/type of medical waste	CDC	EPA	U.S. Hospitals[b]
Microbiological	Yes	Yes	Yes (99.0)
Blood and blood products	Yes	Yes	Yes (93.7)
Pathology	Yes	Yes	Yes (95.6)
Sharps	Yes	Yes	Yes (98.6)
Communicable disease isolation	No	Yes	Yes (94.4)
Contaminated animal carcasses, body parts, and bedding	Yes	Yes	Yes (90.1)
Contaminated laboratory waste	No	Optional	Yes (88.8)[c]
Surgery	No	Optional	Yes (83.2)
Autopsy	No	Optional	Yes (91.9)
Dialysis	No	Optional	Yes (63.4)
Contaminated equipment	No	Optional	No data
Items contacting secretions or excretions	No	No	Yes (63.2)
Intensive care	No	No	Yes (37.4)
Emergency department	No	No	Yes (41.1)
Surgery patients	No	No	Yes (33.2)
Obstetric patients	No	No	Yes (35.1)
Pediatric patients	No	No	Yes (25.3)
Treatment/examination room	No	No	Yes (30.3)
All patient related	No	No	Yes (23.6)

[a]Reference 15.
[b]Percent of responding hospitals that considered the waste infectious.
[c]The survey specifically asked if hospitals considered "miscellaneous laboratory wastes (e.g., specimen or slides)" as infectious.

The survey from which Table 4 was reproduced indicates that responding hospitals classified a median of 15 percent of total waste as infectious.[9] Those hospitals with definitions close to the CDC guidelines averaged 5.5 percent, those approximating the EPA guidelines averaged nearly 13 percent, and those extending universal precaution practices to waste disposal averaged about 23 percent.

In the regulatory impact and flexibility analysis developed for the Occupational Safety and Health Administration (OSHA) proposed regulations on occupational exposure to bloodborne pathogens, similar estimates were derived based on a review of earlier studies and expert opinion. This analysis concluded that the fractions of total hospital waste designated as infectious waste at facilities using the CDC guidelines, facilities adhering to the EPA guidelines, and facilities using universal precautions in waste disposal are approximately 6, 11, and 18 percent, respectively.[10] Another source estimates that about 15 percent of hospital waste is infectious; other estimates range from 5 to 35 percent and from 10 to 20 percent, with one study reporting an overall range of estimates between 3 and 90 percent.[11-14]

It should be noted that these studies and estimates are specific to hospitals and generally relate to the fraction of total waste, not medical waste, that is infectious. The percentage of the total waste stream that is medical waste is not known. For the purpose of this project, the percentage of total waste that is considered to be infectious at other facilities was assumed to be the same as that at hospitals (15 percent).

3.2.2 Chemical and Physical Characteristics

The chemical and physical characteristics of the different waste materials that are treated in medical waste incinerators vary widely. These characteristics are important because they affect combustion efficiency and emission characteristics. Limited data have been generated from a study of hospitals in Ontario, which provided information on the heating value, bulk density, and moisture content of different waste materials. The results from this study are presented in Table 5.[16]

TABLE 5. CHARACTERIZATION OF HOSPITAL WASTE[16]

Component description	HHV dry basis, Btu/lb[a]	Bulk density as fired, lb/ft^3	Moisture content of component, weight %	Heat value as fired, Btu/lb
Human anatomical	8,000-12,000	50-75	70-90	800-3,600
Plastics	14,000-20,000	5-144	0-1	13,900-20,000
Swabs, absorbants	8,000-12,000	5-62	0-30	5,600-12,000
Alcohol, disinfectants	11,000-14,000	48-62	0-0.2	11,000-14,000
Animal-infected anatomical	9,000-16,000	30-80	60-90	900-6,400
Glass	0	175-225	0	0
Beddings, shavings, paper, fecal matter	8,000-9,000	20-45	10-50	4,000-8,100
Gauze, pads, swabs, garments, paper, cellulose	8,000-12,000	5-62	0-30	5,600-12,000
Plastics, PVC, syringes	9,700-20,000	5-144	0-1	9,600-20,000
Sharps, needles	60	450-500	0-1	60
Fluids, residuals	0-10,000	62-63	80-100	0-2,000

[a]HHV = Higher heating value.

These data indicate that the waste can vary considerably in composition and, consequently, in heat content, moisture content, and bulk density. In particular, the heating value can range from a low value of about 1,000 British thermal units per pound (Btu/lb) (primarily low-Btu, high-moisture anatomical waste) to 20,000 Btu/lb (low-moisture, high-heat content plastics such as polyethylene).

The chemical composition of the waste materials, particularly the metals and plastics content, are also of concern because of their impact on air pollutant emissions. Metals that vaporize at the primary combustion chamber temperature (e.g., mercury, cadmium, and arsenic) may be emitted as metal oxides. Halogenated plastics such as polyvinyl chloride (PVC) produce acid gases such as hydrogen chloride (HCl). The presence of the chlorinated waste may also contribute to the formation of toxic organic pollutants such as chlorinated dibenzo-p-dioxins (CDD's) and chlorinated dibenzofurans (CDF's).

To date, only limited data have been compiled on the plastics and metals content of medical wastes. Various studies have reported plastics contents that range from as little as 10 percent to about 30 percent.[7,12,17,18] No quantitative estimates of metals content in MWI waste feed have been developed. However, some facilities have reported significant concentrations of lead and cadmium in incinerator ash. Sources of metals include radiological materials (lead), stabilizers (cadmium) and pigments (chromium, cadmium) in plastics, and batteries (nickel and cadmium). Additional data on plastic and metals content of medical waste may be generated by OSW as data gathering is carried out to implement the MWTA.

3.3 DEFINITION OF MEDICAL WASTE INCINERATOR

For the purposes of this analysis, an MWI is defined as any device in which any amount of medical waste is burned. Based on the current working definition of medical waste, the MWI source category includes a wide variety of incinerators located at many types of facilities.

4.0 MEDICAL WASTE TREATMENT, DESTRUCTION, AND DISPOSAL ALTERNATIVES

4.1 TREATMENT

The potential for disease transmission associated with medical waste has been recognized by the medical community, environmentalists, lawmakers, and the general public, and increasing amounts of medical waste are being treated to reduce the hazard prior to disposal. With the MWTA, Congress has mandated the demonstration of a medical waste tracking program that is designed to evaluate the generation, treatment, disposal, and transportation of medical wastes. The merits of the program will be evaluated at its completion, and the appropriateness of a national program will be determined at that time. The treatment methods discussed in the following paragraphs reduce or eliminate the potential for disease transmission so that medical waste may be managed and disposed of safely. These treatment methods have been tested for the destruction of pathogens. However, their effectiveness in completely sterilizing medical waste has not been determined. Also, except for incineration, the methods below have not been thoroughly studied to determine if any other pollution or health effects are caused by their use.

4.1.1 Incineration[19]

Medical waste is burned in incineration units under controlled conditions to yield ash and combustion gases. Modern incineration units usually consist of two chambers. The waste is combusted in the primary chamber, usually at temperatures between 1200° and 1400°F. Airborne contaminants, such as volatile organics, that are released from the primary chamber are combusted in the secondary chamber.

4.1.2 Steam Sterilization[19,20]

Steam sterilization, or autoclaving, is the process of exposing medical waste to saturated steam under pressure for a specified period of time, to render the waste noninfectious. The effectiveness of autoclaving can be influenced by the duration of the cycle, the amount of pressure, the temperature, the

characteristics of the waste stream, and the design of the equipment.

4.1.3 Thermal Inactivation[21]

Thermal inactivation is similar to steam sterilization but uses dry heat rather than steam. Thermal inactivation may be used to treat both solid and liquid wastes. Solid wastes are treated in an oven, while liquid wastes are treated in a heat exchanger apparatus. Thermal inactivation is not as efficient as steam sterilization and must be monitored carefully so that wastes are exposed to the proper temperatures for the specified duration. This process is not practical for large scale waste treatment.

4.1.4 Chemical Disinfection[21]

Chemical disinfection kills infectious organisms by exposing them to chemicals that are strong oxidizing agents such as hydrogen peroxide or chlorine bleach. This method of treatment is generally used on the surfaces of medical equipment, but has been applied to large-scale medical waste disinfection. Chemical disinfection is generally combined with grinding or shredding prior to, or during, the disinfection process to increase the efficiency of the process and to render the waste unrecognizable.

4.1.5 Gas Sterilization[21]

Gas sterilization involves exposing medical waste to vaporized chemicals that cause oxidation reaction damage to cellular structures. The chemical most often used is ethylene oxide. Unfortunately, ethylene oxide is a suspected human carcinogen and, thus, must be handled and used with extreme caution. Typically, reusable medical equipment is placed in a closed vacuum vessel, ranging in size from a few cubic feet to several thousand cubic feet and exposed to the sterilant gas. Although it is possible to apply this method of treatment to medical waste, the hazards associated with the chemicals preclude the widespread use of gas sterilization.

4.1.6 Irradiation Sterilization[21,22]

Irradiation is currently used to sterilize medical supplies, food, and consumer products and is a technique that may be

applicable to medical waste. Irradiation of medical waste with ionizing or ultraviolet radiation kills infectious agents and destroys the ability of bacteria to replicate.

The most common source of ionizing radiation is from Cobalt-60, which produces gamma radiation. Gamma radiation can penetrate up to several meters of waste and requires minimal amounts of electricity. The exposure time that is required to treat the waste varies as the radiation source decays. One commercial facility formerly used gamma irradiation for medical waste treatment. This facility, however, has switched to radio frequency irradiation treatment.

Ultraviolet radiation does not penetrate the waste as deeply as gamma radiation but has been used successfully in treating wastewaters. The water is exposed to ultraviolet light at a wavelength of approximately 245 nanometers. This wavelength is very close to the optimum germicidal wavelength that renders the wastewater free of infectious organisms.

4.1.7 Microwave Sterilization[23]

Microwaves have been used to treat medical waste. Before being treated with the microwaves, the waste is shredded so that the waste is more efficiently exposed to the microwaves. The shredded waste is sprayed with water and treated with microwaves to a temperature of 200°F.

4.1.8 Radiofrequency Sterilization[24]

The treatment of medical waste using radiofrequency (RF) irradiation is described in a Draft OSW Report to Congress as a treatment method that:

> ... involves the exposure of shredded infectious medical waste material to high-strength, low-frequency, shortwave radiofrequency (RF) radiation to heat the waste to the desired temperature. The heated waste is then stored in insulated containers to maintain the elevated temperature for a period of 4 hours. At the end of the storage period, the waste is disposed of in a landfill or recycled as refuse-derived fuel, or the segregated plastic portion of the waste may be sold as recycled material.

Only one facility is known to be treating medical waste with RF irradiation. This facility combines RF irradiation with waste shredding.

4.2 PHYSICAL DESTRUCTION

Physical destruction of medical waste serves two purposes. First, the waste is made unrecognizable, which is desirable for aesthetic reasons. A number of jurisdictions require that certain types of waste such as tissue and body parts be destroyed prior to disposal. In the regulations adopted by OSW to implement the MWTA, regulated medical waste must be tracked until it is both treated and destroyed, at which time it is no longer considered regulated medical waste. The second effect of destruction is that the volume of the waste is reduced. This consideration is increasingly important as existing landfills approach capacity and new landfills become more costly and difficult to construct. The two major destruction technologies are incineration and grinding or shredding. Most other technologies do not render waste unrecognizable and achieve little or no volume or weight reduction.

4.2.1 Incineration

An MWI combines the functions of waste treatment and destruction. In a well-designed and -operated unit, infectious organisms are destroyed by exposure to high temperature, and the combustible waste materials are reduced to a fine ash. Both the volume and weight of the waste are reduced by up to 95 percent.

4.2.2 Grinding or Shredding

Technology more recently applied to medical waste is grinding or shredding using hammermills or other devices. While these devices can reduce the volume (by about 80 percent) and recognizability of the waste, the weight and potential for infection are not affected. In medical waste applications, grinding or shredding is generally coupled with a disinfection treatment technology. Because the grinding or shredding reduces the waste to small, uniformly sized pieces prior to treatment, the effectiveness of the disinfection process is increased. Two shredding/microwave sterilization systems are in use: one in

Europe and one at a hospital in the United States. A number of domestic companies offer shredding/chemical disinfection systems, and one commercial facility combines shredding and radiofrequency sterilization. Steam sterilization systems that employ shredding typically do so after the waste has undergone sterilization.

4.3 DISPOSAL[25]

Medical waste, with or without prior treatment or destruction, is typically disposed of in a landfill or a sanitary sewer. Solid wastes are usually landfilled, while liquid wastes are disposed of in a sewer. The regulations and requirements for medical waste disposal vary from State to State and from landfill to landfill.

Many States now have some requirements for treating medical waste prior to landfilling. Regulatory activity in this area has increased greatly in the wake of the beach washups in 1988. Incinerated medical waste generally may be landfilled the same as any other solid waste, although there have been some cases where high concentrations of toxic metals have made disposal as a hazardous waste necessary.

Sanitary sewer disposal of treated or untreated liquid medical waste is minimally regulated in comparison to solid medical waste disposal. Many States do not require any treatment of liquids before they are disposed of in the sewer. Specific types of liquid wastes are sometimes required to be treated before disposal, but, in most cases, regulation of sewer disposal is left to local authorities. Often, all that is required for sewer disposal is written permission from the local sewer authority.

5.0 MEDICAL WASTE GENERATOR POPULATION

The estimated number of medical waste generators and annual quantity of infectious waste and total waste produced were presented earlier in Table 1. The amount of total waste was calculated using the estimated amount of infectious waste and the results of a large national survey that indicates that a median of 15 percent of a hospital's total waste is designated as infectious.[9] These calculations are based on the assumption that

the percentage of total waste considered to be infectious at other facilities is the same as that at hospitals. The estimates of infectious waste are based primarily on information presented in two recent reports. The first is a Jack Faucett Associates (JFA) report, which presents an analysis of the impacts of the proposed OSHA standards for occupational exposure to bloodborne pathogens.[26] This report provides estimates by Standard Industrial Classification (SIC) code of the number of generators of infectious waste, the unit generation rate, the unit disposal cost, and the total net compliance cost for disposal. The estimated total quantity of infectious waste generated annually can be derived using the information in this report. (One item necessary for the calculation, the baseline compliance rate, is found in the preamble to the proposed OSHA standards where the JFA study results are presented. This value is the estimated percentage of facilities of each type already in compliance with the proposed regulations.)

Note that the data in this industry profile that are attributed to the JFA report were drawn from the text of that report, which provides estimates for the total number of generators. Data that are presented in the tables in the JFA report and in the preamble to the OSHA regulations for which the report was prepared are only for the portion of the total population that would be affected by the proposed OSHA standard.

The second report is OSW's first interim report to Congress, which was required by the MWTA.[27] This report presents estimates by category of the number of generators of regulated medical waste, the generation rate per facility, and the total quantity generated annually. The estimation methodology is documented in a draft memorandum. The interim OSW report indicates that little information is available on the number of generating facilities or on waste generation rates, particularly for small generators such as doctors' offices. However, a discussion of additional data gathered during the course of the demonstration tracking program is expected in the final report to Congress.

TABLE 6. SUMMARY OF ESTIMATES FROM JACK FAUCETT ASSOCIATES REPORT AND OFFICE OF SOLID WASTE REPORT[26,27]

General category	JFA		OSW	
	No. of facilities	Annual infectious waste generated, tons	No. of facilities	Annual regulated medical waste generated, tons
Hospitals	7,000	162,500	7,100	359,000
Laboratories				
Medical	4,900	8,400		
Research	2,300	21,800		
TOTAL	7,200	30,200	4,300	15,400
Clinics (outpatient care)	41,300	8,100	15,500	16,700
Physicians' offices	179,405	35,100	180,000	26,400
Dentists' offices	94,994	24,800	98,400	7,600
Veterinarians	[a]	[a]	38,000	4,600
Long-term care facilities				
Nursing homes	18,785	100,800		
Residential care	23,897	29,200		
TOTAL	42,682	130,000	12,700	29,600
Free-standing blood banks	672	4,900	900	2,400
Funeral homes	15,051	500	20,400	3,900
Health units in industry	221,700	1,400	[b]	[b]
Fire and rescue	7,200	1,600	[b]	[b]
Corrections	4,300	3,300	[b]	[b]
Police	13,100	<100	[b]	[b]
TOTAL	634,600	402,400	377,300	465,600

[a]These sources of medical waste are covered under other categories in the JFA report.
[b]These sources of medical waste are covered under other categories in the OSW report.

Estimates from the two reports discussed above are summarized in Table 6. For some categories, the estimates from both reports show fair agreement; for other categories, they diverge greatly. Some of the difference in the estimates of waste quantity may result from the differences in the waste definitions used in the two studies. The JFA report is based on "infectious waste" as defined by OSHA to include "blood and blood products, contaminated sharps, pathological wastes, and microbiological wastes." The OSW report is based on "regulated medical waste" as previously presented in Table 3.

In total, the JFA report identifies 14 categories of infectious waste generators, which comprise an estimated 634,600 facilities generating a total of 402,400 tons/yr of infectious waste. The OSW report characterizes nine categories of regulated medical waste generators made up of 377,300 facilities generating a total of 465,600 tons/yr. As would be expected, the human health care industry dominates both estimates in the number of facilities and the quantity of medical waste generated annually. Nevertheless, medical waste generation goes well beyond health care facilities, particularly for the purposes of this project, where medical waste is defined broadly.

Each category presented earlier in Table 1 is discussed separately below. For each category, estimates of facilities and infectious waste generation rates are discussed, as are the available data on the makeup of the medical waste stream, the common treatment and disposal practices, and the historical and projected trends in these areas.

In addition to the JFA and OSW reports, three studies are frequently cited in the discussion that follows. One is an EPA-sponsored study of medical waste generation and management in New Jersey and New York.[28] For this EPA study, medical waste-generating facilities in New Jersey and New York were surveyed, and many site visits were conducted. This study is frequently cited in the OSW report and serves as a basis for some of that report's waste generation estimates.

A second document often referenced in the discussion to follow summarizes the results of another survey of New York medical waste generators.[29] This survey of four source categories was conducted by the New York Department of Health in 1986 and 1987. For the EPA study discussed above, these four source categories were not resurveyed. Instead, the EPA study incorporated the New York survey results.

The third study frequently cited below is a State of Washington survey of infectious waste generation and management practices.[30] In this study, 10 source categories were surveyed. Some data were collected on waste generation rates, but this information is in terms of gallons and cannot be compared readily with estimates in terms of weight.

While these studies each contain useful data, they are not directly comparable. The studies are inconsistent in the categories of generators and medical waste examined, in the types of information gathered, and in the data analyses presented.

5.1 HOSPITALS

5.1.1 Population and Waste Generation Rate

The JFA report and the OSW report agree that there are approximately 7,000 hospitals in the U.S.; however, the OSW report indicates a total annual generation rate over twice that derived from the JFA report, 359,000 tons/yr versus 162,500 tons/yr, respectively. For this category, there is independent evidence that the OSW estimate is likely to be more accurate. As discussed earlier in the section on the characteristics of medical waste, one investigator determined in a large national survey of hospitals that a median of nearly 15 pounds of total hospital waste is produced per patient per day (lb waste/patient-day) and that a median of 15 percent of this waste is designated as infectious.[9] Using total hospital beds and an average occupancy rate, the rate of infectious waste generated nationally at hospitals was calculated to be 1,002 tons/d. This rate translates to about 365,700 tons/yr. As indicated in Table 1, for the purposes of this industry profile,

it is estimated that there are 7,000 hospitals generating 360,000 tons/yr of infectious waste.

The difference between the JFA estimate of annual hospital infectious waste generation and the national hospital survey estimate can be attributed almost entirely to the underlying unit generation rates. In the JFA report, the unit generation rate is estimated at 1 lb infectious waste/patient-day, while the value derived from the national hospital survey is about double that.

5.1.2 Waste Composition

The medical waste stream at hospitals is a heterogeneous mixture of materials that may consist of any of the types of waste discussed earlier in the section on the definition of medical waste. Table 7 presents the Washington State survey results on the types of waste generated by the surveyed source categories. Over 90 percent of the responding hospitals generate sharps, surgery waste, human blood and blood products, waste containing excretions or secretions, and microbiological waste. Over 75 percent of the respondents generate isolation patient waste and pathological waste. Of the respondents that classify some of their own waste as infectious, 43 percent accept infectious waste from other facilities for treatment.[31]

According to the EPA study, over 40 percent of responding New Jersey hospitals indicated that the laboratory is the largest single source of medical waste in the hospital, generating an average of over 45 percent of total medical waste. The operating room was listed by over 30 percent of the hospitals in New Jersey as the largest single medical waste source.[32]

One source has estimated that up to 10 percent of medical waste can be radioactive.[13] Some materials may be considered hazardous under RCRA, particularly organic solvents and some antineoplastic agents (used for cancer chemotherapy).

The national hospital survey cited above indicates that as the size of a hospital (i.e., the number of beds) increases, the quantity of total waste generated per bed also increases.[9] This is not surprising because larger facilities are more likely to

TABLE 7. STATE OF WASHINGTON SURVEY RESULTS: PERCENT OF FACILITIES GENERATING SPECIFIED WASTES, BY SOURCE CATEGORY[a]

Waste type	Source category									
	Hospitals	Laboratories		Clinics		Physicians' offices	Dentists' offices	Veterinarians	Nursing homes	Funeral homes
		Clinical	Research	General	Ambulatory surgery					
Wastes with excretions/secretions	96	64	29	67	63	70	59	84	91	84
Microbiological	92	44	65	57	25	42	3	41	16	0
Human blood and blood products	96	88	53	63	38	64	44	2	23	88
Animal blood and blood products	10	12	59	0	0	3	0	69	0	0
Pathological	88	32	24	32	50	30	31	86	5	28
Sharps	98	92	88	87	100	100	91	96	98	94
Surgery waste	98	8	12	67	88	76	78	92	16	69
Dialysis waste	25	0	6	5	0	3	0	0	0	19
Contaminated animal carcasses/bedding	4	0	47	0	0	0	0	76	0	3
Isolation patient waste	78	8	0	5	0	6	0	37	77	47
Radioactive waste	49	40	53	10	0	9	0	0	0	0
Chemotherapy waste	69	12	0	15	13	18	0	10	2	9
None of the above	2	8	6	10	0	0	3	0	0	3

[a]After Reference 30, pp. 135, 136.

offer procedures and types of care not found at smaller hospitals (e.g., burn units and operating rooms).

5.1.3 Treatment and Disposal

The most common methods of treatment for waste designated as infectious at hospitals are incineration and steam sterilization. According to the National Solid Waste Management Association (NSWMA), 60 percent of hospital infectious waste is incinerated onsite, 20 percent is steam sterilized onsite, and 20 percent is treated offsite.[33] The Washington State survey results (presented in Table 8) indicate that 60 percent of hospitals operate onsite incinerators for infectious waste, 50 percent operate steam sterilizers, and 65 percent pour some waste directly to the sanitary sewer system. (Note that these figures represent the percentage of facilities that use each treatment technique on some portion of the infectious waste stream, not the percentage of waste treated by that technique.) About half the infectious waste in New York is incinerated onsite, and about half the hospitals in New Jersey operate waste incinerators.[34,35]

At least two hospitals have opted recently for shredding/chemical disinfection systems to meet their infectious waste treatment needs.[24,36] These facilities are both located in New Jersey.

5.1.4 Trends

The quantity of waste generated at hospitals has been rising in recent years. The national hospital survey discussed above indicated a generation rate for total waste 15 percent higher than data reported in a similar survey of North Carolina hospitals conducted in 1980.[37] This rise is attributed to the increased use of disposable items in recent years.

Based on past trends, a similar or larger increase in medical waste generation rates is likely in the future because the portion of total hospital waste that is segregated for special treatment has increased even more rapidly than the absolute generation rate. Two surveys of hospitals in the State of New York give evidence of this trend. The New York Department of Health survey in 1986 indicates an infectious waste unit

TABLE 8. STATE OF WASHINGTON SURVEY RESULTS: PERCENT OF FACILITIES USING SPECIFIED ONSITE TREATMENT METHODS, BY SOURCE CATEGORY[a] [b]

Waste type	Source category									
	Hospitals	Laboratories		Clinics		Physicians' offices	Dentists' offices	Veterinarians	Nursing homes	Funeral homes
		Clinical	Research	General	Ambulatory surgery					
Percent (fraction) treating some infectious waste onsite[c]	85 (40/47)	65 (13/20)	86 (12/14)	26 (12/47)	40 (2/5)	25 (6/24)	35 (9/26)	48 (12/25)	21 (7/34)	78 (18/23)
Treatment method										
Incineration	60	0	0	17	0	50	0	25	57	44
Steam sterilization	50	69	92	67	50	67	67	67	43	0
Chemical disinfection	15	54	67	17	100	50	22	58	29	67
Direct pour to sanitary sewer	65	15	17	17	50	67	22	33	14	56
Grind to sanitary sewer	3	0	0	0	0	30	0	0	0	0
Gas sterilization	5	0	0	0	50	0	11	0	14	0
Irradiation	0	0	8	0	0	0	0	0	0	0
Thermal inactivation	0	0	8	0	50	0	11	0	0	0
Other	3	15	0	0	0	0	33	17	14	0

[a]After Reference 30, pp. 42-44.
[b]Percent evaluated relative to the number of facilities that treat some infectious waste onsite.
[c]Evaluated relative to the number of facilities indicating that some infectious waste is generated.

generation rate of about 4 lb/patient-day.[38] A second survey of hospitals in New York conducted by the State Hospital Association in late 1988 indicates that the unit generation rate has increased by about 30 percent to about 5.2 lb/patient-day.[39] However, waste minimization laws and high disposal costs may reverse these trends in the future.

The increase in infectious waste generation rates can be partially attributed to the trend toward more inclusive definitions of infectious waste. This trend began with the issuance of the CDC and EPA guidelines for infectious waste disposal in the early 1980's and has continued as a result of the CDC's universal precaution recommendations. The OSHA standards on occupational exposure to bloodborne pathogens essentially extend the universal precaution recommendations to the status of regulations. While these recommendations and standards do not directly relate to waste disposal, experience shows that hospitals adopting the universal precaution recommendations report significant increases in the quantity of waste designated as infectious. Recently enacted infectious waste management regulations in some States also have extended all or part of the earlier waste disposal guidelines to regulation status. Depending on the results of the current demonstration tracking program under the MWTA, a similar program may be put in place for the entire United States. An additional factor leading to increased quantities of waste being handled as infectious is the refusal of some solid waste haulers and landfills to accept medical waste even if it is not designated as infectious under applicable regulations or guidelines.

Some factors may tend to limit the growth in medical waste generation at hospitals. One is the fact that hospital occupancy rates are falling as a result of efforts to stem the rise in health care costs. Another factor is the possibility that some hospitals will narrow their definitions of infectious waste and improve their waste segregation practices as the cost of treatment and disposal of these materials increases with stricter regulation. The extent to which cost considerations will

counteract concern over potential liability from accidental human exposure to medical waste is not known.

5.2 LABORATORIES

5.2.1 Population and Waste Generation Rate

As indicated in Table 6, the JFA report considers clinical laboratories and research facilities separately, while the OSW report groups these two classes together. The estimates made in the JFA and OSW reports differ significantly both in the number of facilities and in the total quantity of infectious waste generated.

The JFA report estimates about 4,900 medical (clinical) laboratories and about 2,300 research laboratories, for a total of about 7,200 facilities. These estimates were derived from Census of Service Industries and Census of Manufacturers data, published by the U. S. Bureau of the Census, and from a survey of academic laboratories prepared for OSHA.[40] The OSW report estimates a total of 4,300 laboratories. According to draft documentation of this estimate, it is intended to include both clinical and research laboratories. However, the estimate is based on U.S. Department of Health and Human Services data for independent medical laboratories that are eligible for Medicare reimbursement; research laboratories are very unlikely to be included.[41] For the purpose of this industry profile, the JFA report estimate of the number of laboratory facilities was used because this estimate includes both clinical and research laboratories.

The information in the JFA report supports estimates of 8,400 tons/yr of infectious waste from medical laboratories and 21,800 tons/yr of infectious waste from the estimated 2,300 research laboratories that would be affected by the OSHA standards. These estimates are based on a value of 1.75 lb generated per facility employee per day. The JFA report says the unit generation rate results from "subjective estimation and information from BBL Microbiology Systems."[42]

As shown in Table 6, the OSW report estimates 15,400 tons/yr of regulated medical waste generated at all types of

laboratories. This estimate is based on a value of about 600 pounds per month (lb/mo) generated per facility. The unit generation rate was derived from about 40 responses to a survey of laboratories in New Jersey, according to draft documentation.[41]

It is difficult to assess the relative accuracy of these estimates. There are no data by which to evaluate the subjectively derived JFA factor. However, the extent to which the responding facilities used to derive the OSW factor are typical is also unknown. Only three of these facilities were research laboratories. According to draft documentation of the OSW estimates, the three research facilities averaged monthly generation rates that were only about 35 percent of the average generation rate for the clinical facilities.[41] This result is contrary to the results from the JFA report, where research laboratories generated nearly six times as much infectious waste as clinical facilities on an annual, per-facility basis.

An alternative method of estimating total infectious waste generated by laboratories is to use the number of facilities estimated in the JFA report and the per-facility generation rate estimated in the OSW report. On this basis, laboratory infectious waste generation totals about 25,900 tons/yr. This estimation method has been adopted for this industry profile (see Table 1). Note that regardless of the estimation technique used, the laboratory waste totals less than 10 percent (and perhaps less than 5 percent) of the estimated quantity of medical waste generated by hospitals.

None of the estimates presented above include the noninfectious component of laboratory medical waste. One significant component of medical waste included under the working definition for this project not included in the infectious and regulated medical waste estimates discussed above is carcasses of test animals that have not been exposed to infectious agents. According to one estimate, about 17 million animals are used annually for research. Rats and mice account for about

85 percent of this total.[43] No attempt has been made to quantify the total weight of test animal carcasses generated annually.

5.2.2 Waste Composition

According to the EPA study, of the responding laboratories in New Jersey, 95 percent generate sharps, 55 percent generate cultures and stocks, 55 percent generate blood and body fluids, 20 percent generate pathological waste, and less than 5 percent generate animal carcasses and bedding. Twenty-three percent of the New Jersey facilities also generate other materials that are treated as regulated medical waste.[44] Some testing laboratories accept waste from other generators (such as physicians) for disposal, either as a free service to their customers or for a fee.[45]

As shown in Table 7, The State of Washington survey of infectious waste generation and management at 25 Medicare-licensed laboratories (out of a total of 90 in the State) indicated that 92 percent generate sharps, 88 percent generate human blood and blood product waste, 64 percent generate wastes with excretions/secretions, 44 percent generate microbiological waste, and 32 percent generate pathological waste. Other types of infectious waste are generated at less than 15 percent of the facilities. Twenty-five percent of the laboratories that classify some of their own waste as infectious reported accepting infectious waste from other facilities for treatment.[31]

Table 7 also includes data from the 17 research facilities that responded out of a total of 23 identified in Washington State. Of these facilities, 88 percent generate sharps; 65 percent generate microbiological waste; 59 and 53 percent generate animal and human blood and blood product waste, respectively; 47 percent generate contaminated animal carcasses and bedding; 29 percent generate wastes with excretions or secretions; and 24 percent generate pathological waste. Other types of infectious waste are generated by less than 15 percent of the responding research facilities. Of the 14 research facilities that consider some of their own waste infectious, only one reported that it accepts infectious waste from offsite

sources for treatment. However, this facility indicated that it accepts over 240 gallons of waste from offsite each week (though it is not necessarily all liquid waste).[46]

5.2.3 Treatment and Disposal

Clinical laboratories typically contract with a waste hauler rather than treat waste onsite. In the New Jersey survey for the EPA study, about 76 percent of the responding clinical laboratories (a total of 42) contract with a commercial transporter. About 12 percent of the respondents steam sterilize all infectious waste prior to landfilling. (Of all types of laboratories, including clinical facilities, 29 percent steam sterilize some portion of their infectious waste.) Nearly 5 percent send their infectious wastes to a hospital for treatment/disposal. No onsite incinerators were identified.[47]

According to the New York survey, about 83 percent by weight of infectious waste that is generated at clinical laboratories is sent offsite for treatment and disposal. Of this amount, about 37 percent is incinerated, and 63 percent is treated by unspecified means. The predominant onsite treatment method is steam sterilization.[48]

As shown in Table 9, the State of Washington survey indicates that, of the Medicare-licensed laboratories that classify some portion of their waste as infectious, 75 percent have some of the infectious waste treated offsite. Reported offsite treatment methods include incineration (87 percent of facilities that use offsite treatment) and steam sterilization (33 percent). Apparently, some facilities use both methods. As Table 8 shows, onsite treatment of some portion of the infectious waste stream was reported by 65 percent of the laboratories that designate some waste as infectious. Of laboratories that treat onsite, 69 percent use steam sterilization, 54 percent disinfect with chemicals, and 15 percent pour directly to a sanitary sewer. Clearly, some facilities use a combination of onsite treatment methods.

The Washington State survey report also gives information on research facilities in the State. For these facilities, only

TABLE 9. STATE OF WASHINGTON SURVEY RESULTS: PERCENT OF FACILITIES USING SPECIFIED OFFSITE TREATMENT METHODS, BY SOURCE CATEGORY[a] [b]

Waste type	Source category									
	Hospitals	Laboratories		Clinics		Physicians' offices	Dentists' offices	Veterinarians	Nursing homes	Funeral homes
		Clinical	Research	General	Ambulatory surgery					
Percent (fraction) that have some infectious waste treated offsite[c]	47 (22/47)	75 (15/20)	21 (3/14)	62 (29/47)	20 (1/5)	29 (7/24)	19 (5/26)	16 (4/25)	47 (16/34)	9 (2/23)
Treatment method										
Incineration	82	87	100	62	100	71	100	75	81	100
Steam sterilization	0	33	0	14	0	0	0	0	13	0
Chemical disinfection	0	0	0	0	0	0	0	0	0	50
Direct pour to sanitary sewer	5	0	0	0	0	0	0	25	0	0
Grind to sanitary sewer	0	0	0	0	0	0	0	0	0	0
Gas sterilization	0	0	0	0	0	0	0	0	0	0
Irradiation	0	0	0	0	0	0	0	0	0	0
Thermal inactivation	5	0	0	0	0	0	0	25	0	0
Other	5	0	0	3	0	14	20	25	0	0
Do not know	9	7	0	34	0	14	0	0	6	0

[a]After Reference 30, pp. 47, 50, and 51.
[b]Percent evaluated relative to the number of facilities that have some infectious waste offsite.
[c]Evaluated relative to the number of facilities indicating that some infectious waste is generated.

21 percent reported having infectious waste treated offsite. All these facilities used offsite incineration (see Table 9). Eighty-six percent of these facilities reported that some infectious waste is treated onsite. As presented in Table 8, of the facilities reporting onsite treatment, 92 percent use steam sterilization, 67 percent use chemical disinfection, 17 percent pour directly to a sanitary sewer, 8 percent use thermal inactivation, and 8 percent use irradiation. Again, some facilities use a combination of methods.

None of the surveys discussed in the preceding paragraphs indicate incineration as an onsite method of treatment. Although, MWI inventory lists, which were used to produce Table 2, indicate that onsite MWI's do exist at laboratories (no distinction is made between clinical and research labs).

5.2.4 Trends

It is likely that the same influences that cause the quantity of waste designated as infectious by hospitals to grow will likewise affect laboratories. These influences include the increased use of disposables and increasingly comprehensive definitions of infectious waste. However, according to information in the OSHA standards preamble, laboratories already typically apply a broad definition of infectious waste, so the definitional effects should be relatively small.[49]

5.3 CLINICS/OUTPATIENT CARE

5.3.1 Population and Waste Generation Rate

The estimated population of clinics and annual total infectious waste generation rates differ markedly between the JFA and OSW reports. These differences result from divergence in both the definition of this source category and the estimated unit generation rate.

The JFA report designates this source category as "outpatient care." Within this broad category, totaling approximately 41,000 facilities, individual population estimates are made for eight segments. These segments, and the estimated national population of each, are (1) home health care--7,000; (2) health maintenance organizations--654; (3) hospices--812;

(4) drug treatment centers--3,887; (5) ambulatory care centers--4,300; (6) kidney dialysis clinics--861; (7) government outpatient services--22,117; and (8) others that did not warrant individual treatment, such as family planning clinics--1,709. These estimates are drawn from a variety of government, industry, and independent sources. The estimates have been adjusted to avoid double counting, both between segments of the outpatient care industry (e.g., excluding hospices that are administered by home health care agencies) and across generator categories (e.g., excluding dialysis clinics that are based in a hospital). The weakest estimate is for government clinics, for which it was assumed that each of the county and municipal governments in the United States would have one outpatient care facility.[50]

The OSW estimate of clinics is derived from American Medical Association (AMA) data. In draft documentation, OSW indicates that the estimated clinic population is based on the AMA definition of "medical group" (a formal organization of three or more physicians) and the AMA estimate of 15,485 for the population of such medical groups in 1984.[51]

For the purpose of this project, home care waste (at least those materials that are returned to the central facility for disposal) is included in the definition of medical waste. The OSW definition of regulated medical waste specifically excludes medical waste generated in a home-care setting, regardless of where it is disposed. The JFA report population estimate is used for this industry profile because this estimate includes home care settings where medical waste is generated, as well as other outpatient care settings not likely to be included in the OSW estimate.

Despite the fact that the population estimate based on the JFA report is over 2.5 times the OSW estimate, the OSW report estimates an annual generation rate over twice as great as the annual rate indicated by the JFA report. This difference results from the unit generation rates estimated in the two reports. The JFA report uses a rate of 1.5 lb of infectious waste per facility per day based on a survey conducted in King County, Washington.[52]

For the annual total, it is assumed that these facilities operate 261 days per year. Thus, the unit generation rate on a monthly basis is about 33 lb/mo per facility. According to draft documentation, the basis of the OSW estimate of the annual generation rate is the New York survey, which reports an infectious waste generation rate for "diagnostic and treatment centers" of about 180 lb/mo per facility.[53]

It is not known why these unit generation rates differ so much. Possible causes include differences in the types of facilities included in the surveys, regional differences in the management of medical waste (i.e., different definitions of infectious waste), and differences in the size of the facilities surveyed (i.e., the number of patients seen per day). In the absence of better data to support using one estimate over the other, the approach adopted for this industry profile is to use the mean of the two unit generation rates, which results in a unit generation rate of about 106 lb of infectious waste per facility per month. Coupled with the population estimate from the JFA report, this rate yields a total annual generation rate of about 26,300 tons/yr (see Table 1), which is larger than either the JFA or OSW report estimated. Even so, this estimate represents less than 8 percent of the estimated quantity of medical waste generated annually by hospitals.

5.3.2 Waste Composition

The types of medical waste generated by clinics vary because of the many different services these facilities offer. According to the EPA report, the most common waste items are sharps, blood and body fluids (including discarded materials that are contaminated), and lesser amounts of cultures, stocks, and pathological wastes.[54] This assessment is generally borne out by the findings of the Washington State survey, which are presented in Table 7 separately for clinics and ambulatory surgery centers. Only 4 percent of the clinics and none of the ambulatory surgery centers accept infectious waste from offsite sources for treatment.[31]

5.3.3 Treatment and Disposal

Onsite treatment of infectious waste at clinics is unusual. According to the New York survey, less than 3 percent by weight of the infectious waste generated at the responding diagnostic and treatment centers is treated onsite, and steam sterilization is the predominant onsite treatment method.[55] The New Jersey survey results presented in the EPA report indicate that 48 percent of clinics contract with a commercial medical waste transporter (for treatment and disposal), and 30 percent have infectious waste taken to a hospital or laboratory for disposal with that facility's waste. Onsite treatment by steam sterilization was indicated by 19 percent of New Jersey respondents, onsite incineration by 16 percent, disposal of some infectious waste to the sewer by 13 percent, and landfilling without treatment by 8 percent.[56]

Even though onsite incineration was acknowledged by 16 percent of the State of New Jersey survey respondents, Table 2 does not include a category for "clinics" because very few facilities on the State MWI inventory lists (the basis for Table 2) could be identified as such. The few that were identified as clinics are included in Table 2 under "Others/unidentified facilities." Medical centers that could possibly be categorized as clinics are included in Table 2 under "Hospitals."

The State of Washington survey data are presented in Tables 8 and 9. These data generally agree with the New York and New Jersey results. Only 26 percent of clinics and 40 percent of ambulatory surgery centers that consider some waste infectious treat any of the waste onsite. For clinics, steam sterilization predominates; the methods used by the two ambulatory surgery centers that responded are more varied. Among clinics that have some infectious waste treated offsite, incineration is most commonly used. Combining the data from Tables 8 and 9 shows that at least 13 percent of the clinics and 40 percent of the ambulatory surgery centers did not indicate any treatment for their infectious waste prior to disposal. Presumably, the

infectious waste from these facilities goes to landfills without prior treatment.

5.3.4 Trends

The quantity of medical waste generated by clinics has been increasing recently as health care cost considerations have favored outpatient care over hospitalization. This trend is expected to continue. The portion of this waste that is segregated for special treatment and disposal is also likely to increase as a result of the definitional and regulatory factors discussed previously for hospitals. This portion is expected to be larger for clinics than for hospitals or laboratories. According to information in the preamble to the OSHA standards, clinics historically have paid less attention to potentially infectious waste than these other sources.[49] This assertion is borne out by data from the Washington State survey concerning the number of facilities that consider some of the waste they generate to be infectious and that, nevertheless, do not have the waste treated either on- or offsite. In addition to these facilities, 22 percent of responding clinics and 38 percent of responding ambulatory surgery centers indicated that they do not consider any of the waste they generate to be infectious. Of these, 62 percent of the clinics and all the ambulatory surgery centers generate some of the classes of waste listed in Table 7.[57]

5.4 PHYSICIANS' OFFICES

5.4.1 Population and Waste Generation Rate

The estimates of physicians' offices in the JFA and OSW reports are each around 180,000. The estimated annual generation rates also show relatively good agreement, with the estimate derived from JFA data exceeding the OSW estimate by about 33 percent (35,100 tons/yr versus 26,400 tons/yr, respectively).

The JFA estimate is based on a unit generation rate of 1.5 lb of infectious waste per office per day for 261 days per year. This rate is derived from a survey conducted in King County, Washington.[58] The draft OSW documentation uses a unit generation rate of 20 lb/mo per physician estimated from

information collected from physicians and medical waste transporters. Applying a factor of 1.2 physicians per office, OSW concludes that 24 lb/mo are generated by each physician's office.[59] To avoid underestimating the annual generation rate, the higher estimate (based on the JFA report) is used for this industry profile (see Table 1).

5.4.2 Waste Composition

The medical waste stream from physicians' offices varies with specialty. According to the EPA report, all facilities surveyed in New York and New Jersey generate sharps and "other patient-care waste"; some also generate cultures and stocks, blood and body fluids, and pathological waste.[60] Table 7 presents the State of Washington survey results. Of these respondents, all generate sharps; over 60 percent generate surgery waste, waste with excretions or secretions, and human blood and blood products; and about 30 percent generate pathological waste. Less than 10 percent generate the other listed classes of waste. Thirteen percent of the physicians' offices that consider some of their own waste to be infectious also accept some infectious waste from offsite sources for treatment.[31]

5.4.3 Treatment and Disposal

The EPA report indicates that 82 percent of respondent physicians' offices segregate some waste from the general waste stream prior to disposal; the figure from the State of Washington survey is 83 percent.[61,62] As shown in Table 8, the methods of onsite infectious waste treatment reported in the Washington State survey are steam sterilization, direct pour to sanitary sewer, incineration, chemical disinfection (all used by 50 percent or more of the facilities that use onsite treatment), and grinding to sanitary sewer (i.e., using a device similar to a garbage disposal) (used by 30 percent). In the EPA report, steam sterilization, incineration, grinding to sanitary sewer, and chemical disinfection also were named as onsite treatment methods, as was the use of special containers for sharps.[61] Even though a fairly high percentage of Washington respondents (3/24)

indicated operating onsite incinerators, Table 2 does not include a category for physicians' offices because State MWI inventory lists (the basis for Table 2) indicate that physicians' offices do not operate onsite incinerators in significant numbers.

Seventy-one percent of the Washington State respondents that have some infectious waste treated offsite have the waste incinerated (see Table 9). No figure is available from the EPA report for comparison. According to the report, about 40 percent of physicians' offices responding to the New York/New Jersey survey contract with a medical waste hauler for treatment and disposal of such waste.[61]

5.4.4 Trends

As for other sources (e.g., clinics, hospitals), the increased use of disposable materials has probably resulted in an increasing quantity of medical waste generated. The quantity of medical waste being segregated from the general waste stream for special handling is expected to increase in the future as a result of the changing definition of waste to be regarded as infectious and the increasing compliance expected as past guidelines are embodied in regulations and made applicable to physicians. As in the case of clinics, the growth in the rate of segregation should be large for physicians' offices because, historically, these facilities have not closely managed the medical waste stream.[49]

5.5 DENTISTS' OFFICES

5.5.1 Population and Waste Generation Rate

As in the case of physicians' offices, the JFA and OSW reports agree quite closely on the number of dentists' offices nationally, reporting about 95,000 and 98,000, respectively. A representative of the American Dental Association (ADA) has indicated that there are about 140,000 to 150,000 dentists nationwide.[63] Because of group practices, the number of dental offices likely is in the range reported by JFA and OSW.

The estimates of total annual generation differ significantly between the JFA and OSW reports. At

24,800 tons/yr, the estimate derived from the JFA report is over three times as great as the OSW estimate (7,600 tons/yr).

The JFA estimate is based on a unit generation rate (2 lb per office per day) that is a "subjective estimation," which does not lend much credence to the JFA annual estimate.[58] The fact that the unit generation rate for dentists' offices exceeds that for physicians' offices in the JFA report casts further doubt on the accuracy of the JFA estimate.

According to the OSW draft documentation, the total annual generation estimate is based on the estimated number of individual dentists (rather than dental offices) and a generation rate per dentist. The unit generation rate, 10 lb/mo per dentist, is the average of information submitted by the dentists who responded to the survey conducted for the EPA report. The number of practicing dentists, about 127,000, appeared in a 1982 ADA publication.[64] The total thus calculated is presented in the OSW report; the unit generation rate presented in that report (13 lb/mo per dental office) is a calculated value based on this total and the estimated number of dental offices (98,000). Because the OSW unit generation rate is based on survey data, it is likely to be more accurate than the subjective JFA report value.

To estimate the quantity of medical waste generated annually at dentists' offices, a reasonable approach is to use the figure on the number of dentists (about 145,000) from the recent ADA telephone contact and the OSW unit generation rate (10 lb/mo per dentist). By this method, the annual generation rate for dentists' offices is about 8,700 tons/yr. This quantity represents less than 3 percent of the estimated amount generated by hospitals annually. The number of dental offices is estimated at 98,000, based on the OSW documentation memorandum.

5.5.2 Waste Composition

The most frequently reported type of waste at dental facilities is sharps. As seen in Table 7, 91 percent of the dentists' offices responding to the State of Washington survey indicated that sharps are generated, as did 78 percent of the

respondents to the New York/New Jersey survey cited in the EPA report. "Other patient care" waste (70 percent) and pathological waste (30 percent) were the other waste types frequently reported in the EPA report.[65] These responses agree fairly closely with the Washington State findings in Table 7. No dental offices in the Washington study reported accepting infectious waste from offsite for treatment.[31]

5.5.3 Treatment and Disposal

Eighty-three percent of the dental facilities studied for the EPA report segregate some infectious waste from the general waste stream; 69 percent of the respondents to the Washington State survey do so.[62,66] Onsite treatment methods in Washington are summarized in Table 8. Only 35 percent of facilities treat infectious waste onsite. Steam sterilization is the predominant method. Among the New York and New Jersey dentists taking part in the study for the EPA report, the primary onsite treatment method is also steam sterilization when use of a sharps container is removed from consideration as a treatment method.[66]

All the Washington survey respondents that use offsite treatment have waste incinerated (see Table 9). No information is available from the EPA report on offsite treatment methods used by New York and New Jersey dentists, but 27 percent have medical waste removed for treatment and disposal by a specialized medical waste hauler.[67]

5.5.4 Trends

The trends in medical waste generation for dentists' offices are expected to be the same as those discussed in the earlier section on physicians' offices. Increased use of disposables and a broader, more rigorously enforced definition of the wastes that should be specially handled are expected to result in larger quantities of medical waste from these facilities.

5.6 VETERINARIANS

5.6.1 Population and Waste Generation Rate

As shown in Table 6, the OSW report estimates that there are 38,000 veterinarians generating about 4,600 tons/yr of regulated medical waste. The unit generation rate upon which the annual

total is based is 20 lb per veterinarian per month. The OSW draft documentation indicates that the estimated number reflects veterinarians in practices treating animals, according to a 1988 publication of the American Veterinary Medical Association (AVMA). The unit generation rate is the average of information submitted by about 60 veterinarians who responded to the survey undertaken for the EPA report.[68] The JFA report does not evaluate veterinarians.

Additional information was gathered through contacts with veterinary professional organizations. The AVMA currently has about 49,000 members, and there are "a few thousand" nonmember veterinarians. A great deal of veterinary medicine is practiced on farms, and most waste is left on the farm where the animals are treated.[69] The American Animal Hospital Association (AAHA) estimates that there are about 14,000 animal hospitals that specialize in pet treatment. (It is not known if this number includes individuals with small animal practices.) Such facilities typically produce less than 50 lb/mo of regulated medical wastes, as defined by EPA to exclude animal carcasses and treatment waste that do not pose a threat of human infection. Most of the medical waste produced consists of sharps.[70] A representative of the New Jersey Animal Hospital Association (NJAHA) indicated that there are typically two to four doctors per animal hospital and that, as a rule of thumb, each doctor generates about 100 lb of medical waste per year. This figure is based on the CDC infectious waste guidelines, which, like the EPA regulations, require animal treatment waste to be specially handled only if it is potentially infectious to humans.[71]

Based on the AAHA data (14,000 animal hospitals and less than 50 lb each per month), the annual medical waste generated by animal hospitals is less than 4,200 tons/yr. If the quantity of medical waste from large animal practices that is segregated for special handling is assumed to be small, as indicated by the AVMA, a total of 4,200 tons/yr is a reasonable estimate of the quantity of waste entering the medical waste stream from

veterinary facilities. It is uncertain whether medical waste from single veterinarian practices is included in this total.

Combining the data from the NJAHA contact (100 lb per veterinarian per year and about three veterinarians per practice) and the AAHA figure for the national population of animal hospitals (14,000) results in an estimate of 2,100 tons/yr of medical waste generated from this source category. This value is lower than the OSW estimate or the estimate derived above solely from AAHA data.

The annual medical waste generation rates estimated by OSW and derived above from AAHA data agree within 10 percent. The actual annual quantity generated by veterinary facilities is likely to be in this range. To be conservative, the higher estimate of 4,600 tons/yr reported by OSW is accepted for this industry profile. This quantity is only about 1 percent of the estimated amount generated by hospitals.

5.6.2 Waste Composition

The most common medical waste generated by veterinary facilities is sharps. In fact, the representative of NJAHA indicated that sharps represent 99.9 percent of the medical waste generated by animal hospitals (using the OSW definition of regulated medical waste).[71] The other professional organizations agreed that sharps are the primary medical waste generated, but also named such items as blood vials, vaccine vials, and waste with potential to cause disease.[69,70] According to the EPA report, 86 percent of the respondent veterinarians in New York and New Jersey generate sharps, 77 percent generate "other patient waste," and significant numbers generate cultures and stocks, blood and body fluids, and pathological waste.[72] The results of the Washington State survey are presented in Table 7. Again, sharps are most frequently generated (96 percent of respondents), with surgery waste, pathological waste, waste contaminated with excretions or secretions, and contaminated animal carcasses each reported by more than 75 percent. Ninety-three percent of the New York and New Jersey respondents for the EPA study segregate some infectious waste. Most frequently,

sharps are segregated (by 92 percent of the respondents that segregate waste); other materials that are removed from the general waste stream include pathological waste (37 percent), blood-contaminated waste (22 percent), and various other types (20 percent). Forty percent segregate more than one kind of waste.[73] Only 64 percent of the respondents to the Washington survey reported segregating the infectious waste from the general waste.[62]

5.6.3 Treatment and Disposal

According to the Washington State survey none of the respondents accept infectious waste from offsite for treatment.[31] The onsite treatment methods used are presented in Table 8. Forty-eight percent treat some infectious waste onsite. The most frequently used method is steam sterilization (67 percent of those that treat onsite), followed by chemical disinfection, direct pour to sanitary sewer, and incineration. The most frequent onsite "treatment" technique reported by the New York and New Jersey respondents is use of a sharps box, followed by steam sterilization, incineration, and grinding to sanitary sewer, in that order.[73]

As seen in Table 9, only 16 percent of the respondents to the Washington State survey reported having some infectious waste treated offsite. Seventy-five percent of these have the waste incinerated. The EPA report indicates that 29 percent of the New York and New Jersey survey respondents have infectious waste picked up by a specialized medical waste hauler for treatment and disposal.[73] The contacts at professional organizations indicated that most veterinarians use medical waste haulers for disposal.[69-71]

5.6.4 Trends

The quantity of waste from veterinary facilities that enters the medical waste stream for special handling is expected to increase for the same reasons discussed in earlier sections.

5.7 LONG-TERM HEALTH CARE FACILITIES

5.7.1 Population and Waste Generation Rate

The JFA report identifies a total of about 42,700 facilities that fall into this category, including about 18,800 nursing homes and about 23,900 residential care facilities. Nursing homes take direct responsibility for providing medical care, while residential care facilities do not.

The OSW report estimates the number of long-term health care facilities at 12,700. Based on the OSW draft documentation, this estimate represents nursing homes certified by Medicare or Medicaid according to a 1987 Health Care Financing Administration publication.[74] The figure corresponds with the number of Medicare- and Medicaid-certified nursing homes (about 12,600) identified in the JFA report based on 1982 survey data from the National Center for Health Statistics. The greater total number of nursing homes estimated by JFA (18,800) can be explained by the inclusion of noncertified facilities and facilities for emotionally disturbed youth and the mentally ill.

The JFA report indicates estimates of about 100,800 tons/yr generated by nursing homes and 29,200 tons/yr generated by residential care facilities, for a total annual generation rate from the long-term health care source category of about 130,000 tons/yr. The OSW report estimates a total of about 29,600 tons/yr for this category. Given the large discrepancy between the numbers of facilities estimated in the JFA and OSW reports, the large difference in the estimated annual generation rates is not surprising.

The difference between the annual estimates in the reports is exacerbated further by differences in estimation methodology. In the JFA analysis, an infectious waste unit generation rate of 0.5 lb per bed per day was used for both nursing homes and residential health care facilities.[75] The basis for this estimate is a conversation with a representative of the New York Center for Environmental Health. The OSW report used a rate of 390 lb per nursing home per month, citing the EPA report.[76] According to the draft documentation memorandum, residential care

facilities not providing skilled care generate negligible amounts of regulated medical waste.[74]

The EPA report includes the results of separate surveys of New Jersey nursing homes and residential health care facilities. Although the analysis in the report used the median unit generation rates reported for these facilities, the OSW estimate is based on the mean unit generation rate for nursing homes (3.34 lb/patient-month) and the median number of patients (116 per nursing home). Over half the responding residential health care facilities indicated that they generate no medical waste, resulting in a median generation rate of zero. The mean for this type of source is 0.56 lb/patient-month.[77]

Data on "residential health care facilities" are also reported in the New York study. Unfortunately, the meaning of this term is uncertain in this context. The report uses the terms "residential health care facilities," "nursing homes," and "health-related facilities" apparently interchangeably. Whatever the precise meaning of "residential health care facilities," the New York survey reports an average unit generation rate for infectious waste of less than 0.5 lb per bed per week.[78] This value, which is equivalent to approximately 2 lb per bed per month, compares reasonably well with the mean value reported for New Jersey nursing homes in the EPA study, especially considering the uncertainty of what types of facilities are included in the New York survey and the fact that occupancy rates are not accounted for in the New York data.

The more inclusive accounting by JFA of facilities in the long-term health care category is likely to result in a more accurate estimate of total facilities. However, the unit generation rate used in JFA report seems far out of line when compared to the findings of the New Jersey and New York surveys. In fact, because the JFA report cites a New York source, it appears that the unit generation rate determined on a weekly basis by New York could have mistakenly been used by JFA on a daily basis.

An improvement on both the JFA and OSW annual estimation methods can be made by using data from the JFA and EPA reports. Using the mean unit generation rates from the New Jersey survey and data on the number of patients at nursing homes and residential care facilities from the JFA report results in estimates of about 29,700 tons/yr from nursing homes and 1,400 tons/yr from residential health care facilities. Thus, the total for all long-term health care facilities is estimated to be about 31,100 tons/yr. This value is only about 15 percent higher than the value estimated by OSW.

5.7.2 Waste Composition

The type of medical waste most commonly generated at nursing homes is sharps, with 98 percent of the Washington State respondents and 89 percent of the New Jersey respondents indicating that waste sharps are produced. As shown in Table 7, over 75 percent of the nursing homes that responded to the State of Washington survey indicated generation of waste with excretions or secretions and isolation patient waste. No types of waste other than sharps were indicated by more than 10 percent of the New Jersey nursing home respondents.[79]

In the New Jersey survey of residential health care facilities for the EPA report, 68 percent reported that no infectious waste is generated. Twenty-one percent indicated that sharps waste is produced.[80] The Washington State survey did not include this type of facility, so no other data are available.

5.7.3 Treatment and Disposal

The EPA report indicates that the most common method of treating and disposing of medical waste among the respondent nursing homes in New Jersey is to contract with a commercial medical waste hauler. Sixty-three percent of the respondents use this method. Another 12 percent transport medical wastes to a local hospital or laboratory for inclusion in that facility's medical waste stream, and 6 percent send the waste to landfills without prior treatment. Fewer than 5 percent indicated the use of steam sterilizers, incinerators, or sanitary sewers.[81]

Among Washington State nursing home survey respondents that consider some waste infectious, 21 percent treat some of this waste onsite, and 47 percent have some treated offsite (see Tables 8 and 9). Of the nursing homes that acknowledge generating infectious waste, only one respondent accepts waste from offsite for treatment.[31] Only 12 percent indicated that they do not segregate infectious waste from the general waste.[62]

As indicated in Table 8, over half the facilities that treat some waste onsite use incineration; other methods used are steam sterilization, chemical disinfection, direct pour to the sanitary sewer, and gas sterilization. For offsite treatment, 81 percent use incineration (see Table 9).

5.7.4 Trends

Long-term health care facilities are subject to the same forces that have resulted in increased medical waste generation in other source categories. The use of disposable items has increased in recent years and will likely continue to increase unless strong economic or regulatory incentives for reuse or recycling are enacted. The aging of the "baby boomers," and the increase in life expectancy due to improved technology are two factors that are likely to result in an increase in the elderly population. In accommodating this growing population, the number of long-term health care facilities and the amount of medical waste generated at these facilities is also expected to increase. The broadening of the definition of infectious or regulated medical waste and a continued transition from guidelines to regulations is expected to increase the fraction of the general waste stream that is segregated for special treatment. However, this latter effect is not expected to be as great in this industry segment as in many others because, as indicated in the preamble to the OSHA standards, nursing homes and residential care facilities have historically handled medical wastes conservatively.[49]

5.8 FREE-STANDING BLOOD BANKS

5.8.1 Population and Waste Generation Rate

The JFA report designates a blood/plasma/tissue centers category made up of 260 independent blood banks, 400 independent plasma centers, and 12 independent tissue banks, for a total of 672 facilities. The JFA data indicate that about 4,900 tons/yr of infectious waste are generated by these facilities (see Table 6). The estimate of the annual national total is based on a unit generation rate of 1.75 lb per employee per day. This value was estimated based on information from BBL Microbiology Systems.[52]

The OSW estimates, as presented in Table 6, are 900 independent blood banks generating 2,400 tons/yr of regulated medical waste. This estimate is based on a unit generation rate of 440 lb of regulated medical waste per facility per month. According to the OSW draft documentation, these estimates are based on two site visits to blood banks and on contact with a representative of the American Association of Blood Banks.[82]

Little basis exists for choosing between these estimates. In a telephone contact, a representative of the Council of Community Blood Centers indicated that there are about 400 to 500 community blood centers nationwide. This figure does not include American Red Cross blood centers.[83] Based on this contact, it is likely that the OSW estimate of 900 blood banks is more accurate than the JFA estimate. However, the figure cited for community blood centers may include centers associated with hospitals (i.e., that are not "free standing") or centers that JFA classified as plasma centers.

The unit generation rate selected by JFA is not documented. The value used by OSW is based on only two facilities. Data from the District of Columbia Chapter of the American Red Cross indicate that this facility generates approximately 1 ton of medical waste per month while operating 15 mobile blood collection units.[84] However, it is not known how this facility relates in size to others.

To avoid understating the quantity of medical waste generated by blood banks, the larger estimate (4,900 tons/yr) derived from JFA data is used for this industry profile. The assignment of a value to this category is not crucial because this is a minor source, comprising 1 percent or less of medical waste generated nationally.

5.8.2 Waste Composition

The medical waste stream from blood centers consists of virtually everything from the blood collection process, including needles, tubing, finger sticks, sponges, paper, etc. In addition, wastes are generated during testing for the AIDS virus that include diluents from the test's washing process. When blood or blood product units reach their expiration date without being used, they must be disposed of as well.[83,84]

5.8.3 Treatment and Disposal[83,84]

Medical wastes from blood banks are treated and disposed of according to local regulations. Most are taken to local hospitals for onsite incineration, some are incinerated at commercial facilities, and some are treated by steam sterilization and discarded in the general waste stream. The proportional breakdown by treatment method is not known.

5.8.4 Trends

Blood bank medical waste will increase as discussed for other source categories. The impact of definitional changes is not expected to be great; these sources have historically managed medical wastes carefully.[49]

5.9 FUNERAL HOMES

5.9.1 Population and Waste Generation Rate

Based on 1982 Census of Service Industries data, the JFA report estimates that there are about 15,000 funeral homes and crematories in the United States. The OSW report places the number at about 20,400, citing a 1988 trade publication. It is unknown whether the OSW figure includes crematories. Data independent of these two reports were obtained from the National Funeral Directors Association (NFDA). According to this source, there are about 21,000 funeral homes nationwide that are operated

by about 17,500 separate business entities.[85] The close agreement between the OSW and NFDA estimates suggests that the true population is likely to be near 21,000. The lower JFA estimate may be the result of older data.

The data in the JFA report indicate that approximately 500 tons/yr of infectious waste are generated at funeral homes, based on a unit generation rate of 0.5 lb per necropsy. No basis for this unit generation rate is presented.[86]

The OSW report estimates that about 3,900 tons/yr of medical waste are generated by funeral homes annually. The OSW estimate is based on a unit generation rate of 32 lb per facility per month. These figures are based on the EPA report.[87]

The EPA report includes results from a survey of funeral homes in New York and New Jersey. The median medical waste generation rate of the respondents that gave complete data is 31.5 lb per month. The New York/New Jersey survey respondents process a median of nine bodies per month; the unit generation rate on a per-body basis is about 3.5 lb.[88]

The per-body unit generation rates presented in the JFA and EPA reports differ significantly, at 0.5 lb versus 3.5 lb, respectively. Information from the NFDA indicates that less than 1 lb is generated per body.[85] The variation in estimates may result from the use of different definitions of medical or infectious waste. For example, during embalming, the blood is drained from the body and, typically, directed to the sanitary sewer. While this blood would be included under any of the applicable definitions, it clearly has not been counted in the JFA or NFDA unit generation rates because it does not enter the general or medical waste stream. A possible explanation for the higher rate derived in the EPA report could be that some respondents included blood in their accounting of the quantity of medical waste generated.

In any case, the total quantity of medical waste generated by funeral homes is a small portion of the overall total. Even the OSW estimate amounts to less than 1 percent of the estimated national total. For purposes of this industry profile, the NFDA

estimate, rounded up to 1 lb generated per body, was used because the NFDA is considered to be the most reliable source. Using this factor and NFDA statistics indicating that over 90 percent of the 2.2 million persons that die in the United States annually are embalmed, the total quantity of medical waste generated by funeral homes is estimated to be about 900 tons/yr.[89]

5.9.2 Waste Composition

According to the results of both the New York/New Jersey survey (discussed above) and the State of Washington survey, sharps and blood are generated at most funeral homes. Ninety-four percent of the Washington respondents and 51 percent of the New York/New Jersey respondents reported generating sharps; 88 percent and 77 percent, respectively, reported generating blood.[90] As shown in Table 7, other types of waste reported by a significant fraction (greater than 25 percent) of the Washington State survey respondents included waste with excretions or secretions, surgery waste, isolation patients waste, and pathological waste. A significant portion of the New York/New Jersey respondents reported generating "other waste associated with patient care," including such items as plastic sheets/shrouds, rubber gloves, disposable aprons and facemasks, etc. Surprisingly, 19 percent of the Washington funeral homes and 11 percent of the New York/New Jersey facilities reported generating dialysis waste.[91] Seventeen percent of the Washington State respondents that consider some of their own waste infectious indicated that they accept infectious waste from offsite sources for treatment.[31]

5.9.3 Treatment and Disposal

As Table 8 shows, almost 80 percent of the Washington State facilities that consider some of their waste infectious treat at least some of the waste onsite. Chemical disinfection, pouring to the sanitary sewer, and incineration are the treatment methods cited. Among the New York/New Jersey respondents, pouring to the sanitary sewer is mentioned by nearly 77 percent; incineration is used by less than 5 percent. Chemical disinfection was not included as a choice on this survey form.[92]

Offsite treatment methods used by the State of Washington survey respondents are summarized in Table 9. Less than 10 percent of the facilities that designate some of their waste infectious have such waste treated offsite. Two respondents make up the population that uses offsite treatment; both have infectious waste incinerated, and one also uses offsite chemical disinfection.

Less than 10 percent of the New York/New Jersey respondents have medical waste transported to offsite commercial disposal facilities. Over 20 percent send medical waste to landfills without prior treatment.[92] According to the State of Washington survey, 22 percent of the respondents that acknowledge producing infectious waste do not segregate this waste from the general waste. Another 13 percent gave no response or an invalid response on this point.[62]

5.9.4 Trends

Funeral homes are expected to experience growth in the quantity of waste designated as medical waste. It is not known to what extent the use of disposables is growing in this industry. The impetus to use disposables may not be as great at funeral homes as in health care settings because there is no danger of disease transmission between patients. However, occupational exposures are a concern, so the use of disposables may increase for this reason.

According to the OSHA standards preamble, the funeral home industry has not historically managed potentially infectious waste conservatively.[49] For this reason, the definitional changes and evolution toward regulations that have been discussed previously are likely to result in a considerable increase in the fraction of the funeral home waste stream that is segregated for special medical waste treatment.

5.10 SOURCE CATEGORIES EVALUATED ONLY BY JFA

As illustrated by Table 6, the JFA report includes estimates for four minor source categories not evaluated for the OSW Report. No survey or independent data are available for these

categories. The categories are discussed briefly below. The figures presented are accepted for this analysis.

The "health units in industry" category is made up of facilities outside the health care industry that provide some type of health-related services to their employees. This category includes a total of about 221,700 facilities comprised of health units with a physician in charge (2,300), health units with a registered or licensed practical nurse in charge (8,500), health units with some other person in charge (925,300), and facilities with full- or part-time personnel trained in and responsible for emergency medical care (185,600).[93] Despite the very large number of facilities, the JFA data indicate that the total annual quantity of infectious waste generated by these facilities is only about 1,400 tons/yr.

Fire and rescue services include facilities that provide emergency treatment and transportation. Only services not based in hospitals that retain some paid employees are included. The JFA data indicate that there are about 7,200 such facilities--6,700 fire departments and at least 500 private emergency services. Based on an estimate of over 6.4 million medically related emergency runs per year and a unit generation rate of 0.5 lb per emergency, this source category generates about 1,600 tons/yr of medical waste.[94,95] This waste is typically added to the receiving hospital's waste stream.

The JFA report indicates that there are about 4,300 jails and prisons in the United States. These facilities provide some degree of medical services to the inmates, ranging from physical exams to full hospital services. Based on the JFA data, the total quantity of medical waste generated annually is estimated to be 3,300 tons.

The final category evaluated in the JFA report is police departments, of which there are about 13,100. Based on the JFA data, it is estimated that these facilities generate only about 8 tons/yr of medical waste. This insignificant generation category is included on the JFA report because the OSHA standards for which the analysis was conducted concern measures to minimize

occupational exposure to bloodborne pathogens. Police officers are at risk because of the relatively high incidence of AIDS and other bloodborne diseases among intravenous drug users and the potential for encountering injured victims or suspects or sustaining injury themselves. Police laboratory technicians also are at risk. Presumably the medical waste produced by police officers would consist primarily of articles soiled with blood; lab technicians would generate sharps as well.

6.0 MEDICAL WASTE INCINERATOR POPULATION

6.1 NATIONWIDE

The estimated national population of existing MWI's has been presented in Table 2. Estimates are presented in the table for each type of facility at which MWI's are commonly found. For each facility type, the table includes the observed capacity range, estimated average capacity, and estimated percent of total MWI capacity represented by that facility type. In Table 10, the approximate distribution of MWI's by capacity is presented for each type of facility.

As Table 2 shows, hospital MWI's are by far the largest category, both in terms of number and in terms of percent of total capacity. Table 10 illustrates that smaller units predominate for all categories except commercial facilities, with the majority having a capacity of less than 300 lb/hr. The characteristics of the MWI's at each type of facility will be discussed individually in a later section.

The estimates presented in Tables 2 and 10 are based primarily on data received from State air programs and State hospital associations.[1] To estimate the total number of MWI's, the most reliable and complete data were compiled for each category and extrapolated nationwide based on population. Variations on this estimation methodology, as applicable, are discussed in the section covering individual facility types.

Population was selected as the basis for extrapolation because this is a straightforward computation with readily available data. In addition, no method with inherently greater accuracy was identified. An alternative might be to determine,

TABLE 10. PERCENTAGE DISTRIBUTION OF MWI POPULATION BY RATED CAPACITY FOR EACH FACILITY TYPE

Facility type	Rated capacity, lb/hr						
	<100	100 to 199	200 to 299	300 to 499	500 to 999	≥1,000	Total[a]
Hospitals	25	26	11	16	14	6	98
Laboratories	24	21	20	13	12	8	98
Veterinary facilities	69	19	5	3	2	2	100
Nursing homes	47	24	18	1	7	3	100
Commercial facilities	0	12	12	6	18	52	100
Other/unidentified	33	31	19	15	2	0	100

[a]May not equal 100 percent because of rounding error.

for each type of facility, the fraction that operate incinerators in the States for which reliable incinerator data are available and to extrapolate based on the total number of facilities in the United States. However, as indicated in the section on generator population, there is uncertainty about the number of these types of facilities nationwide, and State-by-State accountings generally are not available.

The figures presented in Tables 2 and 10 concerning rated capacity are drawn from a compilation of the most complete State data sets obtained. The most extensive data are from New Jersey, New York, and Washington; data from other States for some facility categories are included as well.[1]

An additional source of data was the responses to information collection requests sent to six multiple-hospital corporations and three commercial MWI companies. The hospital corporations operate up to 20 MWI's each and the commercial disposal facilities also operate several units each.

Data on the age of MWI's was obtained from California, Washington, and Rhode Island, as well as from several of the respondents to the information collection requests. Available data on the age of MWI's are summarized in Table 11.

6.2 STATE DATA

Table 12 presents a summary of the data on MWI's received from the States. This table is a combination of data from the MWI lists, used to derive the nationwide estimates presented in Table 2, and information received during telephone contacts with State air agencies and State hospital associations. Some data from State reports are included also.

6.3 DISCUSSION OF INDIVIDUAL FACILITY CATEGORIES

In the sections that follow, the major categories of MWI facilities are discussed individually. To the extent possible, the discussion includes information on the number of facilities, combustor types, sizes, ages, duty cycles, waste types burned, and other topics relevant to the individual category.

TABLE 11. SUMMARY OF AVAILABLE MWI AGE DATA[1]

Other/unidentified facilities	No. of units in sample	Age, years	
		Range	Average
Hospitals[a]	108	1-33	14
Laboratories[b]	2	10-21	16
Veterinary facilities[b]	10	3-21	13
Nursing homes[c]	6	18-33	24
Commercial facilities[d]	5	3-6	5
Other/unidentified facilities[c]	8	7-30	16

[a]Based on data from CA, RI, and WA.
[b]Based on data from WA.
[c]Based on data from CA and WA.
[d]Based on data from CA and RI.

TABLE 12. MWI POPULATION BY STATE

	Commercial units				Onsite units				
	Existing		Planned						
State	No.	Capacity range, lb/hr	No.	Capacity range, lb/hr	No.	Capacity range, lb/hr	Facilities included	Information type	Comments
Alabama	2	Up to 60,000 lb/wk	ND	ND	250	ND	H, N	Survey data	SRA telephone contact and summary of survey data.
Alaska	1	ND	ND	ND	10 to 12	ND	H	Estimate	SRA telephone contact.
Arizona	1	ND	ND	ND	97	ND	All	List	Data from SRA list; according to SHA, there are two commercial facilities.
Arkansas	1	ND	2	ND	150	ND	ND	Estimate	SRA and SHA telephone contacts. All hospitals (~100) are required to operate incinerators for pathological waste.
California	10	ND	ND	ND	157	ND	H, N, O	List	
Colorado	2	225	8	750-1,700	46	13-1,000	H	List	The eight planned commercial units will be located at five sites.
Connecticut	1	1,200	3	ND	44	20-1,500	All	List	Data on commercials from SRA telephone contact.
Delaware	0	NA	1	ND	20	ND	H,V	Estimate	SRA telephone contact.
Florida	12	300-3,750	ND	ND	273	ND	H,F,V,A, L,0	List	List received from SRA.
Georgia	1	ND	ND	ND	ND	ND			SRA telephone contact.
Hawaii	0	NA	ND	ND	6 or 7	100-1,000	H	Estimate	SRA telephone contact.
Idaho	ND	ND	3	ND	20-25 permitted	ND	H	Estimate	SRA telephone contact.
Illinois	2	ND	2	ND	259	2-1,500	H, F, V, A, L, O	List	Onsite units' charging rate is estimated actual rather than design capacity. Data on commercials from telephone contacts; two existing commercials are hazardous waste incinerators that can burn MW.
Indiana	4	ND	ND	ND	91	Most <7 tons/d	H	Estimate	Have received list from Marion County/Indianapolis. Estimate from telephone contact. In addition, two MWC's may accept MW.
Iowa	O	NA	0	NA	ND	≤125	H	Estimate	SRA and SHA telephone contacts. Two commercial units have been proposed, but no permit applications submitted yet.
Kansas	Some	ND	ND	ND	ND	ND			SRA telephone contact.
Kentucky	1	1,500	0	NA	ND	ND			SRA telephone contact. Two commercial units proposed, but no firm plans.
Louisiana	1	1,500	1	8,000	100-125	<500 to >1,000 (most <500)	H	Estimate	SRA telephone contact. Test report for capacity of existing commercial unit.

TABLE 12. (continued)

State	Commercial units				Onsite units			Information type	Comments
	Existing		Planned						
	No.	Capacity range, lb/hr	No.	Capacity range, lb/hr	No.	Capacity range, lb/hr	Facilities included		
Maine	1	150	Moratorium		22	20-1,000	H, N, L	List	List includes "licensed biomedical incinerators," which would include nursing homes and laboratories, but all listed facilities are hospitals. SRA telephone contact indicates that two commercial facilities were in the preapplication stage, but have been halted by the moratorium.
Maryland	ND	ND	1	12,500	121	ND	All	List	Data on planned commercial from the SRA and SHA telephone contacts.
Massachusetts	3	350-1,200	ND	ND	200	3-1,875	All	List	
Michigan	1	720	5	1,000-2,500	160	ND	H,N	List	Data on commercials from Department of Natural Resources; comments on industry mailout.
Minnesota	0	NA	1	ND	145	50-1,250	H	List	Data on commercials from SRA telephone contact.
Mississippi	0	NA	1	ND	125-175	ND	All	Estimate	SRA telephone contact. Moratorium on medical waste disposal facilities until 4/1/91.
Missouri	2	ND	2	3,500	100	Most <500	H	Estimate	SRA telephone contact. The two proposed commercial units would be located at one facility.
Montana	ND	ND	ND	ND	<50	ND	ND	Estimate	Statewide estimate from SRA telephone contact. Have received list from Missoula County.
Nebraska	0	NA	1	ND	~80	ND	H	Estimate	Data on commercial unit from SRA telephone contact; estimate of hospital units from SRA telephone contacts.
Nevada	0	NA	1	ND	17	40-360	H	List	Data on planned commercial unit and onsite units in two counties from telephone contacts. List includes permitted units in the rest of the State; others may predate permit requirement.
New Hampshire	1	ND	ND	ND	~27	Most 75-150	H		SRA and SHA telephone contacts.
New Jersey	1	5,000	ND	ND	154	20-1,560	All	List	Does not include one hazardous waste incinerator that "occasionally burns a load of MW."
New Mexico	3	75-1,000	ND	ND	31	25-360	H,F,V,A,L	List	List does not include City of Albuquerque or Bernalillo County.
New York	2	1,950	ND	ND	599	3-3,000	All	List	Data on commercial units from site visit; the two units are located at one facility.
North Carolina	7	150-3,250	ND	ND	29	60-2,100	H,L	List	List includes permitted hospital/pathological incinerators; general permit cutoff is 250 lb/hr. The seven commercial units are located at three facilities.

TABLE 12. (continued)

State	Commercial units				Onsite units			Information type	Comments
	Existing		Planned						
	No.	Capacity range, lb/hr	No.	Capacity range, lb/hr	No.	Capacity range, lb/hr	Facilities included		
North Dakota	0	NA	0	NA	50	Most <500	H	Estimate	SRA telephone contact. One 1,200 lb/hr commercial unit under consideration; no permit application yet. Also have nursing home MWI's that typically burn <10 lb/2 d.
Ohio	15	500-1,700	Some	ND	125	25-2,500	H,F,V,A,L, O	Estimate	List received from SRA.
Oklahoma	1	ND	2	ND	93	ND	H,N,L	Preliminary survey data	Preliminary survey data and SRA telephone contact. Planned commercial units not online until 1991-1992.
Oregon	2	200-1,000	ND	ND	31	25-750	H	List	
Pennsylvania	8	ND	ND	ND	186	ND	H	Estimate	Have received lists from Allegheny County and the City of Philadelphia. Estimate from State document. Moratorium on commercial units lifted 6/90.
Rhode Island	1	975	ND	ND	11	50-1,500	H	List	List received from SHA.
South Carolina	3	6,250	ND	ND	70	<500 to 1,000	H	Estimate	SRA telephone contact and test results. The three commercial units are located at one facility; they burn both MSW and MW; rated capacity based on MSW.
South Dakota	0	NA	2	ND	30	ND	H	Estimate	SRA telephone contact.
Tennessee	≥1	ND	Moratorium		126	ND	H	Estimate	Statement accompanying moratorium on all MWI construction issued in February 1990. Six commercial units were proposed at the time. Local agency indicates one existing commercial unit within jurisdiction.
Texas	2	ND	ND	ND	ND	ND			SRA telephone contact indicated that all hospitals are required to have an incinerator. However, SHA contact indicated that in urban areas, only about half the hospitals incinerate their medical waste.
Utah	0	NA	3	ND	20	<500	H	Estimate	SRA telephone contact. Two of the commercial units permits have been issued; the third is pending.
Vermont	0	ND	2	ND	9	ND	H	Estimate	SRA telephone contact. The two planned commercial units will be located at one facility. Expect hospital survey data.
Virginia	1 or 2	ND	ND	ND	ND	ND		Estimate	SRA telephone contact.
Washington	6	1,600-7,500	ND	ND	137	40-825	All	List	Commercial units are municipal waste incinerators, which are allowed to receive MW; the six commercial units are located at four facilities (two facilities have two incinerators each).

TABLE 12. (continued)

State	Commercial units				Onsite units			Information type	Comments
	Existing		Planned						
	No.	Capacity range, lb/hr	No.	Capacity range, lb/hr	No.	Capacity range, lb/hr	Facilities included		
West Virginia	ND	ND	Moratorium		~50	ND	H	Estimate	Estimate from SHA telephone contact. SRA telephone contact indicates that there is a moratorium on construction of new MWI's. Have received three applications for commercial units.
Wisconsin	4	ND	1	ND	ND	ND			Data on commercial units from SRA telephone contact. SHA contact indicated that 80 percent of respondents to a hospital survey incinerate onsite.
Wyoming	0	NA	0	NA	~30	ND	H	Estimate	SRA telephone contacts.

KEY:

General

ND = No data.
NA = Not applicable.
SRA = State regulatory agency.
SHA = State hospital association.

Facility types

H = hospitals/medical centers.
F = funeral homes.
V = veterinaries.
A = animal shelters.
L = laboratories, clinical and research.
N = nursing homes.
O = other/unidentified facilities.
All = all MWI facilities (using current broad working definition).

6.3.1 Hospitals

As seen in Table 2, hospital installations are the largest class of MWI's, both in terms of numbers (approximately 3,200, or over 60 percent of all MWI's) and capacity (almost 65 percent of total MWI capacity). Hospital MWI's are known to range in size (i.e., rated capacity) from 3 lb/hr to 2,500 lb/hr and to average about 270 lb/hr. The national hospital MWI population estimate is derived from data received from 20 States extrapolated based on 1980 census data. The size range and average are based on data from 12 States.

Data received in response to the request for information distributed for this project are more informative with respect to combustor type than the State MWI population data. However, neither of these data sets contained significant amounts of information necessary to classify combustor types beyond the most fundamental designs. Based on the information received, MWI's were divided into two combustor types, starved-air and excess-air. Starved-air MWI's are the most prevalent type and are used to incinerate all types of medical waste, except pathological waste. Excess-air MWI's are generally used for the incineration of waste that contains a very high percentage of pathological material. Data on combustor type and rated capacity are summarized in Table 13.

As illustrated in Table 10, the hospital MWI population is concentrated at the low end of the capacity range, with over 50 percent below 200 lb/hr, and is then spread out fairly uniformly across the range above this level. This table is based on data from State inventories. The size distribution by combustor type among surveyed hospitals is shown in Table 14. The combination of all combustor types in this table differs slightly from the hospital data in Table 10.

Many MWI's at hospitals are very old. As shown in Table 11, based on data from two States (California and Washington), at least one hospital unit was installed as long ago as 1957. The average age of hospital MWI's for which data are available in these two States is about 14 years. Data from two surveys

TABLE 13. SURVEYED HOSPITAL MWI POPULATION BY COMBUSTOR TYPE, WITH RATE CAPACITY STATISTICS[1]

Combustor type	Population		Rated capacity, lb/hr			
	Units	Percent of total	Range	Average	Total	Percent of total
Starved-air	58	78	40-1,060	300	17,385	86
Excess-air	13	18	50-300	138	1,790	9
Unknown	3	4	25-700	358	1,075	5
Total	74	100	25-1,060	274	20,250	100

TABLE 14. PERCENTAGE DISTRIBUTION OF SURVEYED HOSPITAL MWI POPULATION BY RATED CAPACITY FOR EACH COMBUSTOR TYPE

Combustor Type	Rated capacity, lb/hr						
	<100	100 to 199	200 to 299	300 to 499	500 to 999	≥1,000	Total
Starved-air	22	14	24	19	19	2	100
Excess-air	23	62	8	8	0	0	101
Unknown	33	0	0	33	33	0	99
All combustors combined	23	22	20	18	16	1	100

conducted by State hospital associations (Ohio and Wisconsin) indicate mean ages of about 11 years and 15 years, respectively.[96,97] Age data from the hospital MWI survey are not representative. The questionnaires were sent to multiple-hospital corporations with instructions to concentration on newer MWI units.

The duty cycle of MWI's is determined by the design of the waste feed system and the method of ash removal. All MWI's fall into one of three distinct designs, and may be designated as either a batch, an intermittent-, or a continuous-duty incinerator. In a batch unit, the waste is introduced to a cold unit in a single load. The incinerator is operated without additional waste being added until combustion is complete. In intermittent-duty MWI's, waste is introduced periodically during incinerator operation, but the unit must be shut down for ash removal. Continuous-duty means that ash is discharged from the unit during operation, so waste can be fed for an unrestricted length of time.

Some data on the incinerator duty cycles employed by hospitals were obtained in response to the hospital request for information. About 22 percent of MWI's for which responses were received are batch units, 72 percent are classified as intermittent, and 6 percent are continuous units. The batch MWI's average only about 75 lb/hr rated capacity, intermittent MWI's 294 lb/hr, and continuous MWI's 743 lb/hr.

Some data on the prevalence of heat recovery at hospital MWI's are also available from the responses to the requests for information. Based on these data, heat is recovered from about 8 percent of hospital MWI's. Heat recovery is most practical for larger units that burn a more general waste stream, although equipment is available for moderate-sized incinerators as well. It is not known how well the respondents represent the general population of hospital MWI's. According to one source, at least 100 heat-recovery systems were installed on new hospital MWI installations between 1974 and 1983.[98]

It is common practice for hospitals to accept medical waste from offsite sources for incineration. The quantity of offsite waste accepted is generally small. Evidence abounds that waste from doctors' and dentists' offices, laboratories, clinics, nursing homes, veterinary facilities, home care agencies, nursing homes, and smaller hospitals is sometimes burned in hospital MWI's. Of the hospitals that responded to the request for information, 22 percent indicated that some offsite medical waste is accepted for incineration. Seventeen percent of the Ohio Hospital Association survey respondents reported accepting infectious waste from offsite for treatment, and 24 percent of the hospitals that responded to the Wisconsin Hospital Association survey indicated incinerating such waste.

The survey for this project also asked about the point of origin within the hospital for the waste incinerated onsite. Based on the means of the responses, 30 percent of the waste comes from the operating room, 24 percent from patient rooms, 16 percent from the hospital laboratory, 13 percent from pathology, 7 percent from the administrative offices, 4 percent from the pharmacy, 2 percent from the cafeteria, and 4 percent from other sources.

As discussed earlier, the true, long-term capacity utilization rate cannot be computed without knowledge of the operating schedule for which the unit is designed. However, some data on operation practices were reported by the hospital MWI respondents. On the basis of lb/hr combusted, the percent of rated capacity used ranges from only about 2 percent up to 100 percent, with a mean of 56 percent and a median of 55 percent. The number of operating hours per day ranges from 1 to 20, with a mean of 9 and a median of 8. The MWI's are operated a mean of about 285 days per year (median--315 days per year) and a mean of about 2,575 hours per year (median--2,400 hours per year).

6.3.2 Laboratories

As discussed earlier in the section on medical waste generators, clinical laboratories do not often operate onsite MWI's. However, research laboratories that generate animal carcasses frequently do. Note that animal carcasses are not considered infectious or regulated medical waste unless they have been exposed to agents infectious to humans.

The estimated number of laboratory MWI's in the United States is 500, as extrapolated from data received from 11 States (see Table 2). Based on data from six of these States, the average capacity of these units is approximately 340 lb/hr, and the range is from 3 to 3,000 lb/hr. This category comprises about 10 percent of the U.S. MWI population but nearly 12 percent of total MWI capacity. As shown in Table 10, about 65 percent of laboratory MWI's are less than 300 lb/hr, but the remaining units are spread across the range, with 8 percent having capacities of 1,000 lb/hr or greater.

The waste combusted in these units is primarily pathological (i.e., animal carcasses). As shown in Table 11, few data are available on the age of laboratory MWI's. No data are available on duty cycle or heat recovery practices at laboratory MWI's. As discussed in the medical waste generator section, some clinical laboratories accept waste for treatment from offsite sources either as a service to their customers or for a fee. However, incineration is not normally the treatment method employed.

6.3.3 Veterinary Facilities

Data from eight States were used to estimate that about 550 veterinary facilities operate MWI's nationwide. As indicated in Table 2, these units range in size from 15 lb/hr to 2,000 lb/hr, with an average capacity of about 120 lb/hr based on the four States with extensive capacity data. This category comprises about 11 percent of the MWI population, but less than 6 percent of total MWI capacity. Based on data from three States, nearly 70 percent of these units have capacities of less than 100 lb/hr; over 95 percent are less than 500 lb/hr.

Veterinary facilities incinerate primarily animal carcasses, which are typically not considered infectious or regulated medical waste. However, veterinary practices generate the same sorts of treatment wastes typical of human health care. Thus, incineration of veterinary waste has the potential to emit the same pollutants that are characteristic of the incineration of human patient care waste. This potential is the basis for keeping veterinary facilities separate from animal shelters, where health care waste is minimal.

As indicated in Table 11, installation date data are available only for 10 units in the State of Washington. These units range in age from 3 to 21 years, with an average of 13 years.

No data are available on duty cycle or heat recovery practices at veterinary MWI's. Given the very small units typical of this category, the use of heat recovery is unlikely. It is unlikely that waste from offsite sources is accepted at such facilities.

6.3.4 Nursing Homes

Table 2 presents the estimated population of MWI's at nursing homes, about 500 units based on data from 13 States. The average size of these units (based on five States' data) is about 170 lb/hr, and the range is from 3 to 1,300 lb/hr. Only about 3 percent of total MWI capacity is located at nursing homes. Nearly 90 percent of nursing home MWI's are less than 300 lb/hr in capacity based on data from four States. Very little data are available on the age of nursing homes MWI's (see Table 11).

While no data are available regarding duty cycles or heat recovery at nursing homes, the distribution weighted heavily toward the small end of the spectrum indicates that intermittent units without heat recovery are most likely. It is unlikely that medical waste is accepted from offsite at these units.

6.3.5 Commercial Units

It is estimated that there are up to about 150 commercial MWI units in operation. Multiple units at a single facility are common. This estimate was extrapolated from data from 15 States and roughly corroborated by the data on commercial units in Table 12. Based on data from 10 inventories, an average capacity of about 1,180 lb/hr was derived. The range in these data is from 100 to 8,000 lb/hr. While commercial facilities comprise only about 3 percent of the MWI population, slightly over 12 percent of total MWI capacity is in this category. Other data gathered from incinerator manufacturer installation lists and trip reports tend to indicate that the estimated average capacity is low. This will certainly be true in the future; new and proposed commercial facilities tend to be much larger than older units, most frequently between 1,500 and 2,000 lb/hr.

For this project, requests for information were sent to three multiple-facility commercial incineration companies. Responses for 21 MWI's were received. These units range in capacity from 110 lb/hr to 2,500 lb/hr, with a mean capacity of about 1,245 lb/hr and a median of 1,350 lb/hr.

Continuous-duty MWI's account for the majority of commercial units. Among the survey respondents, 17 of the 21 are continuous-duty. Three are intermittent-duty, and one is a batch unit. Information from other sources indicates that at least two rotary kiln combustors are also in use at commercial facilities.

The surveyed MWI's are being extensively utilized. Eighteen of the 21 units are reported to operate 24 hours per day, with a mean over all units of 22 hours per day. (Note that this is inconsistent with the data indicating that only 17 units are continuous-duty.) These commercial MWI's operate from 150 to 365 days per year, averaging 321. The range of operating hours per year is 2,400 to 8,760, with a mean of 7,185 hours per year and a median of 7,600.

The commercial MWI companies were also asked what types of sources generate the medical waste that they incinerate. Based on the means for the responding facilities, 64 percent of the

waste comes from hospitals, 13 percent from clinics, 13 percent from laboratories, 7 percent from physicians' offices, and 1 percent from veterinary facilities. (Rounding error accounts for the total of less than 100 percent.) Again based on the means of the responses, 79 percent of the waste combusted at these commercial facilities is "red bag" waste, 18 percent is pathological, 2 percent is general medical waste, and 1 percent is municipal solid waste.

While heat recovery would seem more feasible for commercial units than for onsite MWI's, available data do not indicate that heat recovery is particularly common. Based on data from the responses, less than 10 percent of commercial facilities practice heat recovery.

6.3.6 Other/Unknown

This category is included to account for facilities that do not fit elsewhere. In some cases, the facilities can be identified but do not belong in any of the major categories. Such facilities include the few clinics, blood banks, etc. that operate onsite incinerators but are not plentiful enough to justify a separate category. More often, the type of facility simply cannot be identified. This frequently occurs when a facility is included in a State list of MWI's, but the facility name does not reveal the facility type. These facilities are included in this category so that they may still be considered in the characterization of the MWI source category.

As indicated in Table 2, there are approximately 150 such facilities nationwide based on extrapolation from 11 States. These facilities have an average capacity of about 170 lb/hr and range from 25 to 900 lb/hr. They represent less than 2 percent of total MWI capacity. Nearly 85 percent of these units have capacities of less than 300 lb/hr. The predominantly small size of the units indicates that batch and intermittent MWI's prevail and that heat recovery is uncommon. Data on the installation dates of the units in this category are scarce (see Table 11).

6.3.7 Municipal Waste Combustors (MWC's) That Cofire Medical Waste

Under the definition for MWI in this project, any device that combusts medical waste is a MWI. Thus, MWC's that combust any amount of medical waste are included. Technically, under the definition of medical waste, most, if not all, MWC's burn some medical waste (i.e., the portion of the waste generated during the course of patient care that is not segregated from the general waste stream for special handling). However, this portion of the medical waste stream that cannot be differentiated from general waste on sight will not be addressed here.

In many States and localities, there are no restrictions on burning the waste designated as potentially infectious in a MWC. However, it is not common for MWC operators to accept medical waste for treatment. This practice often extends beyond the fraction of the waste designated as infectious under applicable regulations to include any waste of similar appearance.

In a report prepared for EPA, 11 MWC facilities (comprising 31 MWC units) that accept medical waste were identified. One of these facilities accepts an average of 50 percent medical waste; at all other facilities the fraction of the total waste stream that is medical waste averages no more than 5 percent. Three additional facilities were identified that previously accepted medical waste but have ceased this practice. One facility stopped because of changes in the regulations that applied, and two ceased because of operational problems and potential hazards believed to be associated with the medical waste.[99]

Additional MWC facilities may accept medical waste in those localities where medical waste management regulations allow it, particularly where there are no restrictions on placing medical waste in the general waste stream. For example, in a report prepared by the State of Washington, all four MWC facilities in the State are identified as potential incinerators of medical waste even though only one of the facilities actively solicits medical waste shipments as a commercial venture.[100]

In Table 2, only the 31 MWC units identified in the report to EPA have been included. No basis exists for extrapolating beyond these units, although more MWC's may be cofiring medical waste, knowingly or unknowingly. The MWC units in Table 2 have not been included in the calculations of total capacity or percent of total capacity because medical waste amounts to only a fraction of the rated capacity of these units.

6.4 TRENDS IN MEDICAL WASTE INCINERATION PRACTICES

6.4.1 Potential Influences On Population Growth

The trend in medical waste management is toward more inclusive definitions of medical waste and toward transformation of what had been guidelines into more restrictive regulations on handling, packaging, treatment, transportation, and disposal of medical waste. As a result, the quantity of waste designated as medical waste that requires special handling is expected to increase. In addition, the cost of complying with more stringent regulations for packaging, transporting, treating, and disposal is expected to drive up the unit cost of having medical waste treated offsite. To avoid the higher disposal costs, an increase in onsite treatment, including incineration, is expected, especially for large-volume generators like hospitals. To handle the larger quantities of medical waste, larger onsite MWI's will be installed. As the incinerator capacity necessary to treat the medical waste grows, the more likely it becomes for facilities to install waste heat recovery equipment. Facilities choosing this course may also choose to accept medical waste from offsite sources (for a fee) to offset costs and to maintain a steady heat load. However, the advantages of acting as a commercial incineration facility may be offset by the increased regulatory requirements that apply to commercial facilities as well as size/space logistical problems. There may be advantages to a group of hospitals' building and using one site rather than paying commercial rates or operating an onsite unit at each hospital.

In addition to the effects on onsite incineration facilities discussed above, the number and capacity of commercial units are

expected to grow to handle the increased medical waste stream from small generators for whom onsite treatment remains impractical. Such small generators are likely to institute more rigorous segregation of medical waste to minimize the increase in the volume generated.

In the discussion above, only the effects of the changes in medical waste management requirements are considered. Against this backdrop, the effects of changing MWI regulations will be played out as well. These effects will depend upon the requirements enacted in each jurisdiction and at the Federal level.

In some States, very restrictive MWI regulations have been enacted for units of all sizes, both new and existing. Such regulations will tend to counteract the move toward onsite incineration discussed above, although the extent of the effect is not yet known. The resultant climate will favor large onsite units with heat-recovery equipment. These facilities may accept medical waste from offsite sources, depending on whether the benefits are perceived to outweigh the disadvantages of becoming subject to commercial facility requirements.

In this climate, growth is most likely to be experienced in the regional MWI sector, with ownership either by a group of generators or by a commercial operator. This arrangement takes advantage of economies of scale in MWI and heat recovery and generally allows better equipment capacity utilization.

Restrictive regulations on all sizes of incinerators may also add impetus to alternative treatment technologies. These methods may become attractive as an alternative to the cost of either onsite incineration or use of a commercial facility in States with very restrictive MWI standards. On the other hand, in some States the costs of other alternatives, such as landfilling, may make onsite incineration economically attractive. It is not yet known what effects restrictive MWI regulations will have on alternative treatment technologies.

In contrast to the regulatory approach discussed above, some States have adopted more restrictive requirements for large MWI's

but have set limits for smaller units that can be met without an add-on air population control device (APCD) by a MWI that is well designed and operated. In these States, market forces will favor better medical waste segregation practices so that smaller onsite units can be used. These forces work against heat recovery and incineration of waste from offsite sources. It is not clear what impact the competing factors will have on the commercial sector. Restrictive regulations on large MWI's will work in opposition to the need for new commercial facilities to treat the waste stream from small generators newly affected by medical waste handling and disposal regulations.

Still other States have MWI regulations that are not restrictive for units of any size. In these States, medical waste management considerations unmitigated by MWI standards are expected to drive MWI growth as previously discussed.

6.4.2 Growth Projections

In the preceding paragraphs the potential effects of changes in medical waste management requirements and changes in MWI regulations were considered; however, it is not known what impact these factors will actually have on medical waste incineration practices. As a result, these factors are not considered in developing MWI sales projections.

Projected MWI sales and distribution by type and size for the 5 years after proposal of the NSPS are presented in Tables 15 and 16.[101] For onsite incinerators, Table 15 illustrates that approximately 64 percent of future sales are expected to be intermittent units. Batch units are expected to represent about 26 percent of future sales. Continuous units comprise the remaining 10 percent of expected sales of onsite MWI's. All future commercial incinerator sales are expected to be continuous units, with nearly 87 percent in the 1,001 to 2,000 lb/hr rated capacity range.

These projections of new onsite and commercial units per year are based on historic sales data obtained through information requests from seven MWI vendors. These seven vendors are believed to represent about two-thirds of the MWI market.[101]

TABLE 15. DISTRIBUTION OF PROJECTED ONSITE MEDICAL WASTE INCINERATOR SALES BY TYPE AND SIZE FOR THE 5 YEARS AFTER PROPOSAL OF THE NSPS[101]

Combustor type and size	Years after proposal of NSPS				
	1	2	3	4	5
Intermittent					
50-400 lb/hr	57	57	57	57	57
401-1,000 lb/hr	19	19	19	19	19
>1,000 lb/hr	4	4	4	4	4
Continuous					
500-900 lb/hr	6	6	6	6	6
901-1,100 lb/hr	1	1	1	1	1
1,101-1,850 lb/hr	5	5	5	5	5
Batch					
150 lb/batch	6	6	6	6	6
500 lb/batch	22	22	22	22	22
1,600-3,780 lb/batch	5	5	5	5	5
TOTAL FOR SALES PERIOD	125	125	125	125	125

TABLE 16. DISTRIBUTION OF PROJECTED COMMERCIAL MEDICAL WASTE INCINERATOR SALES BY TYPE AND SIZE FOR THE 5 YEARS AFTER PROPOSAL OF THE NSPS[101]

Combustor type and size	Years after proposal of the NSPS					Percent of total
	1	2	3	4	5	
Continuous						
500-1,000 lb/hr	0	0	0	0	0	3.3
1,001-2,000 lb/hr	13	13	15	13	13	86.7
2,001-6,588 lb/hr	2	2	2	2	2	10.0
TOTAL FOR SALES PERIOD	15	15	17	15	15	100

The increase in population of new MWI's was fairly consistent from 1985 through 1989. This consistent rate of increase was assumed to continue in projecting future sales.[101]

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16. ABSTRACT

This report presents a profile of the medical waste incinerator (MWI) source category. The purpose of this profile is to characterize the source category for use in subsequent environmental and economic analyses. This is one in a series of reports used as background information in developing air emission standards and guidelines for new and existing MWI's. Definitions of medical waste and MWI's are presented, and the industry structure associated with MWI's is described.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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