HANDBOOK OF HAZARDOUS WASTE INCINERATION

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Preface

Hazardous waste has been dumped indiscriminately, it has been burned uncontrollably, and it has been buried irresponsibly. This book describes methods of disposal of hazardous waste through incineration in a responsible, environmentally secure manner.

The purpose of this book is to present the entire field of hazardous-waste incineration to the reader. Information on regulations, site clean-up, air emissions control, and current and emerging thermal treatment technologies are of relevance to the lay reader as well as the engineering professional. Non-technical people with an interest in this subject matter include supervisory personnel in government and industry, members of public interest groups, members of the news media, and students of environmental technology. The technical material in the text, including calculations of system and equipment parameters and air emissions discharges, should be of interest to the engineer and designer.

The high profile of the problems of hazardous-waste accumulations and disposal has resulted in the mobilization of regulatory disciplines, environmental engineers, environmental scientists, industrial generators, remediation contractors, equipment manufacturers, environmental organizations, and concerned citizens across the country. They are mobilized to reduce the amount of hazardous waste generated and to help ensure that the disposal of these wastes is made in an appropriate manner. This book directly addresses these concerns.

The disposal of hazardous wastes is controlled by regulatory procedures that are described at the beginning of this text. The types of systems available for the incineration of hazardous wastes are detailed in three chapters, followed by specific applications. Three additional chapters are included for these applications: site clean-up, incineration in high-temperature industrial processes, and ocean incineration technology. A chapter is devoted to European systems, which have a longer history than American systems.

Three chapters are devoted to emissions forecasting and control, and the last four chapters cover incinerator calculations, from heat balance techniques to energy recovery. The text is supplemented with appendices containing the basic information necessary to perform incineration calculations. A comprehensive glossary is also included.

Contents

1

Introduction

The demands of present society create wastes that appear to increase in quantity as the standard of living increases. This is true not only in the United States but in the rest of the world as well. The ability of the land, water, and air to absorb these wastes is limited; reminders of this are all too apparent. Poisoned rivers, darkened skies, and wastelands are endemic to the industrialized world. Resistance to this trend, coupled with the start of vigorous attempts to reverse inadequate waste disposal practices has been only a recent occurrence.

Over the past fifteen years the annual expenditure on pollution control in the United States has risen from less than one percent to almost six percent of industrial capital equipment investment. By the end of the century this figure, which does not include pollution control for automobiles or the cost of disposal of municipal solid waste or sewage, is expected to more than double.

The most effective means of dealing with this problem, dramatically illustrated in Fig. 1-1, is to reduce the amount of wastes generated. In industry, this means process modification or the establishment of new markets for generated streams. In the public sector, waste reduction translates to source separation, recycling, and resource recovery.

Waste reduction is a goal that will be driven forward by economic conditions. As the cost of waste disposal increases, new methods of waste

Fig. 1-1. Hazardous-waste dump. Source: USEPA.

reduction will become economically attractive, and will be implemented. It is difficult to imagine; however, a time when there will be no waste generation. For the foreseeable future, despite effective reduction practices, there will still be hundreds of millions of tons of waste that must be destroyed or controlled to protect the public health and the sanctity of the environment.

HAZARDOUS WASTE

The first step in the control of waste disposal is the establishment of waste definitions. There are many different types of wastes from sources throughout the spectrum of industrial, agricultural, mining, and domestic activity, as listed in Table 1-1. The majority of these wastes, those from agriculture and livestock, generally do not pose a severe threat to life. Many other wastes are not life threatening either, but they all must be disposed of in an environmentally sound manner.

A top priority in the restoration and maintenance of a safe and tenable environment is the disposition of a particular classification of waste materials: hazardous wastes. The federal government has established a set of definitions which identify wastes that are of a particular concern. Chapter 2 discusses these wastes in detail.

The term *hazardous waste* has a specific statutory definition. However, in common usage, this term tends to include other wastes. The Toxic Substances Control Act (TSCA) regulates wastes containing PCBs; the Nuclear Regulatory Act deals with wastes having a radioactive content.

Table 1-1. Solid Waste Generation in the United States, 1978.

SOURCE	Million Tons/Year	Percent
Municipal	230	5.2
Industrial	140	3.1
Mineral	1,700	38.2
Animal Wastes	1,740	39.1
Crop Wastes	640	14.4
TOTAL	4,450	100.0

Source: Reference 1.

The wastes discussed in this book will include wastes designated by the Resource Conservation and Recovery Act (RCRA) and those wastes included under TSCA. When the term "hazardous waste" is used, PCBs and related wastes under TSCA will also be included in this designation.

If wastes have been defined as hazardous, the regulations described in Chapter 2 address their storage, transportation, treatment and disposal.

INCINERATION

While industry is struggling with the mechanisms of waste reduction, the avenues previously open for waste disposal are closing, particularly in the area of hazardous wastes. Incineration is becoming more attractive as an alternative disposal method. Features of the incineration option include the following:

- The hazardous component of the waste is destroyed.
- The volume and weight of the waste is reduced to a fraction of its original size.
- Waste reduction is immediate; it does not require long-term residence in a biological treatment pond or other land disposal system.
- Waste can be incinerated on-site, without being transported to a distant area.
- Air discharges can be effectively controlled for minimal impact on the atmospheric environment.
- The ash residue may be subject to de-classification as a hazardous waste. In this case, incineration becomes, essentially, a final disposal method as well as a treatment method for hazardous waste.
- Incineration requires a relatively small disposal area, not the acres and acres needed for lagoons or other land disposal methods.
- Incineration is easily terminated. The cessation of incineration activity will remove any liability for the generator or operator. With land burial, the liabilities are indefinite and uncertain.

- Through heat recovery techniques, the cost of operation can be reduced or offset by the use or sale of energy.

Although incineration is becoming increasingly attractive as a waste disposal option, it is not universally applicable to waste disposal. Note the following considerations:

- Some materials, such as highly aqueous wastes or non-combustible soils, are not incinerable.
- Certain organic materials, particularly those with a chlorine component, tend to generate products of incomplete combustion that are often toxic and present their own disposal problems.
- Incineration represents a high capital cost.
- Skilled operators are required.
- Supplemental fuel is required to bring up an incinerator to operating temperature and, with some materials, to maintain combustion temperatures.

As noted previously, the incineration option is, on balance, an attractive option for a growing number of waste streams. The trend today is an increase in the use of incineration for a wider profile of wastes.

TRANSPORTATION

An issue directly related to the disposal of hazardous waste is the transportation of hazardous waste. Although the federal government has normally taken the lead role in the regulation of transportation activities, the fear of hazardous product and waste incidents is bringing state and local governments into the regulation of these activities. An indication of the seriousness of this issue is presented in Table 1-2, which is a list of the

Table 1-2. Reported Incidents Involving Transportation of Hazardous Materials, 1973-1983.

Transport Mode	Incidents	Deaths	Injuries	Damages[1] ($ Million)
Highway	10,289	19	419	8.15
Rail	975	4	222	4.67
Water	26	0	3	0.07
Air	150	< 1	9	0.43
Freight forwarder	2	0	2	< 0.01
Other	20	0	8	0.01
Total	11,462	24	663	13.33

[1]Property damage reported within 15 days after an accident.

Source: Reference 3.

annual average number of incidents of transport anomalies over a ten year period.

It is interesting to note from this table that the injuries from rail transport are higher per incident than any other named occurrence. While only 8½ percent of the total reported incidents of transportation accidents involving hazardous wastes is associated with rail transport, it results in over one-third of the reported injuries. When a rail car has an accident, the population at large surrounding the track is vulnerable, more so than in any other transport mode. In most instances of highway accidents, the truck driver is normally the only one at risk; the surrounding community is not threatened to the extent typical of rail accidents. These statistics explain the growing concern of state legislatures regarding the proper control of hazardous materials passing through their state.

States that have passed or are considering legislation requiring the registration of hazardous-wastes transport are indicated in Table 1-3 and Fig. 1-2. Twenty-six of these states require hazardous-waste transporters to register with the state and impose fees ranging from $25 to $500. These fees may cover only a single trip, or extend over a whole year. In some states additional registration requirements are mandated, such as inspections in California, Connecticut, and Rhode Island.

One result of the attention that these states are giving to the transportation of hazardous wastes is that the licensing, registration, and permit requirements vary widely, particularly at the state and local level.

The evaluation of incineration compared to other methods of disposal should include considerations of transportation from the generator to the treatment facility.

HAZARDOUS-WASTE INCINERATION

The Federal Government maintains a log of hazardous-waste treatment facilities in the *EPA/DOE Hazardous Waste Control Technology Data Base*. This includes all treatment methods, including incineration. The Department of Energy at the Oak Ridge National Laboratory in Tennessee is the agency responsible for maintenance of this data base.

As of March, 1987, 37 industrial hazardous-waste incinerators and 8 PCB incinerators have been permitted out of a total of 199 such incinerators extant in the United States. The majority of the non-permitted incinerators are either in the process of being permitted, are R&D (used for research and development, generally laboratory installations) incinerators requiring special consideration, or have been registered with EPA but are exempt from hazardous-waste regulations.

The data base contains not only the name and use of the incinerator facilities that have applied for permits, but also technical information on

Table 1-3. States with Proposed or Existing Hazardous Waste Transportation Requirements.

State	Company Registration	Company Fee	Vehicle Registration	Vehicle Fee	Driver Training	Spill Provisions
Alabama	Yes	—	—	—	—	—
Arkansas	Yes	Yes	—	—	—	—
California	Yes	Yes	—	—	Yes	—
Connecticut	Yes	Yes	Yes	—	Yes	Yes
Delaware	Yes	—	Yes	—	—	—
Georgia	Yes	Yes	—	—	—	—
Idaho	Yes	Yes	—	—	—	—
Illinois	Yes	—	Yes	—	—	—
Indiana	Yes	Yes	Yes	—	—	—
Kansas	Yes	Yes	—	—	—	—
Kentucky	Yes	Yes	—	—	—	—
Louisiana	Yes	No	—	—	—	—
Maine	Yes	Yes	Yes	Yes	Yes	—
Maryland	Yes	—	Yes	Yes	Yes	Yes
Massachusetts	Yes	Yes	Yes	Yes	—	Yes
Michigan	Yes	Yes	Yes	Yes	—	—
Minnesota	Yes	—	—	—	—	—
Missouri	Yes	—	—	Yes	—	—
New Hampshire	—	—	Yes	Yes	—	—
New Jersey	—	—	Yes	Yes	—	—
New York	—	Yes	—	—	—	—
North Dakota	Yes	—	—	—	—	—
Ohio	Yes	Yes	—	Yes	—	—
Oklahoma	Yes	—	—	—	—	—
Oregon	Yes	—	—	—	—	—
Pennsylvania	Yes	Yes	—	—	—	Yes
Rhode Island	Yes	—	Yes	Yes	—	—
South Carolina	Yes	—	—	—	—	—
Tennessee	Yes	Yes	—	—	—	—
Texas	Yes	Yes	—	—	—	—
Vermont	Yes	—	Yes	Yes	—	—
Virginia	Yes	—	—	—	—	—
Wisconsin	Yes	—	—	—	—	—

Source: Reference 2.

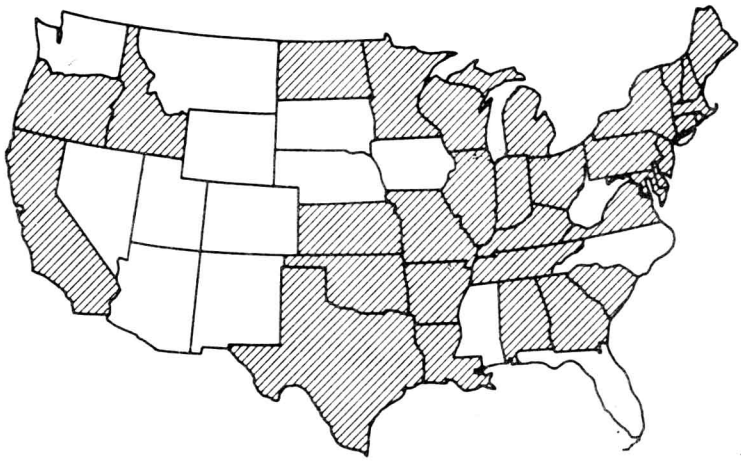

Fig. 1-2. States with proposed or existing hazardous-waste transportation regulations. Source: Reference 2.

each of them. Such information includes waste quantity, hazardous constituents in the waste, heat value of the waste stream, and results of the test burn performed for permit compliance.

REFERENCES

1. *Report to the U.S. Congress—Resource Recovery and Source Reduction,* United States Environmental Protection Agency, Report SW-118, February 1978.

2. *Hazardous Materials: State and Local Activities,* U.S. Office of Technology Assessment, OTA-SET-301, March 1986.

3. *Annual Report on Hazardous Materials Transportation, Calendar Year 1983,* U.S. Department of Transportation.

2

Regulatory Requirements

The federal government has taken the lead in developing a strategy to prevent the discharge or accumulation of hazardous wastes in the environment. The two main regulatory mechanisms for the identification and control of hazardous wastes, RCRA and TSCA, will be discussed in this chapter.

RCRA AND TSCA

The Toxic Substances Control Act (TSCA) addresses the control of *polychlorinated biphenyls* (PCBs) in the environment. It was the first comprehensive piece of legislation designed in response to growing public awareness of and concern about the discharge of industrial pollutants into the air, the water, and the earth. The Resource Conservation and Recovery Act (RCRA) represents the next generation of legislative concern about the discharge of dangerous materials into the environment.

RCRA defines hazardous wastes and describes the methods required for the control of these wastes. It includes wastes from industry, institutions, the public at large, and all other segments of the economy where wastes with a potential negative impact on the quality of life may be generated.

Both RCRA and TSCA regulations require that hazardous-waste generators, transporters, depositories, treatment facilities, and ultimate