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Project Summary

Treatment of Reactive Wastes at Hazardous Waste Landfills

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A study was undertaken to provide information for personnel who must make decisions about the disposition of reactive hazardous wastes (Federal and State personnel, employees accepting hazardous wastes at existing disposal sites, and coordinators performing remedial action at uncontrolled waste sites). These wastes generally display one or more acute physical or chemical hazards and form an immediate threat to human health or the environment. Though Federal regulations place reactive wastes in a special category, they do not identify applicable treatment methods.

In response to the need for better information, this report identified problem wastes, treatment alternatives, and data gaps. Emphasis is placed on simple treatment and disposal schemes that are likely to be the most cost effective. The measures described are either already in use or they are promising techniques that require little further development and have a high probability of success. Information is provided on the possible hazards and the appropriate safety precautions to protect personnel and property.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Though reactive hazardous wastes constitute only about 5% of all hazardous waste, extreme caution must be used during their transportation, handling, storage, treatment, and disposal. These wastes generally display one or more acute physical or chemical hazards and form an immediate threat to human health or the environment (fire or explosion, for example). The Resource Conservation and Recovery Act (RCRA) provides a special classification for reactive wastes and prohibits certain treatment and disposal methods for them, but the regulations do not specify treatment methods that are applicable. Thus adequate information on handling reactive wastes is very much needed, but it is difficult to provide because of the wide variety of chemical behavior that can be expected from materials in this category.

This report provides an information base for personnel who must make decisions about the disposition of reactive wastes--Federal or State personnel, employees accepting hazardous wastes at existing disposal sites, or coordinators performing remedial action at uncontrolled waste sites. Emphasis is placed on simple treatment and disposal schemes that are likely to be the most cost effective. The measures described are either already in use or they are promising techniques that require little further development and have high probability of success. Information is provided on the hazards to be anticipated and the appropriate safety precautions needed to protect personnel and property and to prevent any further environmental damage. Appendices in the full report list representative samples of chemical compounds or species that can be classified as reactive hazardous wastes, and they present alternative treatment technologies identified from the literature.

Methods

Three methods were used to obtain the data in this report: A review of extensive

inhouse background information on the characteristics of reactive hazardous wastes, a review of the recent literature (particularly information on the handling and treatment of hazardous chemicals), and direct comment and information from operators of hazardous waste disposal sites (including those specializing in reactive wastes).

Identification of Problem Wastes

Classification Scheme

The initial classification scheme adopted in this work appears in Table 1 and was originally published as part of the RCRA regulations. Two broad categories of reactive wastes exist--explosive and nonexplosive. The wastes are further divided into the eight categories listed in Table 1. In practice, reactive wastes have a wide range of chemical behavior and many do not fall exclusively into a single category. The following hierarchy is proposed for classifying reactive chemicals based on their potential for causing acute physical damage (fire and explosion) and exposure to toxic gases:

$$VII < VI < VIII < I < IV < III < II < V$$

Some of these classes are further subdivided, with each subcategory having somewhat different reactive effects, consequent hazards, and necessary safety precautions.

The full report describes the properties of reactive wastes in each class, cites representative examples, defines the hazards associated with that type of reactive material, and outlines the necessary safety precautions.

Safety Precautions

Reactive wastes can cause acute adverse effects to human health and thus must be stored, handled, treated, and destroyed by experienced operators. Three types of acute effects can be distinguished: Explosion, fire, and exposure to toxic gases. For many wastes, at least two of these effects may occur simultaneously. Materials that may detonate must be treated with extreme caution.

Transportation of many reactive wastes is extensively covered by DOT regulations. Expert help may be needed to treat or dispose of wastes when they are dangerous or unacceptable for transport because of aging, lack of inhibitors, or deterioration of the container. Reactive wastes should be handled according to the harmful effects of the most hazardous member of a particular class, since reactivity can vary considerably depending on many factors.

The full report provides general guidance as to safety precautions for each class of reactive waste. But more detailed information and experienced personnel are required to permit actual handling of reactive wastes. In addition, specific requirements may be imposed by local codes and ordinances.

Identification of Treatment Alternatives

Defining Alternatives

To define alternative treatment technologies, background data were assessed and the literature was searched for specific examples using commonly recognized chemicals or waste materials from each reactivity class. Next, each treatment technology was classified either as "isolation and containment" or as "destruction." Each technology was then assessed according to the following criteria: Technical feasibility, applicability, chemicals and equipment required, operator requirements, residual production, advantages and disadvantages, and relative cost.

Isolation and Containment

Eight isolation and containment techniques are broadly applicable to a number of reactive waste classes. The degree to which each technique is applicable to these eight classes is indicated in Table 2. No technique is applicable to all eight classes of reactive wastes, but two procedures stand out as generally applicable: (1) dilution with excess solids and sealing in a dry container (applicable to Classes I through V) and (2) mixing with water and excess inert or absorbent solids (applicable to Classes VI, VII, and VIII).

Destruction

Seven techniques for hazard destruction are broadly applicable to a number of reactive waste classes (Table 3). These techniques are not as broadly applicable to a group of waste classes as are those for containment and isolation because destruction requires more specific technology. Mixing with an inert solid followed by open burning may be the most broadly applicable technique, though it is not applicable to Class V (cyanides and sulfides).

Data Gaps and Research Needs

A number of data gaps have been identified by this preliminary study. Some of the most important needs are listed here:

1. A comprehensive listing of hazardous wastes detailing reactive properties, hazards, and necessary safety precautions. A useful body of data does exist (the Oil and Hazardous Materials Technical

*Table 1. Reactive Waste Classes**

Class	Reactivity Characteristic
I	*The waste is normally unstable and readily undergoes violent change without detonating.*
II	*The waste reacts violently with water.*
III	*The waste forms potentially explosive mixtures with water.*
IV	*When mixed with water, the waste generates toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.*
V	*The waste is a cyanide- or sulfide-bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.*
VI	*The waste is capable of detonating or exploding if it is subjected to a strong initiating source or if heated under confinement*
VII	*The waste is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.*
VIII	*The waste is a forbidden explosive as defined in 49 CFR 173 51, or a Class A explosive as defined in 49 CFR 173.53 or a Class B explosive as defined in 49 CFR 173.88.*

*Source: Federal Register, Vol. 45, No. 98, p 33122, May 19, 1980.

Assistance Data System), but many fairly common examples of reactive wastes are not included.

2. A directory of EPA-registered hazardous waste transporters and treatment, storage and disposal facility (TSDF) operators who are qualified and willing to accept specific classes of reactive wastes.

3. Guidance on the maximum quantities of a waste that can be handled by simple procedures.

4. Inventory data indicating the types and quantities of reactive wastes entering the market for treatment and disposal.

5. Development, testing, and documentation of simple techniques for destroying reactive wastes.

Results and Conclusions

Classification of Reactive Wastes

Reactive wastes can be broadly classified as explosive and nonexplosive. They are further divided into eight classes listed in the Federal Register (Vol. 45, No. 98, p. 33122, May 19, 1980). These eight classes account for the chemical diversity of reactive wastes quite well, but a further subdivision of Classes I and II is proposed to allow for a better definition of materials that are pyrophoric, polymerizable, or oxidizers.

Safety Precautions

Reactive wastes pose acute hazards to personnel and property and they may also create longer-term environmental hazards. Blast protection, protective fire-resistant clothing, and breathing apparatus may have to be used, as appropriate. Materials that may explode (particularly wastes that are not well characterized) should not be moved but should be isolated from other wastes, property, and personnel. Wastes that are not explosive should be moved to a safer location to isolate them from other wastes, property, and personnel. Further containment, handling, and treatment requirements can then be determined.

Isolation and Containment Techniques

No universally applicable technique exists for isolating and containing all reactive wastes. Hazards in transportation, handling, and storage of water-reactive wastes can be reduced by diluting the material with an inert solid or absorbent (vermiculite, sand, etc.) and protecting it from moisture. Explosive materials should be kept in a wet state, however, as they are much more shock- and friction-sensitive when dry. For some explosive wastes, any handling or transport can be extremely hazardous. These wastes may have to be destroyed onsite.

Table 2. Isolation and Containment Techniques

	Applicability to Reactive Waste Class*										
	I			II		III	IV	V	VI	VII	VIII
Procedure	A	B	C	A	B						
Mix with excess inert solid material and seal in a dry container	X	X	□	□	□	□	X	X	X	X	X
Mix with excess solid absorbent and seal in a dry container	□	□	□	□	□	□	□	□	X	X	X
Mix with excess solid absorbent in a vented container	X	X	□	□	X	□	X	X	X	X	X
Mix with water and excess inert solid material	X	X	□	X	X	X	X	X	□	□	□
Immerse in alcohol/water mixture	X	X	X	X	X	X	X	X	□	□	□
Immerse in alkaline solution	X	X	X	X	X	X	X	□	X	X	X
Immerse in kerosene	X	X	X	X	X	□	★	X	X	X	X
Encapsulate in a cement matrix	X	X	□	X	X	X	X	★	□	□	□

* X = not applicable, □ = applicable, ★ = applicable only to some members of the class.

Table 3. Destruction Techniques

	Applicability to Reactive Waste Class*										
	I			II		III	IV	V	VI	VII	VIII
Procedure	A	B	C	A	B						
Mix with excess water	X	X	□	□	□	□	X	X	X	X	X
Mix with excess water and vent gases	□	★	□	□	□	□	□	X	X	X	X
Mix with weak alkali	□	X	□	□	□	★	□	□	X	X	X
React with calcium hypochlorite	X	X	X	X	X	X	□	□	X	X	X
React with ferrous chloride solution (reducing agent)	X	X	□	X	★	★	X	X	★	★	X
Mix with alcohol/water and burn	□	X	X	X	X	X	X	X	□	□	□
Mix with solid (vermiculite) and burn	□	□	X	X	□	□	□	X	★	★	★

* X = not applicable, □ = applicable, ★ = applicable only to some members of the class

Destruction Techniques

Two destruction techniques are more broadly applicable than the others--open burning and reaction with water. Open burning may apply to most or all reactive materials except cyanides and oxidizers. This method has been applied to various types of water-reactive materials (e.g., alkaline metals) and avoids some of the complex equipment required for other

destruction techniques. Open burning has also been applied to the destruction of explosives and is still a permitted use for them when they cannot be safely incinerated. Local permit requirements may limit open burning except as an emergency response.

Reaction with water (for Classes I through IV) has more complex requirements than open burning, but energy needs are low. Destruction of water-reactive wastes in aqueous media may lead to the production of explosive or toxic gases that must be vented or scrubbed from the atmosphere. The use of open burning for these wastes produces different reactions that generally avoid the formation of explosive or toxic gases. Explosive wastes are stable in water, but some can be destroyed by alkaline solution.

Reaction with calcium hypochlorite (or other similar chlorine-containing compounds) is a well-developed and widely practiced technique for the destruction of inorganic cyanides. Though other techniques are available, little advantage appears to exist in supplanting this technique with any other. Sulfides can be oxidized by the same technique. Organic sulfides and cyanides can be destroyed by combustion.

Field Interviews

The field interviews covered three major companies in hazardous waste management and three companies specializing in management of reactive wastes. Each company has its own procedures for managing reactive wastes and is selective about the type of wastes it will accept. The major companies tend to be conservative and refer very dangerous wastes to specialist companies. All the companies stressed the importance of obtaining expert advice about the specific waste and its location before attempting to handle it.

Recommendations

1. Work should be done to expand the documentation of reactive hazardous wastes listed in the appendices to the full report. An expanded field interview program should be conducted to assess information available from the literature and from industry. The data should be documented to make them more accessible to TSDF operators. For wastes that have no data available, conservative estimates should be made based on expected chemical properties.

2. Simple techniques and equipment should be developed for destroying wastes in water and aqueous media. Information is needed on appropriate feed rates, venting or scrubbing of off-gases, and treatment and disposal of spent reaction and scrubber solutions.

3. A program should be instituted to further develop the techniques and equipment for the open burning of reactive wastes. The program should define the following parameters: Maximum quantities of waste to be treated, potential hazards, necessary safety precautions for personnel and equipment, requirements for auxiliary fuel, and disposal of residuals.

4. Estimates should be developed to compare the costs of destroying reactive wastes with the costs of alternative technologies, particularly long-term containment or landfill.

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The complete report, entitled "Treatment of Reactive Wastes at Hazardous Waste Landfills," (Order No. PB 84-124 833; Cost: $10.00, subject to change) will be available only from:
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