

VOLUME #1 (BD-1 - BD-7)

DRAFT BACKGROUND DOCUMENTS

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

SECTION 3001 - IDENTIFICATION AND LISTING OF
HAZARDOUS WASTES

SECTION 250.13 - HAZARDOUS WASTE CHARACTERISTICS

BD-1 - IGNITABILITY

BD-2 - CORROSIVENESS

BD-3 - REACTIVITY

BD-4 - TOXICITY

SECTION 250.14 - HAZARDOUS WASTE LISTS

BD-5

BD-6 - RADIOACTIVE WASTE

BD-7 - INFECTIOUS WASTE

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IGNITABILITY

DECEMBER 15, 1978

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

This document provides background information and support for regulations which have been designed to identify and list hazardous waste pursuant to Section 3001 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft to support the proposed regulations. As new information is obtained, changes may be made in the background information and used as support for the regulations when promulgated.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made some changes in the proposed regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

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IGNITABLE WASTE
BACKGROUND DOCUMENT

1.1 Introduction

This background document strives to establish that an important identifying characteristic of hazardous waste is ignitability. Test methods and quantitative limits were evaluated so that identification of ignitable waste could be a simple, economical procedure with reproducible results. In some cases, available test methods were judged to be inadequate, so prose definitions were used to define a particular characteristic until these tests are improved.

Analyzing past waste management, sometimes mismanagement, of ignitable substances revealed incidents of landfill fires. These fires directly or indirectly contributed to the degradation of the environment. Most of the fires could easily have been averted by properly identifying the ignitable waste. When a waste is known to be hazardous, greater care in handling and disposal is required.

1.2 Solid Waste/Characteristic Relationship

Ignitability is one characteristic for defining a waste as hazardous. The mismanagement of ignitable waste may result in fire that will cause damage directly from heat and smoke production or may provide a vector by which other hazardous wastes can be dispersed. An example of this would be the creation of convection currents that could transport toxic particles. A fire may also cause otherwise benign wastes to become hazardous. This could happen when plastics are incinerated propagating noxious fumes.

During and after the disposal of an ignitable waste, there are many available external and internal energy sources which can provide an impetus for combustion, raising temperatures of waste to their flash points. Electrical energy in the form of sparks generated by landfill machinery, and thermal energy resulting from the heat of neutralization (pH change) or from the decomposition of organic waste, are examples of potentially problematic heat sources.

Past management of ignitable waste has resulted in many landfill fires. Some examples of fires and explosions in landfills and treatment facilities can be found in Appendix A. Only recently has there been incentive to perform post-fire investigations at landfills.

Landfill fires are presently being investigated to determine if a particular waste or substance can be identified as having initiated the fires. Also, fires occurring during transportation that involve substances with flash points or greater than 100°F are being researched. (It has been argued that EPA should remain consistent with the Department of Transportation (DOT) which defines flammability with a flash point limit of 100°F.)

Conflagrations -- large, destructive fires -- should continue to be studied to determine what particular waste initiated the fires, the flash points of the initiating ignitable waste, and the source of the igniting energy. Wastes that compound the fire problem -- for example, those which emit noxious fumes or further propagate the flames -- can be studied at the same time. In this manner, a data base can be developed to aid further in the justification of a selected flash point limit and in the further identification of those wastes which should be separated from ignitable waste.

For these reasons, it is desirable to identify wastes that are ignitable so that they can receive proper handling by way of the Resource Conservation and Recovery Act, Subtitle C, regulatory control system.

1.3 Alternative Approaches

While most states, agencies, and organizations that define ignitability use flash point as their limiting criteria, there exists no consensus regarding what that limit should be, what type of categorization system is best, or what terminology is appropriate. For example, DOT defines flash points less than 37.8°C(100°F) as flammable, and flash points greater than 37.8°C but less than 93.3°C(200°F) as combustible*; in comparison, Ohio defines flash points less than 79.4°C(175°F) as flammable and does not recognize the combustible category at all†. The criteria vary greatly from state to agency to organization. Each has developed defining criteria that attempts to solve its own immediate problems. A major effort made by DOT to establish its regulations as standard has affected many public and private institutions, as is evident from the examples listed in the subsections(1.3.a and 1.3.b) below showing the multiple occurrence of the 100°F flash point limit.

*Reference 1

†Reference 4

In some of the alternative approaches, the defining criteria is based upon a classification system in which degrees of hazard are established (for example, extremely hazardous and hazardous). EPA's strategy, however, is to make use of tests that give a definitive answer as to whether a waste is hazardous or not, rather than indicate degree of hazard. Harry A. Wray*, when commenting on an earlier ignitability background document, suggested a classification system based on a combination of the NFPA Code†, DOT and DOL‡ regulations. This classification system solves one of the major problems encountered when defining an ignitable waste. EPA would remain consistent with DOT's terminology and flash point limits; and at the same time regulate ignitable waste with flash points below 140°F (60°C), this limit is discussed later. The proposed classifying limits are:

<u>Flammable</u> extremely flammable	FP ≤ 100°F	Class I
	FP ≤ 20°F	Class IA
	FP ≤ 73°F, BP ≥ 100°C	Class IIA
	FP ≤ 73°F, BP ≤ 100°C	Class IB
	FP > 73°F	Class IC
<u>Combustible</u> ignitable	FP 100 to 200°F	Class II
	FP 100 to 140°F	Class IIA
	FP 140 to 200°F	Class IIB

* Chairman, American Society for Testing Materials (ASTM) Committee on Flash Point Methodology and Government Response. Reference 8, Nov. 17, 1978.

† National Fire Protection Association, reference 9.

‡ Department of Labor

It has been suggested that flash points be standardized to a particular atmospheric pressure, since barometric pressure does vary with different locations, and with time at the same location. One might assume that if the barometer drops appreciably after a flash point determination is made, what was tested as a nonignitable substance at the higher reading may be ignitable at the new pressure, or vice versa. However, this is an unrealistic assumption since, according to the National Oceanic and Atmospheric Administration, the largest barometric deviation in a single day is less than 20mm Hg which changes the flash point at any temperature only 1.2°F, and the barometric pressure difference between elevation changes could be as large as 150mm Hg which changes the flash point by 9°F. Even if these changes were important, the proposed standard measures of test incorporate pressure correction*.

$$F_c = F_o + 0.06(760 - P_o)$$

F_c = converted flash point
 F_o = observed reading
 P_o = observed reading, pressure

* ASTM D-93, ASTM D3278

1.3.a States

California (Reference 1)

Flammable. (a) "Flammable means:

- (1) A liquid which has a flash point at or below 37.8 degrees centigrade (100 degrees fahrenheit) as defined by procedures described in Title 49, Code of Federal Regulations, Section 173.115.
- (2) A gas for which a mixture of 13 percent or less, by volume, with air forms a flammable mixture at atmospheric pressure or the flammable range with air at atmospheric pressure is wider than 12 percent regardless of the lower limits. Testing methods described in Title 49, Code of Federal Regulations, Section 173.115, shall be used.

- (3) A solid which is likely to cause fires due to friction, retained heat from processing or which can be ignited under normal temperature conditions and when ignited burns so as to create a serious threat to public health and safety. Normal temperature conditions means temperatures normally encountered in the handling, treatment, storage and disposal of hazardous wastes.
- (4) A gas, liquid, sludge or solid which ignites spontaneously in dry or moist air at or below 54.3 degrees Centigrade (130 degrees Fahrenheit) or upon exposure to water.
- (5) A strong oxidizer. Section 60415 "Strong Oxidizer" means a substance that can supply oxygen to a reaction and cause a violent reaction, or sustain a fire when in contact with a flammable or combustible material in the absence of air.

Minnesota (Reference 2)

Explosive material: a material that has the property either to involve large volumes of gas that are dissipated in a shock wave or to heat the surrounding air so as to cause a high pressure gas that is dissipated in a shock wave. Explosive materials include, but are not limited to, explosives as defined in 49 C.F.R. S173.50 (1976) and compressed gases as defined in 49 C.F.R. S173.300 (1976).

Flammable material: any material that:

a. has a flash point below 200°F (93.3°C), except the following:

(1) a material comprised of miscible components having one or more components with a flash point of 200°F (93.3°C), or higher, that make up at least 99% of the total volume of the mixture;

(2) A material that has a flash point greater than 100°F (37.8°C) and that when heated to 200°F (93.3°C) will not support combustion beyond the flash;

(3) An explosive material; or

b. may ignite without application of flame or spark including, but not limited to, nitro cellulose, certain metal hydrides, alkali metals, some oily fabrics, processed meals, and acidic anhydrides.

Flash point: the minimum temperature at which a material gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the material.

Oxidative material: any material with the property to readily supply oxygen to a reaction in the absence of air.

Oxidative materials include, but are not limited to, oxides, organic and inorganic peroxides, permanganates, chlorates, perchlorates, persulfates, nitric acid, organic

and inorganic nitrates, iodates, periodates, bromates, perselenates, perbromates, chromates, dichromates, ozone, and perborates. Bromine, chlorine, fluorine, and iodine react similarly to oxygen under some conditions and are therefore also oxidative materials.

Flammable materials: Whenever the flash point of a waste is to be determined, one of the following test procedures shall be used. The test chosen shall be appropriate for the characteristics of the waste that is tested.

- (a) Standard Method of Test for Flash Point by Tag Closed Tester (ASTM D56-70).
- (b) Standard Method of Test for Flash Point of Aviation Turbine Fuels by Setaflash Closed Tester (ASTM D3243-73).
- (c) Standard Methods of Test for Flash Point of Liquids by Setaflash Closed Tester (ASTM D3278-73).
- (d) Standard Method of Test for Flash Point by Pensky-Martens Closed Tester (ASTM D93-73) or alternate tests authorized in this standard.

For any waste containing components with different volatilities and flash points and having a flash point higher than 200°F (93.3°C) according to the test procedure employed, a second test shall be conducted on a sample of the liquid portion of the material that remains after evaporati^on in an open beaker (or similar container), under ambient

pressure and temperature (20 to 25°C) conditions, to 90 percent of original volume or for a period of four hours, whichever occurs first, with the lower flash point of the two tests being the flash point of the material.

Oregon (Reference 3)

Flammability is defined as:

- (a) material which is readily ignited under ambient temperatures
- (b) material which on amount of its physical form or environmental conditions can form explosive mixtures with air and which is readily dispersed in air, such as dusts of combustible solids and mists of flammable or combustible liquids
- (c) material which burns with extreme rapidity, usually by reason of self-contained oxygen, materials which ignite spontaneously when exposed to air
- (d) liquids, solid or gaseous material having a flash point below 100°F (38°C)

Ohio (Reference 4)

Flash points below 175°F

Very volatile flammable liquids, very flammable liquids and gases, and substances that, in the form of dusts or mists readily form explosive mixtures when dispersed in air.

Washington (Reference 6)

Explosives: substances capable of producing an explosion, which are not regulated by chapter 296-52 WAC and which:

- (a) evolve heat or gas when heated to 40°C (100°F); or
- (b) evolve gas or heat when mixed with water at 40°C (100°F); or
- (c) contain oxidizers, that is, substances that yield oxygen readily

Flammable: substances which have a flash point at or below 40°C (100°F), as determined by the Tagliabue open cup tester, or other suitable method.

1.3.6 Agencies and Organizations

Department of Transportation (Reference 5)

- (1) flammable liquids are those having flash points below 100°F.
- (2) Combustible liquids are those having flash points above 100°F and below 200°F.
- (3) a flammable solid is any solid material other than one classified as an explosive, which, under conditions normally incidental to transportation is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation hazard. See Appendix B for details and test methods.

Consumer Product Safety Commission (Reference 7)

- (1) the term "extremely flammable" shall apply to any substance which has a flash point at or below 20°F as determined by the Tagliabue Open Cup Tester
- (2) the term "flammable" shall apply to any substance which has a flash point above 20°F, to and including 80°F, as determined by the tester mentioned above
- (3) "Extremely flammable solid" means a solid substance that ignites and burns at an ambient temperature of 80°F or less when subjected to friction, percussion, or electrical spark
- (4) "Flammable solid" means a solid substance that when tested by the method described in Section 1500.44, ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Environmental Protection Agency (Title 40 (Pesticides), C.F.R., Part 162)

The proposed rulemaking includes flammability labeling requirements. "Extremely flammable" and "flammable" categories correspond to those found in Title 15, U.S. Code, Sec. 1261.

- (1) extremely flammable - a flash point less than 20°F
- (2) Flammable - a flash point greater than 20°F and less than 80°F
- (3) Combustible - a flash point greater than 80°F and less than 150°F.

National Academy of Sciences (Ad - 782 476):

<u>Rating</u>	<u>Definition</u>
0 - Insignificant hazard	Not Combustible
1 - Slightly hazardous	Flash point larger than 140°F (60°C)
2 - Hazardous	Flash point from 100°F to 140°F (37 to 60°C)
3 - Highly hazardous	Flash point less than 100°F and boiling point greater than 100°F
4 - Extremely hazardous	Flash point less than 100°F and boiling point less than 100°F

National Fire Protection Association

Flammable Liquid shall mean a liquid having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 pounds per square inch (absolute) at 100°F (37.8°C) and shall be known as a Class I liquid. Class I liquids shall be subdivided as follows:

Class IA shall include those having flash points below 73°F (22.8°C) and having a boiling point at or below 100°F (37.8°C) Class IB shall include those having flash points below 73°F (22.8°C) and having a boiling point at or above 100°F (37.8°C). Class IC shall include those having flash points at or above 73° (22.8°C) and having flash point at or above 73°F (22.8°C) and below 100°F (37.8°C).

Combustible Liquids shall be subdivided as follows:

Class II liquids shall include those having flash points at or above 100°F (37.8°C) and below 140°F (60°C).

Class IIIA Liquids shall include those having flash points at or above 140°F (60°F) and above 200°F (93.4°C).

Class IIIB Liquids shall include those having flash points at or above 200°F (93.4°C).

Booz-Allen Research, Inc., EPA, 1973 (PB-221-464):

A material is flammable if it has a flash point that is less than 100°F and a boiling point less than 100°F; spontaneous combustion and/or explosive reaction.

Department of the Navy:

<u>Hazard Level</u>	<u>Criteria</u>
4	Flash point less than 73°F and boiling point less than 100°F.
3	Fp less than 73° and Bp greater than 73°F and less than 100°F
2	Fp greater than 100°F and less than 200°F
1	Fp greater than 200°F
0	Material will not burn

1.4 Selected Approach

The problem in writing regulations that define an ignitable solid, liquid, or gas is the choice of a hazardous characteristic that best quantifies the waste. A quick, economical, and reproducible test method must be available to minimize errors in lab and field testing which can end in disaster for facility owners and/or operators.

There are several established methods for measuring the ignitability of liquid waste (that is, pure liquids, solutions, sludges, or solids). These ignitability characteristics are defined in Subsection 1.4b.

The most attractive of these alternatives is the use of flash point as an indicator of ignitability. Use of this indicator offers the public better protection from fires than the others do. Flash point testing can provide reproducible results. Almost all government agencies and professional organizations recognize flash point as the primary indicator of ignitability. For these reasons, flash point testing should be used as an indicator of ignitable liquids.

Autoignition temperature testing is a possible second choice. However, autoignition temperatures are generally quite high, and it is unlikely that wastes would be exposed

to energy sources of the magnitude needed to heat them to their autoignition point. The autoignition temperature cannot be disregarded entirely, though, as internal combustion is a definite problem at disposal sites given the available internal energy sources. Currently available autoignition test methods were judged inadequate for use as an identifier of ignitable waste.

Flash points tend to be much lower than autoignition temperatures. Flash point is defined as the lowest temperature, corrected to a pressure of 101.3 kPa (1013 millibars), of a substance at which application of an ignition source causes the vapors above the substance to ignite under specified conditions of test. Various sources of direct ignition can be present at a land disposal site, such as hot tailpipes, uncontrolled smoking, or sparks from compaction machinery. In such a situation, waste with low flash points are of more concern than those with low autoignition points.

Most companies responding to the Advance Notice of Proposed Rulemaking (ANPR) on Section 3001, distributed to them by EPA, commented that they would like the flash point limit to be 100°F, which would be consistent with DOT.* This limit is used in regulating hazardous waste during disposal. The only basis for the argument advocating the 100°F flash point limit was to maintain consistency with DOT, therefore

*Reference 8

eliminating confusion in handling wastes. While it is recognized that consistency in rulemaking is important, nevertheless it is believed that flash points greater than 100°F pose a human health and environmental threat.

The DOT flash point limit of 100°F that defines a flammable substance was chosen with the rationale that 100°F is about as hot as a shipment of a liquid material would get while being transported in the United States. However, this limit does not take into account all of the heat sources available to waste during transit, storage, and ultimate disposal. Joseph M. Kuchta recommendation on page eight of their report *:

It is recommended that a flammable liquid be defined as one with a flash point below 140°F, as determined in a Tag Closed Cup, and having a vapor pressure not exceeding 40 psia at 100°F. the 140° break point is suggested because ambient temperatures of this order can be encountered during shipment, particularly in hot climates; this break point is also consistent with the NFPA and IMCO classification systems and that proposed by IOTTSG.

The EPA has chosen to use a flash point limit of 60°C (140°F) or lower for defining an ignitable hazardous waste. It should also be mentioned that to avoid confusion between a DOT flammable liquid and an EPA flammable liquid, the Agency has decided to use the term ignitable liquid.

Conditions at present, given available landfill capacity, are such that a higher flash point limit than 60°C (140°F) would generate waste(s) which could conceivably strain existing

*Reference 10

hazardous waste facilities and result in mismanagement of these wastes. Waste disposal companies, in their comments on previous draft regulations, recommended flash point limits be set between 140 and 200°F. The available sources of ignition at landfill sites (that is, unregulated smoking, sparks from gasoline combustion engines, hot exhaust systems, and improper mixing of wastes) causes a degree of hazard in handling waste. It is this degree of hazard the EPA wishes to minimize.

1.4.a Solids, Gases, and Oxidizers

Solids and oxidizers are not easily tested. DOT, in its regulations, uses prose definitions to identify each*. Studies have been initiated by DOT in the past that evaluate existing test methods and proposed quantitative limits. However, for various reasons, they were judged inadequate for regulatory purposes. EPA and DOT are presently working together in the hope that the problems of testing solids and oxidizers can be resolved.

EPA will use DOT's present regulation to identify ignitable gases. These regulations combine a prose definition with test methods organized by the Association of American Railroads . Any gas that when ignited propagates and sustains combustion under ambient conditions is hazardous and must be handled in a safe manner. EPA will regulate the future disposal of contained gases, not allowing large pressurized vessels to be placed in landfills when they are ignitable compressed gases as defined in 49 CFR 173.300(b).

* solid - 49CFR173.150; oxidizer - 49CFR173.151
Reference 11, see Appendix C

1.4.b Definitions

Autoignition (n) -the spontaneous ignition (without an external ignition source) of a material as the result of heat liberation from an exothermic reaction.

Burning Velocity (standard) -fundamental velocity of a combustion wave measured normal to the flame front.

Combustible (adj) -capable of undergoing combustion.

Combustion (n) -a rapid exothermic oxidation process accompanied by continuous evolution of heat and usually light.

Deflagration -combustion which propagates into the reacting medium at a subsonic velocity.

Detonability Limits -the maximum and minimum concentrations of a combustible in an oxidant, e.g., air, which will propagate a detonation when initiated at a specified temperature and pressure.

Detonation -combustion or other reaction which propagates into the reacting medium at a supersonic velocity.

Fire (n) -the phenomenon of combustion.

Fire Point (n) -the minimum temperature to which a material must be heated in an open vessel to sustain combustion for a specified period of time after ignition by an external source.

Flame (n) -a zone of gas or particulate matter or both in gaseous suspension that is undergoing combustion, as evidenced by the evolution of both heat and usually light.

Flame Temperature -the temperature of the product species in flaming combustion.

Flame Speed -velocity of a combustion wave measured relative to a stationary observer.

Flash Point (n) -the lowest temperature, corrected to a pressure of 101.3 kPa (1013 millibars), of a substance at which application of an ignition source causes the vapors above the substance to ignite under the specified conditions of test.

Ignite (v) -to initiate combustion.

Lower Flammable Limit -the lowest concentration of a combustible substance that is capable of propagating a flame through a homogenous mixture of combustible substance and a gaseous oxidizer under specified conditions of test.

Lower Temperature Limits -the lowest temperature at which a combustible substance will produce a vapor concentration equal to the lower flammable limit under specified condition of test.

Minimum Oxygen Concentration -the minimum concentration of oxygen required to sustain burning or flame propagation.

Temperature (N) -the thermal state of matter as measured on a defined scale.

Upper Flammable Limit -the maximum concentration of a combustible substance that is capable of propagating a flame through a homogenous mixture of combustible substance and a gaseous oxidizer under specified conditions of test.

liquid - (flammability Regulations) - a substance that has a definite volume but no definite form except such given by its container. It has a viscosity of 1×10^{-3} to 1×10^3 stokes (1×10^{-7} to $1 \times 10^{-1} \text{ m}^2 \text{ s}^{-1}$) at 104°F (40°C) or an equivalent viscosity at agreed upon temperature. (This does not include powders and granular materials).

Liquids are divided into two classes:

CLASS A (low viscosity) a liquid having a viscosity of 1×10^{-3} to 25.00 stokes (1×10^{-7} to $25.00 \times 10^{-4} \text{ m}^2 \text{ s}^{-1}$) at 104°F (40°C) or an equivalent viscosity at an agreed upon temperature.

CLASS B (high viscosity) - a liquid having a viscosity of 25.01 to 1×10^3 stokes (25.01×10^{-4} to $1 \times 10^{-1} \text{ m}^2 \text{ s}^{-1}$) at 104°F (40°C) or an equivalent viscosity at an agreed upon temperature.

~~Liquid~~ ~~(flammability regulations)~~ - a substance that has a viscosity greater than 1×10^3 stokes ($1 \times 10^{-1} \text{ m}^2 \text{ s}^{-1}$) at 104°F (40°C) or an equivalent viscosity at an agreed upon temperature. (This includes powders and granular materials).

1.5 Test Methods

There are several common methods used in determining the flash point of a liquid. All methods require that the sample be placed in the sample cup and be heated at a slow and constant rate. There are two basic types of apparatus used for testing the flash point of liquids: open cup and closed cup testers. In a closed cup tester, the test flame is inserted into a vapor/air mixture within the cup and over the liquid. In an open cup, the test flame is passed over the vapor/air mixture just above the liquid.

A liquid tested in a closed tester generally flashes at a lower temperature than the same liquid tested in an open cup apparatus. The liquid will flash at the same concentration of vapor and air (lower flammability limits) in both cups. In the open cup, the temperature must be raised to a greater degree than in the closed cup to achieve the lower flammable limits above the liquid. This is due to the vapor being confined in the closed space above the liquid in a closed cup, while the vapor is allowed to diffuse into the atmosphere above the liquid in a open cup*. The closed cup tester simulates the most danerous type of hazardous waste situation (that is, gases from volatile liquids when confined tend to accumulate quicker, expediting ignition). Therefore, it is recommended that this type be used in the determination of flash points.

*Harry A. Wray, November 17, 1978, Ref. 8

There are two types of temperature baths: liquid and air baths. Since the purpose of these temperature baths is to ensure uniform temperature around the entire sample, a liquid bath is superior to an air bath due to the better thermal transport properties of liquids compared to air.

It makes no difference in the test whether the apparatus has a gas or electric burner. Both are equally accurate at the low temperatures of concern.

Another optional feature available is a mixing device. If the sample to be tested is very viscous, tends to skin over, or contains suspended solids, a stirrer should be incorporated into the apparatus. By agitating the sample, it can prevent local temperature variations. Since a test of a pure nonviscous liquid can be run on either type of apparatus, it is recommended that the apparatus with a stirrer be used as standard test equipment.

In Table I there is a comparison of different types of flash point testers offered by two vendors, Fishers and Sargent. The Setaflash Closed Cup Tester is not included because of the relative newness of the device. The price of the Setaflash is between 800 and 1000 dollars. The Pensky-Martens Closed Cup Tester is EPA's first choice followed by the Setaflash Closed Cup Tester. There will follow a discussion on the Setaflash Closed Cup Tester.

TABLE 1-Comparison of Flash Point Tester Types *

<u>Type</u>	<u>Sample Cup</u>	<u>Stirrer</u>	<u>Bath</u>	<u>Type of Temo Control</u>	<u>Cost(1974)</u>
Pensky-Martens (Fischer)	Closed	No	Air	Electric	\$395
Pensky-Martens (Fischer)	Closed	Yes	Air	Electric	\$470
Tagliague (Fischer)	Open	No	Liquid	Electric	\$200
Tagliague (Fischer)	Closed	No	Liquid	Electric	\$300
Cleveland (Fischer)	Open	No	None	Gas	\$265
Cleveland (Sargent)	Open	No	None	Gas	\$120
Cleveland (Sargent)	Open	No	None	Electric	\$240
Pensky-Martens (Fischer)	Closed	No	Air	Gas	\$330
Pensky-Martens (Fischer)	Closed	Yes	Air	Gas	\$400

* Reference 12

28

NUM
100

1.5.a Comparison of Flash Point Test Methods*

Several test methods are recommended by the American Society for Testing and Materials for determining the flash points of petroleum products and other flammable liquids. Four of the most common types used in this country are listed in Table II. Of the four testers listed, the Cleveland open cup is the least reliable one. The poor reproducibility of data by the least reliable one. The poor reproducibility of data by this tester is attributed partly to the prescribed high testing rate and the poor temperature control that results from the use of an open flame for heating the cup; the presence of air convection currents can also affect the results noticeably. Although the Tag open cup uses a temperature bath and a low heating rate, its precision is still not quite as high as that of the Tag closed cup. Regardless of the precision of the testers, it is important to examine the great differences that are frequently obtained for the flash point of a material by the use of the open and closed cup methods.

*This section and Table II were taken from a report by J.M.Kuchta and David Burgess, reference 10.

Generally, the flash points of flammable liquids are lower by the closed cup than by the open cup method. The amount of the difference will vary with the compositions of the liquids and the models of testers used.

According to the available data in the literature, the Tag closed cup is suitable for determining flash points of liquids over a temperature range from about 220°F down to at least 0°F. Although it is currently recommended for determinations up to only 174°F, ASTM Committees (D-2 and E-27) are presently proposing that the maximum temperature be increased to 200 or 220°F for use with liquids having a viscosity of 4 centipoise or less at 100°F. For liquids of higher viscosity or higher flash points, the Pensky-Martens closed cup is recommended. However, one can also extend the use of the Tag tester to the higher viscosity liquids by employing a lower heating rate than presently specified. A heating rate of less than 0.5°F/min or a maximum temperature difference of 5°F between the bath and sample have been found suitable for extending the applicability of this tester to thickened fuels and other highly viscous materials.

Table 2-ASTM Specifications and Measured ¹⁰
Performance for Several Flash Point Testers

<u>Tester</u>	<u>ASTM Designation</u>	<u>Temp. Range F</u>	<u>Heating Rate F/min</u>	<u>Repeatability F</u>	<u>Reproducibility F</u>
Cleveland Open Cup	D 92-66	175	9-11	15	30
Tag Open Cup	D 1310-67	0-200	2	4	7
		201-325	2	9	12
Tag Closed Cup	D 56-64	55	2	2	6
		15-175	2	2	4
Pensky-Martens Closed Cup	D 93-66	220	9-11	4	6
	D 93-73	220	9-11	10	15

¹⁰ Kuchta, J.M. and D. Burgess. Recommendation of Flash Point Method for Evaluation of Flammability Hazard in the Transportation of Flammable Liquids, Safety Research Center, Bureau of Mines, Report #54131, April 29, 1970,

1.5.b Pure Liquids and Solutions

A pure liquid or solution with a flash point less than 60°C (140°F) is a hazardous waste. The 60°C breakpoint is suggested because ambient temperatures of this order can be encountered during the disposal of waste, particularly in hot climates. Heats of chemical reaction, solar radiation, or organic degradation can elevate ground temperature well above DOT's 100°F.

Testing of pure liquids with the apparatus recommended above is a reasonably simple process described in the American Society for Testing and Materials (ASTM) guidelines*.

* Agitation of the liquid is necessary if it has a viscosity of 45 S.U.S.[†] or more at 37.8°C (100°F), or if it contains suspended solids or has a tendency to form a surface film while under testing. It is recommended that the agitation device be used in all tests to simplify testing procedures.

*ASTM D93-72

†S.U.S. means Saybolt Universal Seconds as determined by the Standard Method for Saybolt Viscosity (ASTM D88-56) and may be determined by the use of the S.U.S. conversion tables specified in ASTM test D2161-66 following determination of viscosity in accordance with the procedures specified in the Standard Method for Transparent and Opaque Liquids (ASTM D445-64)

1.5.c Sludges

Sludges are the most prevalent form of waste and are quite difficult to test. Stratification is one of the physical peculiarities of sludges which might affect flash point testing.

If the sludge is stratified, which is likely due to the differing densities of most substances, then the upper layers will inhibit evaporation of the lower layers. The evaporation of the lower layers will occur at the normal rate only when they are in direct contact with the atmosphere by either thermally or mechanically produced holes.

This problem can be overcome by taking two test samples that represent the two extreme situations. These situations are: (1) no mechanical or thermal agitation is present, allowing only the least dense (top) layer to be in contact with the atmosphere enabling it to evaporate; (2) there is vigorous agitation and all components of the sample come into contact with the atmosphere and evaporate.

If flash points of the two samples representing these extremes are taken and neither results in an ignitable solution, then any linear combination of the two situations will also be nonignitable*. However, if either one of these samples has a flash point below 60°C (140°F) then the sludge is a hazardous waste.

The Pensky-Martens Closed Cup Tester is recommended because of the incorporation of a stirring device to handle simply the testing procedure of sludges and slurries. With very viscous materials the Setaflash Closed Cup Tester can be used with greater success.

*The theoretical rationale for the the evaporation-inhibiting effect of layer stratification is as follows: At any given temperature the molecular motion of a sample can be statistically described. Only those molecules with a kinetic energy above a certain level have enough energy to escape the attractive forces of the other molecules in the liquid in the liquid phase. Obviously, those molecules for below the surface have a very small chance of reaching the surface with this minimum kinetic energy intact, since they are constantly being involved in elastic collisions and will, on the average, lose energy in these exchanges since they are themselves above the mean in energy.

1.5.d Solids

The testing of solid waste samples also must be considered. In the burning of most substances, the actual combustion takes place only after the substance has been vaporized or decomposed by heat to produce a gas. Most solids have lower vapor pressures than liquids due usually to the stronger intermolecular forces existing in solids. For this reason, they are less likely to be ignitable since it takes more energy (a higher temperature) to volatize them.

It is rare for a solid to have a flash point in the normal temperature range (except for those solids having substantial vapor pressure, like naphthalene). Therefore, there is less danger of fire from solids. Since solids can exist in many different "states" (granular, amorphous, rigid, etc.), the ignitability testing procedures must be very general with few of the specific details one has come to expect in standards.

There is another reason why solids are more difficult to test for ignitability than liquids. Solids are usually poorer conductors of heat than liquids, and even among themselves vary widely in thermal transport properties. When a solid is heated, heat build-up is intense at the energy source, due to poor conductance. Depending on the duration of heating or the rate of change of heating, different ignition points or flash points would be recorded for a solid. For example, if it were heated slowly, a lower flash point would be observed than if it were heated quickly, due to the inability of solids to quickly reach thermal equilibrium.

For reasons such as these, and where a standard testing procedure is not applicable, a prose definition may be warranted in the case of solids. Such a definition might be similar to the one incorporated in Minnesota's hazardous waste regulations. It reads:

A flammable solid is any solid material other than one classified as an explosive; (1) that under conditions incident to its management, is liable to cause fires through friction, absorption of moisture, spontaneous chemical changes, retained heat from manufacturing or processing, or (2) that can be ignited, and when ignited burns so vigorously and persistently as to create a hazard during its management. Examples of flammable solids include, but are not limited to certain metal hydrides, metallic sodium and potassium, certain oily fabrics, processed metals, and nitrocellulose products.

As mentioned earlier in this document, the largest problem associated with solids seems to be in writing standards for the proper sampling techniques, since each particular "type" of solid state demands a different sampling technique. In a report that was done by the Bureau of Mines for DOT*, there were established two criteria for testing the flammability of solids, ignitability and flame spread behavior.

The report, Classification Test Methods for Flammable Solids, proposes that given the described procedures, most of the ignitable solids can be classified. Three classes of flammable solids were recommended for the transportation regulations:

Class 1: Flammable solids which may ignite when exposed to flame, such as a butane torch, but which propagates flame horizontally at rates less than 10 in/min by the proposed method.

Class 2: Flammable solids which are rated highly flammable either because of their great ease of ignition when exposed to flame such as a butane torch, or because of their ability to propagate flame at rates greater than 10 in/min. (Solids which ignite in less than 1 second by the proposed flame exposure test would be included in this class)

* Reference 13

Class 3: Extremely flammable solids which may ignite spontaneously in dry or moist air at ambient temperatures equal to or less than 130°F. (Solids which react to produce flame or temperature rises over 500°F by the proposed pyrophoricity test would be included in this class).

In order to provide a more enforceable regulation, EPA needs to develop and introduce an acceptable test method for solids. The policy of the Agency has been to ^{choose} criteria that best quantify each hazardous characteristic. The 60°C (140°F) flash point will identify ignitable liquids; and possibly ignitability and flame spread at some determined quantitative limit will identify ignitable solids at some future time.

It may be pointed out that some polymeric materials may be classed as solids but may have residual monomers present which will flash such as polystyrene. Furthermore, waste material may come from a concentrator with absorbed and adsorbed liquids having a low flash point. The Setaflash Close Cup Tester may be used to determine the flash point of these materials.

1.5.e Gases and Oxidizers

As mentioned earlier in this document, hazardous gases and oxidizers will be defined using a prose definition. There is no available test method that adequately evaluates the danger involved in handling either gases or oxidizers in a waste form that may be mixed with other wastes.

Definitions of ignitable gases and oxidizers were selected from DOT's regulations 49 CFR 173.300 and 49 CFR 173.151, respectively.

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Appendix A

**Examples of Accidents
Involving Ignitable Wastes**

Alabama

Anniston, Calhoun County 3/76

Kevlar aramid waste from a Du Pont plant in Richmond, Virginia, which had been brought to Alabama by Southern Metal Processing Company (SMPC), was stockpiled at three locations in Calhoun County. SMPC failed to provide adequate disposal and as a result the corrosive contents leaked onto the ground. There was a major fire at the main site, two firemen become ill presumably due to inhalation of toxic fumes. Du Pont paid \$650,000 for clean-up of the sites.

Iowa

Council Bluffs, Elias Burning Dump 71-76

A gravel pit, located on private property, was filled with rubble one year prior the start of a fire. The fill material consisted mainly of frame buildings taken from a urban renewal area of the city. The fire initated around 8/71 and continued to burn till 7/76. One attempt of the city to extinguish the fire failed. Noxious fumes and smoke was emitted during most of the burning history. County delays and lack of state regulations hampered efforts to control the fire.

Wisconsin

Wonewac, Junean County 2/74

A fire was reported at Wonewac dump. At the scene of the fire 6 volt dry cell and single cell batteries were found with the name Rav-O-Vac on them. The fire was visable for three miles and small explosions were observed.

Texas

Austin, Travis County 7/75

An unlicensed waste hauler, Rabor Enterprises, stored industrial waste at an unauthorized storage dump and left the contents in steel drums, some of which, started leaking. These waste included acids, heavymetals, volatile liquids, and waste oils. Clean-up of the site cost \$76,825.75.

Ohio

Cincinnati, Elda Inc. Dump

An employee of a private dump was burned over 50 percent of his body when several containers of an unknown volatile liquid caught fire and enveloped his bulldozer. Firemen had to run their hoses more than a half mile to extinguish the flames because the dump did not have hydrants.

Illinois

East St. Louis, St. Clare County 8/73 & 4/74

Two serious fires occurred at the site during compaction operations. The fires burned for several days and involved personal dangers. The Mal-Milam Landfill has accepted various industrial waste for the past ten years. Monitoring tests have shown phenol concentrations at 2500 ppb.

Illinois

Calumet, Cook County 9/75

A landfill operator died from severe burns when the compacter that he was operating struck a 55-gallon drum of ethyle acetate. The incident occurred after a scavenger/hauler had deposited a load at the Calumet Industrial Development Landfill in the dark hours of the morning.

Illinois

Chicago, Dan Ryan Expressway

Several dozen barrels of chemical waste exploded in a truck bin spewing barrels and flames over cars smarling rush hour traffic. The chemical, believed to be sodium nitrate, was part of a load being carried by an industrial waste hauler. Two policemen suffered eye injuries from the smoke.

Pennsylvania

Harrisburg, Dauphin County 1/75

An explosion occured at the Harrisburg City incinerator which resulted in building damages totalling approximately \$95,000. The explosion resulted from the ignition of a drum of spray adhesives delivered by the Rolance and Rolance Supply Co.

Pennsylvania

Harrisburg, Dauphin County 3/72

Approximately 85 grates were burned out in the Harrisburg City incinerator. The damage resulted from the incineration of magnesium filings delivered by TRW Systems Group. Resultant cost was \$123,000.

Washington

Everett, Snohomish County 9/74

The N.W. Wire Rope Corp., cleaning off debris from the site of a metal reduction plant, sent 200 cubic yards to a landfill near Siver Lake. The debris consisted of aluminum dust, magnesium chips, and two broken drums of concentrated phosphorus. Upon dumping and compaction, the material ignited and developed into

a fire. Water could not be applied to the waste and explosions eliminated chances to obtain samples.

Minnesota

Minneapolis, Dakota County

An employee of a Dakota County landfill was seriously burned when the piece of equipment he was operating crushed and ignited a container of flammable solvent which had been illegally dumped at the landfill. The employee suffered burns over 85% of his body and spent 4½ months in the hospital.

Appendix B

Test Methods for Ignitable Waste

Table of Contents

B-1,2	Aerosol Flame Projection Tests
B-3	D93-72
B-4	D3278-73
B-5	Reference 13

AMERICAN RAILROADS

OPERATIONS AND MAINTENANCE DEPARTMENT · BUREAU OF EXPLOSIVES
AMERICAN RAILROADS BUILDING · WASHINGTON, D.C. 20036 · 202/293-4048

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ZIANO

AEROSOL FLAME PROJECTION TESTS

Section 173. 300(b) subparagraphs (2), (3), and (4) of Title 49 to the Code of Federal Regulations referenced The Bureau of Explosives' Flame Projection Apparatus, Open Drum Apparatus and Closed Drum Apparatus to be used when examining aerosol products.

The following are descriptions of the equipment and testing procedures to be used when conducting the tests. Any further questions relating to this testing should be addressed to the Director at the above address.

FLAME PROJECTION TEST

EQUIPMENT - The test equipment consists of a base four inches wide and two feet long. A thirty inch rule (with inches marked) is supported horizontally on the side of the base and about six inches above it. A plumber's candle of such height that the top third of the flame is at the height of the horizontal rule is placed at the zero point in the base.

PROCEDURE - The test is conducted in a draft-free area that can be ventilated and the atmosphere cleared between each test. The self-pressurized container is placed at a distance of six inches from the ignition source and the spray jetted into the top third of the flame with valve opened fully for periods of 15 - 20 seconds. The length of the flame projection from the candle position is read on the horizontal scale. Three or more readings are taken on each sample and the average is taken as the result. Samples are also tested with valve in partially open positions to test for "burning back" to valve.

DRUM TESTS

EQUIPMENT- The equipment consists of a 55 - gallon open-head steel drum or similar container which is placed on its side and fitted with a hinged cover over the open end that will open at a pressure of 5 p. s. i.

B-1

52

The closed or solid end is equipped with one shuttered opening at the top. This is for the introduction of the spray. The opening is approximately two inches from the edge of drum head and is two inches in diameter. There is a safety glass or plastic window six inches square in the center of the solid end. A lighted plumber's candle is placed inside the drum on the lower side and midway between the ends.

PROCEDURE - The tests are conducted in the open and when temperature is between 60°F and 80°F.

---- OPEN DRUM TEST ----

This test is conducted with hinged end in a completely open position and with the shutter closed. The spray from the dispenser, with valve opened fully, is directed into the upper half of the open end and above the ignition source for one minute. Any significant propagation of flame through the vapor-air mixture away from the ignition source shall be considered a positive result -- but -- any minor and unsustained burning in the immediate area of the ignition source shall not be considered a positive result.

---- CLOSED DRUM TEST ----

This test is conducted with the hinged cover dropped into position to rest freely against the end and to close the open end of the drum to make a reasonably secure but not necessarily a completely air-tight seal. The shutter is opened and the spray is jetted into the drum through this shutter with valve fully opened for one minute. After clearing the atmosphere in the drum, the jetting is repeated similarly three times. Any explosion or rapid burning of the vapor-air mixture sufficient to cause the hinged cover to move is considered a positive result.

April, 1974

B-1

B-3 ASTM D93-72

Pensky-Martens Closed Cup Tester



Designation: D 93 - 72

IP Designation: 34/71

American National Standard Z117 - 1972
Approved May 18, 1972
By American National Standards Institute
Method 1102—Federal Test
Method Standard No. 791b
Federation of Societies for
Paint Technology Standard No. D1 5-66
British Standard 2838

40: 7 1977

AMERICAN SOCIETY FOR TESTING AND MATERIALS

1916 Race St., Philadelphia, Pa., 19103

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Standard Method of Test for FLASH POINT BY PENSKEY-MARTENS CLOSED TESTER¹

ADOPTED (as method GO-7), 1924; LAST REVISED, 1971

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 93; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. This is also a standard of the Institute of Petroleum issued under the fixed designation IP 34. The final number indicates the year of last revision.

This method was adopted as a joint ASTM-IP Standard in 1967.

1. Scope

1.1 This method covers the determination of the flash point by Pensky-Martens Closed Cup Tester of fuel oils, lube oils, suspensions of solids, liquids that tend to form a surface film under test conditions, and other liquids. For the determination of the flash point of drying oils and solvent-type waxes refer to Note 1.

NOTE 1—The flash point of drying oils may be determined using Method D 1393 and the flash point of solvent-type liquid waxes may be determined using Method D 1437.

NOTE 2—This method may be employed for the detection of contamination of lubricating oils by minor amounts of volatile materials.

2. Applicable Documents

2.1 ASTM Standards:

- D 56 Test for Flash Point by Tag Closed Tester²
- D 1310 Test for Flash Point of Liquids by Tag Open-Cup Apparatus³
- D 1393 Test for Flash Point of Drying Oils⁴
- D 1437 Test for Flash Point of Solvent-Type Liquid Waxes⁴
- E 1 Specification for ASTM Thermometers⁵

3. Summary of Method

3.1 The sample is heated at a slow, constant rate with continual stirring. A small flame is directed into the cup at regular intervals with simultaneous interruption of stirring. The flash point is the lowest temperature at which application of the test flame causes the vapor above the sample to ignite.

4. Apparatus

4.1 *Pensky-Martens Closed Flash Tester*, as described in Appendix A1.

NOTE 3—There are automatic flash point testers available and in use which may be advantageous in the saving of testing time, permit the use of smaller samples, and have other factors which may merit their use. If automatic testers are used, the user must be sure that all of the manufacturer's instructions for calibrating, adjusting, and operating the instrument are followed. In any cases of dispute, the flash point as determined manually shall be considered the reference test.

4.2 *Thermometers*—Two standard thermometers shall be used with the ASTM Pensky-Martens tester, as follows:

4.2.1 For tests in which the indicated reading falls within the limits 20 to 200 F (−7 to +93 C), inclusive, an ASTM Pensky-Martens Low Range or Tag Closed Tester Thermometer having a range from 20 to 230 F (−5 to +110 C) and conforming to the requirements for Thermometers 9F (9C) and as prescribed in ASTM Specification E 1 or IP Thermometer 15F (15C) conforming to specifications given in Appendix A3, shall be used.

4.2.2 For tests in which the indicated reading falls within the limits 230 to 700 F (110 to 371 C), an ASTM Pensky-Martens High

¹ This method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants.

Current edition approved Aug. 29, 1972. Published October 1972. Originally published as D 93 - 21 1924. Last previous edition D 93 - 66.

In the IP, this method is under the jurisdiction of the Subcommittee on Combustion.

In 1971 the scope was revised.

² Annual Book of ASTM Standards, Part 20

³ Annual Book of ASTM Standards, Part 11

⁴ Annual Book of ASTM Standards, Part 22

⁵ Annual Book of ASTM Standards, Parts 18 and 30

Range Thermometer having a range from 200 to 700 F (90 to 370 C) and conforming to the requirements for Thermometers 10F (10C) as prescribed in Specification E 1 or IP Thermometer 16F (16C) conforming to specifications given in Appendix A3, shall be used.

4.2.3 For the range 200 to 230 F (93 to 110 C) either thermometer may be used.

5. Preparation of Apparatus

5.1 Support the tester on a level, steady table. Unless tests are made in a draft-free room or compartment, it is good practice, but not required, to surround the tester on three sides with a shield, each section of which is about 18 in. (46 cm) wide and 24 in. (61 cm) high.

6. Preparation of Sample

6.1 Samples of very viscous materials may be warmed until they are reasonably fluid before they are tested. However, no sample should be heated more than is absolutely necessary. It shall never be heated above a temperature of 30 F (16 C) below its expected flash point.

6.2 Samples containing dissolved or free water may be dehydrated with calcium chloride or by filtering through a qualitative filter paper or a loose plug of dry absorbent cotton. Warming the sample is permitted, but it shall not be heated for prolonged periods or above a temperature of 30 F (16 C) below its expected flash point.

NOTE 4—If the sample is suspected of containing volatile contaminants, the treatment described in 6.1 and 6.2 should be omitted.

7. Procedure

7.1 Thoroughly clean and dry all parts of the cup and its accessories before starting the test, being sure to remove any solvent which had been used to clean the apparatus. Fill the cup with the sample to be tested to the level indicated by the filling mark. Place the lid on the cup and set the latter in the stove. Be sure to have the locating or locking device properly engaged. Insert the thermometer. Light the test flame and adjust it to $\frac{1}{8}$ in. (4 mm) in diameter. Supply the heat at such a rate that the temperature as indicated

by the thermometer increases 9 to 11 F (5 to 6 C)/min. Turn the stirrer 90 to 120 rpm, stirring in a downward direction.

7.2 If the sample is known to have a flash point of 220 (104 C) or below, apply the test flame when the temperature of the sample is not higher than 30 F (17 C) below the flash point, and thereafter at a temperature reading that is a multiple of 2 F (1 C). Apply the test flame by operating the mechanism on the cover which controls the shutter and test flame burner so that the flame is lowered into the vapor space of the cup in 0.5 s, left in its lowered position for 1 s, and quickly raised to its high position. Do not stir the sample while applying the test flame.

7.3 If the sample is known to have a flash point above 220 F (104 C) apply the test flame in the manner just prescribed at each temperature that is a multiple of 5 F (3 C), beginning at a temperature not higher than 30 F (17 C) below the flash point.

7.4 Record as the flash point the temperature read on the thermometer at the time the test flame application causes a distinct flash in the interior of the cup. Do not confuse the true flash point with the bluish halo that sometimes surrounds the test flame at applications preceding the one that causes the actual flash.

DETERMINATION OF FLASH POINT OF SUSPENSIONS OF SOLIDS

8. Procedure

8.1 Bring the material to be tested and the tester to a temperature of 60 ± 10 F (15 ± 5 C) or 20 F (11 C) lower than the estimated flash point, whichever is lower. Completely fill the air space between the cup and the interior of the air bath with water at the temperature of the tester and sample. Turn the stirrer 250 ± 10 rpm, stirring in a downward direction. Raise the temperature throughout the duration of the test at a rate of not less than 2 nor more than 3 F (1 to 1.5 C)/min. With the exception of these requirements for rates of stirring and heating, proceed as prescribed in Section 7.

NOTE: Solid carbon dioxide (CO_2) (dry ice) shall in no case be used to obtain the proper rate of temperature rise, since CO_2 has a blanketing effect which leads to a false flash point.

7 1977

9. Barometric Pressure

9.1 Observe and record the barometric pressure. Make a correction on the following basis: for each 1 in. (25 mm) below 29.92 in. (760 mm) barometric reading, add 1.6 F (0.9 C) to the flash point; for each 1 in. (25 mm) above 29.92 in. (760 mm) barometric reading, subtract 1.6 F (0.9 C) from the flash point. After applying the correction, round off the values obtained to the nearest whole number.

suspect unless they differ by more than the following amounts:

Material	Flash Point Range	Repeatability
Suspensions of solids	95 to 110 F	4 F
All others	220 F and under	4 F
	Above 220 F	10 F

10.1.2 *Reproducibility*—The results submitted by each of two laboratories should not be considered suspect unless the two results differ by more than the following amounts:

10. Precision

10.1 The following criteria should be used for judging the acceptability of results (95 percent probability):

Material	Flash Point Range	Reproducibility
Suspensions of solids	95 to 110 F	6 F
All others	220 F and under	6 F
	Above 220 F	15 F

10.1.1 *Repeatability*—Duplicate results by the same operator should not be considered

APPENDIXES

A1. APPARATUS SPECIFICATIONS

A1.1 A typical assembly of the apparatus, gas heated, is shown in Fig. A1. The apparatus shall consist of a test cup, cover, and stove conforming to the following requirements:

that when at rest the shutter shall exactly close the three openings. When operated to the other extreme, the three cover openings shall be exactly open and the tip of the exposure tube shall be fully depressed.

A1.1.1 *Cup*—The cup shall be of brass, or other nonrusting metal of equivalent heat conductivity, and shall conform to the dimensional requirements in Fig. A2. The flange shall be equipped with devices for locating the position of the cup in the stove. A handle attached to the flange of the cup is a desirable accessory. The handle shall not be so heavy as to tip over the empty cup.

A1.1.2.3 *Flame-Exposure Device*—The flame-exposure device (Fig. A4) shall have a tip with an opening 0.027 to 0.031 in. in diameter. This tip shall be made preferably of stainless steel, although it may be fabricated of other suitable metals. The flame-exposure device shall be equipped with an operating mechanism which, when the shutter is in the "open" position, depresses the tip so that the center of the orifice is between the planes of the under and upper surfaces of the cover proper at a point on a radius passing through the center of the larger opening A (Fig. A3).

A1.1.2 *Cover*:

A1.1.2.1 *Cover Proper*—The cover shown in Fig. A3 shall be of brass (A1.1.1.1), and shall have a rim projecting downward almost to the flange of the cup. The rim shall fit the outside of the cup with a clearance not exceeding 0.014 in. on the diameter. There shall be a locating or locking device, or both engaging with a corresponding device on the cup. The four openings in the cover, A, B, C, and D, are shown in Fig. A3. The upper edge of the cup shall be in close contact with the inner face of the cover throughout its circumference.

A1.1.2.4 *Pilot Flame*—A pilot flame shall be provided for automatic relighting of the exposure flame. A bead 1/32 in. in diameter may be mounted on the cover so that the size of the test flame can be regulated by comparison. The tip of the pilot flame shall have an opening the same size as the tip of the flame exposure device (0.027 to 0.031 in. in diameter).

A1.1.2.2 *Shutter*—The cover shall be equipped with a brass (Section 3) shutter (Fig. A4), approximately 1/16 in. thick, operating on the plane of the upper surface of the cover. The shutter shall be so shaped and mounted that it rotates on the axis of the horizontal center of the cover between two stops, so placed, that when in one extreme position, the openings A, B, and C in the cover are completely closed, and when in the other extreme position, these openings are completely opened. The mechanism operating the shutter should be of the spring type and constructed so

A1.1.2.5 *Stirring Device*—The cover shall be equipped with a stirring device (Fig. A4) mounted in the center of the cover and carrying two 2-bladed metal propellers. A stirrer shaft may be coupled to the motor by a flexible shaft or a suitable arrangement of pulleys.

A1.1.3 *Stove*—Heat shall be supplied to the cup by means of a properly designed stove which is equivalent to an air bath. The stove shall consist of an air bath and a top plate on which the flange of the cup rests.

A1.1.3.1 *Air Bath*—The air bath shall have a cylindrical interior and shall conform to the di-

mensional requirements in Fig. A1. The air bath may be either a flame or electrically heated metal casting (Note A1), or an electric-resistance element (Note A2). In either case, the air bath must be suitable for use at the temperatures to which it will be subjected without deformation.

NOTE A1—If the heating element is a flame or electrically heated metal casting, it shall be so designed and used that the temperatures of the bottom and the walls are approximately the same. On this account it should be not less than $\frac{1}{8}$ in. in thickness. The casting shall be designed so that products of combustion of the flame cannot pass

up and come into contact with the cup.

NOTE A2—If the air bath is of the electric-resistance heated type, it shall be constructed so that all parts of the interior surface are heated uniformly. The wall and bottom of the air bath shall be not less than $\frac{1}{8}$ in. in thickness.

A1.1.3.2 Top Plate—The top plate shall be of metal, and shall be mounted with an air gap between it and the air bath. It may be attached to the air bath by means of three screws and spacing bushings. The bushings should be of proper thickness to define an air gap of $\frac{3}{16}$ in., and they shall be not more than $\frac{1}{8}$ in. in diameter.

A2. MANUFACTURING STANDARDIZATION OF THERMOMETER AND FERRULE

A2.1 The low-range thermometer, which conforms also to the specification for the cup thermometer in the Tag closed tester (Method D 56) and which frequently is fitted with a metal ferrule intended to fit the collar on the cover of the Tag flash tester, can be supplemented by an adapter (Fig. A5) to be used in the larger diameter collar of the Pensky-Martens apparatus. Differences in dimensions of these collars, which do not affect test results, are a source of unnecessary trouble

to manufacturers and suppliers of instruments, as well as to users.

A2.2 Subcommittee 21 on Metalware Laboratory Apparatus, of ASTM Committee E-1 on Methods of Testing, has studied this problem and has established some dimensional requirements which are shown in Fig. A5. Conformity to these requirements is not mandatory, but is desirable to users as well as suppliers of Pensky-Martens Testers.

A3. THERMOMETER SPECIFICATIONS

TABLE A1 IP Thermometer Specifications

NOTE—The stem shall be made with an enlargement having a diameter of 1.5 to 2.0 mm greater than the stem and a length of 3 to 5 mm, the bottom of the enlargement being 64 to 66 mm from the bottom of the bulb. These dimensions shall be measured with the test gage shown in Fig. 1 of Specification E 1.¹

Name	IP 15F	IP 15C	IP 16F	IP 16C
	Pensky-Martens Low		Pensky-Martens High	
Range	20 to 230 F	-7 to +110 C	200 to 700 F	90 to 370 C
Graduation	1 F	0.5 C	5 F	2 C
Immersion, mm	57	57	57	57
Over-all length ± 10 mm	280	280	280	280
Stem diameter, mm	5.5 to 8.0	5.5 to 8.0	5.5 to 8.0	5.5 to 8.0
Bulb shape	cylindrical	cylindrical	cylindrical	cylindrical
Bulb length, mm	9 to 13	9 to 13	10 max	10 max
Bulb diameter, mm	not less than 5.5 and not greater than stem	not less than 5.5 and not greater than stem	not less than 5.5 and not greater than stem	not less than 5.5 and not greater than stem
Length of graduated portion, mm	143 to 177	143 to 177	143 to 177	143 to 177
Distance bottom of bulb to, mm	20 F 75 to 90	-7 C 75 to 90	200 F 75 to 90	90 C 75 to 90
Longer lines at each	5 F	1 C and 5 C	25 F	10 and 20 C
Figured at each	10 F	5 C	50 F	20 C
Expansion chamber	Required	Required	Required	Required
Top finish	Ring	Ring	Ring	Ring
Scale error not to exceed \pm	1 F	0.5 C	2.5 to 500 C 3.5 F above 500 F	1 to 260 C 2 C above 260 C
See notes	¹ and see table for emergent stem temper- atures	and see table for emergent stem temper- atures	and see table for emergent stem temper- atures	¹ and see table for emergent stem temper- atures

TABLE A3 Standardization Temperatures

Temperature	Average Temperature of Emergent Column	Temperature	Average Temperature of Emergent Column
Thermometer 9F (20 to 230 F)		Thermometer 9C (-5 to + 100 C)	
32 F	66 F	0 C	19 C
100 F	86 F	35 C	28 C
160 F	106 F	70 C	40 C
220 F	123 F	105 C	50 C
Thermometer 10F (200 to 700 F)		Thermometer 10C (90 to 370 C)	
212 F	141 F	100 C	61 C
390 F	159 F	200 C	71 C
570 F	180 F	300 C	87 C
700 F	220 F	370 C	104 C
IP 15F (20 to 230 F)		IP 15C (-7 to 110 C)	
32 F	66 F	0 C	19 C
70 F	70 F	20 C	20 C
100 F	86 F	40 C	31 C
150 F	104 F	70 C	40 C
212 F	118 F	100 C	48 C
IP 16F (200 to 700 F)		IP 16C (90 to 370 C)	
200 F	140 F	100 C	61 C
300 F	149 F	150 C	65 C
400 F	160 F	200 C	71 C
500 F	175 F	250 C	78 C
600 F	195 F	300 C	87 C
700 F	220 F	350 C	99 C

NOTE—The emergent column temperatures are those attained when using the thermometers in the test equipment for which the thermometers were originally designed. In some cases these temperatures are markedly different from those realized during standardization.

(Table A2 on next page)

TABLE A2 Specifications for ASTM Thermometers
 All dimensions are in millimeters.
 See Table A3 for Standardization Temperatures.

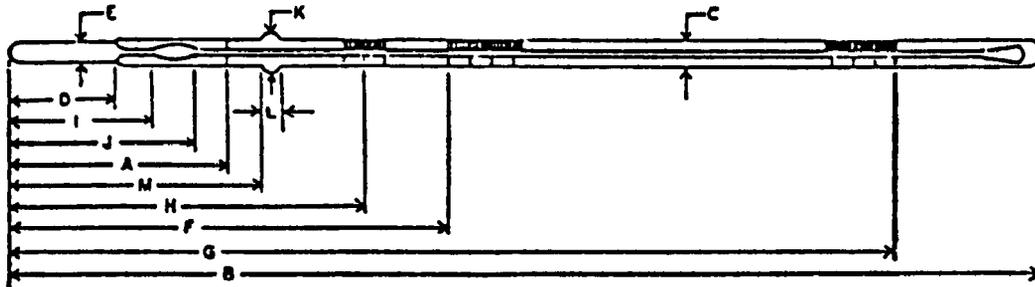
ASTM No. and Name	Range	For Test at	Immersion	Graduations			Scale Error max	Special Inscription	Expansion Chamber
				Subdivisions	Long Lines at Each	Number at Each			
9C - 62 Pensky-Martens, Low Range Tag Closed Tester 9F - 62	-5 to +110 C		57	0.5 C	1 C	5 C	0.5 C	ASTM 9C or 9F 57 MM IMM	160 C
	20 to 230 F			1 F	5 F	10 F	1 F		320 F
10C - 62 Pensky-Martens, High Range 10F - 62	90 to 370 C		57	2 C	10 C	20 C	*	ASTM 10C or 10F 57 MM IMM	*
	200 to 700 F			5 F	25 F	50 F	*		

* Scale error: 1 C up to 260 C; 2 C over 260 C.

† Scale error: 2.5 F up to 500 F; 3.5 F over 500 F.

* An expansion chamber is provided for relief of gas pressure to avoid distortion of the bulb at higher temperatures. It is not for the purpose of joining mercury separations; and under no circumstances should the thermometer be heated above the highest temperature reading.

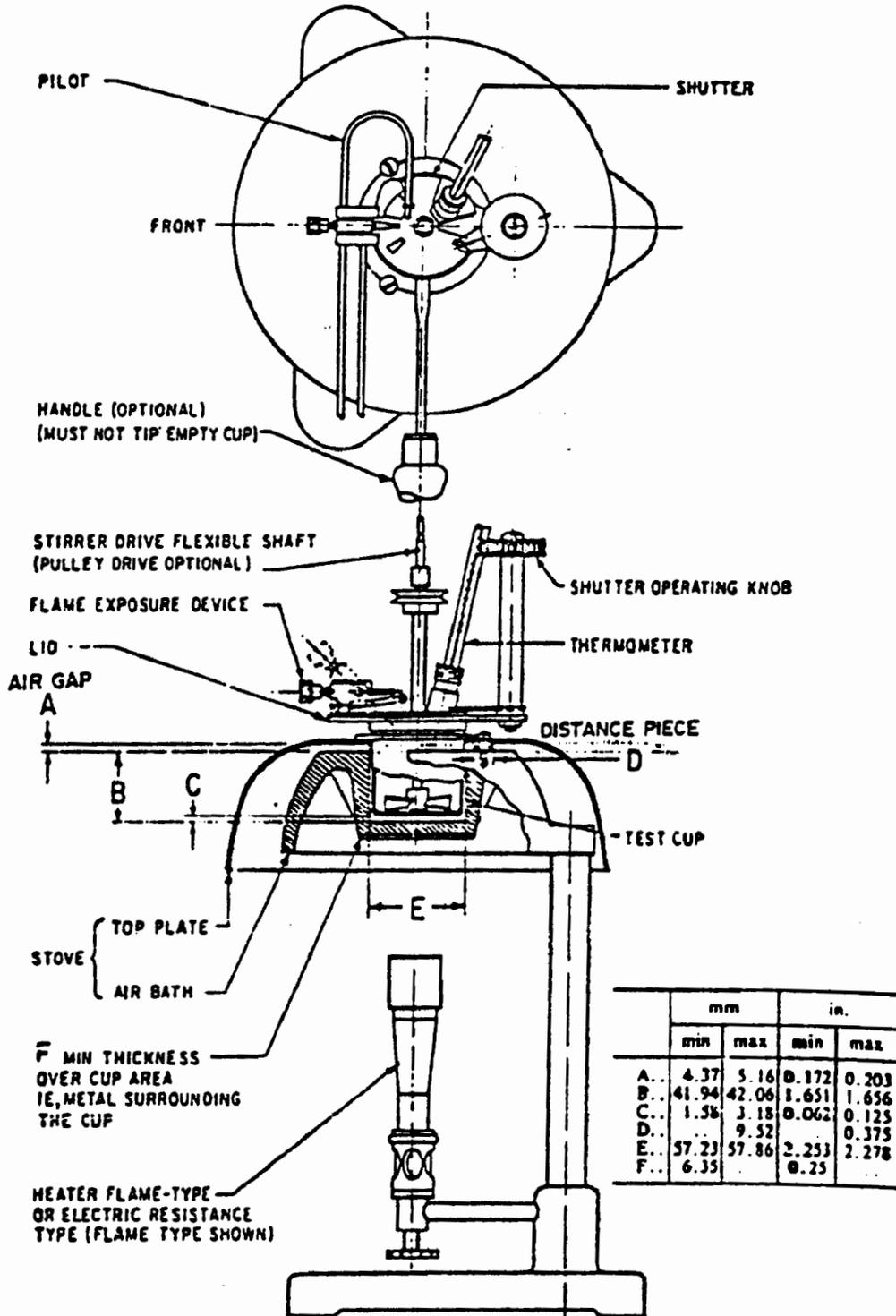
D 93 — 34



Total Length, = J	Bulb		Scale Location			Ice Point Scale	Contraction Chamber		Stem Enlargement					
	Stem OD	Length	OD	Bottom of Bulb to Line at	Distance	Bottom of Bulb to Line at	Distance	Range	Bottom of Bulb to Ice Point	Distance to Bottom, min	Distance to Top, max	OD	Length	Distance to Bottom
B	C	D	E	F		G	H		I	J	K	L	M	
287	6.0	9.0	> stem	0 C		100 C						7.5	2.5	64
	to 7.0	to 13		85 to 98		221 to 237							8.5	3.0 ^d
				32 F		212 F								
287	6.0	8.0	4.5 to 6.0	110 C		360 C						7.5	2.5	64
	to 7.0	to 10		86 to 99		227 to 245							8.5	3.0 ^d
				230 F		680 F								

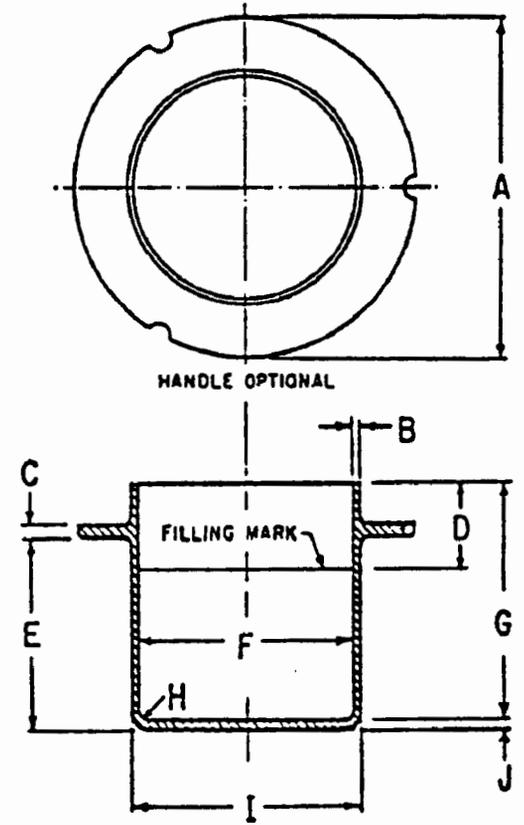
^d The length of the enlargement, and the distance from the bottom of the enlargement to the bottom of the bulb shall be measured with the test gage shown in Fig. A6.

ASTM D 93 — 34



Note: Lid assembly may be positioned either right or left-handed

FIG. A1 Pensky-Martens Closed Flash Tester.

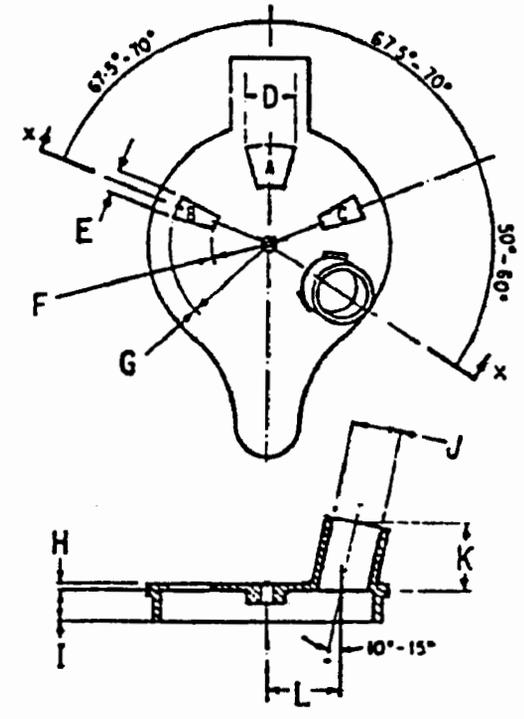


HANDLE OPTIONAL

FILLING MARK

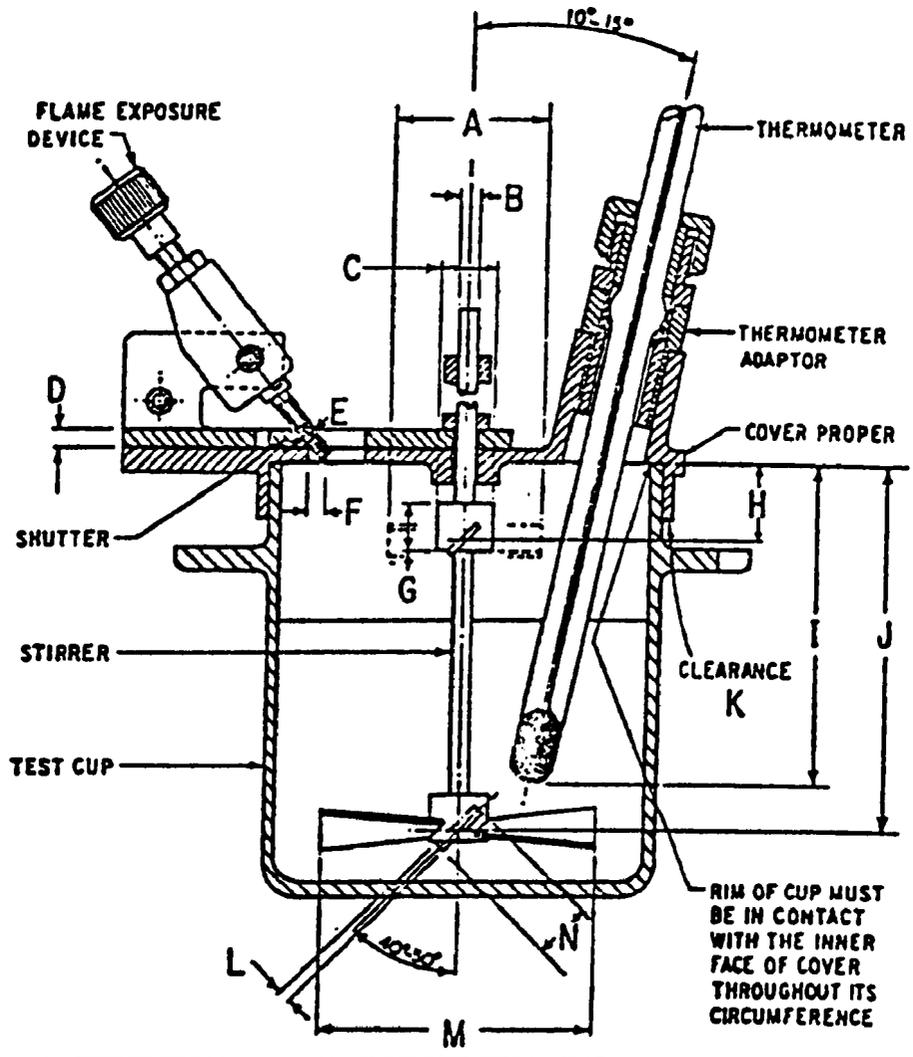
	mm		in.	
	min	max	min	max
A	79.0	79.8	3.11	3.14
B	1.0	...	0.04	...
C	2.8	3.6	0.11	0.14
D	21.72	21.84	0.855	0.860
E	45.47	45.72	1.790	1.800
F	50.72	50.85	1.997	2.002
G	55.75	56.00	2.195	2.205
H	3.8	4.0	0.15	0.16
I	53.90	54.02	2.122	2.127
J	2.29	2.54	0.090	0.100

FIG. A2 Test Cup.



	mm		in.	
	min	max	min	max
D	12.7	13.5	0.50	0.53
E	4.8	5.6	0.19	0.22
F	13.5	14.3	0.53	0.56
G	23.8	24.6	0.94	0.97
H	1.2	2.0	0.05	0.08
I	7.9	...	0.31	...
J	12.27	12.32	0.483	0.485
K	16.38	16.64	0.645	0.655
L	18.65	19.45	0.734	0.766

FIG. A3 Cover Proper.

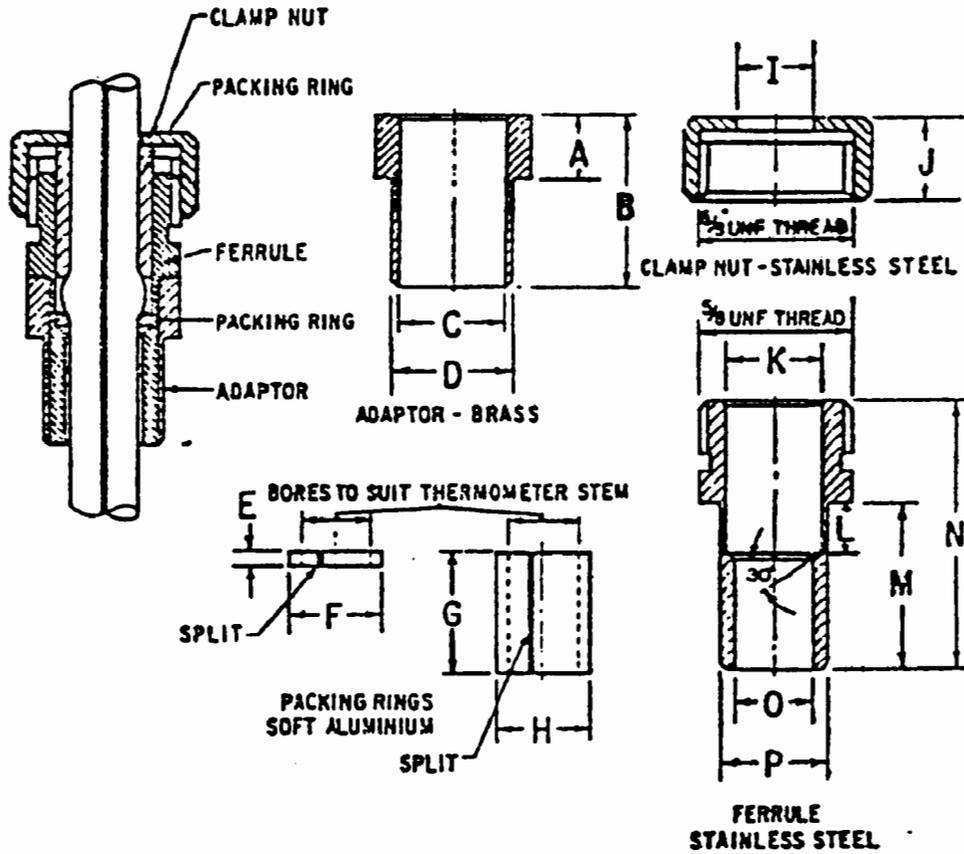


	mm		in.	
	min	max	min	max
A	18.3	19.8	0.72	0.78
B	2.38	3.18	0.094	0.125
C	7.6	8.4	0.30	0.33
D	2.0	2.8	0.08	0.11
E	0.69	0.79	0.027	0.031
F	2.0	2.8	0.08	0.11
G	6.4	10.4	0.25	0.41
H	9.6	11.2	0.38	0.44
I*	43.0	46.0	1.69	1.81
J	50.0	51.6	1.97	2.03
K	...	0.36	...	0.014
L	1.22	2.06	0.048	0.08
M	31.8	44.4	1.25	1.75
N	7.6	8.4	0.30	0.33

* Includes tolerance for length of thermometer given in ASTM Specification E 1, ASTM Thermometers.

FIG. A4 Test Cup and Cover Assembly.

64



	mm		in.	
	min	max	in.	max
A	6.20	6.50	0.244	0.256
B	17.0	18.0	0.67	0.71
C	9.80	9.85	0.386	0.388
D	12.19	12.24	0.480	0.482
E	1.40	1.65	0.055	0.065
F	8.56	8.61	0.337	0.339
G	12.4	13.0	0.49	0.57
H	8.56	8.61	0.337	0.339
I	8.1	8.6	0.32	0.34
J	9.9	10.7	0.39	0.42
K	8.64	8.69	0.340	0.342
L	5.1	5.6	0.20	0.22
M	17.0	17.5	0.67	0.69
N	27.4	28.2	1.08	1.11
O	7.11	7.16	0.280	0.282
P	9.73	9.78	0.383	0.385

FIG. A5 Dimensions for Thermometer Adapter, Ferrule, and Packing Ring.

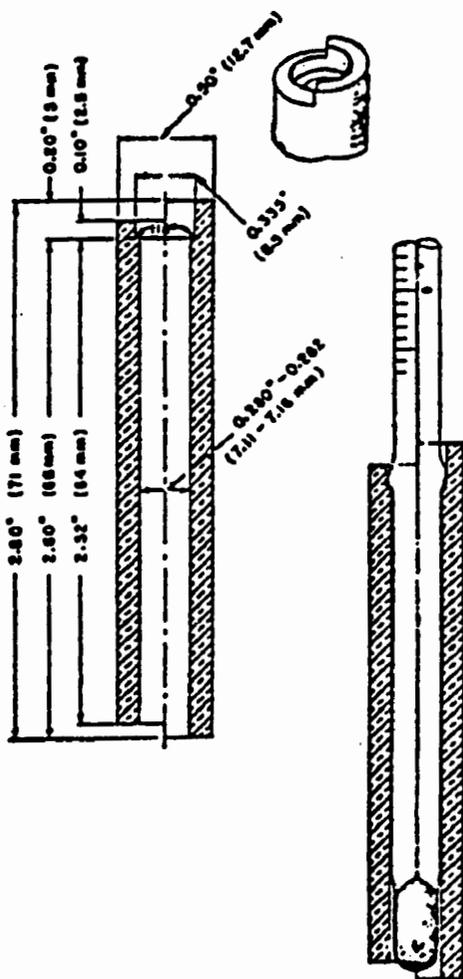


FIG. A6 Test Gage for Checking Enlargements on Thermometers.

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B-4 D3278-73

SETAflash Closed Cup Tester



NOV 7 1977

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AMERICAN SOCIETY FOR TESTING AND MATERIALS

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Standard Methods of Test for FLASH POINT OF LIQUIDS BY SETAFLASH CLOSED TESTER¹

This Standard is issued under the fixed designation D 3278; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the determination of the flash point, by Setaflash® Closed Tester, of paints, enamels, lacquers, varnishes, and related products and their components having flash points, between 32 and 230°F (0 to 110°C) having a viscosity lower than 150 stokes at 77°F (25°C).²

NOTE 1—Tests at higher or lower temperatures are possible.

1.2 The procedure may be used to determine whether a material will or will not flash at a specified temperature or to determine the finite temperature at which a material will flash.

1.3 The results from this method are comparable to those obtained by the Tag Closed Tester procedure described in Method D 563 and the Pensky-Martens Tester method described in Method D 93.

2. Applicable Documents

2.1 ASTM Standards:

- D 56 Test for Flash Point by Tag Closed Tester²
- D 93 Test for Flash Point by Pensky-Martens Closed Tester²
- D 850 Test for Distillation of Industrial Aromatic Hydrocarbons and Related Materials²
- D 1015 Test for Freezing Points of High-Purity Hydrocarbons³
- D 1078 Test for Distillation Range of Volatile Organic Liquids²

3. Summary of Method

3.1 By means of a syringe, 2 ml of sample is introduced through a leakproof entry port into

the tightly closed Setaflash Tester or directly into the cut that has been brought to within 5°F (3°C) below the expected flash point. As a flash/no flash test, the *expected* flash point temperature may be a specification or other operating requirements. The temperature of the apparatus is raised to the precise temperature of the expected flash point by slight adjustment of the temperature dial. After 1 min, a test flame is applied inside the cup and note is taken as to whether the test sample flashes or not. If a repeat test is necessary, a fresh sample should be used.

3.2 For a finite flash measurement, the temperature is sequentially increased through the anticipated range, the test flame being applied at 9°F (5°C) intervals until a flash is observed. A repeat determination is then made using a fresh sample, starting the test at the temperature of the last interval before the flash point of the material and making tests at increasing 1°F (0.5°C) intervals.

4. Apparatus

4.1 *Setaflash Tester*⁴, shown in Fig. X1, and described in Appendix X1.

4.2 *Thermometers*⁵ conforming to specifica-

¹These methods are under the jurisdiction of ASTM Committee D-1 on Paint, Varnish, Lacquer, and Related Products.

Current edition approved Oct. 29, 1973. Published December 1973.

²1974 Annual Book of ASTM Standards, Part 29.

³1973 Annual Book of ASTM Standards, Part 18.

⁴Unit shown in Fig. X1 is manufactured by Stanhope-Seta Ltd., Park Close, Egham, Surrey, England. It is available in the USA from Erdco Engineering Corp., 136 Official Road, Addison, Ill. 60101, or from Paul N. Gardner Co., Station 9, P. O. Box 6633, Fort Lauderdale, Fla. 33316.

⁵Thermometers may be obtained from the suppliers of the Setaflash.

68

tions given in Table X1. Test to determine that the scale error does not exceed 0.5°F (0.25°C). The use of a magnifying lens significantly assists in making temperature observations.

4.3 *Glass Syringe*, 2 ± 0.1-ml capacity at 77°F (25°C), to provide a means of taking a uniform sample. Check the capacity by discharging water into a weighing bottle and weighing. Adjust plunger if necessary. A disposable syringe of equal precision may be used.

4.4 *Cooling Block*, aluminum (described in Appendix X2) which fits snugly within the test cup for rapid cooling of the sample cup.

4.5 *Barometer*.

5. Reagents and Materials

5.1 *p-Xylene*^a—Reference standard for checking the Setaflash Tester.

5.2 *Cooling Mixture* of ice water or dry ice (solid CO₂) and acetone.

5.3 *Liquefied Petroleum Gas*.

5.4 *Heat Transfer Paste*^b

6. Sampling

6.1 The sample size for each test is 2 ml. Obtain at least a 25-ml sample from the bulk source and store in a nearly full tightly closed clean glass container or in other container suitable for the type of liquid being sampled.

6.2 Erroneously high flash points may be obtained if precautions are not taken to avoid loss of volatile material. Do not open sample containers unnecessarily and do not transfer the sample to the cup unless its temperature is at least 20°F (10°C) below the expected flash point. Discard samples in leaky containers.

7. Preparation of Apparatus

7.1 Prior to initial use or after removal of the thermometer, insert the thermometer into its pocket, Fig. X2, with a good heat transfer paste.

7.2 To help in making the necessary settings during a test, determine the relationship between the temperature control dial and thermometer readings at intervals not over 10°F (5°C) throughout the scale range of heater before the initial use.

7.3 Place the tester in a subdued light and in a position where it is not exposed to disturbing drafts. Provide a black-coated shield, if necessary.

7.4 Read the manufacturer's operating and maintenance instructions on the care and servicing of the tester. Observe the specific suggestions regarding the operation of its various controls.

7.5 Check the accuracy of the tester by determining the flash point of the *p-xylene* reference standard in duplicate (Appendix X3). The average of the results should be 81 ± 1.5°F (27.2 ± 0.8°C). If not, remove the thermometer and observe whether sufficient heat transfer paste surrounds the thermometer to provide good heat transfer from the cup to the thermometer.

METHOD A—FLASH/NO FLASH

8. Procedure—Ambient to 230°F (110°C)

8.1 Inspect the inside of the test cup, lid, and shutter mechanism for cleanliness and freedom from contamination. Use an absorbent tissue to wipe clean, if necessary. Lock the cover lid tightly in place.

8.2 Switch the tester on, if not already in stand-by. To rapidly approach the specification flash temperature of the charged sample, turn the heater dial fully clockwise (Note 2) causing the heater signal (red) light to glow. When the thermometer indicates a temperature of about 5°F (3°C) below the specification or target flash point temperature, reduce the heat input to the test cup by slowly turning the heater control dial counter clockwise until the signal light goes out (Note 3).

NOTE 2—When the correct temperature is dialed on the temperature controller, the elapsed time to reach it may be greater than when turned Full On, but less attention will be required in the intervening period.

NOTE 3—The test cup temperature is stable when the signal light slowly cycles on and off.

8.3 Determine the barometric pressure and determine the corrected specification temperature at that barometric pressure (see 13.2).

8.4 After the test cup temperature has stabilized at the specification or target flash point, charge the syringe with the sample to be tested and transfer the syringe to the filling orifice.

^a *p-Xylene* is available as "Flash Point Check Fluid" from Special Products Div., Phillips Petroleum Co., Bartlesville, Okla.

^b Heat transfer paste is available from the supplier of the Setaflash Tester. Dan Corning also can supply a similar paste as their no. 340 silicone.

(Fig. X2) taking care not to lose any sample. Discharge the sample into the test cup by depressing the syringe plunger to its lowest position, then remove the syringe. If the sample has a viscosity greater than 45 SUS at 100°F (37.8°C) or equivalent of 9.5 cSt at 77°F (25.0°C), discharge the contents of the syringe directly into the cup. Immediately close tightly the lid and shutter assembly.

8.5 Set the 1-min timing device by rotating its knob clockwise to the required setting. In the meantime, open the gas control valve and light the pilot and the test flames. Adjust the test flame size with the pinch valve so as to match the size of the $\frac{1}{2}$ in. (4-mm) diameter flame gage.

8.6 After 1 min has elapsed, observe the temperature. If at the specification temperature (accounting for the differences of the barometer reading from 760 mm), apply the test flame by slowly and uniformly opening the slide fully and closing completely over a period of approximately 2½ s. Watch for a flash.

NOTE 4—The sample is considered to have flashed only if a comparatively large blue flame appears and propagates itself over the surface of the liquid. Occasionally, particularly near the actual flash point temperature, application of the test flame may give rise to a halo; this should be ignored.

8.7 Turn off the test and the pilot flame. Clean the apparatus in preparation for the next test.

9. Procedure—32°F (0°C) to Ambient

9.1 If the specification or target flash point is at or below ambient temperature, cool the sample to 10 to 20°F (5 to 10°C) below that point by some convenient means.

9.2 Cool the tester to approximately the temperature of the sample by inserting the cooling block (Appendix X1.2) filled with a cooling mixture (Notes 5 and 6) into the sample well. Dry the cup with a paper tissue to remove any collected moisture prior to adding the sample.

NOTE 5: Caution—Be careful in handling the cooling mixture and cooling block, wear gloves and goggles. Mixtures such as dry ice and acetone can produce severe frost bite.

NOTE 6: Caution—Be careful in inserting the cooling block into the tester cup to prevent damage to the cup.

9.3 Introduce the sample as in 8.4. Allow the

temperature to rise under ambient conditions or increase the temperature of the cup by rotating the heater controller clockwise slowly until the specification temperature adjusted for barometric pressure is reached. Determine whether the sample flashes as in 8.5 and 8.6.

9.4 Turn off the test and pilot flames. Clean up the apparatus.

METHOD B—FINITE FLASH POINT

10. Procedure—Ambient to 230°F (110°C)

10.1 *Preliminary or Trial Test*—Follow steps 8.1 to 8.5 omitting the barometric reading and using an estimated finite flash point instead of a specification flash point temperature.

10.2 After 1 min has elapsed, observe the temperature, apply the test flame by slowly and uniformly opening the slide fully and closing completely over a period of 2½ s. Watch for a flash (Note 3).

10.3 *Finite Flash Point*—If a flash is observed proceed as below.

10.3.1 Using a temperature of 9°F (5°C) lower than the temperature observed in 10.2, repeat 10.1 and 10.2 (Note 6). If a flash is still observed, repeat at 9°F (5°C) lower intervals until no flash is observed.

NOTE 7—Never make a repeat test on the same sample. Always take a fresh portion for each test.

10.3.2 Repeat 10.1 and 10.2 with a new sample, stabilizing the test cup temperature at the temperature at which no flash occurred previously. Observe if a flash occurs at this temperature. If no flash occurs, increase the temperature at 1°F (0.5°C) intervals by making small incremental adjustment to the temperature controller and allowing 1-min intervals between each increment and the flash point test. Record the temperature at which the flash actually occurs. Record the barometric pressure. Turn off pilot and test flames and clean up tester.

10.4 *Finite Flash Point*—If no flash point is observed in 10.2, proceed as follows:

10.4.1 Using a test temperature of 9°F (5°C) higher than the temperature observed in 10.2, repeat steps 10.1 and 10.2 (Note 7). If no flash is observed, repeat at 9°F (5°C) higher intervals until a flash is observed.

10.4.2 Repeat step 10.3.2 with a new sample.

11. Procedure—32°F (0°C) to Ambient Temperature

11.1 *Preliminary or Trial Test*—Cool the sample to 5 to 10°F (3 to 5°C) below the expected flash point.

11.2 Cool the tester to approximately the temperature of the sample by inserting the cooling block filled with a cooling medium, into the sample well (Notes 4 and 5).

11.3 Insert the sample as in 8.4. Set the 1-min timing device. After 1 min, apply the test flame by slowly and uniformly opening the slide fully and closing completely over a period of approximately 2½ s. Observe for a flash (Note 3). Record the temperature.

11.4 *Finite Flash Point*—If a flash is observed, proceed as follows:

11.4.1 Cool a new sample and the sample cup to 9°F (5°C) below the previous temperature (11.3). After 1 min, check for a flash as in 11.3. If the sample flashes, repeat test at 9°F (5°C) lower intervals until no flash is observed.

11.4.2 Repeat with a new sample, cooling both sample and tester to the temperature at which the sample did not flash. After 1 min, observe if a flash occurs at this temperature, if not, increase the temperature at 1°F (0.5°C) intervals by making small incremental adjustments to the temperature controller, allowing 1 min between each increment and the test for the flash point. Record the temperature at which the flash actually occurs. Record the barometric pressure.

11.5 *Finite Flash Point*—If no flash point is observed proceed as follows:

11.5.1 Using a test temperature of 9°F (5°C) higher than the temperature observed in 11.3, repeat step 11.3 (Note 6). If no flash is observed, repeat at 9°F (5°C) higher intervals until flash is observed.

11.5.2 Using a new sample, repeat 11.4.2 until a flash occurs. Record the temperature at which the flash occurs and the barometric pressure.

12. Clean Up Of Apparatus and Preparation for Next Test

12.1 To prepare for the next test, unlock the lid assembly of the tester and raise to the hinge stop. Soak up liquid samples with an absorbent paper tissue and wipe dry. Clean the underside

of the lid and filling orifice. A pipe cleaner may be of assistance in cleaning the orifice.

12.2 If the sample is a viscous liquid or contains dispersed solids, after soaking up most of the sample, add a small amount of a suitable solvent for the sample to the cup and then soak up the solvent and wipe clean the interior surfaces of the cup with an absorbent tissue paper.

NOTE 8—If necessary to remove residual high boiling solvent residues, moisten tissue with acetone and wipe clean.

NOTE 9—If any further cleaning is necessary, remove the lid and shutter assembly. Disconnect the silicone rubber hose and slide the lid assembly to the right to remove. If warm, handle carefully.

12.3 After the cup has been cleaned, its temperature may be rapidly increased to some stand-by value by turning the temperature control dial to an appropriate point.

NOTE 10—It is convenient to hold the test cup at some stand-by temperature (depending on planned usage) to conserve time in bringing the cup within the test temperature range. The cup temperature may be quickly lowered by inserting the aluminum cooling block filled with an appropriate cooling mixture into the cup.

12.4 The syringe is easily cleaned by filling it several times with acetone or any compatible solvent, discharging the solvent each time, and allowing the syringe to air dry with the plunger removed. Replace the plunger, and pump several times to replace any solvent vapor with air.

13. Correction for Barometric Pressure

13.1 When the barometric pressure differs from 760 mm Hg (101.3 kPa), calculate the flash point temperature by means of the following equations:

$$\begin{aligned} \text{Calculated flash point} &= F + 0.06(760 - P) \\ &= C + 0.03(760 - P) \end{aligned}$$

where:

F, C = observed flash point, °F (or °C), and
P = barometric pressure, mm Hg.

13.2 Likewise determine the corrected specification flash point by the following equation:

$$\begin{aligned} F &= S - 0.06(760 - P) \\ C &= S - 0.03(760 - P) \end{aligned}$$

where:

F, C = flash point to be observed to obtain the specification flash point at standard pressure (S),
S = specification flash point.

14. Report

14.1 When using the flash/no flash method, report whether the sample flashed at the required flash point and that the flash/no flash method was used.

14.2 If an actual flash point was determined, report the average of duplicate runs to nearest 1°F (0.5°C) provided the difference between the two values does not exceed 2°F (1°C).

15. Precision^a

15.1 The following criteria should be used for judging the acceptability of results (95 % confidence):

15.1.1 Liquids at or below 45 SUS at 100°F or equivalent viscosity measurements.

15.1.1.1 *Repeatability*—The average of duplicate results obtained by the same operator on

different days should be considered suspect if they differ by more than 3°F (1.7°C).

15.1.1.2 *Reproducibility*—The average of duplicate results, obtained by each of two laboratories should not be considered suspect unless they differ by more than 6°F (3.3°C).

15.1.2 Viscous liquids above 45 SUS at 100°F or liquids with dispersed solids.

15.1.2.1 *Repeatability*—Duplicate results obtained by the same operator on different days should be considered suspect if they differ by more than 6°F (3.3°C).

15.1.2.2 *Reproducibility*—The average of duplicate results obtained by each of two laboratories should not be considered suspect unless they differ by more than 9°F (5°C).

^a Supporting data for this method has been filed at ASTM Headquarters RR 0-1-1000 and reported in Journal of Paint Technology, Vol 45, No. 581 Page 44.

APPENDIXES

X1. APPARATUS SPECIFICATIONS

X1.1 A typical apparatus is shown in Fig. X1 and X2. Electrical heaters are fastened to the cup in such a way so as to provide for efficient transfer of heat. The tester includes a variable heater control device with a scaled dial and a visible signal to indicate when energy is or is not being applied. Energy may be supplied from a 115 or 230-V a-c main service (for stationary use) or by a 12-V d-c battery service (for field use). A regulatable test flame and a pilot flame

to maintain the test flame, are provided. These flames may be fueled by piped gas service (fixed location) or by a self-contained tank of liquefied petroleum gas (5.3) (for portability). A test flame, ½ in. (4 mm) in diameter, is provided against which the size of the flame may be judged. Never recharge the gas tank with the pilot or test flames lighted, nor in the vicinity of other naked flames. A 1-min audible signal is a desirable accessory.

X2. COOLING BLOCK

X2.1 The cooling block with dimensions as shown in Fig. X3, is made of aluminum and covered with

pipe insulation.

X3. SPECIFICATIONS FOR *p*-XYLENE REFERENCE STANDARD

X3.1 *Specific Gravity (60/60°F) (15.6/15.6°C)*—0.860 min, 0.866 max.

X3.2 *Boiling Range*—2°C max from start to dry point, when tested by Method D 850 or Method

D 1078. The range shall include the boiling point of pure *p*-xylene, which is 138.35°C (281.03°F).

X3.3 *Freezing Point*—11.23°C min (95 % molal purity) as determined by Method D 1015.

KEY: Existing rules are printed in standard type face. Proposed additions to existing rules are printed in boldface, while proposed deletions from existing rules are printed within [single brackets]. Additions to proposed rules are underlined and boldfaced, while deletions from proposed rules are printed within [[double brackets]].

TABLE XI Setaflash Thermometers

ASTM No. Name	XXF (XXC) Setaflash Medium	XXF (XXC) Setaflash L3w
Range	32 to 230°F (0 to 110°C)	-10°C - 160° (-23 to 70°C)
Immersion	44.5 ± 1 mm	44.5 ± 1 mm
Graduations		
Subdivisions	1° F (1°C)	1° F (1°C)
Long lines at each	10° F (10°C)	10° F (10°C)
Number at each*	10° F (10°C)	10° F (10°C)
Scale error, max	0.5° F (0.25°C)	0.5° F (0.25°C)
Expansion chamber, for heat to†	248° F (120°C)	176° F (80°C)
Total length	204 ± 3 mm	204 ± 3 mm
Stem, OD	6 to 7 mm	6 to 7 mm
Bulb		
Length	11.7 to 13.7 mm	11.7 to 13.7 mm
OD	4.7 to 5.7 mm	4.7 to 5.7 mm
Scale location:		
Bottom of bulb to 32° F (0°C)	49 to 51 mm	
Bottom of bulb to -10° F (-23°C)		59 mm to 61 mm
Bottom of bulb to 230° F (110°C)	163 to 176 mm	
Bottom of bulb to 160° F (71°C)		183 to 185 mm

- * Number so that figures are read from right to left in a horizontal plane.
- † Expansion bulb to be nitrogen filled for horizontal operation.

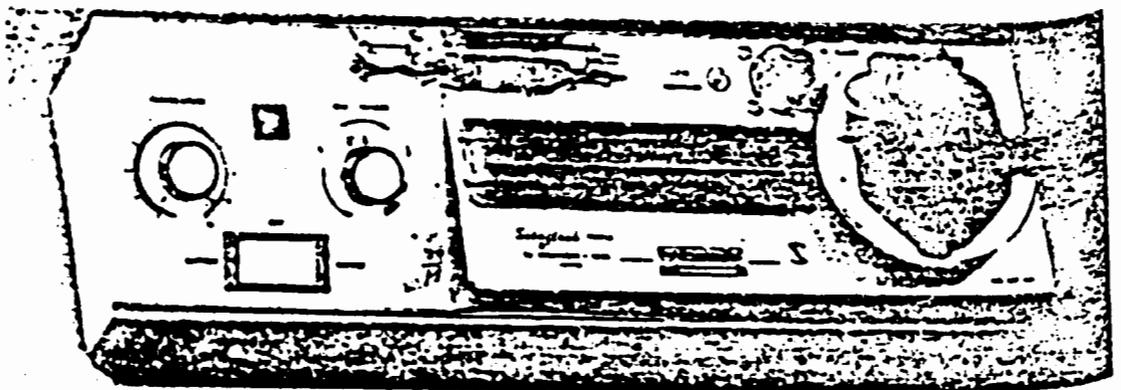
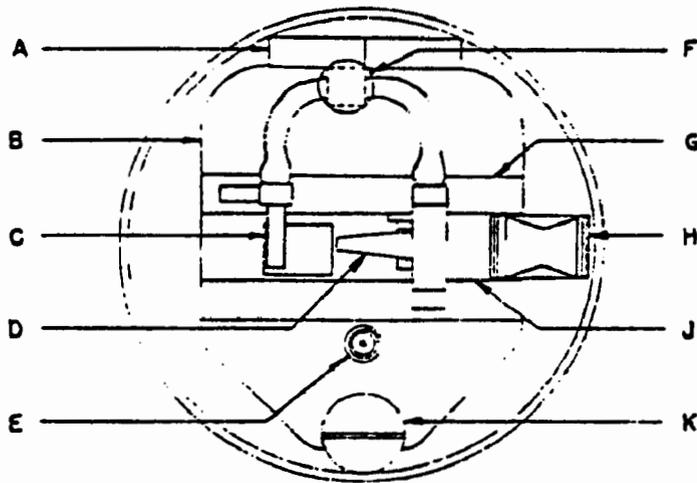
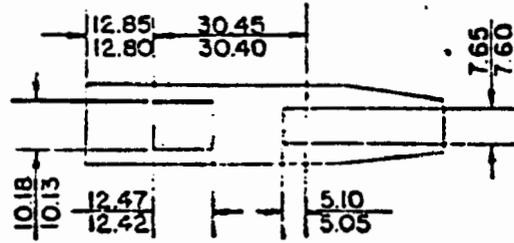
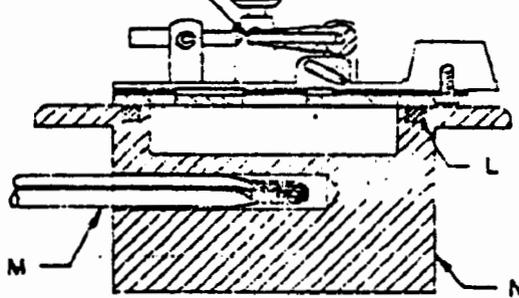


FIG. XI Setaflash Tester.

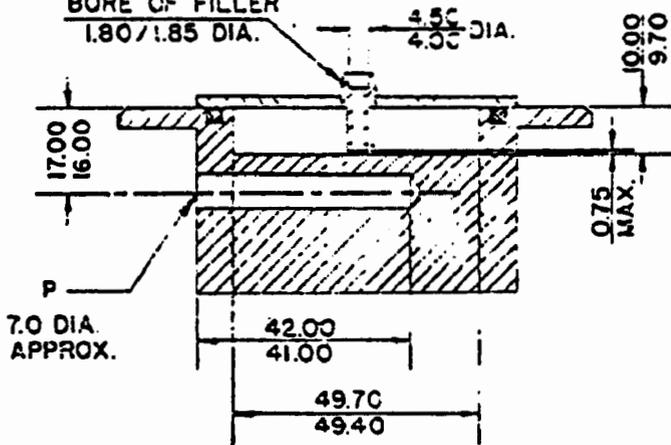


BORE OF JET
 1.65/1.60 DIA.

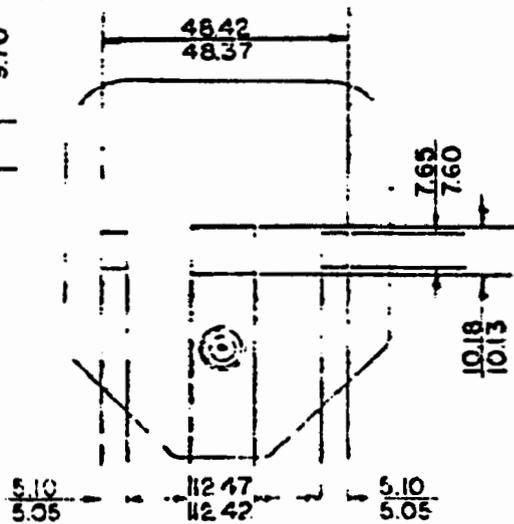


SLIDE (1.22 THICK APPROX.)

BORE OF FILLER
 1.80/1.85 DIA.



SAMPLE BLOCK



LID (2.00 THICK APPROX.)

FIG. X2 Setaflash Unit

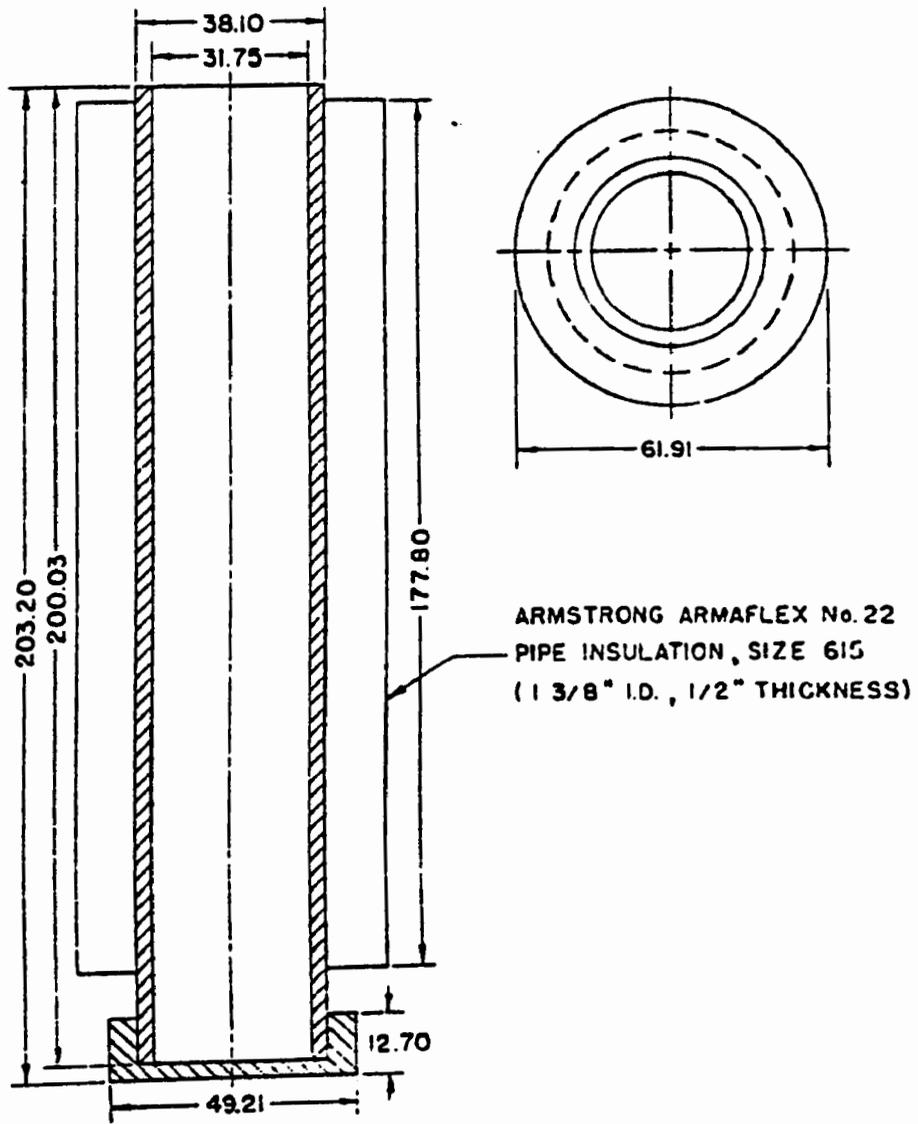


FIG. 3 Cooling Block

B-5 Classification Test
Methods for Flammable Solids

NOV 7

Report of Investigations 7593

Classification Test Methods for Flammable Solids

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Rogers C. B. Morton, Secretary

BUREAU OF MINES
Elbert F. Osborn, Director

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CONTENTS

	<u>Page</u>
Abstract.....	1
Introduction.....	1
Proposed method for flammable solids.....	2
Proposed method for extremely flammable solids.....	8
Classification of flammable solids by proposed test methods.....	10

ILLUSTRATION

1. Apparatus for determining ignitability of flammable solids.....	3
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TABLES

1. Ignitability of various flammable solids by rotating disk ignition method.....	5
2. Horizontal flame spread rates of various solids.....	7
3. Summary of data from self-ignition experiments with various pyrophoric-type materials.....	9
4. Comparison of hazard classification ratings for various flammable solids and pyrophoric-type materials.....	12

CLASSIFICATION TEST METHODS FOR FLAMMABLE SOLIDS

by

J. M. Kuchta¹ and A. F. Smith²

ABSTRACT

Ignition and flammability test methods were developed by the Bureau of Mines for use in the classification of flammable solids by the Department of Transportation. A rotating disk ignition apparatus and a flame-spread-rate apparatus are proposed for determining the ignitability and flammability, respectively, of most flammable solids. Extremely flammable solids, such as pyrophoric materials, are evaluated by determining their ease of spontaneous ignition in an environmental chamber at high-humidity conditions. Data are presented for various representative solids to show the reliability of the test methods for classifying the materials. A classification system is also proposed for use in government transportation regulations.

INTRODUCTION

The Bureau of Mines research programs are partly directed to developing safety guidelines for the reduction of fires and explosions in industries that produce, transport, or utilize mineral fuels and their products. As a result of a request by the Department of Transportation, the Bureau is evaluating test methods for classifying hazardous materials and developing new methods, where necessary, for use in government transportation regulations.³ A report on methods for the classification of flammable liquids was recently prepared under this work.⁴ The present report is on flammable solids for which no classification test method is given in the transportation regulations. According to these regulations, a flammable solid is defined as any solid material, other than an explosive, which can be readily ignited or which can cause or contribute significantly to fire under the conditions encountered during

¹Supervisory research chemist.

²Research chemist.

³Agent T. C. George's Tariff No. 23, Hazardous Materials Regulations of the Department of Transportation, ICC No. 23, Bureau of Explosives, 2 Penn Plaza, New York, 1969.

⁴Kuchta, J. M., and David Burgess. Recommendation of Flash Point Method for Evaluation of Flammability Hazard in the Transportation of Flammable Liquids. April 29, 1970, 11 pp. Available from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Va. 22151. PB-193077.

transportation. Thus, to classify such materials, it is necessary to consider both their ignitability and flame spread behavior. Since existing test methods were not considered adequate for this purpose, new methods were developed which are described in this report. The methods are designed to evaluate (1) flammable solids that require high temperatures or an external energy source for ignition, and (2) extremely flammable solids that can self-ignite at normal ambient temperatures.

PROPOSED METHOD FOR FLAMMABLE SOLIDS

Selection of a test method for classifying flammable solids is complicated by the fact that the ignitability or flammability hazard can vary greatly with the ignition stimulus, as well as with the physical form and size of the material. Minimum spark-ignition energies are frequently used to partially define the ignitability hazard of finely divided materials such as flammable dusts. However, such determinations are much less useful for coarse or massive solids since their spark-ignition energies tend to be extremely large. For example, the values for magnesium dust clouds can increase from 20 to at least 1,900 millijoules when the particle size is varied from about 50 to 200 microns.⁵ Minimum ignition temperatures, such as those determined in heated vessels, also are not considered suitable for this application. The ignition temperatures of most flammable solids, excluding the extremely flammable, are over 500° F^{6 7} and are primarily applicable to situations where the combustible and air are heated uniformly and under quiescent conditions to such elevated temperatures. Accordingly, a method was developed in which flammable solids could be compared by measuring their relative ease of ignition and rate of flame spread when exposed to flames in air. This simulates a typical ignition condition that could result from the inadvertent use of flame devices or from a fire produced in a cargo accident. A method for evaluating extremely flammable solids is given in a subsequent section of this report.

Figure 1 shows a sketch of the apparatus proposed for determining the ease of ignition of flammable solids. The apparatus consists essentially of a rotating disk with a variable slot near the outer circumference through which a pencil-like flame is allowed to pass and impinge on the sample. The slot is 1/4 inch wide and is fitted with an adjustable cover to vary the length of the opening. A butane torch capable of producing a uniform jet, approximately 1/4 inch in diameter and 1-1/4 to 1-1/2 inches long, is employed as the flame source. A propane torch would give essentially the same results. These tests were made with a commercially available torch (Turner burner with pencilpoint burner head, model No. 603)⁸ at a gas pressure of 7±0.5 psig. The minimum time for ignition (sustained flame) is obtained by varying the speed of the rotating disk and the length of the slot opening; disk speeds between 0.4 and

⁵Jacobson, Murray, Austin R. Cooper, and John Nagy. Explosibility of Metal Powders. BuMines Rept. of Inv. 6516, 196-, 25 pp.

⁶Work cited in footnote 5.

⁷National Fire Protection Association. Fire Hazard Properties of Dusts.

Ch. in Fire Protection Handbook. Boston, Mass., 13th ed., 1969, p. 5-51.

⁸Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

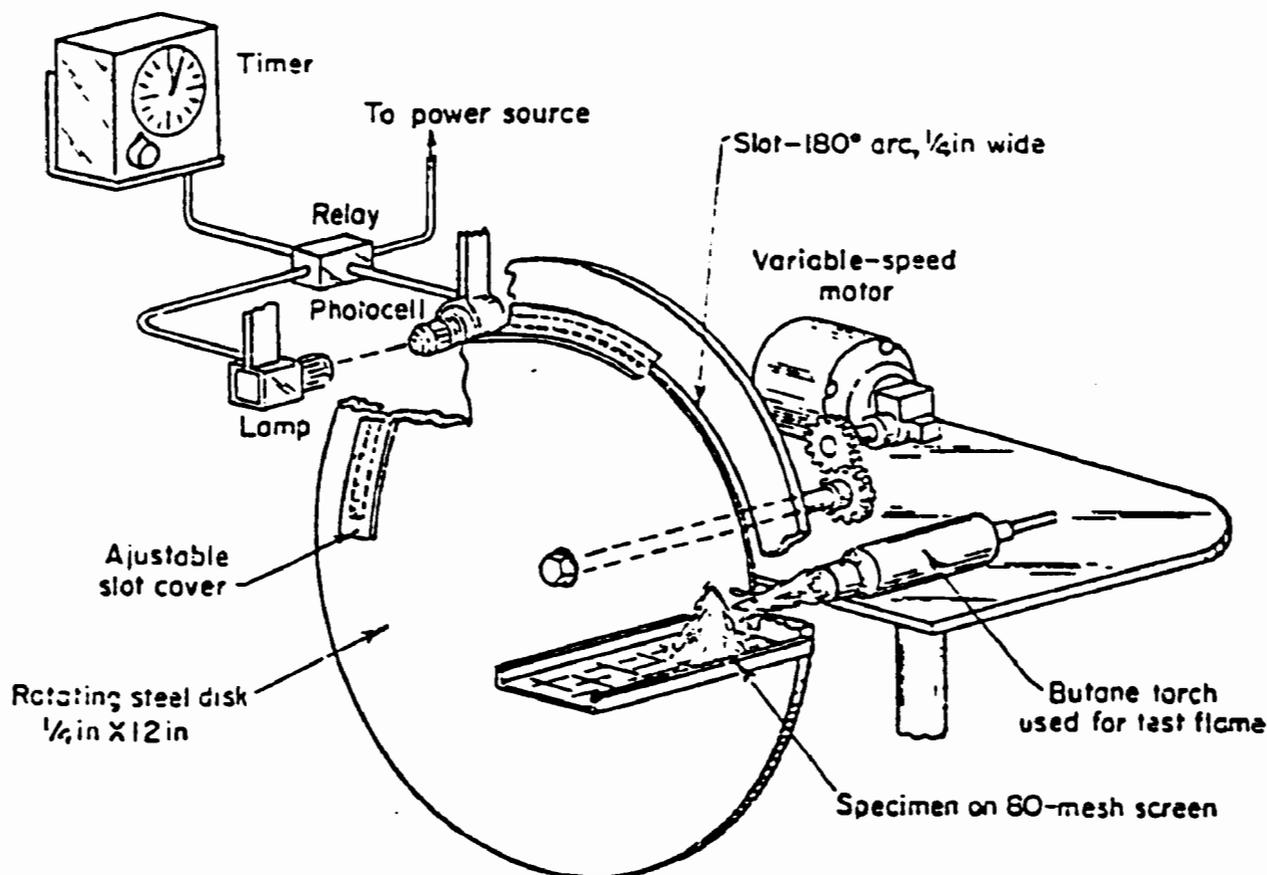


FIGURE 1. - Apparatus for Determining Ignitability of Flammable Solids.

8.5 rpm were used in the present work. Duration of the flame in the slot opening is determined by means of a photoelectric cell and timer, as shown in figure 1. This apparatus is similar in principle to one developed earlier by the Bureau for evaluating the ignitability of potentially unstable substances like organic peroxides.⁹ The latter method used a more severe heat source (oxygen-hydrogen flame) with the sample confined to a small cup, as compared to a totally unconfined sample in the present method. German investigators¹⁰ have proposed the use of a propane or manufactured coal gas flame from a Bunsen burner, as well as various other heat sources, for comparing the ignitability of flammable solids. However, since ignition occurs more readily when the flame is applied to the exposed surfaces of a sample bed, that is, from above rather than from below the bed, the use of a Bunsen flame is greatly limited because of convection and buoyancy effects.

In the proposed method, the flame from the butane torch is applied near the base of the sample bed, which is cone shaped for powders or granular materials and which is supported by an 80-mesh stainless steel screen to permit

⁹Although the Bureau work is unpublished, the method is described in a report by the National Board of Fire Underwriters, Research Report No. 11, 1956, p. 22.

¹⁰Koenen, H., K. H. Ide, and K. H. Swarc. (Safety Characteristics of Explosive Substances.) *Explosivstoffe*, v. 9, 1951, pp. 4-13, 30-42.

vertical circulation of air through the bed. A cone-shaped bed, at least 1 inch in height, was required to obtain the lowest and most reproducible ignition times; smaller size beds yielded inconsistent results for the coarser or less ignitable materials. In addition, the distance between the sample and burner was fixed at approximately 1-1/4 inches, beyond which the ignition times can be expected to increase. With sheet materials, small strips are supported in a vertical position to provide favorable conditions for ignition; the width of the strips is varied, depending upon the thickness of the sample. Generally, the shortest ignition times occur when the flame impinges edgewise on the strips.

Since the ignitability of finely divided solids can vary with particle size, the test samples should be at least as fine as the materials may be during their shipment. Fine powders can be evaluated primarily in their "as-received" condition. However, in the case of coarse materials, samples as fine as about 50 to 150 mesh (Tyler screen series) should also be evaluated, by pulverizing and/or screening the "as-received" materials, insofar as is possible.

Table 1 summarizes the ignition times that were obtained with the rotating disk apparatus for various representative flammable solids. Most of the data are average values of at least two trials. Reproducibility is indicated by the following average ignition times and deviations for replicate trials with three of the finely divided solids. Burner-to-sample distance was 1-1/4 inches.

Camphor.....	0.27±0.2 second (4 trials)
Ammonium dichromate....	6.5±0.3 seconds (4 trials)
Tetraphenyl tin.....	9.4±0.6 seconds (3 trials)

With the 1-1/4-inch burner-to-sample distance, the ignition times ranged from less than 0.02 second for powders such as phosphorus sesquisulfide and red phosphorus to at least 9 seconds for phthalic anhydride and tetraphenyl tin; corresponding times with a 1-1/2-inch burner-to-sample distance ranged from less than 0.6 second to at least 15 seconds. Metal powders like titanium and magnesium, as well as water-wet picric acid (10-12 percent H₂O), displayed a greater ignitability hazard than ammonium dichromate, but less than that of sodium methylate, sodium borohydride, or camphor, each of which ranked just below the most highly ignitable solids. Note that a new stock sample of picric acid was more difficult to ignite than an old stock sample whose water content was apparently lower. For coarse materials whose particle size was varied in these tests, the ignitability hazard generally did not increase with samples as fine as approximately 50 to 150 mesh were used. Because of the nature of such solids as camphor, sodium borohydride, and the water-wet picric acid, their evaluation was necessarily limited to representative samples of the rather coarse "as-received" materials. As expected, wood charcoal samples did not produce normal ignition by this test method, although sustained incandescence was obtained. In addition, none of the sheet-type samples of safety photographic film and butyl rubber displayed a high ignitability hazard.

TABLE 1. - Ignitability of various flammable solids by rotating disk ignition method

	Description	Ignition time, seconds	
		Burner-to-sample distance	
		1.25 in	1.5 in
Granular or powder materials:¹			
Phosphorus sesquisulfide.....	50 to 150 mesh	<0.02	<0.6
Phosphorus, red.....	100 to 200 mesh	<.02	-
Camphor.....	~10 to 30 mesh	.27	.8
Do.....do.....	² .25	-
Sodium methylate.....	70 to 150 mesh	.3	.4
Sodium borohydride.....	~10 to 30 mesh	.35	-
Picric acid, 10-12 pct H ₂ O.....	~10 to 50 mesh	³ 1.1	³ 1.3
Do.....do.....	⁴ 3.1	-
Titanium.....	100 to 200 mesh	1.9	-
Magnesium.....	>80 mesh.....	2.2	4.5
Do.....do.....	² 1.5	-
Do.....	70 to 150 mesh	3.4	-
Ammonium dichromate.....	30 to 100 mesh	6.5	16
2,4-Dinitroaniline.....	40 to 70 mesh	8	13
Do.....	50 to 150 mesh	8.5	-
Tetraphenyl tin.....	50 to 200 mesh	9.5	15
Phthalic anhydride.....	20 to 70 mesh	9	16
Do.....	50 to 150 mesh	>10	-
Charcoal, willowwood.....	40 to 50 mesh	⁵ 6	-
Charcoal, blend.....do.....	⁵ 1.4	-
Sheet materials:⁵			
Photographic film, safety, processed....	1/4 in x 1 in.	2.5	-
Do.....	1/16 in x 1 in.	2.3	-
Photographic film, safety, unprocessed...	1/4 in x 1 in.	2.3	-
Butyl rubber sheet.....	1/4 in x 1 in.	6.5	-
Do.....	1/16 in x 1 in.	9.5	-
Rod-shaped material: ¹ Matches, "strike anywhere."	Matchhead fragments.	.2	-

¹ Cone-shaped beds.

² 1/16-in layer.

³ Old stock sample.

⁴ New stock sample.

⁵ Sustained glow.

⁶ Vertically mounted strips.

To classify flammable solids, a test method is also proposed for determining their horizontal flame spread rates. Although the rates are generally higher with upward burning, depending upon the angle, they are not normally determined in this manner with finely divided solids because of the problem of holding the samples in place. As in the ignition experiments, the samples are

supported by a stainless steel screen (80 mesh) on a rectangular burning rack and ignited at one end with a butane torch or a similar flame source. Samples having essentially the same particle size ranges as in the ignition experiments are also used here. The sample bed should be at least 1/4 inch high and 1/2 inch wide with all sides of the bed exposed to air. The rates are determined by measuring the time required for the flame to travel over a 5-inch sample bed, although longer beds can be used to increase the accuracy of the measurements. A total bed length of 7 inches was used here and the rates were measured over the final 5 inches of burning. To facilitate making these measurements, the burning rack is equipped with two fuse wires (0.5 amp) spaced 5 inches apart and connected to appropriate relays and an electric timer; a stopwatch can also be used for slow-burning solids. The flame spread rates for sheet-type samples are determined by using 1/2-inch or 1-inch by 5-inch strips that are folded to form an inverted V-shaped channel and which are supported on the burning rack by a few fine wires (0.01 inch). Rod- or bar-shaped samples are arranged in a crisscross pattern or other pattern that is most favorable for burning. In the case of materials such as matches, the layers should be arranged to permit measurement of the rate over the surfaces of the matchheads, that is, over the most flammable part.

Similar burning tests are proposed by the Department of Health, Education and Welfare (HEW)¹² for determining the flammability of hazardous household substances. However, the method proposed in the HEW regulation for rigid and pliable solids does not require the use of folded strips, which is a necessary condition for sustained horizontal burning of some flammable solids, including photographic safety films. Also, the method described in the above regulation for powders and granular solids can give lower burning or flame spread rates than expected because of large heat losses and limited air circulation due to the type of sample container used in that method, a flat, rectangular, aluminum foil boat. Furthermore, the proposed visual determination of burning time in the latter method is not reliable for fast-burning substances.

Table 2 summarizes the flame spread rates obtained for various flammable solids by the Bureau's proposed method. The rates were reproducible to within ± 10 to ± 20 percent, depending upon their magnitude, and did not vary greatly when the height of the sample bed was increased from 1/4 to 1/2 inch. (Lower rates usually occur when smaller sample beds are employed.) As noted, the rates of flame spread for the granular or powder materials varied from about 90 in/min or more for phosphorus sesquisulfide and red phosphorus to less than 4 in/min for materials such as phthalic anhydride and tetraphenyl tin. The wood charcoal samples again displayed the least hazard and did not propagate flame after ignition. In comparing tables 1 and 2, it is evident that the ignition data for some materials do not necessarily give the same order of hazard ranking that is indicated by the flame spread data. For example, sodium borohydride is easier to ignite than titanium and magnesium but the latter solids have much higher flame spread rates than that of sodium borohydride. Note also that the rates of metal powders such as magnesium depend

¹² Food and Drug Administration, Department of Health, Education, and Welfare. Hazardous Substances (Code of Federal Regulations, Title 21, Part 191). Federal Register, v. 35, No. 160, Aug. 13, 1970, pp. 239-253.

greatly upon particle size. However, in the case of nonmetal powders, the flame spread rates are not necessarily increased with a decrease in particle size, particularly if the powders tend to agglomerate when forming the sample bed. Thus, although fine samples (~50 to 150 mesh) of the coarse materials should be evaluated where possible, their flame spread hazard with coarser or "as-received" samples must be given equal consideration. Generally, most of the flammable solids that displayed a high ignitability hazard also had high flame spread rates >10 in/min.

TABLE 2. - Horizontal flame spread rates of various solids

Bed size. in.....	Flame spread rate. ¹ in/min		Description
	1/4 x 1/2 x 5	1/2 x 1/2 x 5	
Granular or powder materials:			
Phosphorus sesquisulfide....	115	-	50 to 150 mesh.
Phosphorus, red.....	97	88	100 to 200 mesh.
Titanium.....	60	75	100 to 200 mesh.
Camphor.....	40	35	~10 to 30 mesh.
Magnesium.....	30	-	>80 mesh.
Do.....	-	13	70 to 150 mesh.
Do.....	1.4	1.1	70 to 80 mesh.
Sodium methylate.....	21	29	70 to 150 mesh.
Picric acid, 10-20 pct H ₂ O..	² 5	² 7.5	~10 to 50 mesh.
Do.....	-	³ 5	Do.
2,4-Dinitroaniline.....	-	6.5	40 to 70 mesh.
Do.....	-	1.4	50 to 150 mesh.
Ammonium dichromate.....	1.9	4	30 to 100 mesh.
Do.....	-	3.2	50 to 150 mesh.
Sodium borohydride.....	3.5	3.4	~10 to 30 mesh.
Phthalic anhydride.....	3.8	2.4	20 to 70 mesh.
Do.....	-	1.0	50 to 150 mesh.
Tetraphenyl tin.....	2.8	2.7	50 to 200 mesh.
Charcoal, willowwood.....	⁴ 3	-	40 to 50 mesh.
Charcoal, blend.....	⁴ 2	-	Do.
Strip size. in.....	1/2 x 5	1 x 5	
Sheet materials:			
Photographic film, safety, processed.	26	28	Inverted, V-shaped strips.
Photographic film, safety, unprocessed.	9	11	Do.
Butyl rubber, 1/16 in thick.	1.3	2.2	Do.
Bed size. in.....	1 x 5		
Rod-shaped materials:			
Matches, "strike anywhere"..		27	4 uniform layers.
Do.....		21	2 uniform layers.
Do.....		11	4 crisscrossed layers.

¹Total bed length is 7 in, rates measured over final 5 in of burning.

²Old stock sample.

³New stock sample.

⁴Incandescent-type burning.

PROPOSED METHOD FOR EXTREMELY FLAMMABLE SOLIDS

No standard method is available for evaluating extremely flammable solids, such as pyrophoric powders, which can ignite spontaneously on exposure to air at ambient temperature. A test developed by the Bureau of Explosives (American Association of Railroads) for pyrophoric liquids is considered by a United Nations working group to be adaptable to some solids but not to powderlike substances.^{1,2} This method requires rather large quantities of hazardous materials and involves the use of a sawdust reacting medium, although the particle size, moisture content, and grade of sawdust are not specified. Also, the maximum relative humidity that is specified, 75 percent, may not be high enough for evaluating the pyrophoricity of some materials.

A method is proposed here for determining the ease of ignition of pyrophoric type substances using small samples at ambient temperatures of 90° or 130° F and at various humidity conditions. The higher temperature is the maximum specified by the Department of Transportation for classification regulations. This method requires an environmental chamber in which the relative humidity can be varied from 50 to 90 percent and controlled to within ± 5 percent. The sample is placed in the center of a 4-inch-diameter by 6-inch-long glass reaction tube that is mounted vertically in the environmental chamber and packed with glass wool to minimize heat losses. The reaction tube is open at both ends to permit circulation of air. The extent of reaction is determined by visual observations and by measuring the temperature rise near the top of the sample bed using a 30-gage iron-constantan thermocouple; output of the thermocouple is fed to a continuous-pen recorder. Because of their high reactivity, the samples must be handled in a nitrogen "dry box" and stored in gastight containers.

The present experiments were carried out in a 27-cubic-foot environmental chamber that was available, although a smaller chamber of only a few cubic feet capacity could be used. The chamber was equipped with heating controls and a 12-inch fan (1,500 rpm) to circulate the air through a closed-loop system. A steel shield was installed between the fan and the glass reaction tube to reduce the air flow around the reaction site; however, the results proved to be insensitive to such changes. Sample size and relative humidity were varied to obtain the optimum conditions for ignition; approximately 5 grams (0.16 oz) appeared to be adequate for the pyrophoric solids that were tested. With suspensions or solutions of pyrophoric materials, a sample of 30 ml or more was used; such samples were added to a small quantity of asbestos or glass wool before being placed in the center of the packed reaction tube.

Table 3 summarizes typical data from self-ignition experiments with several representative pyrophoric materials. The white phosphorus ignited at initial temperatures of 90° and 130° F, whereas the sodium, sodium hydride, and lithium hydride ignited only at the higher temperature over the range of relative humidities employed. Although data from all trials are not given, ignition probability tended to be greater at the higher relative humidities.

^{1,2}United Nations Working Group on Organic Peroxides and Pyrophoric Substances, Meeting of March 2, 1970, Geneva, Switzerland.

As noted by the 130° F data for the two hydrides, the times required for ignition generally decreased when the relative humidity was varied from 54 to 88 percent with lithium hydride and from 68 to 87 percent with sodium hydride. Since the measured temperature rises were dependent upon thermocouple location, the values shown in table 3 do not represent maximum values. Where ignitions are indicated, these were verified by visual observation of flame. Normal ignitions were not observed to occur with the two Grignard reagents at 90° or 130° F, although the temperature rises produced with the methyl magnesium chloride reagent (2.85 molar) were at least 1,000° F at the higher-humidity conditions. The phenyl magnesium chloride reagent (2.54 molar) produced only slight charring at 130° F and measured temperature rises were not over 270° F. Essentially the same results were found with this reagent when the sample quantity was increased from 30 to 60 ml or to 120 ml; also, the temperature rises were not any greater when the sample was mixed with a dry red oak sawdust rather than glass wool. Nevertheless, although the temperature rises were less for this material than for the others examined here, they are evidence of noticeable self-reaction which could conceivably lead to ignition under more ideal reaction conditions, such as those possible with large lots of the reactant materials. An increase in the concentration of the Grignard reagent may also increase the possibility of ignition.

TABLE 3. - Summary of data from self-ignition experiments with various pyrophoric-type materials

	Sample quantity	Relative humidity, pct	Initial temp, ° F	Reaction temp (T)		Visual observation
				ΔT, ° F	Time, min	
Solid materials:						
White phosphorus, small-size cuts.	4g	79	130	1,110	0.5	Ignition.
	4g	90	90	820	2	Do.
Sodium, small-size cuts....	4g	85	130	660	8	Do.
	4g	89	90	170	≥4	No ignition.
	4g	74	90	170	≥4	Do.
Lithium hydride, powder....	5g	88	130	1,280	.1	Ignition.
	6g	88	130	>1,500	3	Do.
	5g	78	130	1,200	11	Do.
	4g	76	130	>1,500	7	Do.
	5g	65	130	1,110	27	Do.
	5g	54	130	>1,500	46	Do.
	5g	86	90	270	≥4	No ignition.
Sodium hydride, powder.....	5g	87	130	>1,500	13	Ignition.
	3g	84	130	1,120	10	Do.
	5g	68	130	890	21	Do.
	5g	86	90	190	≥27	No ignition.
Grignard reagents:						
Methyl magnesium chloride..	30 ml	88	130	1,050	26	Charred residue.
	30 ml	79	130	980	27	Do.
	30 ml	65	130	600	25	Do.
	30 ml	55	130	900	16	Do.
	30 ml	92	90	1,010	42	Do.
	30 ml	62	90	530	21	Do.
	30 ml	53	90	560	48	Do.
Phenyl magnesium chloride..	60 ml	86	130	270	46	Slight charring.
	30 ml	88	130	250	22	Do.
	30 ml	65	130	235	22	Do.
	30 ml	56	130	250	21	Do.

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CLASSIFICATION OF FLAMMABLE SOLIDS BY PROPOSED TEST METHODS

The classification of most flammable solids should be possible by the test methods described in this report. Since the ease of ignition of a solid may give a different order of hazard ranking than indicated by its flame-spread behavior, both combustion properties must be considered to obtain a reliable classification. As outlined below, three classes of flammable solids are recommended for the transportation regulations. Where the classification of a particular solid is in doubt, the class reflecting the greater hazard should be assigned.

Class 1: Flammable solids¹³ which may ignite when exposed to flame such as a butane torch, but which propagate flame horizontally at rates less than 10 in/min by the proposed method.

Class 2: Flammable solids¹³ which are rated highly flammable either because of their great ease of ignition when exposed to flame such as a butane torch, or because of their ability to propagate flame at rates greater than 10 in/min. (Solids which ignite in less than 1 second by the proposed flame exposure test would be included in this class.)

Class 3: Extremely flammable solids which may ignite spontaneously in dry or moist air at ambient temperatures equal to or less than 130° F. (Solids which react to produce flame or temperature rises over 500° F by the proposed pyrophoricity test would be included in this class.)

One group of flammable solids that is not included in the above classification is the spontaneous-heating type which may ignite at ambient temperature from slow oxidation. The reaction time for such solids is usually several hours or more. This group includes such solids as granulated charcoal, animal fibers, and particularly, substances which have been contaminated with vegetable oils. To evaluate their maximum spontaneous heating hazard, an adiabatic tester similar to the type developed by the National Bureau of Standards¹⁴ is necessary; however, the design of this type of tester is relatively complex. Simpler designs such as the one developed by Factory Mutual Laboratories¹⁵ simulate adiabatic conditions rather roughly and are not necessarily intended for evaluating solids. Although solids capable of spontaneous heating can pose a serious ignition hazard, they are far less hazardous than pyrophoric materials. Therefore, they should normally be assigned to class 2 of the proposed classification.

¹³For finely divided solids, sample beds should be cone-shaped for ignition tests and at least 1/4 inch high x 1/2 inch wide x 5 inches long for flame spread rate tests; particle size range should be comparable to that possible in shipment.

¹⁴Gross, D., and A. F. Robertson. Self-Ignition Temperatures of Materials From Kinetic-Reaction Data. J. of Res., National Bureau of Standards, v. 61, No. 5, November 1958, p. 413.

¹⁵Little, J. P. An Adiabatic Spontaneous Heating Tester. NFPA Quarterly, April 1958, p. 308.

On the basis of the present experimental data, the flammable substances that were investigated were classified according to the proposed scheme. Table 4 shows the classification ratings for the various materials by this method. This table also compares the ratings or classes that are given by the Inter-Governmental Maritime Consultative Organization (IMCO)¹⁶ and the National Fire Protection Association (NFPA)¹⁷ ¹⁸ for the same materials and for a few others. The IMCO classification designates flammable solids as class 4 with the following subclasses:

Class 4.1: Flammable solids that are easily ignited by external heat sources.

Class 4.2: Spontaneously combustible solids or liquids.

Class 4.3: Substances that emit flammable gases when wet and which may ignite spontaneously in some cases.

The NFPA classes of flammability are defined as follows:

Class 1: Materials that must be preheated to ignite.

Class 2: Materials that must be exposed to relatively high ambient temperatures to ignite and solids that readily give off flammable vapors.

Class 3: Materials that can ignite under almost all ambient temperatures. Solids that can create flash fires and burn rapidly.

Class 4: Materials which vaporize at normal ambient temperatures or are easily dispersed, and which can readily form explosive mixtures in air.

In the NFPA classification, water-reactive materials are included under a separate reactivity hazard category.

Since the classification systems employ different numerical ratings or classes for hazard identification, it is difficult to make a direct comparison of the listings given in table 4. Nevertheless, some significant differences which are evident are worth noting. Under the Bureau classification, white phosphorus and the alkali metals and hydrides that were tested are assigned to class 3, which is identified as the most hazardous class on the basis of pyrophoricity in dry or moist air. Except for white phosphorus, such solids are also included in the most hazardous class by the IMCO classification because of their high reactivity with moisture or water. In comparison, the NFPA flammability classification gives a very low flammability hazard rating (class 1) for some of these same materials (for example, sodium), even though they may ignite spontaneously in moist air at near ambient temperatures. On the other hand, these materials are also listed as highly water-reactive substances by the NFPA. In the case of Grignard reagents, these should and do fall in the pyrophoric class or a lower class, depending upon their composition

¹⁶ International Maritime Dangerous Goods Code, Class 4, Inter-Governmental Maritime Consultative Organization, 101-104 Picadilly, London W1V, 1966, pp. 4000-4410.

¹⁷ National Fire Protection Association. Hazardous Chemicals Data. NFPA No. 49, 1969, 234-pp.

¹⁸ Work cited in footnote 7, pp. 5-155 to 5-207; p. 6-113.

and concentration. Substances which display an equally high flammability and water-reactivity hazard should be assigned to both hazard categories in the Department of Transportation classification regulations; a classification test method for evaluating water-reactive substances is currently being developed by the Bureau.

TABLE 4. - Comparison of hazard classification ratings for various flammable solids and pyrophoric-type materials

Material	Hazard classification rating		
	Bureau of Mines	IMCO ¹	NFPA ²
Phosphorus, white.....	3	4.2	3
Sodium.....	3	4.3	1W
Potassium.....	-	4.3	1W
Lithium.....	-	4.3	1W
Sodium-potassium alloys.....	-	4.3	3W
Sodium hydride.....	3	4.3	-
Lithium hydride.....	3	4.3	4W
Lithium aluminum hydride.....	-	4.3	1W
Grignard reagents:			
Methyl magnesium chloride, 2.85 molar	3	-	-
Methyl magnesium bromide.....	-	4.2	-
Phenyl magnesium chloride, 2.54 molar	2	-	-
Phosphorus sesquisulfide.....	2	4.1	1
Phosphorus, red.....	2	4.1	1
Titanium, powder.....	2	4.1	-
Magnesium, powder.....	2	4.3	1W
Aluminum, powder.....	-	4.3	1
Zirconium, powder, dry.....	-	4.2	4
Camphor or naphthalene.....	2	4.1	2
Sodium methylate.....	2	4.3	-
Sodium borohydride.....	2	4.3	-
Matches, strike anywhere.....	2	4.1	-
Film, motion picture.....	2	4.1	-
Picric acid, >10 pct H ₂ O.....	1	4.1	-
2,4-Dinitroaniline.....	1	(³)	1
p-Nitroaniline.....	-	(³)	1
Ammonium dichromate.....	1	(⁴)	-
Phthalic anhydride.....	1	-	1
Tetraphenyl tin.....	1	-	1
Butyl rubber, sheet or powder.....	1	4.1	-
Charcoal, wood, dry.....	1	-	-
Charcoal, animal or vegetable.....	-	4.2	-

¹ Inter-Governmental Maritime Consultative Organization (London).

² National Fire Protection Association; numbers refer to flammability rating; W indicates water-reactive materials.

³ Classified as poisonous (toxic) substance.

⁴ Classified as oxidizing substance.

With flammable solids like phosphorus sesquisulfide and red phosphorus, the hazard rating (class 2) assigned by the Bureau classification is more severe than that given by the NFPA code (class 1). The lowest IMCO class, which includes most flammable solids, is assigned to the above powders and to materials such as titanium, camphor, motion picture film, and "strike anywhere" matches. All of these are in the intermediate hazard class by the Bureau scheme. Other finely divided solids in this grouping include magnesium, sodium methylate, and sodium borohydride. Although these are not extremely flammable when dry, they are potentially water-reactive, as indicated by the IMCO classification.

The least hazardous flammable solids that were evaluated in this work are included in the last group of substances listed in table 4. This group includes picric acid (>10 pct H_2O), ammonium dichromate, tetraphenyl tin, and other materials having a low ignitability and flammability hazard by the proposed test methods. Under the IMCO classification, some of the materials having a low burning hazard are assigned to other hazard categories instead. For example, ammonium dichromate is classified as an oxidizing substance and dinitroaniline is classified as a poisonous (toxic) substance. Although most charcoals will tend to display a low burning hazard by the proposed flame spread test, they should be assigned to class 2 instead of class 1 under the Bureau classification system because of the spontaneous heating hazard that reportedly can be encountered with such materials. In all cases, the hazard classification should reflect the maximum hazard that the flammable solid may present under transportation conditions likely to be encountered.

Appendix C

DOT Regulations Title 16, CPSC

vided the outside containers are marked as prescribed herein.

(c) Toy paper caps of any kind must not be packed with fireworks.

(d) Each outside container must be plainly marked "TOY CAPS--HANDLE CAREFULLY".

[29 FR 18683, Dec. 29, 1964. Redesignated at 32 FR 5608, Apr. 5, 1967, and amended by Amdt. 173-94, 41 FR 16066, Apr. 15, 1976]

§ 173.110 Charged oil well jet perforating guns, total explosive content in guns not exceeding 20 pounds per motor vehicle.

(a) Charged oil well jet perforating guns transported by motor vehicles operated by private carriers engaged in oil well operations in which the total weight of the explosive contents of shaped charges assembled to guns being transported does not exceed 20 pounds per such vehicle must be packed as prescribed in § 173.80 (b), (c), (d) and (e).

(b) Charged oil well jet perforating guns may be offered for transportation and transported only by private carrier by highway.

[29 FR 18683, Dec. 29, 1964. Redesignated at 32 FR 5608, Apr. 5, 1967, and amended by Amdt. 173-94, 41 FR 16066, Apr. 15, 1976]

§ 173.111 Cigarette loads, explosive auto alarms, toy propellant devices, toy smoke devices, trick matches, and trick noise makers, explosive.

(a) Cigarette loads, explosive auto alarms, toy propellant devices, toy smoke devices, trick matches, and trick noise makers, explosive must be packed in specification containers as follows:

(1) Spec. 15A, 15B, 16A, or 19A (§ 178.168, § 178.169, § 178.185, or § 178.190 of this subchapter). Wooden boxes. Gross weight not to exceed 150 pounds.

(2) Spec. 12B (§ 178.205 of this subchapter). Fiberboard boxes. Gross weight not to exceed 65 pounds.

(3) Each outside container must be plainly marked with the proper descriptive name and "HANDLE CAREFULLY"

[29 FR 18683, Dec. 29, 1964. Redesignated at 32 FR 5608, Apr. 5, 1967, and amended by Amdt. 173-94, 41 FR 16066, Apr. 15, 1976]

§ 173.112 Oil well cartridges.

(a) Oil well cartridges must be so packed that the explosive composition does not exceed 20 grains per cubic inch of space in the outside shipping container and must be in specification containers as follows:

(1) Spec. 15A, 15B, 16A, or 19A (§ 178.168, § 178.169, § 178.185, or § 178.190

of this subchapter). Wooden boxes. Gross weight not to exceed 150 pounds.

(2) Spec. 12B (§ 178.205 of this subchapter). Fiberboard boxes. Gross weight not to exceed 65 pounds.

(3) Each outside container must be plainly marked with the name "Oil Well Cartridge" and "HANDLE CAREFULLY".

[29 FR 18683, Dec. 29, 1964. Redesignated at 32 FR 5608, Apr. 5, 1967, and amended by Amdt. 173-94, 41 FR 16066, Apr. 15, 1976]

§ 173.113 Detonating fuzes, class C explosives.

(a) Detonating fuzes, class C explosives, must be packed in specification containers as follows:

(1) Spec. 12H (§ 178.209 of this subchapter). Fiberboard boxes without liners with well secured inside pasteboard cartons.

(2) In addition to specification containers prescribed in this section, detonating fuzes, class C explosive, may be packed in well secured strong, tight outside wooden or metal boxes. The gross weight of the outside wooden or metal box must not exceed 190 pounds.

(b) Each outside package must be plainly marked "DETONATING FUZES, CLASS C EXPLOSIVES—HANDLE CAREFULLY".

[29 FR 18683, Dec. 29, 1964. Redesignated at 32 FR 5608, Apr. 5, 1967, and amended by Amdt. 173-94, 41 FR 16066, Apr. 15, 1976]

§ 173.114 Actuating cartridges, explosive, fire extinguisher or valve.

(a) Actuating cartridges, explosive, fire extinguisher or valve must be packed in strong wooden or fiberboard boxes.

(b) Each outside container must be plainly marked "ACTUATING CARTRIDGES, EXPLOSIVE, FIRE EXTINGUISHER — HANDLE CAREFULLY" or "ACTUATING CARTRIDGES, EXPLOSIVE, VALVE—HANDLE CAREFULLY".

(c) When shipped as components with fire extinguisher or with valve and with not more than 2 cartridges for each extinguisher or valve, they are exempt from Parts 170-189 of this subchapter.

Subpart D—Flammable, Combustible, and Pyrophoric Liquids; Definitions and Classification

Source: 29 FR 18700, Dec. 29, 1964, unless otherwise noted. Redesignated at 32 FR 5608, Apr. 5, 1967.

§ 173.115 Flammable, combustible, and pyrophoric liquids: definition.

(a) *Flammable liquid.* (1) For the purposes of this subchapter a flammable

liquid means any liquid having a flash point below 100° F. (37.8° C.), with the following exceptions:

(i) Any liquid meeting one of the definitions specified in § 173.300;

(ii) Any mixture having one component or more with a flash point of 100° F. (37.8° C.) or higher, that makes up at least 99 per cent of the total volume of the mixture;

Note 1: A flammable liquid with a flash point of 73° F. or higher in packaging having a capacity of 110 gallons or less packaged prior to January 1, 1978, may be shipped and transported without being subject to any of the requirements of this subchapter applicable to flammable liquids until January 1, 1977.

(2) For the purposes of this subchapter, a distilled spirit of 140 proof or lower is considered to have a flash point no lower than 73° F.

(b) *Combustible liquid.* (1) For the purposes of this subchapter, a combustible liquid is defined as any liquid that does not meet the definition of any other classification specified in this subchapter and has a flash point at or above 100° F. (37.8° C.) and below 200° F. (93.3° C.) except any mixture having one component or more with a flash point at 200° F. (93.3° C.) or higher, that makes up at least 99 per cent of the total volume of the mixture.

(2) For the purposes of this subchapter, an aqueous solution containing 24 per cent or less alcohol by volume is considered to have a flash point no less than 100° F. (37.8° C.) if the remainder of the solution does not meet the definition of a hazardous material as defined in this subchapter.

(3) 200° F. (93.3° C.) is a limitation of the application of the regulations in this subchapter and should not be construed as indicating that liquids with higher flash points will not burn. Markings such as "NONFLAMMABLE" or "NONCOMBUSTIBLE" should not be used on a vehicle containing a material that has a flash point of 200° F. (93.3° C.) or higher.

(c) *Pyrophoric liquids.* (1) For the purposes of this subchapter, a pyrophoric liquid is any liquid that ignites spontaneously in dry or moist air at or below 130° F. (54.5° C.).

Note 1: The Bureau of Explosives is equipped to test samples of flammable liquids to determine whether or not they are pyrophoric.

(d) *Flash point.* (1) "Flash point" means the minimum temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid and shall be determined as follows:

(i) For a homogeneous, single-phase, liquid having a viscosity less than 45 S.U.S. at 100° F. (37.8° C.) that does not form a surface film while under test, one of the following test procedures shall be used:

(A) Standard Method of Test for Flash Point by Tag Closed Tester, (ASTM D56-70);

(B) Standard Method of Test for Flash Point of Aviation Turbine Fuels by Setaflash Closed Tester, (ASTM D3243-73) or

(C) Standard Methods of Test for Flash Point of Liquids by Setaflash Closed Tester, (ASTM D3278-73).

(ii) For a liquid other than one meeting all of the criteria of subparagraph (d)(1)(i) of this paragraph, one of the following test procedures shall be used:

(A) Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, (ASTM D93-71). Alternate tests authorized in this standard may be used.

(B) Standard Method of Test for Flash Point of Aviation Turbine Fuels by Setaflash Closed Tester, (ASTM D3243-73), or

(C) Standard Methods of Test for Flash Point of Liquids by Setaflash Closed Tester, (ASTM D3278-73).

(2) For a liquid that is a mixture of compounds that have different volatility and flash points, its flash point shall be determined as specified in paragraph (d):

(1) of this section, on the material in the form in which it is to be shipped. If it is determined by this test that the flash point is higher than 20° F. (-6.67° C.) a second test shall be made on a sample of the liquid evaporated from an open beaker (or similar container), under ambient pressure and temperature (20 to 25° C.) conditions, to 90 percent of its original volume or for a period of 4 hours, whichever comes first. The lower flash point of the two tests shall be the flash point of the material.

(3) For flash point determinations by Setaflash closed tester, the glass syringe specified need not be used as the method of measurement of the test sample if a minimum quantity of 2 milliliters is assured in the test cup.

(e) "S.U.S." means Saybolt Universal Seconds as determined by the Standard Method of Test for Saybolt Viscosity (ASTM D38-56) (reapproved 1968) and may be determined by use of the S.U.S. conversion tables specified in ASTM Method D2161-66 following determination of viscosity in accordance with the procedures specified in the Standard Method of Test for Viscosity of Transparent and Opaque Liquids (ASTM D445-65).

(f) (Reserved)

(g) If experience or other data indicate that the hazard of a material is greater or less than indicated by the criteria specified in paragraphs (a), (b), and (c) of this section, the Department may revise its classification or make the material subject to the requirements of Parts 170-189 of this subchapter.

[Amdt. 173-78A, 40 FR 22264, May 22, 1975, as amended by Amdt. 173-94, 41 FR 16068, Apr. 15, 1976]

§ 173.116 Outage.

(a) Outage for packings of flammable liquids offered for transportation, except as otherwise provided in this part, must be as prescribed in paragraphs (b) to (h) of this section.

(b) Packagings must not be completely filled. For packagings of a capacity of 110 gallons or less, sufficient outage must be provided so that the packaging will not be liquid full at 130° F. (55° C).

(c) (Reserved)

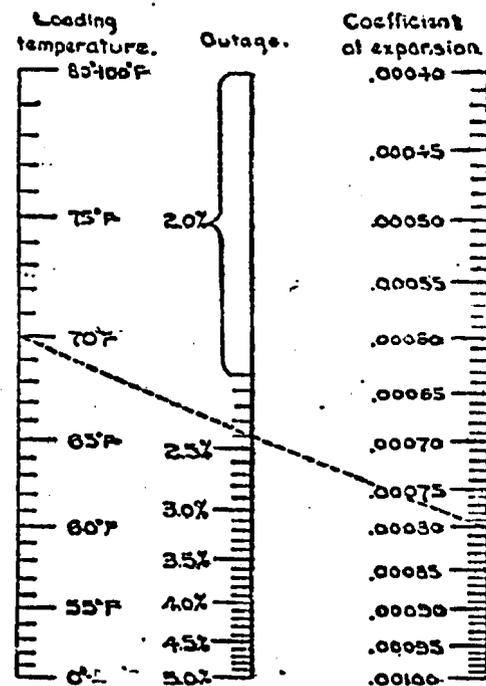
(d) Flammable liquids must not be loaded into domes of tank cars. If the dome of the tank car does not provide sufficient outage, then vacant space must be left in the shell to make up the required outage.

(e) Flammable liquids having vapor pressure of 16 pounds per square inch absolute at 100° F. or less must be so loaded in tank cars that the outage shall be not less than 2 percent.

(f) Flammable liquids having a vapor pressure exceeding 16 pounds per square inch absolute at 100° F. for which minimum outage is not otherwise specifically provided herein, when loaded in uninsulated tank cars, must be so loaded that the minimum outage will be the greatest of the following values:

- (1) Dome capacity.
- (2) Two percent of total capacity of tank and dome.
- (3) Outage as shown in paragraph (g) of this section.

(g) Outage chart for flammable liquids loaded in uninsulated tank cars:



(1) Example: Suppose the temperature of the liquid at time of loading is 70° F. and its coefficient of expansion is 0.0080; lay a ruler on the chart running from 70° to 0.0080 as shown by the dotted line and the required outage is 2.4 percent where the ruler crosses the outage scale.

The following coefficients of expansion per degree Fahrenheit, of the principal flammable liquids shall be used in determining outages:

Acetone.....	0.0085
Amyl acetate.....	0.0088
Benzol (benzene).....	0.0071
Carbon bisulfide.....	0.0070
Ether.....	0.0093
Ethyl acetate.....	0.0079
Ethyl (grain) alcohol.....	0.0051
Methyl (wood) alcohol.....	0.0072
Toluol (toluene).....	0.0083
Gasoline or naphtha:	
50-55° A. P. I.....	0.0055
55.1-60° A. P. I.....	0.0060
60.1-65° A. P. I.....	0.0063
65.1-70° A. P. I.....	0.0070
70.1-75° A. P. I.....	0.0075
75.1-80° A. P. I.....	0.0080
80.1-85° A. P. I.....	0.0085
85.1-90° A. P. I.....	0.0090

A. P. I. (American Petroleum Institute), according to the following formula:

ing is required for transportation by air). In addition, shipments are not subject to Subpart F of Part 172 of this subchapter, to Part 174 of this subchapter except § 174.24 and to Part 177 of this subchapter except § 177.817.

[29 FR 18700, Dec. 29, 1964. Redesignated at 32 FR 5606, Apr. 5, 1967, and amended by Amdt. 173-94, 41 FR 16069, Apr. 15, 1976; Amdt. 173-94A, 41 FR 40681, Sept. 20, 1976]

§ 173.148 Monoethylamine.

(a) Monoethylamine must be packed in specification containers as follows:

(1) Specification 5, 5A, or 5P (§§ 173.30, 173.31, 173.32 of this subchapter). Metal barrel or drum equipped with openings not exceeding 2.3 inches in diameter. Bung labels must be applied and must meet the requirements prescribed in § 173.119(i).

(2) Cylinders as prescribed for any compressed gas except acetylene.

(3) Tank cars prescribed in § 173.119(f) (3).

(4) Specification 106A500X or 110A-500W (§§ 179.300, 179.301) tanks. Authorized only for transportation by rail freight and by highway. (See §§ 174.560 and 177.834(m) of this subchapter for special requirements.)

(5) Specification MC 304 or MC 307 (§§ 178.340, 178.342). Tank motor vehicles. Tank bottom outlets must be equipped with valves conforming with § 178.342-5(a).

[29 FR 18700, Dec. 29, 1964. Redesignated at 32 FR 5606, Apr. 5, 1967, and amended by Amdt. 173-18, 35 FR 1109, Jan. 28, 1970; Amdt. 173-26, 35 FR 7701, May 19, 1970; Amdt. 173-73, 38 FR 20084, July 27, 1973; Amdt. 173-94, 41 FR 16069, Apr. 15, 1976]

§ 173.149 Methyl magnesium bromide in ethyl ether in concentrations not over 40 percent.

(a) Methyl magnesium bromide in ethyl ether in concentrations not over 40 percent must be packed in specification containers as follows:

(1) As prescribed in § 173.134 paragraphs (a) and (b).

(2) Spec. 12B (§ 178.205 of this subchapter). Fiberboard boxes with inside glass bottles not over 1 quart capacity each. Inside containers must be surrounded on all sides with dry absorbent noncombustible material in quantity sufficient to absorb entire contents. Authorized gross weight not over 65 pounds.

(3) Spec. 17C (§ 178.115 of this subchapter). Metal drums (single-trip) with

openings not exceeding 2.3 inches in diameter.

[Order 66, 30 FR 5744, Apr. 23, 1965. Redesignated at 32 FR 5606, Apr. 5, 1967, and amended by Amdt. 173-94, 41 FR 16069, Apr. 15, 1976]

§ 173.149a Nitromethane.

Nitromethane must be packaged as specified in § 173.119(b) except that shipment in cargo tanks, tank cars portable tanks, and any container having a capacity greater than 110 gallons is forbidden.

[Amdt. 173-94, 41 FR 16069, Apr. 15, 1976]

Subpart E—Flammable Solids, Oxidizers, and Organic Peroxides; Definitions and Preparation

Source: 29 FR 18709, Dec. 29, 1964, unless otherwise noted. Redesignated at 32 FR 5606, Apr. 5, 1967.

§ 173.150 Flammable solid; definition.

For the purpose of this subchapter, "Flammable solid" is any solid material, other than one classed as an explosive, which, under conditions normally incident to transportation is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation hazard. Included in this class are spontaneously combustible and water-reactive materials.

[Amdt. 173-94, 41 FR 16069, Apr. 15, 1976, as amended by Amdt. 173-94A, 41 FR 40681, Sept. 20, 1976]

§ 173.151 Oxidizer; definition.

An oxidizer for the purpose of this subchapter is a substance such as a chlorate, permanganate, inorganic peroxide, nitrocarbo nitrate, or a nitrate, that yields oxygen readily to stimulate the combustion of organic matter.

[Amdt. 173-94, 41 FR 16069, Apr. 15, 1976]

§ 173.151a Organic peroxide; definition.

(a) An organic compound containing the bivalent —O—O— structure and which may be considered a derivative of hydrogen peroxide where one or more of the hydrogen atoms have been replaced by organic radicals must be classed as an organic peroxide unless:

(1) The material meets the definition of an explosive A or explosive B, as prescribed in Subpart C of this part, in

§ 173.300 Definitions.

For the purpose of Parts 170–189 of this subchapter, the following terminology is defined:

(a) *Compressed gas*. The term "compressed gas" shall designate any material or mixture having in the container an absolute pressure exceeding 40 p.s.i. at 70° F. or, regardless of the pressure at 70° F., having an absolute pressure exceeding 104 p.s.i. at 130° F.; or any liquid flammable material having a vapor pressure exceeding 40 p.s.i. absolute at 100° F. as determined by ASTM Test D-323.

(b) *Flammable compressed gas*. Any compressed gas as defined in paragraph (a) of this section shall be classed as "flammable gas" if any one of the following occurs:

(1) Either a mixture of 13 percent or less (by volume) with air forms a flammable mixture or the flammable range with air is wider than 12 percent regardless of the lower limit. These limits shall be determined at atmospheric temperature and pressure. The method of sampling and test procedure shall be acceptable to the Bureau of Explosives.

(2) Using the Bureau of Explosives' Flame Projection Apparatus (see Note 1), the flame projects more than 18 inches beyond the ignition source with valve opened fully, or, the flame flashes back and burns at the valve with any degree of valve opening.

(3) Using the Bureau of Explosives' Open Drum Apparatus (see Note 1), there is any significant propagation of flame away from the ignition source.

(4) Using the Bureau of Explosives' Closed Drum Apparatus (see Note 1), there is any explosion of the vapor-air mixture in the drum.

NOTE 1: A description of the Bureau of Explosives' Flame Projection Apparatus, Open Drum Apparatus, Closed Drum Apparatus, and method of tests may be procured from the Bureau of Explosives.

(c) *Non-liquefied compressed gas*. A "non-liquefied compressed gas" is a gas, other than gas in solution, which under the charged pressure is entirely gaseous at a temperature of 70° F.

(d) *Liquefied compressed gas*. A "liquefied compressed gas" is a gas which, under the charged pressure, is partially liquid at a temperature of 70° F.

(e) *Compressed gas in solution*. A "compressed gas in solution" is a non-

liquefied compressed gas which is dissolved in a solvent.

(f) *Flammable range*. The term "flammable range" shall designate the difference between the minimum and maximum volume percentages of the material in air that forms a flammable compressed gas.

(g) *Filling density*. The term "filling density" shall designate the percent ratio of the weight of gas in a container to the weight of water that the container will hold at 60° F. (One pound of water equals 27.737 cubic inches at 60° F.) For example, for a liquefied petroleum gas of 0.504/0.510 specific gravity, a 100-pound cylinder holds 238.1 pounds of water and the filling density is 42 percent; therefore the amount of gas permitted is 0.42×238.1 or 100 pounds.

(h) *Service pressure*. The term "service pressure" shall designate the authorized pressure marking on the container. For example, for cylinders marked "DOT 3A1800", the service pressure is 1800 psig (pounds per square inch gauge).

[29 FR 18743, Dec. 29, 1964. Redesignated at 32 FR 5608, Apr. 5, 1967, and amended by Amdt. 173-16, 34 FR 18248, Nov. 14, 1969; Amdt. 173-54, 36 FR 18169, Sept. 15, 1971; Amdt. 173-94, 41 FR 18079, Apr. 15, 1976; Amdt. 173-94B, 41 FR 57089, Dec. 30, 1976]

§ 173.300a Approval of independent inspection agency.

(a) Any person who (1) does not manufacture cylinders for use in the transportation of hazardous materials and (2) is not directly or indirectly controlled by any person or firm which manufactures cylinders for use in the transportation of hazardous materials, may apply to the Department of Transportation for approval as an independent inspection agency for the purpose of performing cylinder inspections and verifications required by Part 178 of this subchapter.

(b) Each application filed under this section for approval as an independent inspection agency must:

(1) Be submitted in writing to: Office of Hazardous Materials Operations, U.S. Department of Transportation, Washington, D.C. 20590;

(2) State the name, address, principal business activity, and telephone number of the applicant and the name and address of each facility where tests and inspections are to be performed;

(3) State the name, address and principal business activity of each person

action, but shall not refer to action on inanimate surfaces.

(8) "Irritant" means any substance not corrosive within the meaning of section 2(i) of the act (restated in paragraph (b) (7) of this section) which on immediate, prolonged, or repeated contact with normal living tissue will induce a local inflammatory reaction.

(9) "Strong sensitizer" means a substance which will cause on normal living tissue through an allergic or photodynamic process a hypersensitivity which becomes evident on reapplication of the same substance and which is designated as such by the Commission. Before designating any substance as a strong sensitizer, the Commission, upon consideration of the frequency of occurrence and severity of the reaction, shall find that the substance has a significant potential for causing hypersensitivity.

(10) "Extremely flammable" shall apply to any substance which has a flashpoint at or below 20° F. as determined by the Tagliabue Open Cup Tester; "flammable" shall apply to any substance which has a flashpoint of above 20° F., to and including 80° F., as determined by the Tagliabue Open Cup Tester; and "combustible" shall apply to any substance which has a flashpoint above 80° F. to and including 150° F., as determined by the Tagliabue Open Cup Tester; except that the flammability or combustibility of solids and of the contents of self-pressurized containers shall be determined by methods found by the Commission to be generally applicable to such materials or containers, respectively, and established by regulations issued by the Commission, which regulations shall also define the terms "flammable," "combustible," and "extremely flammable" in accord with such methods.

(11) "Radioactive substance" means a substance which emits ionizing radiation.

(12) "Label" means a display of written, printed, or graphic matter upon the immediate container of any substance or, in the cases of an article which is unpackaged or is not packaged in an immediate container intended or suitable for delivery to the ultimate consumer, a display of such matter directly upon the article involved or upon a tag or other suitable material affixed thereto. A requirement made by or under authority of the act that any word, statement, or other information appear on the label shall not be considered to be complied

with unless such word, statement, or other information also appears (i) on the outside container or wrapper, if any there be, unless it is easily legible through the outside container or wrapper and (ii) on all accompanying literature where there are directions for use, written or otherwise.

(13) "Immediate container" does not include package liners.

(14) "Misbranded hazardous substance" means a hazardous substance (including a toy, or other article intended for use by children, which is a hazardous substance, or which bears or contains a hazardous substance in such manner as to be susceptible of access by a child to whom such toy or other article is entrusted) intended, or packaged in a form suitable, for use in the household or by children, if the packaging or labeling of such substance is in violation of an applicable regulation issued pursuant to section 3 or 4 of the Poison Prevention Packaging Act of 1970 or if such substance, except as otherwise provided by or pursuant to section 3 of the act (Federal Hazardous Substances Act), fails to bear a label:

(1) Which states conspicuously:

(A) The name and place of business of the manufacturer, packer, distributor, or seller;

(B) The common or usual name or the chemical name (if there be no common or usual name) of the hazardous substance or of each component which contributes substantially to its hazard, unless the Commission by regulation permits or requires the use of a recognized generic name;

(C) The signal word "DANGER" on substances which are extremely flammable, corrosive, or highly toxic;

(D) The signal word "WARNING" or "CAUTION" on all other hazardous substances;

(E) An affirmative statement of the principal hazard or hazards, such as "Flammable," "Combustible," "Vapor Harmful," "Causes Burns," "Absorbed Through Skin," or similar wording descriptive of the hazard;

(F) Precautionary measures describing the action to be followed or avoided, except when modified by regulation of the Commission pursuant to section 3 of the act;

(G) Instruction, when necessary or appropriate, for first-aid treatment;

(H) The word "Poison" for any hazardous substance which is defined as

loupe, hand slit-lamp, or other expert means. After the recording of observations at 24 hours, any or all eyes may be further examined after applying fluorescein. For this optional test, one drop of fluorescein sodium ophthalmic solution U.S.P. or equivalent is dropped directly on the cornea. After flushing out the excess fluorescein with sodium chloride solution U.S.P. or equivalent, injured areas of the cornea appear yellow; this is best visualized in a darkened room under ultraviolet illumination. Any or all eyes may be washed with sodium chloride solution U.S.P. or equivalent after the 24-hour reading.

(b)(1) An animal shall be considered as exhibiting a positive reaction if the test substance produces at any of the readings ulceration of the cornea (other than a fine stippling), or opacity of the cornea (other than a slight dulling of the normal luster), or inflammation of the iris (other than a slight deepening of the folds (or rugae) or a slight circumcorneal injection of the blood vessels), or if such substance produces in the conjunctivae (excluding the cornea and iris) an obvious swelling with partial eversion of the lids or a diffuse crimson-red with individual vessels not easily discernible.

(2) The test shall be considered positive if four or more of the animals in the test group exhibit a positive reaction. If only one animal exhibits a positive reaction, the test shall be regarded as negative. If two or three animals exhibit a positive reaction, the test is repeated using a different group of six animals. The second test shall be considered positive if three or more of the animals exhibit a positive reaction. If only one or two animals in the second test exhibit a positive reaction, the test shall be repeated with a different group of six animals. Should a third test be needed, the substance will be regarded as an irritant if any animal exhibits a positive response.

(c) To assist testing laboratories and other interested persons in interpreting the results obtained when a substance is tested in accordance with the method described in paragraph (a) of this section, an "Illustrated Guide for Grading Eye Irritation by Hazardous Substances" will be sold by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The guide will contain color plates depicting responses of varying intensity to specific

test solutions. The grade of response and the substance used to produce the response will be indicated.

[33 FR 27012, Sept. 27, 1978; 38 FR 30103, Nov. 1, 1973]

§ 1500.43 Method of test for flashpoint of volatile flammable materials by Tagliabue open-cup apparatus.

SCOPE

1. (a) This method describes a test procedure for the determination of open-cup flashpoints of volatile flammable materials having flashpoints below 175° F.

(b) This method, when applied to paints and resin solutions which tend to skin over or which are very viscous, gives less reproducible results than when applied to solvents.

OUTLINE OF METHOD

2. The sample is placed in the cup of a Tag Open Tester, and heated at a slow but constant rate. A small test flame is passed at a uniform rate across the cup at specified intervals. The flashpoint is taken as the lowest temperature at which application of the test flame causes the vapor at the surface of the liquid to flash, that is, ignite but not continue to burn.

APPARATUS

3. The Tag open-cup tester is illustrated in Fig. 1. It consists of the following parts, which must conform to the dimensions shown, and have the additional characteristics as noted:

(a) *Copper bath*, preferably equipped with a constant level overflow so placed as to maintain the bath liquid level $\frac{1}{8}$ inch below the rim of the glass cup.

(b) *Thermometer holder*. Support firmly with ringstand and clamp.

(c) *Thermometer*. For flashpoints above 40° F., use the ASTM Tag Closed Tester Thermometer, range of +20 to +320° F., in 1° F. divisions, and conforming to thermometer 9F. or ASTM Standard E 1. For flashpoints from 20° F. to 40° F., use ASTM Tag Closed Tester, Low Range, Thermometer 37F. For flashpoints below 20° F., use ASTM Thermometer 33F. The original Tag Open-Cup (Paper Scale) Thermometer will be a permissible alternate until January 1, 1963. It is calibrated to -20° F.

(d) *Glass test cup* (Fig. 2), of molded clear glass, annealed, heat-resistant, and free from surface defects.

(e) *Leveling device*. Leveling device or guide, for proper adjustment of the liquid level in the cup (Fig. 3). This shall be made of No. 18-gage polished aluminum, with a projection for adjusting the liquid level when the sample is added to exactly $\frac{1}{8}$ -inch below the level of the edge or rim of the cup.

(f) "Micro," or small gas burner of suitable dimensions for heating the bath. A screw clamp may be used to help regulate the gas. A small electric heater may be used.

(f) If a guide wire is used, the taper, when passed, should rest lightly on the wire, with the end of the jet burner just clear of the edge of the guide wire. If the swivel-type holder is used, the horizontal and vertical positions of the jet are so adjusted that the jet passes on the circumference of a circle, having a radius of at least 6 inches, across the center of the cup at right angles to the diameter passing through the thermometer, and in a plane 1/4-inch above the upper edge of the cup. The taper should be kept in the "off" position, at one end or the other of the swing, except when the flame is applied.

(g) Light the ignition flame and adjust it to form a flame of spherical form matching in size the 1/2-inch sphere on the apparatus.

(h) Adjust heater source under bath so that the temperature of the sample increases at a rate of $2 \pm 0.5^\circ \text{ F.}$ per minute. With viscous materials this rate of heating cannot always be obtained.

INITIAL TEST

5. Determine an approximate flashpoint by passing the taper flame across the sample at intervals of 2° F. Each pass must be in one direction only. The time required to pass the ignition flame across the surface of the sample should be 1 second. Remove bubbles from the surface of the sample liquid before starting a determination. Meticulous attention to all details relating to the taper, size of taper flame, and rate of passing the taper is necessary for good results. When determining the flashpoint of viscous liquids and those liquids that tend to form a film of polymer, etc., on the surface, the surface film should be disturbed mechanically each time before the taper flame is passed.

RECORDED TESTS

6. Repeat the procedure by cooling a fresh portion of the sample, the glass cup, the bath solution, and the thermometer at least 20° F. below the approximate flashpoint. Resume heating, and pass the taper flame across the sample at two intervals of 5° F. and then at intervals of 2° F. until the flashpoint occurs.

REPORTING DATA

7. The average of not less than three recorded tests, other than the initial test, shall be used in determining the flashpoint and flammability of the substance.

STANDARDIZATION

8. (a) Make determinations in triplicate on the flashpoint of standard paraxylene and of standard isopropyl alcohol which meet the following specifications:

(i) *Specifications for p-xylene, flashpoint check grade.* p-Xylene shall conform to the following requirements:

Specific gravity: $15.56^\circ \text{ C./15.56}^\circ \text{ C.}$ 0.860 minimum, 0.868 maximum.

Boiling range: 2° C. maximum from start to dry point when tested in accordance with the method of test for distillation of industrial aromatic hydrocarbons (ASTM designation: D 630), or the method of test for distillation range of lacquer solvents and diluents (ASTM designation: D 1073). The range shall include the boiling point of pure p-xylene, which is 132.35° C. (231.03° F.).

Purity: 95 percent minimum, calculated in accordance with the method of test for determination of purity from freezing points of high-purity compounds (ASTM designation: D 1015), from the experimentally determined freezing point, measured by the method of test for measurement of freezing points of high-purity compounds for evaluation of purity (ASTM designation: D 1015).

(ii) *Specifications for isopropanol, flashpoint check grade.* Isopropanol shall conform to the following requirements:

Specific gravity: 0.8175 to 0.8185 at $20^\circ \text{ C./20}^\circ \text{ C.}$ as determined by means of a calibrated pycnometer.

Distillation range: Shall entirely distill within a 1.0° C. range which shall include the temperature 80.4° C. as determined by ASTM method D 1073.

Average these values for each compound. If the difference between the values for these two compounds is less than 15° F. (8.5° C.) or more than 27° F. (16° C.), repeat the determinations or obtain fresh standards.

(b) Calculate a correction factor as follows:

$$X = 92 - A$$

$$Y = 71 - B$$

$$\text{Correction} = \frac{X + Y}{2}$$

Where:

- A = Observed flash of p-xylene, and
- B = Observed flash of isopropyl alcohol.

Apply this correction of all determinations. Half units in correction shall be discarded.

PRECISION

9. (a) For hydrocarbon solvents having flashpoints between 60° F. and 110° F. , repeatability is $\pm 2^\circ \text{ F.}$ and the reproducibility is $\pm 5^\circ \text{ F.}$

(b) If results from two tests differ by more than 10° F. , they shall be considered uncertain and should be checked. The calibration procedure provided in this method will cancel out the effect of barometric pressure if calibration and tests are run at the same pressure. Data supporting the precision are given in Appendix III of the 1936 Report of Committee D-1 on Paint, Varnish, Lacquers and Related Products, Proceedings, Am. Soc. Testing Mats., Vol. 56 (1936).

§ 1500.44 Method for determining extremely flammable and flammable solids.

(a) *Preparation of samples*—(1) *Granules, powders, and pastes*. Pack the sample into a flat, rectangular metal boat with inner dimensions 6 inches long x 1 inch wide x one-fourth inch deep.

(2) *Rigid and pliable solids*. Measure the dimensions of the sample and support it by means of metal ringstands, clamps, rings, or other suitable devices as needed, so that the major axis is oriented horizontally and the maximum surface is freely exposed to the atmosphere.

(b) *Procedure*. Place the prepared sample in a draft-free area that can be ventilated and cleared after each test. The temperature of the sample at the time of testing shall be between 68° F. and 86° F. Hold a burning paraffin candle whose diameter is at least 1 inch, so that the flame is in contact with the surface of the sample at the end of the major axis for 5 seconds or until the sample ignites, whichever is less. Remove the candle. By means of a stopwatch, determine the time of combustion with self-sustained flame. Do not exceed 60 seconds. Extinguish flame with a CO₂ or similar nondestructive type extinguisher. Measure the dimensions of the burnt area and calculate the rate of burning along the major axis of the sample.

§ 1500.45 Method for determining extremely flammable and flammable contents of self-pressurized containers.

(a) *Equipment required*. The test equipment consists of a base 8 inches wide, 2 feet long, marked in 6-inch intervals. A rule 2 feet long and marked in inches is supported horizontally on the side of the base and about 6 inches above it. A paraffin candle 1 inch or more in diameter, and of such height that the top third of the flame is at the height of the horizontal rule, is placed at the zero point in the base.

(b) *Procedure*. The test is conducted in a draft-free area that can be ventilated and cleared after each test. Place the self-pressurized container at a distance of 6 inches from the flame source. Spray for periods of 15 seconds to 20 seconds (one observer noting the extension of the flame and the other oper-

ating the container) through the top third of the flame and at a right angle to the flame. The height of the flame should be approximately 2 inches. Take three readings for each test, and average. As a precaution do not spray large quantities in a small, confined space. Free space of previously discharged material.

§ 1500.46 Method for determining flashpoint of extremely flammable contents of self-pressurized containers.

The apparatus used in the Toxicology Open-Cup Flashpoint Apparatus as described in § 1500.43. Some means such as dry ice in an open container is used to chill the pressurized container. The container, the flash cup, and the bath solution of the apparatus (brine or glycol may be used) are chilled to a temperature of about 25° F. below zero. The chilled container is punctured to exhaust the propellant. The chilled formulation is transferred to the test apparatus and tested in accordance with the method described in § 1500.43.

[38 FR 27012, Sept. 27, 1973; 38 FR 30103, Nov. 1, 1973]

§ 1500.47 Method for determining the sound pressure level produced by toy caps.

(a) *Equipment required*. The equipment for the test includes a microphone, a preamplifier (if required), and an oscilloscope.

(1) The microphone-preamplifier system shall have a free-field response uniform to within ± 2 decibels from 50 hertz to 70 kilohertz or beyond and a dynamic range covering the interval 70 to 160 decibels relative to 20 microneutons per square meter. Depending on the model, the microphone shall be used at normal or at grazing incidence, whichever gives the most uniform free-field response. The microphone shall be calibrated both before and after the test of a model of cap. The calibration shall be accurate to within ± 1 decibel. If the calibration is of the pressure type or of the piston-phone plus electrostatic actuator type, it shall be corrected to free-field conditions in accordance with the manufacturer's instructions.

(2) The oscilloscope shall be the storage type or one equipped with a camera. It shall have a response uniform to within ± 1 decibel from 50 hertz to 250 kilohertz or higher. It shall be calibrated

DRAFT

BACKGROUND DOCUMENT

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

SECTION 3001 - IDENTIFICATION AND LISTING OF
HAZARDOUS WASTE

SECTION 250.13 - HAZARDOUS WASTE CHARACTERISTICS

CORROSIVENESS

DECEMBER 15, 1978

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

This document provides background information and support for regulations which have been designed to identify and list hazardous waste pursuant to Section 3001 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft to support the proposed regulations. As new information is obtained, changes may be made in the background information and used as support for the regulations when promulgated.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made some changes in the proposed regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

Alan S. Corson
Hazardous Waste Management Division (WH-565)
Office of Solid Waste
U. S. Environmental Protection Agency
Washington, D.C. 20460

Corrosive Waste

INTRODUCTION: Subtitle C of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (referred to herein as Pub. L. 94-580 or "the Act"), creates a regulatory framework to control hazardous waste. Congress has found that such waste presents "special danger to health and requires a greater degree of regulation than does non-hazardous solid waste" (Section 1002(b)(5) of the Act).

This rule is one of a series of seven being developed and proposed under Subtitle C to implement the hazardous waste management program. It is important to note that the definition of solid waste (Section 1004(27) of the Act) encompasses garbage, refuse, sludges, and other discarded materials including liquids, semi-solids, and contained gases (with a few exceptions) from both municipal and industrial sources. Hazardous wastes, which are a sub-set of all solid wastes and which will be defined by regulation under Section 3001, are those which have particularly significant impacts on public health and the environment.

Subtitle C creates a management control system which, for those wastes defined as hazardous, requires "cradle-to-grave" cognizance including appropriate monitoring, record keeping, and reporting throughout the system. Section 3001 requires EPA to define criteria and methods for identifying and listing hazardous wastes. Those wastes which are identified as hazardous by these means are then included in the

management control system constructed under Sections 3002-3006 and 3010. Those that are excluded will be subject to the requirements for non-hazardous solid waste being carried out by States under Subtitle D under which open dumping is prohibited and environmentally acceptable practices are required.

Section 1004(5) defines a hazardous waste as that which may -

"(A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or

(B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."

Section 3001(b) requires EPA to promulgate regulations identifying those characteristics of a waste which cause a waste to be a hazardous waste.

Three criteria were used in developing the candidate set of characteristics: that a characteristic was specifically stated in Section 3001 by the definition of hazardous waste in Section 1004(5) of the Act; and/or that damage cases collected by EPA over the past several years demonstrated incidents of harm to human health or the environment attributable to a characteristic or property of waste; and/or that other government agencies or private organizations which

regulate or recommend management methods for hazardous substances have identified a characteristic to be of concern.

This candidate set of characteristics was then refined on the basis of the following: that the characteristic could provide a general description of the property or attribute rather than appearing merely as a list of sources; that the likelihood of a hazard developing if the waste were mismanaged is sufficiently great; and that a reliable identification or test method for the presence of the characteristic in waste is available. Use of this last criterion has led EPA to describe each characteristic by developing or adopting specific testing protocols.

This Background Document describes the rationale behind the test procedures developed to describe the corrosivity characteristic stated in the proposed regulations published on December 18, 1978 as 40 CFR 250.10 - 250.15.

For regulatory purposes corrosives have been defined in the following ways:

- (1) substances that cause visible destruction or irreversible alteration in human skin tissue at the site of contact.
- (2) substances that cause metal to corrode at a severe rate.
- (3) substances that are highly acidic or highly alkaline.

The State of New York and several Federal agencies (FDA, CPSC, OSHA) use tissue damage alone as a criterion for corrosiveness and make no reference to effect on inanimate surfaces. DOT employs a definition that includes damage to tissue and metal surfaces, and proposed Minnesota regulations for hazardous waste disposal encompass tissue damage, a severe corrosion rate on steel and pH levels below 3 and above 12. Hazardous waste regulations suggested for the State of Washington specify corrosives as substances which yield a pH less than 3 or greater than 11 when mixed with an equal weight of water, and Illinois EPA land disposal criteria state that wastes with a pH less than 3 or greater than 10 must be analyzed for percentage of acidity or alkalinity. Proposed California regulations for the identification of hazardous wastes characterize a material as corrosive if it has a pH less than or equal to 2 or greater than or equal to 12 or causes destruction of skin tissue. Comments received on the ANPR of May 2, 1977 for hazardous waste guidelines and regulations generally advocate approaches similar to those mentioned above. Approximately 35% of the responses favored standards which address corrosive wastes in need of proper containerization. Another 35% suggested adoption of DOT standards on tissue damage and metal corrosion, and 21% preferred a criterion based on pH. 9% of the responses proposed standards based on other combinations of the tissue damage, metal corrosion rate and pH criteria.

For the purpose of establishing guidelines and regulations for the management of hazardous waste, the definition of a corrosive substance should reflect circumstances surrounding transportation, storage and treatment of the wastes. The primary reason for applying a tissue damage criterion to such situations is to protect waste handlers. A standard technique referenced by Federal agencies and States using this criterion employs the application of the suspected corrosive to the bare, intact skin of albino rabbits followed by an assessment of tissue damage after a 4 hour period. Because the conduction of the test requires special facilities and skilled personnel, it would be difficult and expensive to perform the required procedures for each batch of waste.

For purposes of RCRA, relating tissue damage to an easily measurable characteristic such as pH may be a more practical approach. In injuries attributable to acids and alkalis, the hydrogen ion or hydroxyl ion concentration is a factor related to trauma. Generally, acids coagulate skin proteins and form acid albuminates, and strong alkalis exert chemical action by dissolving skin proteins, combining with cutaneous fats and severely damaging keratin. Alkali burns tend to be progressive due to the formation of soluble alkaline proteinates and are therefore more dangerous than acid burns which are limited by the insolubility of the acid albuminates. Oils and solvents are capable of damaging skin

tissue by removal of surface lipids, but the effects are usually not as severe as those caused by acids and alkalis. It has been suggested that pH extremes below 2.5 and above 11.5 are not tolerated by the body, and contact will often result in tissue damage. The studies establishing these levels were conducted on corneal tissue which is more sensitive to injury than skin. By designating an upper pH limit of 12, sufficient protection should be provided to those exposed to caustic wastes. However, a lower limit at pH 3 has been set to provide additional protection to the environment. Heavy metal salts may become solubilized in acidic media, thereby releasing toxic heavy metals capable of migrating to groundwater and surface waters.

pH determinations can be made simply and inexpensively so the choice of a pH characteristic would not be economically burdensome. pH can be measured by colorimetric or electrometric means. Colorimetric techniques are inexpensive but have limitations that make them inappropriate for use in waste disposal situations. Colorimetric indicators are unreliable at pH levels below 3 and above 10 and may experience interference due to salinity, turbidity, color, protein and colloidal matter present in the test situation. Also, the pH range within which a single indicator functions is relatively narrow.

Electrometric methods are better suited to the pH measurement of waste streams. The hydrogen electrode is the traditional standard for determination of pH values, but it has several

disadvantages. It is awkward to use, attains equilibrium slowly and cannot be employed in the presence of materials which inhibit the reversibility of the electrode process. A more practical method utilizes a glass electrode and a reference electrode of calomel or silver - silver chloride or a combination electrode (glass and reference) connected to an electronic pH meter. The glass electrode is relatively free from most types of interference, but does display impaired responses at low and high pH readings. In highly alkaline solutions the actual pH is somewhat greater than the measured pH, and in very acidic solutions the actual pH is lower than the measured pH. The alkaline error may be reduced by using "low sodium error" electrodes. Other difficulties encountered when using glass electrodes include the effect of corrosive solutions which attack glass and reduce electrode life, and the action of alkali liberated by the electrode itself, thereby influencing the reading of a weakly buffered solution.

Problems can also be created by the form of the test substance. When measuring the pH of suspensions, sols or gels care must be taken to prevent blockage of the liquid junction between the salt bridge and the test solution. Suspension of highly charged sediments such as soils or ion exchange resins may give a pH reading lower than true pH; the solution should be allowed to settle and the pH of the supernatant measured. Oils and viscous materials create sluggish pH response. Glass electrodes requiring less hydration or dissolution of the oily or viscous substance in a partially aqueous solvent should facilitate pH measurement.

The Manual of Methods for Chemical Analysis of Water and Wastes (EPA-625- /6-74-003) describes an acceptable procedure for the measurement of pH.

The greatest difficulty associated with a definition of corrosiveness in terms of pH is the possibility that some corrosive substances will not fit the characteristic. The corrosiveness of aprotic materials, such as the halogens, is not pH-related, and substances of the same pH do not necessarily behave in the same manner. However, the validity of the approach should not be significantly affected. Substances most frequently implicated in occupational skin injuries and environmental damage are sulfuric, hydrochloric, hydrofluoric, nitric, acetic, carbolic, formic, and oxalic acids and inorganic alkalis such as ammonia, caustic soda, and caustic potash.

Application of a characteristic based on pH will encompass other hazardous properties. Damage incidents cited in this chapter describe the consequences of improper disposal of highly acidic and caustic substances which caused contamination of groundwater and surface waters. The disposal of acids and bases together in landfills can create heat generating chemical reactions due to the incompatibility of the wastes. Solubilization of toxic metal salts at pH extremes is another matter of concern. Data on the solubilities of heavy metal salts as a function of pH are available for pure compounds in simple systems. These findings cannot be extrapolated

directly to complex systems, but they indicate trends in the relationship between solubility and pH. Although solubilization of waste stream components is also dependent upon ionic strength, oxidation potential, available anions and complexing and chelating agents, the pH factor is of major importance especially in the high and low ranges that have been mentioned previously in this document as hazardous. It is known that compounds of some elements such as arsenic or selenium become more soluble under alkaline conditions while nickel salts solubilize more readily in an acidic environment, and salts of amphoteric toxic metals such as zinc, copper, chromium and lead display increased solubility at either end of the pH scale. Contact between these types of compounds and strongly acidic or highly alkaline substances can result in increased environmental mobility of the toxic constituents.

The rate at which a substance corrodes metal is also a significant factor when hazardous wastes in metal containers are stored or buried. A hazardous waste with corrosive properties could damage a metal receptacle in which it is contained and be released into the environment, or metal containers holding non-corrosive hazardous wastes could be damaged when contacted by a corrosive waste in the surrounding area. It is suggested that the DOT definition of a severe corrosion rate on steel be adopted to diminish the likelihood of such occurrences.

DOT regulations state that a material has a severe corrosion rate if its corrosion rate exceeds 0.250 inch per

year on steel (SAE 1020) at a test temperature of 130.F. An acceptable test is described in NACE Standard TM-01-69. The test requires inexpensive materials and little technical expertise to conduct. A metal sample of known surface area is placed in the suspected corrosive for a specified length of time, and weight loss due to corrosion is measured. A simple mathematical calculation yields a measurement of the depth of corrosion per year. The procedure was devised primarily to determine the extent to which a particular metal will corrode when in contact with a corrosive liquid. For waste disposal purposes it is important to determine the corrosiveness of the test "solution" itself. The NACE standard is flexible enough to accommodate the minor procedural changes required. Corrosive constituents would not have to be replenished after being exhausted because metal waste containers will be in contact only with a limited amount of solution. If the ratio of the surface area of the metal sample used in the test to the amount of test solution is smaller than the ratio of the inner surface of the container to the amount of corrosive inside, general corrosion will proceed at the rate indicated by the test. There are disadvantages to utilizing this protocol. Localized, galvanic or intergranular corrosion will not be indicated; leakage of hazardous material could occur by these means. Furthermore, some materials exhibiting a severe corrosion rate on steel might not be considered a hazard to public health or to the environment.

In general, though, the NACE procedure is a reasonable method of gauging the ability of a substance to damage metal.

Several other methods of corrosion testing have been considered. NACE Standard TM-01-69 is recommended because necessary equipment is relatively inexpensive, the test may be conducted by someone without a great deal of technical expertise, and the procedure is referenced by the Department of Transportation in 49 CFR 173.240 and is therefore familiar to many potential hazardous waste generators.

ASTM Standard D 2776-72 describes two electrical methods of testing corrosion. The electrical resistance method and the linear polarization method are suitable for determining the corrosiveness of aqueous solutions. Equipment for the tests is expensive, ranging in price from \$395 to \$1500, and requires technical proficiency to manage. Determination of the corrosion rate by the electrical resistance method depends on several successive readings taken over a period of days to weeks. The linear polarization technique requires less time than the electrical resistance method, but several days may pass before valid readings can be obtained in order to allow acclimation of the probe surface to the corrosive medium.

In order to utilize characteristics which can be tested in an economically reasonable manner and are appropriate to circumstances surrounding waste treatment, storage and disposal, corrosiveness has been defined in terms of pH and

ability to damage metal. It is believed that control of disposal of wastes with a pH equal to or less than 3 or equal to or greater than 12 will provide a certain amount of protection to those likely to come into direct contact with the waste. Protection of the environment will be afforded by preventing the solubilization and subsequent migration of heavy metals and by decreasing the likelihood that dangerous heat generating chemical reactions will occur as a result of co-disposal of incompatible wastes. Use of a metal corrosion characteristic will assist the development of proper containerization practices thereby furnishing additional safeguards to public health and the environment.

The following is a brief list of cases documented by EPA illustrating the mismanagement of corrosive wastes.

Damage Incidents

Pennsylvania

North Cordorus Township, 1975

The Sunny Farm Landfill was not authorized to receive industrial waste, but upon inspection such wastes were found. An inspector attempting to halt disposal of a drum of industrial waste was splashed by the contents of the drum as it was being compacted. He sustained burns on the face and neck.

Pleasant Township, 1972

An earthen dike at a refinery waste lagoon ruptured, releasing sludge with a pH of 1.7 into the Allegheny River. About 450,000 fish were killed along a 60 mile stretch of river.

New Beaver Borough, 1971

A sludge composed of spent pickle liquors and organic wastes and having a pH of 1.6 was stored in a mine pit behind a shale dam. Local residents complained of well water degradation, and a nearby pond turned highly acidic and became lifeless.

Elkland Borough, 1973

A former tannery site with 2-4 million gallons of sulfuric acid, tannic acid, lime and sodium hydroxide stored in lagoons and tanks was destroyed by fire. During leveling operations 20,000 gallons of waste liquid spilled and drained into the Cowanesque River, killing everything for 7 miles.

New Jersey

Kin-Buc Landfill, 1974

During the first 10 months of 1974, five chemical waste disposal injuries were noted in the Kin-Buc logs. Injuries included eye irritation and chemical burns from exposure to corrosive wastes.

Virginia

Carbo, 1967

A dike containing an alkaline waste lagoon for a steam generating plant collapsed and released 400 acre feet of fly ash into the Clinch River. It traveled at 1 mile per hour down river for several days, killing 216,000 fish.

Illinois

Granite City, 1975

A leaking storage tank discharged caustic soda into a creek. Five children who came into contact with the creek suffered severe chemical burns.

Texas, 1971

Barrels containing chemical wastes were caught in shrimpers' nets in the Gulf of Mexico. Physical damage to nets and equipment occurred, and exposed shrimper crewmen experienced skin burns and eye irritation.

Minnesota

Pine Bend, 1972

Seepage with a pH less than 2 from a waste basin at a chemical plant was believed responsible for well water degradation by reaction of the acid on subsurface formations.

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BACKGROUND DOCUMENT

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

SECTION 3001 - IDENTIFICATION AND LISTING OF
HAZARDOUS WASTE

SECTION 250.13 - HAZARDOUS WASTE CHARACTERISTICS

REACTIVITY

DECEMBER 15, 1978

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

This document provides background information and support for regulations which have been designed to identify and list hazardous waste pursuant to Section 3001 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft to support the proposed regulations. As new information is obtained, changes may be made in the background information and used as support for the regulations when promulgated.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made some changes in the proposed regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

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Office of Solid Waste
U. S. Environmental Protection Agency
Washington, D.C. 20460

CHAPTER 4 - REACTIVITY

Highly reactive waste present a danger either from high pressure and heat generation and/or toxic fume generation during reaction. Reactive wastes have been implicated in landfill incidents causing damage to persons and property (Table I lists and discusses some of these damage incidents.) Also reactive substances have caused damage during transportation, storage and handling, and various Federal Agencies have promulgated regulations prescribing how these reactive substances should be managed. (Table 2 lists and discusses Federal regulations for ^{reactive materials as well as the} the National Fire Protection Association guidelines.)

For these reasons wastes which are highly reactive should be identified and placed in a management system to ensure proper and precautions handling.

Reactivity is a relative term and has meaning only in a relative sense. Reactive substances have been described as those which:

- 1) autopolymerize
- 2) are unstable with respect to heat or shock
- 3) are explosive
- 4) are strong oxidizers
- 5) react vigorously with air or water
- 6) react with water to generate toxic fumes

These descriptions (or categories) of reactive substances are also relative and not absolute measures.

Rather, these categories are descriptions of either the physical consequences of, or descriptions of, the type of reaction undergone. Also they are not discrete phenomena and a particular waste (or substance) undergoing a reaction might exhibit several of the characteristics of these categories (for example, certain organic peroxides would fall into four of the six categories). These categories not only overlap with each other but also with other characteristics, such as: flammability (the difference between a conflagration and a deflagration is only one of degree), and corrosiveness (the chemical parameters that make something a strong oxidizer can also make it a corrosive).

As discussed in the introduction to the 3001 background documents, a primary goal of OSW has been to identify simple standardized testing methods which a generator could use to unambiguously determine if his waste would fit each 3001 hazard criterion. As was the case for flammable solids the testing methods identified for reactive wastes are less than ideal. The available testing methods suffer from the following deficiencies:

1. The Tests are too Specific

These tests are used to determine how a specific aspect or manifestation of waste reactivity behaves under a special and specific type of stress. For example, DTA (Differential Thermal Analysis) measures how temperature gradients produced by the waste,

(one specific aspect of waste reactivity) behave under a slow input of thermal energy (one special and specific type of stress). This would not indicate how the waste reacts to mechanical shock (a drop test would be necessary to determine that), electrical shock, whether or not the waste is a strong oxidizer, or even what is producing the temperature gradient (pressure buildup, toxic fumes, heat of mixing, etc.). The information derived then is specialized and these tests do not lend themselves for use in a rigid regulatory program.

2. Reactivity of a Sample may not Reflect Reactivity of the Whole Waste:

In the case of wastes which are thermally unstable the reactivity of the sample may not adequately reflect the reactivity of the whole waste. The kinetics of reaction are not only a function of the available initiating sources and ambient temperature, but are also a function of the mass, configuration, geometry, etc. of the sample. For a "runaway" reaction to occur, the system must surpass that steady state where the (heat) produced by reaction is equal to THE ENERGY energy radiated or transferred to the surroundings from the reacting mass. When this critical temperature is reached, the mass experiences catastrophic self-heating. As is obvious from the foregoing, this heat transfer phenomenon is a function of sample size, density, and geometry. The relationships are demonstrated in equation 1, for the rate of temperature rise:

$$CdT/dt = QV\rho \exp (-E/RT) + hs (T - T_0)$$

C = mc

m = mass

c = specific heat

T = Temperature of the material

Q = Heat of decomposition

V = Volume

p = Density

E = Activation energy

R = Gas constant

h = Heat transfer coefficient

S = Surface area of the material

As is evident from the above, the physical parameters (extensive and intensive) of the sample will all play an important part in the rate of temperature rise.

3. The Test Results are in Most Cases Subjective or not Directly Applicable

The ideal test to use in a regulatory program is usually one which requires minimal interpretation: The majority of available reactivity testing methods are not of the "pass-fail" type. Rather the test results usually consist of a first order differential plotted against time or against a standard, from which relative reactivity can be accessed. The decision as to whether a waste meets the criterion now requires interpretation of these results. That the available testing methods are of this type is not surprising, usually when

2020

a test of this sort is run, it is not run to determine reactivity "per se" but rather to elicit information concerning how "fast" a material reacts (or exhibits some measureable physical manifestationⁱ of reaction) to a particular stress (i.e. kinetic information) or how vigorously it reacts (thermodynamic information).

This information may not be directly related to the reactivity. For example, the resultant information extracted from the test might be activation energy, an interesting bit of information, but potentially misleading.

Again this harkens back to the indefinite meaning of the term "reactivity", a term which draws its meaning from the context of its use. A chemist^{might} think of a "reactive" substance as one with a small activation energy (the energy difference between the initial and transition states) i.e. one which reacts easily. Even this simple concept is a relative one, since the magnitude of "low" depends upon the energy profile of the system. We, unlike the hypothetical chemist, are not only interested in things that react "easily" but also those which react vigorously. This depends not only on the activation energy, but also the heat of reaction, the molecularity of the reaction and other factors. We're not really interested in performing a thermodynamic measurement, but rather are interested in observing if the waste in question behaves in such a way to pose a danger under normal handling conditions

5

4. The Standardized Methods That Do Exist Were Not Developed For Waste Testing.

The consequence of this fact^{of} is that standardized methods are applied to non-standardized samples, standardized methods applied to samples with physical consistencies the method was not designed for, and more importantly standardized method used to evaluate (waste) materials even though no data base exists for use of these methods with waste materials.

If such methods^a were used, the results would be difficult to interpret with certainty.

5. The Available Methods Do Not Reflect Waste Management Conditions.

Using a laboratory testing method to predict field behavior is difficult enough for well understood systems. There are always complexities one is not aware of, e.g., trace contaminants, local concentration fluctuations, etc. It is important to attempt to simulate the field conditions as closely as possible. This presents a problem in the case of waste reactivity, not only are we unsure of the ambient conditions the waste will be subject to (there are wide fluctuations), but we cannot even predict the magnitude (and in some case the kind) of stresses, (i.e., initiating forces) which might be present. Ideally, the initiating force used in the testing procedure should be identical (or as similar

4209

as practical) to the field initiating force. Obviously if we cannot predict the initiating force, we can't duplicate it.

The available reactivity testing methods are described and evaluated in Appendix A*. As is evident from those specific evaluations and from the preceding discussion of the five generic shortcomings of the available testing methods, none of these "type" methods are suitable for use to unequivocally determine if a waste is a reactive hazardous waste. This is not as big a problem as might be thought on initial reflection. Most generators who generate waste which are dangerous due to their reactivity are well aware of this property of their waste. Reactive wastes are rarely generated from unreactive feed stocks, or in processes producing unreactive products.

Also, as is evident from the damage incidents synopsis in Table 1, there does not seem to be any widespread consistent pattern of mismanaged reactive wastes. There are only a few damage incidents, and these are either the result of the formation of H₂S (from either soluble sulfides or biological degradation of sulfur containing wastes) or explosions of some "unidentified" waste material. Since there are no systematic

156⁺

* These evaluations are taken from "A second appraisal of methods for Estimating Self Reaction Hazards", E.S. Domalski, Report No. DOT/MTB/OHMD-76-6, "Classification of Test Methods for Oxidizing Materials" V.M. Kuchta, A.C. Furno, and A.C. Imof, Bureau of Mines, Report of Investigations 7594 and "Classification of Hazards of Materials-Water Reactive Materials, and Organic Peroxides", C. Mason and V.C. Cooper, NTIS No. 1B 209422, slightly modified so as to determine applicability to waste materials.

examples of environmental damage from reactive wastes, rather only the anomalous incident. ^{This implies that} either the quantity of reactive waste is small, or it is being properly managed. These few wastes that have been identified as reactive, have been placed on the hazardous waste listings.

Therefore it will only be in rare instances a generator will be unsure of the reactivity class of his waste, or will be unable to judge whether it fits a prose definition, and would therefore require the application of testing protocols to determine the reactivity of his waste. Even in these cases the generator should know what types of stress his waste is unstable towards, and could choose from a battery of tests, chosen and listed on the basis of stress type. The tests chosen (by stress type) for inclusion in the regulations are as follows:

1. Explosion temperature test for thermally unstable waste.
2. The Bureau of Explosives impact apparatus and the test cited in 49 CFR 173.53(b), (c), (d), or (f) as appropriate for waste unstable to shock.

These test are "pass-fail" test which require no subjective interpretation. They may not however, be applicable for all waste types or for all waste management conditions. However, the prose definition should characterize as hazardous those wastes which cannot be tested by the approved methods.

Since the testing methods available are not ideal for identifying those wastes categorized as hazardous due to reactivity, the alternative chosen is to make use of a prose definition coupled with a comprehensive listing and suggested testing methods for those instances where the generator is uncertain if his waste fits the prose definition. The regulation presently being proposed is the following:

Reactive Waste

(1) Definition - A solid waste is a reactive waste if it:

(A) Is normally unstable and readily undergoes violent chemical change without detonating; reacts violently with water, forms potentially explosive mixtures with water, or generates toxic fumes when mixed with water; or is a cyanide or sulfide bearing waste which can generate toxic fumes when exposed to mild acidic or basic conditions.

(B) is capable of detonation or explosive reaction but requires a strong initiating source or which must be heated under confinement before initiation can take place, or which reacts explosively with water.

(C) is readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.

(D) is a forbidden explosive as defines in 49 CFR 173.51, Class A explosive as defined in 49 CFR 173.53, or Class B explosive as defined in 49 CFR 173.58.

NOTE: Such wastes include pyrophoric substances, explosives, autopolymerizable material and oxidizing agents. If it not apparent whether a waste is a reactive waste using this description, then the methods cited below or equivalent methods can be used to determine if the waste is reactive waste.

(2) Identification Method

(A) Thermally unstable wastes can be identified using the Explosion Temperature Test (see Appendix B) of this document. Those wastes for which explosion, ignition, or decomposition occurs at 125°C after 5 minutes are classed as reactive wastes.

(B) Wastes unstable to mechanical shock can be identified using the test cited in 49 CFR 173.53(b), (c), (d), or (f) as appropriate.

This covers all the types of reactivity of concern; oxidizing agents, and autopolymerizers fit into part A, i.e. "undergo violent chemical change", and likewise the rest of the categories listed at the beginning of this chapter are paraphrased in this definition. Also, this is as inclusive as any State regulation, and is a paraphrase of the NFPA category 2, 3, 4 reactive material definitions (which have been advocated for use as a reactivity definition by several commentators to the Advanced Notice of Proposed Rulemaking.

Oxidizing agents are covered under this section of the Section 3001 regulations and are also covered under the ignitable waste definitions. Oxidizing agents fit parts of the prose definition for hazardous waste, however the main danger from these waste are the fires they initiate. Since there are no tests available

satisfactorily determining whether a waste is hazardous due to oxidizing capacity (see Appendix A), these types of wastes are also listed with flammable solids, to be consistent with the DOT approach.

The test chosen as an indicator of thermal instability is a modification of the explosion temperature test (Test VII in Appendix A). The Wood's metal bath has been replaced by a standard temperature bath because of the cadmium fumes given off by the Woods metal bath, and because the Woods metal bath is not commonly available for use. This test was chosen as it met the criteria of being easy to perform (minimal technical skills and standard apparatus are used), and unambiguous to interpret (either some decomposition, ignition or explosion occurs or it doesn't). (See test evaluation Appendix A). The mechanical instability tests chosen are those cited by DOT for transportation (the DOT thermal instability test is included by references in the prose definition). These tests are familiar to industry and DOT has found them to be adequate for transportation purposes. Since the shocks experienced by wastes during management will certainly be of no greater magnitude than the potential shocks a commodity may experience during transport, these tests are satisfactory for our purpose.

TABLE I

DAMAGE INCIDENTS INVOLVING LAND DISPOSAL OF REACTIVE WASTE

1. Baltimore County, Maryland - 6 men hospitalized due to inhalation of hydrogen sulfide gas liberated from salts being landfilled.

2. Edison Township, New Jersey, - bulldozer operator killed at landfill when barrel of unknown waste exploded.

3. Crosby, Texas - residents subjected to sore throats, nausea, and headaches from reaction between oily wastes and acids, dumped in an abandoned sand pit (twenty-six wells were closed by this incident).

4. Edison Township, New Jersey, - cases of conjunctivitis, eye irritation, burn on cornea, and chemical burns due to reactive wastes being landfilled.

5. Juean County, Wisconsin - Police officer injured and squad car damaged by explosion of battery wastes.

6. Santa Cruz, California - Bulldozer operator overcome by hydrogen sulfide fumes generated while mixing tanning waste with other wastes. (Four deaths have occurred in California between 1963 - 1976 from inhalation of H₂S from waste tanning sludge).

7. Northern California - drum of toluene diisocyanate (TDI) exploded spreading extremely toxic toluene diisocyanate throughout the area.

TABLE 2

STATE, FEDERAL AND NFPA REGULATIONS AND GUIDELINES

1. Texas

(Texas Water Quality Board) Texas uses the following definition "Industrial Hazardous Waste" means any waste or mixture of waste which . . . generates sudden pressure by decomposition, heat or other means and would therefore be likely to cause substantial personnel injury. . .-in combination with a listing of 40 reactive compounds.

2. State of Washington

Defines explosive using a 5" drop test, or class A explosive (see DOT) ~~definition~~.

3. Pennsylvania

Combines Flammables and Explosives and uses only the following list:

- (1) Munitions
- (2) Blasting Materials
- (3) Pressurized Cans
- (4) Paint Thinners
- (5) Solvents
- (6) Kerosene
- (7) Oils
- (8) Petrochemical Waste Sludges
- (9) Petroleum Waste Sludge

4. California

Uses the following definition:

" A waste, or component of waste is considered pressure generating or reactive if it:

- 1) Is a Forbidden or class A, B, or C explosive as defined in Title 49 CFR, Sections 173.51, 173.88, and 173.100 respectively" (see DOT)
- "2) Is a water reactive material
- 3) Is in NFPA category 2, 3, or 4 (see NFPA)"

5. Illinois

Uses the following definitions:

"Explosives - Any waste having concentration of 1% or more of a substance described as an explosive (high, low, or permissible) by Sax (Dangerous properties of Hazardous Materials by N. Irving Sax, Van Nostrand Reinhold) shall be considered as explosive "per se".

"Reactives - Any waste having a composition of 5% or more of a substance that (as described by Sax) readily reacts with air, water, or other substances to produce heat and/or toxic fumes shall be considered a reactive waste.. The definition includes oxidizing agents.

6. NFPA

Category 0 - Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

Category 1 - Materials which themselves are normally stable, but which can become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently.

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Category 2 - Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.

Category 3 - Materials which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.

Category 4 - Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.

7. DOT The Department of Transportation lists explosive wastes (these are typically propellants, explosives, initiating compounds etc.) and also specifies testing methods for liquids and solids unstable to thermal and mechanical stresses. (See 49CFR 173.53). We have included all the definitions, listings, and protocols used by DOT in the regulations by reference.

Appendix A

The testing methods examined in this section¹ are separated into tests for thermal instability, (Tests I thru X) tests for impact mechanical shock instability (Tests XI a and b) test identifying oxidizing agents, Tests XII, XIII, and XIV) and a test identifying water reactive materials, Test XV.

¹Most of the information contained in this Appendix was taken from "A second appraisal of methods for Estimating Self Reaction Hazards" E.S. Domalski Report No. DOT/MTB/OHMO-76/6.

A. Tests Identifying Wastes Unstable to Thermal Stress

I. JANAF (Joint Army Navy Air Force) Thermal Stability Test Number Six for Liquid Propellants.

1. Purpose of Test:

To determine the maximum temperatures to which thermally unstable liquids can be subjected for short periods of time without danger of explosive decomposition.

2. Operating Principle:

Under confinement in a microbomb a liquid sample is either heated rapidly and held at a pre-determined temperature for an arbitrary time interval, or heated at a constant rate until evidence of rapid decomposition appears. Spot immersion is also possible, where the microbomb containing the sample is immersed into the bath at some elevated temperature.

3. Test Description:

A microbomb which is drilled and tapped for a thermocouple and burst disc fitting, has an internal volume of 1.3 cm³. A liquid sample of 0.5 ml volume is used and burst diaphragms ranging from 300 to 8400 psi failure pressure can be used. The microbomb is immersed in a bath containing a bismuth-lead alloy, which melts in the range 150 to 250 F. Maintenance of the bath around 200 F and of the heating rate at 20 F per minute, allows detection of rates of decomposition of 2 - 5 F per minute. An air-vibrator is used to agitate the bath and the sample in order

to establish the desired heat transfer between bath and sample. The sample temperature and the temperature difference between the bath and sample are recorded as a functions of time. The temperature at which self-decomposition begins and the rate of decomposition can be derived.

4. Test Evaluation:

This test utilizes small samples of material in good thermal contact with thermostated surroundings. The temperature of the sample can be increased with time at such a slow rate that quasisteady states are maintained.

Rates of decomposition can be estimated from plots of the sample temperature vs. time, and from plots of the temperature difference between the sample and bath vs. time. The slope of the temperature differential curve represents the rate of heat transfer between the sample and the bath. Factors which need to be taken into account are the rate at which the bath is being heated, heating from the self-reaction of the sample, and temperature gradients in the microbomb. From a plot of the self-heating rate of the sample vs. the reciprocal of the temperature, a linear slope proportional to the activation energy should result. The precision of activation energies derived in this manner is about ± 15 percent.

5. Applicability of Test as an Index of Waste Reactivity:

The activation energy of the reaction in question, while certainly an important parameter in assessing waste reactivity

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(as discussed previously) is not the only parameter.

Also important are heat of reaction, waste geometry, density, the heat transfer etc. To indicate a particular activation energy as a cut-off for waste reactivity would result in many false positives, and negatives.

II. ASTM (American Society for Testing Materials) Standard Method of Test E-476-73, Thermal Instability of Confined Condensed Phase Systems (Confinement Test)

1. Purpose of Test:

To determine the temperature at which a chemical mixture will commence reaction, liberating appreciable heat or pressure, when subject to a programmed temperature rise. This method applies to solids or liquids in a closed system in air or some other atmosphere present initially under normal laboratory conditions.

2. Operating Principle:

The sample to be tested is confined in closed vessel equipped with a burst diaphragm, pressure transducer, and thermocouple. The apparatus is equilibrated in a bath at room temperature and subsequently heated at a constant rate. The temperature difference between the bath and sample, the pressure in the closed vessel, and the bath temperature are recorded continuously during the course of the test.

3. Test Description:

This apparatus is a modification of that described under the JANAF Thermal Stability Test. The sample (300 mg.) is placed in the test cell or vessel (volume 1 cm³) and is in intimate contact with a thermocouple. The apparatus also has a burst diaphragm-vent tube system to release gases formed during decomposition if the pressure reaches too high a value, and a pressure transducer to provide measurement of the total pressure inside the vessel as heat is supplied from a bath at a constant rate. The nominal heating rate of the bath is 8 to 10 C per minute. Silicone oil is used in the range 0 to 370 C. and a low-melting alloy (i.e., Wood's metal) in the range 100 to 500 C. Recorders are used to monitor, first, the difference between the sample temperature, T, and bath temperature, T₀, as a function of bath temperature, and, second, pressure, P, as a function of bath temperature. No agitation to minimize thermal lag is used.

4. Test Evaluation:

The threshold temperature is the lowest temperature at the left hand base of the positive peak which appears in the plot of T-T₀ vs T₀. The threshold temperature is an indication of the onset of thermal instability in the sample. A potential hazard exists, therefore, when the temperature of the sample exceeds this value. The instantaneous rate of pressure vs. bath temperature. The maximum pressure generated and the rate of pressure rise are useful hazard parameters related to rough approximations of reaction time, and damage potential.

Examination of the rate of temperature rise of the sample, dT/dt , and rate of temperature rise of the bath, dT_o/dt , not only allows an evaluation of the Arrhenius constants, but also provides for arbitrary scaling of the process. A simpler, and probably preferable procedure, may be to record only T_o corresponding to a runaway condition (e.g., a specified value dT/dt dT_o/dt , or rupture of a pressure disk; there is some arbitrariness in the definition of the runaway criterion, but this feature may not be serious), and then repeat the experiment with a different sample diameter, d . The Frank-Kamenetskii condition then gives the value of E from

$$(d_1/d_2)^2 = (T_{o1}/T_{o2})^2 \exp (E/R)(1/T_{o1}-1/T_{o2})$$

This procedure obviates the necessity of evaluating A and ρ , and allows immediate scaling to any size.

5. Applicability of Test as an Index of Waste Reactivity:

This test suffers from the same drawbacks as the JANAF test (pA-2), i.e. the activation energy gotten from the test is not a definitive indicator of waste reactivity.

III. SELF HEATING ADIABATIC TEST

This test is run under adiabatic conditions, conditions of this sort do not correspond to normal waste management conditions, and the test results by the test is comparable to the test results of I and II. Since different information cannot be gotten from this test, than is already available from tests I and II, and the test conditions correspond less to waste management conditions than do tests I and II, no further evaluation of this test is presented here.

IV. THERMAL SURGE TEST

1. Purpose of Test:

To determine explosion temperature (temperatures for which there is a delay time of 250 sec before explosion).

2. Operating Principle:

The discharge of a capacitor across a thin-walled tube provides the thermal stimulus to initiate explosive decomposition. The time-temperature profile of the decomposition is obtained from oscillographic records. Although the tubes are thin-walled (0.089 mm), they have considerable strength and provide a state of heavy confinement for the explosive or unstable material.

3. Test Description:

A test sample is loaded into hypodermic needle tubing which is heated, essentially instantaneously, by a capacitor discharge. The temperature and time of the explosive event are recorded from a continuous measurement of the electrical resistance of the tubing by means of an oscilloscope. The test is particularly suited to liquid material but solids can also be accommodated by melting prior to their insertion into hypodermic needle tubing. Materials are subject to temperatures in the range of 260 to 1100 C and delay times of 50 m sec. to 50 sec. The delay time, T is given by $A \exp (B/RT)$ where A and B constants (somewhat related to the Arrhenius pre-exponential factor and activation energy), R is the gas constant, and T is the absolute temperature.

Test Evaluation:

The thermal surge test supplies data on explosion temperatures which represent conditions of minimal heat transfer. This test measures the true induction time of an explosive rather than the time required to heat up the sample. Wenograd 15 was able to show a correspondence between the temperature of the system 250 sec prior to explosion and impact test data. The activation energy parameter obtained in thermal surge test measurements under dynamic conditions are considerably lower than those determined in other measurements under isothermal conditions. This test is probably one of the best available approximations to a point source heat initiation of an unstable material in a multicomponent system.

5. Applicability of Test as an Index of Waste Reactivity

The high temperatures the test materials are subject to in this test, do not correspond to those temperatures wastes might be subject to during management (unless the waste is subject to a strong electric discharge). For this reason, this test is unacceptable.

V. ADIABATIC STORAGE TEST

Like test III, this test is run also under adiabatic conditions, and therefore no further evaluation is presented.

25

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VI. ISOTHERMAL STRONG TEST

This test determine the heat generation rate as a function of time and estimates the induction period at a given temperature for a material. This test is run under isothermal conditions and takes anywhere from weeks to months to complete, for these reasons no further evaluation is presented.

VII. EXPLOSION TEMPERATURE TEST

1. Purpose of Test:

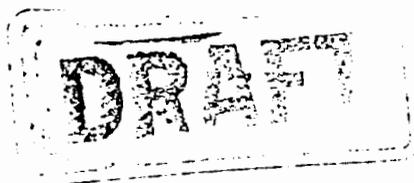
To determine the temperature at which a material explodes, ignites, or decomposes after a five second immersion in a Wood's metal bath.

2. Operating Principle:

This test gives an estimate of how close the explosion temperature is to ambient condition for a material, and, hence, provides a measurable indication of thermal instability.

3. Test Description:

The material to be tested (25 mg.) is placed in a copper test tube (high thermal conductivity) and immersed in a Wood's metal bath. This test is made at a series of bath temperatures, and the time lag prior to explosion at each temperature is recorded. The bath temperature is lowered until a temperature is reached at which explosion ignition, or apparent decomposition does not occur. The bath temperature working range from about 125 to 400 C. The sample is removed from the bath after 5 minutes if no explosion had occurred at 360 C.

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4. Test Evaluation:

The explosion time is very nearby independent of sample size provided the sample size is in the range 10 to 40 mg. Particle size is also important in providing consistent results for a group of materials. Rapid equilibration of the sample upon contact with the high temperature bath will depend upon the heat capacity and thermal conductivity of the material, and could be a major uncertainty in the test. Explosion temperature data is a function of time serve as useful indicators to assist in maintaining safe thermal condition during handling and transport.

5. Applicability of Test as an Index of Waste Reactivity:

This test is the most suitable for our purposes. The test results are pass-fail, either an explosion, ignition, decomposition etc. takes place or not. The results are not subjective in this sense, as are most of the other available tests.

Problems do arise out of distortion of thermal transport from sample size, however, this is a problem with all tests. Also the Woods Metal Bath results in Cadmium fumes being generated and should only be operated in a hood. A sand bath or nonflammable oil bath might be more suitable for our purposes.

VIII. EXOTHERMIC DECOMPOSITION METER TEST

1. Purpose of Test:

To determine the self-heating of a sample at small to moderate heat generation rates as a function of temperature or time.

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2. Operating Principle:

A cylindrical aluminum block contains a cavity which has a Peltier element attached at the bottom and a sample is placed on the Peltier element. Heat flow from the block to sample is measured by means of the Peltier element which provides an electrical signal to a recording device.

3. Test Description:

A sample vessel constructed of stainless steel (volume, 2 cm³) is positioned over a Peltier element, and both are housed inside the cavity of a cylindrical aluminum block. This central block is surrounded by mantles containing electrical heating elements in addition to an insulating layer. The electrical input to the block and mantles is maintained in such a manner as to keep the temperature difference between the block and mantles as small as possible while the block is heated linearly at about 10 C per hour. The heat flow from the aluminum block to the sample is measured by the Peltier element. As soon as the sample begins self-reaction the heat flux to the sample starts to decrease. From a plot of the heat generation of the sample vs. the reciprocal of the absolute temperature, the activation energy can be calculated.

4. Test Evaluation:

Changes in the heat capacity of the aluminum block over the temperature range 20 to 200 C will cause the temperature increase over this range to be slightly non-linear. The Peltier element is temperature dependent, and calibration using a pure copper sample having known thermal properties is recommended.

5. Applicability of Test as an Index of Waste Reactivity

This test yield activation energy as a result, subject therefore to the same drawbacks as tests I and II.

IX Homogeneous Explosion Test

1. Purpose of Test:

To determine the pressure-time profile of the thermal explosion of solid or liquid materials.

2. Operating Principle:

A sample is heated under adiabatic conditions in a closed vessel until explosion occurs. The maximum rate of pressure rise and the maximum overpressure are measured as a function of time at different heat input rates.

3. Test Description:

About 100 ml of a sample is introduced into the lower part of a stainless steel vessel. The lower section is sealed off from a larger upper section above by a membrane (breaking pressure 1 bar). The larger upper section serves as a free space for

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the expansion of reactant or product vapors. During the main part of the induction period, pressure equalization is accomplished by a capillary tube connecting the upper and lower sections of the vessel. The two-compartment vessel is placed inside a larger vessel of 20 liter capacity which seals the former from the external surroundings. A heating mantle around latter vessel allow heating of the inner vessel to take place as near to adiabatic conditions as possible. Around the sample vessel there is also an auxiliary heater which heats the sample at a constant (but adiabatic) rate until explosion occurs. When explosion takes place, the membrane is ruptured and expansion into the larger volume takes place. A piezo-electric pressure transducer records the pressure prior to, during, and after explosion.

4. Test Evaluation:

Differentiation of materials which give large rates of pressure rise and overpressures can be singled out from those which give low values. Subsequent precautions for management can be taken.

5. Applicability of Test as an Index of Waste Reactivity:

This test identifies those wastes which react under thermal stress to produce large pressure gradients. This information could be of use to identify potentially reactive wastes, hazardous due to pressure generation. This type of

reactive waste would also be identified by the explosion temperature test. Since some part of degradation or change in the sample would be apparent for these samples failing this test.

X. Differential Thermal Analysis (DTA) Test

1. Purpose of Test:

To determine exothermic and endothermic reactions in a material as heat is applied at a particular input rate.

2. Operating Principle:

The material under test and a stable reference material are heated simultaneously at the same rate. Exothermic and endothermic traces are measured using a recorder providing a temperature-time plot of the reaction process.

3. Test Description:

The material to be tested (5 to 25 mg) and a reference material (such as alumina or glass beads) are placed into identical compartments in an aluminum block. Heat is supplied to both compartments at the same constant rate of input. Temperatures are measured using thermo-couples in conjunction with automatic recording devices so that a plot of temperature vs. time is obtained. A shift in the base line results from a change in the heat capacity or mass of the material under test. Particular care must be given to the type of temperature sensor used and to the choice of its location in the compartment inside the aluminum block. The geometry of the sample and thermal characteristics (such as thermal conductivity) of the sample will affect the shape of the DTA curve.

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4. Test Evaluation:

From the exotherms and endotherms of the DTA curve decomposition temperatures corresponding to various rates of temperature rise can be obtained. Kinetic parameters can be calculated as a result of properly varying the heating rates and assuming a constant degree of conversion of reactant when a specific thermal event (such as the peak temperature of a given exotherm) takes place. When the temperature sensors are placed in the path of the heat flow the DTA apparatus can measure the enthalpies of processes such as heats of decomposition or transition.

5. Applicability of Test as an Index of Waste Reactivity:

This test will give information as to how a waste reacts, thermally, to thermal stress. There are several problems beyond those normally associated with test's of this kind:

- (1) The stress is specialized, as is the reactivity information.
- (2) The test must be interpreted, and is sometimes ambiguous (as in the case where several reactions are taking place, one of which is endothermic e.g. decomposition of NH_4NO_3).
- (3) Usually very small samples are used, which makes getting a representative sample even more difficult.

On the other hand this is a standardized, procedure which is familiar to industry, widely known and often used.

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B. Tests for Reactive Wastes Sensitive to Mechanical Stress

A great many sensitivity tests using mechanical stimuli have been devised, mostly by the military, hence generally intended for the rating of sensitive energetic materials (explosives and propellants). Since we are interested mostly in waste commercial materials or byproducts of lower sensitivity (although handled in larger amounts), the main problem is to select a few suitable tests from the large number of existing ones.

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XI. Impact Test

1. Purpose of Test:

To determine the minimum drop height of a falling weight which strikes an explosive material and produces either a mild or violent decomposition reaction. Both falling weight and explosive material have a fixed and constant mass.

2. Operating Principle:

Impact energy is supplied to an explosive by a weight of constant mass which is dropped from varying heights to establish the minimum height to provide detonation, decomposition, or charring. The impact provides rapid compression and crushing of the sample (which may involve a frictional component of crystals rubbing against crystals) and detonation ensues.

3. Test Description:

The two most prevalent impact tests are those by Picatinny Arsenal (PA) (Test XI a) and the Bureau of Mines (BM) (Test XI b).

In the PA apparatus a sample is placed in the recess of a small steel die cup, and capped with a thin brass cover. A cylindrical steel plug is placed in the center of the cover, which contains a slotted-vent and the impact of the 2 kilogram weight is transferred to the steel plug.

In the BM apparatus a 20 mg, weight is always employed while the PA sample size may be varied for each experiment. The explosive sample is held between two flat parallel plates made of hardened steel and impact is transmitted to the sample by means of the upper plate. Sample decomposition is detectable by audible, visual or other sensory means.

In an apparatus used by the Bureau of Explosives (part of the Association of American Railroads) and cited in Title 49 CFR (DOT Hazardous Materials Regulations) a falling weight is guided by a pair of rigid uprights into a hammer-anvil assembly containing a 10 mg. sample of explosive. Reproducibility can become a problem here because of a non-ideal collisions between the drop weight and the impact hammer since only a fraction of the drop-weight energy is transmitted to the sample.

4. Test Evaluation:

Greater confinement of the sample will limit the translational component of the impulse to a smaller area as is the case with the PA apparatus. Factors which play an influential role in the test are: materials of construction, sample thickness, sample density, hammer geometry, mass of drop weight, impact area, surface finish, the surrounding atmosphere, temperature, and pressure. Modifications can also be made to accomodate cast and liquid samples.

5. Applicability of These Tests as Indices of Waste Reactivity:

Impact tests suffer from the drawback that the fundamental processes leading to energy release are complicated and poorly understood. Failure of good agreement between various impact tests shows that these tests contain uncontrolled parameters.



2313

On the other hand, (1) partial correlations do exist, (2) the history of the test indicates rough agreement with field experience, (3) the stimulus is of reasonable severity, (4) the test are widely known and relatively wasy to use. These facts make them useful for a partial definition of hazards.

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754

C. Tests Identifying Oxidizing Wastes²

XIII. Burning Rate Test for Solid Oxidizers

1. Purpose of Test:

To determine the relative fire hazard present when inorganic oxidizers are heated in the presence of wood or cellulosic substances.

2. Operating Principle:

A set sample size and ratio of dried sawdust (12-50 mesh) and oxidizer is ignited and the burning rate is determined by measuring the time for the burning to propogate at least 5 inches

²Most of the information contained in this section was taken from "Classification Test Methods for Oxidizing Materials" by J.M. Kuchta, A.L. Furno, and A.C. Imhof, Bureau of Mines, Report of Investigations 7594.

3. Test Discription

For the test, sawdust is initially screened to provide particles ranging in size from 12 to 50 mesh (Tyler screen series). The sawdust is dried in an oven at 215 + 5 F for about six hours, and then test mixtures having various concentrations of the oxidizers are prepared. To obtain a uniform mixture, the materials were agitated for 10 minutes or more in a closed container. Generally, fine oxidizers are used "as received" but coarse oxidizers can be pulverized and screened to obtain samples at least as fine as the wood sawdust. For most of the oxidizers, a particle size range of about 20 to 100 mesh appears to be adequate for determining their hazard classification by this proposed test. However, where the hazard level of such materials is uncertain because of particle size considerations, the burning rates of the mixtures should also be determined using oxidizer samples that have fractions finer than 100 mesh.

Burning rates are measured using a rectangular rack that was mounted horizontally and equipped with a 60-mesh steel screen to support the sample. The sample bed is separated from the side rack mounts to insure unrestricted burning along the sides of the sample. To form the sample bed, the sawdust-oxidizer mixture is placed on a rack between a pair of spacer bars which fixed the bed size and which are removed before ignition. The bed can also be formed in a U-shaped wire screen channel which is transferred onto the burning rack; the wire screen channel is then removed before ignition. The sample is ignited by a propane torch or

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or similar flame source and the burning rate determined by measurements are made with two fuse wire (0.5 amp) stations and an electric timer, although slow-burning mixtures can be followed visually and timed with a stopwatch. The sample bed was normally 7 inches long and the rates are measured over a distance of 5 inches and at least 1 inch from the point of ignition.

4. Test Evaluation:

This proposed test method permits classification of solid oxidizers into two or more groups based on their relative burning rates with a cellulose-type combustible such as wood sawdust. The least hazardous class includes those oxidizers that burn at low rates (10 in/min) when mixed with the select-grade, red oak sawdust. A second class consists of oxidizers, such as the alkali nitrates and chlorates, which burn at relatively high rates (10 in/min) when mixed with this sawdust. A third, more hazardous class should include those oxidizers, which when unmixed or mixed with a combustible, might ignite spontaneously and burn vigorously if moisture is present or if they are heated slightly. This class would include sodium peroxide and calcium hypochlorite (69.5 ptc Cl₂) which gives very high burning rates with the sawdust. A fourth class is also required for those oxidizers, such as ammonium perchlorate, which may detonate when heated under confinement or when exposed to shock.

5. Applicability of Test as an Index of Waste Oxidizing Strength

This method is designed to provide a relative measure of the increased ignition or burning hazard that may exist when inorganic oxidizers are mixed with an organic substance such as sawdust. They are not applicable to organic peroxides or to inorganic oxidizers that may detonate when heated with or without a combustible.

In the application of this test method, it must be recognized that a reliable hazard rating may not be possible for all oxidizers using a single reference combustible. If the adjacent material is not cellulosic in nature, (and in a landfill this may or maynot be the case) it is conceivable that an oxidizer may display a greater level of hazard than observed with the select-grade, red oak sawdust used in the present study.

XIII. Ignition Hazard Test for Liquid Oxidizers:

1. Purpose of Test:

To determine the relative fire hazard by exothermic reaction of liquid inorganic oxidizers with other substances or by decomposition to products which ignite or sustain a fire. Generally, these liquids react with many organic substances and some are capable of producing spontaneous ignition when mixed with the combustible at normal or slightly elevated temperatures; some may also ignite spontaneously when heated in the absence of a combustible material.

2. Operating Principle:

In this proposed test, the ignitability or reactivity of the oxidizer sawdust mixtures is determined in an open reaction vessel using small quantities of the reactants. Temperatures up to at least 190 F are used to compare the oxidizers, depending upon their reactivity. Such temperatures are not necessarily unrealistic, considering particularly the possibility of over-heating from the reaction of liquid oxidizers with contaminants. The reaction vessel in these experiments is a 200-cm³ Pyrex beaker that is equipped with insulated heating tapes and which rested on a flat ceramic heater; however, a stainless steel beaker can be used. Because of possible violent reactions, the reaction vessel is placed in a larger vessel of heavy-duty steel and the experiments are to be performed in a protected area.

3. Test Discription:

In a trial, a predetermined quantity of the sawdust (12 to 50 mesh) is added to the reaction vessel and brought to the desired temperature. The liquid oxidizer is then cautiously injected with a long hypodermic syringe (12 inches) from behind a protective shield, and the extent of reaction is determined from continuous temperature measurements and visual observations.

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The mixture temperature is measured with a 30-gage iron-constantan thermocouple protected against corrosion by a thin-walled glass sheath and located near the center of the reacting mass. Ignitions are confirmed visually since the flame reactions does not necessarily occur in the immediate area of the thermocouple; in many ignitions, the sawdust-oxidizer mixture is scattered or the flames occurred primarily near the top or outside of the test vessel. Generally, evidence of ignition is observed for periods of at least 15 minutes. If no significant temperature increase occurred, experiments are made at higher temperatures and with various sawdust-oxidizer quantities. Preliminary trials are always made with a small quantity of oxidizer (1 ml), particularly in the case of an oxidizer of unknown reactivity.

4. Test Evaluation:

This method is not applicable to detonable liquid oxidizers, such as concentrated hydrogen peroxide (90 pct) or perchloric acid (72 pct). A shock sensitivity or thermal stability test (s.a. test XIV) is required for evaluating these types.

5. Applicability of Test as an Index of Waste Oxidizing Strength
(se Test XII, No. 5).

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XIV. Self-Heating Test for Organic Peroxides¹

1. Purpose of Test:

To determine the minimum ambient temperatures for the self-heating to explosion of thermally unstable compounds in charges of specified shape but varying size.

2. Operating Principle:

The thermal decomposition of organic peroxides is observed from studying temperature-time plots to obtain the critical temperatures for explosion, heat transfer coefficient data, and apparent activation energies.

A circulating fan located within the working space of the furnace provides temperature control to within 0.5 C.

3. Test Description:

A cylindrical tube furnace constructed of steel housed an aluminum open-topped cylindrical container which could hold 40 to 60 grams of organic peroxide. The furnace was heated electrically over the range 50 to 350 C and could be maintained at a fixed temperature to within 0.3 C. The progress of self-heating in the peroxide sample relative to the furnace was observed by using a differential thermocouple at the center of the sample. A second thermocouple attached to the side of the container monitored the surface temperature. Temperature-time plots were recorded for different cylindrical diameters for the samples and critical temperatures were calculated.

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Explosion studies were carried out with sample amounts as large as 800 grams using a somewhat modified apparatus, and similar parameters examined.

4. Test Evaluation:

The chief disadvantage of the method is the long period over which readings must be recorded and the long time required for the furnace to stabilize following a large change in operating temperature.

5. Applicability of Test as an Index of Waste Oxidizing Strength:

This test can be used to identify detonable oxidizers. This does not give any additional needed information than provided by the explosion temperature test.

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XV. Test Method for Water Reactivity³

1. Purpose of Test:

To identify materials which react so violently with water and provide a danger from ignition of nearby combustibles, generation of flammable gases or generation of toxic fumes.

2. Operating Principle:

Water reactivity of a substance is determined either by adding a given weight of water to a given weight of material or vice versa. In either case, the rate of temperature rise and the gross temperature rise are recorded, and the gases evolved are sampled for analysis.

3. Test Description:

Tests XV, XVI, and XVII are taken from "CLASSIFICATION OF HAZARDS OF MATERIALS--WATER-REACTIVE MATERIALS AND ORGANIC PEROXIDES" - C. Mason and J. C. Cooper, NTIS No. PB 209422.

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A28

The sample container is a Pyrex tube, 1-3/8 inches in diameter by 10 inches long, imbedded to a depth of 3-1/2 inches in block of insulating foam (polyurethane or polystyrene) 3 inches square by 5 inches high. A thin piece of copper 3/8 inch square and weighing 0.5 gram (about 0.025 inch thick) is silver-soldered to the tip of a chromel-alumel thermocouple which measures the temperature rise. This thermocouple is placed in the Pyrex tube in such a way that the copper square is near enough to the bottom to be covered by the sample. The output of the thermocouple is fed to a suitable recorder.

An initial estimate of the severity of the reaction is made by adding 5 grams of water slowly to 0.5 gram of material with the apparatus behind a protective shield. Since either toxic or flammable gases may be evolved, the test must be carried out in a suitable fume hood. The temperature rise is measured by adding 10 grams of water slowly (10-20 sec) from behind a protective shield to 1, 2, 5, 10, and 20 grams, successively, of the sample. Measurements are continued until the temperature reaches a peak and then begins to drop. If 1, 2, and 5 grams of the material give virtually no temperature increase in 4 minutes, 10 grams of water are added to 10 grams of sample and the temperature is monitored for 1 hour to determine whether a slow reaction occurs (as in the case of A 4C3). If the reaction is not too violent, 10 grams

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of water are added to 20 grams of the material to see whether a greater rise in temperature results. The procedure may be reversed by adding the material to the water in the container.

The best method to determine whether a flammable or toxic gas is evolved is by chemical analysis of the gas. If a gas is evolved, a sample from the reacting material is collected through a flexible needle inserted into the reaction container to within about an inch of the reacting mixture. The sample is then analyzed on a chromatograph for flammable and/or toxic gas.

4. Test Evaluation:

The test is reproducible to within 10 percent. The test results for known reactives like the hydrides of the alkali metals are positive. There seems to be little difference in the results caused the order of mixing.

5. Applicability of Test as an Index of Waste Reactivity:

A test such as this could be used to identify pyrophoric wastes, wastes which generate toxic gases when contacted with water etc.

The test method appears to define the activity of the various materials tested. Classification of the water reactivity hazard could be based on the temperature rise which is a measure of the heat released by reaction with water. The release of flammable and/or toxic gases would create an additional hazard which could be covered by a classification such as the following:

DU 20
2296

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A30

Reactive Wastes:

Wastes which react with water to give temperature rises of 140° F and evolve toxic or flammable gases.

Wastes which react with water to give temperature rises greater than 140° F or evolve toxic or flammable gases.

Simplified methods of analysis for toxic gas, (particularly HCN and H₂S) must be developed before this test could be considered.

Appendix B

Explosion Temperature Test

1. Purpose of Test:

To determine whether a material explodes, ignites, or decomposes after a five second immersion in a sand bath or low flammability liquid (such as high molecular weight silicone oil) at temperatures up to 125°C and if so, at what temperature.

2. Operating Principle:

This test gives an estimate of how close the explosion temperature is to ambient condition for a material, and, hence, provides a measurable indication of thermal instability.

3. Test Description:

The material to be tested (25 mg.) is placed in a copper test tube (high thermal conductivity) and immersed in the controlled temperature bath. This test is made at a series of bath temperatures, and the time lag prior to explosion at each temperature is recorded (up to 10 min.). The bath temperature is raised until a temperature of 125°C is reached if no explosion, ignition, or apparent decomposition occurs.

Note: This is a modification of the test taken from H. Henkin, and R.G. McGill, Industrial & Engr. Chem. V44 p135

BD-4

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BACKGROUND DOCUMENT

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

SECTION 3001 - IDENTIFICATION AND LISTING OF
HAZARDOUS WASTE

SECTION 250.13 - HAZARDOUS WASTE CHARACTERISTICS

TOXICITY

December 15, 1978

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

This document provides background information and support for regulations which have been designed to identify and list hazardous waste pursuant to Section 3001 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft to support the proposed regulations. As new information is obtained, changes may be made in the background information and used as support for the regulations when promulgated.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made some changes in the proposed regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

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Office of Solid Waste
U. S. Environmental Protection Agency
Washington, D.C. 20460

Table of Contents

Introduction

Toxic properties Considered and Those Selected

Extraction Procedure

- Sample Preparation
- Leaching Media Composition
- Extractant to Sample Ratio
- Agitation Methods
- Extraction Contact Time
- Post Extraction Sample Handling

Groundwater Dilution

Toxicity

- Genetic Activity
- Bioaccumulation and Persistence
- Human Toxicity
- Aquatic Toxicity
- Phytotoxicity

Regulatory Approach Selected

Bibliography

Appendices

- I Proposed Toxicity Definition
- II Mutagenicity Test Protocol
- III Controlled Substances List
- IV Bioaccumulation Potential Test
- V Biodegradation Assay
- VI Daphnia Magna Reproduction Assay
- VII Terrestrial Plant Assays
- VIII Demonstration of Non-Inclusion in the
Hazardous Waste System Procedures

Introduction

Subtitle C of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (referred to herein as Pub. L. 94-580 or "the Act"), creates a regulatory framework to control hazardous waste. Congress has found that such waste presents "special dangers to health and requires a greater degree of regulation than does non-hazardous solid waste" (Section 1002(b)(5) of the Act).

This rule is one of a series of seven being developed and proposed under Subtitle C to implement the hazardous waste management program. It is important to note that the definition of solid waste (Section 1004(27) of the Act) encompasses garbage, refuse, sludges, and other discarded materials including liquids, semi-solids, and contained gases (with a few exceptions) from both municipal and industrial sources. Hazardous wastes, which are a sub-set of all solid wastes and which will be defined by regulations under Section 3001, are those which have particularly significant impacts on public health and the environment.

Subtitle C creates a management control system which, for those wastes defined as hazardous, requires "cradle-to-grave" cognizance including appropriate monitoring, record-keeping, and reporting throughout the system. Section 3001 requires EPA to define criteria and methods for identifying and listing hazardous wastes. Those wastes which are identified as hazardous by these means are then included in the

management control system constructed under Sections 3002-3006 and 3010. Those that are excluded will be subject to the requirements for non-hazardous solid waste being carried out by States under Subtitle D under which open dumping is prohibited and environmentally acceptable practices are required.

Section 1004(5) defines a hazardous waste as that which may -

"(A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or

(B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, ~~or disposed of, or otherwise~~ managed."

Section 3001(b) requires EPA to promulgate regulations identifying those characteristics of a waste which cause a waste to be a hazardous waste. In order to carry out not only the mandate laid out in Sections 1004(5)(A) and 3001(b) but also 1004(5)(B), the development of the toxicity hazardous waste characteristics was keyed to the concept of improper management.

Three criteria were then used in developing the candidate set of characteristics: that a characteristic was specifically stated in Section 3001 by the definition of hazardous waste in Section 1004(5) of the Act; and/or that

damage cases collected by EPA over the past several years demonstrated incidents of harm to human health or the environment attributable to a characteristic or property of waste; and/or that other government agencies or private organizations which regulate or recommend management methods for hazardous substances have identified a characteristic to be of concern.

This candidate set of characteristics was then refined on the basis of the following: that the characteristic could provide a general description of the property or attribute rather than appearing merely as a list of sources; that the likelihood of a hazard developing if the waste were mismanaged is sufficiently great; and that a reliable identification or test method for the presence of the characteristic in waste is available. Use of this last criterion has led EPA to describe each characteristic by developing or adopting specific testing protocols.

This Background Document describes the rationale behind the test procedures developed to describe the toxicity characteristic stated in the proposed regulations published on December 18, 1978 as 40 CFR 250.10 - 250.15 (Appendix I).

The Problem

In order to select those properties of a waste which could result in their becoming a human or environment health hazard, an examination was made of damage which has resulted from past improper disposal.

In 1977, a study (1) of 50 land disposal sites that had received industrial wastes was conducted to determine the

prevalence of subsurface migration of hazardous chemical constituents. At 13 sites, the study was able to obtain confirmatory evidence for the migration of organic chemicals from the disposal location. At these sites organic contamination of the groundwater had occurred. In those cases where it could not be clearly shown that the landfill or lagoon under study was the source of the specific contaminant, the site was ruled out as one at which migration had occurred. Similarly, while heavy metals (excluding iron and manganese) were found at 49 sites, migration could only be confirmed at 30 sites. Selenium, arsenic, and/or cyanide were found in 37 sites with migration confirmed at 30 sites. At 26 of the sites, hazardous inorganic constituents in the water at one or more monitoring wells was found to exceed the EPA drinking water limits. Of the hazardous substances, selenium most frequently exceeded drinking water limits, followed by arsenic, chromium, and lead.

Ground water contamination was measured by drilling sampling wells at various distances from the landfill and at various depths. Distances of wells from the disposal site ranged from 3 to 300 meters (10 - 1000 ft.), while depths ranged from 2 to 49 meters (6 - 160 ft.).

A few specific examples of damage which has occurred as a consequence of improper storage or disposal of wastes further illustrate the problem.

New Jersey

Middlesex County, 1967

A plant recovering metals such as lead and zinc from waste, stockpiled their raw materials in the open. Metals subsequently leached into the ground water resulting in contamination and closure of public water supply wells in 1971 and 1972.

Salem County

Groundwater beneath a 40-acre chemical manufacturing site has been contaminated by waste chemicals disposed of over a 50-year period.

Atlantic County 1973

A landfill which has been the depository of large quantities of industrial wastes is causing a groundwater pollution problem.

Camden County 1973

The wall of an industrial lagoon ruptured resulting in 75,000 gallons of latex paint sludge, containing high concentrations of lead and mercury, entering Hilliard Creek.

Gloucester County 1970

During the 1960's a landfill in Mantua accepted miscellaneous industrial wastes which eventually leached out and entered the Chestnut Branch of Mantua Creek. This subsequently

resulted in contamination of the groundwater system.

Maryland

Somerset County, 1975

At Crisfield there is a holding pond that daily received 15,000 gallons of waste water containing toxic chemicals such as arsenic, lead, nickel, chromium and cyanides. The pond is unlined and contamination of the underground waters has been found to extend to a depth of 50 feet and a radius of 1,000 feet.

Illinois

Jo Daviess County

Between 1966 and 1968 a mining company discharged waste water into an abandoned shaft of a lead-zinc mine. As a result, the Galena-Platteville aquifer has become contaminated.

Washington

Spokane County

Aluminum processing wastes were dumped into an old basalt quarry during the period 1967-1974. Heavy rains in 1973 caused two sources of domestic water to become contaminated with chloride ranging from 600 to over 1100 ppm.

These examples illustrate that damage to ground and surface water frequently result from migration of toxic

chemicals from the initial disposal site. Groundwater contamination is a major concern because it is a source of drinking water for approximately one-half the population of the United State^s. Furthermore because it is widely available, and less subject to the fluctuations that affect surface water supplies, its use is increasing each decade by 25%. Within a specific locality, the quality of groundwater is fairly uniform, and little or no treatment may be required prior to utilization. However, once contaminated, an aquifer cannot be easily restored to its original state and its usefulness as a source of drinking water may be impaired for years.

There is now ample evidence of damage to these important resources ~~as a result of improper disposal of wastes.~~ Table 1 summarizes the results of a 1974 study (2) of ground and surface water contamination in the Northeastern United States. Of the 60 municipal and industrial landfill contamination cases studied, 25 resulted in water supply wells being affected. At least 9 of these wells had to be abandoned.

Toxic Properties Considered and Those Selected

In order to devise a contamination model suitable for use in estimating the consequences of improper disposal, a groundwater scenario was selected. By selecting a groundwater contamination scenario we do not mean to imply that other vectors are not important. However, we do feel though

TABLE 1. SUMMARY OF DATA ON 42 MUNICIPAL AND 18 INDUSTRIAL LANDFILL CONTAMINATION CASES.

<u>Findings</u>	<u>Type of Landfill</u>	
	<u>Municipal</u>	<u>Industrial</u>
Assessment of principal damage		
Contamination of aquifer only	9	8
Water supply well(s) affected	16	9
Contamination of surface water	17	1
Principal aquifer affected		
Unconsolidated deposits	33	11
Sedimentary rocks	7	3
Crystalline rocks	2	4
Type of pollutant observed		
General contamination	37	4
Toxic substances	5	14
Observed distance traveled by pollutant		
Less than 100 feet	6	0
100 to 1,000	8	4
More than 1,000 feet	11	2
Unknown or unreported	17	12
Maximum observed depth penetrated by pollutant		
Less than 30 feet	11	3
30 to 100 feet	11	3
More than 100 feet	5	2
Unknown or unreported	15	10
Action taken regarding groundwater resource		
Water supply well(s) abandoned	4	5
Groundwater monitoring program established	12	2
No known action	26	11

that except in rare cases, control levels set using this model will be sufficient to protect against other routes of contamination.

The contamination model selected is based on chemical wastes creating a problem by leaching or leakage of toxicants from the disposal site to a drinking water aquifer. The control thresholds used in defining the toxicity characteristic have been designed to insure the safe disposal of wastes which could, if improperly disposed of, contaminate groundwater to such an extent that use of the water would constitute a human or environmental health hazard. It must be emphasized that the contamination model has been developed for definitional purposes only. It does not address actual disposal methods which might be used in any specific circumstance. Site or waste specific models could be used in the permit process for determining the suitability of a particular disposal method.

In addition to being chronically toxic upon ingestion, materials present in wastes can cause other environmental and health problems. Toxicity is thus used in its broader sense to encompass the specific properties of acute and chronic toxicity, aquatic toxicity, phytotoxicity, carcinogenicity, mutagenicity, and teratogenicity. Another group of potential hazards consists of those materials which can persist in the environment and bioaccumulate in animal

tissue. Other manifestations of toxicity, while of importance in specific instances, are not thought to be critical to the definition of a hazardous waste.

Inhalation toxicity, for example, has not been specifically addressed in this definition for two reasons:

- 1) The number of volatile chemicals which are toxic by inhalation without also being either flammable, genetically active, bioaccumulative, or toxic by oral ingestion is thought to be very small.
- 2) Wastes containing potentially hazardous volatile chemicals have often resulted in environmental contamination and human exposure through improper handling of wastes at hazardous waste disposal facilities. This is in contrast to problems resulting from improper disposal of potentially hazardous wastes because they were not identified as hazardous. Prevention of improper disposal practices is the objective of the section 3004 regulations not 3001.

Some examples of actual damage incidents, supplied by the California Department of Health, serve to illustrate this second point.

- 1) During late 1975, a liquid waste hauler deposited 5,000 gallons of a liquid waste containing volatile, chlorinated organic compounds into an evaporation pond at a Class I disposal site in the San Francisco

Bay Area. A Class I site is a permitted hazardous waste facility. The material appeared to react with the contents of the pond, releasing a large cloud of extremely odoriferous material. Hundreds of complaints were filed by residents in the City of Richmond, with several persons claiming illness from the odors. A visible plume produced by the incident was reported still visible over ten miles down wind over San Francisco Bay. The hauler had driven from Los Angeles with the waste because Class I disposal site operators in Southern California rejected it due to its odor.

- 2) A load of concentrated nitric acid was discharged into a disposal well at an unauthorized chemical dump in Los Angeles. The well subsequently emitted a brown cloud of nitrogen dioxide. A workman at the site was observed standing over the well shoveling dirt into it in an attempt to stop the discharge of the gas. He wore no respirator.
- 3) The cyanide wells receiving alkaline cyanide wastes at a Class I landfill in Los Angeles were closed down in January 1977, because routine air sampling detected hydrogen cyanide gas being emitted from the landfill in the vicinity of the wells. It is speculated that the acid conditions produced by the decomposing rubbish in the landfill lowered the pH sufficiently to release HCN.

- 4) In Southern California, a mixture of liquid waste, including sludge from the production of perchloroethylene and trichloroethylene, was dumped into a cavity dug in the working face of a Class I landfill. Subsequently dense fumes were seen coming out of the cavity, so two bulldozers were summoned to cover the waste. Both bulldozer operators, as well as a truck driver, were overcome by the fumes.
- 5) At a Class I landfill near San Diego, a waste hauler emptied several gallons of methyltrichlorosilane into the rubbish. The material reacted with moisture in the landfill, releasing hydrogen chloride gas. During covering operations, a bulldozer operator was overcome by the gas and was sent to a hospital for recovery.
- 6) At a Class II-I landfill in Martinez, California, a Health Department inspector observed several large piles of uncovered, powdered waste from refineries discharging large quantities of dust into the air because of the high winds. Samples of the powders were taken, and analysis showed the presence of Cu, V, Ni, Cd, Zn, Pb, Cr, Co, and Hg in varying concentrations from 10 ppm to 2%. Accordingly, to prevent environmental contamination, the site operator was required to cover the material daily.

Prevention of environmental exposure due to improper disposal site practices will be covered under Section 3004 regulations. Protection of disposal site personnel from exposure to hazardous wastes during transportation and at the disposal site will be derived from operational procedures of Section 3004 as well as by regulations of the Occupational Safety & Health Administration. The purpose of the Section 3001 regulations is to identify wastes that are potentially hazardous so that proper management practices can be brought to bear on their disposal. Other sections specify how wastes should be controlled during transportation, disposal, or resource recovery.

Additional properties of toxicants that have not been addressed are those related to allergens and sensitizers. Though exposure to these agents can lead to debilitation, the effects are usually reversible once exposure has ceased. There are two reasons why controlling human exposure to such substances is a problem.

- a. The response of the population to sensitizers and allergens is very diverse; it is doubtful that there is any chemical to which at least some group is not sensitive. Under these circumstances, it is difficult to determine the existence of a significant health hazard.
- b. Procedures for identifying substances with allergic properties are very expensive, time consuming, and imprecise.

Therefore, sensitizers and allergens have not been addressed in these regulations.

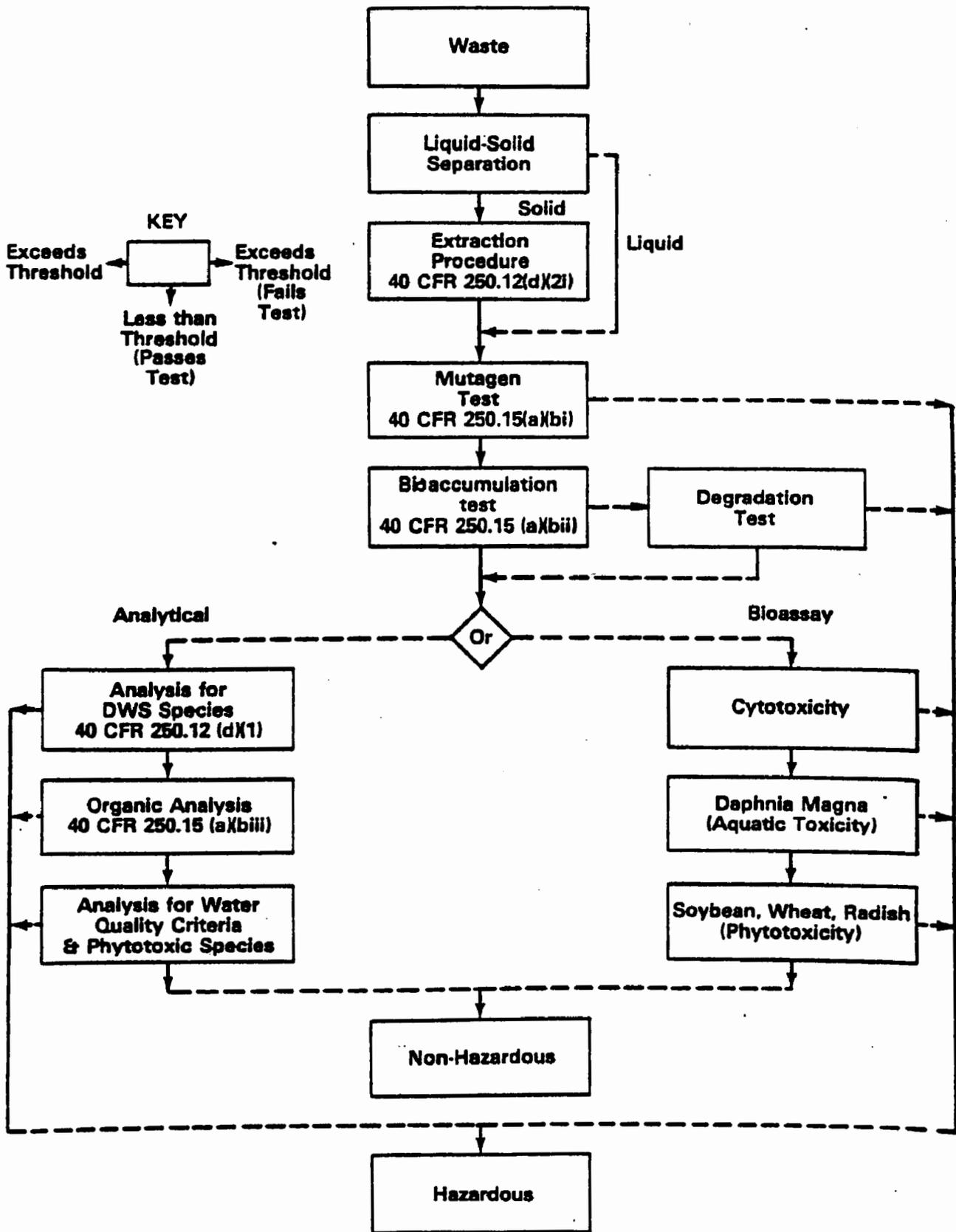
Once those properties of toxicity having a significant effect on public health and the environment were selected, other objectives of the hazardous waste definition became important. These include:

- 1) formulation of a dynamic definition which would not only identify those wastes which contain known toxicants but also those wastes which contain materials or combinations of materials whose toxic properties have not been recognized, and
- 2) specification of toxicant control levels consistent with environmental goals formulated under other regulatory authorities.
- 3) maintenance of low testing costs so that non-hazardous wastes will not be forced into the hazardous waste net as a result of prohibitively expensive test procedures.

The test scheme devised to meet the aforementioned goals employs a combination of analytical procedures and bioassays, and is outlined in Figure 1.

While use of this type of definition has been under active study since June 1977, the data obtained to date is insufficient to permit this total test scheme to be proposed at the present time.

FIGURE 1 PROTOCOL FOR CLASSIFICATION OF HAZARDOUS WASTES



The complete definition would employ biological tests for mutagenic activity and environmental persistence coupled with an instrumental method for bioaccumulation potential. It also includes a choice between using either bioassay or analytical tests for measuring chronic toxicity, aquatic toxicity, and terrestrial plant toxicity. For those toxicants known to be either mutagenic, carcinogenic, or teratogenic but which are not biologically active in the in vitro mutagenicity assays prescribed, control will be via listing on the "Controlled Substances List".

A major goal of the characteristics development program has been to keep testing costs to a minimum consistent with the need for adequate information. Toward this end standard procedures and short-term in vitro bioassays have been selected whenever possible.

In order to take into account the difficulty of formulating a testing scheme applicable to wastes of widely varying complexity, a parallel approach was selected. These two parallel criteria sets are being designed so that either one may be used to evaluate whether a waste is hazardous. The analytical approach relies on a quantitative analysis of the mobile portion of the waste (the extract), combined with hazard thresholds calculated based on mammalian, aquatic, and terrestrial plant toxicity data. If the concentration of any species in the extract exceeds the calculated threshold value the waste is deemed to be a hazardous waste. A

bioassay approach would be available to use when complicated, or hard to analyze, extracts are to be evaluated. In this approach sensitive aquatic and plant species are exposed to the extract and examined for signs of toxicity. If manifestations of toxicity are noted then the waste is a hazardous waste. We feel that using this type of definition is desirable for several reasons.

- 1) The definition is dynamic because it is keyed to waste properties rather than a static list of known hazardous materials or wastes. As new toxic agents enter the waste disposal network they are immediately covered.
- 2) the use of biological indicators offers a mechanism for assessing toxicant synergism and antagonism in complex mixtures characteristic of wastes.
- 3) A choice of cost effective testing schemes is offered to the generators.

At this point it would be useful to examine in some detail the specific aspects of toxicity which are of concern and our present thinking on appropriate test procedures to use in defining what should constitute a hazardous waste. However it must be pointed out that many of these tests and threshold setting approaches have not undergone sufficient testing to permit their incorporation in this initial proposal. The toxicity definition proposed in the Federal Register on December 18, 1978 incorporates a measure of

migration potential coupled with hazard thresholds derived from the National Primary Drinking Water Standards.

The first aspect of toxicity to be discussed relates to the tendency of the constituents of a waste to migrate out and become available to contaminate the environment under poor management conditions. The approach developed to measure this aspect has been termed the Extraction Procedure.

Extraction Procedure

Two general approaches can be used to evaluate the leachability of waste material:

- (1) A very intensive study of the leaching characteristics of a specific waste using conditions representative of both the waste and its disposal or
- (2) A quick test subjecting the waste to standardized procedures.

The intensive study gives more meaningful information about the leaching characteristics of the waste since test conditions can be varied as needed, and the effects of different environmental stresses on leaching can be measured. Such a test takes considerable time, money, and personnel. The standardized test uses only predetermined testing conditions, and therefore it cannot show the effects of the different variables on the waste leaching pattern. It can, however, be used for screening purposes and in this mode can give useful information on the leaching characteristics of a waste in a short period of time and with limited resources.

As with any screening procedure it is important to clearly define how the results are to be interpreted.

In devising a test to use in defining a hazardous waste it is important to insure that problems which may manifest themselves only after many years are identified (i.e., the method must be aggressive enough to accommodate long term exposure conditions).

The RCRA set up a control system for waste disposal in order to insure the safe disposal of those wastes which if improperly disposed of could result in harm to either humans or the environment. It was thus incumbent upon the Agency to develop a definition of a hazardous waste which will identify those wastes which when improperly disposed of could result in the types of damage the Act was passed to prevent. Thus the leaching or mobility test, whose development is described in the following pages, is modeled after a relatively severe form of improper disposal.

Ideally a leaching test would determine three characteristics regarding the release of a parameter, A, from a waste:

- 1) the highest concentration of A to be found in the leachate;
- 2) the total amount of A available from a given amount of waste; and
- 3) the release pattern of A with time.

In order to devise such a standard test a grant was given to the University of Wisconsin, Madison, in July, 1976 to develop a leaching test which could be used widely to assess the leaching characteristics of industrial waste. While this work was in progress, a contract was awarded to the Mitre Corporation to study those leaching tests currently in use by industry and government organizations and to compile and evaluate these procedures. The object was to select the most promising of the available procedures for later evaluation at Madison along with the procedure under development.

During mid-1977 the D19.12 subcommittee of the American Society for Testing Materials (ASTM) began to address the problem of developing a standard extraction procedure. In early 1978 they selected for further evaluation a modified test developed by a supplier of fixation technology, then in use for evaluating the leaching potential of stabilized wastes. Since information on the reproducibility of this procedure was not available, ASTM began an inter-laboratory reproducibility study in the later part of 1978. This study is still in progress. However information developed by members of the ASTM D19.12 subcommittee and made available to us was used in developing the extraction procedure (EP).

Before the work at Wisconsin had been completed, however, it became apparent that the extraction fluid developed

would be too toxic to permit its use later in bioassay tests for toxicants which might have been extracted. Thus in the fall of 1977, research began at the Oak Ridge National Laboratory on an extraction procedure suitable for use in the scheme shown in Figure 1. The development of the extraction procedure which resulted from the work at Wisconsin and Oak Ridge is described on the following pages. (It has been included in the proposed toxicity characteristic, as described in Appendix I.)

Two types of tests are commonly employed for determining the leaching potential of a landfilled waste--batch and column tests. In a batch test, a properly prepared sample of the waste to be tested is placed in a container along with the leaching medium. After a suitable period of time, and under conditions specified as being appropriate to the test, the extract or leachate is separated from the waste and analyzed to determine the material leached from the waste. Column tests, in which the waste is packed in a column and the leaching solution passed through, give a closer approximation of landfill conditions than a batch test, at least at first glance. The column test simulates both the waste-leachate contact (except around the column edge) and the rate of leachate migration found in landfills. The column test also is good for predicting the release pattern with time, since it models the continuous leaching found in landfills and can be run for long periods of time.

However, column tests have the following disadvantages:

1. problems arising from channeling and non-uniform packing.
2. potential unnatural clogging,
3. possible unnatural biological effects,
4. edge effects,
5. long time requirements, and
6. difficulty in obtaining reproducible results even if done by experienced lab personnel.

All of these difficulties, but particularly the time requirement for an adequate column test (months to years), suggest that a batch test be chosen as the standard testing procedure. Both batch and column test might be used though in an intensive study.

There are several parameters affecting toxicant concentration in the extract from a batch test that need to be considered in designing any leaching test. Some of these parameters are:

1. Sample preparation
2. Leaching medium composition
3. Solid to liquid ratio
4. Agitation technique
5. Extraction contact conditions
6. Sample preparation after extraction

Several batch leaching tests have been developed. A survey of some of the existing tests has been done by the Mitre Corporation (3). A summary of the surveyed tests is

given in Table 2. The table provides both the range and the frequency at which values occur within the range for each of the various test variables discussed in this section. For those factors for which the selection of a value is somewhat arbitrary, as in the solid to liquid ratio or the elution time, the range of values reported has been given consideration in the specification of values to be used in a test, and an average value used. For other factors (especially the number of elutions, for example), average values have little meaning. The wide variety in all the specified factors indicates the need for a standardized test so that results on different wastes and by different laboratories will be comparable.

In developing the Extraction Procedure each of the previously described parameters was taken into account. Consideration was given to values already in use in leaching tests developed by other regulatory and testing groups as well as to results of research carried out in support of this effort. A discussion of each of these parameters follows.

Sample Preparation

The initial step in the leaching test is the separation of the solid and liquid components of the waste. "Solid" and "liquid" in this context are defined by the separation. The rationale for the separation process is that the solid and liquid components of the waste will probably separate in

TABLE 2 SUMMARY OF EXISTING LEACHING TEST VARIABLES
(NUMBER OF TESTS SPECIFYING EACH OPERATING VARIABLE INDICATED)

Leachates	No.
H ₂ O. (dist, deion, dist-deion or unspecified)	17
H ₂ O with pH adjustment or simple acid base	5
Site specific	1
Acetate buffer	1
Synthetic municipal landfill leachate	1
Synthetic natural rainwater	1
Bacterial nutrient media	1
Tests with more than one leachate	5

Solid-liquid ratio	range 1:1-1:500	<1:4	1:4	1:5	1:10	>1:10	varied	calculated
		4	4	3	5	2	2	1
Time per elution	range 30 min-10 days	<1 hr	1-24 hrs	24 hrs	48 hrs	72 hrs	>72 hrs	to "equil."
		1	3	7	3	2	3	2
No. of elutions	range 1-10	1	3	5	7	10		
		15	1	1	1	2		
Agitation	shaker, stirring & gas agitation used. Two tests use short agitation times with extended settling times.							
Surface area	unspecified							

a landfill. As Figure 2 illustrates, three separation processes might occur. After the waste is deposited in the landfill, the liquid components could flow downward due to gravity, be absorbed by surrounding materials, or move away from the waste by capillary action. In municipal refuse, the predominant material is often paper so that absorption is probably important. The solid material remaining after the liquid components have moved will be subjected to leaching by whatever leaching media is available in the landfill. Thus, it is more realistic to use only the solid portion of the waste in the leaching test, and to analyze the liquid portion separately, than to use the whole waste in the leaching test. The movement of the liquid portions of a waste from a landfill is not necessarily dependent on the leaching process.

Separations occurring in landfills will depend both on the environment immediately adjacent to the waste and on the landfill conditions and design. Modeling such potentially varied conditions in the laboratory is very difficult. Therefore, it was considered more useful to develop a widely applicable and relatively easy to use solid-liquid separation scheme. Although the separation scheme is not unrealistic with regard to the separation that might occur in a landfill it should not be considered an attempt to model that separation.

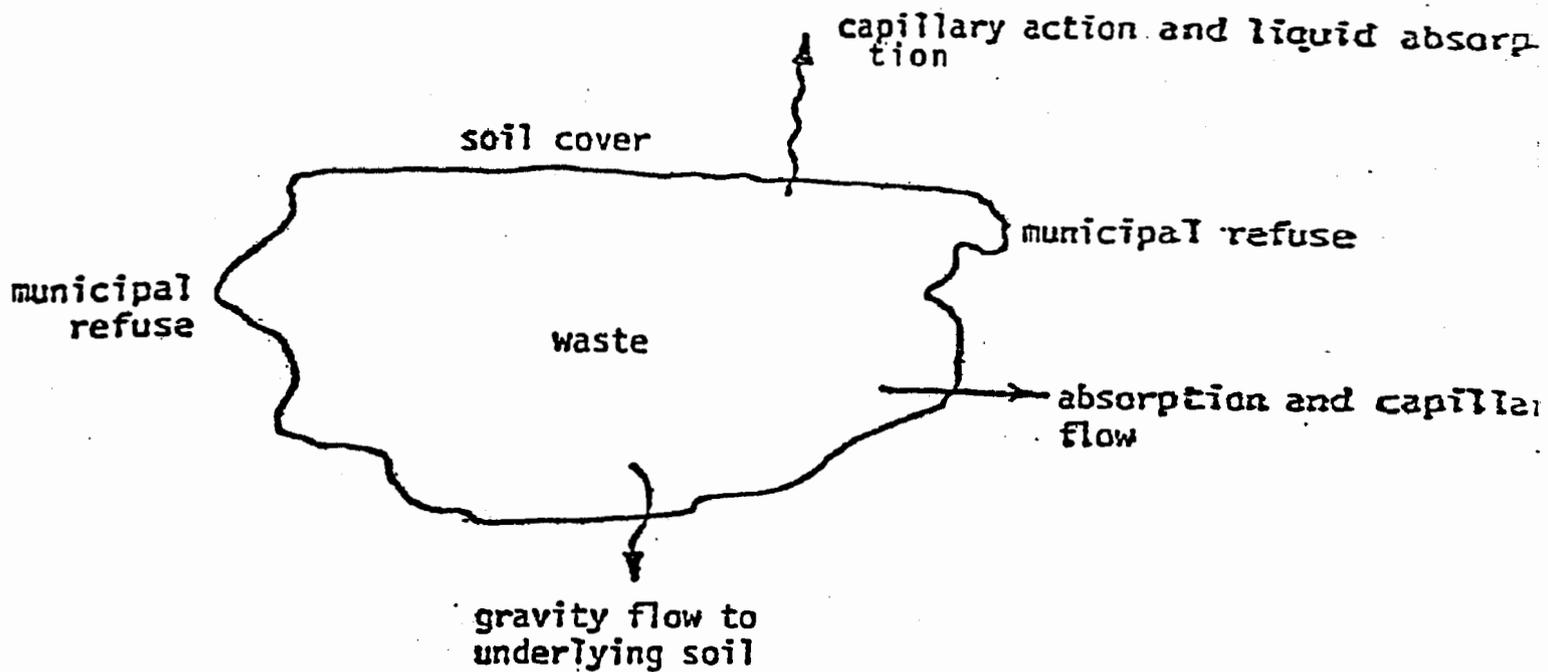


Figure 2. Movement of moisture from waste in a landfill.

Several particle separation techniques are given in Table 3. Of these, screening, filtration and centrifugation were chosen as being the most appropriate for the test scheme. Filtration was chosen as a final step in the scheme, since it is easily applied, readily available and standardized, inexpensive, and roughly approximates the separation processes in the landfill. Filtration operationally defines solids and liquids--anything that will pass through the filter is liquid, and all that does not is solid. It is important that the nature of waste components not be changed, but rather that they simply be separated. This precludes addition of coagulating or deemulsifying agents, for example.

Table 3

A List of Several Particle Separation Techniques

Filtration	Particle Electrophoresis
Sedimentation	Electrostatic Precipitation
Elutriation	Flotation
Centrifugation	Screening

The selection of filter pore size is an important consideration. A small pore size will retain particles in the solid portion which might be considered liquid if a larger pore size were used. For example, hydrous ferric oxide (ferric hydroxide precipitate in water) precipitates in colloidal size particles. A 0.45 micron pore sized filter will trap many of the colloidal sized particles in the solid portion, whereas a larger pore sized filter, e.g., 8.0 micron, will allow most of the colloidal sized particles to pass through the filter. Analysis for iron in the filtrates from the two pore sizes would give different values for the iron concentration in the "liquid" portion. Many materials may occur in or be associated with colloidal sized particles, so it is important to standardize the pore size used and to keep in mind the importance of the pore size on the designated liquid and solid fractions.

Centrifugation is employed in those cases where the nature of the mixture is such that use of filtration would require too much time. Centrifugation conditions have been selected so that separation of particulate material is insured.

A filter pore size of 0.45 micron was selected on the basis of its wide use in water and wastewater analysis, its availability, and the reasonableness of the pore size for modeling landfill situations. Particles larger than 0.45

micron occur in leachate, as shown by suspended solids measurements and the presence of bacteria, but such materials are usually removed by passage through soils, as evidenced by the low suspended solids content of most groundwaters.

In order to insure reproducibility of test results a homogenous sample is required. This can best be accomplished by reducing the particle size of the waste sufficiently to insure that a given aliquot of the original sample is representative of the whole. Since data relating homogeneity to particle size are not available, a compromise was selected between very fine grinding, as specified in the procedures used by Illinois and California, and the use of a monolithic mass as in the ASTM and IU Conversion Systems procedures. ~~The result is the requirement that the solid~~ portion of the waste sample must be ground to pass a 3/8" standard sieve.

However, the concern for reproducibility is balanced by the need to consider real world conditions. A variety of processes have been developed for "fixing" wastes in order to reduce the mobility of the toxic species in the waste. These processes function by either incorporating the waste into a solid matrix, encapsulating the waste with an impervious coating, or causing a reaction within the waste through the addition of binders. These wastes need special consideration with regard to sample preparation. If it can be shown

that these wastes do not physically break down during disposal, then it would be inappropriate to divide the waste into smaller particles than is necessary for testing. The leaching characteristics for a divided waste may be quite different from that of the waste in its original monolithic form.

In order to accommodate this problem a Structural Integrity Procedure (SIP) has been adopted. The SIP is designed to be a moderately severe approximation of the disintegration which might be expected to occur if a fixated waste was used as fill or construction material. Under these conditions crushing might occur from the passage of heavy equipment over the waste.

Mahlock and coworkers (4) determined that a compaction test identical to the procedure of ASTM D698-70 but using only 15 hammer blows simulates the compactive effort that might be expected from passing equipment over a placed landfill. Their 15-blow test uses a 5.5 lb hammer impacting on a 1/30 cu. ft. cylinder of sample after dropping 12 inches. This apparatus would exert an impact of 165 ft-lbs/cu. ft. on the sample.

$$\begin{aligned} v^2 &= 2(\text{acceleration of gravity})(\text{distance}) \\ &= 2(32.2 \text{ ft/sec}^2)(1 \text{ ft}) \\ &= 64.4 \text{ ft}^2/\text{sec}^2 \end{aligned}$$

$$\begin{aligned} \frac{\text{Kinetic energy}}{\text{volume of sample}} &= \frac{1/2 m v^2}{(1/30)} \\ &= \frac{(.5)(5.5/32)(64.4)}{.0333} \\ &= 165 \text{ ft-lbs/cu. ft.} \end{aligned}$$

A modification of this procedure was selected in order to quickly and inexpensively "age" the sample of waste. The goal is to simulate the physical degradation which might take place after the waste has been placed in the disposal site and compacted by earthmoving equipment.

The specific procedure selected was one based on a scaled down version of the 15-blow compaction procedure. The scaled down procedure uses a 0.73 lb hammer acting on a 0.0022 cu. ft. sample with a 6 inch free fall. This device (Figure 3) has approximately the same compaction action as the larger unit.

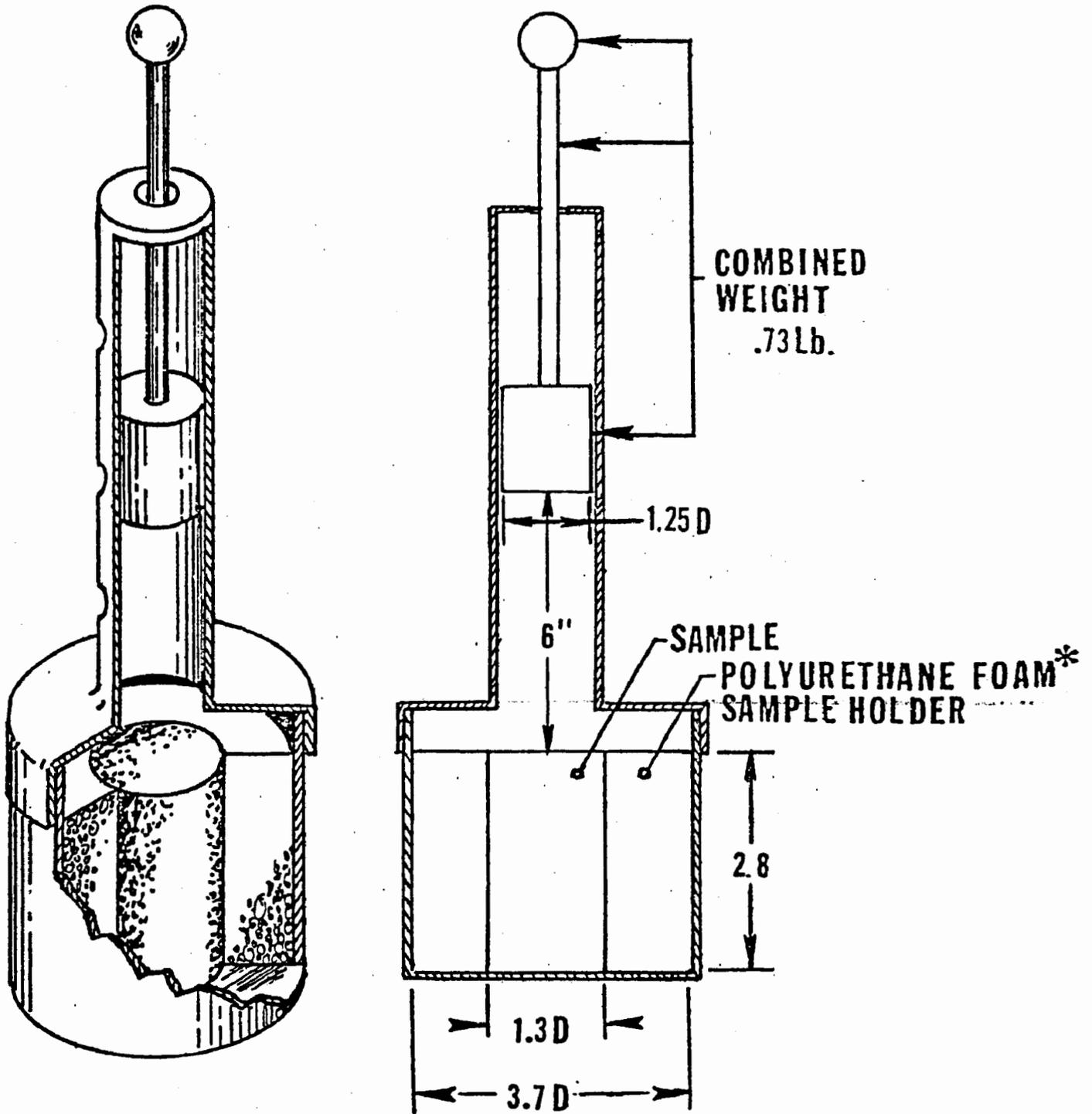
$$\begin{aligned}
 v^2 &= 2 a x \\
 &= (2) (32.2) (0.5) \\
 &= 32.2
 \end{aligned}$$

$$\begin{aligned}
 \frac{\text{Kinetic energy}}{\text{Volume of sample}} &= \frac{1/2 m v^2}{(.0022)} \\
 &= \frac{(0.5)(0.73/32)(32.2)}{(.0022)} \\
 &= 165 \text{ ft lbs/cu. ft.}
 \end{aligned}$$

With a typical stabilized waste, such as that obtained by lime addition to flue gas desulfurization sludge, a sample this size weighs approximately 100 grams. This is a convenient size for extraction using the equipment described in the proposed regulation (40 CFR 250.13).

In order to account for the cushioning or energy dissipation resulting from the compressibility of surrounding wastes, a polymer foam sample holder was incorporated in the design.

Figure 3



COMPACTION TESTER

* Polyurethane foam shall conform to requirements for Grade 21, performance Grade AD or BD, established in ASTM Standard D3453.

Weeter and Phillips (5) evaluated this procedure using a flue gas desulfurization sludge fixated by addition of varying amounts of water. The sludges chosen represented a range of unconfined compressive strengths representative of sludges of all types. Three sludges were examined:

<u>Sample No.</u>	<u>Density (lbs/ft³)</u>	<u>21 day UCS* (lb/in²)</u>
A	50	81
B	120	586
C	101	1450 *

When subjected to a series of blows by the 0.73 lb hammer sample A cracked throughout the upper half of the cylinder while the bottom half remained intact. The pulverized particles formed in the upper half of the cylinder seemed to dissipate much of the energy exerted by the hammer after the third or fourth blow. As a result, the following blows had little effect upon the remaining structure of the cylinder. This may be an approximation of what actually occurs. No visible change in structure was noted in specimens B and C after the SIP procedure.

One shortcoming of the SIP as currently formulated is the lack of any measure of weatherability. Wastes deposited in or on the land will be subjected to effects of water, freeze-thaw cycles, and seasonal and daily temperature changes. We intend to explore these factors and to devise, for use in future regulations, an improved procedure in which these additional factors are incorporated.

* Unconfined Compressive Strength

Leaching Media Composition

Three landfill situations represent the extremes in leaching media composition to which a waste might be subjected in a sanitary landfill, as shown in Table 4. Depending on the relative amounts of the (potentially hazardous) waste and municipal solid waste, and the extent of decomposition of the municipal waste, the appropriate leaching media may range in composition from leachate modeled on actively decomposing, municipal solid waste sanitary landfill leachate to something approaching distilled water. The latter would take on leaching characteristics from the waste itself. This would also represent the situation in which the waste in question is disposed by itself. The third possibility is codisposal with another industrial waste, where the other waste controls the leaching media composition.

As discussed earlier, in order to carry out the mandated enunciation in 1004(5)(B), the concept of improper management has been adopted. Based on this concept of a reasonably worst case disposal situation, the use of the codisposal situation as a model for developing the leaching media composition was selected.

For codisposal with mixed municipal refuse, a municipal landfill leachate could be used. However, municipal landfill leachate has widely differing characteristics depending on the refuse composition, state of decomposition, dimensions

TABLE 4 CLASSIFICATION OF LANDFILLS AS RELATED TO LEACHATE COMPOSITION

<u>Waste Landfilled</u>	<u>Leachate Composition Controlled by</u>
By itself, with relatively small amounts of other wastes, or with decomposed wastes	The waste itself
With municipal wastes	Municipal refuse decomposition products
With major amounts of other industrial wastes	Other industrial wastes

of the landfill, age, degree of channelling of moisture, and both long-term and instantaneous climatic effects, etc. Further, even for a given sample of such leachate, the composition is very complex, precluding developing an exact recipe from which leachate of both reproducible and realistic composition can be produced. Rather than attempt to define a standard landfill, from which leachates representative of different landfill ages would conceivably be obtained, it was deemed more promising to examine the leaching characteristics typical of actively decomposing municipal landfills, and to model a synthetic leachate on the results. Such a synthetic municipal landfill leachate has been developed (6), which simulates aggressive leaching conditions which might be obtained by codisposal of the waste being tested with municipal refuse. University of Wisconsin researchers identified the following parameters to be of importance in describing the leachate that is characteristic of a municipal waste landfill.

- pH
- complexing capacity
- redox potential
- organic solvency
- ionic strength

During the aging cycle of a landfill, these parameters will vary in strength due to changes in the concentrations of

materials producing them. In order to understand and evaluate the variations found in the parameters being considered for the synthetic leachate, some understanding of the processes occurring in landfills is necessary.

Consider a hypothetical landfill with no external influences except for a constant water input; as the landfill ages, a succession of stages will occur.

Initially little or no leachate is produced until the landfill reaches field capacity (becomes saturated with water). The composition of any liquid which is mobilized prior to saturation, due to compaction and squeezing, will depend on the composition of the waste initially landfilled, and may vary greatly.

Three major bacterial processes primarily responsible for degrading refuse are shown in Figure 4. Initially, aerobic decomposition predominates. This phase will generally be very short, given the limited amount of oxygen in the landfill and the high biological oxygen demand (BOD) of the refuse. During this phase, a large amount of heat is produced, raising the landfill temperature well above ambient temperature. (Assuming an initial temperature high enough to start the degradation processes.) Leachate produced during this phase would be expected to dissolve very soluble salts (e.g., NaCl) landfilled with the refuse.

As oxygen is depleted, decomposition caused by facultative anaerobic bacteria will predominate. During this first

THEORETICAL DEGRADATION CURVES

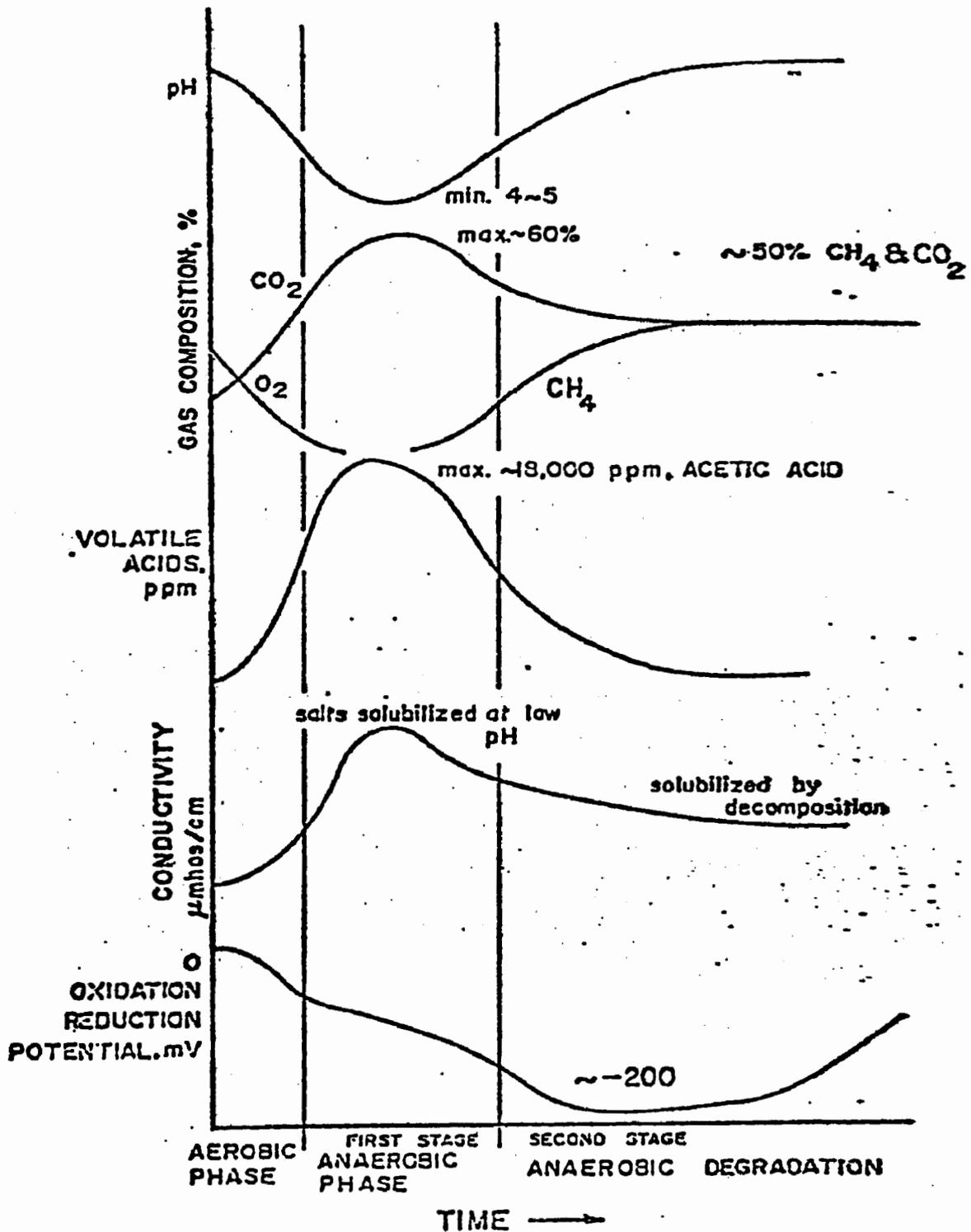


Figure 4 Theoretical degradation curves of a theoretical landfill. From (6)

stage of anaerobic degradation, large amounts of volatile fatty acids (e.g., acetic acid) and carbon dioxide are produced. These acids reduce the pH to the range of 4.5 to 5. The low pH helps to solubilize inorganic materials which, along with the high volatile acid concentrations, produce a high ionic strength (specific conductance). The high volatile acid concentrations also contribute to the high Chemical Oxygen Demand (COD) often found during this phase. The oxidation-reduction potential (redox) is reduced to below 0 mv (with respect to a Standard Calomel Electrode) such that reducing conditions prevail.

The second stage of anaerobic decomposition occurs when methane producing bacteria complement the facultative anaerobes. ~~Methane bacteria are strict anaerobes and require~~ neutral pH levels. Volatile acids produced by facultative anaerobes and other organic matter are converted to methane and carbon dioxide. Thus, the volatile acid concentration is reduced and the gas composition becomes a mixture of carbon dioxide and methane. With the neutral pH necessary for the bacteria to live, fewer inorganic materials will be solubilized, and specific conductance will fall. The redox potential should be lower than the potential during the first stage of anaerobic processes, reflecting the low potential needed for methane production and the higher pH. Eventually, bacterial action may decrease as the substrate

is depleted of oxygen and higher redox potentials may be reestablished by oxygenated water.

Environmental conditions may considerably alter the degradation pattern. The amount of water input has a very important effect on the rate of degradation. Obviously, the composition of the refuse landfilled also has important effects as do landfilling practices and seasonal variations in temperature. To complicate matters further, different microenvironments in the landfill may undergo different stages of decomposition at the same time. For example, Emcon Associates found high volatile acid production, low pH, and methane production occurring simultaneously. Since the low pH is toxic to the methane producing bacteria, it is apparent that different areas of the landfill had different and mutually exclusive conditions, with the leachate reflecting both.

The data used in evaluating the parameters of interest come primarily from either the relatively few studies that have conducted detailed analyses of leachates from a single landfill (7,8), or from work by Chian et al. (9) relating leachate composition from different landfills to landfill age. Analysis of a single leachate sample from a landfill is generally not very useful, since the concentration of a given parameter can not be related to the aging process in the landfill.

Chian et al. (9) analyzed several classes of organic compounds and related variations in their concentrations to landfill age. Figure 5, based on their work, shows the variations of these classes as a percentage of the total organic carbon with landfill age. The age axis should be regarded as approximate, since landfill degradation rates vary with environmental conditions.

There are two factors of importance in modeling pH and redox potential; the measured value and the buffering capacity that maintains that value. The buffering capacity indicates how resistant the measured value will be to change. The minimum pH found in leachate occurs during the period of volatile acid production in first stage anaerobic decomposition. Chian et al. (9) show that the pH and volatile acid trends in real landfills follow the theoretical trends fairly closely. The pH commonly reaches four or five and is heavily buffered by volatile acids. Table 6 gives the pH ranges reported by various authors in literature reviews. As can be seen from the table, a pH of 4.5 is not uncommon in leachates. Furthermore, both the carbon dioxide and the volatile acids achieve maximum buffering capacity near this pH. An "average" landfill probably does not maintain this low a pH for an extended period of time, but, rather, maintains a pH of between 5 and 5.5. The emphasis here is leachate aggressiveness, which warrants the use of the low pH value.

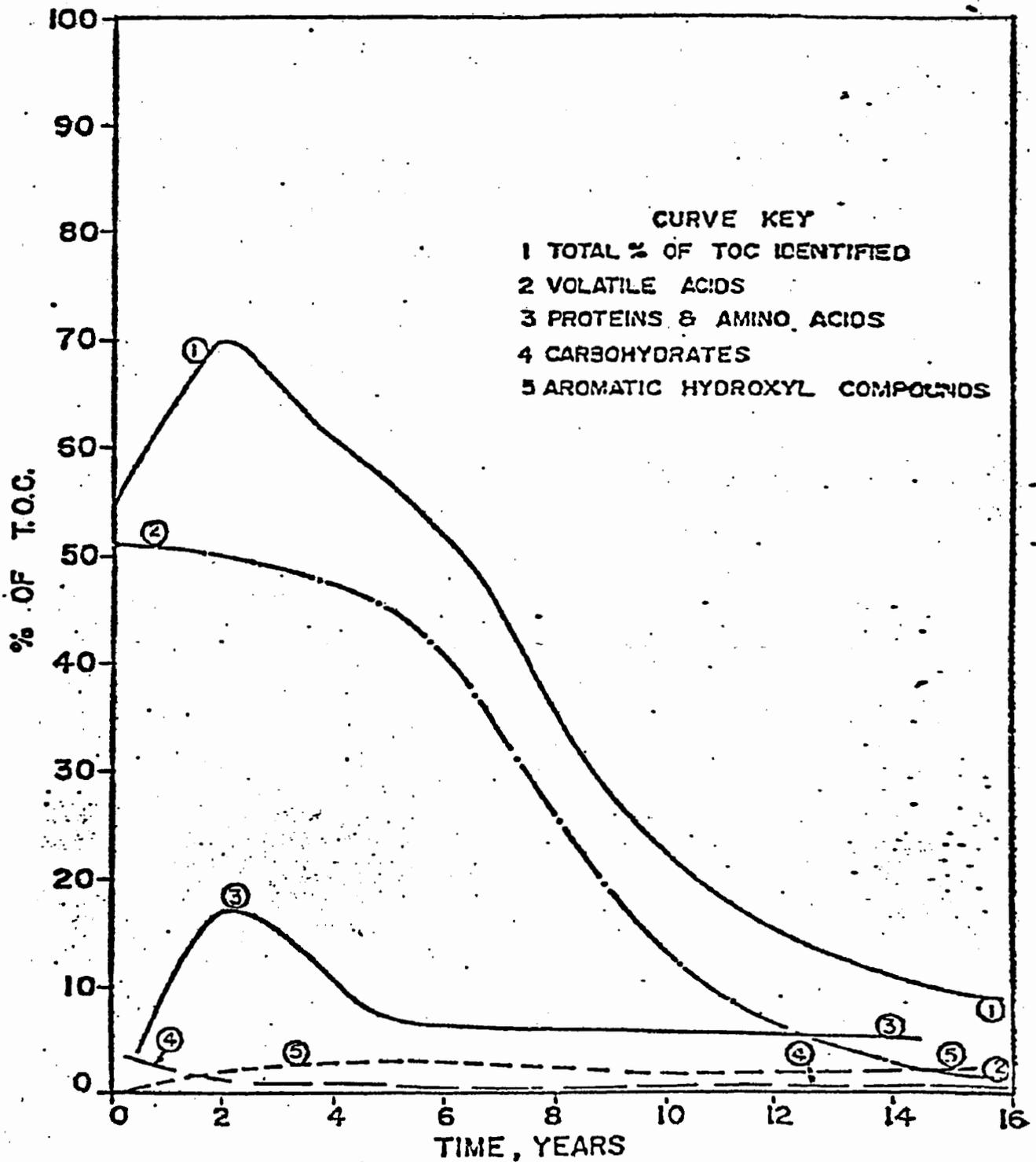


Figure 5 The trends in the identified fractions of leachate TOC vs. the age of the landfill. (From Reference (6).-)

TABLE 6. pH RANGES REPORTED BY VARIOUS AUTHORS FROM
LANDFILL OR LITERATURE SURVEYS

Source	Range
Chian et al. (9)	3.7 - 8.5
Steiner et al. (10)	4.0 - 8.5
Clark et al. (11)	1.5*- 9.5
Encom Associates (7)	3.0 - 8.5
Pohland (12)	4.9 - 8.4

*Site received acidic industrial wastes

In developing the extraction procedure (EP) it was necessary to devise a procedure for operationally maintaining the pH at the selected value while taking into account that a given disposal environment has only a finite buffering capacity. An additional factor which complicated the development of the EP was the need to keep the toxicity of the extractant liquid low to permit the use of bioassay procedures to evaluate the toxicity of the ^{species} migrating from the waste.

The ultimate buffering capacity of real world leachates is a question which has received little attention from the research community. However, data gathered at EPA's Boone County Field Site (3) over a period of 7 years indicates that leachate generated by decomposing municipal refuse generates approximately 0.14 equivalents of acidity per kilogram of dry refuse. Furthermore the acidity is composed of a mixture of volatile organic acids, in which the predominant species are acetic and propanoic acids.

For modeling purposes acetic acid has been selected as the acidification agent. Since it is predominantly pH that is being modeled, use of a single acid presents no problem.

In order to calculate the buffering capacity of the hypothetical disposal environment used in the improper disposal model a site was modeled in which the waste in question comprised 5% of the material in the site.

Furthermore the remaining 95% of the material would be

organic in nature and would decompose to produce acids in a manner similar to municipal refuse. This is a conservative model but not a worst case model, since co-disposal with highly acid waste is not accounted for.

Using the above relationships one finds that: 1 gram of waste could be exposed to approximately 2 milliequivalent of acid. Thus pH control and buffering capacity have been accounted for in the EP by using a titration procedure to maintain the extraction fluid at pH 5 with a limit on total acid to be added set at 2.0 milliequivalents per gram of solid material. Using acetic acid as the acidulant this calculates to 4 ml of 0.5N acetic acid per gram of waste being extracted.

Extractant to Sample

The ratio of waste to extractant used in a standardized extraction procedure is important when the procedure is used for waste characterization purposes. The ratio selected, coupled with the extractant-solid contact time, determines whether saturated or unsaturated conditions will exist. In addition excessive extractant to solid ratios can lead to dilution of migrating species thereby resulting in unreasonably low toxicant concentrations.

The disposal model, since it is not based on any specific disposal site, does not offer any basis on which to set a ratio. However there are scientific and practical considerations which can be used to arrive at a ratio.

The three factors which received primary consideration are:

- a. If the sample:extractant ratio is very low, then sampling and analytical errors will be magnified.
- b. If the sample:extractant ratio is very high it leads to problems with suppression of sparingly soluble species as well as difficulties in agitation and in separation of liquid from solid.
- c. Evaluation of the extract using biological tests requires, in some cases, fairly large volumes of extract. Thus a procedure which maximizes the quantity of extract is desirable.

As Table 2 shows, existing leaching tests use sample: extract ratios anywhere from 1:1 to 1:500. Data (6) indicate that in most cases the experimental results at ratio between 1:5 and 1:20 are close to those calculated assuming a direct concentration dependence on ratio. Thus since no one ratio, within this range, appeared to offer any particular advantage relative to factors a and b, a 1:20 ratio was selected to maximize factor c.

Agitation Methods

In order to obtain reproducible results indicative of the maximum toxicant concentration which might be expected to occur, it is important that a uniform, nondestructive, efficient agitation method be employed. Ham (6) evaluated five agitation methods. These were:

1. Continuous shaking using an oscillating shaker;

2. Continuous mechanical stirring with a flat paddle;
3. Intermittent shaking by hand;
4. Swing type shaking (Fig. 6) and
5. A rotating bottle agitator (Fig. 6).

Ham found that none of the first three methods provided an optimal solid-liquid contact for all wastes. In the continuous shaker (employed in the ASTM procedures) the solids often remained at the bottom of the flasks, particularly if a slow shake speed was chosen, with the result that those solids on the bottom did not get continuously exposed to "fresh" extractant. Ham also expressed concerns with using continuous mechanical stirring with a flat paddle because of its potential for causing abrasion especially with granular materials. He observed that the waste and liquid tended to move at the same speed as the stirrer in the continuously stirred flask, with the result that less than optimal mixing occurred.

Observation of the mixing action using a swing type shaker led to the conclusion that this form of agitation does not seem to provide good mixing. The solid often remained on the bottom and on the side walls of the flask without mixing.

Their conclusion was that in general the different agitation methods provide nearly equivalent results when cumulative release using a series of extractions is the

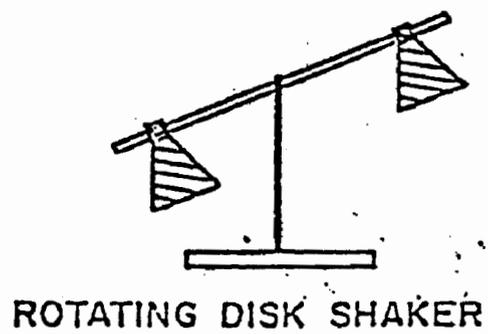
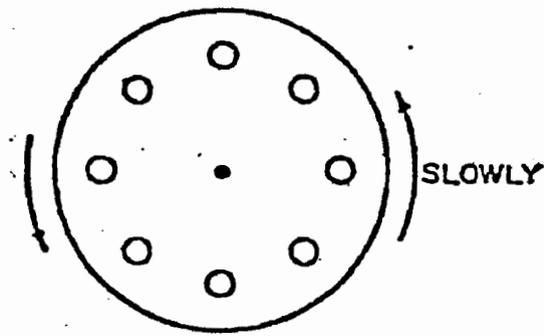
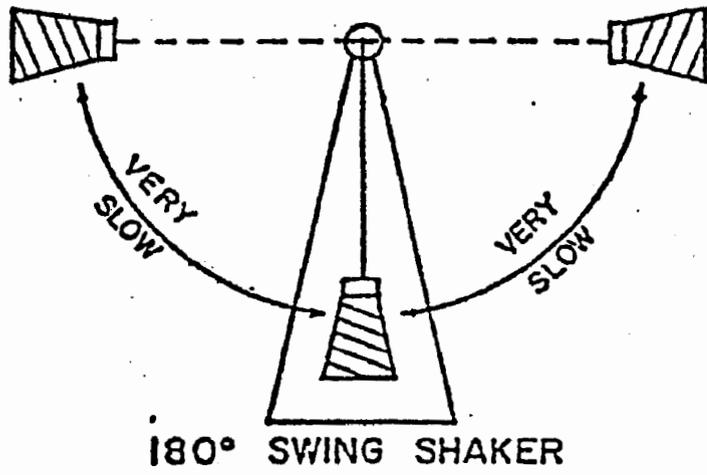


Figure 6 Diagram of the swing shaker and the rotating disc device

parameter measured. However, the rotator method seemed to be the most effective agitation method both from visual observations with different wastes and from some what higher release rates.

Thus in order to allow a waste tester to use available equipment whenever possible, agitation has been defined in a generic way, as follows:

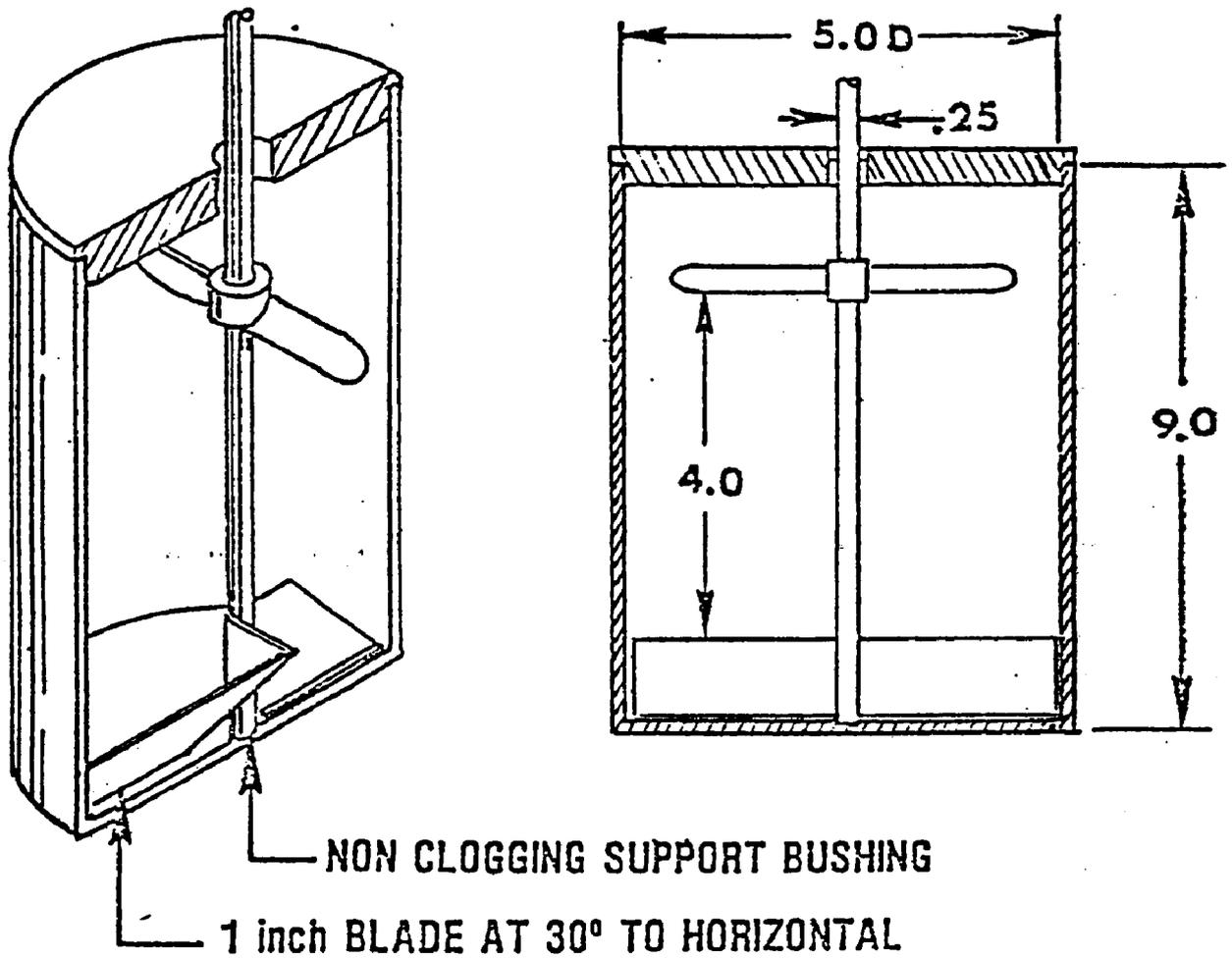
"an extractor which while preventing stratification of sample and extraction fluid also insures that all sample surfaces are continuously brought into contact with well mixed extraction fluid."

During the development of the proposed regulations it was necessary to select an agitation method which satisfied the following criteria:

1. Was usable on a wide variety of waste types.
2. Permitted the pH of the solution to be continuously monitored and adjusted.
3. Resulted in minimum abrasion of particulate material.
4. Did not add to or remove any materials from the extraction solution.

In order to satisfy these requirements an agitator of the design shown in Figure 7 has been developed. Adequate

Figure 7



EXTRACTOR

agitation is obtained at rotational speeds of ≥ 40 rpm. Materials of construction that are being evaluated for their acceptability for a variety of wastes types are 316 stainless steel and polytetrafluoroethylene.

Extraction Contact Time

The liquid-solid contact time is important because it must be long enough to insure the extraction of contaminants which might be mobilized under environmental conditions. However it also must not be overly long since this will increase the testing costs.

The Mitre survey (3) of existing leaching test methods, indicates that there is no consensus within the environmental community as to an appropriate contact time. Their data indicated that ~~the contact times in use per extraction~~ can be broken down into:

less than 24 hours	39%
24 hours	39%
longer than 24 hours	21%

We have thus elected to use a 24 hour contact time since the available test procedures indicated it would be cost effective from the standpoint both of efficiency of extraction and testing costs.

The objective of the extraction procedure is to prepare an extract of the waste in which the concentration of the mobile contaminants simulates the maximum concentration likely to occur in the real world. Furthermore, since the initial extraction usually results in the maximum contaminant concentrations, only a single extraction is required.

During the development of the extraction procedure, a 48 hour procedure using two extractions was studied in order to minimize surface contamination effects. Comments received from various industry groups indicated this was not a major concern and that a more important consideration would be to lower testing costs. Therefore the second extraction was dropped.

Post-Extraction Sample Handling

The contamination scenario on which the extraction procedure is based uses transport of contaminants through the soil to an underlying aquifer as a model. As was discussed under "Sample Preparation" only those particles less than 0.45 microns are likely to reach the aquifer. Thus as in the initial separation the solids are removed from the extract. Since in a disposal environment the liquid likely to reach the aquifer would be a combination of the liquid portion of the waste and the extract of the solid

portion, the original liquid phase is added to the solid phase extract prior to use in toxicity evaluations. It is this combined liquid which is defined as the extract.

However, when analytical characterization is to be employed, there may be times when it is easier to analyze the two phases separately then combine them mathematically.

As has been discussed earlier, the contamination model selected for developing control threshold values is based on leaking or leaching of toxicants from the disposal site to a drinking water aquifer. In order to set a threshold level of a contaminant in the extraction procedure extract, it is necessary to develop a numerical relationship between the concentration of a toxicant in the liquid entering the aquifer and the concentration at the point of human or ~~environmental~~ environmental exposure.

Groundwater Dilution

Because the movement of a pollutant below the surface of the land is governed by ground water flow, an understanding of ground water behavior is essential to the determination of contaminant migration in an aquifer. Generally, recharge to an aquifer is provided by natural sources such as rainfall and subsurface inflow or by artificial sources such as seepage from liquid waste impoundments. Water entering the ground moves vertically through the unsaturated zone then enters the saturated zone and travels in a predominantly horizontal manner in the direction of

decreasing hydraulic gradient. The flow pattern can be altered by induced changes in gradient (e.g. a pumping well). A pollutant entrained in ground water flow may persist throughout the entire sequence of travel but will undergo attenuation. ^{The} degree of attenuation depends on the properties of the pollutant and the hydrogeologic conditions in the aquifer.

Change in the composition of leachate from a landfill is usually achieved through a series of reactions. The quality of leachate depends on the form and quantity of the wastes from which it originates, the disposal conditions, and the physical and chemical properties of its constituents. As the leachate migrates, constituent concentration may be affected by passage through various media.

During percolation through the landfill interior, some components will be removed by adsorptive and complexing reactions, while others will be added by waste solubilization. At the interface between the landfill and the underlying strata, potential attenuating processes include precipitation, filtration of particles, and adsorption on gel precipitates. The existence below the landfill of an unsaturated zone with a liquid and a gas phase increases the possibility of attenuation or delay of contaminants. Permeability is lower than that of an all liquid environment, and flow rates will probably not be uniform, thereby allowing some solute dispersion. Dilution is not significant, but attenuation by chemical

and biochemical processes may occur. The thickness of the unsaturated zone is important in this regard.

At the interface between the unsaturated and saturated zones, leachate movement changes from vertical flow to predominantly horizontal flow. Ground water flow is normally laminar, i.e., characterized by parallel streamlines with ^{little}/_{no} or mixing taking place between adjacent flow paths, although turbulent flow involving mixing can occur during movement through large fissures or in the immediate vicinity of a pumping well. The extent of vertical flow in the saturated zone will depend on leachate density and the presence of vertical fissures or superimposed beds of varying permeabilities.

Leachate does not mix readily with ground water; it may move as a slug, a plume or a mass of degraded water. The ground water flow pattern governs leachate migration, although differences in density and miscibility can cause variation in behavior between the plume of contaminated water and native water. The velocity of contaminant travel may be less than, equal to, or greater than that of ground water.

Pollutants entrained in ground water flow tend to become attenuated with time and distance. Mechanisms involved include adsorption, dispersion, diffusion, precipitation, and degradation. The most significant means of attenuation in the saturated zone may be dilution of the leachate as it follows tortuous flow paths through the aquifer. Constituents of the leachate will be reduced at rates dependent on the individual properties of each. Leachate will tend to the local hydrogeologic framework and

be contained at sites

underlain by fine grained, compact materials with low hydraulic conductivities (slate, shale, soft clays). Migration with attenuation is favored in formations exhibiting intergranular flow (sands, sandstones, sandy clays, gravels) and formations displaying marked fissure flow with an element of intergranular storage (chalk) if the intergranular conductivity is greater than the maximum recharge rate. Rapid leachate migration through coarse, unconsolidated gravel formations and fissured rocks such as limestone and granite allows little attenuation of pollutants.

Distribution of contamination underground also varies according to local aquifer conditions and the nature of the pollutant. ~~Where groundwater flow is rapid, leachate from a~~ point source will form a long thin plume. Low flow rate will contribute to lateral dispersion. Distortion of the shape of the plume can be caused by variations in permeability and by the operation of pumping wells. A plume supported by a constant input of waste will ordinarily stabilize. The tendency of the enclave to become enlarged with addition and dispersion of contaminants is counterbalanced by attenuation mechanisms or discharge to surface waters. Changes in the groundwater flow, recharge and waste disposal rates can cause the plume to expand or contract. The plume of a leachate constituent with greater susceptibility to attenuation will be smaller than that of a persistent contaminant in the same zone.

Degree of pollutant attenuation within an aquifer is basically dependent on site specific conditions, but a reasonable scenario utilizing an attenuation factor can be constructed.

The following assumptions have been made:

1. Disposal takes place in a "nonsecure" landfill.
2. The landfill is situated over a fresh water aquifer and in proximity to life-bearing surface waters.
4. A pumping well is located 500 feet downgradient from the landfill. (States with landfill design criteria specify landfill to water well distances ranging from 500 feet to 1 mile. The more conservative number was chosen for the purposes of this scenario.)

Some insight into the process of pollutant dilution in groundwater for the purposes of scenario construction can be provided by modeling techniques. A model is a simplified representation of a real system, and difficulties are often encountered in quantifying parameters and testing and verifying results under field conditions. Modeling concepts must be applied to a given situation with caution, but a model can supply information on potential groundwater effects. A model to estimate leachate dilution in groundwater and down-gradient well discharge has been devised at the Water Research Center of Medmenham Laboratory in England. ⁽¹⁴⁾ The model is

based on the following assumptions:

1. Leachate of consistent composition is discharged from the entire landfill at a constant rate.
2. There is no chemical change in the leachate as it migrates through the aquifer.
3. The unsaturated zone is considered a delay mechanism only.
4. In the saturated zone, the aquifer is uniform and the natural groundwater gradient is constant.
5. Steady-state conditions exist.

Dilution factors have been calculated using the equation:

$$\frac{C \text{ (groundwater)}}{C \text{ (Leachate)}} = \frac{I}{I = UB/L} \quad \text{Where } C = \text{pollutant concentration}$$

I = leachate infiltration rate, U = groundwater flow rate, B = depth of mixing and L = length of landfill in the direction of groundwater flow. Employing average aquifer characteristics and assuming a constant leachate production rate of 0.3 meter/annum, dilution factors beneath a landfill were calculated for 3 types of aquifers. Results are given below:

Dilution Factors

<u>AQUIFER</u>	<u>Distance from Landfill</u>	
	<u>50 Meters (164 ft.)</u>	<u>300 Meters (984 ft.)</u>
Chalk	15 - 50	100 - 250
Sandstone	3 - 10	15 - 50
Gravel	100 - 200	250 - 500

The lowest dilution factor, 3x, has been calculated for a contaminant migrating through a sandstone aquifer beneath a landfill 50 meters in length. Discharge of the contaminant to a well directly downgradient should result in this degree of attenuation. Any additional dilution would be dependent upon how ^fast water was withdrawn from the well. If high pumping rates are employed water from outside the plume may be drawn into the well thus diluting the contaminated water.

As previously mentioned, models depict idealized situations. Actual field analyses reveal considerable variability in pollutant dilution factors in ground water. To illustrate this, we have chosen to examine the behavior of chloride. The chloride ion is a highly mobile and persistent contaminant. It is readily leached from waste and is resistant to ion exchange, chemical reactions and sorption. Attenuation of chloride during migration is due to dispersion and dilution. Some observed dilution factors for chloride at various distances from waste disposal sites are listed in Table 7.

Table 7 - Chloride Dilution Factors

<u>SITE</u>	<u>DISTANCE</u>	<u>DILUTION FACTORS</u>
Illinois landfill (15)	650 ft.	4-5
Llangollen, Del. landfill (15)	650 ft.	27
Conn. landfill (1)	200 ft.	2.3
Fly ash settling pond (16)	500 ft.	8-9
DuPage County, Ill. landfill (17)	32 ft.	2
Winnetka, Ill. landfill (17)	800 ft.	13
Tythegston landfill, England (14)	330 ft.	2-3

Approximate attenuation factors for hazardous constituents of leachate also vary widely. Table 8 illustrates data from field analysis of several waste disposal sites.

Table 8 - Pollutant Attenuation Factors

<u>SITE</u>	<u>Pollutant</u>	<u>Distance</u>	<u>Attenuation Factor</u>
Iowa landfill (18)	Arsenic	400 ft.	12-13
Fly ash settling pond (16)	Arsenic	500 ft.	4
Kings Kettle landfill, England (14)	Cyanide	430 ft.	50
Coatham Stob landfill, England (14)	Chromium	500 ft.	100
Mitco (14)	Phenol	adjacent	>23
Mitco (14)	Nickel	adjacent	>170
Mitco (14)	Phenol	adjacent	>1000
Mitco (14)	Zinc	adjacent	>14

Because of the variability in observed attenuation factors, a conservative approach has been taken in choosing a factor of

10 over a distance of 500 feet. This factor does not appear to be unreasonable when compared with available data. However, the value of 10 does not represent the minimal amount of dilution that can be expected. For instance, leachate migrating from a disposal site in Islip, New York was not attenuated by that amount until it had migrated a half mile⁽¹⁵⁾. Hydrogeologic conditions in the aquifer permitted rapid flow, thereby discouraging dilution. Although it is emphasized that there will always be instances of lesser and greater attenuation, a factor of 10 should provide a reasonable degree of protection to public health and the environment while taking into consideration the broad range of hydrogeologic conditions at waste disposal sites across the country and the variety of contaminants likely to be released to the environment as a result of land disposal. In addition to the health and environmental problems which result from contamination of groundwater, an additional area of concern is potential damage to aquatic resources caused by contamination of surface water supplies.

Documentation of surface water degradation caused by groundwater which became contaminated as a consequence of improper land disposal of wastes is readily available. In one instance, a producer of organic arsenicals disposed of various sludges and untreated solid wastes in a landfill. Field analyses later revealed high levels of arsenic in the sludge and soil at the disposal site and lower arsenic

levels in both the underlying aquifers and the nearby river. Groundwater samples taken from a monitoring well close to the landfill exhibited arsenic levels as high as 178 mg/l, while water samples taken from the river immediately downstream from the site contained 150 ug/l. Data gathered by the State geological survey indicate that movement of shallow groundwater is carrying the pollutant from the landfill to the river⁽¹⁸⁾. In Maine, contamination has been detected in residential wells near a hazardous waste disposal facility. Pollution has also been found in a local stream, and available hydrogeologic data suggest that it resulted from migration of the substance through the shallow aquifer to the surface water⁽¹⁹⁾. Other studies describe incidents of a similar nature. Liquids and sludges deposited in an unlined surface impoundment at a chemical plant site caused groundwater degradation, and the plume reached a stream adjacent to the site. At this site arsenic levels of 10,000 ppm were found in the groundwater, and 40 ppm were detected in the stream. Phenolic waste water placed in clay-lined lagoons in Maryland migrated to groundwater which then traveled downslope and discharged to a freshwater pond and small stream. In another instance, high concentrations of copper, chromium, and lithium were found in a lagoon containing untreated industrial sludge and liquid wastes. A nearby stream showed signs of contamination due to discharge of groundwater tainted by material from the lagoon⁽²⁰⁾.

Dilution factors for certain substances or specialized situations have been determined by other groups. EPA has previously recognized the existence of such factors in the establishment of effluent standards for endrin, toxaphene, and benzidine. The concentration of benzidine allowed in an "end of pipe" discharge is 100x the ambient water criterion. Effluent may contain 300x the amount of toxaphene specified by the ambient water criterion, and the expected dilution factor for endrin is 375x upon discharge to surface waters.⁽²¹⁾ A discharge location for an aquifer may be a point source, so the effluent guidelines are applicable in part to the development of a dilution factor for this contamination scenario.

Information from a study on ocean dumping of dredged material for the Army Corps of Engineers indicates that material discarded in that manner should be diluted by a factor of 10 within a few minutes.⁽²²⁾ Leachate contaminated groundwater will enter surface waters at a slower rate than dredged material dumped into the ocean and, in most circumstances, should undergo greater dilution.

In an Illinois landfill study,⁽¹¹⁾ dilution factors were calculated for ground to surface water discharge at several locations. Discharge from one landfill to a nearby drainage ditch was diluted an estimated 45x. This factor was considered low because it did not take into account the water moving downward below the landfill or the amount of dilution in the area between the landfill and the ditch. At another location,

it was calculated that chlorides migrating from a fill would be reduced by a factor of 39 upon discharge to a creek. Contaminated groundwater from a third landfill was expected to be diluted 120x when discharged into a river with a low flow rate; much greater dilution would occur at an average flow rate.⁽²³⁾

The dilution model discussed previously also estimates the attenuation of leachate discharge from groundwater to a stream. The model predicts that a pollutant discharged from a 300 m² landfill into a stream immediately downgradient will be diluted 50 fold due to base flow alone over a 1 km stretch. A "worst case" situation would exist if a surface body water were fed entirely by contaminated groundwater, but most groundwater entering surface waters should be diluted by water already present and by discharge from other aquifers

For the purposes of this scenario, a dilution factor of 100 has been chosen for groundwater discharge to surface water. The actual amount of dilution is subject to influences such as the characteristics of the pollutants, hydrogeologic conditions in the aquifer and physical and chemical properties of the mixing zone and receiving waters. For this reason, establishment of a dilution factor is best done on a site-specific basis. However, this contamination scenario is applicable nationwide and therefore must be designed to protect various environments. Available information indicates that 100x is a conservative number, but there will be instances in which less dilution occurs. Additional background information on groundwater dilution theory was obtained from references 24 through 31.

Toxicity

Once the extract has been obtained it must be evaluated to determine if its discharge would result in a human or environmental health hazard. As Figure 1 indicates a variety of mechanisms are available for a toxic effect to occur. The following sections will describe the various properties of toxicity that will be addressed in either the proposed regulations, the Advanced Notice of Proposed Rulemaking, or in future proposals.

Genetic Activity

Chemicals present in the environment have been implicated in the high incidence of cancer in humans. In order to lessen human exposure to carcinogens it is necessary to handle and dispose of wastes containing such chemicals in a manner appropriate for a hazardous material. An additional danger from which society requires stringent protection is exposure to chemicals capable of damaging genetic material (DNA). There are a variety of mechanisms by which chemicals can act to cause damage to genetic material. A program of waste control aimed at identifying and eliminating human exposure to carcinogenic, mutagenic, and teratogenic compounds requires rapid, inexpensive screening methods to pinpoint dangerous materials. In response to this problem, a number of rapid and potentially inexpensive bacterial and in vitro cellular tests have been developed. These tests are designed to identify mutagenic substances by detecting

genetic changes in the test species. Because of the variety of types of DNA damage that must be looked for, no one simple test will suffice. Thus a battery of tests will be employed to screen wastes for their ability to cause DNA damage. While these tests do not measure carcinogenicity per se, there exists a correlation between positive responses in these in vitro assays and ability to cause cancer in whole organisms.

It should be emphasized that short-term tests are only indications of toxicological effects which may occur in whole animals after long induction periods. Their usefulness lies in their convenience; compounds demonstrating activity in selected short-term tests would be expected to be among the more dangerous threats to human and environmental health. Both economic and time considerations prevent testing of wastes for genetic activity and carcinogenicity in whole animal systems. For control purposes, since a choice must be made between testing in an imperfect system and no testing at all, the imperfect option was chosen.

In 1975 the Agency published proposed guidelines for registering pesticides which contained the Agency's first formal mutagenicity testing protocol. Based on comments received both in response to this proposal, and as a result of a study conducted by the Science Advisory Board's Study Group on Mutagenicity Testing, the 1975 proposal was redrafted. It is recommended that these new proposals,

published in February 1978⁽³²⁾, be consulted for a more in-depth discussion of the need for including mutagenicity as a toxic property of concern.

Tests have been selected (Appendix III) on the basis of low cost, short performance time, and relevance to the task of characterizing hazardous waste mixtures. A further goal is to use, wherever possible, test procedures and organisms that are used in other regulatory activities of EPA, DHEW, OSHA, and CPSC.

Compounds are often non-mutagenic until acted upon by the target organism's metabolic system. In addition, the reverse can occur; mutagenic substances can undergo metabolic inactivation. For this reason wastes will be tested both with and without activation. Activation will be conducted by incubating the waste extracts with organ homogenates derived from mammalian species (i.e., rat liver).

It is known that the common mutagenicity test may not respond to several types of known carcinogens. For example, carcinogenic metals and chlorocarbons are not detected by the popular Ames Salmonella assay. In addition, while teratogenicity is a very real concern, it appears that short-term tests are not available for evaluating the teratogenic potential of a complex mixture. To protect against the danger of exposure to hazardous materials known to pass through the screening, a "controlled substances list" will be included in the regulation. Known hazards which are not caught in the other sections of the criteria net will be regulated by this section.

Bioaccumulation and Persistence:

Bioaccumulation can occur through either a physical or a chemical process. As a physical process it relies on the preferential solubility of nonpolar organic compounds in fat tissue relative to the more polar muscle tissue. Furthermore, once a material becomes deposited in body fat, its availability, metabolism, and subsequent elimination from the body slows. While many persistent organic materials such as DDT, endrin, and PCBs are retained and biomagnified through this mechanism, other materials such as mercury and lead are retained through chemical processes. As a chemical process, bioaccumulation relies on the high affinity of some metals for sulfhydryl and disulfide groups associated with proteins. Historically, the former mechanism has accounted for the majority of environmental contamination problems. Contamination by halogenated pesticides and flame retardants has been of special concern. Some recent notable examples are polybrominated biphenyls, Mirex and Kepone. Recognizing this, it appears that a partition test may be helpful in identifying waste extracts containing organic compounds with substantial bioaccumulative potential.

Though this test procedure (Appendix IV) would miss materials which bioaccumulate through the chemical bonding mechanism, this is not thought to be a significant problem. Metals known to exhibit this type of bonding, but which are

not identified by the analytical or the aquatic toxicity phases of the criteria, could be included on the "controlled substance list" used to also identify exceptions to the genetic assay.

While a partition test can indicate a material's propensity to bioconcentrate in an exposed organism, the contaminant must be able to persist both in the environment and in the organism for an appreciably long time. Thus before a waste is considered to be a hazardous waste because of its bioaccumulativenness, the components suspected of being persistent will be evaluated for environmental stability. This procedure will be conducted by exposing the extract to a mixture of microorganisms and allowing biodegradation to proceed for a specified length of time. Specific procedures for conducting such a test are under development in consultation with other EPA regulatory groups. One such procedure is described in Appendix V. Other procedures found to give equivalent results will be made available in the procedures manual to be published upon promulgation.

In order to devise a definition which meets the objectives previously described, namely:

1. is dynamic and applicable to both present and future wastes,
2. specifies control levels consistent with environmental goals formulated under other regulatory authorities, and
3. does not impose a prohibitive economic burden on the regulated community,

twofold definition is desirable. Such a definition would allow a choice of using either analytical or biological indicators. The following discussions have been arranged according to that part of the environment they are designed to protect.

Human Toxicity:

Bioassay

Classical chronic toxicity testing is a prolonged procedure. Historically, potential danger to human health has been determined through chronic feeding studies using whole animals. Usually this has meant feeding a rat, mouse, or other mammal the suspected agent for 3 or more years and

then examining the animal for histopathological effects. This type of testing is prohibitively expensive and time consuming.

Recently a variety of short-term cellular bioassays have been developed for assessing toxicological activity. These short-term tests are still in the infancy of their development. The basis for these in vitro bioassays is the general observation that toxic events which occur in single cell tests have been found to also occur in the whole animal. These in vitro bioassays are reported to correlate qualitatively with in vivo bioassays. Materials potent in one system generally are potent in the other, just as compounds which are weakly active in one are weakly active in the other.

The two major difficulties in defining a bioassay protocol using cellular bioassays are:

1. the lack of a quantitative correlation between cellular and whole animal toxicity, and
2. the fact that cellular bioassays are still in their infancy and there is scientific doubt as to whether the results are meaningful.

Whole animal tests, by virtue of their completeness, have an advantage because they take into account pharmacodynamic distribution and metabolism in the organism. This is especially true with respect to transport of toxicants to the active site in the body. Cell cultures, on the other hand, can employ human cells and therefore might model some aspects of human toxicity more accurately than a rodent bioassay.

Because of the prohibitive cost of whole animal testing coupled with the uncertainty of the meaning of cytotoxicity testing, bioassays suitable for RCRA use in indicating potential human toxicity are not currently available.

Analytical

The Safe Drinking Water Act of 1974 (Public Law 93-523), was passed in order to assure that the public is provided with an adequate supply of safe drinking water. The Act authorized the Environmental Protection Agency to establish Federal standards to protect water supply systems from harmful contaminants. Under this authority the National Interim Primary Drinking Water Regulations (NIPDWR) were promulgated on December 24, 1975. These regulations went into effect on June 24, 1977 and became the standards by which to judge whether or not a given water is safe to drink. The levels specified are based on the Public Health Service Drinking Water Standards of 1962, as revised by the EPA Advisory Committee on the Revision and Application of the Drinking Water Standards. Thus if through improper disposal, sufficient contamination of an aquifer occurs such that drinking water supplies exceed the above standards, sufficient damage will have occurred so as to constitute a health hazard. Exceeding the drinking water standards definitely indicates degradation of water quality sufficient to constitute a health hazard.

Based on the groundwater dilution model, leachate reaching a drinking water aquifer is expected to undergo a tenfold dilution. Thus if the extract from the waste contains any substance for which a standard has been issued at a concentration ten times greater than the standard the waste would be a hazardous waste.

However for the vast majority of organic chemicals drinking water standards based on long-term-in-depth toxicity studies are not available. In order to arrive at an appropriate threshold value for these substances it is first necessary to determine what level of chronic exposure would not result in a health hazard. While such a task is beyond the ability of science to accomplish, a consideration of the hazardous waste definition protocol can simplify the problem.

The initial simplification occurs by removal from consideration of chemicals which are either mutagenic, teratogenic, or oncogenic. A second simplification results from removal of bioaccumulative hazards. These types of hazards are identified through use of specific tests performed on all extracts. Finally, a third simplification can be made by separating inorganic chemicals from organic species. Inorganics can then be controlled through values based on the aforementioned drinking water standards and soon to be issued Water Quality Criteria.

McNamara (33) has studied the problem of calculating chronic no-effect levels using acute toxicity data such as

LD50 values. He found that, though it will err on the safe side for many compounds, a reasonable approximation can be obtained using the relationship:

$$\text{no effect value} = \text{Oral LD50}/1000$$

A similar relationship was found for 90 day no-effect dosages. In this case the lifetime no-effect value can be arrived at by dividing the 90 day value by ten. These relationships developed by McNamara have been incorporated in the delisting mechanism as well as being under consideration for use in future characteristics (see ANPR). Since in some cases lifetime feeding studies have determined no effect dosages directly, these values could then be used without any application factor.

Using this mechanism it is then possible to calculate a threshold value for any organic compound for which the human no effect value is either known or can be calculated. This then creates another problem; that of obtaining human LD50 values.

Experiences obtained during pharmacological studies with drugs indicate that dose-effect relationships are related to organism surface area. Thus to approximate the human oral LD50, given LD50 values for common laboratory species, a relationship based on surface to weight ratios of rats and mice to humans has been considered. For rats and mice the appropriate conversion factors become:

$$\text{human} = \text{rat} \times 0.16$$

$$\text{mouse} = \text{x} \times 0.066$$

In order to arrive at the threshold values to use in assessing the extract toxicity the following considerations have been employed.

1. Assume a 70 kg human consumes two liters of water a day, and that the water contains a substance with an oral human LD50 of α mg/kg.
2. In the event drinking water became contaminated it is conceivable that persons could be drinking this water for much of their life. Thus for safety the water would be considered to be hazardous if it contained a contaminant at a level greater than the lifetime no effect value for that compound. This value is given by the McNamara relationship as .001 times the LD50 value or $.001\alpha$ mg/kg.
3. Furthermore since the person consumes 2 liters of water a day and weighs 70 kg it follows that the water could contain as much as:

$$\frac{(70)(.001\alpha)}{2} \text{ mg/l} = .035\alpha \text{ mg/l}$$

without being dangerous.

4. But, as described previously, since the leachate undergoes a 10 fold dilution before reaching the well, the extract could contain as much as 10 times this amount, or $(.35\alpha \text{ mg/l})$ without exceeding the safe level.
5. Finally to obtain α one uses the relationships previously mentioned:

$$\alpha = \text{oral rat LD50 times } 0.16, \text{ or}$$

$$\alpha = \text{oral mouse LD50 times } 0.066$$

where all LD50 values are expressed in units of mg/kg.

Aquatic Toxicity

Degradation of surface water quality has been found to have occurred, in a number of instances, as a consequence of improper land disposal of wastes. Thus for the definition of a hazardous waste to be complete, it must address protection of aquatic ecosystems.

Bioassay

In order to do this using a bioassay approach, one or more tests are needed which identify wastes posing a danger both to the existing organisms in the exposed community as well as to the ecosystem productivity. Toward this end a program is under way at the Oak Ridge National Laboratory to develop such an assay using the water flea, Daphnia Magna. This assay (Appendix VI), which currently requires 28 days to conduct, measures both survival of the exposed organisms as well as how well they reproduce. Daphnids are exposed to an extract of the waste at several stages of their life cycle, including the sensitive primiparous (or first egg-bearing) instar.

While our experience in using such a procedure has been favorable, many questions remain which have to be answered before such a test can be used for regulatory purposes. Some of these are:

1. What is the intra- and inter- laboratory reproducibility?

2. What is a toxicologically significant response?

3. Can the present 28 day procedure be shortened without losing sensitivity? This is important because a 28 day test is very time consuming and expensive.

Answers to these questions are under study. In addition, through contacts with the WPCF, ASTM, and other groups alternate assays are being evaluated which may offer advantages in terms of less intensive use of laboratory personnel, shorter test duration, less variability of response, and finally cost.

Analytical

Under Section 304(a) of the Clean Water Act (1977), EPA can set water quality criteria which reflect the ambient concentrations of pollutants necessary to protect public health, the aquatic ecosystem, and aquatic-related values such as recreation and aesthetics. Such criteria are based upon chronic toxicity data showing the "no effect" level for sensitive organisms.

Based on the previous discussions, a leachate to surface water dilution of 1000 fold is anticipated. Thus extract control values based on Water Quality Criteria will be set at 1000 times the criteria. At the present time these "Criteria" have not been issued and thus these additional control values have not been included in the present proposal.

Phytotoxicity

Agriculture is one of the most productive resources in the United States. American farmers produce food for the growing population of this country, including feed for livestock, as well as for the people of many other nations who are dependent on the United States for much of their own food. It is thus essential that this vital industry be protected from exposure to materials which could be harmful to crops.

Many of the chemicals which are used or produced as wastes by various industries have some effect on plant life. These effects vary from plant to plant and from species to species. In most cases, the mechanisms by which chemicals cause these effects are unknown. Since most of the effects are harmful ones and are therefore capable of reducing crop yield or saleability, it is important that an attempt be made to prevent exposure of plants to as many harmful substances as possible. It is for this reason that phytotoxicity, or toxicity to plants, has been considered as a property of toxicity in the definition of "hazardous waste."

It is impossible to evaluate all of the effects that just a single chemical may have on each kind of plant under all of the widely differing conditions in the crop-raising areas of the United States. However, the potential exists for great loss from these materials; and given this, it is apparent that some kind of screening program is essential in order to safeguard the crops as much as possible.

Phytotoxicants present in solid wastes which are improperly managed at disposal can enter the plant environment through use of groundwater or surface water for irrigation. During irrigation, the plants absorb the toxicants through the leaves, stems, or roots. The importance of preventing chemical contamination of groundwater and surface water can be seen by realizing how much water from these sources is used for irrigation. According to the U.S. Geological Survey,

The quantity of water withdrawn for irrigation in the United States, Puerto Rico, and the Virgin Islands in 1975 was estimated at 160 million acre-feet. . . . This was an average rate of 140 billion gallons per day, and the water was used on approximately 54 million acres of farmland. This represents an increase in water use of about 10.9 percent over the 1970 estimate and an increase in acreage of about 9.4 percent.²²

~~Plants may also be exposed to toxicants in waste,~~ specifically sewage, through land spreading. Land spreading of sewage sludge is becoming increasingly popular as a method of disposing of waste from sewage treatment plants. While this method of disposal has many advantages, serious damage might result if sludge containing phytotoxic agents is spread on land used for growing crops or for grazing.

Bioassay

The search for new useful agricultural chemicals has yielded a great deal of information on biologically active compounds. Some of this information is related to test methodologies used in investigating the properties of various chemicals, and some is related to the action of the

chemicals themselves. Most previous work has been concerned with the influence that a single chemical, or a small group of related chemicals, has on plants of one or two species.

Because the sensitivity of different plant species to various toxicants varies widely, an attempt has been made to balance the information available about a species against its relative sensitivity to various toxicants, and against the economic importance of the plant in the United States. In general, there is a fairly good correlation between the information available and economic importance. The most popular (and therefore best-known) research plants are also good field crops. Thus, the choices have been limited to wheat, tomato, soybean, corn, radish and the like.

~~There are two approaches to narrowing the field: size~~ of seed and classification of seed plants. First, immediately after germination (emergence of the seedling from the seed), the main food available to the young plant is what was stored in the seedling. The less stored food there is, the sooner the plant must begin uptake of nutrients from the soil and/or water. For this reason, young small-seeded plants, such as wheat and other grasses, lettuce, and radishes, tend to be more sensitive to toxicants in soil and water than are young large-seeded plants, such as corn, soybean, kidney bean, and other beans. Once the seedlings are established, however, this does not apply.

A second approach is a division between monocotyledons and dicotyledons, plants displaying either one or two "seed leaves,"

respectively. There doesn't seem to be a general relationship between degree of sensitivity to toxicants and number of seed leaves. However, both groups have economically important members, and the groups are very different physiologically. Therefore, it would be desirable to test both types. Corn, wheat and other grasses are monocotyledons, while tomatoes, lettuce, soybeans, and other beans are dicotyledons.

Also affecting the variability of conditions in the real world are soil conditions such as pH and soil chemistry. To eliminate these difficulties plants should be grown in either a nutrient solution or a "standard" combination of sterile vermiculite and peat moss.

It is assumed that the irrigation water containing the leachate will reach the plants through some sort of crop sprinkling system, necessitating the use of a spray method of application in the tests. This introduces the question of exposure factors, such as droplet size, which could not be standardized with respect to actual farm conditions, since these vary so widely. However, they can and must be standardized in laboratory tests. Since water-based toxicants seem to "work better" when the droplets size is large (approximately 5 mm), this would be a "worst case" assumption and would be used.

The aim of the phytotoxicity criteria is to determine if a waste might become a hazard to agriculture if disposal was not made in an appropriate manner.

Such a task is difficult even with extensive resources.

A major consideration in developing the tests, however, must be cost effectiveness. Thus, while an "ideal" test procedure should evaluate the plants' responses to exposure throughout a complete life cycle, the time/cost factors have eliminated such an approach.

In trying to determine whether a substance is toxic to plants by exposing plants to that substance, one would have a better chance if several kinds of plants, each of which is very sensitive to at least one of the possible modes of action could be tested. A battery of complementary tests would provide the most useful information for regulatory purposes. This is the route that has been selected for development (Appendix VII). The battery under development includes both germination and seedling growth assays and employs three important crop species; soybean, wheat, and radish. Use of these test procedures though has been delayed until such time as their reproducibility and utility can be validated.

Analytical

For purposes of the analytical option a list would be published of chemicals which are known to be phytotoxic. This list would include the level of each substance in the extraction procedure extract at which the waste would enter the Subtitle C control system.

Regulatory Approach Selected

It is our belief that the toxicity definition outlined in Figure 1, and described on the previous pages, would

substantially meet the goals set forth previously. These goals are twofold:

1. to have a definition which is dynamic and keyed to waste properties in such a manner that as new toxic agents enter the waste disposal network they are immediately covered.
2. To offer the regulated community a choice of cost effective testing schemes geared to the wide variety of waste types produced.

However, we feel that use of this definition is premature at this time. Two factors account for this decision.

1. The lack of validated bioassay procedures.
2. The lack of adequate data with which to determine the impact of the definition both in terms of the cost of testing and the size of the hazardous waste class which would be so created. This is especially important in view of the previously stated goal to keep testing costs low.

Thus in order to carry out the mandate of RCRA and implement a hazardous waste control program without further delay, a modified approach has been proposed. This approach makes use of the Extraction Procedure to measure toxicant availability, combined with use of EPA National Interim Primary Drinking Water Regulations NIPDWS in order to determine maximum allowable environmental contamination levels. Furthermore, since there are many wastes which

contain mobile toxic chemicals for which no NIPDWS are available, an expanded use has been made of lists as identifiers of hazardous waste. These lists are described in a separate Background Document.

The analytical procedures which have been adopted are those which have been developed by EPA and others for use in characterizing industrial effluents and wastewaters. These methods are currently under active study at the EPA Environmental Monitoring and Support Laboratory. As new or improved analytical procedures are developed they will be incorporated into the manual of acceptable procedures to be published prior to promulgation of these draft rules.

In order to offer a means by which a generator can demonstrate that a particular listed waste is in fact not hazardous a means of identifying hazardous wastes other than those identified through through use of DWS is needed.

While use of the analytical, mutagenic, and bioaccumulative tests have not been included in the hazardous waste definition for the second of the aforementioned reasons, this is not a problem when they are used for delisting purposes. Thus these tests are available for generators to use in demonstrating that a particular waste, listed because the Agency has information that it poses a hazard due to its mutagenic, oncogenic, teratogenic, or bioaccumulative activity, or it contains mobile toxic organics, should in fact not be listed. (Appendix VIII).

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Appendix I

(d) Toxic Waste

(1) Definition - A solid waste is a hazardous waste if, according to the methods specified in paragraph (2), the extract obtained from applying the Extraction Procedure (EP) cited below to a representative sample of the waste has concentrations of a contaminant that exceeds any of the following values:

Contaminant	Extract Level, Milligrams per Liter
Arsenic.....	0.50
Barium.....	10.
Cadmium.....	0.10
Chromium.....	0.50
Lead.....	0.50
Mercury.....	0.02
Selenium.....	0.10
Silver.....	0.50
Endrin (1,2,3,4,10,10-hexa- chloro-6,7-epoxy-1,4,4a,5, 6,7,8,8a-octahydro-1, 4-endo, endo-5, 8-di methano naphthalene).	0.002
Lindane (1,2,3,4,5,6- hexachlorocyclohexane gamma isomer).	0.040
Methoxychlor (1,1,1- Trichloroethane). 2,2-bis (p-methoxyphenyl)	1.0
Toxaphene (C ₁₀ H ₁₀ Cl ₈ - technical chlorinated camphene, 67-69 percent chlorine).	0.050
2,4-D, (2,4-Dichloro- phenoxyacetic acid).	1.0
2,4,5-TP Silvex (2,4,5- Trichlorophenoxypro- pionic acid).	0.10

NOTE: Extract levels specified for the above substances equal ten times the EPA National Interim Primary Drinking Water Standards for these substances. These standards are being revised. Extract levels specified above will be changed to reflect revisions to these standards. Also, EPA is considering use of the Water Quality Criteria under the Clean Water Act as a basis for setting extract levels, in addition to the EPA National Interim Primary Drinking Water Standards.

(2) Identification Method

(i) Extraction Procedure

(A) Take a representative sample (minimum size 100 gms) of the waste to be tested and separate it into its component phases using either the filtration method or the centrifugation method described in this section. Reserve the liquid fraction under refrigeration at 1-5°C (34-41°F) for use as described in paragraph (F) of this section.

(I) Filtration Method

Equipment:

Millipore YY22 142 30 filter holder
(Millipore Corp., Bedford, MA 01730)
equipped with an XX42 142 08 accessory
1.5 liter reservoir, or
Nuclepore 420800 142mm filter holder
(Nuclepore Corp., Pleasanton, CA 94566)
equipped with a 1.5 liter reservoir,
or equivalent filter holder.

Procedure:

1. Using the filter holder place a 0.45 micron filter membrane (Millipore type HAWF142, Nuclepore type 112007, or equivalent) on the support screen. On top of the membrane (upstream) place a

prefilter (Millipore AP25124, Nuclepore P040, or equivalent). Secure filter holder as directed in manufacturer's instructions.

2. Fill the reservoir with the sample to be separated, pressurize to no more than 75 psi (7 kg/cm²), and filter until no significant amount of fluid (<5 ml) is released during a 30 minute period.

3. After liquid flow stops, depressurize and open the top of the reservoir, invert the filter unit, replace filter pads as in step 1. above, and resume filtering. Save pads for later use. Repeat this step until no more fluid can be removed from the waste at a pressure of 75 psi (7 kg/cm²).

4. Take the solid material, and any pads used in filtration, and extract as described in paragraph (B). Subtract tare weights of filter pads in calculating the amount of solid material.

(II) Centrifugation Method

Equipment:

Centrifuge (e.g. Damon-IEC catalog no. 7165, Damon-IEC Corp., Needham Heights, MA, or equivalent) equipped with a rotor for 600 ml to 1 liter containers (Damon-IEC catalog no. 976, or equivalent). For flammable material containing wastes, explosion proof equipment is recommended.

Procedure:

1. Centrifuge sample for 30 minutes at 2300 rpm. Hold temperature at 20-40°C (68-104°F).
2. Using a ruler, measure the size of the liquid and solid layers, to the nearest mm (0.40 inch). Calculate the liquid to solid ratio.
3. Repeat 1 and 2 above until the liquid:solid ratio calculated after two consecutive 30 minute centrifugations is within 3%.
4. Decant or siphon off the layers and extract the solid as described in paragraph B.

(B) Take the solid portion obtained in paragraph (i), and prepare it for extraction by either grinding it to pass through a 9.5 mm (3/8") standard sieve or by subjecting it to the following structural integrity procedure.

Structural Integrity Procedure

Equipment:

Compaction Tester having a 1.25 inch diameter hammer weighing 0.73 lbs. and having a free fall of 6 inches (Figure 1) (one suitable device is the Associated Design and Manufacturing Company, Alexandria, Va. 22314, catalog no. 125).

Procedure:

1. Fill the sample holder with the material to be tested. If the waste sample is a monolithic block, then cut out a representative sample from the block having the dimensions of a 1.3" dia. X 2.8" cylinder.
2. Place the sample holder into the Compaction Tester and apply 15 hammer blows to the sample.
3. Remove the now compacted sample from the sample holder and transfer it to the extraction apparatus for extraction.

(C) Take the solid material from paragraph (B), weigh it and place it in an extractor. A suitable extractor will not only prevent stratification of sample and extraction fluid but also insure that all sample surfaces are continuously brought into contact with well mixed extraction fluid.

(When operated at greater than or equal to 40 rpm, one suitable device is shown in Figure 2 and available as Part #3736 produced by the Associated Design and Mfg. Co., Alexandria, VA 22314.)

(D) Add to the extractor a weight of deionized water equal to 16 times the weight of solid material added to the extractor. This includes any water used in transferring the solid material to the extractor.

(E) Begin agitation and adjust the pH of the solution to 5.0 ± 0.2 using 0.5N acetic acid. Hold the pH at 5.0 ± 0.2 and continue agitation for 24 ± 0.5 hours. If more than 4 ml of acid for each gm of solid is required to hold the pH at 5, then once 4 ml of acid per gm has been added, complete the 24 hour extraction without adding any additional acid. Maintain the extractant at 20-40°C (68-104°F) during extraction. It is recommended that a device

such as the Type 45-A pH Controller manufactured by Chemtrix, Inc., Hillsboro, OR 97123, or equivalent, be used for controlling pH. If such a device is not available then the following manual procedure can be employed.

Manual pH adjustment

1. Calibrate pH meter in accordance with manufacturer's specifications.
2. Add 0.5N acetic acid and adjust pH of solution to 5.0 ± 0.2 . If more than 4 ml of acid for each gm of solid is required to hold the pH at 5, then once 4 ml of acid per gm has been added, complete the 24 hour extraction without adding any additional acid. Maintain the extractant at 20-40°C (68-104°F) during extraction.
3. Manually adjust pH of solution at 15, 30, and 60 minute intervals moving to the next longer interval if the pH did not have to be adjusted more than 0.5 pH units since the previous adjustment.
4. Continue adjustment procedure for a period of not less than 6 hours.
5. Final pH after a 24 hour period must be within the range 4.9-5.2; unless 4 ml of acid per gram of solid has already been added.

6. If the conditions of 5 are not met, continue pH adjustment at approximately one hour intervals for a period of not less than 4 hours.

(F) At the end of the 24 hour extraction period, separate the material in the extractor into solid and liquid phases as in paragraph (A). Adjust the volume of the resulting liquid phase with deionized water so that its volume is 20 times that occupied by a quantity of water at 4°C equal in weight to the initial quantity of solid material charged to the extractor (e.g., for an initial weight of 1 gm, dilute to 20 ml). Combine this solution with the original liquid phase from paragraph (A). This combined liquid, and any precipitate which may later form, is the Extraction Procedure Extract.

(ii) Analysis - Analyses conducted to determine conformance with Section 250.13(d)(1) shall be made in accordance with the following or equivalent methods:

(A) Arsenic - Atomic Absorption Method, "Methods for Chemical Analysis of Water and Wastes," pp. 95-96, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(B) Barium - Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," latest edition, or "Methods for Chemical Analysis of Water and Wastes," pp. 97-98, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(C) Cadmium - Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," latest edition, or "Methods for Chemical Analysis of Water and Wastes," pp. 101-103, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(D) Chromium - Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," latest edition, or "Methods for Chemical Analysis of Water and Wastes," pp. 112-113, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974

(E) Lead - Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," latest edition, or "Methods for Chemical Analysis of Water and Wastes," pp. 112-113, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(F) Mercury - Flameless Atomic Absorption Method, "Methods for Chemical Analysis of Water and Wastes," pp. 118-126, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460.

(G) Selenium - Atomic Absorption Method, "Methods for Chemical Analysis of Water and Wastes," p. 145, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(H) Silver - Atomic Absorption Method, "Standard Method for the Examination of Water and Wastewater," latest edition, or "Methods for Chemical Analysis of Water and Wastes," p. 146, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(I) Endrin, Lindane, Methoxychlor, or Toxaphene - as described in "Method for Organochlorine Pesticides in Industrial Effluents," MDQARL, Environmental Protection Agency, Cincinnati, Ohio, November 28, 1973.

(J) 2, 4-D and 2, 4, 5-TP Silvex - as described in "Methods for Chlorinated Phenoxy Acid Herbicides in Industrial Effluents," MDQARL, Environmental Protection Agency, Cincinnati, Ohio, November 28, 1973.

Appendix II

A solid waste is a hazardous waste if the extract obtained from applying the "toxicant extraction procedure" to a representative sample of the waste has any of the following properties, according to the following test protocol.

(1) Contains more than one mg/liter of any compound on the Controlled Substances List in Appendix IVI or gives a positive response in any one of a set of required tests for mutagenic activity. A total of three assays must be conducted. One shall be chosen from group I, one from group II, and one from those listed in group III.

Group I Detection of gene mutations

1. Point mutation in bacteria.

Group II Detection of gene mutations

1. Mammalian somatic cells in culture.

2. Fungal microorganisms.

Group III Detecting effects of DNA repair or recombination as an indication of genetic damage

1. DNA repair in bacteria (including differential killing of repair defective strains).

2. Unscheduled DNA synthesis in human diploid cells.

3. Sister-chromatid exchange in mammalian cells.

4. Mitotic recombination and/or gene conversion in yeast.

A result shall be considered positive for the mutagenic activity assays if a reproducible increase is observed over negative control in the yeast and mammalian cell assays. A result shall be considered positive for the DNA repair assay in bacteria if a reproducible difference in killing is observed between the DNA repair-competent and DNA repair-deficient strains.

Mutagenic Activity Detection

Group I - DETECTION OF GENE MUTATIONS

a. Point Mutations in Bacteria

1. Positive Controls

All assays must be run with a concurrent positive control. Positive control compounds or mixtures shall be selected to demonstrate both the sensitivity of the indicator organism and the functioning of the metabolic activation system.

2. Negative controls

A solvent negative control shall be included.

3. Choice of Organisms

The bacteria used shall include strains capable of detecting base pair substitutions (both transitions and transversions) and frame-shift mutations. The known spectrum of chemical mutagens capable of being detected by the strains shall be considered when selecting the strains. The strains shall also be highly sensitive to a wide range of chemical mutagens. They may include strains whose cell wall, DNA repair, or other capabilities have been altered to increase sensitivity (Ames, 1975; McCann et al., 1975). Although sensitive bacterial assays for forward mutations at specific loci or over some portion of the entire genome may also be appropriate, at the present time the most sensitive and best-characterized bacteria for mutagenicity testing are those capable of indicating reverse mutations at specific loci.

4. Methodology

(i) General. The test shall be performed in all respects in a manner known to give positive results for a wide range of chemical mutagens at low concentrations. Tests must be run with and without metabolic activation. The sensitivity and reproducibility of the metabolic activation systems and strains used shall be evaluated both by reference to past work with the method and by the concurrent use of positive controls.

(ii) Plate assays. In general, the EP extract should be tested by plate incorporation assays at various concentrations. Test conditions should minimize the possible effects due to extraneous nutrients, contamination by other bacteria, and high levels of spontaneous mutants.

(iii) Liquid suspension assays. A few chemicals (e.g., diethylnitrosamine and demethylnitrosamine) will give positive results only in tests in which the test substance, the bacteria, and the metabolic activation system are incubated together in liquid prior to plating, but not in a plate incorporation assay (Bartsch et al., 1976). Thus, tests shall be conducted in liquid suspension as well as on agar plates.

(iv) Doses. The highest test dose which does not result in excessive cell death shall be used.

Group II - DETECTION OF GENE MUTATIONS

a. Mammalian Somatic Cells In Culture

1. Choice of cell systems.

A number of tests in mammalian somatic cells in culture are available in which specific locus effects may be detected in response to chemical exposure (Shapiro et al., 1972; Chu, 1971). The cell line used shall have demonstrated sensitivity of chemical induction of specific-locus mutations by a variety of chemicals. The line shall be chosen for ease of cultivation, freedom from biological contaminants such as mycoplasmas, high and reproducible cloning efficiencies, definition of genetic detection, loci, and relative karyotypic stability. The inherent capabilities of the test cells for metabolic activation of promutagens to active mutagens shall also be considered, as well as the use of metabolic activation systems similar to those used with microorganisms.

2. Methodology.

(i) General. The test shall be performed in all respects in a manner known to give positive results for a wide range of chemical mutagens. The sensitivity of the system, metabolic activation capability, and its reproducibility must be evaluated by reference to past work and by the concurrent use of positive controls. Culture conditions which may affect the detection of mutations and give falsely high or low figures for reasons other than chemical induction shall be avoided. Definition of detected genetic loci studies and verification that the observed phenotypic changes are indeed genetic alterations should be presented.

b. Mutation In Fungi

1. Controls

All considerations discussed under Group I, a. are applicable.

2. Choice of Organisms

The fungi used shall include strains capable of detecting base pair substitutions (both transitions and transversions) and frame-shift mutations. More inclusive assay systems, such as those designed to detect recessive lethals, are also acceptable. The known spectrum of chemical mutagens capable of being detected by the strains shall be considered when selecting the strains. The strains shall also be highly sensitive to a wide range of chemical mutagens. Strains altered in DNA repair or other capabilities with the intent to increase sensitivity may be used, subsequent to validation. Either forward or reverse mutation assays may be applied.

3. Methodology

(i) General: All considerations discussed under Group I a, 4, (i) are applicable. Care should be taken to investigate stage sensitivity, i.e. replicating versus non-replicating cells as well as possible requirement for post-treatment growth.

(ii) Plate Assays: While spot tests and plate incorporation assays are useful for preliminary testing, they shall not be considered conclusive.

Group III - DETECTING EFFECTS ON DNA REPAIR OR RECOMBINATION AS AN

INDICATION OF GENETIC DAMAGE

a. DNA Repair In Bacteria

1. Controls

All considerations discussed under Group I are applicable.

2. General

(i) When the DNA of a cell is damaged by a chemical mutagen, the cell will utilize its DNA repair enzymes in an attempt to correct the damage. Cells which have reduced capability of repairing DNA may be more susceptible to the action of chemical mutagens, as detected by increased cell death rates. For suspension tests using DNA repair-deficient bacteria, the positive control should be similar in toxicity to the test mixture.

(ii) The DNA repair test in bacteria determine if the test substance(s) is more toxic to DNA repair-deficient cells than it is to DNA repair-competent cells. Such differential toxicity is taken as an indication that the chemical interacts with the DNA of the exposed cells to produce increased levels of genetic damage.

3. Choice of organisms

Two bacterial strains, with no known genetic differences other than DNA repair capability, shall be used. The strains selected shall be known to be capable of indicating the activity of a wide range of chemical mutagens. The spectrum of chemical mutagens and chemical mixtures capable of being detected by the strains and procedures used shall be reported.

4. Methodology

(i) Plate test The EP extract should be tested by spotting a quantity on an agar plate which has had a lawn of the indicator organisms spread over it. After a suitable incubation period, the zone of inhibition around the spot shall be measured for each strain and compared for the DNA repair-competent and DNA repair-deficient strains. If no discrete zone of inhibition is seen with either strain, then the results of the tests are not meaningful.

(ii) Liquid suspension test. The liquid suspension test shall also be performed by comparing the rates at which given concentrations of the test substances will kill each of the two indicator strains when incubated in liquid suspension. Conditions should be adjusted so that significant killing of the DNA repair-competent strain occurs, if this is possible. Methodology is discussed in Kelly et al. (1976).

(iii) Doses. The dose level of test substances used in the plate or suspension test shall be adjusted so that significant toxicity to the DNA repair-competent strain is measured. In the plate test, this means that a zone of inhibition must be visible; in the suspension test, significant loss of cell viability must be measured. This may not be possible if the test substance is not toxic to the bacteria or if, in the plate test, it does not dissolve in and diffuse through the agar. The same dose must be used in exposing the DNA repair-competent and repair-deficient strains.

b. Unscheduled DNA Synthesis In Human Diploid Cells

1. General

DNA damage induced by chemical treatment of a cell can be measured as an increase in unscheduled DNA synthesis which is an indication of increased DNA repair. Unrepaired or misrepaired alterations may result in gene mutations or in breaks or exchanges which can lead to deletion and/or duplication of larger gene sequences or to translocations which may affect gene function by position effects (Stich, 1970; Stoltz et al., 1974).

2. Methodology

(i) General. Primary or established cell cultures with normal repair function shall be used. Standardized human cell strains from repositories are recommended. Controls should be performed to detect changes in scheduled DNA synthesis at appropriate sections in the experimental design. The media conditions shall be optimal for measuring repair synthesis.

(ii) Dose. At least five dose levels shall be used and the time in the cycle of cynchonour or non-proliferating cells at which exposure takes place shall be given. The maximum compound dose shall induce toxicity, and the dosing period with the test substance shall not be less than sixty minutes.

c. Sister Chromatid Exchange In Mammalian Cells With And Without Metabolic Activation

1. Controls

All considerations discussed under Group I a. are applicable.

2. General

Cytological techniques are available to evaluate the genetic damage induced by chemicals. In the past few years a technique has been developed for identifying sister chromatid exchanges much more simply and efficiently than by the autoradiographic method. The method utilizes the fact that a fluorescent stain Hoechst 33258 binds to thymidine-containing DNA but not, or far less efficiently, to BrdUrd-substituted DNA. This means that the order of fluorescence would be brightest for DNA unreplicated in BrdUrd, intermediate for DNA after one round of replication in BrdUrd, and least for DNA following two rounds of replication in BrdUrd. Thus a sister chromatid exchange can be seen as a switch of fluorescence pattern at the point of exchange. Perry and Wolff (Nature 251, 156-158 (1974)) combined Hoechst staining with Giemsa staining such that the brightly fluorescing regions stain darkly with Giemsa, and the dully fluorescent regions hardly stain at all.

3. Choice of Organisms

Chromosomal preparations of human peripheral blood leukocytes or Chinese hamster ovary cells shall be used.

4. Methodology

(i) General: The test method must be capable of detecting sister chromatid exchanges. Procedures reported by Perry and Wolff (Nature 251, 156-158 (1974) and Moorhead et al. (Exp. cell Res. 20, 613-616 (1960)) are recommended. Metabolic activation with rat liver S-9 mix should be incorporated whenever it is appropriate.

(ii) Doses: Test substances shall be tested to the highest dose where toxicity does not interfere with the test procedure.

d. Mitotic Recombination and/or Gene Conversion In Yeast

1. Controls

All considerations discussed under Group I are applicable.

2. General

One can effectively study the chromosomes of eukaryotic microorganisms by employing classical genetic methodologies which depend upon the behavior and interaction of specific markers spaced judiciously within the genome. These methods have been developed over several decades and have been applied in recent years to the study of induced genetic damage (Zimmerman, 1971, 1973, 1975; Brusick and Andrews, 1974).

3. Choice of organisms

Diploid strains of yeasts that detect mitotic crossing-over and/or mitotic gene conversion shall be used. Additionally, as appropriate strains are developed, monitoring for induced non-disjunction and other effects may be possible. Mitotic crossing-over shall be detected in a strain of organism in which it is possible, by genetic means, to determine with reasonable certainty that reciprocal exchange of genetic information has occurred.

Strains employed for genetic testing shall be of proven sensitivity to a wide range of mutagens.

4. Methodology

(i) General.

In general, wastes shall be tested in liquid suspension tests.

Appendix III

Controlled Substance List

NOTE: Compounds and classes which have been reported to be either mutagenic, carcinogenic, or teratogenic and which would not give a positive indication of activity using the prescribed tests. Where a class of compounds is listed, inclusion on this list does not mean that all members of the class have been shown to be either mutagenic, carcinogenic, or teratogenic. Demonstration that specific class members contained in the waste have not been shown to be either mutagenic, carcinogenic, or teratogenic, will be sufficient for a demonstration of non-hazard by reason of mutagenic activity (M).

- Aloperidin
- Amantadine
- 4-Aminoantipyrin acetamide
- Aminopterin
- 3-Amino-1,2,4-triazole
- 6-Azauridine
- Azo dyes
- Benzene
- Bisulfan
- Carbon tetrachloride
- Chloroquine
- Chlorambucil
- Cobalt salts
- Colchicine
- Coumarin derivatives
- Cycasin
- Cyclophosphamide
- Dextroamphetamine sulfate
- Diazepam (Valium)
- Diethylstilbesterol
- Dimethylaminoazobenzene
- Dimethylnitrosamine
- Diphenylhydantoin
- Ethionine
- Griseofulvin
- 1-Hydroxysafrole
- Maleic Hydrazide
- Methotrexate
- Methylthiouracil
- Mytomycin-C
- d-Penicillamine
- Phenylalanine
- Phorbol esters
- Quinine
- Resperine
- p-Rosanilin
- Safrole
- Serotonin
- Streptomycin
- Testosterone
- Thioacetamide thiourea
- Trimethadione
- d-Tubocurarine

Appendix IV

Bioaccumulation Potential Test

(a) General

Reverse-phase liquid chromatography is a separation process in which chemicals are injected onto a column of fine particles coated with a nonpolar (water insoluble) oil and then eluted along the column with a polar solvent such as water or methanol. Recent developments in this field have produced a permanently bonded reverse-phase column in which long-chain hydrocarbon groups are chemically bonded to the column packing material which leads to a more reproducible separation. The chemicals injected are moved along the column by partitioning between the mobile water phase and the stationary hydrocarbon phase. Mixtures of chemicals can be eluted in order of their hydrophobicity, with water soluble chemicals eluted first and the oil soluble chemicals last in proportion to their hydrocarbon/water partition coefficient. Calibration of the instrument using compounds of known octanol/water partition coefficient allows this procedure to be used to determine whether an unknown mixture contains compounds with octanol/water partition coefficients above a designated level.

Specific correlations exist between octanol/water partition coefficients and bioconcentration in fish. This test thus offers a rapid, inexpensive method of identifying those mixtures which contain compounds which pose a potential bioaccumulative hazard.

Compounds with log P 3.5, but which readily biodegrade would not be expected to persist in the environment long enough for accumulation to occur. Thus a degradation option has been included in order to exempt these substances from the hazardous waste control system.

(b) Chromatography Conditions

A liquid chromatograph equipped with a high pressure stopflow injector and a 254 nm ultraviolet detector with an 8 ul cell volume and 1 cm path length is employed. The column is a Varian Preparative Micropak C-H (Catalog number 07-000181-00), or its equivalent, consisting of a 250 mm X 8 mm (i.d.) stainless steel cylinder filled with 10 micron lichrosorb to which octadecylsilane is permanently bonded.

The column is operated at ambient temperature. The solvent consists of a mixture of water and methanol (15:85, v/v) which is pumped through the column at 2.0 ml/minute.

(c) Retention Volume Calibration

Chemicals are dissolved in a mixture of acetone and cyclohexane (3:1, v/v). For preparing the calibration curve the quantity of individual chemicals in the solution is adjusted to give a chromatographic peak of at least 25 percent of the recorder scale. Acetone produces a large peak at approximately 2.6 minutes.

Six chemicals for which Log P has been reported are used to calibrate the elution time in units of Log P. The calibration mixture is summarized in Table 1 and includes benzene, bromobenzene, biphenyl, bibenzyl, p,p'-DDE, and 2,4,5,2',5'-pentachlorobiphenyl.

(d) Sensitivity Calibration

The mixture is chromatographed and a calibration curve prepared daily to eliminate small differences due to flow rate or temperature and to follow the retention properties of the column during prolonged use. The calibration is made by plotting Log P vs the logarithm of the absolute retention time (log RT). Figure 1 is an example of such a calibration curve.

(e) Test Procedure

- (1) Prepare a calibration curve as described above.
- (2) Calculate the geometric mean of the instrumental response to the chemicals listed in Table 1 with the exception of the acetone. This value, expressed in ug/25% full scale deflection, is designated the Instrumental Sensitivity (IS).
- (3) Extract X liters of the Extraction Procedure extract to be tested, using dichloromethane, and concentrate the extract to a quantity suitable for injection onto the column.

The quantity X is determined by the instrumental sensitivity and is given by the relationship:

X in liters = IS in micrograms.

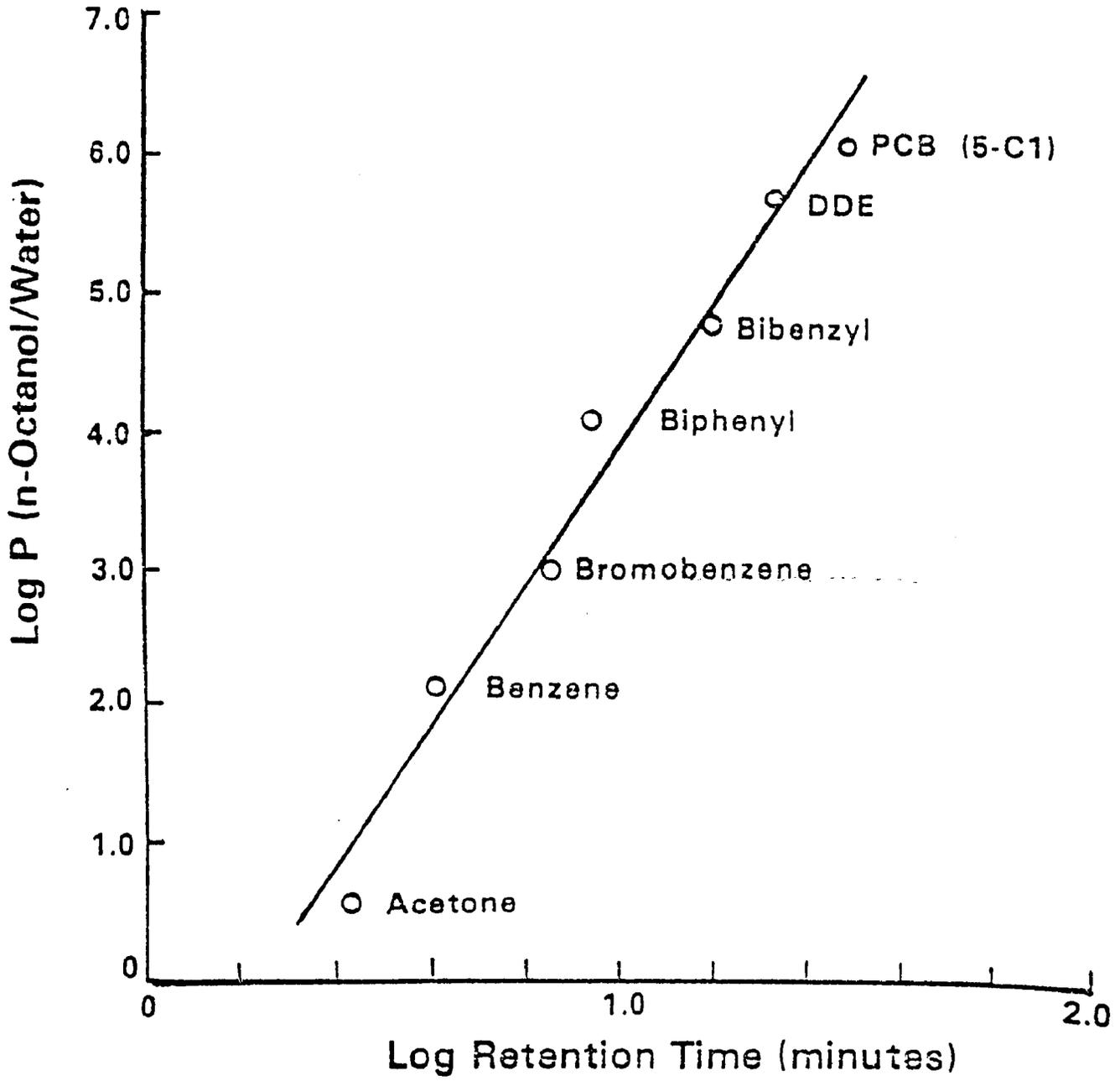
- (4) Analyze the extract using the now calibrated chromatograph. A positive response is defined as an instrumental response greater than or equal to 25 percent full scale detector response in the region of Log P greater than or equal to 3.5.
- (5) If a positive response is indicated in step (4), then subject a sample of the waste to a biodegradation assay and then retest. If a positive response with the degraded waste is not obtained, then the waste is not considered to be hazardous by reason of bioaccumulativenness.

TABLE I

Partition Coefficients for Chemicals Used for Calibration

	<u>Log P</u>
Acetone	0.55
Benzene	2.13
Bromobenzene	2.99
Biphenyl	3.76
Bibenzyl	4.81
p,p'-DDE	5.69
2,4,5,2',5'-Pentachlorobiphenyl	6.11

Figure 1



Appendix v

Test procedures for biodegradation are designed to rapidly estimate the relative importance of biodegradability as a persistence factor in natural environments. The tests evaluate biodegradation rates in comparison with standard reference compounds.

Methods commonly used include a shake flask procedure that follows the loss of dissolved organic carbon (DOC) using organic carbon analysis, a respirometric method with analysis for either oxygen uptake or carbon dioxide evolution resulting from microbial activity, and an activated sludge test.

One shake flask procedure acceptable for use in the screening test for biodegradability is based on the Presumptive Test of the Soap and Detergent Association (1965) and the Modified OECD Screening Test (1971).

The shake flask method is conducted in a mineral salts basal medium with a weak inoculum and relatively low test substrate concentration and serves as a simple model of surface water. The determination of biodegradation is made by measuring the loss of bioaccumulative response after allowing degradation to proceed for 21 days.

Poorly soluble and insoluble materials present special problems in biodegradability tests. Insoluble materials should be dispersed into the systems using a minimal volume of organic solvent if solvent is necessary.

(a) Method Description

Microorganisms are inoculated into flasks that contain a well-defined microbial growth medium (basal medium) and the test compound. Aeration is accomplished by continuous shaking of the flask. Following four adaptive transfers, biodegradation is determined by measuring the reduction (if any) in concentration of bioaccumulative species at the end of the test period.

(b) Basal Medium

The composition of the basal medium shall be as follows.

o Water: High-quality (ASTM Type II or better, ASTM, 1974) water, from a block tin or an all-glass still, containing less than 1 mg/l total organic carbon (TOC).

Phosphate Buffer Solution: Dissolve 8.5 g potassium dihydrogen phosphate, KH_2PO_4 ; 21.75 g dipotassium hydrogen phosphate, K_2HPO_4 ; 33.4 g disodium hydrogen phosphate heptahydrate, $\text{Na}_2\text{HPO}_4 \cdot 7\text{H}_2\text{O}$; and 10 g ammonium chloride, NH_4Cl , in about 500 ml of distilled water and dilute to 1 l.

Magesium sulfate solution: Dissolve 22.5 g $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ in distilled water and dilute to 1 l.

Calcium Chloride Solution: Dissolve 27.5 g anhydrous CaCl_2 in distilled water and dilute to 1 l.

Ferric Chloride Solution: Dissolve 0.25 g $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ in distilled water and dilute to 1 l.

Trace Element Solution: Dissolve 39.9 mg $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$, 57.2 mg H_3BO_3 , 42.8 mg $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ and 34.7 mg $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}$ in distilled water and dilute to 1 l.

Yeast Extract Solution: Dissolve 15 mg of Difco yeast extract in 100 ml distilled water. Prepare immediately before use.

To each liter of water add 1 ml of each above solution except the yeast extract solution. Dispense in 500 ml or 1000 ml portions into 1-liter or 2-liter narrow mouth Erlenmeyer flasks. Stopper the flasks with cotton plugs or the equivalent to reduce evaporation and contamination. Flasks and contents that will not be used on the day of preparation shall be sterilized by autoclaving at 120°C for 20 minutes. Immediately before use, 1 ml of yeast extract solution shall be added to each flask.

(c) Microbial Culture

The microbial culture used as the initial inoculum shall be prepared as follows:

Secondary Effluent Culture: Obtain a sample of secondary effluent of good quality from a sewage treatment plant dealing with a predominantly domestic sewage. Filter through a glass wool pad. Retain the filtrate.

Soil Culture: Obtain 100 g of garden soil (not sterile) and suspend it in 1 ^{liter} of chlorine-free tap water. Do not use soils that are largely clay, sand, or humus. Stir the suspension to thoroughly mix the contents and to break up any clumps. Allow the solids to settle for 30 minutes.

Filter through a glass wool pad. Retain the filtrate.

Mixed Culture Inoculum: Mix 100 ml of secondary effluent filtrate with 50 ml of soil suspension filtrate and use to inoculate the shake flasks within 24 hours of the time of collection of the secondary effluent and soil.

(d) Linear Alkylate Sulfonate (LAS): Obtain a sample of LAS (Standard LAS may be obtained from the U.S. Environmental Protection Agency; Environmental Monitoring and Support Laboratory; Cincinnati, Ohio 45268.) or n-dodecyl benzene sulfonate, sodium salt. Based on the percent of active LAS in the sample, calculate the quantity required to provide 25mg of organic carbon. For 100% sodium n-dodecyl benzene sulfonate this value is 40.3 mg.

(e) Test Mixture: Calculate the quantity of test mixture which will supply 25 mg of organic carbon. If the test mixture is readily soluble in water, it may be more convenient to prepare a solution in distilled water containing 25 mg of organic carbon per ml of solution.

(f) Procedure:

A. Add sufficient test compound (or a solution as described above) to a test flask, containing basal medium, so that the test compound provides 25 mg of organic carbon per liter of basal medium.

B. Add sufficient LAS to a control flask to provide 25 mg of organic carbon per liter of basal medium.

C. Using the mixed microbial inoculum, inoculate flask with 1 ml of inoculum per liter of basal medium.

D. Place the flask on a reciprocating shaker operating at about 128 two-to four-inch strokes per minute or a gyratory shaker operating at 225 to 250 one-to two-inch revolutions per minute. Incubate in the dark at $22 \pm 3^{\circ}\text{C}$.

E. Adaptation: The first flask (as described above) normally will be prepared on a Tuesday. Adaptive transfers shall be made on the following Friday and again on Monday, Wednesday, and Friday of the following week. This schedule is set up for the convenience of laboratories not operating on weekends. On each transfer day, transfer 1 ml of the 48- to 72-hour culture into each liter of fresh basal medium, plus test compound, and basal medium plus reference compound.

Growth of culture within each flask will be indicated by an increasingly hazy or cloudy appearance in the liquid medium and also may be indicated by the deposit of microbial cellular matter along the upper walls of the shake flasks, at the "high water" mark. If the test medium stays clear in the test mixture flask, this may indicate that the test compound is present at a toxic or an inhibitory concentration. In this case, the test procedures should be restarted with the test compound at a lower concentration. If both the test compound and control flasks remain unclouded, it may indicate a defective inoculum or the possibility that some other toxic material was introduced inadvertently.

F. On the thirteenth day following the initial inoculation, and approximately 72 hours after the final adaptive transfer, another transfer shall be made into the test flasks. The procedure is the same as for the adaptive transfers, except that there now will be duplicate preparations for controls and test flasks. There also will be two flasks with basal medium plus test compound but with no inoculum.

G. Following the transfer of inoculum from blank to blanks, and test flask to test flask, the flasks shall be incubated for 21 days. At the end of the incubation period the contents of the blank and test flask shall be analyzed.

H. Homogenize the material in the flask to be analyzed and remove an aliquot sufficient to contain the same amount of waste extract as used in the original evaluation of the waste using the partition coefficient test.

I. Evaluate the sample as described in the Bioaccumulation Potential Test Appendix IV. If a positive result is obtained then the waste is considered to be a hazardous waste. If after analyzing the blanks, a positive result in the BPT is not obtained then the assay for persistence is invalid and must be rerun.

Appendix VI

Daphnia Magna Reproduction Assay

(a) Method

- (1) Tests are run at only one dilution of the neutralized extract.
- (2) First instar D. magna, 12 hours + 12 hours old are utilized.
- (3) One D. magna is placed in 50 ml of extract solution in a 100 ml glass beaker with a watch glass.
- (4) Temperature is maintained at $20.0 \pm 0.5^{\circ}\text{C}$ in an environmental chamber under 12-hour light/dark lighting regime.
- (5) Dilution water is either filtered spring or well water (pH 7.8; alkalinity, 119 mg/l; hardness, 140 mg/l).
- (6) All tests are run with ten replicates, and a set of ten controls. Test organisms are transferred to freshly prepared test solution in clear beakers and fed two ml of prepared food every Monday, Wednesday, and Friday, and the number of young in each beaker are counted.
- (7) Test duration is 28 days or until all animals have died, whichever comes first.

(b) Handling

- (1) Organisms should be handled as little as possible.

- (2) Smooth glass tubes with rubber bulbs should be used for transferring daphnids.
- (3) Food should be added to freshly prepared test solution in 100 ml beakers before animals are transferred.

(c) Food

- (1) Food mixture of 1 mg/ml per animal used.
- (2) 1 mg/ml preparation:
 - (i) Enough Ralston Purina Micro-Mixed Trout Chow is ground and then mixed at high speed with distilled water in a blender to produce 10 mg/ml concentration.
 - (ii) The mixture is then screened to remove unground particles, and refrigerated.
 - (iii) The mixture is diluted with distilled water to 1 mg/ml when needed.

(d) Results

Comment is specifically requested concerning what biological measures to use in defining a significant change in growth or reproduction. Currently under study are the following indicators:

1. Average survival time during test period (days).
2. Average age at first brood release (days).
3. Average number of broods of young per adult.
4. Average number of young produced per adult.
5. Average number of young per brood.

Appendix VII

Terrestrial Plant Assays

(a) Seed Germination Bioassay Protocol

- (1) Seeds (radish, Raphanus sativus 'Early Scarlet Globe') sieved to reduce germination and growth variability. Mesh size: 2.36 mm, 2.00 mm, 1.70 mm (U.S.A. standard testing sieves). One size category used per bioassay.
- (2) 100 ml extract solution diluted 1:10 put in chamber (Figure 2), blotter paper placed upright to absorb solution.
- (3) 150 radish seeds placed in position; saturated paper laid over them and gently pressed until impression seen.
- (4) Second Plexiglas sheet positioned so seeds and blotter paper sandwiched between; Plexiglas taped securely on sides and top (see Figure 2).
- (5) Unit then put in germination chamber.
- (6) Environmental chamber (temperature 25° C, no illumination) houses germination chamber for 48 hrs.
- (7) Length of hypocotyl measure after incubation.
- (8) Standard T-test used to compare dosed seeds to control.

(b) Seedling Growth Study Protocols

- (1) Seedling growth studies are run using wheat (Triticum aestivum) and soybean (Glycine max).
- (2) The seeds are soaked for approximately 3 hours in deionized water.
- (3) 200 ml of soluble plant food with trace elements (1 tblsp per gal water) is added to approximately one liter of sand (acid-washed quartz sand to pass 60 mesh sieve, leached by triple rinse in distilled water) in which the seeds are planted, 25 soybean and 50 wheat seeds per container.
- (4) When the seeds have sprouted (about 72 hrs) the extract diluted 1:10 is added in droplets. Constant pressure is applied via compressed air tank to test solution in a plastic bottle. Solution is forced through tygon tubing to a polyethylene nozzle (inverted buchner funnel). The volume is regulated with a screw clamp adjusted to a flow rate of 6 ml/sec. This design is simple and disposable or acid washable in order to assure ready availability of component parts which are easily cleaned between test runs.
- (5) Seedlings are exposed daily to a dose sufficient to restore loss by evapotranspiration.

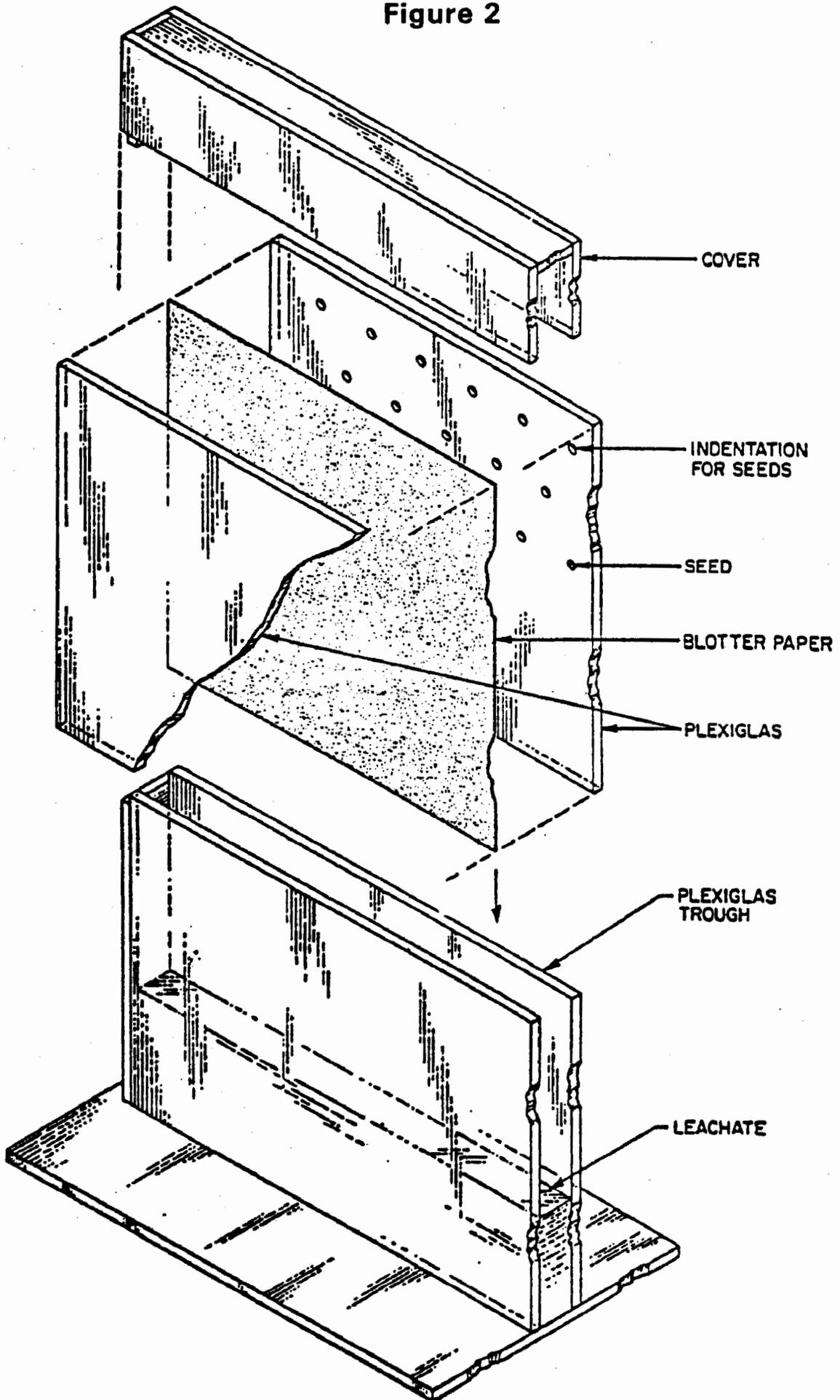
(6) At the end of 2 weeks of exposure, plants are harvested and the following parameters are measured:

- (i) root biomass
- (ii) shoot biomass
- (iii) gross pathology (i.e., necrosis, chlorosis)

(c) Results

Comments are specifically requested concerning the significance of these indicators as measures of damage.

Figure 2



Appendix VIII
Demonstration of Non-Inclusion in the
Hazardous Waste System

(a) Any person wishing to demonstrate to EPA that a solid waste from an individual facility, whose waste is listed in Section 250.14(a) or (b), is not a hazardous waste may do so by performing the tests described below on a representative sample of the waste for those characteristics or properties indicated by the codes (i.e., (I), (C), (R), (N), (T), (A), (O), (M), (B)) following the waste listing. A certification of the test results shall be submitted to the EPA Administrator by certified mail with return receipt requested. The results of the tests must show the waste is non-hazardous for each characteristic or property indicated.

(1) Waste designated as ignitable (I) must be shown by the Section 250.13(a) ignitable characteristic method not to meet the Section 250.13(a) definition.

(2) Waste designated as corrosive (C) must be shown by the Section 250.13(b) corrosive characteristic method not to meet the Section 250.13(b) definition.

(3) Waste designated as reactive (R) must be shown by the Section 250.13(c) reactive characteristic method not to meet the Section 250.13(c) definition.

(4) Waste designated as toxic (T) must be shown by the Section 250.13(d) toxic characteristic method not to meet the Section 250.13(d) definition.

(5) Waste designated as radioactive (A) must be shown to have either of the following properties:

(i) An average radium-226 concentration less than 5 picocuries per gram for solid waste or 50 picocuries (radium-226 and radium-228 combined) per liter for liquid waste as determined by either of the methods cited in Appendix VIII of this Subpart; or

(ii) A total radium-226 activity less than 10 microcuries for any single discrete source.

(6) Waste designated as mutagenic (M), bioaccumulative (B), or toxic organic (O) must be shown to have an Extraction Procedure extract (see Section 250.13(d)(2)) with none of the following properties:

(i) Mutagenic (M): Contains more than one mg/liter of any compound on the Controlled Substances List in Appendix IX of this Subpart or gives a positive response in any one of a set of required tests for mutagenic activity. A total of three assays must be conducted. One shall be chosen from group I, one from group II, and one from those listed in group III. Test protocols are defined in Appendix X of this Subpart.

Group I Detection of gene mutations

1. Point mutation in bacteria.

Group II Detection of gene mutations

1. Mammalian somatic cells in culture.

2. Fungal microorganisms.

Group III Detecting effects of DNA repair or recombination as an indication of genetic damage

1. DNA repair in bacteria (including differential killing of repair defective strains).
2. Unscheduled DNA synthesis in human diploid cells.
3. Sister-chromatid exchange in mammalian cells.
4. Mitotic recombination and/or gene conversion in yeast.

(ii) Bioaccumulative (B): Gives a positive result in the Bioaccumulation Potential Test, defined in Appendix XI of this Subpart.

(iii) Toxic Organic (O): Contains any organic substance which has a calculated human LD50* of less than 800 mg/kg, at a concentration in mg/l greater than or equal to 0.35 times its LD50 expressed in units of mg/kg. For purposes of this Subpart, metallic salts of organic acids containing 3 or fewer carbon atoms are considered not to be organic substances.

*Procedure for Calculating Human LD50 Value:

The LD50 value to be used will be that for oral exposure to rats. Where a value for the rat is not available, mouse oral LD50 data may be employed. Where an appropriate LD50 value for the rat or mouse is listed in the NIOSH Registry of Toxic Effects of Chemical Substances ("Registry"), this value may be used without validation. If other values are used, they must be supported by specific and verified laboratory reports. The appropriate conversion factors to use in calculating LD50s are:

Rat x .16 = human

Mouse x .066 = human

Example: Tetraethylenepentamine

Listed oral rat LD50 is 3990 mg/kg
calculated human LD50 is 3990×0.16
= 638 mg/kg; $638 \times 0.35 = 223$ mg/l

Thus if the EP extract contains more than 223 mg/l of tetraethylenepentamine the waste is hazardous.

BD-5

DRAFT

BACKGROUND DOCUMENT

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

SECTION 3001 - IDENTIFICATION AND LISTING OF
HAZARDOUS WASTE

SECTION 250.14 - HAZARDOUS WASTE LISTS

DECEMBER 15, 1978

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

This document provides background information and support for regulations which have been designed to identify and list hazardous waste pursuant to Section 3001 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft to support the proposed regulations. As new information is obtained, changes may be made in the background information and used as support for the regulations when promulgated.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made some changes in the proposed regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

Alan S. Corson
Hazardous Waste Management Division (WH-565)
Office of Solid Waste
U. S. Environmental Protection Agency
Washington, D.C. 20460

Waste Listing Background Document

Introduction

Subtitle C of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 referred to herein as (Pub. L. 94-580 or) the "Act" , creates a regulatory framework to control hazardous waste. Congress has found that such waste presents "special dangers to health and requires a greater degree of regulation than does non-hazardous solid waste" (Section 1002(b)(5) of the Act).

This rule is one of a series of seven being developed and proposed under Subtitle C to implement the hazardous waste management program. It is important to note that the definition of solid waste (Section 1004(27) of the Act) encompasses garbage, refuse, sludges, and other discarded materials including liquids, semi-solids, and contained gases (with a few exceptions) from both municipal and industrial sources. Hazardous wastes, which are a sub-set of all solid wastes and which will be defined by regulations under Section 3001 of the Act, are those which have particularly significant impacts on public health and the environment.

Subtitle C creates a management control system which, for those wastes defined as hazardous, requires "cradle-

to-grave" cognizance including appropriate monitoring, recordkeeping, and reporting throughout the system. Section 3001 of the Act requires EPA to define criteria and methods for identifying and listing hazardous wastes. Those wastes which are identified as hazardous by these means are then included in the management control system constructed under Sections 3002 - 3006 and 3010. Those that are excluded will be subject to the requirements for non-hazardous solid waste being carried out by States under subtitle D under which open dumping is prohibited and environmentally acceptable practices are required.

Section 1004(5) defines a hazardous waste as that which may -

"(A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or
(B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."

Section 3001(b) requires EPA to promulgate regulations identifying those characteristics of hazardous waste and to list particular hazardous wastes.

The Problem

The purpose of the hazardous waste list as required by Section 3001 of the Act is to identify those wastes which present a hazard to human health and the environment. The wastes so identified are considered hazardous (unless demonstrated otherwise as specified in Section 250.15 of the proposed regulation) and subject to the Subtitle C regulations. A solid waste, or source or class of solid waste is listed if the waste:

- (1) possesses any of the characteristics identified in proposed 40 CFR S250.13, and/or
- (2) meets the statutory definition of hazardous waste: "The term 'hazardous waste' means a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may-
 - (A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or
 - (B) pose a substantial present or potential hazard to human health or the

environment when improperly treated, stored, transported, or disposed of, or otherwise managed."

As may be noted, one branch of the statutory definition of hazardous waste relies on judgments of the overall character and risk of the waste when improperly managed. Over the past several years, EPA has documented several hundred cases of damage to human health or the environment resulting from improper management of waste. Damage cases such as these can be, and in many cases have been, used as the basis for listing of certain hazardous waste.

The agency considered several approaches for formulating the list. The approaches can be broken down into three main types:

- o Substance Lists (such as dioxin, beta naphthalamine, etc.)
- o Process Waste Stream Lists (these can range from the very specific: e.g. 1,1 - dichloro^o-ethylene distillation residues, to the more general, e.g. chlorinated organic distillation residues, to the very broad: e.g. chlorinated solvents).

- o Chemical Class Lists (these can range from the specific: e.g. polynuclear aromatic, to the more general: e.g. alkylating agents).

Testing of pure substances or commercial products is the traditional approach used by regulatory agencies which control these pure substances or commercial products. The purpose of the Act, however, is to control waste materials. These are not normally pure substances (except in the case of spoiled or contaminated batches). Wastes may come from several stages within a production process, or a plant may mix wastes from several processes prior to deposition.

Pure substance listings work well for many agencies, since their responsibilities lie with some aspect of the pure substance. The Department of Transportation, (DOT) for example, uses this approach. Benzene, is listed by DOT as a flammable liquid. A transporter knows, after consulting the DOT listing, that benzene must be handled according to the DOT flammable liquid regulations. Benzene, however, is rarely disposed as benzene. Rather, it might be contained in still bottoms or heavy ends.

In order for a regulation to be effective, it should be structured so that it reflects the organization of the regulated community. Since waste process streams are often the units

of the solid waste regulated by the Act, these same waste process streams can be used to provide a ready means of identification. *So, that, for our purposes,*

← ⁱ It is more informative (for identification purposes) to list "still bottoms from XYZ process - flammable" than it would to list "benzene - flammable". Likewise, there are certain waste classes, such as chlorinated solvents which, if classified as wastes, could be unambiguously identified by such a designation. If these classes also meet the criteria for listing then the classes have also been included.

Finally, there are certain pure substances selected for listing, but only for those cases where the substance (or container) is being discarded. (This includes spill clean-up debris or material from any of the tested substances.) The pure substances on the list were chosen from the DOT poison A, poison B and ORM-A lists, the ⁱpriority pollutants, and the cancelled and selected RPAR pesticides. Those compounds which are included by the hazardous waste characteristics in Section 250.13 of the proposed regulation, ^{or} regulated by the Agency under other authority were not included; similarly the three lists were screened

to minimize duplication.

For background information concerning the listed wastes the Agency is relying on several sources of data. These include industry studies undertaken by the Agency, damage incidents compiled by the Agency, and waste information compiled by State Agencies. Most of these sources give information concerning the chemical and physical properties of the wastes and the identity and sometimes concentration of the constituents of the wastes. For the ignitable, reactive and corrosive characteristics, this information is adequate to assess, with high degree of certainty, that the waste stream will meet the 3001 characteristics and thus pose a hazard to the public health and the environment.

For toxicity, however, the situation is much more complex. As has been discussed in the Section 3001 preamble to the regulation and in the toxicity background document, the Agency is not so much concerned about the concentration and identity of the toxic constituents in the waste as it is about the identity and concentration of the toxic constituents which might be expected to be available to the environment under improper management conditions. The

primary pathway by which toxics are made available to the environment is through leachate and run-off under storage and disposal conditions. The specific identity and concentration of the toxics found in the leachate or run-off is highly dependent upon the conditions of storage and disposal, as well as climatological and other such factors. In fact, these can only be precisely assessed empirically (i.e. the exact conditions (which may vary widely) must be reproduced and the leachate and run-off continually analyzed); any other type of assessment is only an approximation.

Therefore, it is not possible to determine with absolute certainty from the qualitative and quantitative information available whether the wastes will leach toxic contaminants under actual waste management conditions or in some cases, even if they will fail the toxicity characteristic. However, the Agency does have evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated

from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller also found that, in a majority of the 50 sites examined, organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. (Specific identification of these organics was not always undertaken in this work, however, other incidents and reports (2 through 8) do qualitatively identify leached organic contaminants in groundwater.)

Since leaching can only confidently be assessed empirically and because this work¹ gives empirical evidence that most industrial sites do leach toxic, mutagenic or carcinogenic substances in substantial quantities, the

Agency has used these source documents so that if they indicate a particular waste has high concentrations of toxic, mutagenic or carcinogenic constituents, the waste was listed as hazardous. (This assumes that the toxicants will be released if the waste is improperly managed.)

The following discussions of each of the wastes ^{is} located in Section 250.14 of the Act will seem repetitious if read together. The discussions were organized so that each separate one could be read separately without reference to the other listings.

General References

- (1) "The Prevalence of Subsurface Migration of Hazardous Chemical Substances at selected Industrial Waste Disposal Sites", Geraghty and Miller, SW-634, Office of Solid Waste, USEPA, 1978.
- (2) "Hazardous Waste Disposal Damage Report", SW-151.2, Office of Solid Waste, USEPA 1977
- (3) "Hazardous Wastes in Landfill Sites" Dept of the Environment. Great Britain ISBN 0 11 751257 5.
- (4) "Effects of Disposal of Industrial Waste within a Sanitary Landfill Environment" D.R. Streng-Residual Management by Land Disposal EPA - 600/9 76-015.
- (5) "Problems Associated with the Land Disposal of an Organic Industrial Waste Containing HCB" W.J. Farmer et. al, ibid.
- (6) "Pilot-Scale Studies of the Leaching of Industrial Wastes in Simulated Landfills" Jr. R. Newton - Water Pollution Control, 468, (1977)
- (7) Great Britain, Department of Environment, NATO/CCMS, Report on landfill Research and Practice.

"Effect of pH on Removal of Heavy Metals from Leachate by Clay Minerals" - R.A. Griffin et. al, ibid.

Waste chlorinated hydrocarbons from degreasing operations (I,T,O)

This waste is classified as hazardous because of its ignitable and toxic characteristic. According to the information EPA has on this waste stream it meets the RCRA §250.13a and §250.13d characteristics identifying ignitable and toxic waste.

EPA bases this classification on the following information.

Chlorinated solvents such as methylene chloride and trichloroethylene are used in vapor degreasing. These organics are suspected of having carcinogenic properties.

An EPA contractor* has analyzed a sample of degreaser solvents and found that it contained toxic heavy metals, trichloroethylene and one of the samples had a fairly low flash point (see Table I)

TABLE I

LABORATORY ANALYSIS OF DEGREASER SOLVENT SAMPLES
FROM SIC 355 MACHINE SHOPS

Sample	pH	% Water	Flash Point °C(°F)	Heave Metals Concentration, ppm						
				Cd	Cr	Cu	Fe	Pb	Zn	
1	13.2	93	No	<0.1	0.9	2.8	55	1.2	3.6	As Received
	11.8		Flash	0.02	0.6	1.4	20	1.0	1.6	As Water Leached
2	5.5	<0.2	27 ⁽¹⁾	<0.1	0.5	1.1	40	1.3	3.0	As Received
	6.0		(81)	0.06	0.04	0.2	1.0	4.0	3.6 ⁽²⁾	As Water Leached

¹ This is the flash point of a solvent which accounted for about 55 percent of the sample; trichloroethylene, which made up the balances of the sample, does not flash.

² This is within margin of error of analysis method.

Source: Wapora, Inc. Assessment of Industrial Hazardous Waste Practices - Special Machinery Manufacturing Industries PB 256-981 Contract # 68-01-3193 Mar '77

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals ^{were found and} had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Gerhity and Miller⁺ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports 2 through 8 do qualitatively identify leached organic contaminants in groundwater) it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste

disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because municipal drinking water finds its source as groundwater, the presence of available toxic organics in waste as a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

Because of the toxic inorganics and organics which may be in this waste, and the potential of these to migrate as explained above. And because of the potential flammability of this waste, this waste is hazardous.

Waste non-halogenated solvent (such as methanol, acetone, isopropyl alcohol, polyvinyl alcohol, stoddard solvent and methyl ethyl ketone) and solvent sludges from cleaning, compounding milling and other processes (I,O)

This waste is classified as hazardous because of its ignitable^{and toxic} characteristics. According to the information EPA has on this waste stream it meets the RCRA §250.13a characteristic identifying ignitable wastes.

EPA bases this classification on the following information:

1) Wapora Inc. has tested a sample of waste non-halogenated solvent and solvent sludges from cleaning compounding, milling and other processes and found the following:

Data:

Mixed Cleaning Solvents - isopro^Pxy^Al alcohol
and trichloro-ethy^Aene

flash point = 69°F
Pb* 1.0mg/l

Semicondu^Sctor-photoresist and xylene developer

flash point = 76°F
Pb* 1.0mg/l

Glass slurry-isopropyl alcohol base

flash point = 54°F
Pb* 21.0mg/l
Zn* 455mg/l

*refer to toxicity background document

The data presented are available from:

Wapora Inc. Assessment of Industrial Hazardous Waste
Practices-Electronic Components Manufacturing Industry.
OSW. PE-265-532. 1-77.

~~SECRET~~

As is evident from above this waste stream has a flash point of 140°F or below. Ignitables with flash points less than 140°F can become a problem while they are landfilled. During and after the disposal of an ignitable waste, there are many available external and internal energy sources which can provide an impetus for combustion, raising temperatures of waste to their flash points. Disposal of ignitable wastes may result in fire that will cause damage directly from heat and smoke production or may provide a vector by which other hazardous waste can be dispersed.

Ignitable waste tend to be highly volatile and the evaporation of these volatiles contribute to poor air quality. (Refer to ignitability background document for further detail).

The following examples of such wastes have been described in The Handbook of Industrial Waste Composition in California-1978*

1. semiconductor manufacture solvent containing
20% toluene, 50% isopropyl alcohol, 10% xylene,
10% methyl ethyl ketone, and 10% tetra ethyl ketone

2. wash solvents containing 5% freon TE, 5% freon
TF, 1% isopropyl alcohol, 2% acetone, 10% methyl
ethyl ketone, and 10% paint thinner.

*Storm, D. Handbook of Industrial Waste Composition in California 1978
California Department of Health.

3. semi conductor wash solvent containing 60-80% alcohol, J-100, xylene, hexamethyl disilazane, butylalcohol, acetone, and water

4. wash solvents containing 80% freon TMS, 10% acetone, and 10% alcohol

5. wash solvent containing 25% water, 30% VG-solvent, 20% alcohol, and 25% J-100 stripper

2000 gal

6. cleaning solvent containing 30% "photo material", 15% freon X, 15% acetone, 10% solder oil, 10% MC955, and 20% Trico III (2-propanol)

4047 100:
12/1/51:

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Gerhity and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations)..

Gerhity and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports 2 through 8 do qualitatively identify leached organic contaminants in groundwater) it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste

disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste as a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

Because of the toxicity of many of the organics (e.g. xylene, acetone, paint thinners, strippers) listed above and the toxicity of other non-halogenated organic solvents, and the potential of these to migrate, this waste is hazardous.

Waste lubricating oil (T,O)

This waste is classified as hazardous because of its ignitable and toxic characteristic. According to the information EPA has on this waste stream it meets the RCRA §250.13a and §250.13d characteristics identifying ignitable and toxic waste.

EPA bases this classification on the following information.

Lubricating oils are similiar to hydraulic oils and may likewise be contaminated with toxic heavy metals(see section "Hydraulic or cutting oil waste" this document). Also these may contain toxic organic additives- and contaminants s.a. phenols.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals ^{were found and} had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Gerhity and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports 2 through 8 do qualitatively identify leached organic contaminants in groundwater) it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste

disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalometh and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste as a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

Because of the toxic inorganics and organics which may be in this waste, and the potential of these to migrate as explained above. this waste is hazardous.

Waste hydraulic or cutting oil (T,O)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets the RCRA §250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information.

Data

Lapping compound mineral seal oil based

<u>Contaminant</u>	<u>Conc. mg/l</u>
Cd	0.30
Cu	2,570.0
Fe	105.0
Pb	73.0
Zn	458.0

Lapping compound kerosene base

f.p. = 128°F

<u>Contaminants</u>	<u>Conc. mg/l</u>
Pb	0.5
Fe	270.0

Also these oils may contain toxic organic additives and contaminants ,such as phenols,bactericides and chlorinated organics.

The data presented are available from:

Wapora, Inc. Assessment of Industrial Hazardous Waste Practices - Special Machinery Manufacturing Industries PB 256-981 Contract # 68-01-3193 Mar '77

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals ^{were found and} had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

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disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalometh and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste as a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

Because of the toxic inorganics and organics which may be in this waste, and the potential of these to migrate as explained above. this waste is hazardous.

Paint wastes (such as used rags, slops, latex sludge, spent solvent) (T,I,O)

This waste is classified as hazardous because of its ignitable and toxic characteristic. According to the information EPA has on this waste stream it meets the RCRA §250.13a and §250.13d characteristics identifying ignitable and toxic waste.

EPA bases this classification on the following information.

(1) Wapora Inc. has tested a sample of lacquer equipment clean-up waste acetone base and drip varnishing equipment clean-up waste, xylene base and found the following:

(Acetone based lacquer equipment cleanup wastes)

<u>contaminant</u>	<u>conc. mg/l</u>
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Pb	178.00
----	--------

f.p = 70°F

(xylene base drip varnishing equipment clean-up waste)

<u>contaminant</u>	<u>conc. mg/l</u>
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Cr	390.00
----	--------

Cu	37.00
----	-------

Fe	360.00
----	--------

Pb	582.00
----	--------

Zn	1996.00
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f.p = 80-100°F

The data presented are available from:

Wapora. Assessment of Industrial Hazardous Waste Practices: Paint and Allied Products Industry, Contract Solvent Reclaiming Operations. and Factory Application of Coatings. OSW. PB - 251 699. 1976.

As is evident from above this waste stream has a flash point of below 140°F. Ignitables with flash points less than 140°F can become a problem while they are landfilled. During and after the disposal of an ignitable waste, there are many available external and internal energy sources which can provide an impetus for combustion, raising temperatures of waste to their flash points. Disposal of ignitable wastes may result in fire that will cause damage directly from heat and smoke production or may provide a vector by which hazardous substances can be dispersed.

Ignitable waste tend to be highly volatile and the evaporation of volatiles themselves contribute^e to poor air quality. (Refer to ignitability background document for further detail).

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represented hazard to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to

be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010. 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to 0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.01, and 0.5, mg/l respectively in the EP extract.

This waste has been shown to contain chromium and lead at concentrations of 390.0 and 582.0 mg/l respectively, according to PB - 251 - 669, Assessment of Industrial Hazardous Waste Practices: Paint and Allied Products Industry, Contract Solvent Reclaiming Operations, and Factory Application of Coatings.

Also the "Handbook of Industrial Waste Compositions in California" - 1978 (Reference 9) indicated the following compositions for these types wastes:

California manifest (Ref. 9, p. 40)

equipment cleaning solvent and paint sludge
containing 90% pigments, 3% water, and 7%
alcohols, aromatics, and aliphatic hydrocarbons,
ketones

California manifest (Ref. 9, p. 40)

solvent and paint sludge containing 62%
aromatic hydrocarbons, 32% epoxy resins,
6% urea - formaldehyde

California manifest (Ref. 9, p. 41)

solvent and paint sludge containing 0-30% ketones,
0-4% polymer alkyd acrylic resin, 0-40% aliphatic
and aromatis hydrocarbons, 25-45% extenders and
inert organic solids, & Ti O₂

California manifest (Ref. 9, p. 41)

waste solvent containing 0.1 - 12% cobalt salts,
0.1 - 9% manganese salts, and 0.1 - 12% zirconium
naphenic acid

California manifest (Ref. 9, p. 10)

waste cleaning solvent containing 50%
naphtha and 50% acetone

California manifest (Ref. 9, p. 10)

waste solvent containing toluene, methyl ethylketone, acetone; and xylene

California manifest (Ref. 9, p. 40)

solvent and paint sludge containing 2% methylethyl ketone and NaOH

California manifest (Ref. 9, p. 40)

waste solvent containing 30% acetone, 20% isophorone, and 20% ethyl amyl ketone

California manifest (Ref. 9, p. 40)

paint sludge containing 10% cuprous oxide, 2.5% iron oxide, 2.5% lead pigment, 0.5% chromium pigment, 10% titanium pigments and talc, and 68% xylene, ketones, mineral spirits, alkyl/Epoxy resins

California manifest (Ref. 9, p. 40)

paint sludge and solvent containing 2% methyl ethyl ketone & NaOH

California manifest (Ref. 9, p. 41)

waste solvent containing 30-50% epoxy resin & 50-70% amine type solvents

These wastes contain significant amounts of the following ignitable substances:

Naphtha - flash point = 0°F.

Acetone - flash point = 0°F.

Toluene - flash point = 40°F.

Methyl ethyl ketone - flash point = 21°F.

Reference: Fire Protection Handbook, National Fire Protection Association, 1962.

Because of the flash points of many of the solvents and the toxicity of the pigments and solvents typically used (benzene, xylene etc.) in paint manufacture, this waste is to be considered hazardous.

Water - based paint wastes (T)

This waste stream is classified as hazardous because of its toxic properties. According to the data EPA has on this waste stream it meet the RCRA §250.13d characteristic identifying a toxic hazardous waste.

EPA bases this classification on the following information.

(1) Wapora Inc. has tested a sample of water-based paint waste and has found the following.

<u>contaminent</u>	<u>conc.</u>
Inorganic pigment*	2.5%
TiO ₂	4.5%
Binders	20.0%
Fungicides, Germicides, Mildewcides	100-150 mg/l

*hazardous pigments used in paint industry include:
lead carbonate, lead silicate, red lead, antimony oxide, zinc oxide, cadmium lithopone, chrome yellow, molybdate orange, strontium chromate, chrome green, chromium oxide and phthalocyanine green.

The data presented above are available from:

Wapora Inc. Assessment of Industrial Hazardous Waste Practices: Paint and Allied Products Industry, Contract Solvent Reclamining Operations, and Factory Application of Coatings.

PB - 251 669. 1976

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Because of the toxicity ^{and solubility of many} of the pigments used by the paint industry* and the toxicity of many biocides this waste is to be considered hazardous.

Because of the toxicity and solubility of many of the pigments commonly used in water based paints, this waste is to be considered hazardous.

*Versar, Inc Assessment of Industrials Hazardous waste Practices, Inorganic Chemicals Industrys
"Contract # 68-01-2246 and references cited therein, and

Wapora, Inc. Assessment of Industrial Hazardous Waste Practices-Paint and Allied Products Industry Contract Solvent Reclamining Operations and Factory Application of Coatings. 1976 and refernces cited therein.

Tank Bottoms, leaded (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

According to "The Handbook of Industrial waste compositions in California" - 1978, this waste stream has been shown to have the following chemical characteristic

<u>WASTE</u>	<u>COMPONENTS</u>	<u>PAGE</u>
Tank Bottom Sediment	400 ppm ammonia 258 ppm sulfide 2% phenol water, pH 10	54
load size: 100 bbl		
Tank Bottom Sediment	5% gasoline traces inorganic, organic lead, : Balance: water, dirt, iron oxide	141
load size: 100 bbl		

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc). in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Lead is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l

level in the EP extract.

As demonstrated earlier this waste has been shown to contain both organic and inorganic lead.

Because of the toxicity of lead this waste stream is to be considered hazardous.

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations)..

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (Reference 2 through 8) do qualitative

identify leached organic contaminants in groundwater) it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste as a criterical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

Tank bottom sediments have been found to contain 2% phenol - oral rate LD50 = 414 mg/kg. Because of the toxicity of phenols this waste^{is} considered hazardous.

Tank bottom sediments also have been found to contain 5% gasoline, a DOT flammable liquid with a flash point of -45° F.

*"Interim Primary Drinking Water Regulations,"
p. 5756, Federal Register, 2/9/78

Ignitables with flash points less than 140°F can become a problem while they are landfilled. During and after the disposal of an ignitable waste, there are many available external and internal energy sources which can provide an impetus for combustion, raising temperatures of waste to their flash points. Disposal of ignitable wastes may result in fire that will cause damage directly from heat and smoke production or may provide a vector by which other hazardous waste can be dispersed.

Ignitable wastes tend to be highly volatile and the evaporation of these volatiles contributes poor air quality. (Refer to ignitability background document for further detail).

Spent or waste cyanide solutions or sludges (R,T)

Reactive wastes as defined by Section 250.14 of RCRA pose a threat to human health and the environment, either through the physical consequences of their reaction (i.e., high pressure and/or heat generation) or through the chemical consequences of their reaction (i.e., generation of toxic fumes).

Wastes containing cyanide salts may undergo solvolysis, under mildly acid conditions to generate HCN gas. HCN gas* is an intensely poisonous gas even when mixed with air. High concentration produces tachypnea (causing increased intake of cyanide); then dyspnea, paralysis, unconsciousness, convulsions and respiratory arrest. Exposure to 150 ppm for 1/2 to 1 hour may endanger life. Death may result from a few minutes exposure to 300 ppm. Average fatal dose: 50 to 60 mg.

Because of this potential danger cyanide bearing wastes are considered hazardous wastes.

*Merck Index, Eighth Edition, p. 544

Etching Acid solutions or sludges (T,C)

This waste is classified as hazardous because of its corrosive and toxic characteristics. According to the information EPA has about this waste stream it meets both the RCRA S250.13a.2 and S250.13a.4 characteristics identifying corrosive and toxic wastes.

EPA bases this classification on the chemical compositions indicated by the listings from the California Manifest System:

Industry	Process	Generic Name	Components and Typical Load Size
3679 Microwave Components	PCB Chemical Etching	Acid Solution	40-60% water 15-30% sulfuric acid 10-20% chromic acid 3-5 % copper Balance: other metals, proprietary pH 2 1 drum
3679 Circuit Boards	Circuit board fabrication	Acid Solution	5-8% Nitric acid sulfuric acid 5-8% Fluorboric acid 2310 gal.
3679 Microwave Components	Chemical machinery	Acid solution and solvent	a) Aluminum etch b) Trichlorethane c) Machine oil 1 drum 5 drums 9 drums
3679 Printed Circuits	PCB etching (printed circuit board etching)	Acid solution	90-95% ferric chloride Balance: water pH 0 4700 g.
3661 Telephone and Tele- graph Apparatus, Telephones	Copper etching	Acid Solution	7-13% chromic acid 13-20% sulfuric acid water 1000 gal.
Unspecified	Copper	Acid	sodium chloride hydrochloric acid Sodium chlorate copper 180 gal.

Industry	Process	Generic Name	Components and Typical Load Size
3861 Cameras	Etching	Acid Solution	5-15% hydroflouric acid 4800 gal.
Unspecified	Photo- graphic Etching	Alkaline Solution	2700 ppm potassium potassium ferricyanide ferric cyanide water pH 10-11 400 gal.
3711 Automobile Assembly	Etching	Alkaline Solution	sodium hydroxide Alodine 1200 and 1000 pH 10 1500 gal.
Unspecified	Metal etching and finishing	Acid Solution	Iridate #14 Deoxidizer Al-901 Etchlaume #14 1400 gal.
3721 Aircraft	Metal Etching	Acid Solution	3 % hydroflouric and nitric acid 97 % water 100 bbl.
Unspecified	Titanium chemical milling	Acid Solution	5-15 % nitric acid 1- 8% hydroflouric acid 1- 5% titanium pH 1 2400 gal.

As is evident from the California Listings, Etching Acid solutions or sludges have been shown to have low pH or high pH's (unless neutralized). Liquid waste streams with such acidic^{or} (caustic) character present an environmental risk for several reasons. Very low or high pH liquid waste if disposed in a sanitary landfill would leach high concentrations of toxic heavy metals (such as lead) from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly acidic^{or} (caustic) liquid wastes also present a handling risk because of their corrosive properties. OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illnesses resulting from the inhalation of toxic gases formed by the reaction of acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specified limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9-76-003).

A primary exposure route to the public for toxic contaminants is through

drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Waste paint and varnish remover or stripper (I,O)

This waste stream will be similar in composition to "

Paint wastes (such as used rags, slops, latex
sludge, spent solvent) (T,I,O)

and present similar hazards. Please refer to the section
discussing this waste stream|

Solvents and solvent recovery still bottoms (non-halogenated)
(I,T,O)

Solvents and solvent recovery still bottoms (halogenated)
(T,B,O)

This waste is classified as hazardous because of its ignitable, toxic, bioaccumulative, and toxic organic-containing characteristics. According to the information EPA has on this waste stream it meets the RCRA §250.13(a), §250.13(d), characteristics indentifying ignitable and toxic waste.

The Administrator has determined these solvents and still bottoms to be a potential threat to human health and the environment if improperly managed, because of possible toxic organic content, bioaccumulation potential, and mutagenic behavior.

EPA bases this classification on the following information:

1) Wapora Inc., has tested a sample of solvent still bottoms and has found the following:

<u>Contaminant</u>	<u>Conc mg/l</u>
Pb	1113.50
Cr	227.50
Zn	248.78
Solvents of Feedstock	25%

f.p. = 104^oF to 194^oF

The data on this test are available from:

Wapora, Inc. Assessment of Industrial Hazardous Waste Practices - Paint and Allied Products Industry, Contract Solvent Reclaiming Operations and Factory Application of Coatings. PB - 251-669, 1976.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a started specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix AC Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at

concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05 mg/l respective because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to 0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5 mg/l respective in the EP extract.

This waste has been shown to contain lead and chromium at 1113.5 and 227.5 mg/l levels, respectively, according to PB251669, Assessment of Industrial Hazardous Waste Practices: Paint and Allied Products Industry, Contact Solvent Reclaiming Operations, and Factory Application of Coatings. For this reason it is classified as toxic according to RCRA §250.13(d).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (references 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other tri-halomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical

factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

Solvent recovery still bottoms has been found to contain organic solvents at about 25% of feedstock according to Wapora, Inc. in Assessment of Industrial Hazardous Waste Practices Paint and Allied Products Industry, Contact Solvent Reclaiming Operations and Factory Applications of Coatings, PB-251-669, pps 206 to 211. Some of the solvents used in industry have been shown to be mutagenic.

As is evident from the Wapora information this waste stream also has a flash point of 140^oF or below. Ignitables with flash points less than 140^oF can become a problem while they are landfilled. During and after the disposal of an ignitable waste, there are many available external and internal energy sources which can provide an impetus for combustion, raising temperatures of waste to their flash points. Disposal of ignitable waste may result in fire that will cause damage directly from heat and smoke production or may provide a vector by which other hazardous waste can be dispersed.

Ignitable wastes tend to be highly volatile and the evaporation of volatiles contribute to poor air quality. (Refer to ignitability background document for further detail).

WASTE OR OFF-SPEC TOLUENE DIISOCYANATE

The Administrator has determined that this waste is a hazard to human health and the environment if improperly managed. Toluene diisocyanate (TDI) is a pressure generating compound that reacts with water, resulting in evolution of carbon dioxide. Contact with concentrated alkaline compounds such as sodium hydroxide may cause run-away polymerization. It is also listed as a DOT Poison B; it is a strong sensitizing agent and can cause skin irritation, allergic eczema and bronchial asthma in humans.*

There have been several damage incidents associated with disposal of toluene diisocyanate. In California in 1978, a drum containing TDI was picked up by a scavenger waste hauler and placed in an unprotected storage area. After having been exposed to rain, the drum was removed to the Simi Class I Landfill where it exploded, hospitalizing several people. In Detroit in May of 1978, a tank truck waiting to dispose of a quantity of TDI experienced a boil-over. The resulting fumes caused nine people to be hospitalized.

These damage incidents illustrate the hazards created by improper treatment, storage or disposal of waste TDI. In view of the above information we feel that the waste poses a threat to human health and the environment.

* The Merck Index, Eighth Edition, 1968.

Leachate from hazardous waste landfills (T,O,M,B)

Because of the toxicities of the process wastes, generic wastes and waste materials listed by Section 250.14 of the Act, (see individual background section for each waste listed) and the toxicity of those wastes which meet the 250.12 toxicity characteristics (see toxicity background document), any leachate resulting from these wastes is considered a hazardous waste.

ELECTROPLATING

Electroplating Waste Water Treatment Sludge (T)

This waste stream is hazardous because of its toxic properties. According to data EPA has on this waste stream, it meets the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Examples and quantities of toxic constituents of electroplating wastewater treatment sludges are listed below.

- I. Hydroxides of (1) chromium - 330,000 ppm
- (2) cadmium - 20,000 ppm
- (3) lead - 20,000 ppm

Reference: Battelle. Cross - Media Impact of the Disposal of Hazardous Waste from Metals, Inorganic Chemicals and Related Industries. Vol. 1, p. 13, Nov. 1977.

- II. (1) Neutralized hydroxide: 0.5-1% chromium hydroxide sludge (p. 122)
- (2) Lime sludge (p. 113) : cadmium - 630 ppm
- chromium - 9500 ppm
- lead - 770 ppm
- (3) Plating sludge (p.133): chromium - 1-5%
- cadmium - 0-1%

Reference: Storm, D.L. Handbook of Industrial Waste Compositions in California - 1978 California Department of Health Services, Hazardous Materials Management Section Nov. 1978

On the basis of this information we feel that this waste stream poses a threat to human health and the environment.

Material which is within the scope of Section 250.10(b) and is normally shipped using a name listed in Appendix III (Pesticides), Appendix IV (DOT Poison A, Poison B, ORM-A Materials), or Appendix v (Priority Pollutants) (T,O,M)

Off-specification material which is within the scope of Section 250.10(b) and, if met specification would shipped using a name listed in Appendix III, IV, or V (T,O,M)

Spill clean-up residues and debris from spills of materials which appear in Appendix III, IV, or V (T,O,M)

Containers, unless triple rinsed, which have contained materials normally shipped using a name listed in Appendix III, IV, or V (T,O,M)

Introduction: Selected Cancelled and RPAR Pesticides

This listing contains cancelled pesticides and those pesticides with Rebuttable Presumptions Against Their Registration that have sufficient data at this time to conclude that they should be disposed of within the Hazardous Waste Management System. Pesticides that are listed elsewhere in the Sec. 3001 listing have been excluded from this listing to minimize duplication. Although this list is made up of pesticides, our intent was not to regulate pesticides as a class. Rather we are regulating organic chemicals that are disposed of on land and have sufficient toxicological data to justify their inclusion in the Hazardous Waste Management System.

The intended use determines if an organic chemical substance is called a pesticide. The large number of organic chemicals regulated herein that are used as pesticides is an artifact of the available toxicologic data. Pesticides are used on crops for human consumption with the intent to kill or control the pest while not hurting the human consumer of the food. Hence, there has been a large volume of toxicological testing done on these organic chemicals. Because of this relative abundance of good toxicological data for pesticides and the paucity of data for other organic chemical substances, we have included what could appear like a disproportionate number of pesticides on the Hazardous Waste list.

The listing of Hazardous Wastes is limited by the availability of data. A group of organic chemicals with this much toxicological data cannot be ignored. Unfortunately although we have a large quantity of toxicological data for these chemicals we do not have data on the behavior of these

substances under waste management conditions or their behavior when subjected to the extraction procedure test. Little information is available to precisely estimate the amount of a particular chemical substance that can be expected to be solubilized in the environment.

Although information concerning the behavior of these materials under waste management is only partially available, the Agency has decided to regulate these materials because of their toxicity and the long history of mismanagement of waste pesticide and pesticide containers resulting in human, animal and fish fatalities; as well as cases of serious illness. Because of these reported damage incidents (and the inherent toxicity of the substances) these substances fall within the statutory definition of hazardous waste (Section 1004 of the Act).

The Agency intends an upgrading and amending of this listing and will be investigating the hazards associated with the management of many other organic chemicals (some of which are classed as pesticides) as more chemical, toxicologic and physical information becomes available.

Four forms of the listed pesticides are included in the regulation. The four forms are; the pesticide itself, listed as

Material which is within the scope of Section 250.10(b) and is normally shipped using a name listed in Appendix III (Pesticides), Appendix IV (DOT Poison A, Poison B, ORM-A Materials), or Appendix v (Priority Pollutants) (T,O,M)

The off-specification pesticide, listed as

Off-specification material which is within the scope of Section 250.10(b) and, if met specification would shipped using a name listed in Appendix III, IV, or V (T,O,M)

Spill clean up materials resulting from a spill of the pesticide, listed as

Spill clean-up residues and debris from spills of materials which appear in Appendix III, IV, or V (T,O,M)

And the unrinsed containers that contained the pesticide, listed as

Containers, unless triple rinsed, which have contained materials normally shipped using a name listed in Appendix III, IV, or V (T,O,M)

Disposal of Pesticide Material

Remaining stocks of certain cancelled pesticides can only be used for certain uses. Some holders of the cancelled pesticide who do not have an approved application for the cancelled pesticide will find disposal easier than finding some one to use it on an approved application. Thus, there will be people interested in disposing of pure pesticide.

Our files on damage cases from improper disposal of Hazardous Wastes include many incidents of damage due to the indiscriminate disposal of pesticides.

A few examples;

<u>YEAR</u>	<u>INJURY</u>	<u>CAUSE</u>
1972	3 children hospitalized: comatose and respiratory difficulty in Batesville, MS	mother found old oil can by road, poured on ground (methyl parathion)
1972	child ill in Salt Lake, UT	found powdered pesticide with no label, broken, and sat in spilled powder

<u>YEAR</u>	<u>INJURY</u>	<u>CAUSE</u>
1975	child comatose in hospital 2 days in Nash Co., NC	played with bags contained Di-syston pesticide
	organophosphate poisoning child in Robeson, NC	spillage pesticide can as thrown in woods

Disposal of off-specification pesticides

A pesticide batch can be off-specification due to a high concentration of contaminants or congenerated highly toxic species exceeding the allowable limits for the materials market as a pesticide. For example 2,4,5,-T can be produced with varying levels of dioxin depending on temperature control during the reaction. Bad batches could be bad because of a high concentration of dioxin in the pesticide. Specific regulation or analysis of each bad batch to determine if it was toxic enough to require more costly disposal would be extremely expensive.

For infrequent waste streams such as bad batches, controlling the disposal by blanket inclusion of all bad batches of these pesticides is preferred as it has the lowest total resource requirements for industry and EPA.

Our files on damage cases from improper disposal of Hazardous Wastes include incidents of damage due to the toxic effect of cogenerated highly toxic species present in the waste.

For example:

<u>YEAR</u>	<u>INJURY</u>	<u>CAUSE</u>
1971	people ill and 1 hemmoraging of kidney, 60 horses dead, deformed	waste oil sprayed on arena to keep down dust (contained TCDD)

<u>YEAR</u>	<u>INJURY</u>	<u>CAUSE</u>
	foals and dead pets in Verona, MO	
1974	2 girls sick, 1 physically impaired, 35 exposed in Bloomfield and Mosco Mills, MO	oiling down horse arena (dioxin content)

Disposal of spill clean up material from a pesticide spill

Spill clean up materials of these substances are included on the Hazardous Waste list due to the toxic effects of the substance. The mixing of these substances with earth does not mitigate the effect of these substances when disposed of on the land. If it is mobile thru the soil disposal environment, co-disposing of these substances with the earth picked up at the spill site will not materially affect the potential hazard of migration of the substance to ground water.

Disposal of unrinsed containers

Unrinsed containers have the potential for rainfall washing out the contents into the environment. Triple rinsing removes the water solvable material and thus reduces significantly the amount of material available for flushing out by rainfall.

Our files on damage cases from improper disposal of hazardous wastes include many incidents where the unrinsed, used container has caused problems.

For example

<u>YEAR</u>	<u>INJURY</u>	<u>CAUSE</u>
1968	2 boys ill and 1 died of dermal poisoning in Dunning, NE	old drum top cut out for trash and filled with water to play in (Parathion)
1968	abdominal pains, vomiting required hospitalization in Neshanic Station, NJ	pesticide container disposal near well (Lindane)
1969	14 cattle dead in Jerome ID	ate from empty Di-Syston bags which blew into pasture
1972	2 yr. old hospitalized for organophosphate poisoning in Hughes, AR	playing in empty pesticide drums, mayor bought for trash containers (parathion)
1972	2 children die in Memphis, TN	emptied container in backyard (parathion)
1974	2 yr. old ill in Oak City UT	drank from empty can (Furodan)
1974	8 cattle dead in Elizabeth City, NC	farmer burned old pesticide containers (as)

Examples of the types of pesticide related materials that are typically disposed of are illustrated in Figure 1. As is evident from the figure, this type of material can be extremely toxic.

Figure 1

Sample Pesticide* - related waste material disposed of to
California Class 1 sites (1978)

Industry	Process	Generic Name	Components & Typical Load Size
2879 Pesticides	Pesticide production and research	Pesticide wastes	a) solvents 7 tons b) off-spec pesticides 17 tons c) rinse water and pesticides 5 tons d) empty unrinsed containers 25 tons
2879 Pesticide Formulation	Pesticide Blending	Pesticides	2-50% organo phosphates 2-50% chlorination hydrocarbons 2-50% carbanates 2-30% organic metals 2-60% clays 2-60% solvents 7 cu. yds
2879 Pesticides	Unspecified	Pesticides	22% DBCP 6.5% Malthion 81.5% petroleum oil 0.5 ton
2879 Pesticides	Off-spec Aerosol Cans	Tomato Blossom Fruit Set	42% beta-naphoxyacetic acid 523 gal.
2879 Pesticides	Unspecified	Pesticides	a) dinitrophenol solution 46 gal. b) miscellaneous insecticides 5 tons

*Taken from "Handbook of Industrial Waste Compositions
in California" D.L. Storm, Dept. of Health, California 1978

Industry	Process	Generic Name	Components & Typical Lead Size
2879 Pesticides	Intermediates Production	Unspecified	50-60% tetrahydrophthalamide 40-50% water 37 drums
2879 Pesticides	Floor Sweeping	Pesticides	85-95% difolatan fungicide 5-15% floor sweepings 30 drums
2879 Pesticides	Unspecified	Off-spec Chemicals	a) sulfur b) empty bottles c) paint solvent d) mixed pesticides from dust collector 14 tons
2879 Pesticides	Unspecified	Alkaline Solution and Solvent	5% methylene chloride 85% water 10% miscellaneous chemicals and pesticides 1600 gal.

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons ..."* and, as noted

above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document).

*" Interim Primary Drinking Water Regulations,"
p. 5765, Federal Register, 2/9/78

A brief description of the toxic effects that caused the pesticides to be listed follows:

Pesticide	Toxic effects
ARAMITE	Oncogenicity
BAAM (AMITRAZ)	Oncogenicity in mice.
BENOMYL	Reductions in non-target species (earthworms); mutagenicity (multitest); teratogenicity in rats; reproductive effects (spermatogenic reduction in rats); hazard to wildlife (aquatic organisms).
CHLORANIL	Possible oncogen (Innes-Bionetic Study)
CHLOROBENZILATE	Oncogenicity in mice Testicular Effect in Rats
DBCP	Oncongenictiy in mice and rats; reproductive effects in test animals and possibly in humans.
DIALLATE	Oncongenicity in mice and rats.
DIMETHOATE	Oncongenicity in rats; mutagenicity in bacteria, yeast, fungi and mice; fetotoxicity and reproductive effects in mice.
EBDC's	Oncongenicity in mice and rats; Teratogenicity in rats; hazard to wildlife (aquatic organisms).
KEPONE	Oncongenicity in mice and rats.
MALEIC HYDRAZIDE	Oncongenicity in mice, mutagenicity in plants, flies, rats; reproductive effects in rats.
MIREX	None presented pesticide has been cancelled
MONURON	Oncongenicity in mice and rats.
OMPA (Octamethylpyro-phosphoramide)	Oncongenicity
PCNB	Oncongenicity in mice

Pesticide	Toxic effects
PHENARSAZINE CHLORIDE	None presented pesticide was voluntarily cancelled
POLYCHLORINATED TERPHENYLS	None presented pesticide has been cancelled
PRONAMIDE	Oncongenicity in rats
STROBANE	Possible oncogenicity
2,4,5-T	Possible oncogenicity and teratogenic and fetotoxic effects due to dioxin contaminants
1080/1081	Fatalities in non-target mammalian species and endangered species.
THIOPHANATE METHYL	Mutagenicity and reduction of non-target species (earthworms)
TRYSBEN	Oncongenicity due to nitrosamine contaminants

More complete toxicological descriptions can be found in the Federal Register Publication. The dates of the Federal Register Notices for each listed pesticide are given below.

Pesticide	Federal Register Date
Aramite	4/12/77
BAAM	4/6/77
Benomyl	12/6/77
Benzac	8/8/77
Chloranil	1/19/77
Chlorobenzilate	5/26/76
DBCP	9/22/77
Diallate	5/31/77
Dimethoate	9/12/77
EBDC	8/10/77
Kepone	7/27/77
Maleic Hydrazide	10/28/77
MIREX	Cancelled
Monuron	8/16/77
OMPA	5/28/76
PCNB	10/13/77
Phenarzine Chloride	11/21/77
Polychlorinated Terphenyls	Cancelled
Pronamide	5/20/77
Strobane	6/28/76
2,4,5-T	4/21/78

1080/1081

12/1/76

Thiophonate Methyl

12/7/77

Trysben

2/9/78

In the Administrator's judgment this waste stream poses a potential radiological hazard. Our information indicates that waste rock and overburden contain the following:

10pCi/gr average activity of Radium -226.
Reference: Background document - Identification and Listing of Hazardous Radioactive Waste Pursuant to the Resource Conservation and Recovery Act of 1976. December, 1978.

Large volume wastes containing elevated Radium -226 concentrations dispersed throughout a non-radioactive medium present an environmental problem because of potential hazard to the health of those chronically exposed to such wastes.

Radium-226 is a naturally - occurring radionuclide. The extraction and processing of certain ores enriched in radium result in its redistribution, thereby creating opportunities for environmental contamination and exposure of the public to hazardous levels of radioactivity. Radium-226 is relatively abundant and has a half-life of 1620 years. Its radiotoxic properties have been extensively studied in relation to increased incidence of occupationally - related bone cancer and aplastic anemia. The major health hazard is due, however, to inhalation of the decay products of Radium-226. Radon-222, the first generation decay product, is a noble gas. Radon-222, decays to several daughter products which, upon inhalation, deposit in and irradiate the lung by emission of alpha particles. Studies link exposure of this nature with an increase in lung cancer induction. External exposure to gamma radiation emitted by radon

decay products has also been implicated in serious genetic abnormalities and increased incidence of cancer. (See background document for more information).

Radon-222 emanates continuously from the piles ^{of waste rock and OVERBURDEN} creating a hazard to public health.

If improperly managed, these wastes present a potential hazard to human health and the environment. The principal hazards associated with the chlorinator residues and clarifier sludge from zirconium extraction are direct exposure to gamma radiation and contamination of surface and ground waters due to high concentrations of soluble Radium-226. Our information indicates that the wastes contain 150-1300 pCi/gr of Radium-226.

Radium-226 is a naturally-occurring radionuclide with a half-life of 1620 years. It is relatively abundant in the environment. The extraction and processing of certain ores enriched in radium result in the redistribution of the radionuclide, thereby creating opportunities for environmental contamination and exposure of the public to hazardous levels of radioactivity.

The radiotoxic properties of Radium-226 have been extensively studied in relation to an increased incidence of occupationally related cancer. Radium has chemical characteristics similar to calcium and will concentrate in bone after ingestion. Decay by alpha emission follows. External exposure to gamma radiation emitted by radium decay products has also been implicated in increased incidences of cancer and serious genetic abnormalities (See Background Document for additional information)

Reference: Radioactivity Background Document

RCRA §3001. Dec. 1978

In the Administrator's judgment, these wastes pose a potential radiological hazard. Our information indicates that overburden and slimes contain the following:

Mine overburden: 5-10 pCi/gr. average Radium-226 activity
Slimes: 35-45 pCi/gr. average Radium-226 activity

Large volume wastes containing elevated Radium - 226 concentrations dispersed throughout a non-radioactive medium present an environmental problem because of potential hazard to the health of those chronically exposed to such wastes.

Radium-226 is a naturally - occurring radionuclide. The extraction and processing of certain ores enriched in radium result in its redistribution, thereby creating opportunities for environmental contamination and exposure of the public to hazardous levels of radioactivity. Radium - 226 is relatively abundant and has a half-life of 1620 years. Its radiotoxic properties have been extensively studied in relation to increased incidence of occupationally - related bone cancer and aplastic anemia. The major health hazard is due, however, to inhalation of the decay products of Radium-226. Radon-222, the first generation decay product, is a noble gas. Radon-222 decays to several daughter products which, upon inhalation, deposit in and irradiate the lung by emission of alpha particles. Studies link exposures of this nature with an increase in lung cancer induction. External exposure to gamma radiation emitted by radon decay products has also been implicated in serious genetic abnormalities and increased incidence of cancer.
(See background document for more information)

Studies conducted on reclaimed land containing these wastes reveal the existence of a potential public health problem due to elevated air concentrations of radon decay products in some structures built on the reclaimed land. Chronic exposure to the radiation levels in these structures could result in approximately doubling the lifetime risk of developing lung cancer to the exposed person. In Florida, as many as 4000 existing structures may require evaluation to determine whether remedial action is necessary. The application of radiation control measures is strongly recommended ^{for} on the construction of new buildings, especially dwellings. These same studies indicate a correlation between a soil concentration of Radium-226 greater than 5 pCi/gr. and the elevated radon progeny levels in structures built on such land. (See background for additional information).

Reference: Background document - Identification
and Listing of Hazardous Radioactive
Waste Pursuant to the Resource
Conservation and Recovery Act
of 1976. December, 1978.

2874 Waste Gypsum From Phosphoric Acid Production

In the Administrator's judgment, this waste stream poses a potential radiological hazard. Our information indicates that gypsum from phosphoric acid production contains the following:

20-30 pCi/gr average Radium-226 activity.
Reference: Background document - Identification and Listing of Hazardous Radioactive Waste Pursuant to the Resource Conservation and Recovery Act of 1976. December, 1978.

Large volume wastes containing elevated Radium-226 concentrations dispersed throughout a non-radioactive medium present an environmental problem because of potential hazard to the health of those chronically exposed to such wastes.

Radium-226 is a naturally - occurring radionuclide. The extraction and processing of certain ores enriched in radium result in its distribution, thereby creating opportunities for environmental contamination and exposure of the public to hazardous levels of radioactivity. Radium-226 is relatively abundant and has a half life of 1620^{years}. Its radiotoxic properties have been extensively studied in relation to increased incidence of occupationally related bone cancer and aplastic anemia. The major health hazard is due, however, to inhalation of the decay products of Radium-226. Radon-222, the first generation decay products, is a noble gas. Radon-222 decays to several daughter products which, upon inhalation, deposit in and irradiate the lung by emission of alpha^a particles. Studies link exposure of this nature with an increase in lung cancer induction. External exposure to gamma radiation emitted by radon decay products has also been

implicated in serious genetic abnormalities and increased incidence of cancer. (See background document for more information).

Because Radon-222 emanates continuously from the gypsum piles, the waste creates a hazard to human health.

In the Administrator's judgment, this waste stream poses a potential radiological hazard. Our information indicates that slag and fluid bed prills contain the following:

Slag: 20-60 pCi/gr. average Radium-226 activity
Fluid bed prills: 10-15 pCi/gr. average Radium-226 activity.

Large volume wastes containing elevated Radium-226 concentrations dispersed throughout a non-radioactive medium present an environmental problem because of potential hazard to the health of those chronically exposed to such waste.

Radium-226 is a naturally - occurring radionuclide. The extraction and processing of certain ores enriched in radium result in redistribution, thereby creating opportunities for environmental contamination and exposure of the public to hazardous levels of radioactivity. Radium-226 is relatively abundant and has a half-life of 1620 years. Its radiotoxic properties have been extensively studied in relation to increased incidence of occupationally - related bone cancer and aplastic anemia. The major health hazard is due, however, to inhalation of the decay products of Radium-226. Radon-222, the first generation decay product, is a noble gas. Radon-222 decays to several daughter products which, upon inhalation, deposit in and irradiate the lung by emission of alpha particles. Studies link exposures of this nature with an increase in lung cancer induction. External exposure to gamma radiation emitted by radon decay products has also been implicated in serious genetic abnormalities and increased incidenceⁿ of cancer. (See background document for more information).

Radon-222 emanates continuously from these wastes.
A Radium-226 activity level exceeding 5 pCi/gr in the soil of land reclaimed from phosphate mining activities correlates with significant elevation of radon progeny levels inside structures built on such land and, on that basis, creates a hazard to human health. (See background document for additional information).

Reference: Background document - Identification
and Listing of Hazardous Radioactive
Waste Pursuant to the Resource
Conservation and Recovery Act of
1976. December, 1978.

TEXTILES

7251 Wool Fabric Dyeing and Finishing Wastewater Treatment Sludges

This waste stream is hazardous because of its toxic properties. According to data EPA has on this waste stream, it meets the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

The following table compares the concentrations of contaminants found in wool fabric dyeing and finishing wastewater treatment sludges to the limits established by the NIPDWR.

<u>Parameter</u>	<u>Drinking Water Limit (ppm)</u>	<u>Ave. Conc. (ppm)</u>
Arsenic	0.05	< 17
Barium	1.00	< 170
Cadium	0.01	17
Mercury	0.002	< 1.7

Reference: Versar, Inc. Assessment of Industrial Hazardous Waste Practices, Textile Industry PB# 258-953, June, 1976 p.3-23.

The above data suggest that the waste presents a hazard to human health and the environment.

TEXTILES

2261-2

Woven Fabric Dyeing and Finishing Wastewater Treatment Sludges

This waste stream is classified as hazardous because of its toxic properties. According to data EPA has on this waste stream, it meets the RCRA 250.13a(4) characteristic identifying a toxic hazardous waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate^{te} the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

The following table compares the concentrations of contaminants found in woven fabric dyeing and finishing wastewater treatment sludges to the limits established by the NIPDWR.

<u>Parameter</u>	<u>Drinking Water Limit (ppm)</u>	<u>Ave. Conc. (ppm)</u>
Arsenic	0.05	1
Barium	1.0	39
Cadmium	0.01	4.4
Chromium	0.05	1,196
Lead	0.05	36

Reference: Versar, Inc. Assessment of Industrial Hazardous Waste Practices, Textile Industry PB# 258-953
June, 1976 p.3-37

The above data suggest that the waste presents a hazard to human health and the environment.

Knit Fabric Dyeing and Finishing Wastewater Treatment Sludges

This waste stream is classified as hazardous because of its toxic properties. According to data EPA has on the waste stream, it meets the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants^a is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate^{te} groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

The following table compares the concentrations of contaminants found in knit fabric dyeing and finishing wastewater treatment sludge to the limits established by the NIPDWR.

<u>Parameter</u>	<u>Drinking Water Limit (ppm)</u>	<u>Ave. Conc. (ppm)</u>
Arsenic	0.05	< 4.8
Cadmium	0.01	< 4.5
Chromium	0.05	33
Lead	0.05	< 52
Mercury	0.002	1.4

Reference: Versar, Inc. Assessment of Industrial Hazardous Waste Practices, Textile Industry PB# 258-953
June, 1976 p.3-49.

The above data suggest that the waste presents a hazard to human health and the environment.

TEXTILES

2269

Yarn and stock dyeing and finishing wastewater treatment sludges.

This waste stream is classified as hazardous because of its toxic properties. According to data EPA has on the waste stream, it meets the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

Our information indicates that the waste contains chromium, lead and mercury.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

The following table compares the concentrations of contaminants found in yarn, stock dyeing and finishing wastewater treatment sludge to the limits established by the NIPDWR.

<u>Parameter</u>	<u>Drinking Water Limit (ppm)</u>	<u>Ave. conc. (ppm)</u>
Chromium	0.05	31
Lead	0.05	1660
Mercury	0.002	0.66

Reference: Versar, Inc. Assessment of Industrial
Hazardous Waste Practices, Textile
Industry. PB#258-953. June 1976
p. 3-73.

The above data suggests that the waste presents a hazard to human health and the environment.

2279

Carpet Dyeing and Finishing Wastewater Treatment Sludges

This waste stream is classified as hazardous because of its toxic properties. According to data EPA has on this waste stream, it meets the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

The following table compares the concentrations of contaminants found in the waste to the limits established by the NIPDWR.

<u>Parameter</u>	<u>Drinking Water Limit (ppm)</u>	<u>Ave. Conc. (ppm)</u>
Arsenic	0.05	10
Cadmium	0.01	10
Chromium	0.05	112
Lead	0.05	110

Reference: Versar, Inc. Assessment of Industrial Hazardous Waste Practices. Textile Industry. PB# 258-953. June 1976.p.3-61.

The above data suggest that the waste presents a hazard to human health and the environment.

TEXTILES

2299 WOOL SCOURING WASTEWATER TREATMENT SLUDGES

This waste stream is classified as hazardous because of its toxic properties. According to data EPA has on this waste stream, it meets the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

Our information indicates that the waste contains the following toxic substances: Barium, Cadmium, Chromium, Lead.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

The following table compares the concentrations of contaminants found in the waste to the limits established by the NIPDWR.

<u>Parameter</u>	<u>Drinking Water Limit (ppm)</u>	<u>Ave. conc. (ppm)</u>
Barium	1.0	59
Cadmium	0.01	1.2
Chromium	0.05	19
Lead	0.05	28

Reference: Versar, Inc. Assessment of Industrial Hazardous Waste Practices, Textile Industry. PB# 258-953. June. 1976 p.3-14.

The above data suggest that the waste presents a hazard to human health and the environment.

812

Mercury bearing sludges from brine treatment from mercury cell process in chlorine production (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Mercury is one of the toxicants listed by the NIPDWR at a concentration of .002mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to .02mg/l level in the EP extract.

This waste has been shown to contain as high as 100ppm (approximately 100mg/l) mercury according to the following report:

Versar, Inc. "Assessment of Industrial Hazardous waste Practices, Inorganic Chemicals Industry"
"Contract # 68-01-2246 p.5-8"

Because of this the Agency feels that this waste stream could pose a threat to human health and the environment.

Sodium calcium sludge from production of chlorine by
Down Cell process (R)

Reactive wastes as defined by Section 250.14 of RCRA pose a threat to human health and the environment, either through the physical consequences of their reaction (i.e., high pressure and/or heat generation) or through the chemical consequences of their reaction (i.e., generation of toxic fumes).

According to "Assessment of Industrials Hazardous waste Practices, Inorganic Chemicals Industry" (Contract #68-01-2246 Versar Inc. p. 5-11) this waste stream contains a mixture of sodium calcium metal. These metals in their element^{al} state react very vigorously with water to produce hydrogen gas. For this reason this waste is extremely hazardous and must be disposed of under carefully controlled conditions to avoid explosions or fires.

Mercury bearing sludges from brine treatment from mercury cell process in chlorine production (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminents the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Mercury is one of the toxicants listed by the NIPDWR at a concentration of .002mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .02mg/l level in the EP extract.

This waste has been shown to contain free mercury and mercury sulfide*. Because of the extreme toxicity of mercury this waste stream could be hazardous under ^{improper} management conditions.

*Versar, Inc. Assessment of Industrial Hazardous Waste Practices, Inorganic Chemicals Industry "Contract #68-01-2246"
p5-8

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental ^xexposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Lead is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

This waste has been shown to contain lead carbonate in soluble concentrations to 1.7mg/l*. Because of the toxicity and solubility of these constituents and because of the ability of lead to bioaccumulate, these waste streams are considered hazardous.

*Versar, Inc. Assessment of Industrial Hazardous
waste Practices, Inorganic Chemicals Industry
"Contract # 68-01-2246"

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification

of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater) it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other tri-halomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste as a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

This Waste Stream has been found to contain Chlorinated organics in concentrations ranging from .1 to 1.0mg/l. Because of the toxicity of this class of organics this waste stream is to be considered hazardous.

*"Interim Primary Drinking Water Regulations,"
p. 5756, Federal Register, 2/1/78

**Versar, Inc. Assessment of Industrial Hazardous waste Practices, Inorganic Chemicals Industry
"Contract # 68-01-2246 p. 5 - 7

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Chromium is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

This waste has been shown to contain chromium.

Because of the toxicity of chromium, This waste is considered hazardous.

Chromium bearing wastewater treatment sludge and other chromium bearing wastes from production of chrome oxide green pigment (anhydrous & hydrated)
(T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Chromium is of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the TEP extract.

These wastes have been shown to contain* chromic oxide (Cr_2O_3) and chromium hydroxide (CrOH_3). These chromium compounds will be soluble under mildly acidic conditions. For this reason these waste streams are considered hazardous.

*Versar, Inc. Assessment of Industrial Hazardous
waste Practices, Inorganic Chemicals Industry
"Contract # 68-01-2246

2816

Ferric ferrocyanide bearing wastewater treatment
sludges from the production of iron blue pigments
(R)

Reactive wastes as defined by Section 250.14 of RCRA pose a threat to human health and the environment, either through the physical consequences of their reaction (i.e., high pressure and/or heat generation) or through the chemical consequence of their reaction (i.e., generation of toxic fumes).

This waste stream contains* ferric ferrocyanides. Upon action of ^{acid} ~~and~~ this compound will give off hydrocyanic acid. Also ^{sic} ~~acid, basic~~, or neutral solutions of this compound will liberate hydrocyanic acid under strong irradiation.

*Versar, Inc. Assessment of Industrial Hazardous
waste Practices, Inorganic Chemicals Industry
"Contract #68-01-2246

Mercury bearing wastewater treatment sludges from the production of mercuric sulfide pigment (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Mercury is one of the toxicants listed by the NIPDWR at a concentration of .002mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .02mg/l level in the EP extract.

This waste stream contains* mercuric oxide (HgO) . Mercuric oxide is soluble in dilute acid. Because of the extreme toxicity of Mercury and the solubility of this mercury compound this waste stream is to be considered hazardous.

*Versar, Inc. Assessment of Industrial Hazardous waste Practices, Inorganic Chemicals Industry
"Contract #68-01-2246

816 Chromium bearing wastewater treatment sludges
from the production of TiO_2 pigment by the chloride
process (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

These wastes contain* titanium hydroxide and small amounts of vanadium, copper, chromium, zirconium and niobium.

Chromium is one of the toxicants listed in the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

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"Contract #68-01-2246

According to the "Handbook of Industrial Waste Compositions in California - 1978" - D.L. Storm, California Department of Health Services Hazardous Materials Management Section, November 1978, the components of a quantity (4800 gal) of waste acid solution from the chloride process in the production of titanium dioxide had the following ranges:

0 - 15% hydrochloric acid

0 - 30% iron

0 - 1.5% chromium

0 - .16% magnesium

0 - .6% vanadium

0 - .25% niobium

with a pH of 1.5

Because of the toxicity of these contaminants this waste stream is considered hazardous.

Chromium bearing wastewater treatment sludges from the production of TiO_2 pigment by sulfate process (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Chromium is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a ⁵/₁₀₀mg/l level in the EP extract.

This waste has been shown* to contain chromium hydroxide at concentrations of between 0 to 185 ppm in the sludge solids. This waste stream will also contain a large amount of Calcium sulfate. The calcium sulfate will tend to keep the pH of any water (or leachate) percolating through this waste at a pH of approximately 5.5. At this pH the concentration of trivalent chromium in the leachate may be as high as 50mg/l.

*Versar, Inc. Assessment of Industrial Hazardous
waste Practices, Inorganic Chemicals Industry.
Contract # 68-01-2246

Arsenic bearing sludges from purification process
in the production of antimony oxide (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminants the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

These wastes has been shown to contain* Arsenic compounds such as arsenic trisulfide (As_2S_3) Arsenic trisulfide is soluble in alkaline solutions (e.g. carbonates.) Because of the toxicity of arsenic and the solubility of this compound, this waste stream is to be considered hazardous

*Versar, Inc. Assessment of Industrial Hazardous waste Practices, Inorganic Chemicals Industry
"Contract # 68-01-2246

2816

Antimony bearing wastewater treatment sludge from product of antimony oxide (T)

This waste stream will contain* (along with the previously mentioned arsenic Compounds) antimony compounds (e.g. Antimony Trioxide). Antimony Trioxide is readily soluble in acetic acid (a typical light volatile ^{ci} and found in leachates). Antimony poisoning closely parallels arsenic poisoning. Because of the toxicity and solubility of antimony this waste is considered a hazardous waste.

*Versar, Inc. Assessment of Industrial Hazardous waste Practices, Inorganic Chemicals Industry
"Contract # 68-01-2246"

Chromium or lead bearing wastewater treatment sludge from production of chrome yellows and oranges (lead chromate) (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

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At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Chromium and lead are two of the toxicants listed by the NIPDWR both at concentration of .05mg/l because of their toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

This waste has been shown to contain* lead salts (e.g. lead hydroxide, lead chromate, and chromium hydroxide (Cr OH_3)). Chromium hydroxide is soluble in acidic media. At pH 5 a saturated solution will contain $5.2 \times 10^{-1} \text{g/l}$ of trivalent chromium. Under saturated conditions (i.e. if equilibrium were reached) then there would be 100 times the .5mg/l concentration limit in solution. Because of the toxicity of chromium and the solubility of this salt this waste is considered hazardous. Lead chromate is one of the more insoluble lead salts, however it will reach a concentration level up to .2mg/l. Lead hydroxide is soluble however, to concentrations several orders of magnitude greater than the .5mg/l concentration limit, under, neutral, and acidic conditions. Because of the toxicity of lead and the solubility of these salts this

*Versar, Inc. Assessment of Industrial Hazardous Waste Practices, Inorganic Chemicals Industry" Contract # 68-01-2246

stream is to be considered hazardous.

2816

Chromium or lead bearing wastewater treatment sludge from production of molybdate orange (lead molybdate lead chromate) (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Chromium and lead are two of the toxicants listed by the NIPDWR both at concentration of .05mg/l because of their toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

This waste has been shown to contain* lead salts (e.g. lead hydroxide, lead chromate, and chromium hydroxide (Cr OH_3). Chromium hydroxide is soluble in acidic media. At pH 5 a saturated solution will contain 5.2×10^{-1} g/l of trivalent chromium. Under saturated conditions (i.e. if equilibrium were reached) then there would be 100 times the .5mg/l concentration limit in solution. Because of the toxicity of chromium and the solubility of this salt, this waste is considered hazardous. Lead chromate is one of the more insoluble lead salts, however it will reach a concentration level up to .2mg/l. Lead hydroxide is soluble however, to concentrations several orders of magnitude greater than the .5mg/l concentration limit, under, neutral, and acidic conditions. Because of the toxicity of lead and the solubility of these salts this

*Versar, Inc. Assessment of Industrial Hazardous Waste Practices, Inorganic Chemicals Industry" Contract # 68-01-2246

waste stream is to be considered hazardous.

816 Zinc and chromium bearing wastewater treatment sludge from production of zinc yellow pigment (hydrated zinc potassium chromate) (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Chromium is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract. This waste has been shown to contain* Chromium hydroxide. Chromium hydroxide (^{Cr}OH₃) is soluble in acidic media. At pH 5 a saturated solution will contain 5.2×10^{-1} g/l of trivalent chromium. Undersaturated conditions (i.e. if equilibrium were reached), then there would be 100 times the .5mg/l concentration in solution. Because of the toxicity of chromium and the solubility of this salt, this waste is considered hazardous.

*Versar, Inc. Assessment of Industrial Hazardous waste Practices, Inorganic Chemicals Industry
"Contract #68-01-2246

Ash from incinerated still bottoms (paint and pigment production) (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

TABLE # 1*

ANALYTICAL CHARACTERISTICS OF STILL BOTTOMS SAMPLES
COLLECTED FROM SOLVENT RECLAIMING OPERATIONS

Sample Designation	Percent Volatile Carried off at 103-105°C	Percent Trichloro-ethylene	Lead mg/l	Chromium, mg/l	Zinc mg/l	Flash Point,	
						°C	°F
A ₁	77		1700	280	190	48	118
A ₂	79		500	60	130	44	111
B ₁	89		400	60	130	51	124
B ₂	89	6				75	167
D ₁	99		100	10	10	40	104
D ₂	41					46	115
J ₁	14	3				no flash	
J ₂	14					58	136
J ₃	61					53	127
J ₄	28					90	194
X ₁	97	45				84	183
X ₂	97	50				86	187
Y ₁	59		1200	360	100	68	154
Y ₂	58		1200	310	990	82	180
Y ₂	83		100	10	10	74	165
Z	61		3700	730	430	79	174

*Wapora, Inc. Assessment of Industrial Hazardous Waste Practices-Paint and Allied Products Industry Contract Solvent Reclaiming Operations and Factory Application of Coatings. 1976

TABLE 2*

ANALYSIS OF ASH FROM INCINERATED STILL BOTTOMS

<u>Constituent</u>	<u>Concentration, Percent</u>
TiO ₂	Major
SiO ₂	15.00
SrO	2.00
Al ₂ O ₃	.50
Fe ₂ O ₃	.20
MgO	.20
BaO	.10
MoO ₃	.004
PbO	.03
Sb ₂ O ₅	.02
CaO	.005
NiO	.005
SnO ₂	.005
ZnO	.003
CoO	.003
MnO	.003
CuO	.001
Cr ₂ O ₃	.001

Not Detected in Sample: Cd, As, Te, B, W, Ge, Bi, Be, V, Ag.

*Wapora, Inc. Assessment of Industrial Hazardous
Waste Practices-Paint and Allied Products Industry
Contract Solvent Reclaiming Operations and Factory
Application of Coatings. 1976

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Chromium, lead and Barium are three of the toxicants listed by the NIPDWR at a concentrations of .05, .05, and 1.0 mg/l, respectively, because of their toxicity. As explained in the RCRA toxicity background document these converts to concentrations of 0.5, 0.5 and 10.0mg/l, respectively in the EP extract.

This waste has been shown contain* chromic oxide (Cr_2O_3), lead oxide (PbO) and Barium oxide (BaO) at the concentration levels indicated in Tables 1 and 2. The solubility of Barium oxide is 35g/l in cold water, and 900g/l in hot water) in aqueous solution, this is several orders of magnitude greater than the allowable TEP concentration limit, so that a saturated solution would certainly meet the toxicity criteria for barium. Chromic oxide is amphoteric and soluble in acidic and basic solutions as is lead oxides. The solubility of both

*Wapora, Inc. Assessment of Industrial Hazardous waste Practices-Paint and Allied Products Industry Contract Solvent Reclaiming Operations and Factory Application of Coating. 1976

as is lead oxides. The solubility of both of these is such that a saturated solution of either would surpass the TEP concentration limit by at least an order of magnitude. Because of the toxicity and solubility of these salts this waste is considered hazardous.

2819

Arsenic bearing wastewater treatment sludges from production of boric acid. (T)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminants the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

- Arsenic is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

This waste has been shown to contain* Arsenic.

Because of the toxicity of Arsenic this waste is considered hazardous.

*Versar, Inc. Assessment of Industrial Hazardous
waste Practices, Inorganic Chemicals Industry
"Contract #68-01-2246

2834 Arsenic or Organo-Arsenic Containing Wastewater Treatment
Sludges from Production of Veterinary Pharmaceuticals
(T, M, O)

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental-exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminat~~e~~^{te} the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

As stated earlier a primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater.

Geraghty and Miller¹ found that in a majority of the fifty sites examined, organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports 2 through 8 do qualitatively identify leached organic contaminants in groundwater) it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.).

This waste has been shown to also contain * 1,1,2-trichloroethane, phenol, nitrobenzene and o-nitro-aniline because of the toxicity of these compounds this waste is a hazardous waste.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

This waste has been shown to contain Arsenic. According to several sources*, this arsenic has leached out in~~o~~t soil surrounding its disposal site in concentrations from 4-92mg/kg. Because of the toxicity of Arsenic and the apparent solubility of its form in this waste, this waste is considered a hazardous waste.

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- * (1) "Recommendations Secondary Sites" Salsbury Laboratories, Charles City Iowa Dept. of Environmental Quality, Dec. 14, 1977.
- (2) "Report of Investigation of Salsbury Labs., Charles City, Iowa" Region VII, USEPA, Sept. 1977.
- (3) "NPDES Compliance, Monitoring and Waste/Water Character- Salsbury Labs., Charles City, Iowa" 6/19-6/30, 1978 NEIC.

2851 Wastewater treatment and air pollution control sludges from paint production (T)

This waste stream is classified as hazardous because of its toxic properties. According to the data EPA has on its waste stream it meets the RCRA §250.13d characteristic identifying a toxic hazardous waste.

EPA bases this classification on the following information.

(1) Wapora Inc. has tested a sample of wastewater treatment and air pollution sludges and has found the following.

<u>contaminent</u>	<u>conc. (range of samples) mg/l</u>
Hg	0.2 - 0.4
Pb	24.0 - 120.0
Cd	2 - 120
Cr	10 - 217
Zinc	28 - 10,840
Ti	52 - 1205

The data presented above are available from:

Assessment of Industrial Hazardous Waste Practices:
Paint and Allied Products Industry, Contract Solvent Reclaiming Operations, and Factory Application of Coating. OSW, PB - 251 - 669, 1976.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to

0.05, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5, mg/l respectively in the EP extract.

This waste has been shown to contain mercury, lead, cadmium, and chromium at concentrations of 0.2, to 0.4, 24.0 to 120.0, 2.0 to 120.0, and 10.0 to 217.0 mg/l respectively, according to PB - 251 669, Assessment of Industrial Hazardous Waste Practices: Paint and Allied Products Industry, Contact Solvent Reclaiming Operations, and Factory Application of Coating.

Because of the toxicity of these heavy metals this waste is to be considered hazardous.

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

12% Maleic anhydride:

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring

wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalometh^{anes} and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The vacuum still bottoms from maleic anhydride production contain a significant quantity of maleic anhydride which has an oral rat LD50 of 481mg/kg. These^e still bottoms also contain tars believed to be carcinogenic.

- Reference:
1. TRW. Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives. USEPA SW-118c Jan. 1976 p.5-46
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain α - chlorotoluene.

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethane^S and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The still bottoms from the distillation of benzyl chloride are likely to contain alpha-chlorotoluene, a carcinogenic organic.

- References
1. TRW. Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives. USEPA, SW-118c, Jan. 1976 p. 5-49.
 2. NIOSH Registry of the Toxic Effects of Chemical Substances, 1977.

DISTILLATION RESIDUES FROM FRACTIONATING
TOWER FOR RECOVERY OF BENZENE AND CHLOROBENZENE

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain polychlorinated aromatic^s.

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater

above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethane^s and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

Distillation residues from the fractionating tower for the recovery of benzene and chlorobenzene contain polychlorinated aromatics which are believed to be toxic and bioaccumulative.

Reference: TRW. Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides, and Explosives. USEPA, SW-118c, Jan. 1976 p. 5-14.

VACUUM DISTILLATION RESIDUES FROM PURIFICATION OF 1-CHLORO- 4 -
NITROBENZENE

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

Polycyclic Aromatic Tars

Nitro substituted aromatic polymers

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking

into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The vacuum distillation residues contain polyaromatic tars and nitro substituted aromatic polymers which are believed to be toxic.

Reference: TRW Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives Industries, USEPA SW-118c Jan. 1976 p. 5-9.

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following Toxic organic:

13% Hydroquinone

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring

wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The heavy ends from methanol recovery during methyl methacrylate production contain a large amount of hydroquinone. This organic has an oral rat LD 50 of 320mg/kg.

References 1. TRW-Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosive, USEPA, SW-118c, Jan. 1976 p. 5-41.

2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

STILL BOTTOMS FROM FRACTIONATION IN EPICHLOROHYDRIN PRODUCTION

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

10% Dichloropropanol:

Epichlorohydrin:

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work,

(other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalometh^{anes} and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The still bottoms from the fractionation process in epichlorohydrin production contain a significant amount of dichloropropanol, a toxic organic. They also contain epichlorohydrin which is a suspected carcinogen.

- References
1. TRW. Assessment of Industrial Hazardous waste Practices: Organic Chemicals, Pesticides and Explosives USEPA SW-118c January, 1976 p. 5-20
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

HEAVY CHLORINATED ORGANICS PORTION OF FRACTIONATION WASTE FROM
ETHYL CHLORIDE PRODUCTION

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

77% Hexachlorobutadiene

7% Chlorobenzenes

7% Tars and residues

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these

sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

This portion of the fractionation waste from ethyl chloride production contains chlorobenzenes which are carcinogenic and bioaccumulative, and tars and residues which are believed to be carcinogenic. The major constituent is hexachlorobutadiene which is bioaccumulative and toxic (oral rat LD50 of 90 mg/kg).

- References:
1. TRW Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives. USEPA SW-118c. Jan. 1976 p. 5-16.
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

2869 COLUMN BOTTOMS FROM PRODUCTION OF TRICHLOROETHYLENE
AND PERCHLOROETHYLENE

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work,

(other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalometh^{anes} and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

This waste has been shown to contain the following¹
7% Hexachlorobutadiene: Toxic and bioaccumulative
organic (oral rat LD50 = 90mg/~~dog~~^{kg})

7% Chlorobenzenes: carcinogenic and bioaccumulative

7% Tars and residues: carcinogenic potential

Because of the toxicity of these compounds this is a hazardous waste.

- References
1. TRW-Assessment of Industrial Hazardous Waste Practice Organic Chemicals, Pesticides and Explosives USEPA SW-118c Jan. 1976 p. 5-6
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977

DIOXIN - BEARING RESIDUES FROM PRODUCTION
HEXACHLOROPHENOL AND 2,3,5-T
PHENOL 4

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

Dioxin -

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater

concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

These residues contain significant amounts of tetrachlorodibenzodioxin, an extremely toxic organic. Its known toxic effects include anorexia, severe weight loss, hepatotoxicity, hepatoporphyrria, vascular lesions, chloracne, gastric ulcers, teratogenicity and delayed death.

- References:
1. Carter et al. Tetrachlorodibenzodioxin: An Accidental Poisoning Episode in Horse Arenas Science, 188 (4189): 738-740, May 16, 1975.
 2. Processes Research, Inc. A Study of Hazard Emergency Alarm Control System. EPA Contract #68-01-4658 July, 1978.

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

97% higher halogenated hydrocarbons

2% ethylene dichloride

1% tars

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring

wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethane^s and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The heavy ends from the distillation process in vinyl chloride production contain higher halogenated hydrocarbons which are toxic, tars which are carcinogenic and a significant amount of ethylene dichloride, a compound which has an oral rat LD50 of 600mg/kg and is also bioaccumulative.

- References
1. TRW Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives, USEPA, SW-118c, Jan. 1976 p. 5-37.
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

Tetrachloride Fractionation Tower

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Gerhity and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations)..

Gerhity and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports 2 through 8 do qualitatively identify leached organic contaminants in groundwater) it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste

disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste as a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

This waste stream will contain* higher chlorinated hydrocarbons (predominately crude hexachlorobenzene and hexachlorobutadiene). Because of the toxicity of these two organics** and of the other chlorinated organics likely to be in the waste, this waste is a hazardous waste.

* TRW Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives. USEPA SW-118c Jan. 1976 p.571

* NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977,

2869 HEAVY ENDS FROM DISTILLATION OF ETHYLENE DICHLORIDE
IN ETHYLENE DICHLORIDE PRODUCTION

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

23% ethylene dichloride

38% 1, 1, 2 - trichloroethan^e

38% tetrachloroethane

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work,

(other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalometh^{anes} and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The heavy ends from the distillation of ethylene dichloride_A ^{contain significant amounts of EDC} trichloroethane and tetrachloroethane. These compounds are bioaccumulative_Y. Ethylene dichloride has an oral rat LD50 of 690mg/kg, and tetrachloroethane has an oral rat LD50 of 200mg/kg.

- References
1. TRW. Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives. USEPA SW-118c Jan. 1976 p.5-34
 2. NIOSH Registry of the Toxic Effects of Chemical Substances, 1977.

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

Nitrobenzene

Nitrophenol

Dinitrophenol

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring

wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The purification column wastes have been found to contain the toxic organics, nitrophenol and dinitrophenol and nitrobenzene which has an oral rat LD50 of 640mg/kg.

- Reference
1. Mitre Corporation, Nitrobenzene/Amiline Manufacture: Pollutant Prediction and Abatement, EPA Contract #68-01-3188, May, 1978.
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

Furfural - containing tars and polymers:

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring

wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and report (References 2 through 8) qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethane^s and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The still bottoms from furfural production consist of furfural - containing tars and organics. Furfural is toxic organic with an oral rat LD50 of 127mg/kg. Furfural also has a flash point of 140°F and may create a hazard due to ignitability.

- Reference 1. TRW. Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives. USEPA SW-118c Jan. 1976 p. 5-22.
2. NIOSH Registry of the Toxic Effects of Chemical Substances, 1977 .

2869

SPENT CATALYST FROM FLUOROCARBON PRODUCTION

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain antimony pentachloride.

Antimony pentachloride fumes in air and may cause antimony poisoning in humans. Effects include dermatitis, keratitis, conjunctivitis and nasal septal ulceration.

- References
1. TRW, Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives. USEPA. SW-118c Jan. 1976 p. 5-31
 2. ^eMarck Index, Eighth Edition, p. 90

2869 CENTRIFUGE RESIDUE FROM TOLUENE DIISOCYANATE PRODUCTION

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain 3% Isocyanates.

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8)

do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of the persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

Our information indicates that ^otoluene diisocyanate is a pressure generating compound which reacts with water to release carbon dioxide. Also, when contact by concentrated alkaline compounds, run-away polymerization may occur. Furthermore, toluene diisocyanate is listed as a DOT Poison B.

- References
1. TRW, ³⁵Assesment of Industrial Hazardous Waste Practices: Organic, Chemicals, Pesticides and Explosives. USEPA SW-118c Jan. 1976 p. 5-34
 2. Merck Index, Eighth Edition p. 1058
 3. NIOSH Registry of Toxic Effects of Chemical Substances, 1977

2869: LEAD[^] PRECIPITATE FROM LEAD ALKYL^S PRODUCTION
(SLAG)

This waste stream is hazardous because of its toxic properties. According to data EPA has on this waste stream, it meets the RCRA 250.13 a(4) characteristic identifying a toxic hazardous waste.

Our information indicates that the waste contains the following toxic substance:

Lead

Reference: TRW. Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides, Explosives. USEPA SW-118c Jan. 1976 p. 5-47

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminants^{te} the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations). Because of the toxicity of lead, this waste is considered hazardous.

2869

SLUDGE FROM WASTEWATER TREATMENT OF STRIPPING
STILL TAILS - METHYLETHYL PYRIDINE PRODUCTION

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following toxic organics:

Paraldehyde

Pyridines

Picolines

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring

wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The sludge from wastewater treatment of stripping still tails contains paraldehyde, picolines and pyrimidines which are toxic organics.

References: TRW, Assessment of Industrial Hazardous Waste Practices: Organic Chemical, Pesticides and Explosives Industries. USEPA, SW-118c, Jan. 1976 p. 5-28.

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain nitrobenzene:

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking

into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The still bottoms from aniline distillation contain nitrobenzene, a toxic organic with an oral rat LD50 of 640mg/kg.

- References
1. Mitre Corp. Nitrobenzene /Aniline Manufacture: Pollution Prediction and Abatement. EPA Contract #68-01-3188, May 1978 .
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

2869

^u
AQUEOUS EFFLUENT FROM SCRUBBING OF SPENT
ACID IN NITROBENZENE PRODUCTION

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

Nitrobenzene
Nitrophanol
Benzene
Dinitrobenzene

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring

wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in

the hazard determination see Toxicity background document.)

The aqueous effluent ^f from scrubbing spent acid in nitrobenzene production contains

- (1) nitrobenzene: toxic organic with an oral rat LD50 of 640mg/kg
- (2) nitrophenol: toxic organic
- (3) dinitrobenzene: toxic organic
- (4) benzene: suspected carcinogen

- References
1. Mitre Corp. Nitrobenzene /Aniline Manufacture; Pollutant Prediction and Abatement. EPA Contract # 68-01-3188, May, 1978.
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

BOTTOM STREAM FROM QUENCH COLUMN^M - ACRYLONITRILE PRODUCTION
A

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

7% Hydrogen cyanide

0.1% Acrylamide

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring

wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The bottom stream from the quench column in acrylonitrile production contains a significant amount of HCN, an intensely poisonous gas which can cause tachypnea followed by dyspnea, paralysis, unconsciousness, convulsions and respiratory arrest. Death may result in a few minutes from exposure to 300ppm. This waste stream also contains acrylamide, a toxic organic which has an oral rat LD50 170mg/kg.

- References**
1. Mitre Corp. Acrylonitrile Manufacture: Pollutant Prediction and Abatement, USEPA Contract #68-01-3188 p. 133, February, 1978 .
 2. Merck Index, Eighth Edition p. 5-44 .
 3. NIOSH Registry of Toxic Effects of Chemical Substances, 1977 .

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

225ppm HCN

500ppm Nicotinitrile

540ppm Succinonitrile

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard

when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The bottom stream from the wastewater stripper contains HCN, an intensely poisonous gas which can cause tachypnea followed by dyspnea, paralysis, unconsciousness, convulsions and respiratory failure. Exposure to 150ppm for 1/2 - 1 hour may endanger life. This stream also contains the toxic organics, nicotinitrile and succinonitrile.

- References
1. Mitre Corp. Acrylonitrile Manufacture Pollutant Prediction and Abatement USEPA Contract #68-01-3188 p. 137 February, 1978
 2. Merck Index, Eighth Edition
 3. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

STILL BOTTOMS FROM FINAL PURIFICATION OF ACRYLONITRILE

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

Methacrylonitrile

Acrylamide

Acrylic acid

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring

wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The still bottoms contain methacrylonitrile (toxic organic with an oral rat LD50 of 250mg/kg), acrylamide (toxic organic with an oral rat LD50 of 170mg/kg) and acrylic acid (a corrosive and toxic organic with an oral rat LD50 of 340mg/kg).

- References
1. Mitre Corp. Acrylonitrile Manufacture: Pollutant Prediction and Abatement. USEPA Contract #68-01-3188 p. 138, Feb. 1978 .
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

Acrylonitrile -

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking

into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes, and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The waste from the ion exchange column contains acrylonitrile, a toxic, flammable organic with an oral rat LD50 of 82mg/kg.

- References
1. Mitre Corp. Acrylonitrile Manufacture: Pollutant Practices Prediction and Abatement. USEPA Contract #68-01-3188 February, 1978 p. 138
 2. NIOSH Registry of Toxic Effects of Chemical Substances, 1977.

WASTE STREAM FROM HCN PURIFICATION - ACRYLONITRILE PRODUCTION

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

Propenes, Butenes and Pentenes.

Propenes and butenes are flammable gases. Pentene has a flash point of 0°F.

As is evident from above this waste stream has a flash point of 140°F or below. Ignitables with flash points less than 140°F can become a problem while they are landfilled. During and after the disposal of an ignitable waste, there are many available external and internal energy sources which can provide an impetus for combustion, raising temperatures of waste to their flash points. Disposal of ignitable waste may result in fire that will cause damage directly from heat and smoke production or may provide a vector by which other hazardous waste can be dispersed.

Ignitable wastes tend to be highly volatile and the evaporation of these volatiles contributes to poor air quality. (Refer to ignitability background document for further detail).

Reference

1. Mitre Corp. Acrylonitrile Manufacture
Pollutant Prediction and Abatement
USEPA contract #68-01-3188 February, 1978 p. 140.

2869

COLUMN BOTTOMS FROM ACETONITRILE PURIFICATION - ACRYLONITRILE PRODUCTION

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed. Based on available information, we have determined that this waste is likely to contain the following:

Acetonitrile:

Benzene:

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work,

(other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalometh^{anes} and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

The column bottoms from acetonitrile purification contain acetonitrile, and organic substance with a flash point of 42°F, and benzene, a suspected carcinogen.

- References:
1. Mitre Corp. Acrylonitrile Manufacture: Pollutant Prediction and Abatement, USEPA Contract #68-01-3188 February, 1978 p. 139
 2. NIOSH Registry of the Toxic Effects of Chemical Substances, 1977.

2890 Sludges, wastes from tub washes (Ink Formulation) (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic indentifying toxic waste.

The Administrator has determined this waste stream to be a potential threat to the environment if improperly managed.

EPA bases this classification on the following information:

- 1) An EPA contractor has tested a sample of waste sludges and has found the following:

<u>Contaminant</u>	<u>Conc mg/l</u>
Cr as total Chromium	150
Cd	.29
Pb	760

pH = 12.5

The data presented are available from:

Effluent Guidelines for Paint Formulating and the Ink Formulating Industry. EPA 444/1-75/050.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified

limits please refer to the NIPDWR Appendix A-C
Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations.

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05 mg/l respectively because of thier toxicity. As explained in the RCRA toxicity background documents these concentrations convert to 0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5 mg/l respectively in the EP extract.

This waste has been shown to contain chromium, cadmium,

The following section discusses the listed wastes resulting from the manufacture of those organic chemicals commonly used as pesticides. The discussions of these has been organized differently than for those for the other listed waste streams. This has been done because of the repetitive nature of, and similarities between the type of available information on these wastes, and because of the similarities between the types of sources of these wastes (e.g. side reactions, hydrolyzed product, product contamination of waste).

A general section detailing the hazards posed by these types of waste will be followed by descriptions of the reactions undergone in the processes generating these wastes (including identification of toxicity information on potential contaminants).

PESTICIDES: GENERAL DISCUSSION

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations)..

Geraghty and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and references 2 through 8 do qualitatively identify leached organic contaminants in groundwater) it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when improperly managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document).

*"Interim Primary Drinking Water Regulations,"
p. 5756, Federal Register, 2/9/78

The following waste streams:

Wastewater treatment sludges from the production of dieldrin, chlordane, toxaphen, disulfoton, malathion, phorate, carbaryl, trifluraline, alachlor, methyl parathion, parathion, vernolate, methomly, carbofuran, captan, creosote, dithio carbamates, pentachlorophenol, bromacil, diuron, dichlorobenzene and cloroxuron. (O,M,B,)

Wastewater from oxidation of aldrin solution in production of dieldrin. (O,M,B,)

Wastewater from extraction of dieldrin solution in production of dieldrin. (O,M,B)

Wastewater and scrub water from chlorination of cyclopentadiene in production of chlordane. (O,M,B)

Filter solids from filtration of hexachlorocyclopentadiene in production of chlordane. (O,M,B)

Filter cake from filtration of toxaphene solution in production of toxaphene. (O,M,B)

Unrecovered triester from production of disulfoton. (O,M)

Still bottoms from toluene reclamation distillation in production of disulfoton. (O,M)

Filter cakes from filtration of dimethylphosphorothion and DMTA in production of malathion. (O,M)

Liquid wastes from washing and stripping in production of malathion. (O,M,)

Liquid and solid wastes from the washing, stripping and filtration of phorate in phorate production. (O,M)

Filter cake from the filtration of diethylphosphorodithoric acid in the production of phorate. (O,M)

Heavy ends and distillation residues from production of carbaryl. (O,M)

2, 6-D waste by-product from production of 2,4-D. (O,M,B)

Heavy ends or distillation residues from distillation of tetrachlorobenzene in production of 2,4,5-T. (O,M,B)

Scubber and filter wastes from production of atrazine. (O,M)

Filter cake from production of diazinon. (O,M)

By-product salts in production of MSMA. (O,M)

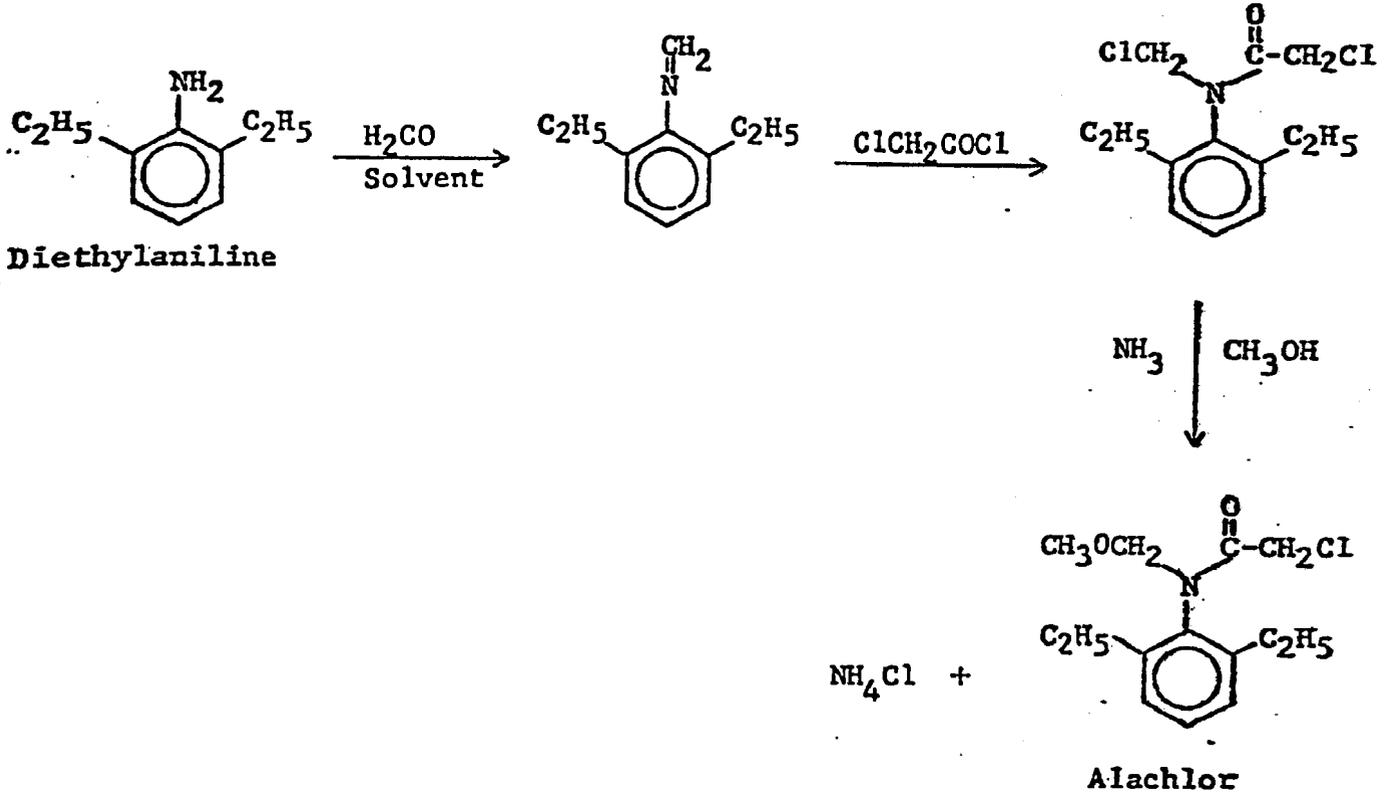
By-product salts in production of cacodylic acid. (T)

Tars from manufacture of bicycloheptadiene and cyclopentadiene. (O,M,B)

potentially contain the organic contaminants listed in the following section under the respective waste stream. The toxicity of these contaminants is also indicated. Because of the toxicity of these contaminants and because of the persistence and bioaccumulation characteristics of many of them, these waste streams are to be considered hazardous, as noted in the specific listing.

Alachlor

Alachlor is produced according to the following reaction scheme¹:



Alachlor, its hydrolyzed derivatives, solvent, and reaction tars may be present in the wastestream.

alachlor - Oral Rat - LD50: 1200 mg/kg²

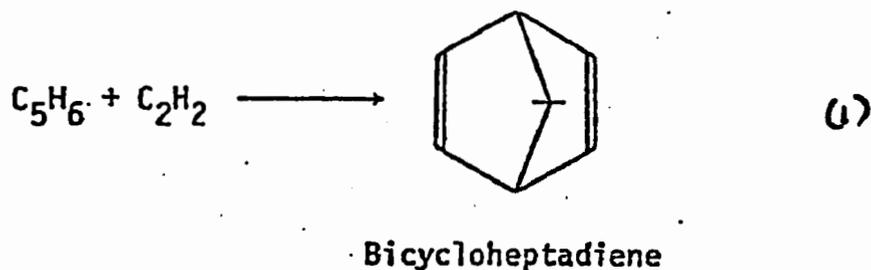
1. Ref 1, p. 153-156
2. Ref 2

References

1. Lawless, E.W., Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
Technical Studies Report: TS -00- 72 - 04.
Washington, U.S. GPO, 1972. 250p.
2. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977.
3. Parsons, T., Editor. Industrial Process
Profiles for Environmental Use: Chapter 8.
Pesticide Industry. EPA - 600/2- 77 - 023h,
Technology Series, Environmental Protection Agency,
Washington, 1977. 232p.

Aldrin, Dieldrin

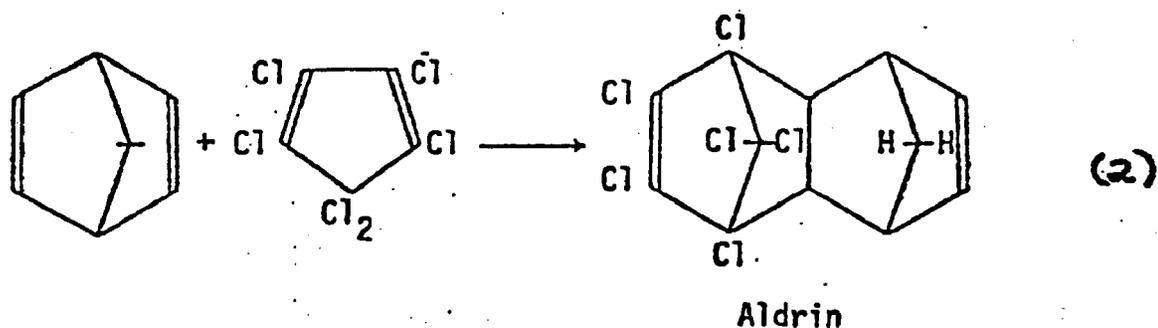
Due to the lack of quantitative information on the contents of the wastestreams, this report is more detailed than is customary. Aldrin and Dieldrin will be considered together since Dieldrin is produced from the epoxidation of Aldrin. In the first step of the reaction, the freshly cracked cyclopentadiene is condensed with acetylene to form bicycloheptadiene.



The reaction is either carried out in an organic solvent or else the acetylene is diluted with a nitrogen stream. The reaction goes in about 30-60% yield in toluene with the major by-products being tricycline and other multiple ring compounds¹. The C_7H_8 produced is removed and the "bottoms" are introduced back into the cracker.

1. ref. 1 pg. 5-88,89

Bicycloheptadiene undergoes a Diels-Alder condensation with hexachlorocyclopentadiene to form Aldrin.



Hexachlorocyclopentadiene may contain as impurities: trichlorocyclopentene isomers, octachlorocyclopentene, and pentachlorocyclopentadiene² formed from incomplete chlorination. C₅H₆ and C₂H₂ may also be present in the diene reactor. Therefore many other chlorinated condensation products are possible, some of high molecular weights.

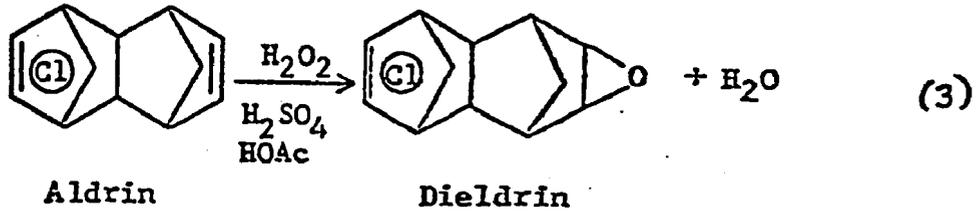
Technical grade Aldrin contains about 12-13% analogs and 5% various other compounds³. A possible source of hazardous wastes would be in the cleaning of the diene reactor (for reaction(2)) where chlorinated tars and Aldrin might be present.

2. ref. 2 pg. 7

3. ref 1 5-88,89

Liquid wastes from spill cleanup or washing go to an asphalt-lined evaporation basin. During shut down, the Aldrin unit is washed with toluene and these wastes go into Dieldrin manufacture⁴.

Dieldrin is produced from the epoxidation of Aldrin with a peracid.



In the first stage of the process, a solution of Aldrin in toluene is filtered and the filter solids are incinerated⁵. The filter solids contain chlorinated tars and higher molecular weight condensation products produced from the diene reaction (2).

4 ref. 3 pg. 80-83
5 ref. 3 pg. 84-87

DV. ab
714°

The filtered Aldrin is oxidized with the peracid with H₂SO₄ as a catalyst. The aqueous phase is removed, the Dieldrin solution is extracted with water, and both these wastewater streams are sent to an evaporation basin⁵.

The waste water is likely to contain sulfuric acid, acetic acid, toluene, Aldrin, Dieldrin, and Aldrin and Dieldrin analogs. The waste may also contain side products from the epoxidation such as glycols, glycol esters and ketone derivatives of Dieldrin⁶.

Aldrin is chemically stable but is oxidized by chlorination, potassium permanganate, ozone and aeration. Incomplete oxidation leads to Aldrin rather than a nontoxic product while Dieldrin is chemically stable towards alkali and mineral acids. Both undergo catalytic decomposition in the presence of an active metal⁷.

The last stage of the process involves solvent stripping and recycling. Tars are removed from the equipment by toluene.

5 ref. 3 pg. 80-83
6 ref. 4 pg. 618-619
7 ref. 5 pg. 42

NO. 2
7139

Toxicity Data⁸

Dieldrin:

oral human - LDLo: 28mg/kg
oral rat - LD50: 46mg/kg
carcinogenic determination: animal positive

Aldrin:

oral human - TCLo: 14mg/kg
oral child - TDLo: 1250 ~~μ~~g/kg
oral rat - LD50: 67mg/kg

Toxic effects - central nervous system
Carcinogenic detn. - indefinite

Toluene:

oral human - LDLo: 50mg/kg
oral rat - LD50: 5000mg/kg

Aquatic toxicity TLM 96: 100-10ppm
DOT - flammable

Cyclopentadiene, Hexachloro:

oral rat - LD50: 113mg/kg

Miscellaneous Information

Aldrin⁹:

water solubility: 27ppb
persistence in soil: more than 12 months

Dieldrin ⁹ :

water solubility: 185ppb
persistence in soil: more than 12 months

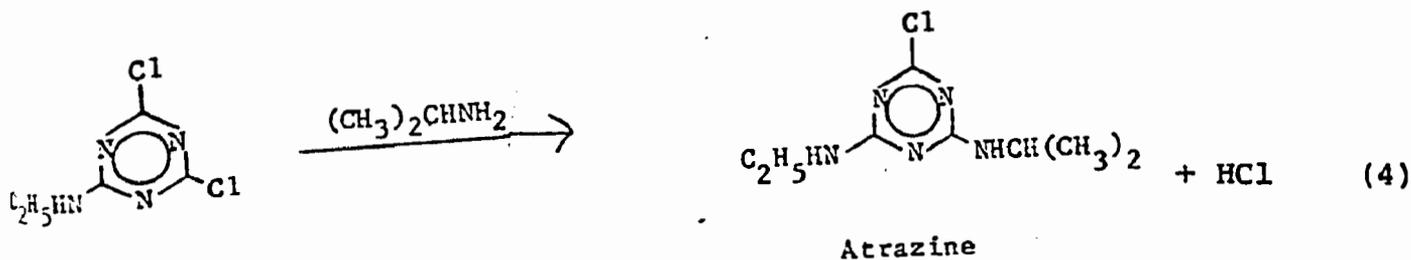
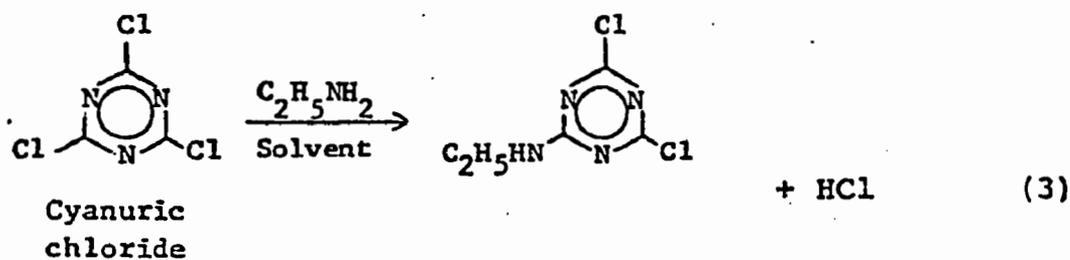
8 ref. 6
9 ref. 5 pg. 164

References

1. Office of Solid Waste Management Programs.
Assessment of Industrial Hazardous Waste Practices:
Organic Chemicals, Pesticides and Explosives.
Environmental Protection Publication SW-118C.
Washington, D.C., U.S. GPO, 1976.
2. Parsons, T., Editor. Industrial Process
Profiles for Environmental Use: Chapter 8.
Pesticide Industry. EPA - 600/2- 77 - 023h,
Technology Series, Environmental Protection Agency,
Washington, 1977. 232p.
3. Lawless, E.W. Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
Technical Studies Report: TS -00- 72 - 04.
Washington, U.S. GPO , 1972. 250p.
4. March, J. Advanced Organic Chemistry:
Reactions, Mechanisms, and Structure.
New York, McGraw-Hill Book Company, 1968. 1098p.
5. Atkins, P. The Pesticide Manufacturing Industry-
Current Waste Treatment and Disposal Practices.
Office of Research and Monitoring, Project 12020FYE.
Washington, U.S. GPO, 1972. 185p.
6. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977.

Atrazine

Atrazine is produced by the following four-step process^{1,2}:



1. Ref 1, p. 14,15,17-20
2. Ref 2, p. 143-147

According to the report by Lowenbach and Schlesinger³, the following pollutants may be present in the waste streams generated from Atrazine production:

	<u>LD₅₀rat^{4*} mg/kg</u>
Cyanuric chloride	**
Ethyl amine	LDLo:400
Isopropylamine	820 (DOT flammable liquid)
Methylethyl Ketone	3400 (DOT flammable liquid)
Diethylamine	540 (DOT flammable liquid)
Diisopropylamine	700 (DOT flammable liquid)
Atrazine	1750
2-chloro-4,6-bis-ethyl amino-s-triazine	5000
2-chloro-4,6-bis-isopropyl amino-s-triazine	5000
Cyanuric acid	LDLo:500
2,6-dichloro-4-ethyl amino-s-triazine	**
2,6-dichloro-4-isopropyl amino-s-triazine	**
2-hydroxy-4,6-bis-ethyl amino-s-triazine	**
2-hydroxy-4,6-bis-isopropyl amino-s-triazine	**
2-hydroxy-4-ethyl amino-6-isopropyl amino-s-triazine	**
Other related s-triazines (hydrolyzed and unhydrolyzed)	**

3. Ref 1

4. Ref 3 * Except where otherwise stated
 ** Not available

	LD ₅₀ rat ^{4*} mg/kg
Cyanogen polymers	**
Cyamelic chloride	**
Cyanuric chloride polymers	**
Oxalyl chloride	**
Cyanogen	inh-rat LC50:350 ppm/lH
Cyanides	(DOT-Poison B)
Cyanic acid	**
Hydrocyanic acid	LDLo:10 (DOT-Poison A)

→ N-nitrosoamines may also be formed from the reaction of secondary amines (atrazine and its side products) with nitrogen oxide⁵.

The calcium chloride and calcium sulfate used to dry cyanogen before the cyanuric chloride reaction may contain cyanogen, cyanogen chloride, cyanuric acid, cyanic acid, chlorine, hydrocyanic acid and water⁶.

The spent carbon catalyst used to catalyze the cyanuric chloride reaction may contain cyanogen chloride, dimers of cyanogen chloride, cyanuric acid, and cyanuric chloride⁷.

5. Ref 1, p.3
 6. Ref 1, p. 15,30
 7. Ref 1, p. 15,31

References

1. Lowenbach, W., Schlesinger, J., and King, J.
Toxic Pollutant Identification: Atrazine Manufacturing.
Office of Energy, Minerals, and Industry, Washington, D.C.,
1978. 54p.
2. Lawless, E.W., Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
Technical Studies Report: TS -00- 72 - 04.
Washington, U.S. GPO, 1972. 250p.
3. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977

Bicycloheptadiene and Cyclopentadiene

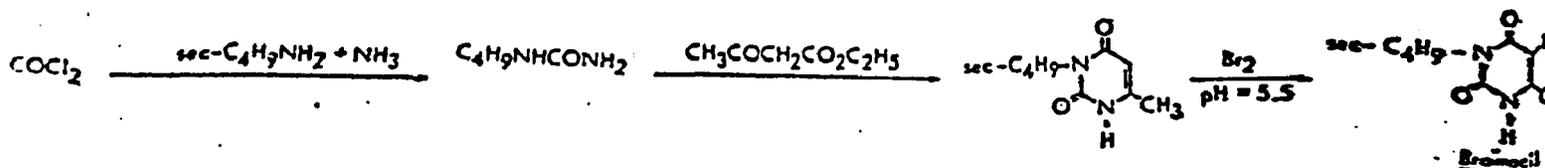
Bicycloheptadiene and cyclopentadiene are used as starting materials for a variety of diene-based chlorinated pesticides. Cyclopentadiene is produced from the cracking of the cyclopentadiene dimer. Bicycloheptadiene is produced from the condensation of cyclopentadiene and acetylene. Numerous higher molecular weight condensation products and tars are formed by this process.

<u>Chemical</u>	Rat <u>LD50¹</u> mg/kg
Bicycloheptadiene	890 (intraperitoneal)
Bicyclopentadiene	353 (oral)

1. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977.

Bromacil

Bromacil is produced according to the following process¹:



The first step of the process is the formation of sec-butyl urea. Possible side products are urea and bis-(sec-butyl) urea. The alkyl urea is next condensed with ethyl-acetoacetate to produce 3-sec-butyl-6-methyl uracil. Other possible side products are 1-sec-butyl-6-methyl-uracil, 6-methyl-uracil, and 1,3-di(sec-butyl)-6-methyl-uracil. The uracil is purified, neutralized with H_2SO_4 , and then brominated to yield Bromacil².

-
1. Ref 1, p. 77,81
 2. Ref 2, p. 52,55,56

Other possible brominated products of the uracils may also be present. All the above mentioned by-products, reaction intermediates, tars, and residues in addition to Bromacil may be found in the wastewater sludge.

Bromacil oral rat LD50: 5200mg/kg³

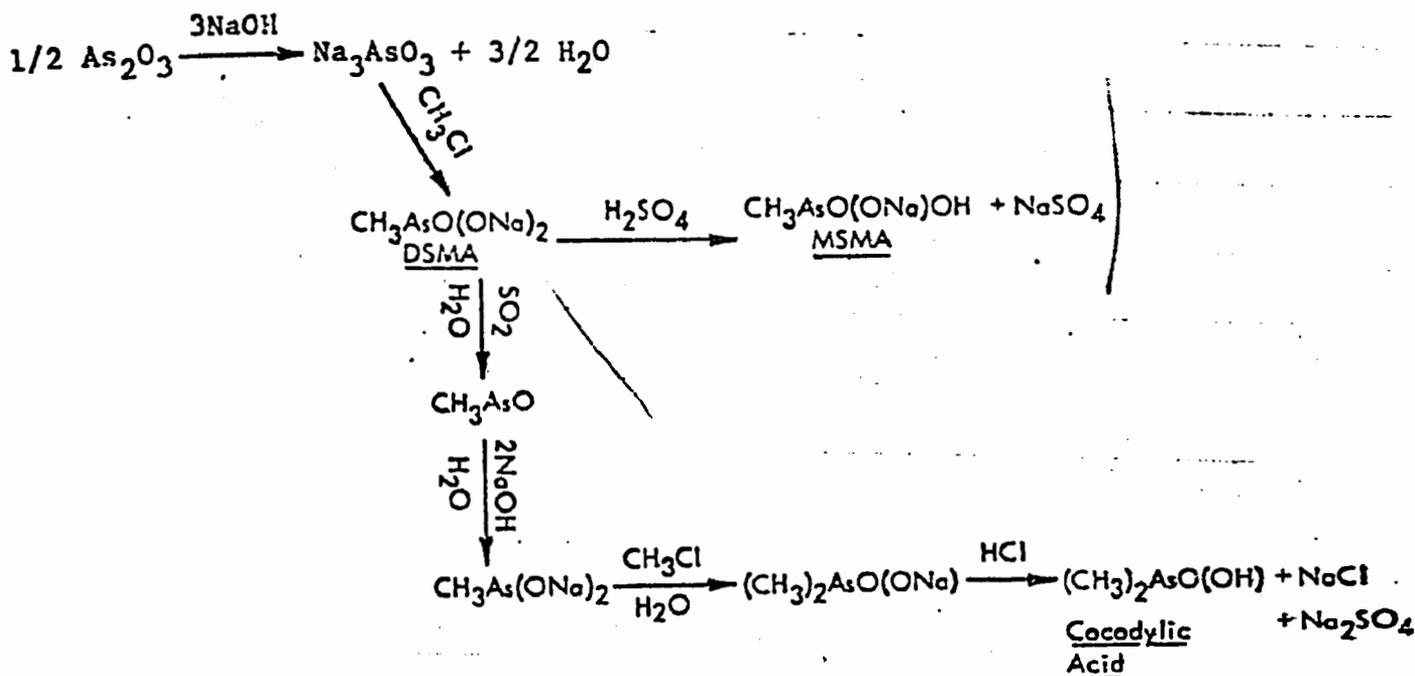
3. Ref 3

References

1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA-600/2-77-023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232p.
2. Effluent Guidelines Division, Office of Water and Hazardous Materials. Development Document for Interim Final Effluent Guidelines for the Pesticide Chemicals Manufacturing Point Source Category. EPA 440/1-75/060d Group II. Washington, 1976
3. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977.

Cacodylic Acid, MSMA

Cacodylic acid and MSMA will be treated together since they are manufactured from the same intermediate. The production scheme is shown below¹:



Discharge at one MSMA plant contains 0.7 to 0.8 ppm arsenic as well as NaCl and Na₂SO₄. The solid waste from the Cacodylic acid process contains a mixture of NaCl, Na₂SO₄ and 1-1 1/2% cacodylate contaminants².

Cacodylic acid and its salts are undergoing pre-RPAR review due to "oncogenicity; mutagenicity; teratogenicity; fetotoxicity; male reproductive effects"³

1. Ref 1, p. 97-104

2. ibid

3. Special Pesticides Review Division Status Report, Nov 2, 1978

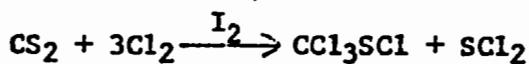
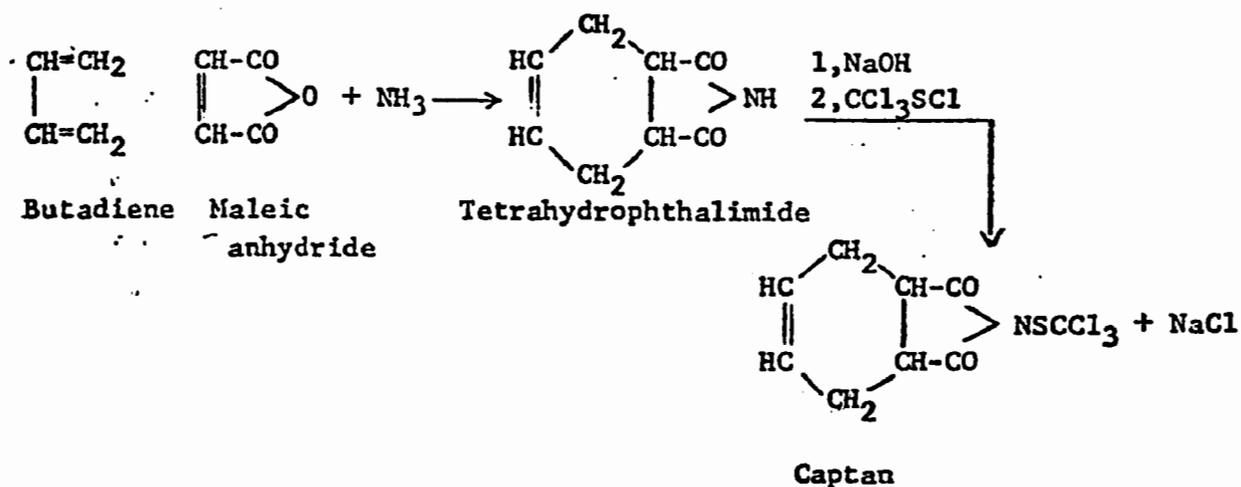
255

Reference

1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA-600/2-77-023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232p.

Captan

Captan is produced by the following process ¹:



Perchloromethyl mercaptan

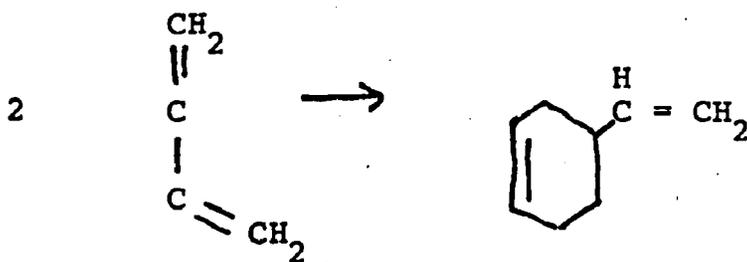
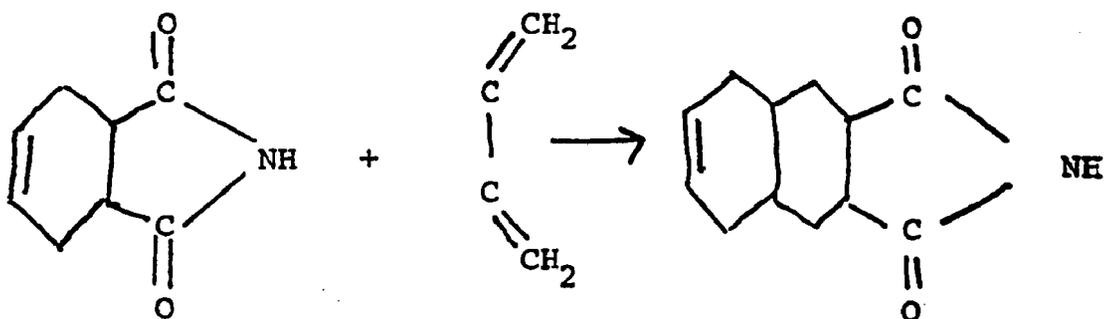
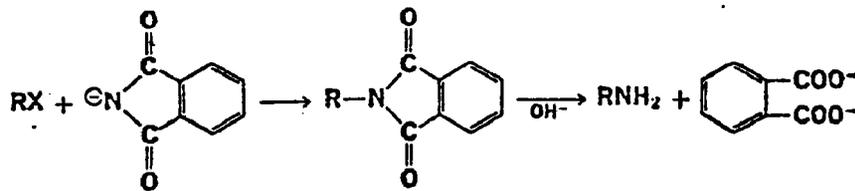
The wastewater treatment sludge may contain captan, starting materials, reaction intermediates, by-products, and tars.

1200 pounds of chemical wastes are generated each year by this process.²

¹. Ref 1, p. 157-162

². Ref 2, p. 93-94

A few possible side reactions ³ are listed below:



Captan is undergoing pre-RPAR review due to possible oncogenicity, mutagenicity and teratogenicity.⁴

3. Ref 3, p. 340

4. Special Pesticide Review Division Status Report - November 2, 1978.

Chemicals

Possible
Found in Wastewater
Treatment Sludges

Oral Rat⁴
LD50 mg/kg*

Captan	9000	
Butadiene	5480	
Maleic anhydride	481 ⁶	
Tetrahydrophthalic acid anhydride	(DOT: corrosive)	
Tetrahydrophthalimide	**	
Perchloromethyl mercaptan	83	
CCl3SNH2	**	
4-Vinyl-1-cyclohexene	3080	(carcinogenic determination: indefinite)
Tetrahydrophthalate	**	
Misc-condensation products	**	
Tars	**	
Carbon disulfide	(DOT: flammable)	
Iodides	**	
Misc. sulfides	**	
Solvent	**	

* Unless otherwise indicated

** Data unavailable

5 . Ref 4

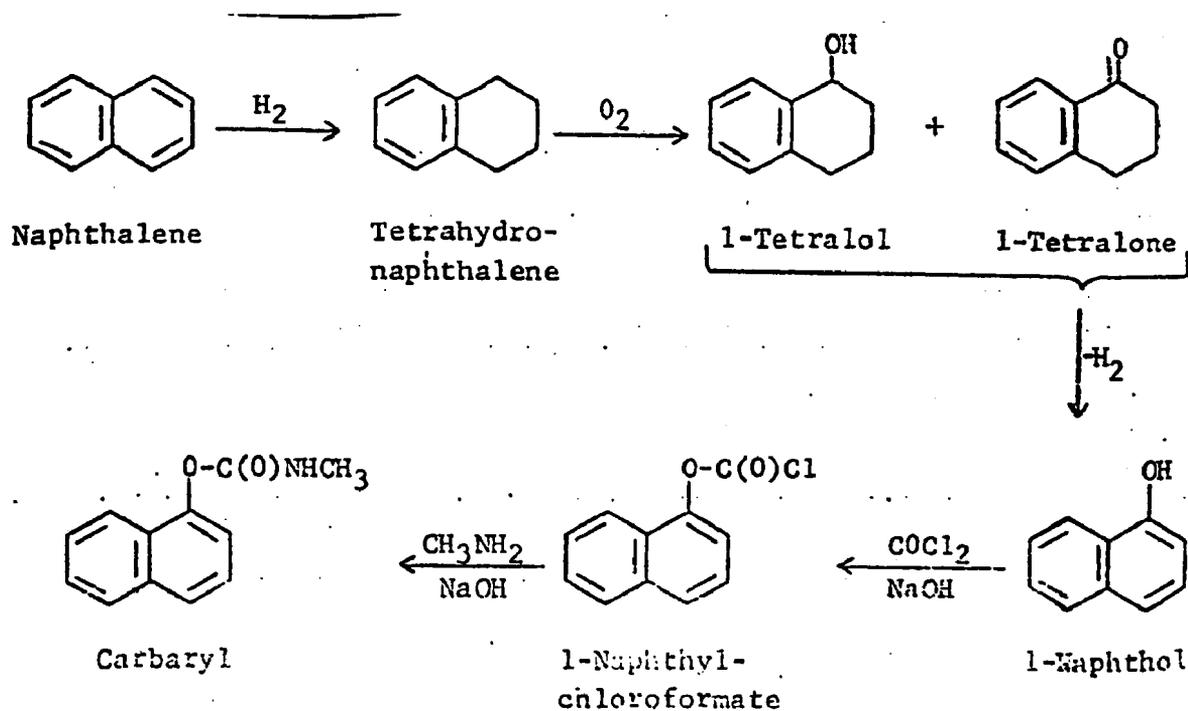
6 . (Federal Register - 10/28/77-Maleic Anhydride
Oncogenic in mice, mutagenic in plants,
flies, rats; reproductive effects in rats)

References

1. Lawless, E.W., Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
Environmental Protection Agency
Washington, 1977. 232p.
Technical Studies Report
2. Parsons, T., Editor. Industrial Process
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New York, McGraw-Hill Book Company, 1968. 1098p.
4. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977.

Carbaryl

Carbaryl is manufactured according to the following production scheme:



The by-products that may be present from the production of 1-naphthol are: unreacted naphthalene, tetrahydronaphthalene, 1-tetralone, 2-tetralone, and 2-naphthol.

The 1-naphthol and its by-products are next reacted with phosgene (COCl_2) and sodium hydroxide to form 1-naphthylchloroformate and sodium chloride. By-products formed in this step are: 2-naphthyl chloroformate and 1-1 (or either 1,2 or 2,2) dinaphthylcarbonate². All of these may be present in the wastewater in small quantities.

The 1-naphthyl-chloroformate is next reacted with methylamine and sodium hydroxide to produce carbaryl. Unreacted tetralone (if present) may react with the amine to form an imine or an enamine^{3,4} which could aromatize to form N-methylnaphthylamine. These would also be present in the wastewater.

Carbaryl is susceptible to basic hydrolysis to yield 1-naphthol⁵ and N-methyl-carbonate.

2. Ref 2, p. 319
3. Ref 3, p. 858
4. Ref 2, p. 667
5. Ref 4, p. 41

Toxicity Data⁶

Carbaryl

Oral rat	-	LD50:	400 mg/kg
Oral man	-	TDLo:	2800 mg ^u /kg
Oral human	-	LDLo:	50 mg/kg

1-naphthol

Oral rat	-	LD50:	2590 mg/kg
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2-naphthol

Oral rat	-	LD50:	2420 mg/kg
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1,2,3,4-tetrahydro-naphthalene

Oral rat	-	LD50:	2860 mg/kg
Oral human	-	LDLo:	500 mg/kg

Aquatic toxicity rating - TLm 96:100-10 ppm

1-tetralone

Oral rat	-	LD50:	810 mg/kg
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Naphthalene

Oral rat	-	LD50:	1780 mg/kg
Oral human	-	LDLo:	50 mg/kg

N-methyl-1-naphthylamine

Oral rat	-	LD50:	1410 mg/kg
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Miscellaneous Information⁷

Carbaryl solubility in water - <0.1%

Carbaryl persistence in soil - 1-3 months

6. Ref. 5

7. Ref. 4 p. 167

7-258/2

References

1. Lawless, E.W. Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
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2. March, J. Advanced Organic Chemistry:
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3. Morrison, R.T. and Boyd, R.N. Organic Chemistry.
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4. Atkins, P. The Pesticide Manufacturing Industry-
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Office of Research and Monitoring, Project 12020FYE.
Washington, U.S. GPO, 1972. 185p.
5. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977.
6. Parsons, T., Editor. Industrial Process
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Technology Series, Environmental Protection Agency,
Washington, 1977. 232p.

Carbofuran

Very little information is available on this manufacturing process. Carbofuran is produced by the reaction of 2,3-dihydro-2,2-dimethyl-7-benzofuranol and methyl isocyanate in the presence of ether and trimethylamine. The carbofuran is recovered from the products, and the waste stream goes through neutralization, concentration equalization, and settling before discharge¹. Normally, wastes from aryl and alkyl carbamate production include liquid streams, vents, and some heavy residues².

Carbofuran³

Oral rat LD50: 5300 ^ug/kg

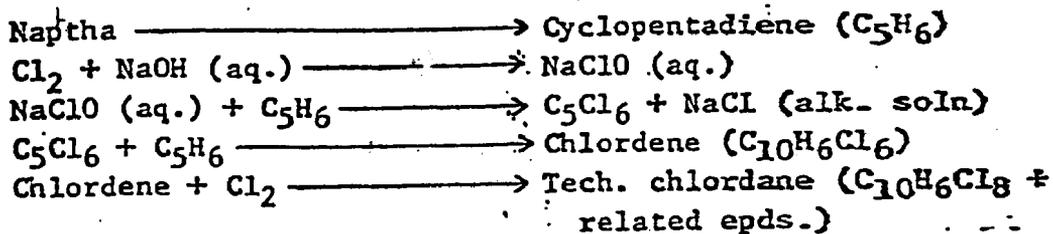
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1. Ref 1, p. 65
 2. Ref 2, p. 50-51
 3. Ref 3

References

1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA - 600/2- 77 - 023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232p.
2. Effluent Guidelines Division, Office of Water and Hazardous Materials. Development Document for Interim Final Effluent Guidelines for the Pesticide Chemicals Manufacturing Point Source Category. EPA 440/1-75/060d Group II. Washington, 1976
3. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977

Chlordane

Chlordane is manufactured, according to the following production scheme:



Cyclopentadiene is produced from the cracking of naphtha. Tars are a by-product of this process and need to be disposed of.

The second phase of the process is the free radical chlorination of cyclopentadiene with NaClO to produce hexachlorocyclopentadiene. Trichlorocyclopentene isomers, octachlorocyclopentene, and pentachlorocyclopentadiene are possible by-products². The wastewater has about 2% NaOH and 400 ppm C₅Cl₆^{3,4}. The above mentioned by-products should also be present as should NaCl, NaClO, and NaClO₃, formed from the disproportionation of ClO⁻.

The C₅Cl₆ solution is next filtered to remove the tars formed in the reaction.

1. Ref 1, p. 88-93

2. Ref 2, p. 7

3. Ref 1, p. 88-93

4. Ref 2, p. 39-40

C_5Cl_6 and C_5H_6 are condensed to form chlordene, $C_{10}H_6Cl_6$. Other types of condensation products are possible such as the condensation of C_5H_6 with some of the by-products of the C_5Cl_6 production step.

Chlorination of chlordene to produce chlordane yields a variety of chlorinated epimers, one of which is the pesticide Heptachlor that results from the substitution chlorination rather than the addition chlorination⁵. Technical grade chlordane contains about 7-8% Heptachlor⁶. Chlordane, Heptachlor, and related compounds may be present in the wastewater from periodic equipment cleaning and production area cleanup.

5. Ref 3, p. 39

6. Ref 1, p. 88-93

Toxicity Data⁷Chlordane

Oral rat LD50: 283 mg/kg

Heptachlor

Oral rat LD50: 40 mg/kg

Cyclopentadiene, Hexachloro

Oral rat LD50: 113 mg/kg

Sodium Chlorate

Oral rat LD50: 1200 mg/kg

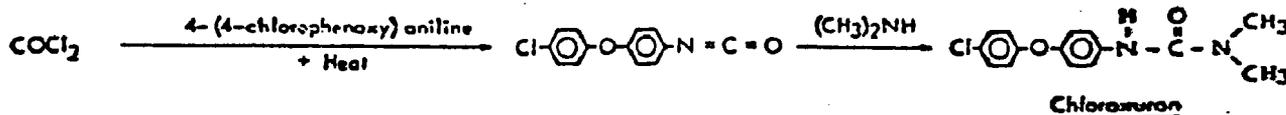
7. Ref 4

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3. Atkins, P., The Pesticide Manufacturing Industry-
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Washington, U.S. GPO, 1972. 185p.
4. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977.

Chloroxuron

Chloroxuron is manufactured according to the following reaction scheme¹:



The waste stream may contain chloroxuron, starting materials, by-products, intermediates, hydrolysis products, tars, and residues.

Chemicals that may be Present
in Waste Stream

Oral Rat²
LD50 mg/kg

Chloroxuron

3700

10

** (dog)

4-(4-chlorophenoxy) aniline

**

p-chlorophenol

**

p-chloro aniline

420

N,N-dimethyl formamide

2800

N,N dimethyl, N¹-(4-hydroxyphenyl) urea

**

1. Ref 1, p. 77

2. Ref 2

** Data unavailable

References

1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA - 600/2- 77 - 023h. Technology Series, Environmental Protection Agency. Washington, 1977. 232 p.
2. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977

Creosote

Creosote, a distillate of coal tar is used primarily for wood preservation. Creosote is presently under RPAR review (FR 10/18/78) due to oncogenic and mutagenic effects. The RPAR working group determined that the oncogenic criteria had been exceeded by considering ^{the following:} occupationally exposed workers who developed tumors, reports of animal experiments in which mice, rats, or rabbits developed tumors from either dermal or inhalation studies, and the Carcinogenic Assessment Group (CAG) conclusions that creosote and coal tars are oncogenic. Creosote and coal tar contain a number of ^o polycyclic and heterocyclic aromatic hydrocarbons which have been well established as carcinogens. Some of these are:

- benz[a]anthracene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[a]pyrene, etc.

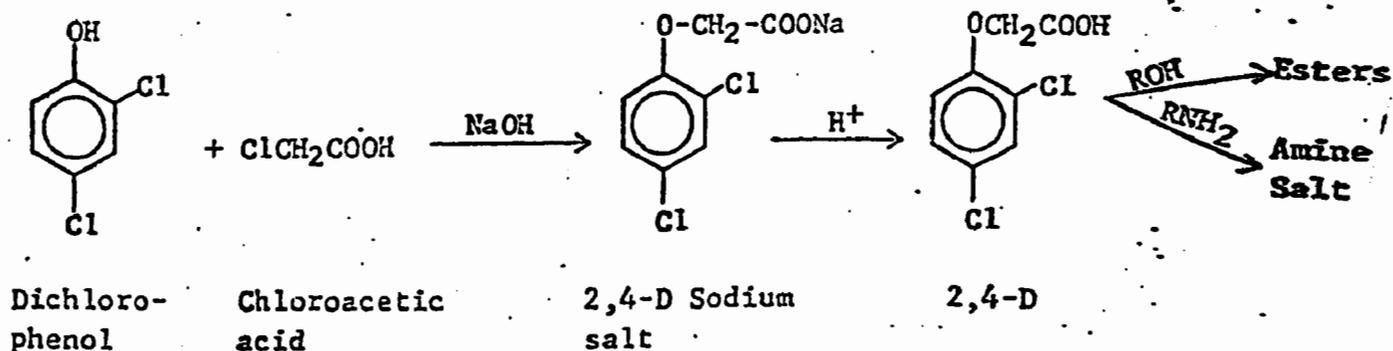
Studies indicate that creosote and coal tar migrate to some extent from treated wood into the surrounding environment.

For additional information, see Federal Register, "Wood Preservative Pesticides," October 18, 1978

2,4 - D

2,4 - D is produced according to the following reaction

scheme¹:



The waste stream from 2,4 - D contains "large amounts of sodium chloride, hydrochloric acid, some caustic, and organics including phenols, chlorophenols and chlorophenoxy acids. These arise from acidification, washing steps, phase separation steps, incomplete yields and chlorination of the phenolic compounds"².

1. Ref 1, p. 128-135

2. Ref 2, p. 24-25

According to Parsons, a typical waste stream may be characterized by:

- Total solids - 104,000 mg/l
- Suspended Solids - 2,500 mg/l
- Chlorides - 52,000 mg/l
- Chlorophenols - 112 mg/l
- Chlorophenoxy Acids - 235 mg/l

The waste streams vary considerably from plant to plant. A primary drinking water standard exists for 2,4 - D.

<u>Chemicals Possibly Present in Waste Stream</u>	<u>Oral Rat³ LD50 mg/kg</u>
2,4 - D	375
2,4 - Dichlorophenol	580 suspected carcinogen
2,6 - Dichlorophenol	2940
Chloroacetic acid	76
2,6 - Dichlorophenoxyacetic acid	**
o - Chlorophenol	670
m - Chlorophenol	570
p - Chlorophenol	**

** data not available
3 Ref 3

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1. Lawless, E.W. Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing
Technical Studies Report: TS -00- 72 - 04.
Washington, U.S. GPO , 1972. 250p.
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4. Atkings, P. The Pesticide Manufacturing Industry-
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Office of Research and Monitoring, Project 12020FYE.
Washington, U.S. GPO, 1972. 185p.

Diazinon

Diazinon is produced by the reaction of diethylphosphorochloridothionate and 2-isopropyl-4-methyl-6-hydroxypyrimidine with sodium carbonate in a solvent such as toluene, benzene, or dioxane¹. The manufacturing process is probably very similar to that for malathion and methyl parathion, and the waste stream should contain the same types of compounds². Some of the organophosphates that may be present in the waste stream are: triethyldithiophosphate, triethylthiophosphate, triethyl trithiophosphate, diethyl thiophosphoric acid, diethylphosph^{oric} acid, 2-isopropyl-4-methyl-6-hydroxypyrimidine (IMHP) and its ester, diazinon, and other organophosphate derivatives of IMHP and ethanol.

Diazinon

Oral rat LD50⁴: 76 mg/kg

-
1. Ref 1, p. 56
 2. See Methyl Parathion and Malathion Background Document
 3. Ref 2, p. 291-299
 4. Ref 3

References

1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA - 600/2- 77 - 023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232p.
2. Warner, J. S., etal. Identification of Toxic Impurities in Technical Grades of Pesticides Designated as Substitute Chemicals. Office of Research and Development. EPA-600/-1-78-031, May, 1978. 387p.
3. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977

Dichlorobenzene

Dichlorobenzene is produced by the chlorination of benzene over iron turnings in a lead or glass-lined reactor¹. The wastewater sludge contains mostly polychlorobenzenes². Iron and lead may also be present in the sludge. Dichlorobenzene is presently undergoing a pre-RPAR review due to possible oncogenic activity.³

<u>Possible Chemicals in Wastewater Sludge</u>	<u>Oral Rat⁴ LD50 mg/kg</u>
Benzene	3800 - suspected human carcinogen
Ortho-dichlorobenzene	500 - suspected carcinogen
Para-dichlorobenzene	500 " "
Chlorobenzene	2910
Trichloro benzene	756
Tetrachloro benzene	1500
Lead	----

1. Ref1, p. 19

2. Ibid

3. Special Pesticide Reviews Division Status Report. Nov 2, 1978.

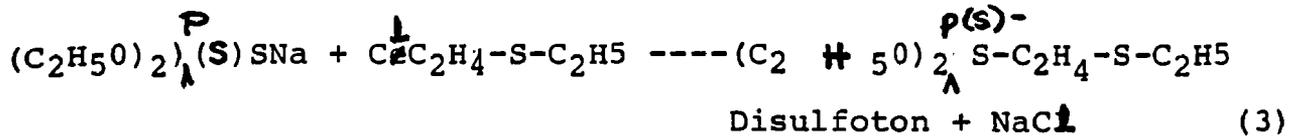
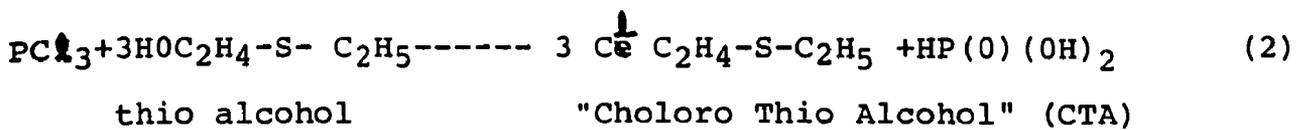
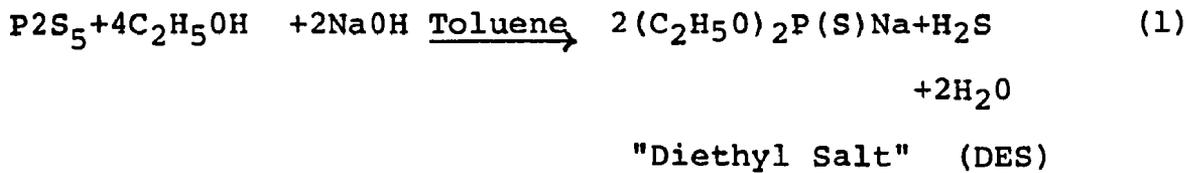
4. Ref 2

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1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA - 600/2- 77 - 023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232p.
2. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977.

Disulfoton

Due to the lack of quantitative information on the composition of the waste streams, the following document described anticipated by-products of the Disulfoton Process-
 Disulfoton is produced according to the following production scheme:



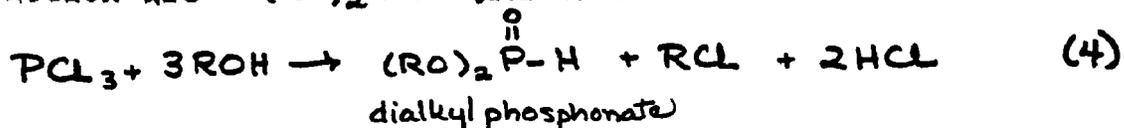
The reaction between P_2S_5 and ethanol in toluene occurs under anhydrous conditions to produce the dialkyl phosphorodithioic acid. The major side product of this reaction is the triester. The dithio acid is next converted to the dithio salt with caustic soda.

1. ref. 1. pg 99 - 103

2. ref. 2. pg 46 - 49

Triester, organic residues, and unreacted ethanol are contained in the organic phase which goes to burial.

PCl_3 and the thio alcohol are combined to form the β chloroethyl thioethyl ether and phosphorous acid, a white crystalline solid of melting point 73.6°C . By-products of the reaction are $(\text{RO})_2\text{PHO}$ and HCl :^{3,4,5}



Phosphorous acid is unstable and undergoes a self oxidation-reduction (3,4) to yield phosphoric acid, phosphine, hydrogen and red phosphorous. Phosphorous acid reacts with alcohols according to the following equation (4):

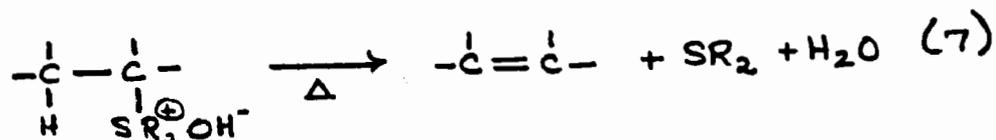
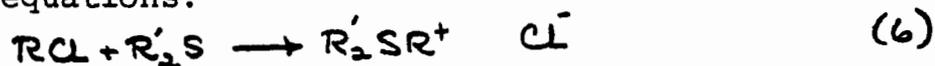


3. ref. 3, pg. 375

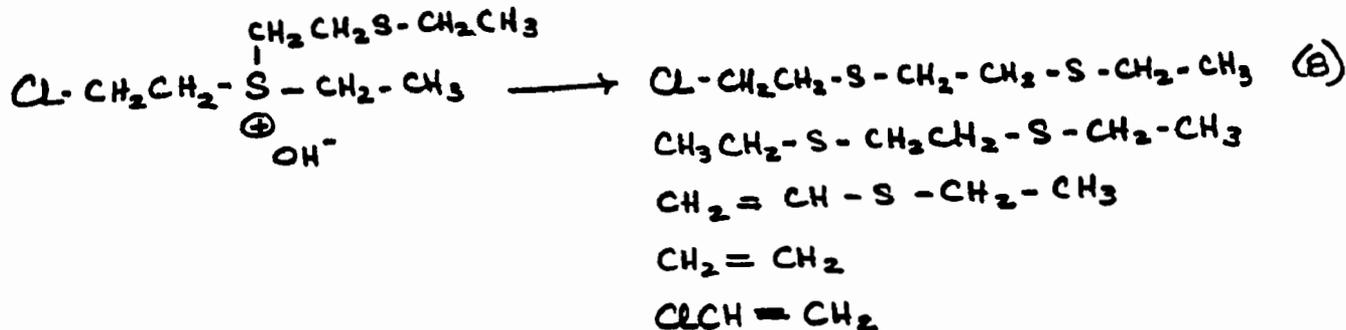
5. ref. 5. pg 64

4. ref. 4. pp 389-481

The third step of the production process involves the reaction between the diethyl^(D) salt (DES) and the chloro^(C)thio alcohol (CTA) to form disulfoton and sodium chloride. A possible side reaction can be represented by the following general equations:



This reaction can lead to the following types of products



6. ref. 6 pg. 329, 764.

The process wastewater next goes is a toluene extractor^{7,8} and skimmer with a final NaOH/NaOCL treatment. The wastewater has a high salt content, high pH, and contains toxic organics,⁹ and phosphates. Intermediate products, residues, and tars are recovered from the still bottom and reactors and are buried.

⁷ ref. 7. pg. 51

⁸ ref. 1 pg. 99-103

⁹ ref. 2. pg. 84-85

Toxicity Data⁸

Disulfoton

oral human LD Lo: 5 mg/kg

oral rate: LDLo: 2 mg/kg

unreported rat: LD50: 2500 mg/kg

Phosphorothioic acid, 0,0,0, - triethyl ester
inhalation rat LCLo: 41 ppm/4 hours

Sulfide, Chloroethyl ethyl
oral rat LD 50: 252 mg/kg

Ethanol, 2-(ethylthio)-
oral rat LD50: 2320 mg/kg

Phosphorous acid, diethyl ester
oral rat LD50: 5190 mg/kg

References

1. Lawless, E.W. Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
Technical Studies Report: TS -00- 72 - 04.
Washington, U.S. GPO , 1972, 250p.
2. Office Water and Hazardous Materials, Effluent Guidelines
Division. Development Document for Interim Final Effluent
Limitations Guidelines for the Pesticide Chemicals
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8. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U. S. Department of Health, Education,
and Welfare. 1977

Dithiocarbamates

Very little information is available on the manufacturing process and waste streams of the dithiocarbamate pesticides. These pesticides are normally produced by the reaction of carbon disulfide, an amine, and either a hydroxide or ammonia¹. The major pesticides of this class plus other possible components in the waste stream are listed below along with available information.

1. Ref 1, p. 60,62

<u>Pesticide</u>	<u>Chemical² Name</u>	<u>Chemical² Structure</u>	<u>Oral Rat³ LD50 mg/kg</u>	<u>Comments</u>
CDCE	2-chloroallyl diethyl thiocarb- -amate	$C_2H_5-N-C-S-CH_2CCl-CH_2$ C_2H_5	850	sol in water ² 100ppm
Nabam	disodium ethylenebisdithio- -carbamate	$CH_2-NH-C-S-Na$ $CH_2-NH-C-S-Na$ S S	395	sold as aqueous ² solution (22%)
Ferbam	ferric dimethyldithiocarbamate- tris(dimethyldithiocarbamate)- iron.	$(CH_3)_2N-CS-S$ $S-CS-N(CH_3)_2$ Fe $S-CS-N(CH_3)_2$	4000	sol in water ² 180ppm carcinogen detn: ³ indefinite
Maneb	manganous ethylene-1,2-bis- dithiocarbamate; [ethylenebis(dithiocarbamate)] manganese	Approx. formula: (is a polymer) $CH_2-NH-CS-S$ $CH_2-NH-CS-S$ Mn	6750	carcinogen det: ³ animal suspected
Zineb	[ethylenebis(dithiocarbamate)] zinc; zinc ethylene-1,2-bis dithio- -carbamate	Approx. formula: (is a polymer) $CH_2-NH-CS-S$ $CH_2-NH-CS-S$ Zn	5200	carcinogen det: ³ animal suspected
	ethylene diamine		760	
	ethylene thiourea		200	carcinogen detn: ³ animal positive
	2,3-dicholoro-propene		320	

2. Ref 2,

3. Ref 3

4. Breakdown product of Maneb - see Ref 2

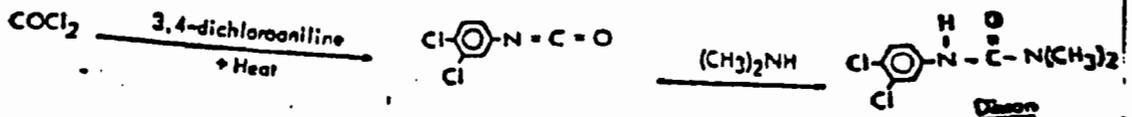
270

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1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA - 600/2-77 - 023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232p.
2. Nonogon Index. A Dictionary of Pesticides, 1975.
3. NIOSH Registry of Toxic Effects of Chemical Substances. Vol I and II. U.S. Department of Health, Education, and Welfare. 1977.

Diuron

Diuron is produced according to the following reaction scheme¹:



3,4-dichlorophenyl isocyanate^{at} is reacted with dimethyl amine in a solvent such as dioxane to produce Diuron. The urea is insoluble and precipitates. The solvent can then be flash-distilled and recycled. The crude product is washed with aqueous HCL to remove insolubles and finally water washed in a precipitator.²

1. Ref 1 p. 77, 82

2. Ref 2 p. 52, 55, 56

The wastewater treatment sludge may contain Diuron, starting materials, solvent, still bottom and reactor tars and residues, and other reaction by-products.

<u>Possible Pollutants Present in Wastestream</u>	<u>Oral Rat³_{LD50} mg/Kg*</u>
Diuron	437
3,4 - dichloroaniline	648
N-3,4 - dichlorophenyl- carbamic acid	**
N,N- dimethyl carbamic acid	**
Solvent	**
Tars	**

* unless otherwise noted

** data unavailable

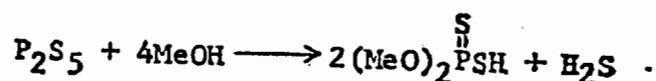
3. ref 3

References

1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA - 600/2- 77 - 023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232p.
2. Effluent Guidelines Division, Office of Water and Hazardous Materials. Development Document for Interim Final Effluent Guidelines for the Pesticide Chemicals Manufacturing Point Source Category. EPA 440/1-75/060d Group II. Washington, 1976.
3. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977.

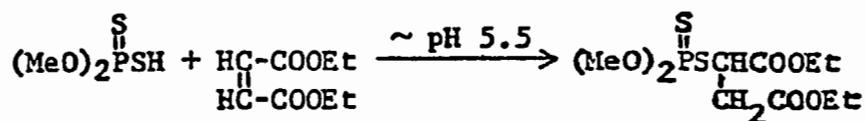
Malathion

Due to the lack of quantitative information on the contents of the waste streams, this document indicates the probable nature of the wastes generated in the manufacturing process. The first step in the production of Malathion is the formation of dimethyl dithiophosphoric acid from P_2S_5 and methanol in toluene:



The major by-product of the reaction is the triester^{2,3}. The filter cake⁴ contains dimethyl dithiophosphoric acid, triester, toluene, and insoluble reaction products.

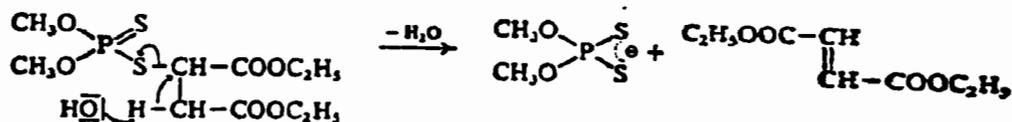
The next step is the reaction of dimethyldithiophosphoric acid and diethylmaleate over a proprietary catalyst⁵:



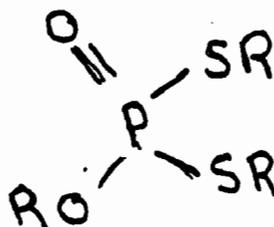
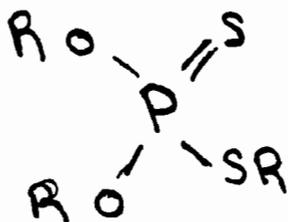
Dimethyl- Diethylmaleate
phosphoro- or fumarate
dithioic (DEM or DEF)
acid (DMTA)

1. Ref 1, p. 104-108
2. Ref 2, p. (5-98)-(5-101)
3. Ref 3, p. 46-48
4. Ref 2, p. (5-98)-(5-101)
5. Ref 1, p. 104-108

After volatile components are stripped off, the stream is then washed with a basic solution. During the wash procedure, the following reaction can occur:⁶



The dithiophosphate anion can undergo reactions with triesters and dithio phosphates to yield compounds of the following form:⁷



The waste stream should contain diethyl maleate, malathion, dimethyl dithiophosphoric acid, dimethyl thiophosphoric acid, dimethyl phosphoric, trimethyl dithiophosphate, other organophosphate derivatives and toluene. Malathion is hydrolyzed and catalytically oxidized by iron salts⁸.

6. Ref 4, p. 28

7. Ref 4, p. 36

8. Ref 5, p. 41

1961

Toxicity Data⁹

Malathion

Oral human - LDLo: 50 mg/kg
Oral human - LDLo: 857 mg/kg
Oral rat - LDLo: 1401 mg/kg
Aquatic toxicity testing - TLm96: 10-under 1 ppm

Maleic Acid, Diethyl Ester

Oral rat - LD50:3200 mg/kg

Maleic Acid, Sodium Salt

Intraperitoneal rat - LD50:600 mg/kg

Phosphorodithioic Acid, 0,0-Dimethyl Ester

Oral rat - LDLo:1000 mg/kg

Toluene

Oral human - LDLo:50 mg/kg
Oral rat - LD50: 4000 mg/kg
Aquatic toxicity rating - TLm96:166-10 ppm
DOT flammable liquid

Phosphoric Acid

Oral rat - LD50:1530 mg/kg
Aquatic toxicity - TLm 96:1000-10 ppm
DOT - corrosive

Phosphoric Acid, Trimethyl Ester

Oral rat - LD50: 840 mg/kg

Phosphorothioic Acid,0,0,0-Trimethyl Ester

Inhalation rat - LCLo: 220ppm/4 hours

9. Ref 6

1901/w

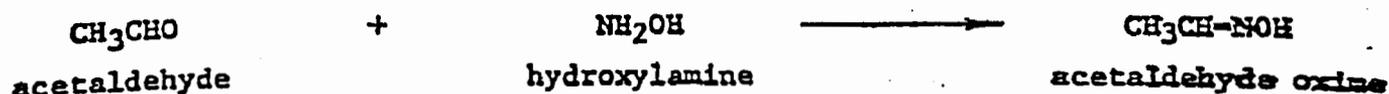
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Environmental Protection Publication SW-118C.
Washington, D.C., U.S. GPO, 1976
3. Effluent Guidelines Division, Office of Water and
Hazardous Materials. Development Document for Interim
Final Effluent Guidelines for the Pesticide Chemicals
Manufacturing Point Source Category. EPA 440/1-75/
060d Group II. Washington, 1976
4. Fest, C. and Schmidt, K.-J. The Chemistry of Organo-
phosphorus Pesticides. New York, Springer-Verlag, 1973.
339p.
5. Atkins, P. The Pesticide Manufacturing Industry-Current
Waste Treatment and Disposal Practices. Office of
Research and Monitoring, Project 12020FYE.
6. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977

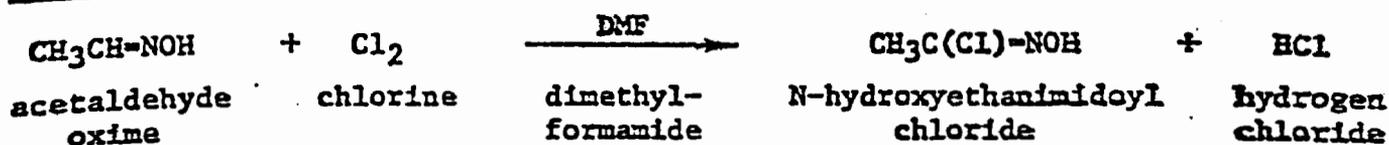
Methomyl

Methomyl may be manufactured by the following chemical reaction scheme¹:

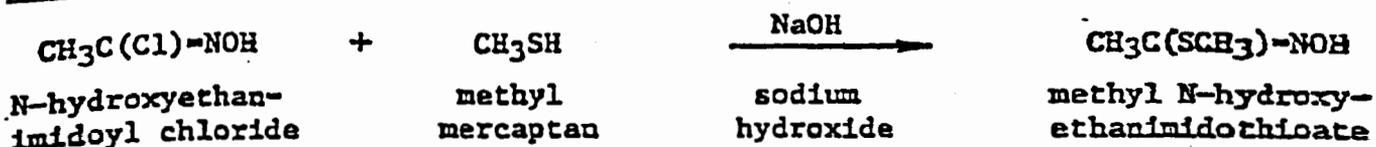
Step 1



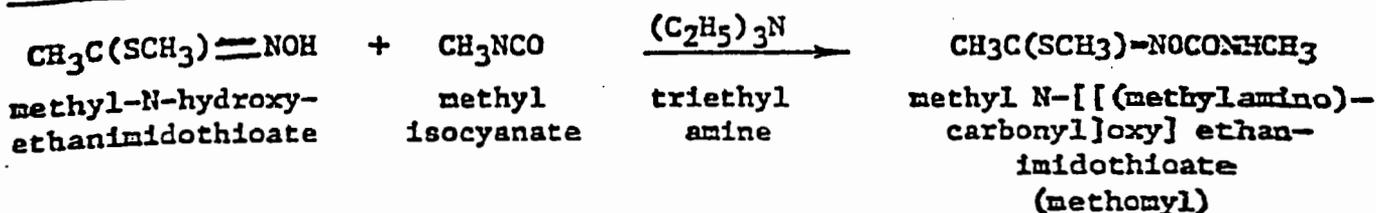
Step 2



Step 3



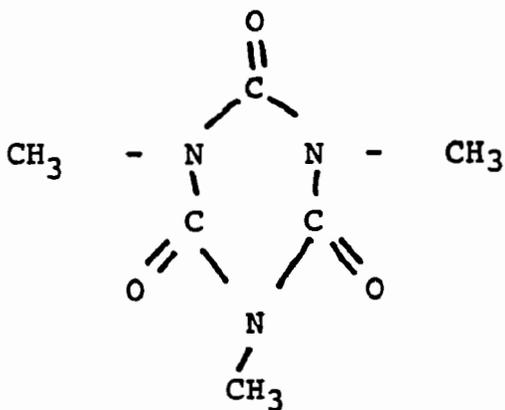
Step 4



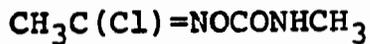
¹. Ref 1 p. 348-352

The following list contains chemicals that may be formed during the production and storage of diazinon and may therefore be present in the waste streams²:

<u>Chemicals</u>	<u>Oral Rat³ LD50 mg/Kg</u>
Methomyl	17



**



**



**



**



(teratogen)



(teratogen)



**

** data unavailable

2. Ref 1 p. 348-352

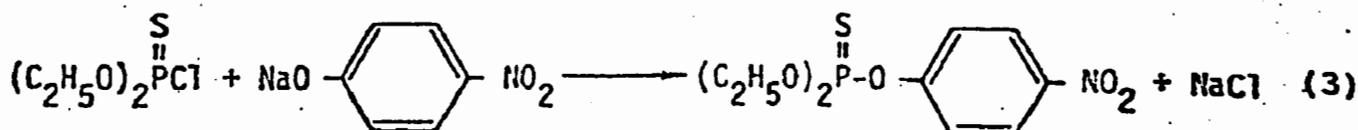
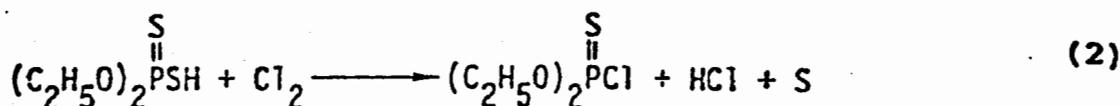
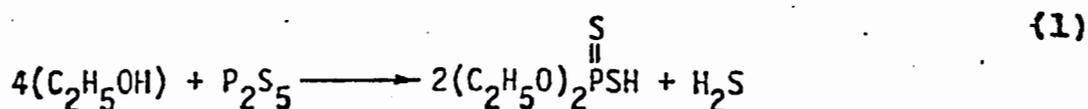
3. Ref 2

References

1. Warner et al.
Identification of Toxic Impurities in Technical Grades of Pesticides Designated as Substitute Chemicals. EPA - 600/1-78-031. May 1978. 387p.
2. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977.

Methyl Parathion and Parathion

The synthesis of Parathion is essentially the same as for Methyl Parathion except that methanol is used as a starting material instead of ethanol. The two will be treated together. Methyl Parathion is produced according to the following production scheme:



Residues and tank bottoms contain large amounts of intermediates and some products². The waste streams may contain^{3,4} sulfur, NaCl, sodium carbonate, trialkyl thiophosphate, dialkydithiophosphoric acid, dialkyl-chlorothiophosphate, paranitrophenol, o-alkyl o,o-bis(4-nitrophenyl) thiophosphate, and other organophosphate derivatives.

1. Ref 1, p. (5-96)-(5-99)

2. Ref 2, p. 34-35

3. Ref 3, p. 53-55

4. Ref 1, p. (5-96)-(5-99)

5,6
Toxicity Data

<u>Chemical</u>	<u>Oral Rat</u> <u>LD50 mg/kg*</u>
Methyl parathion ^A ⁶	9
Parathion ^B	2
para-nitro phenol ^{AB}	350
triethyl thiophosphate	inhalation LCLO: 41 ppm/4H
trimethyl thiophosphate ^A	inhalation LCLO: 220 ppm/4H
diethyldithiophosphoric acid ^B	4510
dimethyldithiophosphoric acid ^A	LDLo: 1000
diethyl-chloro-thiophosphate ^B	LDLo: 1000
dimethyl-chloro-thiophosphate ^A	LDLo: 1000
o-ethyl-o,o-bis(4-nitrophenyl) thiophosphate ^B	67
o-methyl-o,o-bis(4-nitrophenyl) thiophosphate ^A	312
Sulphur ^{AB}	**

* Unless otherwise indicated
** Data not available

5. Ref 4
6. Chemical followed by A formed in Methyl Parathion Process
Chemical followed by B formed in Parathion Process

1642

References

1. Office of Solid Waste Management Programs. Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives. Environmental Protection Publication SW-118C. Washington, D.C., U.S. GPO, 1976.
2. Atkins, P. The Pesticide Manufacturing Industry- Current Waste Treatment and Disposal Practices. Office of Research and Monitoring, Project 12020FYE. Washington, U.S. GPO, 1972. 185p.
3. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA - 600/2- 77 - 023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232p.
4. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977.
5. Lawless, E.W. Pesticide Study Series -5- The Pollution Potential in Pesticide Manufacturing. Technical Studies Report: TS -00- 72 - 04. Washington, U.S. GPO, 1972. 250p.

Pentachlorophenol

Pentachlorophenol is produced by the simple chlorination of phenol over anhydrous aluminum chloride.

The wastewater from this process contains lower chlorinated phenols¹ and possibly pentachlorophenol. Pentachlorophenol and its derivatives are under RPAR review due to "fetotoxicity and teratogenicity."²

<u>Chemical</u>	<u>Oral Rat</u> ³ <u>LD50 mg/kg</u>
Pentachlorophenol	50
Trichlorophenol	820
Tetrachlorophenol	140
2,4-dichlorophenol	580
2,6-dichlorophenol	2940
O-chlorophenol	670
m-chlorophenol	570
p-chlorophenol	**

** Data not available

3. Ref 2

1. Ref. 1 p 23

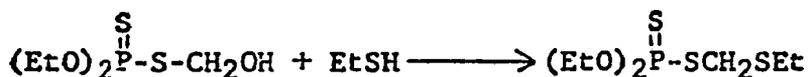
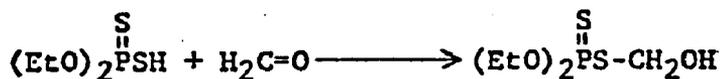
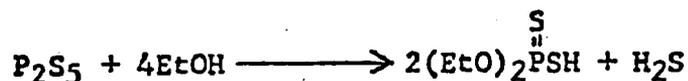
2. Federal Register "Pentachlorophenol and Derivatives" 10/18/78.

References

1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA - 600/2- 77 - 023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232p.
2. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977.

Phorate

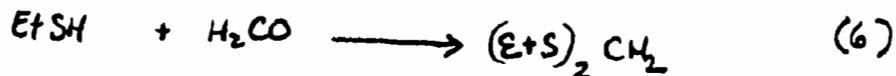
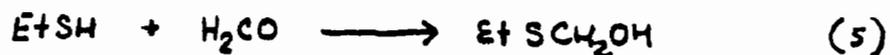
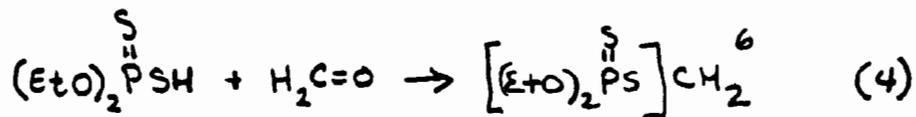
Phorate is produced according to the following production scheme¹:



One of the major byproducts of this reaction is the triester.^{2,3,4} The o-o-o-triethyl-thiophosphate can isomerize to produce o-o-s-triethylphosphate. The filter cake may contain diethyldithiophosphoric acid, triethylthiophosphate, unreacted P₂S₅, and other insoluble reaction products.

The dithiophosphate is condensed with formaldehyde and ethyl mercaptan to produce Phorate. This is washed, steam stripped, and filtered. The solid and liquid wastes may contain Phorate, ethyl mercaptan, formaldehyde, diethyldithiophosphoric acid, and triethylthiophosphate. Additionally, by-products may be formed by the following reactions:

-
1. Ref 1 p. 109-113
 2. Ref 1 p. 99-108
 3. Malathion Background Document
 4. Disulfoton Background Document
 5. Ref 2 p. 36



These above mentioned chemicals may also be present in the wastewater from equipment cleanup.

<u>Chemical</u>	<u>Toxicity Data⁷</u>
	<u>LD50 mg/kg*</u> <u>Oral Rat</u>
Phorate	1.1
Phosphorodithioic Acid, o,o,-Diethyl Ester	4510
Phosphorothioic Acid, o,o,o-Triethyl Ester	inhalation 41ppm/4H
Formaldehyde	800
Ethanethiol	1960
Phosphorodithioic Acid, s,s'-methylene o,o,o',o'- Tetraethyl Ester	13
CH ₃ CH ₂ S CH ₂ (OH)	**
(CH ₃ CH ₂ S) ₂ CH ₂	**
P ₂ S ₅	389

6. Ref 3 p. 665

* unless where otherwise noted

** not available

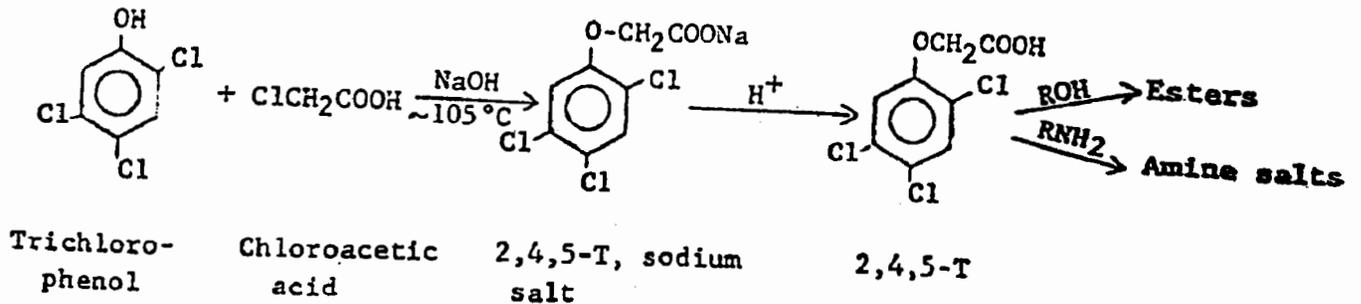
7. Ref 4

References

1. Lawless, E.W. Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
Technical Studies Report: TS -00- 72 - 04.
Washington, U.S. GPO , 1972. 250p.
2. Fest, C. and Schmidt, K.-J.
The Chemistry of Organophosphorus Pesticides.
New York, Springer-Verlay, 1973. 339p.
3. March, J. Advanced Organic Chemistry:
Reactions, Mechanisms, and Structure.
New York, McGraw-Hill Book Company, 1968. 1098p.
4. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977.

2,4,5 - T

2,4,5 - T is manufactured according to the following reaction scheme¹:



The waste stream from 2,4,5 - T contains "large amounts of sodium chloride, hydrochloric acid, some caustic, and organics including solvents, phenols, chlorophenols, and chlorophenoxy acids. These wastes arise from acidification washing steps, phase separation steps, incomplete yields and chlorination of the phenolic compounds"². 2,4,5-tri-chlorophenol may be contaminated with 2,3,7,8-tetrachloro-dibenzo-p-dioxin.³

-
1. Ref 1 p. 136-142
 2. Ref 2 p. 35-37
 3. Ref 3 p. 37-39

Atkins reports that a typical waste stream may be characterized by:

Total solids	104,000 mg/l
Suspended solids	2,500
Chlorides	52,000
Chlorophenols	112
Chlorophenoxy acids	235

The waste streams vary considerably from plant to plant.

<u>Chemicals Possibly Present in Waste Stream</u>	<u>Oral Rat⁴ LD50 mg/kg</u>
2,4,5 - T	300 +
chloroacetic acid	76
o-chlorophenol	670
m-chlorophenol	570
p-chlorophenol	**
2,4-Dichlorophenol	580-suspected carcinogen
2,6-Dichlorophenol	2940
2,3,6-Trichlorophenol	**
2,4,5-Trichlorophenol	820
2,4,6-Trichlorophenol	820
3,4,5-Trichlorophenol	**
Tetrachlorophenol	140

+ - teratogenic due to 2,3,7-8 TCDD contaminant

** data not available

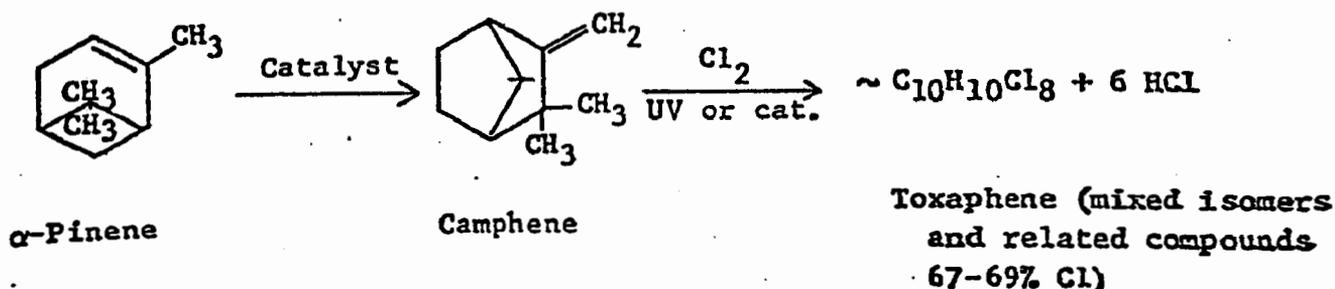
4 Ref 4

References

1. Lawless, E.W. Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
Technical Studies Report: TS -00- 72 - 04.
Washington, U.S. GPO , 1972. 250p.
2. Atkins, P. The Pesticide Manufacturing Industry-
Current Waste Treatment and Disposal Practices.
Office of Research and Monitoring, Project 12012FYE.
Washington, U.S. GPO, 1972. 185p.
3. Effluent Guidelines Division, Office of Water and
Hazardous Materials. Development Document for Interim
Final Effluent Guidelines for the Pesticide Chemicals
Manufacturing Point Source Category. EPA 440/1-75/
060d Group II. Washington, 1976.
4. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977.

Toxaphene

Toxaphene is produced by the following process¹:



Camphene is chlorinated with chlorine over a catalyst or by UV radiation and is then filtered and washed with solvent. The filter cake probably contains tars produced in the chlorination and possibly suspended α -pinene, camphene, toxaphene, solvent, and catalyst. Wastewater used in equipment cleanup may also contain the above mentioned chemicals.

Toxicity Data²

Toxaphene

Oral rat LD50: 60 mg/kg

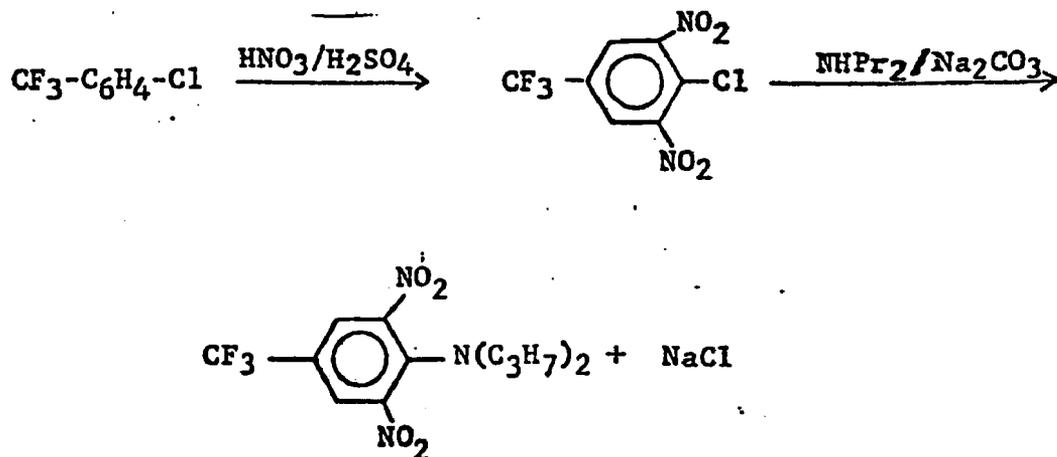
1. Ref 1, p. 94-98
2. Ref 2

References

1. Lawless, E.W., Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
Technical Studies Report: TS -00- 72 - 04.
Washington, U.S. GPO, 1972. 250p.
2. NIOSH Registry of Toxic Effects of Chemical Substances.
VOL I and II. U.S. Department of Health, Education,
and Welfare. 1977.
3. Parsons, T., Editor. Industrial Process
Profiles for Environmental Use: Chapter 8.
Pesticide Industry. EPA - 600/2-77 - 023h,
Technology Series, Environmental Protection Agency,
Washington, 1977. 232p.

Trifluralin

Trifluralin is produced according to the following scheme¹:



According to the report by Lowenbach, Schlesinger, and King² the following chemicals may be present in the waste streams:

1. Ref 1, p. 148-152

2. Ref 2

<u>Chemical</u>	<u>ORAL RAT³ LD50 mg/kg*</u>
p-Chlorobenzotrifluoride	**
o-,m-Chlorobenzotrifluorides	**
Dichlorobenzotrifluorides	**
p-Chlorobenzoic acid	838 mg g/kg (sodium salt)
p-Chloronitrobenzoic acids	3150
p-Chlorodinitrobenzoic acids	**
2,6-dinitro-4- α ' α '-trifluoromethyl phenol	**
Dipropylamine	930
Hydrogen fluoride (and other fluorides)	180 (sodium salt)
Naptha (aromatic)	**
N-Nitroso di-n-propylamine	480 (carcinogenic & neoplastic effects)
Nitrogen oxides	**
Nitrates	**
Nitrites	85 (sodium salt)
Nitrous acid	**
Propylamine	570
Substituted 2,6-dinitroanilines	418 (for dinitro)
Substituted nitrochlorobenzotrifluorides	**
Substituted nitrophenols	**
Substituted sulfonates	**
Sulfates	**
Sulfones	**
Trifluralin	500
Xylene	4300

3. Ref 3

* except where otherwise noted
** data unavailable

References

1. Lawless, E.W. Pesticide Study Series -5-
The Pollution Potential in Pesticide Manufacturing.
Technical Studies Report: TS-00-72 - 04.
Washington, U.S. GPO , 1972. 250p.
2. Lowenbach W., Schlesinger J., and King J.
Toxic Pollutant Identification: Trifluralin
Manufacturing. EPA, Office of Energy,
Minerals, and Industry, 1978. 53p.
3. NIOSH Registry of Toxic Effects of Chemical Substances.
Vol I and II. U.S. Department of Health, Education,
and Welfare. 1977.
4. Office of Solid Waste Management Programs.
Assessment of Industrial Hazardous Waste Practices:
Organic Chemicals, Pesticides and Explosives.
Environmental Protection Publication SW-118C.
Washington, D.C., U.S. GPO, 1976.
5. Parsons, T., Editor. Industrial Process
Profiles for Environmental Use: Chapter 8.
Pesticide Industry. EPA - 600/2- 77- 023h,
Technology Series, Environmental Protection Agency,
Washington, 1977. 232p.

Vernolate

Very little information is available on the production process for this pesticide. Vernolate is probably produced from the reaction of phosgene and di-n-propyl amine to give the intermediate, N,N-di-n-propyl carbamyl chloride. This can then be combined with n-propyl mercaptan, to give vernolate¹. The wastewater treatment sludge may contain: vernolate, the intermediate carbamyl chloride, n-propyl mercaptan, N,N-di-n-propylcarbamic acids, tars and residues from react^{ors} and spills, and solvent .

<u>Chemical</u>	Oral Rat ² <u>LD50 mg/kg</u>
Vernolate	320
Propanethiol	1790

1. Ref 1, p. 61
2. Ref 2

References

1. Parsons, T., Editor. Industrial Process Profiles for Environmental Use: Chapter 8. Pesticide Industry. EPA - 600/2- 77 - 023h, Technology Series, Environmental Protection Agency, Washington, 1977. 232P.
2. NIOSH Registry of Toxic Effects of Chemical Substances. VOL I and II. U.S. Department of Health, Education, and Welfare. 1977.
3. Effluent Guidelines Division, Office of Water and Hazardous Materials. Development Document for Interim Final Effluent Guidelines for the Pesticide Chemicals Manufacturing Point Source Category. EPA 440/1-75/060d Group II. Washington, 1976.

2892 Waste water treatment sludges from explosives, propellants, and initiating compounds manufacture (C,T,R,I).

This waste is classified as hazardous because of its corrosive, toxic, reactive, and ignitable characteristics. According to the information EPA has on this waste stream it meets RCRA Section 250.13 (a), (b), (c), & (d) characteristics identifying corrosive, toxic, reactive, and ignitable waste.

EPA bases this classification on the following information:

TRW has tested a sample of wastewater treatment sludges from explosives, propellants, and initiating compounds manufacture and found the following:

Explosive Manufacture

<u>Contaminant</u>	<u>Concentration mg/l</u>
Nitroglycerin	1800
TNT	70 to 350
pH=1	

Propellants

<u>Contaminant</u>	<u>Concentration mg/l</u>
Nitrocellulose fines	1,000 to 10,000

Initiating Compounds

<u>Contaminants</u>	<u>Concentration mg/l</u>
Pb (lead azide & lead styphnate)	200

The data presented are available from:

TRW. Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives Industries. EPA publication PB-251-307. National Technical Information Service. 1976. and

Development Document for Interim Final Effluent Limitations Guidelines and Proposed New Source Performance Standards for the Explosives Manufacturing. EPA 440/1-76/060-j. March 1976.

As is evident from the above the waste acid sludge has a pH of 3 or below. Liquid waste streams with such acidic character present an environmental risk for several reasons. Very low pH liquid waste if disposed in a sanitary landfill would leach high concentrations of toxic heavy metals (such as lead) from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly acidic liquid wastes also present a handling risk because of their corrosive properties. Highly acidic waste streams are also dangerous because they have been known to initiate potentially dangerous reactions when combined with otherwise innocuous waste.

OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illnesses resulting from the inhalation of toxic gases formed by the reaction of acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the Appendix A-C Chemical Quality, EPA-6570/9 - 76 -003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in ground water. EPA has evidence to indicate that industrial wastes as presently

managed and disposed often leaches into contaminates the groundwater. The Geraghty and Miller(1) report indicated that in 98% of 50 randomly selected onsite industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceed EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05 mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to 0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5 mg/l respectively in the EP extract.

This waste has been shown to contain Pb at 200 mg/l according to EPA 440/1-76/060-j, Development Document for Interim Final Effluent Guidelines and Proposed New Source Performance Standards for Explosives Manufacturing; and PB-251-307, Assessment of Hazardous Waste Practices: Organic Chemicals, Pesticides, and Explosives Industries.

Reactive wastes as defined by Section 250.14 of RCRA pose a threat to human health and the environment, either through the physical consequences of their reaction (i.e., high pressure and/or heat generation) or through the chemical consequences of their reaction (i.e., generation of toxic fumes).

According to Assessment of Industrial Hazardous Waste Practices: Organic Chemicals, Pesticides and Explosives Industry, EPA PB-251-307, 5-109 to 5-130, this waste has been shown to contain nitroglycerin (1800 mg/l) and TNT (70 to 350 mg/l). These contaminants are extremely unstable to thermal stress. For a more detailed discussion of the hazard presented by reactive waste see 3001 background document on reactivity.

As is evident from the above information on the make up of this waste, this waste stream has a flash point of 140° F or below. Ignitables with flash points less than 140° F can become a problem while they are landfilled. During and after the disposal of an ignitable waste, there are many available external and internal energy sources which can provide an impetus for combustion, raising temperatures of waste to their flash points. Disposal of ignitable wastes may result in fire that will cause damage directly from heat and smoke production or may provide a vector by which other hazardous waste can be dispersed. Ignitable wastes tend to be highly volatile and the evaporation of these volatiles contribute to poor air quality. (Refer to ignitability background document for further detail).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Gerhity and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations)...

Gerhity and Miller¹ also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports 2 through 8 do qualitatively identify leached organic contaminants in groundwater) it certainly serves to demonstrate that organic contamination of groundwater frequently results from industrial waste

disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste as a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document.)

This waste will probably** contain aromatic nitrates and toluene, because of the toxicity of these substances and the potential for them to migrate (as explained above). This waste is hazardous

*"Interim Primary Drinking Water Regulations,"
p. 5756, Federal Register, 2/9/78

** Assessment of Industrial Hazardous Waste Practices:
Organic Chemicals, Pesticides and Explosives Industries
U.S. Environmental Protection Agency, (SW-118c) 1976

2892 Catch basin materials in RDX/HMX production (C).

This waste is classified as hazardous because of its corrosive characteristic. According to the information EPA has on this waste stream it meets RCRA Section 250.13 (b) characteristic identifying corrosive waste.

The Administrator has determined this waste to be a potential threat to the environment if improperly managed.

EPA bases this classification on the following information.

1. An EPA contractor has tested a sample of waste sludges and has found the following:

60% acetic acid
2-3% nitric acid
RDX/HMX

The data presented are available from:

Assessment of Industrial Hazardous Waste Practices:
Organic Chemicals, Pesticides and Explosives Industries.
EPA PB-251-307. National Technical Information Service.
1976.

As is evident from the above the waste acid sludge has a pH of 3 or below. Liquid waste streams with such acidic character present an environmental risk for several reasons. Very low pH liquid waste if disposed in a sanitary landfill would leach high concentrations of toxic heavy metals (such as lead) from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly acidic liquid wastes also present a handling risk because of their corrosive properties. Highly acidic waste streams are also dangerous because they have been known to initiate potentially dangerous reactions when combined with otherwise innocuous waste.

OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illnesses resulting from the inhalation of toxic gases formed by the reaction of acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

2892 Spent carbon columns used in treatment of wastewater
-LAP operations (R).

^{reactive} This waste is classified as hazardous because of its characteristic. According to the information EPA has on this waste stream it meets RCRA Section 250.13 (c) characteristic identifying reactive waste.

The Administrator has determined this waste stream to be potential threat to the environment if improperly managed.

EPA bases this classification on the following information.

1. An EPA contractor has tested a sample of waste sludges and has found the following:

<u>Contaminant</u>	<u>Concentration</u>
Nitrobodyes	0.0132 to 0.0416 Kg per Kg of explosives loaded.

The data presented are available from:

Assessment of Industrial Hazardous Waste Practices:
Organic Chemicals, Pesticides and Explosives Industries.
EPA publication PB-251-307. National Technical Information
Service.

Reactive wastes as defined by Section 250.14 of RCRA pose a threat to human health and the environment, either through the physical consequences of their reaction (i.e., high pressure and/or heat generation) or through the chemical consequences of their reaction (i.e., generation of toxic fumes). For further information refer to reactivity background document.

"2892 Wastewater treatment sludges from production of
initiating compounds (T)

See

"2892 Wastewater treatment sludges from explosives,
propellants and initiating compounds manufacture
(C,T,R,I)

This document

2911 Petroleum refining, high octane production neutralization
HF alkylation sludge (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets the RCRA §250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information.

(1) Jacobs Engineering has tested a sample of HF alkylation sludge and found the following:

<u>contaminant</u>	<u>conc. mg/kg sludge (dry)</u>
CN	23.10
Se	7.10
As	2.30
Hg sol	0.07
Ni sol	55.20
Cu sol	14.30
Pb sol	7.10
oil	6.9%

The data presented are available from:

Jacobs Engineering Company. Assessment of Hazardous Waste Practices in the Petroleum Refining Industry. Environmental Protection Publication PB - 259 097. National Technical Information Service. June 1976.

and

Jacobs Engineering Company. Alternative For Hazardous Waste Management in the Petroleum Refining Industry. OSW Contract #68-01-4167. unpublished data. July 1977.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach~~es~~ into and contaminants^{ate} the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the

RCRA toxicity background documents these concentrations convert to 0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5, mg/l respectively in the EP extract.

This waste has been shown to contain selenium, arsenic, mercury, and lead at concentrations of 7.10, 2.30, 0.07 and 7.1 mg/kg sludge (dry) respectively, according to PB-259 097, Assessment of Hazardous Waste Practices in the Petroleum Refining Industry, p. 103 to 104.

2911 Petroleum refining DAF sludge (T)

This waste stream is classified as hazardous because of its toxic properties. According to the data EPA has on this waste stream it meets the RCRA §250.13d characteristic identifying a toxic hazardous waste.

Our information indicates that this waste has the following properties:

(1) Jacobs Engineering has tested a sample of DAF sludge and found the following.

<u>contaminant</u>	<u>conc. mg/kg sludge (dry)</u>
As as Arsenic	2.00
Hg (aqueous state)	0.27
Cr (OH) ₃	140.00
Pb (in the oil)	7.50
oil (light & heavy)	12.5%

The data presented are available from:

Jacobs Engineering Company. Assessment of Hazardous Waste Practices in the Petroleum Refining Industry. Environmental Protection Publication PB-259 097. National Technical Information Service. June 1976.

and

Jacobs Engineering Company. Alternatives For Hazardous Waste Management in the Petroleum Refining Industry. OSW Contract # 68 - 01 - 4167. unpublished data. July 1977.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminants the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic organics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05 mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to 0.5,

10.0, 0.5, 0.5, 0.02, 0.1, and 0.5 mg/l respectively in the EP extract.

This waste has been shown to contain arsenic, mercury, chromium, and lead at concentrations of 2.00, 0.27, 140.0, and 7.50, mg/kg sludge (dry) respectively according to PB - 259 097, Assessment of Hazardous Waste Practices in the Petroleum Refining Industry, p103-104.

2911 Petroleum refining kerosene filter cakes (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets the RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Jacobs Engineering has tested a sample of kerosene filter cake and found the following:

<u>contaminant</u>	<u>conc. mg/kg sludge (dry)</u>
As as Arsenic	2.20
oil (light fraction)	3.5%

The data presented are available from:

Jacobs Engineering Company. Assessment of Hazardous Waste Practices in the Petroleum Refining Industry. Environmental Protection Publication PB - 259 097. National Technical Information Service. June 1976.

and

Jacobs Engineering Company. Alternative For Hazardous Waste Management in the Petroleum Refining Industry. OSW Contract# 68- 01 - 4167. unpublished data. July 1977.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 -003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach~~es~~^{ate} into and contaminat~~es~~^{ate} the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicant^s listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05 mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to 0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5, mg/l respectively

in the EP extract.

This waste has been shown to contain arsenic with a concentration of 2.2 mg/kg sludge (dry), according to PB 259 097. Assessment of Hazardous Waste Practices in the Petroleum Refining Industry, p. 103-104.

2911 Petroleum refining lube oil filtration clays (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets the RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Jacobs Engineering has tested a sample of lube oil filtration clays and found the following:

<u>contaminant</u>	<u>conc. mg/kg sludge (dry)</u>
As as Arsenic	0.07
Cd (organically bound)	0.76
Ni (organically bound)	11.10
Pb (organically bound)	1.28
oil	21.9%

The data presented are available from:

Jacobs Engineering Company. Assessment of Hazardous Waste Practices in the Petroleum Refining Industry. Environmental Protection Publication PB-259 097. National Technical Information Service. June 1976.

and

Jacobs Engineering Company. Alternatives For Hazardous Waste Management in the Petroleum Refining Industry. OSW Contract #68-01-4167. unpublished data. July 1977.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570.9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver, toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.0002, 0.01, and 0.05 mg/l respectively because of their toxicity. As explained in the

RCRA toxicity background documents these concentrations convert to 0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5 mg/l respectively in the EP extract.

This waste has been shown to contain arsenic, cadmium, and lead at concentrations of 0.7, and 1.28 mg/kg sludge (dry) respectively, according to PB-259 097, Assessment of Hazardous Waste Practices in the Petroleum Refining Industry, p. 103-104.

2911 Petroleum refining slop oil emulsion solids (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets the RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Jacobs Engineering has tested a sample of slop oil emulsion solids and found the following.

<u>contaminent</u>	<u>conc. mg/kg sludge (dry)</u>
As as Arsenic	7.40
Hg (grim crude)	0.59
Cr as Cr(OH) ₃	525.00
Ni (in oil)	50.00
Cu (in oil)	48.00
Zn as carbonate	250.00
Cd (in oil)	0.19
Pb as TEL	28.1
oil	48%

The data presented are available from:

Jacobs Engineering Company. Assesement of Hazardous Waste Practices in the Petroleum Refining Industry. Environmental Protection Publication PB - 259 097. National Technical Information Service. June 1976.

and

Jacobs Engineering Company. Alternatives For Hazardous Waste Management in the Petroleum Refining Industry. OSW Contract# 68 - 01 - 4167. unpublished data. July 1977.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches^{etc} into and contaminants the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites^s, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA

toxicity background documents these concentrations convert to 0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5, mg/l respectively in the EP extract.

This waste has been shown to contain arsenic, mercury, chromium, and lead at concentrations of 7.40, 0.59, 525.0, 0.19, and 28.1 mg/kg sludge (dry) respectively, according to PB - 259 097, Assessment of Hazardous Waste Practices in the Petroleum Refining Industry; p 103 - 104.

2911 Petroleum refining exchange bundle cleaning solvent (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Jacobs Engineering has tested a sample of exchange bundle cleaning solvent and found the following.

<u>contaminant</u>	<u>conc. mg/kg sludge (dry)</u>
Se as Oxide or Silicate	27.20
As as Arsenic	10.60
Cr as Oxide or Silicate	311.00
Zn as Oxide or Silicate	194.00
Pb as TEL	78.00
Mo as Oxide or Silicate	6.50
oil (light & heavy)	10.7%

The data presented are available from:

Jacobs Engineering Company. Assessment of Hazardous Waste Practices in the Petroleum Refining Industry. Environmental Protection Publication PB - 259 097. National Technical Information Service. June 1976.

and

Jacobs Engineering Company. Alternatives For Hazardous Waste Management in the Petroleum Refining Industry. OSW Contract# 68 - 01 - 4167. unpublished data. July 1977.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentration).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.01, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to

0.05, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5 mg/l respectively in the EP extract.

This waste has been shown to contain selenium, arsenic, chromium, and lead at concentrations of 27.2, 10.6, 311.0, and 78.0 mg/kg sludge (dry) respectively, according to PB - 259 097, Assessment of Hazardous Waste Practices in the Petroleum Refining Industry, p. 103 - 104.

2911 Petroleum refining API separator sludge(T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Jacobs Engineering has tested a sample of API separator sludge and found the following:

<u>contaminant</u>	<u>conc. mg/kg sludge (dry)</u>
As as Arsenic	6.20
Hg as Carbonate or Hydroxide	0.40
Cr as Carbonate or Hydroxide	253.00
Cd as Carbonate or Hydroxide	0.42
Zn as Carbonate or Hydroxide	298.00
Pb as TEL	26.00
oil as tar	22.6%

The data presented are available from:

Jacobs Engineering Company. Assessment of Hazardous Waste Practices in the Petroleum Refining Industry. Environmental Protection Publication PB-259 097. National Technical Information Service. June 1976.

and

Jacobs Engineering Company. Alternatives For Hazardous Waste Management in the Petroleum Refining Industry. OSW Contract # 68-01-4167. unpublished data. July 1977.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc). in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Ar^senic, mercury, chromium, cadmium, and lead are toxicants listed by the NIPDWR at concentrations of 0.05, 0.002, 0.05, 0.01, and 0.05 mg/l respectively because of their toxicity. As

explained in the RCRA toxicity background documents this converts to 0.5, 0.02, 0.5, 0.1, and 0.5 mg/l level respectively in the EP extract.

This waste has been shown to contain arsenic, mercury, chromium, cadmium and lead at 6.20, 0.40, 253.0, 0.42, and 26.0 mg/kg sludge (dry) respectively, according to PB - 259 097, Assessment of Hazardous Waste Practices in the Petroleum Refining Industry, p. 103-104.

Wastewater Treatment Sludge from Chrome Tannery and
Beamhouse/Tanhouse

This waste stream is classified as hazardous because of its toxic properties. According to data EPA has on these waste stream, they meet the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Our information indicates that the waste contains the following toxic substances in excess of Drinking Water Standards:

Chromium	24000 - 38800 ppm
Lead	140 - 310 ppm

Reference: SCS Engineering. Assessment of Industrial Hazardous Waste Practices in Leather Tanning and Finishing Industry. Nov. 76 PB # 261-018 p. 67, 68, 112.

This waste presents an environmental problem because it may pose a chronic hazard to human health and the environment.

LEATHER TANNING & FINISHING

3111

Wastewater Treatment Screenings from Sheepskin Tannery,
Split Tannery, Retan/Finishers and Chrome Tannery

This waste stream is classified as hazardous because of its toxic properties. According to data EPA has on this waste stream, it meets the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Our information indicates that the waste contains the following toxic substances in excess of Drinking Water Standards:

Chromium: 4200 - 33,000 ppm

Lead: 175 - 280 ppm

Reference: SCS Engineering Assessment of Industrial Hazardous Waste Practices in the Leather Tanning and Finishing Industry. PB # 261-018
Nov. 1976. pp. 67, 88, 97, 120.

We believe the waste presents a hazard to human health and the environment.

Trimblings and Shavings from Chrome and Split Tanneries
Beamhouse/Tanhouse and Retan/Finishers

These waste streams are classified as hazardous because of their toxic properties. According to data EPA has on these waste streams, they meet the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Our information indicates that this waste stream contains the following toxic heavy metals in excess of Drinking Water Standards.

Chromium: 10,000 - 44000 ppm

Lead: 130 - 330 ppm

Reference: SCS Engineering, Assessment of Industrial Hazardous Waste Practices in the Leather Tanning and Finishing Industry. PB # 261-018. Nov. 1976 pp. 64-66, 88, 96, 117, 119

We feel this waste stream poses a hazard to human health and the environment.

Wastewater Treatment Sludge From Dehairing and Tanning

This waste stream is classified as hazardous because of its toxic properties. According to available data, this waste stream meets the RCRA §250.13a(4) characteristic identifying a toxic hazardous waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s.a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

This waste stream has been shown to contain chromium. On that basis we feel it poses a threat to human health and the environment.

Reference: Storm, Handbook of Industrial Waste Compositions in California - 1978 California Department of Health Services, Nov. 1978, p. 66.

3312 Coking; Decanter Tank Pitch/Sludge/Tar (0)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream, it contains phenol in concentrations large enough to classify the waste stream as a hazardous waste.

EPA bases this classification on the following information;

(1) Calspan Corp. has tested a sample of Decanter Tank Pitch/Sludge and found the following:

pH = 8.9 (Dist H₂O leachate)

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Cr	0.01	4
Cu	0.03	1
Mn	0.01	44
Ni	0.05	10
Pb	0.2	30
Zn	0.01	20
CN	0.59	1.3 - 9.8
oil and grease	198	144,000 - 297,000
phenol	500	1,711 - 3,127
conductivity	350	-

(2) <u>Tar Composition</u>	<u>% , Weight</u>
Liquor	1.6 - 5.8
Benzol	0.1 - 0.3
Toluol	0.1 - 0.4
Xylol	0.1 - 0.5
Total Tar Acids (phenols, cresols, xyleneols)	2.0 - 3.9
Total Tar Bases (pyridine, picolines, quinolines)	1.4 - 2.0
Naphtha (coumarone, indene)	0.4 - 2.0
Crude Napthalene	7.7 - 11.7
Methylnapthalene Oil	2.1 - 2.9
Biphenyl Oil	0.9 - 1.5
Acenaphthene Oil	1.4 - 2.8
Fluorene Oil (fluorene, diphenyl oxide)	1.9 - 3.6
Anthracene-Heavy Oil (anthracene, phenanthrene, carbazole)	9.6 - 12.3
Pitch	60.2 - 64.2
Distillation Losses	0.9 - 2.8

Source: "The Coal Tar Data Book." The Coal Tar Research Association, 2nd ed., Section AL, 2-4, 1965.

Ranges of composition of five typical tars.

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

¹
Geraghty and Miller also found that in a majority of the fifty sites examined organic contamination of the groundwater above background levels was observed. In 28 (56%) of these sites chlorinated organics attributable to waste disposal were observed in the groundwater. While specific identification of these organics was not always undertaken in this work, (other incidents and reports (References 2 through 8) do qualitatively identify leached organic contaminants in groundwater), it certainly serves to demonstrate that organic contamination of

groundwater frequently results from industrial waste disposal. Since the Administrator has determined "that the presence in drinking water of chloroform and other trihalomethanes and synthetic organic chemicals may have an adverse effect on the health of persons..."* and, as noted above, because much drinking water finds its source as groundwater, the presence of available toxic organics in waste is a critical factor in determining if a waste presents a hazard when managed. (For a discussion of how the toxicity and concentration of organic contaminants in waste are considered in the hazard determination see Toxicity background document).

Coking Decanter Tank Sludge has been found to contain phenol according to Calspan Corp, Vol III, p. 6-69. App. page 12, 37. Since the water extract of the waste has been shown to contain phenol at a 500 ppm concentration, the phenol is not fixed in the solid matrix. It is therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

*"Interim Primary Drinking Water Regulations,"
p. 5756, Federal Register, 2/9/78.

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices.

April 1977. Contract # 68-01-2604. Vol III, 6-69. App. page 12, 37.

Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937. Pages 4.1-4.4, App. table A-1.

NUS Corp. Development Document for Effluent Limitations. (etc,)
Iron and Steel Industries-Hot Forming and Cold Finishing Segment.
July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract # R-803C19. Page 26-35.

3312 Coking: Oleum Wash Waste (C)

This waste is classified as hazardous because of its corrosive characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13b characteristic identifying corrosive wastes.

EPA bases this classification on the following information. Oleum wash waste is fuming H_2SO_4 . The resulting sludge from the Oleum wash contains up to 50% free acid (Bethlehem Steel Corp., 1978) thereby causing a highly corrosive waste. Sludge is expected to contain heterocyclic hydrocarbons and sulfur containing organics.

Liquid waste streams with such acidic character present an environmental risk for several reasons. Very low pH liquid waste if disposed in a sanitary landfill would leach high concentrations of toxic heavy metals (such as lead) from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly acidic liquid wastes also present a handling risk because of their corrosive properties. Highly acidic waste streams are also dangerous because they have been known to initiate potentially dangerous reactions when combined with otherwise innocuous waste.

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604. Vol III, pages 6-69. App. pages 12, 37.

Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937. page 4,5.

NUS Corp. Development Document for Effluent Limitations. etc,) Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract # R-803619. pages 26-35.

OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illnesses resulting from the inhalation of toxic gases formed by the reaction of acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

This waste is classified as hazardous because of its corrosive characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13b characteristic identifying corrosive wastes.

Crude light oil is recovered from the coke oven off-gas. This light oil is scrubbed with Oleum (fuming H_2SO_4). The scrubbed light oil stream is next neutralized with a caustic wash. This caustic wash generates the sludge that is discussed here.

Liquid waste streams with such caustic character present an environmental risk for several reasons. Very high pH liquid waste if disposed in a sanitary landfill would leach high concentrations of toxic heavy metals from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly caustic liquid wastes also present a handling risk because of their corrosive properties. Highly caustic waste streams are also dangerous because they have been known to initiate potentially dangerous reactions when combined with otherwise innocuous waste.

OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illnesses resulting from the inhalation of toxic gases formed by the reaction of acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604. Vol III 6-69, App. page 12, 37.

Enviro. Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937, page 4,5.

NUS Corp. Development Document for Effluent Limitations. (etc,) Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. July 1976. Contract # R-803619. pages 26-35.

3312 Coking; Ammonia Still Lime Sludge (R)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA §250.13c characteristic identifying reactive waste.

EPA bases this classification on the following information:
 Calspan Corp. has tested a sample of Ammonia Still Lime Sludge and found the following:

pH = 11.5

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Cr	0.02	43-80
Cu	0.09	22.5 - 35
Mn	0.05	500 - 550
Ni	< 0.05	5 - 15
Pb	0.5	< 10 - 67
Zn	< 0.01	550 - 710
CN	198	0.25 - 1,940
F	-	-
oil & grease	-	12,100 - 104,000
phenol	20	3.4 - 1,910
conductivity	> 10,000	-

Reactive wastes as defined by Section 250.14 of RCRA pose a threat to human health and the environment, either through the physical consequences of their reaction (i.e., high pressure and/or heat generation) or through the chemical consequences of their reaction (i.e., generation of toxic fumes).

According to Calspan Corp, Vol III, pages 6-69, this waste stream has been shown to contain up to 1940 ppm cyanides, and to leach 198 ppm cyanides. Under mildly acid and/or basic conditions these may solubilize to generate HCN gas. HCN gas* is an intensely poisonous gas even when mixed with air. High concentration produces tachypnea (causing increased intake of cyanide); then dyspnea, paralysis, unconsciousness, convulsions and respiratory arrest. Exposure to 150 ppm for 1/2 to 1 hour may endanger life. Death may result from a few minutes exposure to 300 ppm. Average fatal dose: 50 to 60 mg.

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604 Vol III, pages 6-69. App. page 12, 37.

Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937. pages 4-5. App. table A-2.

NUS Corp. Development Document for Effluent Limitations. (etc,) Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract # R-803C19. Page 26-35.

3312 Iron Making; Ferromanganese Blast Furnace Dust (T, R)

This waste is classified as hazardous because of its reactive and toxic characteristics. According to the information EPA has about this waste stream it meets both the RCRA S250.13c and S250.13d characteristics identifying reactive and toxic wastes.

EPA bases this classification on the following information; (1) Dravo Corp. and Calspan Corp., have tested samples of Ferromanganese Blast Furnace Dust and found the following:

pH = 9.7 Dist H₂O Leach Test

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	110	1,600 - 45,000
Pb	560	100 - 6000
Al		50,500
K		18,700 - 28,700
Mg		2,800
Ca		16,800 - 19,100
Mn	7.5	155,000 - 212,200
Na		500 - 700
C		71,000 - 95,000
Total fe		48,000 - 53,000
Si O ₂		61,700 - 68,000
Cr	0.2	32
Cu	4.5	200
Ni	0.53	
Sn		400

(2) Primary treatment dusts have been reported as pyrophoric (Dravo Corp., 1976). Ferromanganese dust collected in a bag-house and analyzed by the Calspan solubility test leached exceedingly high concentrations of lead and zinc.

The lead concentrations is several orders of magnitude greater than drinking water standards.

Lead is one of the toxicants listed by the N I P D W R at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain lead at a 560 ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, ferromanganese blast furnace dust has been classified as toxic, and the dust is also classified as reactive due to its pyrophoric nature.

Reactive wastes as defined by Section 250.14 of RCRA pose a threat to human health and the environment, either through the physical consequences of their reaction (i.e., high pressure and/or heat generation) or through the chemical consequences of their reaction (i.e., generation of toxic fumes).

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller¹ report indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604. Vol III, pages 97-144. App. pages 29, 35.

Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937. Pages 4.9, 4.13-14.

NUS Corp. Development Document for Effluent Limitations. (etc,) Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract # R-803C19. Page 63-66.

3312 Iron Making Ferromanganese Blast Furnace Sludge (R)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13c characteristic identifying reactive waste.

EPA bases this classification on the following information: (1) Dravo Corp and Bethlehem Steel have tested a sample of ferromanganese blast furnace sludge and found the following:

pH = 11 Dist. H₂O leach test

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	0.061	1.7 4,100
Pb		2 400
Sn		400 - 600
Al		35,500 - 36,100
k		74,900 - 87,400
Mg		17,000 - 19,300
Ca		63,800 - 69,500
Mn	0.2	57,500 - 68,600
Na		4,800 - 5,100
C		74,000 - 76,000
Total Fe	45.8	1400 - 24,000
Si O ₂		54,200
Cr	< 0.07	0.05 - 18
Cu	< 0.05	0.05
Ni	< 0.08	< 0.05 - 20,000
Cd		< 0.05

Although the data do not present any alarming concentrations of heavy metals, sources indicate that high levels of cyanide in the off-gas from these blast furnaces would be absorbed in scrubber solutions and render the sludge toxic to human health and the environment.

Reactive wastes as defined by Section 250.14 of RCRA pose a threat to human health and the environment, either through the physical consequences of their reaction (i.e., high pressure and/or heat generation) or through the chemical consequences of their reaction (i.e., generation of toxic fumes).

According to Enviro Control, page 4.9, 4.13-14, this waste stream has been shown to contain cyanides. Under mildly acid and/or basic conditions these may solubilize to generate HCN gas. High concentration produces tachypnea (causing increased intake of cyanide); then dyspnea, paralysis, unconsciousness, convulsions and respiratory arrest. Exposure to 150 ppm for 1/2 to 1 hour may endanger life. Death may result from a few minutes exposure to 300 ppm. Average fatal dose: 50 to 60 mg.

*Merck Index, Eighth Edition, p. 544

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol III, pages 97-144. App. pages 29, 35.

Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937. Pages 4.9, 4.13-14.

NUS Corp. Development Document for Effluent Limitations. (etc,) Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract # R-803C19, pages 63-66.

3312 Iron Making, Electric Arc Furnace Dust (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristics identifying toxic wastes.

EPA bases this classification on the following information. Calspan Corp. has tested a sample of Electric Arc Furnace Dust and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Mn	0.26	38,000 - 45,000
Cr	0.34	770 - 1,500
Cu	0.1	1,800 - 3,400
Pb	150	20,000 - 48,000
Ni	< 0.05	170 - 500
Zn	0.7	54,000 - 240,000
F	7.6	1,700 - 2,940
pH	12.6	

According to the Solubility test performed by Calspan Corp. the leachate derived from Electric Arc Furnace Dust contains Pb in concentrations which are several orders of magnitude greater than drinking water standards.

Lead is one of the toxicants listed by the N I P D W R at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain lead at a 150ppm concentration, the heavy metal is not fixed in the Solid Matrix. It is therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604 Vol III, pages 6-69, App. pages 12, 37.

Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937, pages 4.16, 4.23-25, App. Table A-14.

NUS Corp. Development Document for Effluent Limitations. (etc,) Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract # R-803619, page 91-99.

3312 Iron Making, Electric Arc Furnace Sludge (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information:

(1) Calspan Corp. has tested a sample of Electric Arc Furnace Sludge and found the following:

<u>Contaminent</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Mn	0.03	48,000 - 55,000
Cr	94	1,800 - 2700
Pb	2.0	2,000
Cu	0.17	520 - 550
Ni	< 0.05	3,000 - 3,750
Zn	0.06	2,500 - 3,800
pH	11.5	

According to the solubility test performed by Calspan Corp. the leachate derived from Electric Arc Furnace Sludge contains Cr, and Pb in concentrations which are several orders of magnitude greater than drinking water standards.

Chromium and Lead are toxicants listed by the N I P D W R at a concentration of .05mg/l because of their toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain chromium and lead at a 94 and 2.0ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leache into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604 Vol III, pages 6-69, App. pages 12, 37.

Enviro. Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937. page 4.16, 4.23-25, App. table A-15.

NUS Corp. Development Document for Effluent Limitations. (etc,) Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract R-803619. pages 91-99.

3312 Steel Finishing: Alkaline Cleaning Waste (C)

This waste is classified as hazardous because of its corrosive characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13a.2 characteristic identifying corrosive wastes.

Prior to electrolytic or hot-dip plating procedures, cold-reduced steel must be cleaned of oils and lubricants so that no residue is formed during annealing. This is commonly done by application of aqueous alkaline detergent solutions containing such chemicals as sodium hydroxide, sodium orthosilicate, and trisodium phosphate.

These solutions are routinely wasted and may constitute corrosive hazards. Since the pH of these solutions is generally above 12, it is classified as a hazardous waste.

Liquid waste streams with such caustic character present an environmental risk for several reasons. Very high pH liquid waste if disposed in a sanitary landfill would leach high concentrations of toxic heavy metals from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly caustic liquid wastes also present a handling risk because of their corrosive properties. Highly caustic waste streams are also dangerous because they have been known to initiate potentially dangerous reactions when combined with otherwise innocuous waste.

OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illnesses resulting from the inhalation of toxic gases formed by the reaction of acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices.

April 1977. Contract # 68-01-2604. Vol III, 6-69, App. page 12, 37.

Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937. Pages 4.25-27, 4.37.

NUS Corp. Development Document for Effluent Limitations. (etc.) - Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract # R-803619. Page 133-135.

3312 Steel Finishing: Waste Pickle Liquor (C, T)

This waste is classified as hazardous because of its corrosive and toxic characteristics. According to the information EPA has about this waste stream it meets both the RCRA §250.13b and §250.13d characteristics identifying corrosive and toxic wastes.

EPA bases this classification on the following information:

(1) Waste Management Inc. has tested a sample of spent pickle liquor and found the following:

pH = .6

<u>contaminant</u>	<u>conc. mg/l</u>
Cd	461
Cr (total)	11460
Cr VI	.2
Cu	4867
Pb	578
Zn	12680

California Manifest Listings

The following waste discriptions were taken from "Handbook of Industrial Waste Compositions." These waste discriptions are typical of wastes entering the California waste control system. These listings are included to demonstrate that these waste streams can contain the hazardous component indicated.

(2) Pickling liquor - 7% sulfuric acid

(this would give a pH slightly greater than 0, and less than 1)

(3) Metal pickling acid soln.

5-15% Hydrochloric Acid

20-30% Sulfuric Acid

(4) Steelpickling Acid solution

4% Sulfuric Acid

96% H₂O

ph 1

(5) Acid solution, Ironworks

5% Inhibited Hydrochloric Acid

Balance H₂O

(6) Pickling Liquor

4-6% HNO₃

Acid Solution

10-12% H₃PO₄

.5-12% HCl

.5-1% H₂ SO₄ pH = 1

As is evident from the above, the waste pickling liquor has a pH of 2 or below. Liquid waste streams with such acidic character present an environmental risk for several reasons. Very low pH liquid waste if disposed in a sanitary landfill would leach high concentrations of toxic heavy metals (such as lead) from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly acidic liquid wastes also present a handling risk because of their corrosive properties. Highly acidic waste streams are also dangerous because they have been known to initiate potentially dangerous reactions when combined with otherwise innocuous waste.

OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illness resulting from the inhalation of toxic gases formed by the reaction of acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

According to the Analysis performed by Waste Management Inc. Spent pickle liquor, contains Cd, Cr, and Pb, in concentrations which are several orders of magnitude greater than drinking water standards. Since the pH of this waste is very low (0.6, analogous to a 1 to 0.1 molar solution HNO_3 or other strong acid) these heavy metals are mostly in solution and therefore are available to migrate down through a disposal site to groundwater. Chromium and Lead are toxicants listed by the NIPDWR at a concentration of .05mg/l because of their toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract. Cadmium is one of the toxicants listed by the NIPDWR at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract. Since this waste has been shown

to contain Cadmium, Chromium and Lead at a 461, 11460, and 578ppm concentration according to Waste Management Inc., we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDW) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting & Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol III pages 6-69, App. page 12, 37.

Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937, pages 4.25-27, 4.38-40, App. table A-20, 21.

NUS Corp. Development Document for Effluent Limitations. (etc.) Iron and Steel Industries-Hot forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract R-803C19, page 127-133.

Handbook of Industrial Waste Compositions in California 1978
Storm, D, Dept. of Health Calif. pages 72, 74, 84, 85.

3312 Steel Finishing; Cyanide-bearing Wastes from Electrolytic Coating (R)

This waste is classified as hazardous because of its reactive characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13c characteristic identifying reactive waste.

EPA bases this classification on the following, information:

(1) The following table summarizes the composition of electroplating baths. Of particular concern in the waste streams are (1) cyanide-bearing wastes which may result from electroplating of cadmium, copper, brass, and zinc, and (2) heavy metal content of wastes, particularly cadmium and mercury. Certain wastes and plating solutions would be corrosive as well. Corrosivity would be expected to be a problem from the chromium, copper, and zinc plating wastes.

Composition of Electroplating Baths
as Used in Steel Mills

Electrolytic Coatings	Bath Composition (per gallon H ₂ O)
Cadmium	3 oz. Cadmium Oxide 14.5 oz. Sodium Cyanide
Copper (cyanide)	3 oz. Copper Cyanide 4.5 oz. Sodium Cyanide 2 oz. Sodium Carbonate
Brass	3.6 oz. Copper Cyanide 1.2 oz. Zinc Cyanide 4 oz. Sodium Carbonate
Zinc (cyanide)	8 oz. Zinc Cyanide 3 oz. Sodium Cyanide 7 oz. Sodium Hydroxide 1-1/16 oz. Mercuric Salts

California Manifest Listings

The following waste descriptions were taken from "Handbook of Industrial Waste Compositions". These waste descriptions are typical of wastes entering the California waste control system. These listings are included to demonstrate that these waste streams can contain the hazardous component indicated.

(2) Cadmium plating Alkaline solution

1000 - 2500 ppm cadmium

1000 - 3000 ppm cyanide

99% water

ph 11.5

(3) Metal plating, Alkaline tank bottom sediment

2% sodium cyanide

1% zinc

3% copper

4% sodium bicarbonate

1% nickel

89% water

ph 12

(4) Zinc Automatic plating, Alkaline solution

2 oz/gal. zinc

5 oz/gal. sodium cyanide

11 oz/gal caustic

ph 12

(5) Alkaline solution - Metal refining

10% Sodium Cyanide

90% water

ph 12

Reactive wastes as defined by Section 250.14 of RCRA pose a threat to human health and the environment, either through the physical consequences of their reaction (i.e., high pressure and/or heat generation) or through the chemical consequences of their reaction (i.e., generation of toxic fumes).

According to Enviro Control, pages 4.25-27, 4.40-44, this waste stream has been shown to contain cyanides. Under mildly acid and/or basic conditions these may solubilize to generate HCN gas. HCN gas* is an intensely poisonous gas even when mixed with air. High concentration produces tachypnea (causing increased intake of cyanide); then dyspnea, paralysis, unconsciousness, convulsions and respiratory arrest. Exposure to 150 ppm for 1/2 to 1 hour may endanger life. Death may result from a few minutes exposure to 300 ppm. Average fatal dose: 50 to 60 mg.

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604. App. page 12, 37. Vol III, 6-69.

Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937. Pages 4.25-27, 4.40-44.

NUS Corp. Development Document for Effluent Limitations. (etc,) Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.

Dravo Corp. Managing and Disposing of Residues from Environmental Control Facilities in the Steel Industry. June 1976. Contract # R-803C19. Page 133-135.

Handbook of Industrial Waste Compositions in California 1978
Storm, D, Dept. of Health Calif. pages 77, 85, 86.

3312 Steel Finishing: Chromates and Dichromates from Chemical Treatment, Spent Chromating Solution, Chromate Rinse, (T,C)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets both the RCRA §250.13b and §250.13d characteristics identifying corrosive and toxic wastes.

EPA bases this classification on the following information:

(1) Chromating

Chromating is done to develop a protective amorphous chromic oxide layer directly on steel. Chromating solutions are reported to contain 2 to 35mg/l of hexavalent chromium as chromic acid, potassium chromate, or potassium dichromate. Steel is dipped in or sprayed with this solution.

Spent Chromating Solution

Wastes from the chromating process include spent solution which is classified as hazardous. If chromic acid is used in the solution, the waste may be corrosive as well as toxic.

Chromate Rinse

In order to prevent formation of white rust on galvanized steel and corrosion of tin-plated or other types of finished steel, use of a chromate rinse is commonly employed. There is both continuous discharge of chromium and occasional total discharge of the bath. The untreated wastes contain high concentrations of hexavalent chromium as chromic acid, dichromate, or chromate and would thus be considered toxic. Depending on acid concentration, the waste may be corrosive as well.

California Manifest Listings

The following waste descriptions were taken from "Handbook of Industrial Waste Compositions". These waste descriptions are typical of wastes entering the California waste control system. These listings are included to demonstrate that these waste streams can contain the hazardous component indicated.

- (1) Metal Plating Acid Solution,
0-5% Sulfuric Acid and Chromic Acid
Balance: Water
pH 1.3
- (2) Metal Plating Acid Solution
5% Chromic Acid
95% Water
pH 2
- (3) Metal Plating
Chromium Sludges
1-5% Chromium (~~III~~) hydroxide
balance water and calcium sulfate
pH 7

As is indicated by the above information this waste stream can contain chromium. Chromium is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Chromating solutions using Chromic Acid may make the waste hazardous due to its corrosive properties. Also, if the pH of the solution is below or equal to 3 the waste is classified as corrosive. Liquid waste streams with such acidic character present an environmental risk for several reasons. Very low pH liquid waste if disposed in a sanitary landfill would leach high concentrations of toxic heavy metals (such as lead) from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly acidic liquid wastes also present a handling risk because of their corrosive properties. Highly acidic waste streams are also dangerous because they have been known to initiate potentially dangerous reactions when combined with otherwise innocuous waste.

OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illnesses resulting from the inhalation of toxic gases formed by the reaction of acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

References

- (1) Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting & Refining Industry Appendices. April 1977. Contract # 68-01-2604 Vol III 6-69, App. page 12, 37.
- (2) Enviro Control Inc. Hazardous Waste Listings Fully Integrated Steel Mills. May 1978. Contract # 68-01-3937. Page 4.25-27, 4.44-45.
- (3) NUS Corp. Development Document for Effluent Limitations (etc.) Iron and Steel Industries-Hot Forming and Cold Finishing Segment. July 1974. Contract # 68-01-1507.
- (4) Handbook of Industrial Waste Compositions in California 1978. Storm, D, Dept. of Health California. Pages 72, 85.

3331 Primary Copper, Electric Furnace Slag (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about the waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information. Calspan Corp. has tested a sample of Electric Furnace Slag and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	3.0	
Cd	0.15	< 5
Cr	0.02	50
Cu	0.58	3700
Mn	0.2	165
Pb	6	250
Sb	< 0.2	< 100
Se	0.13	10
Ni	< 0.05	5
ph	7.8	
As	0.052	—
Hg	< 0.02	0.5

According to the solubility test performed by Calspan Corp. the leachate derived from *Electric Furnace Slag* contains Cd, Se and Pb in concentration^s which are orders of magnitude greater than drinking water standards. Lead is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract. Cadmium and Selenium are toxicants listed by the NIPDWR at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain cadmium and lead at a .15, .13 and 6 ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting & Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol II page 4-43, App. page 2, 32.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I, page 20-45, Vol III, page 3-11, Contract # 68-01-2552.

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about the waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information. Calspan Corp. has tested a sample of Converter DUST and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	9,000	28,000
Cd	170	5.20
Cr	0.9	50
Cu	31,000	280,000
Mn	33	90
Pb	8.3	8,000
Sb	2.0	500
Se	< 0.05	30
Ni	15	110
ph	3.9	
Hg	0.030	0.8
As	3.44	—

According to the solubility test performed by Calspan Corp. the leachate derived from *Converted Dust* contains Cd, *As, Cr, Pb* in concentration^s which are orders of magnitude greater than drinking water standards. Lead *Chromium And Arsenic* are toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract. Cadmium is one of the toxicants listed by the NIPDWR at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract. *Mercury* is one of the toxicants listed by the NIPDWR at a concentration of .002mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .02mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain *Mercury, Arsenic, Chromium* .03, 3.44, 0.9, cadmium and lead at a *170* and *8.3ppm* concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting & Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol II page 4-43, App. page 2, 32.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I, page 20-45, Vol III, page 3-11, Contract # 68-01-2552.

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about the waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information. Calspan Corp. has tested a sample of *Acid Plant Sludge* and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	300	
Cd	8.4	<5 - 180
Cr	0.5	25 - 90
Cu	850	22,000 - 380,000
Mn	1.0	8 - 170
Pb	7.8	5,900 - > 12000
Sb	< 0.02	200 - 1200
Se	-	40 - 560
Ni	0.64	<10 - 95
ph	3.0	
Hg	-	5 - 6
As	0.805	-

According to the solubility test performed by Calspan Corp. the leachate derived from *Acid Plant Sludge* contains Cd, *As*, Pb, ~~and~~ in concentration^s which are orders of magnitude greater than drinking water standards. Lead ^{*chromium, and Arsenic are*} toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract. Cadmium is one of the toxicants listed by the NIPDWR at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain ^{*Arsenic, Chromium, 0.805, 0.5*} cadmium and lead at a ^{*8.4 and 7.8*} ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting & Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol II page 4-43, App. page 2, 32.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I, page 20-45, Vol III, page 3-11, Contract # 68-01-2552.

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about the waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information. Calspan Corp. has tested a sample of Reveratory Dust and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	-	44,000
Cd	130	310
Cr	0.1	45
Cu	29,000	240,000
Mn	25	100
Pb	7.3	12,000
Sb	< 0.2	750
Se	4.05	80
Ni	2.5	35
ph	4.2	
As	0.3	-
H ₂	0.008	2.5

According to the solubility test performed by Calspan Corp. the leachate derived from *reveratory dust* contains Cd and Pb in concentration^s_A which are orders of magnitude greater than drinking water standards. Lead is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract. Cadmium is one of the toxicants listed by the NIPDWR at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain cadmium and lead at a *130* and *73*ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting & Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol II page 4-43, App. page 2, 32.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I, page 20-45, Vol III, page 3-11, Contract # 68-01-2552. .

3332 Primary Lead, Blast Furnace Dust (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information: Calspan Corp. has tested a sample of Blast Furnace Dust and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
As	0.177	-
Cd	8.0	14,000
Cr	< 0.01	10
Cu	130	5,350
Hg	< 0.02	-
Mn	0.25	-
Ni	0.09	-
Pb	7.3	148,000
Sb	< 0.2	-
Zn	45	82,000
Se	< 0.05	-
ph	8.8	

According to the Solubility test performed by Calspan Corp. the leachate derived from Blast Furnace Dust contains Cd and Pb in concentrations which are orders of magnitude greater than drinking water standards.

Lead is one of the toxicants listed by the N I P D W R at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Cadmium is one of the toxicants listed by the N I P D W R at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain Cadmium and Lead at a 8 and 7.3 ppm concentration, the heavy metals are not fixed in the Solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - '76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leache into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604 Vol II pages 44-64. App. page 3, 32.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol. I pages 20-45, Vol III pages 12-17. Contract # 68-03-2552.

3332 Primary Lead, Lagoon Dredgings (Smelter) (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information:

Calspan Corp. has tested a sample of Lagoon Dredging (Smelter) and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
As	0.231	-
Cd	11	640 - 700
Cr	< 0.01	28 - 60
Cu	0.53	1490 - 6200
Mg	< 0.02	-
Mn	27	-
Ni	0.08	-
Pb	4.5	115,000 - 140,000
Sb	< 0.2	-
Zn	9.5	80,00 - 132,000
Se	< 0.05	-
ph	6.7	-

According to the Solubility test performed by Calspan Corp. the leachate derived from Lagoon Dredging (Smelter) contains Cd and Pb in concentrations which are orders of magnitude greater than drinking water standards.

Lead is one of the toxicants listed by the N I P D W R at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Cadmium is one of the toxicants listed by the N I P D W R at a concentration of .01 mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain cadmium and lead at a 11 and 4.5ppm concentration, the heavy metals are not fixed in the Solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leache into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vols I, II, III. Vol II, pages 44-64. App. pages 3, 32.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I, pages 20-45. Vol III, pages 12-17. Contract # 68-03-2552.

3333 Primary Zinc Smelting and Refining: Gypsum Cake (C,T)

This waste is classified as hazardous because of its corrosive and toxic characteristics. According to the information EPA has about this waste stream it meets both the RCRA §250.13(b) and §250.13(d) characteristics identifying corrosive and toxic wastes.

According to analyses performed by Calspan, Inc. the water extract of gypsum cake (acid cooling tower) has a pH of 1.4. This data can be found in Calspan Report No. ND-5520-M-1, Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry, Appendices, page 32.

Waste streams with such acidic character present an environmental risk for several reasons. Very low pH wastes if disposed in a sanitary landfill when contacted with rainwater, would leach high concentrations of toxic heavy metals (such as lead) from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly acidic wastes also present a handling risk because of their corrosive properties. Highly acidic wastes streams are also dangerous because they have been known to initiate potentially dangerous reactions when combined with otherwise innocuous wastes.

OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illnesses resulting from the inhalation of toxic gases formed by the reaction^{of} acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes, and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial waste as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Cadmium, chromium, and lead are three of the toxicants listed by the NIPDWR at concentrations of 0.01 mg/l, 0.05 mg/l, and 0.05 mg/l, respectively, because of their toxicity. As explained in the RCRA toxicity background document these concentrations convert

to 0.1 mg/l, 0.5 mg/l, and 0.5 mg/l levels respectively, in the EP extract.

This waste has been shown to contain cadmium, chromium, and lead at the following concentrations according to Calspan Report No. ND-5520-M-1, Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry, Appendices, page 4:

Material Analysed	Contaminant Concentration (ppm)		
	Cd	Cr	Pb
Gypsum Cake (Neutral Cooling Tower)	<10	10	98
Gypsum Cake (Acid Cooling Tower)	<10	9	1,750
Gypsum Cake (Land Dump)	550	11	18,100

Since the water extract of the waste has been shown to contain cadmium, chromium, and lead at the concentrations listed below, according to the same report, page 32, we feel that this waste stream poses a threat to human health and the environment.

Gypsum Cake Leachate (Neutral Cooling Tower)	24	0.04	2.1
Gypsum Cake Leachate (Acid Cooling Tower)	11	0.67	1.0

3333 Primary Zinc Smelting and Refining: Acid Plant Sludge (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA §250.13(d) characteristic identifying toxic waste.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial waste as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into

account the upstream (beyond the site) groundwater concentrations).

Lead is one of the toxicants listed by the NIPDWR at a concentration of 0.05 mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a 0.5 mg/l level in the EP extract.

This waste has been shown to contain lead at a 4,350 ppm concentration according Calspan Report No. ND-5520-M-1, Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry, Appendices, page 4.

Since the water extract of the waste has been shown to contain lead at a 1.3 mg/l concentration, according to the same report, page 32, we feel that this waste stream poses a threat to human health and the environment.

3333 Primary Zinc Smelting and Refining: Anode Sludge (C,T)

This waste is classified as hazardous because of its corrosive and toxic characteristics. According to the information EPA has about this waste stream it meets both the RCRA §250.13(b) and §250.13(d) characteristics identifying corrosive and toxic wastes.

According to analyses performed by Calspan, Inc., the water extract of anode sludge has a pH of 2.5. This data can be found in Calspan Report No. ND-5520-M-1, Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry, Appendices, page 32.

Waste streams with such acidic character present an environmental risk for several reasons. Very low pH wastes if disposed in a sanitary landfill when contacted with rainwater would leach high concentrations of toxic heavy metals (such as lead) from ordinary municipal trash. These heavy metals would otherwise remain bound in the waste matrix. Highly acidic wastes also present a handling risk because of their corrosive properties. Highly acidic waste streams are also dangerous because they have been known to initiate potentially dangerous reactions when combined with otherwise innocuous wastes.

OSW has in its files many damage incidents resulting from the mismanagement of highly acidic or caustic wastes. These include: several deaths and many serious illnesses resulting from the inhalation of toxic gases formed by the reaction^{of} acidic wastes with wastes containing sulfide or cyanide salts, contamination and degradation of groundwater and wells from improper disposal of acidic and caustic wastes, severe burns from handling and contact with acidic and caustic wastes, and several incidents of fish kills from discharge of acidic and caustic wastes. (Refer to corrosivity and reactivity background documents for further information).

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial waste as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Cadmium, chromium, and lead are three of the toxicants listed by the NIPDWR at concentrations of 0.01 mg/l, 0.05 mg/l, and 0.05 mg/l, respectively, because of their toxicity. As explained in the RCRA toxicity background document these concentrations convert to 0.1 mg/l, 0.5 mg/l, and 0.5 mg/l respectively, in the EP

extract.

This waste has been shown to contain cadmium, chromium, and lead at the following concentrations according to Calspan Report No. ND-5520-M-1, Assessment of Industrial Hazardous Waste Waste Practices in the Metal Smelting and Refining Industry, Appendices, page 4:

<u>Material Analysed</u>	<u>Contaminant Concentration (ppm)</u>		
	<u>Cd</u>	<u>Cr</u>	<u>Pb</u>
Fresh Anode Sludge	12	10	170,000
Old Anode Sludge (from dump)	1,400	8	87,000

Since the water extract of the waste has been shown to contain cadmium, chromium, and lead, at concentrations of 12 ppm, 0.05 ppm, and 2.0 ppm respectively, according to the same report, page 32, we feel that this waste stream poses a threat to human health and the environment.

3339 Primary Tungsten, Digestion Residue (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information:
 Calspan Corp. has tested a sample of Digestion Residue and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
As	< 0.003	-
Cd	0.15	-
Cr	0.05	-
Cu	90	38,000
Hg	< 0.02	-
Mn	75	-
Ni	60	-
Pb	0.7	90
Sb	< 0.2	< 10
Zn	1.5	850
Se	< 0.05	-
ph	6.4	

According to the solubility test performed by Calspan Corp. the leachate derived from Digestion Residue contains Cd and Pb in concentrations which are orders of magnitude greater than drinking water standards.

Lead is one of the toxicants listed by the N I P D W R at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Cadmium is one of the toxicants listed by the N I P D W R. at a concentration of .00mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain Cadmium and lead at a 0.15 and 0.7ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices
in the Metal Smelting and Refining Industry Appendices. April 1977
Contract # 68-01-2604. Vol II 178-193. App. pages
8, 32.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste
from Metals. Inorganic Chemicals and Related Industries.
Vol I, page 20-45. Vol III, page 53-58. Contract # 68-01-2552.

3332 Primary Lead, Sinter Scrubber Sludge (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information. Calspan Corp. has tested a sample of Sinter Scrubber Sludge and found the following:

<u>Contaminent</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
As	-	-
Cd	9.1	900
Cr	< 0.01	11
Cu	2.6	10,400
Hg	< 0.02	0.1
Mn	1.3	-
Ni	< 0.05	-
Pb	5.5	169,000
Sb	< 0.2	-
Zn	7.5	25,600
Se	0.17	-
ph	6.8	

According to the solubility test performed by Calspan Corp. the leachate derived from Sinter Scrubber Sludge contains Cd and Pb in concentration^S_A which are orders of magnitude greater than drinking water standards. Lead is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract. Cadmium is one of the toxicants listed by the NIPDWR at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain cadmium and lead at a 9.1 and 55ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604 Vol II pages 44-64. App. page 3, 32.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol. I pages 20-45, Vol III pages 12-17. Contract # 68-03-2552.

3313

3313 Ferrochrome Silicon Furnace Emission Control Dust/Sludge (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information.

Calspan Corp. has tested a sample of Ferrochrome Silicon Emission Control Dust/Sludge and found the following:

<u>Contaminent</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Cr	190	41
Cu	0.44	45
Zn	0.3	700
Mn	0.1	700
Ni	< 0.05	
Pb	1.5	
Ph	8.8	

According to the Solubility test performed by Calspan Corp. the leachate derived from ferrochrome silicon emission control dust/sludge contains Cr and Pb in concentrations which are greater than drinking water standards.

Chromium and lead are toxicants listed by the N I P D W R at a concentration of .05mg/l because of their toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain chromium and lead at a 190 and 1.5ppm concentration, the heavy metals are not fixed in the Solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leache into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices
in the Metal Smelting and Refining Industry Appendices.

April 1977. Contract # 68-01-2604 Vol III, page 97-144.

App. pages 29, 35.

3313 Ferrochrome Furnace Emission Control Dust/Sludge (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information:

(1) Calspan Corp. has tested a sample of Ferrochrome Emission Control Dust/Sludge and found the following:

<u>Contaminent</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Cr	710	3,390
Cu	0.2	54
Pb	0.7	300
Zn	0.09	14,000
Mn	0.07	7,200
pH	12.3	

According to the Solubility test performed by Calspan Corp. the leachate derived from Ferrochrome Emission Control Dust/ Sludge contains Cr and Pb in concentrations which are orders of magnitude greater than drinking water standards.

Chromium and Lead are toxicants listed by the N I P D W R at a concentration of .05mg/l because of their toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain chromium and lead at a 710 and .07ppm concentration, ^{respectively,} the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leache into and contaminate the groundwater. The Geraghty and Miller¹ report indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices
in the Metal Smelting and Refining Industry Appendices.

April 1977. Contract # 68-01-2604 Vol III, pages 97-144.

App. pages 29, 35.

3339 Primary Antimony, Pyrometallurgical Blast Furnace Slag (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information:

Calspan Corp. has tested a sample of Blast Furnace Slag and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Sb	100	18,000
Pb	< 0.2	66
Cu	5	50
Zn	1.7	500
Ni	< 0.05	-
Mn	0.01	-
Cr	< 0.01	-
As	3.00	-
Cd	0.09	-
Se	< 0.05	-
ph	9.2	-

According to the Solubility test performed by Calspan Corp. the leachate derived from Blast Furnace Slag contains As in concentration which is orders of magnitude greater than the drinking water standard.

Arsenic is one of the toxicants listed by the N I P D W R at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain Arsenic at a 3ppm concentration, the heavy metal is not fixed in the solid matrix. It is therefore available to migrate down through a disposal site to groundwater. Thus we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leache into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604. Vol II page 132-153. App. page 6, 32.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I, page 20-45. Vol III, page 34-39. Contract # 68-03-2552.

3341 Secondary Lead, Scrubber Sludge from SO₂ Emission Control,
Soft Lead Production (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information.

Calspan Corp. has tested a sample of SO₂ Scrubber Sludge and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	1.3	25
Cd	5	340
Cr	0.05	30
Cu	0.5	20
Mn	0.21	120
Pb	2.5	53,000
Sb	< 0.2	1,100
Sn	1.6	-
Ni		5
pH	8.4	

According to the solubility test performed by Calspan Corp. the leachate derived from SO₂ Scrubber Sludge contains Cd and Pb in concentrations which are orders of magnitude greater than drinking water standards.

Lead is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the TEP extract.

Cadmium is one of the toxicants listed by the NIPDWR at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the TEP extract.

Since the water extract of the waste has been shown to contain cadmium and lead at a 5 and 2.5ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leache into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting & Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol II page 262-282, App. page 10,34.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I page 20-45, Vol III page 12⁰_A126, Contract # 68-01-2552.

3341 Secondary Lead, White Metal Production, Furnance Dust (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA basis this classification on the following information: .

Calspan Corp. has tested a sample of Furnance Dust and found the following:

<u>Contaminent</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	4,000	120,000
Cd	230	900
Cr.	12	150
Cu	45	400
Mn	4	5
Pb	24	120,000
Sb	< 0.02	1800
Sn	860	117,000
Ni		5
pH	3.9	

According to the solubility test performed by Calspan Corp. the leachate derived from Furnance Dust contains Cd, Cr and Pb in concentrations which are several orders of magnitude greater than drinking water standards.

Chromium and Lead are toxicants listed by the NIPDWR at a concentration of .05mg/l because of their toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Cadmium is one of the toxicants listed by the NIPDWR at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain Cd, Cr, and Pb at a 230, 12, and 24ppm concentration, the heavy metals are not fixed in the Solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leache into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol II page 262-282 App. page 10,34.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I page 20-45, Vol III page 120-126, Contract # 68-03-2552.

3341 Secondary Copper, Pyrometallurgical Blast Furnance Slag (T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about the waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information. Calspan Corp. has tested a sample of Blast Furnance Slag and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate Conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	55	75,000
Cd	1.0	< 5
Cr	0.03	20
Cu	170	12,000
Mn	0.3	7,000
Pb	6	2,600
Sb	< 0.2	< 100
Sn	< 0.2	-
Ni		260
ph	9.4	

According to the solubility test performed by Calspan Corp. the leachate derived from Blast Furnance slag contains Cd and Pb in concentration^s_A which are orders of magnitude greater than drinking water standards. Lead is one of the toxicants listed by the NIPDWR at a concentration of .05mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract. Cadmium is one of the toxicants listed by the NIPDWR at a concentration of .01mg/l because of its toxicity. As explained in the RCRA toxicity background document this converts to a .1mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain cadmium and lead at a 1.0 and 6ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller¹ report indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting & Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol II page 239-261, App. page 9, 34.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I, page 20-45, Vol III, page 110-119, Contract # 68-01-2552. .

3341 Secondary Copper, Electrolytic Refining Waste Water Sludge

(T)

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA S250.13d characteristic identifying toxic wastes.

EPA bases this classification on the following information:

Calspan Corp. has tested a sample of Electrolytic Refining waste water sludge and found the following:

<u>Contaminant</u>	<u>Dist. H₂O Leachate conc. ppm</u>	<u>Waste Sample Analysis ppm</u>
Zn	< 0.01	1,850
Cd	0.05	10
Cr	7.1	94,000
Cu	0.63	170,000
Mn	0.06	-
Pb	0.5	900
Sb	< 0.2	-
Sn	< 0.2	20,000
Ni	-	16,600
ph	8.6	

According to the solubility test performed by Calspan Corp. the leachate derived from Electrolytic Refining waste water sludge contains Cr and Pb in concentrations which are orders of magnitude greater than drinking water standards.

Chromium and Lead are toxicants listed by the NIPDWR at a concentration of .05mg/l because of their toxicity. As explained in the RCRA toxicity background document this converts to a .5mg/l level in the EP extract.

Since the water extract of the waste has been shown to contain chromium and lead at a 7.1 and 0.5ppm concentration, the heavy metals are not fixed in the solid matrix. They are therefore available to migrate down through a disposal site to groundwater. Thus, we feel that this waste stream poses a threat to human health and the environment.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

References

Calspan Corp. Assessment of Industrial Hazardous Waste Practices in the Metal Smelting & Refining Industry Appendices. April 1977. Contract # 68-01-2604, Vol II, pages 239-261, App. page 9, 34.

Battelle. Cross Media Impact of the Disposal of Hazardous Waste from Metals. Inorganic Chemicals and Related Industries. Vol I, page 20-45, Vol III, page 110-119. Contract # 68-03-2552.

333417 Secondary Aluminum Smelting and Refining: Secondary
Aluminum Dross Smelting High Salt Slag (T)

This waste is classified as hazardous because of its toxic characteristics. According to information EPA has about this waste stream it meets the RCRA §250.13(d) characteristic identifying toxic wastes.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial waste as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller Report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells

exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Chromium and lead are two of the toxicants listed by the NIPDWR at concentrations of 0.05mg/l because of their toxicity. As explained in the RCRA toxicity background document this converts to a 0.5mg/l level in the EP extract.

This waste has been shown to contain chromium and lead concentrations 60 ppm and 300 ppm respectively, according to Calspan Report No. ND-5520-M-1, Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry, Appendices, page 11.

Since the water extract of the waste has been shown to contain chromium and lead concentrations of 1.5 ppm and 0.24 ppm respectively, according to the same report, page 36, we feel that this waste stream poses a threat to human health and the environment.

3333 Primary Zinc Smelting and Refining: Cadmium Plan^t Residue (T)
A

This waste is classified as hazardous because of its toxic characteristics. According to the information EPA has about this waste stream it meets the RCRA §250.13(d) characteristic identifying toxic wastes.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of drinking water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial waste as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site waste disposal sites toxic heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium, etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account

the upstream (beyond the site) groundwater concentrations).

Cadmium, chromium, and lead are three toxicants listed by the NIPDWR at concentrations 0.01 mg/l, 0.05 mg/l, and 0.5 mg/l respectively, because of their toxicity. As explained in the RCRA toxicity background document these concentrations convert to 0.1 mg/l, 0.5 mg/l, and 0.5 mg/l levels, respectively, in the EP extract.

This waste has been shown to contain cadmium, chromium, and lead at concentrations of 280 ppm, and 24 ppm, and 215,000 ppm, respectively, according Calspan Report No. ND-5520-M-1, Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry, Appendices, page 4.

Since the water extract of the waste has been shown to contain cadmium, chromium, and lead at concentrations of <0.01 ppm, 0.02 ppm, and 9.0 ppm, respectively, according to the same report, page 32, we feel that this waste stream poses a threat to human health and the environment.

3691 Lead acid battery production wastewater
treatment sludge (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Booz-Allen has tested a sample of lead acid battery production wastewater treatment sludge and found the following.

<u>contaminant</u>	<u>conc. kg/kg product</u>
Pb as PbSO ₄ & Pb(OH) ₂	150.00

The data presented are available from:

Booz-Allen. A Study of Hazardous Waste Materials, Hazardous Effects and Disposal Methods. Vol. 1-14. PB - 221 - 466.
Contract #68 - 03 - 0032.

and

Versar, Inc. Assessment of Industrial Hazardous Practices, Storage and Primary Batteries. PB - 241 - 204/7WP. 1975.

The "Handbook of Industrial Waste Compositions in California" - 1978, indicates that a load of this waste had the following composition (Reference 9, p. 10).

Storage battery wastewater treatment sludge - lead hydroxide
load size - 8 yards

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to

0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5, mg/l respectively in the EP extract.

This waste has been shown to contain lead at 150kg/1000 kg product according to PB - 221 - 466, A Study of Hazardous Waste Materials, Hazardous Effects and Disposal Methods; and PB - 241 - 204/7WP, Assessment of Industrial Hazardous Practices, Storage and Primary Batteries.

Because of the toxicity of lead and the solubility of the hydroxide salt (slightly soluble in aqueous solution, soluble in acidic solution) this waste stream is to be considered hazardous.

3691 Lead acid storage battery production & clean-up wastes from cathode and anode paste production (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Booz-Allen has tested a sample of lead acid storage battery production clean-up waste from cathode and anode paste production and found the following.

<u>contaminents</u>	<u>conc. kg/1000 kg product</u>
Pb as PbO, Pb, PbO ₂	67.00

The data presented are available from:

Booz-Allen. A Study of Hazardou Waste Materials, Hazardous Effects and Disposal Methods. Vol. 1-14. PB - 221 - 466.

Contaract #68 - 03 - 0032.

and

Versar, Inc. Assessment of Industrial Hazardous Practices, Storage and Primary Batteries. PB - 241 - 204/7WP. 1975.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to

0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5, mg/l respectively in the TEP extract.

This waste has been shown to contain lead at 67.0 kg/1000 kg product according to Pb - 221 - 466, A study of Hazardous Waste Materials, Hazardous Effects and Disposal Methods; and PB - 241 - 204/7WP, Assessment of Industrial Hazardous Practices, Storage and Primary Batteries.

Because of the toxicity of lead this waste is to be considered hazardous.

3691 Nickel cadmium battery production wastewater treatment sludges (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Booz-Allen has tested a sample of nickel cadmium battery production wastewater treatment sludges and found the following.

<u>contaminant</u>	<u>conc. kg/1000 kg product</u>
Cd as Cd(OH) ₂	5.34
Ni as Ni(OH) ₂	1.66

The data presented are available from:

Booz-Allen. A Study of Hazardous Waste Materials, Hazardous Effects and Disposal Methods. Vol 1-14. PB - 221 - 466. Contract #68 - 03 - 0032.

and

Versar, Inc. Assessment of Industrial Hazardous Practices; storage and Primary Batteries. PB - 241 - 204/7WP. 1975.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s. a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to

0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5, mg/l respectively in the EP extract.

This waste has been shown to contain cadmium at 5.34 kg/1000 kg product, according to PB - 241 - 204, Assessment of Industrial Hazardous Practices, Storage and Primary Batteries.

Because of the toxicity of Cadmium and the solubility (soluble in acid solution) of cadmium hydroxide this waste is considered hazardous.

3691 Cadmium silver oxide battery production wastewater treatment sludge (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Booz-Allen has tested a sample of cadmium silver oxide battery production wastewater treatment sludge and found the following.

<u>contaminent</u>	<u>conc. kg/1000 kg product</u>
Cd as Cd(OH) ₂	5.34
Ag as Silver Oxide	2.24

The data presented are available from:

Booz-Allen. A Study of Hazardous Waste Materials, Hazardous Effects and Disposal Methods. Vol 1-14. PB - 221 - 446. Contract #68 - 03 - 0032.

and

Versar, Inc. Assessment of Industrial Hazardous Practices, Storage and Primary Batteries. PB - 241 - 204/7WP. 1975.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leach into and contaminate the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (s. a. arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to

0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5 mg/l respectively in the EP extract.

This waste has been shown to contain cadmium and silver at 5.34 and 2.24 kg/1000 kg product respectfully, according to PB 241-204/7WP, Assessment of Industrial Hazardous Practices, Storage and Primary Batteries.

Because of the toxicity of cadmium and silver and the solubility of these salts (soluble in acid solution), this waste is to be considered hazardous.

3691 Mercury cadmium battery production wastewater treatment
sludges (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Booz-Allen has tested a sample of mercury cadmium battery production wastewater treatment sludge and found it to contain silver, cadmium and mercury.

(1,022 kg/yr of this waste are landfilled)

Note: This listing will include other storage batteries that are not otherwise listed, that is, Zinc-Silver Oxide & Silver lead as an example

The data presented are available from:

Booz-Allen. A Study of Hazardous Waste Materials, Hazardous Disposal Methods. Vol 1-14. PB 221 - 466. Contract #68 - 03 - 0032.

and

Versar, Inc. Assessment of Industrial Hazardous Practices; Storage and Primary Batteries. PB - 241 - 204/7WP. 1975.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to

0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5 mg/l respectively in the TEP extract.

This waste has been shown to contain cadmium, silver, and mercury at a total concentration of 1,022.3 kg/1000 kg product, according to PB - 241 - 204/7WP, Assessment of Industrial Hazardous Practices, Storage and Primary Batteries.

Because of the toxicity of cadmium, mercury and silver, this waste is to be considered hazardous.

3692 Magnesium carbon battery production chromic acid
wastewater treatment sludges (T)

This waste is classified as hazardous because of its toxic characteristic. According to the information EPA has on this waste stream it meets RCRA §250.13d characteristic identifying toxic waste.

EPA bases this classification on the following information.

(1) Booz-Allen has tested a sample of magnesium carbon battery production chromic acid wastewater treatment sludges and found the following.

<u>contaminant</u>	<u>conc. kg/1000 kg product</u>
Cr as chromium hydroxide and chromium carbonate	11.07

The data presented are available from:

Booz-Allen. A Study of Hazardous Waste Materials, Hazardous Effects and Disposal Methods. Vol 1-14. PB 221-446. Contract #68 - 03 - 0032.

and

Versar, Inc. Assessment of Industrial Hazardous Practices, Storage and Primary Batteries. PB 241-204/7WP. 1975.

The National Interim Primary Drinking Water Regulations (NIPDWR) set limits for chemical contamination of Drinking Water. The substances listed represent hazards to human health. In arriving at these specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. (For a complete treatment of the data and reasoning used in choosing the substances and specified limits please refer to the NIPDWR Appendix A-C Chemical Quality, EPA-6570/9 - 76 - 003).

A primary exposure route to the public for toxic contaminants is through drinking water. A large percentage of drinking water finds its source in groundwater. EPA has evidence to indicate that industrial wastes as presently managed and disposed often leaches into and contaminates the groundwater. The Geraghty and Miller report¹ indicated that in 98% of 50 randomly selected on-site industrial waste disposal sites, toxic heavy metals were found to be present, and that these heavy metals had migrated from the disposal sites in 80% of the instances. Selenium, arsenic and/or cyanides were found to be present at 74% of the sites and confirmed to have migrated at 60% of the sites.

At 52% of the sites toxic inorganics (such as arsenic, cadmium etc.) in the groundwater from one or more monitoring wells exceeded EPA drinking water limits (even after taking into account the upstream (beyond the site) groundwater concentrations).

Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are toxicants listed by the NIPDWR at concentrations of 0.05, 1.00, 0.010, 0.05, 0.05, 0.002, 0.01, and 0.05, mg/l respectively because of their toxicity. As explained in the RCRA toxicity background documents these concentrations convert to

0.5, 10.0, 0.1, 0.5, 0.5, 0.02, 0.1, and 0.5, mg/l respectively in the EP extract.

This waste has been shown to contain chromium levels of 11.07 kg/kg product, according to PB 241-204, Assessment of Industrial Hazardous Practices, Storage and Primary Batteries.

Because of the toxicity of chromium and the solubility of the ^{SALT} hydroxide (in the presence of chloride ion) this waste is to be considered hazardous.

BD-6

DRAFT

BACKGROUND DOCUMENT

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

SECTION 3001 - IDENTIFICATION AND LISTING OF
HAZARDOUS WASTE

SECTION 250.14 - HAZARDOUS WASTE LISTS

RADIOACTIVE WASTE

DECEMBER 15, 1978

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

This document provides background information and support for regulations which have been designed to identify and list hazardous waste pursuant to Section 3001 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft to support the proposed regulations. As new information is obtained, changes may be made in the background information and used as support for the regulations when promulgated.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made some changes in the proposed regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

Alan S. Corson
Hazardous Waste Management Division (WH-565)
Office of Solid Waste
U. S. Environmental Protection Agency
Washington, D.C. 20460

IDENTIFICATION AND LISTING OF HAZARDOUS RADIOACTIVE
WASTE PURSUANT TO THE RESOURCES CONSERVATION AND
RECOVERY ACT (RCRA) OF 1976
Application of Generic Numerical Criteria

I. INTRODUCTION

Numerical criteria were considered for use as uniform measures of hazard for radioactive waste in the initial development of Section 3001. This approach was viewed as the optimal one at the time because it provides relative ease of implementation by both regulator and the industry being regulated, and insures consistency of regulation with respect to criteria being proposed for other hazard characteristics under RCRA. Uniform criteria, for example, could be applied to all waste streams, regardless of origin (except where restricted by the Act), where elevated concentrations of natural radionuclides are present. These criteria would be used both to determine compliance with RCRA permit requirements and eligibility for relief from Section 3001 listing.

The development and application of this regulatory approach, however, is predicated on the availability of supporting data. The extent to which data is available to characterize various wastes and the extent to which this data substantiates the correlation of hazard level (radiological impact) with waste concentration (i.e., radionuclide content), will determine whether uniform criteria can be practically implemented. For diffuse radium-containing waste, supporting information is largely available for only the phosphate and

uranium industries, where the radiological impact of major waste streams has already been evaluated to a large degree. This particular body of data is supportive of a uniform hazard criterion for radium-226, the critical radionuclide involved, between 5 and 10 pCi/g, based on known radon emanation and diffusion rates, with the radium-radon exposure pathway being the prime one of concern.

The following discussion serves a two-fold purpose: 1) to provide rationale and general background for the proposed classification of certain wastes containing radium-226 as hazardous under RCRA, and 2) to propose a framework for development and implementation of numerical concentration criteria for these and other wastes in Section 3001. The Agency will pursue the development of such criteria on a timely schedule and requests that interested parties submit any information or comments they feel relevant to this development. A determination will be made by the Agency shortly following the closing of the ANPR comment period concerning the feasibility of this latter approach for regulating radioactive wastes under Subtitle C of RCRA.

II. BACKGROUND

Under Section 1004(5) of the "Resource Conservation and Recovery Act of 1976" (RCRA or "the Act") solid waste materials which may cause an increase in mortality are termed hazardous waste, and therefore must be considered under the hazardous waste management provisions of Subtitle C of the Act. Since all radioactive materials satisfy this

criterion in the absolute sense, it is necessary to consider all wastes which contain significant concentrations of radioactivity. Excluding those activities or substances subject under the Atomic Energy Act of 1954 (as required by RCRA Section 1006(a)), the radionuclides of concern can be categorized as either naturally-occurring or accelerator-produced.

Naturally-occurring radioactive materials are those containing radionuclides which are present in the earth's crust or atmosphere as the result of natural processes. Among these, uranium-238, uranium-235, and thorium-232, and their respective decay products, as well as potassium-40, carbon-14, and tritium, are the principal radionuclides of interest. The latter three are isotopes of elements which are significant constituents of human tissues. From the standpoint of avoidable human radiation exposure, though, only members of the uranium and thorium decay series are usually significant.

Nuclides of the uranium and thorium decay series are present in elevated concentrations in certain minerals, and are typically redistributed by extraction processes, especially in the mining and milling of uranium, thorium, and phosphates. These large volume sources can be characterized as low-level diffuse wastes by virtue of their relatively low specific activity. Radium-226 concentrations in uranium mill tailings, for example, on the average range from 600 to 700 picocuries per gram of tailings (Swift, 1976), with maximum concentrations in excess of 1500 pCi/g (Hendricks, 1978). This

compares with the average terrestrial concentration of about one picocurie per gram for igneous or sedimentary rocks, and about half a picocurie per gram for soil (NCRP 45, 1975, UNSCEAR, 1977). For phosphate mining and milling wastes, average radium concentrations of 30 to 60 picocuries per gram for slimes, byproduct gypsum, and byproduct slag have been observed (Guimond, 1975).

Discrete radium sources, which are widely used in medical and commercial applications, are potentially hazardous if not handled properly. Overall use is now decreasing, due in large measure to technological advances and radiological health considerations. However, according to the most recent survey available, over 1300 curies of radium (1.3 kg) have been distributed by various manufacturers through 1971 (Pettigrew, et al., 1971). Of this amount, State licensure and registration data accounted for usage of 480 curies of radium at 4200 facilities. Approximately 330 curies of this total are contained in about 50,000 medical sources at 2300 medically related facilities.

Excluding those sources known to be in disposal or storage, the remaining ones are generally either unaccounted for or have been incorporated as low activity sources into various consumer products (e.g., timepieces, smoke detectors, gauges, etc.). Such products may contain up to one millicurie of radium-226 (UNSCEAR, 1977).

A wide variety of accelerator-produced radioisotopes are in use today, particularly in the area of medical and biological applications

(NRC, 1977). Cobalt-57 sources, for example, have widespread use in a number of items, such as anatomical markers which are designed to enhance the ability of the physician to outline areas of the body during radiography. Other sources such as cesium-131, mercury-197 and bismuth-206 are used in various organ scanning procedures.

Due to physical and chemical requirements for their application in medicine, the majority of the material used is small in quantity and short-lived, with half-lives of minutes to days. Cobalt-57, with a half-life of 0.25 year, for the most part represents the upper bound in longevity for those materials in widespread use. Their disposal as radioactive waste is therefore unlikely to pose a significant problem, since they can easily be retained for a sufficient amount of time to insure sufficient decay before disposal. Wastes from industrial and research applications of accelerator-produced radionuclides likewise do not represent a hazard for the same reasons.

III. IDENTIFICATION OF HAZARDOUS RADIOACTIVE WASTE

Radium-226, a radionuclide in the uranium-238 series (Figure 1), is the only radionuclide proposed to be identified as hazardous in waste materials under the Act at this time. The potential health impact of this radionuclide is associated primarily with its emissions of gamma rays and alpha particles from it and its decay products. Listing of radium-226 is based on its persistence and relative abundance in the environment, radiotoxicity, and presence in waste

materials as a result of man's activity , which together result in a relatively higher degree of potential hazard for it than for other radioactive materials discussed above. On a more pragmatic basis, radium-226 requires regulatory consideration under the Act because of the potential health hazard to the public from existing uranium mining and wastes in the Western plateau, phosphate mining and milling wastes in Florida and Idaho, and other mineral extraction wastes for which uniform Federal or State regulations do not exist.

The following radioactive materials, among others, will be reviewed for possible future identification:

Thorium-228

Thorium-230

Lead-210

Polonium-210

Radium-224

Radium-228

Bismuth-207

IV. RATIONALE FOR REGULATION OF RADIOM-226 UNDER RCRA

A. Persistence and Relative Abundance in Environment

Radium-226 is an alpha emitter with a half-life of 1620 years which decays to the radioactive noble gas, radon-222. Radon itself, decays with a half-life of 3.8 days, leading to a series of

short-lived, alpha emitting radionuclides which decay in succession to the longer lived lead-210 (half-life of 22 years), polonium-210 (half-life of 138 days) and eventually, lead-206, which is stable. Being largely an alpha emitter (96%), the gamma component usually associated with radium-containing materials is primarily due to daughter decay.

Radium-226 is naturally present in soils throughout the United States in reported average concentrations ranging from about 0.2 to 3 picocuries per gram. Certain types of rock, such as igneous, have been found to contain a slightly higher average content of radium than other types, such as sandstone and shale. Likewise, for specific mineral ores, such as coal and phosphate, increased radium concentrations as much as an order of magnitude above "background" levels have been noted. Increased concentrations such as these are primarily the result of geochemical action over time.

B. Radiotoxicity

The ubiquitousness of radium in the environment and its usefulness in various commercial applications has led to extensive epidemiological and health effects data on human exposure to radium and its decay products. The reported instances of occupationally-related bone cancer and aplastic anemia in radium dial painters is a classic example. During the years 1917 to 1924, approximately 2,000 individuals were employed in the luminous dial

industry in this country, where radium containing phosphorescent zinc sulfide paint was used. The "tipping" of paint brushes by the painters with their lips led to the continuous ingestion of radium and eventually to clinical manifestations. Since the initial radium dial painter studies of the 1920's, over 700 cases of radium ingestion have been surveyed. Fifty deaths in the United States have been attributed directly to radium exposure and more are likely to have been unreported.

As a general rule, radium is transported in the environment and absorbed by plants in a manner similar to calcium, which is necessary for plant metabolism. Since it has chemical characteristics similar to calcium, radium is likewise absorbed and enters the food chain. The degree of impact on humans through this pathway is dependent upon the characteristics of the soil, the concentration of radium available for uptake, and whether the plant is directly eaten (i.e., the degree of concentration by animal intermediaries). The ingestion of radium through drinking water has also been of concern where elevated concentrations exist by virtue of either natural or technically enhanced sources. After ingestion, radium concentrates in bone where the tabecular and surface tissue received the highest exposure.

Depending on whether an absolute or relative risk estimate for bone cancer, leukemia, and all other cancers is assumed as calculated in the National Academy of Sciences-BEIR⁸ report (1972), an

⁸Biological Effects of Ionizing Radiation

annual rate of total cancers from radium ingestion of 5 or 20 per million person-rem/year is estimated, respectively. Therefore, applying the International Commission on Radiological Protection (ICRP) estimated dose to bone of 0.15 rem per year from an ingestion rate of 10 pCi of radium-226 per day, the annual rate of induced cancer is between 0.7 to 3 cancers per year per million exposed persons (EPA, 1976b).

With regard to external exposure, the penetrating gamma radiation of the radium decay products is of primary concern. For such "whole body" exposure, proximity to the source, the size and geometry of the source, and its activity are factors affecting the degree of exposure. Assuming an exposed population, total body irradiation would be expected to result in 200 lethal and 200 non-lethal cancers per year per 10 annual person-rem, as well as 200 serious genetic abnormalities per rem per 10 live births (NAS/BEIR, 1972).

The major public health hazard of radium, however, is not due to ingestion or external exposure, but more often is due to inhalation of its decay products. Radon-222, the first generation decay product of radium-226, is a radioactive noble gas which has a relatively short half-life (3.8 days). The decay products of radon-222, several of which decay by alpha particle emission, through inhalation can deposit in and irradiate the lung. The observed result of exposure to radon decay products at relatively higher levels of cumulative exposure has been the induction of lung cancer. This response has been demonstrated by extensive epidemiological surveys of underground

uranium miners in this country and miners in a variety of mining operations in other countries. This data indicates an increase in lung cancer over normal incidence of approximately 2 to 5 percent per working level month^{*} cumulative exposure (Ellett, 1977). The basis of this estimate and the qualifying factors related to its derivation are given in Ellett, 1977.

Data are not available to demonstrate unequivocally a linear, non-threshold dose-effect relationship at doses as low as those usually found in the environment. However, the data from the miner studies are consistent with a linear non-threshold hypothesis down to the higher levels measured in some structures in Grand Junction, Colorado, and in Central Florida. It is therefore prudent to assume that on the basis of this as well as more general experience with radiation exposure, that individuals occupying structures with elevated levels of radon are subject to a potential hazard for induction of lung cancer in proportion to the total accumulation of exposure they experience.

C. Ubiquitousness of Radium-226 in Waste Materials

Due to its presence in byproducts and wastes of a number of

^{*}Working level month (WLM): exposure to 1 working level (WL) for 170 hours (a working month). Continuous exposure to radon daughters at 1 WL for one year is equivalent to 36 WLM. A working level is defined as any combination of short-lived radon daughter products in one liter of air that can result in the ultimate emission of 1.3×10^5 MeV of alpha energy.

mineral extraction industries, as well as its continued application in many medical sources and commercial products, the total quantity of radium in distribution has increased steadily. The following is a partial list of sources and processes in which radium may be found in significant quantities:

Ore mining and milling

(including tailings, slag, waste rock, etc., from the uranium, thorium, zirconium, heavy metals, and phosphate industries)

Fossil fuel use (ash and scrubber sludge)

Water Treatment (sludge)

Commercial products, including:

Smoke detectors

Lightning rods

Static eliminators

Radioluminous sources

Industrial gauges

Vacuum tubes

Vacuum gages

Ion generators

Well logging devices

Calibration and check sources

Educational materials

Medical diagnostic and therapeutic sources including:

Needles, capsules and tubes

Plaques

Nasopharyngeal applicators

Radon seeds

Of these sources, wastes from mineral extraction and discarded radium sources represent the major ones of public health concern. Their production and distribution into the general environment may result in contamination with a potential for long-term, or chronic, public health impact and, in the case of discrete sources, more acute hazards. Continuing efforts to assess and control potential hazards due to radium have been ongoing at the State and Federal level, as evidenced by the EPA and the State of Florida phosphate program, the joint Federal/State mill tailings project, and reports of the Conference of Radiation Control Program Directors (1977) and NRC's Task Force on Naturally Occurring and Accelerator Produced Radioactive Materials (NARM) (1977).

a. Diffuse Radium-containing Wastes

This category consists of waste which contains radium dispersed throughout a non-radioactive medium at a relatively low concentration, which would make chronic exposure to the waste and the decay products of radium of principle concern. The elevated radium content of these wastes results primarily from the extraction and processing of mineral ores, which due to geochemical factors are enriched in radium. These process sources, examples of which are listed in Table 1, are large in

TABLE 1

DIFFUSE RADIUM-CONTAINING WASTES
(PARTIAL LISTING)*

Process Source	Waste Material	Primary Locality of Production	Average Ra-226 Concentration (pCi/g)	Annual Quantity Produced (million MT)	Total Average Annual Activity (Ci)
Uranium ore milling	tailings	Western Plateau	600-700 (a)	9 (i)	6000
Phosphate mining	slimes	Florida	45 (b)	32 (b)	1500
	sand tailings		8 (b)	49 (b)	400
	mining debris		13 (c)	-	-
Phosphoric Acid production	gypsum	Florida	33 (b)	23 (b)	800
		Idaho	23 (d)	-	-
		North Carolina	-	-	-
Elemental phosphorus production	slag	Florida	56 (b)	4.5 (b)	200
		Idaho	35 (c)		
		Florida/Tennessee**	18 (b)		
	Fluid bed pills	Florida	-		
		Idaho	13 (e)		
Zirconium extraction	chlorinator res. clarifier sludge	Oregon	150-1300(f)	0.3	
Water Treatment	sludge (lime)	National	6-9 (g)	-	-
Coal Combustion	ash	National	1-8	-	-

(Table cont'd)

* Others for which substantive data is unavailable include some heavy metal, copper, rare earth, and coal extraction and processing wastes.

** One plant using a blend of Tennessee and Florida Ores.

(a) Swift, et al., 1976

(b) Guimond and Windham, 1975

(c) Eadie, et al., 1977a

(d) Eadie, et al., 1977b

(e) University of Florida, 1977

(f) Oregon State Health Division, 1977

(g) Brink, et al., 1976

(h) Martin, 1970

(i) Hendricks, 1978

volume and therefore disposal is less practicable than for discrete radium sources. One non-mineral extraction waste listed, water treatment sludge, results from the removal of various contaminants, including radium, from drinking water in order to satisfy Safe Drinking Water regulations (1976b).

Because of the relatively low activity and diffuse configuration of these wastes, the exposure pathways of major concern are inhalation from radon emanation and, to a lesser degree, direct gamma irradiation. Both pathways of exposure have been found in structures constructed with uranium tailings material in Grand Junction, Colorado, and on phosphate reclaimed land in Central Florida. Concerns resulting from the use of radium-containing raw materials, such as by-product gypsum and coal ash, in construction materials have also been raised (O'Riordan, et al , 1972; Hamilton, E.I., 1972; Moeller and Underhill, 1976). However, while uranium, phosphate, and zirconium ores characteristically contain elevated radium concentrations, the radium content of coal, heavy metal source ores, and water treatment sludge, among others, vary considerably by virtue of geochemical and hydrogeological factors. Some waste materials, such as coal ash, may also have physical properties related to their formation which would decrease radon emanation and diffusion. The public health hazard posed by these wastes, therefore, would vary considerably as a result of these factors.

b. Discrete Radium Sources

The radiological characteristics of radium have encouraged its use in numerous medical, industrial, and military applications, as well as in consumer products, as shown in Table 2. It is extremely difficult, though, to quantify the potential waste source resulting from this broad use over the past several decades. At present, no reporting is required on a national scale of the amount of radium disposed or recycled. To give some indication, since 1964, over 2,300 disposed sources have been sent voluntarily to the Federal radium repository now operated by EPA at Montgomery, Alabama.

In a recent FDA report (1975), roughly twice as much radium was reportedly used in medical as in non-medical applications, with 330 curies contained in 50,000-55,000 medical sources at 2300 facilities, and 150 curies for non-medical applications at 1900 facilities. Radium users constitute about 18% of users of radioactive materials who are subject to licensing by State programs having that authority.* The NRC Task Force on the Regulation of Naturally Occurring and Accelerator-Produced Radioactive Materials (NRC, 1977)

*This percentage, therefore, excludes the use of radium sources in Federal facilities. Of the total 50 States, which individually have the regulatory authority to establish programs for licensing or registering users of NARM, 30 States have licensing programs and 16 have registration programs. The remainder have limited programs or in one case, no program.

TABLE 2

DISCRETE RADIUM-CONTAINING SOURCES*

Source Type	Product	Activity per Source	Uncontrolled Distribution to public
<u>CONSUMER PRODUCTS</u>			
1. Radioluminous Products	Timepieces	0.1-3 μ Ci	Wide
	Aircraft Instruments	\leq 20 μ Ci	Limited**
2. Electronic and electrical devices	Electronic tubes	0.1 μ Ci	Wide
	Fluorescent lamp starters	1 μ Ci	Wide
3. Antistatic devices	Lightning Rod	0.2-1mCi	Wide
	Antistatic devices contained in instruments	10 μ Ci	Wide
4. Gas and aerosol detectors	Smoke and fire detectors	0.01-15 μ Ci	Wide Wide
<u>MEDICAL SOURCES</u>			
1. Sealed sources	Needles, tubes, cells and capsules	1-50mCi	Limited**
	Plaques	5-25mCi	Limited**
	Nasopharyngeal	50mCi	
	Radon seeds	\sim 1mCi	Limited**
<u>INDUSTRIAL</u>			
1. Sealed sources	Well logging	10-50mCi (gamma) 300-600mCi (neutron)	Limited **
	Radiography	10-150mCi	Limited **

* Data extracted from UNSCEAR, 1977 and Pettigrew, et al., 1971

** Limited is used here to denote that no planned distribution to the general public is foreseen.

noted that the health and safety control by these users has been a continuing problem to State authorities.

The principal hazard from medical and industrial uses of radium is the possibility of an acute exposure. By far the most common medical source has been the radium needle, whose primary use is internal implantation for irradiation treatment of malignancies. Other medical sources, such as plaques and nasopharyngeal applicators, also contain similar concentrations of radium which can result in an acute exposure. Accounting of the many sources in existence and those lost or disposed of has been inadequate. Many State regulatory authorities involved in the control of such hazards have reported instances where sources have reached the general environment, and in some cases the general public, via accessible trash and garbage from medical and industrial facilities. There is a clear need for uniform regulation of discarded radium sources and radium-containing products to insure proper accountability and disposal practices.

For the most part, consumer products containing radium are likely to be disposed of as household refuse. However, the disposal of such discarded sources is not likely to be significant because of more restrictive national and international controls which limit the quantities and types of consumer product application. An annual average gonadal dose of less than 1 mrad has been calculated for all disposed consumer products containing radioactive material of any kind (UNSCEAR, 1977).

In summary, wastes containing elevated concentrations of radium-226 are proposed to be listed as hazardous under this Act because:

- a. Radium poses a recognized potential hazard to health.

Factors which contribute to the significance of this hazard include its long half-life and relatively high radiotoxicity;

- b. Radium-226 is found concentrated in both diffuse and discrete waste to levels significantly in excess of its average natural physical abundance; and

- c. There is currently uncontrolled widescale distribution of products, byproducts and wastes containing radium in the environment resulting from man's activities.

V. PROPOSED NUMERICAL HAZARD CRITERIA FOR RADIUM

A radium-containing waste is proposed to be designated as a hazardous waste for the purposes of this Act if a representative sample of the waste has either of the following properties:

- (1) The average radium concentration equals or exceeds 5 picocuries per gram for solid wastes, or 50 picocuries per liter for liquid wastes (for the latter, radium-226 and radium-228 combined)*

- (2) The total activity of any single discrete source equals or exceeds 10 microcuries.

*The radium criterion for liquids is based in part on the EPA Drinking Water regulation which requires measurement of combined radium-226 and radium-228 as part of its analytical regimen.

Perspective

In proposing these numerical hazard criteria for radium-226, it should be recognized that they do not constitute "de minimus" levels, i.e., radiation levels below which exposure is considered negligible. Rather, they specify which wastes are sufficiently high in radium content to involve a high expectation of hazard should the wastes be mismanaged under circumstances reasonably expected to occur. Under these criteria, diffuse wastes which because of their small quantity and configuration, or their radon emanation characteristics, are not hazardous via the pathways described may also be included. This likelihood represents the most important hindrance to the use of these radioactive waste criteria in a uniform manner and will be addressed in Section VI. For radium-containing wastes with concentrations less than those established by these criteria, the well established federal radiation protection requirement that any radiation exposures be maintained as far below limiting radiation protection standards "as practicable" or "reasonably achievable" remains in effect.

Rationale

Solid Waste Concentration Criterion

The radium source-term criterion of 5 pCi/g is based primarily on consideration of the radium-radon exposure pathway and on levels experienced for observed concentrations in waste materials. This pathway is given prime consideration because of the hazard of lung cancer induction associated with the chronic inhalation of radon decay

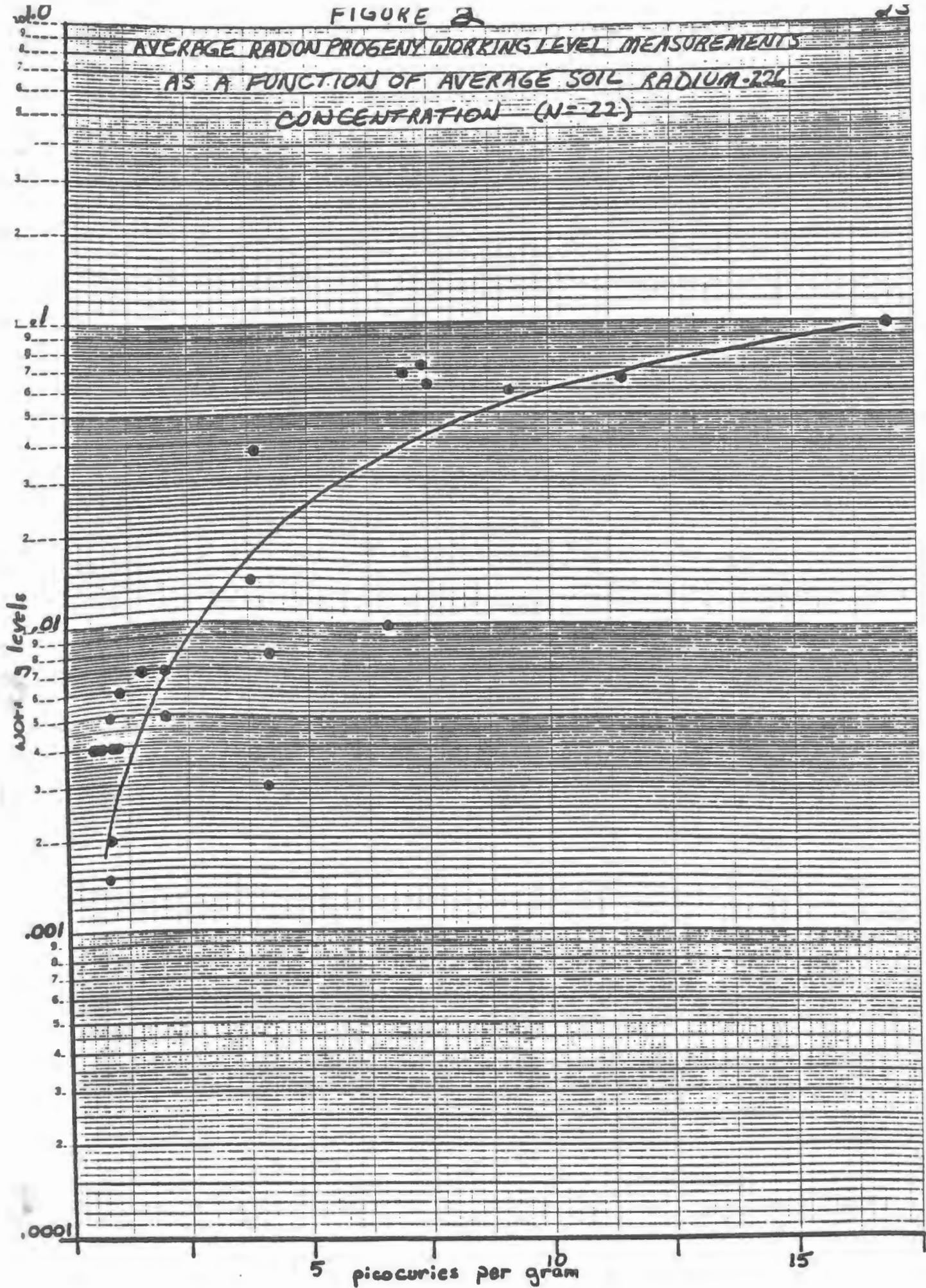
products originating from radon diffusion into structures from underlying radium-containing material. This pathway, which may be of significance at radium concentrations equal to or in excess of the proposed criterion, is the major radiological health concern for radium-bearing waste materials of this type. Data for this situation is available from ongoing studies in Florida^{*} and from studies conducted of housing built over uranium tailings in Grand Junction, Colorado (Culot, et al, 1973).

Indoor radon decay product concentrations in structures built on normal soils throughout the U.S. are usually between .001 and .007 WL, with the average around .003 WL. Preliminary EPA data for twenty-two structures in Florida showed that in general the radon progeny concentration of structures increases as a function of soil radium content. This data was derived from the average radium concentration of core samples taken (to a maximum depth of three feet) at the site, as well as average TLD air sampling measurements for radon decay products. These average measurements are plotted in Figure 2.

^{*}being performed, respectively, by the Environmental Protection Agency (Office of Radiation Programs), the State of Florida (Department of Health and Rehabilitative Services) and the University of Florida (the latter under contract to the Florida Phosphate Council). An EPA technical report providing detailed information on health effects associated with radon decay product exposure on phosphate land in Florida and available control options will be published in January-February 1979.

FIGURE 2

AVERAGE RADON PROGENY WORKING LEVEL MEASUREMENTS
AS A FUNCTION OF AVERAGE SOIL RADIUM-226
CONCENTRATION (N=22)



It is recognized that measurement error ($\pm 25\%$ for TLD air sampling) and the relatively small sample size are qualifying factors in drawing firm conclusions on a defined correlation between soil radium and radon progeny concentrations in structures. However, the relationship is sufficiently defined to permit broad projections for radium concentrations in excess of 5 pCi/g. As Figure 2 shows, for structure sites with such soil concentrations, it is likely that indoor radon progeny concentrations considerably in excess of normal background levels can be observed in many structures. From health effects information analyzed to date (Ellett, 1977), exposure to indoor radon decay product levels in excess of .01 WL (including background), a level which can be associated with land containing greater than 5 pCi/g of radium-226, is estimated to result in an increased lung cancer risk of greater than 1 percent over the normal risk.* This is based upon occupancy of the structure 75 percent of the time.

The University of Florida, as part of its study of the radiological impact of radon in structures on Florida phosphate land, has also collected data for the relationship between soil radium concentration and indoor radon progeny levels as a function of land type for a relatively small sample of structures. Their data show

*With a normal incidence of lung cancer in the United States of about 40 per 100,000 per year, this represents an increase of .4 per 100,000 per year at .01 WL above background (about 30 cancers per 100,000 over a lifetime assumed to be 70 years).

significantly elevated indoor radon decay product concentrations in structures located on soil containing moderate radium concentrations (2 to 7 pCi/g) (University of Florida, 1977).

These latter observations are consistent with the EPA findings, although it is recognized that the values observed in both studies may not be representative of radium-indoor radon progeny relationships in a more extensive sample obtained in a wide geographical area.

Healy and Rodgers (1978) in their review of exposure pathways to the population from radium contaminated soils concluded that the most limiting pathway is the emanation of radon into residences. As shown in Table 3, they indicate that given an assumed exposure limit of 0.01 WL, a soil concentration of 3 pCi/g would be the corresponding limit for soil radium contamination. This soil level is comparable to average natural concentrations found in many parts of the country. Their correlation is based on derived emanation rates of radon through various soil types and a "barrier factor" of 0.2 for transport of radon through a structure's foundation. The correlation provided by this theoretical model compares favorably with the field data graphed in Figure 2.

Using the Federal Radiation Council (FRC) guidance of 170 mrem whole body exposure per year to a member of the general public (Fe60), a corresponding soil concentration limit of 11 μ R/h is calculated by Healy and Rodgers. With the 3 pCi/g estimated limit, this criterion defines a narrow range of consideration (5-10 pCi/g, with appropriate

26
TABLE 3

SUMMARY OF RADIUM LIMITS FOR INFINITE DEPTH OF
CONTAMINATION AND A SANDY SOIL (He 78)

<u>Condition</u>	<u>Dose Used</u>	<u>Derived Level (pCi/g Radium)</u>
Radium Resuspension	0.01 μ Ci - bone	7 000 pCi/g
	0.5 rem/y - lung	2 000 pCi/g
Radium in Foods	0.01 μ Ci - bone	
Home Gardner		300 - 700
All foods		80
External Dose	0.17 rem/y	11
Rn Downwind	0.01 WL	
Small area (35 000 m ²)		490
Large area (6.6 x 10 ⁷ m ²)		5
Rn in Home	0.01 WL	3

consideration of practicality and implementation) for wastes whose hazard is due principally to radon decay products or gamma exposure, or a combination of both.

Indoor concentrations greater than .005 WL have been measured for structures located on sites with soil radium concentrations at or near natural background levels (e.g., 1-3 pCi/g for Florida). Notwithstanding the possibility of some structures having undesirable indoor radon decay product levels at soil radium concentrations less than 5

pCi/gram (due, in part, to uncontrollable factors such as indoor ventilation), it is impractical to provide and implement effective control measures at such levels. Likewise, for radium concentrations at or near background, a degree of hazard in excess of that attributable to normal background levels cannot practicably be delineated on a generic, national basis.

Given these considerations, the criteria should prudently achieve a balance between minimizing public health risk, and the practical considerations of measurement and regulatory implementation. The 5 pCi/g criterion level achieves this balance through reflection of available information concerning hazardous radium concentrations in diffuse wastes, with the inclusion of only those wastes whose radium content and proximity to the population necessitates their consideration under the Act.

Liquid Source Term Criterion:

The 50 pCi/l criterion for liquid waste is based on the EPA Drinking Water Regulation of 5 pCi/l for radium (226 and 228) (EPA, 1976), with a 10-fold dilution factor. This dilution factor, which is uniformly applied in the RCRA Section 3001 toxicity characteristic to substances for which a corresponding Drinking Water regulation exists, is based on the assumption of a 500 feet minimum distance from a landfill or similar disposal site to the nearest potable water well. Radium-228 is included in the characteristic solely for measurement purposes in order to provide consistency with the Drinking Water

standard, which stipulates an analysis of combined radium-226 and radium-228.

Total Activity Criterion:

The basis for this criterion is the Suggested State Regulations for Control of Radiation (SSRCR), Part D, Section 304(a), and 10 CFR 20.304(a) which specify for disposal by burial in soil:

No licensee shall dispose of radioactive material by burial in soil unless the total quantity of radioactive material buried at any one location and time does not exceed, at the time of burial, 1000 times the amount specified (0.01 μ Ci for radium-226).

A total activity criterion is required to delineate a hazard level for discrete sources, where direct exposure is of primary concern. Both alpha and gamma radiation contribute to this exposure with the latter resulting in an estimated exposure rate of 10 μ R/h at one meter from a 10 μ Ci discrete radium source. On the basis of past experience and practice with the distribution and disposal of sources with less radium concentration (watches, clocks, gauges, smoke detectors, etc), it is reasonable to apply the 10 μ Ci criterion for the purposes of RCRA. This "screening level" would exclude most consumer sources from regulatory consideration while insuring such consideration for the majority of medical and industrial sources whose typical millicurie activities have resulted in documented hazardous situations (DHEW, 1975; NRC, 1977).

Extent of Applicability of Criteria to Waste Materials:

As Table 4 shows, the respective criteria levels proposed for

TABLE 4

PROJECTED APPLICABILITY OF PROPOSED RADIUM-226 CRITERIA
FOR SELECTED APPLICABLE WASTES

Process Source Product Use Before Deposition	Waste Material	Average Activity	Potential Public Health Impact Identified	Degree of RCRA & Section 3001 Applicability	Relative Magnitude of Applicable Waste (estimated)
<u>DIFFUSE</u>					
Uranium Ore milling	tailings	600-700pCi/g	Yes	None(NRC regulated)	Large 30 million tons (800 acres)
Phosphate	debris	10-15pCi/g	Yes	Complete	Large*
	slimes	45 pCi/g	Possible	Complete	1x10 ¹¹ gallons
	sand tailings	8 pCi/g	None identified	Partial	Large*
Phosphoric acid production	gypsum	20-30 pCi/g	Yes	Complete	Large, 300 million tons
Elemental phos- phorus production	slag	20-60 pCi/g	Yes	Complete	Large 3x10 ¹⁰ gallons
	fluid bed prills	10-15 pCi/g	None identified	Complete	Small*
Zirconium extraction	chlorinator res. clarifier sludge		None identified	Complete	moderate (4-5 ^{tons &} thousands)
Water Treatment	lime sludge	6-9 pCi/g	None identified	Partial	Moderate**
Coal combustion	ash	1-8 pCi/g	None identified	Partial	Moderate**
<u>DISCRETE</u>					
Consumer Products	Aircraft instruments	20 uCi	None identified	Partial	Small*

TABLE 4 (continued)

	Lightning rod	0.2-1 m Ci	None identified	Complete	Small*
	Antistatic devices (contained in instruments)	10 m Ci	None identified	Partial	Small*
	Smoke and Fire Detectors	0.01-15uCi	None identified	Partial	Small*
Medical Sources	Sealed sources	1-50 m Ci	Yes	Complete	Moderate**
Industrial	Sealed sources	10-600 M Ci	Yes	Complete	Moderate**

* not defined

** not defined; however, is primarily a function of the number of waste generators exceeding these criteria

diffuse and discrete radium-containing wastes would encompass most medical and industrial discrete sources, and a large proportion (by volume) of the wastes generated by the uranium and phosphate extraction industries. Potential hazards have been identified for all of these wastes except those of marginal concentration or activity, such as phosphate sand tailings and consumer products containing very small amounts of radium.

The extent to which each waste category is applicable to the Act with regard to its respective criteria depends on the variability of radium concentration or quantity, with only a small fraction of some waste categories being in excess of the proposed criteria. Wastes which only marginally or non-uniformly fall within the criteria consist largely of diffuse wastes such as water treatment sludge and coal ash whose radium concentrations are a function of the radium-content of their source material. For discrete sources, most medical and industrial sources would qualify, while consumer products* whose activities for readily accessible sources rarely exceed 5 μCi , generally do not.

VI. CONSIDERATIONS FOR GENERIC APPLICATION OF NUMERICAL HAZARD CRITERIA FOR RADIUM-226 CONTAMINATED WASTE UNDER RCRA

With 5 and 10 pCi/g proposed as soil radium contamination criteria based, respectively, on radon decay product and gamma

*Wastes produced by residential generators are exempted under RCRA Section 3001.

exposure hazard, the key to implementation in Section 3001 of RCRA is the proper application of these numerical criteria to wastes which may or may not be characteristically hazardous by one or the other route. While self-shielding may result in lower gamma levels than expected, this would be a relatively minor factor except where material densities are extremely high (e.g., lead or zinc extraction waste, for example). The more important consideration is the radon emanation fraction. The emanation fraction, the measure of radon release from the surface of a radium-containing material, varies by the physical characteristics of the waste material. This fraction or ratio varies considerably from one type of waste to another, which clearly poses a problem to the development of a uniform definition of hazard based solely on concentration. One option would be to incorporate an emanation fraction criterion into the regulations as given in the following example:

Waste would be listed under Section 3001 for either:

- 1) gamma exposure hazard, if the average concentration of the waste is equal to or in excess of 10 pCi/g (about 20 μ R/h continuous exposure), or 2) radon decay product exposure hazard, if the emanation fraction is equal to or in excess of 0.1 (typical soil including waste materials, such as uranium and phosphate mining waste have fractions of approximately 0.2), and the average concentration of waste is equal to or in excess of 5 pCi/g;

The 0.1 emanation fraction value is a factor of two less than the 0.2 fraction for phosphate overburden waste on which the 5 pCi/g criterion is based, and is assumed to reduce the radon diffusion by a like factor which would preclude hazard designation.

Another available option would be to implement a single criterion of 5 pCi/g with provision for relief if the emanation fraction is less than 0.1 and radium content equal to or less than 10 pCi/g. This alternative is effectively identical to the preceding one although it places the burden on the regulated industry to seek relief from RCRA regulation (the other option makes it a condition for inclusion).

Implementation of this hazard definition for Ra-226 in diffuse waste would require representative sampling and analysis to determine average radium concentrations and emanation fractions.

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DEFINITIONS

background (material): A general term describing the level of normal radioactivity and/or external radiation intensity in a given area or environment; background radiation is that produced by sources other than those produced by man, including radioactive elements in the crust or atmosphere of the earth, and cosmic radiations.

byproduct material: Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material (10 CFR 20.3).

curie (Ci): A quantity of radioactive material that undergoes nuclear transformation at a rate of 37 billion events per second; and
millicurie (mCi) = 10^{-3} curie; one microcurie (μ Ci) = 10^{-6} curie; one picocurie (pCi) = 10^{-12} curie.

half-life, physical: The time required for one-half of an initial quantity of radioactive material to undergo nuclear transformation; the half-life is a measure of the persistence of a radioactive material and is unique to each radionuclide.

NARM: naturally-occurring and accelerator-produced radioactive material.

naturally-occurring radioactive material: Material containing radionuclides naturally present in the earth's crust or atmosphere.

accelerator-produced radioactive material: material produced through the nuclear interactions made possible by a nuclear particle or electron accelerator.

phosphogypsum: gypsum produced as a byproduct of the phosphoric acid production process.

radionuclide: a radioactive species of an element having a specific mass, atomic number and nuclear energy state.

radiotoxicity: the property of a material by which it is capable of adversely affecting biological organisms through the mechanism of nuclear radiation.

source material: (i) uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of: (a) uranium, (b) thorium, or (c) any combination thereof. Source material does not include special nuclear material (10 CFR 20.3).

uranium tailings: material comprised of finely divided sands and clays settled out of and dried from uranium mill waste slurries.

working level (WL): term used to describe radon daughter product activities in air. Defined as any combination of short-lived radon daughter products in one liter of air that can result in the ultimate emission of 1.3×10^5 MeV of alpha energy.

working level month (WLM): exposure to 1 WL for 170 hours (a working month). Continuous exposure to radon daughters at 1 WL for one year is equal to about 36 WLM.

BD-7

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BACKGROUND DOCUMENT

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

SECTION 3001 - IDENTIFICATION AND LISTING OF
HAZARDOUS WASTE

SECTION 250.14 - HAZARDOUS WASTE LISTS

INFECTIOUS WASTE

DECEMBER 15, 1978

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

This document provides background information and support for regulations which have been designed to identify and list hazardous waste pursuant to Section 3001 of the Resource Conservation and Recovery Act of 1976. It is being made available as a draft to support the proposed regulations. As new information is obtained, changes may be made in the background information and used as support for the regulations when promulgated.

This document was first drafted many months ago and has been revised to reflect information received and Agency decisions made since then. EPA made some changes in the proposed regulations shortly before their publication in the Federal Register. We have tried to ensure that all of those decisions are reflected in this document. If there are any inconsistencies between the proposal (the preamble and the regulation) and this background document, however, the proposal is controlling.

Comments in writing may be made to:

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Draft Background Document
Hazardous Waste Identification and Listing
Infectious Waste

	<u>Page</u>	
3.1	Introduction	1
3.2	Solid Waste/Disease Relationships	2
3.3	Indicator Organisms	3
3.4	The Source Approach	4
3.5	The Current State Approach	6
3.6	Related Federal Regulations	22
3.7	Epidemiological Evidence	26
3.8	Sources of Infectious Waste	28
3.9	Definitions	29
3.10	Rationale for Regulation of Health Care Facilities Waste--Hospitals and Veterinary Hospitals	33
3.11	Rationale for Regulation of Laboratory Waste	59
3.12	Rational for Regulation of Unstabilized Sewage Treatment Plant Sludge	62
3.13	Methods for Biological Examination of Solid Waste	83
3.14	References	87
	Appendix	

Draft Background Document
Hazardous Waste Identification and Listing
Infectious Waste

3.1 Introduction

The purpose of this chapter of the background document is to present the Agency's rationale in determining the definition of infectious hazardous waste.

To date it has been the policy of the Agency under Section 3001 of the Act, to define chemical and physical hazardous waste characteristics such as toxicity, flammability, and corrosivity, in quantitative terms; i.e. criteria have been chosen that best quantify each hazardous characteristic, with certain hazard levels specified for each tested parameter (e.g., flashpoint for flammability, pH for corrosivity). For enforcement purposes, this method of quantitatively defining a hazardous waste is most desirable. It would follow then, that a similar type of definition for "infectious characteristics" would be the most useful one from a regulatory point of view.

Unfortunately, such quantification of infectious characteristics is not possible, as will be discussed in this document. Instead of specifying a certain number of infectious agents allowed to be present in a waste, the Agency has chosen to define infectious waste by specifying the sources where disease microorganisms may occur. After

consultation with experts in the public health field and consideration of current State regulatory programs, the Agency has reached the conclusion that such source identification of infectious waste is the most inclusive and enforceable method of regulation.

3.2 Solid Waste/Disease Relationships

Basic principles of epidemiology include a chain of events necessary for the transmission of disease microorganisms. In the case of solid waste, the chain involves the production of solid waste contaminated with disease agents, the transfer of the disease agents from a waste to a host, and the manifestation of the disease in a host. The completion of this chain, or transmission of disease, is dependent upon the optimization of many variables. For example, some variables include the kinds and numbers of disease agents found in the solid waste, the environmental conditions of the solid waste substrate, and the capability of the disease agent to survive. Some variables that affect the host's susceptibility to disease are the manner of contact with the waste, the general health and age of the host, his or her previous contact with the disease agent, and his or her response (clinical versus subclinical) to the disease agent.

To specify a "safe" number of disease organisms allowed in a waste would be to ignore the large number of variables involved in the transmission of disease. Additionally, for certain viral and parasitic diseases, it is known that only one organism, if successfully transmitted, can cause a

clinical response in a host; yet for other disease agents it is known that hundreds or even thousands of organisms are necessary. Therefore setting a safe number of organisms for solid waste would involve specifying a safe level for each disease agent and providing a means to analyze for each one. Unfortunately, dose levels for all disease agents are not known at present and methods of environmental sampling and analysis for many disease agents have not been developed.

3.3 Indicator Organisms

Several EPA contacts have suggested the use of indicator organisms such as Salmonella spp., fecal coliforms, or S. aureus as an index of overall (i.e. viral, bacterial, fungal, parasitic) biological hazard of a waste. The problems associated with the use of indicator organisms have been recognized by EPA. For water standards, the Office of Water Program Operations originally suggested the use of fecal coliform as an indicator organism to determine the effectiveness of the chlorination process (40 CFR 133). This standard was later deleted (FR July 26, 1976) (1), with EPA recognizing that fecal coliform is "not an ideal indicator of pathogenic (sic) contamination" but is "a practical indicator of relative disease causing potential."

While microbial concentration standards may be applicable in the evaluation of the efficacy of wastewater treatment systems, their applicability as absolute quality standards remains to be demonstrated. A problem is that in some situations, the die-

off or regrowth of indicator organisms does not always parallel that of the disease organisms, the presence of which they are supposed to indicate. For example, it has been found that certain pathogenic viruses are more resistant to conventional wastewater treatment than are the coliforms (Cooper and Golueke, 1977). (2) As such, it has been decided that indicator organisms will not be used for purposes of defining infectious characteristics in this regulation.

3.4 The Source Approach

Ruling out the specification of "safe" microbial contamination levels and the use of indicator organisms, EPA has chosen to specify the solid waste sources where disease-causing organisms are known to occur, and to define waste from these sources as infectious waste.

The disease-causing organisms are, for purposes of this regulation, to be defined by CDC's "Classification of Etiologic Agents on the Basis of Hazard." (3) Sources of waste where Class 1 agents are known to occur are excluded from the definition of infectious waste, since Class 1 agents are of no or minimal hazard under ordinary conditions. Sources where Class 2 (agents of ordinary potential hazard) and up are known to occur are included, since Class 2 agents are disease causing. Descriptions of the CDC Classes used to identify the infectious waste sources are given below.

Class 2

Agents of ordinary potential hazard. This class includes agents which may produce disease of varying

degrees of severity from accidental inoculation or injection or other means of cutaneous penetration but which are contained by ordinary laboratory techniques.

Class 3

Agents involving special hazard or agents derived from outside the United States which require a federal permit for importation unless they are specified for higher classification. This class includes pathogens which require special conditions for containment.

Class 4

Agents that require the most stringent conditions for their containment because they are extremely hazardous to laboratory personnel or may cause serious epidemic disease. This class includes Class 3 agents from outside the United States when they are employed in entomological experiments or when other entomological experiments are conducted in the same laboratory area.

Class 5

Foreign animal pathogens that are excluded from the United States by law or whose entry is restricted by USDA administrative policy.

NOTE: It has been pointed out that the current CDC list does not include some agents of significance (e.g. Giardia, Ascaris, Legionnaires bacterium) as well as it does include one non-pathogen (Naegleria gruberi). The reader should keep in mind that the list is periodically revised. The most recently published list would be applicable.

The relationship between the agents in these classes and the waste sources where these agents are found was developed by using information found in the literature and consultation with public health experts. This approach is in agreement with the Center for Disease Control, USPHS, for sources other than health-care facilities waste; in agreement with the Joint Commission on Accreditation of Hospitals for sources of hospital waste; in agreement with NIH for sources of laboratory waste; and with the various State regulatory programs for other sources of infectious waste.

3.5 The Current State Approach

Nine states have defined the infectious characteristics of hazardous waste either wholly or in part. Terms such as "biohazardous," "health-services hazardous," "pathological," "biological," and "hazardous-infectious" are used to describe infectious characteristics of the waste of concern. These examples of State definitions are shown in Table 1.

The definitions are derived from one, or a combination, of four methods: a list of infectious (etiologic) agents; a list of infectious items that have a high probability of being contaminated; a list of sources of infectious waste; or a prose definition. The one list of infectious agents referenced is HEW's list of etiologic agents. Table 2 shows a composite matrix of infectious items and sources of infectious wastes, identifying the States that consider each one.

It is interesting to note that not one of these definitions attempts to quantify numbers of disease organisms that would render a waste infectious and that it is these same States that have promulgated criteria for physical/chemical characteristics of hazardous waste on a quantitative basis similar to the ones EPA is considering. The approach that the Agency is taking to define infectious characteristics of waste, then, and the deviance of this approach from that of defining other characteristics of hazardous waste, is in line with the thinking proposed by the most progressive State hazardous waste management programs.

TABLE 1
State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
California Department of Health		Proposed Revisions to the Code, Title 22	<p><u>Biohazardous waste (infectious waste)</u> shall be defined as, but is not limited to;</p> <p>(1) Significant laboratory or pathology waste of an infectious or experimental nature which has not been autoclaved including pathologic specimens (which shall include all human parts removed surgically or at autopsy, specimens or blood elements, excreta and secretions obtained from patients) and disposable fomites such as bandages, dressings, casts, catheters, and tubing which has been in contact with wounds, burns or surgical incisions and which are suspect or have been medically identified as biohazardous.</p> <p>(2) Surgical specimens and attendant disposable fomites.</p> <p>(3) Similar disposable material from outpatient areas and emergency rooms.</p> <p>(4) Equipment, instruments, utensils and fomites of a disposable from the rooms of patients with suspected or diagnosed communicable disease requiring isolation.</p> <p>(5) Sharps which include but are not limited to needles, syringes and blades.</p> <p>(6) Dangerous drugs as defined in Section 4211 of the Business and Professions e.</p>

TABLE 1

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
California Department of Health		Assembly Bill No. 1593: An Act to Amend Section 25116. Ch. 6.5. Division 20, of the Health and Safety Code	<p>"Infectious" means containing pathogenic organisms, or having been exposed, or reasonably being expected to have been exposed, to contagious or infectious disease. Articles which are "infectious" include, but are not limited to, the following:</p> <ol style="list-style-type: none"> (1) Wastes that contain pathologic specimens, tissues, specimens or blood elements, excreta or secretions from humans or animals at a hospital, medical clinic, research center, veterinary institution, or pathology laboratory. (2) Surgical operating room pathologic specimens and articles attendant thereto which may harbor or transmit pathogenic organisms. (3) Pathologic specimens and articles attendant thereto from outpatient areas and emergency rooms. (4) Discarded equipment, instruments utensils and other articles which may harbor or transmit pathogenic organisms from the rooms of patients with suspected or diagnosed communicable disease.

TABLE 1

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
Illinois EPA	Environmental Protection Act	Special Waste Land Disposal Disposal Criteria	<p><u>Industrial Process Effluent</u> - Any liquid, solid, semi-solid or gaseous refuse generated as a direct or indirect result of the creation of a project or the performance of a service, including but not limited to... <u>hospital pathological waste.</u></p> <p><u>Hazardous Waste</u> - Any refuse that...is harmful or potentially harmful to human health or the environment...due to its.. <u>pathological...nature.</u></p>
Maryland Department of Natural Resources	Safe Disposal of Hazardous Substances Act of July 1976	COMAR 08.05.05 Control of the Disposal of Designated Hazardous Substances Regulations .01-.18 .18, Designated Hazardous Substances, Class III, B (4)	A " <u>Designated Hazardous Substance</u> " includes pathological and medical wastes from hospitals, laboratories, and similar operations.

TABLE 1

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
State of Maryland Department of Health and Mental Hygiene		Proposed Regulations for Medical Waste Disposal, "Subcommittee Report to the Task Force on Medical Waste Disposal - December 6, 1976"	<p>The term <u>medical wastes</u>, encompassing materials hitherto called "infectious" "pathological", "contaminated", "special", and "hazardous" shall be replaced with the following new terms:</p> <p>(1) <u>Hospital Medical Wastes</u> - shall mean all solid waste generated within a hospital. Blood and blood products shall be included in this solid waste category.</p> <p>(2) <u>Nursing Home Medical Wastes</u> - shall be defined in two categories, as follows:</p> <p>(a) All disposable fomites from isolation areas, all dressings, pledgets, swabs, tongue depressors, plaster casts, body tissues, laboratory wastes, needles, syringes, I.V. apparatus, and medications (as permitted under Federal, State and local regulations).</p> <p>(b) Additional items which may be included in the above category include diapers and perineal pads.</p>

TABLE 1

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
Minnesota Pollution Control Agency Division of Solid Waste	Minnesota Statutes 1971: Chapters 115, 116,400,473D	Solid Waste Disposal Regulations, Section SW-1	<p><u>Hazardous Infectious Waste</u> - Waste originating from the diagnosis, care or treatment of a person or animal that has been or may have been exposed to a contagious or infectious disease. Hazardous infectious waste includes, but is not limited to,</p> <ol style="list-style-type: none"> (1) All wastes originating from persons placed in isolation for control and treatment of an infectious disease. (2) Bandages, dressings, cases, catheters, tubing, and the like, which have been in contact with wounds, burns, or surgical incisions and which are suspect or have been medically identified as hazardous. (3) All anatomical waste, including human and animal parts of tissues removed surgically or at autopsy. (4) Laboratory and pathology waste of an infectious nature which has not been autoclaved. (5) Any other waste, as defined by the State Board of Health, which, because of its hazardous nature, requires handling and disposal in a manner prescribed for (1) through (5).

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
Minnesota Department of Health, Health Facilities Division		Interpretive Policies for the Physical Plant: Handling and Disposal of Infectious Waste (Current DOH Guidelines)	<u>Infectious Waste:</u> (1) <u>Hazardous Infectious Waste</u> (same as above). (2) <u>General Infectious Waste</u> (contaminated): (a) Bandages, dressing, casts, catheters tubing, and the like, which have in contact with wounds, burns, or surgical incisions, but are not suspected or have been not medically identified as being of a hazardous infectious nature. (b) Discarded hypodermic needles and syringes, scalpel blades, and similar materials, when suspected or identified to be of a hazardous infectious nature. (c) Incinerator ashes from infectious waste.

TABLE 1

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
Minnesota Pollution Control Agency		Proposed, but to no longer be part of the hazardous waste regulations, HW-1	<p><u>Health services hazardous wastes:</u> wastes that originate from the diagnosis, care, or treatment of a human or an animal, and wastes of similar composition, excluding animal or human corpses but including:</p> <p>(1) Laboratory wastes, including:</p> <p>(a) Pathological specimens: tissues and specimens of blood elements, excreta, and secretions obtained from patients.</p> <p>(b) Infectious cultures: cultures that have been used in the detection, maintenance, or isolation of infectious organisms or suspected infectious organisms including, but not limited to microorganisms and helminths capable of producing infection or infectious disease.</p> <p>(c). Disposal fomites: any waste that may harbor or transmit infectious organisms.</p>

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
Minnesota Pollution Control Agency, (CONT.)		Proposed, but to no longer be part of the hazardous waste regulations, HW-1	<p>(2) Surgical and obstetrical wastes, pathological specimens, and disposal fomites from surgical operating rooms, outpatient areas, emergency rooms and similar areas where such wastes are generated.</p> <p>(3) Equipment, instruments, utensils, and fomites of a disposable nature from the rooms of patients with suspected or diagnosed communicable disease, or from the rooms of patients who by nature or their disease are required to be isolated by the State Board of Health.</p> <p>(4) Hypodermic needles and syringes, scalpel blades, suture needles and similar materials.</p> <p>(5) Mixtures of any of the wastes in (1) through (5) and other wastes that have been collected within the same container.</p>

TABLE 1

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
NSWMA		Gaynor Ward Dawson Draft of Model Criteria for Hazardous Waste	Materials or wastes which are capable of transmitting infectious diseases at a probability level above that from daily life should be defined as hazardous wastes.
New York Department of Environmental Conservation	6 NYCRR Part 360, Solid Waste Management Facilities		<u>Criteria for identifying Hazardous Substances:</u> <u>Infectious:</u> Materials containing infectious agents which are capable of causing death or severe illness, or which are highly contagious.
Oregon Department of Environmental Quality	Oregon Laws 1971 (HB 1051), Chapter 648	DEQ 41, Chapter 340	<u>"Hazardous Solid Waste"</u> includes "infectious", but infectious not defined.

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
Pennsylvania Department of Environmental Resources	Pennsylvania Solid Management Act (35 PS6-001), PL 241	Hazardous Waste Management Profile	<u>General Classification of Hazardous Wastes</u> (1) <u>Pathogenic Materials</u> (a) biological solids (b) laboratory wastes (c) infectious wastes (2) <u>Other Hazardous Solid Waste</u> (a) diseased animals
Texas Department of Health Resources		Comments to ANPR	<u>Hazardous biological waste should include all pathological waste from chemical biological and contagious wards as well as animals dead of unknown disease and unstabilized domestic sewage.</u>
State of Washington Department of Ecology		Washington Administrative Code (WAC) Hazardous Waste Regulation, Chapter 173-302 WAC	<u>Waste containing etiologic agents are toxic dangerous wastes. Etiologic agent means a viable microorganism or its toxin, which causes or may cause human disease, and is limited to those agents listed in 42 CFR 72.25(c) of the regulations of the Department of HEW.</u>

TABLE 1

State Definitions Of Infectious Waste

State Agency	Legislative Authority (if any)	Title of Regulation/ Guideline/ Document	Definition(s)
Ontario, Department of the Environment, Waste Management Branch			<u>Pathological waste</u> - Waste resulting from the discard of tissue or of material or equipment subject to contamination with infectious organisms.
Ontario, Department of the Environment, Air Management Branch			<u>Pathological Waste</u> - Carcasses, human and animal, solid organic wastes from hospitals, laboratories, abattoirs, and animal compounds, disposable operating theatre garments and swabs, maternity and incontinent pads, disposable diapers, and other similar items which might contain pathogenic bacteria.

Table 2A.

Areas/Sources Identified as Sources of Infectious Wastes, By State

	California	Illinois	Maryland	Minnesota	New York	Oregon	Pennsylvania	Texas	Washington	Ontario
Abattoir									X	
Animal Compounds									X	
Veterinary Hospitals	X									
Health Services			X							
Hospital, "pathological waste"	X	X	X						X	
Emergency Rooms	X		X							
Isolation Rooms	X	X	X				X			
Laboratory	X	X	X			X			X	
Outpatient Areas	X									
Pathology Laboratory	X									
Surgical Operating Room	X		X							
Medical Clinics	X									
Nursing Homes		X								
Research Center	X									
Sewage Sludge							X			

Table 2B.
Items Identified, By State

	California	Illinois	Maryland	Minnesota	New York	Oregon	Pennsylvania	Texas	Washington	Ontario
Autopsy Specimens	X		X							
Blood Specimens	X	X	X							
Excreta	X		X							
Human Carcasses									X	
Obstetrical Waste			X						X	
Pathologic Specimens	X		X							
Secreta	X		X							
Surgical Specimens	X		X							
Tissues	X	X	X							
Etiologic (infectious) Agent-containing items				X				X	X	
Attendant Disposable Fomites	X	X	X						X	
Disposable Diapers		X							X	
Instruments (disposable)	X		X							
I.V. Apparatus		X								
Perineal Pads		X								
Sharps	X	X	X							
Utensils	X		X							
Dangerous Drugs	X	X								

Table 2 B (Cont.)

Items Identified, By State

	California	Illinois	Maryland	Minnesota	New York	Oregon	Pennsylvania	Texas	Washington	Ontario
Biological Solids						X				
Incinerator Ash From Infectious Waste			X							
Diseased Animals			X			X	X		X	

3.6 Related Federal Regulations and Guidelines

No current federal regulations specifically address the problem of infection as related to solid waste. The Department of Transportation has published Interim Hazardous Materials Regulations (49 CFR Parts 171-177) (4) in which "etiologic agent" is defined (173.386) for purposes of commodity transport. The definition reads as follows:

§ 173.386 Etiologic agents; definition and scope.

(a) Definition. For the purpose of Parts 170-189 of this subchapter:

(1) An "etiologic agent" means a viable micro-organism, or its toxin, which causes or may cause human disease, and is limited to those agents listed in 42 CFR 72.25(c) of the regulations of the Department of Health, Education, and Welfare.

HEW's list (5) consists of the following etiologic agents.

BACTERIAL AGENTS

Actinobacillus--all species.
Arizona hinshawii--all serotypes.
Bacillus anthracis.
Bartonella--all species.
Bordetella--all species.
Porrelia recurrentis, B. vincenti
Brucella--all species.
Clostridium botulinum, Cl. chauvoei, Cl. haemolyticum, Cl. histolyticum, Cl. novyi, Cl. septicum, Cl. tetani.
Corynebacterium diphtheriae, C. equi, C. haemolyticum, C. pseudotuberculosis, C. pyogenes, C. renale.
Diplococcus (Streptococcus) pneumoniae.
Erysipelothrix insidiosa.
Escherichia coli, all enteropathogenic serotypes.
Francisella (Pasteurella) tulcrensis.

Haemophilus ducreyi, H. influenzae.
Herellea vaginicola.
Klebsiella--all species and all serotypes.
Leptospira interrogans--all serotypes.
Listeria--all species.
Mima polymorpha.
Moraxella--all species.
Mycobacterium--all species.
Mycoplasma--all species.
Neisseria gonorrhoeae, N. meningitidis.
Pasteurella--all species
Pseudomonas pseudomallei.
Salmonella--all species and all serotypes.
Shigella--all species and all serotypes.
Sphacrophorus necrophorus.
Staphylococcus aureus.
Streptobacillus moniliformis.
Streptococcus pyogenes.
Treponema carateum, T. pallidum, and T. pertenu.
Vibrio fetus, V. comma, including biotype El Tor, and V. parahemolyticus.
Yersinia (Pasteurella) pestis.

FUNGAL AGENTS

Actinomycetes (including Nocardia species, Actinomyces species and Arachnia propionica).
Blastomyces dermatitidis.
Coccidioides immitis.
Cryptococcus neoformans.
Histoplasma capsulatum.
Paracoccidioides brasiliensis.

VIRAL, RICKETTSIAL, AND CHLAMYDIAL AGENTS

Adenoviruses--human--all types.
Arboviruses.
Coxiella burnetii.
Coxsackie A and B viruses--all types.
Cytomegaloviruses.
Dengue virus.
Echoviruses--all types.
Encephalomyocarditis virus.
Hemorrhagic fever agents, including Crimean hemorrhagic fever (Congo), Junin, and Machupo viruses, and others as yet undefined.

Hepatitis-associated antigen.
Herpesvirus--all members
Infectious bronchitis-like virus.
Influenza viruses--all types.
Lassa virus.
Lymphocytic choriomeningitis virus.
Marburg virus.
Measles virus.
Mumps virus.
Parainfluenza viruses--all types.
Polioviruses--all types.
Poxviruses--all members,
Psittacosis-Ornithosis-Trachoma-Lympho-
granuloma group of agents.
Rabies virus--all strains.
Reoviruses--all types.
Respiratory syncytial virus.
Rhinoviruses--all types.
Rickettsia--all species.
Rubella viruses--all types.
Simian virus.
Tick-borne encephalitis virus complex, in-
cluding Russian spring-summer enceph-
alitis, Kyasanur forest disease, Omsk hemor-
rhagic fever, and Central European enceph-
alitis viruses.
Vaccinia virus.
Varicella virus.
Variola major and Variola minor viruses.
Vesicular stomatis virus.
Yellow fever virus.

Comments addressing this Interim Regulation are filed in DOT's Docket HM-142. Many responses suggest that the definition of etiologic agent be expanded to include agents harmful to plants and animals. DOT has not yet published a response to comments.

In considering the possibility of adopting this regulation for defining infectious waste, EPA was concerned with the enforceability of such a list because wastes cannot be adequately

tested. EPA would prefer to rely on such a list as a way to identify sources that may contain these etiologic agents. The CDC "Classification of Etiologic Agents on the Basis of Hazard," a more complete list which includes animal etiologic agents, will be used for source-identification purposes. (See Appendix VI of the regulation.)

EPA has previously defined infectious waste in "Guidelines for Thermal Processing and Land Disposal of Solid Waste," FR, August 14, 1974.(6) The definition, which is reprinted below, is felt to be unenforceable, as are most State definitions of infectious waste. Items specified in this definition would be included in the "sources," under the proposed approach. Also, this definition ignores the sewage sludge problem.

"Infectious waste" means:

- (1) Equipment, instruments, utensils, and fomites of a disposable nature from the rooms of patients who are suspected to have or have been diagnosed as having a communicable disease and must, therefore, be isolated as required by public health agencies;
- (2) laboratory wastes such as pathological specimens (e.g., all tissues, specimens of blood elements, excreta, and secretions obtained from patients or laboratory animals) and disposable fomites (any substance that may harbor or transmit pathogenic organisms) attendant thereto;
- (3) surgical operating room pathologic specimens and disposable fomites attendant thereto and similar disposable materials from outpatient areas and emergency rooms.

3.7 Epidemiological Evidence

In 1967, for the first time solid waste was thoroughly investigated as a reservoir for infectious microorganisms. Thrift G. Hanks, M.D., completed an exhaustive study entitled Solid Waste/Disease Relationships: A Literature Survey. (7) Routes of transmission of human disease from solid waste were described as "pathways," (see diagram below), and all evidence from the literature on solid waste/disease correlation was brought together. Hanks summarizes his findings with the following statement:

The literature fails to supply data which would permit a quantitative estimate of any solid waste/disease relationship. The circumstantial and epidemiologic information does support a conclusion that, to some disease, solid wastes bear definite, if not well defined, etiologic relationship. The diseases so implicated are infectious in nature; no relationship can be substantiated for noncommunicable disease agents associated with solid wastes, not because of negating data, but because of lack of data.

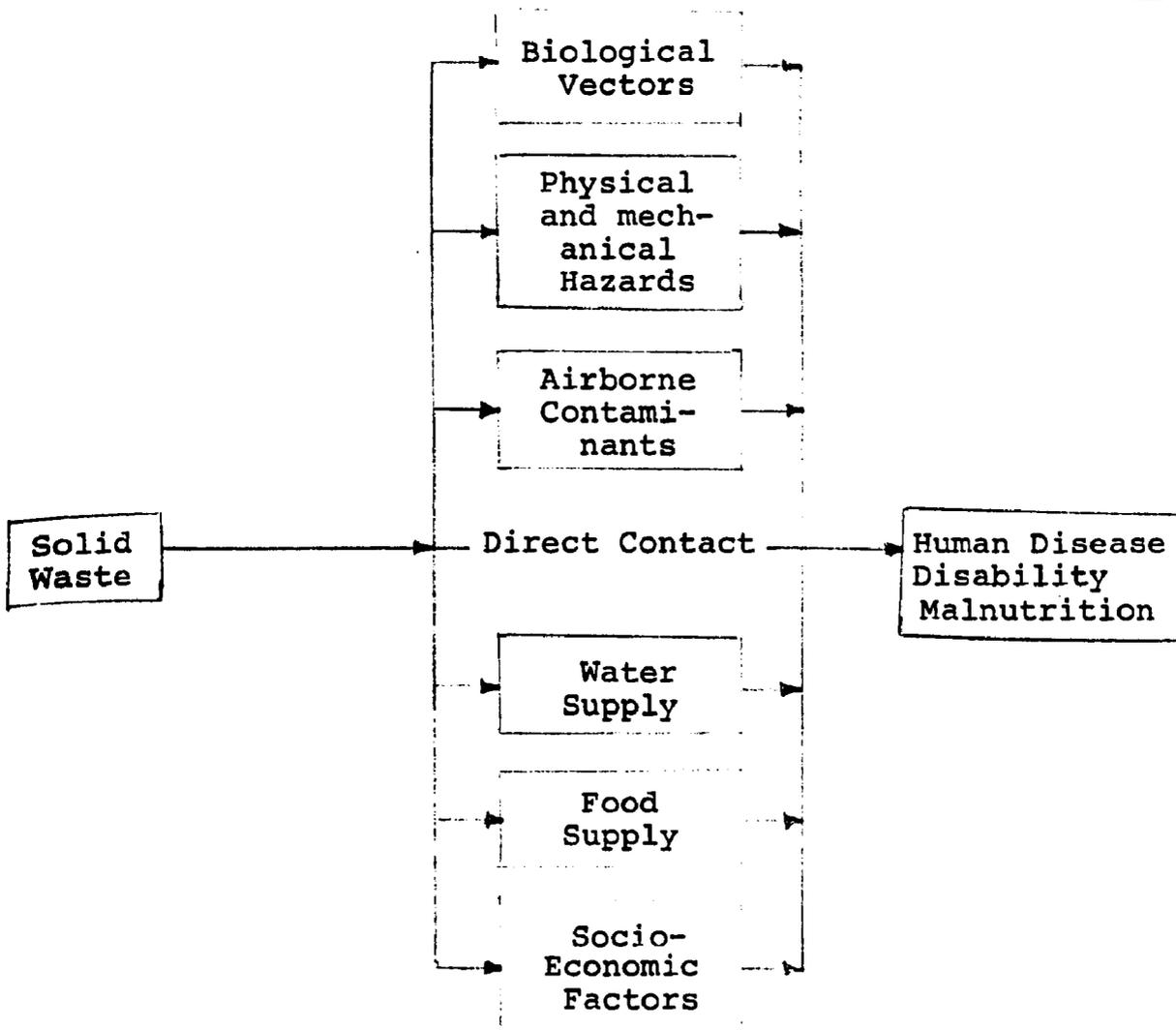


Figure 1. T.G. Hanks' Postulated Solid Waste/Human Disease Pathways

There appears to be a paucity of epidemiological data on the subject mainly because funds have never been appropriated for gathering such data. It has not been until recently that EPA has undertaken any epidemiologic studies related to solid waste, which will be completed in several years. Until then, regulation must be based on the microbiological data from studies of the various sources of waste, and on the principles of epidemiology and solid waste-disease relationships.

3.8 Sources Identified

For purposes of defining infectious waste, the sources of these wastes have been identified in the regulation by SIC number with the corresponding industry. These sources are regrouped here for discussion purposes in this document under the following headings:

- 3.10 Rationale for Regulation of Health Care
 Facilities Waste
 - . Hospitals
 - . Veterinary Hospitals
- 3.11 Rationale for Regulation of Laboratory Waste
- 3.12 Rationale for Regulation of Unstabilized Sewage
 Treatment Plant Sludge

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3.9 Definitions (8, 9, 10)

For clarification the later discussions, the following definitions are provided:

ANIMAL WASTE - Waste generated from animal care or use; including bedding, egestion, excretions, secretions, tissue, remains, and any inedible by-products of animal processing for food and fiber-production.

AUTOCLAVE - An apparatus for effecting sterilization by steam under pressure. It is fitted with a gauge and a mechanical system which automatically regulates the pressure and the temperature to which the contents are subjected.

BACTERIA - Any of numerous unicellular microorganisms of the class Schizomycetes, occurring in a wide variety of forms, existing either as free-living organisms or as parasites, and having a wide range of biochemical, sometimes pathogenic, properties.

ENTERIC - of or within the intestine.

ETIOLOGIC AGENT - A viable microorganism or its toxin which causes, or may cause human disease. In the case of DOT Regulations, etiologic agents are (or are suspected to be) in relatively small concentrated samples which are shipped to special laboratories for identification.

FOMITE - An inanimate object such as an article of clothing, a dish, a toy, or a book, that is not itself corrupted but is able to harbor pathogenic organisms which may by that means be transmitted to others.

FUNGUS - Any of numerous plants of the division or subkingdom Thallophyta, lacking chlorophyll, ranging in form from a single cell to a body mass of branched filamentous hyphae that often produce specialized fruiting bodies, and including the yeasts, molds, smuts, and mushrooms.

INFECTION - The entry and development or multiplication of an infectious agent in the body of man or animal. Infection is not synonymous with infectious disease; the result may be inapparent or manifest. The presence of living infectious agents on exterior surfaces of the body or upon articles of apparel or soiled articles is not infection, but rather is contamination of such surfaces and articles.

INFECTIOUS AGENT - An organism, mainly microorganisms (bacterium, protozoan, spirochete, fungus, virus, rickettsia, or other) but including helminths, capable of producing infectious disease.

INFECTIOUS DISEASE - A disease of man or animal resulting from an infection.

PATHOGEN - An organism capable of producing disease.

PATHOLOGICAL WASTE - Tissues, parts, and organs of humans and animals.

PROTOZOAN - Any of the single-celled, usually microscopic organisms of the phylum or subkingdom Protozoa, which includes the most primitive forms of animal life.

RICKETTSIA - Any of various microorganisms of the genus Rickettsia, carried as parasites by many ticks, fleas, and lice. Transmitted to man, they cause diseases such as typhus, scrub typhus, and Rocky Mountain spotted fever.

SOLID WASTE - Any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities, not including solid or dissolved material in domestic sewage, or solid or dissolved material in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under section 402 of the Federal Water Pollution Control Act, as amended (86 Stat. 880), or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923).

SEWAGE Sludge - The residue resulting from wastewater treatment.

SPIROCHETE - Any of various slender, nonflagellated, twisted microorganisms of the order spirochaetales, many of which are pathogenic, causing syphilis, relapsing fever, yaws, and other diseases.

SURGICAL AND AUTOPSY WASTE - Waste that includes tissue, limbs, organs, placentas, and similar types of materials; synonymous with pathogenic waste.

VIRUS - Any of the various submicroscopic pathogens consisting essentially of a core of a single nucleic acid surrounded by a protein coat, having the ability to replicate only inside a living cell.

ZOONOSIS - An infection or infectious disease transmittable under natural conditions from vertebrate animals to man.

3.10 Rationale for Regulation of Health Care Facilities Waste

The nature of waste generated by health care facilities is of concern to EPA due to a certain amount of potentially disease-contaminated materials found in the waste that are not normally found in other institutional solid wastes. Some studies have stated that the type and numbers of bacteria and viruses found in health-care solid waste are little different from that found in wastes generated from dwelling units, offices, factories and other institutions. Other researchers have given a completely opposite view and stated that health care facility wastes may be potentially dangerous to the environment due to their infectious content. (11)

Both hospitals and veterinary hospitals (for more specific breakdown by Standard Industrial Classification Code see §250.14 (b) of the regulations) are health care facilities that are considered to be generators of infectious waste for purposes of the regulation. EPA realizes that there are different problems associated with the infectious wastes from the treatment of people vs. animals and by no means does the Agency intend to imply that these two types of health care facilities generate the same types and amounts of waste or should treat or dispose of their wastes by the same methods. A discussion of each type of health care facility and sources of waste associated with them are given below.

Hospitals

Theoretically, the difference between the biological hazard of waste generated in hospitals, with their population of "sick" people, and the waste generated by dwelling units

and other buildings that are occupied basically by "well" people, lies in the waste's content. A proportion of the waste materials generated by hospitals in the treatment of patients has been exposed directly or indirectly to various pathogens in concentrated forms. From 2 to 8 percent of hospital wastes, for example, consists of such materials as: dressings from wounds, incisions, and burns; plaster casts; infectious laboratory samples; bacteriological cultures and media; pathological specimens; animal remains and biological specimens; body fluids and secretions; blood, urine, feces, and tissues; needles and syringes; disposable treatment devices made of plastic, metal, and glass; "sharps"; newborn, pediatric, and geriatric diapers; and various contaminated disposable containers. (12)

The leading generation points for these known infectious wastes are surgical suites, isolation wards for communicable diseases, clinical and research laboratories, research animal quarters, the autopsy suite and pathology laboratory, and the renal dialysis department. Another generation point is any care and treatment area or room for a known infectious case--inpatient, outpatient or emergency. As these wastes come from specific departments or sources, segregation is possible by handling all wastes from these particular areas as being infectious. The major problems in isolating possibly "infectious" wastes arise from the general patient care and treatment areas, both inpatient and outpatient, where large numbers of patients are being cared for by nursing personnel and diagnosis is often

incomplete at the time. It is these areas that infection potential of most waste is unknown. So, at some point, there is a reasonable possibility that infectious wastes can be intermixed with other wastes.

Three surveys have been made which cover quite extensively hospital practices with regard to waste collection and disposal (Iglar and Bond, 1971; (13) Burchinal and Wallace, 1971; (14) Esco/Greenleaf, 1972 (15)). The main interest, however, has been in evaluating the overall waste collection and disposal systems, with infectious wastes being considered as only one aspect of the overall situation. This section is concerned with discussing the infectious wastes which are identified in the literature.

The composition of infectious wastes is well known. They include items from surgery such as dressings, contaminated disposable items, drapes, and human tissue (amputated limbs, tissues, organs, placentas); items from pathology and the laboratory such as tissues, chemicals, bacteriological cultures, urine, blood, and feces; animal remains and biological specimens; and general infected material from the wards such as gauze dressings and bandages, swabs, plaster casts, sputum cups, paper tissues soaked with nose and throat secretions, and wound drainage.

Some authors distinguish between "pathological" wastes and "hazardous" or "infectious" wastes (Litsky, et al., 1972). (16) They call "pathological" materials those from surgery, laboratories, etc., and "hazardous" waste everything else--everything

from the hospital floor and everything that comes in contact with patients. Disposal systems in the hospital are often different for the two types of waste, but for transport and disposal away from the hospital these authors found that the two cannot be separated. The Esco/Greenleaf report (1972) (15) had this to say:

"Early in the study we concluded that there is no practical way of segregating contaminated and uncontaminated waste in a hospital, and that, with few exceptions, contaminated and uncontaminated wastes are co-mingled together either on purpose or accidentally so that by the time these materials reach the back door of the hospital for disposal ...there is no distinction...Therefore everything ...from a hospital floor must be considered to be contaminated and should be classified as waste."

This position is not uniformly held. Burchinal and Wallace (1971) (14) state that only 25 to 30 percent of the total waste generated in a hospital can be considered dangerous, and if this is kept apart from the remaining waste there is no need to treat the total waste as contaminated.

Surgery, autopsy, and the laboratories generate most of the segregated pathologic waste. The waste for the Los Angeles County - USC Medical Center is given in Table 8 (Esco/Greenleaf, 1972). (15)

An investigation by G.H. Reavely and P.G. Warwick of the University of Western Ontario (Anon, 1972c) (17) defined pathological wastes as "all substances which cannot be reesterilized or reused originating within or brought into patient care, laboratory and autopsy areas." Patient care areas not only included

those traditionally considered to be sources of infectious waste, but also ward areas, doctors' offices, outpatient clinics, and treatment rooms. Infectious waste averaged 43 percent of the total waste in the hospitals studied, and the general patient care areas generated almost three quarters of this infectious waste.

Table 8

Quantities of Pathological Wastes Generated Daily
at LAC-USC Medical Center from Various Divisions

(Esco/Greenleaf, 1972)

<u>Areas</u>	<u>Quantity of Waste (gal/day)</u>
Lab Services (Basement)	30
Autopsy and Lab Areas (2nd Floor)	80
Laboratories (2nd Floor)	45
Pathology Lab (16th Floor)	30
Surgical Delivery (4th Floor)	<u>2</u>
	Total 187 gallons/day

Using a density factor of 5.2 lbs./gal. based upon 70% moisture, a calculated production of 1000 lbs/day may be expected for the pathology incinerator.

A survey in California (Anon, 1972b) (18) concluded that it was possible to safely separate and collect infectious waste within a hospital, but this does result in increased costs of waste handling. With an average total waste per patient day of 10.25 lbs., the average infectious waste measured was only 0.38 lbs.

Investigations by Bond and Michaelson (1964) (19) on the effects of waste handling upon air and surface contamination give some indication of what types of contamination to expect. They found that soiled laundry handling had by far the most significant influence on increased airborne bacteria.

Further investigations have been carried out on the solid waste itself. Armstrong (1969) (20) looked at refuse chutes with respect to airborne bacteria. He found that placing the refuse in bags reduces the number of airborne bacteria generated, and that the possibility exists for the transmission of viable organisms to other parts of the hospital by way of the refuse chute.

Research at the University of West Virginia Medical Center (Burchinal and Wallace, 1971; (14) Wallace, et al., 1972; (21) Smith, 1970; (22) Trigg, 1971 (23)) revealed that pathogenic organisms can be present in hospital solid waste in significantly high concentrations, and especially so if an organic substrate is present. Coliform counts ranged from less than one per gram of refuse at some stations to as high as 8.6 per gram. Fecal

streptococci ranged from less than 1 per gram to as high as 8.0 per gram; staphylococci from less than 2 per gram to 7.1 per gram; Candida albicans from less than 2 per gram to 3.8 per gram; Pseudomonas sp. from less than 2 per gram to 8.4 per gram, and spore counts from less than 1.5 to 3.9 per gram (Trigg, 1971).

Substantial numbers of organisms of human origin were found, which suggests the presence of virulent pathogenic bacteria and viruses living on the solid waste in undetected numbers. Bacillus organisms made up 80 to 90 percent of all microbes observed with staphylococci and streptococci each composing between 5 and 10 percent of the population.

Staphylococcus aureus was by far the most predominant pathogen detected in the waste. Spore forming organisms were not present in sufficient numbers to constitute a potential hazard if accepted methods of sterilization are followed. Nursing stations, such as the operating rooms, where pathological waste is separated from other waste, show much lower microbial concentrations in general refuse than other stations. The stations generating the refuse most highly contaminated with coliform bacteria are the intensive care units and pediatrics.

Virus survival studies indicate that almost all materials found in the hospital solid waste could be vehicles for transmission of viruses (Burchinal and Wallace, 1971; (14) Wallace, et al., 1972 (21)). Various types of waste were artificially con-

taminated with viruses to established recovery times and rates. Vaccinia, Polio 1, Coxsackie A-9, and Influenza PR-8 were the viral strains used for inoculation. Paper and cotton fabric both held active viruses for long periods of time--from 5 to 8 days in most cases. Virus titer decreased in most cases at a steady rate with increasing time, implying that the agent loses its viability upon incubation.

An air sampling program was carried out at the Los Angeles County-USC Medical Center (Esco/Greenleaf, 1972). (15) Results are given in Table 9 and substantiate the earlier findings of Bond and Michaelson that laundry handling does generate considerably greater aerosols than does trash handling.

Estimates of the total waste generated by hospitals vary widely, ranging from about 10 lbs/patient/day to as much as 40-50 lbs/patient/day (Litsky, et al., 1972; (16) Oviatt, 1969; (24) Wallace, et al., 1972; (21) Anon, 1972b(18); Small, 1971(25)). Tables 10 and 11 give a breakdown of the types of wastes generated and the disposal costs for seven California hospitals. The great variation is caused by the quantity of disposable items used. The trend has been toward greater use of disposables because of decreased danger of cross-infection and supposedly greater economy. It has now become evident that "disposables" are really merely "throw-aways"; and their actual disposal presents a large problem. Even the cost advantage is open to question; Table 12 indicates that disposables cost more to handle and dispose of than reusables.

Table 9

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Summary of Air Sampling Data at LAC-USC Medical Center
(Esco/Greenleaf, 1972)

<u>Station</u>	<u>Number of Observations</u>	<u>Mean Coliforms per cubic foot</u>	<u>No. of Samples with Colonies too Numerous to Count</u>
Trash Chute Room			
Inside	99	14.1	2
Outside	96	8.8	0
Laundry Chute Room			
Inside	58	38.3	2
Outside	57	31.4	5
Sorting Area	54	71.0	7
Station Utility Room	55	5.0	0

Breakdown of Daily Waste Production (Lbs/Day) By Types of Wastes (Esco/Greenleaf, 1972)

<u>Type of Waste</u>	<u>LAC-USC Medical Center</u>	<u>Long Beach General Hospital</u>	<u>Harbor General Hospital</u>	<u>Ranchos Los Amigos Hos- pital</u>	<u>John Wesley Hospital</u>	<u>Olive View Hospital</u>	<u>Mira Loma Hospital</u>
# of Beds	3000	428	715	1188	259	725	232
Sharps, Needles, Etc.	75	3	22	40	8	20	5
Path. & Surgical	1000	trace	156	4	115	6	trace
Soiled Linen (Reusable)	45,000	3,740	13,600	16,320	2,900	5,630	1,120
Rubbish	16,200	540	6,569	2,760	717	1,722	362
Reusable Patient Items	trace	trace	trace	trace	trace	trace	trace
Non-combustibles	1,500	75	465	725	80	250	80
Non-grindable (a) Garbage	1,800	150	660	875	160	475	110
Food Service Items (Reusable)	9,000	1,400	2,400	4,200	800	2,500	600
Radiological	trace	—	trace	trace	—	trace	—
Ash & Residue	trace	—	20	20	50	20	25
Animal Carcasses	25	—	220	20	10	23	—
Food Waste (Grindable)	2,600	330	950	1,100	210	1,860	150
Total Production	77,700	6,238	25,062	26,064	5,050	12,506	2,452

-43-

1972

Table 10 (CONT.)

Daily Production Disposable	23,000	1,098	9,062	5,554	1,350	4,376	732
Pounds per bed patient	11.6	3.6	16.7	6.0	7.9	7.8	5.1
Pounds per capita. (b)	3.75	2.08	5.57	2.80	3.44	4.32	3.37
<hr/>							
Daily Production Reusable	54,000	5,140	16,000	20,520	3,700	8,130	1,720
Pounds per bed patient	27.2	16.9	29.6	22.1	21.7	14.5	11.9
Pounds per capita (b)	8.75	9.74	9.73	10.20	9.41	8.08	7.93

(a) Predominantly garbage mixed with substantial quantities of paper, plastics, metal, etc.

(b) Per capita production based on equivalent 24-hour population.

Annual, Daily, and Unit Operating Costs (Esco/Greenleaf, 1972)

	<u>IAC-USC Medical Center</u>	<u>Long Beach General Hospital</u>	<u>Harbor General Hospital</u>	<u>Rancho Los Amigos Hospital</u>	<u>John Wesley Hospital</u>	<u>Olive View Hospital</u>	<u>Mira Loma Hospital</u>
Quantity of Waste Produced							
Disposables (Tons/Day)	11.60	0.55	4.53	2.77	0.68	2.19	0.37
Reusables (Tons/Day)	27.25	2.57	8.00	10.26	1.85	4.06	0.86
Total Waste (Tons/Day)	38.85	3.12	12.53	13.03	2.53	6.25	1.23
Cost of System Operation							
Annual	\$2,396,850	\$223,600	\$777,435	\$656,340	\$296,582	\$750,585	\$175,200
Daily	\$ 6,566	\$ 612	\$ 2,130	\$ 1,798	\$ 813	\$ 2,056	\$ 480
Average Daily Cost per Ton							
Disposables	\$ 305	\$ 325	\$ 327	\$ 364	\$ 664	\$ 516	\$ 551
Reusables	110	168	82	77	195	229	322
Total Wastes	170	197	170	168	321	329	390
Average Daily Cost/Bed Patient [Calculated based on total number of patients not total number of beds].							
Disposables	\$ 1.76	\$ 0.58	\$ 2.73	\$ 1.09	\$ 2.65	\$ 2.02	\$ 1.42
Reusables	1.49	1.44	1.21	.85	2.13	1.65	1.91
Total Wastes	3.25	2.02	3.94	1.94	4.78	3.67	3.33

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Table 12

Cost Comparison of Disposable and Reusable Wastes at IAC-USC Medical Center
(Esco/Greenleaf, 1972)

Daily Costs of Handling and Disposal

Type of Waste	Ave. Wt. lbs/day	Labor	Bldg. & Equip.	Other (a)	Total	Ave. Cost	
						Per ton	Per Bed
Disposables							
Rubbish	16,200	\$2,235	\$104	\$ 85	\$2,424	\$300	\$1.22
Other	<u>7,000</u>	<u>1,027</u>	<u>40</u>	<u>60</u>	<u>1,127</u>	<u>322</u>	<u>.56</u>
Total	23,200	\$3,262	\$144	\$145	\$3,551	\$305	\$1.78
Reusables							
Soiled Linen	45,000	\$1,255	\$ 45	---	\$1,300	\$ 57	\$0.65
Food Service Items	9,000	1,403	---	---	1,403	312	.70
Other	<u>trace</u>	<u>312</u>	<u>---</u>	<u>---</u>	<u>312</u>	<u>---</u>	<u>.15</u>
Total	54,500	\$2,970	\$ 45	---	\$3,015	\$110	\$1.50
Total All Materials	77,700	\$6,232	\$189	\$145	\$6,566	\$170	\$3.28

(a) Miscellaneous expendable supplies and dumping fees.

Disposable items are found in all the areas of the hospital, and have special application in burn therapy, aseptic techniques, and isolation cases. Typical items are found in Table 13. They are combinations of materials such as paper, plastic, rayon, acrylic, cellulose, nylon, glass and metal. The plastic content is much higher than the 2-3 percent found in municipal solid waste; one study of infectious waste found it to be 11.42 percent hard plastic and 7.09 percent soft plastic (Anon, 1972b).(18) Expenditures have risen from \$30 million in 1966 to \$126 million in 1970, and may rise to an estimated \$900 million in 1978 (Fahlberg, 1973).(26) Further estimates say that a hospital can double its waste output by completely switching to disposable linen (Salkowski, 1970).(27) Disposables add two problems to the waste treatment process; first they increase the volume so that disposal systems are taxed and second the plastic components are hard to degrade. Also, it may be that some plasticizers are toxic. The John Hopkins School of Hygiene and Public Health in Baltimore has found that plasticizers in blood bags leach into the stored blood and go on to lodge in lungs, spleen, liver, and abdominal fat. Tests of embryonic heart cell cultures revealed that the cells died when plastic tubing was substituted for rubber (Anon, 1971b). (28)

When a simple change as supplying paper towels to each patient's room was made at the Baylor University Medical

Table 13

Common Disposable Items Used in the Hospital

Catheters and catheterization trays
Cutting Blades
Eating utensils
Emesis basins
Enema administration bags and buckets
Examination gloves
Exchange transfusion trays with tubing and fittings
Foley catheter trays
Hypodermic syringes with and without attached needles
Hypodermic needles
Hypodermic syringes pre-filled with medication
Irrigation trays
Lumbar puncture trays
Manometer trays
OB and surgical packs
Oxygen canopies
Petri dishes
Prefilled nursers
Prepared enemas
Sheets and pillowcases
Spinal anesthesia trays
Surgeons gloves
Surgical prep trays
Suture removal kits
Venous pressure trays

Center, it was found an additional wastebasket was then required. The maintenance cost from plugged toilets increased, and the labor charge for emptying and washing wastebaskets increased by 30 percent, but the number of cloth towels used did not decrease (Paul, 1964). (29) The pure bulk of the disposables presents the problem that most authors comment on, but other hazards are also present. Discarded needles and cutting edges remain a hazard to collection personnel. Scavenging of the dumping areas for useable items and play items for children show that spread of infectious disease is a real hazard in the disposal of disposables (Walter, 1964; (30) Mattson, 1974 (31)). Disease organisms can also be introduced to a landfill in great quantities via disposable linens and diapers (Ostertag and Junghaus, 1965; (32) Peterson, 1974 (33)).

Some indication of the numbers of disposable hypodermic needles used by individual hospitals can be obtained from the literature. Michaelson and Vesley (1966) (34) found from 14,000 to 833,000 used annually at various hospitals in 1966, and Baker (1971) (35) found over 550,000 used annually in 1968. There are proper ways to collect and destroy these items, such as collecting them at the individual nursing stations and returning them to central storage to be crushed and broken into fragments, then incinerated. They can also be collected in special boxes and sent directly to the incinerator, or collected at the nursing stations and sent to central service to be autoclaved and melted into one mass (Paul, 1964). (29) Some hospitals have even tried

replacing the needles on a one for one basis as they are used, then destroying the old ones (Deschambeau, 1967).(36) Even though the users are aware of the need to destroy the waste syringes and needles, many still escape unscathed. Profit oriented hospital workers have been known to extract these from the daily waste and sell them to street drug users (Hewer, 1971).(37) Even at the final landfill site, these needles can be reclaimed for drug users and children who find them to be satisfactory squirt guns (Healy, 1965).(38)

Based on the above discussion, the Agency concluded that it is necessary to regulate only certain sources of infectious waste within hospitals, rather than all waste from these facilities. Further, the Agency concluded that it is unnecessary to regulate waste materials from these sources which have been properly treated by the hospital to render them non-infectious (see §250 Subpart A Regulations, Appendix VII, Infectious Waste Treatment Specifications.)

The following departments of hospitals are subject to Subtitle C regulation:

- Obstetrics department including patients' rooms
- Emergency departments
- Surgery department including patients' rooms
- Morgue
- Pathology department
- Autopsy department
- Isolation rooms
- Laboratories
- Intensive Care Unit
- Pediatrics department

Veterinary Hospitals

While veterinary hospitals have some of the waste disposal problems which hospitals caring for people have, these problems are mainly confined to disposing of dead animals, animal waste, and waste generated during treatment of animals. Animal waste includes waste generated from animal care or use, including excretions, secretions, tissue, remains, and any inedible by-products of animal processing for food and fiber production.

It has been pointed out to the Agency that the majority of diseases that could be transmitted through improper disposal of veterinary hospital waste are primarily ones that are transmitted only from animal to animal. It is true that several hundred diseases are transmitted from animal to animal, but more than 150 zoonotic diseases are transmitted between animals and man.

Decker and Steele (38a) report the human health problems that are created by pathogenic zoonoses. Some of the most significant bacterial zoonoses are salmonellosis, staphylococcal and streptococcal infections, tetanus, tuberculosis, brucellosis, leptospirosis, and colibacillosis. Animal wastes also play a significant role in the distribution of fungal diseases by providing nutrients for the survival and growth of fungi in man's environment.

Q fever, a rickettsial disease, is transmitted to man primarily through air laden with dust containing animal wastes. It is largely an occupational disease of cattlemen, slaughterhouse workers, and woolsorters, but may also attack those residing adjacent to feedlots and stockyards. A troublesome parasitic disease transmitted through animal wastes is trichinosis which persists even though the practice of feeding swine raw garbage has been greatly reduced in recent years.

Less is known regarding the role of animal wastes in the direct transmission of viral diseases than in bacterial diseases. However, the importance of animal wastes in the reproduction of insect vectors of many diseases is well documented.

Anthrax

Anthrax is one of the oldest diseases identified with animals that is transmissible to man. Anthrax has been present in the United States for at least the last 100 years. The disease is primarily an occupational hazard of industrial workers who process hides, hair (especially from goats), bone and bone products, and wool, and of veterinarians and agricultural workers who handle infected animals. (39)

Infection of the skin is by contact with tissues of animals (cattle, sheep, goats, horses, pigs, and others) dying of the disease; or contaminated hair, wool, hides, and

soil associated with infected animals. Inhalation anthrax results from inhalation of anthrax spores. Gastrointestinal anthrax arises from ingestion of contaminated undercooked meat. Anthrax spreads among herbivorous animals through contaminated soil and feed and among omnivorous animals through contaminated meat, bone meal or other feeds. Biting flies and other insects are suspected of serving as vectors. Vultures have spread the organism from one area to another. The spores of Bacillus anthracis, the infectious agent, which resist environmental factors and disinfection, remain viable in contaminated areas for many years after the source-animal infection has terminated. (39)

Initial symptoms of inhalation anthrax are mild and non-specific, resembling common upper respiratory infection; acute symptoms of respiratory distress, fever and shock follow in from 3 to 5 days, with death shortly thereafter.

Gastrointestinal anthrax is more difficult to recognize, except that it tends to occur in explosive outbreaks; abdominal distress is followed by fever, signs of septicemia, and death in the typical case.

Untreated cutaneous anthrax has a fatality rate of from 5-20%, but with effective antibody therapy, few deaths occur. (39)

Salmonellosis

Although this disease is discussed in the section on sewage sludge, the important role that animals play in the transmission of the disease shall be stressed here.

Animal excreta and inedible by-products of food processing, such as viscera, bones, and feathers are vehicles that carry salmonella organisms from their animal hosts to man.(40) Direct contact with such wastes constitutes an occupational hazard for livestock producers, slaughterhouse and rendering plant workers; contamination of edible food products with feces provides a means of carrying the organism to the consumer, to the home, or to the institutional environment.

Animal wastes are also a vital factor in perpetuating and extending the prevalence of animal hosts of the Salmonellae. (41) Feeding of animal feces to poultry, swine, beef, and dairy cattle is one means of increasing the incidence of animal salmonella hosts, as is the use of contaminated animal protein supplements in animal feeds.

In 1965 a waterborne outbreak in southern California affected some 16,000 people. How the water supply of the city of Riverside became contaminated is unknown, but Salmonella typhimurium (Phage II), the cause of the outbreak, is widely disseminated in animals not only in California but throughout the world. There has been speculation that contamination could have originated in feedlots where cattle were passing Salmonella typhimurium hundreds of miles away, and due to seepage along earthquake faults, the bacteria appeared in the water supply. (38)

Tuberculosis

Tuberculosis must still be considered as an important disease related to animal wastes. While bovine tuberculosis caused by Mycobacterium bovis has been effectively controlled in this country, it is occasionally found in some wild animals, as well as in food animals and in pets.

Mycobacterium tuberculosis, the human type of tubercle bacillus, is capable of infecting cattle swine, and household pets.

Mycobacterium avium, the etiologic agent of tuberculosis in gallinaceous birds, is capable of producing tuberculosis in swine and of infecting cattle to such an extent that reactions are produced in routine tuberculin testing of cattle.

The bovine tubercle bacillus is transmitted to man through respiratory secretions, feces, and milk. In those few cases where infection of man with the bovine tubercle bacillus is known, there usually is an occupational contact with cattle. (38)

Brucellosis

Brucellosis is commonly an occupational disease of those with close contact with cattle and swine and their viscera and excreta. The disease in man and animals is caused by any one of three species of Brucella.

Brucella abortus is predominantly of bovine origin, Brucella suis of swine origin, and Brucella melitensis primarily infects goats. Cows may become infected with Brucella suis or Brucella melitensis as well as Brucella abortus. Swine may become infected with all three species; however, they are most susceptible to Brucella suis. Many outbreaks of brucellosis have been traced to contaminated water courses from meat-processing plants, rendering plants, and contaminated farms. (38)

The disease is systemic, with acute or insidious onset, characterized by continued, intermittent or irregular fever of variable duration, headache, weakness, profuse sweating, chills, or chilliness, arthralgia, depression, and generalized aching. Non-purulent meningitis and pneumonitis may occur. The disease may last for several days, many months, or occasionally several years. Orchitis and vertebral osteomyelitis are uncommon but characteristic features. Recovery is usual but disability is often pronounced. The fatality rate is 2% or less; higher for Brucella melitensis infections than for other species. Clinical diagnosis is often difficult and uncertain. Death is rare in persons without complications. (39)

Leptospirosis

Leptospirosis is a spirochetal disease of large proportions and is world-wide in distribution. A number of animal

species host the leptospira, including the domestic food-producing species. Cattle and swine are the principal domestic animals involved--leptospirosis occurs in epizootic form in stables and feedlot herds. Dogs and rodents are frequently infected.

Leptospirae are transmitted from the animal host to man through a number of routes. Documented sources of human infection are rice fields, swimming "holes", sewers, and a number of occupations in which exposure to infected animals is by direct contact. (38)

The disease in man shows a wide range of symptoms and severity, depending on the species of leptospira involved, exposure, and the health of the individual. It presents symptoms similar to influenza, enteric viral infections, infectious gastroenteritis, and a number of other diseases. Fatality is low, but increases with advancing age and may reach 20% or more in patients with jaundice and kidney damage. (39)

Tularemia

The reservoir for Tularemia is normally wild animals, but is occasionally found in sheep. Mode of transmission is by inoculation of the skin, conjunctival sac or anal mucosa with blood or tissue while handling infected animals, as in skinning, dressing, or performing necropsies; or by fluids from infected flies, ticks, or other animals, or through the bite of arthropods including a species of deer fly. The

disease is characterized by sudden and dramatic onset of chills and fever. Fatality in untreated cases is about 5%; with treatment, negligible. (39)

Although the above discussion of disease transmitted to man from animal has centered on occupational hazard data, the same types of wastes are generated from certain departments of veterinary hospitals. Again, as with hospitals, the Agency has concluded that only a portion of the total waste load of veterinary hospitals is a source of infectious waste (unless properly treated prior to disposal to render non-infectious).

For purposes of identifying sources of infectious waste, the following departments of veterinary hospitals are subject to Subtitle C regulation:

- Emergency department
- Surgery department including patients' room
- Morgue
- Pathology department
- Autopsy department
- Isolation rooms
- Laboratories
- Intensive care unit

NOTE: The Agency realizes that the names of the above departments are normally applied to hospitals for humans; the departments of veterinary hospitals that are functionally equivalent would be applicable.

3.11 Rationale for Regulation of Laboratory Waste

Data are generally not available that can be used to show evidence of disease associated with laboratory waste. In a recently published study at the University of Texas (Pike, 1975) (42), some waste/disease data can be extracted from the 50-year data base of published and unpublished cases of laboratory-associated infections.

As shown in the reproduced table (Table 7), 46 cases of laboratory-acquired infections related to the (waste) source of discarded glassware are shown. Of these cases, 34 were related to bacteria, 10 related to viruses, and 2 to rickettsiae. Of the total number of reported laboratory-associated infections studied, the 46 associated with discarded glassware represent about 1% of the total.

The Center for Disease Control has determined that certain microorganisms are of potential hazard to human health and the environment, as published in the "Classification of Etiologic Agents on the Basis of Hazard." Since it has been determined by HEW that classes 2 through 5 are of potential hazard, then any laboratory dealing with these agents would be generating a potentially hazardous, infectious waste. Given that most hospitals and laboratories know which organisms are used in their work, the list is appended

to the regulation to indicate the type of laboratory which would be included by the specified SIC codes. It must be recognized however, that many times in diagnostic work the organisms involved are unknown. By regulating laboratories as the "source" of infectious waste, the unknown presence of pathogenic organisms can be controlled. Thus, the CDC list is used as a basis for including laboratories as a source of infectious waste, but the list cannot be used alone to define this source, due to the nature of the waste from diagnostic labs.

TABLE 7 - Distribution of Cases According to Proved or Probable Source of Infection

Sources	Agents							Total
	Bacteria	Viruses	Rickettsiae	Fungi	Chlamydiae	Parasites	Unspecified	
Accident	378	174	45	33	14	38	21	703
Animal or ectoparasite	149	249	66	151	32	11	1	659
Clinical specimen	90	175	2	1	0	19	0	287
Discarded glassware	34	10	2	0	0	0	0	46
Human autopsy	56	9	4	0	0	1	5	75
Intentional Infection	14	1	0	0	0	4	0	19
Aerosol	101	92	217	88	22	2	0	522
Worked with the agent	381	213	100	62	43	28	0	827
Other	7	1	7	0	1	0	0	16
Unknown or not indicated	459	125	130	18	16	12	7	767
Total	1669	1049	573	353	128	115	34	3921

-61-

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3.12 Rationale for Regulation of Unstabilized Sewage Treatment Plant Sludge

The Agency has decided to regulate "domestic" or "municipal" sewage sludge from publicly owned treatment works under the authority of Section 405 of the Clean Water Act, supplemented by Section 4004 of RCRA. Unstabilized sewage sludge from industrial or other sources is considered to be a hazardous waste subject to regulation under Subtitle C of RCRA. Thus the following discussion applies to sewage sludges from industrial and other sources, which in many cases are similar or identical in character to domestic or municipal sludges.

The fact that pathogens do survive in sewage sludge has been addressed by EPA in the November 1977 Federal Register notice entitled "Municipal Sludge Management: Environmental Factors; Technical Bulletin." (43) In this publication, EPA recommends that sewage sludge be "stabilized" before landspreading "to reduce public health hazards and to prevent nuisance odor conditions." Stabilization of sewage sludge is defined as chemical, physical, thermal, or biological treatment processes that result in the significant reduction of odors, volatile organics, and pathogenic organics. EPA, in the same publication, recognizes that "although these conditions can reduce the number of influent fecal coliforms by 97 percent or more, the remaining levels of microorganisms may still have public health significance". And, further, that "under certain conditions. . .it may be necessary to achieve additional bacterial, parasite, and/or virus reduction beyond that attained by stabilization.'

In this bulletin general requirements for land application of sludges are given. Reference is made to "Process Design Manual for Sludge Treatment and Disposal" (EPA 625/1-74-006; October 1974) which specifies in more detail the techniques for sludge stabilization.

The bulk of the information presented in this section of the background document is identical to that presented in the background document for §257.4-5 (Land Criteria) to be used for Section 4004 of RCRA. (45) Section 4004 regulations will require sewage treatment plant sludge to be "stabilized" to "reduce public health hazards."

Pathogenic organisms occurring in sewage sludge cover a wide variety of bacteria, viruses and intestinal parasites. Their individual presence, as well as their numbers, will vary considerably from community to community depending upon rates of disease in the contributing population. (46) Routes of infection to humans and animals from sewage sludge may be through direct contact with contaminated environments or through the ingestion of contaminated food and water.

Bacteria

Among the bacteria that are commonly found in sewage sludge, is the group referred to as the "enteric bacilli" that naturally inhabit the gastrointestinal tract of humans. In their virulence for humans, the enteric bacilli fall into three general categories: pseudomonas species, salmonella species, and shigella species.

Pseudomonas

The pseudomonas species include the proteus organisms, Pseudomonas aeruginosa, and Alcaligenes faecalis. These common inhabitants of the normal human gastrointestinal tract are ordinarily non-pathogenic, causing disease (most often of the urinary tract) only under special circumstances.

Salmonella

The genus Salmonella contains a wide variety of highly invasive "species" pathogenic for humans or animals, and usually for both. Largely as the result of systematic studies, over 700 Salmonella species have been identified on the basis of specific antigens. Three distinguishable forms of salmonellosis occur in humans: enteric fevers, septicemias, and acute gastroenteritis.

The prototype of enteric fever is caused by Salmonella typhosa. The organism is usually acquired by ingestion of contaminated food or water, and the focus of occurrence in the United States is in the South. There were 375 cases of typhoid fever reported in the U.S. for the year 1976.(47)

The second form of salmonellosis is Salmonella septicemia, which is characterized by high, remittent fever and bacteremia, ordinarily without apparent involvement of the gastrointestinal tract. The third form, gastroenteritis, is a disease confined primarily to the gastrointestinal tract, and in most cases is caused by the Salmonella sp. typhimurium.

Shigella

The third category of enteric bacteria is the Shigella genus. The shigella cause in humans a disabling disease known as bacillary dysentery. This is an acute infection of the large intestines, resulting in diarrhea, which, if sufficiently severe, may be accompanied by bleeding from the colon. All known species of the genus Shigella are pathogenic for humans, with the following being the most common: S. dysenteriae, S. flexneri, and S. sonnei.

None of the enteric bacilli form spores. Spores are resistant bodies produced by large number of bacterial species that enable them to withstand unfavorable environmental conditions such as heat, cold, desiccation and chemicals. Since enteric bacilli are not spore formers, their survival span outside of their normal environment (human intestinal tract) is usually measured in days or months, compared to years for spore forming bacteria. Most sludge stabilization processes would create an unfavorable environment for enteric bacilli to survive.

A pathogenic bacterium frequently found in sewage sludge, although not an enteric organism, is the tubercle bacillus Mycobacterium tuberculosis. This organism is responsible for nearly all cases of pulmonary tuberculosis. Tubercle bacilli are very hardy organisms, and can withstand fairly extreme environmental conditions.

Viruses

The second group of pathogenic organisms found in sewage sludge are the enteric viruses. Viruses present certain differences from bacteria and possess many characteristics peculiar to their own group. Biologically, the most important difference between viruses and bacteria is that viruses must invade the living tissue cells or bacteria cells to multiply within them, whereas the bacteria do not invade the cells of their host.

More than 70 serologically distinct human enteric viruses can occur in sewage sludge. (48) The major pathogenic enteric virus groups are the Polio viruses, Coxsackie viruses, Echoviruses and the Hepatitis virus.

Poliomyelitis, caused by the poliovirus, is an acute systemic infection which, in its clinically recognizable form appears as an involvement of the central nervous system and often results in a variable degree of permanent paralysis. The escape of the virus from the body of the infected person is in respiratory tract secretions and in the feces.

Coxsackie viruses are responsible for common enteric infections and a variety of illnesses, including several clinically distinct ones in humans.

Echoviruses comprise a group of biologic agents brought together chiefly because they infect the human intestinal tract. Certain species are known to cause aseptic meningitis, febrile illnesses and diarrheal diseases in infants and children.

Infectious hepatitis is an acute infectious disease that causes fever, nausea, abdominal discomfort, followed by jaundice. It is caused by a resistant virus. The Hepatitis virus is shed from the body through the feces, and fecal-oral spread is probably the most common method of transmission.

Parasites

The third group of pathogenic organisms found in waste water treatment sludges are the intestinal parasites. Those parasites of concern to humans can be subdivided into two categories: (1) Protozoa, and (2) Helminths. Subgroups of the Protozoa group include amoebas, flagellates, and ciliates. Subgroups of the Helminths include trematodes and nematodes.

Protozoa

At least five species of amoebae live in the intestinal tract of humans, with Entamoeba histolytica being the only proven pathogen. Infection with E. histolytica may produce chronic diarrhea, amoebic hepatitis, abscess of the liver, brain, lung, and ulceration of the skin. Amoebae have two stages in their life cycles, a mobile form and a cyst form. The cysts are infective upon passage from the body, and are survive in a moist and cool environment. Giardia lamblia, another protozoan, is also found in sewage sludge. Like the amoeba, G. lamblia is a parasite of the human intestinal tract and is responsible for certain conditions such as diarrhea or symptoms referable to the gall bladder.

Balantidium coli is the only ciliate human parasite and is the largest of human protozoan parasites. It invades

a tissue and produces intestinal pathology similar to that of E. histolytica.

Helminths

Helminths are commonly referred to as worms. In a more restricted sense the name worm, or preferably helminth, is applied to a few phyla of animals, all of which superficially resemble one another in being "wormlike," though in life and structure they are widely different. Ascaris lumbricoides is the longest-known human parasite in this group. It was not until early in the present century that Ascaris was recognized as being as injurious and sometimes dangerous parasite.

Ascaris lumbricoides is a large nematode; the females commonly reach a length of 8 to 14 inches. The adult normally lives in the small human intestine, where it commonly bites the mucous membranes to extract tissue juices. Ascaris produce a tremendous number of eggs (ova) which are passed out of the body in the feces. Infection ordinarily results from swallowing the embryonated eggs, which are in most cases conveyed to the mouth by food or water. In heavy infections the migration of the larvae through the lungs causes hemorrhaging and sets up a severe pneumonia which may be fatal. The ova of the Ascaris are extremely durable, and are capable of withstanding severe environmental conditions.

Other Helminths encountered in sewage sludge are the tapeworms or Cestoidea. Although 25 or 30 different species of tapeworms have been recorded in man, only 4 adult species are to all common. These are Dibothriocephalus latus, Taenia

solium, I. saginata, and Hymenolepis nana. With the exception of the species of Hymenolepis, infection with the common human species results from eating raw or imperfectly cooked beef, pork, or fish in which the larvae have developed. Hymenolepis sp. on the other hand, need no intermediate host. It is able to complete its entire life cycle in a single host; thus, when eggs are ingested by man, the larvae migrate into the lumen of the intestine.

Numerous studies report that pathogenic organisms present in sludge are either killed or greatly reduced in number when exposed to various stabilization methods used.

The specific number of an organism necessary for the establishment of the potential for disease is related to various factors; etiologic agent, susceptibility of host etc. However, there is evidence that with many pathogens this dose may be rather high, in particular the enteric pathogens. DuPont et. al (49) reported that approximately 10^5 Salmonella cells (including S typhi) are required to cause a disease. This would tend to support the premise that by reducing the number of pathogenic organisms in sludge, the public health hazards associated with its use would be greatly minimized.

A review of the literature (7) has shown that there is a paucity of epidemiological data linking disease transmission of humans and animals directly to the landspreading of wastewater treatment sludges. The data that do exist, indicate

that the transmission of enteric disease or parasitic infestation were related to the use of raw or unstabilized sludges on cropland. Sepp (50) in his literature review on the landspreading of wastewater sludge, lists numerous reports of infection both to humans and animals believed to be caused by ingestion of raw vegetables fertilized by raw sludges. In specific cases, Kreuz (51) and Kroger (52) reported disease outbreaks caused by Salmonella species on lettuce grown on soil fertilized by raw sludge. Such evidence indicates that there is a public health risk associated with the landspreading of unstabilized sludges.

Data linking disease transmission to humans and animals from the landspreading of stabilized sludges is virtually nonexistent. This lack of data can possibly be attributed to the fact that most individuals can tolerate the number of pathogenic organisms that survive the sludge stabilization process, or the ingestion of these organisms result only in sporadic cases of infection, of which the source is difficult to trace. Based on the knowledge of the human immune system, the former is a more plausible assumption. Work by Dupont et al (49) tends to support the former possibility, since their studies indicated that with many pathogens the infective dose may be rather high, in particular the enteric pathogens.

The stabilization process will reduce the pathogen population in sludge; the level of reduction will vary with the process used and numerous other variables, e.g., time, temperature, pH etc. Since available epidemiological evidence links disease transmission to the landspreading of unstabilized sludge and not stabilized sludge, it is evident that there is a correlation between the concentration of pathogens in the sludge and disease transmisssion.

Wastewater sludge stabilization is normally accomplished by anaerobic and aerobic digestion, and lime treatment. Lesser used methods include heat treatment, ponding and long time storage, chlorination, and composting. The stabilization of sludge by thermal irradiation is being addressed, but at this time the process is still in the experimental state.

As previously mentioned, the extent to which pathogenic organisms are reduced is related to the stabilization process used as well as other variables. Not all stabilization processes affect pathogenic organisms in the same manner, therefore, some processes are more effective in reducing the pathogen population than others. Also the levels of stabilization within a particular process will vary as to their effectiveness in reducing pathogenic organism numbers, e.g., anaerobic digestion of sludge for a two week period in the

thermophilic range (125 F), is more effective in reducing pathogens than sludge digested anaerobically for two weeks in the mesophilic range (95 F).

The following is some of the information encountered relative to the effectiveness of various sludge stabilization processes in reducing pathogenic organisms. Table 3 summarizes these findings.

During anaerobic stabilization, the sludge temperature may reach 149 F by microbial action. However, the normal range for essentially all digesters in the United States is between 80 F to 100 F. (44) Although conditions in the digester are unfavorable for multiplication of most pathogenic organisms, they are not lethal and the principal bactericidal effect appears to be related to natural die-off with time. (44)

Kabler (53) reported that anaerobic digestion was comparatively ineffective in the inactivation of parasitic ova. Viable Ascaris eggs have been recovered following anaerobic digestion for as long as three (54) and six (55) months. An analysis of raw sludge from two community wastewater treatment plants revealed the presence of helminth ova and salmonella species. The same sludge after being stabilized by anaerobic digestion tested negative for both organisms. (56) Rudolfs et al. reported that after 6 months exposure to the anaerobic digestion process at 75 to 85 F, 46 percent of the ascarid eggs appeared normal. Other studies (54,57) reported that anaerobic digestion with different retention times removes

the eggs of A. lumbricoides 0 to 45 percent.

Two groups (58,59) observed that there was 90 and 69 percent diminution of tubercle bacilli, while two others (60,61) noted "survival" of M. tuberculosis after anaerobic digestion.

McKinney et. al(62) found in their studies that approximately 93 percent of S. typhosa were removed after being exposed to anaerobic digestion process for 20 days. Kenner (63) reported that sludge treated by anaerobic digestion has been shown to contain Salmonella and Pseudomonas organisms.

Cram (54) reported from his studies, that activated sludge treatment does not affect the viability of E. histolytica cysts or ascarid eggs. Aeration in the activated sludge process for 5 months showed no effect on ascarid eggs except a slow reduction in numbers (64), Kabler (53) reported that studies indicate that activated sludge reduced S. typhosa and strains of bacilli 91 to 99 percent.

Table 3 Removal of Pathogens by Sewage Treatment Processes (53)
(Percent)

	Trickling Filter	Activated Sludge	Anaerobic Digestion	Chlorination	Stabilization Ponds
<u>Enteric Bacteria</u>					
Total Counts	70-95	70-99	-	96-99	-
Coliform	82-97	91-93	-	99-99+	59-99+
Fecal Strep	84-94	-	-	-	-
Typhoid group	84-99+	Present: 95-99.2	Not found: 25-092.4	98-99	41/ml;N.D.
Shigella	-	97-98	-	-	-
Cholera	-	Not found	-	-	-
<u>M. Tuberculosis</u>					
M. Tuberculosis	Survive; 66-99	Survive; 88	Survive; 69-90	Survive; 99+	-
<u>Enteroviruses</u>					
Polio	-	Survive	-	99	-
Coxsackie	Reduced; 60	Survive	Survive	-	-
ECHO	-	-	-	-	-
Infectious hepatitis	-	-	-	-	Survive or inactivated
<u>Parasites</u>					
Tapeworm Ova	18-26	Not removed	97	No effect	-
E. histolytica cysts	88-99.9	No reduction	Removed	-	-
Ascaros lumbricolides ova	-	-	45; reduced	-	-
Taenia saginata	62-70	Little effect; Very slow			

Enteric virus inactivation during the treatment of wastewater by the activated sludge process has been reported extensively in the literature. (65-70) Carlson (71) et al reported that after 6 months of aeration, polioviruses were removed or inactivated to a point at which infectiousness for mice was greatly reduced. Sproul (72) reported that virus removal of 90 percent or more has been obtained in a number of studies with activated sludge process. Kelly et al (73) reported that Coxsackie virus survived activated sludge treatment.

Table 4

Removal of viruses by bench scale activated sludge units

Test No.	Coxsackie virus A9		Poliovirus 1	
	Volatile solids (mg/l)	Virus Inactivated (Percent)	Volatile solids (mg/l)	Virus Inactivated (Percent)
1	600	98.8	200	79
2	650	96.1	400	88
3	1,000	99.2	600	90
4.	1,100	99.1	600	91
5	1,500	97.4	1,200	92
6	1,500	99.4	1,200	91
7			4,000	94

Bacterial inhibition from caustic conditions has long been known. (74) Studies have shown that *Salmonella typhosa* did survive in concentrations in the range of pH 11.01-11.50 longer than two hours, while *Shigella dysenteriae* was destroyed rapidly in all pH range studies; pH 11.01-11.50 produced 100% kill in 75 minutes. (75) However, the effectiveness of lime treatment on parasitic ova and viruses has not been demonstrated.

Destruction of pathogenic organisms in sludge or in sludge-refuse mixtures by composting has been reported extensively in the literature. (76-83) Table 5 indicates that 60 C (140 F) for one hour appears to kill all pathogens, with possible exception of Tubercle bacillus. (84) M. tuberculosis was shown to be destroyed within two weeks at temperature 60 C (140 F) or above. (55)

Table 5*

Time-Temperatures Required for Organism Destruction (84)

Organism	Destruction Time-Temperature		Destruction Time-Temperature	
	Temp (.F)	Time (min)	Temp (.F)	Time (min)
Salmonella typhosa	131-140	30	140	20
Salmonella sp.	131	60	140	15-20
Shigella sp.	131	60	---	---
Ent. histolytica cysts	113	few	131	few seconds
Taenia saginata	131	few	---	---
Mycobacterium tubercu- losis var. hominis	151	15-20	152.6	momentary
Necator americanus	113	50	---	---
Ascaris lumbricoides eggs	122	60	---	---

* Adapted from Gotass

Long-term storage of sludge has been suggested as one of the simplest methods of reducing pathogenic organism numbers (85). Hinesly (86) reported that after storage of sludge for 30 days, fecal coliforms were reduced by 99.9 percent. However, Dotson (87) thought that parasites would probably persist much longer.

Heat treatment is a well known method of destroying pathogenic organisms. Three methods that have been applied

to sludge treatment are low pressure oxidation, heat drying and pasteurization. During the low pressure oxidation (LPO) process, the sludge temperature is elevated to between 350 and 400 F, pressure is raised to 180 to 210 psi, and the retention time is between 20 and 30 minutes. The process kills all pathogenic organisms due to the high temperature achieved and the retention time. Over 26 U.S. cities are currently using the LPO process.

Heat drying of sludge is presently being carried out in a number of U.S. cities. However, the numbers are declining because of cost of fuel necessary for the drying process, and also because the market for heat dried sludge did not develop as hoped. The temperature achieved during the heat drying process kills most bacteria.

Pasteurization is a process where the sludge is heated to a specific temperature for a period of time that will destroy pathogenic organisms. In most cases this is accomplished by the use of steam. Currently, pasteurization is used only in Europe.

While the technical literature presents some conflicting data as to the degree that pathogenic organisms are reduced by various sludge stabilization methods, it does generally indicate that the stabilization process will reduce most pathogenic organisms significantly. This reduction, in turn minimizes the public health risks associated with the landspreading of stabilized sludges.

To survive and remain virulent, pathogenic organisms usually depend on the favorable conditions of a host. When an organism encounters a situation in which it cannot function normally, growth stops and the organism dies. Numerous environmental conditions may affect the organism after it leaves the natural host. Although organic matter in the sludge acts as a protective agent, organisms are stressed by waste treatment and encounter unfavorable moisture conditions, pH, temperature, sunlight, and nutrient levels when applied to land. Toxic substances in the sludge, soil antibiotics, and antagonistic organisms may also present obstacles to pathogen survival.

In soils receiving sewage sludge, most pathogens will disappear or be reduced to low numbers in two to three months. Although some pathogens have long survival time in soil (Table 6), most do not survive long on plant surfaces. When long survival times have been reported, initial inoculation levels were high, most pathogens were subsequently detected in low numbers, and no indication was given of the actual disease potential. (88)

Table 6 contains part of the data extracted by Dunlop (89) from his literature review pertaining to the survival of pathogenic organisms in soil, water and crops. Except for Ascaris ova, the table shows that most pathogenic organisms die off within one year. The two studies reporting Ascaris ova living 2-7 years were both conducted in Europe. Muller (90) reported in Germany that Ascaris ova survived up to 7 years

Table 6

Survival times of Pathogenic Microorganisms in various media (89)*

Organisms	Medium	Type of Application*	Survival time
Ascaris Ova	Soil	Not stated	2-5 years
	Soil	Sewage	Up to 7 years
	Plants and Fruits	AC	1 month
Endamoeba Histolytics cysts	Soil	AC	8 days
	Tomatoes	AC	18-42 hours
	Lettuce	AC	18 hours
Enteroviruses	Roots of bean plants	AC	At least 4 days
	Soil	AC	12 days
	Tomato & pea roots	AC	4-6 days
Salmonella	Strawberries	AC	6 hours
	Soil	AC	74 days
	Soil	AC	70 days
	Soil	AC	At least 4 days
	Pea plant stems	AC	14 days
	Radish plant stems	AC	4 days
	Soil	AC	Up to 20 days
	Lettuce & endive	AC	1-3 days
	Soil	AC	2-110 days
	Soil	AC	Several months
	Lettuce	Infected feces	18 days
	Radishes	Infected feces	53 days
	Soil	Infected feces	74 days
Salmonella, other than typhi	Soil	AC	15-70 days
	Vegetables	AC	2-7 weeks
	Tomatoes	AC	Less than 7 days
	Soil	Sprinkled with domestic sewage	40 days
	Potatoes	Sprinkled with domestic sewage	40 days
	Carrots	Sprinkled with domestic sewage	10 days
	Cabbage and gooseberries	Sprinkled with domestic sewage	5 days
	Shigella	Streams	Not stated
Harvested Fruits		AC	Minutes to 5 days
Market tomatoes		AC	At least 2 days
Market apples		AC	At least 6 days
Tomatoes		AC	2-7 days
Tubercle Bacilli	Soil	AC	6 months
	Grass	AC	14-15 months

*Artificial Contamination

in garden soil. Gudzhabidze (91) reported in the Soviet Union that Ascaris ova survived 2-5 years in soil of irrigated agriculture fields. The literature reviewed does not reveal any studies in the United States where Ascaris ova survived in sludge amended soils for more than one year.

Hess et al. (92) reported the survival of salmonellae on grass contaminated with sludge for 40 to 58 weeks in a dry atmosphere. McCarty and King (93) found that enteric pathogens could survive and remain virulent for up to two months. Rudolfs et. al. (94) concluded from field studies that the survival of representatives of the Salmonella and Shigella genera on tomato surfaces did not exceed seven days, even when the organisms were applied with fecal organic material. He attributed their short survival time to the lack of resistant stages; thus making them more vulnerable to adverse environmental conditions.

Martin (95), inoculating sterile virgin soils with E. typhosa, found they died out rapidly, but in sterilized contaminated soils growth occurred and the bacteria survived for numerous months. Rudolfs (94) in his literature review, found that the survival time of E. typhosa ranged from less than 24 hours to more than two years in freezing moist soils, but generally less than 100 days.

Approximately 90 different enteric viruses have been recovered from municipal sewage. However, there are few

published reports on the survival of viruses in soil, and persistence on crops. Larkin et al. (96) described the persistence of polioviruses for 14 to 30 days on lettuce and radishes inoculated with sludge. According to Cliver (97) the soil is generally not a very adverse environment for viruses. Neither chemical nor biological inactivation occurs very rapidly, but enteroviruses do lose infectiousness as a function of time and temperature in the soil. Poliovirus 1, retained in sand from septic tank effluent, was inactivated at a rate of 13 to 18 percent per day at 20 to 25 C and at 1.1 percent per day at 6 C to 8 C. (97)

Rudolfs et al. (94) reported that unlike pathogenic bacteria, the parasitic amoeba, Endamoeba histolytica, forms resistant cysts which enable the organism to survive under adverse conditions. However, on the basis of laboratory and field studies on the survival of Endamoeba histolytica cysts, the cysts proved to be extremely sensitive to desiccation. Rudolfs concluded from his studies that field-grown crops contaminated with cysts of E. histolytica are considered safe in the temperate zone one week after contamination has stopped and after two weeks in wetter tropical regions.

It has been shown in the general survey of the literature (94) that certain parasite eggs, especially those of Ascaris, are markedly resistant to external conditions. Yoshida (98) found that mature eggs of A. lumbricoides were still viable after five to six months under layers of soil in winter. He

also found (99) that exposure to strong sunlight checked egg development and eventually killed them.

Brown (100) reported that the type of soil was an important factor in the viability of Ascaris eggs. Experiments showed Ascaris eggs in feces deposited on sandy soil in the sun were degenerated in 21 days. In the shade, however, 91 percent of the eggs contained mobile embryos in 35 days, and decreased to 69 percent in 54 days.

Otto (101) studied the moisture requirements of Ascaris eggs and found they did not develop to embryonation in atmosphere of less than 80 percent relative humidity, although they remained viable for varying lengths of time in atmospheres containing less moisture.

Spindler (102) in his studies on isolating Ascaris eggs from soil, found the number of embryonated eggs to be surprisingly small in spite of the fact that the soils were, in many cases, being subjected to continuous application of sewage. Vassilkova (103) in his study of contamination of sewage farm vegetables with helminth eggs, reported that the Ascaris eggs found on vegetables, only 36 percent were viable.

Except in the two reported cases (90,91) the literature indicates that the survival time of most pathogens found in wastewater sludge is limited to weeks or months, depending on environmental conditions.

3.13 Methods for Biological Examination of Solid Waste

Bacteria

Mirdza L. Peterson of EPA has published "Methods for Bacteriological Examination of Solid Waste and Waste Effluents." (104) After examining methods currently available for measuring the bacteriological quality of solid waste, reliable methods were established which are best suited to routinely measure, under practical conditions, the bacteriological quality of solid waste in and around waste processing areas. These methods were not developed to be an all-inclusive battery of tests for microorganisms in solid waste; rather, these methods test for only a few of the possible microorganisms in the solid waste.

Three procedural lines of investigation were undertaken in this effort: (1) to develop methods suitable for indicating the sanitary quality of solid waste before and after processing or disposal; (2) to develop methods suitable for determining the efficacy of operational procedures in removing or destroying the microorganisms; and, (3) to develop methods suitable for indicating the health hazard of solid waste in which pathogenic species may be present in small numbers. Methods presented in this publication are ones for determining: total viable bacterial cell number, total coliforms, fecal coliforms, heat-resistant spores, and enteric pathogens, especially *Salmonella* sp.

The determination of approximate total viable bacteria multiplying at a temperature of 35 C may yield useful information concerning the sanitary quality of a waste entering a processing or a disposal site, and provide useful information in judging

the efficiency of procedures employed in solid waste processing and/or disposal operations.

The coliform bacteria have long been used in the United States as indicators of fecal pollution in sanitary bacteriology. Some members of the coliform group of organisms are found in the feces of warm-blooded animals, in the guts of cold-blooded animals, in soils, and on many plants. Studies have shown that warm-blooded mammal feces from humans, animals, or birds may at any time contain disease-producing microorganisms. (105) It was pointed out that cold-blooded animal feces are quantitatively insignificant as a source of pollution, but the coliform bacteria from plants or soils that have the same significance as those from feces; on the other hand, the coliform bacteria deriving from soils or plants that have not been exposed to recent fecal contamination has less public health significance.

The method for determining viable heat-resistant spore-formers is used to detect spores that survive 80 C temperature for as long as 30 minutes. With respect to survival under heat stress, most microorganisms in an actively growing (vegetative) state are readily killed by exposures to temperatures of around 70 C for 1 to 5 minutes. (106) Cells inside of material such as discarded meat products may resist heat longer because the heat does not penetrate immediately into the center of solid masses. Large masses of non-fluid solid matter require

a long exposure time (1-1/2 to 2 hr), even in an autoclave (121 C) to be heated thoroughly so that the center reaches a sporocidal temperature. Other reports (107) point out that although internal air temperatures of municipal incinerators usually range from 1200 to 1700 F (650 to 925 C) in continuous operation, intermittent use, overcharging of the incinerator, and high moisture content of the waste may slow the process and interfere with sterilization of the residue.

Fecal pollution of the environment by untreated and improperly disposed waste may add enteric pathogenic bacteria to a body of water or a water supply. The most common type of pathogen which may be found in untreated waste is Salmonella. The wide distribution of the many types of Salmonella in many species of animals with which man has contact or may use as food makes it difficult to prevent transmission to man. (108) Infections may occur through food, milk, or water contaminated with infected feces or urine, or by the actual ingestion of the infected animal tissues. (109) Salmonella has been found in many water supplies (110), polluted waters (111-113), raw municipal refuse and in incinerator residue (111-117)

General laboratory procedures, sample collection and preparation procedures, and bacteriological examination procedures for the organisms mentioned above can be found in Appendix A-3.1.

Parasites

The FDA has recently prepared a methodology for Ascaris determination in vegetable and sludge samples (118). The

presence of Ascaris eggs, which exit from their host via the feces, is of concern to EPA in sewage sludge. These eggs are highly resistant to extreme temperatures, drying, and chemical action, and have been known to remain alive in digested sewage sludge for years. Ascaris methodology is presented in Appendix A-3.3.

Viruses

Since evidence exists that viruses can survive secondary waste treatment processes including terminal disinfection, as well as the sludge digestion process, a method for determining enteroviruses in solid waste is given. This method was developed in an EPA study entitled "Evaluation of Health Hazards Associated with Solid Waste Sewage Sludge Mixtures" (EPA contract No.68-03-0128). (55) The method was employed by the Tennessee Department of Public Health Laboratories in Nashville to determine the presence of ECHO, Coxsackie, and Polio viruses. The methodology, although given in a descriptive form in the study, has been broken down into steps in Appendix A-3.2. Since sampling procedures in the report were given for a specially prepared windrow of solid wastes, they are not included in Appendix A-3.2. Appendix A-3.1 should be consulted for sample collection procedures.

Fungi

A method for identifying pathogenic fungi in solid waste samples was developed in the same EPA report cited for virus methodology, above. (12) Again, reference should be made to Appendix A-3.1 for sampling procedures; the fungi methodology is presented in Appendix A-3.4.

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APPENDIX A-3

Methods for Biological Examination of Solid Wastes

- A-3.1 Bacteriological Examination**
- A-3.2 Virological Examination**
- A-3.3 Determination of Ascaris spp. Eggs**
- A-3.4 Determination of Pathogenic Fungi**

**METHODS FOR BACTERIOLOGICAL EXAMINATION
OF SOLID WASTE AND WASTE EFFLUENTS***

Mirdza L. Peterson

General Laboratory Procedures

Glassware washing.

All glassware known to contain infectious material must be sterilized by autoclaving before washing. All glassware that is to be used in microbiological tests must be thoroughly washed before sterilization, using a suitable detergent and hot water, and followed by hot water and distilled water rinses. Six to 12 rinses may be required to remove all traces of inhibitory residues from the glass surface.

Sterilization.

Dry heat is used for the sterilization of glass sampling bottles, foil-covered flasks, beakers, graduates, pipettes packed tightly in sealed cans, or articles that are corrosively attacked by steam. Recommended time-temperature ratio for dry heat sterilization is 170 C for 2 hr.

Saturated steam under pressure (or autoclaving) is the most frequently used sterilization method. Media, dilution water, and materials (rubber, paper, cotton, cork, heat-stable plastic tubes, and closures, for example) are sterilized by autoclaving at 121 C. Sterilization time for media and dilution water (for volumes up to 500 ml) is 15 min; 1,000-ml quantities are held for 20 min, instruments for 15 min, gloves for 20 min, and packs for 30 min (measured from the time the autoclave temperature reaches 121 C).

Membrane filters are sterilized for 10 min at 121 C with fast steam exhaust at the end of the sterilization process.

Heat-sensitive carbohydrates and other compounds are sterilized by passage through a cellulose ester membrane or another bacteria-retaining filter.

* From Physical, Chemical, and Microbiological Methods of Solid Waste Testing, U.S. EPA Office of Testing and Monitoring, National Environmental Research Center, Cincinnati. May 1973.

Culture media.

The use of dehydrated media is recommended whenever possible, since these products offer the advantages of good consistency from lot to lot, require less labor in preparation, and are more economical. Each lot should be tested for performance before use.

Measurement of the final pH of a prepared culture medium should be accomplished colorimetrically after autoclaving and cooling. Acceptable pH range is 7.0 ± 0.1 .

Media should be stored in a cool, dry, and dark place to avoid dehydration, deterioration, and adverse light effects. Storage in the refrigerator usually prolongs the shelf-life of most media. Media should not be subjected to long periods of storage, because certain chemical reactions may occur in a medium even at refrigerator temperatures.

Many of the media referred to below can be obtained from commercial sources in a dehydrated form with complete information on their preparation. These media will therefore be listed but not described in this section. Described in this section are those media that are formulated from ingredients or from dehydrated materials. Culture media (Difco or BBL products) are listed as follows:

- Bacto-agar
- Bismuth sulfite agar
- Blood agar
- Brain heart infusion broth
- Brilliant green agar
- Brilliant green lactose bile, 2 percent
- Coagulase mannitol agar
- Dextrose
- E. C. broth
- Eosin methylene blue agar, Levine
- Fluid thioglycollate medium
- Gelatin
- H-broth
- Indole nitrite medium
- KCN medium

Lactose
Lactose tryptose broth
Lauryl tryptose broth
Lysine decarboxylase medium
M-Endo broth
M-FC broth
MacConkey's agar
Malonate broth, Ewing modified
Maltose
Mannitol
Mannitol salt agar
Methyl red-Voges Proskauer medium
Nitrate broth
Nutrient agar
Phenol red broth base
Phosphate buffer, APHA, pH 7.2
Sabouraud's dextrose agar
Salmonella-Shigella agar
SBG enrichment broth
Selenite-F enrichment broth
SIM medium
Simmons citrate agar
Sucrose
Triple sugar iron agar
Trypticase soy agar
Tryptone glucose extract agar
Urea agar base concentrate (sterile)
XLD agar

Culture media requiring preparation.

Blood Agar: Suspend 40 g of trypticase soy agar in a liter of distilled water. Mix thoroughly. Heat with agitation and boil for 1 min. After solution is accomplished, sterilize by autoclaving for 15 min at 121 C. Cool agar to 45 to 50 C, and add 5 to 7 percent sterile, defibrinated sheep blood, mixing evenly throughout the medium. Pour into sterile Petri dishes. After solidification, invert dishes and incubate overnight.

Phenol Red Broth Base: Dissolve 15 g in a liter of distilled water. Add 5 to 10 g of desired carbohydrate. Use Durham fermentation tubes for detection of gas formation. Arrange tubes loosely in suitable containers and sterilize at 116 to 118 C for 15 min.

Phosphate Buffer Solution: To prepare stock phosphate buffer solution, dissolve 34.0 g potassium dihydrogen phosphate, KH_2PO_4 , in 500 ml distilled water, adjust to pH 7.2 with 1N NaOH, and dilute to 1 liter with distilled water. Add 1.25 ml stock phosphate buffer solution to 1 liter distilled water. Dispense in amounts that will provide 99 ± 2.0 ml or 9 ± 0.2 ml after autoclaving at 121 C for 15 min.

COLLECTION AND PREPARATION OF SAMPLES

Method for Collection of Solid Waste or Semi-Solid Waste Samples

Equipment and materials.

Necessary items are as follows:

1. Sample containers, specimen cups, sterile, 200-ml size (Falcon Plastics, Los Angeles)
2. Sampling tongs, sterile (stainless steel, angled tips, 18 in. long)
3. Shipping container, insulated, refrigerated, 6 by 12 in. I.D.
4. Disposable gloves

Procedure.

1. Using sterile tongs, collect 20 to 40 random 100- to 200-g samples and place in sterile sampling containers. When collecting samples from contaminated sources, wear disposable gloves and avoid contaminating the outside of the container.
2. Identify samples on tag and indicate time and date of sampling. If incinerator residue samples are taken, record operating temperatures of incinerator.
3. Deliver samples to laboratory. It is recommended that the examination be started preferably within 1 hr after collection;* the time elapsing between collection and examination should in no case exceed 8 hr.

Method for Collection of Liquid Samples-Quench and Industrial Waters or Leachate

Equipment and materials.

Necessary items include a screw-capped, 250-ml, sterile sample bottle or a 16-oz, sterile plastic bag.

Procedure.

Collect sample in bottle or plastic bag, leaving an air space in the container to facilitate mixing of the sample before examination. When collecting samples from contaminated sources, wear disposable gloves and avoid contaminating the outside of the container.

Identify and deliver samples to laboratory. When shipping samples to laboratory, protect containers from crushing and maintain temperature below 10C during a maximum transport time of 6 hr. Examine within 2 hr. If water sample contains residual chlorine, a dechlorination agent such as sodium thiosulfate is added to collection bottles to neutralize any residual chlorine and to prevent a continuation of the bactericidal action of chlorine during the time the sample is in transit to the laboratory. Enough sodium thiosulfate is added to the clean sample bottle before sterilization to provide an approximate concentration of 100 mg per liter in the sample.

*If sample is shipped to a laboratory for analysis and examination cannot begin within 1 hr. of collection, the container must be insulated and sample maintained below 10 C during the maximum transport of 6 hr. Such samples should be refrigerated upon receipt in the laboratory and processed within 2 hr.

Method for Collection of Incinerator Stack Effluents

Equipment and materials.

Necessary items include an Armstrong portable sampler (2), equipped with sampling assembly (Figure 1). The sampler is mounted on a steel plate (6 by 12 in.) and can be enclosed by a metal cover with a handle attached. On one side of the base is a vacuum pump with a 6-ft cord and switch. The pump is capable of drawing up to 1 cu ft per min of air (vacuum of 5.6 in. [14.3 cm] of water). On the other side of the base, a 700-ml, wide-mouth, Pyrex bottle contains 300 ml of 0.067 M phosphate buffer solution (pH 7.2) prepared by standard methods (3). The two-hole rubber stopper has a 1-in. (2.54 cm) piece of cotton-plugged glass tubing in one of the two holes. The stopper, glass tube, and contents of the bottle are maintained sterile. The bottle is held to the base plate by three removable spring clips, which are attached at the base and at a wire triangle slipped over the top of the bottle. The sampling probe is made of stainless steel tubing of appropriate diameter (e.g., 0.25-in. I.D. [0.64 cm]). The probe end has a right-angle bend so that the opening faces the stack-gas current. The tubing must be long enough to reach all parts of the stack: The tubing is coiled to permit additional cooling of the gases and is straight for 1 or 2 ft (30.48 or 60.96 cm) at a right angle to the other straight length. Before use, the sampling probe is sterilized by dry heat sterilization. It is important to keep the inside of the probe dry to minimize adsorption of microorganisms on the walls of the tubing. When sampling, the probe is inserted into the stack at locations that will yield a representative sample. The other end of the sterile probe is inserted through the sterile rubber stopper to approximately 0.5 in. (1.27 cm) above the buffered water. This is done to reduce the frothing that would occur if the probe were inserted below the surface; enough froth results in capturing the microorganisms.

Procedure.

1. Draw stack effluent through the sterile stainless steel tube by a 1.0 cfm vacuum pump; cool the tube with a water jacket.
2. Obtain a 10-cu-ft sample by drawing the stack effluent for 10 min.
3. Identify sample on tag and examine within 4 hr. The Armstrong portable sampler provides a method for qualitative, nonisokinetic sampling and is adjustable to isokinetic conditions.

Method for Collection of Dust Samples

Equipment and materials.

Necessary items include the following:

1. Andersen sampler (4)
2. Trypticase soy agar containing 5 percent sheep blood (6 plates per sample)
3. Eosin methylene blue agar

Procedure.

1. Draw air through the sterile, assembled sampler at 1.0 cfm with a vacuum of 15 in. of mercury.
2. Remove agar plates from the sampler, cover, and incubate at 35 ± 0.5 C. Use aseptic technique throughout the procedure.

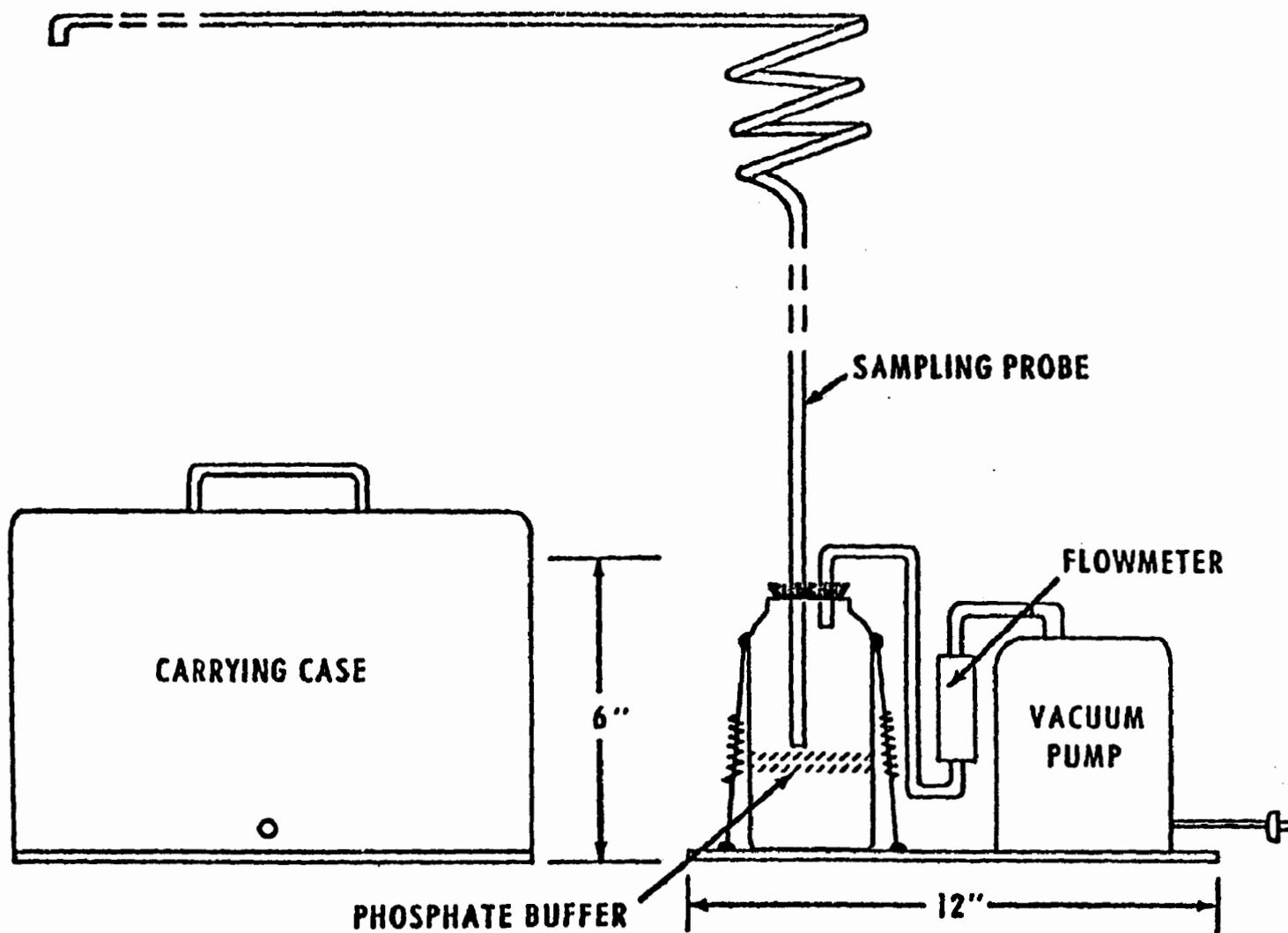


Figure 1. Portable sampler for microorganisms in incinerator stack emission.

Method for Preparation of Solid and Semi-Solid Samples for Analyses

Equipment and materials.

Necessary items are as follows:

1. Cold phosphate buffer, 0.067 M, pH 7.2, sterile (3)
2. Blender, Waring (Model 1088), sterile
3. Balance, with weights, 500-g capacity
4. Tongs, sterile
5. Beakers, two, 5,000 ml and 1,000-ml sizes, sterile, covered with aluminum foil before sterilization.

Procedure.

1. Using aseptic technique, composite all random samples into a 5,000-ml beaker. Mix well.
2. Weigh 200 g of the subsample into a 1,000-ml beaker.
3. Transfer the weighed sample to a sterile blender.
4. Add 1,800 ml of sterile, phosphate buffered solution to the blender.
5. Homogenize for 15 sec at 17,000 rpm (5).
6. Prepare a series of decimal dilutions as described below in "Methods for Preparation of Decimal Dilutions of a Solid, Semi-Solid, or Liquid Waste Material."

Solid waste and residue samples for enteric pathogenic bacteria are examined directly without homogenization.

BACTERIOLOGICAL EXAMINATION OF WASTE AND RELATED MATERIALS

Method for Preparation of Decimal Dilutions of a Solid, Semi-Solid, or Liquid Waste Material

Immediately after homogenization of any sample (see procedure under Method for Preparation of Solid and Semi-Solid Samples for Analyses) transfer a 1-ml portion of the homogenate (10^{-1} dil) to a dilution bottle containing 99 ml of phosphate buffered solution. Stopper and shake the bottle 25 times.

Prepare dilutions as indicated in Figure 2. Again shake each dilution vigorously 25 times after adding an aliquot of sample.

These dilutions are used to inoculate a series of selected culture media for the detection of various groups of microorganisms as described in the following sections of this paper.

Methods for Total Viable Bacterial Cell Number

The chief cultural method for determining total viable bacterial densities has been the agar plate method (3, 6, 7). Experience indicates that an enumeration of total number of viable bacteria multiplying at a temperature of 35 C may yield useful information concerning the sanitary quality of the waste entering a processing or a disposal site and provide useful information in judging the efficiency of procedures used in solid waste processing and/or disposal operations. The viable microbial count also provides valuable information concerning the microbiological quality of environmental aerosols existing in or around a waste processing plant or a disposal site.

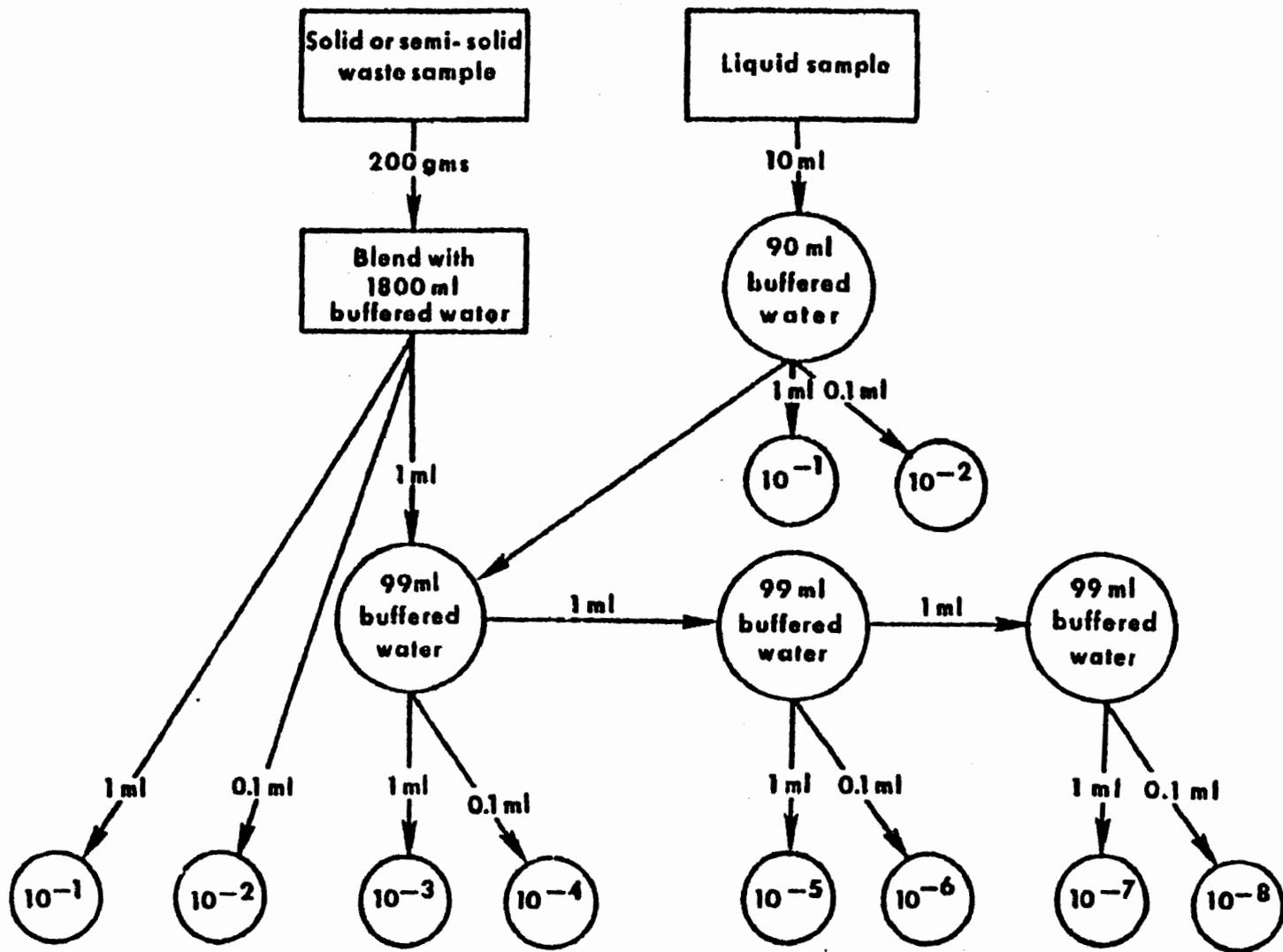


Figure 2. Preparation of decimal dilutions.

Equipment, materials, and culture media

1. Pipettes, 1.1 ml with 0.1 ml and 1 ml graduations
2. Dilution blanks, phosphate buffered solution, 99 ml \pm 1 ml (cold)
3. Culture dishes (100 x 15 mm), plastic, sterile
4. Water bath for tempering agar, 45 \pm 1 C
5. Incubator 35 \pm 0.5 C
6. Colony counter, Quebeck
7. Sterile glass spreader, bent rod
8. Trypticase soy agar with 7 percent defibrinated sheep blood (TSA + blood)
9. Tryptone glucose extract agar (TGE)

Prepare TGE agar as indicated on label and hold in a melted condition in the water bath (45 C).

Dissolve ingredients of TSA and heat to boiling. Sterilize by autoclaving at 121 C for 15 min. Cool to 45 C and add sheep blood. Dispense in Petri plates and allow to solidify. Invert plates and place them in incubator overnight to dry.

Procedure for bacterial count by pour plate.

Pipette 1 ml, 0.1 ml, or other suitable volume of the sample into each of appropriately marked, duplicate culture plates, being sure to shake each dilution bottle vigorously 25 times to resuspend material that may have settled out.

2. Add 10 to 12 ml of melted TGE agar to the sample in the Petri plate.
3. Mix dilution and the agar medium by rotating or tilting the plate.
4. Allow plates to solidify as rapidly as possible after pouring.
5. Invert plates and incubate them at 35 C \pm 0.5 C for 24 \pm 2 hr.
6. Count all colonies using Quebeck colony counter, the objective being to count plates with 30 to 300 colonies.
7. Compute the colony count per gram of waste (wet weight) or related solid material, and per 100 ml of water. The number of bacteria should not include more than two significant figures.

Procedure for bacterial count by streak plate.

1. Dispense 0.1 ml samples of the serially diluted homogenate (or liquid) on the surface of each of appropriately marked, duplicate TSA + blood agar plates.
2. Using a sterile glass spreader and starting with the highest dilution plates, spread the inoculum evenly over the agar surface.
3. Invert plates and incubate them at 35 C for 24 hr \pm 2 hr.
4. Count the number of colonies on plates with 30 to 300 colonies.
5. Select and mark colonies for further testing.

Methods for Presence of Members of Coliform Group

The presence of fecal matter in waste and related materials is determined by the standard tests for the coliform group described in Standard Methods for the Examination of Water and Waste Water (3). The completed Most Probable Number (MPN) procedure is employed. The testing method includes the elevated temperature test (44.5 C) that indicates the fecal or nonfecal origin of coliform bacteria. Comparative laboratory studies conducted showed that the MPN estimate is the most suitable method for achieving a representative enumeration of the coliform organisms in solid waste and waste effluents (9).

Equipment and materials.

1. Pipettes, sterile—deliveries to 10 ml, 1 ml (1.1 ml), and 0.1 ml
2. Media prepared in fermentation tubes:
 - Lauryl tryptose broth
 - Brilliant green lactose bile broth, 2 percent
 - Lactose tryptose broth
 - E.C. broth
3. Media for plating:
 - Eosin methylene blue agar plates
 - Nutrient agar slants
4. Dilution blanks, phosphate buffer solution, sterile, 99-ml or 90-ml amounts
5. Incubator, adjusted to $35\text{ C} \pm 0.5\text{ C}$
6. Water bath, adjusted to $44.5\text{ C} \pm 0.2\text{ C}$

Procedure for total coliform group.

Presumptive Test.

1. Inoculate a predetermined volume of sample into each of 5 lauryl tryptose broth tubes. The portions of the sample used for inoculation should be decimal multiples and submultiples of 1 ml.
2. Incubate the fermentation tubes at $35 \pm 0.5\text{ C}$ for $24 \pm 2\text{ hr}$.
3. Examine for the presence of gas. If no gas is formed, incubate up to $48 \pm 3\text{ hr}$. Record the presence or absence of gas formation at each examination of the tubes, regardless of the amount.

Confirmed Test.

1. Submit all presumptive test tubes showing any amount of gas at the end of 24- and 48-hr incubation to the confirmed test. Using a sterile platinum loop 3 mm in diameter, transfer one loopful of medium from the presumptive test fermentation tube to a fermentation tube containing brilliant green lactose bile broth.
2. Incubate the inoculated brilliant green lactose bile broth tube for $48 \pm 3\text{ hr}$ at $35 \pm 0.5\text{ C}$. The presence of gas in any amount in the fermentation tube of the brilliant green lactose bile broth within $48 \pm 3\text{ hr}$ indicates a positive confirmed test.

Completed Test.

1. Submit all confirmed test tubes showing any amount of gas to the completed test. Streak an eosin methylene blue agar plate from each brilliant green bile broth tube as soon as possible after the appearance of gas.
2. Incubate the plates at 35 ± 0.5 C for 24 ± 2 hr.
3. Fish one or more typical or atypical colonies from plating medium to lactose tryptose broth fermentation tubes and nutrient agar slants.
4. Incubate the broth tubes and the agar slants at 35 ± 0.5 C for 24 ± 2 hr or 48 ± 3 hr if gas is not produced in 24 hr.
5. Prepare gram stained smears from the nutrient agar slants if gas is produced in any amount from lactose broth.
6. Examine smears under oil immersion. If typical coliform staining and morphology are found on the slant, the test may be considered completed and the presence of coliform organisms demonstrated.

Procedure for fecal coliform group (E. C. broth).

1. Submit all gas positive tubes from the Standard Methods presumptive test (lauryl tryptose broth) to the fecal coliform test. Inoculate an E. C. broth fermentation tube with a 3-mm loop of broth from a positive presumptive tube.
2. Incubate the broth tube in a water bath at 44.5 ± 0.2 C for 24 hr. All E. C. tubes must be laced in the water bath within 30 min after planting.

Gas production in the E. C. broth fermentation tubes within $24 \text{ hr} \pm 2 \text{ hr}$ is considered a positive reaction indicating fecal origin.

Computing and recording most probable number (MPN).

The calculated estimate and the 95 percent confidence limits of the MPN described in the 13th edition of Standards Methods for Examination of Water and Waste Water (3) are presented in Table 1. This table is based on five 10-ml, five 1.0-ml, and five 0.1-ml sample portions. When the series of decimal dilutions such as 1.0, 0.1, and 0.01 ml are planted, record 10 times the value in the table; if a combination of portions of 0.1, 0.01, and 0.001 ml are planted, record 100 times the value in the table. MPN values for solid samples are calculated per g of wet weight; MPN for liquid samples are recorded per 100 ml.

Method to Determine the Presence of Viable Heat-Resistant Spore Number

Equipment and materials.

1. Test tubes, sterile, screw capped, 20 x 150 mm
2. Pipettes, sterile, graduated, 10-ml
3. Water bath, electrically heated, thermostatically controlled at 80 ± 0.5 C, equipped with thermometer (range 0 to 110 C), NBS certified. Volume of water should be sufficient to absorb cooling effect of rack of tubes without drop in temperature greater than 0.5 C.
4. Test tube support for holding tubes

TABLE 1.
MPN INDEX AND 95 PERCENT CONFIDENCE LIMITS FOR
VARIOUS COMBINATIONS OF POSITIVE AND NEGATIVE RESULTS
WHEN FIVE 10-ML PORTIONS, FIVE 1-ML PORTIONS, AND FIVE
0.1-ML PORTIONS ARE USED.*

No. of Tubes Giving Positive Reaction out of			MPN Index per 100 ml	95% Confidence Limits		No. of Tubes Giving Positive Reaction out of			MPN Index per 100 ml	95% Confidence Limits	
5 of 10 ml Each	5 of 1 ml Each	5 of 0.1 ml Each		Lower	Upper	5 of 10 ml Each	5 of 1 ml Each	5 of 0.1 ml Each		Lower	Upper
0	0	0	<2								
0	0	1	2	<0.5	7	4	2	1	26	9	78
0	1	0	2	<0.5	7	4	3	0	27	9	80
0	2	0	4	<0.5	11	4	3	1	33	11	93
1	0	0	2	<0.5	7	4	4	0	34	12	93
1	0	1	4	<0.5	11	5	0	0	23	7	70
1	1	0	4	<0.5	11	5	0	1	31	11	89
1	1	1	6	<0.5	15	5	0	2	43	15	110
1	2	0	6	<0.5	15	5	1	0	33	11	93
2	0	0	5	<0.5	13	5	1	1	46	16	120
2	0	1	7	1	17	5	1	2	63	21	150
2	1	0	7	1	17	5	2	0	49	17	130
2	1	1	9	2	21	5	2	1	70	23	170
2	2	0	9	2	21	5	2	2	94	28	220
2	3	0	12	3	28	5	3	0	79	25	190
3	0	0	8	1	19	5	3	1	110	31	250
3	0	1	11	2	25	5	3	2	140	37	340
3	1	0	11	2	25	5	3	3	180	44	500
3	1	1	14	4	34	5	4	0	130	35	300
3	2	0	14	4	34	5	4	1	170	43	490
3	2	1	17	5	46	5	4	2	220	57	700
3	3	0	17	5	46	5	4	3	280	90	850
4	0	0	13	3	31	5	4	4	350	120	1,000
4	0	1	17	5	46	5	5	0	240	68	750
4	1	0	17	5	46	5	5	1	350	120	1,000
4	1	1	21	7	63	5	5	2	540	180	1,400
4	1	2	26	9	78	5	5	3	920	300	3,200
4	2	0	22	7	67	5	5	4	1600	640	5,800
									≥2400		

*Source: *Standard Methods for the Examination of Water and Wastewater*, 13th ed. Published, 1971, p. 673. Reproduced by permission, American Public Health Association, American Water Works Association, and Water Pollution Control Federation.

Procedure.

1. Transfer 10 ml from each original sample and from each successive dilution thereof to screw-capped test tubes, being careful to avoid contaminating the lip and upper portion of tube with sample.
2. Place tubes in a rack.
3. Place rack of tubes in water bath at 80 C for 30 min. Tubes should be immersed so that the water line is approximately 1½ in. above the level of samples in the tubes.
4. At the end of the 30-min holding period, remove the rack of tubes from the water bath and place in cold water for 5 min to cool.
5. Determine viable heat-resistant spore count by agar pour-plate method (see, Procedure for Bacterial Count by Pour Plate *under* Methods for Total Viable Bacterial Cell Number).
6. Report results as "viable heat-resistant spore count per gram."

Methods to Detect Enteric Pathogenic Bacteria

Equipment, materials and media.

1. Incubator, 37 C
2. Water baths, constant temperature, 39.5 C and 41.5 C
3. Flasks, wide-mouth, 500-ml
Membrane filter holder
Flasks, vacuum, 2,000-ml
4. Balance, with weights, 100-g capacity
5. Needle, inoculating
6. Media and reagents:
 - Selenite brilliant green/sulfa enrichment broth
 - Selenite F enrichment broth
 - Eosin methylene blue (EMB) agar
 - Salmonella-Shigella (SS) agar
 - Bismuth sulfite (BS) agar
 - McConkey's agar
 - Brilliant green (BG) agar
 - Triple sugar iron (TSI) agar
 - Urea medium
 - XLD agar
 - Salmonella antiserums
 - Shigella antiserums
 - Biochemical media (15)
9. Diatomaceous earth (Johns-Marville, Celite 505), sterile

Procedure to detect pathogens in solid waste and incinerator residue.

1. Add a previously weighed, 30-g sample to each of two flasks containing 270 ml Selenite F enrichment broth, and also to each of two flasks containing 270 ml Selenite brilliant green/sulfa (SBG) enrichment broth. Shake to mix.
Incubate one Selenite F and one SBG flask at 39.5 C and the other two at 41.5 C for 16 to 3 hr.

BRF

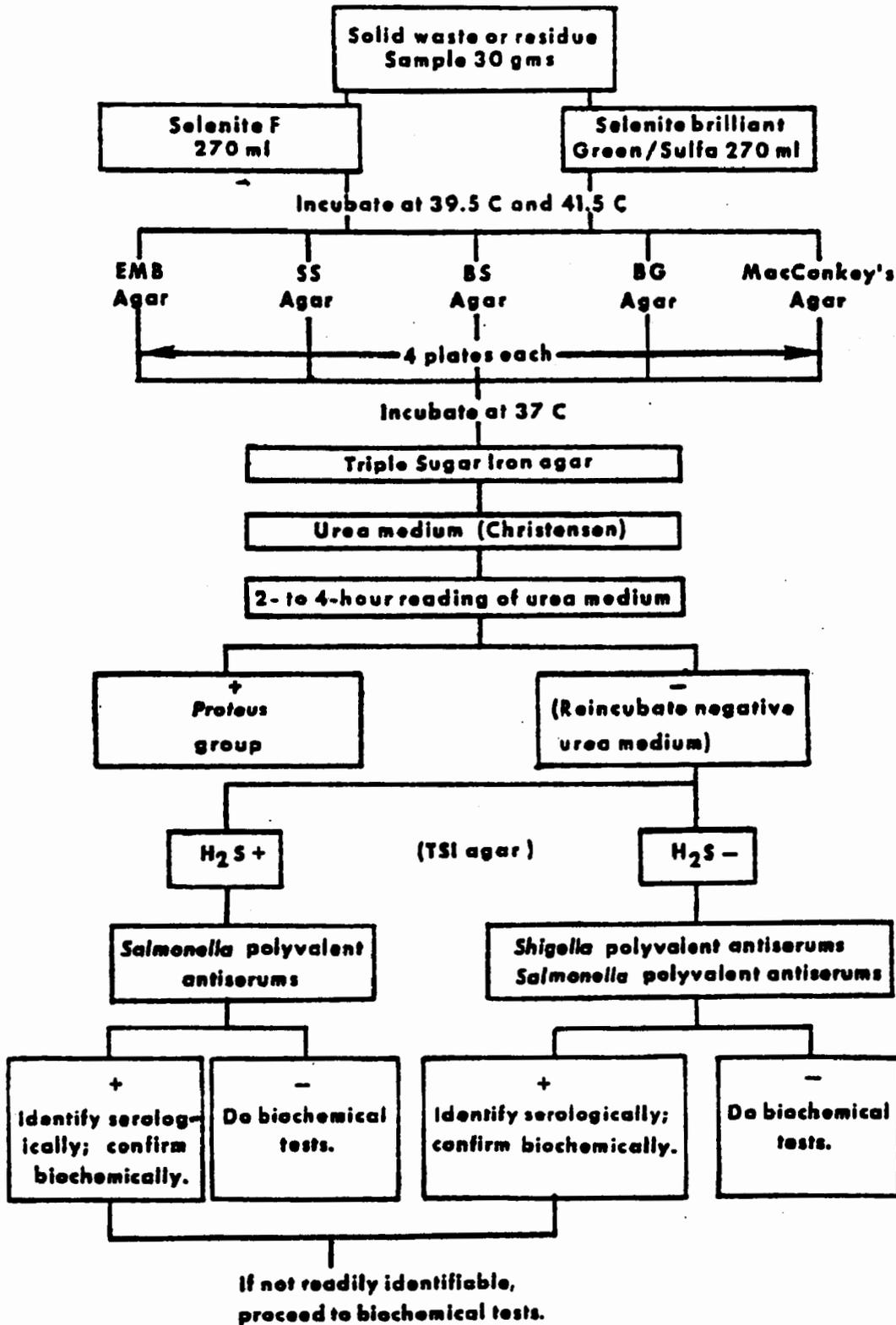


Figure 3. Isolation and preliminary identification.

TABLE 2. DIFFERENTIATION OF ENTEROBACTERIACEAE BY BIOCHEMICAL TESTS.

TEST or SUBSTRATE	ESCHERICHIEAE		EDWARDSIELLEAE	SALMONELLEAE			KLEBSIELLEAE								PROTEAE						
	Escherichia	Shigella	Edwardsiella	Salmonella	Arizona	Citrobacter	Klebsiella	Enterobacter				Serratia	Proteobacterium	Proteus				Providencia			
								cloacae	aerogenes	hypochoerensis				typhimurium		vulgaris	morbida	morgani	rustigii	glasgowensis	stuartii
										37C	55C		37C	55C	25C						
INDOL	+	- or +	+	-	-	-	- or +	-	-	-	-	-	-	- or +	+	-	+	+	+	+	+
METHYL RED	+	+	+	+	+	+	-	-	-	+ or -	-	+ or -	- or +	- or +	+ or -	+	+	+	+	+	+
VOGES-PROSKAUER	-	-	-	-	-	-	+	+	+	+ or -	+	- or +	+ or -	+	- or +	-	- or +	-	-	-	-
SHIMONS' CITRATE	-	-	-	d	+	+	+	+	+	(+) or -	d	+	+	+	d	d	+ or (+)	-	+	+	+
HYDROGEN SULFIDE (TSI)	-	-	+	+	+	+ or -	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
UREASE	-	-	-	-	-	d ^u	+	+ or -	-	-	-	d	-	d ^u	d ^u	+	+	+	+	-	-
ECN	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+ or -	+	+	+	+	+	+
MOTILITY	+ or -	-	+	+	+	+	-	+	+	+	d	+	+	+	+ or -	+	+	+	+	+	+
GELATIN (40C)	-	-	-	-	(+)	-	-	(+) or -	- or (+)	-	-	+	+	+ or (+)	+ or (+)	+ or (+)	+	-	-	-	-
LYSINE DECARBOXYLASE	d	-	+	+	+	-	+	-	+	+	+ or -	+	+	-	-	-	-	-	-	-	-
ARGININE DIHYDROLASE	d	- or (+)	-	(+) or +	+ or (+)	d	-	+	-	-	-	-	-	- or +	-	-	-	-	-	-	-
ORNITHINE DECARBOXYLASE	d	d ⁽¹⁾	+	+	+	d	-	+	+	+	+	+	+	-	-	+	+	-	-	-	-
PHENYLALANINE DEAMINASE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+
MALONATE	-	-	-	-	+	d	+	+ or -	+ or -	+ or -	+ or -	-	-	- or +	-	-	-	-	-	-	-
GAS FROM GLUCOSE	+	-(1)	+	+	+	+	+	+	+	+	+	+	+	+ or -(2)	- or +	+ or -	+	d	- or +	+ or -	-
LACTOSE	+	-(1)	-	-	d	d	+	+	+	- or (+)	- or (+)	d	(+)	- or (+)	d	-	-	-	-	-	-
SUCROSE	d	-(1)	-	-	d	d	+	+	+	d	d	+	+	+	+	+	d	-	d	d	d
MANNITOL	+	+ or -	-	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	+ or -	-	d
DULCITOL	d	d	-	d ⁽²⁾	-	d	- or +	- or +	-	-	-	-	-	-	-	-	-	-	-	-	-
SALICIN	d	-	-	-	+	d	+	+ or (+)	+	d	d	+	+	+	+	d	d	-	d	-	-
ADONITOL	-	-	-	-	-	-	+ or -	- or +	+	-	-	d	d	d	-	-	-	-	d	+	-
INOSITOL	-	-	-	d	-	-	+	d	+	-	-	+	+	d	-	-	-	-	+	-	+
SORBITOL	+	d	-	+	+	+	+	+	+	-	-	+	+	+	-	-	-	-	d	-	d
ARABINOSE	+	d	-	+(?)	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
RAFFINOSE	d	d	-	-	-	d	+	+	+	-	-	+	+	-	+ or (+)	-	-	-	-	-	-
ERANHOSE	d	d	-	+	+	+	+	+	+	+	+	-	-	-	d	-	-	-	+ or -	-	-

(1) Certain biotypes of *S. flexneri* produce gas. *S. sonnei* cultures ferment lactose and sucrose slowly and demonstrate ammonia evolution.
 (2) *S. agalae*, *S. cholerae-suis*, *S. enteritidis* biotype Paratyphi A and Pullorum, and a few others ordinarily do not ferment dulcitol promptly. *S. cholerae-suis* does not ferment arabinose.
 (?) Gas volume produced by cultures of *Serratia*, *Proteus*, and *Providencia* are small.

+, 99 percent or more positive in 1 or 3 days. -, 99 percent or more negative. d, different biochemical types (+, (-), -). (+), delayed positive. + or -, majority of cultures positive.
 - or +, majority negative. or, weakly positive reaction.

*Source: *Identification of Enterobacteriaceae* by P.R. Edwards and W.H. Ewing. Third edition, 1972, p. 24. Reproduced by permission.

3. After incubation, streak one loopful from each enrichment medium on each of four plates of Salmonella-Shigella and other selective enteric media.
4. Incubate the plates at 37 C for 24 to 48 hr and pick suspicious colonies to triple sugar iron agar slants.
5. Incubate the slants at 37 C for 24 hr and complete identification by appropriate methods as described by Edwards and Ewing (20). Isolation, preliminary identification, and biochemical testing are described in Figure 3 and in Table 2.

Procedure to detect pathogens in quench or industrial waters and in leachate.

1. Place enough sterile diatomaceous earth on the screen of a stainless steel membrane filter holder to form a 1-in. layer.
2. Filter 800-ml sample through the earth layer.
3. Remove one-half the diatomaceous earth layer with a sterile spatula and place into 90 ml of Selenite F enrichment broth; place other half of the earth layer into 90 ml of Selenite brilliant green/sulfa enrichment broth. Shake both flasks to mix.
4. Incubate both flasks in a water bath at 39.5 C for 16 to 18 hr.
5. Proceed as directed in steps 3 through 5 of Procedure to Select Pathogens in Solid Waste and Incinerator Residue.

Method for Examination of Stack Effluents

As described in Methods for Collection of Incinerator Stack Effluents (using the Armstrong sampler), the microorganisms are impinged into a 300-ml phosphate buffer solution.

Filter 100 ml of the "inoculated" phosphate buffer solution through a 0.45µ HA membrane filter (3).

2. Transfer membrane filter with sterile forceps to a culture plate containing trypticase soy agar.
3. Incubate culture plate under constant saturated humidity for 20 hr (± 2 hr) at 35 C.
4. After incubation, remove cover from culture plate and determine colony count with the aid of a low-power (10-15 magnifications) binocular, wide-field microscope. Characterize colonies using specific isolation media.
5. Remove a 10-ml portion of the "inoculated" phosphate buffer solution and examine for viable heat-resistant spores as directed in steps 1 through 6 of the procedure under Method to Determine the Presence of Viable Heat-Resistant Spore Numbers.

Microbial counts are reported as organisms per cubic foot of air. If the sample is not taken under isokinetic conditions, the results are qualitative. If the stack velocity is known and remains relatively constant, however, the flow rate of the sampler can be adjusted to isokinetic conditions to yield quantitative results.

Method for Examination of Dust

As described in Methods for Collection of Dust Samples, the Andersen sampler is used with two types of media--trypticase soy agar (TSA-BBL product) containing 5 percent sheep blood, and eosin methylene blue agar (EMB-Difco product). The TSA/blood agar is used to isolate a wider range of fastidious organisms such as *Staphylococci*, *Streptococci*, and *Diplococci*. The EMB agar is used to isolate gram-negative bacteria. The plates are incubated aerobically at 37 C for 24 hr. (Preliminary studies showed that few organisms in the dust would grow under anaerobic conditions.) Enumeration of colonies is made with a Quebec colony counter. Microbial count is reported as organisms per cubic foot of air. At times, when microbial counts are high, the sampling time is 0.25 min, thus yielding 0.25 cu ft air.

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A-3.2 METHOD for VIROLOGICAL EXAMINATION of SOLID WASTE

1. Place 2 g of sample in flask containing 20 ml of cold, sterile distilled water and glass beads.
2. Vigorously shake flask.
3. Pour contents into sterile centrifuge tube.
4. Clarify suspension by centrifugation in a refrigerated centrifuge (4 C) at 1500 rpm for 20 minutes.
5. Pour off supernate and recentrifuge for 1 hr. at 3000 rpm.
6. Remove clear supernate from sediment.
7. Add an antibiotic solution to give a final concentration per ml of 1000 units of penicillin and 1000 ug of streptomycin.
8. Hold sample at room temperature for 30 min.
9. Inoculate sample into 3 tubes of primary monkey kidney cells (e.g. African Green).
10. Inoculate sample also into 3 tubes of Hep 2 cells.
11. Incubate tubes in roller drum at 98.6 F (37 C) for 8 to 9 days.
12. Observe cell cultures daily for virus activity.

A-3.3 DETERMINATION OF ASCARIS spp. EGGS in SOLID WASTE

1. Materials

- 1.1 Balance: 10 g - 1 kg capacity.
- 1.2 Beakers: 150 ml & 600 ml
- 1.3 Bottle: 125 ml, Wheaton.
- 1.4 Bottle shaker.
- 1.5 Brush: B-8695 Scientific Products.
- 1.6 Centrifuge: rotor radius 14.6 cm.
- 1.7 Centrifuge tubes: 15 ml and 50 ml.
- 1.8 Cheesecloth: FSN 8305-00-205-3496.
- 1.9 Counter: differential
- 1.10 Culture dish: with 2 mm grid.
- 1.11 Inverted microscope
- 1.12 Pipettes: Pasteur type and 5 ml serological.
- 1.13 Rubber bulb: ca. 2 ml
- 1.14 Tray: round, 10.5 inches diameter, 3 inches high
e.g., Beckman Instrument Co. 82-018.

2. Reagents

- 2.1 Saline: 0.85% NaCl in H₂O.
- 2.2 Naconol: 0.4% of concentrate in H₂O
- 2.3 Hydrochloric acid: 2% solution in H₂O.
- 2.4 Solvent: alcohol:acetone:xylene in 1:1:2 ratios.

3. Sample Preparation

3.1 Vegetable Samples

- 3.1.1 The sample size for vegetables is 1 kg.
Leafy vegetables occurring in heads (cabbage, lettuce

etc.) are first separated into individual leaves.

3.1.2 Dispense 250 ml of the nacconol solution into the tray.

3.1.3 Individual vegetables are placed in the tray, and thoroughly scrubbed with the brush.

3.1.4 Allow the vegetable to drain for 10 seconds and then set aside.

3.1.5 Steps 3.1.2 & 3.1.3 are repeated until the entire sample is washed; nacconol solution is replaced as necessary.

3.1.6 Pour the contents of the tray into a 600 ml beaker.

3.1.7 Rinse the tray 3 times with 25 ml of the nacconol solution and add each rinse to the beaker.

3.1.8 Distribute the suspension into 50 ml centrifuge tubes.

3.1.9 Rinse the beaker 3 times with 10 ml nacconol solution, then add each rinse to the centrifuge tubes or to an additional centrifuge tube.

3.2 Sludge Samples

3.2.1 Weight out 10 g of sludge and add it to 90 ml of saline in the 125 ml bottle.

3.2.2 Place the bottle on the shaker; shake vigorously for 5 minutes (the speed control of an International Size-2 Shaker (International Equipment Company, Model 2) is set at the midpoint).

3.2.3 Pour the suspension through 1 layer of wet cheesecloth into a 150 ml beaker.

3.2.4 Rinse the bottle 3 times with 5 ml saline and add each rinse to the beaker.

3.2.5 Transfer the contents of the beaker to seven 15 ml centrifuge tubes.

3.2.6 Rinse the beaker 3 times with 5 ml of saline and add each rinse to the centrifuge tubes.

4. Centrifugation Procedure

4.1 Centrifuge the tubes collected in 3.1 and/or 3.2 at 2,000 rpm (radius 14.6 cm) for 4 minutes.

4.2 Remove and discard the supernatant.

4.3 Add 2 ml of saline to each tube.

4.4 Combine the sediments into one tube using a Pasteur pipette to transfer the sediment and to rinse each tube 3 times with 2 ml of saline. Each rinse is also added to the collecting tube.

4.5 When the collecting tube is full, it is balanced with a blank, centrifuged at 2,000 rpm for 4 minutes; supernatant is discarded. Repeat if necessary.

4.6 Add saline to the 15 or 50 ml graduation mark on the collecting tube and resuspend the sediment; centrifuge at 2,000 rpm for 4 minutes.

4.7 Discard the supernatant; add 2 ml of saline and resuspend the sediment.

4.8 Transfer the suspension to the culture dish; rinse the tube 3 times with 2 ml of saline and add each rinse to the culture dish. Add 8 ml of the 2% hydrochloric acid to the dish (to prevent mold growth) and cover the dish.

5. A Warning

Ascaris spp. ova are infective to humans. Areas which become contaminated should be wiped with the solvent solution.

6. Viability Determination

6.1 Culture dishes from step 4.8 are allowed to incubate at room temperature (ca 24 C) for 3 weeks.

6.1 Check the fluid levels in the culture dishes twice weekly; a depth of 3 mm should be maintained by addition of H₂).

7. Microscopic Examination

7.1 Systematically search the bottom of the dish with the aid of an inverted microscope, using the grid markings as guides.

7.2 With American Optical 1810 equipment 24X objective and 10X eyepieces, the 2 mm grid width is just spanned.

7.3 Count the embryonated and the unembryonated eggs with the differential counter.

7.4 Ascaris spp. eggs are usually 60 to 70 um long and 40 to 50 mm wide; the outer covering, a rough albuminous coat, is often yellowish brown in color; beneath the coat there is a thick layer of clear shell. If the center of the egg is amorphous or slightly granular, the egg was not fertilized and will not develop. An organized center indicates a fertilized egg. With

incubation (step 6 above), fertilized eggs develop into embryonated eggs which contain a second-stage nematode larva in a cuticular sheath. Types of Ascaris spp. eggs are illustrated in the following references.

8. References

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A-3.4 METHODS FOR IDENTIFYING PATHOGENIC FUNGI IN SOLID WASTE**1. Sample Preparation**

1.1 Add 5 g of composite sample to 100 ml of sterile physiological saline (0.85% salt solution).

1.2 Shake to suspend sample.

1.3 Separate supernatant and centrifuge at 2500 rpm for 15 min.

1.4 Decant supernatant

1.5 Thoroughly mix sediment and add to sterile screw cap vials containing 10,000 units of penicillin and 10 mg of streptomycin.

1.6 Allow suspension to stand at room temperature for 20 min.

2. Swiss Mice Inoculation

2.1 Inoculate three white Swiss mice (4 to 6 weeks of age) intraperitoneally with 0.5 ml of concentrated sediment.

2.2 At the end of 3 weeks sacrifice mice.

2.3 Remove liver and entire spleen and place in sterile petri dish.

2.4 Mince tissues.

2.5 Use small portions of minced tissues to inoculate two tubes of Sabouraud's agar and two tubes of Sabouraud's agar containing 0.5 mg of Actidione (cycloheximide) per ml and 0.05 mg of chloromycetin per liter.

2.6 Incubate cultures for 4 weeks, making weekly examinations (make smears of suspicious colonies; identify fungi by cultural characteristics.)

3. Actidione and chloromycetin inoculation

3.1 Prepare two tubes of Sabouraud's agar and two tubes of Sabouraud's agar containing 0.5 mg Actidione per ml and 0.05 g of chloromycetin per liter.

3.2 Inoculate with a small portion of concentrated sediment.

3.3 Incubate all tubes at 25 C and examine weekly.

3.4 At the end of 6 weeks make smears of suspicious colonies and identify by cultural characteristics.