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Industrial Waste Exchange: A Mechanism for Saving Energy and Money

L. L. Gaines

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Energy and Environmental Systems Division
Special Projects and Industrial Applications Group

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CONTENTS

TABLES

FIGURES

PREFACE

The research reported here was sponsored by the Waste Products Utilization Branch, Office of Industrial Programs, U.S. Department of Energy. The Branch endeavors to promote the efficient use of materials and energy through research and development in the area of waste products utilization. It is known that significant quantities of industrial wastes are produced and disposed of annually. Instead of being disposed of, many of these materials could be reused, with or without treatment, to displace new materials. The energy and other costs required to produce those new materials would be saved, and disposal costs for the waste would be avoided. Industrial waste exchanges provide one mechanism for promoting the reuse of industrial wastes. This report describes how such exchanges work, gives examples of the energy and monetary savings possible, discusses impediments to successful operation, and gives recommendations for overcoming these impediments.

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ABSTRACT

Industrial waste exchanges have been established to assist in the transfer of waste materials to companies that can use them, as is or treated, to displace virgin raw materials as process inputs. A waste exchange may provide information that expedites the transfer, or it may actually take possession of the material. Benefits of industrial waste exchange include avoided disposal costs and reduced energy and dollar costs for raw materials. Uses can be found for most wastes listed in waste-exchange catalogs, including spent acid, waste solvents, and used lubricating oils; substantial savings of energy and dollars are often possible through recycling of these potentially valuable materials. Lack of economical separation technology, the small quantities available at some sites, restrictive or uncertain regulation, and lack of knowledge of a material's uses are all barriers to successful operation of industrial waste exchanges, but these barriers can be overcome by appropriate action.

1 INTRODUCTION

1.1 WHAT IS A WASTE EXCHANGE?

A waste exchange is a facility that enables industrial process wastes, by-products, surpluses, or materials that do not meet specifications to be transferred from one company to another company where they are used as process inputs. Because many of these materials are of low or negative value, it does not pay to transport them great distances.* A waste exchange is therefore a regional venture by nature; on the other hand, the area it serves must be large enough to include a variety of industries. Several too-small exchanges have merged with others or ceased operation. A list of operating waste exchanges in the U.S. and their locations is shown in Table 1.

*Higher-value materials may find more-distant markets and even markets overseas.

Table 1 U.S. Waste Exchanges, 1981

State	Exchange or Company	Address	Phone	Contact[a]	Type[b]	Profit or Non-Profit[c]	Funded by[d]	Year[e]	Area Served
Calif.	Zero Waste Systems, Inc.	2928 Poplar St., Oakland 94608	(415) 893-8257	Dr. P. Palmer	M	P	P	1973	unspecified
Calif.	California Waste Exchange	2151 Berkeley Way, Berkeley 94708	(415) 540-2043	Dr. P.H. Williams	IA	N	G	1976	California
Colo.	Colorado Waste Exchange	1390 Logan Denver 80203	(303) 831-7411	O.L. Webb	I	N	T	1981	Colorado
Conn.	World Ass. for Safe Transfer and Exchange	130 Freight St. Westbury 06702	(203) 574-2463	M. Veroneau	I[f]	N	P	1978	World
Fla.	Iso-Chem Marketing, Inc.	P.O. Box 1268 Orange Park 32073	(904) 264-0700	A.L. Tripi*	M	P	P	--	Southeast
Ga.	Georgia Waste Exchange[g]	181 Washington St., S.W. Atlanta 30303	(404) 659-4444	B. Fridlin	I	N	T	1976	Georgia
Ill.	Industrial Material Exchange Service[g]	2200 Churchill Rd., Springfield 62706	(217) 782-6760	L. Moore	I	N	G	--	Illinois
Ill.	American Chemical Exchange	4849 Golf Rd., Skokie 60076	(312) 677-2800	J.T. Harris or L. Eler	M	P	P	1976	unspecified
Ill.	Environmental Clearing-house Organization	3426 Maple Lane, Hazel Crest 60429	(312) 335-0754	W. Petrick*	M	P	P	--	unspecified
Ind.	Environmental Quality Control, Inc.	1220 Waterway Blvd., Indianapolis 46202	(317) 634-2142	N.L. Beck*	I	N	P	1978	Indiana
Ky.	Louisville Area Waste Exchange[g]	300 W. Liberty St., Louisville 40202	(502) 582-2421	S. Lampe	--	--	--	1981?	--
Maine	New England Materials Exchange	P.O. Box 947, Kennebunk 04043	(207) 985-6116	D.L. Trask	IA	N	P	1981	New England
Mass.	The Exchange	63 Rutland St., Boston 02118	(617) 266-8498	H. Hurst	M	P	P	1975	World
Mich.	American Materials Exchange Network[g]	19489 Lahser Rd., Detroit 48219	(313) 532-7900	V. Dixon	--	--	--	1981?	--
Mo.	Midwest Industrial Waste Exchange	10 Broadway, St. Louis 63109	(314) 231-5555	C.H. Wiseman, Jr.	I	N	T	1975	Midwest
N.H.	Resource Conservation and Recovery Agency	P.O. Box 268, Stratham 03885	(603) 772-6261	D. Green	--	--	--	1981	--
N.J.	Industrial Waste Information Exchange	5 Commerce St., Newark 07102	(201) 623-7070	W. Pagne	I	N	T	1978	New Jersey
N.Y.	Enkarn Research Corp.	P.O. Box 590, Albany 12201	(518) 436-9684	J.T. Engster	I[h]	P	P	1977	World
N.Y.	Northeast Industrial Waste Exchange	700 E. Water St., Syracuse 13210	(315) 422-6572	W. Banning*	I	N	G & T	--	Northeast
N.C.	Piedmont Waste Exchange	Inst. for Urban Studies Charlotte 28223	(704) 597-2307	E. Dorn*	I	N	U	--	Carolinas
N.C.	Pacific Environmental Services, Inc.	1905 Chapel Hill Rd., Durham 27707	(919) 493-3536	D. Kent*	I[i]	P	P	1981	Carolinas, Virginia

Table 1 (Cont'd)

State	Exchange or Company	Address	Phone	Contact Name[a]	Type[b]	Profit or Non-Profit[c]	Funded by[d]	Year[e]	Area Served
Ohio	Ohio Resource Exchange	2415 Woodmere Dr., Cleveland 44106	(216) 371-4869	R. Immerman	IA	P	P	1979	Midwest
Ohio	Industrial Waste Information Exchange[i]	1646 W. Lane Ave., Columbus 43221	(614) 486-6741	N.A. Brokaw*	I	N area	T	1977	Columbus
Ore.	Oregon Industrial Waste Information Exchange[k]	3335 W. 5th Ave., Portland 97204	(503) 221-0357	D. Clark	I	N	T	1978	unspecified
Penn.	National Waste Exchange	P.O. Box 190, Silver Spring 17575	--	R.D. Schaible	I[l]	--	P	1981	U.S.
Penn.	Pennsylvania Waste Information Exchange[m]	22 N. 3rd St., Harrisburg 17101	(717) 255-3252	P.J. Overmayer	I	N	T	1980	Pennsylvania
Tenn.	Tennessee Waste Exchange	708 Fidelity Federal Bldg., Nashville 37219	(615) 256-5141	N. Niemeier	I	N	T	1980	Tennessee
Texas	Chemical Recycle Information Program	1100 Milam Bldg., Houston 77002	(713) 651-1313	J. Westrey*	I	N	T	1976	Gulf Coast
Utah	W.S. Hatch Co.[g]	P.O. Box 1825, Salt Lake City 84110	(801) 295-5511	--	--	--	P	1981?	--
Wash.	Information Center for Waste Exchange[g]	2112 3rd Ave., Seattle	(206) 623-5235	J. Henry	I	N	P	1977	Washington
W. Va.	Union Carbide Corp.	P.O. Box 8361, Bldg. 3005, S. Charleston 25303	(304) 747-5362	R.L. Floyd	M[n]	P	P	1971	U.S.

[a]Asterisk (*) indicates that person reviewed a draft of this report.

[b]M = Materials exchange, I = Information clearinghouse, IA = Active information clearinghouse.

[c]P = for profit, N = nonprofit.

[d]P = private company, T = trade association or chamber of commerce, G = Government, U = University.

[e]Year established.

[f]Operates computer database.

[g]From Ref. 1; unverified because no response received to letter.

[h]Handles surplus materials; charges a commission for successful transfer.

[i]Want to become brokerage.

[j]Dormant.

[k]Reported closing.

[l]Manages other exchanges.

[m]Merging with Northeast Exchange.

[n]In-house only.

The waste generator involved in waste exchange benefits from the revenues from the sale of waste and the avoided disposal costs, and the user benefits from reduced raw-materials costs. Benefits to the nation include decreases in its dependence on imported resources, in energy required for production of new materials, in public-health hazards, and in amounts of land and money required for waste disposal. The benefits are achieved through any successful waste exchange. However, the characteristics and methods of industrial waste exchanges may differ in several important aspects.

1.2 TYPES OF WASTE EXCHANGES

Waste exchanges differ according to whether or not they actually handle materials. The most common type of waste exchange does not handle materials, but is only an information clearinghouse. Waste-generating companies inform the exchange about the quantity, composition, and location of the wastes they generate and the frequency with which the wastes are available for exchange. Companies wishing to use wastes as process inputs supply similar information about their needs. The required information is usually sent to the exchange on a standard form, an example of which is shown in Fig. 1. A nominal listing fee is often required. The information on wastes available and wanted is published in the exchange's catalog, which typically appears quarterly and may be available free or for a small charge. Waste-exchange catalogs sometimes include a newsletter and advertisements for consultants and firms offering waste-handling services. Fig. 2 shows representative listings from a catalog. To protect company proprietary information and to discourage possible government involvement, catalog listings are often confidential. A party interested in using available wastes or supplying needed materials must write an inquiry to the exchange, which forwards the letter to the listing company. The function of the information clearinghouse generally ends there; it is up to the listing company to contact the inquiring party and negotiate an exchange, which may involve a one-time transfer, several transfers, or even the continuous transfer of wastes. The companies are generally under no obligation to inform the clearinghouse of the results of negotiation. They may even prefer to "keep a good deal quiet" from their competitors. A schematic showing how an information clearinghouse assists the transfer of wastes is shown in Fig. 3. Sometimes an information clearinghouse makes an active effort to find possible users for available wastes, most of which are not successfully exchanged simply by catalog listings. (The California Waste Exchange, for example, determines possible users and informs them of appropriate materials available.) This function requires more than the usual small part-time staff. One waste-exchange operator suggested a central information service funded by the Departments of Commerce and Energy and the Environmental Protection Agency (EPA).

The other type of waste exchange is a materials exchange that, for a brokerage fee, actually takes possession of the wastes and participates in the

MIDWEST INDUSTRIAL WASTE EXCHANGE

Ten Broadway, St. Louis, Missouri 63102 Telephone (314) 231-5555/TWX 910-761-1080

CONFIDENTIAL LISTING FORM

Company Name: ____________________

Mailing Address: ____________________

____

Company Contact: ____________________

Telephone Number: ____________________

MIWE Use Only

Code # __________

Date: __________

PLEASE READ BEFORE SIGNING

All listings will be identified by code number only. A copy of all inquiries and replies will be forwarded to us for information and handling. Initiating contact with the interested party will, therefore, be left to our discretion. We recognize that detailed description and accuracy of the listing is our responsibility. We further understand that the MIWE will not be involved in negotiations between our firm and potential users or suppliers and will not determine what may constitute hazardous conditions or substances.

SIGNED: ____________________

DATED: ____________________

- -

LISTING INFORMATION

Check one: This is a listing for ____material available.
____material wanted.

The following item should be listed in the next Clearinghouse Catalog and News published by the Midwest Industrial Waste Exchange. (Use separate form for each item to be listed.)

MATERIAL (Describe material as accurately as possible, keeping in mind what the reader of your listing may want to know.)

QUANTITY (Indicate amount per period of time, i.e., gals/wk, lbs/month, etc., and describe whether the material is offered/requested on a one-time or continuous basis.)

PACKAGING (Drum, bulk, etc.)

LOCATION (Give general area or state where material is available/wanted.)

Please enclose the $25.00 fee for each item. This listing fee includes publication in three consecutive issues or until the waste is no longer available, whichever comes first. Checks should be made payable to the St. Louis Regional Commerce and Growth Association.

Co-sponsors: St. Louis Regional Commerce & Growth Association/Chamber of Commerce of Greater Kansas City

Fig. 1 Example of Waste-Exchange Listing Form (Source: Ref. 2)

PWIX PENNSYLVANIA WASTE INFORMATION EXCHANGE

SAMPLE

CLASSIFICATION: 3 — **Code #A-4** — ITEMS AVAILABLE

Item: Hydrated Lime Slurry or paste-chemical analysis, approximately the same as dry hydrated

Quantity: Tonnage amounts in bulk

CLASSIFICATION: 4 — **Code #S-3** — ITEMS SOUGHT

Item: Mixture of Paints and Solvents

Quantity: 50 to 75 55-gal. drums/month

Code #N-2 — SERVICES NEEDED

Services/Process: Solvent Regeneration

ENGINEER/CONSULTANTS — DIRECTORY OF GENERAL SERVICES

Green Valley Engineering Associates
10 Cedar Drive
Dillsburg, PA 17019

Contact: Jane Doe, Director - Technical Services
Telephone: 717/555-1212
Service: Solid and hazardous waste management, including testing, and assistance with regulatory compliance.

A SERVICE OF THE PENNSYLVANIA CHAMBER OF COMMERCE

222 NORTH THIRD STREET
HARRISBURG, PENNSYLVANIA 17101
717/255-3252

Printed on 100% recycled paper.

Fig. 2 Representative Listings from a Waste-Exchange Catalog (Source: Ref. 3)

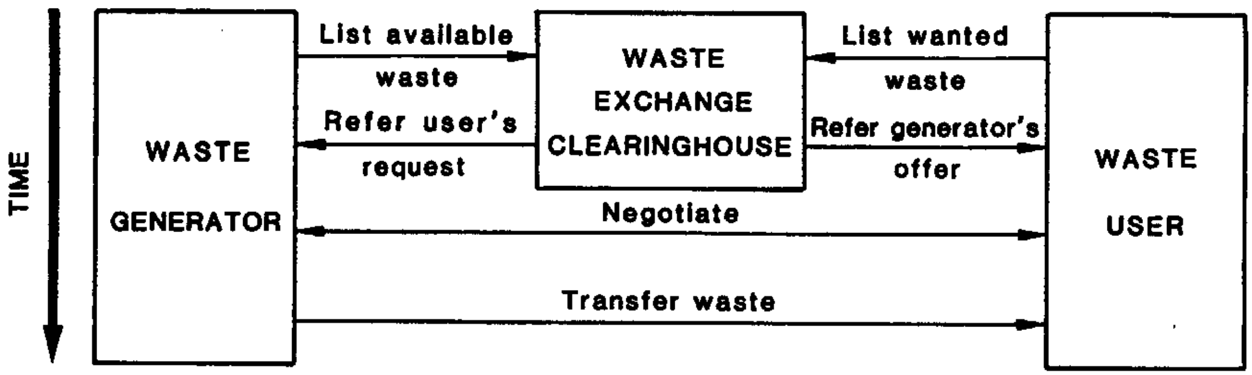

Fig. 3 Schematic of Waste Transfer Assisted by an Information Clearinghouse

negotiations. This type of exchange often actively seeks buyers for wastes. A schematic of waste transfer through a materials exchange is shown in Fig. 4. In some cases, the materials exchange performs minimal processing on the waste to make it a suitable raw material for the buyer's use. Still other companies, as their main line of business, reprocess wastes into valuable products for resale. More detail concerning the operation of specific waste exchanges can be found in Ref. 4.

The second important characteristic of waste exchanges is their status as public, nonprofit operations or profit-making businesses. This characteristic is not uncorrelated with the first; most information clearinghouses are operated and subsidized by government, chambers of commerce, or trade associations, and most materials exchanges are private enterprises. (Some privately run exchanges regard subsidized exchanges as direct competitors with an unfair advantage.) It is clear that little money is to be made by publishing a quarterly catalog, but materials brokerage fees do offer potential profits.

The third important characteristic of a waste exchange is the types of material it handles. This topic will be treated in Section 1.3.

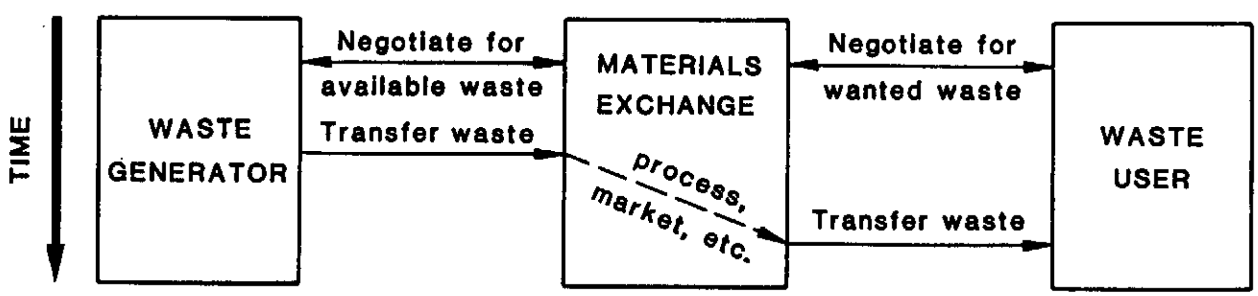

Fig. 4 Schematic of Waste Transfer through a Materials Exchange

1.3 TYPES OF MATERIALS HANDLED BY WASTE EXCHANGES

The word "waste" is interpreted in various ways by the different waste exchanges. Some include surplus materials -- oversupplies of virgin materials -- in their listings, while others specifically exclude them. One for-profit materials exchange deals almost exclusively in surplus textiles. Other exchanges restrict their operations to materials for which no markets or extremely limited markets now exist. Wastes with limited markets are generally disposed of in landfills or otherwise, at a cost to the generator. These are the materials for which waste exchange offers the greatest potential for dollar and energy savings, and therefore these are the ones discussed in this report. A list of the categories of wastes chosen for study is shown in Table 2.

Another necessary distinction is that between hazardous and non-hazardous wastes. Some exchanges handle only one or the other. The distinction is not strictly correlated with the categories in Table 2, but most hazardous materials are found in categories 1 (acids and alkalis), 2 (organics and solvents), 3 (metals and metal-containing sludges), and 11 (inorganics). The operative definition of "hazardous," for our purposes, is to be found in the Resource Conservation and Recovery Act of 1976 (PL94-580,

Table 2 Categories of Wastes

Category Number	Materials Included
1	acids and alkalis
2	organic chemicals and solvents
3	metals and metal-containing sludges
4	minerals, including glass and sand
5	oils, fats, and waxes
6	food processing wastes
7	paper and wood
8	plastics and rubber
9	spent catalysts
10	textiles, fur, and leather
11	inorganic chemicals
12	other

RCRA) and its associated regulations (for example, 40 CFR Parts 260-265[5]). Because of the importance and complexity of these regulations, we will summarize the relevant points in the the following section.

1.4 RCRA, HAZARDOUS WASTE, AND WASTE EXCHANGES

Although RCRA deals with a number of topics related to resource recovery, the area of hazardous waste has generated the bulk of regulations and the most interest. There is a chain of regulation that extends from those who generate hazardous waste to those who transport, store, treat, and dispose of it. However, facilities that recycle or reuse hazardous wastes are excluded from these regulations for all wastes except those containing the most hazardous materials. This exemption should provide considerable incentive for material recovery, but because of the length (hundreds of pages) of the hazardous-waste regulations and their complexity, many people (including some waste-exchange operators) are not aware of it. However, transport and storage of the particularly hazardous materials is still regulated. (See p. 33120 §261.6 in Ref. 5 for the exact regulations that apply.)

Hazardous waste is defined in RCRA to be "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."[6]

Subsequent regulations define criteria for determining if a waste is hazardous and, in addition, list particularly hazardous materials for special consideration. These materials, for which transport and storage regulations apply even if the materials are to be reused or recycled, are listed in 40 CFR Part 261 Subpart D, which is reproduced in the Appendix. Sludges are also regulated. In 40 CFR Part 261 Subpart C, which is also reproduced in the Appendix, four criteria for identifying hazardous wastes not specifically listed in Subpart D are defined precisely. These are ignitability, corrosivity, reactivity, and EP toxicity.* It has been estimated that on the order of 20% of industrial wastes are hazardous according to these definitions, and many of them are listed as available in waste-exchange catalogs. The hazardous nature of these wastes is extremely important in determining the benefits of exchanging them, because the costs of regulated disposal, storage, and treatment may be avoided by recycling. Several of the

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*Toxicity determined by an extraction procedure.

materials discussed in the next section are hazardous wastes that can be economically recycled.

2 OPPORTUNITIES FOR MATERIALS RECOVERY USING A WASTE EXCHANGE

This section presents examples of materials that, though now disposed of, could be transferred using a waste exchange and recycled for monetary and energy savings. For each category listed in Table 2, typical waste-exchange listings are presented, relevant characteristics of the materials are discussed, and a single example is chosen for more detailed examination. Possible methods for recycling or reusing the waste material are suggested and compared with current disposal alternatives with respect to cost and energy savings. Impediments and incentives to exchange of the specific materials are noted.

Several impediments common to the exchange of waste materials can be identified. Once a buyer for a listed material is located, there are some fixed costs that must be borne by the companies involved in an exchange. These include costs related to price negotiations, arrangements for transport, material testing, and any equipment adjustments or modifications needed to handle the material. These costs may be small on a per-pound basis when large quantities of material are exchanged regularly, but they are considerable for materials available one time only, irregularly, or in extremely small quantities.

2.1 CATEGORY 1: ACIDS AND ALKALIS

A page of typical waste-exchange listings of acids and alkalis available is shown in Fig. 5. The most obvious characteristic of these listings is their diversity. Each includes a different reagent with different impurities, and reagent concentrations range from 6% to 80%. The next important characteristic is that most of the wastes are available in large quantities, generally tens of thousands of gallons per month, increasing the chances for economical treatment. The final characteristic is that many of the wastes are hazardous under RCRA regulations because they are corrosive ($pH < 2$ or $pH > 12.5$). This means that they cannot be disposed of without prior treatment, such as neutralization and precipitation. The cost of this treatment is $30–150/ton, including screening and sedimentation;[7] thus there is considerable incentive to avoid disposal. Although several firms, for instance the Stauffer Chemical Company in Martinez, California, recycle acids commercially, large volumes of acids and alkalis are still available for exchange. One impediment to the recycling of these materials is their high water content, which makes transport over long distances expensive. It is therefore plausible that a central regional recycling facility, perhaps specializing in one type of waste, such as spent hydrofluoric acid (HF) from printed circuit etching, would be most successful.

The specific material from the acid and alkali category chosen for more detailed examination is sulfuric acid (H_2SO_4). Large volumes of sulfuric acid

Acids

- Code #: A-76
  Material: Industrial Chemical Products of Detroit, Inc., Sol-Klean 1177M. Approx. 80% phosphoric acid, 10 butyl ether, no contaminants, clear colorless liquid Bp 210°F, Sp. gr. 1.40 solubility in H_2O complete. Possible use derusting steel parts, cleaning/finishing.
  Quantity: One time offer - 220 gals.
  Packaging: 55 gal. drums
  Location: Joplin, MO

- Code #: A-116
  Material: A 32% solution of hydrochloric acid. Has a slight green coloration and contains 1% phosphorous acid and 5-10% acetic acid.
  Quantity: Approx. 2,000 gals./week. Available on a continuous basis.
  Packaging: Bulk
  Location: Northeastern PA

- Code #: A-118
  Material: Spent sulfuric acid, 15% to 40% H_2SO_4, suspended solids approx. 100 ppm sand, balance water.
  Packaging: 100,000 gal./mo. available on daily basis
  Location: Western PA

Caustics

- Code #: A-14
  Material: Alkalin solution, primary components: sodium hydroxide (60-70 gms./liter), sodium carbonate (80-120 gms./liter), sodium aluminate (50-75 gms./liter).
  Quantity: 100-120,000 gals./mo.
  Packaging: Bulk transport
  Location: Pittsburgh, PA

- Code #: A-31
  Material: Caustic treated aluminum chloride material comprised of aluminum hydroxide (6%), sodium chloride (13%), organics (1%), and water (80%).
  Quantity: 1500 gals./day
  Packaging: Tank cars

- Code #: A-34
  Material: Caustic solution of organic and inorganic salts. Prevalent salts are sodium methacrylate, sodium acrylate, and sodium chloride. Normal pH is 9-13.
  Quantity: 25,000 gals./week continuous
  Packaging: Bulk

Fig. 5 Example of Listings of Acids and Caustics (Source: Ref. 3) are produced annually in the U.S. (42.2×10^6 tons in 1978)[8] and, although over 60% is consumed in phosphoric acid production, on the order of 10% is used and spent in cleaning, plating, and copper leaching and as a catalyst. Table 3 shows recent and projected uses of sulfuric acid. The 15-40% H_2SO_4 listed as Code A-118 in Fig. 5 is typical of many waste-exchange listings of available acid. The material is hazardous because it has a pH below 2. Several possibilities are available for recycling it. The first of these is purification and reconcentration to recycle the spent acid to its original use. It is estimated that reconcentration of H_2SO_4 from 88% to 99% cost about $60/ton in 1979, about 10% more than the cost of virgin acid.[9] In addition, the process was reported to be energy intensive; the energy requirement is calculated to be 0.6×10^6 Btu/ton with no heat recovery, and virgin acid

Table 3 U.S. Demand for Sulfuric Acid in 1978 and 1983

Use	Demand (10^3 tons)	
	1978	1983
Fertilizers (other than ammonium sulfate)	26,232	27,550-31,640
Petroleum Refining	2,053	1,930-2,155
Copper Leaching	1,652	1,825-2,105
Ammonium Sulfate	1,593	1,625-1,850
Alcohols	1,080	1,195-1,270
Titanium Dioxide	896	730-840
Hydrofluoric Acid	846	840-895
Uranium/Vanadium Ore Processing	728	1,010-1,065
Aluminum Sulfate	700	700-775
Cellulosics	483	485-540
Iron and Steel Pickling	355	310-365
Surface-Active Agents	330	330-365
Batteries	207	220-240
Phenol	30	negligible
Other	5,788	5,935-6,495
Total	42,972	47,500-49,800

Source: Adapted from Ref. 8.

requires only 0.8 x 10^6 Btu/ton.[10] Therefore, reconcentration appears to be justified primarily to avoid disposal costs. The Stauffer plant in California is reported to be regenerating H_2SO_4 by using a thermal reaction to break it down and reformulate it.[7] The company apparently finds the process economically attractive.

Another possible use for spent acid is as a replacement for virgin acid in processes that require less-concentrated or less-pure acid. Lead-acid storage batteries require a weight concentration of only 36%. Thus, the most concentrated part of the example stream (40% H_2SO_4) could possibly be used in batteries after filtration of the suspended sand. Cost of this treatment would be less than the avoided disposal cost. The value of 40% H_2SO_4 is now about 15¢/gal (about $35/ton) on the East coast,[11] so the stream should be worth up to $15,000 a month. Note, however, that this discussion assumes there are no troublesome contaminants in the acid that would be difficult to remove and would lower the resale value. Waste-exchange listings may not contain sufficient information on material composition for all end-users to be certain of the material's usefulness and should in many cases be supplemented with more precise data from the generator.

Waste streams with higher concentrations of acid (more than 65%) can be used to produce superphosphate fertilizers. In cases where the H_2SO_4 is too dilute or is otherwise unsuitable for reuse, neutralization may be necessary. However, this need not necessarily be followed by disposal, because neutralization with lime ($Ca(OH)_2$) yields gypsum ($CaSO_4$), which is of low value (about $5/ton) but salable. Neutralization with sodium hydroxide (NaOH) yields sodium sulfate (Na_2SO_4), which can be dehydrated and used as a dessicant. It is interesting to note that the caustics used to neutralize waste acid are themselves energy intensive (5 x 10^6 Btu/ton for $Ca(OH)_2$, 25 x 10^6 Btu/ton for NaOH)[10] and expensive ($31/ton of CaO, $1220/ton of NaOH).[11] Therefore, only unrecyclable waste caustic should be used for this purpose.

2.2 CATEGORY 2: ORGANICS AND SOLVENTS

There are many listings in the organics and solvents category from all of the waste exchanges. A typical page of listings is shown in Fig. 6. A large variety of materials is offered, but they all have one thing in common: they are combustible and can be burned to recover 10,000-20,000 Btu/lb. Some of the materials, in particular aromatic compounds and halogenated organics, are listed as hazardous. These therefore cannot be disposed of in landfills, and their storage, transport, and incineration must be accompanied by various permits, manifests, and licenses. Combustion of these materials is an acceptable method of disposal, but the temperature must be high enough to insure complete destruction, and acid gases (in particular HCl from decomposition of chlorinated organics) must be removed. Acid gas may be removed by installing a scrubber or avoided by incinerating the wastes in a cement kiln. Cement-kiln combustion is acceptable even for such highly toxic

CODE # A5-74
Solvents (MEK, butyl cellosolve, mineral spirits, naphtha, alcohols) used in cleaning aluminum can coating equipment. 5,000 gal./quarterly. 55-gal. drums. E. NY.

CODE # A5-75
Solvent; parts degreaser. 100 gal./yr. 55-gal. drums. Cent. NY.

CODE # A5-76
Isopropyl alcohol contaminated with approx. 15% water. 100 gal./mo. 55-gal. drums. S. NJ.

CODE # A5-77
Contaminated paint thinner. 110 gal./wk. 55-gal. drums. Cent. NY.

CODE # A5-78
Chlorothene VG (Dow Chemical) with 5% red dye penetrant & 5% oil contamination. 2,000 gal./mo. Bulk. RI.

CODE # A5-79
Spent methanol with approx. 10% water. 550 gal./wk. 55-gal. drums. RI.

— NEW LISTINGS —

CODE # A5-80
Theoretical weight: toluol 0.9%, xylol 6.3%, solvesso 100 30.1%, solvesso 150 20.1%, butanol 13.9%, diacetone alcohol 7.7%, cellosolve acetate 9.1%, butyl cellosolve 2.8%, butyl carbitol 6.3%; solids .5% by weight as low mole. wt. polyester. 5,000 gal./quarterly. Bulk. E. PA.

CODE # A5-81
Toluene with 10-15% adhesive residues. 6,000 gal./bi-wk. Bulk. N. NJ.

CODE # A5-82
50% trichloroethane, 25% cutting oil, 25% #10 hydraulic oil. 550 gal./quarterly. 55-gal. drums. Cent. NY.

CODE # A5-83
Spent solvents from machine shop. Two 55-gal. drums/mo. E. PA.

CODE # A5-84
Methyl isobutyl ketone, 1% dissolved urethane resin. 1,000 gal./mo. 55-gal. drums. E. NY.

CODE # A5-85
40% chlorinated organics in toluene, 55% ring chlorinated toluene. 60,000 gal./mo. Bulk. TN.

CODE # A5-86
Crude coal tar. 300,000 gal./once. Bulk. TN.

CODE # A5-87
Dichlorophenol & isomers: 3,4 DCP 60%, 2,5 DCP 5%, 2,4 DCP 5%, anisol isomers 20%, trichlorinated benzene 10%. 13,000 gal./mo. Bulk. TX.

CODE # A5-88
Used ketones with no metals or solids. 55-gal./mo. 55-gal. drums. E. NY.

CODE # A5-89
Alkaline catalyzed water-based latex suspensions, 50% suspended solids; contains neoprene, butadiene-styrene, acrylic, latices. 500 gal./mo. 55-gal. drums. E. NY.

CODE # A5-90
80% xylene, 20% paint alkyd baking enamel. 2,000 gal./quarterly. 55-gal. drums. W. NY.

CODE # A5-91
Flammable solvents, 90,000-100,000 BTU/lb. 5,000 gal./mo. Bulk. NYC area.

CODE # A5-92
Solvents; 20-90% chlorinated. 3,000 gal./mo. Bulk. NYC area.

CODE # A5-93
65% diethylene glycol 65%; tri & monoethylene glycols 35%; asking $1.45/gal. FOB PR;. sample avail. 10,000-20,000 gal./mo. Bulk. PR.

CODE # A5-94
Dimethyl acetamide with 15% water; sample avail. 23,000 gal./once. Bulk. PR.

CODE # A5-95
Mineral spirits with rustproofing oil & polishing coolant. 360 lbs./quarterly. 55-gal. drums. NH.

CODE # A5-96
Solvents from cleaning & painting operations; may include methyl ethyl ketone, varsol, 1,1,1 trichloroethane, paint thinners, reducers, ethyl acetate, toluene, kerosene. 100-200 gal./mo. 55-gal. drums. Cent. NY.

CODE # A5-97
Solvents, primarily toluene, from adhesive process cleanup. Ten 55-gal. drums/mo. N. NJ.

CODE # A5-98
Denatured alcohol: 92.3% ethyl alcohol, 4.9% amyl acetate, 1.06% cryolite, .73% zirconium, .73% aluminum, .34% phosphorus. 600 gal./yr. 30-gal. drums. W. PA.

CODE # A5-99
Methanol, approx. 10% water. 1,000 gal./quarterly. 55-gal. drums. W. PA.

CODE # A5-100
1,1,1 trichloroethane 450 mg/l; 1,1,2,2 tetrachloroethylene 66320 mg/l; chlorides 11,000 mg./l. 20 gal./mo. 55-gal. drums. E. PA.

CODE # A5-101
Organic solvents. 500 gal./yr. 55-gal. drums. W. PA.

CODE # A5-102
Xylol generated from industrial painting; 10-15% solids. 220 gal./mo. W. PA.

CODE # A5-103
Mixed paint lacquer & thinner sludge from spraying operation, some pumpable. 2,500 gal./yr. 55-gal. drums. N. NJ.

CODE # A5-104
Approx. 40% 1,1,1 trichloroethane, 58% oil, 2% solids. 55 gal./mo. 55-gal. drums. RI.

Fig. 6 Example of Listings of Organics and Solvents (Source: Ref. 12) materials as PCBs (polychlorinated biphenyls), because the combustion temperature is high and the alkaline cement neutralizes the HCl.* Combustion in a cement kiln is reported to cost $50-70/ton;[7] but 20-40 x 10^6 Btu are displaced, saving $30-60/ton if the displaced energy is from coal, the major fuel used in cement plants, and $60-120/ton if it is from gas. The process is economical because substantial disposal costs are avoided. High-temperature waste incineration is not economical, costing $250-500/ton.

The bulk of the waste-exchange listings in this category are for solvents of various types, most available in large quantities. Most are not hazardous or are hazardous (flammable) but not listed in 40 CFR Part 261 Subpart D, so they are not regulated if they are to be reused or recycled. Solvent recycling (distillation, steam stripping, extraction) is reported to cost $50-100/ton,[7] and the value of the solvent recovered is at least $300/ton, so the process is economical. Many companies (for example, Systech) are in the business of solvent recycling, and there are several listings in waste-exchange catalogs for waste solvents wanted. However, large quantities of solvents are still available for recycling. Possible reasons for this are (a) contaminants that are difficult to remove, (b) high water content that increases treatment and transport costs, (c) the presence of close-boiling compounds that are difficult to separate, and (d) the lack of a local recycling facility.

The example chosen for more detailed analysis is a mixture of phenol and oil, about 4000 lb of which are available daily in Piedmont, N.C.[13] This material was probably disposed of in drums prior to enactment of RCRA regulations, but this is no longer an acceptable alternative because phenol is on the hazardous-waste list in Subpart D. No data are available on the proportions of the two components, so the analysis is done conservatively, for a 90% oil, 10% phenol mixture. This mixture can be burned to recover about 17,500 Btu/lb, replacing about $0.11 worth of oil. On the other hand, the two components can be separated by first extracting the phenol into an aqueous alkaline solution and then stripping or distilling it from that solution. The approximate cost for this treatment is $50-100/ton.[7] The current price of phenol is $0.36/lb,[11] so a 10% phenol stream would yield materials worth $0.14/lb, or $280/ton. This is $60/ton more than the revenues from combustion. The energy required to make one pound of phenol is about 27,000 Btu,[14,15] so recovering a 10% solution saves about 3,000 Btu in process energy (6 x 10^6 Btu/ton), much of it in the form of oil. Both the revenues and the energy recovered increase for higher proportions of phenol, so the separation should be economical. This phenol/oil mixture may be unrecovered because only 4000 lb/day (about 500 gal/day) are available, and this may be too small a quantity to justify the capital expenditure for separation equipment. In this case, a specialized recycling facility would be required locally.

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*This approach has been endorsed by the California Air Resources Board even for PCBs, and the State of Ohio endorsed as environmentally acceptable a plant burning nonhalogenated wastes.[7] A decision concerning whether or not cement-kiln combustion is acceptable will be made by each state.

2.3 CATEGORY 3: METALS AND METAL-CONTAINING SLUDGES

Typical listings of metals and metal-containing sludges are shown in Fig. 7. The materials are not flammable, and, except for concentrated acid solutions and certain wastes containing heavy metals like lead and cadmium, are not hazardous. There are numerous acid solutions listed (from electroplating and cleaning processes) that contain small quantities of metal, and there are also many sludges listed. There are also some listings of surplus metals and scrap that have established markets. The acid solutions can often be cleaned and reconcentrated with known technology. Many of the

Code Identification: A-16-8

Item:	Steel Shot Blast Dust. 30% Shot & Dust, 70% contaminant (Oil, Grease, Dust).
Availability:	8 tons/month. Continuous. Drum.
Location:	Fort Worth, Texas. Varying quantities available nationwide.

Code Identification: A-15-5

Item:	Sludge containing Copper Oxide, Copper Hydroxide, and Sodium Hydroxide. Samples available for quanitative analysis.
Availability:	2,000 gallons one time. Possibility of 250 gallons/month. Drums.
Location:	Wisconsin

Code Identification: A-15-27

Item:	Copper Refining Reverb Furnace Baghouse Dust. Cu approx. 22%, Fe approx. 5%, Pb approx. 3%
Availability:	3-5 tons/month. Drums.
Location:	Pennsylvania

Code Identification: A-15-28

Item:	Induction Melting Brass Furnace Baghouse Dust. ZnO 71%, Zn 57%, Cu .7%, Carbon 14%. This material is classified as non-hazardous.
Availability:	1,000 lbs/month. Bagged.
Location:	Pennsylvania

Code Identification: A-15-29

Item:	CuO sludge, 80% moisture, 6-8% Cu. This material is classified as non-hazardous.
Availability:	50-75 tons/year. Drum/bulk.
Location:	Pennsylvania

Fig. 7 Example of Listings of Metals and Metal-Containing Sludges (Source: Ref. 2)

listed wastes contain metals in higher concentrations than the concentrations in ores currently being mined, and could be treated as ores. However, the quantities of waste are often too small to justify a facility; therefore either a central plant or transport to a primary metal-producing plant is needed.

The example chosen in this category is a copper oxide (CuO) sludge containing 6-8% Cu and 80% moisture. It is not classified as hazardous. The other constituents are unspecified and are presumably neither valuable nor problematic. The sludge can be dewatered, leaving a solid containing 30-40% copper (a typical ore concentration is 0.6%). The solid could probably be charged to the converter of a conventional copper smelter, where it would be reduced to copper metal. The energy saved would be approximately 60×10^6 Btu/ton of displaced copper from ore, or about 5×10^6 Btu/ton of sludge processed. The value of the copper is $0.78/lb,[16] or about $110/ton of sludge, and the marginal cost of increased charge to the converter would be low.

The major impediment to recycling this waste stream is the small quantity (only 50-75 tons) available annually. Total annual revenue from copper recovery would be only about $6000.

2.4 CATEGORY 4: MINERALS, INCLUDING GLASS AND SAND

Examples of minerals available are shown in Fig. 8. There are not many listings; most of the materials offered are of extremely low value and are available in large quantities. Their production is generally not energy intensive. The materials are neither combustible nor hazardous, so disposal in landfills is possible. Because of the materials' low value, transport does not pay; however, if a local user can be found, disposal costs can be avoided and energy that would have been used to mine the material displaced can be saved. Waste exchanges are an appropriate medium by which to find local customers for these materials.

Category 4: Minerals	
Available	
A6 - 4	Gypsum Plaster: $CaSO_4 \cdot \frac{1}{2}H_2O$); (80%) Chips: 2 - 3" sq. X 1/8" thick; (15%). Formed Molds discarded, average 12X12X6 inches; (5%) Powder. Color: White. 3000 lb/wk. In unsealed 100 lb. sacks. Portland.
A64 - 4	Silicon Sludge in powder form when suspended in 70% water. Hardens like concrete when water is removed. Approx. 10.000 lbs/mo. beginning in late 1979. Stored in plastic-lined tanks. Portland area.
A101 - 4	Scrap/Broken Glass: 1 ton/wk. on a regular basis. Loose. Portland metro area.

Fig. 8 Example of Listings of Minerals (Source: Ref. 17)

Several of the materials listed are not obviously useful or recyclable -- for example, glass cullet with ceramic inks, china pieces, and a mixture of sand, mica, and feldspar. Perhaps these could be used as soil conditioners or filtration media; testing would be needed to determine the usefulness of each waste material.

The chosen example in this category is 137,000 lb of sand, available monthly. Mining and transport of sand requires about 1×10^6 Btu/ton, some of which could be saved by using this waste material. If the energy saved were from oil, it would be worth about $400/month. Possible customers include cement- or glass-manufacturing companies. The waste sand's actual usefulness will of course depend on its grain size and purity.

2.5 CATEGORY 5: OILS, FATS, AND WAXES

Typical listings in the category of oils, fats, and waxes are shown in Fig. 9. Most of the available wastes are lubricating or hydraulic oils; all are combustible, with heats of combustion about 19,000 Btu/lb. Some are hazardous because of high aromatics content or, as is often the case with used automotive lubricating oil, high lead content. This means that the current practice of spreading this material on roads cannot be continued. Most of the listings are for relatively small quantities of material, so a central facility for treating wastes from many sources is appropriate. An economical means for collecting such dispersed commodities needs to be developed.

Used lubricating oils will be examined in more detail. In some cases, extensive processing may not be necessary to reclaim this material; oil and water separation and sedimentation and filtration may be all that is required to remove contaminants. The used oil can then be burned as a fuel, replacing virgin oil valued at $0.11/lb. Alternatively, more extensive treatment of "lube" oils can be used to refine them again (or "re-refine" them) into a replacement for virgin lube-oil base stock valued at $1.12/gal, or about $0.17/lb. Table 4 compares the economics of processing used oils for fuel and of re-refining by the solvent/distillation process developed at the Department of Energy's Bartlesville Energy Technology Center (BETC). The re-refining process has higher costs and higher revenues, but sale as fuel has a higher return on investment. Future regulatory decisions will influence businesses' choice of market for used oil.

Combustion recovers only the oil's heat of combustion. Re-refining by the BETC solvent/distillation process requires 2500 Btu/lb,[18] and the refined product replaces virgin lubricating oils that have a process energy requirement of 8000 Btu/lb,[19] thus displacing processing energy of 5500 Btu/lb each time it is recycled. When it can no longer be refined, it is still available for combustion. It is estimated that re-refining of used crankcase oils alone could save $43\text{-}76 \times 10^{12}$ Btu/yr, or $7\text{-}12 \times 10^6$ bbl/yr of oil more than combustion could save.[18]

- Code #: A-38
  Material: Used mobile DTE 25 and 26 hydraulic oil with small amounts of used lube oils and gear oils. 90% hydraulic oil with some lube oil and gear oil.
  Quantity: Est. 10,000 U.S. gals./yr. available on periodic basis
  Packaging: Drums

- Code #: A-40
  Material: Lubricating oils: Exxon separtan EP 150; Exxon separtan 220; Bruko D-260; Exxon lidok EP-2 grease; United cutting oil; VAR-SOL; all reclaimable or burnable as fuel.
  Quantity: Approx. 15,000 gals./yr. - available on a bi-monthly basis
  Packaging: Drums or bulk -- preferably bulk pick-up
  Location: Saegertown, PA - 3 miles east of Interstate 79

- Code #: A-46
  (See solvents for listing.)

- Code #: A-52
  Material: Lubricating and hydraulic oils.
  Quantity: 2000 gals./yr.
  Packaging: 55 gal. drums
  Location: Pittsburgh, PA

- Code #: A-84
  Material: Water soluble oil. SECO cutting oil by the Sun Oil Co.
  Quantity: 200 gals./wk. Available periodically
  Packaging: Drums or bulk storage tank

- Code #: A-85
  Material: Lubricating oil. EP gear oil and hydraulic oil.
  Quantity: 50,000 gals./yr. Available periodically
  Packaging: Bulk storage tanks

- Code #: A-90
  Material: Waste oils from machinery lubrication.
  Quantity: 50 gals./mo. in 55 gal. drums
  Packaging: Drums

- Code #: A-111
  Material: Gulf soluble oil, R-220 gearbox oil.
  Quantity: Approx. 1000 gals./6 mos.
  Packaging: Bulk
  Location: Southeastern PA

Fig. 9 Example of Listings of Oils (Source: Ref. 3)

2.6 CATEGORY 6: FOOD PROCESSING WASTES

Figure 10 lists some of the few food processing wastes available. None of the materials is hazardous. Their value is low, and so transport over large distances (more than 25 miles) does not pay. There are listings of wastes of both animal and vegetable origin, but the latter predominate. These materials are all combustible, but they are generally wet, so the heat of combustion is only about 5000 Btu/lb. Direct combustion is feasible in some old boilers, and bioconversion is possible using fermentation and anaerobic digestion. Thermal processes for gasification and liquefaction are also known.

Table 4 Recycling Used Automotive Lubricating Oil: Annual Economics of Re-refining and of Processing for Fuel

Economic Factor	Rate	Recycling Method: Processing for Fuel	Recycling Method: Re-refining
Process costs ($\$10^3$)			
Raw used oil, 10^7 gal	\$ 0.37/gal	3700	3700
Power	\$ 0.06/kWh	19	246
Steam, 150 psi sat	\$ 5.04/100 lb	--	98
Solvent	\$ 2.00/gal	--	108
Fuel	\$ 0.40/gal	--	308
Catalyst	\$125.00/ft^3	--	17
Hydrogen	\$ 6.00/10^3 SCF	--	162
Operating labor	\$ 20.00 x 10^3/operator	50	240
Overhead	100% of operating labor	50	240
Maintenance	5% of investment	13	260
Insurance, taxes	3% of investment	8	156
Depreciation	10% of investment	27	520
Total		3867	6055
Revenues ($\$10^3$)			
Lube oil	\$ 1.12/gal	--	7840
Fuel	\$ 0.45/gal	4455	945
Total		4455	8785
Profits ($\$10^3$)			
Before taxes		588	2730
Income taxes	50% of profit	294	1365
After taxes		294	1365
After-tax return on investment (%)		111	26.3

Source: Adapted from Ref. 18.

A-29	16	Vegetable Nut Waste, food grade	107,000 lbs./wk.	Northern NJ
A-30	16	Vegetable Leaf Waste, food grade	120,000 lbs./wk.	Northern NJ

Fig. 10 Example of Listings of Food-Processing Wastes (Source: Ref. 20)

The example chosen was listed in the June 1981 bulletin of the Oregon Industrial Waste Information Exchange. The waste material is steer and cow manure from the paunches of slaughtered animals, available in bulk year-round on a regular basis. The quantity is unspecified. Anaerobic digestion is suggested for this material, even if the quantity is low, because the technology is simple and capital costs are low. Total cost of the process is about $\$8$-$9/10^6$ Btu, or \$16-18/ton of manure (assuming 20% overall gas yield). The value of the gas displaced is about $\$3/10^6$ Btu, or \$6/ton of manure, and the sludge can be sold as low-value fertilizer. The process is therefore economical if disposal costs of greater than \$10/ton are avoided or if gas prices rise to $\$8/10^6$ Btu.

2.7 CATEGORY 7: PAPER AND WOOD

Typical listings for paper and wood wastes are shown in Fig. 11. The materials available are uniform in chemical composition, and all could be burned as fuel if no possibility existed for recycling. The heat of combustion is 8000 Btu/lb (dry), so each ton burned displaces \$24 worth of coal. However, these materials can only be burned in certain boilers equipped to handle untreated solid fuels. In addition, with wood selling at \$30/ton, it does not pay to transport it over large distances. Paper recycling is a well-established industry, but collection and transport of small quantities of waste to a large central facility may not be economical. This is a frequent impediment to recycling of waste materials.

The example chosen for this category is 250 tons/month of sawdust and shavings, available in Tennessee. This example is typical in that the quantity of material available is extremely small. This material would be an excellent feed for paper manufacture, and each ton would save on the order of 2×10^6 Btu in processing energy used to reduce wood to a small particle size, plus the energy required to grow the trees displaced. The material could also be used in particle-board manufacture, with similar energy savings.

2.8 CATEGORY 8: PLASTICS AND RUBBER

Figure 12 shows examples of plastics and rubber available from one waste exchange. They share two important characteristics: they are non-hazardous and they are combustible, with heating values up to 20,000 Btu/lb. Therefore, if no higher-value use is found, these materials can be burned; each ton replaces \$40-60 worth of coal. An exception is polyvinyl chloride

- Code #: A-86
  Material: Wood, paper, rags
  Quantity: 300 cubic yds./mo. Available periodically
  Packaging: Bulk container - open top

- Code #: A-107
  Material: Office papers, cardboard boxes, corrugated cardboard, kraft paper, some wooden pallets and assorted lumber.
  Quantity: Approx. 25 cubic yds/mo. available
  Packaging: Bulk
  Location: Southeastern PA

- Code #: A-114
  Material: Scrap paper fiber cores. Approx. 100" long, 10½" I.D. - ½" wall pressed paper core. Approx. 42 lbs. ea.
  Quantity: 1 trailer load ea. 6-8 wks. (320 cores)
  Packaging: loose-loaded into trailers
  Location: Eastern PA

- Code #: A-115
  Material: Scrap fiber cores; 3" I.D., lengths vary from 12" - 21", average weight is 1 lb.
  Quantity: Continuous generation averaging 80,000/mo.
  Packaging: To be determined
  Location: Eastern PA

Fig. 11 Example of Listings of Wood and Paper Wastes (Source: Ref. 3)

A9 - 8	Closed Cell Sponge Rubber: from soft to firm density in webb form. Black primarily, with some tan. No large full-sized pieces. Potential energy source. Approx. one dumpster load/wk. Stored loose in bins. Portland.
A39 - 8	Polyester Soft Drink Containers: material - polyethylene terephalate (PET). Color: clear & green. 10-20 tons/mo. Packaged to suit market. Oregon.
A59 - 8	"Ethafoam": made by Dow Chemical Co. Scraps from toy-making: 1X2X36", 1X2X24", & smaller strips. Designed for use as packaging material. Small pick-up load once/mo. on a regular basis. Portland.
A105 - 8	Acrylic Scrap: approx. 10,000 lbs. available in mixed sizes. Packaged on gaylords which would need to be returned. East Multnomah County, Oregon.
A144 - 2	All Major Plastics: Extrusion, blow mold, & injection mold grades; regrind or pelletized (reprocessed) available. Colors/additives to order. Available from plastic recycler on one-time, regular or irregular basis. Quantities vary with availability (1,000-40,000 lbs). Packaged gaylords or barrels. Oregon.
A152 - 8	Polypropylene Fines: some lumping but mostly free flowing. All white. Approx. lbs/month on on-going basis. Chicago Il metro area.
A163 - 8	Used Tires: Available in passenger car/heavy truck/heavy equipment sizes. Could be used for school playgrounds. Packaged loose, Eugene.
A166 - 8	Golf Car Bodies: white fibre glass. Used & broken. Available free on a one time basis. Approx. 60, loose. Portland metro area.

Fig. 12 Example of Listings of Plastics and Rubber (Source: Ref. 17)

(PVC), a ton of which replaces only $25 worth of coal. On combustion, PVC releases HCl gas; if the material burned contains more than a few percent PVC, the HCl must be scrubbed from the stack gas. PVC can be burned in cement kilns or fluidized-bed combustors with alkaline media, as can all chlorinated organics, to eliminate HCl emissions.

Thermoplastic scrap of a single material can often be recycled back to the same material if it is clean or can be cleaned. Recycling can be done in-house or by commercial scrap dealers and processors. The costs of this type of recycling are low, and the recycled material can usually be sold for about half the price of virgin material. Almost all of the approximately 35,000 Btu/lb (mostly oil and gas) required to make these plastics is recovered in the recycling process. In spite of the advantages of recycling, numerous listings of single-component plastic materials appear in waste-exchange catalogs. Of course, some plastics are colored or otherwise contaminated, decreasing their value as recyclable thermoplastics.

Although technology exists for plastics separation, mixed thermoplastic streams cannot generally be separated economically. With new material often costing only about $0.40/lb, separation does not pay, even though energy savings from reuse are substantial. More research needs to be done to find an economical means of separating mixed or contaminated plastics.

The example chosen in this category is 100 tons a month of clean rubber chips from automotive batteries,* available in the Midwest. This material can be treated in the same way as discarded tires; technologies are described in more detail in Ref. 21, and impediments are discussed in Ref. 22. The quantity available is too small to justify a dedicated treatment facility. This waste stream has a heat of combustion of 15,000 Btu/lb, and one ton could be cofired with coal in a stoker-fired boiler to displace $45 worth of coal. The marginal cost is extremely low, because the battery cases are chipped already and they must be transported even for disposal. The energy displaced is valued at about $0.023/lb, or $4,600/month. Alternatively, the material could be pyrolyzed, as could any of the materials in this category. However, the process is only economical on a large scale, and therefore many suppliers would be needed to make it pay. This is an impediment to construction of a pyrolysis plant. Net products from the pyrolysis of rubber are oil (up to 0.6 lb/lb input) and char. Together these are valued at about $0.12/lb of input if the char can be used to replace carbon black, and they cost $0.08 to produce. Materials requiring up to 23,000 Btu can be displaced by each pound of rubber pyrolyzed. Note, however, that the favorable economics and energy balance depend on the suitability of the char product to displace carbon black, and this is still under dispute.

Still another possibility for this material is to further reduce its size cryogenically or by the Gould mechanical process and use it as an

*Most automotive battery cases are now made of polypropylene, but hard rubber is still used for heavy-duty vehicle and industrial battery cases.

extender for the original compound. The cost to freeze this material with liquid nitrogen (LN_2) and grind it in a hammermill is less than $0.05/lb, and material costing $0.50/lb is displaced. The energy to freeze and grind the material, including the energy to produce the LN_2, is about 1,500 Btu/lb, and this displaces 38,300 Btu/lb that would have been required to make new rubber. Thus the process looks good on both energy and financial grounds.

Another attractive possible use for waste battery chips is as a replacement for some of the asphalt in pavement. The mixture known as asphalt-rubber lasts considerably longer than conventional asphalt. If a 25% rubber mix lasts twice as long as ordinary asphalt, each pound of rubber displaces 5 lb of asphalt at $0.056/lb, for a total value of $0.28. Savings in labor from not having to resurface as frequently more than offset the small additional first cost of using asphalt-rubber. The asphalt displaced has a heating value of 90,000 Btu per lb of rubber used. However, a major impediment to the use of asphalt-rubber is that highway officials do not always consider life-cycle costs when deciding on road surface materials, especially if they are short of capital because of shrinking gasoline-tax revenues. In addition, further study is needed to document the performance of asphalt-rubber.

2.9 CATEGORY 9: SPENT CATALYSTS

Figure 13 shows a typical waste-exchange listing of spent catalysts. There are very few listings for this category in any of the bulletins, probably because of the high value of the precious metals contained in many catalysts. These are generally recovered either in-house, by the catalyst manufacturer, or by a specialized firm. Appropriate buyers for spent catalysts can probably be found by consulting the Thomas register;[23] however, if no buyer can be located, or the materials do not meet specifications, they may be offered through a waste exchange.

One catalyst that did find its way onto a waste-exchange listing is 110 gal/year of 25% palladium (Pd), 25% hydrochloric acid catalyst. Insufficient information is given on the chemical composition to be certain of appropriate treatment. Presumably, the other 50% is water and the material is not 25% Pd, but 25% of Pd on alumina or zeolite support. This is a typical hydrocracking catalyst, and cost $10-15/lb in 1979.[9] Therefore, material worth $3,000 or more could be recovered from the small quantity of spent catalyst listed for exchange if it found its way to a firm handling this type of waste.

2.10 CATEGORY 10: TEXTILES, FUR, AND LEATHER

Listings from the textile, fur, and leather category are shown in Fig. 14. These materials are nonhazardous, and they are combustible. Typical

- Code #: A-105
  Material: Spent catalyst fines from fluid catalytic cracking unit electrostatic precipitator containing 57% silica and 41% alumina.
  Quantity: 12.5 tons/wk. Available on a continuous basis.
  Packaging: Bulk - 20 yd^3 closed roll-off containers.
  Location: Southeastern PA

- Code #: A-120
  Material: Spent vanadium catalyst
  Quantity: 3,500 lbs./yr. available once a yr.
  Packaging: 50 liter fibre drums
  Location: Western PA

Fig. 13 Example of Listings of Spent Catalysts (Source: Ref. 3)

A-87	Drapery remnants	300-500 yds.	monthly	Piedmont, N.C.
A-93	100% Acrylic thread waste, dyed		monthly	Piedmont, N.C.
A-101	Millends, overruns, remnants, cotton, poly-cotton blends suitable wovens & knitted materials	truckloads	bi-monthly	Piedmont, N.C.
C-19	Hosiery thirds and waste	250 lbs	weekly	Piedmont, N.C.
C-64	Leather cuttings Cotton flannel cuttings	2,000 lbs 30,000 lbs	monthly weekly	Piedmont, N.C.
C-159	Thirds in knitted greige socks (unfinished)	500-600 lbs	once/twice monthly	Piedmont, N.C.
D-62	Hosiery nylon waste leg blanks, panty hose rags	50-75 lbs	weekly	Piedmont, N.C.
R-17	Hosiery knitting waste Hosiery clips and strings	450 lbs 900 lbs	weekly weekly	Piedmont, N.C.
S-38	Nylon automotive velvet	varying amts. (in rolls)	continuous	Western, N.C.

Fig. 14 Example of Listings of Textiles and Leather (Source: Ref. 13)

heating values are on the order of 10,000 Btu/lb, so each pound burned would displace $0.015 worth of coal. Pyrolysis would yield products worth $0.06 or less, and bioconversion would yield even less-valuable products. It is therefore worth looking for higher-value uses for these materials that typically cost over $1.00/lb new. No furs were listed in any of the waste-exchange bulletins, and no way was identified for the small scraps of leather available to be used as material, so we will discuss textiles only. Mixed textile wastes are of extremely low value; the only use identified was in vulcanized fiber, a composite material made by pressing fibers with a resin binder to produce a reinforced plastic. Cotton wastes, such as mattress-ticking trim, could be bleached and used in the production of rag paper.

The waste examined in greater detail is 50-75 lb/week of leg blanks and nylon panty-hose rags. This is clearly another example of material recovery impeded by small quantity. Nylon is a thermoplastic material and can simply and cheaply be remelted and used to replace virgin nylon for an energy saving of about 90,000 Btu/lb, much of it in the form of oil. The material would be some nonstandard beige color and therefore unsuitable for wearing apparel unless dyed a darker shade, but the mechanical properties should be adequate for production of gears or other mechanical parts. The price in November 1981 of virgin nylon 66 was $1.81/lb,[24] so considerable savings are possible from using recycled material.

2.11 CATEGORY 11: INORGANIC CHEMICALS

Some of the many listings of inorganic chemicals are shown in Fig. 15. There is a tremendous variety of materials offered in various quantities. Some of the wastes are valuable, others are worthless. Some are harmless, and others, such as cyanide sludge, are extremely hazardous. Many of the offerings are for sludges, and valuable materials could be reclaimed if an economical technology were developed for recovery of materials from sludge.

The waste chosen for discussion is a solution of copper sulfate ($CuSO_4$), from a printed-circuit plating line, containing 14-21 oz Cu/gal (average, 18-19 oz/gal). The solution did not meet specifications and is available once only, in a relatively small quantity (1,600 gal), and this is a major impediment to recycling. The listing does not give sufficient information to ascertain why the solution did not meet specifications. Reuse would save the most energy and money. Water or additional salt could be added to adjust the concentration. Solid impurities could be filtered out. If treatment and reuse as $CuSO_4$ solution is not practical, the copper could be recovered by electrolysis (electrowinning) at an energy cost of 12,000 Btu/lb, much less than the 50,000 Btu/lb needed to produce copper from ore.[25] The value of the copper in the waste listed for one-time exchange is $1,440.

A-4-1	Ammonium sulfide, tech grade. 55 gal. One-time. Drum. South Denver.
A-4-2	Chlorine gas, tech grade. 1 cylinder size G. One-time. South Denver.
A-4-3	Sodium cyanide, tech grade. 25 lbs. One-time. Drum. South Denver.

Fig. 15 Example of Listings of Inorganic Chemicals (Source: Ref. 26)

3 CONCLUSION: IMPEDIMENTS TO SUCCESSFUL WASTE EXCHANGE AND RECOMMENDATIONS FOR OVERCOMING THEM

We have demonstrated in Section 2 that in almost every category of waste there are materials that could be exchanged with substantial benefits. Actual exchanges accomplished through a waste clearinghouse from April 1978 through September 1980, and the associated energy savings calculated by the clearinghouse, are shown in Table 5. The total energy savings for two and a half years of operation were 10×10^9 Btu, or 4×10^9 Btu/year. As a plausible hypothesis, suppose 50 exchanges were in operation and were five times as large or effective as those now operating; total savings would be 10^{12} Btu, the equivalent of 100,000 barrels of oil. Calculation of energy savings potentially achievable if all wastes listed as available were exchanged would, because of the diversity, require analysis of each material.

The table lists only one or two exchanges per month from a catalog of about 100 entries. Even if the listing is incomplete, it is illustrative of the low success rate achieved by some waste exchanges. Little information is available on actual exchanges; clearinghouses do not usually collect statistics, and materials exchanges keep them proprietary. However, one clearinghouse estimated that 20-25% of their listings resulted in exchanges;[27] another source estimates an average of 10%.*[28] A recent study analyzed the effectiveness of one exchange during its first six months of operation.[29] The results are summarized in Table 6, where it can be seen that, in terms of percent of material available, inorganic chemicals were the most actively exchanged materials.

Considerable benefits are possible through waste exchange; more material transfers would increase the benefits actually realized. We have identified several major barriers that impede waste exchange, and we will now recommend actions that can be taken to overcome them.

One major barrier to the successful exchange of many listed wastes is the lack of economical technology for their treatment. This lack is greatest in the area of separation of mixed or contaminated wastes. Technology is generally available but often is not economical. Some examples in which economical separation technology is needed are materials recovery from sludges, separation of close-boiling liquids, and separation of mixed plastic or fiber wastes. Research on improved separation processes is strongly recommended. In addition, industrial waste generators should be encouraged to think about recycling before they unnecessarily mix or contaminate process waste streams. As one commercial recycler puts it, "Recycling works only when materials are known to be and planned to be recycled."[30] Alternatively, process or feedstock modifications that result in less waste can be

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*But it must be noted that once avenues are found for reusing waste materials, they are used routinely without further involvement of the waste exchange.

Table 5 Successful Waste Transfers: Energy Savings Analysis

Period and Waste Description	Volume	Estimated Savings (10^6 Btu)
April 1 - June 30, 1978		
Metal Racks	0.25 tons	2.3
Waxed Sulphate Board	45.50 tons	1,203.0
Polyethelene Drums	0.60 tons	22.3
Paint	0.20 tons	1.4
Solvent	0.16 tons	1.1
July 1 - September 30, 1978		
Chlorine Tablets	100 lb	11.7
Waste Acid	500 gal	6.23
Beef Byproducts	600 yd^3/6 mo	NA[a]
Waxed Paper Labels	20 tons	487.8
Waste Solvent	159 gal	4.45
Wood Pallets	4,000 units	63.0
Voting Booths	30 units	0.52
October 1 - December 31, 1978		
Broken Plastic Berry Flats	2,500 units	27.8
Sheet Aluminum	52 sheets 4,316 lb	610.7
Acetone	1,300 gal	78.2
Gasoline/Oil Mixture	5 gal	0.6
Gasoline (35%)/Diesel (65%) Mix	10,000 gal	1,422.0
Chlorinated Solvent Recovery Waste	6,500 gal	152.0
Broken Wood Pallets/Cardboard	200 units	3.15
January 1 - April 15, 1979		
5-Gallon Metal Cans	100 units	5.67
Used Lacquer Thineer	200 gal	21.2
Full-Twist Glass Gallon Jars	1,440 units	3.42
Liquid Waxes Mixture	5,800 gal	84.9
April 16 - July 31, 1979		
Plate Glass	2 tons/mo	4.0
Paper Cores	1,000 units	475.0
Kraft Paper	38 rolls	3.61
Wood Pallets	200 units	3.15
August 1 - October 31, 1979		
Mercury	1 lb	NA
Paint Thinner	50 gal	5.3
Plastic Yo-yos	14,000 units	16.32
16-Gallon Metal Drums	30 units	4.88
Thermal Plastic	700 lb/day	5.6/day
DuPont "Alathon"	100,000 lb	495
Subtotal		5,226.30

Table 5 (Cont'd)

Period and Waste Description	Volume	Estimated Savings (10^6 Btu)
November 1, 1979 - January 31, 1980		
Excelsior	6 large bags	NA
Sawdust	1,000 yd^3	2,808
Mercury	4-6 oz	NA
Wood Pallets	100 units	1.58
Scrap Board	3,800 lb	22.0
February 1, 1980 - April 30, 1998		
Car Oil (1/3) Mixed with Water (2/3)	5 gal	0.07
Mixed Paint & Chemical Sludge	1,300 gal	12.9
Contaminated Waste Gas	1 gal	0.013
Dirty Solvents	1,700 gal	35.7
Used Lacquer Thinner	4,000 gal	424
Wood Pallets	200 units	3.16
May 1 - July 31, 1980		
Wood Pallets	50 units	0.79
Waxed 8-oz Cold Cups	2,500 units	5.7
Plastic Credit Cards	1.5 tons	144.5
Hardwood Crates	200 units	1.1
Oil & Kerosene Mixture	150 gal	19.55
Cardboard	10 yd^3	3.15
August 1 - September 30, 1980		
Sawdust	2 yd^3	0.57
Polyethelene Terephalate (PET) (soft drink containers)	13,000 lb	241.1
Wood Pilings	240 ton	504.0
Tubuler Polyethylene Sheets	250 lb/mo	43.4/mo
Mixed Solvents	300 gal/yr	6.3/yr
High-Density Rolled Plastic	6 tons	222.6
Mercury Batteries	200 lb	NA
Mixed Solvents	50 gal	1.1
Used Motor Oil	200 gal/yr	26.1/yr
Wood Pallets	2,000 units	31.5
Injection Grade Polyethylene	5,000 lb	92.8
Calcium Hydroxide Sludge	70 ton/wk	383.1/wk
Subtotal		5,034.78
Grand Total		10,261.08

Source: Adapted from Ref. 31.

[a]NA = No data available.

Table 6 Status of Wastes Listed[a]

Waste Type	Transferred (%)	Negotiations in Progress (%)	Not Transferred (%)
Acids	4	9	87
Alkalis	13	25	62
Other inorganics	27	27	46
Metal/metal sludges	5	19	76
Organics/solvents	13	23	64
Oils/fats/waxes	--	27	73
Plastics	--	67	33
Textiles/leather/rubber	--	58	42
Wood/paper	--	40	60
Miscellaneous wastes	14	19	67

Source: Adapted from Ref. 29.

[a]Status at end of first six months of operation of the waste exchange.

considered. The government could provide incentives, through tax credits or rapid-depreciation allowances, for capital expenditures that reduce the volume or hazard of wastes or make the wastes more amenable to recovery (for example, by source separation).

A second impediment to waste exchange is that many listings are for small quantities of materials or for materials available only once and dispersed over a broad geographical area. It is generally not economical to treat a small quantity of material, and a continuing supply of input is needed to justify purchasing equipment to treat materials that can't be reused as is. Thus, in the absence of economical small-scale technology, dispersed wastes must be collected and transported to a central recycling facility that receives material from many sources. Not enough of these facilities are in operation to treat available wastes. Their establishment should be encouraged in any way possible. Loan guarantees, regulatory exemptions, and tax relief* might be appropriate. The problem of dispersed wastes is compounded by the fact that the low value per pound of many of the materials, particularly those with high water content, makes transport over large distances uneconomical. Therefore, research on appropriate methods for collection of dispersed low-value materials is badly needed. The methods would apply to recycleable materials in municipal waste, and to biomass and biomass wastes as well. It would also be worthwhile to develop portable recycling equipment.

* The Senate is considering several measures in this area.

Many waste-exchange operators identify restrictive regulation of hazardous waste -- and uncertainty about and misunderstanding and fear of regulations -- as a third impediment to waste exchange. First, many people do not realize that recyclers of all but listed hazardous wastes are exempt from RCRA regulations. Second, RCRA mandates cradle-to-grave responsibility for generators of hazardous waste, who therefore fear that they are liable for improper handling of their wastes by treatment facilities. However, it appears that responsibility can be transferred to a licensed facility through contractual agreement; this matter will be decided by the courts. Third, under RCRA regulations, generators need a permit if they are to store listed hazardous wastes for more than 90 days, even if the wastes are to be recycled. However, waste-exchange catalogs are often published quarterly, and negotiations for transfer take time, so this restriction severely limits hazardous-waste exchange. Finally, regulations concerning hazardous waste have changed several times and could change still further.* The resulting uncertainty deters companies from getting involved. Therefore, regulations must be finalized and people educated as to their proper interpretation. Numerous companies have sprung up to help waste generators cope with hazardous-waste regulations. In addition, the EPA maintains the "RCRA Hotline" to answer questions about hazardous-waste regulations (800-424-9346; in Washington, D.C., 382-3000). However, still more public education about regulations is needed. To complicate the situation even further, states have their own hazardous-waste regulations, and these are not uniform. A waste may be listed as hazardous in one state and not in another.

Another impediment to waste exchange is that many companies do not know what materials are available or what they could be used for. Companies are also reluctant to deviate from established practice in waste handling; the current system works, and a new system is an unkown. Small companies often do not have the technical expertise either to recognize or to treat potentially usable materials offered for exchange. This problem can be solved in large part by an "intelligent" waste exchange that does not simply pass information about material availability through to its clients. Instead, the listings are examined and the exchange contacts potential users with information explaining how they could use specific materials. "In most cases, market research and development is necessary in order to establish an outlet for waste materials."[32] Most subsidized waste exchanges do not have the technical staff needed to do this, but most for-profit exchanges offer this service, among others, and appear to be operating successfully.** Therefore, waste exchanges should be encouraged to find uses for available materials.

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*The EPA expects to propose a new definition of solid waste that will affect recycling of hazardous wastes. Even if the new definition is clearer and exempts certain recyclable materials, the change may cause additional confusion.

**This is not necessarily an argument against subsidized exchanges, because private ventures often handle only those materials from which the greatest profits are available.

Recycling companies that treat wastes to make them suitable for reuse and then seek markets for them, as well as consultants who help generators recover their own wastes, should also be encouraged through such means as tax or regulatory relief and loan guarantees.

In summary, we find that, although considerable savings of both energy and money are possible through waste exchange, several major impediments limit the number of actual exchanges that take place. These impediments include the lack of economical separation technology, the small quantities of material available at each site, restrictive or uncertain regulation, and lack of knowledge on the part of potential waste users. None of these barriers is insurmountable if appropriate action is taken.

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APPENDIX: 40 CFR PART 261 SUBPARTS C AND D

The following material is reproduced from the Federal Register, Vol. 45, No. 98, for May 19, 1980, Part III, Environmental Protection Agency - Hazardous Waste Management System: Identification and Listing of Hazardous Wastes, pages 33121-33127. The pertinent material is in Subpart C - Characteristics of Hazardous Waste and Subpart D - Lists of Hazardous Wastes.

to being used, re-used, recycled or reclaimed is subject to the following requirements with respect to such transportation or storage:

(1) Notification requirements under Section 3010 RCRA.

(2) Part 262 of this Chapter.

(3) Part 263 of this Chapter.

(4) Subparts A, B, C, D and E of Part 264 of this Chapter.

(5) Subparts A, B, C, D, E, G, H, I, J and L of Part 265 of this Chapter.

(6) Parts 122 and 124 of this Chapter, with respect to storage facilities.

Subpart B—Criteria for Identifying the Characteristics of Hazardous Waste and for Listing Hazardous Waste

§ 261.10 Criteria for identifying the characteristics of hazardous waste.

(a) The Administrator shall identify and define a characteristic of hazardous waste in Subpart C only upon determining that:

(1) A solid waste that exhibits the characteristic may:

(i) Cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or

(ii) Pose a substantial present or potential hazard to human health or the environment when it is improperly treated, stored, transported, disposed of or otherwise managed; and

(2) The characteristic can be:

(i) Measured by an available standardized test method which is reasonably within the capability of generators of solid waste or private sector laboratories that are available to serve generators of solid waste; or

(ii) Reasonably detected by generators of solid waste through their knowledge of their waste.

§ 261.11 Criteria for listing hazardous waste.

(a) The Administrator shall list a solid waste as a hazardous waste only upon determining that the solid waste meets one of the following criteria:

(1) It exhibits any of the characteristics of hazardous waste identified in Subpart C.

(2) It has been found to be fatal to humans in low doses or, in the absence of data on human toxicity, it has been shown in studies to have an oral LD 50 toxicity (rat) of less than 50 milligrams per kilogram, an inhalation LC 50 toxicity (rat) of less than 2 milligrams per liter, or a dermal LD 50 toxicity (rabbit) of less than 200 milligrams per kilogram or is otherwise capable of causing or significantly contributing to an increase in serious irreversible, or incapacitating reversible, illness. (Waste listed in accordance with these criteria will be designated Acute Hazardous Waste.)

(3) It contains any of the toxic constituents listed in Appendix VIII unless, after considering any of the following factors, the Administrator concludes that the waste is not capable of posing a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed:

(i) The nature of the toxicity presented by the constituent.

(ii) The concentration of the constituent in the waste.

(iii) The potential of the constituent or any toxic degradation product of the constituent to migrate from the waste into the environment under the types of improper management considered in paragraph (a)(3)(vii) of this section.

(iv) The persistence of the constituent or any toxic degradation product of the constituent.

(v) The potential for the constituent or any toxic degradation product of the constituent to degrade into non-harmful constituents and the rate of degradation.

(vi) The degree to which the constituent or any degradation product of the constituent bioaccumulates in ecosystems.

(vii) The plausible types of improper management to which the waste could be subjected.

(viii) The quantities of the waste generated at individual generation sites or on a regional or national basis.

(ix) The nature and severity of the human health and environmental damage that has occurred as a result of the improper management of wastes containing the constituent.

(x) Action taken by other governmental agencies or regulatory programs based on the health or environmental hazard posed by the waste or waste constituent.

(xi) Such other factors as may be appropriate.

Substances will be listed on Appendix VIII only if they have been shown in scientific studies to have toxic, carcinogenic, mutagenic or teratogenic effects on humans or other life forms.

(Wastes listed in accordance with these criteria will be designated Toxic wastes.)

(b) The Administrator may list classes or types of solid waste as hazardous waste if he has reason to believe that individual wastes, within the class or type of waste, typically or frequently are hazardous under the definition of hazardous waste found in Section 1004(5) of the Act.

(c) The Administrator will use the criteria for listing specified in this section to establish the exclusion limits referred to in § 261.5(c).

Subpart C—Characteristics of Hazardous Waste

§ 261.20 General.

(a) A solid waste, as defined in § 261.2, which is not excluded from regulation as a hazardous waste under § 261.4(b), is a hazardous waste if it exhibits any of the characteristics identified in this Subpart.

[Comment: § 262.11 of this Chapter sets forth the generator's responsibility to determine whether his waste exhibits one or more of the characteristics identified in this Subpart]

(b) A hazardous waste which is identified by a characteristic in this subpart, but is not listed as a hazardous waste in Subpart D, is assigned the EPA Hazardous Waste Number set forth in the respective characteristic in this Subpart. This number must be used in complying with the notification requirements of Section 3010 of the Act and certain recordkeeping and reporting requirements under Parts 262 through 265 and Part 122 of this Chapter.

(c) For purposes of this Subpart, the Administrator will consider a sample obtained using any of the applicable sampling methods specified in Appendix I to be a representative sample within the meaning of Part 260 of this Chapter.

[Comment: Since the Appendix I sampling methods are not being formally adopted by the Administrator, a person who desires to employ an alternative sampling method is not required to demonstrate the equivalency of his method under the procedures set forth in §§ 260.20 and 260.21.]

§ 261.21 Characteristic of ignitability.

(a) A solid waste exhibits the characteristic of ignitability if a representative sample of the waste has any of the following properties:

(1) It is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume, and has a flash point less than 60°C (140°F), as determined by a Pensky-Martens Closed Cup Tester, using the test method specified in ASTM Standard D-93-79, or a Setaflash Closed Cup Tester, using the test method specified in ASTM standard D-3278-78, or as determined by an equivalent test method approved by the Administrator under the procedures set forth in §§ 260.20 and 260.21.[1]

[1] ASTM Standards are available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

(2) It is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes and, when ignited, burns so vigorously and persistently that is creates a hazard.

(3) It is an ignitable compressed gas as defined in 49 CFR 173.300 and as determined by the test methods described in that regulation or equivalent test methods approved by the Administrator under §§ 260.20 and 260.21.

(4) It is an oxidizer as defined in 49 CFR 173.151.

(b) A solid waste that exhibits the characteristic of ignitability, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number of D001.

§ 261.22 Characteristic of corrosivity.

(a) A solid waste exhibits the characteristic of corrosivity if a representative sample of the waste has either of the following properties:

(1) It is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5, as determined by a pH meter using either the test method specified in the "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods" [2] (also described in "Methods for Analysis of Water and Wastes" EPA 600/4–79–020, March 1979), or an equivalent test method approved by the Administrator under the procedures set forth in §§ 260.20 and 260.21.

(2) It is a liquid and corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55°C (130°F) as determined by the test method specified in NACE (National Association of Corrosion Engineers) Standard TM–01–69 [3] as standardized in "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods," or an equivalent test method approved by the Administrator under the procedures set forth in §§ 260.20 and 260.21.

(b) A solid waste that exhibits the characteristic of corrosivity, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number of D002.

[2] This document is available from Solid Waste Information, U.S. Environmental Protection Agency, 26 W. St. Clair Street, Cincinnati, Ohio 45268.

[3] The NACE Standard is available from the National Association of Corrosion Engineers, P.O. Box 986, Katy, Texas 77450.

§ 261.23 Characteristic of reactivity.

(a) A solid waste exhibits the characteristic of reactivity if a representative sample of the waste has *any* of the following properties:

(1) It is normally unstable and readily undergoes violent change without detonating.

(2) It reacts violently with water.

(3) It forms potentially explosive mixtures with water.

(4) When mixed with water, it generates toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.

(5) It is a cyanide or sulfide bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment.

(6) It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.

(7) It is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.

(8) It is a forbidden explosive as defined in 49 CFR 173.51, or a Class A explosive as defined in 49 CFR 173.53 or a Class B explosive as defined in 49 CFR 173.88.

(b) A solid waste that exhibits the characteristic of reactivity, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number of D003.

§ 261.24 Characteristic of EP Toxicity.

(a) A solid waste exhibits the characteristic of EP toxicity if, using the test methods described in Appendix II or equivalent methods approved by the Administrator under the procedures set forth in §§ 260.20 and 260.21, the extract from a representative sample of the waste contains any of the contaminants listed in Table I at a concentration equal to or greater than the respective value given in that Table. Where the waste contains less than 0.5 percent filterable solids, the waste itself, after filtering, is considered to be the extract for the purposes of this section.

(b) A solid waste that exhibits the characteristic of EP toxicity, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number specified in Table I which corresponds to the toxic contaminant causing it to be hazardous.

Table I.—Maximum Concentration of Contaminants for Characteristic of EP Toxicity—Continued

EPA hazardous waste number	Contaminant	Maximum concentration (milligrams per liter)
D004	Arsenic	5.0
D005	Barium	100.0
D006	Cadmium	1.0
D007	Chromium	5.0
D008	Lead	5.0
D009	Mercury	0.2
D010	Selenium	1.0
D011	Silver	5.0
D012	Endrin (1,2,3,4,10,10-hexachloro-1,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano naphthalene.	0.02
D013	Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer.	0.4
D014	Methoxychlor (1,1,1-Trichloro-2,2-bis [p-methoxyphenyl]ethane).	10.0
D015	Toxaphene ($C_{10}H_{10}Cl_8$, Technical chlorinated camphene, 67–69 percent chlorine).	0.5
D016	2,4-D, (2,4-Dichlorophenoxyacetic acid).	10.0
D017	2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid).	1.0

Subpart D—Lists of Hazardous Wastes

§ 261.30 General.

(a) A solid waste is a hazardous waste if it is listed in this Subpart, unless it has been excluded from this list under §§ 260.20 and 260.22.

(b) The Administrator will indicate his basis for listing the classes or types of wastes listed in this Subpart by employing one or more of the following Hazard Codes:

Ignitable Waste	(I)
Corrosive Waste	(C)
Reactive Waste	(R)
EP Toxic Waste	(E)
Acute Hazardous Waste	(H)
Toxic Waste	(T)

Appendix VII identifies the constituent which caused the Administrator to list the waste as an EP Toxic Waste (E) or Toxic Waste (T) in §§ 261.31 and 261.32.

(c) Each hazardous waste listed in this Subpart is assigned an EPA Hazardous Waste Number which precedes the name of the waste. This number must be used in complying with the notification requirements of Section 3010 of the Act and certain recordkeeping and reporting requirements under Parts 262 through 265 and Part 122 of this Chapter.

(d) Certain of the hazardous wastes listed in § 261.31 or § 261.32 have exclusion limits that refer to § 261.5(c)(5).

§ 261.31 Hazardous waste from nonspecific sources.

Industry and EPA hazardous waste No.	Hazardous waste	Hazard code
Generic:		
F001	The spent halogenated solvents used in degreasing, tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and the chlorinated fluorocarbons; and sludges from the recovery of these solvents in degreasing operations.	(T)
F002	The spent halogenated solvents, tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, o-dichlorobenzene, trichlorofluoromethane and the still bottoms from the recovery of these solvents.	(T)
F003	The spent non-halogenated solvents, xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, n-butyl alcohol, cyclohexanone, and the still bottoms from the recovery of these solvents.	(I)
F004	The spent non-halogenated solvents, cresols and cresylic acid, nitrobenzene, and the still bottoms from the recovery of these solvents	(T)
F005	The spent non-halogenated solvents, methanol, toluene, methyl ethyl ketone, methyl isobutyl ketone, carbon disulfide, isobutanol, pyridine and the still bottoms from the recovery of these solvents.	(I, T)
F006	Wastewater treatment sludges from electroplating operations	(T)
F007	Spent plating bath solutions from electroplating operations	(R, T)
F008	Plating bath sludges from the bottom of plating baths from electroplating operations	(R, T)
F009	Spent stripping and cleaning bath solutions from electroplating operations	(R, T)
F010	Quenching bath sludge from oil baths from metal heat treating operations	(R, T)
F011	Spent solutions from salt bath pot cleaning from metal heat treating operations	(R, T)
F012	Quenching wastewater treatment sludges from metal heat treating operations	(T)
F013	Flotation tailings from selective flotation from mineral metals recovery operations	(T)
F014	Cyanidation wastewater treatment tailing pond sediment from mineral metals recovery operations	(T)
F015	Spent cyanide bath solutions from mineral metals recovery operations	(R, T)
F016	Dewatered air pollution control scrubber sludges from coke ovens and blast furnaces	(T)

§ 261.32 Hazardous waste from specific sources.

Industry and EPA hazardous waste No.	Hazardous waste	Hazard code
Wood Preservation: K001	Bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote and/or pentachlorophenol	(T)
Inorganic Pigments:		
K002	Wastewater treatment sludge from the production of chrome yellow and orange pigments	(T)
K003	Wastewater treatment sludge from the production of molybdate orange pigments	(T)
K004	Wastewater treatment sludge from the production of zinc yellow pigments	(T)
K005	Wastewater treatment sludge from the production of chrome green pigments	(T)
K006	Wastewater treatment sludge from the production of chrome oxide green pigments (anhydrous and hydrated)	(T)
K007	Wastewater treatment sludge from the production of iron blue pigments	(T)
K008	Oven residue from the production of chrome oxide green pigments	(T)
Organic Chemicals:		
K009	Distillation bottoms from the production of acetaldehyde from ethylene	(T)
K010	Distillation side cuts from the production of acetaldehyde from ethylene	(T)
K011	Bottom stream from the wastewater stripper in the production of acrylonitrile	(R, T)
K012	Still bottoms from the final purification of acrylonitrile in the production of acrylonitrile	(T)
K013	Bottom stream from the acetonitrile column in the production of acrylonitrile	(R, T)
K014	Bottoms from the acetonitrile purification column in the production of acrylonitrile	(T)
K015	Still bottoms from the distillation of benzyl chloride	(T)
K016	Heavy ends or distillation residues from the production of carbon tetrachloride	(T)
K017	Heavy ends (still bottoms) from the purification column in the production of epichlorohydrin	(T)
K018	Heavy ends from fractionation in ethyl chloride production	(T)
K019	Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production	(T)
K020	Heavy ends from the distillation of vinyl chloride in vinyl chloride monomer production	(T)
K021	Aqueous spent antimony catalyst waste from fluoromethanes production	(T)
K022	Distillation bottom tars from the production of phenol/acetone from cumene	(T)
K023	Distillation light ends from the production of phthalic anhydride from naphthalene	(T)
K024	Distillation bottoms from the production of phthalic anhydride from naphthalene	(T)
K025	Distillation bottoms from the production of nitrobenzene by the nitration of benzene	(T)
K026	Stripping still tails from the production of methyl ethyl pyridines	(T)
K027	Centrifuge residue from toluene diisocyanate production	(R, T)
K028	Spent catalyst from the hydrochlorinator reactor in the production of 1,1,1-trichloroethane	(T)
K029	Waste from the product stream stripper in the production of 1,1,1-trichloroethane	(T)
K030	Column bottoms or heavy ends from the combined production of trichloroethylene and perchloroethylene	(T)
Pesticides:		
K031	By-products salts generated in the production of MSMA and cacodylic acid	(T)
K032	Wastewater treatment sludge from the production of chlordane	(T)
K033	Wastewater and scrub water from the chlorination of cyclopentadiene in the production of chlordane	(T)
K034	Filter solids from the filtration of hexachlorocyclopentadiene in the production of chlordane	(T)
K035	Wastewater treatment sludges generated in the production of creosote	(T)
K036	Still bottoms from toluene reclamation distillation in the production of disulfoton	(T)
K037	Wastewater treatment sludges from the production of disulfoton	(T)
K038	Wastewater from the washing and stripping of phorate production	(T)
K039	Filter cake from the filtration of diethylphosphorodithoric acid in the production of phorate	(T)
K040	Wastewater treatment sludge from the production of phorate	(T)
K041	Wastewater treatment sludge from the production of toxaphene	(T)
K042	Heavy ends or distillation residues from the distillation of tetrachlorobenzene in the production of 2,4,5-T	(T)
K043	2,6-Dichlorophenol waste from the production of 2,4-D	(T)
Explosives:		
K044	Wastewater treatment sludges from the manufacturing and processing of explosives	(R)
K045	Spent carbon from the treatment of wastewater containing explosives	(R)
K046	Wastewater treatment sludges from the manufacturing, formulation and loading of lead-based initiating compounds	(T)
K047	Pink/red water from TNT operations	(R)
Petroleum Refining:		
K048	Dissolved air flotation (DAF) float from the petroleum refining industry	(T)
K049	Slop oil emulsion solids from the petroleum refining industry	(T)
K050	Heat exchanger bundle cleaning sludge from the petroleum refining industry	(T)
K051	API separator sludge from the petroleum refining industry	(T)
K052	Tank bottoms (leaded) from the petroleum refining industry	(T)
Leather Tanning Finishing:		
K053	Chrome (blue) trimmings generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue; and shearing.	(T)

§ 261.32 Hazardous waste from specific sources. —Continued

Industry and EPA hazardous waste No.	Hazardous waste	Hazard code
K054	Chrome (blue) shavings generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue; and shearling.	(T)
K055	Buffing dust generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; and through-the-blue.	(T)
K056	Sewer screenings generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue; and shearling.	(T)
K057	Wastewater treatment sludges generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; retan/wet finish; no beamhouse; through-the-blue and shearling.	(T)
K058	Wastewater treatment sludges generated by the following subcategories of the leather tanning and finishing industry: hair pulp/chrome tan/retan/wet finish; hair save/chrome tan/retan/wet finish; and through-the-blue.	(R, T)
K059	Wastewater treatment sludges generated by the following subcategory of the leather tanning and finishing industry: hair save/non-chrome tan/retan/wet finish.	(R)
Iron and Steel:		
K060	Ammonia still lime sludge from coking operations	(T)
K061	Emission control dust/sludge from the electric furnace production of steel	(T)
K062	Spent pickle liquor from steel finishing operations	(C, T)
K063	Sludge from lime treatment of spent pickle liquor from steel finishing operations	(T)
Primary Copper: K064	Acid plant blowdown slurry/sludge resulting from the thickening of blowdown slurry from primary copper production	(T)
Primary Lead: K065	Surface impoundment solids contained in and dredged from surface impoundments at primary lead smelting facilities	(T)
Primary Zinc:		
K066	Sludge from treatment of process wastewater and/or acid plant blowdown from primary zinc production	(T)
K067	Electrolytic anode slimes/sludges from primary zinc production	(T)
K068	Cadmium plant leach residue (iron oxide) from primary zinc production	(T)
Secondary Lead: K069	Emission control dust/sludge from secondary lead smelting	(T)

§ 261.33 Discarded Commercial Chemical Products, Off-Specification Species, Containers, and Spill Residues Thereof.

The following materials or items are hazardous wastes if and when they are discarded or intended to be discarded:

(a) Any commercial chemical product, or manufacturing chemical intermediate having the generic name listed in paragraphs (e) or (f) of this section.

(b) Any off-specification commercial chemical product or manufacturing chemical intermediate which, if it met specifications, would have the generic name listed in paragraphs (e) or (f) of this section.

(c) Any container or inner liner removed from a container that has been used to hold any commercial chemical product or manufacturing chemical intermediate having the generic name listed in paragraph (e) of this section, unless:

(1) The container or inner liner has been triple rinsed using a solvent capable of removing the commercial chemical product or manufacturing chemical intermediate;

(2) The container or inner liner has been cleaned by another method that has been shown in the scientific literature, or by tests conducted by the generator, to achieve equivalent removal; or

(3) In the case of a container, the inner liner that prevented contact of the commercial chemical product or manufacturing chemical intermediate with the container, has been removed.

(d) Any residue or contaminated soil, water or other debris resulting from the cleanup of a spill, into or on any land or water, of any commercial chemical product or manufacturing chemical intermediate having the generic name listed in paragraphs (e) or (f) of this Section.

[Comment: The phrase "commercial chemical product or manufacturing chemical intermediate having the generic name listed in . . ." refers to a chemical substance which is manufactured or formulated for commercial or manufacturing use. It does not refer to a material, such as a manufacturing process waste, that contains any of the substances listed in paragraphs (e) or (f). Where a manufacturing process waste is deemed to be a hazardous waste because it contains a substance listed in paragraphs (e) or (f), such waste will be listed in either §§ 261.31 or 261.32 or will be identified as a hazardous waste by the characteristics set forth in Subpart C of this Part.]

(e) The commercial chemical products or manufacturing chemical intermediates, referred to in paragraphs (a) through (d) of this section, are identified as acute hazardous wastes (H) and are subject to the small quantity exclusion defined in § 261.5(c). These wastes and their corresponding EPA Hazardous Waste Numbers are:

Hazardous waste No.	Substance [1]
	1080 see P058
	1081 see P057
	(Acetato)phenylmercury see P092
	Acetone cyanohydrin see P069
P001	3-(alpha-Acetonylbenzyl)-4-hydroxycoumarin and salts
P002	1-Acetyl-2-thiourea
P003	Acrolein
	Agarin see P007
	Agrosan GN 5 see P092
	Aldicarb see P069
	Aldifen see P048

—Continued

Hazardous waste No.	Substance [1]
P004	Aldrin
	Algimycin see P092
P005	Allyl alcohol
P006	Aluminum phosphide (R)
	ALVIT see P037
	Aminoethylene see P054
P007	5-(Aminomethyl)-3-isoxazolol
P008	4-Aminopyridine
	Ammonium metavanadate see P119
P009	Ammonium picrate (R)
	ANTIMUCIN WDR see P092
	ANTURAT see P073
	AQUATHOL see P088
	ARETIT see P020
P010	Arsenic acid
P011	Arsenic pentoxide
P012	Arsenic trioxide
	Athrombin see P001
	AVITROL see P008
	Aziridene see P054
	AZOFOS see P061
	Azophos see P061
	BANTU see P072
P013	Barium cyanide
	BASENITE see P020
	BCME see P016
P014	Benzenethiol
	Benzoepin see P050
P015	Beryllium dust
P016	Bis(chloromethyl) ether
	BLADAN-M see P071
P017	Bromoacetone
P018	Brucine
P019	2-Butanone peroxide
	BUFEN see P092
	Butaphene see P020
P020	2-sec-Butyl-4,6-dinitrophenol
P021	Calcium cyanide
	CALDON see P020
P022	Carbon disulfide
	CERESAN see P092
	CERESAN UNIVERSAL see P092
	CHEMOX GENERAL see P020
	CHEMOX P.E. see P020
	CHEM-TOL see P090
P023	Chloroacetaldehyde
P024	p-Chloroaniline
P025	1-(p-Chlorobenzoyl)-5-methoxy-2-methylindole-3-acetic acid
P026	1-(o-Chlorophenyl)thiourea
P027	3-Chloropropionitrile
P028	alpha-Chlorotoluene
P029	Copper cyanide
	CRETOX see P106
	Coumadin see P001
	Coumafen see P001
P030	Cyanides

Hazardous waste No.	Substance [1]
P031	Cyanogen
P032	Cyanogen bromide
P033	Cyanogen chloride
	Cyclodan see P050
P034	2-Cyclohexyl-4,6-dinitrophenol
	D-CON see P001
	DETHMOR see P001
	DETHNEL see P001
	DFP see P043
P035	2,4-Dichlorophenoxyacetic acid (2,4-D)
P036	Dichlorophenylarsine
	Dicyanogen see P031
P037	Dieldrin
	DIELDREX see P037
P038	Diethylarsine
P039	0,0-Diethyl-S-(2-(ethylthio)ethyl)ester of phosphorothioic acid
P040	0,0-Diethyl-0-(2-pyrazinyl)phosphorothioate
P041	0,0-Diethyl phosphoric acid, 0-p-nitrophenyl ester
P042	3,4-Dihydroxy-alpha-(methylamino)-methyl benzyl alcohol
P043	Di-isopropylfluorophosphate
	DIMETATE see P044
	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro endo, endo see P060
P044	Dimethoate
P045	3,3-Dimethyl-1-(methylthio)-2-butanone-O-[(methylamino)carbonyl] oxime
P046	alpha,alpha-Dimethylphenethylamine
	Dinitrocyclohexylphenol see P034
P047	4,6-Dinitro-o-cresol and salts
P048	2,4-Dinitrophenol
	DINOSEB see P020
	DINOSEBE see P020
	Disulfoton see P039
P049	2,4-Dithiobiuret
	DNBP see P020
	DOLCO MOUSE CEREAL see P108
	DOW GENERAL see P020
	DOW GENERAL WEED KILLER see P020
	DOW SELECTIVE WEED KILLER see P020
	DOWICIDE G see P090
	DYANACIDE see P092
	EASTERN STATES DUOCIDE see P001
	ELGETOL see P020
P050	Endosulfan
P051	Endrin
	Epinephrine see P042
P052	Ethylcyanide
P053	Ethylenediamine
P054	Ethyleneimine
	FASCO FASCRAT POWDER see P001
	FEMMA see P091
P055	Ferric cyanide
P056	Fluorine
P057	2-Fluoroacetamide
P058	Fluoroacetic acid, sodium salt
	FOLODOL-80 see P071
	FOLODOL M see P071
	FOSFERNO M 50 see P071
	FRATOL see P058
	Fulminate of mercury see P065
	FUNGITOX OR see P092
	FUSSOF see P057
	GALLOTOX see P092
	GEARPHOS see P071
	GERUTOX see P020
P059	Heptachlor
P060	1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-endo, endo-dimethanonaphthalene
	1,4,5,6,7,7-Hexachloro-cyclic-5-norbornene-2,3-dimethanol sulfite see P050
P061	Hexachloropropene
P062	Hexaethyl tetraphosphate
	HOSTAQUICK see P092
	HOSTAQUIK see P092
	Hydrazomethane see P068
P063	Hydrocyanic acid
	ILLOXOL see P037
	INDOCI see P025
	Indomethacin see P025
	INSECTOPHENE see P050
	Isodrin see P060
P064	Isocyanic acid, methyl ester
	KILOSEB see P020
	KOP-THIODAN see P050
	KWIK-KIL see P108
	KWIKSAN see P092
	KUMADER see P001
	KYPFARIN see P001
	LEYTOSAN see P092
	LIQUIPHENE see P092
	MALIK see P050
	MAREVAN see P001
	MAR-FRIN see P001
	MARTIN'D MAR-FRIN see P001
	MAVERAN see P001
	MEGATOX see P005
P065	Mercury fulminate
	MERSOLITE see P092
	METACID 50 see P071
	METAFOS see P071
	METAPHOR see P071
	METAPHOS see P071
	METASOL 30 see P092
P066	Methomyl
P067	2-Methylaziridine
	METHYL-E 605 see P071
P068	Methyl hydrazine
	Methyl isocyanate see P064
P069	2-Methyllactonitrile
P070	2-Methyl-2-(methylthio)propionaldehyde-o-(methylcarbonyl) oxime
	METHYL NIRON see P042
P071	Methyl parathion
	METRON see P071
	MOLE DEATH see P108
	MOUSE-NOTS see P108
	MOUSE-RID see P108
	MOUSE-TOX see P108
	MUSCIMOL see P007
P072	1-Naphthyl-2-thiourea
P073	Nickel carbonyl
P074	Nickel cyanide
P075	Nicotine and salts
P076	Nitric oxide
P077	p-Nitroaniline
P078	Nitrogen dioxide
P079	Nitrogen peroxide
P080	Nitrogen tetroxide
P081	Nitroglycerine (R)
P082	N-Nitrosodimethylamine
P083	N-Nitrosodiphenylamine
P084	N-Nitrosomethylvinylamine
	NYLMERATE see P092
	OCTALOX see P037
P085	Octamethylpyrophosphoramide
	OCTAN see P092
P086	Oleyl alcohol condensed with 2 moles ethylene oxide
	OMPA see P085
	OMPACIDE see P085
	OMPAX see P085
P087	Osmium tetroxide
P088	7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid
	PANIVARFIN see P001
	PANORAM D-31 see P037
	PANTHERINE see P007
	PANWARFIN see P001
P089	Parathion
	PCP see P090
	PENNCAP-M see P071
	PENOXYL CARBON N see P048
P090	Pentachlorophenol
	Pentachlorophenate see P090
	PENTA-KILL see P090
	PENTASOL see P090
	PENWAR see P090
	PERMICIDE see P090
	PERMAGUARD see P090
	PERMATOX see P090
	PERMITE see P090
	PERTOX see P090
	PESTOX III see P085
	PHENMAD see P092
	PHENOTAN see P020
P091	Phenyl dichloroarsine
	Phenyl mercaptan see P014
P092	Phenylmercury acetate
P093	N-Phenylthiourea
	PHILIPS 1861 see P008
	PHIX see P092
P094	Phorate
P095	Phosgene
P096	Phosphine
P097	Phosphorothioic acid, 0,0-dimethyl ester, 0-ester with N,N-dimethyl benzene sulfonamide
	Phosphorothioic acid 0,0-dimethyl-0-(p-nitrophenyl) ester see P071
	PIED PIPER MOUSE SEED see P108
P098	Potassium cyanide
P099	Potassium silver cyanide
	PREMERGE see P020
P100	1,2-Propanediol
	Propargyl alcohol see P102
P101	Propionitrile
P102	2-Propyn-1-ol
	PROTHROMADIN See P001
	QUICKSAM see P092
	QUINTOX see P037
	RAT AND MICE BAIT see P001
	RAT-A-WAY see P001
	RAT-B-GON see P001
	RAT-O-CIDE #2 see P001
	RAT-GUARD see P001
	RAT-KILL see P001
	RAT-MIX see P001
	RATS-NO-MORE see P001
	RAT-OLA see P001
	RATOREX see P001
	RATTUNAL see P001
	RAT-TROL see P001
	RO-DETH see P001
	RO-DEX see P108
	ROSEX see P001
	ROUGH & READY MOUSE MIX see P001
	SANASEED see P108
	SANTOBRITE see P090
	SANTOPHEN see P090
	SANTOPHEN 20 see P090
	SCHRADAN see P085
P103	Selenourea
P104	Silver Cyanide
	SMITE see P105
	SPARIC see P020
	SPOR-KIL see P092
	SPRAY-TROL BRAND RODEN-TROL see P001
	SPURGE see P020
P105	Sodium azide
	Sodium coumadin see P001
P106	Sodium cyanide
	Sodium fluoroacetate see P056
	SODIUM WARFARIN see P001
	SOLFARIN see P001
	SOLFOBLACK BB see P048
	SOLFOBLACK SB see P048
P107	Strontium sulfide
P108	Strychnine and salts
	SUBTEX see P020
	SYSTAM see P085
	TAG FUNGICIDE see P092
	TEKWAISA see P071
	TEMIC see P070
	TEMIK see P070
	TERM-I-TROL see P090
P109	Tetraethyldithiopyrophosphate
P110	Tetraethyl lead
P111	Tetraethylpyrophosphate
P112	Tetranitromethane
	Tetraphosphoric acid, hexaethyl ester see P062
	TETROSULFUR BLACK PB see P048
	TETROSULPHUR PBR see P048
P113	Thallic oxide
	Thallium peroxide see P113
P114	Thallium selenite
P115	Thallium (I) sulfate
	THIFOR see P092
	THIMUL see P092
	THIODAN see P050
	THIOFOR see P050
	THIOMUL see P050
	THIONEX see P050
	THIOPHENIT see P071
P116	Thiosemicarbazide
	Thiosulfan tionel see P050
P117	Thiuram
	THOMPSON'S WOOD FIX see P090
	TIOVEL see P050
P118	Trichloromethanethiol
	TWIN LIGHT RAT AWAY see P001
	USAF RH-8 see P069
	USAF EK-4890 see P002
P119	Vanadic acid, ammonium salt
P120	Vanadium pentoxide
	VOFATOX see P071
	WANADU see P120
	WARCOUMIN see P001
	WARFARIN SODIUM see P001
	WARFICIDE see P001
	WOFOTOX see P072
	YANOCK see P057
	YASOKNOCK see P058
	ZIARNIK see P092
P121	Zinc cyanide
P122	Zinc phosphide (R,T)
	ZOOCOUMARIN see P001

[1] The Agency included those trade names of which it was aware; an omission of a trade name does not imply that the omitted material is not hazardous. The material is hazardous if it is listed under its generic name.

(f) The commercial chemical products or manufacturing chemical intermediates, referred to in paragraphs (a), (b) and (d) of this section, are identified as toxic wastes (T) unless otherwise designated and are subject to the small quantity exclusion defined in § 261.5 (a) and (b). These wastes and their corresponding EPA Hazardous Waste Numbers are:

Hazardous Waste No.	Substance[1]
	AAF see U005
U001	Acetaldehyde
U002	Acetone (I)
U003	Acetonitrile (I,T)
U004	Acetophenone
U005	2-Acetylaminoflourene
U006	Acetyl chloride (C,T)
U007	Acrylamide
	Acetylene tetrachloride see U209
	Acetylene trichloride see U228
U008	Acrylic acid (I)
U009	Acrylonitrile
	AEROTHENE TT see U226
	3-Amino-5-(p-acetamidophenyl)-1H-1,2,4-triazole, hydrate see U011
U010	6-Amino-1,1a,2,8,8a,8b-hexahydro-8-(hydroxymethyl)8-methoxy-5-methyicarbamate azirino(2',3':3,4) pyrrolo(1,2-a) indole-4, 7-dione (ester)
U011	Amitrole
U012	Aniline (I)
U013	Asbestos
U014	Auramine
U015	Azaserine
U016	Benz[c]acridine
U017	Benzal chloride
U018	Benz[a]anthracene
U019	Benzene
U020	Benzenesulfonyl chloride (C,R)
U021	Benzidine
	1,2-Benzisothiazolin-3-one, 1,1-dioxide see U202
	Benzo[a]anthracene see U018
U022	Benzo[a]pyrene
U023	Benzotrichloride (C,R,T)
U024	Bis(2-chloroethoxy)methane
U025	Bis(2-chloroethyl) ether
U026	N,N-Bis(2-chloroethyl)-2-naphthylamine
U027	Bis(2-chloroisopropyl) ether
U028	Bis(2-ethylhexyl) phthalate
U029	Bromomethane
U030	4-Bromophenyl phenyl ether
U031	n-Butyl alcohol (I)
U032	Calcium chromate
	Carbolic acid see U188
	Carbon tetrachloride see U211
U033	Carbonyl fluoride
U034	Chloral
U035	Chlorambucil
U036	Chlordane
U037	Chlorobenzene
U038	Chlorobenzilate
U039	p-Chloro-m-cresol
U040	Chlorodibromomethane
U041	1-Chloro-2,3-epoxypropane
	CHLOROETHENE NU see U226
U042	Chloroethyl vinyl ether
U043	Chloroethene
U044	Chloroform (I,T)
U045	Chloromethane (I,T)
U046	Chloromethyl methyl ether
U047	2-Chloronaphthalene
U048	2-Chlorophenol
U049	4-Chloro-o-toluidine hydrochloride
U050	Chrysene
	C.I. 23060 see U073
U051	Cresote
U052	Cresols
U053	Crotonaldehyde
U054	Cresylic acid
U055	Cumene
	Cyanomethane see U003
U056	Cyclohexane (I)
U057	Cyclohexanone (I)
U058	Cyclophosphamide
U059	Daunomycin
U060	DDD
U061	DDT
U062	Diallate
U063	Dibenz[a,h]anthracene
	Dibenzo[a,h]anthracene see U063
U064	Dibenzo[a,i]pyrene
U065	Dibromochloromethane
U066	1,2-Dibromo-3-chloropropane
U067	1,2-Dibromoethane
U068	Dibromomethane
U069	Di-n-butyl phthalate
U070	1,2-Dichlorobenzene
U071	1,3-Dichlorobenzene
U072	1,4-Dichlorobenzene
U073	3,3'-Dichlorobenzidine
U074	1,4-Dichloro-2-butene
	3,3'-Dichloro-4,4'-diaminobiphenyl see U073
U075	Dichlorodifluoromethane
U076	1,1-Dichloroethane
U077	1,2-Dichloroethane
U078	1,1-Dichloroethylene
U079	1,2-trans-dichloroethylene
U080	Dichloromethane
	Dichloromethylbenzene see U017
U081	2,4-Dichlorophenol
U082	2,6-Dichlorophenol
U083	1,2-Dichloropropane
U084	1,3-Dichloropropene
U085	Diepoxybutane (I,T)
U086	1,2-Diethylhydrazine
U087	0,0-Diethyl-S-methyl ester of phosphorodithioic acid
U088	Diethyl phthalate
U089	Diethylstilbestrol
U090	Dihydrosafrole
U091	3,3'-Dimethoxybenzidine
U092	Dimethylamine (I)
U093	p-Dimethylaminoazobenzene
U094	7,12-Dimethylbenz[a]anthracene
U095	3,3'-Dimethylbenzidine
U096	alpha,alpha-Dimethylbenzylhydroperoxide (R)
U097	Dimethylcarbamoyl chloride
U098	1,1-Dimethylhydrazine
U099	1,2-Dimethylhydrazine
U100	Dimethylnitrosoamine
U101	2,4-Dimethylphenol
U102	Dimethyl phthalate
U103	Dimethyl sulfate
U104	2,4-Dinitrophenol
U105	2,4-Dinitrotoluene
U106	2,6-Dinitrotoluene
U107	Di-n-octyl phthalate
U108	1,4-Dioxane
U109	1,2-Diphenylhydrazine
U110	Dipropylamine (I)
U111	Di-n-propylnitrosamine
	EBDC see U114
	1,4-Epoxybutane see U213
U112	Ethyl acetate (I)
U113	Ethyl acrylate (I)
U114	Ethylenebisdithiocarbamate
U115	Ethylene oxide (I,T)
U116	Ethylene thiourea
U117	Ethyl ether (I,T)
U118	Ethylmethacrylate
U119	Ethyl methanesulfonate
	Ethylnitrile see U003
	Firemaster T23P see U235
U120	Fluoranthene
U121	Fluorotrichloromethane
U122	Formaldehyde
U123	Formic acid (C,T)
U124	Furan (I)
U125	Furfural (I)
U126	Glycidylaldehyde
U127	Hexachlorobenzene
U128	Hexachlorobutadiene
U129	Hexachlorocyclohexane
U130	Hexachlorocyclopentadiene
U131	Hexachloroethane
U132	Hexachlorophene
U133	Hydrazine (R,T)
U134	Hydrofluoric acid (C,T)
U135	Hydrogen sulfide
	Hydroxybenzene see U188
U136	Hydroxydimethyl arsine oxide
	4,4'-(Imidocarbonyl)bis(N,N-dimethyl)aniline see U014
U137	Indeno(1,2,3-cd)pyrene
U138	Iodomethane
U139	Iron Dextran
U140	Isobutyl alcohol
U141	Isosafrole
U142	Kepone
U143	Lasiocarpine
U144	Lead acetate
U145	Lead phosphate
U146	Lead subacetate
U147	Maleic anhydride
U148	Maleic hydrazide
U149	Malononitrile
	MEK Peroxide see U160
U150	Melphalan
U151	Mercury
U152	Methacrylonitrile
U153	Methanethiol
U154	Methanol
U155	Methapyrilene
	Methyl alcohol see U154
U156	Methyl chlorocarbonate
	Methyl chloroform see U226
U157	3-Methylcholanthrene
	Methyl chloroformate see U156
U158	4,4'-Methylene-bis-(2-chloroaniline)
U159	Methyl ethyl ketone (MEK) (I,T)
U160	Methyl ethyl ketone peroxide (R)
	Methyl iodide see U138
U161	Methyl isobutyl ketore
U162	Methyl methacrylate (R,T)
U163	N-Methyl-N'-nitro-N-nitrosoguanidine
U164	Methylthiouracil
	Mitomycin C see U010
U165	Naphthalene
U166	1,4-Naphthoquinone
U167	1-Naphthylamine
U168	2-Naphthylamine
U169	Nitrobenzene (I,T)
	Nitrobenzol see U169
U170	4-Nitrophenol
U171	2-Nitropropane (I)
U172	N-Nitrosodi-n-butylamine
U173	N-Nitrosodiethanolamine
U174	N-Nitrosodiethylamine
U175	N-Nitrosodi-n-propylamine
U176	N-Nitroso-n-ethylurea
U177	N-Nitroso-n-methylurea
U178	N-Nitroso-n-methylurethane
U179	N-Nitrosopiperidine
U180	N-Nitrosopyrrolidine
U181	5-Nitro-o-toluidine
U182	Paraldehyde
	PCNB see U185
U183	Pentachlorobenzene
U184	Pentachloroethane
U185	Pentachloronitrobenzene
U186	1,3-Pentadiene (I)
	Perc see U210
	Perchlorethylene see U210
U187	Phenacetin
U188	Phenol
U189	Phosphorous sulfide (R)
U190	Phthalic anhydride
U191	2-Picoline
U192	Pronamide
U193	1,3-Propane sultone
U194	n-Propylamine (I)
U196	Pyridine
U197	Quinones
U200	Reserpine
U201	Resorcinol
U202	Saccharin
U203	Safrole
U204	Selenious acid
U205	Selenium sulfide (R,T)
	Silvex see U233
U206	Streptozotocin
	2,4,5-T see U232
U207	1,2,4,5-Tetrachlorobenzene
U208	1,1,1,2-Tetrachloroethane
U209	1,1,2,2-Tetrachloroethane
U210	Tetrachloroethene
	Tetrachloroethylene see U210
U211	Tetrachloromethane
U212	2,3,4,6-Tetrachlorophenol
U213	Tetrahydrofuran (I)
U214	Thallium (I) acetate
U215	Thallium (I) carbonate
U216	Thallium (I) chloride
U217	Thallium (I) nitrate
U218	Thioacetamide
U219	Thiourea
U220	Toluene
U221	Toluenediamine
U222	o-Toluidine hydrochloride

Hazardous Waste No.	Substance[1]
U223	Toluene diisocyanate
U224	Toxaphene
	2,4,5-TP see U233
U225	Tribromomethane
U226	1,1,1-Trichloroethane
U227	1,1,2-Trichloroethane
U228	Trichloroethene
	Trichloroethylene see U228
U229	Trichlorofluoromethane
U230	2,4,5-Trichlorophenol
U231	2,4,6-Trichlorophenol
U232	2,4,5-Trichlorophenoxyacetic acid
U233	2,4,5-Trichlorophenoxypropionic acid alpha, alpha, alpha- Trichlorotoluene see U023
	TRI-CLENE see U228
U234	Trinitrobenzene (R,T)
U235	Tris(2,3-dibromopropyl) phosphate
U236	Trypan blue
U237	Uracil mustard
U238	Urethane
	Vinyl chloride see U043
	Vinylidene chloride see U078
U239	Xylene

[1] The Agency included those trade names of which it was aware; an omission of a trade name does not imply that it is not hazardous. The material is hazardous if it is listed under its generic name.

Appendix I—Representative Sampling Methods

The methods and equipment used for sampling waste materials will vary with the form and consistency of the waste materials to be sampled. Samples collected using the sampling protocols listed below, for sampling waste with properties similar to the indicated materials, will be considered by the Agency to be representative of the waste.

Extremely viscous liquid—ASTM Standard D140–70 Crushed or powdered material—ASTM Standard D346–75 Soil or rock-like material—ASTM Standard D420–69 Soil-like material—ASTM Standard D1452–65

Fly Ash-like material—ASTM Standard D2234–76 [ASTM Standards are available from ASTM, 1916 Race St., Philadelphia, PA 19103]

Containerized liquid wastes—"COLIWASA" described in "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods," [1] U.S. Environmental Protection Agency, Office of Solid Waste, Washington, D.C. 20460. [Copies may be obtained from Solid Waste Information, U.S. Environmental Protection Agency, 26 W. St. Clair St., Cincinnati, Ohio 45268]

Liquid waste in pits, ponds, lagoons, and similar reservoirs.—"Pond Sampler" described in "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods." [1]

This manual also contains additional information on application of these protocols.

[1] These methods are also described in "Samplers and Sampling Procedures for Hazardous Waste Streams," EPA 600/2–80–018, January 1980.

Appendix II— EP Toxicity Test Procedure

A. Extraction Procedure (EP)

1. A representative sample of the waste to be tested (minimum size 100 grams) should be obtained using the methods specified in Appendix I or any other methods capable of yielding a representative sample within the meaning of Part 260. [For detailed guidance on conducting the various aspects of the EP see "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods," SW–846, U.S. Environmental Protection Agency Office of Solid Waste, Washington, D.C. 20460. [1]]

2. The sample should be separated into its component liquid and solid phases using the method described in "Separation Procedure" below. If the solid residue [2] obtained using this method totals less than 0.5% of the original weight of the waste, the residue can be discarded and the operator should treat the liquid phase as the extract and proceed immediately to Step 8.

3. The solid material obtained from the Separation Procedure should be evaluated for its particle size. If the solid material has a surface area per gram of material equal to, or greater than, 3.1 cm^2 or passes through a 9.5 mm (0.375 inch) standard sieve, the operator should proceed to Step 4. If the surface area is smaller or the particle size larger than specified above, the solid material should be prepared for extraction by crushing, cutting or grinding the material so that it passes through a 9.5 mm (0.375 inch) sieve or, if the material is in a single piece, by subjecting the material to the "Structural Integrity Procedure" described below.

4. The solid material obtained in Step 3 should be weighed and placed in an extractor with 16 times its weight of deionized water. Do not allow the material to dry prior to weighing. For purposes of this test, an acceptable extractor is one which will impart sufficient agitation to the mixture to not only prevent stratification of the sample and extraction fluid but also insure that all sample surfaces are continously brought into contact with well mixed extraction fluid.

[1] Copies may be obtained from Solid Waste Information, U.S. Environmental Protection Agency, 26 W. St. Clair Street, Cincinnati, Ohio 45268.

[2] The percent solids is determined by drying the filter pad at 80° C until it reaches constant weight and then calculating the percent solids using the following equation:

$$\frac{(\text{weight of pad + solid}) - (\text{tare weight of pad})}{\text{initial weight of sample}} \times 100 = \%\ \text{solids}$$

5. After the solid material and deionized water are placed in the extractor, the operator should begin agitation and measure the pH of the solution in the extractor. If the pH is greater than 5.0, the pH of the solution should be decreased to 5.0 ± 0.2 by adding 0.5 N acetic acid. If the pH is equal to or less than 5.0, no acetic acid should be added. The pH of the solution should be monitored, as described below, during the course of the extraction and if the pH rises above 5.2, 0.5N acetic acid should be added to bring the pH down to 5.0 ± 0.2. However, in no event shall the aggregate amount of acid added to the solution exceed 4 ml of acid per gram of solid. The mixture should be agitated for 24 hours and maintained at 20°–40° C (68°–104° F) during this time. It is recommended that the operator monitor and adjust the pH during the course of the extraction with a device such as the Type 45–A pH Controller manufactured by Chemtrix, Inc., Hillsboro, Oregon 97123 or its equivalent, in conjunction with a metering pump and reservoir of 0.5N acetic acid. If such a system is not available, the following manual procedure shall be employed:

(a) A pH meter should be calibrated in accordance with the manufacturer's specifications.

(b) The pH of the solution should be checked and, if necessary, 0.5N acetic acid should be manually added to the extractor until the pH reaches 5.0 ± 0.2. The pH of the solution should be adjusted at 15, 30 and 60 minute intervals, moving to the next longer interval if the pH does not have to be adjusted more than 0.5N pH units.

(c) The adjustment procedure should be continued for at least 6 hours.

(d) If at the end of the 24-hour extraction period, the pH of the solution is not below 5.2 and the maximum amount of acid (4 ml per gram of solids) has not been added, the pH should be adjusted to 5.0 ± 0.2 and the extraction continued for an additional four hours, during which the pH should be adjusted at one hour intervals.

6. At the end of the 24 hour extraction period, deionized water should be added to the extractor in an amount determined by the following equation:

$V = (20)(W) - 16(W) - A$

V = ml deionized water to be added

W = weight in grams of solid charged to extractor

A = ml of 0.5N acetic acid added during extraction.

7. The material in the extractor should be separated into its component liquid and solid phases as described under "Separation Procedure."

8. The liquids resulting from Steps 2 and 7 should be combined. This

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