

## CHAPTER II

### MANAGEMENT OF SOLID WASTES

#### 2.1 Energy Center Waste Classification

An inventory of the laboratory chemicals and general process wastes generated by the research activities at the Pittsburgh Energy Technology Center was conducted during Fiscal Year 1977. (2) As a result of that survey, the laboratory chemical wastes, solvents, dusts, sludges and slag reported are listed in tabular form in Table 2-1. Although the quantities reported may have been as low as twenty milliliters, we have included all substances found in order to develop a comprehensive listing. Quantities of the specific waste categories that are generated at the facility will have great influence on the optimal methodology to be used for the transport and disposal of the residues. In order to provide the proper perspective, Table 2-2 lists the waste streams (and volumes) in the order of volumes generated.

Table 2-1 is based on statutory definitions proposed by the regulations now being promulgated by the U.S. Environmental Protection Agency. Upon determination or assignment of the probable hazard class (using handbook data) of the residues, a suggested processing and/or disposal technique is indicated. The management alternatives are selected on the basis of the waste parameters and the system which will be approved by the cognizant enforcement authorities. Some laboratory chemical wastes exhibit more than one hazardous feature and (in this instance) a judgement was made to select the processing or disposal method most suitable for the multiple hazards.

| WASTE SUBSTANCE                        | I<br>Ignit. | R<br>React. | C<br>Corros. | T<br>Toxic.<br>Heavy Me. | H<br>Mutag. | B<br>Bioacc. | O<br>Toxic,<br>Fraction | Pretreat | Inciner. | Land<br>Disposal | Remarks   |
|--|-------------|-------------|--------------|--------------------------|-------------|--------------|-------------------------|----------|----------|------------------|---|
| Acetone, $CH_3COCH_3$                  | X           | - *         | -            | -                        | -           | -            | -                       |          | X        |                  |   |
| Acetonitrile (nitrile)                 | X           | X *         | -            | -                        | ?           | -            | X                       | X        |          |                  | LD <sub>50</sub> = .2 mg/l ELIMINATE!!!         |
| Alcohol, Ethyl $CH_3CH_2OH$            | X           | - *         | -            | -                        | -           | -            | -                       |          | X        |                  |   |
| Alcohol, Methyl $CH_3OH$               | X           | - *         | -            | -                        | -           | -            | -                       |          | X        |                  |   |
| Alcohol, Isopropyl                     | X           | - *         | -            | -                        | -           | -            | -                       |          | X        |                  |   |
| Alumina $Al_2O_3$                      | -           | -           | -            | -                        | -           | -            | -                       |          |          | X                | May be carcinogenic inhaled                     |
| Aluminum Sulfate (Alum) $Al_2(SO_4)_3$ | -           | -           | X (wet)      | -                        | -           | -            | -                       |          |          | X                | Untaminated (no organics)                       |
| Ammonium Hydroxide $NH_4OH$            | -           | X           | X (wet)      | X                        | -           | -            | -                       | X        |          | X                | Neutralize if necessary                         |
| Ammonium Sulfide $(NH_4)_2S$           | -           | X *         | X (wet)      | X                        | -           | -            | X                       | X        |          | X                | On DOT Poison List                              |
| Benzene $C_6H_6$                       | X           | -           | -            | -                        | ?           | -            | X                       |          | X        |                  |   |
| Benzene Thiol (Thiophenol) $C_6H_5SH$  | -           | -           | -            | -                        | -           | -            | X                       | X        | X        |                  | Human LD <sub>50</sub> = 2.6 mg/l Potent Poison |
| 2-Benzyl-                              |             |             |              |                          | X           | ?            | X                       |          | X        |                  |   |
| Benzyl-isothiourea Hydrochloride       | -           | -           | -            | -                        | X           | ?            | X                       | X        |          | X                | LD <sub>50</sub> = 8.4 mg/l POISON              |
| Benzyl Mercaptan (Alpha toluenethiol)  | -           | - *         | -            | -                        | -           | ?            | X                       |          | X        |                  |   |
| Boric Acid                             | -           | -           | -            | -                        | -           | -            | -                       |          |          | X                |   |
| Butyl Chloride (1 Chlorobutane)        | X           | X *         | -            | L                        | -           | -            | X                       | X        |          | X                | Will release chloring-burned                    |
| 1-Butane Thiol (n Butyl-mercaptan)     | X           | X *         | -            | -                        | Y           | -            | X                       | X        | X        |                  |   |
| Cadmium Sulfide                        | -           | - *         | -            | -                        | -           | -            | -                       | X        |          | X                |   |
| Calcium Carbonate $CaCO_3$             | -           | -           | -            | -                        | -           | -            | -                       |          |          | X                |   |
| Calcium Chloride $CaCl_2$              | -           | -           | -            | -                        | -           | -            | -                       |          |          | X                |   |
| Calcium Hydroxide (lime) $CaOH$        | -           | -           | X (wet)      | -                        | -           | -            | -                       |          |          | X                |   |
| Carbon, Spent Activated                | -           | -           | -            | -                        | -           | -            | ?                       | ?        |          | X                | Depends on contaminant                          |
| Carbon Disulfide                       | X           | -           | -            | X                        | ?           | -            | -                       | X        |          | X                | Releases toxic fume on burn.                    |
| Carbon Tetrachloride                   | -           | - *         | -            | +                        | X           | ?            | -                       | X        |          | X                | On Controlled Substance List                    |
| Chloroform                             | -           | -           | -            | -                        | -           | -            | X                       | X        |          | X                |   |
| Coal Dust                              | -           | -           | -            | ?                        | ?           | ?            | ?                       |          | X        | X                | Insufficient Data                               |
| Coal/oil/Catalyst Mix                  |             |             |              | ?                        | ?           | ?            | ?                       |          | X        |                  | Insufficient Data                               |
| Coal/Oil/Surfactant Slurry             | -           | -           | ?            | ?                        | ?           | ?            | ?                       |          | X        |                  | Insufficient Data                               |
| Coal Derived Liquids                   | ?           | ?           | ?            | ?                        | ?           | ?            | ?                       |          | X        |                  | Insufficient Data                               |
| Cyclohexane                            | X           | - *         | -            | -                        | -           | -            | -                       |          | X        |                  |   |

Table 2-1 PETC Laboratory Waste Listing, Hazardous Classifications and Recommended Disposal Methodology.

| WASTE SUBSTANCE                                  | I<br>Ignit. | R<br>React. | C<br>Corros. | T<br>Tox.<br>Heavy.Met. | H<br>Mutag. | B<br>Bioacc. | O<br>Toxic<br>Org. Fr. | Pretreat | Inciner. | Land<br>Disposal | Remarks                                  |
|--|-------------|-------------|--------------|-------------------------|-------------|--------------|------------------------|----------|----------|------------------|--|
| Dicahydronaphthalene (Decalin)                   | -           | - *         | -            | -                       | -           | ?            | X                      |          |          | X                |  |
| Dichloromethane (methylene chlor.)               | -           | - *         | -            | -                       | -           | -            | X                      |          |          | X                |  |
| Dicyclopentadiene                                | -           | - *         | -            | -                       | -           | -            | X                      |          |          | X                |  |
| Dimethylene Triamine                             | -           | - *         | -            | -                       | -           | ?            | X                      | X        |          |                  | LD <sub>50</sub> = .04 mg/l ELIMINATE!!! |
| Dimethylgloxime                                  | -           | -           | -            | -                       | -           | ?            | X                      |          |          | X                |  |
| Ethanol (Grain Alcohol)                          | X           | - *         | -            | -                       | -           | -            | -                      |          | X        |                  |  |
| Ether, Petroleum (See Benzene)                   | X           | X           | -            | -                       | -           | -            | -                      |          | X        |                  |  |
| Ethyl Acetate                                    | X           | - *         | -            | -                       | -           | -            | -                      |          | X        |                  |  |
|  |             |             |              |                         |             |              |                        |          |          |                  |  |
| Ferric Chloride FeCl <sub>3</sub>                | -           | X           | X            | -                       | -           | -            | -                      |          |          | X                |  |
| Ferric Nitrate Fe(NO <sub>3</sub> ) <sub>3</sub> | -           | X *         | X            | -                       | -           | -            | -                      |          |          | I                |  |
| Fluorocarbon (Chloropenta Fluoroethane)          | -           | -           | -            | -                       | -           | ?            | -                      |          |          | I                |  |
| Formaldehyde (Formalin)                          | -           | -           | -            | -                       | -           | -            | X                      |          |          | I                |  |
| Freon TF   | -           | -           | -            | -                       | -           | -            | -                      |          |          | I                |  |
| 1-Heptane Thiol                                  | X           | X *         | -            | -                       | -           | -            | -                      |          | X        |                  | Reactive. Caution in handling.           |
| Heptadecanol                                     | -           | -           | -            | -                       | -           | -            | -                      |          |          | I                |  |
| Heptane (Heptyl Hydride)                         | X           | -           | -            | -                       | -           | -            | -                      |          | X        |                  |  |
| 2,4-Hexadienal                                   | -           | -           | -            | -                       | -           | ?            | X                      |          |          | I                |  |
| Hexane (Hexyl Hydride)                           | X           | - *         | -            | -                       | -           | -            | -                      |          | X        |                  |  |
| Hydrochloric Acid                                | -           | -           | X            | -                       | -           | -            | -                      | X        |          | I                |  |
| Hydrofluoric Acid                                | *           | -           | X            | -                       | -           | -            | -                      | X        |          | I                |  |
|  |             |             |              |                         |             |              |                        |          |          |                  |  |
| Isooctane(2-methyl heptane)                      | X           | - *         | -            | -                       | -           | -            | -                      |          | X        |                  |  |
|  |             |             |              |                         |             |              |                        |          |          |                  |  |
| Kerosene (Ultrasene)                             | -           | -           | -            | -                       | -           | -            | -                      |          | X        |                  |  |
|  |             |             |              |                         |             |              |                        |          |          |                  |  |
| Lithium Alumhydride (in ether)                   | X           | X           | X            | ?                       | -           | -            | -                      |          | X        |                  | Use Caution in Burning                   |
| Lithium Borohydride                              | X           | X           | X            | ?                       | -           | -            | -                      |          | X        |                  | Use Caution in Burning                   |
|  |             |             |              |                         |             |              |                        |          |          |                  |  |
| Magnesium Chloride                               | -           | -           | -            | -                       | -           | -            | -                      |          |          | X                |  |
| Mercuric Sulfide                                 | -           | -           | -            | ?                       | -           | -            | -                      | X        |          | X                |  |
| Methanol   | -           | -           | -            | -                       | -           | -            | X                      |          |          | X                |  |

Table 2-1 Facility Waste Listing, Hazardous Classifications and Recommended Disposal Methodology (continued)

| WASTE SUBSTANCE   | I<br>Ignit. | R<br>React. | C<br>Corros. | T<br>Toxic<br>(Inq. Mat.) | H<br>Mutag. | B<br>Bioacc. | O<br>Toxic<br>Org. Fr. | Pretreat | Inciner. | Land<br>Disposal | Remarks                        |
|---|-------------|-------------|--------------|---------------------------|-------------|--------------|------------------------|----------|----------|------------------|--------------------------------|
| 1-methyl naphthalene C <sub>10</sub> H <sub>7</sub> CH <sub>3</sub> | -           | -           | -            | -                         | -           | ?            | -                      |          |          | X                |                                |
| Methylene Chloride (Dichloromethylene)                              | -           | - *         | -            | -                         | ?           | -            | X                      | X        |          | X                | On EPA Priority Chemicals list |
| n-Butyl Chloride (carbinyl)   | X           | - *         | -            | -                         | -           | -            | X                      |          | X        |                  |                                |
| n-Capric acid (decanoic acid)                                       | -           | - *         | -            | -                         | -           | -            | -                      |          |          | X                | Odorous                        |
| n-Butyl Amine (1-aminobutane)                                       | X           | - *         | -            | -                         | ?           | ?            | X                      |          | X        |                  |                                |
| Nitric Acid   | -           | -           | X            | -                         | -           | -            | -                      | X        |          | X                | Neutralize                     |
| Nitromethane  | -           | X *         | -            | -                         | -           | ?            | -                      | X        |          | X                | Highly Reactive-Segregate      |
| Oil, Compressor   | -           | -           | -            | -                         | ?           | ?            | ?                      |          | X        |                  | By Statute-Oils are hazardous  |
| Oil, Fuel   | -           | -           | -            | -                         | ?           | ?            | ?                      |          | X        |                  | See Above. Impurities toxic    |
| Oil, Pina   | -           | -           | -            | -                         | -           | -            | -                      |          |          | X                | Non-petro. base not included   |
| Oil, Pump   | -           | -           | -            | -                         | ?           | ?            | ?                      |          | X        |                  | Hazar. by Statute              |
| Oil (C <sub>5</sub> -C <sub>31</sub> )                              | -           | -           | -            | -                         | ?           | ?            | ?                      |          | X        |                  | See Above                      |
| Oil and Tar   | -           | -           | -            | -                         | ?           | ?            | ?                      |          | X        |                  | See Above                      |
| Octane  | X           | X *         | -            | -                         | -           | -            | -                      |          | X        |                  |                                |
| p-Chlorothiophenol (Chlor. Phenol)                                  | -           | X(fumes)    | -            | -                         | -           | -            | X                      |          |          | X                |                                |
| Pentane   | X           | X(heated)   | -            | -                         | -           | -            | -                      |          | X        |                  |                                |
| Perchloric Acid   | -           | X           | X            | -                         | -           | -            | -                      |          |          | X                | Segregate-Oxydizer             |
| Phenol C <sub>6</sub> H <sub>5</sub> OH                             | -           | X *         | -            | -                         | -           | -            | X                      | X        |          | X                | On DOT Poison B List           |
| Phenyl 2-thionyl Ketone   | -           | X(heated)   | -            | -                         | -           | -            | X                      | X        |          | X                | Potent Poison                  |
| Phenothiazene C <sub>12</sub> H <sub>9</sub> NS                     | -           | X *         | -            | -                         | -           | -            | X                      | X        |          | X                |                                |
| Phosphoric Acid   | -           | X(heated)   | X            | -                         | -           | -            | -                      | X        |          | X                | Neutralize                     |
| Phosphorous Pentoxide   | -           | X           | X            | -                         | -           | -            | -                      | X        |          | X                | Neutralize                     |
| Potassium Chloride  | -           | -           | -            | -                         | -           | -            | -                      |          |          | X                |                                |
| 2-Propanol (Propyl Alcohol)   | X           | -           | -            | -                         | -           | -            | -                      |          | X        |                  |                                |
| Pyridene  | X           | X           | -            | -                         | -           | -            | X                      |          | X        |                  |                                |
| 2-Pentanol (methyl propyl carbinol)                                 | -           | X *         | -            | -                         | ?           | ?            | X                      | X        |          | X                |                                |
| Quinoline   | -           | X(heated)   | -            | -                         | -           | -            | X                      | X        |          | X                |                                |
| Sodium, Metal   | -           | X           | -            | -                         | -           | -            | -                      | X        |          | X                | Highly reactive in water       |

Table 2-1 Facility Waste Listing, Hazardous Classifications and Recommended Disposal Methodology (Continued)

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| WASTE SUBSTANCE  | I<br>Ignit. | R<br>React. | C<br>Corros. | T<br>Toxic<br>Hea. Met | M<br>Mutag. | B<br>Bioacc. | O<br>Toxic<br>Org. Fr. | Pretreat | Inciner. | Land<br>Disposal | Remarks                                 |
|--|-------------|-------------|--------------|------------------------|-------------|--------------|------------------------|----------|----------|------------------|---|
| Sodium Borohydride (Powder) $\text{NaBH}_4$                | -           | X           | -            | ?                      | -           | -            | -                      |          |          | X                |   |
| Sodium Hydroxide   | -           | X           | X            | -                      | -           | -            | -                      | X        |          | X                | Neutralize                              |
| Solvent, HyFlash   | X           | ?           | -            | -                      | ?           | ?            | ?                      |          | X        |                  | Impurities determine toxicity           |
| Solvent, Degreassol  | X           | -           | -            | -                      | ?           | ?            | ?                      |          | X        |                  | See above                               |
| Solvent, Cleaning Nacy 40                                  | X           | ?           | -            | -                      | ?           | ?            | ?                      |          | X        |                  | See above                               |
| Sulfuric Acid  | -           | -           | X            | -                      | -           | -            | -                      | X        |          | X                | Neutralize                              |
|  |             |             |              |                        |             |              |                        |          |          |                  |   |
| Tetrahydrofuran (ether)                                    | X           | X           | -            | -                      | -           | -            | -                      | X        |          | X                | May form unstable peroxide              |
| Thiobenzanilide  | -           | X *         | -            | -                      | -           | ?            | ?                      |          |          | X                |   |
| Thiocresol   | -           | X *         | -            | -                      | ?           | ?            | ?                      |          |          | X                |   |
| Thiofuran  | X           | X *         | -            | -                      | -           | ?            | -                      |          | X        |                  | Reactive-Care in Burning                |
| Thiophenol (Phenyl mercaptan)                              | -           | X *         | -            | -                      | -           | -            | X                      | X        |          |                  | $\text{LD}_{50}$ =2.6 mg/l ELIMINATE!!! |
| Thioxylene $\text{C}_6\text{H}_5\text{SH}$                 | X           | X *         | -            | -                      | -           | -            | -                      |          | X        |                  |   |
| Toluene (methyl benzene) $\text{C}_6\text{H}_5\text{CH}_3$ | X           | X *         | -            | -                      | -           | -            | X                      |          | X        |                  |   |
| Trans-2-Butene   | X           | X *         | -            | -                      | -           | ?            | X                      |          | X        |                  |   |
| 1-2-4 Trimethylbenzine                                     | -           | -           | -            | -                      | ?           | ?            | -                      |          |          | X                | (pseudodocumene)                        |
| Tri-sodium phosphate                                       | -           | -           | C            | -                      | -           | -            | -                      | X        |          | X                | Neutralize                              |
|  |             |             |              |                        |             |              |                        |          |          |                  |   |
| Iylene   | X           | X *         | -            | -                      | -           | -            | X                      |          | X        |                  |   |
|  |             |             |              |                        |             |              |                        |          |          |                  |   |
| OTHER WASTES   |             |             |              |                        |             |              |                        |          |          | X                |   |
|  |             |             |              |                        |             |              |                        |          |          |                  |   |
| Flyash   | -           | -           | -            | ?                      | ?           | ?            | ?                      |          |          | X                | Depends on the impurities               |
| Slag   | -           | -           | -            | ?                      | ?           | ?            | ?                      |          |          | X                | See Above                               |
| Line Sludge  | -           | -           | -            | ?                      | -           | -            | ?                      |          |          | X                | Depends on impurities                   |
| Coal Conversion Waste Water                                | -           | -           | ?            | ?                      | ?           | ?            | ?                      |          |          | X                | See Above                               |
| Process Char   | -           | -           | -            | ?                      | ?           | ?            | ?                      |          |          | X                | See Above                               |
| Coal Conversion Solid Wastes (Char)                        | -           | -           | -            | ?                      | ?           | ?            | ?                      |          |          | X                | Depends on Impurities                   |
| Liquefaction Residues                                      | ?           | ?           | ?            | ?                      | ?           | ?            | ?                      |          |          | X                | See Above                               |
|  |             |             |              |                        |             |              |                        |          |          |                  |   |
|  |             |             |              |                        |             |              |                        |          |          |                  |   |
|  |             |             |              |                        |             |              |                        |          |          |                  |   |

Table 2-1 Facility Waste Listing, Hazardous Classifications and Recommended Disposal Methodology (Continued)

|   | GALLONS |
|---|---------|
| 1. Oil (lubricating) .....                | 5000    |
| 2. Condensate Water-Untreated .....       | 3000    |
| 3. Coal-Oil Slurries.....                 | 2500    |
| 4. Coal Fines.....                        | 2000    |
| 5. Slag.....                              | 2000    |
| 6. Coal Liquefaction Products.....        | 1950    |
| 7. Flyash and Char.....                   | 1500    |
| 8. Aqueous Solutions (Indeterminate)..... | 750     |
| 9. Oil and Water Emulsions.....           | 600     |
| 10. Organic Laboratory Solvents.....      | 550     |

Note: Mixed Laboratory Chemicals - 2750 gallon capacity (55 gallon drums packaged with absorbents).

Table 2-2 Pittsburgh Energy Technology Center Waste Streams Processed by Disposal Vendors in FY1978. (22)

The inventory conducted at the Pittsburgh Energy Technology Center reported one hundred and seven (107) different residues that could be defined in the hazardous waste perspective. Many of the wastes are generic or generally described materials such as oils, coal/oil/catalyst, solvents, slags, flyash and sludge. Analyses may be necessary to fully characterize these substance for the purpose of rationally choosing a management plan.

A. Ignitable Wastes -Some thirty four (34) of the reported residues exhibit the characteristics which classifies them statutorily as hazardous wastes due to ignitability. Most of the substances are liquid hydrocarbons generally derived from coal chemical processing. Most would be amenable to mixing with each other to enhance the opportunities for bulk handling. There are some solid wastes included in the list, but the volumes generated are quite small and can be packaged or dissolved (with organic waste solvents) to enable agglomeration into bulk quantities.

B. Reactive Residues -Thirty-six of the reported laboratory chemical wastes would be considered reactive under the proposed federal regulations. The material may be reactive in the presence of oxidizers, when exposed to acids or strong alkalais, may generate fumes when in contact with water, or when heated. The waste may exhibit strong oxidizing characteristics. All of the above circumstances were considered in the classification of the residues listed in Table 2-1. More detail regarding reactivity could be included in an individual waste data sheet (see Figure 2-1) to be developed for a comprehensive solid waste management plan.

Many of the indeterminate wastes cannot be identified in this

ACETONE

I. Identification:

Commodity Safety System No. 0057 NIOSH Listing AL31500

Chemical Name ACETONE CAS No. 000067611

Molecular Formula MOFM: O-C3-H6

Chemical Synonyms: ACETON (German, Dutch, Polish) \* ACETONE(DOT) \*  
DIMETHYLKETAL \* DIMETHYL KETONE \* KETONE, DIMETHYL \*  
beta-KETOPROPANE \* METHYL KETONE \* 2-PROPANONE \*  
PYROACETIC ETHER

II. Hazard Classification:

DOT : Flammable Liquid, Label: Flammable Liquid, Exemptions and packing-  
Exempt from specification packaging, marking, and labeling re-  
quirements if packed in metal containers not over 1 quart capacity  
each, or in containers not over 1 pint or 16 ounces by weight each,  
both packed in strong outside containers.

Degree of Risk: Serious due to flammable material and can injure through  
breathing or touching. Acetone is narcotic in high con-  
centrations. In industry, no injurious effects from its  
use have been reported other than skin irritation and  
headaches from prolonged inhalation.

Precautions: Keep away from heat, sparks, open flames.  
Avoid breathing fumes and vapors.

First Aid: Immediately flush skin with plenty of water. Flush eyes with  
water for at least 15 minutes.

Danger of Fire: Can be ignited at almost any temperature.

Control of Fire: Use "alcohol" foam, water may be ineffective or increase  
danger.

Stability: (Reactivity) Can react vigorously with oxidizing materials.

Toxicity: Lowest Published Lethal Dose (LDLo): 50 mg/kg -Oral Human  
Oral Rat LD50 : 9750 mg/kg.

Processing & Disposal: First Choice: Incineration (with flue gas scrub.)  
Others: Deep Well Injection.

Recycle Potent.: Can be distilled and recycled. Economics: Not Feasible

Figure 2-1 Sample Data Sheet for Hazardous Chemical Wastes -General Data



CSS=Commodity Safety System  
CAS=Chemical Abstract Service  
MOFM=Molecular Formula

WASTE MANAGEMENT DATA SHEET

\_\_\_\_\_

A. IDENTIFICATION: CSS # \_\_\_\_\_ NIOSH Listing \_\_\_\_\_  
CAS No. \_\_\_\_\_ Chemical Name \_\_\_\_\_ MOFM \_\_\_\_\_  
Chemical Synonym: \_\_\_\_\_

B. Mixed Waste:- \_\_\_\_\_ (Liquid, Sludge, Solid) Major Constituents:  
EPA Hazard Classification \_\_\_\_\_ Certified By \_\_\_\_\_

C. Storage: Code \_\_\_\_\_ Location \_\_\_\_\_  
DOT Container \_\_\_\_\_ (5 gal., Drum # \_\_\_\_\_ )  
SPECIAL PRECAUTIONS \_\_\_\_\_  
\_\_\_\_\_

D. TRANSPORT: Labeling \_\_\_\_\_ Identification \_\_\_\_\_  
Manifest \_\_\_\_\_ Signed By \_\_\_\_\_  
Contractor \_\_\_\_\_ Contr. Signature \_\_\_\_\_  
Removal Date \_\_\_\_\_  
Permit No's (for treatment and disposal) \_\_\_\_\_

E. ACCIDENT PLAN: FIRE PROTECTIVE MEASURES  
Explosion  
Spills

Figure 2-2 Sample Data Sheet for Hazardous Wastes-Operations

category because additional data regarding the constituents and their fractional make-up of the total waste is required to determine the potential reactivity of the residue.

C. Corrosive Wastes -Fifteen (15) corrosive wastes are identified by using text book information on the residues generated at the Center. Most of the tabulated substances listed as corrosive included laboratory waste acids (disposed of mainly through the laboratory drainage system) and alkaline chemicals. Some organic chemicals are also corrosive, but they would also be categorized as hazardous due to ignitable or reactive characteristics. Quantities do not appear to be a factor at the Center in the management of corrosive wastes, however the inventory may have missed some larger waste streams.

D. Toxic Wastes -Establishment of toxicity criteria by implementation of the prescribed toxicant extraction procedure is aimed at toxic heavy metal ions dissolved in the waste material. Most likely candidates for this classification would be the inorganic chemicals listed in the inventory. Approximately ninety percent (90%) of the wastes (by weight) generated at the facility fall into this group. The flyash, slag, and sludges from wastewater treatment may all be defined as toxic (hazardous) due to character of the extract obtained by using the mandated test procedures. It is extremely important to make an assessment of heavy metal leaching from the flyash and slag generated by the coal conversion processes. This is critical as the disposal requirements are radically altered and the costs of proper management may be increased by one or two orders of magnitude. None of the inventoried substances can be categorized due to lack of data.

Some chemicals reported at the Center are on the lists (EPA) of substances that have displayed a high level of mutagenic activity. Mutagenicity testing would be needed to definitely establish the hazardous nature of the specific waste streams involved as they may not be pure chemicals. Three chemical wastes were found to have some reference to mutagenic or carcinogenic potential in the literature. Most mutagenic substances are organic or organo-metallic materials. Some active mutagenicity characteristics has been reported for the polycyclic aromatic hydrocarbons (PAH), benzo-a-pyrene being the most ubiquitous species. This compound has been analyzed in solid and liquid residues from coal conversion processes. A program to provide data for mutagenic assessment of the high volume waste streams would be of great value in determination of required treatment levels for the solid wastes generated at the Center.

Bioaccumulative aspects of coal chemicals are documented in the literature. Many of the derived coal chemicals are long chain polymers which would theoretically give a positive result in the suggested test procedures. Consequently, some measurements should be carried out on the more significant waste streams (criteria is volume) to establish or rule out this hazard in the perspective of waste management at the Energy Technology Center.

Of serious consequence to any formulated management plan for the residues generated at the Center is the statutory hazardous waste ruling due to toxic organic fractions. Following the proposed calculation procedure, thirty-one (31) of the reported laboratory chemical wastes would be declared "hazardous" depending on concentrations of the chemical in the toxicant extract. Since most of these chemicals are in the liquid or semi-solid state, and the procedure dictates their inclusion (all the liquid

fraction becomes a part of the extract) in the sample to be analyzed for classification, it would appear that the concentration limit of one mg/l would be exceeded. The unknown nature of twenty-two of the entries in Table 2-1 is also of some concern. The chemical kinetics of the undeterminate materials should be of some interest as their influence on potential environmental impacts and subsequent management costs can be significant.

One aspect of this category is that it serves to acquire a realization of the potency of some poisons appearing on the list of residues. Four waste chemicals with a calculated LD<sub>50</sub> of less than 2.6 mg/l appear in the tabulation. Acetonitrile, benzene thiol, dimethylene triamine and thiophenol should be eliminated from the laboratory shelves. If the chemicals are absolutely required for the research operations, then extreme care and warnings over and above poison labels on the bottles should be implemented. Any proposed management plan should develop a control mechanism for chemicals of this type.

## 2.2 Waste Management - STORAGE

Management of the solid residues resulting from ongoing operations at the Pittsburgh Energy Technology Center must include some storage management procedures. This is necessary to implement a system that minimizes environmental pollution and does so at a reasonable cost. Safe and efficient practices must be designed into the system. Handling and storage of spent laboratory chemicals in their myriad of forms and hazards must be addressed. The management of the bulk wastes produced at the center may be of greater importance from a cost effective view.

## A. Laboratory Wastes -Storage

Some segregation measures must be utilized to furnish a safe and efficient system of storage of laboratory chemical wastes at the Center. The general groupings for segregation purposes and ultimate processing include: flammables - liquid and solid residues aggregated to facilitate bulk transport and incineration or processing whether it takes place on or off-site; reactive chemicals - oxidants and highly reactive (explosives, heat sensitive materials, water activated) chemicals; toxic chemical wastes (that are not reactive or flammable) with heavy metal fractions, mutagenically active constituents or toxic organic substances which render them hazardous; corrosive liquids - weak and strong acids and alkalis which may also be reactive with other chemical wastes to create highly toxic fumes on contact; and non-hazardous bulk and containerized wastes. Resource recovery is an alternative that should be assessed due to the potential enhancement of the option if segregation is practiced at this phase of the management cycle.

1. Flammables -(a) Liquids-Many of the hydrocarbons listed as laboratory waste chemicals are considered ignitable by statutory definition. Heptane, octane, benzene, etc. would be included in this category. The alcohols, benzenes, and hydrocarbon liquids can be combined in a single bulk container. It is advisable to determine the compatibility of the liquid wastes in question by testing with minute quantities of each fluid. A small sample of the flammable waste (5 ml. or less) and the already agglomerated liquid should be combined in a well ventilated and flame free area (or under a laboratory hood in a metal crucible).

Combination of this group of liquid wastes in 55 gallon drums with storage in a cool, well ventilated area (until pickup by the disposal contractor) is a viable storage technique. This protocol will furnish the economies of bulk handling (if volumes generated are sufficiently large, installation of an outside underground storage tank with capacity ranging from 1000 to 3000 gallons may be justified) and the opportunity to recover the heating value of the material in a fuel blending operation. It will also reduce the cost of processing (incineration is the disposal process of choice) as the incineration process will be self-sustaining and will not require auxiliary fuel. Transport and disposal costs can be reduced to one-third to one-half of that of small volume lot processing.

(b) - There are only a few solid flammable wastes involved in the Center's operations. Agglomeration of solid flammable waste materials is not so attractive a technique (as with liquids) as the possibility of mixing two reactive wastes is greater. A testing program to determine reactivity of the various flammable solid waste streams may be necessary, but this program is not feasible at Bruceton unless larger volumes of this type of residue are generated. Solid flammable wastes must be containerized separately in accordance with U. S. Department of Transportation regulations, and Factory Mutual requirements. Due to the very small quantities involved at PETC, some thought should be given to the possibility of liquifying the solid flammables by mixing with the waste solvents to combine them into one waste stream.

2. Reactive Chemicals -Some highly reactive oxidizing agents may be included among the laboratory waste chemicals reported in the facility inventory. Main groups of chemical oxidizers are listed in Table 1-1

under group 7-A. Oxygen will be released by these substances to enhance the potential for combustion. Other chemicals may be especially reactive when combined with the oxidizers. This class is identified in Table 2-1 with an asterisk in the reactivity column. Overage ether (kept on the laboratory shelf for an extended time period) may break down to form unstable peroxides which could detonate on exposure to vibration, shock, or heat. Development of a detailed data sheet (see Figure 2-1) for each chemical discarded from laboratory operations could be a valuable tool in devising and maintaining a safe, efficient hazardous waste program at the Technology Center.

Storage of spent chemicals at the Center must be planned with this particular hazard in mind. Segregation of mutually reactive chemicals must be practiced to minimize the danger of explosion, fire and generation of toxic fumes. The storage area must be well ventilated (to prevent accumulation of toxic or reactive fumes, kept cool and located in a relatively isolated setting.

3. Corrosive Materials: Strong acids and alkali (although both are corrosive) should be kept separated to preclude violent reactions which accompany their combination. Most import is the use of proper containers (corrosion resistant to that particular chemical) to prevent accidental leakage during the storage phase of waste management. The hazardous waste inventory did not pinpoint large volumes of acids and alkalis at the Pittsburgh Energy Technology Center. This finding should be double-checked (especially in the program project areas) as this class of waste is almost ubiquitous. Proper labeling and close supervisory control of the storage area will be the most effective tool for insuring safe handling of this type of waste.

4. Toxic Chemical Wastes- This class of materials usually does not exhibit the hazards described above. Consequently, storage restrictions may be less stringent with regard to these residues. Containerization will be the most likely method used for isolating and storing the laboratory chemical wastes. General storage requirements which follow will cover this class of materials. Identification and labeling of the wide range of materials and their specific hazard classification is an important component of any comprehensive solid waste management plan implemented at the Pittsburgh Energy Technology Center.

#### B. Process Wastes-Storage

The indeterminate wastes which may be classified in the toxic waste category (slags, char, flyash, sludges, etc.) will not usually be stored with the other chemical wastes. Volumes generated will call for other design concepts in the storage phase. Sludges should be stored in specially designed containers which facilitate loading into transport vehicles. Many container types (closed vessels-tank, leak-proof open boxes and drums) are available and will be selected to provide optimum service depending on the physical and chemical properties of the residue. Flyash, char and slag are not usually containerized. Small volumes are discharged directly into the open box container in which they will be transported off-site for disposal. Larger volume becomes a function of the generating process and disposal techniques. This group of waste materials will be stored on-site in lagoons or impoundments which act as the dewatering unit as well. If vacuum filters or other dewatering devices are employed as a part of the process, the dry (or relatively dry) residue is stored in open piles. Control of run-off and discharges



(which may need further treatment) must be considered in the design and construction of proper storage areas.

If the slags, chars, and other solid residues are determined to be non-hazardous (statutory definition), they will still be subject to the same storage design requirements as the toxic bulk material. Discharges from the storage pile would need to be controlled, but may not require treatment. Hydrological isolation may be a prerequisite of the storage construction in the case of toxic substances.

### C. General Storage Considerations

Establishment of a central chemical waste storage area should be considered at the Pittsburgh Energy Technology Center. Typical design and operational procedures to be incorporated in the activity include:

1. The chemical waste storage area should be located in a separate, remotely located building to minimize damage from potential violent reactions and fires.
2. The building should be adequately ventilated to prevent accumulation of toxic and flammable vapors.
3. Chemical wastes must be stored in a controlled arrangement with potential reactivity in case of accidental mixing as the main criteria. Each of the listed chemical wastes in Table 2-1 should be coded on the operations data sheet for storage proximity compatibility. A general guide that may be useful is the partial listing (chemical classes relevant to those reported at PETC) of the U.S. DOT Loading and Storage Chart of Hazardous Chemicals tabulated in Table 2-3.
4. The laboratory chemical wastes should be packed and stored in

| Group Classification & Number  |    | 10 | 11 | 12 | 13 | 14 | 15 |
|--|----|----|----|----|----|----|----|
| Flammable liquids or flammable gases; Flammable liquid or flammable gas label.....                 | 10 | -  | -  | -  | -  | X  | -  |
| Flammable solids or oxidizing materials; Flammable solid, oxidizer, or organic peroxide label..... | 11 | -  | -  | *X | -  | X  | -  |
| Corrosive liquids; Corrosive label.....  | 12 | -  | *X | -  | -  | X  | -  |
| Nonflammable gases; Nonflammable gas label.....  | 13 | -  | -  | -  | -  | -  | -  |
| Poisonous gases or liquids, in cylinders, projectiles or bombs, Poison gas label.....              | 14 | X  | X  | X  | -  | -  | -  |
| Radioactive materials.....   | 15 | -  | -  | -  | -  | -  | -  |

The above table shows the hazardous materials which must not be loaded or stored together.

The letter X at an intersection of horizontal and vertical columns shows that those articles must not be loaded or stored together, for example: Flammable liquids or gases should not be loaded or stored with poisonous gases or liquids.

\* Unless loaded in opposite ends of car, corrosive liquids must not be loaded with flammable solids, oxidizing materials, except that shippers loading carload shipments of corrosive liquids and flammable solids or oxidizing materials and who have obtained prior approval from the Department may load such materials together when it is known that the mixture of contents will not cause a dangerous evolution of heat or gas

Table 2-3 Loading and Storage Chart of Hazardous Materials. (7)

containers complying with U.S. DOT specifications. In this manner, they will be ready for pickup and shipment by the contractor, thus minimizing preparation and demurrage charges.

5. Placement of acids, solvents, or chemical wastes in breakable containers should be arranged for minimum probability of accidents i.e. store glass containers close to the floor. Shelving and arrangement of the storage area must be designed to prevent and eliminate poor handling practices as much as possible.

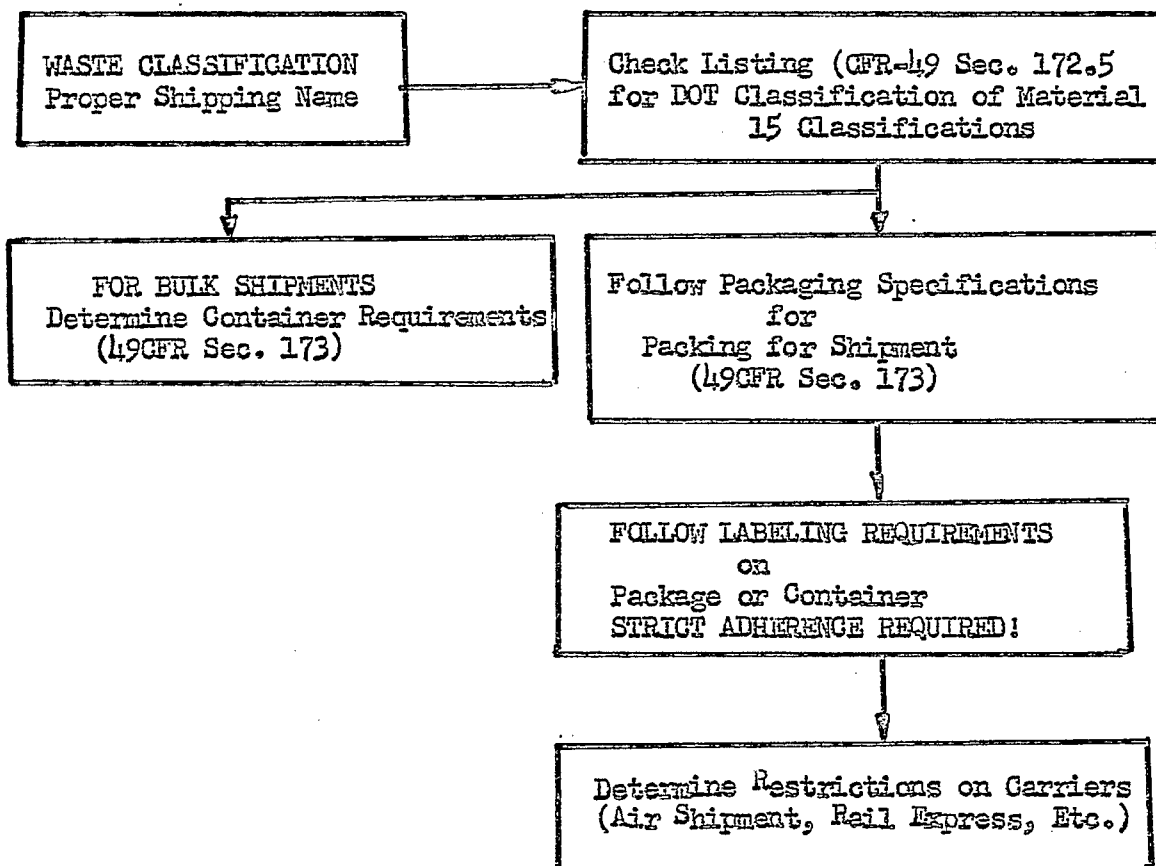
6. Access to the storage area must be rigidly controlled to avoid or prevent poor management practices. Central authority by delegation of responsibility for operation of the storage area should be implemented to insure success of the selected management plan.

7. A running inventory of waste materials and their location in the storage area should be maintained.

### 2.3 Waste Management - TRANSPORT

U.S. DOT regulations (7) are used as the primary instrument to control the movement of hazardous wastes from generation point to treatment or disposal location. The statutes are comprehensive in scope, ranging from packaging requirements in great detail to design requirements for railroad tank cars. Design criteria mandated include safety precautions for protection of personnel, selection of materials of construction of containers, transport vessels and storage units. Protocol for compliance with DOT regulations is outlined in Figure 2-3.

The laboratory waste chemicals are packed in drums (filled with vermiculite) which are fabricated to DOT specifications. Small quantities of spent chemicals are usually kept in the original bottles and



Part 172 - Lists hazardous materials shipping names of all materials subject to CFR-49).

Part 173 - Covers regulations pertaining to Shippers (PETC).

- Sub. a. Classification, motor carrier regulations. Preparation of articles for transportation.
- b. Explosives
- c. Flammable, combustible and pyrophoric liquids.
- d. Flammable solids and oxidizing materials.
- e. Corrosive materials.
- f. Compressed gases.
- g. Poisonous materials, etiologic agents and radioactive materials.
- h. Marking and labeling of hazardous materials.

Figure 2-3 Protocol for Use by PETC to Comply with DOT Regulations.

and cans and stowed in the metal drums. The individual containers are cushioned by the vermiculite, which acts both as shock absorber to prevent breakage and as a fire retardent absorbent (in the case of leakage of flammable liquids. Care and judgement must be exercised in selecting the waste chemicals to be placed in the same transport drum.

Liquid and solid wastes in drum (5, 30 and 55 gallon sizes) quantities should be stored and shipped in the approved container for that particular class of waste. Accumulation of truck load lots (78 drums) is necessary to take advantage of discounted transportation charges. Proper labeling and identification are imperative as punitive fines are levied for violations of the DOT regulations.

Bulk wastes generated at the Pittsburgh Energy Technology Center are transported in the appropriate vehicle- tank truck for liquid wastes; open or closed truck bodies which are leakproof (for sludges) for the solid wastes. Transport distances become critical in the economic sense when carrying large masses of waste materials from one location to another.

#### 2.4 Waste Management - PROCESSING & DISPOSAL

The final component in the waste management chain embodies processing (if necessary) and ultimate disposal. Because there are only three final sinks for the constituents produced during the coal conversion process- air, water and land - this phase of the system essentially redistributes the wastes to each of them.

Some processing alternatives will change the chemical nature of residues to an end product which is no longer toxic or polluting. One example is that of the reduction of cyanides (a highly potent toxic

chemical) to carbon and nitrogen by chemical reactions of hyperchlorination. Other treatment techniques include volume reduction (and redistribution) such as incineration which reduces the volume of liquid or solid wastes by rapid oxidation (combustion). The combustion products are redirected to the air sink, mainly in the form of oxides and water vapor. Very little solid residue remains when burning liquid wastes. Residues from the combustion of solid wastes may present greater environmental problems than the original material.

Industrial wastewater treatment employs processes which include chemical reactions (in the treatment for heavy metals) to concentrate the toxic fractions into forms which are insoluble in water. The precipitate forms a semi-solid and the supernatant (water fraction) becomes a treated effluent. Lime or soda ash neutralization of acids which contain high concentrations of heavy metal ions in solution is one example of this category. Other unit processes include biological treatment which utilizes bacteria (usually in an aerobic pathway in order to take advantage of higher removal efficiencies) and air or oxygen to enable bacterial biota degrade the organic contaminants in industrial wastewater.

Direct land disposal techniques may be satisfactory in the management of some residues generated at the Center. Sanitary landfills with daily covering of deposited residuals with soils is not really applicable to the undeterminate wastes expected from coal conversion processes. However, specially engineered facilities (with prevention of releases of toxic substances to the water media as the primary design criterion) may be adequate in protecting the environment and public health. Adequacy is highly dependent on physical, biological and chemical characteristics

of the particular wastes (chars, flyash, slag, wastewater treatment plant sludges). Phenol attenuation (and other similar organics) by selective organisms in biologically active soils may be an attractive and economic alternative for processing of some high volume wastes which have as much as ten percent organic fractions. (23)

Chars or residues from combustion processes (flyash and bottom ash) which are usually made up of 99.5 percent inorganic compounds may need pretreatment prior to disposal using a land sink. Stabilization if it is in a thixotropic sludge form (flue gas desulfurization wastes); chemical fixation to render the heavy metal fractions insoluble and prevent leaching with release to the water sink are two management alternatives.

Encapsulation of the pollutant with a counteracting material as part of the land disposal concept is also a choice. The counteractant may be crushed limestone which may keep any water discharges low in heavy metal ions. Man-made material liners and natural clay materials may be considered to act as a hydrological barrier between the waste and groundwater. Again, all of the alternatives indicated are influenced by the nature of the residue. Consequently, the importance of determining the character of the large volume waste streams resulting from coal conversion operations becomes critical to the economic feasibility of the conversion process itself.

#### 2.4.1 Chemical Processing

Due to the very small volumes of highly toxic wastes generated by laboratory activities at the Pittsburgh Energy Technology Center, this option does not appear to be one of the choices open to the decision-makers. As stated previously, these reported toxic chemical wastes

would be candidates for chemical destruction, but the quantities indicated are very small. Elimination of the substances from the laboratory or dispatch to a disposal contractor who uses a centralized treatment facility is more feasible. Acetonitrile is the only residue from the laboratory that fits this category. All of the highly toxic chemical wastes generated by this particular laboratory are combustible thus making controlled incineration (with gas cleaning auxiliaries) the processing and disposal choice.

#### 2.4.2 Incineration

This processing (or disposal) alternative is the most promising for proper management of most of the waste laboratory chemicals. Table 2-4 contains a list of the reported laboratory waste chemicals in which incineration is the recommended management option. In some instances the unit will need gas scrubbing devices due to air pollutants released during the combustion process.

Of the many types of industrial waste incinerators available, two basic designs are applicable to the residues being considered, rotary kilns and liquid injection units. Rotary kilns employ large horizontal or slanted chambers which rotate as the waste is burned inside. The slowly rotating cylinder provides tumbling action to improve efficiency of complete combustion of the solid or liquid wastes. The technology for this type was adapted from lime and cement processing operations. Most organic wastes in solid, semi-solid (sludge) or liquid form can be handled. Residence time in the kiln can be adjusted from several seconds to hours to assure complete destruction of some highly toxic pesticides and pollutants. Combustion temperatures range from 1500°F



| Chemical Waste         | Potent. Combustion Products |                 |                 |                  |                 | Other Criteria |
|------------------------|-----------------------------|-----------------|-----------------|------------------|-----------------|----------------|
|                        | HCL/<br>COCl <sub>2</sub>   | SO <sub>x</sub> | NO <sub>x</sub> | Other            | Heavy<br>Metals |                |
| Acetone                |                             |                 |                 |                  |                 |                |
| Acetonitrile           |                             |                 | X               |                  |                 |                |
| Alcohol                |                             |                 |                 |                  |                 |                |
| Anthracene             |                             |                 |                 |                  |                 |                |
| Benzene                |                             |                 |                 |                  |                 | (2)            |
| Butane                 |                             |                 |                 |                  |                 | (2)            |
| Butyl Mercaptan        |                             | X               |                 | H <sub>2</sub> S |                 | (1)            |
| Butyl Phenol           |                             |                 |                 |                  |                 |                |
| Carbolic Acid (Phenol) |                             |                 |                 |                  |                 |                |
| Carbon Disulfide       |                             | X               |                 |                  |                 | (1)            |
| Carbon Tetrachloride   | X                           |                 |                 | Cl <sub>2</sub>  |                 | (1)            |
| Creosote (Coal Tar)    |                             |                 |                 |                  |                 | (2)            |
| Cresol (Cresylic Acid) |                             |                 |                 |                  |                 |                |
| Cyclohexane            |                             |                 |                 |                  |                 | (2)            |
| Dichloromethane        | X                           |                 |                 | Cl <sub>2</sub>  |                 | (3)            |
| Dicyclopentadiene      |                             |                 |                 |                  |                 | (2)            |
| Dimethylamine          |                             |                 | X               |                  |                 | (1)            |
| Ethane                 |                             |                 |                 |                  |                 | (2)            |
| Ethanol                |                             |                 |                 |                  |                 |                |

(1) Controlled incineration of materials acceptable if equipped with a scrubber, catalytic or thermal unit to reduce NO<sub>x</sub>, or SO<sub>x</sub> emissions.

(2) Incineration of concentrated materials and dilute organic mixtures is acceptable.

(3) Incineration acceptable -preferably after mixing with another combustible fuel; a scrubber is necessary to remove halo acids produced.

Table 2-4 Technology Center Selected Chemicals-Incineration Recommended. (17)

| Chemical Waste   | Potent. Combustion Products |                 |                 |                       |                 | Other Criteria |
|------------------|-----------------------------|-----------------|-----------------|-----------------------|-----------------|----------------|
|                  | HCL/<br>COCl <sub>2</sub>   | SO <sub>x</sub> | NO <sub>x</sub> | Other                 | Heavy<br>Metals |                |
| Ethyl Acetate    |                             |                 |                 |                       |                 | (2)            |
| Formaldehyde     |                             |                 |                 |                       |                 |                |
| Freon            | X                           |                 |                 | Cl <sub>2</sub><br>HF |                 | (3)            |
| n-Heptane        |                             |                 |                 |                       |                 | (2)            |
| Hexane           |                             |                 |                 |                       |                 | (2)            |
| Isopentane       |                             |                 |                 |                       |                 | (2)            |
| Methanol         |                             |                 |                 |                       |                 |                |
| Methyl Mercaptan |                             | X               |                 | H <sub>2</sub> S      |                 | (1)            |
| Napthalene       |                             |                 |                 |                       |                 | (2)            |
| Nitromethane     |                             |                 | X               |                       |                 | (1)            |
| n-Pentane        |                             |                 |                 |                       |                 | (2)            |
| Phenols          |                             |                 |                 |                       |                 |                |
| n-Propyl Alcohol |                             |                 |                 |                       |                 |                |
| Propylene        |                             |                 |                 |                       |                 | (2)            |
| Pyridene         |                             |                 | X               |                       |                 | (1)            |
| Quinone          |                             |                 |                 |                       |                 | Needs Detail   |
| Toluene          |                             |                 |                 |                       |                 | (2)            |
| Xylene           |                             |                 |                 |                       |                 | (2)            |

Note: Partial table taken from reference (18)

Table 2-1 Selected Chemicals-Incineration Recommended (Continued) (17)

to 3000°F. This type of incinerator can process all combustible and non-combustible liquid and solid wastes generated at the Center. Units are manufactured to handle 100 lbs./hr to 4000 lbs/hr. Reported capital costs for the incinerator are \$2500-\$10,000/daily ton.(19) A skid-mounted rotating kiln incinerator is available for transport to the waste generating site.

The other combustion unit of interest is the liquid injection unit. This type of incinerator would be the most likely choice for the Center based on the laboratory chemical wastes generated there. The combustible liquid waste is filtered and then atomized through nozzles to be injected into the combustion chamber of the vertical or horizontally mounted vessel. An on-site unit for the Pittsburgh Energy Technology Center may be viable because the variability of liquid wastes is relatively narrow. A more or less uniform combustible residual fuel is available for heat recovery to evaporate residues with low BTU content. Utilization of waste heat for productive purposes is an attractive side issue in the present climate of expensive fuel supplies. The apparent limiting parameter for the liquid injection incinerator is the rate of heat release. A high BTU combustible waste cannot be fired at high flows, although throughput of the unit can be increased if non-flammable aqueous waste streams are evaporated simultaneously in the combustion chamber.

If sufficient volumes of combustible waste liquids are generated at the Pittsburgh Energy Technology Center and regulatory enforcement drives the contracted price for disposal to a high level, this option (on-site incineration or a variation) may be a very feasible choice. Management of liquid combustible wastes at two Energy Centers (Pittsburgh and Morgantown) may be economically feasible at this time for a truck

mounted portable unit that can be operated at both locations. A feasibility study to determine the economics and constraints of a joint effort by both facilities should be mounted. Choices to be considered include: (a) a skid-mounted rotary kiln incinerator for liquid and solid wastes, which is portable and can be operated at both locations as needed; (b) a liquid injection unit (portable or stationary) without gas scrubbing capabilities; and (c) a liquid injection incinerator (portable or stationary) with gas scrubbing capabilities in order to handle a wider spectrum of residuals. In order to avoid maintenance problems and use ordinary personnel for operation, it is recommended that liquid wastes which generate hydrochloric acid, chlorine gas, or hydrogen sulfide be avoided.

#### 2.4.3 Land Disposal

In the context of coal conversion residues and laboratory chemical wastes, land disposal techniques can be classified as: (1) pretreatment of the waste by dewatering, stabilization, solidification or leachate attenuation; (2) ordinary landfill operations and control; and (3) Special landfill design for hydrological isolation, encapsulation in situ, codisposal with attenuating mechanisms, and biological reduction opportunities.

##### 1. Waste Pretreatment (at disposal site).

Some processes have evolved for treating of hazardous solid wastes prior to land disposal. Major objectives of the processes are chemical and/or physical alteration of the solubility characteristics of the waste to prevent release of heavy metal ions, permanent isolation by

container encapsulation in non-biodegradable leakproof plastics. In the case of sludges, if volumes justify the economics, further dewatering or separation techniques such as pressurized ultrafiltration and centrifugation will be implemented for volume reduction (if the supernatant can be discharged without further treatment).

(a) Chemical Fixation and Stabilization - This process generally is accomplished by the addition of a fixative which will chemically or mechanically bind the pore water in thixotropic sludge (such as FGD wastes). Lime and flyash, calcined slag and lime, or a combination of lime, cement and bentonite are incorporated into the semi-solid residue. The material will stabilize and solidify from a pumpable fluid to a soil-like material in eight to twenty-four hours. The reactions continue over time with maximum strength and fixation occurring in twenty-eight to forty days. The final product exhibits better leaching characteristics (lower heavy metal ion concentrations in the extract). The soluble biological and organic fractions are not altered to any great extent by the application of this process type.

This pretreatment may be required by the proposed EPA regulations in order to prevent a hydraulic head on the impermeable liner, thus theoretically eliminating leaching of heavy metals through an impermeable membrane. Chemical fixation is practical only where huge volumes of semi-solid wastes are generated, heavy metals in soluble form are present in the residue, and organic fractions are of no concern. Further study of coal conversion residues are needed to assess this management alternative. It may be viable in handling of chars, lime sludges from fluidized bed gasification, soluble salt residues from magnetohydrodynamics research, and ashes which result from coal conversion processes.

(b) Partial Pretreatment - Some mechanisms utilized to avoid heavy metal leaching include adjustment of the pH and alkalinity of the waste stream. For smaller quantities of sludges and solid wastes containing relatively large fractions of toxic heavy metals (selenium, cadmium, lead, chromium, nickel and zinc), dosing with lime or other alkaline materials may be an effective solution. Disposing of the residues on a bed of crushed limestone may further protect the water environment.

(c) Aeration of Organic Wastes - Temporary storage in a vessel which is equipped with mechanical aeration capability may be a cost-effective option in treating some organic wastes. The unit will act as an aerobic digester to biologically degrade organic fractions. This will be successful only where establishment of an efficient bacterial population is possible. Some problems may be inherent in this choice due to the wide range of organic substances (which in themselves may be toxic to biota) in the residues generated at the Center.

(d) Permanent Container Encapsulation - Disposal of highly soluble heavy metal residues and very toxic organic chemicals may be suitably accomplished by encapsulating the container (box, pail, or drum) in a non-degrading impervious material. This work has been extensively studied by the U.S. Environmental Protection Agency (20). The toxic and hazardous substances are containerized and the overall container is encapsulated in polyolefin plastics or fiberglass coats which are chemical, shock and heat resistant. Costs for this process were estimated to be \$6-15 per drum. As of this time, the encapsulation process is not available, but it does hold some promise for economic management of relatively small volumes of highly toxic substances.

(e) Encapsulation in-situ - Disposal of heavy metal residues (which may include the process waste streams at the Center) from coal conversion in a crushed limestone capsule has been one technique approved by environmental enforcement agencies in the past. The limestone is placed completely around (top, bottom and sides) the deposited waste in layers of one foot or more. Any water moving through the alkaline limestone will have a high pH and alkalinity, thus theoretically placing the leachate in a pH range in which most of the heavy metals are insoluble. Some calculations have indicated the limestone would provide sufficient alkalinity to neutralize a normally slightly acidic groundwater for almost 200 years. This technique is based on the premise that good operating conditions and faithful implementation of the design and construction will prevail.

## 2. Sanitary Landfill Disposal

The ability of a sanitary landfill to fulfill the necessary needs for preventing environmental impacts is based on three critical factors: (a) hydrogeological setting of the facility; (b) chemical and physical characteristics of the residues processed; and (c) design and operation of the site.

Optimal site selection is the one choice which exerts the greatest influence on environmental impacts and the cost of disposal. Unfortunately, from an operational perspective, the optimal site location is one in which there is the most competition with other uses for the land. Consequently, most land disposal operations are located by other criteria i.e. political and social pressures, land costs and availability (usually marginal for most uses including land disposal of residuals).

Hydrogeological setting relevant to land disposal includes the topographical features (steep hills and ravines introduce drainage and stability problems), depth to bedrock and soil characteristics (such as renovation potential i.e. ability of the soils to attenuate organics and heavy metals), bedrock character (fractured bedrock or limestone formations will preclude isolation from ground water at any depth), and depth to ground water (to avoid deposition and subsequent migration of toxic elements in the ground water system). Adequate quantities of suitable soils which must be used for cover is another parameter of concern.

The chemical and physical nature of the wastes are critical with respect to potential and actual environmental impacts. A residual which exhibits a lack of hazard characteristics as defined by RCRA regulations would appear to have few if any possible impacts on the water system. Only a few of the reported laboratory waste chemicals would be considered non-hazardous (statutory definition). However, due to the small volumes (approximately a half ton per year) it may be possible to utilize the sanitary landfill concept for disposal. One hundred pounds of chemical wastes combined with some eight hundred tons of municipal refuse in a codisposal arrangement will offer very little potential for environmental contamination.

Daily operations and the basic design of the disposal facility can prevent environmental impacts or keep them minimal. Properly designed surface run-off diversion systems (to divert water away from the wastes) can prevent the residuals from reaching field capacity (saturation). In this situation, leachate will not be generated. Effective revegetation programs combined with a suitably designed soil erosion and sedimentation



scheme will minimize or prevent siltation with degradation of water quality as a consequence. Efficient operating procedures used in the placement, compaction and containment of the deposited residuals will provide optimal conditions for avoiding settling and structural problems at some future time.

### 3. "Secure" Chemical Landfill

Proposed federal regulations outline the design requirements for chemical disposal sites. Table 2-5 lists the restrictions and design criteria which must be met to be classified (and permitted) as a chemical waste landfill. Interpretation of the statutes imply disposal of any chemical wastes (if they are safe from dangerous reactions, fire and explosion by reacting with other residuals) in a facility which follows the proposed design.

At the present time, the only disposal facilities now in operation which comply with the necessary criteria are located in western Ohio, Indiana, and Illinois. They are facilities with the necessary natural clay deposits (and required permeability) having depths ranging from 45-90 feet. However, they are not in total compliance due to the lack of leachate treatment facilities. The possibility of discovering sites with deep natural clays (with  $1 \times 10^{-7}$  cm/sec permeability) in southwestern Pennsylvania and northern West Virginia is remote, but it is possible.

There is some opportunity for taking advantage of some fortuitous circumstances that will yield the necessary design features at disposal facilities in this locale. Disposal of fixed FGD sludges, which are reported to attain the necessary low permeability with time,

| CLASSIFICATION   | CRITERIA  | CONDITIONS   |
|--|---|--|
| Natural Conditions   | 10 ft. thick minimum of natural in-place clay with permeability of $< 1 \times 10^{-7}$ cm/sec  | If evaporation rate exceeds precipitation by at least 20 inches per year and No overflow is expected to occur.   |
| Designed Site - I  | Leachate collection system on top of a minimum soil or clay barrier with a min. thickness of 5 ft. with permeability not greater than $1 \times 10^{-7}$ cm/sec   | Leachate Collection and Treatment will be required.  |
| Designed Site - II   | Soil Liner-3 ft. thick min. with $< 1 \times 10^{-7}$ cm/sec over a synthetic membrane $> 20$ mil. thick with $< 1 \times 10^{-7}$ cm/sec permeability.<br><br>Leachate Collection & Removal on top of soil mantle. Leachate detection and removal beneath the synthetic membrane | Leachate Collection and Treatment will be required.<br><br>Leachate Detection & Removal System needed.<br><br>Water Quality Monitor System not required due to detection system. |
| <p><u>General Requirements</u> (All Classifications unless specifically deleted):</p> <ol style="list-style-type: none"> <li>1. Liquids must be treated to non-flowing consistency.</li> <li>2. Water Quality Monitoring System is required.</li> <li>3. Five foot separation from bottom of liner and high ground water table. 500 feet from nearest functioning public or private water supply.</li> </ol> |   |  |

Table 2-5 Secure Chemical Landfill Design Criteria, Proposed by EPA (4)

after their disposal may artificially create the necessary barrier. IUCS (International Utility Conversion Systems), Stabatrol, Inc, and Environmental Technology, Inc. are three corporations that are in the process of developing chemical landfills in the Tri-state area using the above described concept. An assessment of the feasibility of this disposal route for the undeterminate waste streams generated at the Pittsburgh and Morgantown Energy Technology Centers should be implemented. In addition, the above concept may be needed to manage the expected large volume wasted streams from full-scale coal conversion processing units.

Some potential exists for the construction of disposal sites which may not required compliance with the stringent design criteria outlined in Table 2-5. For the present time, some waste streams (lime kiln dust, power plant flyash, flue gas desulfurization sludge, and mining wastes) will be exempt from the standards being proposed until more data can be accumulated regarding the hazardous characteristics of these materials. Some coal conversion wastes would be very similar in nature to the special wastes. Development of hazard characteristics of typical solid and semi-solid residuals resulting from coal conversion processing becomes especially critical in light of the above described situation.

Concepts and proposals for safe and impact-free processing and disposal of coal conversion residues must be formulated and assessed as soon as possible due to the institutional regulatory climate. Statutes have a tendency to become set in stone and regulators will interpret them in the narrowest possible sense. Because of the potential economies inherent in land disposal of huge masses of residuals, a safe, viable and economic concept must be proven and accepted by the long line of regulatory bodies from local up to federal level.