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FACILITIES STORING HAZARDOUS WASTE IN CONTAINERS

A Technical Resource Document for Permit Writers

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Facilities Storing Hazardous Waste in Containers, 11/2/82 (Draft)

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A technical resource document for permit writers. Includes detailed information about design, equipment, and specific procedures for evaluating data in an application.

PREFACE

This is one of a series of technical resource documents that provides information on standards for facilities that treat, store, or dispose of hazardous waste.

The documents are being developed to assist permit writers in evaluating facilities against standards (40 Code of Federal Regulations, Part 264) issued under Subtitle C of the Resource Conservation and Recovery Act (RCRA) of 1976, as amended. Included in these documents is detailed information about design, equipment, and specific procedures for evaluating data submitted by the permit applicant, as well as bibliographies that can be used to locate additional information.

The series, which is being produced by the Technology Branch of EPA's Office of Solid Waste, includes guidance on:

- containers
- tanks
- compatibility of wastes
- incineration

Permit writers should keep in mind when using this material that the regulations are subject to change through amendments and modifications and should incorporate any changes into their evaluations of facilities.

The material contained herein is for guidance purposes only and is not enforceable. The technical resource documents are not to be interpreted as amending the facility standards in 40 CFR Part 264.

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INTRODUCTION

This manual provides the permit writer with a systematic approach to evaluating permit applications from facilities that store hazardous waste in containers.

Owners and operators of facilities that use containers to store hazardous waste are regulated under authority of Section 3004 of the Resource Conservation and Recovery Act (RCRA). Regulations promulgated under RCRA on the use and management of containers are found in Sections 264.170-264.178, Subpart I, Title 40, of the Code of Federal Regulations (CFR). The procedural requirements for obtaining a hazardous waste facility permit are in 40 CFR 122 and 124.

EPA's regulations provide for issuing hazardous waste facility permits in two phrases: Part A of the permit application (interim status) and Part B of the permit application (permanent status--the final permit). Interim status allows facilities that are in existence to continue operations while administrative action on the final permit is under way. These facilities must submit Part B of the permit application 180 days prior to beginning physical construction.

Part B of the permit application requires information on the equipment, structures, and procedures used for managing hazardous waste at the facility. The application must also provide data on the physical and chemical characteristics of the wastes to be handled. (See 40 CFR §122.25 of the Consolidated Permit Regulations for the contents of Part B.)

The permit writer evaluates the information provided in Part B of the application to determine whether the facility meets the administrative and technical standards (40 CFR 264) and the procedural requirements for obtaining a permit (40 CFR 122 and 124). The permit writers' manuals provide background information and procedures for evaluating the data provided by the applicant.

The administrative procedures permit manual (prepared by EPA's Office of Enforcement)[1] provides information on procedures to follow from the initial contact with an applicant through review, public hearing, and any administrative appeals of permit decisions. The manual also contains guidance for conducting technical reviews.

Various sections of the final regulations for storage reflect the use of best engineering judgment (BEJ). This concept entails the application of case-by-case judgment, based on site-specific circumstances, in evaluating facilities for issuing permits. In those sections of the regulations that have been written from a BEJ standpoint, some flexibility is allowed on the part of the owner or operator in meeting permit requirements. The Agency feels that evaluating facilities individually will ensure the protection of human health and the environment and, at the same time, avoid overly restrictive requirements that might result from application of specific uniform rules for all facilities.

BEJ provides for tailoring of permit requirements to the specific wastes, facility design, and environmental conditions of the storage area, based on the best engineering judgment of the permit writer. In order to make these judgments, the permit writer must have access to information on current technologies and the specific site.

The storage regulation for containers requires complete containment of the waste. No discharge into the land, surface water, or ground water is permitted. Three lines of defense against potential discharge are built into the regulation: (1) a primary containment device (the container itself); (2) regular inspections to verify condition of containers and to ensure that leaks or other problems do not go unnoticed; and (3) a secondary containment system capable of holding any discharges that should occur.

The regulatory definition of "containers" is "any portable device in which a material is stored, transported, treated, disposed of, or otherwise handled" (40 CFR Section 260.10). Specific standards for managing hazardous waste stored in containers are in Subpart I, 40 CFR §§264.170-177. These standards cover the following general areas:

- condition of containers
- compatibility of wastes with container material and of wastes with wastes
- management of containers
- inspections
- containment
- special requirements for ignitable or reactive wastes
- special requirements for incompatible wastes
- closure

CHAPTER 2

QUESTIONS TO BE CONSIDERED BY THE PERMIT WRITER

These questions will aid permit writers in evaluating applications of owners or operators of facilities that use containers for storage of hazardous waste. The first section is a checklist of questions designed to assess the completeness of the application. The second section consists of general design and operating questions.

A. Checklist for Permit Writers

The following outline will assist permit writers in assessing the completeness and adequacy of a permit application.

1. General Facility Description

   - number of containers
   - location of containers
   - buffer zone for ignitable/reactive waste in containers (§264.176)

2. Chemical and Physical Analyses of Wastes

   - information necessary to determine waste-to-waste compatibility, waste-to-container compatibility, and ignitability or reactivity

3. Waste Analysis Plan

   - analyses or trial tests used to determine waste-to-waste and waste-to-container compatibilities
   - analyses for determination of ignitability and reactivity
   - methods for selecting representative samples
   - frequency with which original analysis will be reviewed or repeated
   - source of other information on composition and

characteristics of waste for off-site facilities

- inspection of shipments received at the facility

4. Description of Security

5. Inspection Schedule

   - schedule for inspecting container storage areas and containment systems, as specified in §264.174

   - list of items to be inspected for corrosion or rusting of containers, cracking of containment base, etc.

6. Justification for Waiver of Preparedness and Prevention Requirements

7. Contingency Plan

   - actions to be taken in response to fires, explosions, or unplanned releases of hazardous waste

   - arrangements with police department, fire department, hospitals, contractors, and State and local emergency response teams

   - list of emergency coordinators

   - list and location of emergency equipment

   - evacuation plan, if necessary

8. Description of Procedures to:

   - prevent hazards in unloading

   - prevent runoff from handling areas

   - prevent contamination of water supplies

   - mitigate effects of equipment failure and power outages

   - prevent exposure of personnel to hazardous waste

9. Description of Precautions to Prevent Accidental Ignition or Reaction

   - precautions to prevent ignition or reaction of ignitable, reactive, or incompatible waste

   - documentation demonstrating compliance with §264.17(a) (see item 20 of this checklist)

10. Traffic Pattern and Volume

11. Facility Location

- political jurisdiction in which facility lies
- if facility is in an area listed in Appendix VI of Part 264, demonstration of compliance with the seismic standard (see §§264.18 and 122.25(a)(11)(ii) for details)
- identification of whether facility is located in 100-year floodplain
- if facility is in a 100-year floodplain, engineering analyses showing design of operational units and flood-protection devices and their ability to withstand forces of a 100-year flood, or procedures for removing hazardous waste prior to a flood (see §§264.18(b) and 122.25(a)(11)(iv) for details)
- if existing facility is not in compliance with §264.18(b), a plan and schedule for bringing facility into compliance

12. Outline of Training Program

13. Closure Plan (see §264.112 for details)

14. Closure Cost Estimate and Financial Assurance Mechanism (see §§264.142 and 264.143 for details)

15. Documentation of Compliance with §264.147, Liability Requirements, if Applicable

16. Proof of Coverage by State Financial Mechanism, Where Appropriate (see §§264.149 or 264.150)

17. Topographic Map (see §122.25(a)(19) for details)

18. Design Information When a Containment System is Required*

- design parameters, dimensions, and materials of construction
- how containers will be managed so that they are not stored in accumulated liquids

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* A containment system is not required in storage areas where containers hold only wastes that do not contain free liquids, if the conditions in 40 CFR 264.175(c) (46 FR 55112, November 6, 1981) are met.

- description of methods to prevent run-on

- capacity of the containment system

- procedures for analyzing and removing accumulated liquids

19. Justification for Waiver of Containment System Requirements

20. Procedures for Handling Incompatible, Ignitable, or Reactive Waste

    - for offsite facilities, procedures for inspecting each shipment of waste received at the facility (part of the waste analysis plan)

    - procedures for treating waste prior to placement in containers, where applicable

    - procedures used to prevent a waste from being placed in an unwashed tank that previously held an incompatible waste

    - procedures used to prevent incompatible wastes from being placed in the same container

    - documentation of compliance with buffer zone requirement

B. Questions to Be Answered by the Permit Writer

The following questions can be used by the permit writer in evaluating the information in the permit application and in preparing a facility permit. The text of this manual provides the permit writer with information as to how these questions can be answered.

1. Type of Container and Condition

   Is the vessel portable (i.e., is it a container)?

   Is the container in "good condition" (free of leaks, excessive rusts and dents, corrosion, etc.)?

   Is the container marked in accordance with Department of Transportation (DOT) specifications?

   Are there procedures to ensure that should the condition of a container deteriorate to the point that it can no longer be used, will its contents be transferred to a container that is in good condition (e.g., does the permit applicant have an adequate supply of empty drums that can be used in this type of situation, etc.)?

2. Compatibility of Waste with Container

Does the waste analysis plan specify adequate procedures for determining whether the waste is compatible with the container construction or lining material?

3. Management of Containers

Are containers handled in such a way as to ensure that ruptures, leaks, or other damage do not occur?

Are containers always kept closed except when emptying and filling?

How are leaking and otherwise damaged containers handled? Are they discarded or sent to a reconditioner?

4. Inspection

Does the inspection schedule contain the items required by §264.174?

Are the inspection procedures adequate to detect leaking and otherwise damaged containers and deterioration of the containment system components?

5. Containment

Is the containment system base free of cracks and gaps and sufficiently impervious to hold spilled or leaked waste or precipitation until it is detected and removed?

Does the design of the containment system provide a means to prevent containers from prolonged contact with accumulated waste (e.g., drainage designs, elevation of the containers on racks or pallets)?

Is the capacity of the system 10 percent of the total volume of the containers or of the largest container (whichever is greater)?

Does the design of the containment system include measures to prevent run-on?

Are plans or procedures for removal of waste from the containment area adequate to prevent overflow?

6. <u>Ignitable, Reactive, and Incompatible Waste</u>

Are containers of ignitable and/or reactive waste located at least 50 feet from the property line of the facility?

Are procedures for management of incompatible wastes adequate to satisfy the requirements of §264.177?

7. <u>Closure</u>

Has waste been charaterized (chemical composition, physical state, etc.)?

Has maximum inventory at closure been estimated?

Are expected year of closure and schedule of closure procedures itemized?

How will wastes and residue be removed from the containers?

Will the waste be treated, stored, or disposed of onsite or offsite?

How will the containment system components be decontaminated or cleaned? If not possible, does the plan specify an option for removal and disposal?

How will contaminated soils, cleaning products, equipment, residues, etc., be disposed of?

CHAPTER 3

TYPES OF CONTAINERS

At present, there are no containers of which the Agency is aware that are manufactured specifically for the storage of hazardous waste, with the exception of those used for high-level radioactive waste. Therefore, drums made for other purposes have been adopted for containerizing hazardous waste. Specific designs appropriate for the contruction of containers for various types of hazardous waste would likely be more protective. These would be developed by analyzing many of the considerations pertinent to hazardous waste storage (for example, corrosivity, longevity of storage, etc.). Currently, EPA is reviewing drum design standards developed by various organizations in an attempt to resolve this issue. Because no current design standards exist, however, containers that are commonly used in the storage of hazardous waste will be discussed in this chapter.

This chapter emphasizes factors relevant to the evaluation of the appropriateness and effectiveness of each type of container. Compatibility and corrosion factors for each kind of container are also highlighted since these components are inseparably linked to safety and to the prevention of discharge of hazardous wastes.

Steel drums of 55-gallon capacity and plastic containers are most frequently used to containerize and store hazardous waste. The useful life of a container is dependent on its resistance to corrosion and to chemical deterioration. Steel drums, often with appropriate protective lining or coating material, are suitable for the storage of corrosive, reactive, ignitable, or toxic waste. Plastic containers are also well adapted for holding corrosive wastes since they are generally resistant to chemicals.

Since compatibility of the waste with the structural material of the container is important to prevention of failure of the container, this compatibility must be determined prior to storage. To ascertain the compatibility of a specific waste with a specific container, the following information is needed: (1) characteristics of the waste, (2) intended use of the container and its structural characteristics, (3) length of storage, and (4) storage conditions (e.g., temperature and humidity). This determination is so critical that a container that has been specifically designed for a particular substance may not be suitable for an off-specification batch of that same substance. For example, a chemical compound contaminated with only a few parts per million (ppm) of chloride may begin to deteriorate rapidly an unprotected steel container. For more information on compatibility, see EPA's permit writers' guide on compatibility of hazardous wastes.[2]

In addition, this chapter addresses the advantages and disadvantages of various containers that may be used for the storage of hazardous waste. Special considerations for selecting appropriate containers for the storage of flammable and combustible wastes are also discussed.

A. Steel Containers

Steel containers vary in capacity from 1- to 12-gallon metal pails to the standard-size 55-gallon drum. Other standard sizes are presented in Table 3-1. This section deals primarily with the 55-gallon drum because of its overwhelming popularity in storage.

The metal pail is defined by the U.S. Department of Commerce as a single-rolled shipping container with a volume of from 1 to 12 gallons. Pails are generally constructed of minimum 28-gauge mild steel. This gauge is often specified for pails that are designed to hold dry bulk materials. Standard markings include the steel gauge, capacity, and date of manufacture. For example, the marking 28-5-77 denotes a 28-gauge pail of 5-gallon capacity made in 1977. Pallets should be provided when pails are used to store hazardous waste.

1. Compatibility and Corrosion

As already mentioned, compatibility of waste with the container is integral to prevention of discharge of the waste and subsequent contamination of the environment. Storage conditions such as humidity, pH, and temperature can significantly affect the corrosion resistance of a particular container. (See Chapter 4, "Management of Containers," for a further discussion.) When assessing the suitability of a container for a particular waste, the permit writer must rely on the best available data.

Steel drums are usually fabricated from mild steel or low-alloy steels and have a low resistance to corrosion. Noncoated steel drums are well suited for wastes that are not highly corrosive such as mild alkaies, mild acids, and nonhalogenated organics. They are generally not compatible, however, with strong

TABLE 3-1

Types of Containers

Container size, description	Usable volume, cu. ft.
Metal drums[a-e]	
55 gal., steel, std., 18-gage plate, DOT[a]-17E, new	7.35
55 gal., steel, std., 16-gage plate, DOT-17C, new	7.35
55 gal., steel, removable head, 18-gage, Rule 40, new	7.35
55 gal., steel, removable head, 18/16 gage, DOT-17H, new	7.35
55 gal., steel, removable head, 18 gage, used, reconditioned	7.35
55 gal., steel, std., 18 gage, used, inspected, cleaned	7.35
55 gal., aluminum, std., 0.102-in. plate	7.35
55 gal., type 304 stainless steel, std., 16 gage, DOT-5C	7.35
30 gal., steel, std., 20 gage, DOT-17E	4.00
30 gal., steel, removable head, 20-gage, Rule 40	4.00
16 gal., steel, removable lug cover, 22 gage	2.14
55 gal., steel-mill galvanized, std., 18 gage, DOT-17E	7.35
55 gal., steel, removable head, 40-mil polyethylene liner, external fittings, 20/18 gage, 53.5-gal. usable volume, DOT-37M	7.20
Fiber drums	
61 gal., 9 ply, 400-lb. load limit, dry products only, Rule 40	8.15
55 gal., 9 ply, 400-lb. load limit, dry products only, Rule 40	7.35
47 gal., 9 ply, 400-lb. load limit, dry products only, Rule 40	6.28
41 gal., 9 ply, 400-lb. load limit, dry products only, Rule 40	5.48
30 gal., 9 ply, 400-lb. load limit, dry products only, Rule 40	4.00
30 gal., 7 ply, 225-lb. load limit, dry products only, Rule 40	4.00
15 gal., 6 ply, 150-lb. load limit, dry products only, Rule 40	2.00
55 gal., 9 ply, polyethylene barrier, 400-lb. load limit, Rule 40	7.35
55 gal., 9 ply, polyethylene-aluminum foil liner, 400-lb. load limit, Rule 40	7.35
55 gal., 10 ply, blow-molded 15-mil polyethylene liquid-tight liner, tight head, steel cover with 2- and 3/4-in. NPT openings, 600-lb. load limit, DOT-21C,21CP liquid products	7.35
30 gal., 9 ply, same as preceding except 450-lb. load limit	4.00
30 gal., 8 ply, 300-lb. load limit, removable fiber cover, no barrier	4.00
15 gal., 6 ply, same as preceding except 150-lb. load limit	2.00
1 gal., 5 ply, same as preceding except 150-lb. load limit	0.1335
55 gal., 9 ply, 400-lb. load limit, semisquare removable fiber cover, "Rocon" style	7.35
45 gal., same as preceding	6.01
Bags, multiwall paper, polyethylene (PE) film	
Pasted-valve bag, 20 1/2 × 22-in. face, 5 1/2-in. top and bottom with 1-mil free film, 2/50, 1/60 kraft, plain, no printing, PE internal sleeve	1.33
Sewn-valve bag, 15 × 5 1/2 × 30 1/4 in., 5 1/2-in. PE internal sleeve with 1-mil free film, 2/50, 1/60 kraft, plain, no printing	1.33
Pasted-valve bag, 18 1/2 × 22 3/4 in., 3 1/2-in. top and bottom, PE internal sleeve, 3/50 kraft, plain, no printing	0.84
Sewn open-mouth bag, 20 × 4 × 30 3/4 in., 3/50, 1/60 kraft, plain	2.00
Sewn-valve bag, 19 × 5 × 33 1/2 in., 5 1/2-in. tuck-in sleeve, 3/50, 1/60 kraft, plain	2.00
Pasted-valve bag, 24 × 25 1/4 in., 5 1/2-in. top and bottom, tuck-in sleeve, 3/50, 1/60 kraft, plain	2.00
Pasted open-mouth baler bags, 22 × 24 in., 6-in. bottom, 1/130 kraft (or 2/70), plain	
Flat-tube, open-mouth bag, 10-mil PE film, plain, 20 1/2 × 34 1/4 in.	1.33
Square-end valve bag, 20 1/2 × 22-in. face, 5 1/2-in. top and bottom, 10-mil PE film, plain	1.33
Small bags, pouches, folding boxes	
Pouch, 8 3/4 × 16 3/4 in., 2-ply PE film, 2-mil thickness/ply	0.12
Bag, sugar-pocket style, 6 × 2 3/4 × 16 3/4 in., 2- to 40-lb. basis weight, natural kraft paper	0.12
Bag, pinch style, 8 3/4 × 3 × 21 in.; 2- to 40-lb. basis weight, natural kraft	0.12
Folding box, 5 × 1 × 8 in., reverse-tuck design, 12-point kraft board with bleached white exterior	0.028
Folding box, 9 1/2 × 4 1/2 × 15 in., full overlap top and bottom, 30-point chip board with bleached white exterior	0.37
Corrugated cartons, bulk boxes	
Regular slotted carton (RSC), 24 × 16 × 6 in., 275-lb. test double wall, stapled (stitched) joint	
RSC, 16 × 6 × 24 in., 275-lb. test double wall, stitched joint, end-opening style	
Bag-in-box, RSC, 15 × 15 × 22 in., 275-lb. test double wall, stitched liner, 600-lb. test, double wall	2.86
Bulk box, 600/600 (test in lb. for both pieces), laminated inner lining approximately 41 × 34 × 38 in., less PE liner and pallet	5.00
Carboys, plastic drums, jars, bottles	
Carboy, 13 1/2 gal., polyethylene, blow-molded	1.35
Drum, polyethylene, 15 gal., blow-molded, ICC-34 (DOT-34)	2.00
Carboy, 15 gal., glass, nitric acid service, wooden crate	2.00
Jug, 1 gal., glass, with finger handle, plastic cap	0.1335
Bottle, 1 qt., glass, "Boston" round, plastic cap	0.034
Jar, 1 qt., glass, wide mouth, plastic cap	0.034

(cont.)

TABLE 3-1

Types of Containers

Container size, description	Usable volume, cu. ft.
Carboys, plastic drums, jars, bottles (*continued*)	
Jar, 1 gal., polyethylene, wide mouth, plastic cap	0.1333
Bottle, 1 gal., polyethylene, narrow neck, plastic cap	0.1333
Bottle, 1 qt., polyethylene, narrow neck, plastic cap	0.034
Jar, 1 pt., polyethylene, wide mouth, plastic cap	0.017
Cans, pails	
Pail, 5 gal., steel, tight head, 28-gage black steel, PE pour spout, unlined	0.67
Pail, 5 gal., 28-gage black steel, removable head, unlined, lug cover, wire bail handle	0.67
Can, 1 gal., friction wedge lid, handle (paint can)	0.1333
Can, 1 qt., friction wedge led (paint can)	0.034
Can, 1 gal., oblong "F" style, handle, screw cap	0.1333
Can, 1 qt., oblong "F" style, screw cap	0.1333
Wrap materials	
Film, polyethylene, non-shrink, blown-tube type, yield = 30,000 sq. in./(lb.)(mil), (Zendel std. packaging)[a]	—
Film, polyethylene, shrinkable 70% machine direction, 30% cross machine direction, yield before shrinkage = 30,000 sq. in./(lb.)(mil), (Zendel S-203)[a]	—
Film, polypropylene, shrinkable, yield before shrinkage = 31,100 sq. in./(lb.)(mil), Udel LTS[a]	—
Paper, kraft, wrapping quality, 50 lb./ream basis weight, yield = 3,000 sq. ft./ream	—

Source: Perry and Chilton, Chemical Engineer's Handbook, McGraw-Hill, 5th Ed., 1973, Ch. 7

acids, strong alkalies, or halogenated chemicals (both organic and inorganic) because these compounds tend to corrode steel drums fairly rapidly.

2. <u>Coatings and Linings</u>

Protective coatings and linings are layers of materials that are impermeable to specific chemical compounds in which they are applied and are used to prevent or retard significantly the corrosion of the containers. Useful life is thereby increased. Coatings are also used for abrasion resistance and to facilitate cleaning. The same or different coatings may be applied to the inside and outside of the container.

Coatings and linings are usually applied to containers using spray equipment followed by curing in baking ovens. The function, ~~degradation, performance, and types of coatings and linings are~~ discussed below.

a) <u>Functions</u>. A coating or lining serves two principal functions: (1) it protects the substrate (metal) from attack by a corrosive waste; and (2) it prevents the formation of hazardous products arising from any chemical reaction between waste and structural material. Sometimes a toxic gas inside the coating is produced, and the pressure from this gas may, in some instances, rupture the container or cause bulges. Lined containers are easier to clean.

The type of waste to be stored may dictate that it is prudent for an owner or operator to choose a coated container. For example, acidic or chloride-containing wastes should not be stored in steel containers unless they are coated. Polyvinyl chloride or polyester coatings exhibit good resistance to inorganic acids and alkalies. If organic solvents are to be stored, a coated container would not be used. Other factors, in addition to the materials being stored, should be considered in the decision as to whether to use a lined container. For instance, some coatings, such as chlorinated rubbers, are degraded by heat and ultraviolet light, while others, such as epoxies, are degraded by cold temperatures.

b) Degradation. Degradation of a coating is evidenced by changes in coating color, blistering, and, ultimately, peeling.

c) Performance. The performance of a coating depends upon its application and is influenced by the following factors: (1) nature of waste; (2) pH, (3) ambient temperature; (4) storage conditions, e.g., exposure to weather; and (5) thickness of the coating. These factors affect the stability of the coating and, therefore, its resistance to chemical attack.

One of the most important properties associated with the chemical resistance of a coating is its permeability. This is an inherent property determined by the nature of the resin or resins used, the formulation, the film thickness, the nature of the environment, and the temperature. The extent of permeation is determined by the actual conditions of use. Some chemicals are more highly permeating than others. Permeability increases rapidly with increasing temperature and decreases with increasing film thickness. Solvation and absorption are other physical phenomena that can be detrimental to a coating.

d) Types of Coating and Lining

The general characteristics of commonly used industrial coating of each type of material are categorized in Table 3-2 by the general nature of the binder. It is important to recognize that differences in manufacturing processes and additives used to make coatings may result in considerable differences in lifetime and performance of coatings of the same generic type.

Furthermore, combinations of one or more generic types of coatings may provide protective systems with a resistance different and even superior to the separate components. An example is the addition of silicone to alkyds, or vinyls to other types of coatings to improve not only water and temperature resistance, but ease of application. Another instance is the copolymerization ~~of epoxy with phenolics that makes an air-dry~~ epoxyphenolic with superior chemical resistance superior to either the phenolic or epoxy alone.

The most widely used lining materials today are ployethylene, chlorinated polyethylene, and polypropylene. These materials have an excellent chemical resistance to strong acids and strong alkalies in concentrated and dilute form, but exhibit a poor resistance to certain organic solvents. They also feature excellent weatherability and durability.

Phenolics, vinyls, epoxies, and polyesters are among the many organic coatings applied to metal containers. The following are some of the most common materials used:

TABLE 3-2

Properties of Principal Coating Resins

	Description	Performance	Limitations	Comments
Alkyds	Esterification of polyhydric alcohol (glycerol) and a polybasic acid (phthalic acid), modified with a drying oil. Hardens by solvent evaporation and oxidation	Good resistance to atmospheric weathering and moderate chemical fumes; not resistant to chemical splash and spillage. Long oil alkyds have good penetration although are slow drying. Short oil alkyds are fast drying. Temperature resistant to 225 F.	Not chemically resistant; not suitable for application over alkaline surfaces such as fresh concrete.	Long oil alkyds make excellent primers for rusted and pitted steel and wooden surfaces. Corrosion resistance is adequate for mild chemical fumes that predominate in many industrial areas. Used as interior and exterior industrial and marine finishes.
Vinyls	Polyvinyl chloride—polyvinyl acetate copolymer dissolved in strong polar solvent, generally a ketone. Coating hardens by solvent evaporation.	Insoluble in oils, greases, aliphatic hydrocarbons and alcohols. Resistant to water and salt solutions. Not attacked at room temperature by inorganic acids and alkalis. Fire resistant; good abrasion resistance.	Strong polar solvents redissolve the vinyl. Initial adhesion poor. Relatively low thickness per cost (1.5–2.0 mils). Some types will not adhere to bare steel without primer. Pinholes in dried film more prevalent than other types.	Tough and flexible; low toxicity; tasteless; colorless; fire resistant. Used in potable water tanks and sanitary equipment; widely used industrial coating.
Chlorinated rubbers	Formed by adding chlorine to unsaturated isoprene units. Resin is dissolved in aromatic hydrocarbons, esters and ketones. Hardens by solvent evaporation.	Low moisture permeability and excellent resistance to water. Resistant to strong acids, alkalis, bleaches, soaps and detergents, mineral oils, mold and mildew. Good abrasion resistance.	Redissolved in strong solvents. Degarded by heat (200 F. dry and 140 F. wet) and ultraviolet light, but can be stabi zed to improve these properties. May be difficult to spray, especially in hot weather.	Fire resistant; odorless; tasteless and non-toxic. Quick drying and excellent adhesion to concrete and steel.. Used in concrete and masonry paints, swimming pool coatings, industrial coatings, marine finishes.
Epoxy, amine cured	Reaction of active hydrogens of aliphatic amines with epoxy groups of bisphenol-A epichlorhydrin resin. Coating hardens by solvent evaporation and cures by cross linking. Amine adduct epoxies consist of partially prepolymerized coatings to which the remainder of the amine is added prior to application to complete the cross linking.	Excellent resistance to alkalis, most organic and inorganic acids, water and aqueous salt solutions. Solvent resistance and resistance to oxidizing agents is good as long as not continually wetted. Amine adducts have slightly less chemical and moisture resistance.	Harder and less flexible than other epoxies and intolerant of moisture during application. Coating will chalk on exposure to ultraviolet light. Strong solvents may lift coatings. Temperature resistance: 225 F. dry, 190 F. wet. Will not cure below 40 F.; should be topcoated within 72 hr. to avoid intercoat delamination. Maximum properties require about seven days cure.	Good chemical and weather resistance. Best chemical resistance of epoxy family. Excellent adhesion to steel and concrete. Widely used in maintenance coatings and tank linings.
Epoxy, polyamide cured	Reactive polyamide resins (condensation products of dimerized fatty acids with polyamines) combined with epoxide groups in the epoxy resin. Coating hardens by solvent evaporation but cures by cross linking.	Superior to straight epoxies for water resistance. Excellent adhesion, gloss, hardness impact and abrasion resistance. More flexible and tough than amine epoxies. Chemical resistance slightly less than straight epoxies. Temperature resistance: 225 F. dry; 150 F. wet.	Cross linking does not occur below 40 F. Maximum resistances generally require seven days cure at 70 F.	Easier to apply and topcoat, more flexible and better moisture resistance than straight epoxies. Excellent adhesion over steel and concrete. A widely used industrial and marine maintenance coating. Some formulations can be applied to wet or underwater surfaces.
Epoxy ester	Formed by reaction between epoxy resin and unsaturated fatty acids (commonly linseed and soya oils). Coating hardens by solvent evaporation and oxidation.	Least resistant of epoxy family. Good weather resistance; chemical resistance better than alkyds and usually sufficient to resist normal atmospheric corrosive attack.	Not resistant to strong chemical fumes, splash or spillage. Temperature resistance 225 F. dry.	A high quality oil base coating, good compatibility with most other coating types. Easy to apply. Used widely for atmospheric resistance in chemical environments on structural steel, tank exteriors, etc.

TABLE 3-2

Properties of Principal Coating Resins

	Description	Performance	Limitations	Comments
Epoxy, coal tar	Coal tar mixed with epoxy resin and cured using either an amine or a polyamide. Coating hardens and cures by cross linking.	Excellent resistance to salt and fresh water immersion. Very good acid and alkali resistance. Solvent resistance is good, although immersion in strong solvents may leech the coal tar.	Embrittles on exposure to cold or ultraviolet light. Cold weather abrasion resistance is poor. Should be topcoated within 48 hr. to avoid intercoat adhesion problems. Will not cure below 50 F. Black or dark colors only. Temperature resistance 225 F. dry, 150 F. wet.	Good water resistance. Thicknesses to 10 mils per coat. Can be applied to bare steel or concrete without a primer. Low cost per unit coverage.
Latex	Latex resins (generally styrene-butadiene, polyvinyl acetate, acrylic or blends) are emulsified in a water vehicle. After application the water evaporates and the resin particles coalesce and sinter to form the coating.	Resistant to water, mild chemical fumes and weathering. Good alkali resistance. Latexes are compatible with most generic coating types, either as an undercoat or topcoat.	Must be stored above freezing. Does not penetrate chalky surfaces. Exterior weather and chemical resistance not as good as solvent or oil base coatings.	Ease of application and cleanup. No toxic solvents. Good concrete and masonry sealers because breathing film allows passage of water vapor. Used as interior and exterior coatings.
Polyesters	An unsaturated polyester (resulting from esterification reaction between polyhydric alcohol and polybasic acid) is further reacted with diallyl phthalate to cross link and harden.	Excellent resistance to acids, organic solvents and water, as well as abrasion and abuse resistance.	Hard and inflexible. Very short pot life. Swelled and softened by strong alkalis. Minimum thickness of 6 mil required for cure.	Inert, tile-like appearance. Good adhesive and cohesive strength. High film build per coat (10 mils). Used in maintenance coatings and linings for tanks and process equipment.
Silicone	Composed of the siloxane bond with various organic side chains.	As heat resistant coating, requires catalyzation and baking. With aluminum pigments can withstand 1,000 F.; with ceramic frits up to 1,400 F. As a water repellant, resinous silicones in hydrocarbon solvents are used on masonry. Water soluble alkaline silicone in water are used on limestone and concrete.	Heat resistant silicones have moderate chemical fume resistance at lower temperatures.	Can be combined with other coating types to improve properties such as heat and moisture resistance. Water repellants are clear, breathing and durable. Used as stack coatings and above grade water repellants.
Zinc rich	Inorganic type consists of zinc dust in binder such as a silicate. Can be post or self cure, and can harden either by curing compound, water evaporation or hydrolyzation. Organic form used vehicles such as epoxies, phenoxies or chlorinated rubber. Hardens by chemical cross linking or solvent evaporation.	Resistant to weathering and mild chemical fume environments. Zinc in the coating is attacked when pH is below 6 or above 10.5. Inorganic type is resistant to abrasion and temperatures up to 700 F.	Requires clean steel surfaces. More difficult to apply than conventional coatings. Topcoating may be difficult especially with inorganics. Must be topcoated in severe corrosion environments.	Eliminates pitting corrosion. Despite limitations, widely used as industrial and marine primer. In mild environments can be used as one coat system.
Fire retardant	Flame retardant use non-flammable resins and plasticizers with compounds (such as bromates) that generate non-flammable gases. Intumescent coatings bubble and swell upon heating, thus insulating substrate from the fire.	Can reduce surface flammability or initial heat effects of fire but should be used only with conventional fire protection methods. Properties are generally better the thicker the coating.	May not be as chemically resistant as same type non-fire retardant coating. Generally provide only a few minutes delay. Some intumescent coatings are water sensitive and will not retain full properties after prolonged exposure to weather.	Used to reduce flame spread on combustible materials and to initially insulate structural steel from heat of fire.

Source: K. B. Tator, "Engineers Guide to Protective Coatings", Chemical Engineerin Vol. 79, No. 27, Dec. 4, 1972.

1. Amine-cured epoxy coatings are widely used on tanks and containers. They exhibit excellent resistance to alkalies, most organic and inorganic acids, water and aqueous salt solutions, and organic solvents. Their main disadvantage is that they tend to chalk and deteriorate with prolonged exposure to ultraviolet light (i.e., sunlight).

2. Polyamide-cured epoxy coatings are superior to ordinary epoxies for their water resistance, hardness, impact and abrasion resistance, and adhesive strength. Their chemical resistance is comparable to that of ordinary epoxies, and their temperature resistance is higher.

3. Epoxy esters are the least resistant of the epoxy family. However, they have good weather and chemical resistance and are usually able to resist normal atmospherics corrosive attacks. They are not resistant to strong chemical fumes.

4. Polyesters are commonly used as maintenance coatings and linings for tanks and process equipment. They also may be used to coat steel containers. They exhibit excellent resistance to acids, organic solvents, water, abrasion, and improper handling. They tend, however, to swell and soften in the presence of strong alkalies.

In evaluating the compatibility of a coating or lining material with a specific waste, the permit writer may need to consult with its manufacturer. The characteristics of the waste must, however, be known, particularly pH and concentration of reactive chemical constituents, before contacting a coating or lining manufacturer.

Some examples of deterioration of liners by incompatible wastes include: polyvinyl chloride by strong polar solvents; chlorinated rubbers by strong solvents; polypropylene, polyethylene and ABS (acrylonitrile-butadiene-styrene) polymers by benzene, carbon tetrachloride, or acetone.

4. <u>Specifications</u>

The hazardous waste storage regulations do not include a design standard for containers that prescribes strength, corrosion resistance, and other factors related to the structure of containers. Such a design standard may, however, be instituted in the future. Although design standards are not a matter of regulations, the permit writer is urged to review the corrosion and compatibility characteristics of proposed waste and container systems, recommend changes, and make suggestions for improvements.

The Department of Transportation's (DOT) hazardous materials regulations (49 CFR 173, 178, and 179) require that all hazardous materials (including waste) be transported in containers that have been designed according to DOT specifications and have been approved by DOT. At some future date, EPA may decide to require that containers used for onsite storage of hazardous waste also be DOT approved.

Standard DOT specifications for steel drums are given in Table 3-3. Heavier gauge drums are used to store and transport liquids, whereas lighter (22- to 26-gauge) steel drums are normally reserved for handling dry bulk materials. Drums used to store liquids are generally specified by volume while those used to store bulk solids are usually specified by dimensions.

Containers certified by DOT as returnable are generally constructed of 18 or lower gauge metal. Steel drums must also bear a code indicating the metal gauge, volume capacity, manufacturer's name, and date of manufacture. In general, drums that are designed to contain liquids are usually of a closed-head type, with a 2-inch-pipe-thread opening for filling and emptying,

TABLE 3-3

TYPICAL STEEL-DRUM SPECIFICATIONS FOR HAZARDOUS MATERIALS

Capacity gal	Inside diameter	Inside height	Outside diameter	Overall height	Steel gauge, body	Steel gauge, cover	Steel gauge, bottom	Steel gauge, ring	Tare weight (approx.)	DOT spec.
55	22 1/2	32 11/16	23 27/32	34 13/16	16	16	16	12	64.5	17C
55	22 1/2	32 11/16	23 27/32	34 13/16	8	16	18	12	55.5	17H
30	18 1/4	27 5/16	19 19/32	29	18	18	18	12	37.5	17C & 17H

Notes:

1. All dimensions given in inches. Dimensions are within normal manufacturing tolerances of ± 1/16 in. (± 1/8 in. on height).

2. Container weights shown are approximate and may vary within the allowable limits for manufacturers' standard gauge.

3. On the 55-gal drum, a third rolling hoop, directly below the top rim, gives strength and rigidity to meet specifications.

4. These drums meet Department of Transportation Specifications DOT 17H and DOT 17C for storage and shipment of hazardous materials. They also meet Rule 40 of the Uniform Freight Classification, and Rule 260 of the National Freight Classification. DOT 17H drums also comply with ANSI standards.

5. Table and notes from Inland Steel Container Co.

Source: Schultz, G.A., "In-Plant Handling of Bulk Material in Packages and Containers", Chemical Engineing Deskbook, Vol. 85, No. 24, Oct. 30, 1978.

and a 3/4-inch-pipe-thread opening for venting. Dry products are packed in removable head drums. The removable cover is fastened in place with a locking ring tightened by a bolt or toggle lever. Variations include a friction plug in the head or bug-type cover with approximately 20 tabs on the cover that can be bent under the rim of the drum.[3]

5. Advantages and Disadvantages

See Table 3-4 for a brief overview of the advantages and disadvantages of using drums for storage of hazardous waste.

TABLE 3-4

ADVANTAGES AND DISADVANTAGES OF DIFFERENT TYPES OF CONTAINERS

	ADVANTAGES	DISADVANTAGES
STEEL	1. Versatile - heavy and light-weight gauges available 2. Widely available 3. Durable 4. Structurally superior to all other materials 5. Reusable in some cases 6. If lined, highly resistant to many wastes	1. If unlined, not for corrosive wastes 2. Expensive (coated drums more so) 3. Heavier
PLASTICS	1. Durable 2. Widely available 3. Easy to clean 4. Reusable in some cases 5. For wide range wastes	1. Not for concentrate organics 2. Not amendable to rc handling
[illegible]BER	1. Light weight 2. Low cost	1. Only for dry solids unless coated 2. Structurally inferi to steel/plastic 3. Less durable 4. Damage by weather 5. Not reusable
WOOD BARRELS/ KEGS	1. Low cost	1. Unlined barrels not for liquids 2. Damaged by weather 3. Not reusable
BAGS/SACKS	1. Lightweight 2. Low cost	Questionable for hazar waste storage: 1. Low durability 2. Large volumes bulk difficult to handl 3. Not for liquids, i able, reactive was 4. Not for handling w mechanical equipme 5. Not reusable
CARBOYS	1. Efficient for small amounts	Glass/earthenware not recommended for hazard waste storage: 1. Fragility 2. Not for handling w mechanical equipme

B. Plastic Containers

1. Compatibility

Plastics are highly resistant to inorganic acids and caustic materials at various concentrations. They are, however, degraded relatively rapidly by organic solvents. Polythylene and polypropylene tolerate dilute organic acids, but are not resistant to concentrated organic acids. The chemical resistance of some important plastics is shown in Table 3-5.

2. Specifications

Plastic containers are manufactured in the same sizes and capacities as steel containers. Refer to Table 3-3 for these specifications.

3. Advantages and Disadvantages

See Table 3-4.

C. Fiber Containers

Fiber drums are rigid containers commonly used for storing noncorrosive dry bulk solids. The sidewalls are usually made of kraft piles bonded by an adhesive. The top and bottom ends are made of fiberboard or steel, fitted to the cylindrical shell and tapped or latched into place. Sometimes the walls are lined or coated.

The strength of a fiber drum is directly related to the number of plies in the walls. The strength is measured and drums rated by the burst-strength test. Strength rating for the sidewalls range from 250 to 900 lb/in. The bulk capacity of fiber drums varies from 30 to 400 lbs. Various construction techniques are

CHEMICAL RESISTANCE OF IMPORTANT PLASTICS

		Poly-propylene poly-ethylene	CAB*	ABS+	PVC o	Saran	Polyester glass	Epoxy glass	Phenolic asbestos	Fluoro-carbons	Chlori-nated polyether Penton	Poly-carbonate
Acids	10% H_2SO_4		2	1			1	1	1			
	50% H_2SO_4		4	1			2	1	1			
	10% HCl	1	1	1	1	1	1	1	1	1	1	1
	10% HNO_3		4	2			2	2	3			
	10% Acetic		2	1			1	1	1			
Alkalies	10% NaOH		3		2	3	3	1	4			
	50% NaOH	1	4	1	1	3	4	2		1	1	1
	NH_4OH		4		1	4	3	1				
Salts	NaCl								1			
	$FeCl_3$								1			
	$CuSO_4$	1	1	1	1	1	1	1	1	1	1	1
	NH_4NO_3								2			
Gases	Wet H_2S	1	1		1	1	1	1				
	Wet Cl_2	4	4	1	2	4	2	2	1	1	1	
	Wet SO_2	1	4		1	2	1	1				
Organics	Gasoline	4	1	1	1	1	1	1	1		1	1
	Benzene		4	4	4	3	2	1	1		3	3
	CCl_4		4	4	3	3	1	2	1	1	3	4
	Acetone		4	4	4	3	4	2	4		2	2
	Alcohol		4	1	1	1	1	1	1		1	1

Ratings are for long-term exposure at ambient temperatures (<100°F)

1 = Excellent

2 = Good

3 = Fair

4 = Poor

* Cellulose acetate butyrate

\+ Acrylonitrile butadiene styrene polymer

o Polyvinyl chloride, type I

Chemical resistance of Saran-lined pipe superior to extruded Saran in some environments

Refers to general-purpose polyesters. Special polyesters have superior resistance, especially alkalies.

After Perry and Chilton's, Chemical Engineer's Handbook.

used for specific bulk-handling and liquid-handling requirements (Table 3-6).

1. Compatibility

As previously stated, fiber containers are normally used for solids. If, however, a coating which is liquid resistant is applied to the inside of a fiber drum, it can be used to store liquids. Liquid-resistant coatings are commonly made from plastics such as polyethylene. The compatibilities for plastic-coated fiber drums would then be determined in the same way as for plastic containers.

2. Coating and Linings

In order to resist moisture, linings and coatings are often applied to fiber drums that are to be used to store hygroscopic material. In addition, chemical attack or deterioration due to weather can be guarded against by a lining that is non-reactive with the waste or is durable to the climatic conditions.

3. Specifications

In the discussion of specifications for steel containers, it was noted that containers for shipping purposes must comply with DOT standards. This is true for any type of containers used to transport hazardous materials.

DOT fiber drums usually are specified according to inside diameter, wall thickness, and overall outside height. Wall construction, type of ends and any special barrier treatment are also directed by DOT. The capacity and construction of standard fiber drums made in accordance with DOT specifications are listed in

TABLE 3-6

Materials and Closures of Fiber Drums

Basic construction
All fiber
Fiber sidewalls, wooden heads
Fiber sidewalls, metal heads
Typical top and bottom construction
Wood top and bottom with metal seal
Metal top and bottom
Metal cover with locking bands
Recessed fiber ends
Metal top and bottom with friction covers
General types of closures
Held by tape
Lever-actuated bands
Crimped lids
Nails
Metal clips

Source: Schultz, G.A., "In-Plant Handling of Bulk Material in Packages and Containers," Chemical Engineering Deskbook, Volume 85, No. 24, Oct. 30, 1978.

Table 3-1.

4. Advantages and Disadvantages

See Table 3-4

D. Barrels and Kegs

Barrels are bilged (bulging) cylindrical containers with flat heads of equal diameters. Their rated capacity usually exceeds 30 gallons and their materials of construction may be low-carbon steel, stainless steel, or a variety of woods, depending on their use.

They are generally divided into two classes: (1) non-watertight slack barrels with paper liners to prevent sifting, which are usually used for dry materials and (2) tight barrels used to ship liquids.

1. Compatibility

If barrels are made of wood and are unlined, hazardous liquids should not be stored in them. This is due to the fact that wood is relatively pervious to most liquids. For the same reason, dry materials that must remain dry should not be stored outdoors in wooden barrels. Barrels and kegs, however, are not often use for the storage of hazardous waste.

2. Coatings and Linings

Barrels are frequently coated with paraffin in order to make them watertight. Noncorrosive or mildly corrosive liquids can then be stored in barrels with such a coating. Other lining materials, such as blends of wax and polyethylene, also provide greater resistance to corrosive materials.

3. Specifications

For barrels constructed of stainless steel, the type of steel used in the shell and head sheets is identified by an American Iron and Steel Institute (AISI) type number. The AISI sets design specifications and standards for iron and steel storage vessels including tanks and containers. AISI designations are related in a limited way to DOT specifications. For example, the type of manufacture of a stainless steel container is shown by an AISI number, and may be included as a part of the DOT specifications. The letters HT (heat treatment) following the steel designation indicate the containers that have been subjected to stress relieving or heat treatment during manufacture.

Barrels and kegs that are approved by DOT have been constructed in accordance with standards related to: (1) rated capacity; (2) composition of materials; (3) construction of container; (4) dimension of container; (5) closures; (6) markings; and (7) leakage tests.

E. Bags and Sacks[6]

Frequently, paper bags are used for packaging pesticides, and plastic bags are used as liners in rigid containers. Bags and sacks are also commonly manufactured from transparent films such as cellophane, polyethylene, polypropylene, woven paper and plastic mesh; and from various textiles. Custom paper bags are also made with special barrier sheets (e.g., foil or polyethylene) in almost any size desired to meet special requirements. Completely siftproof and moisture proof construction are also available. Two bag designs are commonly used:

1) Valve design - this has both ends closed during fabrication. The filling is done through a small opening (valve) in one corner of the bag.

2) Open-mouth design - this has one end closed at the factory. The other end is closed after filling.

Bags and sacks are sometimes used to store hazardous waste. However, due to their low durability and lack of strength relative to, for example, steel or plastic containers, the permit writer should carefully scrutinize the design of any bag or sack proposed for use in storage of hazardous waste as well as the handling methods proposed. Judgment must be used to consider the situation as a whole.

1. Compatibility

Since bags and sacks are manufactured in a wide variety of materials, a given waste is probably compatible with some type of bag or sack in most cases. Off-specification chemical products that become wastes may be stored in their original paper or plastic packing only if the storage conditions are compatible with the packing.

It should be noted that plastic bags should be especially guarded against high ambient temperatures to prevent rapid deterioration.

2. Specifications

Table 3-1 gives specifications of standard-size bags in accordance with the Uniform Freight Classification Committee.

DOT also gives specifications for bags and sacks in 49 CFR 17

F. Carboys

A carboy is a container made of glass, earthenware, plastic or metal having a capacity of five to thirteen gallons. They are used principally for carrying corrosive liquids, chemicals, distilled spirits, and similar materials. Carboys are usually encased in a rigid protective outer container.[6]

Glass or earthenware carboys are generally not recommended for the storage of hazardous waste because they may break. When faced with a proposal to use carboys, the permit writer is advised to heed the same cautions as when confronted with a plan to store hazardous waste in bags or sacks.

1. Compatibility

Generally, glass carboys may be used to store an off-specification batch of a substance.

Carboys made of polyethylene are incompatible with wastes containing benzene, acetone, carbon tetrachloride, or alcohol.

2. Specifications

Carboys designed in accordance with DOT specifications include the following: (1) name and year of manufacture marked on the outside of the container; (2) acid-proof stoppers or other devices, with gaskets securely fastened; (3) venting devices, when necessary, to prevent internal pressures in excess of 8 psig at 130F; (4) wooden boxes completely enclosing the body of the carboy, or wooden boxes completely enclosing the body and neck, carrying cleats; (5) specified shock tests; and (6) liquid-tight cap of suitable plastic or other material or liquid-tight cap up to the venting pressure when such venting is prescribed.

G. Containers for Storing Ignitable and Combustible Liquids

Ignitable and combustible liquid wastes should be stored in metal containers that meet the requirements of Chapter I, Title 49, of the Code of Federal Regulations (DOT regulations), or National Fire Protection Association, NFPA-386, Standards for Portable Shipping Tanks. In order to comply with these standards, the applicant must use containers with one or more devices installed that have sufficient emergency venting capacity to limit internal pressure to 5 psig or 30 percent of the bursting pressure of the container, whichever is greater under fire exposure conditions.[3] At least one pressure-activated vent having a minimum capacity of 600 cubic feet of free air per hour (14.7 atm. and 60F) must be used. It should be set to open at not less than 5 psig. If fusible vents are used, they should be activated by elements that operate at a temperature not exceeding 300F. When used for paints, drying oils, and similar materials, where the pressure-activated vent can become plugged, fusible vents or vents that soften to failure at a maximum of 300F under fire exposure, may be used to meet the emergency venting requirement.[8]

CHAPTER 4

MANAGEMENT OF CONTAINERS

A. Introduction

This chapter deals with the management of containers and specific relevant issues that, in most cases, have been addressed in the regulations. These areas of concern, along with the cited regulations, are: condition of containers (§264.171); compatibility of waste with containers (§264.172); incompatible wastes (§264.177); ignitable or reactive waste (§264.176); and secondary containment (§264.175).

In addition, container-handling techniques, current storage practices, facility design considerations and operating procedures, and information about liners is discussed.

B. Current Storage Practices

As described in Chapter 3, few containers are, in general, designed specifically for the storage of hazardous waste. Also, management of hazardous waste storage sites is not a well-developed art. Therefore, much of the content of this chapter borrows from functions relevant to storage or various materials in containers (e.g., warehousing techniques), where extrapolation of good practices to hazardous waste management is considered desirable. The applicability of several types of containers to hazardous waste management was discussed in Chapter 3.

Containers used to store hazardous waste can be efficiently handled in a few different ways in order to minimize the possibility of ruptures and leaks and make effective use of space. These methods are described below.

Storage practices discussed in this section pertain to both indoor and outdoor facilities. It should be noted that in addition to the storage practices where combustible or flammable wastes are stored, the standards set forth in NFPA 30[8] for storage of flammable and combustible liquids should be complied with. These standards specify requirements for: (1) quantities and height limits (2) separation and aisles, (3) building design factors related to stacking drums, when containers are stored indoors, and (4) fire protection.

1. Stacking in Pallets and on Plywood Sheets

Drums, kegs, and pails of various sizes are frequently stored on pallets. A pallet is a flat, portable platform properly constructed to sustain loading and handling by mechanical equipment. A standard pallet dimension is 40 by 45 inches, which allows for sufficient loading and fits into trailers and freight cars. Other sizes are also available. Expendable pallets are made of paperboard or foam plastic and can also be manufactured from foam blocks glued to a corrugated fiber sheet. Wood pallets are made from a variety of woods; solid plastic pallets are also available. The latter have the advantages of not splintering and of requiring less maintenance. The bearing load of the cheapest pallet is about 500 lbs., while the sturdier pallets can carry up to 10,000 lbs. The Material Handling Association issues specifications for pallets.

Depending upon the type of container used, the characteristics of the waste stored, and the amount of space available, the owner or operator can place containers in single rows on a pallet or stack them. For example, if space is tight and containers amenable to stacking are used, stacking on pallets can be an efficient usage of space. Another advantage of pallets is that they hold containers a few inches off the base of the containment area and may be effective in preventing standing liquids (accumulated precipitation, leaked or spilled waste, or both) from coming into direct contact with the containers, thereby accelerating corrosion. Use of pallets between containers also facilitates later movement of the containers.

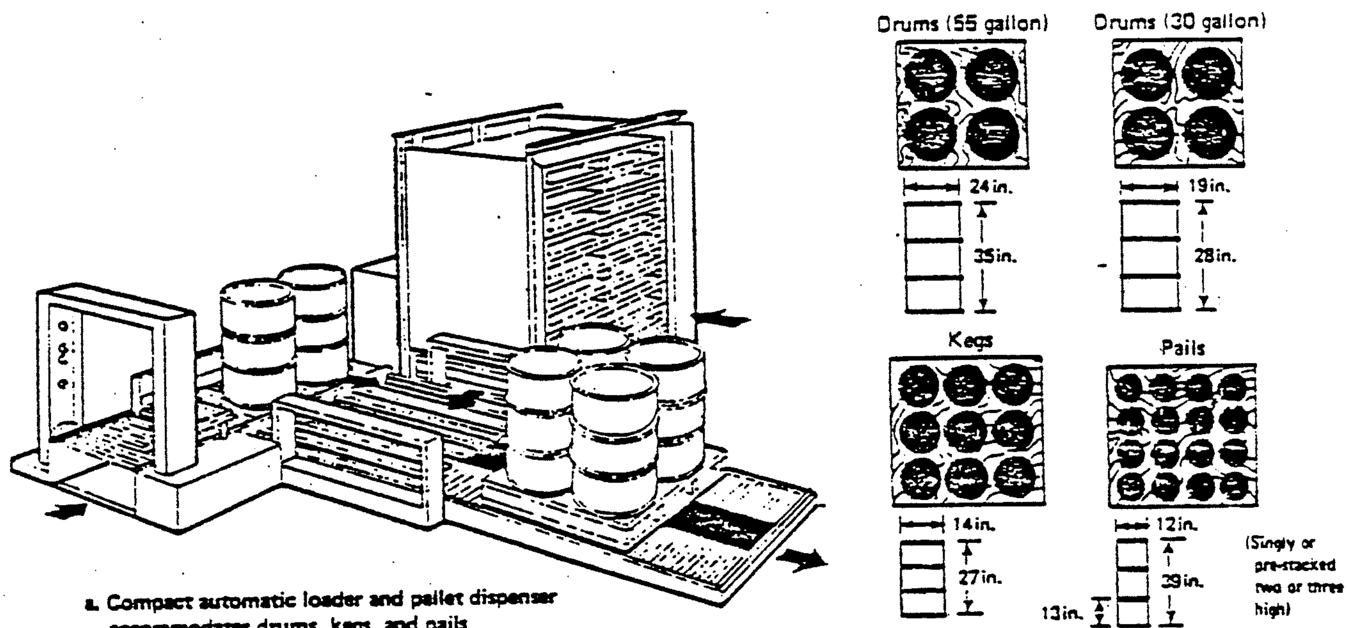
Figure 4-1 illustrates an automatic pallet dispenser. Also shown are standard loading patterns that make efficient use of pallet space.

Plywood sheets are also frequently used instead of pallets. Containers are stacked vertically in order to facilitate handling and storage.

It is important both for purposes of safety and to prevent possible rupture or weakening of bottom containers that the containers not be stacked too high. Factors to consider in determining the maximum height of a stack include: (1) type of containers; (2) condition of containers; (3) maximum lift of fork-lift used to handle the containers; (4) type of fork-truck attachments available; (5) use of pallets or plywood sheets. All of these factors must be judged together in ascertaining a maximum height for stacked containers or, indeed, whether containers

FIGURE 4-1

Automatic Container Palletizing



a. Compact automatic loader and pallet dispenser accommodates drums, kegs and pails

b. Standard loading patterns for drums, kegs and pails make efficient use of space

Source: Perry and Chilton, Chemical Engineer's Handbook, McGraw-Hill, 5th Ed., 1973, Ch. 7.

should be stacked at all. This is an area where the permit writer's judgment must be used, giving consideration to the individual facility and the wastes to be stored. Some containers may, for example, be too unwieldy to stack. It may not be prudent to stack drums of highly hazardous waste. Regardless of the type of container used or the degree of hazard of the waste, containers of hazardous waste probably should not be stacked very high; exactly how high is a matter of negotiation between the permit writer and the permit applicant.

For containers storing ignitable/flammable or combustible materials, the NFPA standards shown in Table 4-1 should be applied. Classes IA, IB, and IC apply to flammable liquids. Classes II and III apply to combustible liquids. Flammable and combustible liquids are defined in NFPA 30,[8] the Flammable and Combustible Liquids Code. Stack heights for groups of materials are given. When two or more classes of materials are stored in the same stack, the most conservative figure should be observed to maximize safety.

2. Racks

Usually built of tubular steel, racks are structures on which containers may be stored either vertically or horizontally. The racks may be coated with a variety of corrosion-resistant materials.

Racks can be used to store either a single row of containers or a double row (see the NFPA publication number 231C, titled "Rack Storage of Materials").[9]

TABLE 4-1

Outdoor Liquid Storage in Containers

Class	Container (<60 gal.) Storage Max per Pile		Container (>60 gal.) Storage Max per Pile		Distance Between Piles or Racks
	Gallons	Height (ft)	Gallons	Height (ft)	(ft)
1A	1,100	10	2,200	7	5'
1B	2,200	12	4,400	14	5
1C	4,400	12	8,800	14	5
II	8,800	12	17,600	14	5
III	22,000	18	44,000	14	5

Source: "Flammable and Combustible Liquids Code, 1981", National Fire Protection Association, ANSI/NFPA 30, Boston, MA.

3. Equipment

Many types of equipment are used in container handling. This includes fork-lift trucks and front-end loaders equipped with drum-cradles or drum-grabbers.

4. Aisle Space

Another area of concern in proper drum storage is adequate aisle space. The owner or operator of a facility must maintain sufficient aisle space to allow the unobstructed movement of personnel, fire protection equipment, spill control equipment, and decontamination equipment to any area of facility operation in an emergency unless it can be demonstrated to the Regional Administrator that aisle space is not needed for any of these purposes (40 CFR 264.35, Subpart C-Preparedness and Prevention). The exact amount of aisle space, how many aisles and their placement in the storage area, is another judgment. The amount of aisle space proposed by the permit applicant must be considered and its adequacy evaluated based on the facility plan as a whole.

Some guidance as to approximate aisle space can be taken from NFPA recommendations. It should be noted, however, that, with the exception of the specific materials and/or situations that NFPA is considering in each standard, the information is to be considered guidance only and should not necessarily be applied to storage of other types of hazardous materials. The purpose in presenting the NFPA data is to give examples. The NFPA data is based on separation of materials in order to prevent hazardous situations, as well as to allow access. NFPA 30[8] specifies that palletized or stacked containers of flammable or combustible materials should be arranged so that rows of drums are separated from each other by a minimum aisle of 4 feet. Aisles should be provided so that no container is more than 12 feet from an aisle. Where liquids are stored on racks, a minimum 4-foot aisle is to be provided between adjacent rows or racks and adjacent storage of liquids. Main aisles should be a minimum of 8 feet wide.

C. Condition of Containers

The regulation (§264.171) specifies that if a container holding hazardous waste is not in good condition, or if it begins to leak, the waste must be transferred to a container that is in good condition or the waste must be managed in some other way that complies with the requirements of Part 264.

"Good condition" is a matter of judgment--a container not in "good condition" would be evidenced by conditions such as severe rusting, leaks, ruptures, and structural defects (such as excessive bulges or dents). The permit writer must use his own discretion in evaluating types of containers and the conditions given by the permit applicant.

Design of containers is discussed in Chapter 3. The design affects a container's ability to withstand weathering, handling, and containerization of wastes for a long period of time. Hence, design indirectly affects the container condition.

Other factors to consider in assessing a permit applicant's storage management plan with respect to the potential effect on the integrity of containers are discussed below.

1. Climatic Conditions

The physical environment in which containers are stored affects their durability.

Corrosion resistance and other physical aspects of a container can be adversely affected by improper storage. For instance, high humidity may lead to reduced corrosion resistance, particularly in the case of indoor storage. High temperatures may also accelerate the corrosion of steel drums.

The ability of a coating to withstand deterioration is also affected by the environmental conditions of the storage area. Although many frequently used coatings are resistant to weathering, problems can develop in cetain situations. For example, some kinds of chlorinated rubber are degraded by heat, particularly when wet, and by ultraviolet light. Coal-tar epoxies become brittle when exposed either to cold or to ultraviolet light. Amine-cured epoxy coatings, widely used in tanks and containers, deteriorate upon exposure to light. Containers with any of these types of coatings should, consequently, not be stored in sunlight.

2. Markings

Containers that have been transported to the facility must be marked according to DOT regulations. Flammable and combustible materials may be labelled according to NFPA specifications. These markings often provide information that may facilitate safe handling and prevent situations that could lead to premature failure of the containers.

Markings may be placed on labels or tags or stenciled on drums.

Information such as the type of hazardous waste stored and the manifest identification number is generally given. Caution labels, placards, and/or warnings (e.g., poison, explosives, corrosives) may be attached as required by DOT standards. Flammable liquids may also include the following marking in accordance with NFPA 30: "FLAMMABLE - KEEP FIRE AWAY."[8]

Palletized loads of containers require the same markings and identifications as individual drums.

3. Dating of Containers now is required

A system of dating the age of drums, while not required, would allow the owner/operator to anticipate when drums may need to be replaced. Drum dating, coupled with knowledge of the deteriorative effects of the waste, can provide a more accurate schedule of drum deterioration and subsequent replacement. The dates may be marked on the drum or placed on a schematic of the drum storage area.

4. Steps to Take If a Container Is Not in Good Condition

The permit applicant should have plans for removing containers from service that are no longer in "good condition." If a container is leaking, if it is suspected that a failure may be imminent due to rusting or structural defects, or if it is at the end of its useful storage life, the contents of the container should be transferred to a serviceable container. When a leak is discovered and a suitable replacement drum cannot be found immediately, it may be acceptable for the leaky container to be placed in an overpack (a recovered drum that is large enough to hold the first container and its contents). The holes are then filled with absorbent material.

5. Recovery and Reuse of Containers

Containers constructed of metal are commonly reused, recycled, or reconditioned. This minimizes disposal of hazardous wastes and maximizes resources. For a detailed report on container reconditioning, consult "Barrel and Drum Reconditioning Industry Status Profile."[10]

If a permit applicant wishes to use reconditioned or recycled drums, the permit writer should make a careful review to ensure that the reconditioned drums will be adequate to contain the waste.

D. Compatibility of Waste with Container (§264.172)

The container and any linings must be compatible with the waste stored in the container. For a discussion of compatibility of waste see EPA's manual titled "Compatibility of Wastes in Hazardous Waste Management Facilities."[2]

E. Incompatible Wastes (§264.177)

The facility standards for handling incompatible wastes require that (a) incompatible wastes must not be stored together in the same container, (b) hazardous waste must not be placed in an unwashed container that previously held an incompatible waste or material, and (c) hazardous wastes stored in containers must be separated from other incompatible wastes or materials or protected from them by a dike, herm, wall, or other device.

The owner or operator can eliminate or at least minimize mistakes owing to incompatibility by conducting proper waste analyses, keeping accurate records, and handling the waste carefully.

Separate spill and run-off collection sumps are also advisable in storage areas for incompatible wastes. The wastes discharged from collection sumps should be segregated from other wastes that are incompatible. Site or floor plans of the facility or piping and instrumentation diagrams (P&IDs) showing location of collection sumps should be furnished by the facility owner or operator.

F. <u>Storage of Ignitable or Reactive Waste (§264.176)</u>

Containers of ignitable or reactive wastes must be located at least 15 meters (50 ft.) from the facility property line. Facility owners or operators should also take precautions to prevent accidental ignition or reaction of these wastes by separating and protecting them from open flames, smoking, cutting and welding, contact with hot surfaces, frictional heat, spontaneous ignition sources (e.g., from heat-producing chemical reactions), and radiant heat. NFPA standards for flammable and combustible materials shoud be applied when storing ignitable or reactive waste.

G. <u>Containment (§264.175)</u>

In storage areas where a secondary containment system is required, the system must be sufficiently impervious that it will hold collected material until detection and removal. The containment system must also drain efficiently so that standing liquid will not remain on the base for extended periods of time subsequent to leakage or precipitation, and containers must be protected from accumulated liquids. The containment system must be large enough to hold 10 percent of the volume of the containers or the volume of the largest containers, whichever is greater. Run-on must be prevented unless the containment system is large enough to accommodate it, and collected material must be removed from the collection area as soon as necessary in order to prevent overflow.

Storage areas that store containers holding only wastes that do not contain free liquids are not required to have a secondary containment system, provided that (1) the storage area is sloped or is otherwise designed and operated to drain and remove liquid resulting from precipitation or (2) the containers are elevated or are otherwise protected from contact with accumulated liquid (§264.175(C)).

Some of the general factors to be considered in designing and evaluating a containment system are discussed below:

1. Properties of the Waste Stored

Some consideration should be given to compatibility of the type of wastes stored with the liner or base to be used. For example, if highly corrosive wastes are to be stored, a very durable, corrosion-resistant base should be installed.

2. Number of Containers

The maximum number of containers, volume of waste, stack height, aisle space, and size of the storage area within the containment area should be considered.

3. Container Capacity

The secondary containment system must be designed to allow for accumulation of precipitation. Storm intensity in the area where the facility is located should be used to determine maximum precipitation. The flow velocity in the drainage system (i.e., drainage channel or pipe) and the bottom and side slopes of the containment structure must also be considered. The design specifications of the facility will indicate if the capacity of the containment system will equal or exceed 10 percent of the total capacity of the containers in the drainage area.

Storm frequency and intensity (expressed in inches) data for a given area are published by the U.S. National Weather Service. Data can also be obtained from the National Climatic Center in Ashville, North Carolina. Run-off volume is commonly calculated as a fraction of rainfall, which is known as the run-off coefficient. Capacity of the containment system can be calculated from these sources. (Refer to the Soil Conservation Service handbook for a detailed discussion of these calculations.)[11]

The storage area should be graded in a manner to divert spills away from buildings or other enclosures or should be surrounded by a curb to contain spills. When curbs are used, provisions must be made for draining accumulated ground or rain water, or spills of liquids. Drains must discharge at a safe location and be accessible to operation under fire conditions.

4. <u>Adequacy of the Containment System</u>

Section 264.175 requires that the containment system base must be "free of cracks or gaps and . . . sufficiently impervious to contain leaks, spills, and accumulated rainfall until the collected material is detected and removed." Since no material is totally impervious, the permit writer must determine if the material proposed for the base by the permit applicant is adequate to hold waste or precipitation until it can be detected and removed.

Waste migration through a base or liner material can be calculated based on the permeability of the base material and the hydraulic impact load of the waste. Formulas and a detailed discussion of how to perform the calculation can be found in EPA's manual on Landfill and Surface Impoundment Performance Evaluation.[12]

If the permit writer can be assured that the base of the containment system will be dry most of the time, there would be a negligible hydraulic impact load on the base and, therefore, minimal waste migration through the base. If all of the other standards for containers in Subpart I are met, the base should remain dry most of the time. For example, if the permit applicant provides a design showing that (a) spilled or leaked waste or precipitation will remain on the base for short periods only (i.e., because the base is sloped to provide drainage or accumulated liquids are pumped out of the containment area shortly after being detected); (b) that waste will not contaminate the outside of the containers and, therefore, generate leachate after precipitation; or (c) that the storage area will be inspected weekly and that the inspector will be able to visually assess the condition of all containers and that any spills or leaks will be quickly cleaned up, then the thickness of the base should not be dependent on waste migration. It should, rather, be based on the ability of the base to adequately support the weight of the drums. In order to make this type of assessment, the permit application should provide the permit writer with the engineering data used to contruct the base.

The permit writer may decide, however, that other storage management plans or designs in which accumulated liquids would remain on the base for longer periods of time, or in which it, might not be possible to closely monitor each container, might be acceptable. In these cases, the permit applicant must demonstrate that the waste will be contained by the base for the life of the facility. To do this, the permit applicant needs to submit calculations showing time for waste to leak through the base, as mentioned previously.

5. Auxiliary structures

The design of the containment system may include curbs or dikes surrounding the storage area and in areas between incompatible wastes. Curbs or dikes may, in some cases, be an integral part of the design for containment capacity and is one means of preventing run-on. Ditches or trenches surrounding the perimeter of the storage area may also be used to prevent run-on.

The Subpart I regulations do not require that these barriers be impervious to the waste being stored; however, the permit writer will probably want to be assured that they have been constructed of a reaonably impermeable material. Curbs may of the storage area may also be used to prevent run-on.

The Subpart I regulations do not require that these barriers be impervious to the waste being stored; however, the permit writer will probably want to be assured that they have been constructed of a reaonably impermeable material. Curbs may typically be made of concrete and are sometimes coated with an impermeable material such as epoxy. Berms and ditches may be lined with a synthetic membrance or may be made of a natural liner material such as clay. (For more information on liners see Lining of Waste Impoundment and Disposal Facilties.[13])

Generally, however, materials such as concrete and asphalt are utilized in storage areas for containers. Liners may be used in placed of, or in addition to, concrete and asphalt.

The height of curbs, walls, or dikes is important not only for containment of spilled or leaked waste and accumulated precipitation, but in the prevention of run-on into the storage area. Run-on can be diverted by proper grading. In evaluating the height and capacity of the containment structure, the permit writer should take into consideration storm intensity and frequency data in the area of the facility and capacity of the leachate and run-off collection system. If a containment system is not capable of adequately discharging run-off from the containment area during a severe storm, the containment structure must provide sufficient holding capacity to prevent overflow. In addition, the containment system design should allow for a reasonable safety factor beyond the minimum height of the barrier.

These include drains that lead into a sump under the base; a sloped base that directs liquids into a sump; elevation of containers on pallets or racks and a plan to pump accumulated liquids out of the storage area; and a roof over the container area. The last design, it should be noted, would only protect against contact of containers with precipitation. Discharged waste would have to be removed in some other manner.

Where a drainage sump is provided, the permit writer should ascertain if the sump, pump, and discharge piping are of sufficient capacity and if the materials of construction are compatible with the wastewater. The permit applicant should provide sump, pump, and piping specifications and diagrams for review.

7. Ability to Clean Up and Remove Spills

The permit writer must be assured that the facility owner or operator has adequate plans and equipment for cleaning up and/or removing any spilled or leaked waste in the containment area. A contingency plan should be included in the permit application for this purpose.

CHAPTER 5

INSPECTIONS OF CONTAINER FACILITIES

Regular inspections of container storage areas is a major management tool for preventing discharge of hazardous waste into the environment. The regulations require that containers, container storage areas, and containment systems be inspected weekly (§264.174).

In a container storage area, inspections can only be expected to reveal obvious problems and give the facility owner or operator a general idea of the type and rate of long-term deterioration of containers. Because corrosion inside a container cannot be detected by visual inspection of a container (external corrosion would be evident) and because sudden or accidental damages occur (e.g., ruptures or leaks), the facility owner or operator should expect to find failures when he make inspections. Inspections must, of course, be combined with remedial action.

The permit writer should review the inspection plan as well as proposed emergency measures in the permit application.

This chapter discusses inspection techniques and evaluation of inspection plans.

A. Containers

Corrosion of metal containers is the major cause of leaks at container storage facilities. To some degree, corrosion of metal is a natural phenomenon. With time, all metals corrode to a certain extent. Since it is an aging process, the management of the site should be planned with the idea that containers susceptible to corrosion will deteriorate over time and, hence, require replacement.

Corrosion may be accelerated when corrosive wastes are stored or when containers are exposed to weather conditions. (See Chapter 4 for a discussion of the impact of climatic conditions on containers.)

The information presented in this chapter should be regarded as a general overview of the subject of corrosion. The permit writer should refer to the guidance manual on hazardous wastes compatibility[2] for more information on corrosion.

A visual maintenance check is the simplest way to detect any corroded, leaking, or structurally defective containers. Since corroded or deteriorating containers will eventually lead to leakage, the detection and packing of faulty containers is integral to spill and leak prevention.

Various forms of corrosion produce different visual results. Some of these corrosion types and signs to be alert for are outlined below.

1. Forms of Corrosion[14]

Corrosion is most often confined to the metal surface of a container. The complete corrosion reaction is divided into an anodic portion and a cathodic portion, occurring simultaneously at discrete points on metallic surfaces. Local cells created either on a single metallic surface (because of local point-to-point differences on the surface) or between dissimilar metals may generate the flow of electricity from the anodic to the cathodic areas. Bimetallic cells derive their driving voltage from the interaction of two different metals. Bimetallic cells are created by the connection of two dissimilar metals.

Corrosion may be uniform or localized. Its product may be easily recognizable, as the reddish-brown particles in the case of iron oxide. The various forms of corrosion are identified below and are illustrated in Figure 5-1.

- Uniform Corrosion. Uniform attack over large areas is the most common form of corrosion. Proper selection of containers and linings or coatings can significantly reduce corrosive action. If corrosion causes discoloration in a particular case, uniform corrosion may be more easily spotted than localized attacks on metal containers.

- Crevice Corrosion. Various changes in the area surrounding the crevices of a container (usually at the seams), such as a deficiency of oxygen or changes in acidity, may cause corrosion. Corrosion also commonly occurs in crevices that contain, for example, dirt deposits, corrosion products, or scratches in the paint film. Consequently, particular attention should be paid to seams when inspections are carried out.

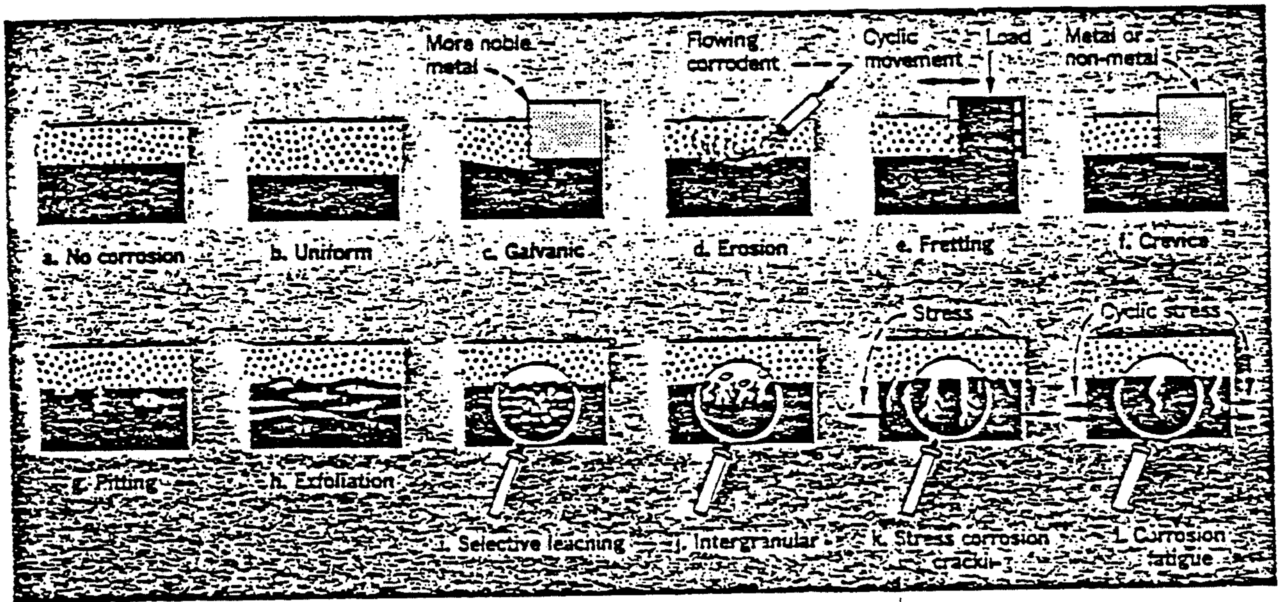
- Pitting Corrosion. Pitting corrosion is caused by the formation of holes in an otherwise relatively unattacked surface. The holes can have various shapes, with the shape often being responsible for continued corrosion. Pitting is generally a slow process (taking several months or years to become visible). The small size of a pit and the small amount of metal dissolved make detection difficult in the early stages. Selection of containers known to be resistant to pitting in a given environment is usually the best protection against this problem.

- Exfoliation and Selective Leaching. Exfoliation is corrosion that spreads below the surface. It differs from pitting in that the attack has a laminated appearance. Whole layers of material are eaten away and the attack is usually marked by a flaky and sometimes blistered surface. Exfoliation and selective leaching occur mostly on steel-aluminum alloys. Consequently, special attention should be given to container bottoms.

- Intergranular Corrosion. In a severe case of intergranular corrosion, the surface of the metal container will appear

FIGURE 5-1

TYPES OF CORROSION



LOCALIZED corrosion is more difficult to control than uniform attack

Source: M. Hawthorne, "Understanding Corrosion", Chemical Engineering, Vol. 79, No. 27, Dec. 4, 1972.

rough and feel "sugary."

- Stress-corrosion Cracking. Stress-corrosion cracking is often identified by the presence of crack branching. A metal container that fails because of stress-corrosion cracking will usually have visible corrosion products on the fracture surface. Stacking containers may exacerbate this form of corrosion. Therefore visual inspection should include checking of stack heights.

- Galvanic Corrosion. Galvanic corrosion is the excess corrosion rate that is associated with electrons flowing from an anode to a cathode in the same environment. Galvanic corrosion is an important consequence of coupling two metals widely separated in the galvanic series. The result is an accelerated attack on the more active metal. Therefore visual inspection should include the checking of the types of containers stored next to each other, as well as how they are stored.

Where corrosion or defects are anticipated and visual inspection confirms the expectation, the contents must be transferred to a container that is in good condition.

Although inspections of containers are required weekly, under some circumstances certain containers should be inspected more frequently. Reasons for additional inspections include: results of previous inspections, contruction and potential for corrosion of the container, properties and corrosion rates of the wastes, potential risk of air or water pollution, and safety to personnel. In addition, containers holding new wastes that have not previously been stored at the facility may warrant more frequent inspections until adequate data on the containers' performance have been collected.

B. Container Storage Areas and the Containment System

1. Visual Inspection

Curbs or dikes can be examined for deterioration and containers can be moved from the base periodically in order to detect any cracks or holes in the base. (Moving the containers probably provides a better than usual inspection of the drums as well.) Vegetation surrounding dikes should be examined for any changes that may be caused by leachate or overflow of spilled waste; a change might be either more luxuriant growth or dying vegetation. Further, the base should be checked to see that containers are not standing in liquids or, if the containment design includes a sloped base or drains, that liquids appear to run off or drain properly. Subsequent to a rainfall, leakage, or spillage, systems designed to remove liquids should be examined to determine if they are functioning properly. Drains should be checked, for example, to see that they are not clogged.

2. Testing

Auxiliary features such as drainage systems, sumps, and pumps should be tested periodically. Emergency response equipment such as alarms and communication systems should also be tested.

As with containers, certain situations or conditions may warrant more frequent inspection of some areas. Situations where drums are subject to the elements, such as outdoor storage, and sections of the containment area that are deteriorating more rapidly than other parts may justify more frequent inspections.

C. Evaluation of an Inspection Plan

An inspection plan should be comprised of a checklist of equipment and items to be inspected, directions for the method of inspection, and a separate schedule for those areas to be inspected more frequently than specified in the regulations. Unlike the design evaluation of a facility, which tends to be conceptual, the inspection evaluation is necessary to make certain that the owner/operator performs all mechanical, visual, or other routine or special inspections. As long as the containers are inspected and judged to be in good condition, the inspection plan may be viewed as satisfactory. The inspection plan should specifically note that the owner/operator is responsible for the detection of corrosion, cracks, leaks, bulges, buckles, and other signs of deterioration. The inspection plan should also indicate that the owner/operator will use industrially acceptable practices to locate any faulty items and make necessary repairs as soon as possible. Remedial procedures for faulty containers, spills, and leaks should be included in the plan. The plan may also provide for changes in operational procedures to ensure the safe operation of the facility.

The evaluation of an inspection plan should include a review of employees' qualifications to conduct inspections, procedures for responding to improper operations observed during inspections, recordkeeping procedures, the inspection log, and personnel training plan. Some key items to be inspected are listed in Table 5-1.

TABLE 5-1

CONTAINER STORAGE FACILITY INSPECTION POINTS

I. Containers

1. corrosion, leakage, or structural defects
2. proper placement
3. proper stacking (including required aisle space)
4. segregation of incompatible wastes
5. missing or improper labeling
6. properly closed containers

II. Container Storage Area and Containment System

1. base for lacerations, cracks
2. berms/dikes for cracks, structural stability, freeboard
3. collection sump and pumping systems for proper operation, periodic maintenance (visual and physical tests)
4. emergency response equipment for alarms, communication systems, fire fighting capabilities
5. fences or barriers for controlling access to the facility
6. clean-up procedures for debris and refuse
7. personnel safety precautions
8. surrounding vegetation for changes
9. base drainage system, if used (visual and physical tests)

CHAPTER 6

HAZARDOUS WASTE CONTAINER COSTS

Data presented on costs of operating a container facility is provided in this manual purely for informational purposes. The permit writer is not required to evaluate a permit applicant's costs for maintaining a container storage facility. However, he should be cognizant of the economics of options available to the permit applicant. The costs provided here are brief, general, and are not meant to substitute for current market figures. They should not be used for engineering design.

A. Introduction

The cost of constructing and operating a container storage area can be broken down into three main components:

(1) cost of the containers,

(2) cost of constructing the containment system, and

(3) operating cost.

Operating costs will not be addressed in this chapter, because it is dependent on site-specific factors such as frequency of moving or emptying containers.

B. Container Costs

The most widely used type of container is the 55-gallon steel drum. Table 6-1 presents the prices of new 55-gallon drums obtained from the Bureau of Census report "Steel Shipping Drums and Paints" (also known as the M 34K report).[15] Table 6-2 presents cost data on steel drums obtained in a survey by the National Barrel and Drum Association.

TABLE 6-1

PRICES OF NEW CONTAINERS
(Bureau of the Census Survey)

	PRICE (in dollars) *	
	March 1980	March 1979
Tight Head		
18-gauge and heavier	18.07	17.26
19- and 20-gauge**	18.39	16.86
Open Head		
18-gauge and heavier	22.37	19.33
19- and 20-gauge**	16.82	15.60

* Container price is at the point of production. It includes the net sales price, f.o.b. plant, after discounts and allowances, exclusive of freight charges and excise taxes.

** Includes 20/18 gauge containers

Source: "Steel Shipping Drum and Paints," Report M34K, Bureau of Census.

TABLE 6-2

PRICES OF NEW AND RECONDITIONED DRUMS
(NABADA survey)

Drum Type	Mean Price ($)	Standard Deviation	Range Min.	Range Max.
New Tight Head	17.47	2.66	13.50	27.00
New Open Head	19.42	4.31	15.00	34.00
Reconditioned Tight Head	11.74	1.33	9.00	15.19
Reconditioned Open Head	11.89	1.79	9.75	15.50
Laundry/Service Fee	5.78	1.18	4.00	9.80

Source: Survey conducted by National Barrel and Drum Association for EPA report: "Barrel and Drum Reconditioning: Industry Status Profile," Solid and Hazardous Waste Research Division, Municipal Environmental Research Laboratory, Cincinnati, Ohio.[10]

Costs may be substantially higher for other types of containers and vary widely with size. The cost of a painted steel (liquidexpansion) container ranges from $58 for an 8-gallon container to $120 for a 40-gallon container. Steel ASME expansion (painted) containers range from $240 for an 18-gallon container to $1,925 for a 515-gallon container.

C. Containment System Costs[16]

The cost of a typical containment system for a container storage area can be subdivided into three major cost components:

(1) base,

(2) curb or dike, and

(3) sump pump.

The estimating costs for model containment systems designed for the storage of 100, 200, and 500 55-gallon drums are presented below. The major assumptions in estimating these costs have been:

(1) containers (2 1/2' diameter x 4' height) are stacked in two tiers;

(2) no special foundation design (e.g., use of pilings) was necessary; and

(3) the base is surrounded by 6-inch curbs and drains to a sump pump.

1. Area of Containment System

a. 100 containers (stacked 7 in 7 rows, 2 tiers high) 3 ft./container

= 450 sq. ft. (21' x 21')

+ 50% for access and drainage

= 1000 sq. ft. (32' x 32')

Area = 111 sq. yds.

Perimeter = 42 yds.

b. 200 containers (stacked 10 in 10 rows, 2 tiers high)

= 900 sq. ft. (30' x 30')

+ 50% for access and drainage

= 2025 sq. ft. (45' x 45')

Area = 225 sq. yds.

Perimeter = 60 yds.

c. 50 containers (stacked 16 in 16 rows, 2 tiers high)
3 ft. container

= 2250 sq. ft. (47' x 47')

+ 50% for access and drainage

= 5000 sq. ft. (71' x 71')

Area = 556 sq. yds.

Perimeter = 94 yds.

2. Cost Estimates

	Number of Containers		
	100	200	500
Base = $10/sq. yd.	$1,110	$2,250	$5,560
Curb = $11/yd.*	462	660	1,034
Pump = $2,000*	2,000	2,000	2,000
Total	$3,572	$4,910	$8,594
Cost per container	$36	$25	$17
Annualized cost over a 20-year period	$219	$300	$526

(annualization factor = .0612)

These storage areas can be compared by utilizing the following table:

Number of Containers	Storage Space ($ft.^2$)	Total Space ($ft.^2$)	Cost per container	Annualized cost
100	450	1000	$36	219
200	900	2025	25	300
500	2250	5000	17	526

Obviously, other container arrangements are possible and may be acceptable to the permit writer. In every case cost estimates should be obtained for the specific facility in question, utilizing up-to-date data.

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