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Technical Guidance Document

DETERMINING THE INTEGRITY OF CONCRETE SUMPS

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Project Officer

David Carson
Waste Minimization, Destruction
and Disposal Research Division
Risk Reduction Engineering Laboratory
Cincinnati, Ohio 45268

RISK REDUCTION ENGINEERING LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

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FOREWORD

This Technical Guidance Document (TGD), prepared in cooperation with the Office of Solid Waste and Emergency Response, presents recommended procedures for assessing the structural integrity of hazardous waste sumps constructed of concrete. This document describes: 1) mechanisms that can cause failure of concrete structures, 2) procedures to be used in performing a basic investigation, 3) steps to be followed in conducting a secondary investigation, 4) methods of concrete repair, and 5) protective coatings that can be applied to concrete.

ABSTRACT

This guidance document explains how to assess the structural integrity of a hazardous waste sump that is made of concrete. First, mechanisms of concrete structural failure are examined to provide a foundation for conducting investigations. Steps for basic and secondary investigations, including methods for concrete inspection and sump leak testing, are presented. As part of the basic investigation, an approach for static head leak testing of water-filled sumps is provided. Lastly, methods for concrete repair and information on coatings for concrete are presented.

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CONTENTS

CONTENTS (continued)

CONTENTS (continued)

FIGURES

TABLES

SECTION 1

INTRODUCTION

PURPOSE AND OBJECTIVES

This guidance document focuses on hazardous waste sumps and the steps that can be used to assess their structural integrity. Because of the apparent lack of a nationally-recognized technique to assess the condition of existing concrete sumps, the U.S. Environmental Protection Agency (EPA) has assembled existing knowledge concerning concrete structures and applicable leak detection technologies in this document. Guidance is presented to sump owners on how to assess the integrity of their sumps.

REGULATORY OVERVIEW

Pursuant to Subtitle C of the Resource Conservation and Recovery Act (RCRA), tank systems that are used to store/treat hazardous waste are regulated under 40 CFR Parts 260, 261, 262, 264, 265, 270, and 271 (July 14,1986, FR 51, 25422 -25486). These regulations do not apply to underground tanks storing petroleum or hazardous substances under RCRA Subtitle I. These regulations apply to any tank system (aboveground, inground, underground), of any material (steel, concrete, fiberglass).

The terms "sump" and "tank" are defined below to provide a foundation for this regulatory discussion. In 40 CFR 260.10, EPA defines these terms as follows:

- "Sump" means any pit or reservoir that meets the definition of a tank and those troughs/trenches connected to it that serve to collect hazardous waste for transport to hazardous waste storage, treatment, or disposal facilities. This description does not apply to sumps covered by the exception EPA added to this definition in the Liner and Leak Detection rule on January 29, 1992 (57 FR 3486).
- "Tank" means a stationary device, designed to contain an accumulation of hazardous waste which is constructed primarily of non-earthen materials (e.g., wood, concrete, steel, plastic) that provide structural support.

The definition of a sump has been interpreted by EPA to include sumps that are designed to serve as a primary containment system for hazardous waste as well as those designed to serve as a secondary containment system for tanks that contain hazardous waste (September 2, 1988, FR 53, 34084 - 34085).

Subpart J of Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," and Part 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," (Appendix A) set forth the requirements for hazardous waste tank systems. As previously discussed, these requirements also apply to sumps. The regulatory discussion in this subsection examines EPA requirements for assessing the structural integrity of hazardous waste tank systems as applied to sumps.

Owners and operators of existing sumps without secondary containment are required by 40 CFR 264.191 and 265.191 to determine whether the sump is capable of storing or treating hazardous waste without posing a threat of release of hazardous waste to the environment (i.e., not leaking or not "unfit for use").[1] The assessment must determine that the sump is adequately designed and has sufficient structural strength and compatibility with wastes managed to ensure that it will not collapse, rupture, or fail. The assessment must consider:

- Design standards;
- Hazardous characteristics of the wastes;
- Existing corrosion protection;
- Age of the system; and
- Results of:
    - A leak test,
    - An internal inspection, or
    - Other tank integrity examination.

The assessment must be reviewed and certified by an independent, qualified Registered Professional Engineer and must be kept on file at the facility.

All new sumps must be assessed before being put into use (40 CFR 264.192 and 265.192). Existing sumps without secondary containment must be leak- tested on an annual basis or assessed by an independent Registered Professional Engineer using a procedure and a schedule that will be adequate to detect leaks or conditions that may lead to leaks (40 CFR 264.193(i) and 265.193(i)).

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[1] The regulations require that the assessment be conducted by January 12, 1988. However, the regulations applicable to aboveground, onground, and underground tanks that can be entered for inspection (e.g., sumps) are promulgated pursuant to RCRA (pre-HSWA) authorities. Sumps located in an authorized state do not have to be assessed until the state amends its regulations and imposes a deadline. Sumps located in unauthorized states must be assessed within the Federal deadline (January 12, 1988).

Existing sumps that are found not to be leaking (structurally sound) and fit for use are required to install secondary containment in accordance with the phase-in schedule presented in Sections 264.193(a) and 265.193(a) (see Table 1-1); whereas existing sumps that are found to be leaking or unfit for use must go through a remedial process described in Sections 264.196 and 265.196. Once an existing sump without a secondary containment system has leaked or caused a release, it must be repaired and a secondary containment system must be installed that satisfies the requirements of Sections 264.193 and 265.193. If the sump cannot be repaired, it must be permanently removed from service in accordance with Sections 264.197 and 265.197.

Some owners of existing sumps may decide to meet the requirement of retrofitting secondary containment by installing a new sump within their old sump (allowing the old sump to serve as the secondary container). Such an approach to meeting the secondary containment requirement requires the old sump to be assessed as structurally sound, or to be repaired and made structurally sound.

Because concrete is not impermeable, to make a concrete sump or secondary container structurally sound, the unit must be coated or lined with a material that is impermeable to prevent migration of contaminants into and through the concrete structure. Such a coating must be compatible with the materials that may be contained by the structure.

OVERVIEW OF CONCRETE SUMP INTEGRITY DETERMINATION

Although methods for assessing the integrity of typical closed tank systems are fairly well established, standard methods for assessing the integrity of sumps, systems that are open to the atmosphere, had not been developed. Consequently, EPA has created this Technical Guidance Document (TGD) to assist sump owners in making this assessment.

A sump integrity investigation can be outlined as follows:

- The basic investigation involves the following steps:
  - Planning of the investigative survey,
  - Reviewing engineering data,
  - Preparing the sump for inspection,
  - Performing the inspection, and
  - Conducting a sump tightness test.
- A secondary investigation must be performed if the basic investigation is inconclusive. Such investigation may require non-destructive (e.g., pulse-echo) or destructive (obtaining core samples and performing laboratory analysis) concrete testing techniques.

TABLE 1-1. RETROFIT SCHEDULE FOR SECONDARY CONTAINMENT

Type of Sump	Secondary Containment Retrofit Deadline
Existing Sump Used to Store or Treat EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F027	Within 2 years from Jan. 12, 1987.
Existing Sump of Known and Documented Age	Within 2 years from Jan. 12, 1987, or when the sump has reached 15 years of age, whichever comes later.
Existing Sump for Which the Age Cannot be Documented.....	Within 8 years from Jan. 12, 1987.
- if Sump Age is > 7 years	By the time the facility reaches 15 years of age, or within 2 years of Jan. 12, 1987, whichever comes later.
Existing Sump that Stores or Treats Materials that Become Designated as Hazardous Waste After Jan. 12, 1987	Within the above-listed schedules, except that the date on which the material becomes a hazardous waste must be used in place of Jan. 12, 1987, as a basis.

ORGANIZATION OF THIS DOCUMENT

The remaining sections of this document are organized as follows:

- Section 2 discusses mechanisms of concrete structural failure;
- Section 3 describes how to conduct a basic and secondary sump investigation;
- Section 4 provides an overview of methods used for concrete repair; and
- Section 5 presents information on coatings for concrete.

Appendices provide the reader with supporting information such as copies of regulations, sources of additional information, and a listing of useful references.

SECTION 2

UNDERSTANDING MECHANISMS THAT CAUSE FAILURE OF CONCRETE STRUCTURES

Two major failure mechanisms can cause loss of structural integrity in a sump, namely stress-induced cracks and joint failure. Another possible source of sump leakage is gradual permeation of hazardous materials through sump walls that do not have a protective coating. This section will focus on major structural failure mechanisms as they can result in the most sudden and drastic releases from a sump.

BASIC SUMP DESIGN

Sumps can vary greatly in size and design. They can range in capacity from a few to hundreds of thousands of gallons. Small sumps can be built in place or they can be precast and delivered to the site. Small precast structures have the design advantage of lacking joints, a structural component that can fail. As a result of their size, large sumps are constructed in place and require joining of large blocks of concrete, each poured and cured as a unit (monolith). These monoliths are connected by joints. Figure 2-1 shows that various types of joints can be created to join sump slabs with their walls as well as to join monolith wall sections. The exhibit shows that a typical joint in a sump can consist of:

- Bars of steel (rebar) that are used to reinforce the joint of the monolith structures;
- Joint compounds (e.g., bonders and fillers) to help secure the joint; and
- Field-molded or preformed seals (e.g., waterstops, gaskets, or compression seals) to make the joint water tight and to protect the reinforcing steel from conditions that facilitate corrosion.

MAJOR MODES OF STRUCTURAL FAILURE

Cracks

Concrete failure can be caused by shear, compressive, and tensile stresses in the concrete. These stresses usually result from structural movement and/or forces applied to the structures. When these stresses reach limits that the structure is unable to resist, cracks usually occur

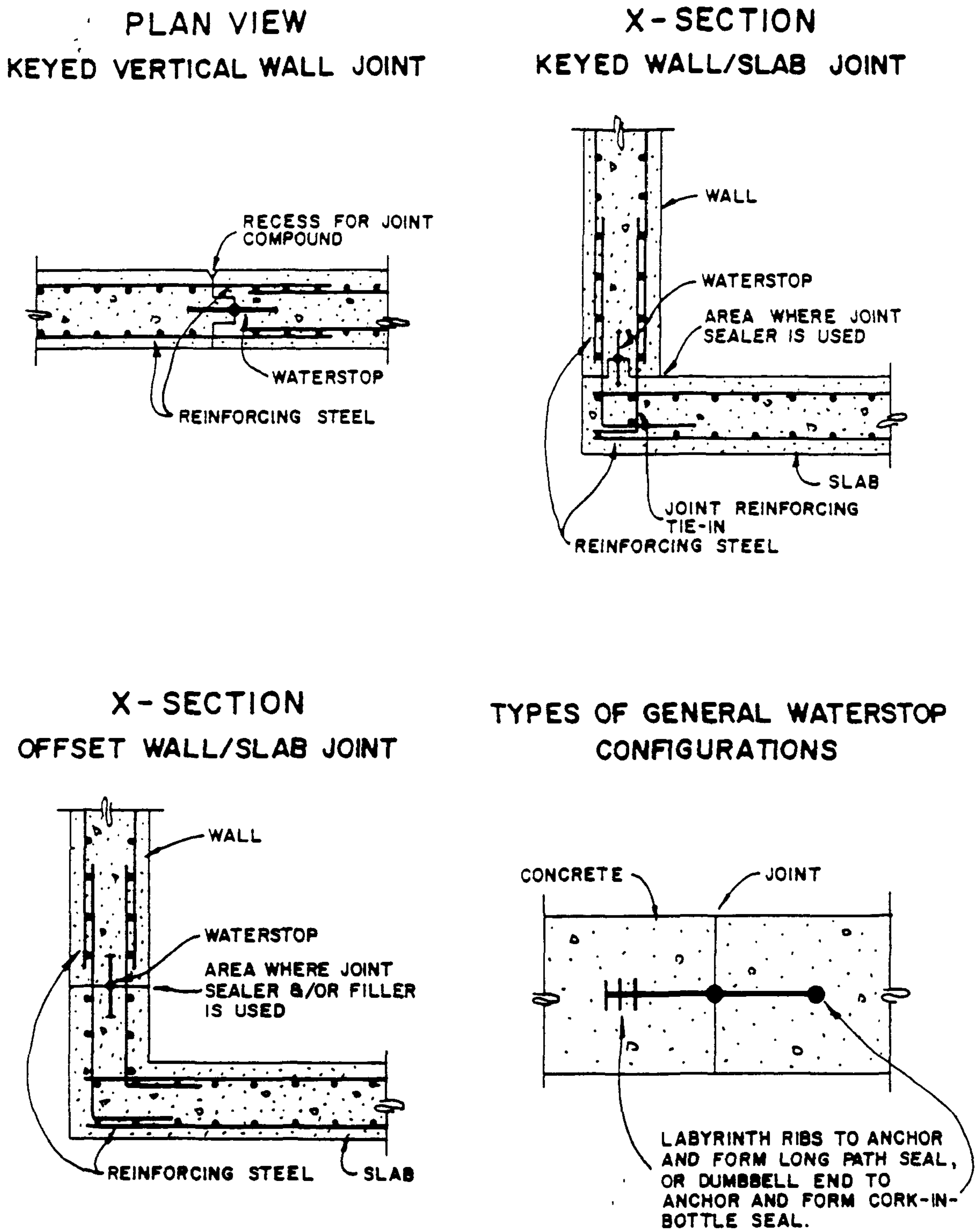

Figure 2-1. Joints - Schematic Diagram

in the concrete. The following are examples of factors that can cause such stresses:

- Structural overload;
- Differential settlement;
- Inadequate bonding between piping imbedded in the concrete and the concrete;
- Inadequate construction joints;
- Improper placement of backfill behind the structure;
- Corrosion of the steel reinforcing. The corrosion process generates chemicals (iron oxides and hydroxides) that have a greater volume than the original metal, causing the structure to shift and crack;
- Temperature changes that cause expansion and contraction of the concrete and subsequent cracking; and
- Chemicals that come in contact with the structure that can result in expansive reactions causing tensile stresses.

In addition to external forces, inappropriate design or construction methods may cause structural failure. For example, insufficient cover over the rebar, inadequate placement of construction joints, improper concrete mixture and/or curing, lack of proper drainage behind the wall of the sump, and design errors can contribute to loss of structural integrity.

If not repaired, even small cracks in the concrete can present a problem because they often expand, allowing more liquid into the matrix of the concrete and thereby promoting further concrete degradation. Thus, appropriate and timely repairs of small cracks are required to prevent leakage of substances out of the sump structure.

Possible concrete failures caused by shear, compressive, and tensile forces usually can be identified by the appearance of structural cracks. For minor stress failures, more detailed analysis of the structure is required (see Section 3). Note that some structural cracks may be too severe to repair, thus necessitating replacement of the sump.

<u>Joint Failure</u>

Another potential leakage point in concrete sumps occurs at construction joints. Typical causes of joint failure include the following:

- Improper design (including designing an insufficient number of joints);

- Application of stresses that exceed the conditions for which the joint was designed;

- Improper preparation of joint surface inhibiting adhesion of the joint material to the structure;

- Use of poor or inappropriate joint material (e.g., filler or waterstop); and

- Improper construction.

In general, joint failure usually is detected by a visual inspection of the joint seal and the surrounding concrete. Appropriate and timely repair of a failed joint is essential to preventing leakage from a sump.

Water stop failure is a special type of joint failure that can result from a variety of causes, and is thus discussed in greater depth below. Waterstops can be made of rigid or flexible materials such as polyvinyl chloride (PVC), high density polyethylene (HDPE), low density polyethylene (LDPE), Polypropylene (PP), Nylon (NYL), or various natural or synthetic or rubber compounds. Waterstop failure can be caused by:

- Excessive structural movement at the joint causing the waterstop to rupture;

- Poor concrete mixture causing honeycomb areas around the waterstop (creating a poor surface for a seal, particularly with a rigid waterstop);

- Improper surface preparation preventing proper bonding to the concrete;

- Breaks or discontinuities in the waterstop resulting from poor construction practices; and/or

- Incompatibility of the waterstop material with the sump contents.

Defects in the waterstop are not always evident from visual inspection. Some common signs that may be a result of a defective waterstop are wetness of concrete at the joints and deterioration of the structure adjacent to the waterstop. If these signs are present, but a thorough investigation of the sump reveals no apparent defects in the concrete, the integrity of the joints and waterstops should be questioned; and they should be examined.

To prevent liquids from escaping from the sump, failed waterstops must be repaired. The installation of a secondary waterstop and joint filler are common methods of repair. If not repaired, a waterstop not only allows flow of liquids through the structure, but can result in a reduction in the structural strength of the sump. Joint repair is further discussed in Section 3 of this report.

HELPFUL REFERENCES

The following documents provide information on concrete structures, causes of concrete failure, ways to detect a failure, and problems that may occur if faults are not repaired.

- ACI 504R-90: Guide to Joint Sealants for Concrete Structures.
- ACI SCM 21-89: Repairs of Concrete Structures -- Assessments, Methods and Risks.
- ACI 224.1R-89: Causes, Evaluation, and Repair of Cracks in Concrete Structures.
- McDonald, J. E., Repair of Waterstop Failures: Case Histories, U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Technical Report REMR-CS-4, 1986.
- Stowe, R. J. and H. T. Thornton, Jr., Engineering Condition Survey of Concrete in Service, U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Technical Report REMR-CS-1, 1984.
- ACI 201.1R-68(84): Guide for Making a Condition Survey of Concrete in Service.
- ACI Compilation No. 5: Concrete Repair and Restoration, 1980.

SECTION 3

CONDUCTING A SUMP INTEGRITY INVESTIGATION

INTRODUCTION

Owners and operators of existing sumps, which are used for treating or storing hazardous wastes and do not have secondary containment, are required by 40 CFR 264.191(a) and 265.191(a) to determine that the sump is capable of storing or treating hazardous waste without posing a threat of release of hazardous waste to the environment. A written assessment of the integrity of the sump must be kept on file at the facility. This assessment must conclude that the sump is adequately designed and has sufficient structural strength and compatibility with wastes being stored or treated to ensure that it will not collapse, rupture, or fail. Furthermore, the assessment must be reviewed and certified by an independent, qualified Registered Professional Engineer. The assessment may be complicated by the fact that many sumps are constructed so that only the interior surface can be visually inspected. The following must be addressed by the assessment:

- Design standards of the sump (including troughs and trenches connected to the collection basin);
- Hazardous characteristics of the wastes;
- Existing corrosion protection measures;
- Documented or estimated age of the sump; and
- Results of a leak test, internal inspection, or other tank integrity examination addressing cracks, leaks, corrosion, and erosion.

Until secondary containment is installed, 40 CFR 264.193(i) and 265.193(i) require the sump to be leak-tested annually or the overall condition to be assessed by an alternate procedure on an appropriate schedule. The frequency of the assessment and procedure used must be adequate to detect obvious cracks, leaks, and corrosion or erosion that may lead to cracks or leaks. The material used to construct the sump, age of the sump, type of corrosion or erosion protection used, rate of corrosion or erosion observed during the previous inspection, and the characteristics of the waste being stored or treated must all be considered in determining the frequency of assessments. If the sump is permitted, a schedule should have been developed during the permitting process.

The purpose of this section is to provide sump owners and operators guidance in conducting the required assessments. A two-phased approach is presented. The first phase, or the basic investigation, evaluates the general condition of the sump structure and identifies areas of suspected deficiencies or problems. The determination of a need for a secondary investigation, which includes test methods that are highly specialized, time consuming, and/or costly, should be based on the results of the basic investigation.

THE BASIC INVESTIGATION

The basic investigation should provide the owner or operator with sufficient information to determine the integrity of the sump or determine if additional testing is required. The steps involved in the basic investigation include:

- Planning the investigation;
- Reviewing existing data;
- Preparing the sump for inspection;
- Performing a preliminary inspection, or
- Conducting a sump tightness test; and
- Preparing a report.

The steps presented in this document represent a logical progression in completing the assessment. While the steps are recommended, they are not required. Each of the steps is discussed below.

Planning the Investigation

The overall purpose of the investigation is to determine whether the sump is leaking; unfit for use; or whether it will collapse, rupture, or fail. Furthermore, the owner or operator must ensure that the investigation addresses all required considerations including documenting the design standards and the age of the sump, assessing waste compatibility, and evaluating existing corrosion protection. To make sure that all of these other considerations are addressed, the scope and objective of the investigation should be clearly established. To make the best use of time and resources, a plan for gathering documentation and the appropriate procedures and techniques for cleaning, inspecting, and testing the sump should be determined before beginning the investigation. The owner or operator should plan to take the sump out of service for at least 7 days for cleaning, inspecting, and testing.

Early in the planning process, the owner or operator should carefully review qualifications and select personnel to conduct the operations required by the investigation. Personnel should have knowledge of causes of concrete failure and practical experience diagnosing concrete defects. A list of individuals and firms who assess tank system integrity can be found in Compilation of Persons Who Design, Test, Inspect, and Install Storage Tank Systems, US EPA/530-SW-88-019, February 1988. The owner or operator must remember that the assessment cannot be certified by his own engineer. The assessment must be reviewed and certified by an independent, qualified Registered Professional Engineer.

Review Existing Data

A review of existing data regarding the sump will serve two purposes. First, the assessment must address the considerations presented above (i.e., document sump age, design, corrosion or erosion protection, and waste compatibility); existing data should provide the owner or operator with information necessary to complete the assessment. Second, a thorough evaluation of concrete integrity in existing structures must consider all aspects of design, construction, operation, and maintenance. Available information, including design documents, as-built drawings, operation and maintenance records, existing test reports, and records of waste composition can be reviewed for both purposes.

The written assessment must document the age of the sump if the information is available. Note should be made that the owner or operator must know the age of the sump to determine when secondary containment is required. If the age of the sump cannot be documented, the age of the facility should be documented. This may be determined through a review of dated blueprints, contracts, and insurance forms.

Preparing the Sump for Inspection

Before the condition of all internal surfaces can be assessed, stored wastes must be removed from the sump. It may be necessary to clean the internal surfaces to remove waste residues, dirt, and weakened aggregate. Cleaning also may be required to protect the inspector from exposure to hazardous materials. Appropriate safety precautions for working with hazardous materials should be observed during the cleaning process. Where appropriate, safety precautions related to confined space entry should be employed.

The owner or operator should be aware that waste and debris generated by the clean-up process (e.g., sand, water, concrete), if considered to be a mixture of a solid waste and hazardous waste, must be managed as a hazardous waste unless:

- The mixture includes a waste listed as hazardous in Subpart D of Part 261 because of a characteristic (i.e., ignitability, corrosivity, reactivity, toxicity) and the mixture no longer exhibits the characteristic [see 40 CFR 261.3(a)(2) (iii) and (iv)]. For example, if a spent non-halogenated solvent (F003) is managed in the sump, wastes and debris generated from sump cleaning would not need to be managed as hazardous waste if they did not exhibit the characteristic of ignitability. On the other hand, wastes and debris generated from cleaning a sump managing a spent halogenated solvent used in degreasing (F001), which is listed as a toxic waste, must be managed as hazardous waste.

- The mixture no longer exhibits the characteristic that causes the waste managed in the sump to be hazardous (see 40 CFR 261.3(d)(1)). For example, wastes and debris generated from cleaning a sump manag ing a waste exhibiting the toxicity characteristic for chromium (D007) are not considered hazardous if testing (i.e., TCLP) demonstrates that the chromium concentration in the sump cleaning waste is below 5 mg/l.

A comprehensive reference for commonly-used cleaning methods is the American Concrete Institute's A Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete, ACI 515.IR-79, Section 3.4 - Surface Preparation. Methods that can be used to clean concrete include:

Steam Cleaning--

Wastes can be removed from the sump surface through the use of steam. Surfactants can be incorporated, as appropriate, to facilitate chemical decomposition. An advantage of steam cleaning is that thermal decomposition or hydrolysis may occur, depending on the nature of the wastes managed in the sump. However, if the steam is applied using a hand-held wand, the operation is labor intensive; if the steam application is automated, the operation requires costly, specialized equipment.

Scarification--

Scarification by a mechanical impacting device can be used to remove thick overlays of dirt or weakened material. Grinding may be useful when small areas are to be cleaned or when the cleaned surface must be smooth. Advantages of scarification include: deeper penetration and removal of waste residues than most surface removal techniques and suitability for application to large as well as small areas.

Water blasting or sand blasting is usually necessary after scarification to remove weakened aggregate, generating substantial quantities of contaminated debris. This method also presents a potential explosion hazard if pockets of combustible wastes are encountered. Finally, obstructions such as pipes or pumps in the sump can make scarification of some of the concrete surfaces extremely difficult.

Blast Cleaning--

Blast or abrasive cleaning is an effective method to remove laitance, dirt, efflorescence, and weak surface material. Three types of blast cleaning procedures are: dry sandblasting, wet sandblasting, and high-pressure water jetting.

High-pressure water jetting is a relatively-inexpensive, non-hazardous surface cleaning technique that uses off-the-shelf equipment. Variations, such as use of hot or cold water, solvents, and surfactants can be incorporated to meet site-specific needs. Because no solid abrasive is used, however, waste that has penetrated the surface layer may not be removed completely. Another disadvantage to this method is the need to collect and treat a significant volume of contaminated water.

Dry sandblasting has three disadvantages: generation of large amounts of dust and debris, slowness, and the possibility of detonating pockets of combustible contaminants. Wet sandblasting has an advantage over conventional (dry) sandblasting, because the need for a dust collection system is eliminated. However, wet sandblasting requires collection and treatment of contaminated liquids.

Acid Etching--

This method uses a commercial grade hydrochloric acid solution that is spread over the concrete surface by a stiff-bristle broom or brush. The surface is then flushed with water. Prior to acid etching, the surface should be examined to determine the necessity for pre-cleaning to remove surface contaminants that acid etching will not remove, such as moderate grease and oil.

An advantage of acid etching is that certain contaminants are decomposed or neutralized as they are removed from the surface. However, two disadvantages include: hazards due to the acid and the necessity of special application equipment. Because acid etching is less dependable than mechanical abrading, it is only recommended where no alternative means of cleaning are possible. If acid etching must be employed, it should be performed by experienced applicators.

Chemical Cleaning--

This step may be necessary prior to blast cleaning or acid etching to remove surface contaminants such as oil, grease, and dirt. Solutions of caustic soda or trisodium phosphate may be used, as well as proprietary detergents specially formulated for use on concrete. Such chemicals are applied with vigorous scrubbing, followed by flushing with water to remove both the detergent and contaminants. Solvents should not be used for this purpose, because they tend to dissolve the material, spread the contamination over a larger area, and may carry the contaminants farther into the wall.

Performing a Preliminary Inspection

The preliminary inspection discussed below is primarily a visual inspection to assess the condition of the interior surfaces of the sump. Limited testing, such as with a rebound hammer (ASTM C 805-85), also may be conducted to assess the uniformity of the concrete to delineate zones or regions of poor quality or deteriorated concrete. As noted above, all appropriate safety precautions should be observed during the inspection.

The following is a summary of the basic procedures that can be employed in a preliminary inspection:

- The alignment of the concrete elements should be checked, and the sump structure should be assessed for signs of irregular foundation settlement or deflection. Signs include bulges and low or high areas in the sump walls or floor that are accompanied by cracking.

- All exposed concrete surfaces should be visually examined for evidence of deterioration, which is defined as any harmful change in the concrete's normal mechanical, physical, or chemical properties caused by separation of its components. Deteriorated areas should be classified, measured, and located on a surface defect drawing or sketch (see Figure 3-1 for an example surface defect drawing). Surface deterioration classifications include: disintegration, distortion, efflorescence, exudation, incrustation, pitting, popout, erosion, scaling, peeling, spalling, stalactites, stalagmites, dusting, or corrosion.

- All cracks should be investigated. If possible, the concrete should be inspected for cracks immediately after removal of liquid, because cracks tend to be larger while swollen with moisture. Additionally, the contrast created by the darker, moist crack with the quicker-drying uncracked concrete surface tends to make cracks more visible. Stained cracks can be an indication of liquid seepage out of or into the sump. Rust-stained straight cracks can indicate corrosion of reinforcing steel.

- Cracked areas should be measured, classified, and located on the surface defect drawing or sketch. Cracks should be classified by direction, width, and depth:

  - The following can be used to identify direction: longitudinal, transverse, vertical, diagonal, and random.

  - Suggested width ranges include: fine (less than 1 mm), medium (between 1 and 2 mm), and wide (over 2 mm). Cracks that are 6 mm or more in width usually penetrate the entire wall.

  - Crack types include pattern cracking, checking, hairline cracking, and D-cracking.

- Surfaces should be inspected for evidence of chemical attack commonly due to sulfates, acids, and alkali-aggregate reaction.

- Previously-repaired areas should be examined for integrity and bonding with concrete.

- Pipe penetrations should be checked closely, because they are especially vulnerable to leaking.

- Joints, adjacent concrete, and joint filler should be examined to determine their condition.

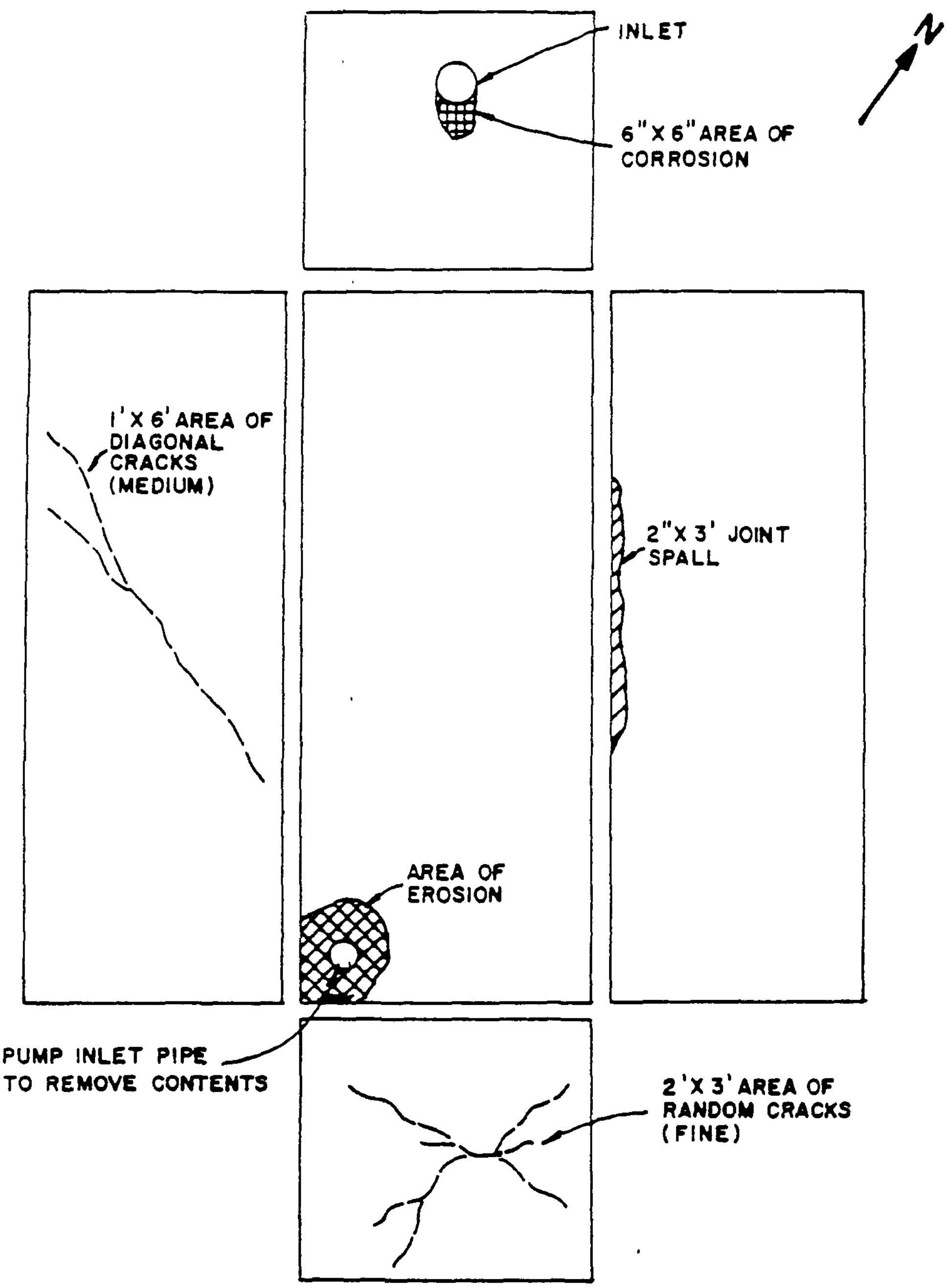

Figure 3-1. Example Sump Surface Defect Drawing*

* Problems with joints may be best shown by the inspector in a separate drawing.

It is also important to inspect any surface coatings or linings, because they serve as the first line of defense against leakage, while also protecting the concrete. Many of the related inspection tools and methods are sophisticated and require extensive training of the inspecting technician; some are as simple as piercing the coating with a pen knife, but even such methods require considerable prior experience on the part of the inspector to be reliable. Procedures that can be used to inspect coatings or linings include:

- Coating thickness can be measured by a Tooke gauge, which makes a precise angled cut through the coating. The cut is then examined through a 50x magnifier. Because coatings have a permeation rate, albeit slight, a minimum thickness must be maintained to ensure effectiveness.

- Pinholes and cracks usually can be found visually with the aid of a 30x magnifier. If possible, the coating should be examined while still wet, as well as dry, since cracks may shrink after drying.

- It may be possible to use the Holiday test, which is commonly used to check for tiny discontinuities (pinholes) in coatings on steel tanks, to investigate coatings covering electrically-conductive concretes. The test locates discontinuities through passage of an electrical current to the tank where there is no resistant coating. However, the test is normally used on metal tanks, and the high voltages necessary to use it on concrete may cause damage to the coating. More information on the Holiday test and appropriate safety precautions can be found in the National Association of Corrosion Engineers' publication RP-01-88 Discontinuity (Holiday) Testing of Protective Coatings.

- The coating should be inspected for signs indicating loss of adhesion to the concrete. Some of the signs are visible, such as wrinkling. Most of the reliable adhesion tests are destructive. On hard coatings, however, a steel pipe rolled across the surface will usually reveal areas of poor adhesion by a change in sound.

- The coating should be inspected for signs of contamination. Visible signs that the coating is contaminated include: swelling or blistering, yielding a "fish eye" effect; softening; and crinkling of the surface, yielding an "alligator" effect. Symptoms that do not necessarily mean the coating is failing include discoloration or "bleaching," and etching of the surface.

- Photographs of the coating should be taken and saved for comparison with photographs from future inspections.

Conduct a Sump Tightness Test

Because sumps, including connecting troughs, are generally configured as open-topped tanks, they are not amenable to precision leak testing techniques applied to enclosed under-ground storage tank systems. Two tests, however, that may be successfully applied to sumps are the static head test and tracer tests. Each is discussed below.

Static Head Test--

The static head test is a volumetric leak test whereby the sump is filled with water and checked for changes in volume by measuring the drop in water level over time. This method can be applied to most enterable sumps; however, sumps containing equipment that may be damaged by water cannot be leak tested using this method. The problem with this test, however, is that the precision of the test varies inversely with the exposed surface area of the sump contents. This means that the test may last several days to detect a small leak in a large sump.

The following steps present the recommended approach for conducting the static head test. Steps 1 through 5 address test setup and equilibration. The remaining steps address the actual test period. Figure 3-2 illustrates a typical setup. The recommended steps are:

1. Isolate the sump to prevent any liquids from entering or leaving during the test period. Attach a steel rule or other appropriate depth gauge to the side of the sump to monitor depth throughout the test period.

2. Fill the sump with water, record the water level from the gauge, measure the dimensions, and calculate the exposed surface area of the sump contents.

3. Cover openings with plastic sheeting, supported on lumber (if neces sary) to maintain a saturated atmosphere over the sump and prevent evaporative water loss. The plastic sheeting should be sloped (if necessary) to shed rain and prevent pooling.

4. Install a small chamber (approximately 1 foot in diameter x 2 feet in length) for use as a stilling well and calibration chamber (Figure 3-2). The chamber should be placed at a location in the sump that will provide the most accurate measurement of a drop in water level. The chamber should not be completely submerged so that its contents will remain isolated from the sump contents. The level inside the chamber should be allowed to equilibrate with the level of the sump contents through an open stopcock valve located below the water line.

5. Install a device in the stilling well/calibration chamber to measure water level changes. A sensitive, float-activated sensor, pressure transducer, or other water level sensor should be used that can detect small changes in head and distinguish a leak from background "noise." However in small sumps, the depth gauge may be adequate to determine if the sump is leaking. See Appendix F for sources of sensitive sensors.

6. Monitor the water level and temperature for at least 24 hours to verify that the system has equilibrated (i.e., absorption by the concrete pores and cracks has ceased).

7. Calibrate the equipment as follows or follow the manufacturer's recommendations:

   - Close the stopcock valve on the calibration chamber to isolate it from the sump.

   - Start and zero the recording equipment, and note the level on the depth gauge.

   - Place a known volume in the calibration chamber (metal calibration slug or known volume of water) and record the rise in water level.

   - Calculate the predicted rise in water level and use that value to calibrate the equipment (see Table 3-1 for a sample calculation).

   - Repeat the calibration process until 3 consecutive readings are within 10 percent of one another.

8. Open the calibration chamber stopcock to allow free water movement between the sump and the chamber. Record the water level and temperature at the start of the test and periodically throughout the test period. The monitoring period should include at least 1 diurnal cycle (24 hours) to record the effect of temperature fluctuations. The total length of the test should be sufficient to assure the certifying engineer of the sump's condition. It may be necessary to extend the test period several days if a leak is suspected on the basis of the initial test period (especially in sumps with a large surface area). A continuously-recording device provides the most useful data record for analysis.

9. Calculate the leak rate in gallons per hour (see Table 3-2 for sample calculations). For example, a water level drop of 1 mm per hour from a 2 m by 2 m sump represents a loss of 400 cc (0.106 gallons) per hour.

Tracer Tests--

Leak testing also can be accomplished by mixing a tracer (i.e., a distinctive chemical substance) with water in the sump. If the sump leaks, the water carries the tracer which then disperses into the surrounding soil.

Before beginning the test, the backfill around the sump should be checked for constituents than could interfere with detection of the tracer. The tracer should be applied at a concentration that is detectable at least

TABLE 3-1. SAMPLE CALIBRATION CALCULATIONS

Diameter of calibration chamber = 25.3 cm
R = Radius (cm)
Area = (R*R)*Pi
Area = 502.725510 sq. cm
1 cu. cm = 2.6417E-04 gallons
1.0 ml = 1.0000280 cu. cm

Measured Change In Depth (mm)	Volume (cu. cm)	Volume (gal)
0.001	0.05027255	1.3281E-05
0.002	0.10054510	2.6561E-05
0.003	0.15081765	3.9842E-05
0.004	0.20109020	5.3122E-05
0.005	0.25136275	6.6403E-05
0.006	0.30163530	7.9684E-05
0.007	0.35190785	9.2964E-05
0.008	0.40218040	1.0624E-04
0.009	0.45245295	1.1953E-04
0.01	0.50272551	1.3281E-04
0.02	1.00545102	2.6561E-04
0.03	1.50817653	3.9842E-04
0.04	2.01090204	5.3122E-04
0.05	2.51362755	6.6403E-04
0.06	3.01635306	7.9684E-04
0.07	3.51907857	9.2964E-04
0.08	4.02180408	1.0624E-03
0.09	4.52452959	1.1953E-03
0.10	5.02725510	1.3281E-03
0.20	10.0545102	2.6561E-03
0.30	15.0817653	3.9842E-03
0.40	20.1090204	5.3122E-03
0.50	25.1362755	6.6403E-03
0.60	30.1635306	7.9684E-03
0.70	35.1907857	9.2964E-03
0.80	40.2180408	1.0624E-02
0.90	45.2452959	1.1953E-02

(continued)

TABLE 3-1. (continued)

Measured Change In Depth (mm)	Volume (cu. cm)	Volume (gal)	
1.00	50.2725510	1.3281E-02	
0.01989	1.000028 *	2.5000E-02 *	(Cal. slug)
2.00	100.545102	2.6561E-02	
3.00	150.817653	3.9842E-02	
3.76489	189.270626 *	5.0000E-02 *	(Cal. slug)
4.00	201.090204	5.3122E-02	
5.00	251.362755	6.6403E-02	
6.00	301.635306	7.9684E-02	
7.00	351.907857	9.2964E-02	
8.00	402.180408	1.0624E-01	
9.00	452.452959	1.1953E-01	
10.00	502.725510	1.3281E-01	

* Exact volumes of calibration slug.

TABLE 3-2. FORMULAS FOR CONVERTING MEASURED DEPTH CHANGE TO LEAK RATE IN GALLONS PER HOUR

For a RECTANGULAR OR SQUARE SUMP

Leak Rate (gals./hour) = $(d_f - d_i) \times L \times W \times CF$

Where d_f = Final depth in inches, feet, or millimeters

d_i = Initial depth in inches, feet, or millimeters

L = Length (inside) of sump in feet*

W = Width (inside) of sump in feet*

CF** = 0.00866 if $(d_f - d_i)$ is in inches

= 0.104 if $(d_f - d_i)$ is in feet

= 0.000341 if $(d_f - d_i)$ is in millimeters

For a ROUND SUMP

Leak Rate (gals./hour) = $(d_f - d_i) \times D^2 \times CF$ divided by 4

Where D = Diameter (inside) of sump in feet*

$(d_f - d_i)$ and CF are same as for rectangular sump

* If L and W (or D for round sumps) are given in meters instead of feet, multiply leak rate calculated from these formulas by 10.8.

** The conversion factors (CF's) are based on a 72-hour test period (time between initial and final depth measurements). If a different period was used, divide the calculated leak rate by the correct number of hours, then multiply by 72 to obtain the corrected leak rate.

If the leak rate in metric units is desired, multiply the leak rate calculated in gallons per hours by 3.79 to get leak rate in liters per hour.

one order of magnitude above the background concentration should a leak be present. The type of tracer that is selected should be distinct from the wastes managed in the sump, so that it may be detected should a leak have already occurred.

If the sump is located at or below the ground water level, ground water monitoring is used to detect the presence of the tracer outside the sump (Figure 3-3) . If the sump is located above the water table, then monitoring of the vadose zone water can be conducted through the use of suction lysimeters or shallow ground water monitoring wells.

If the tracer is not detected through monitoring, the sump can be considered to be tight. Sufficient time, however, must be allowed for the tracer to diffuse through the medium and be detected for tracer monitoring to be successful. The waiting time will vary depending on the type of tracer used and the leak rate.

If the sump system can be sealed, volatile tracers may be used and leaks detected using soil vapor monitoring techniques. Without a seal, a volatile tracer could evaporate from the test liquid (water) before it has time to "leak" to the soil. It may be possible to prevent evaporation of the tracer by covering the sump with a gas impermeable membrane and "sealing" it at the edges (e.g., with sand bags as weights). Vapor monitoring wells could be constructed in a manner similar to ground-water monitoring wells (Figure 3-3). Vapors can rise unassisted through the wells or can be withdrawn by hand-operated or mechanical pumps. Collected samples can be sent to a lab for analysis or can be analyzed on site using portable equipment.

Monitoring for volatile tracers also can be conducted by driving a probe into the ground. A tool known as a "punch probe" or "bar punch" can be used to quickly punch a small-diameter hole 125 to 150 cm deep into the soil surrounding the sump. A probe or tube is then immediately dropped into the hole and the hole is sealed at the top with soil or clay. Vapors are drawn through the tube and sampled just as from a cased monitoring well.

Two primary advantages to using a probe rather than a monitoring well are that locations can be sampled quickly and at a lower cost. The disadvantages include: ability to reach only a limited depth, soils that are too firm or rocky are hard to penetrate, very loose soils will collapse in the hole before probe insertion, and resulting samples sizes are small. Punches will not pierce cement concrete, but can pierce asphaltic concrete.

<u>Preparing a Report</u>

The investigation should be concluded with a formal report clearly stating the condition of the sump. Evidence of structural failure and any existing or potential problems in its surrounding site, foundation, electrical features, mechanical features, or hydraulic features should be noted and explained. The report should include a detailed site plan, accurate

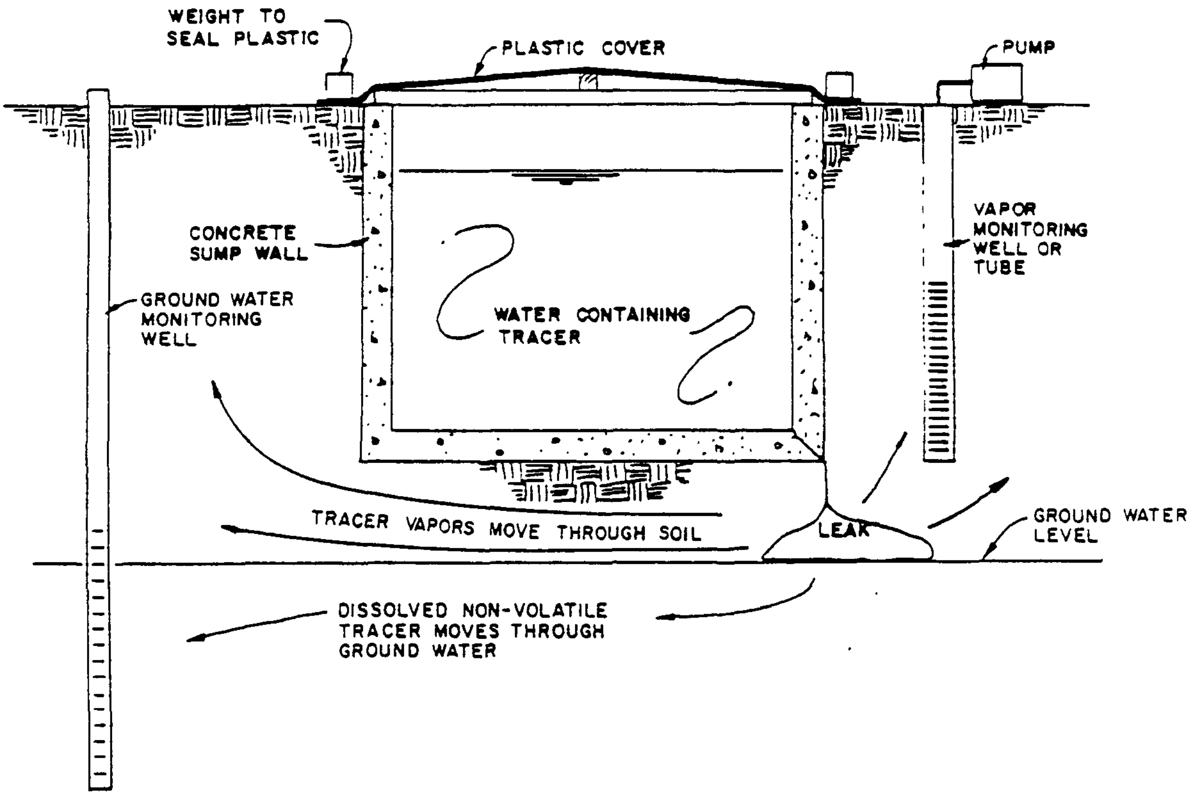

Figure 3-3. Tracer Test in an Open Sump

plan and section drawings or sketches of the sump and foundation, and references to all engineering design and construction inspection data reviewed. Waste analysis and compatability determinations also should be included. In addition, the report should summarize the inspection and any testing performed. The visual inspection should be documented with photographs and surface defect drawings or sketches locating and defining damaged, deteriorated, or cracked concrete. When appropriate, recommendations for conventional or state-of-the-art repairs should be given.

While an independent Registered Professional Engineer is not required to perform the visual inspection or conduct the leak test, he is required to review documentation and certify, based on knowledge and belief, that the sump is sound. Therefore, the information contained in the final report must be sufficiently detailed to provide a basis for this judgment.

THE SECONDARY INVESTIGATION

To certify the sump as sound, it may be necessary to conduct a detailed secondary investigation to supplement the results of the basic investigation. Non-destructive techniques, such as the acoustic pulse-echo, may be used to further examine cracks, voids, and concrete thickness. If the results of the non-destructive tests are inconclusive, it may be necessary to have a petrographic analysis performed on concrete samples by a laboratory. Non-destructive tests, sampling, and laboratory analysis are further discussed below.

Non-Destructive Testing

A number of common techniques are available for non-destructively test ing existing concrete structures for discontinuities such as cracks or voids. A sump owner or operator should be aware, however, that several methods are clearly not suited for sumps because of required test conditions or equipment constraints. For example, infrared thermographic and X-ray techniques are proven examination methods; but the thermographic technique requires incident sunlight; and X-ray tests require access to both sides of the concrete structure.

Several tests have potential for use in sumps. Although the suitability of these methods has been well-documented for use on large concrete structures such as roads and dams, most currently require further developmental work before they can be routinely, and cost-effectively, applied to concrete sumps. Suitable test methods include:

Acoustic Pulse-Echo--

A mechanical pulse is generated by impact or electronically on one face of the concrete slab. The signal passes through the slab, reflects from the back face of the slab, and is received by a transducer at the front face. If the concrete is solid, the oscilloscope screen displays two signals; one corresponding to the original impact, and the other for the reflected pulse. Intermediate signals indicate the presence of internal discontinuities (e.g., cracks). If the thickness of the slab is known, the pulse velocity can be determined. Generally, the higher the pulse velocity, the higher the quality of the concrete.

Acoustic pulse-echo still requires developmental work before it can be routinely applied to concrete slabs and walls. For example, pulses generated within the sonic range, such as those produced by a Schmidt hammer, are not resolvable in concrete less than several feet thick. Even in the ultrasonic range, which is more suited to thin concrete sections, the signal-to-noise ratio must be reduced to readily detect thin cracks and flaws.

Impact Echo--

The impact-echo method (API SP-112) is a modified version of the pulse-echo technique. A spring-loaded impactor imparts compression and shear waves to the concrete. The reflected waves are monitored by a transducer. Although developed recently, the method is considered viable for routine use on concrete slabs.

Ultrasonic Pulse Velocity--

A precursor of the acoustic pulse-echo technique is the ultrasonic pulse velocity method (ASTM C 597-83). It differs from the acoustic pulse-echo technique in that it is designed to be applied in situations where both sides many of the concrete structure are accessible -- a situation that is not common in sumps. It can be applied on a single side, but with limited precision. If used by an expert, however, some useful data on flaws may be obtained. The advantage of this technique is that it is currently available in off-the-shelf, portable instruments.

Ultrasonic Spectroscopy--

This technique is still in experimental stages, but it is based on the principle that propagation of elastic waves in concrete will result in scattering, mode conversion, and dispersion due to inclusions, boundaries, and inhomogeneities of materials. It may prove feasible for determining the size of existing cracks.

Radar--

Current technology uses a pulse of low-power radio frequency energy that is directed into the concrete. When an interface (such as a pavement/base interface) is encountered, a portion of the energy is reflected back to an antenna. The reflected energy is converted to a visual form on an oscilloscope or strip chart for interpretation; special attention must be given to data interpretation as it can be easily misinterpreted. This technique can be applied from a single side of a structure and is capable of detecting microcracks. Low-power, high-resolution radar has been used successfully to detect deterioration in large structures;

however, future development of smaller, portable instruments will be necessary to make it suitable for use in sumps.

Gamma Radiometry--

This method incorporates a Geiger or scintillation counter to measure the backscatter of gamma radiation from a concentrated source (ASTM C 1040-85). It is a useful and relatively simple means to determine variations in density within the concrete. The method can be used on sump surfaces, because only one side of the concrete structure being tested needs to be accessible. Gamma radiometry, however, does not yield information regarding the cause of the density variation; which may be due to cracks, less dense aggregate, trapped moisture, or other irregularities. This test should be viewed as a preliminary screening tool; further investigation using other techniques will be necessary.

Core Sampling

If non-destructive tests are inconclusive, especially in cases where a leak is suspected, it may be necessary to analyze samples of the concrete in a laboratory. Due to the associated cost and destructive nature of the sampling process (i.e., coring), this practice is not recommended for routine assessment of sumps. This discussion is intended to provide the reader with a broad overview of the process for obtaining concrete samples. For further information, the reader is referred to Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete (ASTM C 42-87), and Standard Practice for Examination and Sampling of Hardened Concrete in Constructions (ASTM C 823-83).

Concrete slabs and walls are typically sampled by removing core specimens with a rotary drill. In general, the number of samples taken must be sufficient to be representative of the concrete structure, but also will be dependent upon the scope of the laboratory testing program. Two types of core samples can be taken: (1) those that are intended to represent the variability of the concrete, and (2) those that are intended to display a specific feature of interest. Samples of specific features, such as isolated spalls or popouts, should include representative examples of the feature as well as the underlying and adjacent concrete. Development of a sampling plan is discussed further in ASTM C 823-83.

The core sample should be taken perpendicular to the concrete surface and should include the exposed surface, near-surface concrete, and concrete at depth. For concrete slabs or walls less than 1 foot thick, ASTM C 823-83 recommends that the sample extend through the entire depth of the concrete. If the concrete is greater than 1 foot thick, a minimum core depth of 1 foot is recommended. Deeper drilling, however, may be necessary to determine the extent of cracking, condition of joints, extent of any cement-aggregate reactions, condition of concrete in contact with subgrade material, and variability of the concrete.

If the core extends through the depth of the concrete, a soil sample may be taken to test for the presence of wastes managed in the sump. Various equipment is available for the collection of soil samples. Two standard tools that are suitable for soil sampling under these circumstances are the soil probe and the soil auger. Once collected, the soil sample should be placed in a container that is compatible with the analyte class of interest and shipped to a qualified laboratory for analysis.

After sampling has been completed, the cored areas will require repair. Even though core sampling is destructive, the resulting holes can be repaired to be more leak resistant than the existing concrete. Methods of concrete repair are discussed in Section 4.

Laboratory Investigation

As discussed earlier, some qualitative information can be obtained by visually examining the concrete surface, however, the most useful data for determining sump soundness comes from a qualified petrographer examining sections of core samples brought into the laboratory. For further information on petrographer qualifications, apparatus used in the examination, specimen preparation, and sample examination, the reader is referred to the Standard Practice for Petrographic Examination of Hardened Concrete (ASTM C 856-83). The purpose of this discussion is to provide a sump owner or operator with an overview of the useful information that can be obtained from a laboratory investigation.

A petrographic examination of a concrete sample can provide the following general information:

- Condition of the concrete;
- Causes of inferior quality, distress, or deterioration;
- Probable future performance;
- Whether the concrete was constructed as specified;
- Description of the cement matrix, including the kind of hydraulic binder used, degree of hydration, degree of carbonation, unsoundness of the cement, presence of a mineral admixture, nature of the hydration products, adequacy of curing, and unusually high water/cement ratio of the paste;
- Determination of presence and effects of alkali-silica, alkali-carbonate, or cement-aggregate reactions or reactions between contaminants and the matrix;
- Attack by sulfate or other chemicals;
- Harmful effects of freezing or thawing;

- Safety of the structure with respect to present or proposed use;
- Damage due to fire;
- Performance of the coarse or fine aggregate or determination of aggregate composition;
- Factors that caused a given concrete structure to serve satisfactorily in its environment; and
- Presence and nature of surface treatments.

Though a complete petrographic examination is capable of providing all of the above mentioned information, not all of it is necessary to determine sump soundness. The owner or operator should consult with an experienced petrographer to determine the scope of the examination and the kind of information needed. At a minimum, however, the core sample should be examined for the following:

- Condition of the aggregate,
- Pronounced cement-aggregate reactions,
- Deterioration of aggregate particles in place,
- Denseness of cement paste,
- Homogeneity of the concrete,
- Depth and extent of carbonation,
- Occurrence and distribution of fractures,
- Characteristics and distribution of voids, and
- Presence of contaminating substances.

If soil samples were taken concurrently with concrete cores, they can be analyzed to determine if wastes managed in the sump are present in surrounding soils, indicating leakage from the sump. The appropriate technique and level of detection that will be used to analyze the samples will be dependent upon the nature of the wastes and their behavior in the environment (e.g., degradation). All testing, however, should be in accordance with EPA approved test methods found in SW-846, Test Methods for Evaluating Solid Waste, (3rd edition). The owner or operator should consult with a qualified laboratory to determine the appropriate analytical procedures and test parameters.

SECTION 4

METHODS OF CONCRETE REPAIR

INTRODUCTION

As discussed in Section 2, stress-induced cracks and joint failure are two common reasons for sump failure. To prevent hazardous wastes from being released into the environment, an owner or operator may find it necessary to initiate repairs on cracks or failed joints. Furthermore, 40 CFR 264.15(c) and 265.15(c) require an owner or operator to remedy any deterioration or malfunction identified in any hazardous waste management unit and CFR 264.196 and 265.196 sets forth what the owner/operator is to do in response to leaks or spills and disposition of leaking or unfit-for-use tank systems. The purpose of this section is to provide a brief overview of methods available to repair cracks and failed joints in concrete sumps.

CRACKS

Cracks occur when a concrete structure is unable to withstand stresses such as differential settlement, structural overload, and temperature changes. If cracks are not too severe, it is possible to initiate repairs to prevent leakage of wastes out of the sump structure. If they are not repaired, however, cracks can expand and continue to deteriorate the structural integrity of the sump. As cracks expand and allow more liquid into the matrix of the concrete, deterioration can be accelerated.

For repairs to be successful, however, the cause of the crack must first be identified or the repaired area may experience the same type of failure. As discussed in Section 3, several methods can be used to determine if cracking is caused by structural movement or due to other factors such as chemical attack or inferior quality. These methods include:

- Monitoring existing cracks for movement,
- Core sampling, and
- Petrographic analysis of concrete samples.

Once the cause of the crack failure is known, the concrete can be repaired properly. For example, resin-based epoxies can be used to "weld" the cracked area and restore structural strength and integrity to the concrete structure. Because epoxies do not allow flexibility in the repaired area, their use should be limited to non-moving cracks such as those caused by shrinkage during the curing process.

If the sump is subject to movement, however, a compound containing polyurethane is more appropriate for repairs. When properly used, this type of repair effectively stops movement of liquid through cracks while allowing some movement and flexibility in the concrete structure. Structural strength is not restored to the concrete with this type of repair.

JOINT FAILURE

Sump failure also can be attributed to joint failure. As discussed in Section 2, joint failure can be caused by improper sump design, stress, improper joint preparation, use of poor or inappropriate joint material, and improper construction. A visual inspection of the joint filler and the surrounding concrete is generally sufficient to determine if the joint has failed. Deteriorated joint filler, honeycomb concrete surrounding the waterstop, and moisture accumulation in the joint of a dry sump are some suspect conditions. As with cracks, failed joints should be repaired to restore structural integrity to the sump and prevent wastes from entering the environment. Methods of repair must be specific to the cause of failure to avoid a recurrence.

METHODS OF CONCRETE REPAIR

A number of techniques can be used to repair joints and cracks in concrete. Nine methods that may be used for repairing concrete sumps are:

Grouting

Grout is a commonly used material for concrete repair. A chemical grout can be used to repair cracks as small as 0.002 inches while Portland cement grout can be used for wide cracks. Non-shrinking grout can be used to repair honeycombed or defective concrete after removal of the damaged area. Several other grouts, including chemical, epoxy, cement-based, and polymer grouts, are available to meet wide-ranging concrete repair needs.

Patching

Patching is a commonly-used method to replace loose, spalled, or crumbled concrete with new material. Portland cement mortar/concrete (PCC), polymer- and epoxy-modified PCC, and fiber-reinforced materials can be used for patching. Because surface deterioration is generally symptomatic of underlying structural problems, patching is effective only if structural repairs are initiated. For example, spalled areas on an unlined concrete unit should not be repaired prior to investigation into its cause. Spalling can be an indicator of a leak that is causing the concrete to deteriorate.

Joint Repairing

Joint failures can involve various structural components such as the waterstop, filler, and concrete surrounding the joint. The method of joint repair is dependent upon the structural components involved and the mode of failure. Generally speaking, a joint repair may require removal of filler material, inspection of the waterstop and surrounding concrete, repair of the concrete, replacement of the waterstop (possibly a different type), and resealing of the joint with appropriate filler material. Common techniques of joint repair include poured-in-place seals and pre-formed seals.

Joint failure resulting from movement along the joint may require use of a flexible, elastomeric seal and a joint device. A joint device is a mechanism that allows for controlled movement along joints. For example, a joint device may consist of a system of dowels that span the joint, providing limited flexibility where bi-directional movement is anticipated. Such a system allows movement while preventing structural damage to the sump.

Strengthening

Strengthening the structure is a means to address structural overload that can be caused by excessive tensile, compressive, and shear stresses. Common methods used for strengthening structures include post-tensioning, tie-down, bracing, and grouting. Depending on the situation, strengthening methods can become quite complicated.

Epoxy Injection

Narrow and extremely fine cracks, down to 0.05mm (0.002 inches) in width, can be repaired through epoxy injection techniques. A specially-formulated, low-viscosity epoxy is used in this process. Because the epoxy material does not allow structural movement in the repaired area, use is limited to dormant cracks such as those that develop during the concrete curing process.

Drilling and Plugging

Drilling and plugging is a repair method in which a hole is drilled the length of the crack and is subsequently filled with grout or resilient material. The plugging material used is dependent upon the objective of the repairs. To use this method of repair, the crack must be accessible at one end and must extend in a fairly straight line.

Flexible Sealing

Active cracks can be repaired with a flexible seal that will allow some movement of the concrete structure. The crack must first be routed and the surface properly prepared. Once this has been accomplished, the crack is filled with a flexible sealant.

Drypacking

Drypacking is a repair method where a low-water-content mortar is used to produce a connection with the existing concrete structure. For a successful repair, the use of drypack is limited to narrow, dormant cracks. Because the drypacking material has a low water/cement ratio, shrinkage is not a problem.

Overlaying

Concrete overlays are sometimes used to repair concrete surfaces that contain numerous fine cracks. This method is not recommended for active cracks. Site conditions must be considered when choosing an overlay material.

HELPFUL REFERENCES

A list of member concrete repair specialty firms can be obtained from the International Association of Concrete Repair Specialists (IACRS), Dulles International Airport, P.O. Box 17402, Washington, D.C. 20041. The following documents provide further information on concrete repair methods:

- American Concrete Institute, ACI 224.IR-84, Causes, Evaluation, and Repair of Cracks in Concrete Structures, Detroit, MI, 1984.
- American Concrete Institute, ACI 504R-90, Guide to Sealing Joints in Concrete Structures, Detroit, MI, 1990.
- American Concrete Institute, ACI Compilation No. 5, Concrete Repair and Restoration, Detroit, MI 1980.
- American Concrete Institute Committee 311, ACI Publication SP-2, ACI Manual of Concrete Inspection, Seventh Ed., Detroit, MI, 1988.
- American Water Works Association, ANSI/AWWA D110-86, AWWA Standard for Wire-Wound Circular Prestressed-Concrete Water Tanks, Denver, CO, 1987.
- McDonald, J.E., Repair of Waterstop Failures: Case Histories, U.S. Army Corps of Engineers, Technical Report REMR-CS-4, Vicksburg, MS, 1986.

SECTION 5

COATINGS FOR CONCRETE STRUCTURES

INTRODUCTION

As discussed earlier in this document, 40 CFR 264.191, 264.192, 265.191, and 265.192 require that new and existing sumps be adequately designed and have sufficient structural strength and compatibility with the wastes being stored or treated to ensure that they will not collapse, rupture, or fail. To prevent releases to the environment, 40 CFR 264.193 and 265.193 require installation of secondary containment. Secondary containment systems are required to be designed, installed, and operated to prevent any migration of wastes or accumulated liquid to soil, ground water, or surface water.

To meet the intent of the above requirements, an owner or operator must apply a protective coating or liner to a concrete sump that is used to manage wastes or used to provide secondary containment. First, protective coatings or barriers can prevent concrete deterioration, which can potentially lead to sump failure. Second, because unprotected concrete is considered permeable to liquids, a coating or barrier is necessary to prevent releases of hazardous wastes or constituents into the environment. To be effective, the appropriate coating or barrier must be compatible with the waste to be managed in the sump.

The purpose of this section is to provide an overview of the basic properties of coatings, discuss the factors influencing selection of an appropriate coating, and describe coating installation. A more detailed evaluation of coatings is provided in Appendix B.

COATINGS

Four types of coatings, or barrier systems, are generally applied to concrete: waterproofing systems, dampproofing systems, protective systems, and decorative paint. Each of these systems is thoroughly reviewed in the American Concrete Institute's (ACI) publication: <u>A Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete</u> (ACI 515.IR-79). Because dampproofing and decorative paint are of little use in enhancing waste compatibility or preventing releases to the environment, they will not be discussed further in this document. This section will focus on protective and waterproofing coatings that are suitable for use on concrete sumps.

TABLE 5-1. PROTECTIVE BARRIER SYSTEMS - GENERAL CATEGORIES*

Severity of Chemical Environment	Total Nominal Thickness Range	Typical Protective Barrier Systems	Typical but not Exclusive Uses of Protective Systems in Order of Severity
Mild	Under 40 mil (1 mm)	Polyvinyl butyral, polyurethane, methyl methacrylate, alkyl-alkoxysilane, epoxy, acrylic, chlorinated rubber, styrene-acrylic copolymer Asphalt, coal tar, chlorinated rubber, epoxy, polyurethane, vinyl, neoprene, coal tar epoxy, coal tar urethane	- Protection against de-icing salts - Reduce exposure regarding freeze/thaw resistance - Prevent staining of concrete - Use for high-purity water service - Protect concrete in contact with chemical solutions having a pH as low as 4, depending on the chemical.
Intermediate	125 to 375 mil (3 to 9 mm)	Sand-filled epoxy, sand-filled polyester, sand-filled polyurethane, and bituminous materials. This filler is usually silica sand.	- Protect concrete from abrasion and intermittent exposure to dilute acids in chemical, dairy, and food processing plants.
Severe	20 to 250 mil (1/2 to 6 mm)	Glass-reinforced epoxy, glass-reinforced polyester, pre-cured neoprene sheet, plasticized PVC sheet	- Protect concrete tanks and floors during continuous exposure to dilute mineral, (pH is below 3) organic acids, salt solutions, strong alkalies.
Severe	20 to 280 mil (1/2 to 6-3/4 mm) Over 250 mil (6 mm) Over 250 mil (6 mm)	Composite systems: (a) Filled epoxy system topcoated with a pigmented but unfilled epoxy (b) Asphalt membrane covered with acid-proof brick using a chemical-resistant mortar (c) Glass-reinforced furan membrane covered with acid-proof brick using a chemical-resistant mortar.	- Protect concrete tanks during continuous or intermittent immersion, exposure to water dilute acids, strong alkalies, and salt solutions. - Protect concrete from concentrated acids or acid/solvent combinations. - Protect concrete from acid/solvent combinations.

* This table is reproduced from ACI 515.1R-32 and is used with the permission of the American Concrete Institute.

operator be cautious and be assured that the coating will meet his needs. Coating materials made by different manufacturers do not perform equally, even when classified as the same generic type. The specific ingredients or quantities of similar ingredients used by different coating manufacturers varies, which can affect coating performance. Therefore, coating selection should be based on actual testing or past experience.

Testing should be conducted by applying the desired coating to concrete specimens and subjecting both to the actual sump environment or one that simulates as closely as possible this environment. If a coating must be selected before tests of significant duration can be conducted, the supplier should be requested to submit fully-documented case histories where his coating has protected concrete under the same or similar environmental conditions.

Finally, it should be noted that if conditions are severe enough to deteriorate good quality concrete, it may be difficult to find a coating that will provide complete and lasting protection. Under these circumstances, consideration should be given to neutralizing severely aggressive liquid wastes.

Waterproofing Coatings

Waterproofing coatings typically are used to prevent water (e.g., ground water) from passing into, through, or out of concrete under hydrostatic pressure. Traditionally, waterproofing coatings consist of multiple layers of bituminous-saturated felt or fabric cemented together with hot-applied coal tar pitch or asphalt for application to the outside surface of a concrete structure. Cold-applied systems using multiple applications of asphaltic mastics and glass fabrics also have been used. Recently, however, a number of other waterproofing coatings are available, such as elastomeric membrane barriers, cementious membranes, modified bituminous materials, bentonite- based materials, and various proprietary types. Commonly-used waterproofing coatings are discussed more fully in Appendix B.

COATING INSTALLATION

Coatings can be applied to either the inside facing or outside facing of a concrete structure, depending on the type of protection needed. In most cases, a protective coating will be installed on the inside facing of the sump to prevent contact of the wastes and the concrete surface and to provide a secure bond between the coating and the concrete. To preserve this bond between the protective coating and the concrete, it may be necessary to install a waterproofing coating on the outside face of the sump to prevent water infiltration. Figure 5-1 is a cross-section that shows both an internal protective coating and external waterproofing coating as they could be applied to a concrete sump.

Protective coatings are designed to protect concrete from deterioration when it is exposed to chemicals. Waterproofing is used to prevent movement of water into, through, or out of concrete under hydrostatic pressure. Although both types of coatings are designed for a specific purpose, it is possible that either type of coating could simultaneously serve both functions. For example, certain types of waterproofing also may protect concrete from corrosive soil conditions.

Protective Coatings

In general, the vulnerability of concrete to chemical attack results from three of its characteristics: permeability, alkalinity, and reactivity. Penetration of liquids into concrete is sometimes accompanied by chemical reactions with cement, aggregates, or embedded steel. For example, acidic compounds, salts of weak bases, ammonium salts, and some polyhydroxy compounds, such as glycols, can deteriorate concrete. Most carbonates and nitrates, some chlorides, fluorides, and silicates; petroleum products that are free of fatty oil additives; and weak alkaline solutions, however, are normally harmless to mature concrete. For more specific information on determining waste compatibility with concrete, the reader is referred to ACI's publication 515.IR-79 on barrier systems (discussed above) and the Portland Cement Association's publication: Effects of Substances on Concrete and Guide to Protective Treatments, Where Required (1981).

Protective coatings inhibit chemical deterioration by preventing contact of the sump contents with concrete surfaces. However, not all individual coatings are equally suited for use under all circumstances. In other words, a coating that is effective under one set of operating conditions and a given chemical environment may not be effective in preventing deterioration under different circumstances. The selection of an appropriate coating will be dependent upon the type and concentration of wastes managed in the sump, as well as frequency and duration of contact. Physical conditions, such as temperature, pressure, mechanical wear or abrasion, and freeze/thaw cycles also are important considerations. When selecting a coating, the owner or operator should be aware of the following:

- The coating must be resistant to deterioration or degradation by the wastes to which it will be exposed. The wastes should not cause swelling, dissolving, cracking, or embrittlement of the coating at operating temperatures. For example, organic solvents are generally incompatible with chlorinated rubber coatings, and oxidizing acids are generally incompatible with epoxy coatings.

- The coating must exhibit good adhesion to the concrete and must have a very low permeability. Certain wastes can diffuse or permeate through coating materials, causing loss of adhesion, without appearing to have degraded the coating material. This phenomenon is typical of acidic chemicals on plastic or rubber coatings.

- The temperature of the wastes contacting the coating material will affect performance. Each material has its own characteristic maximum operating temperature for a given environment. Rapid temperature changes can crack some coating materials or break the bond between the coating and concrete.

- The abrasion resistance must be adequate to prevent the coating material from being abraded under operating conditions.

- Materials that are completely bonded to the concrete substrate are preferred over those that are unbonded. Bonded materials prevent water, which has entered through a membrane rupture, from migrating at the coating/concrete interface. Leaks in unbonded coatings are more difficult to trace than leaks in fully bonded coatings.

- If coating materials are exposed to weather, they must be resistant to ultraviolet light and ozone, or provisions should be made to protect exposed areas with weather resistant flashing materials. As an example, some preformed barriers use clear polyethylene films that should not be left exposed.

- Liquid-applied materials should not be used over unreinforced light weight aggregate concrete fills or thin veneers that use PVA or latex additives or bonding adhesives.

- Liquid-applied barriers may not cover, hide, or level surface irregularities.

- Where conditions may cause deterioration of the concrete around the reinforcing steel, a method for the direct protection of the steel may be desirable.

- Coatings should not be used as surface applications over concrete decks that already have a barrier or coating on the underside. Blistering or delamination can result from entrapped moisture. An exception is an unbonded coating that is vented or a coating that has an adequate transmission rate.

Table 5-1 summarizes the types of coatings typically used to protect concrete under differing chemical environments (e.g., mild, intermediate, and severe). Some of the generic types of materials used for coatings include asphalt, coal tar, polyvinyl chloride, acrylics, epoxy, neoprene, chlorinated rubber, and polyurethanes. Thickness of coatings is generally dependent upon the severity of the environment. Coatings can be hot-applied, cold-applied, or sheet-applied, depending upon the particular coating material. Appendix B more fully describes the most common materials used as protective coatings for concrete. Many of those described are suitable for use with sumps.

The owner or operator should work closely with the coating supplier to select a coating that will be effective. It is important that the owner or

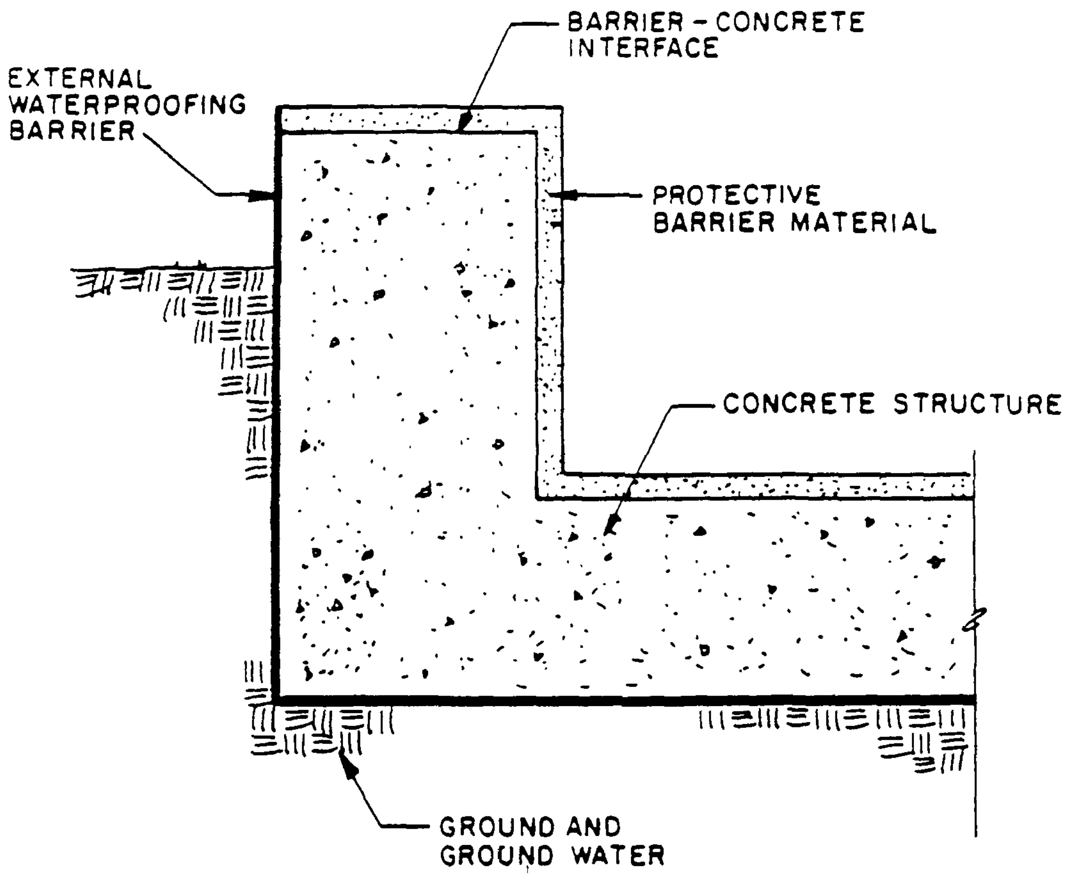

Figure 5-1. Typical Application of External Waterproofing and Internal Protective Barrier Systems to Concrete Sumps

Before installation of the desired coating can begin, the sump surface must be thoroughly cleaned; inspected; patched or repaired; and tested for moisture accumulation, cleanliness, and surface strength. The condition of the surface of the concrete (especially cleanliness) is critical to success ful installation of the coating. A smooth surface essentially free of honeycomb, depressions, fins, holes, humps, dust, dirt, oils, and other surface contaminants is necessary to provide continuous support to the coating material (otherwise punctures can be expected) and good adhesion. Release agents on forms, curing compounds, and evaporation-retarding admixtures may create adhesion problems for coatings on new concrete. Methods for cleaning concrete surfaces have been discussed earlier in Section 3 of this document.

After the sump has been thoroughly cleaned, it should be inspected for defects and repaired, where necessary. Section 4 of this document discusses common techniques used to repair or patch concrete. However, the owner or operator should be aware that patching materials containing polymer additives designed to improve adhesion to concrete may adversely affect adhesion between the patched area and the selected coating. The coating manufacturer may recommend specific patching materials.

Finally, the concrete surface should be tested for cleanliness, moisture accumulation, and surface condition. Wiping the surface should not leave a white powder or dust on a dark cloth. Water should not bead on the surface as this indicates the presence of oil. Moisture should not accumulate on the sump surface in less time than is required to cure the coating material. A test sheet of polyethylene can be taped to the concrete surface to determine the time for moisture to accumulate on the underside of the sheet. If scraping the concrete surface with a putty knife produces a loose, powdery material, then excessive laitance is present. A patch of the coating should be applied to the prepared sump surface to test the surface strength of the concrete. Since there is no standard patch test method, the manufacturer of the coating material should be asked to recommend test methods.

The owner or operator should carefully oversee all surface preparation and coating installation to assure that work is completed in accordance with the coating manufacturer's specifications. Following are additional suggestions for coating installation:

- Follow the manufacturer's guide specification. Resolve questions or disputed areas before contract documents or final specifications are issued for bids and eventual award of a contract.

- Specify that all technical data from the manufacturer and applicator be submitted to the specifying agency for approval after award of the contract.

- Establish the limitations and requirements during application that will be imposed by weather conditions (e.g., temperature, rain, wind).

- Request that the manufacturer confirm that the coating selected is suitable for the end use intended. Their performance guarantee should be defined by the manufacturer.

- Specify that the applicator of a liquid-applied coating be approved and certified by the manufacturer of the system.

APPENDIX A: REGULATIONS:

SUBPART J OF PART 264 AND 265

(5) Spilled or leaked waste and accumulated precipitation must be removed from the sump or collection area in as timely a manner as is necessary to prevent overflow of the collection system.

[*Comment*. If the collected material is a hazardous waste under Part 261 of this Chapter, it must be managed as a hazardous waste in accordance with all applicable requirements of Parts 262 through 266 of this chapter. If the collected material is discharged through a point source to waters of the United States, it is subject to the requirements of section 402 of the Clean Water Act, as amended.]

(c) Storage areas that store containers holding only wastes that do not contain free liquids need not have a containment system defined by paragraph (b) of this section, except as provided by paragraph (d) of this section or 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.

(d) Storage areas that store containers holding the wastes listed below that do not contain free liquids must have a containment system defined by paragraph (b) of this section:

(1) FO20, FO21, FO22, FO23, FO26, and FO27.

(2) [Reserved]

[46 FR 55112, Nov. 6, 1981, as amended at 50 FR 2003, Jan. 14, 1985]

§ 264.176 Special requirements for ignitable or reactive waste.

Containers holding ignitable or reactive waste must be located at least 15 meters (50 feet) from the facility's property line.

[*Comment*: See § 264.17(a) for additional requirements.]

§ 264.177 Special requirements for incompatible wastes.

(a) Incompatible wastes, or incompatible wastes and materials (see Appendix V for examples), must not be placed in the same container, unless § 264.17(b) is complied with.

(b) Hazardous waste must not be placed in an unwashed container that previously held an incompatible waste or material.

[*Comment*: As required by § 264.13, the waste analysis plan must include analyses needed to comply with § 264.177. Also, § 264.17(c) requires wastes analyses, trial tests or other documentation to assure compliance with § 264.17(b). As required by § 264.73, the owner or operator must place the results of each waste analysis and trial test, and any documented information, in the operating record of the facility.]

(c) A storage container holding a hazardous waste that is incompatible with any waste or other materials stored nearby in other containers, piles, open tanks, or surface impoundments must be separated from the other materials or protected from them by means of a dike, berm, wall, or other device.

[*Comment*: The purpose of this section is to prevent fires, explosions, gaseous emission, leaching, or other discharge of hazardous waste or hazardous waste constituents which could result from the mixing of incompatible wastes or materials if containers break or leak.]

§ 264.178 Closure.

At closure, all hazardous waste and hazardous waste residues must be removed from the containment system. Remaining containers, liners, bases, and soil containing or contaminated with hazardous waste or hazardous waste residues must be decontaminated or removed.

[*Comment*: At closure, as throughout the operating period, unless the owner or operator can demonstrate in accordance with § 261.3(d) of this chapter that the solid waste removed from the containment system is not a hazardous waste, the owner or operator becomes a generator of hazardous waste and must manage it in accordance with all applicable requirements of Parts 262 through 266 of this chapter].

Subpart J—Tank Systems

SOURCE: 51 FR 25472, July 14, 1986, unless otherwise noted.

§ 264.190 Applicability.

The requirements of this Subpart apply to owners and operators of facilities that use tank systems for storing or treating hazardous waste except as otherwise provided in paragraphs (a) and (b) of this section or in § 264.1 of this part.

(a) Tank systems that are used to store or treat hazardous waste which contains no free liquids and are situated inside a building with an impermeable floor are exempted from the requirements in § 264.193. To demonstrate the absence or presence of free liquids in the stored/treated waste, EPA Method 9095 (Paint Filter Liquids Test) as described in "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods" (EPA Publication No. SW-846) must be used.

(b) Tank systems, including sumps, as defined in § 260.10, that serve as part of a secondary containment system to collect or contain releases of hazardous wastes are exempted from the requirements in § 264.193(a).

(Information collection requirement contained in paragraph (a) was approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25472, July 14, 1986, 51 FR 29430, Aug. 15, 1986, as amended at 53 FR 34086, Sept. 2, 1988]

§ 264.191 Assessment of existing tank system's integrity.

(a) For each existing tank system that does not have secondary containment meeting the requirements of § 264.193, the owner or operator must determine that the tank system is not leaking or is unfit for use. Except as provided in paragraph (c) of this section, the owner or operator must obtain and keep on file at the facility a written assessment reviewed and certified by an independent, qualified registered professional engineer, in accordance with § 270.11(d), that attests to the tank system's integrity by January 12, 1988.

(b) This assessment must determine that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated, to ensure that it will not collapse, rupture, or fail. At a minimum, this assessment must consider the following:

(1) Design standard(s), if available, according to which the tank and ancillary equipment were constructed;

(2) Hazardous characteristics of the waste(s) that have been and will be handled;

(3) Existing corrosion protection measures;

(4) Documented age of the tank system, if available (otherwise, an estimate of the age); and

(5) Results of a leak test, internal inspection, or other tank integrity examination such that:

(i) For non-enterable underground tanks, the assessment must include a leak test that is capable of taking into account the effects of temperature variations, tank end deflection, vapor pockets, and high water table effects, and

(ii) For other than non-enterable underground tanks and for ancillary equipment, this assessment must include either a leak test, as described above, or other integrity examination, that is certified by an independent, qualified, registered professional engineer in accordance with § 270.11(d), that addresses cracks, leaks, corrosion, and erosion.

(NOTE: The practices described in the American Petroleum Institute (API) Publication, Guide for Inspection of Refinery Equipment, Chapter XIII, "Atmospheric and Low-Pressure Storage Tanks," 4th edition, 1981, may be used, where applicable, as guidelines in conducting other than a leak test.)

(c) Tank systems that store or treat materials that become hazardous wastes subsequent to July 14, 1986, must conduct this assessment within 12 months after the date that the waste becomes a hazardous waste.

(d) If, as a result of the assessment conducted in accordance with paragraph (a), a tank system is found to be leaking or unfit for use, the owner or operator must comply with the requirements of § 264.196.

(Information collection requirements contained in paragraphs (a) through (d) were approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25472, July 14, 1986; 51 FR 29430, Aug. 15, 1986]

§ 264.192 Design and installation of new tank systems or components.

(a) Owners or operators of new tank systems or components must obtain and submit to the Regional Administrator, at time of submittal of Part B information, a written assessment, reviewed and certified by an independent, qualified registered professional engineer, in accordance with § 270.11(d), attesting that the tank system has sufficient structural integrity and is acceptable for the storing and treating of hazardous waste. The assessment must show that the foundation, structural support, seams, connections, and pressure controls (if applicable) are adequately designed and that the tank system has sufficient structural strength, compatibility with the waste(s) to be stored or treated, and corrosion protection to ensure that it will not collapse, rupture, or fail. This assessment, which will be used by the Regional Administrator to review and approve or disapprove the acceptability of the tank system design, must include, at a minimum, the following information:

(1) Design standard(s) according to which tank(s) and/or the ancillary equipment are constructed;

(2) Hazardous characteristics of the waste(s) to be handled;

(3) For new tank systems or components in which the external shell of a metal tank or any external metal component of the tank system will be in contact with the soil or with water, a determination by a corrosion expert of:

(i) Factors affecting the potential for corrosion, including but not limited to:

(A) Soil moisture content;

(B) Soil pH;

(C) Soil sulfides level;

(D) Soil resistivity;

(E) Structure to soil potential;

(F) Influence of nearby underground metal structures (e.g., piping);

(G) Existence of stray electric current,

(H) Existing corrosion protection measures (e.g., coating, cathodic protection), and

(ii) The type and degree of external corrosion protection that are needed to ensure the integrity of the tank system during the use of the tank system or component, consisting of one or more of the following:

(A) Corrosion-resistant materials of construction such as special alloys, fiberglass reinforced plastic, etc.;

(B) Corrosion-resistant coating (such as epoxy, fiberglass, etc.) with cathodic protection (e.g., impressed current or sacrificial anodes); and

(C) Electrical isolation devices such as insulating joints, flanges, etc.

(NOTE: The practices described in the National Association of Corrosion Engineers (NACE) standard, "Recommended Practice (RP-02-85)—Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems," and the American Petroleum Institute (API) Publication 1632, "Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems," may be used, where applicable, as guidelines in providing corrosion protection for tank systems.)

(4) For underground tank system components that are likely to be adversely affected by vehicular traffic, a determination of design or operational measures that will protect the tank system against potential damage; and

(5) Design considerations to ensure that:

(i) Tank foundations will maintain the load of a full tank;

(ii) Tank systems will be anchored to prevent flotation or dislodgment where the tank system is placed in a saturated zone, or is located within a seismic fault zone subject to the standards of § 264.18(a); and

(iii) Tank systems will withstand the effects of frost heave.

(b) The owner or operator of a new tank system must ensure that proper handling procedures are adhered to in order to prevent damage to the system during installation. Prior to covering, enclosing, or placing a new tank system or component in use, an independent, qualified installation inspector or an independent, qualified, registered professional engineer, either of whom is trained and experienced in the proper installation of tank systems or components, must inspect the system for the presence of any of the following items:

(1) Weld breaks;

(2) Punctures;

(3) Scrapes of protective coatings;

(4) Cracks;

(5) Corrosion;

(6) Other structural damage or inadequate construction/installation.

All discrepancies must be remedied before the tank system is covered, enclosed, or placed in use.

(c) New tank systems or components that are placed underground and that are backfilled must be provided with a backfill material that is a noncorrosive, porous, homogeneous substance and that is installed so that the backfill is placed completely around the tank and compacted to ensure that the tank and piping are fully and uniformly supported.

(d) All new tanks and ancillary equipment must be tested for tightness prior to being covered, enclosed, or placed in use. If a tank system is found not to be tight, all repairs necessary to remedy the leak(s) in the system must be performed prior to the tank system being covered, enclosed, or placed into use.

(e) Ancillary equipment must be supported and protected against physical damage and excessive stress due to settlement, vibration, expansion, or contraction.

[NOTE: The piping system installation procedures described in American Petroleum Institute (API) Publication 1615 (November 1979), "Installation of Underground Petroleum Storage Systems," or ANSI Standard B31.3, "Petroleum Refinery Piping," and ANSI Standard B31.4 "Liquid Petroleum Transportation Piping System," may be used, where applicable, as guidelines for proper installation of piping systems.]

(f) The owner or operator must provide the type and degree of corrosion protection recommended by an independent corrosion expert, based on the information provided under paragraph (a)(3) of this section, or other corrosion protection if the Regional Administrator believes other corrosion protection is necessary to ensure the integrity of the tank system during use of the tank system. The installation of a corrosion protection system that is field fabricated must be supervised by an independent corrosion expert to ensure proper installation.

(g) The owner or operator must obtain and keep on file at the facility written statements by those persons required to certify the design of the tank system and supervise the installation of the tank system in accordance with the requirements of paragraphs (b) through (f) of this section, that attest that the tank system was properly designed and installed and that repairs, pursuant to paragraphs (b) and (d) of this section, were performed. These written statements must also include the certification statement as required in § 270.11(d) of this chapter.

(Information collection requirements contained in paragraphs (a) and (g) were approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25472, July 14, 1986, 51 FR 29430, Aug. 15, 1986]

§ 264.193 Containment and detection of releases.

(a) In order to prevent the release of hazardous waste or hazardous constituents to the environment, secondary containment that meets the requirements of this section must be provided (except as provided in paragraphs (f) and (g) of this section):

(1) For all new tank systems or components, prior to their being put into service;

(2) For all existing tank systems used to store or treat EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F027, within two years after January 12, 1987;

(3) For those existing tank systems of known and documented age, within two years after January 12, 1987 or when the tank system has reached 15 years of age, whichever comes later;

(4) For those existing tank systems for which the age cannot be documented, within eight years of January 12, 1987; but if the age of the facility is greater than seven years, secondary containment must be provided by the time the facility reaches 15 years of age, or within two years of January 12, 1987, whichever comes later; and

(5) For tank systems that store or treat materials that become hazardous wastes subsequent to January 12, 1987, within the time intervals required in paragraphs (a)(1) through (a)(4) of this section, except that the date that a material becomes a hazardous waste must be used in place of January 12, 1987.

(b) Secondary containment systems must be:

(1) Designed, installed, and operated to prevent any migration of wastes or accumulated liquid out of the system to the soil, ground water, or surface water at any time during the use of the tank system; and

(2) Capable of detecting and collecting releases and accumulated liquids until the collected material is removed.

(c) To meet the requirements of paragraph (b) of this section, secondary containment systems must be at a minimum:

(1) Constructed of or lined with materials that are compatible with the wastes(s) to be placed in the tank system and must have sufficient strength and thickness to prevent failure owing to pressure gradients (including static head and external hydrological forces), physical contact with the waste to which it is exposed, climatic conditions, and the stress of daily operation (including stresses from nearby vehicular traffic).

(2) Placed on a foundation or base capable of providing support to the secondary containment system, resistance to pressure gradients above and below the system, and capable of preventing failure due to settlement, compression, or uplift;

(3) Provided with a leak-detection system that is designed and operated so that it will detect the failure of either the primary or secondary containment structure or the presence of any release of hazardous waste or accumulated liquid in the secondary containment system within 24 hours, or at the earliest practicable time if the owner or operator can demonstrate to the Regional Administrator that existing detection technologies or site conditions will not allow detection of a release within 24 hours; and

(4) Sloped or otherwise designed or operated to drain and remove liquids resulting from leaks, spills, or precipitation. Spilled or leaked waste and accumulated precipitation must be removed from the secondary containment system within 24 hours, or in as timely a manner as is possible to prevent harm to human health and the environment, if the owner or operator can demonstrate to the Regional Administrator that removal of the released waste or accumulated precipitation cannot be accomplished within 24 hours.

[NOTE: If the collected material is a hazardous waste under Part 261 of this chapter, it is subject to management as a hazardous waste in accordance with all applicable requirements of Parts 262 through 265 of this chapter. If the collected material is discharged through a point source to waters of the United States, it is subject to the requirements of sections 301, 304, and 402 of the Clean Water Act, as amended. If discharged to a Publicly Owned Treatment Works (POTW), it is subject to the requirements of section 307 of the Clean Water Act, as amended. If the collected material is released to the environment, it may be subject to the reporting requirements of 40 CFR Part 302.]

(d) Secondary containment for tanks must include one or more of the following devices:

(1) A liner (external to the tank);

(2) A vault;

(3) A double-walled tank; or

(4) An equivalent device as approved by the Regional Administrator

(e) In addition to the requirements of paragraphs (b), (c), and (d) of this section, secondary containment systems must satisfy the following requirements:

(1) External liner systems must be:

(i) Designed or operated to contain 100 percent of the capacity of the largest tank within its boundary;

(ii) Designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration. Such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event.

(iii) Free of cracks or gaps; and

(iv) Designed and installed to surround the tank completely and to cover all surrounding earth likely to come into contact with the waste if the waste is released from the tank(s) (i.e., capable of preventing lateral as well as vertical migration of the waste).

(2) Vault systems must be:

(i) Designed or operated to contain 100 percent of the capacity of the largest tank within its boundary;

(ii) Designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration. Such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event;

(iii) Constructed with chemical-resistant water stops in place at all joints (if any);

(iv) Provided with an impermeable interior coating or lining that is compatible with the stored waste and that will prevent migration of waste into the concrete;

(v) Provided with a means to protect against the formation of and ignition of vapors within the vault, if the waste being stored or treated:

(A) Meets the definition of ignitable waste under § 262.21 of this chapter; or

(B) Meets the definition of reactive waste under § 262.21 of this chapter, and may form an ignitable or explosive vapor.

(vi) Provided with an exterior moisture barrier or be otherwise designed or operated to prevent migration of moisture into the vault if the vault is subject to hydraulic pressure.

(3) Double-walled tanks must be:

(i) Designed as an integral structure (i.e., an inner tank completely enveloped within an outer shell) so that any release from the inner tank is contained by the outer shell.

(ii) Protected, if constructed of metal, from both corrosion of the primary tank interior and of the external surface of the outer shell; and

(iii) Provided with a built-in continuous leak detection system capable of detecting a release within 24 hours, or at the earliest practicable time if the owner or operator can demonstrate to the Regional Administrator, and the Regional Administrator concludes, that the existing detection technology or site conditions would not allow detection of a release within 24 hours.

[NOTE: The provisions outlined in the Steel Tank Institute's (STI) "Standard for Dual Wall Underground Steel Storage Tanks" may be used as guidelines for aspects of the design of underground steel double walled tanks.]

(f) Ancillary equipment must be provided with secondary containment (e.g., trench, jacketing, double-walled piping) that meets the requirements of paragraphs (b) and (c) of this section except for:

(1) Aboveground piping (exclusive of flanges, joints, valves, and other connections) that are visually inspected for leaks on a daily basis;

(2) Welded flanges, welded joints, and welded connections, that are visually inspected for leaks on a daily basis;

(3) Sealless or magnetic coupling pumps and sealless valves, that are visually inspected for leaks on a daily basis; and

(4) Pressurized aboveground piping systems with automatic shut-off devices (e.g., excess flow check valves, flow metering shutdown devices, loss of pressure actuated shut-off devices) that are visually inspected for leaks on a daily basis.

(g) The owner or operator may obtain a variance from the requirements of this section if the Regional Administrator finds, as a result of a demonstration by the owner or operator that alternative design and operating practices, together with location characteristics, will prevent the migration of any hazardous waste or hazardous constituents into the ground water; or surface water at least as effectively as secondary containment during the active life of the tank system or that in the event of a release that does migrate to ground water or surface water, no substantial present or potential hazard will be posed to human health or the environment. New underground tank systems may not, per a demonstration in accordance with paragraph (g)(2) of this section, be exempted from the secondary containment requirements of this section.

(1) In deciding whether to grant a variance based on a demonstration of equivalent protection of ground water and surface water, the Regional Administrator will consider:

(i) The nature and quantity of the wastes;

(ii) The proposed alternate design and operation;

(iii) The hydrogeologic setting of the facility, including the thickness of soils present between the tank system and ground water, and

(iv) All other factors that would influence the quality and mobility of the hazardous constituents and the potential for them to migrate to ground water or surface water

(2) In deciding whether to grant a variance based on a demonstration of no substantial present or potential hazard, the Regional Administrator will consider:

(i) The potential adverse effects on ground water, surface water, and land quality taking into account:

(A) The physical and chemical characteristics of the waste in the tank system, including its potential for migration.

(B) The hydrogeological characteristics of the facility and surrounding land,

(C) The potential for health risks caused by human exposure to waste constituents,

(D) The potential for damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents, and

(E) The persistence and permanence of the potential adverse effects;

(ii) The potential adverse effects of a release on ground-water quality, taking into account:

(A) The quantity and quality of ground water and the direction of ground-water flow,

(B) The proximity and withdrawal rates of ground-water users,

(C) The current and future uses of ground water in the area, and

(D) The existing quality of ground water, including other sources of contamination and their cumulative impact on the ground water quality,

(iii) The potential adverse effects of a release on surface water quality taking into account

(A) The quantity and quality of ground water and the direction of ground water flow,

(B) The patterns of rainfall in the region,

(C) The proximity of the tank system to surface waters,

(D) The current and future uses of surface waters in the area and any water quality standards established for those surface waters, and

(E) The existing quality of surface water, including other sources of contamination and the cumulative impact on surface-water quality; and

(iv) The potential adverse effects of a release on the land surrounding the tank system, taking into account:

(A) The patterns of rainfall in the region, and

(B) The current and future uses of the surrounding land.

(3) The owner or operator of a tank system, for which a variance from secondary containment had been granted in accordance with the requirements of paragraph (g)(1) of this section, at which a release of hazardous waste has occurred from the primary tank system but has not migrated beyond the zone of engineering control (as established in the variance), must:

(i) Comply with the requirements of § 264.196, except paragraph (d), and

(ii) Decontaminate or remove contaminated soil to the extent necessary to:

(A) Enable the tank system for which the variance was granted to resume operation with the capability for the detection of releases at least equivalent to the capability it had prior to the release; and

(B) Prevent the migration of hazardous waste or hazardous constituents to ground water or surface water; and

(iii) If contaminated soil cannot be removed or decontaminated in accordance with paragraph (g)(3)(ii) of this section, comply with the requirement of § 264.197(b).

(4) The owner or operator of a tank system, for which a variance from secondary containment had been granted in accordance with the requirements of paragraph (g)(1) of this section, at which a release of hazardous waste has occurred from the primary tank system and has migrated beyond the zone of engineering control (as established in the variance), must.

(i) Comply with the requirements of § 264.196 (a), (b), (c), and (d); and

(ii) Prevent the migration of hazardous waste or hazardous constituents to ground water or surface water, if possible, and decontaminate or remove contaminated soil. If contaminated soil cannot be decontaminated or removed or if ground water has been contaminated, the owner or operator must comply with the requirements of § 264.197(b); and

(iii) If repairing, replacing, or reinstalling the tank system, provide secondary containment in accordance with the requirements of paragraphs (a) through (f) of this section or reapply for a variance from secondary containment and meet the requirements for new tank systems in § 264.192 if the tank system is replaced. The owner or operator must comply with these requirements even if contaminated soil can be decontaminated or removed and ground water or surface water has not been contaminated.

(h) The following procedures must be followed in order to request a variance from secondary containment:

(1) The Regional Administrator must be notified in writing by the owner or operator that he intends to conduct and submit a demonstration for a variance from secondary containment as allowed in paragraph (g) according to the following schedule:

(i) For existing tank systems, at least 24 months prior to the date that secondary containment must be provided in accordance with paragraph (a) of this section.

(ii) For new tank systems, at least 30 days prior to entering into a contract for installation.

(2) As part of the notification, the owner or operator must also submit to the Regional Administrator a description of the steps necessary to conduct the demonstration and a timetable for completing each of the steps. The demonstration must address each of the factors listed in paragraph (g)(1) or paragraph (g)(2) of this section;

(3) The demonstration for a variance must be completed within 180 days after notifying the Regional Administrator of an intent to conduct the demonstration, and

(4) If a variance is granted under this paragraph, the Regional Administrator will require the permittee to construct and operate the tank system in the manner that was demonstrated to meet the requirements for the variance.

(i) All tank systems, until such time as secondary containment that meets the requirements of this section is provided, must comply with the following:

(1) For non-enterable underground tanks, a leak test that meets the requirements of § 264.191(b)(5) or other tank integrity method, as approved or required by the Regional Administrator, must be conducted at least annually.

(2) For other than non-enterable underground tanks, the owner or operator must either conduct a leak test as in paragraph (i)(1) of this section or develop a schedule and procedure for an assessment of the overall condition of the tank system by an independent, qualified registered professional engineer. The schedule and procedure must be adequate to detect obvious cracks, leaks, and corrosion or erosion that may lead to cracks and leaks. The owner or operator must remove the stored waste from the tank, if necessary, to allow the condition of all internal tank surfaces to be assessed. The frequency of these assessments must be based on the material of construction of the tank and its ancillary equipment, the age of the system, the type of corrosion or erosion protection used, the rate of corrosion or erosion observed during the previous inspection, and the characteristics of the waste being stored or treated.

(3) For ancillary equipment, a leak test or other integrity assessment as approved by the Regional Administrator must be conducted at least annually.

[NOTE: The practices described in the American Petroleum Institute (API) Publication Guide for Inspection of Refinery Equipment, Chapter XIII, "Atmospheric and Low-Pressure Storage Tanks" 4th edition, 1981, may be used, where applicable, as guidelines for assessing the overall condition of the tank system.]

(4) The owner or operator must maintain on file at the facility a record of the results of the assessments conducted in accordance with paragraphs (i)(1) through (i)(3) of this section.

(5) If a tank system or component is found to be leaking or unfit for use as a result of the leak test or assessment in paragraphs (i)(1) through (i)(3) of this section, the owner or operator must comply with the requirements of § 264.196.

(Information collection requirements contained in paragraphs (c), (d), (e), (g), (h), and (i) were approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25472, July 14, 1986; 51 FR 29430, Aug. 15, 1986, as amended at 53 FR 34086, Sept. 2, 1988]

§ 264.194 General operating requirements.

(a) Hazardous wastes or treatment reagents must not be placed in a tank system if they could cause the tank, its ancillary equipment, or the containment system to rupture, leak, corrode, or otherwise fail.

(b) The owner or operator must use appropriate controls and practices to prevent spills and overflows from tank or containment systems. These include at a minimum:

(1) Spill prevention controls (e.g., check valves, dry disconnect couplings);

(2) Overfill prevention controls (e.g., level sensing devices, high level alarms, automatic feed cutoff, or bypass to a standby tank); and

(3) Maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation.

(c) The owner or operator must comply with the requirements of § 264.196 if a leak or spill occurs in the tank system.

(Information collection requirements contained in paragraph (c) were approved by the Office of Management and Budget under control number 2050-0050)

§ 264.195 Inspections.

(a) The owner or operator must develop and follow a schedule and procedure for inspecting overfill controls

(b) The owner or operator must inspect at least once each operating day.

(1) Aboveground portions of the tank system, if any, to detect corrosion or releases of waste;

(2) Data gathered from monitoring and leak detection equipment (e.g., pressure or temperature gauges, monitoring wells) to ensure that the tank system is being operated according to its design; and

(3) The construction materials and the area immediately surrounding the externally accessible portion of the tank system, including the secondary containment system (e.g., dikes) to detect erosion or signs of releases of hazardous waste (e.g., wet spots, dead vegetation).

[NOTE: Section 264.15(c) requires the owner or operator to remedy any deterioration or malfunction he finds. Section 264.196 requires the owner or operator to notify the Regional Administrator within 24 hours of confirming a leak. Also, 40 CFR Part 302 may require the owner or operator to notify the National Response Center of a release.]

(c) The owner or operator must inspect cathodic protection systems, if present, according to, at a minimum, the following schedule to ensure that they are functioning properly:

(1) The proper operation of the cathodic protection system must be confirmed within six months after initial installation and annually thereafter; and

(2) All sources of impressed current must be inspected and/or tested, as appropriate, at least bimonthly (i.e., every other month).

[NOTE: The practices described in the National Association of Corrosion Engineers (NACE) standard, "Recommended Practice (RP-02-85)—Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems," and the American Petroleum Institute (API) Publication 1632, "Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems," may be used, where applicable, as guidelines in maintaining and inspecting cathodic protection systems.]

(d) The owner or operator must document in the operating record of the facility an inspection of those items in paragraphs (a) through (c) of this section.

(Information collection requirements contained in paragraph (a) and (d) were approved by the Office of Management and Budget under control number 2050-0050)

§ 264.196 Response to leaks or spills and disposition of leaking or unfit-for-use tank systems.

A tank system or secondary containment system from which there has been a leak or spill, or which is unfit for use, must be removed from service immediately, and the owner or operator must satisfy the following requirements:

(a) *Cessation of use; prevent flow or addition of wastes.* The owner or operator must immediately stop the flow of hazardous waste into the tank system or secondary containment system and inspect the system to determine the cause of the release.

(b) *Removal of waste from tank system or secondary containment system.* (1) If the release was from the tank system, the owner/operator must, within 24 hours after detection of the leak or, if the owner/operator demonstrates that it is not possible, at the earliest practicable time, remove as much of the waste as is necessary to prevent further release of hazardous waste to the environment and to allow inspection and repair of the tank system to be performed.

(2) If the material released was to a secondary containment system, all released materials must be removed within 24 hours or in as timely a manner as is possible to prevent harm to human health and the environment.

(c) *Containment of visible releases to the environment.* The owner/operator must immediately conduct a visual inspection of the release and, based upon that inspection:

(1) Prevent further migration of the leak or spill to soils or surface water; and

(2) Remove, and properly dispose of, any visible contamination of the soil or surface water.

(d) *Notifications, reports.* (1) Any release to the environment, except as provided in paragraph (d)(2) of this section, must be reported to the Regional Administrator within 24 hours of its detection. If the release has been reported pursuant to 40 CFR Part 302, that report will satisfy this requirement.

(2) A leak or spill of hazardous waste is exempted from the requirements of this paragraph if it is:

(i) Less than or equal to a quantity of one (1) pound, and

(ii) Immediately contained and cleaned up.

(3) Within 30 days of detection of a release to the environment, a report containing the following information must be submitted to the Regional Administrator:

(i) Likely route of migration of the release;

(ii) Characteristics of the surrounding soil (soil composition, geology, hydrogeology, climate);

(iii) Results of any monitoring or sampling conducted in connection with the release (if available). If sampling or monitoring data relating to the release are not available within 30 days, these data must be submitted to the Regional Administrator as soon as they become available.

(iv) Proximity to downgradient drinking water, surface water, and populated areas; and

(v) Description of response actions taken or planned.

(e) *Provision of secondary containment, repair, or closure.* (1) Unless the owner/operator satisfies the requirements of paragraphs (e)(2) through (4) of this section, the tank system must be closed in accordance with § 264.197.

(2) If the cause of the release was a spill that has not damaged the integrity of the system, the owner/operator may return the system to service as soon as the released waste is removed and repairs, if necessary, are made.

(3) If the cause of the release was a leak from the primary tank system into the secondary containment system, the system must be repaired prior to returning the tank system to service.

(4) If the source of the release was a leak to the environment from a component of a tank system without secondary containment, the owner/operator must provide the component of the system from which the leak occurred with secondary containment that satisfies the requirements of § 264.193 before it can be returned to service, unless the source of the leak is an aboveground portion of a tank system that can be inspected visually. If the source is an aboveground component that can be inspected visually, the component must be repaired and may be returned to service without secondary containment as long as the requirements of paragraph (f) of this section are satisfied. If a component is replaced to comply with the requirements of this subparagraph, that component must satisfy the requirements for new tank systems or components in §§ 264.192 and 264.193. Additionally, if a leak has occurred in any portion of a tank system component that is not readily accessible for visual inspection (e.g., the bottom of an inground or onground tank), the entire component must be provided with secondary containment in accordance with § 264.193 prior to being returned to use.

(f) *Certification of major repairs.* If the owner/operator has repaired a tank system in accordance with paragraph (e) of this section, and the repair has been extensive (e.g., installation of an internal liner; repair of a ruptured primary containment or secondary containment vessel), the tank system must not be returned to service unless the owner/operator has obtained a certification by an independent, qualified, registered, professional engineer in accordance with § 270.11(d) that the repaired system is capable of handling hazardous wastes without release for the intended life of the system. This certification must be submitted to the Regional Administrator within seven days after returning the tank system to use.

[NOTE: The Regional Administrator may, on the basis of any information received that there is or has been a release of hazardous waste or hazardous constituents into the environment, issue an order under RCRA section 3004(v), 3008(h), or 7003(a) requiring corrective action or such other response as deemed necessary to protect human health or the environment.]

[NOTE: See § 264.15(c) for the requirements necessary to remedy a failure. Also, 40 CFR Part 302 may require the owner or operator to notify the National Response Center of certain releases.]

(Information collection requirements contained in paragraphs (d), (e), and (f) were approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25472, July 14, 1986; 51 FR 29430, Aug. 15, 1986, as amended at 53 FR 34086, Sept. 2, 1988]

§ 264.197 Closure and post-closure care.

(a) At closure of a tank system, the owner or operator must remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), contaminated soils, and structures and equipment contaminated with waste, and manage them as hazardous waste, unless § 261.3(d) of this Chapter applies. The closure plan, closure activities, cost estimates for closure, and financial responsibility for tank systems must meet all of the requirements specified in Subparts G and H of this Part.

(b) If the owner or operator demonstrates that not all contaminated soils can be practicably removed or decontaminated as required in paragraph (a) of this section, then the owner or operator must close the tank system and perform post-closure care in accordance with the closure and post-closure care requirements that apply to landfills (§ 264.310). In addition, for the purposes of closure, post-closure, and financial responsibility, such a tank system is then considered to be a landfill, and the owner or operator must meet all of the requirements for landfills specified in Subparts G and H of this part.

(c) If an owner or operator has a tank system that does not have secondary containment that meets the requirements of § 264.193 (b) through (f) and has not been granted a variance from the secondary containment requirements in accordance with § 264.193(g), then:

(1) The closure plan for the tank system must include both a plan for complying with paragraph (a) of this section and a contingent plan for complying with paragraph (b) of this section.

(2) A contingent post-closure plan for complying with paragraph (b) of this section must be prepared and submitted as part of the permit application.

(3) The cost estimates calculated for closure and post-closure care must re-

flect the costs of complying with the contingent closure plan and the contingent post-closure plan, if those costs are greater than the costs of complying with the closure plan prepared for the expected closure under paragraph (a) of this section.

(4) Financial assurance must be based on the cost estimates in paragraph (c)(3) of this section.

(5) For the purposes of the contingent closure and post-closure plans, such a tank system is considered to be a landfill, and the contingent plans must meet all of the closure, post-closure, and financial responsibility requirements for landfills under Subparts G and H of this Part.

(Information collection requirements contained in paragraphs (a)-(c) were approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25472, July 14, 1986; 51 FR 29430, Aug. 15, 1986]

§ 264.198 Special requirements for ignitable or reactive wastes.

(a) Ignitable or reactive waste must not be placed in tank systems, unless:

(1) The waste is treated, rendered, or mixed before or immediately after placement in the tank system so that:

(i) The resulting waste, mixture, or dissolved material no longer meets the definition of ignitable or reactive waste under §§ 261.21 or 261.23 of this Chapter, and

(ii) Section 264.17(b) is complied with; or

(2) The waste is stored or treated in such a way that it is protected from any material or conditions that may cause the waste to ignite or react; or

(3) The tank system is used solely for emergencies.

(b) The owner or operator of a facility where ignitable or reactive waste is stored or treated in a tank must comply with the requirements for the maintenance of protective distances between the waste management area and any public ways, streets, alleys, or an adjoining property line that can be built upon as required in Tables 2-1 through 2-6 of the National Fire Protection Association's "Flammable and Combustible Liquids Code," (1977 or 1981) (incorporated by reference, see § 260.11).

§ 264.199 Special requirements for incompatible wastes.

(a) Incompatible wastes, or incompatible wastes and materials, must not be placed in the same tank system, unless § 264.17(b) is complied with.

(b) Hazardous waste must not be placed in a tank system that has not been decontaminated and that previously held an incompatible waste or material, unless § 264.17(b) is complied with.

Subpart K—Surface Impoundments

Source: 47 FR 32357, July 26, 1982, unless otherwise noted.

§ 264.220 Applicability.

The regulations in this subpart apply to owners and operators of facilities that use surface impoundments to treat, store, or dispose of hazardous waste except as § 264.1 provides otherwise.

§ 264.221 Design and operating requirements.

(a) Any surface impoundment that is not covered by paragraph (c) of this section or § 265.221 of this chapter must have a liner for all portions of the impoundment (except for existing portions of such impoundments). The liner must be designed, constructed, and installed to prevent any migration of wastes out of the impoundment to the adjacent subsurface soil or ground water or surface water at any time during the active life (including the closure period) of the impoundment. The liner may be constructed of materials that may allow wastes to migrate into the liner (but not into the adjacent subsurface soil or ground water or surface water) during the active life of the facility, provided that the impoundment is closed in accordance with § 264.228(a)(1). For impoundments that will be closed in accordance with § 264.228(a)(2), the liner must be constructed of materials that can prevent wastes from migrating into the liner during the active life of the facility. The liner must be:

(1) Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

(2) Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

(3) Installed to cover all surrounding earth likely to be in contact with the waste or leachate.

(b) The owner or operator will be exempted from the requirements of paragraph (a) of this section if the Regional Administrator finds, based on a demonstration by the owner or operator, that alternate design and operating practices, together with location characteristics, will prevent the migration of any hazardous constituents (see § 264.93) into the ground water or surface water at any future time. In deciding whether to grant an exemption, the Regional Administrator will consider:

(1) The nature and quantity of the wastes;

(2) The proposed alternate design and operation;

(3) The hydrogeologic setting of the facility, including the attenuative capacity and thickness of the liners and soils present between the impoundment and ground water or surface water; and

(4) All other factors which would influence the quality and mobility of the leachate produced and the potential for it to migrate to ground water or surface water.

(c) The owner or operator of each new surface impoundment, each new surface impoundment unit at an existing facility, each replacement of an existing surface impoundment unit, and each lateral expansion of an existing surface impoundment unit, must install two or more liners and a leachate collection system between such liners. The liners and leachate collection system must protect human health and the environment. The requirements of this paragraph shall apply with respect to all waste received after the issuance of the permit. The requirement for the installation of two or more liners in this paragraph may be satisfied by the installation of a top liner designed, operated and constructed of materials to prevent the migration of any constituent into such liner during the period such facility remains in operation (including any post-closure monitoring period), and a lower liner designed, operated, and constructed to prevent the migration of any constituent through such liner during such period. For the purpose of the preceding sentence, a lower liner shall be deemed to satisfy such requirement if it is constructed of at least a 3-foot thick layer of recompacted clay or other natural material with a permeability of no more than 1×10^{-7} centimeter per second.

(d) Paragraph (c) of this section will not apply if the owner or operator demonstrates to the Regional Administrator, and the Regional Administrator finds for such surface impoundment, that alternative design and operating practices, together with location characteristics, will prevent the migration of any hazardous constituent into the ground water or surface water at least as effectively as such liners and leachate collection systems.

(e) The double liner requirement set forth in paragraph (c) of this section may be waived by the Regional Administrator for any monofill, if:

(1) The monofill contains only hazardous wastes from foundry furnace emission controls or metal casting molding sand, and such wastes do not contain constituents which would render the wastes hazardous for reasons other than the EP toxicity characteristics in § 261.24 of this chapter; and

(2)(i)(A) The monofill has at least one liner for which there is no evidence that such liner is leaking. For the purposes of this paragraph, the term "liner" means a liner designed, constructed, installed, and operated to prevent hazardous waste from passing into the liner at any time during the active life of the facility, or a liner designed, constructed, installed, and operated to prevent hazardous waste from migrating beyond the liner to adjacent subsurface soil, ground water, State mechanisms are at least equivalent to the financial mechanisms specified in this subpart. The Regional Administrator will evaluate the equivalency of the mechanisms principally in terms of (1) certainty of the availability of funds for the required closure or post-closure care activities or liability coverage and (2) the amount of funds that will be made available. The Regional Administrator may also consider other factors as he deems appropriate. The owner or operator must submit to the Regional Administrator evidence of the establishment of the mechanism together with a letter requesting that the State-required mechanism be considered acceptable for meeting the requirements of this subpart. The submission must include the following information: The facility's EPA Identification Number, name, and address, and the amount of funds for closure or post-closure care or liability coverage assured by the mechanism. The Regional Administrator will notify the owner or operator of his determination regarding the mechanism's acceptability in lieu of financial mechanisms specified in this subpart. The Regional Administrator may require the owner or operator to submit additional information as is deemed necessary to make this determination. Pending this determination, the owner or operator will be deemed to be in compliance with the requirements of § 265.143, § 265.145, or § 265.147, as applicable.

(b) If a State-required mechanism is found acceptable as specified in paragraph (a) of this section except for the amount of funds available, the owner or operator may satisfy the requirements of this subpart by increasing the funds available through the State-required mechanism or using additional financial mechanisms as specified in this subpart. The amount of funds available through the State and Federal mechanisms must at least equal the amount required by this subpart.

§ 265.150 State assumption of responsibility.

(a) If the State either assumes legal responsibility for an owner's or operator's compliance with the closure, post-closure care or liability requirements of this part or assures that funds will be available from State sources to cover those requirements, the owner or operator will be in compliance with the requirements of § 265.143, § 265.145, or § 265.147 if the Regional Administrator determines that the State's assumption of responsibility is at least equivalent to the financial mechanisms specified in this subpart. The Regional Administrator will evaluate the equivalency of State guarantees principally in terms of (1) certainty of the availability of funds for the required closure or post-closure care activities or liability coverage and (2) the amount of funds that will be made available. The Regional Administrator may also consider other factors as he deems appropriate. The owner or operator must submit to the Regional Administrator a letter from the State describing the nature of the State's assumption of responsibility together with a letter from the owner or operator requesting that the State's assumption of responsibility be considered acceptable for meeting the requirements of this subpart. The letter from the State must include, or have attached to it, the following information: The facility's EPA Identification Number, name, and address, and the amount of funds for closure or post-closure care or liability coverage that are guaranteed by the State. The Regional Administrator will notify the owner or operator of his determination regarding the acceptability of the State's guarantee in lieu of financial mechanisms specified in this subpart. The Regional Administrator may require the owner or operator to submit additional information as is deemed necessary to make this determination. Pending this determination, the owner or operator will be deemed to be in compliance with the requirements of §§ 265.143, § 265.145, or § 265.147, as applicable.

(b) If a State's assumption of responsibility is found acceptable as specified in paragraph (a) of this section except for the amount of funds available, the owner or operator may satisfy the requirements of this subpart by use of both the State's assurance and additional financial mechanisms as specified in this subpart. The amount of funds available through the State and Federal mechanisms must at least equal the amount required by this subpart.

Subpart I—Use and Management of Containers

§ 265.170 Applicability.

The regulations in this subpart apply to owners and operators of all hazardous waste facilities that store containers of hazardous waste, except as § 265.1 provides otherwise.

§ 265.171 Condition of containers.

If a container holding hazardous waste is not in good condition, or if it begins to leak, the owner or operator must transfer the hazardous waste from this container to a container that is in good condition, or manage the waste in some other way that complies with the requirements of this part.

§ 265.172 Compatibility of waste with container.

The owner or operator must use a container made of or lined with materials which will not react with, and are otherwise compatible with, the hazardous waste to be stored, so that the ability of the container to contain the waste is not impaired.

§ 265.173 Management of containers.

(a) A container holding hazardous waste must always be closed during storage, except when it is necessary to add or remove waste.

(b) A container holding hazardous waste must not be opened, handled, or stored in a manner which may rupture the container or cause it to leak.

[*Comment:* Re-use of containers in transportation is governed by U.S. Department of Transportation regulations, including those set forth in 40 CFR 173.28.]

[45 FR 33232, May 19, 1980, as amended at 45 FR 78529, Nov. 25, 1980]

§ 265.174 Inspections.

The owner or operator must inspect areas where containers are stored at least weekly looking for leaks and for deterioration caused by corrosion or other factors.

[*Comment:* See § 265.171 for remedial action required if deterioration or leaks are detected.]

§ 265.175 [Reserved]

§ 265.176 Special requirements for ignitable or reactive waste.

Containers holding ignitable or reactive waste must be located at least 15 meters (50 feet) from the facility's property line.

[*Comment:* See § 265.17(a) for additional requirements.]

§ 265.177 Special requirements for incompatible wastes.

(a) Incompatible wastes, or incompatible wastes and materials, (see Appendix V for examples) must not be placed in the same container, unless § 265.17(b) is complied with.

(b) Hazardous waste must not be placed in an unwashed container that previously held an incompatible waste or material (see Appendix V for examples), unless § 265.17(b) is complied with.

(c) A storage container holding a hazardous waste that is incompatible with any waste or other materials stored nearby in other containers, piles, open tanks, or surface impoundments must be separated from the other materials or protected from them by means of a dike, berm, wall, or other device.

[*Comment:* The purpose of this is to prevent fires, explosions, gaseous emissions, leaching, or other discharge of hazardous waste or hazardous waste constituents which could result from the mixing of incompatible wastes or materials if containers break or leak.]

Subpart J—Tank Systems

Source: 51 FR 25479, July 14, 1986, unless otherwise noted.

§ 265.190 Applicability.

The regulations of this subpart apply to owners or operators of facilities that use tank systems for storing or treating hazardous waste, except as otherwise provided in paragraphs (a) and (b) of this section or in § 265.1 of this part.

(a) Tank systems that are used to store or treat hazardous waste which contains no free liquids and that are situated inside a building with an impermeable floor are exempted from the requirements in § 265.193. To demonstrate the absence or presence of free liquids in the stored/treated waste, EPA Method 9095 (Paint Filter Liquids Test) as described in "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods" (EPA Publication No. SW-846) must be used.

(b) Tank systems, including sumps, as defined in § 260.10, that serve as part of a secondary containment system to collect or contain releases of hazardous wastes are exempted from the requirements in § 265.193(a).

(Information collection requirement contained in paragraph (a) was approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25479, July 14, 1986, as amended at 53 FR 34087, Sept. 2, 1988]

§ 265.191 Assessment of existing tank system's integrity.

(a) For each existing tank system that does not have secondary containment meeting the requirements of § 265.193, the owner or operator must determine that the tank system is not leaking or is unfit for use. Except as provided in paragraph (c) of this section, the owner or operator must obtain and keep on file at the facility a written assessment reviewed and certified by an independent, qualified, registered professional engineer in accordance with § 270.11(d), that attests to the tank system's integrity by January 12, 1988.

(b) This assessment must determine that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to ensure that it will not collapse, rupture, or fail. At a minimum, this assessment must consider the following:

(1) Design standard(s), if available, according to which the tank and ancillary equipment were constructed.

(2) Hazardous characteristics of the waste(s) that have been or will be handled.

(3) Existing corrosion protection measures.

(4) Documented age of the tank system, if available, (otherwise, an estimate of the age); and

(5) Results of a leak test, internal inspection, or other tank integrity examination such that:

(i) For non-enterable underground tanks, this assessment must consist of a leak test that is capable of taking into account the effects of temperature variations, tank end deflection, vapor pockets, and high water table effects,

(ii) For other than non-enterable underground tanks and for ancillary equipment, this assessment must be either a leak test, as described above, or an internal inspection and/or other tank integrity examination certified by an independent, qualified, registered professional engineer in accordance with § 270.11(d) that addresses cracks, leaks, corrosion, and erosion.

(NOTE: The practices described in the American Petroleum Institute (API) Publication, Guide for Inspection of Refinery Equipment, Chapter XIII, "Atmospheric and Low-Pressure Storage Tanks," 4th edition, 1981, may be used, where applicable, as guidelines in conducting the integrity examination of an other than non-enterable underground tank system.)

(c) Tank systems that store or treat materials that become hazardous wastes subsequent to July 14, 1986 must conduct this assessment within 12 months after the date that the waste becomes a hazardous waste.

(d) If, as a result of the assessment conducted in accordance with paragraph (a) of this section, a tank system is found to be leaking or unfit for use, the owner or operator must comply with the requirements of § 265.196.

(Information collection requirements contained in paragraphs (a)-(d) were approved by the Office of Management and Budget under control number 2050-0050)

§ 265.192 Design and installation of new tank systems or components.

(a) Owners or operators of new tank systems or components must ensure that the foundation, structural support, seams, connections, and pressure controls (if applicable) are adequately designed and that the tank system has sufficient structural strength, compatibility with the waste(s) to be stored or treated, and corrosion protection so that it will not collapse, rupture, or fail. The owner or operator must obtain a written assessment reviewed and certified by an independent, qualified, registered professional engineer in accordance with § 270.11(d) attesting that the system has sufficient structural integrity and is acceptable for the storing and treating of hazardous waste. This assessment must include, at a minimum, the following information:

(1) Design standard(s) according to which the tank(s) and ancillary equipment is or will be constructed.

(2) Hazardous characteristics of the waste(s) to be handled.

(3) For new tank systems or components in which the external shell of a metal tank or any external metal component of the tank system is or will be in contact with the soil or with water, a determination by a corrosion expert of:

(i) Factors affecting the potential for corrosion, including but not limited to:

(A) Soil moisture content;

(B) Soil pH;

(C) Soil sulfides level;

(D) Soil resistivity;

(E) Structure to soil potential;

(F) Influence of nearby underground metal structures (e.g., piping);

(G) Stray electric current; and,

(H) Existing corrosion-protection measures (e.g., coating, cathodic protection), and

(ii) The type and degree of external corrosion protection that are needed to ensure the integrity of the tank system during the use of the tank system or component, consisting of one or more of the following:

(A) Corrosion-resistant materials of construction such as special alloys or fiberglass-reinforced plastic;

(B) Corrosion-resistant coating (such as epoxy or fiberglass) with cathodic protection (e.g., impressed current or sacrificial anodes); and

(C) Electrical isolation devices such as insulating joints and flanges.

NOTE: The practices described in the National Association of Corrosion Engineers (NACE) standard, "Recommended Practice (RP-02-85)—Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems," and the American Petroleum Institute (API) Publication 1632, "Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems," may be used, where applicable, as guidelines in providing corrosion protection for tank systems.

(4) For underground tank system components that are likely to be affected by vehicular traffic, a determination of design or operational measures that will protect the tank system against potential damage; and

(5) Design considerations to ensure that:

(i) Tank foundations will maintain the load of a full tank;

(ii) Tank systems will be anchored to prevent flotation or dislodgement where the tank system is placed in a saturated zone, or is located within a seismic fault zone; and

(iii) Tank systems will withstand the effects of frost heave.

(b) The owner or operator of a new tank system must ensure that proper handling procedures are adhered to in order to prevent damage to the system during installation. Prior to covering, enclosing, or placing a new tank system or component in use, an independent, qualified installation inspector or an independent, qualified, registered professional engineer, either of whom is trained and experienced in the proper installation of tank systems, must inspect the system or component for the presence of any of the following items:

(1) Weld breaks;

(2) Punctures;

(3) Scrapes of protective coatings;

(4) Cracks;

(5) Corrosion;

(6) Other structural damage or inadequate construction or installation.

All discrepancies must be remedied before the tank system is covered, enclosed, or placed in use.

(c) New tank systems or components and piping that are placed underground and that are backfilled must be provided with a backfill material that is a noncorrosive, porous, homogeneous substance and that is carefully installed so that the backfill is placed completely around the tank and compacted to ensure that the tank and piping are fully and uniformly supported.

(d) All new tanks and ancillary equipment must be tested for tightness prior to being covered, enclosed or placed in use. If a tank system is found not to be tight, all repairs necessary to remedy the leak(s) in the system must be performed prior to the tank system being covered, enclosed, or placed in use.

(e) Ancillary equipment must be supported and protected against physical damage and excessive stress due to settlement, vibration, expansion or contraction.

NOTE. The piping system installation procedures described in American Petroleum Institute (API) Publication 1615 (November 1979), "Installation of Underground Petroleum Storage Systems," or ANSI Standard B31.3, "Petroleum Refinery System," may be used, where applicable, as guidelines for proper installation of piping systems.

(f) The owner or operator must provide the type and degree of corrosion protection necessary, based on the information provided under paragraph (a)(3) of this section, to ensure the integrity of the tank system during use of the tank system. The installation of a corrosion protection system that is field fabricated must be supervised by an independent corrosion expert to ensure proper installation.

(g) The owner or operator must obtain and keep on file at the facility written statements by those persons required to certify the design of the tank system and supervise the installation of the tank system in accordance with the requirements of paragraphs (b) through (f) of this section to attest that the tank system was properly designed and installed and that repairs, pursuant to paragraphs (b) and (d) of this section were performed. These written statements must also include the certification statement as required in § 270.11(d) of this chapter.

(Information collection requirements contained in paragraphs (a) and (g) were approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25479, July 14, 1986, 51 FR 29430, Aug. 15, 1986]

§ 265.193 Containment and detection of releases.

(a) In order to prevent the release of hazardous waste or hazardous constituents to the environment, secondary containment that meets the requirements of this section must be provided (except as provided in paragraphs (f) and (g) of this section):

(1) For all new tank systems or components, prior to their being put into service;

(2) For all existing tanks used to store or treat EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F027, within two years after January 12, 1987;

(3) For those existing tank systems of known and documentable age, within two years after January 12, 1987, or when the tank systems have reached 15 years of age, whichever comes later;

(4) For those existing tank system for which the age cannot be documented, within eight years of January 12, 1987; but if the age of the facility is greater than seven years, secondary containment must be provided by the time the facility reaches 15 years of age, or within two years of January 12, 1987, whichever comes later; and

(5) For tank systems that store or treat materials that become hazardous wastes subsequent to January 12, 1987, within the time intervals required in paragraphs (a)(1) through (a)(4) of this section, except that the date that a material becomes a hazardous waste must be used in place of January 12, 1987.

(b) Secondary containment systems must be:

(1) Designed, installed, and operated to prevent any migration of wastes or accumulated liquid out of the system to the soil, ground water, or surface water at any time during the use of the tank system; and

(2) Capable of detecting and collecting releases and accumulated liquids until the collected material is removed.

(c) To meet the requirements of paragraph (b) of this section, secondary containment systems must be at a minimum:

(1) Constructed of or lined with materials that are compatible with the waste(s) to be placed in the tank system and must have sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrological forces), physical contact with the waste to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation (including stresses from nearby vehicular traffic);

(2) Placed on a foundation or base capable of providing support to the secondary containment system and resistance to pressure gradients above and below the system and capable of preventing failure due to settlement, compression, or uplift;

(3) Provided with a leak detection system that is designed and operated so that it will detect the failure of either the primary and secondary containment structure or any release of hazardous waste or accumulated liquid in the secondary containment system within 24 hours, or at the earliest practicable time if the existing detection technology or site conditions will not allow detection of a release within 24 hours;

(4) Sloped or otherwise designed or operated to drain and remove liquids resulting from leaks, spills, or precipitation. Spilled or leaked waste and accumulated precipitation must be removed from the secondary containment system within 24 hours, or in as timely a manner as is possible to prevent harm to human health or the environment, if removal of the released waste or accumulated precipitation cannot be accomplished within 24 hours.

NOTE: If the collected material is a hazardous waste under Part 261 of this chapter, it is subject to management as a hazardous waste in accordance with all applicable requirements of Parts 262 through 265 of this chapter. If the collected material is discharged through a point source to waters of the United States, it is subject to the requirements of sections 301, 304, and 402 of the Clean Water Act, as amended. If discharged to Publicly Owned Treatment Works (POTWs), it is subject to the requirements of section 307 of the Clean Water Act, as amended. If the collected material is released to the environment, it may be subject to the reporting requirements of 40 CFR Part 302.

(d) Secondary containment for tanks must include one or more of the following devices:

(1) A liner (external to the tank);

(2) A vault;

(3) A double-walled tank; or

(4) An equivalent device as approved by the Regional Administrator.

(e) In addition to the requirements of paragraphs (b), (c), and (d) of this section, secondary containment systems must satisfy the following requirements:

(1) External liner systems must be:

(i) Designed or operated to contain 100 percent of the capacity of the largest tank within its boundary;

(ii) Designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration. Such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event;

(iii) Free of cracks or gaps; and

(iv) Designed and installed to completely surround the tank and to cover all surrounding earth likely to come into contact with the waste if released from the tank(s) (i.e., capable of preventing lateral as well as vertical migration of the waste).

(2) Vault systems must be:

(i) Designed or operated to contain 100 percent of the capacity of the largest tank within its boundary;

(ii) Designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration. Such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event;

(iii) Constructed with chemical-resistant water stops in place at all joints (if any);

(iv) Provided with an impermeable interior coating or lining that is compatible with the stored waste and that will prevent migration of waste into the concrete;

(v) Provided with a means to protect against the formation of and ignition of vapors within the vault, if the waste being stored or treated:

(A) Meets the definition of ignitable waste under § 262.21 of this chapter, or

(B) Meets the definition of reactive waste under § 262.21 of this chapter and may form an ignitable or explosive vapor; and

(vi) Provided with an exterior moisture barrier or be otherwise designed or operated to prevent migration of moisture into the vault if the vault is subject to hydraulic pressure.

(3) Double-walled tanks must be:

(i) Designed as an integral structure (i.e., an inner tank within an outer shell) so that any release from the inner tank is contained by the outer shell;

(ii) Protected, if constructed of metal, from both corrosion of the primary tank interior and the external surface of the outer shell; and

(iii) Provided with a built-in, continuous leak detection system capable of detecting a release within 24 hours or at the earliest practicable time, if the owner or operator can demonstrate to the Regional Administrator, and the Regional Administrator concurs, that the existing leak detection technology or site conditions will not allow detection of a release within 24 hours.

NOTE: The provisions outlined in the Steel Tank Institute's (STI) "Standard for Dual Wall Underground Steel Storage Tanks" may be used as guidelines for aspects of the design of underground steel double-walled tanks.

(f) Ancillary equipment must be provided with full secondary containment (e.g., trench, jacketing, double-walled piping) that meets the requirements of paragraphs (b) and (c) of this section except for:

(1) Aboveground piping (exclusive of flanges, joints, valves, and connections) that are visually inspected for leaks on a daily basis;

(2) Welded flanges, welded joints, and welded connections that are visually inspected for leaks on a daily basis;

(3) Sealless or magnetic coupling pumps and sealless valves, that are visually inspected for leaks on a daily basis; and

(4) Pressurized aboveground piping systems with automatic shut-off devices (e.g., excess flow check valves, flow metering shutdown devices, loss of pressure actuated shut-off devices) that are visually inspected for leaks on a daily basis.

(g) The owner or operator may obtain a variance from the requirements of this Section if the Regional Administrator finds, as a result of a demonstration by the owner or operator, either: that alternative design and operating practices, together with location characteristics, will prevent the migration of hazardous waste or hazardous constituents into the ground water or surface water at least as effectively as secondary containment during the active life of the tank system or that in the event of a release that does migrate to ground water or surface water, no substantial present or potential hazard will be posed to human health or the environment. New underground tank systems may not, per a demonstration in accordance with paragraph (g)(2) of this section, be exempted from the secondary containment requirements of this section. Application for a variance as allowed in paragraph (g) of this section does not waive compliance with the requirements of this subpart for new tank systems. (1) In deciding whether to grant a variance based on a demonstration of equivalent protection of ground water and surface water, the Regional Administrator will consider:

(i) The nature and quantity of the waste;

(ii) The proposed alternate design and operation;

(iii) The hydrogeologic setting of the facility, including the thickness of soils between the tank system and ground water; and

(iv) All other factors that would influence the quality and mobility of the hazardous constituents and the potential for them to migrate to ground water or surface water.

(2) In deciding whether to grant a variance based on a demonstration of no substantial present or potential hazard, the Regional Administrator will consider:

(i) The potential adverse effects on ground water, surface water, and land quality taking into account:

(A) The physical and chemical characteristics of the waste in the tank system, including its potential for migration,

(B) The hydrogeological characteristics of the facility and surrounding land,

(C) The potential for health risks caused by human exposure to waste constituents,

(D) The potential for damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents, and

(E) The persistence and permanence of the potential adverse effects;

(ii) The potential adverse effects of a release on ground-water quality, taking into account:

(A) The quantity and quality of ground water and the direction of ground-water flow,

(B) The proximity and withdrawal rates of water in the area,

(C) The current and future uses of ground water in the area, and

(D) The existing quality of ground water, including other sources of contamination and their cumulative impact on the ground-water quality;

(iii) The potential adverse effects of a release on surface water quality, taking into account:

(A) The quantity and quality of ground water and the direction of ground-water flow,

(B) The patterns of rainfall in the region,

(C) The proximity of the tank system to surface waters,

(D) The current and future uses of surface waters in the area and any water quality standards established for those surface waters, and

(E) The existing quality of surface water, including other sources of contamination and the cumulative impact on surface-water quality, and

(iv) The potential adverse effects of a release on the land surrounding the tank system taking into account:

(A) The patterns of rainfall in the region, and

(B) The current and future uses of the surrounding land.

(3) The owner or operator of a tank system, for which a variance from secondary containment had been granted in accordance with the requirements of paragraph (g)(1) of this section, at which a release of hazardous waste has occurred from the primary tank system but has not migrated beyond the zone of engineering control (as established in the variance), must:

(i) Comply with the requirements of § 265.196, except paragraph (d); and

(ii) Decontaminate or remove contaminated soil to the extent necessary to:

(A) Enable the tank system, for which the variance was granted, to resume operation with the capability for the detection of and response to releases at least equivalent to the capability it had prior to the release, and

(B) Prevent the migration of hazardous waste or hazardous constituents to ground water or surface water; and

(iii) If contaminated soil cannot be removed or decontaminated in accordance with paragraph (g)(3)(ii) of this section, comply with the requirements of § 265.197(b);

(4) The owner or operator of a tank system, for which a variance from secondary containment had been granted in accordance with the requirements of paragraph (g)(1) of this section, at which a release of hazardous waste has occurred from the primary tank system and has migrated beyond the zone of engineering control (as established in the variance), must:

(i) Comply with the requirements of § 265.196(a), (b), (c), and (d); and

(ii) Prevent the migration of hazardous waste or hazardous constituents to ground water or surface water, if possible, and decontaminate or remove contaminated soil. If contaminated soil cannot be decontaminated or removed, or if ground water has been contaminated, the owner or operator must comply with the requirements of § 265.197(b),

(iii) If repairing, replacing, or reinstalling the tank system, provide secondary containment in accordance with the requirements of paragraphs (a) through (f) of this section or reapply for a variance from secondary containment and meet the requirements for new tank systems in § 265.192 if the tank system is replaced. The owner or operator must comply with these requirements even if contaminated soil can be decontaminated or removed, and ground water or surface water has not been contaminated.

(h) The following procedures must be followed in order to request a variance from secondary containment:

(1) The Regional Administrator must be notified in writing by the owner or operator that he intends to conduct and submit a demonstration for a variance from secondary containment as allowed in paragraph (g) of this section according to the following schedule:

(i) For existing tank systems, at least 24 months prior to the date that secondary containment must be provided in accordance with paragraph (a) of this section; and

(ii) For new tank systems, at least 30 days prior to entering into a contract for installation of the tank system.

(2) As part of the notification, the owner or operator must also submit to the Regional Administrator a description of the steps necessary to conduct the demonstration and a timetable for completing each of the steps. The demonstration must address each of the factors listed in paragraph (g)(1) or paragraph (g)(2) of this section.

(3) The demonstration for a variance must be completed and submitted to the Regional Administrator within 180 days after notifying the Regional Administrator of intent to conduct the demonstration.

(4) The Regional Administrator will inform the public, through a newspaper notice, of the availability of the demonstration for a variance. The notice shall be placed in a daily or weekly major local newspaper of general circulation and shall provide at least 30 days from the date of the notice for the public to review and comment on the demonstration for a variance. The Regional Administrator also will hold a public hearing, in response to a request or at his own discretion, whenever such a hearing might clarify one or more issues concerning the demonstration for a variance. Public notice of the hearing will be given at least 30 days prior to the date of the hearing and may be given at the same time as notice of the opportunity for the public to review and comment on the demonstration. These two notices may be combined.

(5) The Regional Administrator will approve or disapprove the request for a variance within 90 days of receipt of the demonstration from the owner or operator and will notify in writing the owner or operator and each person who submitted written comments or requested notice of the variance decision. If the demonstration for a variance is incomplete or does not include sufficient information, the 90-day time period will begin when the Regional Administrator receives a complete demonstration, including all information necessary to make a final determination. If the public comment period in paragraph (h)(4) of this section is extended, the 90-day time period will be similarly extended.

(i) All tank systems, until such time as secondary containment meeting the requirements of this section is provided, must comply with the following:

(1) For non-enterable underground tanks, a leak test that meets the requirements of § 265.191(b)(5) must be conducted at least annually;

(2) For other than non-enterable underground tanks and for all ancillary equipment, an annual leak test, as described in paragraph (i)(1) of this section, or an internal inspection or other tank integrity examination by an independent, qualified, registered professional engineer that addresses cracks, leaks, corrosion, and erosion must be conducted at least annually. The owner or operator must remove the stored waste from the tank, if necessary, to allow the condition of all internal tank surfaces to be assessed.

NOTE: The practices described in the American Petroleum Institute (API) Publication Guide for Inspection of Refining Equipment, Chapter XIII, "Atmospheric and Low Pressure Storage Tanks," 4th edition, 1981, may be used, when applicable, as guidelines for assessing the overall condition of the tank system.

(3) The owner or operator must maintain on file at the facility a record of the results of the assessments conducted in accordance with paragraphs (i)(1) through (i)(3) of this section.

(4) If a tank system or component is found to be leaking or unfit-for-use as a result of the leak test or assessment in paragraphs (i)(1) through (i)(3) of this section, the owner or operator must comply with the requirements of § 265.196.

(Information collection requirements contained in paragraphs (c)-(e) and (g)-(i) were approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25479, July 14, 1986; 51 FR 29430, Aug. 15, 1986, as amended at 53 FR 34087, Sept. 2, 1988]

§ 265.194 General operating requirements.

(a) Hazardous wastes or treatment reagents must not be placed in a tank system if they could cause the tank, its ancillary equipment, or the secondary containment system to rupture, leak, corrode, or otherwise fail.

(b) The owner or operator must use appropriate controls and practices to prevent spills and overflows from tank or secondary containment systems. These include at a minimum:

(1) Spill prevention controls (e.g., check valves, dry discount couplings);

(2) Overfill prevention controls (e.g., level sensing devices, high level alarms, automatic feed cutoff, or bypass to a standby tank); and

(3) Maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation.

(c) The owner or operator must comply with the requirements of § 265.196 if a leak or spill occurs in the tank system.

(Information collection requirements contained in paragraph (c) were approved by the Office of Management and Budget under control number 2050-0050)

§ 265.195 Inspections.

(a) The owner or operator must inspect, where present, at least once each operating day:

(1) Overfill/spill control equipment (e.g., waste-feed cutoff systems, bypass systems, and drainage systems) to ensure that it is in good working order;

(2) The aboveground portions of the tank system, if any, to detect corrosion or releases of waste;

(3) Data gathered from monitoring equipment and leak-detection equipment, (e.g., pressure and temperature gauges, monitoring wells) to ensure that the tank system is being operated according to its design; and

(4) The construction materials and the area immediately surrounding the externally accessible portion of the tank system including secondary containment structures (e.g., dikes) to detect erosion or signs of releases of hazardous waste (e.g., wet spots, dead vegetation);

NOTE: Section 265.15(c) requires the owner or operator to remedy any deterioration or malfunction he finds. Section 265.196 requires the owner or operator to notify the Regional Administrator within 24 hours of confirming a release. Also, 40 CFR Part 302 may require the owner or operator to notify the National Response Center of a release.

(b) The owner or operator must inspect cathodic protection systems, if present, according to, at a minimum, the following schedule to ensure that they are functioning properly:

(1) The proper operation of the cathodic protection system must be confirmed within six months after initial installation, and annually thereafter; and

(2) All sources of impressed current must be inspected and/or tested, as appropriate, at least bimonthly (i.e., every other month).

NOTE: The practices described in the National Association of Corrosion Engineers (NACE) standard, "Recommended Practice (RP-02 85)—Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems," and the American Petroleum Institute (API) Publication 1632, "Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems," may be used, where applicable, as guidelines in maintaining and inspecting cathodic protection systems.

(c) The owner or operator must document in the operating record of the facility an inspection of those items in paragraphs (a) and (b) of this section.

(Information collection requirements contained in paragraphs (a)-(c) were approved by the Office of Management and Budget under control number 2050-0050)

§ 265.196 Response to leaks or spills and disposition of leaking or unfit-for-use tank systems.

A tank system or secondary containment system from which there has been a leak or spill, or which is unfit for use, must be removed from service immediately, and the owner or operator must satisfy the following requirements:

(a) *Cessation of use; prevent flow or addition of wastes.* The owner or operator must immediately stop the flow of hazardous waste into the tank system or secondary containment system and inspect the system to determine the cause of the release.

(b) *Removal of waste from tank system or secondary containment system.* (1) If the release was from the tank system, the owner or operator must, within 24 hours after detection of the leak or, if the owner or operator demonstrates that that is not possible, at the earliest practicable time remove as much of the waste as is necessary to prevent further release of hazardous waste to the environment and to allow inspection and repair of the tank system to be performed.

(2) If the release was to a secondary containment system, all released materials must be removed within 24 hours or in as timely a manner as is possible to prevent harm to human health and the environment.

(c) *Containment of visible releases to the environment.* The owner or operator must immediately conduct a visual inspection of the release and, based upon that inspection:

(1) Prevent further migration of the leak or spill to soils or surface water; and

(2) Remove, and properly dispose of, any visible contamination of the soil or surface water.

(d) *Notifications, reports.* (1) Any release to the environment, except as provided in paragraph (d)(2) of this section, must be reported to the Regional Administrator within 24 hours of detection. If the release has been reported pursuant to 40 CFR Part 302, that report will satisfy this requirement.

(2) A leak or spill of hazardous waste that is:

(i) Less than or equal to a quantity of one (1) pound, and

(ii) Immediately contained and cleaned-up is exempted from the requirements of this paragraph.

(3) Within 30 days of detection of a release to the environment, a report containing the following information must be submitted to the Regional Administrator:

(i) Likely route of migration of the release;

(ii) Characteristics of the surrounding soil (soil composition, geology, hydrogeology, climate);

(iii) Results of any monitoring or sampling conducted in connection with the release, (if available). If sampling or monitoring data relating to the release are not available within 30 days, these data must be submitted to the Regional Administrator as soon as they become available.;

(iv) Proximity to downgradient drinking water, surface water, and population areas; and

(v) Description of response actions taken or planned.

(e) *Provision of secondary containment, repair, or closure.* (1) Unless the owner or operator satisfies the requirements of paragraphs (e) (2) through (4) of this section, the tank system must be closed in accordance with § 265.197.

(2) If the cause of the release was a spill that has not damaged the integrity of the system, the owner/operator may return the system to service as soon as the released waste is removed and repairs, if necessary, are made.

(3) If the cause of the release was a leak from the primary tank system into the secondary containment system, the system must be repaired prior to returning the tank system to service.

(4) If the source of the release was a leak to the environment from a component of a tank system without secondary containment, the owner/operator must provide the component of the system from which the leak occurred with secondary containment that satisfies the requirements of § 265.193 before it can be returned to service, unless the source of the leak is an aboveground portion of a tank system. If the source is an aboveground component that can be inspected visually, the component must be repaired and may be returned to service without secondary containment as long as the requirements of paragraph (f) of this section are satisfied. If a component is replaced to comply with the requirements of this subparagraph, that component must satisfy the requirements for new tank systems or components in §§ 265.192 and 265.193. Additionally, if a leak has occurred in any portion of a tank system component that is not readily accessible for visual inspection (e.g., the bottom of an inground or onground tank), the entire component must be provided with secondary containment in accordance with § 265.193 prior to being returned to use.

(f) *Certification of major repairs.* If the owner or operator has repaired a tank system in accordance with paragraph (e) of this section, and the repair has been extensive (e.g., installation of an internal liner; repair of a ruptured primary containment or secondary containment vessel), the tank system must not be returned to service unless the owner/operator has obtained a certification by an independent, qualified, registered professional engineer in accordance with § 270.11(d) that the repaired system is capable of handling hazardous wastes without release for the intended life of the system. This certification must be submitted to the Regional Administrator within seven days after returning the tank system to use.

NOTE: The Regional Administrator may, on the basis of any information received that there is or has been a release of hazardous waste or hazardous constituents into the environment, issue an order under RCRA section 3004(v), 3008(h), or 7003(a) requiring corrective action or such other response as deemed necessary to protect human health or the environment.

NOTE: See § 265.15(c) for the requirements necessary to remedy a failure. Also, 40 CFR Part 302 requires the owner or operator to notify the National Response Center of a release of any "reportable quantity."

(Information collection requirements contained in paragraphs (d)-(f) were approved by the Office of Management and Budget under control number 2050-0050)

[51 FR 25479, July 14, 1986, as amended at 53 FR 34087, Sept. 2, 1988]

§ 265.197 Closure and post-closure care.

(a) At closure of a tank system, the owner or operator must remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), contaminated soils, and structures and equipment contaminated with waste, and manage them as hazardous waste, unless § 261.3(d) of this Chapter applies. The closure plan, closure activities, cost estimates for closure, and financial responsibility for tank systems must meet all of the requirements specified in Subparts G and H of this Part.

(b) If the owner or operator demonstrates that not all contaminated soils can be practicably removed or decontaminated as required in paragraph (a) of this section, then the owner or operator must close the tank system and perform post-closure care in accordance with the closure and post-closure care requirements that apply to landfills (§ 265.310). In addition, for the purposes of closure, post-closure, and financial responsibility, such a tank system is then considered to be a landfill, and the owner or operator must meet all of the requirements for landfills specified in Subparts G and H of this part.

(c) If an owner or operator has a tank system which does not have secondary containment that meets the requirements of § 265.193(b) through (f) and which is not exempt from the secondary containment requirements in accordance with § 265.193(g), then,

(1) The closure plan for the tank system must include both a plan for complying with paragraph (a) of this section and a contingent plan for complying with paragraph (b) of this section.

(2) A contingent post-closure plan for complying with paragraph (b) of this section must be prepared and submitted as part of the permit application.

(3) The cost estimates calculated for closure and post-closure care must reflect the costs of complying with the contingent closure plan and the contingent post-closure plan, if these costs are greater than the costs of complying with the closure plan prepared for

the expected closure under paragraph (a) of this section.

(4) Financial assurance must be based on the cost estimates in paragraph (c)(3) of this section.

(5) For the purposes of the contingent closure and post-closure plans, such a tank system is considered to be a landfill, and the contingent plans must meet all of the closure, post-closure, and financial responsibility requirements for landfills under Subparts G and H of this Part.

(Information collection requirements contained in paragraphs (a)-(c) were approved by the Office of Management and Budget under control number 2050-0050)

§ 265.198 Special requirements for ignitable or reactive wastes.

(a) Ignitable or reactive waste must not be placed in a tank system, unless:

(1) The waste is treated, rendered, or mixed before or immediately after placement in the tank system so that:

(i) The resulting waste, mixture, or dissolved material no longer meets the definition of ignitable or reactive waste under §§ 261.21 or 261.23 of this chapter; and

(ii) Section 265.17(b) is complied with; or

(2) The waste is stored or treated in such a way that it is protected from any material or conditions that may cause the waste to ignite or react; or

(3) The tank system is used solely for emergencies.

(b) The owner or operator of a facility where ignitable or reactive waste is stored or treated in tanks must comply with the requirements for the maintenance of protective distances between the waste management area and any public ways, streets, alleys, or an adjoining property line that can be built upon as required in Tables 2-1 through 2-6 of the National Fire Protection Association's "Flammable and Combustible Liquids Code," (1977 or 1981), (incorporated by reference, see § 260.11).

§ 265.199 Special requirements for incompatible wastes.

(a) Incompatible wastes, or incompatible waste and materials must not be placed in the same tank system unless § 265.17(b) is complied with.

(b) Hazardous waste must not be placed in a tank system that has not been decontaminated and that previously held an incompatible waste or material, unless § 265.17(b) is complied with.

§ 265.200 Waste analysis and trial tests.

In addition to performing the waste analysis required by § 265.13, the owner or operator must, whenever a tank system is to be used to treat chemically or to store a hazardous waste that is substantially different from waste previously treated or stored in that tank system; or treat chemically a hazardous waste with a substantially different process than any previously used in that tank system:

(a) Conduct waste analyses and trial treatment or storage tests (e.g., bench-scale or pilot-plant scale tests); or

(b) Obtain written, documented information on similar waste under similar operating conditions to show that the proposed treatment or storage will meet the requirements of § 265.194(a).

NOTE: Section 265.13 requires the waste analysis plan to include analyses needed to comply with §§ 265.198 and 265.199. Section 265.73 requires the owner or operator to place the results from each waste analysis and trial test, or the documented information, in the operating record of the facility.

§ 265.201 Special requirements for generators of between 100 and 1,000 kg/mo that accumulate hazardous waste in tanks.

(a) The requirements of this section apply to small quantity generators of more than 100 kg but less than 1,000 kg of hazardous waste in a calendar month, that accumulate hazardous waste in tanks for less than 180 days (or 270 days if the generator must ship the waste greater than 200 miles), and do not accumulate over 6,000 kg on-site at any time.

(b) Generators of between 100 and 1,000 kg/mo hazardous waste must comply with the following general operating requirements:

(1) Treatment or storage of hazardous waste in tanks must comply with § 265.17(b).

(2) Hazardous wastes or treatment reagents must not be placed in a tank if they could cause the tank or its inner liner to rupture, leak, corrode, or otherwise fail before the end of its intended life.

(3) Uncovered tanks must be operated to ensure at least 60 centimeters (2 feet) of freeboard, unless the tank is equipped with a containment structure (e.g., dike or trench), a drainage control system, or a diversion structure (e.g., standby tank) with a capacity that equals or exceeds the volume of the top 60 centimeters (2 feet) of the tank.

(4) Where hazardous waste is continuously fed into a tank, the tank must be equipped with a means to stop this inflow (e.g., waste feed cutoff system or by-pass system to a stand-by tank).

NOTE: These systems are intended to be used in the event of a leak or overflow from the tank due to a system failure (e.g., a malfunction in the treatment process, a crack in the tank, etc.).

(c) Generators of between 100 and 1,000 kg/mo accumulating hazardous waste in tanks must inspect, where present:

(1) Discharge control equipment (e.g., waste feed cutoff systems, by-pass systems, and drainage systems) at least once each operating day, to ensure that it is in good working order;

(2) Data gathered from monitoring equipment (e.g., pressure and temperature gauges) at least once each operating day to ensure that the tank is being operated according to its design;

(3) The level of waste in the tank at least once each operating day to ensure compliance with § 265.201(b)(3);

(4) The construction materials of the tank at least weekly to detect corrosion or leaking of fixtures or seams; and

(5) The construction materials of, and the area immediately surrounding, discharge confinement structures (e.g., dikes) at least weekly to detect erosion or obvious signs of leakage (e.g., wet spots or dead vegetation).

NOTE: As required by § 265.15(c), the owner or operator must remedy any deterioration or malfunction he finds.

(d) Generators of between 100 and 1,000 kg/mo accumulating hazardous waste in tanks must, upon closure of the facility, remove all hazardous waste from tanks, discharge control equipment, and discharge confinement structures.

NOTE: At closure, as throughout the operating period, unless the owner or operator can demonstrate, in accordance with § 261.3(c) or (d) of this chapter, that any solid waste removed from his tank is not a hazardous waste, the owner or operator becomes a generator of hazardous waste and must manage it in accordance with all applicable requirements of Parts 262, 263, and 265 of this chapter.

(e) Generators of between 100 and 1,000 kg/mo must comply with the following special requirements for ignitable or reactive waste:

(1) Ignitable or reactive waste must not be placed in a tank, unless:

(i) The waste is treated, rendered, or mixed before or immediately after placement in a tank so that (A) the resulting waste, mixture, or dissolution of material no longer meets the definition of ignitable or reactive waste under § 261.21 or § 261.23 of this chapter, and (B) § 265.17(b) is complied with; or

(ii) The waste is stored or treated in such a way that it is protected from any material or conditions that may cause the waste to ignite or react; or

(iii) The tank is used solely for emergencies.

(2) The owner or operator of a facility which treats or stores ignitable or reactive waste in covered tanks must comply with the buffer zone requirements for tanks contained in Tables 2-1 through 2-6 of the National Fire Protection Association's "Flammable and Combustible Liquids Code," (1977 or 1981) (incorporated by reference, see § 260.11).

(f) Generators of between 100 and 1,000 kg/mo must comply with the following special requirements for incompatible wastes:

(1) Incompatible wastes, or incompatible wastes and materials, (see Appendix V for examples) must not be placed in the same tank, unless § 265.17(b) is complied with.

(2) Hazardous waste must not be placed in an unwashed tank which previously held an incompatible waste

or material, unless § 265.17(b) is complied with.

[51 FR 25479, July 14, 1986, as amended at 53 FR 34087, Sept. 2, 1988]

Subpart K—Surface Impoundments

§ 265.220 Applicability.

The regulations in this subpart apply to owners and operators of facilities that use surface impoundments to treat, store, or dispose of hazardous waste, except as § 265.1 provides otherwise.

§ 265.221 Design requirements.

(a) The owner or operator of a surface impoundment must install two or more liners and leachate collection system in accordance with § 264.221(c) of this chapter, with respect to each new unit, replacement of an existing unit, or lateral expansion of an existing unit that is within the area identified in the Part A permit application, and with respect to waste received beginning May 8, 1985.

(b) The owner or operator of each unit referred to in paragraph (a) of this section must notify the Regional Administrator at least sixty days prior to receiving waste. The owner or operator of each facility submitting notice must file a Part B application within six months of the receipt of such notice.

(c) Paragraph (a) of this section will not apply if the owner or operator demonstrates to the Regional Administrator, and the Regional Administrator finds for such surface impoundment, that alternative design and operating practices, together with location characteristics, will prevent the migration of any hazardous constituent into the ground water or surface water at least as effectively as such liners and leachate collection systems.

(d) The double liner requirement set forth in paragraph (a) of this section may be waived by the Regional Administrator for any monofill, if:

(1) The monofill contains only hazardous wastes from foundry furnace emission controls or metal casting molding sand, and such wastes do not contain constituents which would render the wastes hazardous for reasons other than the EP toxicity characteristics in § 261.24 of this chapter; and

(2)(i)(A) The monofill has at least one liner for which there is no evidence that such liner is leaking. For the purposes of this paragraph the term "liner" means a liner designed, constructed, installed, and operated to prevent hazardous waste from passing into the liner at any time during the active life of the facility, or a liner designed, constructed, installed, and operated to prevent hazardous waste from migrating beyond the liner to adjacent subsurface soil, ground water, or surface water at any time during the active life of the facility. In the case of any surface impoundment which has been exempted from the requirements of paragraph (a) of this section on the basis of a liner designed, constructed, installed, and operated to prevent hazardous waste from passing beyond the liner, at the closure of such impoundment the owner or operator must remove or decontaminate all waste residues, all contaminated liner material, and contaminated soil to the extent practicable. If all contaminated soil it is not removed or decontaminated, the owner of operator of such impoundment must comply with appropriate post-closure requirements, including but not limited to ground-water monitoring and corrective action;

(B) The monofill is located more than one-quarter mile from an underground source of drinking water (as that term is defined in § 144.3 of this chapter); and

(C) The monofill is in compliance with generally applicable groundwater monitoring requirements for facilities with permits under RCRA section 3005(c); or

(ii) The owner or operator demonstrates that the monofill is located, designed and operated so as to assure that there will be no migration of any hazardous constituent into ground water or surface water at any future time.

(e) In the case of any unit in which the liner and leachate collection system has been installed pursuant to the requirements of paragraph (a) of this section and in good faith compli-

APPENDIX B

PROTECTIVE AND WATERPROOFING COATINGS FOR CONCRETE

PROTECTIVE COATINGS

The following subsections describe the most common materials used for protective coatings:

Acrylic Resins

Acrylic resins are formulated from the vinyl polymerization of acrylic monomers that are modified by the addition of plasticizers and prepolymers. They are used as a thin unfilled coating or as a thick sand-filled mortar.

Asphalt

Suitable products for use as protective coatings may be made from either high-consistency natural asphalts or from refinery-produced products that may vary significantly in consistency. Various fillers, fibers, solvents, or even polymers, may be added to improve or modify certain physical characteristics. Coating materials may range in consistency from thin, cold-applied liquids to heavy, hot-applied mastics. Because of their good resistance to acids and oxidizing solutions, asphalt coatings, alone or in combination with reinforcements such as bituminized glass fabrics, may be used for protection of concrete vessels used to contain acids and salt solutions. However, resistance to solvents is poor. Resistance to water is often considered to be lower than it is with coal-tar-derived products.

Bituminous Emulsions

Bituminous emulsions are made using either asphalt or coal tar base binders, which are modified as required by the manufacturer prior to emulsification. The binders are dispersed in water, using either mineral stabilizers or chemical-type emulsifying agents to assist in dispersion and to retain emulsion stability. Coal tar base emulsions are usually mineral stabilized. Bituminous emulsions frequently possess thixotropic or "false body" characteristics, which permit application of relatively thick coats of materials with a minimum of sagging. They may be brush, spray, or roller applied. Films deposited from emulsions are likely to be more permeable to water vapor but are often capable of withstanding higher temperatures than asphalt coatings. Films deposited from the mineral stabilized emulsions are considered to have excellent atmospheric exposure characteristics.

Chlorinated Rubber

Chlorinated rubber resins are produced by chlorinating isoprene rubber. Coatings containing chlorinated rubber adhere well to concrete and are widely used for concrete floor coatings, traffic paints, and swimming pools. They have excellent resistance to alkalies, moisture, and abrasion. They have adequate resistance to a wide range of common acids, aliphatic hydrocarbons, and lower alcohols. Resistance is poor to nitric, acetic, and sulfurous acids, and concentrated aqueous ammonia. Aromatic hydrocarbons, fatty acids, and animal and vegetable oils dissolve chlorinated rubber. These coatings have limited resistance to heat and will decompose when used above 225° F. In continuous, direct sunlight, only pigmented materials, or those with ultraviolet absorbers, can be used satisfactorily.

Coal Tar

Coal-tar-based coating materials are derived from the destructive distillation of coal. They range in consistency from thin liquids to heavy mastics and/or semi-solids and can either be hot-applied or may be applied cold. Emulsions of coal tar also are available. Cold-applied barriers usually contain a solvent; those that do are known as cutbacks. The hot-applied and cutback forms may suffer surface cracking, resulting in an "alligator" texture when exposed to the atmosphere; however, coal tar emulsions have excellent atmospheric exposure characteristics. Coal-tar-based coatings have excellent water resistance. Their resistance to acids is moderate and is good to alkalies. They normally do not support bacterial growth.

Composite Barriers

Two types of composite coatings are popular. Acid-proof brick or tile barriers are used to protect concrete from very aggressive chemicals when an easily-cleanable surface is required. The primary component, a chemical-resistant material, is applied directly to the concrete surface. The secondary component, brick or tile with a chemical-resistant mortar, is used to protect the relatively-fragile primary component from mechanical abuse or excessive temperature. Chemical-resistant mortars include: furan, phenolic, sulfur, silicate, and polyester mortars.

Filled epoxy, topcoated with an epoxy is another common composite barrier. An epoxy resin, normally solventless, is blended with aggregate (usually silica of various sizes) to produce a coating that can be either sprayed, brushed, squeegeed, or troweled. This system is used to seal the concrete surface and fill the surface porosity prior to topcoating with a protective barrier that is resistant to the intended environmental conditions.

Epoxy Resins

The epoxy resin normally used for protective coatings is based on a reaction product of bisphenol A and epichlorohydrin. The epoxy resin, which is usually a liquid, must have a curing agent or hardener added. The most commonly-used curing agents are aliphatic amines, amine adducts, amidoamines, and polyamides. Properly selected and applied epoxy systems provide a very tough, durable barrier with excellent caustic, acid, and solvent resistance. Epoxy formulations are compatible with concrete, providing excellent adhesion.

Filled Epoxy, Polyester, and Urethane Resins

A low-viscosity resin is blended with graded fillers (in the range of 40 to 200 mesh) to form a trowelable mix that is applied approximately 1/4-inch-thick to a concrete floor. Vertical walls may be covered to this thickness by using specially-formulated materials. A high proportion of fillers, generally 5 to 1 by weight of activated resin, reduces the coefficient of thermal expansion and makes the coating more resistant to thermal shock. Fillers also reduce shrinkage stresses formed when the liquid epoxy polymerizes to a solid. These coating materials are normally formulated to protect concrete floors subject to intermittent chemical exposure.

Glass-Reinforced Epoxy Resin

A glass-reinforced epoxy barrier is multi-coat, in the dry-film thickness range of 20 mil to 250 mil. As thickness increases, a greater chance exists that discontinuities or pinholes in the barrier material will be eliminated. This type of coating is used to protect concrete from acids and other aggressive chemicals that could cause rapid concrete disintegration.

Glass-Reinforced Furan Resin

This system is similar to the glass-reinforced system discussed above. A primer must be applied to the concrete surface before the furan resin, to prevent the acid catalyst used to cure the furan from attacking the concrete. After the primer is applied, one coat of a filled furan mortar is troweled on the surface and glass cloth is embedded in the furan before it hardens. After the furan has set, a second trowel coat of furan mortar is applied. After the furan has hardened, a 60 mil layer of neoprene latex is spray-applied. The neoprene acts as a parting agent so that the furan resin mortar, used with an acid-proof brick covering, will not adhere to the glass-reinforced furan barrier.

Precured Neoprene Sheet

Precured neoprene sheet, ranging in thickness from 60 to 125 mil, is often used in severe chemical service conditions. It can be applied to a smooth concrete surface by using neoprene adhesives. Joints will be reliable, if constructed properly, because neoprene adhesives have the same chemical resistance as the neoprene sheet. If the concrete structure to be protected has a complicated geometry, a catalyzed neoprene solvent-based formulation may be spray- or brush-applied to a thickness of 60 mil. This material will have the same chemical resistance as the sheet material.

Plasticized Polyvinyl Chloride (PVC) Sheet

PVC sheet can be used as a protective coating for certain severe chemical service conditions. Its application is similar to precured neoprene sheet discussed above.

Polyester Resins

Two types of polyester resins are normally used as protective coatings in more severe chemical environments. One is based on the reaction between maleic anhydride and bisphenol A, and the other is produced by reacting acrylic acid with an epoxy and is commonly called a "vinyl ester." These resins are mixed with styrene monomer to lower viscosity and improve workability. The liquid resin is converted to a solid by using a peroxide catalyst such as benzoyl peroxide and an accelerator such as dimethyl analine. The concentration of the catalyst may be varied to change the rate of curing. A water-resistant primer should be applied to the concrete surface before the resin is applied. A final topcoat containing 1 to 2 percent paraffin prevents the material from remaining tacky.

Glass-Reinforced Polyester Resin

This type of coating is similar to the glass-reinforced epoxy coating previously discussed. Two forms of glass reinforcement are used with polyester coating materials. One form uses glass fibers as either non-woven mat or woven fabric. The other uses glass flakes, approximately 5 mil thick and 60 mil in diameter, as reinforcement. A water-resistant primer on the concrete surface is necessary for proper curing of the coating materials.

Polyurethane Resins

Urethane coating materials are formulated from the reaction of a resin component (polyol) and an isocyanate curing agent. The name "urethane" encompasses a large family of materials, so care must be taken to match job service requirements with the proper type of coating. Generally, urethanes have good resistance to chemical attack and excellent impact and abrasion resistance. They have excellent adhesion characteristics, are hard, yet flexible; and exterior grades exhibit long-term gloss and color retention. Although they are usually supplied as two component systems, single component systems, which are cured by moisture in the air, are available.

Polyvinyl Butyral

Polyvinyl butyral resin has excellent resistance to weathering and is used to seal concrete surfaces. The resin is dissolved in a solvent and is applied in thin films of less than 3 mils per coat.

WATERPROOFING COATINGS

Following is a brief overview of commonly used systems for waterproofing concrete structures:

Hot-Applied Bituminous Materials

The materials used for hot-applied systems are bituminous substances of either coal tar pitch or asphalt derived from petroleum. The bitumens used in hot-applied systems have very little strength within themselves. Fabrics and felts are used as reinforcement to withstand the strains of expansion, contraction, temperature changes, vibrations, and structure movement. Fabric has two advantages over felt: 1) it is stronger, more pliable, and conforms more readily to irregular surfaces; therefore, it is generally used as reinforcement at corners and angles; and 2) it can absorb vibration and movement better than felt.

Cold-Applied Bituminous Materials

Cold bituminous systems use asphalt emulsions or solvent cut-back asphaltic mastics. As with hot-applied systems, these mastics and emulsions have little strength, so fabric is necessary for reinforcement. It is difficult to determine when the emulsions are fully cured; but it is important to prevent reemulsion by preventing water contact with emulsions that have not completely cured. Cold-applied systems are easier to use than hot-applied systems where smoke, vapor, or fire considerations prohibit use of bituminous heating equipment close to the application.

Liquid-Applied Elastomeric Materials

Elastomeric materials are liquids that are applied by means of squeegee, roller, brush, trowel, or spray. When cured, they form a film resistant to water and many other chemicals. With some of these materials, the manufacturer may require reinforcement with glass fabric. Liquid-applied membranes are formulated as single- or multi-component products such as neoprene (polychloroprene), neoprene-bituminous blends, polyurethane, polyurethane- bituminous blends, and epoxy-bituminous blends.

Sheet-Applied Barrier Materials

Precured elastomeric sheet materials may be fully bonded to the substrate or unbonded depending upon the manufacturer's recommendations. (Sheets that are unbonded are usually found between layers of concrete; bonding is recommended for lining sumps.) Sheet-applied materials, generally available, are listed below:

- Neoprene is a synthetic rubber identified as polychloroprene. It has good resistance to intermittent oil exposure and to bacteria, fungi, acids, ultraviolet light, and ozone. It is usually applied in 60 mil sheets and may be used either exposed or below wearing surfaces.

- Butyl is a synthetic rubber identified as polyisobutylene. It is best suited for below grade, concealed waterproofing installations. Resistance to ozone, ultraviolet, bacteria, fungi, and soil acids is good.

- EPDM is a synthetic rubber resulting from the polymerization of ethylene and propylene. Properly-formulated compounds based on EPDM provide good resistance to ozone, ultraviolet light, and weathering. EPDM remains elastic through a wide range of temperatures.

- Plasticized PVC is produced by adding a plasticizer to hard and rigid PVC plastic. The result is a soft, pliable material that has properties similar to the three elastomeric materials listed above. Some vinyls have relatively poor resistance to direct exposure to ultraviolet rays and weather compared to elastomeric materials.

Neoprene, butyl, and EPDM sheets are joined by adhesive bonding. The adhesives are usually solvent-based elastomers that are brush applied to the barrier surfaces where the sheets will overlap to form the joint. Solvent cementing (chemical welding) is used to bond adjoining sheets of PVC. The solvent dissolves the overlapping sheet surfaces to be joined, which are then pressed together. When the solvent diffuses, the sheets are united.

Preformed Barrier Materials

A prefabricated waterproofing barrier usually consists of polyethylene film, polyvinylchloride film, or non-woven plastic fabric, coated on one or both sides with bituminous materials derived from either asphalt or coal tar base materials and usually modified with various polymers to improve physical properties. Preformed barrier materials are supplied in either sheet or roll form and range in thickness from 40 to 200 mil. The roll form is generally more pliable and can be formed around and into corners. Sheet material is not as pliable and must be cut to fit corners and other changes in the form of the concrete surface.

Cementious Membrane Barrier Materials

These membranes are waterproofing barriers that become hard and rigid after being mixed. They can be applied by trowel, spray, or by the dry-shake/power trowel method to thickness ranging between 1/8 inch for normal applications to 1/4 to 2 inch for heavy traffic bearing applications. Cementious membranes can be dressed to provide a smooth, rough, or textured finish. These membranes are commonly used on surfaces that will be left exposed, such as pools, tanks, fountains, and concrete decks.

APPENDIX C

SOURCES OF INFORMATION

1. American Concrete Institute
   Box 19150
   Detroit, MI 48219-0150
   (313) 532-2600

2. American National Standards Institute, Inc.
   1430 Broadway
   New York, NY 10018
   (212) 354-3300

3. American Society of Civil Engineers
   345 East 47th Street
   New York, NY 10017
   (212) 705-7496

4. American Society for Concrete Construction
   426 South Westgate
   Addison, IL 60101
   (708) 543-0870

5. American Society for Testing and Materials
   1916 Race Street
   Philadelphia, PA 19103
   (215) 299-5462 customer service: (215) 299-5585

6. American Waterworks Association
   6666 West Quincy Avenue
   Denver, CO 80235
   (303) 794-7711

7. Canadian General Specifications Board
   Canadian Government, Secretary
   Phase III
   9C1 Place du Portage
   Hull, Quebec K1A 0S5

8. Concrete Reinforcing Steel Institute
933 North Plum Grove Road
Shamburg, IL 60173
(708) 517-1200

9. Construction Specifications Institute
601 Madison Street
Alexandria, VA 22314
(703) 684-0300

10. International Association of Concrete Repair Specialists
P.O. Box 17402
Dulles International Airport
Washington, DC 20041
(202) 260-0009

11. National Association of Corrosion Engineers
P.O. Box 218340
Houston, TX 77218
(713) 492-0535

12. National Institute of Standards and Technology
Center for Building Technology
Building 226 Room B158
Gaithersburg, MD 20899
(301) 975-6063

13. National Precast Concrete Association
825 East 64th Street
Indianapolis, IN 46220
(317) 253-0486

14. National Ready Mix Concrete Association
900 Spring Street
Silverspring, MD 20910
(301) 587-1400

15. Ontario Hydro
Director of Research
800 Kipling Avenue S.
Toronto, Ontario M8Z 5B2
Canada (416) 231-4111

16. Portland Cement Association
1520 Old Orchard Road
Skokie, IL 60077
(708) 966-6200

17. U.S. Army Corps of Engineers
    Concrete Laboratory, Waterway Experimental Station
    3909 Halls Ferry Road
    Vicksburg, MS 39180-6199
    (601) 636-3111

18. U.S. Army Corps of Engineers
    Inspection Division
    20 Massachusetts Avenue NW
    Washington DC 20314-1000
    (202) 272-0222

19. U.S. Department of the Navy
    Naval Publications and Forms Center
    Military Specifications, Commanding Officer
    5801 Tabor Avenue
    Philadelphia, PA 19120
    (215) 697-2000

APPENDIX D

USEFUL REFERENCES: AN ANNOTATED LISTING

1. American Concrete Institute, ACI 201.1R-68, Guide For Making a Condition Survey of Concrete in Service, 1984.

   This Guide provides a system for reporting on the condition of concrete in service. A detailed checklist is presented for conducting a survey of the condition of concrete. The definition of terms associated with the durability of concrete is included as an appendix.

2. American Concrete Institute, ACI 207-3R, ACI Manual of Concrete Practice, Part 1, 1979.

   This document addresses core drilling in concrete.

3. American Concrete Institute, ACI 224.1R-89, Causes, Evaluation, and Repair of Cracks in Concrete Structures, 1989.

   The causes of cracks in concrete structures are summarized. The procedures used to evaluate cracking in concrete and the principal techniques for the repair of cracks are presented. Evaluation techniques and criteria are described. The key methods of crack repair are discussed, and guidance is provided for their proper application.

4. American Concrete Institute, ACI 228.1R-89, In-Place Methods for Determination of Strength of Concrete, 1989.

   Methods for determining the in-place compressive strength of concrete are discussed. Recommendations are given as to the number of tests needed and statistical interpretation of test results.

5. American Concrete Institute, ACI 311.4R-88, Guide for Concrete Inspection, 1988.

   This committee report discusses the types of inspection activities involved in concrete construction as well as the responsibilities of the various individuals and organizations involved. Recommended minimum levels on inspection and the means for implementing these plans are given for various purposes and projects.

6. American Concrete Institute, ACI 350R-89, Environmental Engineering Concrete Structures," 1989.

This committee report contains recommendations for structural design, materials, and construction of structures commonly used in water and wastewater treatment works such as concrete tanks and reservoirs. Special emphasis is placed on crack minimization and special load accommodation. Design of joints, proportioning of concrete, placement, curing, and protection against chemicals also are described.

7. American Concrete Institute, ACI 504R-90, Guide to Sealing Joints in Concrete Structures, 1990.

Joint sealants are described and illustrated. Joint movement and design, joint sealant function, sealant installation, and joint sealant repair are discussed.

8. American Concrete Institute, ACI 515.1R-79 (85), A Guide to the Use of Waterproofing, Dampproofing, Protective and Decorative Barrier Systems for Concrete, 1985.

This committee report includes a table listing the effects of various chemicals on concrete, and sections on concrete conditioning, waterproofing, and dampproofing barrier systems, as well as protective and decorative barrier systems. Concrete cleaning methods also are delineated. Information provided will assist in the selection, placement, installation, and inspection of these barrier systems.

9. American Concrete Institute, ACI Compilation No. 5, Concrete Repair and Restoration, Detroit, 119 pp., 1980.

This compilation of papers on concrete repair and restoration is reprinted from Concrete International: Design and Construction, V.2, No. 9, September 1980. Special emphasis is placed on bridge repair and restoration with many case histories discussed.

10. American Concrete Institute, ACI SCM 21-89, Repairs of Concrete Structures -- Assessments, Methods and Risks, 1989.

Provides a collection of case studies on concrete repair that apply ACI guides for performing a condition survey and strength evaluation.

11. American Concrete Institute Committee 311, ACI Publication SP-2, ACI Manual of Concrete Inspection, Seventh Edition, 1981.

This document outlines fundamental concepts relating to concrete, inspections procedures for new construction, and some methods of repair (e.g., grouting and epoxy resin injection).

12. **American Concrete Institute, Special Publication 108, Whiting, David and Arthur Walitt, Eds., <u>Permeability of Concrete</u>, Detroit, pp. 225, 1988.**

Concrete permeability influences the durability and ultimate longevity of concrete structures. At the 1987 ACI Fall Convention, new materials for reducing permeability and techniques for its measurement are rapidly being developed. The 11 papers presented at this convention form the subject matter. Both materials aspects and test procedures are described.

13. **American Concrete Institute, Special Publication 112, Lew, H.S., Ed., <u>Nondestructive Testing</u>, Detroit, 221 pp., 1988.**

A collection of papers dealing with various aspects of the non-destructive testing of concrete including laboratory studies, field applications, and statistical analysis of data.

14. **ASTM, C 42-87, <u>Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete</u>, 1987.**

This test method covers obtaining, preparing, and testing (1) cores drilled from concrete for length or compressive or splitting tensile strength determinations and (2) beams sawed from concrete for flexural strength determinations.

15. **American Society for Testing and Materials (ASTM), C 215-85, <u>Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens</u>, 1985.**

This test method is intended primarily for detecting significant changes in the dynamic modulus of elasticity of laboratory or field test specimens that are undergoing exposure to weathering or other types of potentially deteriorating influences.

This test method may be used to assess the uniformity of field concrete, but it should not be considered as an index of compressive or flexural strength nor as an adequate test for establishing the compliance of the modulus of elasticity of field concrete with that assumed by design.

The conditions of manufacture, the moisture content, and other characteristics of the test specimens materially influence the results obtained.

Different computed values for the dynamic modulus of elasticity may result from widely different resonant frequencies of specimens of different sizes and shapes of the same concrete. Therefore, comparison of results from specimens of different sizes or shapes should be made with caution.

16. ASTM, C 457-82a, Standard Practice for Microscopical Determination of Air-Void Content and Parameters of the Air-Void System in Hardened Concrete, 1988.

This standard practice describes microscopical determinations of air void content, specific surface, spacing factor, and air-paste ratio of the air-void system in hardened concrete. Two methods are included: the linear transverse (Rosiwal) method and modified point-count method.

17. ASTM, C 597-83, Standard Test Method for Pulse Velocity through Concrete, 1983.

This test method may be used to advantage to assess the uniformity and relative quality of concrete, to indicate the presence of voids and cracks, to estimate the depth of cracks, to indicate changes in the properties of concrete, and in the survey of structures, to estimate the severity of deterioration or cracking.

NOTE 1. Moisture content of concrete can affect pulse velocity.

The results obtained by the use of this test method should not be considered as a means of measuring strength nor as an adequate test for establishing compliance of the modulus of elasticity of field concrete with that assumed in design.

NOTE 2. When circumstances permit, a velocity/strength (or velocity/modulus) relationship may be established by the determination of pulse velocity and compressive strength (or modulus of elasticity) on a number of samples of concrete. This relationship may serve as a basis for the estimation of strength (or modulus of elasticity) by further pulse/velocity tests on that concrete.

The procedure is applicable in both field and laboratory testing regardless of size or shape of the specimen within the limitations of available pulse-generating sources.

NOTE 3. Presently available test equipment limits path lengths to approximately 50 mm (2 in.) minimum and 15 m (50 ft.) maximum, depending, in part, upon the frequency and intensity of the generated signal. The upper limit of the path length depends partly on surface conditions and partly on the characteristics of the interior concrete under investigation. The maximum path length is obtained by using transducers of relatively low vibrational frequencies (10 to 20 kHz) to minimize the attenuation of the signal in the concrete. (The resonant frequency of the transducer assembly, that is, crystals plus backing plate, determines the frequency of vibration in the concrete.) For the shorter path lengths where loss of signal is not the governing factor, it is preferable to use vibrational frequencies of 50

kHz or higher to achieve more accurate transit-time measurements and hence greater sensitivity.

18. **ASTM, C 805-85, Standard Method for Rebound Number of Hardened Concrete, 1985.**

A steel hammer impacts with a predetermined amount of energy, a steel plunger in contact with a surface of concrete, and the distance that the hammer rebounds is measured.

The rebound number determined by this method may be used to assess the uniformity of concrete in situ, to delineate zones or regions (areas) of poor quality or deteriorated concrete in structures, and to indicate changes with time in characteristics of concrete such as those caused by the hydration of cement so that is provides useful information in determining when forms and shoring may be removed.

This test method is not intended as an alternative for strength determination of concrete.

Optimally, rebound numbers should be correlated with core testing information. Due to the difficulty of acquiring the appropriate correlation data in a given instance, the rebound hammer is most useful for rapidly surveying large areas of similar concretes in the construction under consideration.

19. **ASTM, C 823-83 (88), Standard Practice for Examination and Sampling of Hardened Concrete in Constructions, 1983.**

The examination may provide a basis for laying out in situ testing of the concrete.

The sampling can provide materials for petrographic examination, in accordance with Practice C 856, chemical or physical analytical procedures, or any of a wide variety of destructive or non-destructive tests to determine physical, mechanical, or structural properties of the concrete.

The results of examination and sampling carried out in accordance with this practice may be used for a variety of purposes and to serve a variety of objectives.

20. **ASTM, C 856-83, Standard Practice for Petrographic Examination of Hardened Concrete, 1983.**

The probable usefulness of petrographic examination in specific instances may be determined by discussion with an experienced petrographer of the objectives of the investigation proposed or underway may include:

- Determination in detail of the condition of concrete in a construction.

- Determination of the causes of inferior quality, distress, or deterioration of concrete in a construction.

- Determination of the probable future performance of the concrete.

- Determination whether the concrete in a construction was or was not as specified. In this case, other tests may be required in conjunction with petrographic examination.

- Description of the cementitious matrix, including qualitative determination of the kind of hydraulic binder used, degree of hydration, degree of carbonation, if present, evidence of unsoundness of the cement presence of a mineral admixture, the nature of the hydration products, adequacy of curing, and unusually high water/cement ratio of the paste.

- Determination whether alkali-silica or alkali-carbonate reactions, or cement-aggregate reactions, or reactions between contaminants and the matrix have taken place, and their effects upon the concrete.

- Determination of whether the concrete has been subjected to and affected by sulfate attack, or other chemical attack, or early freezing, or to other harmful effects of freezing and thawing.

- Part of a survey of the safety of a structure for a present or proposed use.

- Determination whether concrete subjected to fire is essentially undamaged or moderately or seriously damaged.

- Investigation of the performance of the coarse or fine aggregate in the structure, or determination of the composition of the aggregate for comparison with aggregate from approved or specified sources.

- Determination of the factors that caused a given concrete to serve satisfactorily in the environment in which it was exposed.

- Determination of the presence and nature of surface treatments, such as dry shake applications on concrete floors.

21. **ASTM, C 1040-85, <u>Standard Test Methods for Density of Unhardened and Hardened Concrete in Place by Nuclear Methods</u>, 1985.**

These test methods are useful as rapid, non-destructive techniques for the in-place determination of the density of unhardened concrete. The backscatter method is also useful for the same purpose on hardened concrete. The fundamental assumptions inherent in the test methods are that Compton scattering is the dominant interaction and the the material under test is homogeneous.

These test methods are suitable for control and for assisting in acceptance testing during construction, for evaluation of concrete quality subsequent to construction, and for research and development.

NOTE 1. Care must be taken when using these test methods in monitoring the degree of consolidation, which is the ratio of the actual density achieved to the maximum density attainable with a particular concrete. The methods presented here are used to determine the actual density. A density measurement, by any method, is a function of the components of concrete and may vary, to some extent, in response to the normal, acceptable variability of those components.

Test results may be affected by reinforcing steel, by the chemical composition of concrete constituents, and by sample heterogeneity. The variations resulting from these influences are minimized by instrument design and by the user's compliance with appropriate sections of the test procedure.

Results of tests by the backscatter method also may be affected by the density of underlying material. The backscatter method exhibits spatial bias in that the apparatus's sensitivity to the material under it decreases with distance from the surface of the concrete.

22. **ASTM, E 177-90, Standard Practice for Use of the Terms Precision and Bias in ASTM Test Methods, 1990.**

Part A of the "Blue Book," Form and Style for ASTM Standards, requires that all test methods include statements of precision and bias. This practice discusses these two concepts and provides guidance for their use in statements about test methods.

Precision -- A statement of precision allows potential users of a test method to assess in general terms the test method's usefulness with respect to variability in proposed applications. A statement on precision is not intended to contain values that can be exactly duplicated in every user's laboratory. Instead, the statement provides guidelines as to the kind of variability that can be expected between test results when the method is used in one or more reasonably competent laboratories.

Bias -- A statement on bias furnishes guidelines on the relationship between a set of typical test results produced by the test method under specific test conditions and a related set of accepted reference values.

23. **ASTM, Annual Book of ASTM Standards, Vol 04.02, Concrete and Aggregates, 1990.**

Specifications, test methods, practices, and definitions of terms relating to aggregates, concrete reinforcing steel, etc.

24. ASTM, Manual of Aggregate and Concrete Testing, **revised 1987.**

This Manual of Aggregate and Concrete Testing is intended to supplement, not in any way to supersede, the various ASTM methods of sampling and testing of aggregate and freshly mixed and hardened Portland cement concrete. This manual was prepared by Committee C-9 on Concrete and Concrete Aggregates and has been accepted by the Society for publication as information only. The manual is not a part of the ASTM methods. Comments and suggestions on the manual will be welcomed by Committee C-9.

Many specifications for aggregates and concrete are based on the results of ASTM methods of testing and therefore strict adherence to the requirements of the test methods is important. The methods have been prepared carefully, but it is impractical to describe the minute details of manipulations. Improper use of test procedures can result in inaccurate data and mistaken conclusions about aggregate and concrete quality. Accordingly, this manual directs attention to many of the factors that might affect the results of the tests.

25. **American Water Works Association, ANSI/AWWA D110-86, AWWA Standard for Wire-Wound Circular Prestressed-Concrete Water Tanks, 1987.**

This ANSI/AWWA standard covers current recommended practice for the design, construction, inspection, leak test, leak repair, and maintenance of wire and strand-wound circular prestressed-concrete water containing structures. This standard applies to containment structures for use with potable water and non-aggressive process water and wastewater only and should not be used in the design of containment for highly-aggressive waters or high-temperature waters without special considerations. It is not intended for use designing structures for storage of chemicals or slurries.

26. **American Water Works Association Committee on Water Holding Structures, "A Summary Report on Concrete Waterholding Structures,"**

Journal of the American Water Works Association, pp 458-459, August 1978.

This committee report defines the scope of the AWWA Committee on Concrete Water Holding Structures and presents the results of a survey on leakage allowances in concrete reservoirs. A bibliography of literature dealing with concrete waterholding structures is included.

27. Closner, J.J., Design and Application of Prestressed Concrete for Oil Storage, The American Society of Mechanical Engineers, New York, 11 pp., 1975.

This paper presents some of the existing examples of concrete in the petroleum storage field as well as the features available with prestressed concrete tanks. The design, construction, lining, and costs associated with prestressed concrete tanks also are discussed.

28. U.S. Environmental Protection Agency - Office of Solid Waste, EPA/530-SW-86-044, Technical Resource Document for Storage and Treatment of Hazardous Waste in Tank Systems, December 1986.

This document provides owners or operators of hazardous waste storage tanks guidance in preparing Part B permit applications and for the Federal and State officials who will be processing these applications required by Title 40, Code of Federal Regulations, Part 270 (40 CFR 270). Included is an extensive table of leak detection methods.

29. U.S. Environmental Protection Agency - Office of Solid Waste, EPA/530-SW-88-0005, Draft Report - Clean Closure of Hazardous Waste Tank Systems and Container Units, November 12, 1987.

This report examines various methods of cleaning hazardous waste storage units, including those constructed of concrete. Cleaning methods are examined in terms of their applicability for 10 categories of contaminants. Advantages and disadvantages of the methods are listed.

30. U.S. Environmental Protection Agency - Hazardous Waste Engineering Research Laboratory, EPA/600/2-85/028, Guide for Decontaminating Buildings, Structures, and Equipment at Superfund Sites, March 1985.

This document served as a primary source document for EPA/530-SW-88-0005. It outlines various methods of cleaning and addresses related engineering considerations, safety concerns, advantages, disadvantages, waste disposal options, and costs. Case studies are also included in an appendix.

31. Grotta, H.M., et al, Development of Novel Decontamination Techniques for Chemical Agents Contaminated Facilities Phase I Identification and Evaluation of Concepts, U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD, Report DRXTH-TE-CR-83208, Volumes I and II, 1983 (Distribution limited to Government Agencies).

In this technical report, both old and new untried methods of decontaminating concrete are described. The objective of this research and development program on novel processing technology is to identify, evaluate, and develop novel techniques to decontaminate Army buildings and their contents that have become contaminated with chemical agents. In this Phase I study, about 65 concepts were generated and described to permit their evaluation against the criteria of mass transfer, destruction efficiency, safety, damage to structures, penetration depth, applicability to complex structures, operating costs, capital costs, and waste treatment costs. The most promising concepts were the use of hot gases, vapor circulation, and chemical methods using either monoethanol amine, n-octyl-pyridinium aldoxime bromide (OPAB) or ammonia. These methods will be laboratory tested in a future study.

32. Hooten, R. Douglas, "Permeability and Pore Structure of Cement Pastes Containing Fly Ash, Slag, and Silica Fume," American Society for Testing and Materials, reprinted from Special Technical Publication 897, Philadelphia, pp. 128-143, 1986.

A part of research to develop a highly durable concrete container for radioactive waste disposal in chloride and sulfate-bearing granite ground water, a variety of cement pastes were studied. Various proportions of fly ash, slag, and silica fume were used to make cement paste. While all three supplementary cementing materials reduced ultimate permeabilities, silica fume was most effective in reducing permeability at early ages.

33. Hooten, R. Douglas, "Problems Inherent in Permeability Measurement," presented at and in Proceedings of the Engineering Foundation Conference on Advances in Cement Manufacture and Use, Potosi, Missouri, July 31-August 5, 1988.

This paper discusses some of the variables affecting permeability testing of concrete. Current laboratory testing methodology is addressed and some thoughts are offered on improved techniques. The paper concludes by stressing the importance of developing standardized permeability testing methods for concrete.

34. Hooten, R. Douglas and Lillian D. Wakeley, Influence of Test Conditions on Water Permeability of Concrete in a Triaxial Cell, Unpublished.

The hydraulic conductivity of three concretes with a high ratio of water to cementitious solids are measured in a triaxial cell. Test variables included confining pressure, driving pressure, the ratio of these two pressures, and sample length. The effect of these variables on measured permeability is discussed.

35. International Association of Concrete Repair Specialists, "Concrete You Can See Through," Concrete Repair Bulletin, Volume 2, No. 1, February 1989.

Provides brief description of concrete petrographic examination and a range of costs per sample.

36. International Association of Concrete Repair Specialists, Surface Preparation Guidelines for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Oxidation, Nos. 03730, 03731, 03732, and 03734, 1989.

This Technical Committee document presents guidelines and illustrations for surface preparation in repair of concrete that has deterioriated as a result of reinforcing steel oxidation.

37. McDonald, James E., Repair of Waterstop Failures: Case Histories. U.S. Army Corps of Engineers, Technical Report REMR-CS-4, Washington, DC, 244 pp., 1986.

Twenty case histories concerning the repair of waterstop failures are presented. The materials and techniques used in the repair are emphasized. Information in each case history (if available) includes (a) project description, (b) location and cause of leakage, (c) repair material, and (d) follow-up evaluation results.

38. National Association of Corrosion Engineers (NACE), RP-01-88, Discontinuity (Holiday) Testing of Protective Coatings, 1988.

This standard provides procedures for determining discontinuities in coatings on conductive surfaces, including some concretes, using two types of test equipment: low voltage wet sponge and high voltage spark testers. Also included are instructions for testing repaired areas and safety precautions.

39. NACE, RP-02-88, Inspection of Linings on Steel and Concrete, 1988.

Presented are proper inspection procedures for linings on steel and concrete. Inspection of surface preparation, coating materials, and application of coatings are addressed. Pre-job conference instructions and information on the type of inspection equipment also are provided.

40. Portland Cement Association, 15071:03D, Underground Concrete Tanks, undated.

This information sheet briefly discusses underground concrete tank design, construction, testing, and surface treatment and gives suggestions for further reference in each topic. A set of drawings of an underground tank are provided to help in making preliminary estimates and in drawing final plans.

41. Portland Cement Association, Effect of Various Substances on Concrete and Protective Treatments, Where Required, 1981.

Describes concrete compatibility with various substances and presents guidance on the use of surface barriers.

42. Stowe, Richard L. and Henry T. Thornton, Jr., Engineering Condition Survey of Concrete in Service, U.S. Army Corps of Engineers, Technical Report REMR-CS-1, Washington, DC, 109 pp., 1984.

This report provides guidance and summarizes pertinent inspection procedures and methods of evaluation of concrete in service in existing civil works structures. Topics include reviewing engineering data, field investigations, and laboratory investigations.

43. Thornton, Henry T., Jr., and A. Michael Alexander, Development of Nondestructive Testing Systems for In Situ Evaluation of Concrete Structures, U.S. Army Corps of Engineers, Technical Report REMR-CS-10, Washington, DC, 167 pp., 1987.

Additional capability to non-destructively evaluate concrete in large structures was required. This report is divided into five tasks: Non-destructive methods for interior concrete; Underwater mapping and profiling; Engineering guidance for evaluation of concrete in service; vibration signature measurements; and model analysis, finite- element feasibility. An effort was made to develop an ultrasonic pulse-echo system for the investigation and evaluation of the interior of concrete structures. The system is presently useful for making thickness measurements on concrete pavements and floor slabs. Limited tests have shown that a metal plate and a plastic pipe can be located in a concrete slab of 9 inches of thickness or less. In addition, a high-resolution acoustic mapping system was developed which will provide an accurate and comprehensive evaluation of top surface wear on underwater horizontal surfaces. The mapping system can operate in 5 to 30 feet of water and produce accuracies of +/- 2 inches vertically and +/- 1 foot laterally. Vibration signatures were obtained from various large structures using the impact-resonance technique.

44. Whiting, D., Rapid Determination of the Chloride Permeability of Concrete, Federal Highway Administration, Report No. FHWA/RD-81/119, Washington, DC, 174 pp., 1981.

The most promising method developed to determine the permeability of concrete to chloride ions involves application of d.c. voltage in the range of 60.0 to 80.0 volts for 6 hours to either a section of reinforced concrete bridge deck or a core taken from a concrete structure. To run one complete test takes two days. Concretes can be ranked according to high, moderate, low, or very low chloride permeability.

45. Woodland, L.R., et al, Pilot Plant Testing of Caustic Spray/Hot Gas Building Decontamination Process, U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD, Report No. AMXTH-TE-CR-87112, August 1987.

A decontamination method was developed and tested to eliminate the explosive and toxic hazard of munition processing wastes. A pilot project using hot gas treatment was begun at Cornhuskers AAP (Grand Island, NE) in a contaminated cinderblock building. The pilot-scale test indicated that a 900 degree F gas stream heating the inside wall and floor surfaces to about 500 degrees F will reduce wall surface explosive contaminant concentration to about 1 mg/sq cm, reduce the concrete block interior explosive contaminant concentration to about 0.11 ug/gm, and minimize the loss of structural strength from heating to 5 percent of compressive strength and 20 to 30 percent less in tensile strength.

APPENDIX E

USEFUL REFERENCES: TOPIC AREA CROSS-REFERENCE

DOCUMENT	Design/ Construction	Cleaning	Interior Surface Barrier Systems	Examination of Exposed Surfaces	Examination of Internal Structure	Leak Detection	Repair	Other
	Major Technical Topics Related to Concrete Sumps							
AMERICAN CONCRETE INSTITUTE (ACI)								
ACI 201.1R-68	X	--	--	X	X	--	X	X
ACI 207-3R	--	--	--	--	X	--	--	--
ACI 224.1R-89	--	X	X	X	X	--	X	--
ACI 228.1R-89	--	--	--	--	X	--	--	--
ACI 311.4R-88	--	--	--	--	--	--	--	X*
ACI 350R-89	X	--	X	--	--	--	--	--
ACI 504R-90	X	X	X	X	--	--	X	--
ACI 515.1R-79 (85)	--	X	X	--	--	--	X	--
ACI Comp. No. 5	--	X	--	--	--	--	X	--
ACI SCM 21-89	--	--	--	X	X	--	X	--
ACI SP-2	X	--	--	--	--	--	X	--
ACI SP-108	--	--	--	--	--	--	--	X**
ACI SP-112	--	--	--	--	X	--	--	--
AMERICAN SOCIETY FOR TESTING & MATERIALS (ASTM)								
ASTM C 42-87	--	--	--	--	X	--	--	--
ASTM C 215-85	--	--	--	--	X	--	--	--
ASTM C 457-82a	--	--	--	--	X	--	--	--
ASTM C 597-93	--	--	--	--	X	--	--	--
ASTM C 805-85	--	--	--	--	X	--	--	--
ASTM C 823-83 (88)	--	--	--	--	X	--	--	--
ASTM C 856-83	X	--	--	X	X	--	--	--
ASTM C 1040-85	X	--	--	--	X	--	--	--
ASTM E 177-90	--	--	--	--	--	--	--	X*
Annual Book of Standards, Vol. 04.02	X	--	--	X	X	--	X	--
ASTM "Manual of Aggregate & Concrete Testing"	--	--	--	--	X	--	--	--

X = Addresses the topic   * = Addresses test methods-precision and bias.   ** = Addresses concrete permeability.

(continued)

APPENDIX E (continued)

DOCUMENT	Major Technical Topics Related to Concrete Sumps							
	Design/ Construction	Cleaning	Interior Surface Barrier Systems	Examination of Exposed Surfaces	Examination of Internal Structure	Leak Detection	Repair	Other
AMERICAN WATER WORKS ASSOCIATION (AWWA)								
ANSI/AWWA D110-86	X	--	--	X	--	X	X	--
Concrete Water-Holding Structures	--	--	--	--	--	X	--	--
CLOSNER: AMERICAN SOCIETY OF MECHANICAL ENGINEERS	X	--	X	--	--	--	--	--
U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)								
EPA/530-SW-86-044	--	--	--	--	--	X	--	--
EPA/530-SW-88-0005	--	X						
EPA/600/2-85/028	--	X	--	--	--	--	--	--
GROTTA - U.S. ARMY TOXIC & HAZARDOUS MATERIALS AGENCY	--	X	--	--	--	--	--	--
HOOTEN - AMERICAN SOCIETY FOR TESTING & MATERIALS	--	--	--	--	--	--	--	X**
HOOTEN - ENGINEERING FOUNDATION CONFERENCE	--	--	--	--	--	--	--	X**
HOOTEN - UNPUBLISHED PAPER	--	--	--	--	--	--	--	X**
INTERNATIONAL ASSOCIATION OF CONCRETE REPAIR (IACR)								
Concrete Repair Bulletin, Vol 2, No. 1	--	--	--	--	X	--	--	--
Technical Guidelines 03730-03734	--	X	--	--	--	--	X	--
McDONALD - U.S. ARMY CORPS OF ENGINEERS	--	--	--	--	--	--	X	--
NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE)								
NACE RP-01-88	--	--	X	X	--	--	--	--
NACE RP-02-88	--	--	X	X	--	--	--	--

X = Addresses the topic   * = Addresses test methods-precision and bias.   ** = Addresses concrete permeability.

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APPENDIX E (continued)

DOCUMENT	Major Technical Topics Related to Concrete Sumps							
	Design/ Construction	Cleaning	Interior Surface Barrier Systems	Examination of Exposed Surfaces	Examination of Internal Structure	Leak Detection	Repair	Other
<u>PORTLAND CEMENT ASSOCIATION (PCA)</u>								
"Underground Concrete Tanks"	X	--	--	--	--	--	X	--
"Effects of Various Substances on Concrete and Protective Treatments, Where Required"	--	--	X	--	--	--	--	--
<u>STOWE - U.S. ARMY CORPS OF ENGINEERS</u>	X	--	--	X	X	--	X	--
<u>THORNTON - U.S. ARMY CORPS OF ENGINEERS</u>	--	--	--	--	X	--	--	--
<u>WHITING, FHWA/RD-81/119</u>	--	--	--	--	--	--	--	X**
<u>WOODLAND, AMXTH-TE-CR-87112</u>	--	X	--	--	--	--	--	--

X = Addresses the topic   * = Addresses test methods-precision and bias.   ** = Addresses concrete permeability.

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APPENDIX F

WATER LEVEL MEASURING EQUIPMENT

If inspection of the sump indicates that a leak may be present, the certifying engineer may require that a leak test be performed. The static head test described in Section 3 of this document relies upon detection of changes in the water level within the test sump. In small sumps, a temporary scale may be mounted on the sump wall or the water level on a side wall may be marked, thereby permitting changes in water level to be observed and recorded over a period of hours or days.

In sumps with a large surface area, electro-mechanical devices such as a float-operated strain gauge (load cell) or linear variable displacement transformer (LVDT) may be appropriate for detecting small changes in the liquid level.

Horner Creative Products of Bay City, Michigan, has a strain gauge system marketed under the name "Horner Ezy-Chek II - Underfill Method." This system normally is used to test underground storage tanks with capacities to 12,000 gallons by using an underfill method which requires that the tank be only 95 percent full. This tank configuration represents a liquid surface area of approximately 16.36 m^2 (152 sq. ft.); thus, this equipment is appropriate for monitoring water level in sumps up to approximately 150 sq. ft. in surface area.

For sumps with larger surface areas, more sensitive devices are necessary to monitor surface levels such as the LVDT with a computerized data acquisition system developed by CCS Control Systems, San Dimas, California. This system uses a specially-designed float-activated LVDT system with computerized data processing to eliminate "noise" and to identify true changes in water surface level.

Certain sump configurations may prevent the use of the static head test; in which case, a tracer test may prove useful. A water-soluble, non-toxic tracer is introduced into the sump and allowed to escape with the leak, if one is present. The unique chemical tracer can be detected on the outside of the sump if a release has occurred. The choice of tracer and monitoring method is site-specific. Tracer tests are used routinely by Tracer Research Corporation, Tucson, Arizona, to verify the integrity of underground storage tanks.

GLOSSARY

"Aboveground tank" means a device meeting the definition of "tank" as set forth in Section 260.10 that is situated in such a way that the entire surface area of the tank is completely above the plane of the adjacent surrounding surface and the entire surface area of the tank (including the tank bottom) can be visually inspected.

"Ancillary equipment" means any device including, but not limited to, such devices as piping, fittings, flanges, valves, and pumps, that is used to distribute, meter, or control the flow of hazardous waste from its point of generation to storage or treatment tank(s), between hazardous waste storage and treatment tanks to a point of disposal on site, or to a point of shipment for disposal off site.

"Authorized state" means a state operating a hazardous waste program approved by EPA and authorized to administer and enforce its hazardous waste program in lieu of the federal program.

"CFR" means the Code of Federal Regulations.

"Characteristics" means the characteristics of a hazardous waste: ignitability, corrosivity, reactivity, and toxicity. Any solid waste that exhibits one or more of these characteristics is classified as a hazardous waste.

"Certification" means a statement of professional opinion based upon knowledge and belief.

"Component" means either the tank or ancillary equipment of a tank system.

"Corrosion" means disintegration or deterioration of concrete or reinforcement by electrolysis or chemical attack.

"Efflorescence" means a deposit of salts, usually white, formed on a surface, the substance having emerged from below the surface.

"Erosion" means deterioration brought about by the abrasive action of fluids or solids in motion.

"Existing tank system" or "existing component" means a tank system or component that is used for the storage or treatment of hazardous waste and is in operation, or the installation of which has begun, on or prior to the effective date of the regulations (July 14, 1986). Installation will be considered to have commenced if the owner or operator has obtained all federal, state, and local approvals or permits necessary to begin physical construction of the site or installation of the tank system, and if either: 1) a continuous on-site physical construction or installation program has begun; or 2) the owner or operator has entered into contractual obligations, which cannot be cancelled or modified without substantial loss, for physical construction on the site or installation of the tank system scheduled to be completed within a reasonable time.

"**Exudation**" means a liquid or viscous gel-like material discharged through a pore, crack, or opening in the surface.

"**Facility**" means all contiguous land, structures, appurtenances, and improvements on the land used for treating, storing, or disposing of hazardous waste. A facility may consist of several treatment, storage, or disposal operational units (e.g., one or more landfills, surface impoundments, or combinations of them).

"**Ground water**" means water below the land surface in a zone of saturation.

"**Hazardous waste**" means a solid waste that meets one of two conditions and has not been excluded from regulation:

1) Exhibits a characteristic of a hazardous waste (40 CFR Sections 261.20 through 261.24), or

2) Has been listed as hazardous (40 CFR Sections 261.31 through 261.33).

"**Honeycomb**" means voids left in concrete due to failure of the mortar to effectively fill the spaces among coarse aggregate particles.

"**HSWA**" means the Hazardous and Solid Waste Amendments of 1984 (Public Law 98-616).

"**Incrustation**" means a crust or coating, generally hard, formed on the surface of concrete or masonry construction.

"**Interim status**" means that period in which a treatment, storage, or disposal facility can operate without a permit (facilities that were in existence, or for which construction had commenced, prior to November 19, 1980; or in existence on the effective date of regulatory changes under RCRA that cause the facility to be subject to Subtitle C regulation). Applicable standards are found at 40 CFR Part 265.

"**Incompatible waste**" means a hazardous waste which is unsuitable for: 1) placement in a particular device or facility because it may cause corrosion or decay of containment materials (e.g., container inner liners or tank walls); or 2) co-mingling with another waste or material under uncontrolled conditions because the co-mingling might produce heat or pressure, fire or explosion, violent reaction, toxic dusts, mists, fumes or gases, for flammable fumes or gases.

"**Inground tank**" means a device meeting the definition of "tank" set forth in Section 260.10 that has a portion of the tank wall situated to any degree on or within the ground, thereby preventing expeditious visual inspection of the surface area of the tank that is on or in the ground.

"**Inner liner**" means a continuous layer of material placed inside a tank or container which protects the construction materials of the tank or container from the contained waste or reagents used to treat the waste.

"**Laitance**" means an accumulation of fine particles on the surface of fresh concrete due to upward movement of water (as when excessive mixing water is used).

"**Leak-detection system**" means a system capable of detecting the failure of the primary containment structure or the presence of hazardous waste or accumulated liquid in the secondary containment structure. Such a system must employ operational controls (e.g., daily visual inspections for releases into the secondary containment system of aboveground tanks) or consist of an interstitial monitoring device designed to detect continuously and automatically the failure of the primary containment structure or the presence of a release of hazardous waste into the secondary containment structure.

"**Listed**" means a hazardous waste that has been placed on one of three lists: non-specific source wastes, specific source wastes, commercial chemical products.

"**Management**" or "**hazardous waste management**" means the systematic control of the collection, source separation, storage, transportation, processing, treatment, recovery, and disposal of hazardous waste.

"**New tank system**" or "**new tank component**" means a tank system or component that will be used for the storage or treatment of hazardous waste and for which installation has commenced after July 14, 1986. However, for the purposes of Sections 264.193(g)(2) and 265.193(g)(2), a new tank system is one for which construction commences after July 14, 1986.

"**Onground tank**" means a device meeting the definition of "tank" in Section 260.10 that is situated in such a way that the bottom of the tank is on the same level as the adjacent surrounding surface so that its external tank bottom cannot be visually inspected.

"**Operator**" means the person responsible for the overall operation of the facility.

"**Owner**" means the person who owns a facility or part of a facility.

"Pitting" means development of relatively small cavities in a surface, due to a phenomena such as corrosion or cavitation, or, in concrete, localized disintegration.

"Popout" means the breaking away of small portions of a concrete surface due to internal pressure which leaves a shallow, conical depression.

"Release" means any spilling, leaking, emitting, discharging, escaping, leaching, or disposing into ground water, surface water, or subsurface soils.

"Scaling" means local flaking or peeling away of the near surface portion of concrete or mortar.

"Secondary containment" means a method of containing releases; technologies include liners, vaults, and double-walled tanks.

"Spall" means a fragment, usually in the shape of a flake, detached from a larger mass by a blow, by the action of weather, by pressure, or by expansion within the large mass.

"Storage" means the holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed of, or stored elsewhere.

"Sump" means any pit or reservoir that meets the definition of tank and those troughs/trenches connect to it that serve to collect hazardous waste for transport to hazardous waste storage, treatment, or disposal facilities. This description does not apply to sumps covered by the exception EPA added to this definition in the Liner and Leak Detection rule on January 29, 1992 (57 FR 3486).

"Tank" means a stationary device, designed to contain an accumulation of hazardous waste, which is constructed primarily of non-earthen materials (e.g., wood, concrete, steel, plastic) which provide structural support.

"Tank system" means a hazardous waste storage or treatment tank and its associated ancillary equipment and containment system.

"Toxic waste" means a hazardous waste that has been listed in 40 CFR Sections 261.31 through 261.33 because it contains one of the toxic constituents included in 40 CFR Part 261, Appendix VIII. (Substances included in Appendix VIII have been shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life forms.)

"Treatment" means any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste non-hazardous, or less hazardous; safer to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume.

"Underground tank" means a device meeting the definition of "tank" set forth in Section 260.10 whose entire surface is wholly submerged within the ground (i.e, totally below the surface of and covered by the ground).

"Unfit-for-use tank system" means a tank system that has been determined through an integrity assessment or other inspection to be no longer capable of storing or treating hazardous waste without posing a threat of hazardous waste release to the environment.