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Project Summary

Freeboard Determination and Management in Hazardous Waste Surface Impoundments

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A rule-of-thumb minimum freeboard requirement of two feet (60 cm) has been used in the past for hazardous waste surface impoundments. In many situations, however, this minimum value may not be sufficient to prevent overtopping. Consequently, a procedure was developed for calculating freeboard values in surface impoundments where the liquid depths are shallow and fetches are short, as is typical in hazardous waste surface impoundments. The procedure takes into account all of the parameters that influence freeboard and presents the information in a format that can be used on a site-specific basis. Additional support information in the full report includes an example calculation of freeboard requirement, site specific data obtained from research using a mass liquid balance, and a listing of the various types of liquid level detection equipment.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Purpose and Scope

The purpose of the full document is to present all of the information necessary to calculate freeboard requirements on site-specific basis. Section 3.0 presents the procedure for calculating freeboard and provides a discussion of the factors that influence freeboard, such as fetch, liquid depth, wave height and period, wind set-up, and wave run-up. Each factor is discussed and incorporated into the mathematical procedure for determining freeboard. Section 4.0 presents information on two basic methods for detecting and maintaining a predetermined liquid level. Both methods, active and passive level control, are discussed along with suggested safety margins.

Supplemental material included in the appendices is intended to augment the information presented in the body of the document. The appendices include: (1) the procedure for calculating freeboard using a hypothetical surface impoundment design; (2) data collected from a field study on a liquid mass balance at a surface impoundment; and (3) a discussion of various types of liquid level detection equipment that are currently available.

Regulatory Context

Regulations listed in 40 CFR require owners and operators to maintain surface impoundment liquid levels in a manner that prevents overtopping. Regulations that address overtopping are found in CFR 264, 265, and 270. Part 264 addresses operational standards for hazardous waste treatment, storage, and disposal facilities. Part 265 presents interim standards for these facilities and Part 270 discusses the current permitting requirements. Regulations, current

through July 15, 1985, are presented below:

Section 264.221(f) states:

"a surface impoundment must be designed, constructed, maintained, and operated to prevent overtopping resulting from normal or abnormal operations; overfilling; wind and wave action; rainfall; run-on; malfunctions of level controllers, alarms, and other equipment; and human error."

Section 264.226(b) (1) states:

"while a surface impoundment is in operation, it must be inspected weekly and after storms to detect evidence of deterioration, malfunctions, and improper operation of overtopping control systems."

Section 165.222 (a) and (b) state:

(a) "A surface impoundment must maintain enough freeboard to prevent any overtopping of the dike by overfilling, wave action, or a storm. Except as provided in paragraph (b) of this section, there must be at least 60 centimeters (two feet) freeboard."

(b) "A freeboard level less than 60 centimeters (two feet) may be maintained if the owner or operator obtains certification by a qualified engineer that alternate design features or operating plans will, to the best of his knowledge and opinion, prevent overtopping of the dike. The certification, along with a written identification of alternate design features or operating plans preventing overtopping, must be maintained at the facility."

Section 265.226 (a) (1) states:

"The owner or operator must inspect the freeboard level at least once each operating day to ensure compliance with 265.222."

Additional information requirements are necessary for the U.S. Environmental Protection Agency (EPA) to determine compliance with the Part 264 standards, including:

Section 270.17 (b) (2):

"Detailed plans and an engineering report describing how the surface impoundment is or will be designed, constructed, operated and maintained to meet the requirements of 264.221." This submission addresses the prevention of overtopping.

Section 270.17(d):

"A description of how each surface impoundment, including the liner and cover systems and appurtenances control of overtopping, will be inspected in order to meet the requirements of 264.226(b). This information should be included in the inspection plan submitted under 270.14 (b) (5)."

The EPA plans to update the above regulations. These new regulations should be consulted to determine if any changes have been made to those given above.

One intent of the full document is to present a method for calculating freeboard which complies with regulations concerning overtopping as defined by 40 CFR 264, 265, and 270 These regulations have been formulated with the goal of eliminating, to the extent practical, the overtopping of liquids from surface impoundments. No single system, however, provides for absolute prevention of escape. Therefore, it is also the intent of this document to present information for use in designing a containment system which provides the maximum, practically achievable, level of freeboard safety during the operational life of the facility

The goal of the full document is to present performance guidelines and operating characteristics rather than specific numerical design values. However, a minimum freeboard of two feet is recommended. Information provided in this document is intended to offer the owner/operator flexibility in designing a suitable overtopping prevention system without dictating rigid design requirements.

Procedures set forth in the full document for calculating minimum freeboard are based on current technology. Several design methods exist, however, which meet the requirements of 40 CFR 264.221(f). It is the responsibility of the owner/operator to document the integrity of the selected system as well as the ability of the system to meet the regulatory requirements.

Freeboard Determinations

The overall design for freeboard allowance should be tailored to surface impoundments on a case-by-case basis to ensure that overtopping does not occur. To minimize the potential for overtopping, surface impoundments should include the following:

1. Passive outfalls from the surfac impoundment, such as weirs spillways which are insensitive inflow should be incorporated int the design. In the event waste released, these structures direc liquid waste to an on-site holding treatment facility. Passive outfa structures are intended for use on in the event of an automated lev control system malfunction, gros human error, or unforesee catastrophic natural events;
2. If outfall structures are sensitive inflow (i e , where outfall rates mu be increased to maintain freeboa as inflow increases) automat control should be provided v signals from level sensin instruments. In these situations th automated system should include high-level alarm;
3. For surface impoundments receivir waste via inflow structures, desig features should be incorporate which allow for flow of waste to th surface impoundment to be halte immediately in the event overfilling or failure of any surfac impoundment component. The flo of waste can be controlled by a automated level sensing syste which, in the case of a syste failure, can be operated manually;
4. Run-on control structures should b designed to divert the pea discharge from a 100 year/24 ho storm unless it can be shown that th surface impoundment is engineere to accept the additional volum without sacrificing minimu freeboard;
5. Freeboard should be defined as th minimum distance between th highest liquid level in the surfac impoundment, where the highe liquid level includes changes in wat elevation due to a 100 year/24-ho storm surge, and the liquid lev which would result in the release stored liquid from the surfac impoundment by overtoppin Freeboard allowances should b calculated for all surfac impoundments using the maximu fetch (usually the diagon *measurement across the surfac* impoundment) and the maximu historically determined sustaine wind speed to calculate wind se up, wave height, and wave run-u The minimum amount of freeboa maintained in the impoundme should be based on site speci calculations but should never be le

than two feet (60 cm) except as provided for in 40 CFR 265.222 (b). If the impoundment is equipped with a passive outfall such as a weir or spillway, freeboard should be measured from the highest allowable liquid level to the top of the lowest discharge level of the passive outfall structure. When no passive outfalls are present, the freeboard should be the distance from the highest allowable liquid level to the top of the lowest elevation of the retaining structure. Freeboard should not be considered as storage capacity. Changes in liquid level due to a 100 year/24 hour storm should be engineered into the normal storage capacity of the surface impoundment; and

6. A weekly inspection schedule of all overtopping prevention equipment should be followed along with a daily inspection of freeboard. Additional inspections should be conducted following significant rainfall events to verify the integrity of the system and that minimum allowable freeboard has been maintained. Inspections should be made on level control sensors, alarms, and outfall structures. A written record should be maintained which documents the liquid levels, when inspections were conducted, who performed the inspections, and any observations made as to the integrity of the overtopping control systems. It is also recommended that a routine maintenance schedule be implemented for all overtopping control systems.

Calculating Freeboard

The following procedure was developed to allow estimation of freeboard in conditions where short fetches and shallow liquid depths predominate. For the purpose of this document, short fetches will be considered any distance less than 5,280 feet (1,600 meters) and shallow depths will be defined as values less than 30 feet (9 meters). These values were selected because more than 90% of hazardous waste surface impoundments fit into these definitions.

The first step in calculating freeboard is to accurately measure the physical dimensions of the surface impoundment. These measurements include length and width to determine the maximum fetch as well as the maximum liquid depth possible in the surface impoundment. Sidewall slopes should be measured or determined from as-built engineering drawings. Having defined these values it will be necessary to collect local information on such weather conditions as rainfall and wind speed.

Based on this information, calculations for wave height, wave period, wind set-up, and wave run-up can be used to determine freeboard requirements.

Freeboard Management

Maintaining liquid level can be viewed as a two-phase problem. First, there is the need to monitor and control the liquid level at or below the established value. To accomplish this, passive and active (electrically operated) level control systems may be employed. Regardless of the type of system selected, it is advisable to identify a specific system prior to finalizing impoundment design so needed modifications can be incorporated into the design and construction plan for the impoundment.

The second phase in the design of a SI should include a passive level control device such as a weir, spillway, or outflow pipe. The purpose of the passive structure is to prevent catastrophic failure of the impoundment dike in the event that the active level control system fails or an unforeseen natural event occurs. Passive level control devices should be designed for use only in emergency situations, not as part of normal facility operations unless the passive structure is part of a flow through treatment process. In an emergency, the passive level control should direct the liquid to a tank or another surface impoundment.

Quality Assurance

It is advisable to implement a quality assurance program to ensure that the freeboard control system selected operates according to the manufacturer's design specifications. Since a specific freeboard control system (or any components of the system) are not recommended, no specific quality assurance program will be recommended. Rather, the approach taken is to present general procedures which should be observed to ensure that all level control devices are installed correctly and operate properly.

All surface impoundments should use accurately calibrated equipment to measure both inflow and outflow. Automated inflow and outflow structures, when used, should have the capacity to be operated manually in the event automatic controls fail to regulate the flow of liquid. All surface impoundments should be equipped with fail safe high level alarms. It is also advisable to install level sensing probes which interfere with inflow and outflow structures.

Regardless of the type of overtopping system selected, the owner/operator should maintain a written record documenting the procedures used to install and calibrate all equipment and structures associated with liquid level control. In addition, documentation should include verification that the type of system selected is compatible with the type of waste impounded. Once installed, the system should be tested to verify that it is fail safe. These tests should be designed to test the integrity of the entire system, including deliberate actions to verify operation of all fail safe aspects of the system.

After the system has been verified as operating properly, the calibration and testing procedures should be incorporated into a program for routine maintenance of all liquid level control system components. Personnel assigned the responsibility for daily inspection and routine maintenance of the liquid level control system should be familiar with operation of all system components and should have a written protocol detailing the lines of authority, the procedures and schedule for testing the equipment (including calibration specifications), reporting requirements, and all associated contingency plans.

Summary and Recommendations

Procedures used in the past for calculating freeboard at surface impoundments were generally based on procedures and information developed by the Waterways Experiment Station and by other investigators. Much of this information is dated and does not take into account some of the variables that affect the ultimate freeboard value. To address these short falls a new procedure was developed which addresses all of the factors that determine freeboard and incorporates them into an easy-to-follow format. Many of the coefficients used in the original work have been updated using new values derived from ongoing research. Unfortunately, updated information was not available for all parameters (e.g., roughness coefficient), therefore, values were either extrapolated or out-of-date published values were used. In spite of these limitations, the

new procedure presented in the full report represents the most up-to-date method for determining freeboard. The procedure takes into account all of the climatic factors and liquid characteristics that influence freeboard.

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The complete report, entitled "Freeboard Determination and Management in Hazardous Waste Surface Impoundments," (Order No. PB 88-243 787/AS; Cost: $21.95, subject to change) will be available only from:
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